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SAP Event Stream Processor: Developer Guide

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Content

1 Introduction

SAP Event Stream Processor makes use of Continuous Computation Language (CCL) and its components to develop projects. You can use CCL through a command line interface, or in conjunction with the SAP Event Stream Processor Studio.

If you are looking for information on building CCL projects or building applications that will create CCL projects, begin with this guide. Once you get started with development, you may also want to refer to the *SAP Event Stream Processor: CCL Reference*.

In this section:

1.1 How SAP Event Stream Processor Works

SAP Event Stream Processor enables you to create and run complex event processing applications to derive continuous intelligence from streaming event data in real time.

Event stream processing is a technique for analyzing information about events, in real time, for situational awareness. When vast numbers of event messages are flooding in, it is difficult to see the big picture. With event stream processing, you can analyze events as they stream in, and identify emerging threats and opportunities as they happen. Event stream processing filters, aggregates, and summarizes data to enable better decision-making based on more complete and timely information.

Event Stream Processor includes:

- A development platform, called ESP Studio, for building and testing event-based applications without significant programming effort.
- A run-time environment optimized for enterprise-scale, event-driven applications. Event Stream Processor processes data continually as it arrives, before storing it on disk, thus achieving extremely high throughput and low latency, enabling better decision making based on more complete and timely information.

Unlike traditional databases, which are designed for on-demand queries and transaction processing, ESP is optimized for continuous queries. Thus, instead of replacing databases, it complements them to help solve new classes of problems where continuous, event-driven data analysis is required.

So, even though Event Stream Processor can be installed and run as a standalone application, it is most commonly used as a component in a business solution based on SAP HANA. Not only can ESP look up information in SAP HANA tables and write data to SAP HANA tables, but the ESP Studio can be run from inside the SAP HANA studio.

SAP Event Stream Processor Deployments

Data flows into the SAP Event Stream Processor server from external sources through built-in or custom adapters, which translate incoming messages into a format that is accepted by the SAP Event Stream Processor server.

This figure shows a typical ESP deployment. Continuous queries, developed and tested as projects using the SAP Event Stream Processor Studio, are deployed to an SAP Event Stream Processor server. Output adapters translate rows processed by the server into message formats that are compatible with external destinations, such as SAP HANA, and send those messages downstream. SAP HANA cockpit provides an operations console for configuring ESP.

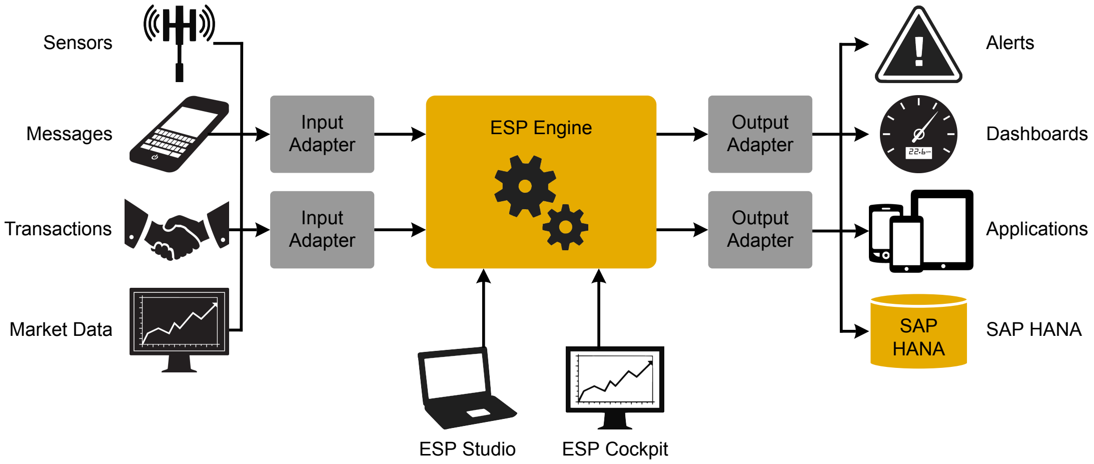


Figure 1: Event Stream Processor Deployment

Getting Results from a Project

The output from Event Stream Processor can be used in several ways. These options are not mutually exclusive, and can be used in any combination.

You can:

- Push output into SAP HANA database tables, either by logging events in the tables, or by updating database tables based on the results of continuous queries.
- Send output to downstream applications to act on the information. The output can be pushed directly to an application (via an adapter), or published onto a message bus. For example, you can open an urgent work order in response to new information, or change a price based on market conditions.

- Stream output to a live operational dashboard, or other custom UI, typically via WebSockets.
- Start a new streaming project that binds (connects) to an output stream in a running project.
- Query event windows maintained in streaming projects using SAP HANA Smart Data Access.

1.2 Event Stream Processing Compared to Databases

ESP complements traditional databases to help solve new classes of problems where continuous, event-driven data analysis is required.

ESP provides active monitoring of event streams, with the ability to generate immediate alerts, notifications or responses when something happens.

ESP is not a replacement for databases. While databases excel at storing and querying static data, and reliably processing transactions, ESP excels at continuously analyzing fast moving streams of data.

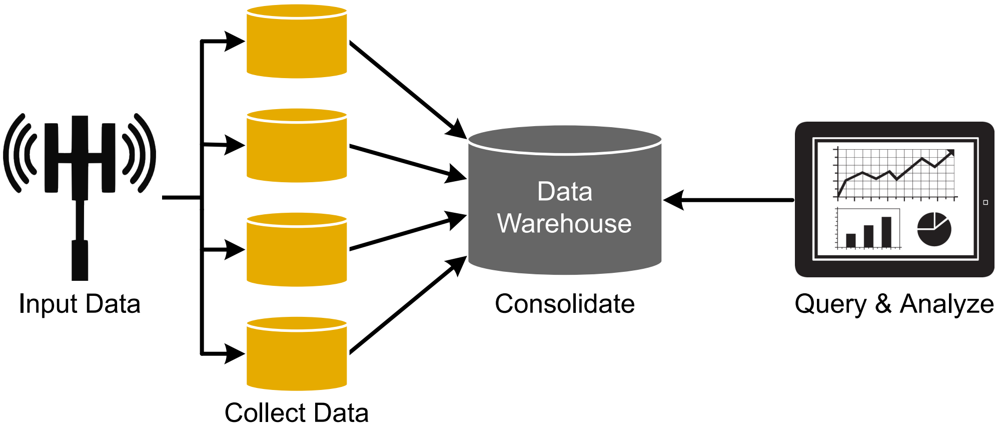


Figure 2: Traditional Business Intelligence: On-Demand Queries

ESP is not an in-memory database, although it stores all data in memory. ESP is optimized for continuous queries, rather than on-demand queries and transaction processing.

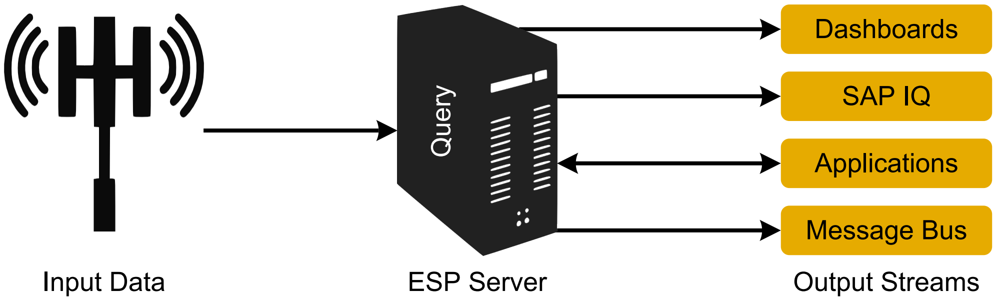


Figure 3: Query Runs Continuously on Changing Data Minimal Latency – Fast Response

1.3 Continuous Computation Language

Continuous Computation Language (CCL) is the primary event processing language of SAP Event Stream Processor. You define projects using CCL.

CCL is based on Structured Query Language (SQL), and adapted for stream processing.

CCL supports sophisticated data selection and calculation capabilities, including features such as data grouping, aggregations, and joins. However, CCL also includes features that are required to manipulate data during real-time continuous processing, such as windows on data streams, and pattern and event-matching.

A SQL query typically executes only once each time it is submitted to a database server, and is resubmitted every time a user or an application needs to re-execute the query. By contrast, a CCL query can continuously process dynamic data, making it a key distinguishing feature. Once you define a CCL query in the project, it is registered for continuous execution and stays active indefinitely. When the project is running in the ESP server, a registered query executes each time an event arrives from one of its datasources.

Although CCL borrows SQL syntax to define continuous queries, the ESP server does not use a SQL query engine. Instead, it compiles CCL into a highly efficient byte code that is used by the ESP server to construct continuous queries within the data-flow architecture.

CCL queries are converted to an executable form by the CCL compiler. ESP servers are optimized for incremental processing, so the query optimization is different than for databases. Compilation is typically performed within the Studio, but you can also compile projects by invoking the CCL compiler from the command line.

CCLScript

CCLScript is a scripting language that brings extensibility to CCL, allowing you to create custom operators and functions that go beyond standard SQL. CCLScript consists of expressions used to compute values from other values, as well as variables and looping constructs, with the ability to organize instructions in functions. CCLScript syntax is similar to C and Java, though it also has similarities to languages that solve relatively small programming problems, such as AWK and Perl. CCLScript also allows you to define any complex computations using procedural logic rather than a relational paradigm. You can learn more about CCL Script in the *SAP Event Stream Processor: CCL Reference*.

1.4 Methods for Working with Streaming Projects

There are a number of ways to create, edit, and deploy SAP Event Stream Processor projects.

SAP Event Stream Processor

SAP Event Stream Processor Studio provides two perspectives to create, edit, test, and deploy CCL projects: the SAP ESP Run-Test and SAP ESP Authoring perspectives. The SAP ESP Authoring perspective includes a choice of two different editors – a syntax-aware text editor and a drag-and-drop visual editor. You can easily switch between the visual editor and the text editor at any time, and any changes you make in one editor are reflected in the other. The SAP ESP Run-Test perspective provides a variety of tools that make it easy to test streaming projects. You can deploy projects to the server, stream in sample data, and view output. Additional tools facilitate debugging and performance tuning. You can access all ESP Studio components and features from within SAP HANA studio, as well as some SAP HANA-specific features, using the Streaming Plugin for SAP HANA studio.

For more information, see Working with Projects in Studio [page 33]

Application-Generated Content

Applications can generate and deploy dynamic streaming content. Similar to the way applications can create database content by executing SQL DDL commands, applications can create and deploy CCL projects. An application can deploy predefined CCL projects as needed, or alternatively, an application can dynamically create and deploy CCL. The SAP Event Stream Processor server provides a REST interface that applications can use to deploy CCL to the server. Alternatively, there is a Java library that you can use for applications written in Java. These applications have the ability to connect to the SAP HANA system via TCP sockets. For Java programmers, there is also a library to read and write CCL files.

Text Editors, Command Line Tools and Other Methods

Because streaming projects are simple text files, you can also use any editor to create, view and edit CCL projects. You can compile and deploy through the command line tools (which are documented in the *SAP Event Stream Processor: Utilities Guide*), the REST interface provided by the ESP server, or the Java API.

2 CCL Project Basics

ESP projects are written in CCL, a SQL-like language that specifies a data flow (by defining streams, windows, operations, and connections), and provides the ability to incorporate functions written in other languages, such as CCLScript, to handle more complex computational work.

Projects consist of a set of event streams, other required datasources, and the business logic applied to incoming event data to produce results. At its most basic level, a project consists of the following elements:

Element	Description
Input streams and windows	Receive input data flowing into the project. An input stream can receive: • Incoming event data on an event-driven basis. • Static or semistatic sets of data that are loaded once or periodically refreshed. Input streams that have state—that is, they can retain and store data—are called windows.
Adapters	Connect an input stream or window to a datasource, and connect an output stream or window to a destination. ESP includes: • An extensive set of input and output adapters to subscribe to and publish data. • An adapter toolkit for building custom external (Java) adapters. • A variety of SDKs to build custom external adapters in a number of programming languages. While an adapter connects the project to external inputs and outputs, technically it is not part of the project.
Derived streams and windows	Take data from one or more streams or windows and apply a continuous query to produce a new stream or window. Derived streams that have state—that is, they can retain and store data—are called windows.

All project information is stored in the project's CCL file, `<project-name>.ccl`, which is the definition of the project in Continuous Computation Language. The project also has one or more CCR files. These project configuration (.ccr) files are XML files that contain runtime and deployment configuration for the project, including adapter, parameter, and binding definitions. A project can have multiple CCR files allowing you to specify different adapters in different deployment environments, or to change runtime parameter values.

In this section:

An event is a message that contains information about an actual business event that occurred. Creating SAP Event Stream Processor projects allows you to consume and process input events and generate output events.

Operation Codes [page 16]
The operation code (opcode) of an event record specifies the action to perform on the underlying store of a window for that event.

Streams and Windows [page 17]
Both streams and windows can process events. The difference is that windows have state, meaning they can retain events, and can apply operations across the set of events in the window, while streams are stateless, and only operate on the current event. Streams and windows offer different characteristics and features, but also share common designation, visibility, and column parameters.

Schemas [page 27]
A schema defines the structure of data rows in a stream or window.

Adapters [page 28]
Adapters connect SAP Event Stream Processor to the external world.

SAP HANA Reference Tables [page 29]
Reference table queries help augment the streaming data in a SAP Event Stream Processor project with information from a table or view in SAP HANA.

CCL Functions [page 29]
A function is a self-contained, reusable block of code that performs a specific task.

Queries in CCL [page 30]
CCL queries are attached to derived streams or windows to select data from one or more inputs and transform it into the desired output.

Bindings Between CCL Projects [page 31]
Bindings enable data to flow between projects by allowing a stream, keyed stream, or window in one project to subscribe or publish to a stream, keyed stream, or window in another project.

2.1 Events

An event is a message that contains information about an actual business event that occurred. Creating SAP Event Stream Processor projects allows you to consume and process input events and generate output events.

In ESP, an event is represented by a set of typed fields and an operation code.

Examples of business events that are often transmitted as streams of event messages include:

- Financial market data feeds, which transmit trade and quote events. Each event could consist of ticker symbol, price, quantity, and time.
- Radio Frequency Identification System (RFID) sensors, which transmit events indicating that an RFID tag was sensed nearby.
- Electronic sensors, which transmit messages indicating the health of remote equipment and its components.
- Click streams, which transmit a message (a click event) each time a user clicks a link or button on a website.

- Database transaction events, which occur each time a record is added or updated.

In this example, a project monitors streams of financial market data. The stream `StreamTrades` accepts an `insert` event, which populates the columns `Ts`, `Symbol`, `Price`, and `Volume`:

```
StreamTrades ESP_OPS="insert" Ts="2012" Symbol="DRCT" Price="30.4400"
Volume="100"
```

Event Blocks

You can publish business events into ESP projects in collections called event blocks, which improve the performance of your projects. Event blocks come in two different types: envelopes and transactions. As an event block is being processed by a window, resulting rows are stored until the last event of the block is processed, after which the resulting events are sent downstream.

Event blocks have the following properties:

- Envelopes:
    - Each row in an envelope is treated atomically; a failure in an event does not discard the envelope. This behavior is useful if a model's performance is important, but not necessarily the integrity of the data.
- Transactions:
    - A transaction is discarded if any one event in the block fails. Use this behavior to guarantee that logical blocks of events are completely error-free.
    - Before a transaction block is sent downstream, all events in the transaction are compressed as much as possible. For example, an event with an insert and then an update will compress down to a single insert with updated values.

2.2 Operation Codes

The operation code (opcode) of an event record specifies the action to perform on the underlying store of a window for that event.

In many Event Stream Processor use cases, events are independent of each other; each carries information about something that happened. In these cases, a stream of events is a series of independent events. If you define a window on this type of event stream, each incoming event is inserted into the window. If you think of a window as a table, the new event is added to the window as a new row.

In other use cases, events deliver new information about previous events. ESP maintains a current view of the set of information as the incoming events continuously update it. Two common examples are ordering books for securities in capital markets, and opening orders in a fulfillment system. In both applications, incoming events may indicate the need to do one of the following:

- Add an order to the set of open orders
- Update the status of an existing open order
- Remove a canceled or filled order from the set of open orders

To handle information sets that are updated by incoming events, Event Stream Processor recognizes the following opcodes in incoming event records:

- `insert`: inserts the event record.
- `update`: updates the event record with the specified key. If no such record exists, it prompts a runtime error.
- `delete`: deletes the record with the specified key. If no such record exists, it prompts a runtime error.
- `upsert`: updates the record with the matching key. If no such record exists, it inserts the record.
- `safedelete`: deletes the record with the matching key. If no such record exists, it does nothing.

All event records include an opcode. Each stream or window in the project accepts incoming event records and produces event records. Output events, including opcodes, are determined by their source (window, stream, or keyed stream) and the processing specified for it.

2.3 Streams and Windows

Both streams and windows can process events. The difference is that windows have state, meaning they can retain events, and can apply operations across the set of events in the window, while streams are stateless, and only operate on the current event. Streams and windows offer different characteristics and features, but also share common designation, visibility, and column parameters.

Streams process incoming events and produce output events according to the continuous query that is attached to the stream, but no data is retained.

A window consists of a table where incoming events can add, update, or delete rows. You can set the size of the window based on time or the number of events recorded. For example, a window might retain all events from the past 20 minutes, or the most recent 1,000 events. A window can also retain all events. In this case, the incoming event stream is self-managing, in that it contains events that both insert rows into the window and delete rows from the window, so that the window does not grow infinitely large. Windows are needed to perform aggregate operations and joins, since you cannot do this on streams. Although you can join a stream to a window, or join a window to another window, you can’t join two streams together, because they are stateless: an event in one stream would not have anything to join with in the other stream.

Windows behave like streams in that they actively emit events (based on the input events being applied to the window). Windows can also emit events in the absence of input: a time-based retention policy on a window causes the window to emit “delete events” as rows in the window age-out.

All windows require a primary key, and every row in the window has a unique primary key value. The key value and opcode of an incoming event determine how the event is applied to the window, whether it is added as a new row, or updates or deletes an existing row in the window. Streams, on the other hand, do not usually require a primary key. If a primary key is defined on a stream, then we refer to the stream as a “keyed stream”, because the presence of the primary key designation changes the behavior of the stream with respect to opcodes. The following table compares feature capabilities between streams and windows:

Feature Capability	Streams	Windows
Data retention	None	Yes, rows (based on retention policy).
Available store types	Not applicable	Memory store or log store. Windows are assigned to a memory store by default. The state of windows assigned to log stores is restored after a project restart.

Feature Capability	Streams	Windows
Primary key required	No. However, a primary key can be designated (optional).	Yes, explicit or deduced.
Support for aggregation operations	No	Yes
Behavior on receiving insert, update, or delete	• Unkeyed stream: Produces insert. Converts update to insert. Ignores delete. • Keyed stream: Opcodes are passed unchanged. Does not detect duplicate inserts, or any updates/deletes against non-existent key values.	Produces insert, update, or delete according to the OpCode Rules for Window listed below.
Behavior on receiving upsert or safedelete	• Unkeyed stream: Converts upsert to insert. Ignores safedelete. • Keyed stream: Reject upserts and safedeletes as bad events.	Produces insert, update, or delete according to the exceptions listed below.
Filter semantics	• Unkeyed stream: Assumes all events to be inserts and emits only inserts for all events that satisfy the filter condition and have insert, update or upsert opcodes. Ignores events with delete and safedelete opcodes. • Keyed stream: Emits the incoming event if it passes the filter condition without regard to, and without altering, the opcode.	Modfies the opcode according to whether the previous event with the same key passed or failed the filter.
Can directly feed a window	Yes, but requires aggregation or the use of `nextval()` or `uniqueval()` functions to produce a primary key for the window.	Yes
Can serve as a project input element	Yes	Yes
Can serve as a project output element	Yes	Yes

Opcode Rules for Event Stream Processor Windows

A window can emit events with different opcodes, depending on what changes are made to the window contents by an incoming event. For example:

- At the most basic level, an incoming event is applied to the window, and the window emits an event that reflects the change to the window.
- In a window performing aggregation logic, an incoming event record with an insert opcode can update the contents of the store, and output an event record with an update opcode. This can also happen in a window implementing a left join.

- In a window with a count-based retention policy, an incoming event record with an insert opcode can cause the store to exceed this count. The window deletes the excess row, producing an event record with a delete opcode, and an insert event with a new row.
- An error is generated on duplicate inserts, bad updates, and bad deletes.
- Windows with a retention policy treat an update as an upsert, since the row being updated could have been removed from the window because of the retention policy.

Derived Streams and Windows

A derived stream or window is the result of taking one or more streams or windows as input, and applying a continuous query. This means either a SELECT clause in a CREATE STREAM or CREATE WINDOW statement, or a Flex operator applying CCLScript to events that arrive from one or more input streams or windows. Derived streams either direct data locally within a project, or publish the data to external destinations.

In this section:

Streams [page 20]
Streams subscribe to incoming events and process the event data according to the rules you specify (which you can think of as a "continuous query") to publish output events. Because they are stateless, they cannot retain data, and they use little memory because they do not store events.

Windows [page 20]
A window is a stateful element that can be named or unnamed, and retains rows based on a defined retention policy.

Retention Policies [page 23]
A retention policy specifies the maximum number of rows or the maximum period of time that data is retained in a window. The retention policy for a window is defined using a KEEP clause.

Input, Output, and Local [page 26]
You can designate streams, windows, and keyed streams as input or derived. Derived streams and windows can be designated as either output or local.

Making Windows Recoverable [page 27]
By default, any window you create is assigned to a memory store. Memory stores hold all data in memory, and are not recoverable. You can make the contents of a window recoverable by assigning the window to a log store.

Related Information

Specifying a Retention Policy [page 92]

2.3.1 Streams

Streams subscribe to incoming events and process the event data according to the rules you specify (which you can think of as a "continuous query") to publish output events. Because they are stateless, they cannot retain data, and they use little memory because they do not store events.

Streams can be designated as input or derived. Input streams are the point at which data enters the project from external sources via adapters. A project may have any number of input streams. Input streams do not have continuous queries attached to them, although you can define filters for them. Derived streams either direct data locally within a project, or publish it to external destinations.

Because a stream does not have an underlying store, the only thing it can do with arriving input events is to insert them. Insert, update, and upsert opcodes are all treated as inserts. Delete and safedelete are ignored. The only opcode that a stream can include in output event records is insert.

If you specify a key on a stream, the stream's opcode handling semantics change, and it becomes a keyed stream. A keyed stream can pass insert, update, and delete events with the opcode unchanged, but will treat them all the same.

Local and output streams take their input from other streams or windows, rather than from adapters, and they apply a continuous query to produce their output. Local streams are identical to output streams, except that local streams are hidden from outside subscribers. Thus, a subscriber cannot subscribe to a local stream. You cannot monitor or subscribe to local streams in the SAP Event Stream Processor Studio.

Each subscribed stream has a single thread that posts rows to all clients. If one subscriber to this stream backs up and the client's queue is filled, it blocks subscription for all other clients.

2.3.2 Windows

A window is a stateful element that can be named or unnamed, and retains rows based on a defined retention policy.

Create a window if you need data to retain state. To create a window, you can:

- Open the **Streams and Windows** compartment of the visual editor in the SAP Event Stream Processor in Studio, and click **Input Window**.
- Use the CREATE WINDOW statement in the text editor. When creating the window, and to retain rows, assign a primary key

Since a window is a stateful element, with an underlying store, it can perform any operation specified by the opcode of an incoming event record. Depending on what changes are made to the contents of the store by the incoming event and its opcode, a window can produce output event records with different opcodes.

For example, if the window is performing aggregation logic, an incoming event record with an insert opcode can update the contents of the store and thus produce an event record with an update opcode. The same could happen in a window implementing a left join.

A window can produce an output event record with the same opcode as the input event record. For example, if a window implements a simple copy or a filter without any additional clauses, the input and output event records have the same opcode.

An incoming event record with an insert opcode can produce an output event record with a delete opcode. For example, a window with a count-based retention policy (for example, keeping five records) will delete those records from the store when the sixth event arrives, thus producing an output event record with a delete opcode.

Each subscribed window has a single thread that posts rows to all clients. If one subscriber to this window backs up and the client's queue is filled, it blocks subscription for all other clients.

Named Windows

Named windows can be derived or input:

- Derived windows can be:
    - Output, which can send data to an adapter.
    - Local windows, which are private and invisible externally. If a window does not have a qualifier, it is considered local.
- Input, which can send and receive data through adapters.

Both input and output windows are visible externally and can be subscribed to or queried.

The following table compares input, output, and local windows:

Type	Receives Data From	Sends Data To	Visible Externally
input	Input adapter or external application that sends data into ESP using the ESP SDK.	One or more of the following: other windows, keyed streams, and output adapters.	Yes
output	Other windows, streams, or keyed streams.	One or more of the following: other windows, keyed streams, and output adapters.	Yes
local	Other windows, streams, or keyed streams.	Other windows or keyed streams.	No

Unnamed Windows

Unnamed windows are implicitly created:

- When using a join with a window that produces a stream.
- When the KEEP clause is used with the FROM clause of a statement.

In both situations, when an unnamed window is created, it always includes a primary key.

> **Note**
>
> Although unnamed windows use additional memory, there is no memory reporting on them.

This example creates an unnamed window when using a join with a window:

```
CREATE INPUT WINDOW Win1 SCHEMA (Key1 INTEGER, Col1 STRING, Col2 STRING) PRIMARY
KEY (Key1);
```

```
CREATE INPUT WINDOW Win2 SCHEMA (Key1 STRING, Col3 STRING) PRIMARY KEY (Key1);
CREATE OUTPUT WINDOW Out1 PRIMARY KEY DEDUCED AS SELECT Win1.Key1, Win1.Col1,
Win1.Col2, Win.2.Col3
FROM Win1 INNER JOIN Win2 ON Win1.Col1 = Win2.Key1;
```

> Note
>
> The unnamed window is created to ensure that a join does not see records that have not yet arrived at the join. This can happen because the source to the join and the join itself are running in separate threads.

These four examples demonstrate when an unnamed window is created using a KEEP clause.

Example 1 creates an unnamed window on the input `Trades` for the `MaxTradePrice` window to keep track of a maximum trade price for all symbols seen within the last 10,000 trades:

```
CREATE WINDOW MaxTradePrice
PRIMARY KEY DEDUCED
STORE S1
AS SELECT
        trd.Symbol, max(trd.Price) MaxPrice
FROM Trades trd KEEP 10000 ROWS
GROUP BY trd.Symbol;
```

Example 2 creates an unnamed window on `Trades`, and `MaxTradePrice` keeps track of the maximum trade price for all the symbols during the last 10 minutes of trades:

```
CREATE WINDOW MaxTradePrice
PRIMARY KEY DEDUCED
STORE S1
AS SELECT
        trd.Symbol, max(trd.Price) MaxPrice
FROM Trades trd KEEP 10 MINUTES
GROUP BY trd.Symbol;
```

Example 3 creates an unnamed window when using a window on a stream:

```
CREATE INPUT STREAM DataIn
SCHEMA (Symbol string, price money(2), size integer);
CREATE OUTPUT WINDOW MovingAvg
PRIMARY KEY DEDUCED AS SELECT DataIn.Symbol Symbol ,
        avg(DataIn.price) AvgPrice ,
        sum(DataIn.size) TotSize
FROM DataIn KEEP 5 MIN
GROUP BY DataIn.Symbol;
```

Example 4 creates a `FiveMinuteVWAP` unnamed window from the source stream `Trades`. Since the stream is an input to an aggregation, the unnamed window is created to allow the stream to have a retention policy:

```
CREATE INPUT STREAM Trades
SCHEMA (Tradeid integer, Symbol string, Price money(2), Shares integer)
CREATE WINDOW FiveMinuteVWAP
PRIMARY KEY DEDUCED AS SELECT
        trd.Symbol, trd.Price, trd.Shares,
        vwap(trd.Price, trd.Shares)
FROM Trades KEEP 5 MINUTES
GROUP BY trd.Symbol;
```

2.3.3 Retention Policies

A retention policy specifies the maximum number of rows or the maximum period of time that data is retained in a window. The retention policy for a window is defined using a KEEP clause.

Overview

There are two main types of retention policies:

- Time-based policies specify how long each row is held in the window. For example, if you say KEEP 5 MINUTES, the window holds all events received (or updated) in the last 5 minutes. After an event has been in the window for 5 minutes, it is deleted from the window (unless it gets updated, which resets the 5 minute clock).
- Count-based policies specify the number of events (rows) to keep in the window. For example, if you say KEEP 100 ROWS, the window keeps 100 events. Once it reaches the maximum number, the oldest events over 100 rows are deleted.

You can also set KEEP ALL, which keeps all events in the window. If you don't specify a retention policy, the window defaults to KEEP ALL.

> ⚠ Caution
>
> Using KEEP ALL can be dangerous. Unless your window receives delete events that naturally control the size of the window, the window grows unbounded, eventually consuming all memory and causing the project to shut down.

The KEEP clause can be applied to both named and unnamed windows, and affects your project very differently depending on where it is applied.

Using the KEEP Clause in Aggregation

The most common use case scenario for a KEEP clause is aggregating over a stream:

```
CREATE INPUT STREAM SENSOR_IN
  SCHEMA (
    SENSOR_ID integer ,
    VALUE float);

CREATE OUTPUT WINDOW moving_avg
PRIMARY KEY DEDUCED
AS SELECT
    SENSOR_IN.SENSOR_ID,
    avg(SENSOR_IN.VALUE) AS AVG_VAL
FROM SENSOR_IN KEEP 2 MINUTES
GROUP BY SENSOR_IN.SENSOR_ID;
```

In this example, the retention policy creates an unnamed window on the input stream holding all events received in the last 2 minutes. This creates a 2-minute moving average for each sensor ID.

You can also define a retention policy for a named window, where the KEEP clause follows the PRIMARY KEY:

```
CREATE INPUT WINDOW event_log
SCHEMA (
    SEQUENCE integer ,
    PARTCOUNT integer)
PRIMARY KEY (SEQUENCE)
KEEP 1000 ROWS;
```

There is a functional difference between the using a KEEP clause for a named window, and using it in a FROM clause. The following example uses both:

```
CREATE OUTPUT WINDOW movement
PRIMARY KEY DEDUCED
KEEP 2 HOURS
AS SELECT
  device_events.c_sensor_id sensor_id ,
  valueinserted ( device_events.c_value ) value ,
  valueinserted ( device_events.c_class ) class,
  avg(device_events.c_value) avg,
  stddev_pop(device_events.c_value) stddev
FROM device_events KEEP 5 MINUTES
GROUP BY device_events.c_sensor_id ;
```

In the example above, KEEP 2 HOURS is directly applied to the aggregate window `movement`. This policy means that any sensor that hasn't sent a new or updated value in the last 2 hours is dropped from the window. The second retention policy, KEEP 5 MINUTES, is applied to the events streaming into the window, instead of the window itself. It determines the set of events the window is aggregating over, creating a 5 minute moving average.

Sliding Windows

If you use the KEEP clause with no modifier, the default type of window is a sliding window. This window type follows the default time-based and count-based retention behaviours.

Jumping Windows

Using the KEEP clause with an EVERY modifier produces a jumping window, which deletes all of the retained rows when the time interval expires or a row arrives that would exceed the maximum number of rows. For example:

- Time-based retention: if the policy is KEEP EVERY 5 MINUTES, the window accumulates events for 5 minutes after receiving the first event. Then, all rows in the window are deleted and the window restarts accumulating events with the next one received.
- Count-based retention: if the policy is KEEP EVERY 10 ROWS, the window accumulates events until the 10th event. Then, all events are deleted and the window restarts accumulating events with the next one received.

> **i Note**
>
> You can specify retention on input windows (or windows where data is copied directly from its source) using either log file-based stores or memory-based stores. For other windows, you can only specify retention on windows with memory-based stores.

Count-based Retention Applied to Non-Key Columns

Count-based retention policies also supports retention based on content/column values. Using the PER subclause, you can specify either an individual column, or a comma-delimited list of columns. A specific column can only be used once in a PER subclause. You cannot use primary key or autogenerate columns in the PER subclause, because these are unique entities for which multiple values cannot be retained.

The following example creates a sliding window that retains two rows for each unique value of `Symbol`. Once two records have been stored for any unique `Symbol` value, the arrival of a third deletes the oldest stored record with the same Symbol value:

```
CREATE INPUT WINDOW TradesWin1
SCHEMA TradesSchema
PRIMARY KEY(Id)
KEEP 2 ROWS PER(Symbol);
```

Using Slack to Optimize Performance for Count-based Retention

In a count-based retention policy, you can also set an optional slack value to enhance performance. The default value for SLACK is 1, which means that every new inserted record deletes the oldest record, causing significant processing overhead. Since it isn't always important to maintain a window at a precise size, significant performance gains can be achieved by defining a larger slack value for a window. This is most evident for high frequency event streams. For example:

```
CREATE WINDOW Last100Trades PRIMARY KEY DEDUCED
KEEP 100 ROWS SLACK 10
AS SELECT * FROM Trades
WHERE Trades.Volume > 1000;
```

In this example, rather than always maintaining the window at 100 rows, the SLACK value in the retention policy allows the window to grow to 110 rows, then delete the oldest 10 events all at once.

> **i Note**
>
> You cannot use the SLACK value in a jumping window's retention policy, because it cannot be used with the EVERY modifier.

Retention Semantics

When the insertion of one or more new rows into a window triggers the deletion of preexisting rows (due to retention), the window propagates the inserted and deleted rows downstream to relevant streams and subscribers. However, the inserted rows are placed before the deleted rows, since the inserts trigger the deletes.

2.3.4 Input, Output, and Local

You can designate streams, windows, and keyed streams as input or derived. Derived streams and windows can be designated as either output or local.

Input and Output Streams and Windows

Input streams and windows can accept data from a source external to the project using an input adapter or by connecting to an external publisher. You can attach an output adapter or connect external subscribers directly to an input window or input stream. You can also use an ad-hoc query to select rows from an input window, insert rows in an input stream or insert, update, or delete rows in an input window.

Output windows, streams, and keyed streams can publish data to an output adapter or an external subscriber. You can use an ad-hoc query to select rows from an output window.

Local streams, windows, and keyed streams are invisible outside the project and cannot have input or output adapters attached to them. You cannot subscribe to or use an ad-hoc query for the contents of local streams, windows, or keyed streams.

Example

This is an input stream with a filter:

```
CREATE SCHEMA mySchema (Col1 INTEGER, Col2 STRING);
CREATE INPUT STREAM IStr2 SCHEMA mySchema
    WHERE IStr2.Col2='abcd';
```

This is an output stream:

```
CREATE OUTPUT STREAM OStr1
    AS SELECT A.Col1 col1, A.Col2 col2
    FROM IStr1 A;
```

This is an input window:

```
CREATE SCHEMA mySchema (Col1 INTEGER, Col2 STRING);
CREATE MEMORY STORE myStore;
CREATE INPUT WINDOW IWin1 SCHEMA mySchema
    PRIMARY KEY(Col1)
    STORE myStore;
```

This is an output window:

```
CREATE SCHEMA mySchema (Col1 INTEGER, Col2 STRING);
CREATE MEMORY STORE myStore;
CREATE OUTPUT WINDOW OWin1
    PRIMARY KEY (Col1)
    STORE myStore
    AS SELECT  A.Col1 col1, A.Col2 col2
    FROM IWin1 A;
```

Local Streams and Windows

Use a local stream, window, or keyed stream when the stream does not need an adapter, or to allow outside connections. Local streams, windows, and keyed streams are visible only within the containing CCL project, which allows for more optimizations by the CCL compiler. Streams and windows that do not have a qualifier are local.

> **Note**
>
> A local window cannot be debugged because it is not visible to the SAP ESP Run-Test tools such as viewer or debugger.

> **Example**
>
> This is a local stream:
>
> ```
> CREATE SCHEMA mySchema (Col1 INTEGER, Col2 STRING);
> CREATE LOCAL STREAM LStr1
>     AS SELECT i.Col1 col1, i.Col2 col2
>     FROM IStr1 i;
> ```
>
> This is a local window:
>
> ```
> CREATE SCHEMA mySchema (Col1 INTEGER, Col2 STRING);
> CREATE MEMORY STORE myStore;
> CREATE LOCAL WINDOW LWin1
>     PRIMARY KEY (Col1)
>     STORE myStore
>     AS SELECT i.Col1 col1, i.Col2 col2
>     FROM IStr1 i;
> ```

2.3.5 Making Windows Recoverable

By default, any window you create is assigned to a memory store. Memory stores hold all data in memory, and are not recoverable. You can make the contents of a window recoverable by assigning the window to a log store.

To start using log stores, you can change the default settings for all windows in the project, or you can assign log stores directly to specific windows. See Data Retention and Recovery with Stores [page 184] for more information.

2.4 Schemas

A schema defines the structure of data rows in a stream or window.

Every row in a stream or window has the same structure (schema), including the column names and datatypes and the order in which the columns appear. Multiple streams or windows can use the same schema, but each stream or window can only have one schema.

You can make a schema in one of the following ways:

- Create a named schema using the CREATE SCHEMA statement. Named schemas are useful when the same schema will be used in multiple places, since any number of streams and windows can reference a single named schema.
- Create an inline schema within a stream or window definition.

> Example
>
> Simple Schema CCL Example
>
> This example uses a CREATE SCHEMA statement to create the named schema `TradeSchema`:
>
> ```
> CREATE SCHEMA TradeSchema (
>         Ts BIGDATETIME,
>         Symbol STRING,
>         Price MONEY(4),
>         Volume INTEGER
> );
> ```
>
> This example uses a CREATE SCHEMA statement to make an inline schema:
>
> ```
> CREATE STREAM trades SCHEMA (
>         Ts bigdatetime,
>         Symbol STRING,
>         Price MONEY(4),
>         Volume INTEGER
> );
> ```

2.5 Adapters

Adapters connect SAP Event Stream Processor to the external world.

An input adapter connects an input stream or window to a data source. It reads the data output by the source and modifies it for use in ESP projects.

An output adapter connects an output stream or window to a data sink. It reads the data output by the ESP project and modifies it for use by the consuming application.

Adapters are attached to streams and windows using the ATTACH ADAPTER statement. Start them by using the ADAPTER START statement. Some projects may need to start adapters in a particular order, for example, to load reference data before attaching to a live event stream. Adapters can be assigned to groups and the ADAPTER START statement can control the start-up sequence of the adapter groups.

See the *SAP Event Stream Processor: Adapters Guide* for detailed information about configuring individual adapters, datatype mapping, and schema discovery.

Related Information

Adding an Input Adapter [page 297]

Adding an Adapter to a Project [page 80]
Adding an Output Adapter for SAP HANA [page 309]

2.6 SAP HANA Reference Tables

Reference table queries help augment the streaming data in a SAP Event Stream Processor project with information from a table or view in SAP HANA.

This CCL element enables you to establish a reference to a table or view in SAP HANA from within the ESP project, then use the reference in a join along with streams and windows. When an event arrives via a stream or window, the reference executes a query on the table in the external database and uses the returned data in the join to enrich streaming data with information from the database.

To create a reference, you need:

- The name of the database service to use.
- The name of the table from which to retrieve information.
- The schema of the table.

You can also specify:

- The primary key of the table as the primary key of the reference.
- That the reference should attempt to reconnect when the connection is lost.
- How many attempts to make.
- How long to wait between attempts.

In CCL, use the CREATE REFERENCE statement to define the reference, then use the FROM and ON clauses to join data from the reference with streams and windows in the ESP project. You can also use the **Reference** shape (found under Streams and Windows in the palette) within the SAP ESP Authoring perspective's visual editor.

In CCLScript, you can use an iterator over a reference from a local DECLARE block and in the Flex operator in the same way you use an iterator over a window. You may also iterate over a reference using the key search (if a primary key is defined), record-matching search, and for loop functionality. See the *SAP Event Stream Processor: CCL Reference* for more information on these statements and clauses.

2.7 CCL Functions

A function is a self-contained, reusable block of code that performs a specific task.

SAP Event Stream Processor supports:

- Built-in functions, including aggregate, scalar, and other functions.
- User-defined CCLScript functions.
- User-defined external C/C++ functions.
- User-defined external Java functions.

Built-in functions come with the software and include functions for common mathematical operations, aggregations, datatype conversions, and security.

The ESP server only accepts user-defined functions if the `enable-udfs` property is set to true in the cluster configuration. By default, this property is set to false and projects containing external user defined functions (UDFs) cannot run successfully. See *Enabling External User Defined Functions* in the *SAP Event Stream Processor: Cockpit Guide* for detailed instructions.

> i Note
>
> Because Java and C/C++ user-defined functions are not run in a secure sandbox, it is possible to write functions that access the file system or network I/O. Therefore it is important to do a thorough code review with a focus on security before deploying a user-defined function to ESP.

Order of Evaluation of Operations

Operations in functions are evaluated from right to left. This is important when variables depend on another operation that must pass before a function can execute because it can cause unexpected results. For example:

```
integer a := 1;
integer b := 2;
max( a + b, ++a );
```

The built-in function `max()`, which returns the maximum value of a comma-separated list of values, returns 4 since ++a is evaluated first, so `max(4, 2)` is executed instead of `max(3, 2)`, which may have been expected.

2.8 Queries in CCL

CCL queries are attached to derived streams or windows to select data from one or more inputs and transform it into the desired output.

CCL embeds queries within CREATE STREAM and CREATE WINDOW statements in the same way that standard SQL uses CREATE VIEW statements. Unlike SQL, in CCL, SELECT is not a statement but rather is a clause used within a CREATE `<object-type>` statement.

Where the visual editor lets you select data using visual components referred to as simple queries, these queries are actually CCL statements that create a stream or window with an attached query.

To develop queries in CCL, refer to topics under CCL Query Construction [page 203], or see the *Statements* and *Clauses* topics in the *SAP Event Stream Processor: CCL Reference*.

2.9 Bindings Between CCL Projects

Bindings enable data to flow between projects by allowing a stream, keyed stream, or window in one project to subscribe or publish to a stream, keyed stream, or window in another project.

> ℹ Note
>
> This functionality is not supported in streaming lite.

A binding is a named connection from an input or output stream (or keyed stream or window) of one project to an input stream (or keyed stream or window) of another; you can configure it at either end.

- An input stream can subscribe to one or more streams in other projects. These streams do not have to be output streams—you can create an output binding on an input stream.
- An output stream can publish to one or more input streams in other projects. An output stream cannot receive incoming data, whether by subscription or publication.

Bindings reside in the project configuration file (`.ccr`), so you can change them at runtime. The streams being bound require compatible schemas.

See Using Bindings to Connect CCL Projects [page 199] for examples and more information.

3 Internal and External Ports for SAP HANA Smart Data Streaming

Internal and external ports are fixed values that are automatically assigned and cannot be changed. Learn which ports are assigned for internal, external, Web Services Provider, and Streaming Web Service uses.

Port Use	Port Assigned
Internal	3xx16
External	3xx26
Web Services Provider (SOAP port)	9090
Web Services Provider (REST port)	9091
Web Services Provider (WebSocket port)	9092
Streaming Web Service	9093

4 Working with Projects in Studio

SAP Event Stream Processor Studio provides provides two perspectives to create, edit, test and deploy CCL projects: the SAP ESP Run-Test and SAP ESP Authoring perspectives.

You can access all ESP Studio components and features from within SAP HANA studio, as well as some SAP HANA-specific features, using the Streaming plugin for SAP HANA studio.

The perspectives provide an environment for working with sample streaming projects, and for running and testing applications with various debugging tools. You can record and playback project activity, upload data from files, manually create input records, and run ad hoc queries against the server.

You can compile projects into an executable project file. The project file can be shared, tested, developed, and run in the Studio regardless of the operating system on which it was compiled.

Data-Flow Programming

In data-flow programming, you define a set of event streams and the connections between them, and apply operations to the data as it flows from source to output.

Data-flow programming breaks a potentially complex computation into a sequence of operations with data flowing from one operation to the next. This technique also provides scalability and potential parallelization, since each operation is event-driven and independently applied. Each operation processes an event only when it is received from another operation. No other coordination is needed between operations.

The sample project shown in this figure is a simple example of data-flow programming. Each of the continuous queries in this example—the VWAP aggregate, the IndividualPositions join object, and the ValueByBook aggregate—is a type of derived stream, as its schema is derived from other inputs in the diagram, rather than originating directly from external sources.

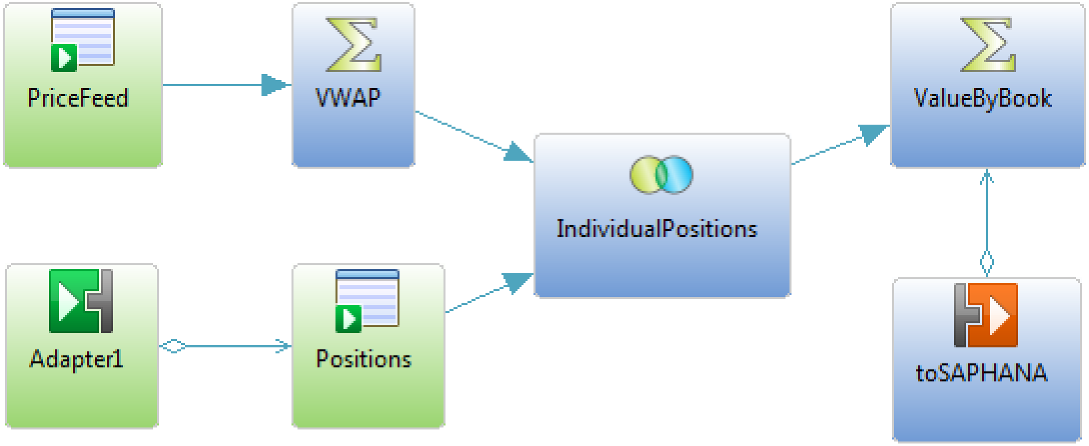
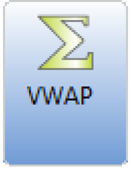
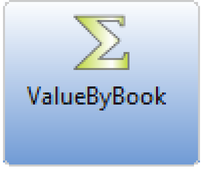


Figure 4: Data-Flow Programming – Simple Example

You can create derived streams in a diagram using the simple query elements provided in the Studio visual editor, or by defining your own explicitly.

Element	Description
PriceFeed 	Represents an input window, where incoming data from an external source complies with a schema consisting of five columns, similar to a database table with columns. In Event Stream Processor, however, the streaming data is not stored in a database.
Positions 	Another input window, with data from a different external source. Both Positions and PriceFeed are included as windows, rather than streams, so that the data can be aggregated.
VWAP  	Represents a simple continuous query that performs an aggregation, similar to a SQL SELECT statement with a GROUP BY clause.
IndividualPositions 	Represents a simple continuous query that performs a join of Positions and VWAP, similar to a SQL FROM clause that produces a join.
ValueByBook  	Another simple query that aggregates data from the stream IndividualPositions.

In this section:

The SAP Event Stream Processor Studio is an interactive development environment for building and testing event-based applications. It includes the SAP ESP Authoring and SAP ESP Run-Test perspectives, as well as a visual and text editor.

Cluster Connectivity [page 61]

In Studio, you can run a project on either a local or a remote cluster, using any of three methods of authentication. You can automatically run a project on a local cluster without needing to perform any prior steps. To run a project on a remote cluster, however, first connect to that cluster. This requires some simple configuration steps.

Developing Projects with Studio [page 72]

Use either the visual editor or the text editor within the SAP ESP Authoring perspective to create and modify your projects. Start by developing a simple project, then test it iteratively as you gradually add greater complexity.

Running and Testing Projects with Studio [page 114]

Running a project automatically starts the project either on a default local cluster or on another connected cluster, enabling you to upload data from a file, manually enter data, and view streams in that project. Test a project by compiling and running it on a server, accessing and filtering streams, saving and uploading data to the SAP Event Stream Processor server, and setting project configurations.

4.1 ESP Studio Basics

The SAP Event Stream Processor Studio is an interactive development environment for building and testing event-based applications. It includes the SAP ESP Authoring and SAP ESP Run-Test perspectives, as well as a visual and text editor.

Perspectives

By default, all perspectives are open. To switch to another perspective, click its tab, just below the main menu bar. The following table describes the activities you can perform in the different perspectives.

Perspective	Activities
SAP ESP Authoring	• Create and edit projects. • Develop projects and diagrams in the visual editor, a graphical editing environment. • Develop projects in the text editor, a text-oriented editing environment where you edit CCL code. • Compile projects.

Perspective	Activities
SAP ESP Run-Test	• Start and connect to servers. • Run projects. • Enter test data by uploading data files to a server, or entering data manually to a stream. • Publish data. • Execute a query against a running project. • Use the event tracer and debugger to set breakpoints and watchpoints, and trace the flow of data through a project. • Record incoming event data to a playback file, and play back captured data into a running project. • Monitor performance.

Authoring Perspective Components

The visual editor, text editor, and other tools and views in the SAP ESP Authoring perspective allow you to create, view, and edit a diagram or CCL file. When viewing the SAP ESP Authoring perspective, its components are:

Editor
: Authoring perspective where you edit the diagram (in the visual editor) or CCL (in the text editor). The visual and text editors are completely integrated. When you save and switch to the other editor, your work is saved there as well. You can switch between editors in several ways, including right-clicking and selecting **Switch**, or choosing **F6**.

Palette
: Includes groups of tools used to create new CCL elements on the diagram. Most shapes in the palette correspond to a CCL statement.

Project Explorer
: Provides a hierarchical tree structure of folders and files. Adding a new ESP project displays it in the project explorer. As you add new elements to the project, such as new windows or streams, you can display them in the project explorer by selecting **Refresh** from the project explorer context menu. The **Toggle ESP Nature** option in the context menu toggles the appearance of ESP-specific context menu options for individual projects in the project explorer.

Properties view
: Displays the properties of the object selected in the diagram. You can also set properties in this view, and edit expressions.

Outline view
: Provides an index to all elements in the diagram as a hierarchical tree structure. Also shows the order in which adapters are started. Right-click an element in this view to show it in the diagram, delete it, modify it, or add a child element.

Overview
: Helps you understand the big picture, and navigate easily to different areas of a large, complex diagram. For large diagrams you can scroll the editor by dragging the gray box in the overview.

Search
: Provides full-text search capability for finding text strings in the workspace. Useful in navigating the file explorer, and project contents in the text editor. You can filter search results, and copy, remove, or replace results found.

Problems
: Displays errors found when you compile a project.

Console	Displays messages generated when interacting with ESP components.

Run-Test Perspective Components

You can access various tools to test, monitor, debug, and fine-tune a project from the SAP ESP Run-Test perspective. The components of the SAP ESP Run-Test perspective are:

Server View	Start and connect to available servers. Your first project is there, already running.
Manual Input view	Manually create and publish events as input to a stream or window.
Playback view	Record data flowing into a running project, or play back recorded files.
File Upload view	Publish an existing data file to an input stream or window.
SQL Query view	Run a snapshot SQL query. It captures a snapshot of the current window state and displays results in the Console.
Console view	Review log messages and other tracing and debugging information useful to developers.
Stream view	Show the events of an output stream or the retained events in an output window of a running project.
Monitor view	Monitor performance of a running project.
Debugger view	Debug a project by setting breakpoints and watchpoints.
Event Tracer view	Trace the flow of data through a project.

Eclipse Terms

The SAP Event Stream Processor Studio uses some Eclipse terms:

Term	Description
View	A named window in the Studio user interface. Views are tabbed so several can overlap and occupy the same pane. The SAP ESP Run-Test perspective, for example, includes the server view, manual input view, file upload view, and playback view. You can move, minimize, and resize views.
Perspective	A named set of views. Like views, perspectives are tabbed so several can use the same space. Perspectives in Studio include SAP ESP Authoring and SAP ESP Run-Test.
Workspace	The Studio workspace is a directory that stores projects. This workspace is distinct from cluster workspaces, which are logical groupings of deployed projects.

In this section:

Launching Studio [page 38]

Start SAP Event Stream Processor Studio using the desktop shortcut, Windows Start menu, or the command line. If you installed the Streaming plugin for SAP HANA studio, you can access SAP Event Stream Processor functionality within the SAP HANA studio by opening the SAP ESP Run-Test and SAP ESP Authoring perspectives.

Editing in the Text Editor [page 39]

The text editor is a text authoring environment within the SAP Event Stream Processor Studio for editing CCL code.

Editing in the Visual Editor [page 41]

In the visual editor, the project is represented by one or more diagrams that show streams, windows, adapters, and the data flows between them. Add or remove shapes and connections or edit shape attributes to make changes to a project.

Project Execution and Testing [page 46]

Run and test all aspects of a project using the SAP Event Stream Processor Studio.

Event Stream Processing with SAP HANA [page 47]

SAP Event Stream Processor integrates with SAP HANA in a number of ways, providing multiple methods for sharing data, all of which you can tailor to fit your projects.

SAP HANA Navigator [page 52]

When you install the Streaming studio plugin for SAP HANA studio, you can use the SAP HANA Navigator to select tables and views within SAP HANA, then drop them directly into a project diagram in the Studio visual editor. This creates a new adapter reference or named schema in the SAP ESP project.

The Studio Log File [page 52]

SAP Event Stream Processor Studio logs activity and records it in a log file. Access this log file to view Studio activity and to help troubleshoot events such as unexpected shut down.

Customizing the Studio Work Environment [page 53]

Customize your SAP Event Stream Processor Studio interface to work the way you prefer.

Sample Streaming Projects for Studio [page 59]

SAP Event Stream Processor Studio includes several completed example projects.

4.1.1 Launching Studio

Start SAP Event Stream Processor Studio using the desktop shortcut, Windows Start menu, or the command line. If you installed the Streaming plugin for SAP HANA studio, you can access SAP Event Stream Processor functionality within the SAP HANA studio by opening the SAP ESP Run-Test and SAP ESP Authoring perspectives.

Procedure

In SAP HANA studio, go to ▶ **Window** ▶ **Open Perspective** ▶ **Other** ▶, then open the **SAP ESP Authoring** or **SAP ESP Run-Test** perspective.

Platform	Method
Windows	In SAP HANA studio, go to › **Window** › **Open Perspective** › **Other** ›, then open the **SAP ESP Authoring** perspective or the SAP ESP Run-Test perspective. From outside of SAP HANA studio, either: ○ Double-click the **SAP ESP Studio** shortcut on your computer desktop, or, ○ Select Event Stream Processor Studio from the Start menu.
Linux or UNIX	In SAP HANA studio, go to › **Window** › **Open Perspective** › **Other** ›, then open the SAP ESP Authoring or SAP ESP Run-Test perspective. From outside of SAP HANA studio, either: ○ Double-click the **SAP ESP Studio** shortcut on your computer desktop, or, ○ At the command line, enter `$STREAMING_HOME/studio/streamingstudio`.

For more information on each perspective, see ESP Studio Basics [page 35].

4.1.2 Editing in the Text Editor

The text editor is a text authoring environment within the SAP Event Stream Processor Studio for editing CCL code.

Context

You can work in the text editor exclusively, or use it as a supplement to the visual editor. The text editor offers syntax completion options, syntax checking, and error validation.

A single CCL file can be open in only one editor at a time. The visual and text editors are completely integrated: when you save and switch to the other editor, your work is saved there as well.

You may find that you prefer the text editor when adding advanced features to your projects. For example, you can add:

- Complex queries that exceed the capabilities of the visual editor.
- DECLARE blocks for declaring project variables, parameters, datatypes, and functions.
- CCLScript event handlers that you invoke with Flex operators.
- User-defined functions.
- Reusable modules and schemas that can be used multiple times in a project, or across projects.

Several features simplify the process of editing CCL code in the text editor:

Feature	Description
Completion Proposals	Activate completion proposals in workspace [**Ctrl** + **Space**].
Case-Insensitive Syntax Highlighting	Done automatically when editing CCL code.
Error Validation/Syntax Checking	Access the Problems view to see errors in CCL code.
Compile and Report Compilation Errors	Access the Problems view to see errors in CCL code.

The ESP server only accepts user-defined functions if the `enable-udfs` property is set to true in the cluster configuration. By default, this property is set to false and projects containing external user defined functions (UDFs) cannot run successfully. See *Enabling External User Defined Functions* in the *SAP Event Stream Processor: Cockpit Guide* for detailed instructions.

For CCL language details, see the *SAP Event Stream Processor: CCL Reference*.

Procedure

1. Select the SAP ESP Authoring perspective.
2. In the project explorer, expand the project container, and double-click the `.ccl` file name to open it in the text editor.

   > i Note
   >
   > Advanced CCL users can include multiple CCL files in the same project by using an IMPORT statement to import shared schemas and module definitions from another file. When using the IMPORT statement to import one CCL file into another, both CCL files must be contained within the same project. If not, you receive an error message stating that the file cannot be located.

3. Begin editing text in the text editor window.

   > → Tip
   >
   > If you open a `.ccl` file in the text editor when the same project is open in the visual editor, the text editor opens in read-only mode and you cannot edit the file.
   >
   > Close both the visual editor and text editor for the project, and then reopen the project in the text editor.

   > i Note
   >
   > Backslashes within string literals are used as escape characters; specify any Windows directory paths with two backslashes.

4. (Optional) Press **Ctrl+Space** to show a syntax completion proposal.
5. (Optional) To insert CREATE statement template code, right-click, choose **Create**, and then choose the element to create.
6. (Optional) To search for text, choose **Search** > **File**.
   You can also start a new search from the link in the **Search** view, when no search results are visible.

   > → Tip
   >
   > Double-click a search result to highlight it in the text editor.

7. (Optional) To write comments in CCL that appear as tooltips for shapes in the visual editor, insert a comment immediately preceding the declaration statement for the corresponding shape.

   For example, to insert a tooltip for an input window, type:

   ```
   /**InputWindowInStudio*/
   ```

```
CREATE INPUT WINDOW InputWindow1 ;
```

8. Choose ▶ **File** ▶ **Save** ▶ (**Ctrl+S**) to save the `.ccl` file and the project.

4.1.3 Editing in the Visual Editor

In the visual editor, the project is represented by one or more diagrams that show streams, windows, adapters, and the data flows between them. Add or remove shapes and connections or edit shape attributes to make changes to a project.

Context

The visual editor lets you create and edit projects while visualizing the data flow and navigating within the project. The visual and text editors are completely integrated. When you save and switch to the other editor, your work is saved there as well.

Diagrams

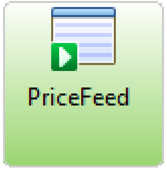
When you open a project in the visual editor, the project shows a collection of stream and window shapes that are connected with arrows showing the flow of data. You develop the project by selecting new input and output streams, windows, and other elements from the palette, dropping them onto the diagram, connecting them, and configuring their behavior.

Every project has at least one diagram. A diagram in the visual editor is a projection of the associated CCL statements in the project.

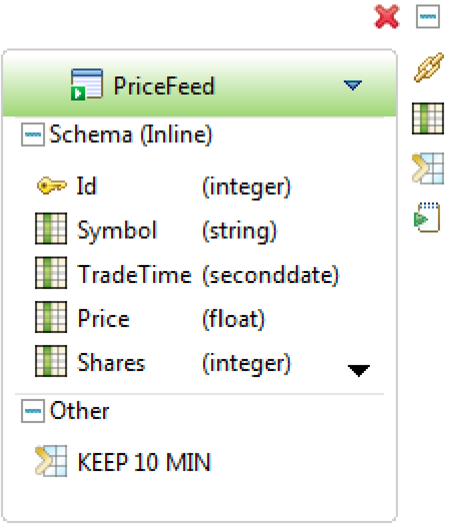
When you add a shape or other element to a diagram, it is automatically added to the project when you save. You can delete an element from a diagram only, or from the project.

Display diagrams in verbose or iconic mode:

iconic — compartments are collapsed to save space.



verbose — all compartments in elements are visible.



- To expand or collapse all shapes in the diagram, use the **All Verbose** or **All Iconic** buttons on the main toolbar.
    - To expand an individual shape, select it and click the "+" box in the shape toolbar.
    - To collapse an individual shape, select it and click the "-" box in the shape toolbar.
- To change the orientation, in the visual editor toolbar click **Layout left to right** or **Layout top down** .

For more display options, right-click an object or the diagram surface and choose from the context menu.

Shapes

Each shape in the palette creates a specific type of stream or window, adapter, connection, reusable schema or module, or a store, to create a data flow.

Shape	Purpose	Usage
Connector	Creates flows between streams and windows, establishes references between streams and shared components, or attaches notes to shapes.	Click to select the connector tool, then click each of the shapes in the diagram to be connected.
Note	Creates a comment on the diagram only. This comment does not appear in the CCL file.	Documents additional user-generated information in the SAP ESP Authoring perspective for a project in Studio.
Input Stream	The entry point for unkeyed event streams into a project. Receives data from either an input adapter or an external publisher.	A stream does not retain any data and does not have a state. Data in an input stream is not keyed.

Shape	Purpose	Usage
Derived Stream (Local) Derived Stream (Output)	Applies a continuous query to data arriving from another stream or window to produce a new stream.	Streams do not retain data and do not have keys. They are "insert only," meaning that their output consists only of inserts. Input must be a stream or a stream-window join. By default, new streams (including derived streams) are output, so they are visible to external subscribers. You can change the property to local.
Derived Window (Local) Derived Window (Output)	Applies a continuous query to data arriving from another stream or window. Retains data, and retention rules can be set.	Data must be keyed so that every row has a unique key. Processes inserts, updates, and deletes both as local and output. You can use the toolbar to change the output to local, if you do not want it visible to external subscribers.
Input Window	The entry point for event streams into a project where incoming events have primary keys and there is a desire to maintain a window of event data. Supports opcodes (insert, update, delete, upsert). Use this as an entry point for event streams if: • The stream contains insert, update and delete events, or, • You need to retain a set of incoming events.	Window size can be set by row count with a fixed number of input records, or by time with records being kept for a specified period. The window must be keyed, that is, every row must have a unique key value.
Flex	A programmable operator that uses custom CCLScript scripts to process incoming events.	A Flex operator can take input from any number of streams and/or windows and will produce a new derived stream or window (either local or output).
Aggregate	Takes input from a single stream or window and groups records using a common attribute. Produces a single output record for each group. Uses aggregate functions like sum(), count(), and so on.	Always creates a new window. Requires a GROUP BY element. You can optionally set window size using retention rules.
Compute	Takes input from a single source and computes a new record for every record received. Allows you to change the schema on events, computing new fields and changing existing fields.	Produces a derived stream when the input is a stream. Produces a derived keyed stream when the input is a keyed stream. Produces a derived window when the input is a window.
Filter	Takes input from a single source and applies a filter. Creates a stream of records that match the filter criteria.	Produces a derived stream when the input is a stream. Produces a derived keyed stream when the input is a keyed stream. Produces a derived window when the input is a window.

Shape	Purpose	Usage
Join	Takes input from two or more sources and joins them based on common data elements.	See Joins [page 210].
Pattern	Takes input from two or more sources and detects patterns of events. One output record is produced every time a pattern is detected.	Detects patterns in the incoming data. See Pattern Matching [page 218].
Union	Merges input from two or more sources. One output record is produced for every input record.	All inputs must have a common schema.
Named Schema	Represents a CCL CREATE SCHEMA statement. Reusable definition of column structure that can be referenced by streams and windows.	A schema defined outside of an object that can be used in multiple places, since any number of streams and windows can reference a single named schema.
Module	Represents a CCL CREATE MODULE statement. Creates a new module that can be used in one or more places in the project.	A module can contain all the same elements as a project and provides for reuse.
Log Store	Stores data held in windows. Provides disk-based recovery but is slower than a memory store.	By default, new windows are assigned to a memory store. Where recoverability of data in a window is required, create a log store and assign the window to it.
Memory Store	Stores data held in windows.	Faster than a log store but does not recover data after shutdown: • (Default) Created implicitly by the CCL compiler, if no other store is specified. • (Optional) Created explicitly, with windows assigned to specific stores, to optimize performance.
Input Adapters	Connects an input stream or input window to an external data source.	Must be connected to either an input stream or input window. To use schema discovery—that is, to import the schema from the source—add the input adapter first, and then use schema discovery to create a connected input stream or window with the imported schema.
Output Adapters	Connects an output stream or window to a destination.	Must be connected to either an output stream or an output window.

Shape	Purpose	Usage
Reference	A CCL element that establishes a reference from an external database table to a project in ESP. Use reference—in joins and in CCLScript programs—inside a module as well as within the main body of your project.	Can be used for data lookup and to enrich data streaming in SAP Event Stream Processor with information permanently stored in an external database table. For example, customer address and credit card information. For schema discovery, datatypes in the source schema for the reference must be compatible with those found in the external database table the reference queries. If incompatible, unexpected behavior such as an abnormal shutdown can occur.

Procedure

1. In the SAP ESP Authoring perspective, navigate to the project explorer.
2. Double-click the `.cclnotation` file name of your project to open it in the visual editor.

   > i Note
   >
   > If you see an error message indicating that the linked file does not exist, this is likely because the name of the `.ccl` linked to the `.cclnotation` file has changed. To open the `.cclnotation` file, right-click and choose **Change Linked CCL File**, then select the `.ccl` file to be used with this `.cclnotation` file.

3. Click in the diagram to begin editing using the palette.

   > → Tip
   >
   > To make the visual editor window full-screen, double-click the `<name>`**:Diagram** tab at the top. Double-click again to revert.

4. Create streams, windows, and shared components, relate them using continuous queries, and attach them to adapters by clicking a shape tool in the palette and then on an empty area in the diagram.

   > → Tip
   >
   > To view actions needed to complete a shape definition, hover the mouse over the shape in the diagram.

   The border changes from red to grey when the shape definition is complete and correct.
5. Save as you go (**Ctrl+S)**.
   This saves changes to both the `.cclnotation` file (the diagram) and the `.ccl` file (the CCL).
6. (Optional) To add a comment to a shape that will appear within a tooltip when you hover, select the comment field in the Properties view for the highlighted shape.

   > → Tip
   >
   > Enable tooltip comments. Select the **Show comments in shape tooltips** checkbox in **Window** > **Preferences** > **SAP Event Stream Processor** > **CCL Visual Editor**.

7. To toggle between the visual editor and the text editor, choose **Switch to Text** or **Switch to Visual** (**F4**).
8. To close the diagram, press **Ctrl+W** or **Ctrl+F4**, or click the **X** on the tab at the top of the editor .

> i Note
>
> The visual editor, like other graphical user interfaces, offers several ways to accomplish most tasks, although this guide may not list all of them. For example, in many contexts you can carry out an action by:
>
> - Clicking a button or other icon in a shape, or on the main toolbar.
> - Using a shortcut key.
> - Double-clicking an element to open it.
> - Right-clicking to select from the context menu.
> - Selecting from the main menu bar.
> - Editing element values in the Properties view.
>
> The SAP Event Stream Processor Studio also includes features common to Eclipse-based applications.

4.1.4 Project Execution and Testing

Run and test all aspects of a project using the SAP Event Stream Processor Studio.

During development, you can use the SAP Event Stream Processor Studio to run any compiled project against a local or remote server, view data flowing through the streams and windows defined in the project, execute queries, and use debugging tools. Your project configuration and licensing determine the type of server connections you can use when running projects. Some adapters also have special licensing requirements.

In the SAP Event Stream Processor Studio you can connect immediately to a local cluster to run projects, using default security established for ESP during installation. A cluster consists of a group of server nodes, which are processes that run on hosts. A cluster can have a single node or multiple nodes.

In a production environment, you typically run projects on a remote server. Administrators monitor, manage, and configure ESP server nodes, clusters, and projects using SAP ESP Cockpit. Command-line utilities and procedures are also available, as discussed in the *SAP Event Stream Processor: Configuration and Administration Guide*.

Related Information

Testing the Project with Recorded Data [page 315]

4.1.5 Event Stream Processing with SAP HANA

SAP Event Stream Processor integrates with SAP HANA in a number of ways, providing multiple methods for sharing data, all of which you can tailor to fit your projects.

In this section:

4.1.5.1 Creating or Modifying a Project in SAP HANA Studio

Create, open, import, rename or delete SAP ESP projects in the SAP HANA studio workspace directory.

Prerequisites

You have installed and are working in the Streaming plugin for SAP HANA studio.

Context

You can also open or import multiple existing projects from an ESP Studio workspace to an SAP SAP HANA studio workspace. See Opening a Project in SAP HANA Studio [page 49] for more information.

Procedure

1. In the SAP HANA studio menu bar, go to **File** > **New** > **Project...**, then select **Event Stream Processor** > **New ESP Project**.

2. In the **Name** field, enter a valid project name. Create a name that:
    - Starts with a lowercase letter, underscore, or dollar sign.
    - Uses lowercase letters, numbers, underscores, or dollar signs for all other characters.
    - Cannot contain spaces.
3. In the **Directory** field, accept the default location or browse to a directory in which to store the new project folder. In the Streaming plugin, the default directory is the SAP SAP HANA studio workspace directory.
4. Click **Finish** to create the project files.
   The new project opens in the visual editor with one input stream, NEWSTREAM, and an inline schema ready for editing.

Opening a Project in SAP HANA Studio

Prerequisites

You have installed and are working in the Streaming plugin for SAP HANA studio.

Procedure

1. In the SAP HANA studio menu bar, click ▶ **Windows** › **Open Perspective** › **Other** › **SAP ESP Authoring** ◀ and click **OK**.
2. In the studio toolbar, click the **Open ESP Project** icon.
3. Browse to the root directory of the project.
4. (Optional) Select **Copy projects into workspace** to copy and open the project in the workspace. Changes are made to the copy only.

   If you do not select this option, the project opens in its original location.
5. Click **Finish**.

Importing a Project into SAP HANA Studio

Procedure

1. In the SAP HANA studio menu bar, click ▶ **Windows** › **Open Perspective** › **Other** ◀.
2. From the **Open Perspective** dialog, select **SAP ESP Authoring** and click **OK**.
3. In the **SAP ESP Authoring** perspective, right-click the project explorer view, and select **Import** from the context menu.
4. In the Import dialog, expand the **General** folder and click **Existing Projects into Workspace**, then click **Next**.

5. Enable the **Select root directory option** and enter or browse to the root directory containing the projects you are importing.
6. (Optional) Clear the check mark from any projects you do not want to import.
7. (Optional) Clear the **Copy projects into workspace** option.
8. Click **Finish**.

4.1.5.2 Opening a Project in SAP HANA Studio

Open an existing project in the SAP HANA studio.

Prerequisites

You have installed and are working in the Streaming plugin for SAP HANA studio.

Procedure

1. In the SAP HANA studio menu bar, click › **Windows** › **Open Perspective** › **Other** › **SAP ESP Authoring** ›.
2. Click **OK**.
3. In the studio toolbar, click the **Open ESP Project** icon.
4. Browse to the root directory of the project.
5. (Optional) Select **Copy projects into workspace** to copy and open the project in the workspace. Changes are made to the copy only.

   If you do not select this option, the project opens in its original location.
6. Click **Finish**.

4.1.5.3 Importing a Project into SAP HANA Studio

If you have projects that are not located in your current workspace, import them into the SAP HANA workspace.

Procedure

1. In the SAP HANA studio menu bar, click › **Windows** › **Open Perspective** › **Other** ›.

2. From the **Open Perspective** dialog, select **SAP ESP Authoring** and click **OK**.
3. In the **SAP ESP Authoring** perspective, right-click the project explorer view, and select **Import** from the context menu.
4. In the Import dialog, expand the **General** folder and click **Existing Projects into Workspace**, then click **Next**.
5. Enable the **Select root directory option** and enter or browse to the root directory containing the projects you are importing.
6. (Optional) Clear the check mark from any projects you do not want to import.
7. (Optional) Clear the **Copy projects into workspace** option.
8. Click **Finish**.

4.1.5.4 Reference Queries for HANA Tables and Views

Reference table queries provide a way to augment the streaming data in a project with information from a table or view in SAP HANA.

Incoming events can arrive with only a portion of the information necessary to complete the processing you wish to specify in your project. When that additional information is present in existing tables in an external database, you can use reference table queries to look it up. There are two parts to this: creating the reference to an external table and using the reference to execute an ad hoc query in a join or Flex operator.

When creating the reference, first determine what data you want to use. Then identify the external database table containing the data by name, obtain the schema of the table, and find out what service to use to contact the database. Decide whether you want to attempt to reconnect if the connection is dropped, and if so, how many times, and how long to wait between attempts.

When joining a stream or window to a reference, determine what you want as the output of the join. There are numerous restrictions on how you can use references in joins, and what types of output you can obtain. For example, if you want the output of the join to be a window, you must specify the primary key of the reference and use the complete primary key in the ON or WHERE clause of the join.

There are several different ways to use references within CCLScript programs. You can iterate over the rows in the table or grab specific rows. Basically, you can utilize a reference in the same ways you can utilize a window. It is simply another source of data for processing in your CCLScript routine.

You can use references - in joins and in CCLScript programs - inside a module as well as within the main body of your project. Like stores, references used in a module must be bound to a reference defined in the main body of your project.

To learn more about creating and configuring reference table queries, see Working with Reference Table Queries [page 223].

4.1.5.5 Creating a Database Table

Create a table in the SAP HANA database, using the studio.

Prerequisites

Set up a HANA service. See *Adding an ODBC Connection to an External Database* in the *SAP Event Stream Processor Configuration and Administration Guide* for more information.

Context

From the SAP ESP Authoring perspective:

Procedure

1. Open, or create, the project from which you want to create your SAP HANA table.
2. Select the ESP project element from which to create the SAP HANA table. This feature is supported on all input and output elements except error streams, and reference table queries. Local elements do not support this feature.
3. Display the context menu and select the **Create Database Table** option.
4. In the **Service** field, accept the default value, or click the **Discover** button and select a value from the list.
5. In the **Target Schema** field, click the **Discover** button and select a value from the list.
6. In the **Target Table** field, accept the default value, type in a new value, or click the **Discover** button and select a value from the list.
7. In the **Table Modification** section, select **New Table** or **Replace Table**. An error will be generated if you choose **New Table** and the table already exists in the selected schema, or if the table does not exist in the selected schema and you have chosen **Replace Table**.
8. In the **Table Kind** section, select **Row** or **Column**.
9. Click **OK**.

In this section:

Datatype Mapping to SAP HANA Tables [page 52]
Reference information on how SAP Event Stream Processor datatypes map to SAP HANA datatypes.

Datatype Mapping to SAP HANA Tables [page 52]
Reference information on how SAP Event Stream Processor datatypes map to SAP HANA datatypes.

4.1.5.5.1 Datatype Mapping to SAP HANA Tables

Reference information on how SAP Event Stream Processor datatypes map to SAP HANA datatypes.

For each datatype in the ESP stream or window from which you are creating an SAP HANA table, this table shows what datatype will be created in the SAP HANA table.

Event Stream Processor Datatypes	SAP HANA Datatypes
bigdatetime	timestamp
binary	varbinary(5000)
boolean	tinyint
seconddate	date
double	real
fixed_decimal	decimal
int32	integer
int64	bigint
interval	bigint
money	decimal(19,4)
moneyX	decimal(19,X)
string	nvarchar(5000)
time	time
msdate	timestamp

4.1.6 SAP HANA Navigator

When you install the Streaming studio plugin for SAP HANA studio, you can use the SAP HANA Navigator to select tables and views within SAP HANA, then drop them directly into a project diagram in the Studio visual editor. This creates a new adapter reference or named schema in the SAP ESP project.

You can then use the new reference in a join along with SAP Event Stream Processor streams and windows. When an event arrives via a stream or window, the reference executes a query on the table in SAP HANA and uses the returned data in the join to enrich streaming data with information from the database.

4.1.7 The Studio Log File

SAP Event Stream Processor Studio logs activity and records it in a log file. Access this log file to view Studio activity and to help troubleshoot events such as unexpected shut down.

The Studio log file resides in your workspace directory under `workspace/.metadata/.log`. View the log within Studio:

1. Select **Help > About Studio**.
2. Click **Configuration Details**.
3. Click **Configuration**.
4. Click **View Error Log**.
5. If prompted, select a text editor to view the file.

The log provides read-only details on internal Studio activity. You cannot modify the file to change what it reports on, or its level of verbosity.

4.1.8 Customizing the Studio Work Environment

Customize your SAP Event Stream Processor Studio interface to work the way you prefer.

Context

> i Note
>
> As an Eclipse-based application, the SAP Event Stream Processor Studio automatically includes many features not specific to SAP Event Stream Processor. Features documented here have been tested with the SAP Event Stream Processor Studio. Other Eclipse features may not work as expected. For example, the Team Synchronizing perspective is not supported.

In this section:

Editing Studio Preferences [page 54]
Use the **Preferences** dialog to customize your SAP Event Stream Processor Studio..

Keyboard Shortcuts [page 57]
Use keyboard shortcuts to quickly access various functions within the visual or text editors.

Manual Input Settings [page 57]
Set default values and formats for datatypes of the data you publish to a stream from the **Manual Input** view. This view is helpful for simplifying output for testing purposes as you prepare to create a project in Studio.

Setting CCL Compiler Options [page 59]
You can adjust the CCL compiler options.

4.1.8.1 Editing Studio Preferences

Use the **Preferences** dialog to customize your SAP Event Stream Processor Studio..

Context

You can also access many of these preferences from the related view in theESP Studio.

Procedure

1. Choose ▶ **Window** ▶ **Preferences** ▶.
2. Select and expand **SAP Event Stream Processor** to find the preferences you want to set. All preference settings are optional.

   SAP Event Stream Processor
   - Set which editor you want to open when you create a new project.
   - Set defaults for the server URL, the workspace, and HANA Service Entry.
   - Set an operation time limit for the Studio to time out when starting, stopping, and compiling projects (default is 5 minutes). If communication between the Studio and the Java SDK times out, the following error message appears in the **Problems** view: `failed to create input stream: Read timed out`. If this occurs, then manually restart the operation.

   CCL Text Editor
   - Set various defaults for refactoring, syntax coloring, and templates for statements and schemas.
   - Set whether to have the Text Editor automatically close punctuation and comments.

   CCL Visual Editor
   - Use the **Shape Colors** tab to choose defaults for creating and displaying shapes in diagrams.
   - Use the **Shape Fonts** tab to set the font used in shapes.

   Run Test
   - Use the **Run Test** tab to set defaults for the server workplace and connections, add new connections, enable and disable the preference for automatically reconnecting projects upon connecting to a server, set limits and filters for the stream view and server view, and set other options for running projects in Studio.
   - Use the **Data Input Settings** tab to set file upload and SQL Query view options.
   - Use the **Security Settings** tab to configure Kerberos and RSA authentication for when projects are run and deployed.
3. On each preference dialog, either:
   - Click **Apply** to save the new settings, or,
   - Click **Restore Defaults** to revert any changes you make.

   Only the settings in the current dialog are applied or restored.

   > i Note
   >
   > You may be asked to restart SAP Event Stream Processor Studio for your changes to take effect.

4. Click **OK** to exit the Preferences dialog.

In this section:

SAP Event Stream Processor: Run-Test Preferences [page 55]
Run-Test perspective settings in SAP HANA studio.

4.1.8.1.1 SAP Event Stream Processor: Run-Test Preferences

Run-Test perspective settings in SAP HANA studio.

In **Window** › **Preferences** › **SAP Event Stream Processor** › **Run Test**, you can configure the following run-test settings.

Preference	Description
Use Secure Storage for Streaming Credentials	Store your username and password credentials for Event Stream Processor server connections in secure storage. This ensures that you do not have to enter username and password information each time you connect to a server.
Filter serverview meta-data streams	Prevent any metadata streams from loading with the input and output windows when connecting to a project. This improves project connection time.
Stop and remove existing project on run	When you want to run a project on a workspace but there is already a project with the same name running on that workspace, check this option to stop and remove the running project. The default value is true.
Always start previously running run-test views on project start	Check this option if you want the previously opened run-test views to restart automatically. By default, this option is disabled to keep project connection time to a minimum.
Clear all cached run-test views	Check only if you do not want to cache your run-test views. This means that previously opened run-test views will not re-open when you reconnect to a server. Uncheck to cache your run-test views so they automatically open when you reconnect to a server. This helps save time when running projects within Studio.

Preference	Description
Streamviewer lossy subscription **Other Run-Test lossy subscription**	Check **Streamviewer lossy subscription** to allow the stream viewer subscriber to drop rows if it is unable to keep up with the data flowing through the server. Check **Other Run-Test lossy subscription** to do the same for the Run-Test subscribers. These include: • SQL Query • Event Tracer • File Upload • Monitor • Playback Enabling lossy subscription is helpful when Studio is blocking incoming data and slowing down the project. Disabling lossy subscription means that every row produced by the stream is displayed in Studio at the risk of impacting project performance. Enable this setting when connecting to production systems.
StreamViewer number of rows displayed	Choose the number of rows to show in the Stream View. The number can be between 1 and 1000000, but increasing the value increases memory consumption. The default value is 25.
Streamviewer pulsed subscribe interval (seconds) **Other pulsed subscribe interval (seconds)**	Group stream updates to be released as often as prescribed, preventing them from occurring continuously. Check **Streamviewer pulsed subscribe interval (seconds)** to tell Studio how often to show stream updates in the Stream View. Check **Other pulsed subscribe interval (seconds)** to do the same for the Run-Test subscribers. These include: • SQL Query • Event Tracer • File Upload • Monitor • Playback To improve Studio performance, raise the value of the pulsed subscribe intervals. However, if the output store is holding on to too much data, then lower the pulsed subscribe intervals. To avoid performance issues, use non-zero values. If either preference is set to 0, then Studio does not perform a pulsed subscription on the related stream. By default, **Streamviewer pulsed subscribe interval (seconds)** is set to 1, and **Other pulsed subscribe interval (seconds)** is set to 2. Disable pulsed subscribe intervals when subscribing to streams or windows that produce mostly inserts, as this may have a detrimental effect on performance.
Compiler output directory	Change the directory for your compiled projects. If you set this to a relative path, the path is relative to the project's directory in the Studio workspace.

Preference	Description
Watch Fetch Limit	Control the number of rows displayed in Studio when a breakpoint is triggered. The default value is 10.

4.1.8.2 Keyboard Shortcuts

Use keyboard shortcuts to quickly access various functions within the visual or text editors.

To show a list of all available keyboard shortcuts, press **Ctrl+Shift+L**.

To add a keyboard shortcut:

1. Select **Window** > **Preferences** > **General** > **Keys** .
2. Select a command from the list.
3. In the **Binding** field, add the new shortcut.
4. Click **OK**.

4.1.8.3 Manual Input Settings

Set default values and formats for datatypes of the data you publish to a stream from the **Manual Input** view. This view is helpful for simplifying output for testing purposes as you prepare to create a project in Studio.

To configure these settings, choose **Window** > **Preferences** , then expand **SAP Event Stream Processor** and **Run Test**. Settings for most datatypes are in **Manual Input Settings** preferences. Settings for the money(n) datatype are in **Manual Input Settings - Money Types** preferences.

> i Note
>
> When you double-click an input field containing a negative value, only the text up to the minus symbol is selected. If you want to select the value including the minus symbol, single-click and highlight the text. This affects the **Manual Input Settings** and **Manual Input Settings - Money Types** preferences, and the **Manual Input** view in Studio.

Setting	Description
Publish Multiple Rows	Indicates whether data from an input stream is published in single instances or as multiple rows.
Use Current Date	Indicates whether data should be published under the current date or maintain its historical date.

Setting	Description
Interpret Date values in Manual Input and Stream Viewer as UTC	Indicates whether Manual Input and Stream Viewer date values are interpreted as UTC or in the local time zone. i Note This has no effect on the Playback tool.
binary	Indicates a binary value to be published to a stream. Use this setting to monitor the binary value of a stream by placing a traceable value in the field.
boolean	May be set to **True** or **False**.
string	Indicates the default value Studio accepts for string types.
integer	Indicates the default value Studio accepts for integer types. Does not accept values with decimal points.
float	Indicates the default value Studio accepts for float types.
long	Indicates the default value Studio accepts for long types.
interval	Indicates the default value Studio accepts for interval types.
seconddate	Indicates the default value for seconddate types. Click **Select** to open a calendar dialog and choose a default date with second precision.
bigdatetime	Indicates the default value for bigdatetime types. Click **Select** to open a calendar dialog and choose a default bigdatetime with microsecond precision.
msdate	Indicates the default value for msdates types. Click **Select** to open a calendar dialog and choose a default timestamp with millisecond precision.
time	Indicates the default value Studio accepts for time types.

i Note

You see an error message at the top of the preference window when you enter incorrect characters, or exceed the number of allowed characters in the field.

Related Information

Manually Entering Data to a Stream [page 120]

4.1.8.4 Setting CCL Compiler Options

You can adjust the CCL compiler options.

Procedure

1. Choose **Window** > **Preferences**.
2. Click **SAP Event Stream Processor** > **Run Test**, and go to **Compiler output directory**.
3. To change the directory for your compiled projects, click **Change...**, select a directory, and click **OK**.
4. To confirm any other changes, click **OK**.

> i Note
>
> By default, the compile directory is set to `bin`, which means the `.ccx` files are created in a subdirectory relative to the project's directory.

4.1.9 Sample Streaming Projects for Studio

SAP Event Stream Processor Studio includes several completed example projects.

Along with the portfolio valuation sample project, ESP comes with several other example projects. The Welcome page in ESP Studio provides samples of completed projects that you can explore and run. If you are using the Streaming plugin for the SAP HANA studio, the examples do not display by default on the Welcome page. Instead, customize the Welcome page in SAP HANA studio to show the samples. Click the Customize Page icon in the top right corner of the Welcome page to open the **Customize** dialog. Select the **Home** tab and in the **Root Pages** section, select the **Samples** option and click **OK**. The Welcome page now displays a Samples subpage.

You can view the examples in Studio and run them against sample data installed with the product. Stepping through examples is an ideal way to watch a simplified set of event data flow through the system.

The examples include:

Indexes Calculation
: Shows how continuous computations can be applied to a stream of market prices to deliver insight into the market. This example demonstrates reusable modules. Each of the market calculations is defined in an external module, that is, a module defined in a separate CCL file, and then imported into the project. Parameters (in this case, time and intervals) are set when the module is called.

Pattern Matching
: Provides a simple example of situation detection: watching for a pattern of events. The example demonstrates how to watch for employee fraud in a retail setting, based on transaction patterns from a point-of-sale system. The example applies three filter queries to an input stream of transactions, and then uses a pattern query (CCL MATCHING clause) to produce a possible fraud alert event when all of the criteria occur in the defined time interval.

Top 3 Prices	Creates a window showing the top three distinct trade prices for each symbol. The example uses a Flex operator to create a custom operator with an embedded CCLScript script. A Flex operator creates a single output stream or window, and allows greater flexibility and control than a simple SELECT statement. The example also uses a named schema, which can be defined once and shared by the input stream and output window.
VWAP	Defines an input stream of stock market prices, as they might be reported from an exchange, and computes a moving average price called the volume weighted average price (VWAP). Uses a filter, and a simple aggregation (GROUP BY).

For details of each example, click **Samples** on the SAP Event Stream Processor Welcome page.

See the *SAP Event Stream Processor: CCL Reference* for more code samples that demonstrate CCL and CCLScript.

In this section:

Loading a Sample Project [page 60]
Load and run one of the example projects installed with Event Stream Processor to view end-to-end project execution in your workspace.

Related Information

About the Portfolio Valuation Sample Project [page 291]

4.1.9.1 Loading a Sample Project

Load and run one of the example projects installed with Event Stream Processor to view end-to-end project execution in your workspace.

Prerequisites

- To run these examples, you may need to disable McAfee host intrusion prevention. See your McAfee documentation for details.
- If you are using the streaming plugin for the SAP HANA studio:
  1. Click the Customize Page icon in the top right corner of the Welcome page to open the **Customize** dialog.
  2. Select the **Home** tab, and, in the **Root Pages** section, select the **Samples** option and click **OK**.

  Now you can access the example projects from the **Samples** subpage on the Welcome page.

Procedure

1. Navigate to the Studio Welcome page.
2. Select **Samples**. Look at the samples and read their descriptions.
3. Click the name of the sample to load into your workspace. The SAP ESP Authoring perspective opens and loads the example.
   Project explorer shows all example projects, plus any other projects you have created.
4. Click ▶ in the main toolbar to run the project.

   > i Note
   >
   > If you are prompted for a user name and password for the local cluster, first change the default system-generated credentials. See Prompted for Local Cluster Password [page 347].

5. The sample opens in the SAP ESP Run-Test perspective. To load and run sample data through the project:
   a. Open the playback tab, located below the server view.
   b. Select the input data file.
   c. Click ▶ in the playback tab to run the sample data.

   Look at the various elements in the perspective to learn about the process.
   - Server view shows localhost and connection information, as well as the sample project, which is now subscribed to the example stream.
   - The console shows a series of status messages detailing server activity.
6. Open windows and streams to view published data in stream view.
   a. In server view, double-click each output window or output stream.

      Each stream or window opens in a separate tab. For example, the IndexesCalculation example opens four tabs, with one input stream and three output windows.
   b. Double-click and open input windows and input streams to view input data.

Next Steps

Run a second sample project. Server view now shows both samples. Expand it to show all streams for each project.

4.2 Cluster Connectivity

In Studio, you can run a project on either a local or a remote cluster, using any of three methods of authentication. You can automatically run a project on a local cluster without needing to perform any prior steps. To run a project on a remote cluster, however, first connect to that cluster. This requires some simple configuration steps.

A cluster consists of one or more workspaces, each with one or more projects. These projects can be running or stopped. All workspaces are within one server, which allows you to simultaneously work with multiple projects.

A local cluster allows users to work on projects from their local machine. Use a local cluster to develop and test a project, but do not use a local cluster in production. Disconnecting a local cluster also stops the cluster. Internet access is not required.

> i Note
>
> If you are using the Streaming plugin for SAP HANA studio, you cannot run projects locally. In order to run an ESP project from the SAP HANA studio, you must be connected to a remote cluster.

A remote cluster allows users to connect to a server that is more powerful than the default server. The ability to use manual input, playback, and other Studio features is available. A remote cluster also allows users to share a project within the cluster with other users.

To run a project on a remote cluster, the remote cluster connection must first be configured in Studio. The administrator of the remote cluster must start it outside of the Studio. Once the cluster is running, you can connect to it from Studio and run the project.

When you click the run button, by default, Studio will perform your most recent run operation. Alternatively, you can right-click to specify a different option.

When you have Studio installed on a separate machine from the SAP ESP server, you cannot run projects on the default local cluster. Instead, connect to the SAP ESP server and then run your project. See Connecting to a Remote Cluster [page 67] for detailed instructions.

In this section:

Connect to a remote server using RSA authentication.

Modifying a Remote Cluster Connection [page 70]
Change the authentication settings of a remote cluster connection that is already configured.

Managing Secure Storage Credentials for an ESP Server Connection [page 70]
Use secure storage to encrypt username and password credentials for an SAP Event Stream Processor server connection in Studio. Secure storage enables credential information for the SAP ESP server connections to persist in Studio.

4.2.1 Changing Networking Preferences

Modify the default preferences for how the machine running ESP Studio connects with other ESP machines.

Context

SAP Event Stream Processor Studio sets the **Active Provider** to **Direct** to guarantee that network connections do not use a proxy server. If your network requires a different setting (such as the Eclipse default of setting it to **Native** if present, or **Manual** otherwise), modify the network preferences for Studio.

Procedure

1. Open the Studio.
2. Select ▶ **Preferences** ▶ **General** ▶ **Network Connections** ◀.
3. Set the connection options as required for your network. If unsure, confirm the settings with your system or network administrator. To connect to a Web service through a proxy server:
   - Select **Native** from the *Active Provider* dropdown menu to use the system configured proxy settings.
   - Select **Manual** to configure your own proxy settings:
     - Set the proxy information for the HTTP or HTTPS schema.
     - Set up proxy bypass for certain hosts. Add both the fully qualified domain name and short name of each host to the *Proxy bypass* list.

   If you set *Active Provider* to **Native** or **Manual**, and you are connecting to the server using a native connection (directly rather than through a Web service), ensure both the fully qualified domain name and the short name of the server host are added to the *Proxy bypass* list. Otherwise, the connection may fail.
4. Click **Apply** to save your new settings, then click **OK**.

4.2.2 Running a Project from a Local Cluster

Connect SAP Event Stream Processor Studio to the local cluster and run the project there.

Context

Run ESP Project ▶ enables you to run projects on a local or remote cluster from either the **SAP ESP Authoring** perspective or the **SAP ESP Run-Test** perspective.

> i Note
>
> If you are using the Streaming plugin for SAP HANA studio, you cannot run projects locally. In order to run an ESP project from the SAP HANA studio, you must be connected to a remote cluster.

When you have Studio installed on a separate machine from the SAP ESP server, you cannot run projects on the default local cluster. Instead, connect to the SAP ESP server and then run your project. See Connecting to a Remote Cluster [page 67] for detailed instructions.

Procedure

- Either from the **SAP ESP Authoring** perspective:
  a. Select a project and open it in either the visual editor or the CCL editor.
  b. Select **Run ESP Project** ▶.

  > i Note
  >
  > If you are prompted for a user name and password for the local cluster, first change the default system-generated credentials. See Prompted for Local Cluster Password [page 347].

  The Server View in the SAP ESP Run-Test perspective opens, showing the project connection. A successful connection shows the server streams below the server folder, and the Console shows the server log for the project.

  If the connection is unsuccessful, you see a Server Connection error dialog.
- Or from the **SAP ESP Run-Test** perspective.
  a. Select **Run ESP Project** ▶.

  > i Note
  >
  > If you are prompted for a user name and password for the local cluster, first change the system-generated credentials. See Prompted for Local Cluster Password [page 347].

  The system displays a list of projects in the **Select Project** pop-up window.
  b. Select the project that you want to run.

> i Note
>
> Select the dropdown menu to the immediate right of **Run ESP Project** to bring up the list of running or recently opened projects.

4.2.3 Configuring a Remote Cluster Connection

Use SAP Event Stream Processor Studio preferences to manage remote cluster connections and authentication methods.

Prerequisites

The administrator of the remote cluster has provided the necessary information about the cluster: host name, port number, authentication method, and, if using RSA, the RSA user, password and keystore.

Procedure

1. To add a new remote cluster connection, open the SAP ESP Run-Test perspective, and select **New Server URL** in the server view toolbar.

   > i Note
   >
   > Alternatively, in the server view toolbar, you can also select **Studio Preferences** and add a new connection through ▸ **SAP Event Stream Processor** ▸ **Run Test** ◂, and click **Run Test**. Select **New**.

2. In the **New Server** dialog, enter the host name and port number for the cluster connection.

   Host: myserver.mycompany.com

   Port: 12345
3. Select a connection protocol: **Native**, or **Web Services**.
   - If you select **Web Services**, edit your network connection preferences. See Changing Networking Preferences [page 63] to configure a proxy server.
   - You can only connect through **Web Services** using the REST port. Before selecting this option, configure the Web Services Provider in the `wsp.xml` file. See *Configuring the Web Services Provider* in the *SAP Event Stream Processor: Adapters Guide*.
   - Connecting through a Web service is primarily intended for scenarios where a client is behind a firewall. Otherwise, use a native connection when possible, for performance reasons.
4. (Optional) To enable encryption for Cluster Manager connections, select **SSL**.
5. If you selected **Web Services** as the connection protocol, select User/Password as the authentication method. Otherwise, select Kerberos, RSA, or User/Password.
6. If you selected RSA, enter the following information:

RSA User:	Provide the key alias.
RSA Password:	Provide the keystore password.
RSA Key store:	Provide the file name for the key store which contains the private key.

7. Click **OK**.

Results

In the SAP ESP Run-Test perspective, the server view accesses the list of stored server connections. Depending on the authentication method, Studio attempts to connect immediately (for RSA and Kerberos modes), or shows a login dialog for each cluster configured for User/Password authentication.

> **i Note**
>
> To connect all listed servers, select **Reconnect All** in the server View toolbar.

4.2.4 Choosing a Default Streaming Server Connection

Choose which ESP server to use for compiling SAP ESP projects.

Prerequisites

You have configured a remote cluster connection.

Context

Studio has the local cluster and uses it by default for compiling projects. Therefore, you only need to do these steps if you want to compile using a different server.

Procedure

1. In Studio, select ▶ **Window** ▶ **Preferences** ◀.
2. In the Preferences dialog, select **SAP Event Stream Processor**.
3. In the **Default Server URL** field, click **Change** and select a server from the Select Default Server URL dialog. Click **OK**.

   The Default Server URL preference determines which SAP ESP server Studio connects to for compiling projects.

4. In the Preferences dialog, click **Apply**, then **OK**.

4.2.5 Connecting to a Remote Cluster

Connect to a remote cluster from Studio to run a project on the cluster.

Prerequisites

The cluster administrator has started the remote cluster outside of SAP Event Stream Processor Studio. If using Kerberos authentication, run a program outside of SAP Event Stream Processor Studio to obtain a current Ticket Granting Ticket (TGT).

Procedure

1. Select the **SAP ESP Run-Test** perspective.
   The server view opens, displaying a list of the available clusters.
2. Right-click on the entry for the cluster you want (for example, myserver.mycompany.com:12345).
   Studio displays a pop-up menu.
3. Select **Connect Server**. If this remote cluster employs user/password authentication, you will be prompted to provide the required user name and password. Studio does not store this information.
   The server view displays the workspaces on the cluster and the projects in each workspace.
4. Right-click on the project you want to run.
   Studio displays a pop-up menu.
5. Select **Show in** from the menu.
   Studio displays a pop-up menu listing ways to view the project's progress.
6. Select the viewing method, for example **Event Tracer View**.
   Studio starts displaying the project's progress in the specified view.

4.2.6 Connecting to a Project

Connect to a project in the SAP ESP Run-Test perspective to view current project activity. Starting a project automatically connects you to that project. If you have to disconnect from your server, for example, by exiting Studio, you must reconnect to your projects again to view their activity in the Run-Test perspective.

Prerequisites

You have connected to an SAP Event Stream Processor server.

Procedure

1. From the SAP ESP Run-Test perspective, right-click the project you want to connect to.
2. Select **Connect to Project**.

   You can now see current project activity in the Run-Test views, such as the stream view.
3. (Optional) Select **Disconnect from Project** to no longer be able to view project activity in the SAP ESP Run-Test perspective.

   > i Note
   >
   > Disconnecting from a project means that you will no longer be able to view current project activity in Studio, but the project will continue to run.

4.2.7 Connecting to a Kerberos-Enabled Server

Connect to a remote server using Kerberos authentication.

Prerequisites

The system administrator has provided the necessary elements for connecting to a Kerberos enabled server: Key Distribution Center, Kerberos Realm, Service, User name, and Cache.

Procedure

1. In the Server View, select ▶ **Studio Preferences** ▶ **SAP Event Stream Processor** ▶ **Run Test** ▶ **Security Settings** ◀.
   Studio displays the **Security Settings** screen.
2. Fill the Key Distribution Center, Kerberos Realm, Service, User name, and Cache fields based on information provided by your system administrator.
3. Click **Apply**.
4. Click **OK** to exit Studio Preferences.

4.2.8 Connecting to an RSA-Enabled Server

Connect to a remote server using RSA authentication.

Prerequisites

The system administrator has provided the necessary elements for connecting to an RSA enabled server: RSA User, Keystore Password and RSA Keystore.

Procedure

1. In the Server View, select **Studio Preferences** > **SAP Event Stream Processor** > **Run Test** > **Security Settings**.
   Studio displays the **Security Settings** screen.
2. Enter the following information:

RSA User	Provide the user name of the keystore.
Keystore Password	Provide the password of the keystore.
RSA Keystore	Provide the name of the keystore file.

3. Click **Apply**.
4. Click **Ok** to exit Studio Preferences.
5. Enter the following command to import the keystore to the PKCS12 type store:

   ```
   $JAVA_HOME/bin/keytool  -importkeystore -srckeystore keystore.jks  -
   destkeystore keystore.p12 -deststoretype PKCS12
   ```

   Creates a PKCS12 keystore.
6. Enter the following command to extract a pem format private key:

   ```
   openssl pkcs12 -in keystore.p12 -out keystore.private -nodes
   ```

   Creates a private key.
7. Copy the private key file to the directory where the keystore file is located.
8. In the Server View, connect to a remote cluster using RSA authentication.

4.2.9 Modifying a Remote Cluster Connection

Change the authentication settings of a remote cluster connection that is already configured.

Context

If the administrator of the cluster changes its authentication settings, modify the cluster connection in Studio accordingly.

Procedure

1. In the server view of the SAP ESP Run-Test perspective, select **Studio Preferences** > **SAP Event Stream Processor Studio** > **Run Test**.
   Studio displays the **Run Test** screen.
2. Select an existing server connection.
   The **Remove** and **Edit** buttons are activated.
3. Click **Edit**.
   Studio displays the **Remote Server Connection** screen.
4. Make your changes and click **OK**.
   Studio displays the **Run Test** screen.
5. Click **OK** to save your changes.

4.2.10 Managing Secure Storage Credentials for an ESP Server Connection

Use secure storage to encrypt username and password credentials for an SAP Event Stream Processor server connection in Studio. Secure storage enables credential information for the SAP ESP server connections to persist in Studio.

Context

Store username and password credentials in secure storage for ESP server connections. Secure storage stores credentials so that you do not have to enter username and password information each time you connect to a server. Studio stores the connections securely so your credentials are safe.

Enter username and password credentials in the following situations:

- The first time you connect to a server in Studio.

- If you choose not to persist credential information.
- If the credential information in secure storage has been reset or removed.

When you connect to a server in Studio, the **Set Credentials** prompt dialog contains the checkbox **Store Event Stream Processor Credentials in Secure Storage**. Click the checkbox to store the username and password information you entered. If you do not choose to store the credentials using the **Store Event Stream Processor Credentials in Secure Storage** option, you can store the credentials by opening the **Preferences** dialog.

Store credential information in secure storage.

Procedure

1. In the main menu, select ▶ **Windows** ▶ **Preferences** ▶.
2. Select ▶ **SAP Event Stream Processor** ▶ **Run-Test** ▶.
3. Click on the checkbox for **Use Secure Storage for ESP Credentials**.
4. Click **Apply** then **OK**.
   The credentials you entered when prompted are saved in `C:\Users\<username>\.eclipse\org.eclipse.equinox.security\secure_storage`.

Modifying Credentials in Secure Storage for an ESP Server Connection

Context

Modify username and password credentials in secure storage for an SAP Event Stream Processor server connection. Change username and password information as required.

Procedure

1. In the main menu, select ▶ **Windows** ▶ **Preferences** ▶.
2. Open the **Secure Storage** preference page. Either:
   - Select ▶ **Event Stream Processor** ▶ **Run-Test** ▶ and click on the **Secore Storage Settings** link, or,
   - Select ▶ **General** ▶ **Secutiry** ▶ **Secure Storage** ▶.
3. Click on **UI Prompt**; then click on **Change Password**.
4. Modify the password information.

   Passwords are case-sensitive. You can use any alpha-numeric combination as well as symbols.
5. Click **Yes** or **No** for **Password Recovery**.

   Password Recovery prompts you to provide two questions and their expected answers. Once enabled, you can click on **Password Recovery**, answer the two questions, and recover your password, which avoids having to change the password. You can only access **Password Recovery** from the **Secure Storage** preference page.

6. Click **Finish**.

4.3 Developing Projects with Studio

Use either the visual editor or the text editor within the SAP ESP Authoring perspective to create and modify your projects. Start by developing a simple project, then test it iteratively as you gradually add greater complexity.

Context

You can create and edit a project in the SAP Event Stream Processor Studio (or in the Streaming plugin for SAP HANA studio) using either the visual editor or the text editor. When you create a new project, ESP creates a `.ccl` file and a `.cclnotation` file automatically. You can edit either file in its respective editor; all changes are reflected in the parallel file. For example, if you add and configure an input adapter in the visual editor, then switch to the text editor, you see the ATTACH INPUT ADAPTER statement with all configured properties.

Procedure

1. Create a new project. See Creating or Modifying an ESP Project [page 74].
2. Add input streams and windows. See Adding an Input Stream or Window to a Project [page 79].
3. Add output streams and windows with simple continuous queries. Gradually add complexity. See Simple Queries [page 204].
4. Attach adapters to streams and windows to subscribe to external sources or publish output. See Adding an Adapter to a Project [page 80].
5. (Optional) Use functions in continuous queries to perform mathematical operations, aggregations, datatype conversions, and other common tasks:
    - Built-in functions for many common operations
    - User-defined functions written in the CCLScript programming language
    - User-defined external functions written in C/C++ or Java
6. (Optional) Create named schemas to define a reusable data structure for streams or windows. See Working with Schemas [page 81].
7. (Optional) Create memory stores or log stores to retain the state of data windows in memory or on disk. See Data Retention and Recovery with Stores [page 184].
8. (Optional) Create modules to contain reusable CCL that can be loaded multiple times in a project. See Modularity [page 172]
9. Compile the project. See Compiling a Project [page 113].

10. Run the compiled project against test data, using the debugging tools in the SAP ESP Run-Test perspective in SAP HANA studio and command line utilities. See Running and Testing Projects with Studio [page 114].

    Repeat this step as often as needed.

In this section:

4.3.1 Creating or Modifying an ESP Project

Use the SAP Event Stream Processor Studio to create, open, import, rename or delete projects that can run on the ESP Server.

Context

Continuous queries are organized into projects that also define inputs, outputs, a schema and other options for processing event data.

Procedure

1. Select **File** > **New** > **SAP ESP Project...** .
2. Enter a valid project name:
   - Starts with a lowercase letter, underscore, or dollar sign.
   - Uses lowercase letters, numbers, underscores, or dollar signs for all other characters.
   - Cannot contain spaces.

   For example, enter **`myfirstproject`**.
3. In the **Directory** field, accept the default location or browse to a directory in which to store the new project folder.
   creates three files in the named directory:

`<project-name>.ccl`	contains the CCL code.
`<project-name>.cclnotation`	contains the diagram that corresponds to the `.ccl` file.
`<project-name>.ccr`	contains the project configuration.

   For example, for a project directory named "trades," smart data streaming creates a `trades.ccl`, `trades.cclnotation`, and `trades.ccr` file in the `trades` directory.
4. Click **Finish** to create the project files.
   The new project opens in the visual editor with one input stream, NEWSTREAM, and an inline schema ready for editing.

Related Information

Creating the Project [page 295]

Opening an Existing Project

Procedure

1. In the project explorer, expand project folders to see project files.
2. Double-click a file to open it for editing.
   - `.ccl` files open in the CCL editor
   - `.cclnotation` files open in the visual editor

   > i Note
   >
   > If you see an error message indicating that the linked file does not exist, this is likely because the name of the `.ccl` linked to the `.cclnotation` file has changed. To open the `.cclnotation` file, right-click and choose **Change Linked CCL File**, then select the `.ccl` file to be used with this `.cclnotation` file.

   You cannot have both the `.cclnotation` and `.ccl` files for the same project open at the same time.

Importing a Project into Your Workspace

Context

This procedure does not apply to the Streaming plugin for SAP HANA Studio. To import projects into SAP HANA, see the section *Importing Multiple Projects*.

Procedure

1. Choose **File** > **Open** > **ESP Project**.
2. Browse to the root directory of the project.
3. (Optional) Select **Copy projects into workspace**.
   - **Copy projects into workspace** copies the project in the workspace and opens it from there. Changes are made to the copy only.
   - If this option is not checked, the project opens in its original location.
4. Click **Finish**.

Importing Multiple Projects

Context

If you have multiple projects existing in the same directory outside of your default workspace, you can import all of those projects to your workspace at once. When importing projects, you can copy them into your workspace, or point to their original location. If you make copies, changes you make to the workspace copies are not reflected in the original location.

Procedure

1. Right-click the project explorer and select **Import** from the context menu.
2. In the Import dialog, expand the **General** folder and click **Existing Projects into Workspace**.
3. Click **Next**.
4. Enable the **Select root directory option** and enter or browse to the root directory containing the projects you want to import.
5. (Optional) Clear the check mark from any projects you do not want to import.
6. (Optional) Clear the **Copy projects into workspace** option.
7. Click **Finish**.

Renaming a Project

Procedure

1. Select the project folder in the project explorer.
2. Right click and select **Rename**.
   The same naming rules that apply when creating a project also apply when renaming a project:
   - Starts with a lowercase letter, underscore, or dollar sign.
   - Uses lowercase letters, numbers, underscores, or dollar signs for all other characters.
   - Cannot contain spaces.
3. In the **Rename Resource** field, enter the new project name.
   All three of the files in the project folder are automatically renamed:

`<project_name>.ccl`	contains the CCL code.
`<project_name>.cclnotation`	contains the diagram that corresponds to the `.ccl` file.
`<project_name>.ccr`	contains the project configuration.

4. Click **OK**.
   You will see the name change reflected in the project folder and the three project files.

Deleting a Project

Procedure

1. In the project explorer and select a project, or multiple projects.
2. Right click and select **Delete**.
3. (Optional) In the dialog, click **Preview** to view a list of the selected projects. If you selected multiple projects to delete, the preview option allows you to uncheck any projects you want to keep.
4. (Optional) Check the **Delete project contents on disk** option to completely erase projects from the ESP workspace and from your machine.

   If this option is not checked, ESP deletes the project from the project explorer, but does not remove the project from your workspace directory.
5. Click **OK**.

4.3.2 Creating or Modifying a Project in SAP HANA Studio

Create, open, import, rename or delete SAP ESP projects in the SAP HANA studio workspace directory.

Prerequisites

You have installed and are working in the Streaming plugin for SAP HANA studio.

Context

You can also open or import multiple existing projects from an ESP Studio workspace to an SAP SAP HANA studio workspace. See Opening a Project in SAP HANA Studio [page 49] for more information.

Procedure

1. In the SAP HANA studio menu bar, go to ▶ **File** ❯ **New** ❯ **Project...** ❯, then select ▶ **Event Stream Processor** ❯ **New ESP Project** ❯.
2. In the **Name** field, enter a valid project name. Create a name that:
   - Starts with a lowercase letter, underscore, or dollar sign.
   - Uses lowercase letters, numbers, underscores, or dollar signs for all other characters.
   - Cannot contain spaces.
3. In the **Directory** field, accept the default location or browse to a directory in which to store the new project folder. In the Streaming plugin, the default directory is the SAP SAP HANA studio workspace directory.

4. Click **Finish** to create the project files.
   The new project opens in the visual editor with one input stream, NEWSTREAM, and an inline schema ready for editing.

Opening a Project in SAP HANA Studio

Prerequisites

You have installed and are working in the Streaming plugin for SAP HANA studio.

Procedure

1. In the SAP HANA studio menu bar, click ▶ **Windows** ▶ **Open Perspective** ▶ **Other** ▶ **SAP ESP Authoring** ▶ and click **OK**.
2. In the studio toolbar, click the **Open ESP Project** icon.
3. Browse to the root directory of the project.
4. (Optional) Select **Copy projects into workspace** to copy and open the project in the workspace. Changes are made to the copy only.

   If you do not select this option, the project opens in its original location.
5. Click **Finish**.

Importing a Project into SAP HANA Studio

Procedure

1. In the SAP HANA studio menu bar, click ▶ **Windows** ▶ **Open Perspective** ▶ **Other** ▶.
2. From the **Open Perspective** dialog, select **SAP ESP Authoring** and click **OK**.
3. In the **SAP ESP Authoring** perspective, right-click the project explorer view, and select **Import** from the context menu.
4. In the Import dialog, expand the **General** folder and click **Existing Projects into Workspace**, then click **Next**.
5. Enable the **Select root directory option** and enter or browse to the root directory containing the projects you are importing.
6. (Optional) Clear the check mark from any projects you do not want to import.
7. (Optional) Clear the **Copy projects into workspace** option.
8. Click **Finish**.

4.3.3 Adding an Input Stream or Window to a Project

You can add input streams and windows to a project, which accept data from a source external to the project.

Context

You can create an input stream or window by adding an adapter that supports schema discovery, and generating the stream or window to inherit the schema of the external data source automatically. You can then add columns, and specify whether they need an autogenerate clause, which automatically generates data for specified columns.

Procedure

1. From the SAP ESP Authoring perspective, in the palette menu of the visual editor, open the **Streams and Windows** category and select either:
    - **Input Stream**
    - **Input Window**
2. Select a location in the diagram and click to add the shape.
3. To set the name of the input stream or window, either:
    - Click to edit the shape name, or,
    - In verbose mode, click the **Edit** icon next to the name.

    > Note
    >
    > When you create a duplicate named window or stream in the visual editor, then save your file and switch to the text editor, a third copy of the original stream or window is created. You can see this third copy only when you switch back to the visual editor. To remove it, click **Remove all shapes from diagram** to clear out all the shapes, then click **Add all shapes** to bring back the original stream or window, and the duplicate stream or window.
4. Click **Add Column** to add each new column to the schema, then set key columns and edit column expressions.
5. (Optional) To delete columns, select them and press **Delete**.
6. (Optional for windows, not permitted for streams) Select **Set Keep Policy** and choose an option.
7. (Optional) Double-click the policy to edit its parameters.
8. (Optional for both windows and streams) Select **Set Autogenerate** , choose the columns from the Candidate list (only columns with a `long` datatype will populate the Candidate list) and click **Add**.

    > Note
    >
    > You can also manually specify a column to add to the autogenerate list by clicking **Add Column** and entering in a column name. You can only use columns with the `long` datatype.

9. (Optional) To remove columns from the autogenerate list, select them and click **Remove**.
10. To set a From value for the autogenerate clause to start with, click **Select** and choose a variable or parameter from the list. You can also manually enter a variable or parameter that is used within a declare block of a column with a `long` datatype.
11. Click **OK**.

4.3.4 Adding an Adapter to a Project

Attach an adapter to a project by inserting it into the project diagram, connecting it to a stream or window, and setting properties.

Procedure

1. From the SAP ESP Authoring perspective, open the **Input Adapters** or **Output Adapters** compartment in the palette.
2. Click an adapter shape in the palette, then click in the diagram.
3. Attach the adapter to a stream or window. Either:
    - Generate and attach the stream or window automatically, using schema discovery (best practice for adapters that support it), or,
    - Create the stream or window, then attach it to an:
        - **Input adapter:** click the **Connector** tool, then click the adapter shape in the diagram, then click the stream or window.
        - **Output adapter:** click the **Connector** tool, then click the stream or window in the diagram, then click the adapter shape.
4. (Optional) Edit the adapter name.
5. (Optional) Edit the adapter properties. Choose one of the following:
    - Select **Consolidate Adapter Properties from the adapter properties dialog**. When this setting is enabled, the system looks for matching property pairings in the CCR, and removes them from the adapter properties collection. This setting is only relevant when an adapter has a property set configured; however, it is a global setting that affects all such adapters, not just the one you are currently attaching to the project.
    - Select **Use named property set** to use a named property set from the project configuration file, then configure any properties that are not included in the property set.
    - In the table, modify adapter properties manually.

Related Information

Adapters [page 28]

4.3.5 Working with Schemas

Discover external schemas and create CCL schemas, streams, or windows based on the format of the data from the data source that is connected to an adapter.

Every row in a stream or window has the same structure (schema), including the column names and datatypes and the order in which the columns appear. Multiple streams or windows can use the same schema, but each stream or window can only have one schema.

Rather than manually creating a new schema in your ESP project, you can use schema discovery to discover and automatically create a schema, stream, or window based on the format of the data from the data source to which your adapter connects. For example, if you create a table in your SAP HANA database, use the SAP HANA Output adapter to connect to the database. You can then use schema discovery to discover and create a schema, stream, or window in your ESP project that corresponds to the schema of the table you created in your SAP HANA database.

While using discovery is a convenient way to create your CCL schema, pay attention to the datatypes that the CCL columns inherit from the external data source. Discovery tries to maintain the same level of precision, or greater, when mapping source datatypes to ESP datatypes. Some databases, such as SAP IQ, support microsecond precision for the `SQL_TIMESTAMP` and `SQL_TYPE_TIMESTAMP` datatypes. As such, schema discovery maps these types to the ESP datatype `bigdatetime`, which also supports microsecond precision. If your ESP project does not require this level of precision, you can, after generating your schema through discovery, modify the schema to use a lower-precision datatype, such as `msdate` for millisecond precision.

To enable schema discovery, configure the properties of the adapters that support the feature.

In this section:

4.3.5.1 Discovering a Schema

Use the **Schema Discovery** button in the visual editor to discover and automatically create a schema based on the format of the data from the adapter.

Prerequisites

- For a database adapter, you need access to the database on the system from which you are using the SAP Event Stream Processor Studio.
- Define a data service using the ESP data services view, and add the adapter to the diagram.

Procedure

1. In the SAP ESP Authoring perspective, open or create a project with an input adapter and configure the adapter for schema discovery. In the adapter shape, click **Edit Properties** and complete the dialog:
   - Select **Use named property set** and select a property set from the drop down menu, or,
   - Select **Consolidate adapter properties from 'Adapter Properties' dialog** and enter property values in the Basic and (optionally) Advanced tabs. Required properties are in red.

   For example, to use schema discovery for the File CSV Input adapter, first configure the directory and file properties for the adapter, to specify the absolute path to the data files you want the adapter to read.

   > **i Note**
   >
   > To create a named property set, edit adapter properties in the project configuration file.

2. Click **Schema Discovery** on the adapter toolbar.
   - If the schema is successfully discovered, a dialog appears where you can view and select a schema.
   - If the schema is not successfully discovered, an error message appears stating that no schema was discovered for the adapter. You can:
     - Check that the adapter properties are configured for schema discovery.
     - Check to see if the adapter supports schema discovery.
3. Select a schema, and click **Next**.
4. In the dialog for creating an element, select an option:

Adapter State	Available Options
The adapter is not attached to a stream or window.	○ **Create a new input stream (with inline schema)**: creates and attaches a new stream to the adapter, creates an inline schema for the stream, and populates the stream with the schema discovered from the adapter. ○ **Create a new input window (with inline schema)**: creates and attaches a new window to the adapter, creates an inline schema for the window, and populates the window with the schema discovered from the adapter.

Adapter State	Available Options
	○ **Create a new input stream (with attached schema)**: creates and attaches a new stream to the adapter, creates and attaches a new named schema to the stream, and populates the stream with the schema discovered from the adapter. ○ **Create a new input window (with attached schema)**: creates and attaches a new window to the adapter, creates and attaches a new named schema to the window, and populates the window with the schema discovered from the adapter. ○ **Create a new named schema**: creates a new named schema and populates it with the schema discovered from the adapter.
The adapter is already attached to a stream or window.	○ **Apply the schema to the connecting stream or window**: populates the stream or window with the schema discovered from the adapter. ○ **Create a new named schema:** creates a new named schema and populates it with the schema discovered from the adapter.

5. Click **Finish**.
   - The mapping file you specified in the Adapter Mapping File property is populated with mappings based on the schema you selected.
   - Either the window or stream that is attached to the adapter is populated with the schema you selected or a new named schema is created in the project to which the adapter is attached.
6. (Optional) Create or modify a mapping of adapter columns to ESP columns.
   a. In the adapter shape, click **Edit Properties** .
   b. In the Adapter Properties screen, click the **Advanced** tab.
   c. Click the **Value** column of the **Field Mapping** row.
   The system displays an ellipsis in that field.
   d. Click on the ellipsis.
   The system displays the **Define Adapter Field Mapping (Permutation)** screen.
   e. Click the **Column** field next to the database column you want to map to your ESP column.
   A down arrow is displayed, indicating a dropdown list of choices is available.
   f. Click the mouse in the entry field to display the dropdown list and select the ESP column to which you wish to map the database column.
   g. Clear the check boxes next to any database columns that you do not wish to map (only checked columns will be mapped) and click **OK**.
   Studio removes the dialog and redisplays the Adapter Properties screen with the new mapping in the **Field Mapping Value** column.
   h. You can also click **Select All** to place a check in all the database column check boxes or **Remove All** to remove the check from all of the check boxes.

4.3.5.2 Discovering Schema and Creating a Mapping File for the SAP RFC Adapter

Use the **Schema Discovery** button in the visual editor to discover function, table, or query schema and create a mapping file for the RFC adapter.

Prerequisites

Add the SAP RFC adapter to the diagram.

Procedure

1. In the SAP ESP Authoring perspective, configure the RFC Input or Output adapter for schema discovery. In the adapter shape, click **Edit Properties** and set these properties:
   - Adapter Configuration File
   - Adapter Mapping File
   - SAP Host
   - SAP System Number
   - SAP Client
   - Username
   - Password

   Ensure there are no checkboxes selected, and click **OK**.
2. Click **Schema Discovery** on the adapter toolbar.
   - If the schema is successfully discovered, a dialog appears where you can view and select schemas.
   - If the schema is not successfully discovered, an error message appears stating that no schema was discovered for the adapter. Check that the adapter properties are configured for schema discovery and that no checkboxes are selected in the Edit adapter properties dialog.
3. In the schema discovery dialog:
   - (RFC Input adapter only) Select which remote schemas to search: **Functions**, **Tables**, or **Queries**. Scroll through to view the discovered functions, tables, or queries.
   - (RFC Output adapter only) Scroll through to view the discovered schemas. Only function schemas display.
4. Select a function, table, or query and click **Select Schema**.
5. Click **Next**.
6. In the Create Element dialog, select an option:
   - **Assign schema to the connecting stream/window**: populates the stream or window to which the adapter is attached with the selected adapter schema.
   - **Create new named schema**: creates a new named schema in ESP which is made up of the RFC schema elements.

7. Click **Next**.
8. From the left column, select the remote fields for your schema and click **Select Field(s)**.
   These fields now appear under the Selected Mapping fields column. To remove any fields from this column, select the field and click **Select Field(s)** again.
9. Click **Finish**.
   - The mapping file you specified in the Adapter Mapping File property is populated with mappings based on the schema you selected.
   - Either the window or stream that is attached to the adapter is populated with the schema you selected or a new named schema is created in the project to which the adapter is attached.

Next Steps

- For BW mode, edit the generated mapping file by adding the `<variables>` element.
- For Generic RFC mode, edit the generated mapping file by adding the `<variables>` and `<input>` elements.

4.3.5.3 Discovering Schema and Creating a Mapping File for the Web Services (SOAP) Adapter

Use the **Schema Discovery** button in the visual editor to discover schema and create a mapping file for the Web Services (SOAP) adapter.

Prerequisites

Add the Web Services (SOAP) adapter to the diagram.

Procedure

1. In the SAP ESP Authoring perspective, configure the Web Services (SOAP) Input or Output adapter for schema discovery. In the adapter shape, click **Edit Properties** and set these properties:
   - Adapter Configuration File
   - Adapter Mapping File
   - Discovery WSDL URL
   - Discovery Working Directory
   - Discovery Service Name

   Ensure there are no checkboxes selected, and click **OK**.
2. Click **Schema Discovery** on the adapter toolbar.

    - If the schema is successfully discovered, a dialog appears where you can view and select schemas.
    - If the schema is not successfully discovered, an error message appears stating that no schema was discovered for the adapter. Check that the adapter properties are configured for schema discovery and that no checkboxes are selected in the Edit Adapter Properties dialog.
3. Select a discovered schema and click **Next**.
4. In the Create Element dialog, select an option:
    - **Assign schema to the connecting stream/window**: this populates the stream or window to which the adapter is attached with the selected adapter schema.
    - **Create new named schema**: this creates a new named schema in ESP which is made up of the Web Services (SOAP) schema elements.
5. Click **Finish**.
    - The mapping file you specified in the Adapter Mapping File property is populated with mappings based on the schema you selected.
    - Either the window or stream that is attached to the adapter is populated with the schema you selected or a new named schema is created in the project to which the adapter is attached.

4.3.5.4 Creating a Schema in the Visual Editor

Create a shared schema object that can be referenced from any number of streams or windows.

Procedure

1. From the SAP ESP Authoring perspective, in the palette menu under the Shared Components category, select **Named Schema** (▦).
2. Click anywhere in the visual editor to place the schema.
3. Set the name of the schema by either:
    - Double-clicking the name label, or,
    - Editing the name field from within the Properties window.
4. Click **Add Columns** (▦) to add individual columns.
5. Edit column names and datatypes.

    > → Tip
    >
    > When entering column names and their datatypes, use **Tab** to easily move between cells in the table.
6. (Optional) Connect the schema to one or more streams or windows using the connector tool.

4.3.5.5 Creating a Schema in the Text Editor

Enter a CREATE SCHEMA statement using the text editor to provide users with a shared schema object that can be referenced from any number of streams or windows.

Procedure

In the text editor, enter valid CCL for the CREATE SCHEMA statement.

- Enter text manually.
- Choose **Create** › **Schema**, and edit the draft CCL code as needed.

For example, this statement creates a shared schema object named SchemaTrades1, with four columns:

```
CREATE SCHEMA SchemaTrades1 (
Symbol STRING ,
Seller STRING ,
Buyer STRING ,
Price FLOAT )
```

4.3.5.6 Adapter Support for Schema Discovery

Some of the adapters that come with ESP support schema discovery, while others do not. If you use an adapter that supports schema discovery, you need to set certain properties.

For additional details on the adapter properties, see the specific adapter section.

Adapter	Supports Schema Discovery	Required Properties
Atom Feed Input	No	—
Database Input	Yes	Database Service Name of database service from which the adapter obtains the database connection.
Database Output	Yes	Database Service Name of service entry to use.
File/Hadoop CSV Input	Yes	File Input Transporter: • Dir • File • AccessMode • (Optional) ScanDepth CSV String to ESP Formatter • ExpectStreamNameOpcode

Adapter	Supports Schema Discovery	Required Properties
File/Hadoop CSV Output	No	—
File/Hadoop JSON Input	No	—
File/Hadoop JSON Output	No	—
File/Hadoop XML Input	No	—
File/Hadoop XML Output	No	—
File/Hadoop XML Event Input	Yes	File Input Transporter: • Dir • File • AccessMode • (Optional) ScanDepth
File/Hadoop XML Event Output	No	—
File FIX Input	No	—
File FIX Output	No	—
FIX Session Input	No	—
Flex Output	No	—
FTP CSV Input	No	—
FTP CSV Output	No	—
FTP Event XML Input	No	—
FTP Event XML Output	No	—
HTTP Client JSON Output	No	—
HTTP Client Output	No	—
HTTP Client XML Output	No	—
HTTP Output	No	—
JDBC Input	Yes	JDBC Input Transporter: • Host • Port • User • Password • DbName • DbType • DbDriver

Adapter	Supports Schema Discovery	Required Properties
JDBC Output	Yes	JDBC Output Transporter: • Host • Port • User • Password • DbName • DbType • DbDriver
JMS CSV Input	Yes	JMS Input Transporter: • ConnectionFactory • JndiContextFactory • JndiURL • DestinationType • DestinationName • MessageType • (Optional) ScanDepth
JMS CSV Output	No	—
JMS Event XML Input	Yes	JMS Input Transporter: • ConnectionFactory • JndiContextFactory • JndiURL • DestinationType • DestinationName • MessageType • (Optional) ScanDepth
JMS Event XML Output	No	—
JMS FIX Input	No	—
JMS FIX Output	No	—
JMS MAP Input	No	—
JMS MAP Output	No	—
JMS Object Input	No	—
JMS Object Output	No	—
Log File Input	No	—
KDB Input	Yes	• KDB Server • KDB Port • KDB User • KDB Password

Adapter	Supports Schema Discovery	Required Properties
KDB Output	Yes	• KDB Server • KDB Port • KDB User • KDB Password
NYSE Technologies Input	Yes	Discovery Directory Path Absolute path to the adapter discovery directory.
Open Input	No	—
Open Output	No	—
Random Tuples Generator Input	No	—
Replication Server Input	Yes	• RSSD Host • RSSD Port • RSSD Database Name • RSSD User Name • RSSD Password
RTView Output	No	—
SAP ASE Output	Yes	DB Service Name The name of the database service that represents the SAP ASE database into which information will be loaded.
SAP HANA Output	Yes	DB Service Name The name of the database service that represents the SAP HANA database into which information will be loaded.
SAP IQ Output	Yes	DB Service Name The name of the database service that represents the IQ database into which information will be loaded.
SAP RFC Input	Yes	• Adapter Configuration File • Adapter Mapping File • SAP Host • SAP System Number • SAP Client • Username • Password

Adapter	Supports Schema Discovery	Required Properties
SAP RFC Output	Yes	• Adapter Configuration File • Adapter Mapping File • SAP Host • SAP System Number • SAP Client • Username • Password
SMTP Output	No	—
Socket CSV Input	No	—
Socket CSV Output	No	—
Socket Event XML Input	No	—
Socket Event XML Output	No	—
Socket FIX Input	No	—
Socket FIX Output	No	—
Socket JSON Input	No	—
Socket JSON Output	No	—
Tibco Rendezvous Input	No	—
Tibco Rendezvous Output	No	—
Web Services (SOAP) Input	Yes	• Adapter Configuration File • Adapter Mapping File • Discovery WSDL URL • Discovery Working Directory • Discovery Service Name i Note The adapter does not support schema discovery if you are using HTTP Basic Access Authentication.

Adapter	Supports Schema Discovery	Required Properties
Web Services (SOAP) Output	Yes	• Adapter Configuration File • Adapter Mapping File • Discovery WSDL URL • Discovery Working Directory • Discovery Service Name **i Note** The adapter does not support schema discovery if you are using HTTP Basic Access Authentication.
WebSphere MQ Input	No	—
WebSphere MQ Output	No	—
SAP Event Stream Processor Add-In for Microsoft Excel	No	—
ESP Web Services Provider	No	—

4.3.6 Specifying a Retention Policy

The keep policy determines the basis for retaining rows in a window.

You can set a keep (or retention) policy for any window with a memory-based store, including any simple query that produces a window.

Retention policies for windows that use a log store are only supported for input windows.

The following table describes the options for keep policies:

Options	Description
All rows	Retain all rows in the window (default).
Last row	Retain only the last row in the window.

Count	Either:
	• Enter the absolute number of rows to retain, or,
	• Choose **Select** and select a previously declared variable or parameter to determine a specific range of rows to retain in the window.
	If the list is empty and you want to base the count on a parameter or variable, switch to the text editor and define it in a DECLARE block at the beginning of the CCL. For example:
	`DECLARE`
	`integer test :=50;`
	`end;`
	Then go back and select it.

Options	Description
Every	(Optional) Works with the Count and Time options. When used with the Count option, Every retains a number of rows based on the Count value specified, and purges all of the retained rows once a row arrives that would exceed the specified maximum number of rows. This purge occurs after the specified Count number has been reached. When used with the Time option, Every retains a number of rows within a specified time interval. Once the time interval expires, all rows are purged simultaneously. i Note When this option is used, the resulting retention is based on a jumping window policy. Otherwise, the resulting retention is based on a sliding window policy.
Slack	For a count-based policy, set the number of rows to delete when the maximum number of rows is reached (the Count value). Default is 1, that is, when the window contains `<count-value>` rows, each new row causes the oldest row to be deleted. Setting Slack to greater than 1 can optimize performance.
Time	Set a time limit on the window, and specify a time period to determine what age of row to retain in the window. Press **Ctrl+Space** to choose the unit of time.
PER clause	(Optional) Works with the Time and Count options. When used with the Count option, PER works in conjunction with the specified Count number to retain the Count number of rows across each column specified under the PER clause. When used with the Time option, PER works in conjunction with the specified Time interval to retain the rows within that Time interval across each column specified under the PER clause. List the names of the columns that need to be retained in the PER clause box, with a comma separating each column name entered.

Related Information

Streams and Windows [page 17]
Creating and Modifying Aggregate Queries [page 222]
Creating and Modifying Join Queries [page 213]

4.3.7 Setting Key Columns

Set primary keys in the visual editor within the column compartment of the window, and Flex operator shapes.

Context

Multiple columns can be designated as primary keys. In the visual editor, primary keys appear as 🔑 icons. Deduced primary keys, which appear as 🔑🔑 icons, are calculated when the PRIMARY KEY DEDUCED flag is set for the target element.

> i Note
>
> Only windows support PRIMARY KEY DEDUCED. You can modify the deduced key property for these elements from the Properties view.

The ability to set key columns and view key column icons as described here does not apply when using column expressions.

Procedure

1. From the SAP ESP Authoring perspective visual editor, expand the **Columns** compartment of the desired query object (window, or Flex shape).
2. Click the icon to the left of the column name to make it a primary key.

   A single-key icon 🔑 now designates the column as a primary key.
3. (Optional) To set a primary key for query objects with a deduced primary key, click any column or deduced key within the target window.
   The column you initially selected and all other deduced key columns are now primary keys. In addition, the target window is no longer PRIMARY KEY DEDUCED.
4. (Optional) To remove the primary key designation from a column, click 🔑 to the left of the column name.
   A column icon replaces the single key icon, indicating that the column is no longer part of the primary key.

4.3.8 Editing Column Expressions

Modify column expressions for windows and streams using an inline editor or dialog-based expression editor.

Procedure

1. (Optional) To add a column expression, click **Add Column Expressions** in the shape toolbar.
2. Expand the **Column Expressions** compartment.
3. To modify a column expression, choose one of the following options:
   - Double-click to open the inline editor. Type into the edit box to edit the existing expression or enter a new one. Press **Ctrl+Space** for a list of available columns and functions.
   - Press **Ctrl+F2** to open the expression editor. Press **Ctrl+Space** to show the available input columns and built-in functions, or manually enter the expression.
   - Modify the expression in the Properties view.

   > → Tip
   >
   > When entering column names and their datatypes, use **Tab** to easily move between cells in the table.

Related Information

CCL Functions [page 29]

4.3.9 Creating a Database Table

Create a table in the SAP HANA database, using the studio.

Prerequisites

Set up a HANA service. See *Adding an ODBC Connection to an External Database* in the *SAP Event Stream Processor Configuration and Administration Guide* for more information.

Context

From the SAP ESP Authoring perspective:

Procedure

1. Open, or create, the project from which you want to create your SAP HANA table.
2. Select the ESP project element from which to create the SAP HANA table. This feature is supported on all input and output elements except error streams, and reference table queries. Local elements do not support this feature.
3. Display the context menu and select the **Create Database Table** option.
4. In the **Service** field, accept the default value, or click the **Discover** button and select a value from the list.
5. In the **Target Schema** field, click the **Discover** button and select a value from the list.
6. In the **Target Table** field, accept the default value, type in a new value, or click the **Discover** button and select a value from the list.
7. In the **Table Modification** section, select **New Table** or **Replace Table**. An error will be generated if you choose **New Table** and the table already exists in the selected schema, or if the table does not exist in the selected schema and you have chosen **Replace Table**.
8. In the **Table Kind** section, select **Row** or **Column**.
9. Click **OK**.

In this section:

Datatype Mapping to SAP HANA Tables [page 52]
Reference information on how SAP Event Stream Processor datatypes map to SAP HANA datatypes.

Datatype Mapping to SAP HANA Tables [page 52]
Reference information on how SAP Event Stream Processor datatypes map to SAP HANA datatypes.

4.3.9.1 Datatype Mapping to SAP HANA Tables

Reference information on how SAP Event Stream Processor datatypes map to SAP HANA datatypes.

For each datatype in the ESP stream or window from which you are creating an SAP HANA table, this table shows what datatype will be created in the SAP HANA table.

Event Stream Processor Datatypes	SAP HANA Datatypes
`bigdatetime`	`timestamp`
`binary`	`varbinary(5000)`
`boolean`	`tinyint`
`seconddate`	`date`

Event Stream Processor Datatypes	SAP HANA Datatypes
`double`	`real`
`fixed_decimal`	`decimal`
`int32`	`integer`
`int64`	`bigint`
`interval`	`bigint`
`money`	`decimal(19,4)`
`moneyX`	`decimal(19,X)`
`string`	`nvarchar(5000)`
`time`	`time`
`msdate`	`timestamp`

4.3.10 Creating Windows and Streams from a Database Table

Create windows and streams from SAP HANA tables for an ESP project in Studio.

Procedure

1. In ESP Studio, open the SAP ESP Authoring perspective, and select the data services view.
2. Select an SAP HANA table.
3. Drag and drop the SAP HANA table into the project workspace.
4. From the **Create CCL from Service Entry** dialog, click the **Service** button, and select a data service.
5. From **Create Type**, specify the type of stream or window to create:
   - Input Stream
   - Output Stream
   - Input Window
   - Output Window
6. If you selected output stream or output window in the previous step, specify the **Output Adapter Type** as:
   - Generic Database Output (default)
   - Hana Database Output
7. Select a **Schema**:
   - Named Schema Assignment
   - Inline
8. Click **OK**.

4.3.11 Using the SAP HANA Repository

There are various advantages to placing your ESP projects into the SAP HANA repository, including version control, and the ability to share your project files with other team members and create delivery units. Create a new ESP project and share it to create a link between your development workspace and the SAP HANA repository.

Procedure

1. Create a new ESP project in the SAP HANA studio.
2. Share the project to create a link between project-specific files in your development workspace and the SAP HANA repository. See *Tutorial: Share an Application Project* in the *SAP HANA Developer Guide* .

   Saving the project in your workspace automatically saves it to the repository.
3. Compile your project when you are ready to test it.

   At this point, you can create a delivery unit. See *Create a Delivery Unit* in the *SAP HANA Developer Guide* .
4. Right-click on your project folder, select ▶ **Team** ▶ **Activate** ◀ to activate, and automatically deploy your project to the ESP server.

Results

Switch to the SAP ESP Run-Test perspective to verify that the project is running.

If the project is not running after one minute and does not appear in the SAP ESP Run-Test perspective, use the XS Job Dashboard in the SAP HANA XS Administration Tool to locate the `sap.hana.streaming.repoplugin::plugin.xsjob` job and troubleshoot errors. See *The XS Job Dashboard* in the *SAP HANA Administration Guide* for additional details. Make any necessary changes to your project CCL file, then recompile and reactivate the project.

Related Information

SAP HANA Developer Guide

SAP HANA Administration Guide

4.3.12 Project Configurations

A project configuration is an XML document that governs specific runtime properties of a project, including stream URI bindings, adapter properties, parameter values, and advanced deployment options.

Project configuration files are created and edited separately from the project they are attached to, and are identified by their `.ccr` file extension. View and edit project configuration files in the project explorer view in the SAP ESP Authoring perspective.

Configuration files maintain all runtime properties outside the CCL. Thus, you can maintain CCL and CCX files under version control, while varying runtime properties. This lets you move a project from a test environment to a production environment without modifying the CCL and CCX files.

By default, when you create a new project, ESP also creates a new project configuration file. One project may have multiple configuration files attached to it, so you can manually create new project configurations. However, opening your project using SAP Event Stream Processor Studio only deploys the original CCR file created with the project, and this CCR file has the same name as the CCX file. To deploy your project with a separate CCR file, launch the project using the `streamingclusteradmin` utility from the command line. For more information on how to add and run projects from the command line, see *streamingclusteradmin in Command Line Mode* in *SAP Event Stream Processor: Utilities Guide*.

In this section:

4.3.12.1 Creating a Project Configuration

When you create a new project, a project configuration file is automatically generated. However, you can create additional project configuration files and edit configuration properties.

Procedure

1. From SAP Event Stream Processor Studio, select **File** > **New** > **CCR Project Configuration**.
2. Select the folder in which to store the new configuration file, and assign it a file name.
3. Click **Finish.**
   The CCR Project Configuration editor window appears.

4.3.12.2 Opening an Existing Project Configuration

Open an existing project configuration file.

Procedure

1. From SAP Event Stream Processor Studio, select **Window** > **Open Perspective** > **ESPAuthoring**, or click the **SAP ESP Authoring** tab.
2. Select **Window** > **Show View** > **Project Explorer**.
3. Locate the project configuration file, which appears as `<project-name>.ccr`, and double-click to open.

4.3.12.3 Datatypes

SAP Event Stream Processor supports integer, float, string, money, long, and timestamp datatypes for all of its components.

Datatype	Description
`bigdatetime`	Timestamp with microsecond precision. The default format is YYYY-MM-DDTHH:MM:SS:SSSSSS. All numeric datatypes are implicitly cast to `bigdatetime`. The rules for conversion vary for some datatypes: • All `boolean`, `integer`, and `long` values are converted in their original format to `bigdatetime`. • Only the whole-number portions of `money(n)` and `float` values are converted to `bigdatetime`. Use the `cast` function to convert `money(n)` and `float` values to `bigdatetime` with precision. • All `seconddate` values are multiplied by 1000000 and converted to microseconds to satisfy `bigdatetime` format. • All `msdate` values are multiplied by 1000 and converted to microseconds to satisfy `bigdatetime` format.
`bigint`	An alias for `long`.
`binary`	Represents a raw binary buffer. Maximum length of value is platform-dependent, with a size limit of 2 gigabytes. NULL characters are permitted.
`boolean`	Value is true or false. The format for values outside of the allowed range for `boolean` is 0/1/false/true/y/n/on/off/yes/no, which is case-insensitive.
`seconddate`	Date with second precision. The default format is YYYY-MM-DDTHH:MM:SS.
`decimal`	Used to represent numbers that contain decimal points. Accepts `precision` and `scale`, two mandatory parameters that determine the range of values that can be stored in a `decimal` field. `precision` specifies the total number (from 1 to 34) of digits that can be stored. `scale` specifies the number of digits (from 0 to `precision`) that can be stored to the right of the decimal point. The value 88.999p10s3 would have a decimal datatype of (10,3), which means the value has a decimal precision of 10 and a decimal scale of 3. The `money` type is more efficient than the `decimal` type. Use `money(n)` when possible.
`double`	A 64-bit numeric floating point with double precision. The range of allowed values is approximately -10^{308} through $+10^{308}$. Equivalent to `float`.
`float`	A 64-bit numeric floating point with double precision. The range of allowed values is approximately -10^{308} through $+10^{308}$. Equivalent to `double`.

Datatype	Description
integer	A signed 32-bit integer. The range of allowed values is -2147483648 to +2147483647 (-2^{31} to 2^{31}-1). Constant values that fall outside of this range are automatically processed as long datatypes.
interval	A signed 64-bit integer that represents the number of microseconds between two timestamps. Specify an interval using multiple units in space-separated format, for example, "5 Days 3 hours 15 Minutes". External data sent to an interval column is assumed to be in microseconds. Unit specification is not supported for interval values converted to or from string data. When an interval is specified, the value must fit in a 64-bit integer (long) when it is converted to the appropriate number of microseconds. For each interval unit, the maximum allowed values that fit in a long when converted to microseconds are: • MICROSECONDS (MICROSECOND, MICROS): +/- 9223372036854775807 • MILLISECONDS (MILLISECOND, MILLIS): +/- 9223372036854775 • SECONDS (SECOND, SEC): +/- 9223372036854 • MINUTES (MINUTE, MIN): +/- 153722867280 • HOURS (HOUR,HR): +/- 2562047788 • DAYS (DAY): +/- 106751991 The values in parentheses are alternate names for an interval unit. When the maximum value for a unit is specified, specifying another unit causes an overflow. Specify each unit only once.
long	A signed 64-bit integer. The range of allowed values is -9223372036854775808 to +9223372036854775807 (-2^{63} to 2^{63-1}). Any constants in the integer range are assumed to be integers. To convert these constants to a long type, use the to_long function.
money	A legacy datatype maintained for backward compatibility. It is a signed 64-bit integer that supports 4 digits after the decimal point. Currency symbols and commas are not supported in the input data stream. The money type is more efficient than the decimal type. Use this type when possible.

Datatype	Description
`money(n)`	A signed 64-bit numerical value that supports varying scale, from 1 to 15 digits after the decimal point. The input data stream supports decimal points, but not currency symbols and commas. The supported range of values change, depending on the specified scale: `money(1)`: -922337203685477580.8 to 922337203685477580.7 `money(2)`: -92233720368547758.08 to 92233720368547758.07 `money(3)`: -9223372036854775.808 to 9223372036854775.807 `money(4)`: -922337203685477.5808 to 922337203685477.5807 `money(5)`: -92233720368547.75808 to 92233720368547.75807 `money(6)`: -92233720368547.75808 to 92233720368547.75807 `money(7)`: -922337203685.4775808 to 922337203685.4775807 `money(8)`: -92233720368.54775808 to 92233720368.54775807 `money(9)`: -9223372036.854775808 to 9223372036.854775807 `money(10)`: -922337203.6854775808 to 922337203.6854775807 `money(11)`: -92233720.36854775808 to 92233720.36854775807 `money(12)`: -9223372.036854775808 to 9223,372.036854775807 `money(13)`: -922337.2036854775808 to 922337.2036854775807 `money(14)`: -92233.72036854775808 to 92233.72036854775807 `money(15)`: -9223.372036854775808 to 9223.372036854775807 Specify explicit scale for money constants with `Dn` syntax, where `n` represents the scale. For example, 100.1234567D7, 100.12345D5. Implicit conversion between `money(n)` types is not supported because there is a risk of losing range or scale. Perform the `cast` function to work with money types that have different scale.
`string`	Variable-length character string, with byte values encoded in UTF-8. Maximum string length is platform-dependent, with a size limit of 2 gigabytes. This size limit is reduced proportionally by the size of other content in the row, including the header.
`time`	Stores the time of day as a two-byte field with a range of 00:00:00 to 23:59:59. The default format is HH24:MM:SS.
`msdate`	A timestamp with millisecond precision. The default format is YYYY-MM-DDTHH:MM:SS:SSS.

4.3.12.4 Setting Parameters in Project Configuration

Edit existing parameter definition values and remove deleted parameters.

Context

The list of parameter definitions is automatically populated based on parameters within any CCL documents in the project folder. You can change parameter definition values in the CCR editor. You can remove parameters if the definition has been deleted from the CCL document.

Procedure

1. Select the **Parameters** tab in the Project Configuration editor.
2. To modify a parameter value, click the parameter and change the value in the **Parameter Details** pane.

   > i Note
   >
   > You cannot modify the parameter **Name** field.
   >
   > You cannot use functions within parameter value fields. The Project Configuration editor only accepts simple values that adhere to the standards set by ESP datatypes. See *Datatypes* for more information.

3. To remove deleted parameter definitions from the list, select **Remove**.

   > i Note
   >
   > A parameter definition marked as (removed) has been deleted from the original CCL file and can be removed from the parameter definition list.

Related Information

Datatypes [page 101]

4.3.12.5 Editing Adapter Property Sets in Project Configuration

Use the CCR Project Configuration editor to configure adapter property sets in a project configuration file. Property sets are reusable sets of properties that are stored in the project configuration file. Using an adapter property set also allows you to move adapter configuration properties out of the CCL file and into the CCR file.

Context

Property sets appear in a tree format, and individual property definitions are shown as children to property sets.

Procedure

1. From the SAP ESP Authoring perspective, double-click the `.ccr` file to open the CCR Project Configuration editor.
2. Select the **Adapter Properties** tab.
3. (Optional) To create a list of adapter property sets that correspond to the ATTACH ADAPTER statements in the main CCL file for the project, click **Add from CCL**.
4. To create a new adapter property set, click **Add**.
5. In the Property Set Details pane, define a name for the property set.
6. To add a new property to a property set, right-click the set and select **New** > **Property**.

   > i Note
   >
   > You can add as many property items to a property set as required.

7. To configure a property:
   a. In the Property Details pane, define a name for the property.
   b. To define a property as an environment variable:
      - For Windows, use the format %`<environment-variable-name>`%.
      - For Unix, use the format ${`<environment-variable-name>`}.

   c. Enter a value for the property.
8. (Optional) To encrypt the property value:
   a. Select the property value and click **Encrypt**.
   b. Enter the required fields, including Cluster URI and credential fields.
   c. Click **Encrypt**.
   The value, and related fields, are filled with randomized encryption characters.

   > i Note
   >
   > To reset the encryption, click **Encrypt** beside the appropriate field. Change the values, as appropriate, then click **Reset**.

9. To remove items from the All Adapter Properties list:
   - Right-click a property set and select **Remove**, or
   - Right-click a property and select **Delete**.

4.3.12.6 Editing Bindings in Project Configuration

Configure input and output bindings to enable streams or windows in different projects to provide or receive data between one another.

Prerequisites

The streams or windows you want to bind have:

- Compatible schemas
- The same datatype for each field name
- The same column order
- The same number of columns

Ensure the cluster your projects are on is configured with user/password authentication, and the cluster user has publishing and subscribing permissions.See *SAP Event Stream Processor: Cockpit Guide* for more information on permissions.

If you plan to bind to a project in another cluster, define the cluster of interest in the SAP ESP Run-Test perspective and add the cluster to the Cluster tab.

Context

Configuring bindings directly connects the output of one project to the input of another. Bindings connect projects to one another in the same way that adapters connect projects to outside data sources or destinations.

Bindings can be local, within the same cluster, or can connect projects in one cluster to projects in different clusters. You can configure bindings from either the source or the destination project—that is, you can choose to publish or to subscribe. An input stream can receive data from different sources through multiple bindings; both input and output streams can provide data to different destinations through multiple bindings.

Bindings can convey data:

- From an output stream or window in the current project to an input stream or window in a remote project. This is called an output binding.
- From a stream or window in a remote project to an input stream or window in the current project. This is called an input binding, and it is the default setting for a binding in the CCR file.
- From an input stream or window in one project to an input stream or window in another project. This is called an input-to-input binding. If you configure an input-to-input binding on the input stream or window that is providing the data, you must select the Output Binding type. By default, an input stream or window assumes that any binding configured on it is an input binding. However, if you configure an input-to-input binding on the input stream or window that is receiving the data, do not set Binding Type to Output Binding. For information on setting the Output parameter in the CCR file, see the *Using Bindings to Connect CCL Projects* topic.

Binding information is specified in the project configuration (CCR) file so that binding references may be changed at runtime, allowing the project to be used in multiple environments.

Procedure

1. In the CCR Project Configuration editor, select the **Bindings** tab.
2. To add a binding, click **Add**, or to display a list of available streams/windows, click **Discover**.

   You can create multiple bindings on a single stream or window.
3. To configure individual binding settings, use the **Binding Details** pane on the right side of the CCR Project Configuration editor.

Field	Description
Binding Type	Property name as it appears in the ccr file: `Output` Type: `boolean` For most bindings this option defaults to the correct value. Set this option to **Output Binding** only to configure an input stream or window in this project to send data to an input stream or window in a remote project. When you select **Output Binding** on an input stream, you tell the binding to publish (send data out) to the remote input stream. If you do not check the **Output Binding** box, the binding subscribes to data from the remote input stream because bindings on input streams receive data by default. i Note Set this option to **Output Binding** only when you configure a binding on an input stream or window that is providing output. If you configure the binding on the stream or window that is receiving input, do not set this to **Output Binding**. (It is never necessary to select **Output Binding** when you configure a binding on an output stream; output streams can only produce output.)
Binding name	Property name as it appears in the CCR file: `BindingName` Type: `string` (Optional) Apply a name to the binding.
Local stream/window	Property name as it appears in the CCR file: `<Binding name>` Type: `string` Enter the name of the local stream or window (for example, localStream1) or click **Discover** to view and select from a list of streams/windows.
Reconnect Interval (seconds)	Property name as it appears in the ccr file: `ReconnectInterval` Type: `integer` If the connection between the local and remote streams is lost, the project attempts to reconnect at the specified interval. To suppress all reconnection attempts, set Reconnect Interval to 0. Use positive whole number values to set the reconnection interval. Default interval is 5 seconds.
Remote Stream properties	

Field	Description
Cluster	Property name as it appears in the ccr file: `Cluster` Type: `string` Select the cluster that contains the project to bind to. i Note You can select only clusters listed on the Cluster tab of the SAP ESP Run-Test perspective.
Remote stream/window	Property name as it appears in the ccr file: `RemoteStream` Type: `string` Enter the name of the remote stream or window (for example, remoteStream1) or click **Discover** to view and select from a list of streams/windows. If you use **Discover**, make sure the cluster and project that you are binding to are both running. If they are not, **Discover** cannot find their streams or windows.
Workspace	Property name as it appears in the ccr file: `Workspace` Type: `string` Enter the workspace name (for example, ws1) or click **Discover** to view and select from a list of workspaces. If you use **Discover**, make sure the cluster and project that you are binding to are both running. If they are not, **Discover** cannot find their workspaces.
Project	Property name as it appears in the ccr file: `Project` Type: `string` Enter the project to access (for example, project1) or click **Discover** to view and select from a list of projects. If you use **Discover**, make sure the cluster and project that you are binding to are both running. If they are not, **Discover** cannot find the project.
Guaranteed Delivery properties	
Enable Guaranteed Delivery	Property name as it appears in the ccr file: `EnableGD` Type: `boolean` Enable GD for a binding to guarantee that if the connection between the binding and the remote stream is severed (by shutting down the project that contains the local stream, for example), all transactions that are supposed to be transmitted through the binding during its downtime are processed once the connection is re-established. i Note When you enable GD on a binding, make sure: ○ The binding's source data window is running in GD mode or GD mode with checkpoint. ○ The binding's target data window is backed by a log store.

Field	Description
Enable Guaranteed Delivery Cache	Property name as it appears in the ccr file: `EnableGDCache` Type: `string` Enable this binding to cache data. When the source data window is in GD mode with checkpoint, the binding receives checkpoint messages that indicate the last row of data that has been checkpointed by the window. If the binding is enabled for GD caching, it caches incoming transactions until it receives a checkpoint message from the source window. The checkpoint message triggers the binding to send all cached transactions up to the one indicated in the checkpoint message, to the target window. The binding issues a `GD commit` to the source data window after releasing cached data. If GD caching is disabled, SAP ESP ignores checkpoint messages and the binding forwards data based on the **Guaranteed Delivery Batch Size**. ESP ignores **Enable Guaranteed Delivery Cache** if the source data window is not in GD mode with checkpoint.
Guaranteed Delivery Name	Property name as it appears in the ccr file: `GDName` Type: `string` Supply a unique name for the GD session (subscription) this binding establishes.
Guaranteed Delivery Batch Size	Property name as it appears in the ccr file: `GDBatchSize` Type: `integer` Set this property to customize batch size. The value you enter has to be a positive integer greater than 0. The default value is 1.
Advanced Properties	
Droppable	Property name as it appears in the ccr file: `Droppable` Type: `boolean` (For input bindings only) If the reader cannot keep up, the connection to the bound stream or window is dropped and attempts to reconnect. The default value is false.
Keep Base	Property name as it appears in the ccr file: `KeepBase` Type: `boolean` (For input bindings only) Set this property to true to receive the initial contents of the stream, as well as the updates. The default value is true.

Field	Description
Lossy	Property name as it appears in the ccr file: `Lossy` Type: `boolean` (For input bindings only) If set to true, the binding is lossy and if the binding cannot keep up (meaning when the first project cannot send information to the second project), some data may be lost. If set to false, the binding is not lossy and cannot lose data if it cannot keep up. Setting this property to false may have negative performance impact. The default value is false.
Mirror	Property name as it appears in the ccr file: `Mirror` Type: `boolean` (For input bindings only) If set to true, the input binding stream or window keeps the same data as the remote stream or window to which it is bound and clears the data when the remote stream data is cleared. If set to false, the local binding stream or window does not check the status of the remote stream or window data and always keeps the local input binding stream or window data. The default value is false.
Only Base	Property name as it appears in the ccr file: `OnlyBase` Type: `boolean` (For input and output bindings) Set to true to receive only the initial contents of the stream. The default value is false.
Base Drain Timeout	Property name as it appears in the ccr file: `BaseDrainTimeout` Type: `integer` (For input bindings only) The maximum time, in milliseconds, to receive all base data for the connected stream before the connected remote project forces a disconnection. The default value is 0.
Pulse	Property name as it appears in the ccr file: `Pulse` Type: `integer` (For input bindings only) Specify a period, in seconds, in which the remote stream or window pulses to check for updates. Use a non-zero value to enable this property. The default value is 0.
Queue Size	Property name as it appears in the ccr file: `QueueSize` Type: `integer` (For input bindings only) The maximum number of records to queue up before the binding connection is dropped. The default value is 0.

Field	Description
Query	Property name as it appears in the ccr file: `Query` Type: `string` (For input bindings only) A string which specifies a valid SELECT SQL statement.

4. (Optional) To remove a binding, select it and click **Remove**.

Related Information

Using Bindings to Connect CCL Projects [page 199]

4.3.12.7 Sample Project Configuration File

If you prefer using text editor instead of the Studio Project Configuration editor, use this example to help you build and modify your own project configuration (`.ccr`) files.

In this example, notice that the `.ccr` file is organized in sections according to the preferences being set, including clusters, managers, bindings, parameters, adapters, and project settings. For information on adapters and adapter property sets, see the *SAP Event Stream Processor: Adapters Guide*.

```
<?xml version="1.0" encoding="UTF-8"?>
<Configuration xmlns="http://www.sybase.com/esp/project_config/2010/08/">
  <Runtime>
    <Clusters>
      <!-- We need this only if we have a project/stream binding. -->
      <Cluster name="cluster1" type="local">
        <Username>atest</Username>
        <Password>secret</Password>
      </Cluster>
      <Cluster name="cluster2" type="remote">
        <Username>user2</Username>
        <Password>Pass1234</Password>
        <!-- Managers section is required for a remote cluster. Managers for a 
local cluster are retrieved internally from the node. -->
        <Managers>
          <Manager>http://<host>:<RPC port></Manager>
        </Managers>
      </Cluster>
    </Clusters>
    <Bindings>
      <Binding name="stream1">
        <Cluster>cluster1</Cluster>  <!-- this is always needed. -->
        <Workspace>w1</Workspace>
        <Project>p1</Project>
        <BindingName>b1</BindingName>
        <RemoteStream>remote1</RemoteStream>
      </Binding>
      <Binding name="stream2">
        <Cluster>cluster2</Cluster>  <!-- this is always needed -->
        <Workspace>w2</Workspace>
        <Project>p2</Project>
        <BindingName>b2</BindingName>
        <RemoteStream>remote2</RemoteStream>
      </Binding>
      <Binding name="stream3">
        <Cluster>cluster3</Cluster>  <!-- this is always needed -->
        <Workspace>w3</Workspace>
        <Project>p3</Project>
        <BindingName>b3</BindingName>
        <RemoteStream>remote3</RemoteStream>
      </Binding>
    </Bindings>
    <Parameters>
      <Parameter name="myparam1">foo</Parameter>
      <Parameter name="myparam2">1234</Parameter>
      <Parameter name="myparam3">true</Parameter>
    </Parameters>
    <AdaptersPropertySet>
      <PropertySet name="datalocation1">
        <Property name="myhost1">5555</Property>
      </PropertySet>
      <PropertySet name="datalocation2">
        <Property name="myhost2">6666</Property>
      </PropertySet>
    </AdaptersPropertySet>
  </Runtime>
  <Deployment>
    <Project ha="false">
      <Options>
        <Option name="time-granularity" value="5"/>
        <Option name="debug-level" value="3"/>
        <Option name="java-max-heap" value="512"/>
        <OptionList name="java-classpath">
          <OptionListItem>C:/something/example1.jar</OptionListItem>
          <OptionListItem>C:/something/example2.jar</OptionListItem>
          <OptionListItem>C:/something/</OptionListItem>
        </OptionList>
      </Options>
      <Instances>
        <Instance>
          <Failover enable="false"/>
          <Affinities>
            <Affinity charge="positive" strength="strong" type="controller"
value="myController"/>
          </Affinities>
        </Instance>
      </Instances>
    </Project>
  </Deployment>
</Configuration>
```

If you are ready to deploy projects, see the *SAP Event Stream Processor: Configuration and Administration Guide* for an example of the deployment section of this file.

4.3.13 Compiling a Project

Compile and run a ESP project.

Prerequisites

- You have chosen a default SAP ESP server connection. For details, see Choosing a Default Streaming Server Connection [page 66].
- You have opened the CCL project you are compiling. You do this from the project explorer in the SAP ESP Authoring perspective.

Context

When you compile a project, SAP ESP produces an executable `.ccx` file from CCL code. This file is necessary to run a project.

Procedure

1. To compile a project without running it, either to check for errors or just to have an updated `.ccx` file, click **Compile Project** 010 on the main toolbar, or press **F7**.
2. To compile and run the project, click **Run ESP Project** ▶.

   The project automatically compiles and runs. The server view in the SAP ESP Run-Test perspective opens, showing the project connection. A successful connection displays the server streams below the server folder. If the connection is unsuccessful, you see a server connection error dialog.

   > i Note
   >
   > You cannot cancel project compilation after it has started. By default, Studio is configured to time out if project compilation takes longer than 5 minutes. If you need more time for a project to compile, consider changing the Operations Timeout setting in the **SAP Event Stream Processor** Preference settings. For more information, see Editing Studio Preferences [page 54].

   > i Note
   >
   > When you have Studio installed on a separate machine from the SAP ESP server, you cannot compile projects on the default local cluster. Instead, connect to the SAP ESP server and then compile your project. See Connecting to a Remote Cluster [page 67] for detailed instructions.

Results

Studio saves all open files belonging to the project, compiles the project, and creates the `.ccx` file (the compiled executable). Compilation errors are displayed in **Problems** or **Console** view in each perspective, depending on the type of error. If you selected **Run Project** ▶, it also runs the compiled project.

> **i Note**
>
> The `.ccx` file is platform-independent. You can migrate, test, develop, and run the file in Studio running on different operating systems. For example, you can compile a project in Studio on Unix, and deploy the same file in Studio on Windows.

Studio returns an error when a project refers to a schema from an imported file but the project compiles without errors. Refresh the file by closing the project or create the files in the opposite order.

4.4 Running and Testing Projects with Studio

Running a project automatically starts the project either on a default local cluster or on another connected cluster, enabling you to upload data from a file, manually enter data, and view streams in that project. Test a project by compiling and running it on a server, accessing and filtering streams, saving and uploading data to the SAP Event Stream Processor server, and setting project configurations.

Prerequisites

- To run a project, ensure that one or more connected workspaces are available.
- When Studio is installed on a separate machine from the SAP ESP server, you cannot run projects on the default local cluster. Instead, connect to the SAP ESP server to run your project.
- Connect to SAP Event Stream Processor server. See Connecting to a Remote Cluster [page 67] for detailed instructions.

Procedure

1. Select and open the `.ccl` file you want to run.

   If no editors are open, pick a project to run.
2. To run the project, either:
   - Click **Run Project** ▶ in the main toolbar (in either the SAP ESP Authoring or the SAP ESP Run-Test perspective) to run the project in the default/most recently used workspace, or,
   - Click the dropdown arrow next to the Run Project tool and choose **Run Project in Workspace**, then select the workspace where this project will run.

The project runs and shows results in the SAP ESP Run-Test perspective.

> **i Note**
>
> If you have run the project before and encounter an error stating that a failure occurred because the application already exists, the project may still exist on the server in a stopped state. Remove the project from the SAP ESP Run-Test server view, and restart the project from the SAP ESP Authoring perspective.

In this section:

Caching Project Settings [page 116]
When running projects within Studio, you can save time by caching your run-test views so they open to your previous settings.

Working in Server View [page 116]
The server view shows SAP Event Stream Processor servers available for connecting and running projects.

Viewing a Stream [page 117]
Stream view shows all of the events of an output stream and all of the retained events in an output window for the running project.

Specifying a Pulse Rate [page 118]
You can specify how often you see changes and updates in a stream. When a data stream contains few items with a high volume of changes, you can set a pulse rate so that changes are delivered periodically, in optimally coalesced blocks.

Uploading Data to the Server [page 119]
Use the File Upload tool to load event data from files into a running project. Normally, you use this tool to test projects. Date and time stamps in data loaded through the File Upload tool are assumed to be in the local timezone.

Manually Entering Data to a Stream [page 120]
Manually create and publish an event as input to a stream or window. By default, date and time stamps in data loaded through the Manual Input tool are assumed to be in the local timezone. You can change this setting to use Universal Coordinated Time (UTC) through your Studio preferences.

Monitoring Project Performance [page 121]
The Monitor View shows visual indicators of queue size, throughput, and CPU use for each stream and window (including local streams and windows) in a project.

Running a Snapshot SQL Query against a Window [page 123]
In the SQL Query view, run a snapshot SQL query against an output window in a running project, and show the results in the Console.

Playback View [page 123]
The playback view records incoming data to a playback file, and plays the captured data back into a running Event Stream Processor instance. You can also use it in place of the file upload tool to upload data files at a controlled rate. All date and time stamps within the playback view are assumed to be in UTC.

Debugging [page 128]
The SAP ESP Run-Test perspective in Studio contains two tools for debugging data flow and to assist you in locating and fixing bugs within the project: the debugger, which allows you to set breakpoints,

and the event tracer, which shows the impact of each incoming event on all streams and windows of a project.

4.4.1 Caching Project Settings

When running projects within Studio, you can save time by caching your run-test views so they open to your previous settings.

Context

Items cached include:

- The list of Stream View stream tabs.
- The current Manual Input Stream.
- The current SQL Query, Playback, Upload, Monitor, Event Tracer projects.

Procedure

1. Click **Windows** > **Preferences** > **Event Stream Processor Run-Test** .
2. Select **Always start previously running run-test views on project start**.
3. Uncheck **Clear all cached run-test views**.

> i Note
>
> Ensure that you clear this option, because if you clear the cache, there will not be anything saved to load. Select this option only if you do not want to cache your run-test settings.

4.4.2 Working in Server View

The server view shows SAP Event Stream Processor servers available for connecting and running projects.

You can:

- Connect to or disconnect from a project, enable a local or remote cluster.
- Stop or force stop a project, if necessary.
- Add a new server URL to the list of available connections, remove an existing server, or reconnect all listed servers.
- Show a server in monitor view or event tracer view.
- Load projects into a workspace.
- Filter metadata streams (default).

Metadata streams are created automatically, and are typically used by administrators in a production system to obtain health and performance information about the currently running project. For details of what each stream contains, see *Metadata Streams* in the *SAP Event Stream Processor: Configuration and Administration Guide*.

4.4.3 Viewing a Stream

Stream view shows all of the events of an output stream and all of the retained events in an output window for the running project.

Context

> **i Note**
>
> By default, stream view interprets date values using the local time zone. To display date values using UTC, edit the manual input settings. See the *Manual Input Settings* topic for more information.

Procedure

1. In the SAP ESP Run-Test perspective, select the stream or window from the server view.
2. Right-click the output stream or window, and select **Show In** > **StreamViewer** (or **New StreamViewer**).
   A tab opens in the stream view showing all new events. If you selected a window, all retained rows currently in the window are displayed.
3. To manipulate your subscription list, or individual stream subscriptions, select the subscription to edit and choose one of these buttons at the top of the stream view:
   - **Close Subscription URL** disconnects and closes the stream view.
   - **Clear** clears contents and pauses the subscription.
   - **Show Current Subscription in new View** shows the publish date of the stream (if available).
   - **Set StreamViewer number of rows displayed** lets you choose the number of rows to show in the stream view. The number can be between 1 and 1000000. The default value is 25.
4. (Optional) To save data from the stream view, click **Clipboard Copy**.

Related Information

Manual Input Settings [page 57]

4.4.4 Specifying a Pulse Rate

You can specify how often you see changes and updates in a stream. When a data stream contains few items with a high volume of changes, you can set a pulse rate so that changes are delivered periodically, in optimally coalesced blocks.

Context

A stream containing three ticker symbols, for example, may generate thousands of updates every second. You can set the pulse period to control the frequency at which you receive updates when viewing the stream. If you set the pulse to refresh every 5 seconds, the subscription then delivers, at most, one updated record for each of the three symbols every five seconds.

There are two preferences that control the subscription feature in Studio:

- **StreamViewer pulsed subscribe interval**
- **Other pulsed subscribe interval**

Both preferences are measured in seconds. If either of these preferences is set to 0, then Studio does not perform a pulsed subscription on the related stream.

> ℹ Note
>
> If you have a small data set and you set the pulse to refresh frequently, such as once every 1 or 2 seconds, the Stream View may be empty for some streams because there are no new updates

Go through the following steps to change the default settings:

Procedure

1. Choose **Window** › **Preferences** .
2. In the left pane, expand **Event Stream Processor** › **Run-Test** .
3. Enter new values for **StreamViewer pulsed subscribe interval** or **Other pulsed subscribe interval** or both.
4. Click **Apply**.
5. Click **OK** to close the dialog.

4.4.5 Uploading Data to the Server

Use the File Upload tool to load event data from files into a running project. Normally, you use this tool to test projects. Date and time stamps in data loaded through the File Upload tool are assumed to be in the local timezone.

Prerequisites

Ensure that the project is running.

Procedure

1. In the SAP ESP Run-Test perspective, select the **File Upload** view in the lower-left pane.

   > i Note
   >
   > The File Upload tool uploads the data file as fast as possible. For playing back data at controlled rates, use the Playback tool.

2. Click **Select Project** in the toolbar in the upper right corner of the File Upload view.
3. Select the project to which you want data uploaded, and click **OK**.
4. Click **Browse** to open the file choice dialog and navigate to the input file to upload.
5. Select one or more files to upload:
   - The ESP server supports ESP binary (`.bin`), ESP XML (`.xml`), and comma-separated values and text (`.csv` or `.txt`) files. Regardless of file type, each record in the file has to start with the input stream or window name in the first field, followed by the opcode in the second field, then the actual contents of the record in the remaining fields.
   - Use the format `yyyy-MM-'dd'T'HH:mm:ss` when uploading any `SecondDate` data from a file. For example, `TradeTime="2000-05-04T12:00:00"`.
   - Use the format `yyyy-MM-'dd'T'HH:mm:ss.SSS` when uploading any `MsDate` data from a file. For example, `Tradetime="2000-05-04T12:00:00.000"`.
6. Click **Upload**. A progress bar tracks the upload status.

   The File Upload view allows you to perform these additional actions:

UI control	Action
Remove File	Discard a previously selected file from the Input File(s) menu.
Cancel	Cancel a file upload currently in progress. i Note Any data sent before the upload is cancelled is still processed.

UI control	Action
Use Transaction	Process multiple records as a single transaction. If **Record Buffer** is specified, group that many records in each transaction. If not, process the entire file as one transaction.
Record Buffer	Specify the number of records to group together and process in a single transaction.

4.4.6 Manually Entering Data to a Stream

Manually create and publish an event as input to a stream or window. By default, date and time stamps in data loaded through the Manual Input tool are assumed to be in the local timezone. You can change this setting to use Universal Coordinated Time (UTC) through your Studio preferences.

Context

Manually publishing input events to a project is useful when testing a project.

Procedure

1. In the SAP ESP Run-Test perspective, select the **Manual Input** view in the lower-left pane.
2. Click **Select Stream** () in the toolbar in the upper right corner of the Manual Input view.
3. In the Select Stream dialog, select the stream and click **OK**.
4. Edit available data columns as desired.
5. To edit more than one row of the data, select **Edit Multiple Rows** () and choose the rows to modify.
6. If you are publishing to a window, indicate the opcode by selecting one of the data events. If you are publishing to a stream, only insert events are supported.
7. (Optional) Select **Use Current Date** to change the value of any bigdatetime or date object in the manual input view to the present date.
8. Click **Publish** to send the event to the project.

Related Information

Manual Input Settings [page 57]

4.4.7 Monitoring Project Performance

The Monitor View shows visual indicators of queue size, throughput, and CPU use for each stream and window (including local streams and windows) in a project.

Each node corresponds to a stream in the model with the lines outlining the path the data flows through. The color of each node represents either QueueDepth or Rows Processed (/sec), depending on your specifications.

For example, if you select the **Color Queue Depth** option, the (Red) Range >= field defaults to 125, and the (Yellow) Range >= field defaults to 20. This means:

- If the queue depth of the stream node is greater than or equal to 125, the node is red.
- If the queue depth of the stream node is between 20 and 124, the node is yellow.
- If the queue depth of the stream node is less than 20, the node is green.
- If the nodes remain white, it indicates that the monitor is not receiving data from the stream processor.

The Monitor View depicts CPU utilization as a black pie wedge in the ellipses of the node. Based on the options chosen, the remainder of the ellipses are red, yellow or green. A fully black node represents 100 percent CPU use, based on a single CPU core. With multicore or multiprocessor environments, a fully black node may be greater than 100 percent.

You can look at a specific node's performance statistics by moving your cursor over the node in the diagram.

> i Note
>
> Monitoring data is available only if the time-granularity option (otherwise known as the performance monitor refresh interval) is enabled. The time-granularity option specifies, in seconds, how often the set of performance records — one per stream and one per gateway connection — is obtained from the running ESP project.

In this section:

4.4.7.1 Running the Performance Monitor

View visual indicators of queue size and CPU usage for each stream and window.

Prerequisites

The project you wish to monitor is running.

Context

You can specify a delay by changing the performance timer interval.

Procedure

1. In the Studio SAP ESP Run-Test perspective, select the server view.
2. Right-click on a running project and select **Project Properties**.
3. In the dialog, set **Performance Monitoring Refresh Interval** to a number greater than 0.

   The default setting is 5. The performance monitor will not run if the refresh interval is set to 0.
4. In the monitor view, click **Select Running Project** (📄).
5. Click **OK**.
6. Select **QueueDepth** or **Rows Processed** to specify how to color each node in the performance diagram. For either option:
   - Type in a number or use the arrow buttons in the (Red) Range >= field to select the range to create a red node.
   - Type in a number or use the arrow buttons in the (Yellow) Range >= field to select the range to create a yellow node.

   > i Note
   >
   > Nodes are green when they fall within a range that is not in either the (Red) Range >= or the (Yellow) Range >=.
7. Click **Zoom In** or **Zoom Out** to see a larger or smaller view of the diagram.

4.4.7.2 Saving a Performance Diagram as an Image

Save a performance diagram.

Context

You can modify the performance diagram properties using the Monitor window in the SAP ESP Run-Test perspective. The diagram appears in the Event Tracer window, and can be saved only from that window.

Procedure

1. In the SAP ESP Run-Test perspective, select the **Event Tracer** view.

2. Click **Save**.
3. Enter a file name and save location. Click **Save**.
   The file is saved as a JPEG image in the location you specified.

4.4.8 Running a Snapshot SQL Query against a Window

In the SQL Query view, run a snapshot SQL query against an output window in a running project, and show the results in the Console.

Procedure

1. In the SAP ESP Run-Test perspective, select the **SQL Query** view in the lower-left pane.
2. Click **Select Project**.
3. Select the project and window to query, and click **OK**.
4. Enter your query.
   For example, `Select * from <stream>`.
5. Click **Execute**.
   The results are displayed in the Console.

4.4.9 Playback View

The playback view records incoming data to a playback file, and plays the captured data back into a running Event Stream Processor instance. You can also use it in place of the file upload tool to upload data files at a controlled rate. All date and time stamps within the playback view are assumed to be in UTC.

Playback View Options

Feature	Description
Select playback file	Select the file format to use with the Event Stream Processor recorder.
Start playback	Starts playing the current playback file.
Stop playback	Stops playback or record, closes the associated file and closes the associated playback or record context.
Start Recording	Prompts the user to select the file in which to store recorded data and starts the Event Stream Processor recorder.
At Timestamp rate	This slider is used during playback to vary the rate of playback

Feature	Description
XML/CSV datemask	Applies a datetime mask to read data from the source file. The default datetime format is UTC, or %Y-%m-%dT%H:%M:%S. This option cannot change delimiters, which are the characters that separate each value: "-", "T", ":").

Playback Mode Options

Feature	Description
Full rate	**Full rate** indicates that the speed of playback is not imposed by the Studio. **Full rate** is dependent on factors such as the computer that is running Studio, or network latency.

Feature	Description
Timestamp column	The **timestamp column** option tells the recorded file to play back using the timing rate information from a specified column. During playback, timestamps determine the time interval between records. **Note** `.bin` and `.rec` file types are not supported by this function. To change the project runtime to the time the data was recorded: 1. Select **timestamp column**. 2. Check **Use Recorded time**. 3. Enter a column name in the **timestamp column** field. To return to current time, restart the project. The **timestamp column** field supports these datetime datatypes: - `BIGDATETIME` - `SECONDDATE` - `TIME` - `INTERVAL` - `INTEGER` - `LONG` When entering a datemask in the **XML/CSV datemask** field, these datatypes have a default format: - `BIGDATETIME`: YYYY-MM-DDTHH:MM:SS:SSSSSS - `SECONDDATE`: YYYY-MM-DDTHH:MM:SS - `TIME`: HH24:MM:SS **Note** These formats cannot change delimiters. These datatypes do not support a datemask: - `INTERVAL` - `INTEGER` - `LONG`
Rec/ms	The records-per-millisecond (**rec/ms**) mode lets playback occur at a records-per-millisecond rate. The option allows you to set an initial rec/ms rate, which you can modify using the **At Timestamp rate** slider tool.

Supported File Extensions and Operation Codes

The Studio recorder supports these file formats:

- `.xml` (ESP XML)
- `.csv` (comma-separated values)
- `.bin` (ESP Binary)
- `.rec` (Studio recorded file)

Regardless of file type, each record in the file has to start with the input stream or window name in the first field, followed by the opcode in the second field, then the actual contents of the record in the remaining fields. The default date/time format for all supported date/time datatypes is `%Y-%m-%dT%H:%M:%S`. For example, `2011-06-30T17:00:00.000`.

Supported operation codes, and their abbreviated forms, are:

- INSERT: `I` or `i`
- UPDATE: `U` or `u`
- DELETE: `D` or `d`
- SAFEDELETE: `S` or `s`
- UPSERT: `P` or `p`

Additional Formatting Rules for CSV and XML Files

For CSV files, the value order has to correspond to the schema definition of the input stream or window. For example:

```
isSensorStream,i,2011-06-30T17:00:00.000,34.614,-111.843,Tower,Camp Verde
T11,1,96.8
```

For CSV files, null values are only allowed if the correct number of fields are represented and delimited by commas (or whatever single-character delimiter is used from the ASCII printable character set). For example:

```
isSensorStream,i,2011-06-30T17:00:00.000,,,,Camp Verde T11,,96.8
```

For XML files, the columns can be in any order as long as the column names correspond to the schema names. You can omit any fields rather than leaving them empty (null value). For example:

```
<Positions ESP_OPS="i" BookId="Book1" Symbol="MSFT" SharesHeld="3000"
Basis="528400"/>
```

Binary files recorded in previous releases cannot be played back until they are converted to the new binary format using `streamingconvert`. See *streamingconvert* in the *SAP Event Stream Processor: Utilities Guide*.

SAP Event Stream Processor records in `.rec` format, preserving the original timing of the incoming data.

> **i Note**
>
> Binary messages are architecture-dependent. Binary messages created in a big-endian machine cannot be loaded into the ESP server running in a little-endian machine, and vice-versa.

In this section:

Recording Incoming Data in a Playback File [page 127]

Record incoming data that is flowing into Event Stream Processor to a playback file that you can save and view at a later time.

Playing Recorded Data [page 128]
View and play previously recorded data in a running Event Stream Processor instance.

4.4.9.1 Recording Incoming Data in a Playback File

Record incoming data that is flowing into Event Stream Processor to a playback file that you can save and view at a later time.

Prerequisites

Connect to an SAP Event Stream Processor server. Have your streams and windows visible in the Stream View.

Procedure

1. Open the SAP ESP Run-Test perspective.
2. In the Playback view, click **Select Project** .
3. Select the project you want to record. Click **OK**.
4. Click the **Record** icon.
5. Select the streams and windows to record, or click **Select All** to record all streams and windows in the project. Click **OK**.
6. Select or create a file in which to save the recording. Click **OK**.
7. Send data to your selected streams using either:
    - The Manual Input view to input data and publish to your streams, or,
    - **File Upload** to retrieve an existing data file and publish to your streams.
8. Click **Stop** to stop recording.

4.4.9.2 Playing Recorded Data

View and play previously recorded data in a running Event Stream Processor instance.

Context

> i Note
>
> You may select Playback view options before or after you select a file for playback.

Procedure

1. Click **Playback File** 📄.
2. Browse for and select the file you want to play back.

   The playback file is added to the Playback File History. You can also play back a file registered in the history. Double-click a history entry to activate it for playback.

   > i Note
   >
   > You can delete an item from the history using the either the **Remove** button or **Delete** key. Modifications to the playback history are permanent.
3. Click **Play** to begin playback.
   By default, the data appears in the Stream View at the rate it was recorded.

4.4.10 Debugging

The SAP ESP Run-Test perspective in Studio contains two tools for debugging data flow and to assist you in locating and fixing bugs within the project: the debugger, which allows you to set breakpoints, and the event tracer, which shows the impact of each incoming event on all streams and windows of a project.

Use the debugging tools during project development, not while Event Stream Processor is in production mode. Debugging features are normally disabled. Place the system in Trace mode before using the debugging features.

Studio offers an extensive suite of tools for debugging projects, but you can debug from the command line as well. See the *SAP Event Stream Processor: Utilities Guide*.

In this section:

Debugging with Breakpoints and Watch Variables [page 131]

Use Studio to control a running project by enabling tracing, pausing, resuming, and stepping of data flow through Event Stream Processor streams. You can also create breakpoints and watch variables on a running application.

4.4.10.1 Event Tracer View

The event tracer is a tool for debugging data flow. It shows the impact an event has on each stream and window of the project.

The event tracer view shows the transaction flow through the model and lets you view data in each node (stream or window). The nodes depicted in the event tracer view are drawn as a data flow, depicting the relationships between the nodes. The following table describes the function of each available button in the event tracer view.

Button	Function
Select Running Project	Presents a list of running projects available to monitor from Studio.
Layout TopDown	Arranges shapes vertically for a top-to-bottom data flow.
Layout Left to Right	Arranges shapes horizontally for a left-to-right data flow.
Save	Saves the image as a JPG file.
Zoom In	Enlarges the size of the image.
Zoom Out	Reduces the size of the image.
Zoom Page	Restores the size of the image to its original size.
Print Performance Data to Console	Prints the collected data to the console.
Close Subscription	Closes the subscription and clears the view.
Show Current Subscription in New View	Displays the current subscription in a separate view.
Fit Shape Ids	Expands a shape to show the name of the stream or window.
Initialize With Base Data	Sends all event data from Event Stream Processor through the event tracer.

In this section:

Tracing Data Flow in the Event Tracer [page 130]

Run the event tracer to trace data flow.

Viewing the Topology Stream [page 131]

The Topology Stream constructs the data-flow diagram, where relationships between the nodes of a project are represented as line segments.

4.4.10.1.1 Tracing Data Flow in the Event Tracer

Run the event tracer to trace data flow.

Prerequisites

The ESP server is running.

Procedure

1. In Studio, in the SAP ESP Run-Test perspective:

Method	Procedure
Event Tracer	1. Click the event tracer view. 2. Click **Select Running Project** (📄) to show running projects that contain streams or windows. 3. Select a running project for the event tracer. 4. Click **OK**.
Server View	1. Select the server view. 2. To refresh the server view, click **Reconnect All**. 3. Select a running project that contains streams. 4. Right-click the project node, and select ▶ **Show in** ▶ **Event Tracer View** ◀.

   The nodes depicted in the viewer are drawn as a data flow. As a transaction is processed by each node, the color of the node changes to reflect the type of transaction.

2. Double-click a node to show the corresponding stream's data in the console view.
3. Load test data to view the impact on each stream in the event tracer. Do one of the following:
   - Click the **Upload File** tab in the toolbar below the Activate Project pane to upload data from a file.
   - In the manual input view, manually enter individual transactions by clicking the **Select Stream** icon. Select a stream. To confirm, click **OK**.

Results

The shapes in the event tracer view change color.

4.4.10.1.2 Viewing the Topology Stream

The Topology Stream constructs the data-flow diagram, where relationships between the nodes of a project are represented as line segments.

Procedure

1. In the SAP ESP Run-Test perspective, select **Event Tracer** view.
2. Click **Select Running Project**. Select the desired project, and click **OK**.
3. To view the entire diagram, select **Layout top down** or **Layout left to right**.
4. To view a particular node, select the section of the data-flow diagram that contains the desired stream.

4.4.10.2 Debugging with Breakpoints and Watch Variables

Use Studio to control a running project by enabling tracing, pausing, resuming, and stepping of data flow through Event Stream Processor streams. You can also create breakpoints and watch variables on a running application.

Breakpoints are locations in a stream or window's input or output that stop the flow of data in the Event Stream Processor model. A watch variable inspects the data. The following table describes the function of each studio breakpoint button:

Button	Function
Trace On	Instructs Event Stream Processor to begin tracing (debugging). Set this parameter to use the Event Stream Processor breakpoint APIs.
Trace Off	Stops tracing (debugging).
Step Project	Steps through the running Event Stream Processor project.
Pause Project	Pauses playback for projects recorded as .rec files. i Note When the project is paused, the records from Manual Input and File Upload cannot be updated to streams until the project is resumed.
Enable All Breakpoints	Enables all breakpoints in the list.
Disable All Breakpoints	Disables all breakpoints in the list.
Insert Breakpoint	Inserts a breakpoint item into the watch table.
Insert Watch	Inserts a watch item into the watch table.
Print Breakpoint Data to Console	Prints the breakpoint and pause state data for the current stream to the console.

Breakpoint Commands

The following breakpoint commands initiate long-running operations. Each of these can be cancelled before completion by clicking **Cancel Current Step**.

Button	Function
Step Quiesce from Base	Automatically steps all the derived (non-base) streams until their input queues are empty.
Step Quiesce	Automatically steps the stream and all its direct and indirect descendants until all of them are quiesced.
Step Transaction	Automatically steps until the end of transaction.
Step Quiesce Downstream	Steps the descendants of the stream but not the stream itself.

> i Note
>
> Breakpoints and watch variables persist to the workspace.

In this section:

Breakpoints [page 132]
You can insert a breakpoint for any stream in the project.

Watch Variables [page 134]
Insert watch variables into the watch table of the Breakpoints view in the Debugger to inspect data as it flows through the project.

Pausing SAP Event Stream Processor [page 135]
Pause SAP Event Stream Processor while playing back projects with `.rec` file types.

Stepping Through a Project in Studio [page 136]
Single-step through a project in SAP Event Stream Processor.

4.4.10.2.1 Breakpoints

You can insert a breakpoint for any stream in the project.

Breakpoint types include:

Local breaks on input to the stream.

Input breaks on a specific input stream to a stream (only Flex, join, and union can have multiple input streams).

Output breaks when data is output from the stream.

A breakpoint can be associated with a counter (enableEvery). When a counter (n) is associated with a breakpoint, the breakpoint triggers after n events flow through the breakpoint. The counter is then reset to zero.

In this section:

Adding Breakpoints [page 133]
Add breakpoints to streams in Event Stream Processor.

Parent topic: Debugging with Breakpoints and Watch Variables [page 131]

Related Information

Watch Variables [page 134]
Pausing SAP Event Stream Processor [page 135]
Stepping Through a Project in Studio [page 136]

4.4.10.2.1.1 Adding Breakpoints

Add breakpoints to streams in Event Stream Processor.

Prerequisites

- The Debugger view of the SAP ESP Run-Test perspective in Studio is open.
- Trace mode is enabled.

Procedure

1. Click **Trace On**.
2. Click **Insert Breakpoint** (⊞).
3. Select the stream where you want to set a breakpoint.
4. Select the type of stream.
5. Specify when the breakpoint should trigger by entering a value in the **enableEvery** field.
6. Click **Add**.

   The selected stream appears in the table within the Insert Breakpoint dialog box.
7. Click **OK**.

   The breakpoint appears in the Debugger view within the Breakpoint table.
8. Right-click the breakpoint and select an option:
   - **Enable Breakpoint**
   - **Disable Breakpoint**

    - **Remove Breakpoint**

9. (Optional) To enable or disable all breakpoints, select either **Enable All Breakpoints** or **Disable All Breakpoints**.
10. (Optional) To remove all breakpoints, right-click within the Breakpoints table and select **Remove All Breakpoints**.
11. Click **Trace Off** to run Event Stream Processor.

4.4.10.2.2 Watch Variables

Insert watch variables into the watch table of the Breakpoints view in the Debugger to inspect data as it flows through the project.

A watch corresponds to:

- Current input of a stream
- Current output of a stream
- Queue of a stream
- Transaction input of a stream
- Transaction output of a stream
- Output history of a stream
- Input history of a stream

Add the watches you want to monitor to the watch table before running Event Stream Processor. When Event Stream Processor runs, the watch table is updated dynamically as run-control events (run, step, pause) are sent through Event Stream Processor.

In this section:

Parent topic: Debugging with Breakpoints and Watch Variables [page 131]

Related Information

Breakpoints [page 132]
Pausing SAP Event Stream Processor [page 135]
Stepping Through a Project in Studio [page 136]

4.4.10.2.2.1 Adding Watch Variables

Add a watch element to a breakpoint.

Prerequisites

- The Debugger view of the SAP ESP Run-Test perspective in Studio is open.
- Trace mode is enabled.

Procedure

1. Click **Trace On**.
2. Right-click in the Watch table.
3. Select **Add Watch**.
4. Select a stream from the Watch Choices box.
5. Select the type of watch you want to set up on that stream.
6. Click **Add**.
   The watch appears in the table at the bottom of the dialog box.
7. Click **OK**.
   The watch appears in the Watch table in the Debugger view.
8. To remove watches, right-click within the Watch table and select, either:
   - **Remove Watch** to remove a single select watch variable, or,
   - **Remove All Watches** to remove all watch variables.

4.4.10.2.3 Pausing SAP Event Stream Processor

Pause SAP Event Stream Processor while playing back projects with `.rec` file types.

Prerequisites

- The Debugger view of the SAP ESP Run-Test perspective is open.
- Trace mode is enabled.

Procedure

1. In the Debugger, click **Pause Project** (⏸).
2. To resume Event Stream Processor, click **Resume Project,** or click **Trace Off** to close the debugger.

Task overview: Debugging with Breakpoints and Watch Variables [page 131]

Related Information

Breakpoints [page 132]
Watch Variables [page 134]
Stepping Through a Project in Studio [page 136]

4.4.10.2.4 Stepping Through a Project in Studio

Single-step through a project in SAP Event Stream Processor.

Prerequisites

- The Debugger view of the SAP ESP Run-Test perspective is open.
- The project is paused.

Procedure

1. In the Debugger view, click **Step Project** (⤵) to perform the next step in the project.
2. Click **Cancel Current Step** to terminate the action.

Task overview: Debugging with Breakpoints and Watch Variables [page 131]

Related Information

Breakpoints [page 132]
Watch Variables [page 134]

Pausing SAP Event Stream Processor [page 135]

5 Beyond the Basics

Use advanced CCL techniques, such as declare blocks, modules, and Flex operators, to develop sophisticated and complex projects.

In this section:

You can set an aging policy to flag records that have not been updated within a defined interval. This is useful for detecting records that may be stale.

Using Bindings to Connect CCL Projects [page 199]
Create bindings between projects to let data flow between them.

5.1 Keyed Streams

Keyed streams save resources by letting you pass insert, update, and delete events through a project without storing the events in memory. Keyed streams also let your project perform certain relational operations, including joins, computes, and filters, without storing the data in memory.

To create a keyed stream, define a primary key for a stream. Inserts, updates, and deletes are assumed to be related to this primary key.

Like other streams, keyed streams can be either input or derived.

A keyed stream:

- Supports a primary key but does not ensure that it is unique.
- Rejects events that have a null primary key value.
- Propagates insert, update, and delete opcodes as is, without modifying or validating them. Ensure that you validate these inserts, updates, and deletes elsewhere in the project.
- Does not detect duplicate inserts, bad updates, or bad deletes.
- Rejects events with upsert or safedelete opcodes.
- Treats all events as inserts for processing purposes, though they may contain different opcodes.

Supported Operations and Features

When a keyed stream is the target for the result of the operation, it supports:

- Inputs
- Computes
- Unions
- Pattern Matching
- Filters (see Filters [page 140] for details)
- Simple joins (see Joins [page 141] for details)
- Flex operations (see Inputs and Outputs [page 140] for details)

Keyed streams support guaranteed delivery.

Unsupported Operations and Features

When the keyed stream is the target for the result of the operation, it does not support:

- Aggregations.
- Joins in which the only inputs are windows. You can get around this by performing a window-window join first, then feeding the results into a keyed stream.

Keyed streams reject:

- Upserts
- Safedeletes
- Any record with a primary key column that has a null value

For additional restrictions, see Inputs and Outputs [page 140], Joins [page 141], and Filters [page 140].

Inputs and Outputs

Keyed streams can send to and receive from other streams (including other keyed streams), Flex operators, and windows. They can serve as inputs to relational operations like joins, aggregations, and computes, or as outputs to relational operations.

Exceptions and considerations:

- A keyed stream cannot feed a window. Add a KEEP clause to the keyed stream to turn it into an unnamed window, which allows it to use memory and retain its state.
    - If you use a KEEP ALL clause, the unnamed window validates inserts, updates, and deletes.
    - If you use a KEEP clause with any other retention policy, the unnamed window treats updates as upserts and deletes as safedeletes. The unnamed window traps duplicate inserts unless the retention policy has allowed the original insert to be purged.
- When a stream feeds a keyed stream, the keyed stream produces inserts. When a keyed stream feeds a keyless stream, the stream follows its semantics of converting updates to inserts and silently dropping deletes.
- When a window feeds a keyed stream, the keyed stream outputs the inserts, updates, and deletes it receives with no changes.
- When a keyed stream feeds a Flex operator, the CCLScript code does not have access to the old record in the case of an update. The old record is always null.
- When a Flex operator feeds a keyed stream, the CCLScript code can generate only insert, update, and delete opcodes. Upsert and safedelete opcodes are not allowed.
- When a keyed stream feeds an event cache, the coalesce option is limited to the case when the records are coalesced on the key field.

Filters

When you use a WHERE clause, filter on columns that have values that do not change between an insert event and subsequent update and delete events. If the columns change, related events can be lost; for example, downstream elements might receive update or delete events without the insert that provided the data being updated or deleted, or fail to receive a delete for a previous insert.

In this example, we create two very similar elements, a keyed stream named `KS1`, and a window named `W1`:

```
CREATE OUTPUT STREAM KS1 PRIMARY KEY (Key1) AS SELECT In1.Key1,
In.Val1, In1.Val2 FROM In1 WHERE In1.Val1 > 10;
CREATE OUTPUT WINDOW W1 PRIMARY KEY (Key1) AS SELECT In1.Key1,
In.Val1, In1.Val2 FROM In1 WHERE In1.Val1 > 10;
```

Suppose `In1` sends this data:

```
<In1 ESP_OPS="I" Key1="1" Val1="5" Val2="abcd"/>
<In1 ESP_OPS="u" Key1="1" Val1="15" Val2="abcd"/>
<In1 ESP_OPS="d" Key1="1" Val1="6" Val2="abcd"/>
```

Keyed stream `KS1` and window `W1` produce different output:

```
<KS1 ESP_OPS="u" Key1="1" Val1="15" Val2="abcd"/>
<W1 ESP_OPS="i" Key1="1" Val1="15" Val2="abcd"/>
<W1 ESP_OPS="d" Key1="1" Val1="15" Val2="abcd"/>
```

Rather than filtering on `Val1`, which changes, filter on `Val2`, which does not. This approach provides more predictable results.

Joins

When a keyed stream is the target of an inner join, ensure that the columns on which the join is performed do not change across an insert event and related update and delete events that follow. If the columns change, related events can be lost; the keyed stream may send update or delete events without the insert that provided the data being updated or deleted, or fail to send a delete for a previous insert.

Keyed streams are stateless except when performing a join with a window. In this type of join, the keyed stream uses memory to store a reference to the records in the window.

Restrictions on joins:

- A keyed stream can only be an outer member of an outer join (inner joins are supported).
- A keyed stream may not participate in a full join.
- When you join a keyed stream with a window, only events that arrive in the keyed stream trigger a join; changes to the window do not.
- A keyed stream cannot be the target of a join when all inputs to the join are windows (named or unnamed).

5.2 Implicit Columns

All streams, windows, and keyed streams use three implicit columns called ROWID, ROWTIME, and BIGROWTIME.

Column	Datatype	Description
ROWID	long	Provides a unique row identification number for each row of incoming data.
ROWTIME	seconddate	Provides the last modification time as a date with second precision.

Column	Datatype	Description
BIGROWTIME	bigdatetime	Provides the last modification time of the row with microsecond precision. You can perform filters and selections based on these columns, like filtering out all of those data rows that occur outside of business hours.

You can refer to these implicit columns just like any explicit column (for example, using the `stream.column` convention).

5.3 Adding a Binding to a Project

Add a binding into your project using the visual editor in the SAP ESP Authoring perspective. This functionality is not supported in streaming lite.

Prerequisites

The two projects that you wish to bind together are ready for editing.

Context

There are three ways to add a binding to your project.

> i Note
>
> This functionality is not supported in streaming lite.

Add a binding by dragging a stream or window from the project explorer

Procedure

1. Open the project to which you want to add a binding in the visual editor.
2. In your project explorer, expand the folder of the second project to bind to the first project.
3. Click the output stream or window to bind to the first project, and drag-and-drop it into the first project's diagram.
    - A new input stream or window is automatically created and added to the diagram of the first project. The new stream or window is named using the format `<First-Project-Name>_<Stream-Or-`

`Window-Name>` and has an inline schema that is identical to the schema of the stream/window from the second project.
    - An icon appears to the left side of the stream or window that contains the binding, signifying either an input ▶ or an output ◀ binding.
    - A new tab for the Project Configuration editor opens within the visual editor.
    - A new binding is created and automatically added to the Project Configuration (ccr) file, which contains values for the **Binding name**, **Local stream/window name**, **Remote stream**, **Workspace**, and **Project** properties.
4. Use the Project Configuration editor to specify a value for the **Cluster** property, and optionally, values for other properties.
5. Save your changes to the project, as well as the project configuration file.

Add a binding from a stream or window shape within a diagram

Procedure

1. Open the project to which you want to add a binding in the visual editor.
2. In the project diagram, click the binding icon 🔗 in the stream/window shape to bind to another stream or window.
   A new **Select Binding Target** window opens.
3. Select the stream/window to bind to the first stream or window, and click **OK**.
    - A new tab for the Project Configuration editor opens within the visual editor.
    - An icon appears to the left side of the stream or window that contains the binding, signifying either an input ▶ or an output ◀ binding.
    - A new binding is created and automatically added to the Project Configuration (ccr) file, which contains values for the **Binding name**, **Local stream/window name**, **Remote stream**, **Workspace**, and **Project** properties.
4. Use the Project Configuration editor to specify a value for the **Cluster** property, and optionally, values for other properties.
5. Save your changes to the project, as well as the project configuration file.

Add a binding by clicking within a diagram

Procedure

1. Open the project to which you want to add the binding in the visual editor.
2. Right-click any blank space in the diagram, and select **Add** > **Binding (in CCR)**.
   A new **Binding (in CCR)** window opens.

3. Select a stream or window for the **Local stream/window** field and a remote stream or window for the **Remote stream** field.
4. Click **OK**.
    - A new tab for the Project Configuration editor opens within the visual editor.
    - An icon appears to the left side of the stream or window that contains the binding, signifying either an input ▶ or an output ◀ binding.
    - A new binding is created and automatically added to the Project Configuration (ccr) file, which contains values for the **Binding name**, **Local stream/window name**, **Remote stream**, **Workspace**, and **Project** properties.
5. Use the Project Configuration editor to specify a value for the **Cluster** property, and optionally, values for other properties.
6. Save your changes to the project, as well as the project configuration file.

5.4 Splitting Inputs into Multiple Outputs

The splitter construct is a multi-way filter that sends data to different target streams depending on the filter condition. It works similar to the ANSI 'case' statement.

Context

You can create a splitter to provide an operator that can split an input into multiple outputs.

Procedure

1. Open the SAP ESP Authoring perspective.
2. In the visual editor palette, under **Streams and Windows**, select **Splitter**.
3. Select a location in the diagram and click to add the shape.
4. To set the name of the splitter, either:
    - Click to edit the shape name, or, press **F2**.
    - In verbose mode, click the **Edit** icon next to the name.
5. (Optional) Click to make it an output (instead of local) if you want the splitter outputs to be visible via subscription in the runtime model.
6. Connect the splitter to a single input stream or a window.
7. (Optional) Add or remove `Column Expressions` for the splitter.
8. Create the splitter logic using `Add When` and `Add Else`. This creates the splitter output elements.
9. (Optional) Connect the splitter output elements of the splitter to other streams or windows.

5.5 Declare Blocks

Declare blocks enable you to include elements of functional programming, such as variables, parameters, typedefs, and function definitions in CCL data models.

CCL supports global and local declare blocks.

Global declare blocks
: Available to an entire project; however, you can also set individual global declare blocks for each module.

> i Note
>
> Global declare blocks are merged together if more are imported from other CCL files. Only one is allowed per project.

Local declare blocks
: Declared in CREATE statements, are available only in the SELECT clause of the stream or window in which they are declared.

> i Note
>
> The variables and functions defined in a local declare block are only available in the SELECT clause and anywhere inside the Flex operator.

CCL variables allow for the storage of values that may change during the execution of the model. Variables are defined in the declare block using the CCLScript syntax.

CCL typedefs are user-defined datatypes and can also be used to create an alias for a standard datatype. Use typedef to shorten long type names. Once a typedef has been defined in the declare block, use it instead of the datatype in all CCLScript statements, and throughout the project.

CCL parameters are constants for which you can set the value at the model's runtime. Use these parameters instead of literal values in a project to allow behavior changes at runtime, such as window retention policies, store sizes, and other similar changes that can be easily modified at runtime without changing the project. Define CCL parameters in a global declare block, and initialize them in a project configuration file. You can also set a default value for the parameter in its declaration, so that initialization at server start-up is optional.

You can create CCLScript functions in a declare block to allow for operations that are more easily handled using a procedural approach. Call these CCLScript functions from stream queries and other functions throughout the project.

5.5.1 Typedefs

Use typedefs to declare new names for existing datatypes.

Syntax

```
typedef existingdatatypeName newdatatypeName;
```

Components

Component	Description
`existingdatatypeName`	The original datatype.
`newdatatypeName`	The new name for the datatype.

Usage

Typedefs allow you to give new names for existing datatypes, which you can use to define new variables and parameters, and specify the return type of functions. Declare typedefs in declare blocks, UDFs and inside Flex procedures. The types declared in typedefs must resolve to simple types.

> i Note
>
> For unsupported datatypes, use a typedef in a declare block to create an alias for a supported datatype.

Example

This example declares euros to be another name for the money(2) datatype:

```
typedef money(2) euros;
```

Once you have defined the euro typedef, use:

```
euros price := 10.80d2;
```

The example is the same as:

```
money(2) price := 10.80d2;
```

5.5.2 Parameters

Parameters are constants that you set during project setup using the server-command name or the project configuration file.

Syntax

```
parameter typeName parameterName1 [:= constant_expression]
[,parameterName2 [:= constant_expression],…];
```

Components

Component	Description
`typeName`	The datatype of the declared parameter.
`parameterName`	The name of the declared parameter.
`constant_expression`	An expression that evaluates to a constant.

Usage

Parameters are defined using the qualifier `parameter`. Optionally, you can specify a default value. The default value is used only if no value is provided for the parameter at server start-up.

Parameters can use only basic datatypes, and are declared in the global DECLARE block of a project or a module. Parameters cannot be declared with complex datatypes. Since parameters are constant, their value cannot be changed in the model.

Parameters at Project Setup

You can define parameters inside the global declare block for both a project and a module. Project-level parameters can be bound on server start-up, while module-level parameters are bound when the module is loaded.

You can assign values to parameters at server start-up time on the command line used to start the server or through the project configuration file. Provide values for any project parameters that do not have a default value. Parameters can only be bound to a new value when a module or project is loaded.

Specify a default value in the parameter declaration. The default value is used for the parameter if it is not bound to a new value when the project or module is loaded. If a parameter does not have a default value, it is bound when the module or project is loaded, or an error occurs.

When a parameter is initialized with an expression, that expression is evaluated only at compile time. The parameter is then assigned the result as its default value.

When supplying values at runtime for a parameter declared as an interval datatype, interval values are specified with the unit notation in CCL and with a bare microsecond value in the project configuration file. See the *SAP Event Stream Processor: Configuration and Administration Guide* for more information on project configurations and parameters in the project configuration file.

5.5.3 Variables

Variables represent a specific piece of information that may change throughout project execution. Variables are declared using the CCLScript syntax.

Syntax

```
typeName {variableName[:=any_expression] [, ...]}
```

Usage

Variables may be declared within any declare block, CCLScript UDFs, or Flex procedures. Multiple variables may be declared on a single line.

The declaration of a variable can also include an optional initial value, which must be a constant expression. Variables without an initial value initialize to NULL.

Variables can be of complex types. However, complex variables can only be used in local declare blocks and declare blocks within a Flex stream.

Variables declared in a local declare block may subsequently be used in SELECT clauses, but cause compiler errors when used in WHERE clauses.

Example

This example defines a variable, then uses the variable in both a regular stream and a Flex stream.

```
declare
 INTEGER ThresholdValue := 1000;
end;
//
// Create Schemas
Create Schema TradeSchema(
    Ts bigdatetime,
    Symbol STRING,
    Price MONEY(4),
    Volume INTEGER
);
Create Schema ControlSchema (
    Msg STRING,
    Value   INTEGER
); //
// Input  Trade Window
//
CREATE  INPUT  WINDOW TradeWindow
  SCHEMA TradeSchema
  PRIMARY KEY (Ts);
//
// Input Stream for Control Messages
```

```
//
CREATE INPUT STREAM ControlMsg SCHEMA ControlSchema ;
//
// Output window, only has rows that were greater than the thresholdvalue
// was when the row was received
CREATE  Output  WINDOW OutTradeWindow
    SCHEMA (Ts bigdatetime, Symbol STRING, Price MONEY(4), Volume INTEGER)
    PRIMARY KEY (Ts)
as
select *
    from TradeWindow
    where TradeWindow.Volume > ThresholdValue;
//
//Flex Stream to process the control message
CREATE FLEX FlexControlStream
  IN ControlMsg
  OUT OUTPUT WINDOW SimpleOutput
  SCHEMA ( a integer, b string, c integer)
     PRIMARY KEY ( a)
BEGIN
    ON ControlMsg
    {
        // change the value of ThresholdValue
        if ( ControlMsg.Msg = 'set')  {ThresholdValue:=ControlMsg.Value;}
        // The following is being populate so you can see that the
ThresholdValue is being set
        output [a=ControlMsg.Value; b=ControlMsg.Msg; c=ThresholdValue; |];
    }
    ;
END;
```

5.5.4 Declaring Project Variables, Parameters, Datatypes, and Functions

Declare variables, parameters, typedefs, and functions in both global and local DECLARE blocks.

Procedure

1. Declare a parameter using the SAP ESP Authoring perspective visual editor:
    a. In the Outline view, right-click Statements or one of its child folders (those directly below it) and select **Modify** > **Edit Global Declaration(s)**.
    b. In the Edit Expression Value pop-up window, enter the new parameter. To see a list of datatypes, press **Ctrl+Space**.
    The new parameter is visible under Statements > Globals > DeclareGlobalBlock.

    > **i Note**
    >
    > You can double-click on either DeclareGlobalBlock or the current parameter listed to launch the Edit Expression Value pop-up window.

2. To declare parameters, variables, or user-defined CCLScript functions using CCL:
    a. Create a global declare block for your project by using the DECLARE statement in your main project file.

b. Add parameters, variables, or user-defined CCLScript functions to the global declare block.

   Elements defined in this declare block are available to any elements in the project that are not inside a module.

c. Create local declare blocks by using the DECLARE statement within derived streams, windows, or both.

d. Add variables, parameters, or user-defined CCLScript functions to the local declare block.

   These elements are available only from within the stream, window, or Flex operator in which the block is defined.

5.6 Flex Operators

Flex operators provide extensibility to CCL, allowing custom event handlers, written in CCLScript, to produce derived streams or windows.

A Flex operator produces derived streams, windows, or keyed streams in the same way that a CREATE statement produces these elements. However, a CREATE statement uses a CCL query to derive a new window from the inputs, whereas a Flex operator uses a CCLScript script.

Flex operators make CCL extensible, allowing you to implement event processing logic that would be difficult to implement in a declarative SELECT statement. CCLScript gives you process control and provides data structures that can retain state from one event to the next.

All of the features of CCLScript are available for use in a Flex operator, including:

- Data structures
  - Variables
  - EventCache (windows)
  - Dictionaries
  - Vectors
- Control structures
  - While
  - If
  - For

A Flex operator can take any number of inputs, and they can be any mix of streams, keyed streams, or windows. You can write a CCLScript event handler for each input. When an event arrives on that input, the associated CCLScript script or method is invoked.

You do not need a method for every input. Some inputs may merely provide data for use in methods associated with other inputs; for inputs without an associated method, incoming events do not trigger an action, but are available to other methods in the same Flex operator.

Use multiple output statements to process an event; the outputs are collected as a transaction block. Similarly, if a Flex operator receives a transaction block, the entire transaction block is processed and all output is collected into another transaction block. This means that downstream streams, and the record data stored within the stream, are not changed until the entire event (single event or transaction block) is processed.

In this section:

Creating a Flex Operator in the Visual Editor [page 151]
  Create a Flex operator to add an event handler written in CCLScript to the project.

Flex Logging [page 152]
  (Windows only) Flex provides logging functions to trace program activity and log errors.

5.6.1 Creating a Flex Operator in the Visual Editor

Create a Flex operator to add an event handler written in CCLScript to the project.

Procedure

1. Open the SAP ESP Authoring perspective.
2. In the visual editor palette, in **Streams and Windows** , select **Flex** ().
3. Click anywhere in the diagram to place the Flex operator.
4. To set the name of the Flex operator, choose one of the following:
   - Click and press **F2** to edit the operator name.
   - In verbose mode, click the edit icon next to the name.
5. Connect the Flex shape to the appropriate input streams or windows.

   > **i Note**
   >
   > When you connect a stream or window to a Flex operator, the source is added as an input to the Flex shape by default, and an On Input method is created from the source stream or window.

6. Click **Add Columns** to define the schema of the events produced by the Flex operator, or set the schema to a named schema in the Properties View.
7. For each input to the Flex operator, the visual editor automatically adds a null input method. To add input methods without first connecting the Flex shape to an input, use the **Add On Input Method** in the shape toolbar.

   Each method is a CCLScript script that is invoked when an event arrives on the associated input. In other words, these are event handlers.
   a. To edit the CCLScript script for each method, select the Flex shape and press **F6** to switch to the text editor.
      The text editor opens with the cursor at the CREATE FLEX statement.
   b. Edit the CCLScript script.
   c. Press **F6** to switch back to the visual editor.
8. (Optional) Add an aging policy.
9. (Optional) Click **Set Output Keep Policy** and set keep policy options.

5.6.2 Flex Logging

(Windows only) Flex provides logging functions to trace program activity and log errors.

Functions

Logging from within the Flex operator is performed with functions `log_<severity>` (`<strings>`) and `log_<severity>_cat` (`<category>`, `<strings>`).

The following is a complete list of logging function names, listed by severity level, from high severity to low:

```
log_emergency                   log_emergency_cat
log_alert                       log_alert_cat
log_critical                    log_critical_cat
log_error                       log_error_cat
log_warning                     log_warning_cat
log_notice                      log_notice_cat
log_info                        log_info_cat
log_debug                       log_debug_cat
log_trace                       log_trace_cat
```

The argument `<strings>` in `log_<severity>` and `log_<severity>_cat` functions is a list of one or more strings that are concatenated to produce a log message. Non-string variables and expressions can be converted to a string with the Flex function `to_string(...)`. For example:

```
log_info('Received event seq. ',to_string(seqno),' A=',to_string(my.A));
```

Each location within a Flex operator code has a logging category assigned based on the syntactic context of the location.

The category identifier has two roles:

- A record in a Flex log file identifies the category that produced the record, and indicates the source of the logging record.
- Category identifiers are assigned logging threshold levels that control logging activity and exclude undesired logging. For example, if the logging threshold level for a category is set to `error`, then an attempt to log with lesser severities, such as `warning`, is ignored.

Whenever a `log_<xxx>` or `log_<xxx>_cat` call is made, Flex determines the logging category and establishes a list of enveloping contexts' categories based on the call's syntactic scope. The context depends on whether the call occurs inside the Flex operator or not, and inside a module or not. Each context is assigned a category identifier, which can also be associated with a logging threshold setting. This assignment is automatic and is performed by the compiler.

If a logging level is unassigned for the context's category, logging functions attempt to search enveloping contexts, in nesting order towards the outer scope, until a category with an assigned logging level is found. The logging level is then used to determine if the function produces a log record or is treated as a no-op. If no assigned logging level is found in the current context's category or in the enveloping contexts, then a global setting is applied. The global logging category is a blank string.

For logging calls located inside a Flex operator but outside of a module, the logging category name starts with a period to distinguish global locations from module locations.

The function `log_<severity>_cat` takes an extra `<string>` argument to identify a subcategory relative to the current context. This allows you to create custom subcategories for more fine-grained logging control or logging source identification. For example, if a logging category for a given Flex code location is `X`, and the subcategory argument to `log_<severity>_cat` is `Y`, then the logging category used by `log_<severity>_cat` is `X.Y`, whereas a `log_<severity>` function placed at the same location uses `X` as the context.

> **i Note**
>
> An exception to the use of a period in the global category name is if `log_<severity>_cat` is executed at the global scope. In this case, `log_<severity>_cat` does not use a period before a subcategory argument.

Logging Levels

The following table lists the admissible logging level settings:

0	emergency
1	alert
2	critical
3	error
4	warning
5	notice
6	info
7	debug
8	trace
	unset
	off

Logging level settings are case-insensitive, and you can specify either a numeric or textual value.

A logging level set to **`off`** disables logging for the designated category regardless of the severity of the logging request.

An **`unset`** logging level causes the logging level value to be inherited from the enclosing context. Logging functions search from the innermost context towards the global context until a category with a set value is found. If all intermediate contexts are **`unset`**, then the global context's category logging level is applied. A blank string logging level value is identical to **`unset`**.

If the global logging level is specified using more than one option, there is an order of precedence:

1. The value of `flex-logging-level`
2. The value of `debug-level`
3. The global logging category setting in the CCR file

If `flex-logging-level` is not set, it defaults to the value of `debug-level`.

> **Note**
>
> `flex-logging-level` allows logging level values 0 to 8, but `debug-level` takes only values 0 to 7. The values for level 8 and **`off`** cannot be inherited by the Flex global logging level from `debug-level`, so values 8 and **`off`** must be assigned through the `flex-logging-level` command line option or the CCR file.

Location

The Flex log file name is `flex.log` in the project working directory.

Log files can be rolled over based on size. You can control rolling over with the options `flex-logfile-size` and `flex-logfile-depth`, which have an effect similar to what options `logfile-size` and `logfile-depth` have for master server log files. For more information, see *Project Log Files* in the *SAP Event Stream Processor: Configuration and Administration Guide*.

Example

The following example demonstrates the nesting order and naming of logging categories for a program using the Flex operator but not making use of modules. The comment above each argument explains the scope traversal of the category.

> **Note**
>
> The name for the global category is actually an empty string, not "{global}".

```
DECLARE
    integer myfunction1()
    {
        // {global}
        log_info('101', '102');
        // mycat0 → {global}
        log_info_cat('mycat0', '101', '102');
        return 0;
    }
END;
CREATE INPUT STREAM in_1 SCHEMA (a integer);
CREATE INPUT STREAM in_2 SCHEMA (a integer);
CREATE FLEX myflex
IN in_1, in_2
OUT OUTPUT STREAM myflex_out SCHEMA (a integer)
BEGIN
    DECLARE
        integer myfunction2()
        {
            // .myflex → {global}
            log_info('111', '112');
            // .myflex.mycat1 → .myflex → {global}
            log_info_cat('mycat1', '111', '112');
            return 0;
        }
    END;
    ON in_1
    {
        // .myflex → {global}
        log_info('121', '122');
        // .myflex.mycat2 → .myflex → {global}
        log_info_cat('mycat2', '121', '122');
    };
    ON in_2
    {
        // .myflex → {global}
        log_info('131', '132');
        // .myflex.mycat3 → .myflex → {global}
        log_info_cat('mycat3', '131', '132');
    };
    EVERY 5 SECONDS
    {
        // .myflex → {global}
        log_info('141', '142');
        // .myflex.mycat4 → .myflex → {global}
        log_info_cat('mycat4', '141', '142');
    };
END;
```

The default logging level setting for all categories except the global one is **`unset`**, causing the Flex operator to search in outer scopes. However, logging levels for categories can be assigned at project creation through the CCR file or at runtime using the Java API or `streamingprojectclient` command line utility. The following example is a possible CCR file for the above example:

```
<?xml version="1.0" encoding="UTF-8"?>
<Configuration xmlns="http://www.sybase.com/esp/project_config/2010/08/">
  <Runtime>
    <Logging>
        <Category name="" level="INFO" />
        <Category name="mycat0" level="TRACE" />
        <Category name=".myflex" level="TRACE" />
        <Category name=".myflex.mycat2" level="TRACE" />
   </Logging>
  </Runtime>
</Configuration>
```

When modules are used, the context depends on the module instance name (not module name) performing the function call. In the following example, the module name is `mymodule` and the instance names are `inst1` and `inst2`.

```
DECLARE
    integer myfunctiong1()
    {
        // {global}
        log_info('101', '102');
        // mycat0 → {global}
        log_info_cat('mycat0', '101', '102');
        return 0;
    }
END;
CREATE MODULE mymodule
IN in1
OUT out1
BEGIN
    DECLARE
        integer myfunction1()
        {
            // inst1 → {global}
            // inst2 → {global}
            log_info('111', '112');
            // inst1.mycat1 → inst1 → {global}
            // inst2.mycat1 → inst2 → {global}
            log_info_cat('mycat1', '111', '112');
            return 0;
        }
    END;
    CREATE INPUT STREAM in1 SCHEMA (a integer);
    CREATE FLEX myflex
    IN in1
    OUT OUTPUT STREAM out1 SCHEMA (a integer)
    BEGIN
        DECLARE
            integer myfunction2()
            {
                // inst1.myflex → inst1 → {global}
                // inst2.myflex → inst2 → {global}
                log_info('121', '122');
                // inst1.myflex.mycat2 → inst1.myflex → inst1 → {global}
                // inst2.myflex.mycat2 → inst2.myflex → inst1 → {global}
                log_info_cat('mycat2', '121', '122');
                return 0;
            }
        END;
        ON in1
        {
            // inst1.myflex → inst1 → {global}
            // inst2.myflex → inst2 → {global}
            log_info('121', '122');
            // inst1.myflex.mycat3 → inst1.myflex → inst1 → {global}
            // inst2.myflex.mycat3 → inst2.myflex → inst1 → {global}
            log_info_cat('mycat3', '131', '132');
        };
    END;
END;
CREATE INPUT STREAM inxs10 SCHEMA (a integer);
CREATE INPUT STREAM inxs20 SCHEMA (a integer);
LOAD MODULE mymodule AS inst1 IN in1 = inxs10 OUT out1 = outxs10;
LOAD MODULE mymodule AS inst2 IN in1 = inxs20 OUT out1 = outxs20;
```

The following CCR file sets logging levels for the example above:

```
<?xml version="1.0" encoding="UTF-8"?>
<Configuration xmlns="http://www.sybase.com/esp/project_config/2010/08/">
  <Runtime>
    <Logging>
        <Category name="" level="INFO" />
        <Category name="mycat0" level="TRACE" />
        <Category name="inst1" level="TRACE" />
        <Category name="inst2" level="TRACE" />
        <Category name="inst1.mycat1" level="TRACE" />
        <Category name="inst1.myflex" level="TRACE" />
        <Category name="inst1.myflex.mycat2" level="TRACE" />
        <Category name="inst1.myflex.mycat3" level="TRACE" />
        <Category name="inst1.myflex.mycat3" level="TRACE" />
   </Logging>
  </Runtime>
</Configuration>
```

Related Information

Flex Logging Functions
Project Log Files
Editing Deployment Options in Project Configuration

Using CCLScript in Flex Operators
CREATE FLEX Statement
streamingprojectclient

5.7 Automatic Partitioning

You can improve the performance of a given element and complex projects, which perform computationally expensive operations such as aggregation and joins, by using automatic partitioning. Automatic partitioning is the creation of parallel instances of a given element and partitioning input data into these instances. Partitioning data this way results in higher performance as the workload is split across the parallel instances.

Usage

You can create parallel instances of a keyed stream, stream, window, or module by using the PARTITION BY clause, or adding a partition policy through the Studio Visual editor. Add this clause within a CCL statement such as CREATE STREAM, CREATE WINDOW, or LOAD MODULE. Specify the partitioning degree, elements to be partitioned, and a partitioning function.

The partitioning degree is the natural number of parallel instances you wish to create for a given element (keyed stream, stream, window, or module). As an alternative to specifying the partitioning degree as a constant, you can specify it using an integer parameter with an optional default value. You can then provide the actual value for the parameter in the CCR project configuration file.

When using the PARTITION BY clause, partition at least one input stream of the corresponding element by specifying a partitioning function. In the case that an element accepts multiple input streams and some of these input streams do not have a partitioning function defined, those streams are broadcast to all parallel instances.

The partitioning function is effectively a demultiplexer which determines the target parallel instances for a given partitioning key. There are three valid types of partition functions: ROUNDROBIN, HASH, and CUSTOM. Choose a type based on the calculations you are performing on the input data. For example, ROUNDROBIN is sufficient for stateless operations like simple filters, but not for aggregation as this would produce differing results. HASH is necessary for grouping records together, but grouping may not evenly distribute the data across instances.

The CUSTOM partitioning function is defined as an inline function that does not take any parameters. This function creates an implicit global parameter called `<target-name>_partitions` where `<target-name>` represents the name of the current element you are partitioning. For example, if you are partitioning an output window called `maxPriceW`, use `maxPriceW_partitions` as the global parameter name. The value of this parameter is equal to the number of partitions.

```
CREATE INPUT STREAM priceW SCHEMA (isin string, price money(2));
CREATE OUTPUT WINDOW maxPriceW SCHEMA (isin string, maxPrice money(2))
PRIMARY KEY DEDUCED
KEEP 5 MINUTES
PARTITION by priceW
{
     integer hashValue := ascii(substr(priceW.isin,1,1));
     return hashValue % maxPriceW_partitions;
}
PARTITIONS 2
as
SELECT upper(left(priceW.isin,1)) isin, max(priceW.price) maxPrice
FROM priceW
GROUP BY upper(left(priceW.isin,1));
```

Do not explicitly provide a runtime value for this parameter. To ensure uniqueness, the compiler generates an error if you create a global variable by the same name.

The CUSTOM partitioning function returns an integer which determines the parallel instance that should receive a given event (row). A modulo operation applies to this result, which ensures that the returned instance number is greater than or equal to zero and is less than the number of available instances. This prevents runtime errors. For example, if you create three partitions, those partitions will have the IDs 0, 1, and 2.

Ordering of Partitioned Results

Note that for the same input data, the output of partitioned elements may differ from the output of a non-partitioned element. This is because:

- Operating systems schedule threads in a non-deterministic way, and
- Parallel execution of instances using multiple operating system threads introduces indeterminism, and
- To maximize the throughput of the partitioned element, no explicit synchronization between parallel instances takes place.

The stream partitions that are instantiated by the ESP server at runtime are local and cannot be subscribed or published to. However, these streams are visible in Studio so you can view their utilization and adjust the partition count accordingly.

Restrictions

You cannot apply the PARTITION BY clause to inputs, splitters, unions, reference streams, or adapters. Doing so results in a syntax error. However, you can partition these elements within a module that you are partitioning.

Example: Roundrobin Partitioning

The following example uses ROUNDROBIN partitioning on a CCL query with one input window (`TradeWindow`) to create two parallel instances of an output window (`TradeOutWindow`):

```
CREATE INPUT WINDOW TradeWindow
SCHEMA (
        Ts BIGDATETIME,
        Symbol STRING,
        Price MONEY(2),
        Volume INTEGER)
PRIMARY KEY (Ts);
```

```
CREATE OUTPUT WINDOW TradeOutWindow
SCHEMA (
        Ts BIGDATETIME,
        Symbol STRING,
        Price MONEY(2),
        Volume INTEGER)
PRIMARY KEY (Ts)
PARTITION
    by TradeWindow ROUNDROBIN
PARTITIONS 2
as
SELECT * FROM TradeWindow
WHERE TradeWindow.Volume > 10000;
```

Example: HASH Partitioning

The following example uses HASH partitioning on a CCL query with one input window (`priceW`) to create five parallel instances of an output window (`maxPriceW`):

```
CREATE INPUT STREAM priceW
SCHEMA (isin string, price money(2));
CREATE OUTPUT WINDOW maxPriceW
SCHEMA (isin string, maxPrice money(2))
PRIMARY KEY DEDUCED KEEP 5 MINUTES
PARTITION
    by priceW HASH(isin)
PARTITIONS 5
as
SELECT upper(left(priceW.isin,1)) isin, max(priceW.price) maxPrice FROM priceW
GROUP BY upper(left(priceW.isin,1));
```

The following example uses HASH partitioning on one of the input windows (`priceW`) on a join while the other input window (`volumeW`) is broadcast, creating two parallel instances of an output window (`vwapW`):

```
CREATE INPUT WINDOW priceW
SCHEMA (isin string, price float)
PRIMARY KEY (isin) KEEP 5 MINUTES;
CREATE INPUT WINDOW volumeW
SCHEMA (isin string, volume integer)
PRIMARY KEY (isin) KEEP 5 MINUTES;
CREATE OUTPUT WINDOW vwapW
PRIMARY KEY DEDUCED KEEP 1 MINUTE
PARTITION
    by priceW HASH (isin)
PARTITIONS 2
as
SELECT priceW.isin, vwap(priceW.price, volumeW.volume) vwap_val
FROM priceW LEFT JOIN volumeW ON priceW.isin = volumeW.isin
GROUP BY priceW.isin;
```

Example: CUSTOM Partitioning

The following example uses CUSTOM partitioning on a CCL query with two input windows (`priceW` and `volumeW`), creating two parallel instances of an output window (`vwapW`):

```
CREATE INPUT WINDOW priceW
SCHEMA (isin string, price float)
PRIMARY KEY (isin) KEEP 5 MINUTES;
CREATE INPUT WINDOW volumeW
SCHEMA (isin string, volume integer)
PRIMARY KEY (isin) KEEP 5 MINUTES;
CREATE OUTPUT WINDOW vwapW
SCHEMA (isin string, vwap float)
PRIMARY KEY DEDUCED
PARTITION
by priceW {
        return ascii(substr(priceW.isin,1,1)) % vwapW_partitions;
    },
by volumeW {
        return ascii(substr(volumeW.isin,1,1)) % vwapW_partitions;
    }
partitions 2
as
SELECT priceW.isin, vwap(priceW.price, volumeW.volume) vwap_val
FROM priceW LEFT JOIN volumeW ON priceW.isin = volumeW.isin
GROUP BY priceW.isin;
```

In this section:

5.7.1 Guidelines for Partitioning Flex Operators

General guidelines, tips, and examples of partitioning elements using Flex operators.

Local Variables

Each partition has its own locally declared variables. Therefore, a counter of all input records only counts records that arrive at a certain partition. If you wish to use a locally declared counter, it is recommended that you use it in line with the given partition key and that you verify the results of the partitioned element.

Globally Declared Variables

Globally declared variables can also be tricky. Multiple partitions in parallel can change a globally declared variable in parallel and race-conditions cannot be avoided. For example, if a window has a user-defined method which increases a global counter variable by 1 at the arrival of each record, once this window is partitioned, each parallel instance independently changes the counter at the arrival of a record. Since every instance runs in a separate thread, there is no way to determine the order in which instances update the counter. Therefore, two partitions trying to increment a globally declared counter can create inconsistencies so that increments get overwritten.

Multiple Inputs

You can partition Flex operators which have multiple inputs. In such cases, if you do not specify a partitioning function, one of the inputs is automatically broadcast to the partitioned Flex instances.

Transactions

Partitioning Flex operators has major implications for transactions. Transactions are automatically broken down into smaller subtransactions. If one of these subtransactions fails, the others do not automatically fail with it. This can change the transaction semantics and lead to inconsistent results.

The diagram below shows a non-partitioned scenario where the transaction consists of four records. The records are processed as one block by the Flex operator and an output transaction is produced that consists of these four records.

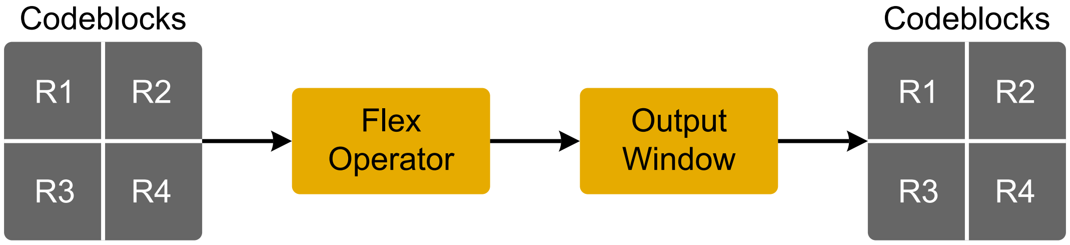


Figure 5: Flex Operator - No Partition

In a Flex operator, you can write code to start and end a transaction. In the partitioned case, these start and end codeblocks are called within each partition for each created subtransaction. If output events are created in the start and end transaction blocks, this can lead to problems such as key duplications, which can easily be created by partitioning. Since such duplications lead to rollbacks of transactions, whole subtransactions are rolled back.

In the non-partitioned case, there are no issues because only one event (start, start_trans) is created for each transaction. In the partitioned case, each partition creates one of these events which results in duplicate keys and one of the subtransactions is rolled back.

If you wish to partition a Flex operator, do not write records in the transaction start and end blocks.

```
CREATE FLEX w3
    IN w2_out
    OUT OUTPUT WINDOW w3_out
    SCHEMA s1
    Primary Key (c1) KEEP 10 ROW
//    PARTITION BY w2_out HASH(c1) PARTITIONS 2
BEGIN
    ON w2_out
    {
        output setOpcode([c1= w2_out;|  c2 = 'event';], upsert);
    };
    on start transaction {
       output setOpcode([c1=start;|  c2 = 'start_trans';], upsert);
        };
END;
```

Pulsed Output

You can use pulsed output (EVERY X SECONDS) in Flex operators to send events every X seconds instead of sending events with every new input record. The example of the partitioned case below shows how doing this can lead to problems. Each of the partitions sends events after 1 second. The partitions need to ensure that the events produced every second do not collide with each other and create duplicate key records.

```
CREATE FLEX w3
    IN w2_out
    OUT OUTPUT WINDOW w3_out
    SCHEMA s1
    Primary Key (c1) KEEP 10 ROW
//    PARTITION BY w2_out HASH(c1) PARTITIONS 2
BEGIN
    ON w2_out
    {
        //collect records
    };
    EVERY 1 SECONDS{
        //i.e. output averages per group
    }
END;
```

Here is an example scenario that uses partitioning:

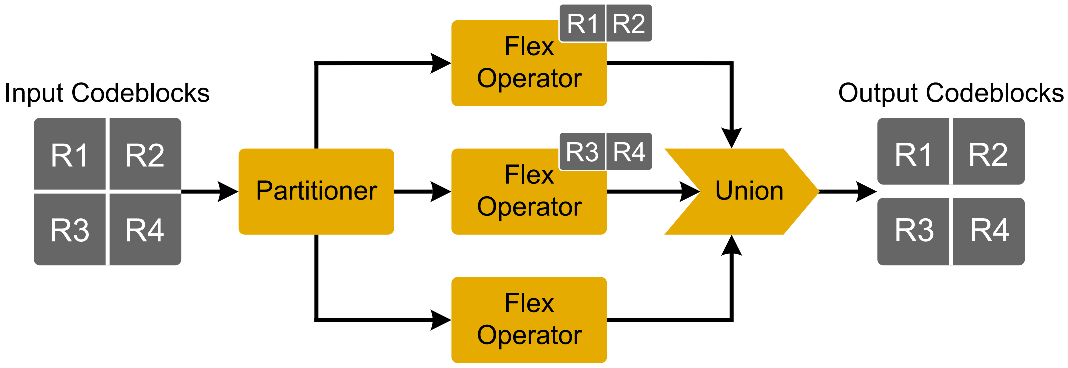


Figure 6: Flex Operator - Partitioned

```
Create Schema TradeSchema (
   Ts INTEGER,
   Symbol STRING);
Create Schema TradeTotal (
   Symbol STRING,
   Counter INTEGER);
CREATE  INPUT  WINDOW TradeWindow
    SCHEMA TradeSchema
    PRIMARY KEY (Ts) keep 5 minutes;

CREATE FLEX FlexStateManager IN TradeWindow
     OUT OUTPUT WINDOW FlexOutput
    SCHEMA TradeTotal
    Primary Key (Symbol) KEEP 10 ROW
    PARTITION
        BY TradeWindow HASH(Symbol)
    PARTITIONS 3
BEGIN
    declare
     integer mycounter:=0;
     dictionary(string, integer) counterMap;
     typeof(TradeWindow) my;
    end;
    ON TradeWindow
    {
        if(isnull(counterMap[TradeWindow.Symbol])){
              counterMap[TradeWindow.Symbol]:=1;
          }
          else{
              print('counter.. ',to_string(counterMap[TradeWindow.Symbol]));
              counterMap[TradeWindow.Symbol]:=counterMap[TradeWindow.Symbol]+1;
          }
    };
    EVERY 1 SECONDS{
        for (k in counterMap) {
              output setOpcode([ Symbol=k;| Counter=counterMap[k]], upsert);
          }
    };
END;
```

If the input events are inserts, for example, (0, SAP), (1, SAP), (1, SAP), (3, XY), (4, XY), (wait for 1 second), (5, XY), then the produced output would be (SAP, 3), (XY, 2), and after one second (SAP, 3) and (XY, 3). The dictionary in each partition stores local data that has been counted. Keep in mind that each partition is independent from each other.

Iterators

Normally, an iterator iterates over a complete input window. In the case of partitioning, the iterator is only able to iterate over the subset of events that are sent to a specific partition. Therefore, to create meaningful output in a partitioned case, ensure the use of iterators is in line with the defined partitioning key.

5.7.2 Guidelines for Partitioning CCLScript

General guidelines, tips, and examples of partitioning elements using CCLScript logic.

Local Variables

Each partition has its own locally declared variables. Therefore, a counter of all input records only counts records that arrive at a certain partition. If you wish to use a locally declared counter, it is recommended that you use it in line with the given partition key and that you verify the results of the partitioned element.

Globally Declared Variables

Globally declared variables can also be tricky. Multiple partitions in parallel can change a globally declared variable in parallel and race-conditions cannot be avoided. For example, if a window has a user-defined method which increases a global counter variable by 1 at the arrival of each record, once this window is partitioned, each parallel instance independently changes the counter at the arrival of a record. Since every instance runs in a separate thread, there is no way to determine the order in which instances update the counter. Therefore, two partitions trying to increment a globally declared counter can create inconsistencies so that increments get overwritten.

Event Caches, Dictionaries, Vectors, and Methods

When using complex data structures like event caches, dictionaries, and vectors, be aware that partitioning may change the semantics of your original usage and lead to unexpected results.

For example, if an event cache is not defined with a key, then its original intent is to keep all records for the given time period or the limit of the number of records. However, with partitioning, records in the original event cache are distributed to several parallel event caches. Therefore, if it was required to calculate a sum() over the original event cache, partitioning would generate sum() values for each parallel event cache and as a result, break the original semantics.

Both event caches and partitioning have a concept of key. For event caches, a key defines how records in an event cache are distributed across buckets. For partitioning, a key defines how incoming records are distributed over several parallel instances. Whenever the keys for the event cache and partitioning do not match and you partition an element (stream or window) with an event cache, this can change its original semantics of the partitioned element.

Even if the event cache key matches with the partitioning key, it may still generate unexpected results with partitioning when the event cache applies a row-based retention policy and the coalesce flag is not set (see Example 1). Without setting the coalesce flat, an event cache treats records for INSERT, UPDATE, and DELETE with the same key as distinct records. When the event cache is partitioned, the same KEEP policy is used in all parallel instances. As a result, there will be n*k (where n is the number of partitions and k is the number of rows kept by the event cache) records kept by all the parallel event caches, as opposed to k records in the case of no partitioning.

Example 1:

```
CREATE input stream priceW schema (ts msdate, isin string, price float);
CREATE output stream maxPriceW schema (ts msdate, isin string, price float)
declare
        eventCache(priceW[isin], 10 events) cache;
end
PARTITION
    by priceW HASH(isin)
PARTITIONS 2
as
SELECT priceW.ts, priceW.isin isin, avg(cache.price) price FROM priceW;
```

Additionally, user-defined methods or Flex elements can perform more complicated operations on an event cache. For example, you can use the keyCache() function to access any other cache bucket independent of your current key. Partition these elements carefully since this can also alter the intended semantics. In the example below, the `Symbol` and `Symbol2` attributes of `QTrades` are in the same domain. When the Flex `TradesFlex` element is hash partitioned by its input, `QTrades`, according to `Symbol`, it is possible that the bucket for `Symbol2` of a record to reside in a different parallel instance and therefore, the keyCache() statement would not be able to retrieve that bucket in the current partition.

Example 2:

```
CREATE FLEX TradesFlex
    IN QTrades
OUT OUTPUT WINDOW Top3Trades SCHEMA TradesSchema PRIMARY KEY(Symbol,Price)
PARTITION
    BY QTrades HASH (Symbol)
PARTITIONS 3
    BEGIN
        DECLARE
            eventCache(QTrades[Symbol], manual, Price asc) tradesCache;

        ON QTrades {
            keyCache( tradesCache, [Symbol=QTrades.Symbol2;|] );
            typeof(QTrades) rec := insertIntoCache( QTrades );
            if(rec.Id) {

                if(rec.Id <> QTrades.Id) {
                    output setOpcode(rec, delete);
                }
                output setOpcode(QTrades, upsert);
            }
        };
END;
```

Similar situation can happen for other complex data structure like dictionaries and vectors. In general, if you are writing any CCLScript logic for streams or windows that are partitioned, be aware that the logic functions only on a subset of the data and therefore, the partitioned results may be different from non partitioned streams or windows.

5.7.3 Guidelines for Partitioning Elements with Retention Policies

General guidelines, tips, and examples of partitioning elements which use retention policies.

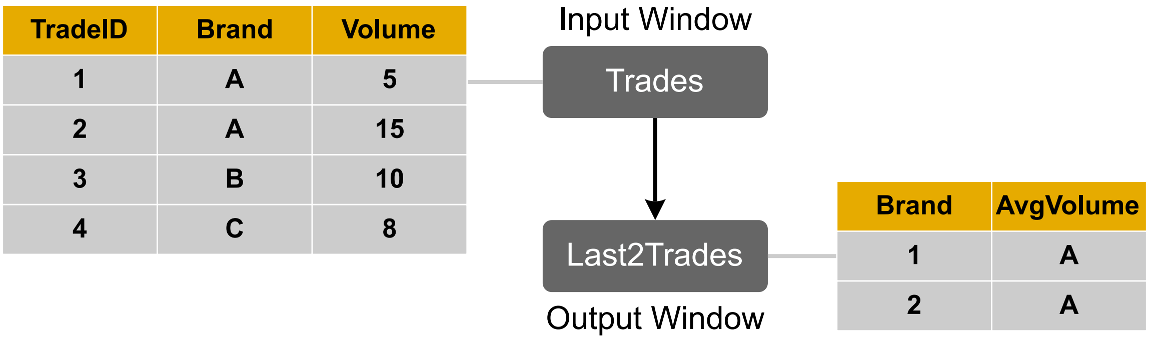
A retention policy specifies the maximum number of rows or the maximum amount of time that data is retained in a window. If you partition a window for which you have previously specified a retention policy, the window retains the policy.

An exception to this behavior is row-based retention because the state maintained by the ESP project is larger. For example, in a non-partitioned project, specifying a retention policy for N rows stores exactly N rows. However, if using stream partitioning and you create K number of partitions, each of these partitions stores N rows.

If you specified a retention policy for a union stream, which serves as a connection point for the other downstream elements, the policy of N rows is preserved. However, there are no guarantees as to which rows will be stored in the union because the policy stores different row sets based on the order in which the events arrive at the union.

Here is a non-partitioned scenario where the window stores the exact number of specified rows (2 rows in this example):

```
CREATE INPUT WINDOW Trades SCHEMA (TradeId long, Brand string, Volume integer)
PRIMARY KEY (TradeId);
CREATE OUTPUT WINDOW Last2Trades SCHEMA (Brand string, AvgVolume integer)
PRIMARY KEY DEDUCED
KEEP 2 ROWS
AS
SELECT T.Brand, avg(T.Volume) as AvgVolume FROM Trades as T GROUP BY (T.Brand);
```



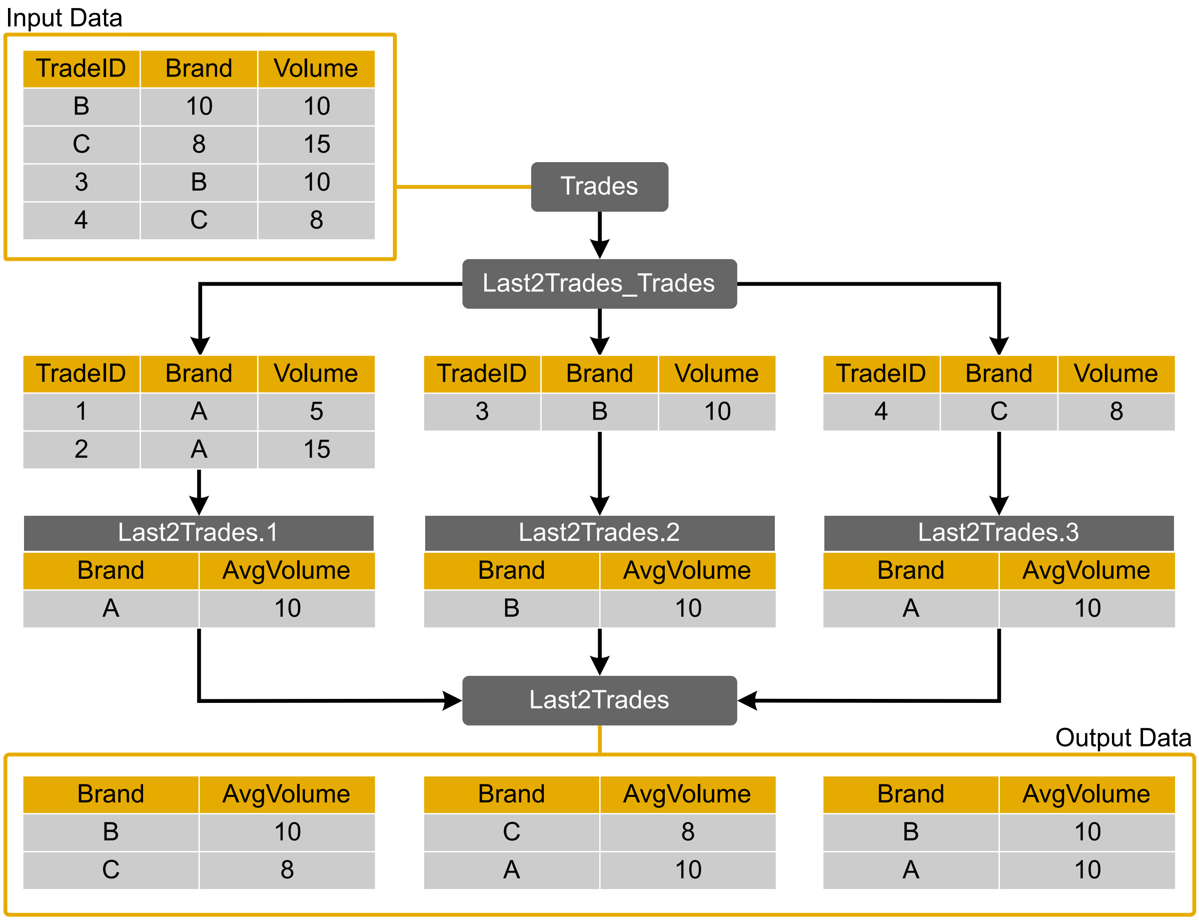
TradeID	Brand	Volume
1	A	5
2	A	15
3	B	10
4	C	8

Brand	AvgVolume
1	A
2	A

Figure 7: Retention Policy - No Partition

Once the output window is partitioned, each partition stores the specified number of rows (<partitionCount>*2 rows in this example). The union also carries an automatically derived retention policy of 2 rows which ensures that the same number of rows are exposed as in the non-partitioned case. However, partitions are not synchronized which may lead to different rows in the final output, and therefore skew results.

```
CREATE INPUT WINDOW Trades SCHEMA (TradeId long, Brand string, Volume integer)
PRIMARY KEY (TradeId);
CREATE OUTPUT WINDOW Last2Trades SCHEMA (Brand string, AvgVolume integer)
PRIMARY KEY DEDUCED
KEEP 2 ROWS
PARTITION
    BY HASH (Brand)
    PARTITIONS 3
AS
SELECT T.Brand, avg(T.Volume) as AvgVolume FROM Trades as T GROUP BY (T.Brand);
```



Input Data

TradeID	Brand	Volume
B	10	10
C	8	15
3	B	10
4	C	8

TradeID	Brand	Volume
1	A	5
2	A	15

TradeID	Brand	Volume
3	B	10

TradeID	Brand	Volume
4	C	8

Last2Trades.1

Brand	AvgVolume
A	10

Last2Trades.2

Brand	AvgVolume
B	10

Last2Trades.3

Brand	AvgVolume
A	10

Output Data

Brand	AvgVolume
B	10
C	8

Brand	AvgVolume
C	8
A	10

Brand	AvgVolume
B	10
A	10

Figure 8: Retention Policy - Partitioned

5.7.4 Guidelines for Partitioning Aggregation

General guidelines, tips, and examples of partitioning elements using aggregation.

When using HASH partitioning over any key aside from the GROUP BY key, the elements with the same value for the GROUP BY clause may not be located in the same partition and this may break the aggregation semantically.

The example below uses events that make up a part identifier for industrial parts. This identifier contains a part number and a group ID for the group to which a part belongs. For example, AA0001 is a part that belongs to the group AA (for example, engine) and has the part number 0001.

For example, to count all parts of a certain group, specify GROUP BY (left(T.PartId,2)). To ensure that the aggregation result is correct, you would have to send all the elements with the same group ID (as indicated by the two leftmost character of the PartId) to the same partition. However, this is not possible because you would have to specify PARTITION BY HASH (left(PartId,2)).

```
CREATE INPUT WINDOW Trades SCHEMA (TradeId long, PartId string, Volume integer)
PRIMARY KEY ( TradeId );
CREATE OUTPUT WINDOW TradeVolumePerGroup SCHEMA (PartGroup string, Volume
integer)
PRIMARY KEY DEDUCED
PARTITION
     BY HASH ( PartId )
     PARTITIONS 2
AS
SELECT left(T.PartId,2) as PartGroup, sum(T.Volume) as Volume FROM Trades as T
GROUP BY ( left(T.PartId,2) );
```

You can work around this limitation by introducing a new column through an intermediate stream which represents the GROUP BY KEY explicitly and can, therefore, be used as a HASH key.

```
CREATE INPUT WINDOW Trades SCHEMA (TradeId long, PartId string, Volume integer)
PRIMARY KEY ( TradeId );
CREATE OUTPUT WINDOW Trades1 SCHEMA (TradeId long, PartId string, PartGroup
string, Volume integer)
PRIMARY KEY ( TradeId )
AS
SELECT T.TradeId as TradeId, T.PartId as PartId, left(T.PartId,2) as PartGroup,
T.Volume as Volume FROM Trades as T;
CREATE OUTPUT WINDOW TradeVolumePerGroup SCHEMA (PartGroup string, Volume
integer)
PRIMARY KEY DEDUCED
PARTITION
     BY HASH ( PartGroup )
     PARTITIONS 2
AS
SELECT T.PartGroup as PartGroup, sum(T.Volume) as Volume FROM Trades1 as T GROUP
BY ( T.PartGroup );
```

5.7.5 Guidelines for Partitioning Modules

General guidelines, tips, and examples of partitioning modules.

You can partition an entire module when loading it (using the LOAD MODULE statement) by specifying which stream you wish to partition and the partitioning method. You can only partition a module by its input streams or windows. Mention them only once, even if they are mapped to multiple internal module streams or windows.

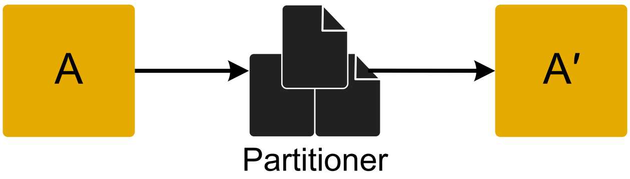


Figure 9: Module - Normal Case

A module can contain a partitioned stream or load other partitioned modules. However, be aware that the total amount of partitions that your ESP project has overall can quickly grow. Specifically, if you partition a module, all internal module partitions are partitioned again when loading the module. For example, if a module partitions a stream by 5 and the module is partitioned by 4, you would have 20 parallel instances of the stream that the module partitions.

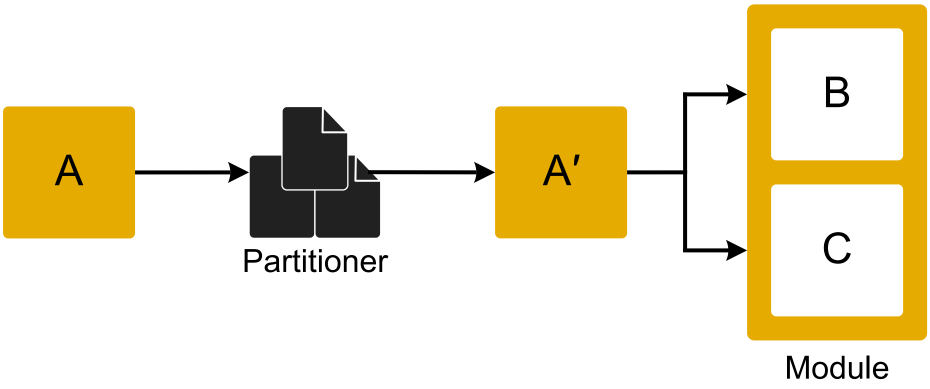


Figure 10: Module Case Partition - Correct

If you create too many partitions, the ESP server may not be able to start properly. It is recommended that the number of partitions within your ESP project stays below the number of processors on your machine.

It is not possible to partition a stream that has more than one downstream connection. As a result, ESP Server inserts a copy of the partitioned stream between the stream and the partitioner. This copy does the distribution to all the successor nodes. The ID of this copied node is suffixed by .clone.

The example below displays the principle of partitioning modules. You can find the complete and running example in `$STREAMING_HOME/examples/ccl/SubmodulesPartitioned`. Ensure you specify the PARTITION BY clause last in the LOAD MODULE clause.

```
import 'module1.ccl';
CREATE INPUT Window InStocks SCHEMA StocksSchema Primary Key (Ts)KEEP ALL;
LOAD MODULE Module1 AS Module1_instance_01
   IN rawStockFeed = InStocks
   OUT infoByStockSymbol = CompStocks2
   Parameters myparam = 1000
   STORES store1 = MyStore1
   PARTITION
BY InStocks HASH (Ts)
   PARTITIONS 3;
```

5.7.6 Guidelines for Partitioning Joins

General guidelines, tips, and examples of partitioning joins.

It is recommended that you partition joins using only HASH or CUSTOM partitioning methods as the ROUNDROBIN partitioning method typically produces inconsistent join results. You can specify a partitioning method for only a subset of the join inputs with data from the other join inputs being broadcast to all parallel join instances. For example, if a join element has three input windows but you only specify HASH partitioning for Input1, then the other two inputs (Input2 and Input3) are broadcast by default.

Choosing a Partitioning Key

When using the HASH partitioning method, it is recommended that you use a hash key for each join input that is a subset of the join key for this input. For example, for join window InputWindow1, the join conditions are InputWindow1.key1 and InputWindow1.key2. The join keys for InputWindow1 are InputWindow1.key1 and InputWindow1.key2, so it is recommended that you choose a hash key for InputWindow that is either InputWindow1.key1 or InputWindow1.key2. Using different logic can break the original join semantics and produce unexpected results.

Similarly, when using the CUSTOM partitioning method, design the partitioning logic so that it is in line with the join keys. For example, for the join window below, you can only specify a partition method on W1 or W2. For W1, meaningful hash keys are (Key1W1), (Key2W1), and (Key1W1, Key2W1). For W2, meaningful hash keys are (Key1W2), (Key2W2), and (Key1W2, Key2W2). If you use HASH partitioning for both W1 and W2, then meaningful hash key pairs are (Key1W1) - (Key1W2), (Key2W1) - (Key2W2), and (Key1W1, Key2W1) - (Key1W2, Key2W2).

```
CREATE INPUT WINDOW W1 SCHEMA (Key1W1 integer, Key2W1 string, Val1W1 integer,
Val2W1 string) PRIMARY KEY (Key1W1, Key2W1);
CREATE INPUT WINDOW W2 SCHEMA (Key1W2 integer, Key2W2 string, Val1W2 integer,
Val2W2 string) PRIMARY KEY (Key1W2, Key2W2);
CREATE OUTPUT WINDOW OW1
PRIMARY KEY (Key1W2, Key2W2)
AS SELECT W1.*, W2.*
FROM W1 INNER JOIN W2 ON W1.Key1W1 = W2.Key1W2 AND W1.Key2W1 = W2.Key2W2;
```

Effects of Partitioning on Outer Joins

Although partitioning is generally supported for all types of joins (inner, outer, left, right, and full), partitioning the outer side of an outer join may change the original join semantics and lead to different results than a nonpartitioned scenario.

Here is an example of a left outer join:

```
CREATE INPUT WINDOW W1 SCHEMA (KeyW1 integer, ValW1 integer) PRIMARY KEY (KeyW1);
CREATE INPUT WINDOW W2 SCHEMA (KeyW2 integer, ValW2 integer) PRIMARY KEY (KeyW2);
CREATE OUTPUT WINDOW OW1
PRIMARY KEY (KeyW1)
PARTITION
    BY W2 HASH (KeyW2)
PARTITIONS 2
AS SELECT W1.*, W2.*
FROM W1 OUTER JOIN W2 ON W1.KeyW1 = W2.KeyW2;
```

The input data of W1 is: `<W1 ESP_OPS="i" KeyW1=”1”, ValW1=”100”>`

The input data of W2 is: `<W2 ESP_OPS="i" KeyW2=”1”, ValW2=”200”>`

Given this input data for W1 and W2, the join result in a non-partitioned case would be `<W1 ESP_OPS="i" KeyW1=”1”, ValW1=”100”, KeyW2=”1”, ValW2=”200”>`.

However, because the default partitioning method for W1 is broadcast and W1 is the outer side of the given left outer join, record `<W1>` is sent to both instances of the join in the partitioned case. The join instance, which also receives the record from W2, then produces the result record `<OW1 ESP_OPS="i" KeyW1=”1”,`

`ValW1=”100”, KeyW2=”1”, ValW2=”200”>`. The other instance also produces the result record `<OW1 ESP_OPS="i" KeyW1=”1”, ValW1=”100”>`. Since `W1.KeyW1` is the primary key of the join window, depending on which of the two results arrive last at the final implicit union node, the record contained in the final join window can be either `<OW1 ESP_OPS="i" KeyW1=”1”, ValW1=”100”, KeyW2=”1”, ValW2=”200”>` or `<OW1 ESP_OPS="i" KeyW1=”1”, ValW1=”100”>`.

Similar scenarios can also occur for right and full joins.

5.7.7 Guidelines for Partitioning Elements on Log Stores

Guidelines for sizing a log store when partitioning elements that are within a log store.

The rules below assume that the log store is dedicated to a partitioned stream. For non-join cases, the rules are:

- When there is no retention specified, the sizing calculation is 2 * N where N is the size allocated for the stream in the non-partitioned case.
- When there is retention on the target, the sizing calculation is N * (K + 1) where N is the size allocated for the non-partitioned case and K is the number of partitions. This is because each partition honors the retention clause.

In the case of joins, also include the space required to store the input to the join in the log store. This means that the sizing calculation is N when you are partitioning the input, and N * K when you are broadcasting the input where N is the size required to store the input.

5.7.8 Creating a Partition in the Visual Editor

Partition an existing keyed stream, stream, window, or module in the visual editor.

Prerequisites

(Optional) To use a parameter to specify the number of partitions you wish to create, create a global parameter first.

Procedure

1. Click **Add Partition Policy** .
2. Select a partition policy.
3. In the Properties view, specify a value or parameter for the **Number of Partitions** to create. To use a parameter, either enter the parameter name or click **Select** and select the parameter from the list.

4. Select the new partition and edit its properties in the Properties view:

Partition Policy	Steps
ROUNDROBIN	1. Select a source for the partition.
HASH	1. Select a source for the partition. 2. Select the columns to use for the HASH function and click **Add**.

CUSTOM	1. Select a source for the partition.
	2. On the Expression tab, edit the partition function. To show syntax completion proposals, press **Ctrl+Space**.
	3. To ensure that the function returns a valid partition ID, apply a modulo operation in the return statement and use the implicit global parameter of the partition as its divisor. For example, for an output window called `maxPriceW`, use `maxPriceW_partitions` as the divisor:
	`BY priceW`
	`{`
	`     integer hashValue :=`
	`ascii(substr(priceW.isin,1,1));`
	`     return hashValue %`
	`maxPriceW_partitions;`
	`}`

5.8 Modularity

A module in SAP Event Stream Processor offers reusability; it can be loaded and used multiple times in a single project or in many projects.

Modularity organizes project elements into self-contained, reusable components, or modules, which have well-defined inputs and outputs, and allow you to encapsulate data processing procedures that are commonly repeated.

Modules, along with other objects such as import files and the main project, have their own scope, which defines the visibility range of variables or definitions. Any variables, objects, or definitions declared in a scope are available within that scope only; they are unavailable to the containing scope—called the parent scope—or to any other outer scope. The parent scope can be a module or the main project. For example, if module A loads module B and the main project loads module A, then module A's scope is the parent scope to module B. Module A's parent scope is the main project.

Modules have explicitly declared inputs and outputs. Inputs to the module are associated with streams or windows in the parent scope, and outputs of the module are exposed to the parent scope using identifiers. When a module is reused, any streams, variables, parameters, or other objects within the module replicate, so that each version of the module exists separately from the other versions.

You can load modules within other modules, so that module A can load module B, which can load module C, and so on. Module dependency loops are not valid. For example, if module A loads module B, which loads A, the CCL compiler generates an error indicating a dependency loop between modules A and B.

When you load a module, you can connect or bind its input streams or windows to streams in the project. The output of a module can be exposed to its parent scope and referenced in that scope using the aliases provided in the LOAD MODULE statement.

Parameters inside the module are bound to parameters in the parent scope or to constant expressions. Stores within the module are bound to stores in the parent scope. Binding a store within a module to a store outside the module means that any windows using the module store instead use the bound store.

> i Note
>
> All module-related compilation errors are fatal.

In this section:

Using a Module Within a Project [page 173]
Create an instance of a defined module within a project, and allow the inputs and outputs of the module to be bound to streams or windows in the project.

Creating a Module in the Visual Editor [page 174]
Add a new module to an existing project in the visual editor.

Editing a Module in the Visual Editor [page 175]
Edit basic module properties and module input, output, and import functions.

Creating a Reusable Module File [page 176]
Create a new, separate module file that can be imported into a project.

Importing Definitions from Another CCL File [page 176]
Import a module file to use the module in your project.

Configuring a Loaded Module [page 177]
Add or remove input and output bindings and parameter values (if any) for a specific module instance.

Configuring a Module Repository [page 178]
Create a folder in which to store modules, and configure the SAP Event Stream Processor Studio to use it.

Related Information

Sample Project with Modules [page 317]

5.8.1 Using a Module Within a Project

Create an instance of a defined module within a project, and allow the inputs and outputs of the module to be bound to streams or windows in the project.

Context

Existing modules, either created within the project or imported, can be used anywhere in a project. When you use (load) a module in a project, you attach the module inputs and outputs to streams or windows in the project by configuring bindings, and set any parameters used in the module.

Procedure

1. Open the SAP ESP Authoring perspective.
2. In the **Module** drawer of the visual editor palette, locate and select the module to add to the project.

   The palette lists any modules defined in the current project, either in the main CCL file or in any imported CCL files. If Studio does not find any CREATE MODULE statements, the palette drawer is empty.
3. Click anywhere in the diagram to place the loaded module.

5.8.2 Creating a Module in the Visual Editor

Add a new module to an existing project in the visual editor.

Context

Create modules directly in a project when you do not plan to reuse them widely across other projects.

Procedure

1. Open the SAP ESP Authoring perspective.
2. In the visual editor palette, in Shared Components, select **Module** ().
3. Select a location in the diagram and click to add the shape.

Next Steps

Open the module to edit it by clicking the **Open Module Diagram** in the toolbar of the module shape. This opens a new diagram where you can add input streams or windows, simple queries, and derived streams or windows. When finished, return to the diagram that has the CREATE MODULE shape, and configure the inputs and outputs, selecting from the elements defined in the module.

5.8.3 Editing a Module in the Visual Editor

Edit basic module properties and module input, output, and import functions.

Prerequisites

Create a module.

Context

Specific module inputs and outputs are determined by project developers. Imported modules have restrictions on editing, but you can modify module inputs and outputs.

Procedure

1. Open the SAP ESP Authoring perspective.
2. In the visual editor, select the module to edit.
3. To edit the module name to be unique across all object names in the scope for this module, choose one of the following:
   - Click the module name.
   - In verbose mode, click **Edit** .
   - Select the module, and in the Properties view modify the **name** value.

   By default, the properties view is in the lower left of the SAP ESP Authoring perspective.
4. Click **Add Module Exported Reference(s)** ( ).
5. In the Module Exported Reference(s) dialog, select the reference(s) to add or remove, then click **OK**.
6. Click **Add Module Inputs** ().
7. In the Module Inputs dialog, select the inputs to add or remove, then click **OK**.
8. Select **Add Module Outputs** ().
9. In the Module Outputs dialog, select the outputs to add or remove, then click **OK**.
10. To access and edit the contents of the CREATE MODULE statement, select **Open Module Diagram** ().
11. Edit the module in the diagram that opens.
12. Add comments in the properties view.

5.8.4 Creating a Reusable Module File

Create a new, separate module file that can be imported into a project.

Context

You can create modules within a project, or in separate files that you can then import into a project. Create separate module files if you are likely to reuse a particular module often, in different projects. Module files are CCL files hold an individual CREATE MODULE statement.

Procedure

1. Choose **File** > **New** > **CCL Module File**.
2. Enter a unique file name.
   This becomes the module name, and is unique across all object names in the scope for this module.
3. (Optional) Specify a different folder.
   By default, the module is created in the workspace for the current project.
4. Modify the module as required and save.
   To edit the CCL, see *CREATE MODULE Statement* in the *SAP Event Stream Processor: CCL Reference*.

5.8.5 Importing Definitions from Another CCL File

Import a module file to use the module in your project.

Context

You can do this either in the text editor using the IMPORT statement, or by using the visual editor, as described here.

Procedure

1. Open the SAP ESP Authoring perspective.
2. Open the visual editor by clicking **Switch to Visual**, or pressing **F4**.
3. If Outline view is not visible, select **Window** > **Show View** > **Outline**, or press **Alt+Shift+O**.

4. In the Outline view, expand the **Statements** list.
5. Right-click the **Imports** statement and select **Create Child** > **Import**.
6. Select the file or files to import and click **OK**.
7. Expand the imported file until you see the imported module.
8. Click and drag the module anywhere in the diagram.

5.8.6 Configuring a Loaded Module

Add or remove input and output bindings and parameter values (if any) for a specific module instance.

Context

Active modules are created when existing module definitions are used to create new module instances.

Procedure

1. Open the SAP ESP Authoring perspective.
2. In the diagram, select the module instance to edit.
3. To edit the name of the module instance, either:
    - Click the load module instance name.
    - In verbose mode, click **Edit**.
4. Set the input bindings by adding connectors:
    a. Expand the Input Bindings compartment to that you can see the list of inputs.
    b. Add connectors to the shape in the order of the list of inputs. To see the schema for an input or how a particular input is used in the module, you can look "inside" the module by clicking the **Open Module Diagram** on the shape toolbar. This opens the model in a separate editor so that you can see the structure of the module.
5. Output bindings are set automatically, and the outputs appear on the diagram attached to the module instance. Rename the outputs as desired.

    > i Note
    >
    > For input bindings, the schema on both sides of the binding needs to be compatible.

6. (Optional) Modify input or output bindings by selecting an individual binding in the loaded module, and changing any of the following options in the Properties window:

Property	Value
inputStreamOrWindow	Select the available input stream or window components from the list.
streamOrWindowInModule	Select the available stream or window to bind with existing stream or window inputs.
comment (Output only)	Add a comment or description of the output stream.
name (Output only)	Add a name to the output stream.

7. If the module uses any parameters, parameter bindings are listed in the module instance shape on the diagram. Set parameter values in the Properties View:

parameterInModule	the parameter name.
parameterValue	the value to set this parameter to, for this instance of the module.

8. (Optional) Click **Add Store Binding** ( ). If you omit a store binding, the default memory store is used. You can also specify a store for windows in the module.
9. Edit the store binding by selecting and modifying the available fields in the Properties window:

storeInModule	the classification of the string, by default NULL.
storeValue	value phrase that defines the parameter binding.

10. To access input or output windows used inside a loaded module, select **Open Module Diagram** ( ).

5.8.7 Configuring a Module Repository

Create a folder in which to store modules, and configure the SAP Event Stream Processor Studio to use it.

Context

Modules are reusable blocks of CCL containing one or more CREATE MODULE statements. A module repository is a directory that contains these files. Once this directory has been created and configured in Studio, modules can be stored in it and loaded into projects using the SAP ESP Authoring perspective palette.

Procedure

1. Create a new folder, or select an existing folder, to serve as the module repository.
2. In SAP ESP Authoring perspective, click **Windows** > **Preferences** > **SAP Event Stream Processor** .
3. Enter the full path to the folder you want to use as the module repository in the **Module Repository Directory** field.
4. Click **Apply**.

5. Click **OK**.

5.9 Error Streams

Error streams gather errors and the records that caused them.

Description

Error streams provide ways to capture error information along with the data that caused an error. This can assist in debugging errors during development, as well as provide real-time monitoring of projects in a production environment.

You can specify more than one error stream in a single project.

An error stream is identical to other user-defined streams, except it:

- Receives records from its source stream or window only when there is an error on that stream or window. The record it receives is the input to the source stream or window that caused the error.
- Has a predefined schema that cannot be altered by the user.

The following table describes the schema for an error stream:

Column	Datatype	Description
`errorCode`	integer	The numeric code for the error that was reported.
`errorRecord`	binary	The record that caused the error.
`errorMessage`	string	Plain text message describing the error.
`errorStreamName`	string	The name of the stream on which this error was reported.
`sourceStreamName`	string	The name of the stream that sent the record that caused the error.
`errorTime`	bigdatetime	The time the error occurred; a microsecond granularity timestamp.

Error Codes and Corresponding Values

- NO_ERR - 0
- GENERIC_ERROR - 1
- FP_EXCEPTION - 2
- BADARGS - 3
- DIVIDE_BY_ZERO - 4
- OVERFLOW_ERR - 5
- UNDERFLOW_ERR - 6
- SYNTAX_ERR - 7

Limitations

The syntax of the error stream provides a mechanism for trapping runtime errors, and has these limitations:

- Only errors that occur during record computation are captured in error streams. Errors in computations that occur at server start-up, such as evaluation of expressions used to initialize variables and parameters, are not propagated to error streams. Other errors, such as connection errors and noncomputational errors, are not captured in error streams.
- Errors that occur during computations that happen without a triggering record will propagate an error record where the errorRecord field contains an empty record. Examples include the `ON START TRANS` and `ON END TRANS` blocks of the Flex block.
- For `recordDataToRecord`, the stream name must be a string literal constant. This allows a record type of the return value to determined during compilation.
- The triggering record must be retrieved using provided schemas. No native nested record support is provided to refer to the record directly.
- The triggering record reported is the immediate input for the stream in which the error happened. This may be a user-defined stream or an intermediate stream generated by the compiler. When using `recordDataToString` and `recordDataToRecord`, the first argument must match the intermediate stream if one has been generated.
- The subscription utility does not automatically decrypt (that is, convert from binary to ASCII) the error record.
- Output adapters do not automatically decrypt (that is, convert from binary to ASCII) the error record.
- Arithmetic and conversion errors occurring in external functions (such as C and Java) are not handled. These errors are the user's responsibility.
- Error streams are not guaranteed to work within the debugger framework.

In this section:

5.9.1 Monitoring Streams for Errors

Use error streams to monitor other streams for errors and the events that cause them. You can create error streams in the Studio visual editor, or directly in CCL.

Process

1. Identify the project and the specific streams to monitor.
2. Decide whether to use multiple error streams, then determine the visibility for each error stream.
3. Create the error streams in that project. See Creating an Error Stream in the Visual Editor [page 182].
4. Display some or all of the information from the error streams in the error record; that is, information aggregated or derived from the error records. See Displaying Error Stream Data [page 183].

5.9.2 Examples: Error Streams in CCL

View CCL examples of error streams in use.

In a project that has one input stream and two derived streams, create a locally visible error stream to monitor all three streams using:

```
CREATE ERROR STREAM AllErrors ON InputStream, DerivedStream1, DerivedStream2;
```

To keep a count of the errors according to the error code reported, add:

```
CREATE OUTPUT WINDOW errorHandlerAgg SCHEMA (errorNum integer, cnt long)
PRIMARY KEY DEDUCED
AS
SELECT e.errorCode AS errorNum, COUNT(*) AS cnt
FROM AllErrors e
GROUP BY e.errorCode;
```

In a project that has three derived streams, create an externally visible error stream to monitor only the third derived stream (which calculates a volume weighted average price) using:

```
CREATE OUTPUT ERROR STREAM vwapErrors ON DerivedStream3;
```

To convert the format of the triggering record from binary to string, add:

```
CREATE OUTPUT STREAM vwapMessages SCHEMA (errorNum integer, streamName string,
errorRecord string) AS
SELECT  e.errorCode AS errorNum,
        e.errorStreamName AS streamName,
        recordDataToString(e.sourceStreamName, e.errorRecord) AS errorRecord
FROM vwapErrors e;
```

5.9.3 Creating an Error Stream in the Visual Editor

Add error streams using the Studio visual editor.

Context

Whether you are debugging a project in development or monitoring a project in production mode, error streams let you see errors and the records that cause them in other streams in real time.

> i Note
>
> An error stream cannot monitor other error streams.

Procedure

1. Open the SAP ESP Authoring perspective.
2. In the visual editor, open the project.
3. Click the error stream shape in the palette, then click an empty area in the diagram.
4. Click the **+** (plus) sign.
   You see a list of streams in the project that can be monitored.
5. Specify the streams you want to monitor: click **Select All** or click each stream to monitor, then click **OK**.
   The streams you specified are connected to the error stream by red lines indicating that they are sending error information.

5.9.4 Modifying an Error Stream

When you are debugging a project in development or monitoring a project in production mode, you can change the specific streams that an error stream is monitoring.

Context

> i Note
>
> An error stream cannot monitor other error streams.

Procedure

1. Open the SAP ESP Authoring perspective.
2. In the visual editor, open the project.
3. Locate the error stream shape in the work area and review the list of input streams.
4. Click the **+** (plus) sign, then click each stream to monitor, and click **OK**. Or, use the Connector in the palette to connect an input stream to the error stream.
   A red line connects each stream to the error stream and the new stream names appear on the Inputs list.
5. (Optional) To remove input streams from the error stream, click the X in a red circle, then select each stream to remove. Click **OK**.
   The red lines connecting the streams to the error stream and the stream names on the Inputs list are removed.

5.9.5 Displaying Error Stream Data

By default, error streams created in Studio are output. However, if you configure error streams as local, or create them directly in CCL (where the default is local), you can change them back to output to make them visible to external subscribers. This makes real-time monitoring of the error streams possible.

Context

In production mode, project monitoring may be performed externally.

Procedure

1. Open the SAP ESP Authoring perspective.
2. In the visual editor, open the project.
3. To enable real-time monitoring of errors encountered by the project, click the **Type** icon in the Error Stream to toggle it from OUTPUT to LOCAL.
4. To enable ad hoc SQL queries, add a window (for example, ErrorState) to the project, downstream from the error stream.
   The ErrorState window preserves the state of the error stream so it can be queried using the `streamingquery` utility. See *streamingquery* in the *SAP Event Stream Processor: Utilities Guide* for an example of using `streamingquery` to check the ErrorState.

5.10 Data Retention and Recovery with Stores

Every window is assigned to a store, which holds the retained records. By default, all windows are assigned to a memory store. You can create log stores to add data recoverability and to optimize performance, then assign windows to specific stores.

Memory Stores

A memory store holds all data in memory. Memory stores retain the state of queries for a project from the most recent server start-up for as long as the project is running. Because query state is retained in memory rather than on disk, access to a memory store is faster than to a log store.

Use the CREATE MEMORY STORE statement to create memory stores. If no default store is defined, new windows are automatically assigned to a memory store.

Log Stores

The log store holds all data in memory, but also logs all data to the disk, guaranteeing data state recovery in the event of a failure. Use a log store to recover the state of a window after a restart.

Use the CREATE LOG STORE statement to create a log store. You can also set a log store as a default store using the CREATE DEFAULT LOG STORE statement, which overrides the default memory store.

Log store dependency loops can cause compilation errors when using log stores. You might create log store loops when you use multiple log stores in a project, and assign windows to these stores. For the best results, assign log stores to source windows only, or to assign all windows in a stream path to the same store. For example, if you assign Windows A, B, and C to `logstore1`, then assign Window D to `logstore2`, Window E should not be assigned to `logstore1`. As well, even if another window, such as Window F, gets its information from Window D, it should not be assigned to `logstore1`, but `logstore2`, or another new log store.

Use the consistent recovery option when using multiple log stores in a project. Consistent recovery ensures that all log stores in a project are kept consistent with each other and prevents the possibility of duplicate rows appearing during the recovery process. See the *Consistent Recovery* topic for more information.

In this section:

5.10.1 Using Log Stores for Data Recovery

A log store provides data recovery inside a window if a server fails or is shut down unexpectedly.

Properly specified log stores recover window elements on failure, and make sure data gets restored correctly if the server fails and restarts. You can use log stores with windows that have no retention policy; you cannot use log stores with stateless elements. However, a Guaranteed Delivery stream will use a log store to hold its output events until receipt is confirmed by all subscribers. See *Guaranteed Delivery* for more information.

When using log stores, consider:

- Log stores only store window contents.
- Log stores do not directly store intermediate state, such as variables.
- Local Flex stream variables and data structures are not directly stored. However, they may be regenerated from source data if the source data is in persistent storage.
- Log stores do not preserve opcode information. (During periodic log store compaction and checkpointing, only the current window state is preserved. Records are then restored as inserts.)
- Row arrival order is not preserved. In any window, multiple operations may be collapsed into a single record during log store compaction, changing arrival order. Inter-window arrival order is not maintained.
- You can define one or more log stores in a project. When using multiple stores, make sure you prevent the occurrence of log store loops, which cause compilation errors. A log store loop is created when, for example, `Window1` in `Logstore1` feeds `Window2` in `Logstore2`, which feeds `Window3` in `Logstore1`.
- When using multiple log stores in a project, make sure Consistent Recovery is enabled in the project's deployment options. Consistent Recovery ensures that even if a server or connection fails, all log stores in a project are consistent with one another. See *Consistent Recovery* for more information.
- The contents of memory store windows that receive data directly from a log store window are recomputed once the log store window is restored from disk.
- The contents of memory store windows that receive data from a log store window via other memory store windows are also recomputed, once the input window's contents have been recomputed.
- The contents of a derived window attached to a log store will be recovered directly by the log store, even if the derived window is fed by an upstream window that is also assigned to a log store.
- In the case of partitioning, if the input of the partition target is a stream, which is a stateless element, then operations such as filter, compute, aggregate, and join are not supported.
- If the input of a partitioned target is on a memory store and the target is on a log store, this is supported only if the memory store (input element) can recover its data from an element that is on a log store.

> i Note
>
> If a memory store window receives data from a log store window via a stateless element such as a stream, its contents are not restored during server recovery. If a window that is fed by a stream needs to be recovered on startup, assign that window to a log store.

When you shut down the server normally, it performs a quiesce and checkpoint before it shuts down. It is therefore able to store all data currently in the project, as the data has been fully processed and is in a stable state. When an abnormal system shutdown occurs between checkpoints, there is no way of knowing the state of the system or where the uncheckpointed data was. Therefore, the uncheckpointed data on the input windows attached to log stores is replayed by streaming events down the project as though they were going through the input windows for the first time. The uncheckpointed data is replayed in an attempt to attain a state as close as possible to the state of ESP before the abnormal shutdown.

Log stores are periodically compacted, at which point all data accumulated in the store is checkpointed and multiple operations on the same key are collapsed. After a checkpoint, the store continues appending incoming data rows to the end of the store until the next checkpoint.

> i Note
>
> The recovery of data written to the store, but not yet checkpointed, is available only for input windows. When you assign a window to a log store, you should also assign all of its input windows to a log store. Otherwise, data written to the window after the last checkpoint is not restored.

Unlike memory stores, log stores do not extend automatically. Use the CCL `maxfilesize` property to specify the log store size. The size of a log store is extremely important. Log stores that are too small can cause processing to stop due to overflow, and can also cause significant performance degradation due to frequent cleaning cycles. A log store that is too large can hinder performance due to larger disk and memory requirements.

Parent topic: Data Retention and Recovery with Stores [page 184]

Related Information

Creating a Log Store [page 186]
Creating a Memory Store [page 197]

5.10.2 Creating a Log Store

If failover is enabled, configure a log store to capture the data that flows through a project.

Prerequisites

- Determine the size of your log store.
- Review Log Store Guidelines [page 188].

Context

> i Note
>
> Log stores do not store SAP Event Stream Processor event logs (cluster logs, server logs, or project logs).

Create one log store per project, unless you have Consistent Recovery enabled. See *Consistent Recovery* for more information.

The preferred location for log store files is the base directory where project files are stored.

Procedure

1. Open the SAP ESP Authoring perspective.
2. In the text editor, create a log store using the CREATE LOG STORE statement:

```
CREATE [DEFAULT] LOG STORE storename
PROPERTIES
filename='filepath'
    [sync={ true | false},]
    [sweepamount=size,]
    [reservepct=size,]
    [ckcount=size,]
    [maxfilesize=filesize];
```

3. For the `filename` property, enter either a relative (preferred) or absolute file path for the location of the log store:

Option	Description
Relative path (recommended)	A relative path is relative to the ESP base directory. When sandboxing is enabled, a relative path is relative to the ESP sandbox base directory. Using a relative path means that your log store automatically points to either the base directory or the sandbox base directory. Relative paths do not point to the directory stack; this means that the path does not start with a drive letter or slash (/).
Absolute path (not recommended)	An absolute path points to any location on your machine, regardless of the current working directory (base directory). For Windows systems, an absolute path begins with the drive letter; on UNIX and Solaris systems, the absolute path begins with a slash (/). When sandboxing is enabled, absolute paths are changed into relative paths, relative to the sandbox base directory, and interpreted as literally as possible. For Windows, drive letters will be turned into a folder and preserved in the new sandbox base directory. For example, a sandbox base directory of `work1/esp/sandbox` with log stores with filename parameters of `D:/esp/logstore` and `data/logstore` running in project `importantp1` in workspace `worksp1` instance number 0 becomes: ○ For `D:/esp/logstore:` ○ work1/esp/sandbox/store/d/esp/logstore/worksp1.important1.0 ○ For `data/logstore`: ○ work1/esp/sandbox/store/data/logstore/worksp1.importantp1.0

The relative path location must be a shared disk available to all cluster nodes. The log store path is specified in the `filename` property within the log store definition. When sandboxing is enabled, both a relative path and absolute path automatically place log stores under `<sandbox-base-directory>/store/<filename-property>/<workspace-name>.<project-name>.<instance-number>`. When sandboxing is disabled, a relative path automatically places the log store under `<base-directory>/<workspace-name>.<project-name>.<instance-number>`. When sandboxing is disabled, an absolute path points to any location on your machine, regardless of the current working directory (base directory). You can view base directory and sandbox base directory definitions in the cluster configuration file, under the controller section. In ESP Cockpit, you can view them in the **Applications** section of cluster configuration.

Use a relative path. If you use an absolute path, first ensure that all cluster nodes can read and write to the absolute path you specify. This means that the location must be the same for all cluster nodes. Also ensure that no two projects use the same path for the log store location. If using a shared disk is not possible, configure a strong affinity to ensure the project always runs on the same cluster node.

4. Enter appropriate values for the remaining properties in the CREATE LOG STORE statement.
5. Click **Compile** (F7).
6. Click **Run Project**.

In this section:

Log Store Guidelines [page 188]
There are several considerations to review before adding a log store to your project.

Sizing a Log Store [page 190]
Calculate the size of the log store your project requires. Correctly sizing your log store is important because stores that are too small or large can lead to performance issues.

Log Store Sizing Reference [page 194]
Set sizing parameters for a log store using a CREATE LOG STORE statement.

Log Store Optimization Techniques [page 197]
Specify persistence to optimize data models for maximum performance.

Task overview: Data Retention and Recovery with Stores [page 184]

Related Information

Using Log Stores for Data Recovery [page 185]
Creating a Memory Store [page 197]

5.10.2.1 Log Store Guidelines

There are several considerations to review before adding a log store to your project.

General Guidelines

- Place log stores on a shared drive available to all the machines in the cluster.
- Keep windows that change at substantially different rates in different log stores. If a log store contains a large but nearly-static window and a small but rapidly changing window, each cleaning cycle must process large amounts of data from the static window. Keeping windows separate optimizes cleaning cycles.
- If using a log store with a window that changes infrequently, enable Auto Checkpoint to ensure that data is periodically checkpointed. Periodic checkpoints will minimize data loss when the project is unexpectedly restarted. See *Auto Checkpoint* or *Editing Deployment Options in Project Configuration* in the *SAP Event Stream Processor: Configuration and Administration Guide* for more information on using Auto Checkpoint.
- Put any window into a log store that:
  - Is fed by stateless elements (streams).

    - Is fed by more than one upstream source in the project data flow. This is necessary for recovery because the arrival order of rows is not preserved.
    - Cannot produce the same result before and after a disruptive event such as a server crash, based on data replayed during the recovery process.
- Derived windows can be recovered from their upstream input windows or directly from log stores. Recovery time is faster when all windows are assigned to log stores, but normal state processing is affected.
- Log stores use window names internally for identification. Start a new file for a log store when renaming a window to which it is attached.
- Variables and CCLScript data structures (dictionaries, vectors, and event caches) do not persist in log stores and cannot be recovered after a failure. Use these structures with log stores only when:
    - You can provide logic to reconstruct the structures on restart.
    - Processing is not affected if the structures are missing after a restart.

  Data structures that are defined in DECLARE blocks may be fully or partially restored by the recovery process. However, achieving the desired recovery state after a project restart depends on the project's structure. For example, assume that there is an input window A that is assigned to a log store and window A has a retention policy of one hour. Flex operator B receives its input from A and contains data structures. The type of data structure, and the way it is configured, will affect how much data is recovered in the recovery process:
    - If Flex B has a dictionary that holds data for longer than an hour, the dictionary will be partially restored as Flex B receives rows from window A during the recovery process.
    - If Flex B has a dictionary that holds a last value received for every key value, and receives values more frequently than once per hour for every key value, the dictionary will be fully restored during the recovery process.
    - If Flex B has a five minute event cache that only holds records, the event cache will hold records that were replayed as a part of the recovery process in the last five minutes.

Guidelines for Guaranteed Delivery

All the general guidelines above apply to log stores for windows with guaranteed delivery. In addition:

- Streams cannot be assigned to log stores; however, when they are enabled for Guaranteed Delivery, streams must be given a GD log store to hold all of their output events until receipt is confirmed by all subscribers. A GD log store can be assigned through the Properties window for the stream in Studio.
- Ensure that the GD log store for every guaranteed delivery stream or window is large enough to accommodate the required events. If the log store runs out of room, the project server shuts down. Because copies of events are kept in the same GD log store the stream or window is assigned to, the size of the GD log store for a guaranteed delivery stream or window must be significantly larger than a non-GD log store for a window.
- Put any window on which GD is enabled, and all input windows that feed GD windows, into a log store. You can put windows located between the input and GD windows in a memory store if, upon restart, they can be reconstructed to exactly the same state they were in before the server went down. If an intermediate window cannot be reconstructed to its previous state, put it in a log store.
    - If consistent recovery is not enabled, put the GD windows and all their feeder windows into the same log store. Note, however, that placing many windows in the same log store adversely affects performance.
    - If consistent recovery is enabled, you can employ as many log stores for your GD and feeder windows as necessary.

Parent topic: Creating a Log Store [page 186]

Related Information

Sizing a Log Store [page 190]
Log Store Sizing Reference [page 194]
Log Store Optimization Techniques [page 197]

5.10.2.2 Sizing a Log Store

Calculate the size of the log store your project requires. Correctly sizing your log store is important because stores that are too small or large can lead to performance issues.

Prerequisites

Review Log Store Guidelines [page 188].

Context

Start this procedure by calculating your project's internal record size. An internal record represents a row in a window. Each row contains a fixed-size header plus a variable-size payload containing the column offsets, column data, and any optional fields. Use this formula for the calculation in the first step of this procedure:

$$\text{HeaderSize}(56) + \text{Offsets}(4 * \text{M}) + \textstyle\sum_{1}^{M} \text{PS}$$

In the formula:

- M represents the number of columns
- PS represents the primitive datatype size for each of the M columns

Primitive datatypes are the building blocks that make up more complex structures such as records, dictionaries, vectors, and event caches. The following table provides the size of primative datatypes:

Datatype	Size in Bytes	Notes
Boolean	1	
Decimal	18	

Datatype	Size in Bytes	Notes
Integer	4	
Long	8	
String	1 + number of characters in the string	Estimate an average length
Float	8	
Money(n)	8	
SecondDate	8	
Time	8	
MsDate	8	
BigDateTime	8	
Binary	4 + number of bytes in the binary value	Estimate an average length

> i Note
>
> Guaranteed delivery (GD) logs hold events stored for delivery. If no GD logs are stored in the log store, you may skip the first three steps of this procedure. Instead, compute the dataSize using the Playback feature in Studio or the `streamingplayback` utility to record and play back real data to get a better idea of the amount of data you need to store. (See Playback View [page 123] for details on Playback or the *SAP Event Stream Processor: Utilities Guide* for details on `streamingplayback`.) The log store reports "`liveSize`" in the project log file (`esp_server.log`) when the project exits (with log level three or higher) or after every compaction (with log level six or higher). Use the "`liveSize`" value for the dataSize referenced in step 2 of this procedure and beyond.

Procedure

1. (Optional if no GD logs are stored in the log store) For each window, calculate the size of an internal record. If the window supports GD, compute the size for the GD logs separately.

   For purposes of illustration, use this schema:

   ```
   CREATE SCHEMA TradesSchema AS (
          TradeId    LONG,
          Symbol     STRING,
          Price      MONEY(4),
          Volume     INTEGER,
          TradeDate  BIGDATETIME
   );
   ```

   a. Using the primitive sizes from the Primitive Datatype Sizes table above, compute the column values—the total size in bytes for the datatypes in the schema. For the sample schema, assuming an average STRING length of 4, the calculation is:

   ```
   8 + (4 + 1) + 8 + 4 + 8 = 33 bytes
   ```

b. Add the size of the offsets to the size of the column values. The offsets are calculated as (4 * M) where M is the number of columns. Plugging in the sample schema's five columns, we get:

```
(4 * 5) + 33 = 53 bytes
```

c. Add the size of the row header, which is always 56 bytes:

```
56 + 53 = 113 bytes
```

d. Round up to the nearest number divisible by:
   - 8 if ESP is running on a 64-bit architecture
   - 4 if ESP is running on a 32-bit architecture

   For a 64-bit installation, use this formula, where URS is the unrounded record size value you computed in step 1:

```
URS + (8 - (URS modulo 8))
```

   (For a 32-bit installation, substitute a 4 for each 8 in the formula.) Continue with the example, where ESP is running on a 64-bit machine:

```
113 + (8 - (1)) = 120 bytes
```

e. Label your result recordSize and make a note of it.

2. Estimate the maximum amount of data, in bytes, that you expect to collect in the log store. To do this, determine the maximum number of records each window assigned to the log store will contain. If the window supports guaranteed delivery, treat the GD logs as a separate window. For the record count, use the maximum number of uncommitted rows you expect the GD logs to contain for this window. Add 1000 to this value, since GD logs are purged only when there are at least 1000 fully committed events.
   a. For each window, determine the data size by multiplying the expected record count by the recordSize you computed in step 1.
   b. Sum the data size for all the windows and GD logs to get the total size of the data that will be stored in the log store. Label this value dataSize.
   c. Sum the record counts for each window and GD log assigned to this log store and label that value recordCount.
3. (Optional if no GD logs are stored in the log store) To calculate the basic indexing overhead, multiply the recordCount from the previous step by 96 bytes. Add the result to the dataSize value.
4. Choose the value of the `reservePct` parameter. Calculate the required store size, in bytes, including the reserve, as follows, where dataSize is the value you computed in the previous step:

   storeBytes = dataSize * 100 / (100 - `reservePct`)

   Round storeBytes up to the next megabyte.
5. Ensure the reserve cannot be overrun by the uncheckpointed data.

   Estimate the maximum amount of uncheckpointed data that is produced when the input queues of all the streams, except source streams, are full. Count the records in the queues that are located early in the sequence together with any records they produce as they are processed through the project. Include the number of output records produced by the stream for each of its input records.

This example shows the stream queue depth set to the default of 1024, for a log that contains four streams ordered like this:

```
source --> derived1 --> derived2 --> derived3
```

a. Determine the number of records produced by each stream as it consumes the contents of its queue:
   - 1024 records may end up in `derived1`'s input queue. Assuming the queue produces one output record for one input record, it produces 1024 records.
   - 2048 records may end up in `derived2`'s input queue (1024 that are already collected on its own queue, and 1024 more are `derived1`). Assuming that `derived2` is a join and generates an average of 2 output records for each input record, it produces 4096 records ([1024 + 1024] * 2).
   - 5120 records may end up in `derived3` (1024 from its own queue and 4096 from `derived2`). Assuming a pass-through ratio of 1, `derived3` produces 5120 records.

   Take all branches into account when the project's topology is not linear. The pass-through ratio may differ for data coming from the different parent streams. Add up the data from all the input paths. Each stream has only one input queue, so its depth is fixed, regardless of how many parent streams it is connected to. However, the mix of records in each queue may vary. Assume the entire queue is composed from the records that produce that highest amount of output. Some input streams may contain static data that is loaded once and never changes during normal work. You do not need to count these inputs. In the example, `derived2` is a join stream, and has static data as its second input.

b. Calculate the space required by multiplying the total number of records by the average record size of that stream.
   For example, if the records in `derived1` average 100 bytes; `derived2`, 200 bytes; and `derived3`, 150 bytes, the calculation is:

   (1024 * 100) + (4096 * 200) + (5120 * 150) = 1,689,600

   Trace the record count through the entire project, starting from the source streams down to all the streams in the log store. Add the data sized from the streams located in the log store.

c. Multiply the record count by 96 bytes to calculate the indexing overhead and add the result to the volume in bytes:

   (1024 + 4096 + 5120) * 96 = 983,040

   1,689,600 + 983,040 = 2,672,640

   Verify that this result is no larger than one quarter of the reserve size:

   uncheckpointedBytes < storeBytes * (`reservePct` / 4) / 100

   If the result is larger than one quarter of the reserve size, increase the reserve percent and repeat the store size calculation. Uncheckpointed data is mainly a concern for smaller stores. Other than through the uncheckpointed data size, this overhead does not significantly affect the store size calculation, because the cleaning cycle removes it and compacts the data.

6. When you create the log store, place the value you arrived at for your log store size here, in the CREATE LOG STORE statement's `maxfilesize` parameter.

Task overview: Creating a Log Store [page 186]

Related Information

Log Store Guidelines [page 188]
Log Store Sizing Reference [page 194]
Log Store Optimization Techniques [page 197]

5.10.2.3 Log Store Sizing Reference

Set sizing parameters for a log store using a CREATE LOG STORE statement.

The CREATE LOG STORE parameters described here control the size and behavior of the log store.

maxfilesize Parameter

The maximum file size is the largest size, in bytes, that the log store file is allowed to reach. To calculate this value, see Sizing a Log Store [page 190] for instructions on calculating this value.

It is important to size log stores correctly because unlike memory stores, log stores do not extend automatically. A store that is too small requires more frequent cleaning cycles, which severely degrades performance. In the worst case, the log store can overflow and cause processing to stop. A store that is too large also causes performance issues due to the larger memory and disk footprint; however, these issues are not as severe as those caused by log stores that are too small.

reservePct Parameter

The reserve is intermediate or free space maintained in every log store, which is used when the store is resized and during periodic cleaning of the store. The `reservePct` value is a percentage of the size of the log store.

> i Note
>
> If the reserve space is too small and the project runs until the store fills with data, a resize attempt may cause the store to become wedged. This means that it cannot be resized, and the data can be extracted from it only by SAP Technical Support. It is safer to have too much reserve than too little. The default of 20 percent is adequate in most situations. Multigigabyte stores may use a reduced value as low as 10 percent. Small stores, under 30 MB, especially those with multiple streams, may require a higher reserve (up to 40 percent). If you find that 40 percent is still not enough, increase the size of the store.

SAP Event Stream Processor automatically estimates the required reserve size and increases the reserve if it is too small. This usually affects only small stores. It is a separate operation from resizing the log store itself, which is performed by a user.

i Note

Increasing the reserve reduces the amount of space left for data. Monitor project log messages for automatic adjustments when you start a new project. You may need to increase the store size if these messages appear.

As the store runs, more records are written into it until the free space falls below the reserve, at which point the source streams are temporarily stopped, the streams quiesced, and the checkpoint and cleaning cycle are performed. Streams do not quiesce immediately, but must first process any data collected in their input queues. Any data produced during quiescence is added to the store, meaning that the reserve must be large enough to accommodate this data and still have enough space left to perform the cleaning cycle. If this data overruns the reserve, it cannot perform the cleaning cycle and the store becomes wedged. The automatic reserve calculation does not account for data that is no checkpointed.

Log Store Size Warnings

As the amount of data in the store grows, if the free space falls below 10 percent (excluding the reserve), Event Stream Processor starts reporting `log store is nearing capacity` in the project log file (`esp_server.log`). If the data is deleted from the store in bursts (for example, if data is collected during the day, and data older than a week is discarded at the end of the day), these messages may appear intermittently even after the old data has been flushed. As the cleaning cycle rolls over the data that has been deleted, the messages disappear.

Unless your log store is very small, these warnings appear before the store runs out of space. If you see them, stop Event Stream Processor when convenient, and increase the store size. Otherwise, Event Stream Processor aborts when the free space in the project falls below the reserve size.

Recovering from a Wedged Log Store

If a log store is sized incorrectly, the entire reserve may be used up, which causes the store to become wedged. If this happens, you cannot resize the log store or preserve the content. Delete the store files and restart Event Stream Processor with a clean store. If you make a backup of the store files before deleting them SAP Technical Support may be able to extract content. Change the store size in the project, and it is resized on restart. You cannot decrease the store size. When you restart a project after resizing the store, it will likely produce project log messages about the free space being below the reserve until the cleaning cycle assimilates the newly added free space.

ckcount Parameter

The `ckcount` checkpointing count parameter affects the size of uncheckpointed data. This count shows the number of records that may be updated before writing the intermediate index data. Setting it to a large value amortizes the overhead over many records to make it almost constant, averaging 96 bytes per record. Setting it to a small value increases the overhead. With the count set to zero, index data is written after each transaction, and, for the single-transaction records, the overhead becomes:

96 + 32 * ceiling ($\log_2$(number_of_records_in_the_stream))

If a stream is small (for example, fewer than 1000 records), the overhead for each record is:

96 + 32 * ceiling ($\log_2$(1000)) = 96 + 32 * 10 = 416

In many cases, the record itself is smaller than its overhead of 416 bytes. Since the effect is logarithmic, large streams are not badly affected. A stream with a million records has a logarithm of 20 and incurs an overhead of 736 bytes per record. The increased overhead affects performance by writing extra data and increasing the frequency of store cleaning.

If your project includes any windows configured for guaranteed delivery (GD), consider adjusting the value of `ckcount` to improve performance and latency.

sweepamount Parameter

The `sweepamount` parameter determines how much of the log store file is “swept through” during each cleaning pass. The value is between 5 percent to 20 percent of the `maxfilesize` parameter. A good lower bound for the sweep size is half the size of the write cache on your storage array. Usually, it indicates a sweep size of 512 to 1024 megabytes. Smaller sweep sizes minimize spikes in latency at the expense of a higher average latency. High values give low average latency with higher spikes when reclaiming space.

If the value of the `sweepamount` parameter is too small, the system performs excessive cleaning; in some cases, this does not allow the log store to free enough space during cleaning.

The size of the sweep is also limited by the amount of free space left in reserve at the start of the cleaning cycle. If the reserve is set lower than the sweep amount and the sweep does not encounter much dead data, the sweep stops if the relocated live data fills up the reserve. The swept newly cleaned area becomes the new reserve for the next cycle. Unless other factors override, you should keep the sweep and the reserve sizes close to each other. `reservePct` is specified in percent, while `sweepamount` is specified in megabytes.

If your project includes any windows configured for guaranteed delivery (GD), consider adjusting the value of `sweepamount` to improve performance and latency.

Log Store Size and File Locations

Ensure the total size of all log store files does not exceed the size of the machine’s available RAM. If this occurs, the machine takes longer to process the data, causing all monitoring tools to display low CPU utilization for each stream, and standard UNIX commands such as `vmstat` to display high disk usage due to system paging.

For storing data locally using log stores, you should use a high-speed storage device, for example, a redundant array of independent disks (RAID) or a storage area network (SAN), preferably with a large dynamic RAM cache. For a moderately low throughput, place backing files for log stores on single disk drives, whether SAS, SCSI, IDE, or SATA.

Parent topic: Creating a Log Store [page 186]

Related Information

Log Store Guidelines [page 188]
Sizing a Log Store [page 190]
Log Store Optimization Techniques [page 197]

5.10.2.4 Log Store Optimization Techniques

Specify persistence to optimize data models for maximum performance.

- Whenever possible, create a small log store to store static (dimension) data, and one or more larger log stores for dynamic (fact) data.
- If you are using multiple log stores for larger, rapidly changing, dynamic (fact) data, try to organize the stores on different RAID volumes.
- The correct sizing of log stores is extremely important.

Parent topic: Creating a Log Store [page 186]

Related Information

Log Store Guidelines [page 188]
Sizing a Log Store [page 190]
Log Store Sizing Reference [page 194]

5.10.3 Creating a Memory Store

Create a memory store to retain the state of continuous queries in memory, from the most recent server startup.

Prerequisites

To ensure optimal performance, consult with your system administrator on the type, number, and index values for memory stores.

Procedure

1. In the visual editor palette, in Shared Components, click **Memory Store**.
2. Select a location in the diagram and click to add the shape.
3. Connect the memory store to a window.
4. Specify a name for the store that is unique within its scope for the project or module.
5. (Optional) Click **Set Store Properties** and modify property values. The following table describes the memory store properties you can modify:

Property	Description
Index Size Hint (KB) (INDEXSIZE-HINT)	(Optional) Determines the initial number of elements in the hash table, when using a hash index. The value is in units of 1024. Setting this higher consumes more memory, but reduces the chances of spikes in latency. Default is 8KB.
Index Kind (INDEXTYPE)	The type of index mechanism for the stored elements. Default is **Tree**. Use **Tree** for binary trees. Binary trees are predictable in use of memory and consistent in speed. Use **Tree** for hash tables, as hash tables are faster, but they often consume more memory.

6. (Optional) Select **Default** to make this the default store for the project (or module).

Task overview: Data Retention and Recovery with Stores [page 184]

Related Information

Using Log Stores for Data Recovery [page 185]
Creating a Log Store [page 186]

5.11 Setting an Aging Policy

You can set an aging policy to flag records that have not been updated within a defined interval. This is useful for detecting records that may be stale.

Context

Aging policies are an advanced, optional feature for a window or other stateful elements.

Procedure

1. Open the SAP ESP Authoring perspective.
2. In the visual editor, select a window or other stateful element to which you want to add an aging policy.
3. Select **Set Aging Policy** 🕒 and set values, which are described in the following table:

Value	Description
Aging Time	This is an interval value. Any record in the window that has not been updated for this much time will have the Aging Field incremented. The timer is reset when the record is updated (or the Aging Time Field changes). The period can be specified in hours, minutes, seconds, milliseconds, or microseconds.
Aging Field	The field in the record is incremented by 1 every time the aging time period elapses and no activity has occurred on the record, or until a maximum defined value is reached. The default value is 1.
(Optional) Max Aging Field Value	The maximum value that the aging field can be incremented to. If not specified, the aging field is incremented once.
(Optional) Aging Time Field	The start time of the aging process. If not specified, the internal row time is used. If specified, the field must contain a valid start time.

4. (Optional) Double-click the policy to edit its parameters.

Results

When the project runs, records accumulate until the Aging Time or Max Aging Field Value is reached. On an update to a record, the age is reset to 0.

5.12 Using Bindings to Connect CCL Projects

Create bindings between projects to let data flow between them.

You can enable a binding in a project's `.ccr` file, as long as the streams or windows you are binding have compatible schemas. See *CCL Project Basics>Bindings between CCL Projects* for more information.

Binding to a Stream on an SSL-Enabled Cluster

This example shows a binding called `BaseInputBinding` that connects a local input stream called `sin` to a remote output stream that is also called `sin`. When the SSL protocol is enabled on the manager node of the data source stream cluster, the `<Manager>` element that specifies the cluster hostname and port in the `.ccr` file requires the https:// prefix. If you omit it, the binding cannot pass data, so the input stream does not receive anything.

```
<Configuration>
  <Runtime>
    <Clusters>
      <Cluster name="cluster1" type="remote">
        <Username>USER_NAME</Username>
        <Password>PASSWORD</Password>
        <Managers>
          <Manager>https://CLUSTER_MANAGER_HOSTNAME:
          CLUSTER_MANAGER_RPC_PORT</Manager>
          <!-- use https:// when SSL is enabled -->
        </Managers>
      </Cluster>
    </Clusters>

    <Bindings>
      <Binding name="sin">
        <Cluster>cluster1</Cluster>
        <Workspace>ws2</Workspace>
        <Project>prj2</Project>
        <BindingName>BaseInputBinding</BindingName>
        <RemoteStream>sin</RemoteStream>
      </Binding>
    </Bindings>
  </Runtime>
</Configuration>
```

Reconnection Intervals for Bindings

This example shows two bindings, `b1` and `b2`, on a local input stream called `MyInStream`. The `b1` binding includes a reconnection interval option specifying that if the connection between `MyInStream` and the remote output stream is lost, the project will attempt to reconnect every 10 seconds. Because the `b2` binding does not specify a reconnection interval, its reconnection attempts will occur at the default interval of five seconds:

```
<Bindings>
  <Binding name="MyInStream">
    <Cluster>c1</Cluster>
    <Workspace>w1</Workspace>
    <Project>p1</Project>
    <BindingName>b1</BindingName>
    <RemoteStream>MyInStream1</RemoteStream>
    <ReconnectInterval>10</ReconnectInterval>
  </Binding>
  <Binding name="MyInStream">
    <Cluster>c1</Cluster>
    <Workspace>w1</Workspace>
    <Project>p1</Project>
    <BindingName>b2</BindingName>
    <RemoteStream>MyInStream2</RemoteStream>
  </Binding>
</Bindings>
```

To suppress all reconnection attempts, set `<ReconnectInterval>` to 0. Use positive whole number values to set the reconnection interval in seconds.

Configuring an Input Stream or Window to Provide Output

This example shows how to configure an input stream to send data to another input stream by setting the <Output> parameter in the <Binding> element to true.

> ℹ Note
>
> Set the <Output> parameter to true only when you configure a binding on an input stream or window that is providing output. If you configure the binding on the stream or window that is receiving input, do not set the <Output> parameter. When you configure a binding on an output stream, you do not have to set the <Output> parameter, since output streams can only produce output.

In this example, output from the input stream `MyInStream`, in the local project, is bound to the input stream `MyInStream1` in project `p2`. The line `<Output>true</Output>` tells the binding to publish (send data out) to the remote stream. Without that line, this binding would subscribe to data from `MyInStream1` because bindings on input streams receive data by default:

```
<Binding name="MyInStream">
  <Cluster>c1</Cluster>
  <Workspace>w1</Workspace>
  <Project>p2</Project>
  <BindingName>b1</BindingName>
  <RemoteStream>MyInStream1</RemoteStream>
  <Output>true</Output>
</Binding>
```

Configuring a Window for Guaranteed Delivery

This example shows how to enable and configure guaranteed delivery (GD) on a window's output binding. The GD parameters are the same for input bindings.

Enable GD for a binding to guarantee that if the connection between the binding and the remote stream is severed (by shutting down the project that contains the local stream, for example), all transactions that are supposed to be transmitted through the binding during its downtime are processed once the connection is re-established.

Use these parameters in the <Binding> element of your `.ccr` file to set a binding to support guaranteed delivery:

- <EnableGD> – Specifies whether guaranteed delivery is enabled for this binding. Values are true and false.

  > ℹ Note
  >
  > When you enable GD on a binding, make sure:
  > - The binding's source data window is running in GD mode or GD mode with checkpoint.
  > - The binding's target data window is backed by a log store.

- <GDName> – Supply a unique name for the GD session (subscription) this binding establishes.
- <GDBatchSize> – The number of transactions this binding may collect in a batch before releasing the batch to the target window. The binding issues a `GD commit` to the source data window after releasing the data. This setting is ignored when the source data window is in GD mode with checkpoint and the <EnableGDCache> parameter on this binding is set to true. The default value is 10.

- <EnableGDCache> – Enable this binding to cache data. When the source data window is in GD mode with checkpoint, the binding receives checkpoint messages that indicate the last row of data that has been checkpointed by the window. If the binding is enabled for GD caching, it caches incoming transactions until it receives a checkpoint message from the source window. The checkpoint message triggers the binding to send all cached transactions up to the one indicated in the checkpoint message, to the target window. The binding issues a `GD commit` to the source data window after releasing cached data. If GD caching is disabled, checkpoint messages are ignored and the binding forwards data based on the value of <GDBatchSize>. The setting of <EnableGDCache> is ignored if the source data window is not in GD mode with checkpoint. Values are true (default) and false.

In this example, output from the local output stream `MyOutStream` is bound to `MyInStream1` in project `p1`. GD and GD caching are enabled. The GD session name is `b1_GD1` and the GD batch size is 20 transactions:

```
<Binding name="MyOutStream">
  <Cluster>c1</Cluster>
  <Workspace>w1</Workspace>
  <Project>p1</Project>
  <BindingName>b1</BindingName>
  <RemoteStream>MyInStream1</RemoteStream>
  <ReconnectInterval>5</ReconnectInterval>
  <EnableGD>true</EnableGD>
  <GDName>b1_GD1</GDName >
  <GDBatchSize>20</GDBatchSize >
  <EnableGDCache>true</EnableGDCache >
</Binding>
```

6 CCL Query Construction

Use a CCL query to produce a new derived stream or window from one or more other streams or windows. You can construct a query to filter data, combine two or more queries, join multiple datasources, use pattern matching rules, and aggregate data.

You can use queries only with derived elements, and can attach only one query to a derived element. A CCL query consists of a combination of several clauses that indicate the appropriate information for the derived element. A query is used with the AS clause to specify data for the derived element.

You can also use the generic derived stream and derived window shapes in Studio to create complex queries.

Choose the element type according to your input, output, and retention requirements for data, and for preserving insert, update, and delete operations.

The following table specifies the rules for derived streams, derived windows, and derived keyed streams.

Element	Input	Output	Retains state	Preserves inserts, updates, and deletes
Derived Stream	Another stream	Stream	No	No
Derived Window	Another stream or window	Window	As defined in retention policy (default is keep all rows)	Yes i Note To derive a window from a stream, include a GROUP BY clause in the query.
Derived Keyed Stream	Another stream or window	Stream	As defined in retention policy; otherwise no	Yes

In this section:

Use joins to combine multiple datasources into a single query.

Pattern Matching [page 218]

Use the MATCHING clause in your CCL query to take input from one or more elements (streams, windows, or keyed streams), and produce records when a prescribed pattern is found within the input data.

Aggregation [page 220]

An aggregation window collects input records and groups them based on the values in the columns specified with the GROUP BY clause, producing one row of output per group. The output record for each group can contain summary statistics about the records in the group, such as average, sum, count, min, max, etc.

Working with Reference Table Queries [page 223]

Reference table queries enable you to look up information in an SAP HANA database table in response to an incoming event.

Creating and Modifying Compute Queries [page 234]

In the visual editor, produce a simple query that transforms the schema or field values of each incoming record. Each incoming event produces one new output event from the fields defined by the column expressions.

Connecting a Stream to a Derived Window [page 235]

Use a GROUP BY clause or the `nextval()` function to connect a stream to a derived window as part of a complex query.

6.1 Simple Queries

Accomplish most common querying tasks (filter, aggregate, join, compute, union, and pattern) using a set of queries available in the visual editor, or their equivalents in CCL.

The tools for these six queries are available as objects in the palette, in **Streams and Windows**:

Filter allows you to filter a stream down to only the events of interest, based on a filter expression. Similar to the SQL WHERE clause.

Aggregate allows you to group events that have common values and compute summary statistics for the group, such as an average. You can also define a window size, based on either time or number of events. Uses the CCL GROUP BY clause, similar to SQL GROUP BY.

Join allows you to combine records from multiple streams or windows, forming a new record with information from each source. Comparable to a join in SQL, where you specify two or more sources in the FROM clause.

Compute allows you to create a new event with a different schema, and compute the value to be contained in each column (field) of the new event. Comparable to a projection in SQL, where you use a SELECT statement to specify the column expressions, and FROM to specify a single source.

Union allows you to combine multiple streams or windows that all share a common schema into a single stream or window. Similar to the SQL UNION operator.

Pattern

allows you to watch for patterns of events within a single stream or window or across multiple streams and windows. When ESP detects an event pattern in a running project, it produces an output event. This uses the CCL MATCHING clause.

The following table summarizes the CCL equivalents for simple queries:

Simple Query	CCL
Filter	WHERE clause
Aggregate	GROUP BY clause
Join	FROM clause, WHERE clause, ON clause
Compute	Simple SELECT statement, with column expressions
Union	UNION clause
Pattern	MATCHING clause

Simple Queries from CCL Statements

If you create queries in CCL and want them to appear as simple query shapes in the visual editor, insert a comment immediately preceding the CREATE STREAM or CREATE WINDOW statement, in the following form, where `<QUERY-TYPE>` is the shape name in the visual editor.

```
/**@SIMPLEQUERY=<QUERY-TYPE>*/
```

For example, this comment causes a CREATE WINDOW statement to map to an aggregate shape in the visual editor: `/**@SIMPLEQUERY=AGGREGATE*/`.

Without this comment immediately preceding the CREATE WINDOW statement, the visual editor shows the generic derived window shape.

> i Note
>
> You cannot modify CCL code in the text editor and in the visual editor concurrently. If the visual editor is open, then the text editor becomes read-only.

CCL Statements from Simple Queries

When you create a simply query from the palette, the CCL element it creates is based on these rules:

- If the input for the filter, compute, or union object is:
  - A stream, the object creates a stream.
  - A window or Flex stream, the object creates a window.
- If a join object takes input only from streams, then the join object creates a stream. If the input is from one or more windows or Flex streams, then the join object creates a window. In a stream-window join, the join object creates a stream.
- All aggregate objects create a window.

- All pattern objects create a stream.

Related Information

Creating and Modifying Join Queries [page 213]
Creating and Modifying Aggregate Queries [page 222]

6.2 Filtering

Use the WHERE clause in your CCL query to filter data to be processed by the derived elements (streams, windows, or keyed streams).

The WHERE clause restricts the data captured by the SELECT clause, reducing the number of results generated. Only data matching the value specified in the WHERE clause is sent to your derived elements.

The output of your derived element consists of a subset of records from the input. Each input record is evaluated against the filter expression. If a filter expression evaluates to false (0), the record does not become part of the derived element.

When using the WHERE clause with a keyed stream, filter on columns that have values that do not change between an insert event and subsequent update and delete events. If the columns change, related events can be lost; for example, downstream elements might receive update or delete events without the insert that provided the data being updated or deleted, or fail to receive a delete for a previous insert.

This example creates a new window, `IBMTrades`, where its rows are any of the result rows from `Trades` that have the symbol "`IBM`":

```
CREATE WINDOW IBMTrades
    PRIMARY KEY DEDUCED
    AS SELECT * FROM Trades WHERE Symbol = 'IBM';
```

In this section:

Creating and Modifying Filter Queries [page 207]
Use the visual editor to produce a simple query that only passes on events with specific characteristics. Filter uses a CCL WHERE clause.

6.2.1 Creating and Modifying Filter Queries

Use the visual editor to produce a simple query that only passes on events with specific characteristics. Filter uses a CCL WHERE clause.

Procedure

1. In the visual editor palette of the SAP ESP Authoring perspective, in **Streams and Windows**, click **Filter** ( ).
2. Select a location in the diagram and click to add the shape.
3. Attach the filter object to any stream, window, or Flex operator. Filter objects can have only one input.
4. Edit the value of the filter expression by selecting the value and changing it as necessary. The default value is 1.

   Any expression that evaluates to '1' is true, and passes all records through. A value of zero is false.
5. (Optional) Use the toggle option to designate the filter object as LOCAL or OUTPUT. By default, filters are OUTPUT.

6.3 Splitting Up Incoming Data

Use the SPLITTER construct to separate incoming data according to filtering rules and write it out to different target streams.

When you want to separate incoming data into several subsets and process those subsets differently, use the CREATE SPLITTER construct. This construct operates like the ANSI case statement: it reads the incoming data, applies the specified filtering conditions, and writes out each subset of the data to one or more target streams.

The target streams are implicitly defined by the compiler. The schema for the target streams are derived based on the `column_list` specification. All the targets are defined as either local or output, depending on the visibility clause defined for the splitter. The default is local.

> **i Note**
>
> When the splitter has an output visibility, output adapters can be directly attached to the splitter targets, even though those targets are implicitly defined.

The first condition that evaluates to true (non-zero value) causes the record as projected in the column_list to be inserted into the corresponding target streams. Subsequent conditions are neither considered nor evaluated.

When the source of a splitter is a window:

- Copy the primary keys as-is. The other columns can be changed.
- If you use the output in a join, specify a retention policy.

- The output is a stateless object and does not receive updates, only base data.
- Projections that contain a non-deterministic expression may produce unpredictable results.

Example

This example creates a schema named `TradeSchema` and applies it to the input window Trades. `IBM_MSFT_Splitter` evaluates and routes data to one of three output windows. Event records with the symbol IBM or MSFT are sent to the `IBM_MSFT_Tradeswin` window. Event records where the product of `trw.Price * trw.Volume` is greater than 25,000 are sent to the `Large_TradesWin` window. All event records that do not meet the conditions placed on the two previous output windows are sent to the `Other_Trades` window.

```
CREATE SCHEMA TradeSchema (
Id long,
Symbol STRING,
Price MONEY(4),
Volume INTEGER,
TradeTime SECONDDATE
) ;
CREATE INPUT WINDOW Trades
SCHEMA TradeSchema
PRIMARY KEY (Id) ;
CREATE SPLITTER IBM_MSFT_Splitter
AS
WHEN trw.Symbol IN ('IBM', 'MSFT') THEN IBM_MSFT_Trades
WHEN trw.Price * trw.Volume > 25000 THEN Large_Trades
ELSE Other_Trades
SELECT trw. * FROM Trades trw ;
CREATE OUTPUT WINDOW IBM_MSFT_TradesWin
PRIMARY KEY DEDUCED
AS SELECT * FROM IBM_MSFT_Trades ;
CREATE OUTPUT WINDOW Large_TradesWin
PRIMARY KEY DEDUCED
AS SELECT * FROM Large_Trades ;
CREATE OUTPUT WINDOW Other_TradesWin
PRIMARY KEY DEDUCED
AS SELECT * FROM Other_Trades ;
```

6.4 Unions

Use a UNION operator in your CCL query to combine the results of two or more queries into a single result.

If the union is on a window or keyed stream, duplicate rows are eliminated from the result set due to the primary key. If the union is on a stream, duplicates flow through.

The input for a union operator comes from one or more streams or windows. Its output is a set of records representing the union of the inputs.

Example

This example shows a simple union between two windows, `InStocks` and `InOptions`:

```
CREATE INPUT WINDOW InStocks
    SCHEMA StocksSchema
    Primary Key (Ts);
```

```
CREATE INPUT WINDOW InOptions
    SCHEMA OptionsSchema
    Primary Key (Ts);
CREATE OUTPUT WINDOW Union1
    SCHEMA OptionsSchema
    PRIMARY KEY DEDUCED
    AS SELECT s.Ts as Ts, s.Symbol as StockSymbol,
           Null as OptionSymbol, s.Price as Price, s.Volume as Volume
    FROM InStocks s
UNION
    SELECT s.Ts as Ts, s.StockSymbol as StockSymbol,
           s.OptionSymbol as OptionSymbol,  s.Price as Price,
           s.Volume as Volume
    FROM InOptions s;
```

In this section:

Creating and Modifying Union Queries [page 209]
Use the visual editor to produce a union query, which combines two or more input streams or windows into a single output. All inputs must have matching schema.

Example: Merging Data from Streams or Windows [page 210]
Use the UNION clause to merge data from two streams or windows and produce a derived element (stream, window, or keyed stream).

6.4.1 Creating and Modifying Union Queries

Use the visual editor to produce a union query, which combines two or more input streams or windows into a single output. All inputs must have matching schema.

Procedure

1. In the visual editor palette of the SAP ESP Authoring perspective, in **Streams and Windows**, select **Union** ().
2. Select a location in the diagram and click to add the shape.
3. Attach the union object to two or more inputs, which can be streams, windows, or Flex operators.

   > Note
   >
   > To add additional inputs to the union object, you can use the **Connector** tool in the Palette or the **Union** icon () in the shape toolbar.

4. (Optional) Use the toggle option to designate the union object as LOCAL or OUTPUT. By default, unions are OUTPUT.

6.4.2 Example: Merging Data from Streams or Windows

Use the UNION clause to merge data from two streams or windows and produce a derived element (stream, window, or keyed stream).

Procedure

1. Create a new window:

   ```
   CREATE WINDOW <name>
   ```

   You can also create a new stream or keyed stream.
2. Specify the primary key:

   ```
   PRIMARY KEY (…)
   ```
3. Specify the first derived element in the union:

   ```
   SELECT * FROM StreamWindow1
   ```
4. Add the UNION clause:

   ```
   UNION
   ```
5. Specify the second derived element in the union:

   ```
   SELECT * FROM StreamWindow2
   ```

6.5 Joins

Use joins to combine multiple datasources into a single query.

Streams, windows, and keyed streams can participate in a join. A join can contain any number of windows, but only one stream. Self joins are also supported. For example, you can include the same window more than once in a join, provided each instance has its own alias.

In a stream-window join, the target can be a stream or a window with aggregation. Using a window as a target requires an aggregation, because the stream-window join does not have keys and a window requires a key. The GROUP BY column in aggregation automatically forms the key for the target window.

> ℹ Note
>
> Unnamed windows are implicitly created when using a join with a window that produces a stream. The unnamed window is created to ensure that a join does not see records that have not yet arrived at the join. This can happen because the source to the join and the join itself are running in separate threads.

Joins are performed in pairs, but you can combine multiple joins to produce a complex multitable join. Depending on the complexity and nature of the join, the compiler may create intermediate joins. The comma join syntax supports only inner joins, and the WHERE clause in this syntax is optional. If you omit the WHERE clause, the join creates a many-many relationship between the streams in the FROM clause.

Joins in ANSI syntax can add the DYNAMIC modifier to a window or stream to indicate that its data changes frequently. A secondary index is created on windows joining with an incomplete primary key of a DYNAMIC window or stream. This improves performance but uses additional memory proportional to the total data length of key columns in the index. By default, windows and streams are STATIC and no secondary indexes are created.

The following table describes the join types supported by smart data streaming.

Join Type	Syntax	Description
Inner Join	`INNER JOIN`	One record from each side of the join is required for the join to produce a record.
Left Outer Join	`LEFT JOIN`	A record from the left side (outer side) of the join is produced regardless of whether a record exists on the right side (inner side). When a record on the right side does not exist, any column from the inner side has a NULL value.
Right Outer Join	`RIGHT JOIN`	Reverse of left outer join, where the right side is the outer side and the left side is the inner side of the join.
Full Outer Join	`FULL JOIN`	A record is produced whether there is a match on the right side or the left side of the join.

The following table describes the join cardinalities supported by smart data streaming.

Type	Description
One-One	Keys of one side of the join are completely mapped to the keys of the other side of the join. One incoming row produces only one row as output.
One-Many	One record from the one side joins with multiple records on the many side. The one side of the join is the side where all the primary keys are mapped to the other side of the join. Whenever a record comes on the one-side of the join, it produces many rows as the output.
Many-Many	The keys of both side of the join are not completely mapped to the keys of the other side of the join. A row arriving on either side of the join has the potential to produce multiple rows as output.

i Note

When a join produces multiple rows, the rows are grouped into a single transaction. If the transaction fails, all of the rows are discarded.

Example

This example joins two windows (`InStocks` and `InOptions`) using the FROM clause with ANSI syntax. The result is an output window:

```
CREATE INPUT Window InStocks SCHEMA StocksSchema Primary Key (Ts) ;
CREATE INPUT Window InOptions SCHEMA OptionsSchema Primary Key (Ts) KEEP ALL ;
CREATE Output Window OutStockOption  SCHEMA OutSchema
    Primary Key (Ts)
    KEEP ALL
AS
    SELECT InStocks.Ts Ts,
        InStocks.Symbol Symbol,
        InStocks.Price StockPrice,
        InStocks.Volume StockVolume,
        InOptions.StockSymbol StockSymbol,
        InOptions.OptionSymbol OptionSymbol,
        InOptions.Price OptionPrice,
        InOptions.Volume OptionVolume
    FROM InStocks JOIN InOptions
      ON
        InStocks.Symbol = InOptions.StockSymbol and
                    InStocks.Ts = InOptions.Ts ;
```

Keyed Stream Joins

When a keyed stream is the target of an inner join, ensure that the columns on which the join is performed do not change across an insert event and related update and delete events that follow. If the columns change, related events can be lost; the keyed stream may send update or delete events without the insert that provided the data being updated or deleted, or fail to send a delete for a previous insert.

Keyed streams are stateless except when performing a join with a window. In this type of join, the keyed stream uses memory to store a reference to the records in the window.

Restrictions on joins:

- A keyed stream can only be an outer member of an outer join (inner joins are supported).
- A keyed stream cannot participate in a full join.
- When you join a keyed stream with a window, only events that arrive in the keyed stream trigger a join; changes to the window do not.
- A keyed stream cannot be the target of a join when all inputs to the join are windows (named or unnamed).

Nested Joins

Implementing a nested join requires several important functions. Nested join syntax is supported in CCL, but you cannot create or edit a nested join in the visual editor. When a nested join is defined in the CCL file, and you switch to the visual editor, you see an empty join compartment.

In this section:

Creating and Modifying Join Queries [page 213]
Using the visual editor, produce a simple query that combines fields from multiple input events into a single output event.

Key Field Rules [page 214]
Key field rules ensure that rows are not rejected due to duplicate inserts or the key fields being NULL.

Join Examples: ANSI Syntax [page 215]
Examples of different join types using the ANSI syntax.

Join Example: Comma-Separated Syntax [page 217]
An example of a complex join using the comma-separated syntax.

6.5.1 Creating and Modifying Join Queries

Using the visual editor, produce a simple query that combines fields from multiple input events into a single output event.

Procedure

1. In the visual editor palette, in **Streams and Windows**, select **Join** ().
2. Select a location in the diagram and click to add the shape.
3. Connect the join object to the streams or windows that provide the inputs to the join.

   Connect join objects to two or more streams, windows, or Flex operators. Join objects can take input from two or more objects, but can produce only one output.

   > i Note
   >
   > Streams, windows and keyed streams can participate in a join. However, only one stream can participate in a join. For details of supported joins, see Joins [page 210].

   > → Tip
   >
   > To add multiple connections, **Shift+click** while holding the **Connector** tool. To return to normal selection, press **Esc** or click the **Select** tool in the palette to release it.

4. Use **Copy Columns from Input** to select input fields to include in the output of this query.
5. Add column expressions , as necessary.
6. Edit a column expression by selecting one of the tabs in the Properties view and editing the corresponding fields, or by:
   - Double-clicking to open the inline editor.
   - Selecting an expression and pressing **Ctrl+F2** to edit it using the pop-up expression editor.

   > → Tip
   >
   > When entering column names and their datatypes, use **Tab** to easily move between cells in the table.

7. Click **Add Join Condition** to specify the columns to use to match incoming events across the different sources.

   Complete the **Edit Join Expression** dialog to define the join type, data sources for the ON clause, and any other join constraints.

   > i Note
   >
   > If you create a join using comma-separated syntax in the text editor, and then add an ON clause using the **Edit Join Expression** dialog in the visual editor, the WHERE clause initially created in the comma-separated syntax will not be removed. This does not affect the result, however it will negatively affect performance.

If you do not see the columns you want in the **Edit Join Expression** dialog, ensure you have connected the join object to the correct input sources.

8. To join a column to itself, click **Add Input Alias** in the shape toolbar.
   A column alias is required to provide a unique name for each join condition.
9. (Optional) Use the toggle option to designate the join object as LOCAL or OUTPUT. By default, joins are OUTPUT.
10. (Optional) Select **Set Keep Policy** and choose an option.
    To edit the keep policy, right-click the input window or stream in the **Inputs** menu. Select **Set Keep Policy** to add a keep policy, and **Delete Keep Policy** to remove it.

Related Information

Specifying a Retention Policy [page 92]
Simple Queries [page 204]

6.5.2 Key Field Rules

Key field rules ensure that rows are not rejected due to duplicate inserts or the key fields being NULL.

- The key fields of the target are always derived completely from the keys of the 'many' side of the join. In a many-many relationship, the keys are derived from the keys of both sides of the join.
- In a one-one relationship, the keys are derived completely from either side of the relationship.
- In an outer join, the key fields are derived from the outer side of the join. An error is generated if the outer side of the join is not the many-side of a relationship.
- In a full-outer join, the number of key columns and the type of key columns need to be identical in all sources and targets. Also, the key columns require a `firstnonnull` expression that includes the corresponding key columns in the sources.

When the result of a join is a window, specific rules determine the columns that form the primary key of the target window. In a multitable join, the same rules apply because conceptually each join is produced in pairs, and the result of a join is then joined with another stream or window, and so on.

The following table summarizes the key field rules for joins:

Join Type	One-One	One-Many	Many-One	Many-Many
INNER	Include keys from at least one side in the projection list (or a combination of them if keys are composite).	Include keys from the right side in the projection list.	Include keys from the left side in the projection list.	Include keys from both sides in the projection list.
LEFT	Include keys from the left side alone.	Not allowed.	Include keys from the left side in the projection list.	Not allowed.

Join Type	One-One	One-Many	Many-One	Many-Many
RIGHT	Include keys from the right side alone.	Include keys from the right side in the projection list.	Not allowed.	Not allowed.
OUTER	Form keys using `firstnonnull()` on each pair of keys from both sides.	Not allowed.	Not allowed.	Not allowed.

6.5.3 Join Examples: ANSI Syntax

Examples of different join types using the ANSI syntax.

Refer to these inputs for the examples below:

```
CREATE INPUT STREAM S1 SCHEMA (Val1S1 integer, Val2S1 integer, Val3S1 string);
CREATE INPUT WINDOW W1 SCHEMA (Key1W1 integer, Key2W1 string, Val1W1 integer,
Val2W1 string) PRIMARY KEY (Key1W1, Key2W1);
CREATE INPUT WINDOW W2 SCHEMA (Key1W2 integer,  Key2W2 string, Val1W2 integer,
Val2W2 string) PRIMARY KEY (Key1W2, Key2W2);
CREATE INPUT WINDOW W3 SCHEMA (Key1W3 integer,  Val1W3 integer, Val2W3 string)
PRIMARY KEY (Key1W3);
```

Simple Inner Join: One-One

Here, keys can be derived from either W1 or W2:

```
CREATE OUTPUT WINDOW OW1
PRIMARY KEY  (Key1W2, Key2W2)
AS SELECT W1.*, W2.*
FROM W1 INNER JOIN W2 ON W1.Key1W1 = W2.Key1W2 AND W1.Key2W1 = W2.Key2W2;
```

Simple Left Join: One-One

The keys are derived from the outer side of the left join. It is incorrect to derive the keys from the inner side because the values could be null:

```
CREATE OUTPUT WINDOW OW2
PRIMARY KEY (Key1W1, Key2W1)
AS SELECT W1.*, W2.*
FROM W1 LEFT JOIN W2 ON W1.Key1W1 = W2.Key1W2 AND W1.Key2W1 = W2.Key2W2;
```

Simple Full Outer Join: One-One

The key columns all have a required `firstnonnull` expression in it:

```
CREATE OUTPUT WINDOW OW3
PRIMARY KEY (Key1, Key2)
AS SELECT firstnonnull(W1.Key1W1, W2.Key1W2) Key1, firstnonnull(W1.Key2W1,
W2.Key2W2) Key2, W1.*, W2.*
FROM W1 FULL JOIN W2 ON W1.Key1W1 = W2.Key1W2 AND W1.Key2W1 = W2.Key2W2;
```

Simple Left Join: Many-One

All the keys of W2 are mapped and only one key of W1 is mapped in this join. The many-side is W1 and the one-side is W2. The keys are derived from the many-side:

```
CREATE OUTPUT WINDOW OW4
PRIMARY KEY (Key1W1, Key2W1)
AS SELECT W1.*, W2.*
FROM W1 LEFT JOIN W2 ON W1.Key1W1 = W2.Key1W2 AND W1.Val2W1 = W2.Key2W2;
```

Simple Left Join: Many-One (DYNAMIC Modifier)

W3 is `DYNAMIC` and only one key of W1 is mapped in this join, so a secondary index is created on W1. W1 is also `DYNAMIC`, but all keys of W3 are mapped, so no secondary index is created on W3:

```
CREATE OUTPUT WINDOW OW5
PRIMARY KEY DEDUCED
AS SELECT W1.*, W3.*
FROM W1 (DYNAMIC) LEFT JOIN W3 (DYNAMIC) ON W1.Key1W1 = W3.Key1W3;
```

Simple Inner Join: Many-Many

This is a many-many join because neither of the keys is fully mapped. The keys of the target are the keys of all the windows participating in the join:

```
CREATE OUTPUT WINDOW OW6
PRIMARY KEY (Key1W1, Key2W1, Key1W2, Key2W2)
AS SELECT W1.*, W2.*
FROM W1 JOIN W2 ON W1.Val1W1 = W2.Val1W2 AND W1.Val2W1 = W2.Val2W2;
```

Simple Stream-Window Left Join

When a left join involves a stream, the stream is on the outer side. The target cannot be a window unless it is also performing aggregation:

```
CREATE OUTPUT STREAM OSW1
AS SELECT S1.*, W2.*
FROM S1 LEFT JOIN W2 ON S1.Val1S1 = W2.Key1W2 AND S1.Val3S1 = W2.Key2W2;
```

Complex Window-Window Join

The keys for OW4 can be derived either from W1 or W2 because of the inner join between the two tables:

```
CREATE OUTPUT WINDOW OW7
PRIMARY KEY DEDUCED
AS SELECT S1.*, W1.*, W2.*, W3.*   //Some column expression.
FROM S1 LEFT JOIN (W1 INNER JOIN (W2 LEFT JOIN W3 ON W2.Key1W2 = W3.Key1W3) ON
W1.Key1W1 = W2.Key1W2 AND W1.Key2W1 = W2.Key2W2) ON S1.Val1S1 = W1.Key1W1
WHERE W2.Key2W2 = 'abcd'
GROUP BY W1.Key1W1, W2.Key2W2
HAVING SUM(W3.Val1W3) > 10;
```

Complex Stream-Window Join

Here, the join is triggered only when a record arrives on S1. Also, because there is aggregation, the target is a window instead of being restricted to a stream:

```
CREATE OUTPUT WINDOW OW8
PRIMARY KEY DEDUCED
AS SELECT S1.*, W1.*, W2.*, W3.*   //Some column expression.
FROM S1 LEFT JOIN (W1 INNER JOIN (W2 LEFT JOIN W3 ON W2.Key1W2 = W3.Key1W3) ON
W1.Key1W1 = W2.Key1W2 AND W1.Key2W1 = W2.Key2W2) ON S1.Val1S1 = W1.Key1W1
WHERE W2.Key2W2 = 'abcd'
GROUP BY W1.Key1W1, W2.Key2W2
HAVING SUM(W3.Val1W3) > 10;
```

6.5.4 Join Example: Comma-Separated Syntax

An example of a complex join using the comma-separated syntax.

This join is a complex join of three windows using the comma-separated join syntax. The WHERE clause specifies the conditions on which records are joined.

```
CREATE OUTPUT WINDOW OW4
PRIMARY KEY DEDUCED
AS SELECT W1.*, W2.*, W3.*
FROM W1, W2, W3
WHERE W1.Key1W1 = W2.Key1W2 AND W1.Key2W1 = W2.Key2W2  AND W1.Key1W1 = W3.Key1W3;
```

6.6 Pattern Matching

Use the MATCHING clause in your CCL query to take input from one or more elements (streams, windows, or keyed streams), and produce records when a prescribed pattern is found within the input data.

Pattern streams can check whether events (rows from the input sources matching certain criteria) occur during a specific time interval, then send records to downstream streams if a match has occurred.

Pattern matching can be used to distill complex relationships between data into compact and easily-maintainable expressions.

> **i Note**
>
> The pattern rule engine uses any incoming event in order to match the defined pattern, regardless of the opcode of the incoming event. Include the opcode in each event's definition to filter out unwanted rows.

This example creates an output stream, `ThreeTrades`, which monitors the `QTrades` streams and sends a new event when it detects three trades on the same symbol within five seconds. The output of this stream is the symbol of the traded stock, and its latest three prices. The trades do not have to occur consecutively, but must occur within five seconds of each other. Multiple patterns may be in the process of being matched at the same time.

```
CREATE OUTPUT STREAM ThreeTrades
AS
SELECT
    T1.Symbol,
    T1.Price Price1,
    T2.Price Price2,
    T3.Price Price3
FROM
    QTrades T1,
    QTrades T2,
    QTrades T3
MATCHING[5 SECONDS: T1, T2, T3]
ON T1.Symbol = T2.Symbol = T3.Symbol;
```

For details on the MATCHING clause, see the *SAP Event Stream Processor: CCL Reference Guide*.

In this section:

6.6.1 Creating and Modifying Pattern Queries

In the visual editor, run a pattern-matching query that watches for a specific pattern of incoming events on one or more inputs and produces an output event when the pattern is detected. Pattern uses the CCL MATCHING clause.

Procedure

1. Open the SAP ESP Authoring perspective.
2. In the visual editor palette, in **Streams and Windows**, click **Pattern** ().
3. Select a location in the diagram and click to add the shape.
4. Connect the Pattern shape to one or more streams or windows that are the inputs to query.
5. Add columns:
    a. Click **Copy Columns from Input** () in the shape toolbar to select the columns to copy into the schema for the Pattern query.

       This is the schema of the new event that is produced when the pattern is detected.
    b. Add additional columns by clicking **Add Column Expression** in the shape toolbar.
6. Edit a column expression by selecting one of the tabs in the Properties view and editing the corresponding fields, or by:
    - Double-clicking to open the inline editor.
    - Selecting an expression and pressing **Ctrl+F2** to edit it using the pop-up expression editor.

> → Tip
>
> When entering column names and their datatypes, use **Tab** to easily move between cells in the table.

7. Create and edit a pattern expression:
    a. Click **Add Pattern** ().
    b. Enter an alias for the event.
    c. Enter either a time interval or parameters.
    d. To define the expression, right-click **Pattern** to add an event. Continue right-clicking elements of the expression to add operators and refine the event expression. Then click **Next.**
    e. Click **Add** to add a join condition.
8. (Optional) Use the toggle option to designate the pattern object as LOCAL or OUTPUT. By default, patterns are OUTPUT.

6.7 Aggregation

An aggregation window collects input records and groups them based on the values in the columns specified with the GROUP BY clause, producing one row of output per group. The output record for each group can contain summary statistics about the records in the group, such as average, sum, count, min, max, etc.

All records in each group have the same values for the columns specified in the GROUP BY clause. All columns specified in the GROUP BY clause must also be included in the SELECT clause, because these columns form the primary key for the aggregation window. This is why the primary key for the aggregate window uses the PRIMARY KEY DEDUCED clause instead of explicitly specifying a primary key.

When using aggregation, consider the memory usage implications. All of the input records for which an aggregate function is to be calculated are stored in memory. The data structure that holds all the records in memory is called the aggregation index.

Using the KEEP Clause for Aggregation Windows

When creating a window in CCL, the KEEP policy can be specified as part of the FROM clause to define an unnamed window, or it can be defined for the window itself. In the case of an aggregation window, the effects of the two are very different and are often misunderstood.

The first (and most common) method is to apply a KEEP clause to the input, creating an unnamed window that will be used for the input to the aggregation. In the following example, the aggregation is applied to an unnamed window that contains all events received from stream `Stream123` in the last 5 minutes:

```
CREATE INPUT STREAM Stream123
SCHEMA (SourceID string ,
        Value Integer ,
        Tstamp msdate );
/**@SIMPLEQUERY=AGGREGATE*/
CREATE OUTPUT WINDOW MovingAverage
PRIMARY KEY DEDUCED
AS SELECT
        Stream1.SourceID SourceID ,
        avg ( Stream123.Value ) Value ,
        max ( Stream123.Tstamp ) Tstamp
FROM Stream123 KEEP 5 MINUTES
GROUP BY Stream123.SourceID ;
```

The second method is to apply a KEEP clause to the window being created. Here, the KEEP policy will be applied to the output; it will be applied after aggregation and will be applied to the group records. Thus the KEEP policy will delete the summary record of any group that hasn't been added or updated recently, according to the KEEP policy. The following example uses this method:

```
CREATE INPUT WINDOW Window1
SCHEMA (SourceID string ,
        Value Integer ,
        Tstamp msdate )
PRIMARY KEY (SourceID)
KEEP 1 HOUR;
/**@SIMPLEQUERY=AGGREGATE*/
CREATE OUTPUT WINDOW MovingAverage
PRIMARY KEY DEDUCED
KEEP 5 MINUTES
```

```
AS      SELECT
         Window1.SourceID SourceID ,
         avg ( Window1.Value ) Value ,
         max ( Window1.Tstamp ) Tstamp
FROM Window1
GROUP BY Window1.SourceID ;
```

Note that this example does not create a 5 minute moving average. The KEEP 5 MINUTES policy is applied after aggregation and is applied to the rows in the window `MovingAverage`. So the average and max values will be computed across all records held in `Window1` (which has all record received in the last 1 hour), but any group that has not been added or updated in the last 5 minutes will be deleted from the `MovingAverage` window. Thus the window `MovingAverage` has a one hour moving average for all groups added or updated in the last 5 minutes.

Aggregating Over Streams: Avoiding Unbounded Growth

You often need to create an aggregation window that is fed by a stream, allowing you to compute aggregate values over events received from the stream. To compute aggregation values, an aggregation index is created on the input to an aggregation window. When a stream serves as the input to an aggregation window, it's important to specify a KEEP policy as part of the FROM clause, to limit the size of the aggregation index. Failure to specify a KEEP policy in the FROM clause will lead to unbounded growth of the aggregation index, eventually consuming all system resources and causing the project to shut down.

To prevent this, construct a SELECT clause that only uses additive aggregation functions. These are special aggregate functions that do not require an aggregation index and are computed incrementally.

When the projection contains only additive aggregation functions, the server performs additive optimization; therefore, there is no need to maintain an aggregation index, and memory does not grow. Supported additive aggregation functions are `sum`, `count`, `avg`, and `valueInserted`. For more information, see Improving Aggregation Performance [page 335]. Note that `last()` is not an additive function; you must use `valueinserted()` rather than `last()`. Here is an example:

```
CREATE INPUT STREAM Stream2
SCHEMA (SourceID string ,
         Value Integer ,
         Tstamp msdate );
/**@SIMPLEQUERY=AGGREGATE*/
CREATE OUTPUT WINDOW MovingAverage
PRIMARY KEY DEDUCED
AS      SELECT
         Stream2.SourceID SourceID ,
         avg ( Stream2.Value ) Value ,
         valueInserted ( Stream2.Tstamp ) Tstamp
FROM Stream2
GROUP BY Stream2.SourceID ;
```

> **i Note**
>
> If even one of the non-GROUP BY column expressions does not have an additive aggregation function, the server needs to maintain an aggregation index resulting in unbounded memory growth. If you select a column without specifying an additive aggregation function, it is considered as a non-additive function forcing the server to maintain an aggregation index.

Advanced Aggregation Techniques

In addition to the GROUP BY clause, you can optionally specify a GROUP FILTER and GROUP ORDER BY clause. The GROUP ORDER BY clause orders the records in a group by the specified columns before applying the GROUP FILTER clause and the aggregation functions. With the records ordered, aggregation functions sensitive to the order of the records such as `first`, `last`, and `nth` can be used meaningfully.

The GROUP FILTER clause is executed after the GROUP ORDER BY clause and eliminates any rows in the group that do not meet the filter condition. The specified filter condition can be used independently of the GROUP ORDER BY clause, but by ordering the group before filtering, the rank function can be used to filter the group. Here is an example:

After you execute the GROUP ORDER BY clause, every row in the group is ranked from 1 to N. This allows you to specify rank `() < 11` in the GROUP FILTER clause, which means that the aggregation function is only applied to the first 10 rows in the group after it has been ordered by the columns specified in the GROUP ORDER BY clause.

You can also specify an optional HAVING clause, which applies a filter after applying the aggregation functions to the records in a group. In other words, a filter specified in a HAVING clause will filter out the aggregate record for any group that does not meet the filter criteria.

> ℹ Note
>
> Note: You can only specify GROUP ORDER BY, GROUP FILTER, and HAVING clauses in conjunction with a GROUP BY clause.

In this section:

Creating and Modifying Aggregate Queries [page 222]
Using the visual editor, produce a simple query that combines data, similar to the CCL GROUP BY, GROUP FILTER, and GROUP ORDER clauses.

6.7.1 Creating and Modifying Aggregate Queries

Using the visual editor, produce a simple query that combines data, similar to the CCL GROUP BY, GROUP FILTER, and GROUP ORDER clauses.

Procedure

1. Open the SAP ESP Authoring perspective.
2. In the visual editor palette, in **Streams and Windows**, select **Aggregate** (Σ).
3. Select a location in the diagram and click to add the shape.
4. Connect the Aggregate shape to an input.
   The aggregate border changes from red to black, indicating that it is valid, now that it has input.

5. Add columns:
    a. Click **Copy Columns from Input** () in the shape toolbar to select the columns to copy into the schema for the Aggregate window.
    b. Add additional columns by clicking **Add Column Expression** in the shape toolbar.
6. Edit a column expression by selecting one of the tabs in the Properties view and editing the corresponding fields, or by:
    - Double-clicking to open the inline editor.
    - Selecting an expression and pressing **Ctrl+F2** to edit it using the pop-up expression editor.

    > → Tip
    >
    > When entering column names and their datatypes, use **Tab** to easily move between cells in the table.
7. Click **Add GroupBy Clause** ({ }) in the shape toolbar to edit the grouping of columns in the aggregate object.

    > i Note
    >
    > The Aggregate shape must have exactly one GROUP BY expression.
8. (Optional) Click **Set Keep Policy** () to create a retention window.

    The default policy is to keep all rows of incoming data. You can also choose to keep only the last row, a specific number of rows, or keep the rows for a specific time. This defines the KEEP clause. You can also go further, and retain the rows defined by the KEEP clause to span retention across multiple specified columns. This spanning of retention across columns is done by listing column names in the PER clause.
9. (Optional) Use the Toggle option to designate the aggregate object as LOCAL or OUTPUT. By default, aggregates are OUTPUT.

Related Information

Specifying a Retention Policy [page 92]
Simple Queries [page 204]

6.8 Working with Reference Table Queries

Reference table queries enable you to look up information in an SAP HANA database table in response to an incoming event.

Incoming events can arrive with only a portion of the information necessary to complete the processing you wish to specify in your project. When that additional information is present in existing tables in an SAP HANA database, you can use reference table queries to look it up. There are two parts to this: creating the table reference query, and using it to execute an ad hoc query in a join or Flex operator.

When creating the reference, determine what data you want to use. Then identify the table containing the data by name, obtain the schema of the table, and find out what service to use to contact the database. Decide whether you want to attempt to reconnect if the connection is dropped, and if so, how many times, and how long to wait between attempts.

When joining a stream or window to a reference, determine what you want as the output of the join. There are numerous restrictions on how to use references in joins, and what types of output you can obtain. For example, if you want the output of the join to be a window, you have to specify the primary key of the reference and use the complete primary key in the ON or WHERE clause of the join.

There are several different ways to use references within CCLScript programs. You can iterate over the rows in the table or grab specific rows. Basically, you can use a reference in the same ways you use a window. It is simply another source of data for processing in your CCLScript routine.

You can use references—in joins and in CCLScript programs—inside a module, as well as within the main body of your project. Like stores, references used in a module must be bound to a reference defined in the main body of your project.

Prerequisites

Install the SAP HANA ODBC client on the system where you want to run projects that include reference table queries. The minimum required version of the SAP HANA ODBC client is 1.0.73, but you should install the most recent version.

Database Service Definition

All connections to external databases, including reference table queries, are made using data services defined in the cluster. You can define or modify a data service definition using the Data Services view in the SAP ESP Authoring perspective. You can also use Studio to define the default SAP HANA service entry.

> **i Note**
>
> If the SAP HANA database on which you are making these queries is on an SAP HANA cluster, see *Configuring to Support SAP HANA Failover* in the *SAP Event Stream Processor: Configuration and Administration Guide* for details on how to add the other nodes in the SAP HANA cluster to the database service definition.

Caching

When a project joins streaming data to SAP HANA tables, such as customer or instrument information, reference table queries may repeatedly make the same requests. Since turning on caching for a reference table query enables local storage of previous query results, caching can improve the performance of the join or Flex operation using the reference table query. It can also reduce network traffic when the SAP HANA table being queried is on the network.

By default, caching is turned off (you can explicitly turn it off by setting `cachePolicy` to **NONE**). Turn it on by setting `cachePolicy` to **ONACCESS**.

By default, there are no limits on the size of the cache or the age of the cached query results, so the size of the cache keeps increasing as query results are cached. And, once the query results have been retrieved and cached, they will never be retrieved again.

If you want to be able to retrieve query results, you can specify the maximum physical size of the cache (`maxCacheSizeMB`), or how old a cached query result can be (`maxCacheAge`) before it is no longer returned when the query runs again, or both.

Error Handling

When you start a project that contains a reference table query, the query does a table schema compatibility check. The reference scans the database table and verifies that:

- For each column specified in the reference, there is a column of the same name (case-insensitive) in the table.
- The datatype of the column in the table is compatible with the datatype of the column in the reference.
- If the reference definition specifies a primary key, there is a matching primary key in the database. If the reference definition doesn't specify a primary key, it doesn't matter whether or not the database has a primary key.

To check the type for each mapped column and to be as database-agnostic as possible, the reference attempts to pull a sample row from the database. If it can pull that column into ESP, the check succeeds. Otherwise it fails, except in these cases:

- If the query that the reference uses to do the type-checking is rejected by the database (because it doesn't support SQL 2003 standards), the reference doesn't complete type-checking, but allows the project to start up, providing a warning that it can't guarantee that the type mapping is valid.
- If the table has no data in it, the type-checking stops, and a warning is printed that it can't guarantee that the type mapping is valid.

While a project is running, the error scenarios are mostly connection-based. When a failure is caused by a lost connection, the server attempts to reconnect based on the reconnect parameters specified in the reference's definition.

In this section:

Use a reference table query to obtain data from an SAP HANA database table for processing by a CCLScript routine in a Flex operator.

Using a Reference Table Query in CCLScript [page 231]

This example uses a reference table query within a CCLScript routine that iterates over the rows in a table to obtain data about a specified baseball player's batting history that is then used to compute statistics.

Using a Reference Table Query in CCLScript to Get a Single Row from a Table [page 233]

This example uses a reference table query within a CCLScript routine to obtain a single row from a table.

6.8.1 Creating a Reference Table Query Using Schema Discovery

Create a reference in a ESP project that queries a table in an SAP HANA database.

Context

You can create reference table queries either in the Studio visual editor, or directly in CCL. Create a reference table query in CCL using the CREATE REFERENCE statement.

If you create the reference table query using the visual editor, you can:

- Use the schema discovery wizard to fill out the query properties.
- Manually enter values for each property.
- Use a mix of both discovery and manual input through the properties view.

Procedure

1. Open the SAP ESP Authoring perspective.
2. In the palette, expand Streams and Windows and select **Reference** ( ).
3. Select a location in the diagram and click to add the shape.
4. Provide a name for the **Reference** ( ).
5. Click on Schema Discovery ( ).
   Studio displays the Schema Discovery dialog box. The **service** field is populated with the name of the default SAP HANA service entry, as defined in Studio. If you have not designated a default SAP HANA service entry, you are prompted to do so.
6. In the **service** field:
   - Leave the specified service name, to use it when connecting to the external database.

- ○ Replace the specified service with another service, as defined in the Studio Data Services View.
- ○ Click on **Discover** and select from the list of services displayed.

7. In the **Source Schema** field:
    - ○ Enter the name of the schema for the external database containing the table the reference will query.
    - ○ Click on **Discover** and select from the list of schemas displayed.
8. In the **Source** field:
    - ○ Enter the name of the table the reference will query.
    - ○ Click on **Discover** and select from the list of tables displayed.
9. Select the **Discover Primary Keys** checkbox to define primary keys in the reference matching those in the external database table. This is optional, but highly recommended to provide maximum flexibility when using the reference.
10. Click **OK**.

    By default, ESP builds the reference schema based on the schema of the external database table. Once the reference schema has been built, you can remove a column by right-clicking anywhere on the column and choosing **delete element**. Edit the column properties within the reference shape by double-clicking on the property names or edit them in the Properties view. The datatypes in the source schema for the reference must be compatible with those in the target SAP HANA database table.

    You can create a reference within a module; a reference created outside of a module cannot be used in a module. See Creating a Module in the Visual Editor [page 174] .

Results

This method omits several additional properties that you can set through the properties view of the SAP ESP Authoring perspective. See *CREATE REFERENCE Statement* in the *SAP Event Stream Processor: CCL Reference* for a list of all the properties and their definitions.

Related Information

SAP Event Stream Processor: CCL Reference

6.8.2 Using a Reference Table Query in a Join

This example shows the procedure for creating a reference table query, an input stream, and an output stream that implements a join of data from the reference table query and the input stream to add customer data to an incoming order.

Procedure

1. Obtain the necessary information about the external database table containing the information you wish to look up:
   - The name of the table containing the data
   - The schema for that table
   - The service to use to connect to it
2. Create the reference table query in your project:

   ```
   CREATE REFERENCE customerRef
   SCHEMA (customerID integer, fullName string, address string)
   PRIMARY KEY (customerID)
   PROPERTIES
   service='databaseLookup',source='customerAddr',sourceSchema='addressSchema';
   ```

   The schema of the reference does not have to include all of the columns in the source table or list them in the same order. For each column that you do specify in the schema, however, the column name must match the column name in the database, and the datatype must be compatible with the datatype in the database.

   The `customerID` column is the primary key in the source table, and it contains a unique number assigned to each customer. A primary key is not required to produce a stream; only a window. If you declare a primary key for the reference, however, it must match the primary key in the table. So, whenever the table has a primary key, it is a good practice to make it the primary key of the reference table query (giving you the flexibility to produce either a stream or a window).

   When you specify a primary key in a reference table query, also include the `sourceSchema` property, which identifies the schema, in this case `addressSchema`, of the database containing the table.
3. Create the input stream for events to enter the project:

   ```
   CREATE INPUT STREAM orderStream
   SCHEMA (orderID integer, customerID integer, itemID integer);
   ```
4. Create an output stream that implements a join of the incoming event with the data obtained from the reference table query:

   ```
   CREATE OUTPUT STREAM orderWithCustomerInfoStream
   SCHEMA (orderID integer, customerName string, customerAddress string)
   AS SELECT orderStream.orderID, customerRef.fullName, customerRef.address
   FROM orderStream, customerRef
   WHERE orderStream.customerID=customerRef.customerID;
   ```

   While the column names in the output stream's schema declaration, `customerName` and `customerAddress`, do not have to match the column names in the table, `fullName` and `address`, the datatypes in the output stream's schema must match the datatypes in the table.

6.8.3 Using a Reference Table Query in a Module

This example obtains a bibliography for the specified author using a reference table query inside of a module.

Context

In this example, an order for a book produces a list of other books by that author. Because this list may be desired in response to other events, it is produced within a module.

Procedure

1. Obtain the necessary information about the external database table containing the information you wish to look up:
   - The name of the table containing the data
   - The schema for that table
   - The service to use to connect to it
2. Create the reference table query in your project. When you define a reference in a module, it is always mapped to a reference in your project that contains the connection information for the database:

   ```
   CREATE REFERENCE getBiblio
   SCHEMA (authorName string, bookTitle string, publisher string)
   PROPERTIES
   service='databaseLookup',source='bibliographies',sourceSchema='bookSchema';
   ```

   If you think that the reference table query will make the same requests many times, specify a cache. This example shows a cache that can use up to two megabytes of storage and holds a query result for up to two hours:

   ```
   CREATE REFERENCE getBiblio
   SCHEMA (authorName string, bookTitle string, publisher string)
   PROPERTIES
   service='databaseLookup',source='bibliographies',sourceSchema='bookSchema',
   cachePolicy='ONACCESS',maxCacheSizeMB=2,maxCacheAge=2 hours;
   ```

   > ℹ Note
   >
   > To decide whether to enable caching, consider how often you expect the same request to be made. To decide whether to limit the size of the cache or the amount of time a query result is held, consider the amount and type of data you expect the query to return.

3. Create an input stream for order events to enter the project:

   ```
   CREATE INPUT STREAM orderStream
   SCHEMA (orderID integer, customerID integer, itemID integer, authorName
   string);
   ```

4. Create a module that uses this table reference query. In the module, you only need to specify the name and schema of the reference table query:

```
CREATE MODULE listOtherBooks
IN orderStream
OUT otherBooks
REFERENCES getBiblio
BEGIN
    CREATE REFERENCE getBiblio
        SCHEMA (authorName string, bookTitle string, publisher string);
    CREATE INPUT STREAM orderStream
        SCHEMA (orderID integer, customerID integer, itemID integer, 
authorName string);
    CREATE OUTPUT STREAM otherBooks
        SCHEMA (authorName string, bookTitle string, publisher string)
        AS SELECT orderStream.authorName, getBiblio.bookTitle, 
getBiblio.publisher
        FROM orderStream, getBiblio
        WHERE orderStream.authorName=getBiblio.authorName;
END;
```

5. Load the module to generate the list of other works by the author of the book that was ordered. Loading the module creates a mapping between the streams in the main project and in the module. The output from the module goes to the `otherBooks` local stream in the main project:

```
LOAD MODULE listOtherBooks AS listAll
    IN
        orderStream = orderStream
    OUT
        otherBooks = otherBooks
    REFERENCES
        getBiblio = getBiblio;
```

6. Create an output stream to read the local stream `otherBooks` and display the list of other books by the author:

```
CREATE OUTPUT STREAM otherBooksOutput
SCHEMA (authorName string, bookTitle string, publisher string)
AS SELECT * FROM otherBooks;
```

6.8.4 Using a Reference Table Query in a Flex Operator

Use a reference table query to obtain data from an SAP HANA database table for processing by a CCLScript routine in a Flex operator.

Procedure

1. Obtain the necessary information about the external database table containing the information you wish to look up:
   - The name of the table containing the data
   - The schema for that table
   - The service to use to connect to it

2. Create the reference table query in your project.
3. Create the input stream or window.
4. Create the Flex operator:
    a. From the palette, under **Streams and Windows**, select **Flex** (), then click an empty area in the diagram.
    b. From the palette, select **Connector** and connect the input stream or window to the Flex operator.
    c. From the palette, select **Connector** and connect the reference table query to the Flex operator.
    d. Define the schema for the Flex operator.
    e. (Optional) Click on **Aging Policy** ().
    f. (Optional) Click **Set Output Keep Policy** () to set keep policy options.
5. Implement a CCLScript routine:
    a. In the Flex operator, under Methods, click on the () of the expression you wish to edit.
    b. In the **Edit Expression Value** dialog box, write the CCLScript script you wish to implement.

       See Using a Reference Table Query in CCLScript [page 231] and Using a Reference Table Query in CCLScript to Get a Single Row from a Table [page 233] for examples of CCLScript routines in a Flex operator.

6.8.5 Using a Reference Table Query in CCLScript

This example uses a reference table query within a CCLScript routine that iterates over the rows in a table to obtain data about a specified baseball player's batting history that is then used to compute statistics.

Procedure

1. Obtain the necessary information about the external database table containing the information you wish to look up:
    - The name of the table containing the data.
    - The schema for that table.
    - The service to use to connect to it.
2. Create the reference table query in your project.

   For example, create a reference table query named `AtBats`:

   ```
   CREATE REFERENCE AtBats
   SCHEMA (teamAtBat INTEGER, player STRING, bases INTEGER)
   PRIMARY KEY (teamAtBat)
   PROPERTIES service='HANA',source='Batting',sourceSchema='BattingSchema';
   ```

   The `teamAtBat` is incremented each time a player bats a ball, providing a unique number for each at-bat by a member of the team, so that column is the primary key in the source table. It must also be the primary key of the reference table query. Because we have specified a primary key in this reference, we have to include the `sourceSchema` property, which identifies the schema, `BattingSchema`, of the database containing the table.

3. Create the input stream for events to enter the project.

   For any event that is the appearance, or mention, of a player's name, create an input stream named StatRequest, consisting of a single string, player:

   ```
   CREATE INPUT STREAM StatRequest SCHEMA (player STRING);
   ```

4. Initialize the Flex operator, named Percentage, to read in the reference query AtBats and the input stream StatRequest, specify the output stream PercentageOutput, and set the variables <atBats> and <hits> to zero:

   ```
   CREATE FLEX Percentage IN AtBats, StatRequest
   OUT OUTPUT STREAM PercentageOutput SCHEMA (atBatPercentage float)
   BEGIN
      ON StatRequest {
         integer atBats := 0;
         integer hits := 0;
   ```

5. Close the Flex operator by dividing the number of <hits> by the number of <atBats> to calculate the batting average, <percentage>, placing that value in the <atBatPercentage> column of the output stream, and outputting it:

   ```
         float percentage := hits/atBats;
         output [atBatPercentage=percentage];
      };
   END;
   ```

6. Between the initialization and close of the Flex operator, add a CCLScript routine to iterate through the entries in the Batting table to find out how many times the player was at bat and how many times he hit a ball. There are three ways to do this:

   a. Use the for and if commands to handle iterating through the records, and take advantage of the <AtBats_stream> that is automatically created with the **AtBats** reference query:

      ```
            for ( record in AtBats_stream ) {
               if ( record.player = StatRequest.player ) {
                  if ( record.bases > 0 ) {
                     hits := hits + 1;
                  }
                  atBats := atBats + 1;
               }
            }
      ```

      This method has the advantage of being easy to read and maintain.

   b. Use the modified for command syntax that incorporates testing whether the player name from the input stream matches the player name in the table entry:

      ```
            for ( record in AtBats_stream where player = StatRequest.player ) {
               if ( record.bases > 0 ) {
                  hits:= hits + 1;
               }
               atBats := atBats + 1;
            }
      ```

      This method has the advantage of reducing processing time, because the records of other players are never pulled from the reference table.

c. Explicitly create and modify the iterator to use across the table, again taking advantage of the <AtBats_stream> that is automatically created with the AtBats reference query:

```
 AtBats_iterator := getIterator( AtBats_stream );
resetIterator( AtBats_iterator);
setRange( AtBats_iterator, player, StatRequest.player );
typeof(AtBats) result := getNext( AtBats_iterator );
while (not(isnull(result))) {
  if ( result.bases > 0 ) {
    hits := hits + 1;
  }
  atBats := atBats + 1;
  result := getNext( AtBats_iterator );
}
```

This method has the advantage of giving you the most explicit control over the processing.

6.8.6 Using a Reference Table Query in CCLScript to Get a Single Row from a Table

This example uses a reference table query within a CCLScript routine to obtain a single row from a table.

Context

In this example, we want to obtain a list of chain restaurants that have a franchise in a specified city.

Procedure

1. Obtain the necessary information about the external database table containing the row you want to obtain:
   - The name of the table containing the data
   - The schema for that table
   - The service to use to connect to it
2. Create a reference table query in your project.

   In this example, the reference table name is restaurants:

   ```
   CREATE REFERENCE restaurants
   SCHEMA (storeID integer, city string, name string, address string)
   PROPERTIES service='HANA', source='restaurants';
   ```

   Because we have not specified a primary key in this reference, you can omit the sourceSchema property.
3. Create a second reference table query in your project.

   In this example, the reference table query name is chainList:

   ```
   CREATE REFERENCE chainList
   SCHEMA (chainID integer, name string, headquarterAddress string)
   ```

```
PROPERTIES service='HANA', source='chainList';
```

4. Create the input stream for events to enter the project.

   In this example, the input stream is named `restaurantQuery`, and consists of a single string, `city`:

   ```
   CREATE INPUT STREAM restaurantQuery SCHEMA (city string);
   ```

5. Initialize the Flex operator, named `optionQuery`, to read in the reference table queries `restaurants` and `chainLis`, and `restaurantQuery`. Output the restaurant chain names in the output stream `chainsInCity` when it receives the name of a city in the `restaurantQuery` stream:

   ```
   CREATE FLEX optionQuery
   IN restaurants, chainList, restaurantQuery
   OUT OUTPUT STREAM chainsInCity
   SCHEMA (name string, address string)
   BEGIN
      ON restaurantQuery {
   ```

6. Add a CCLScript routine to produce the list of chains that have a presence in the city. For each restaurant chain in the `chainList` table, it grabs the first instance of that chain name in the `restaurants` table whose address is in the city specified in the `restaurantQuery` input stream and outputs the restaurant chain name and address.

   ```
         for (record in chainList_stream) {
            typeof(restaurants) inCity :=
   restaurants_stream{[city=restaurantQuery.city;name=record.name;]};
            output [name=inCity.name;address=restaurants.address;];
         }
   ```

7. Since you are not performing any calculations at this time, close the Flex operator.

   ```
      };
   END;
   ```

6.9 Creating and Modifying Compute Queries

In the visual editor, produce a simple query that transforms the schema or field values of each incoming record. Each incoming event produces one new output event from the fields defined by the column expressions.

Context

The compute query creates in-line expressions in a stream or window. In the visual editor, the compute query is a shape within the palette. In the text editor, the compute query shape becomes a SELECT statement with column expressions.

Procedure

1. Open the SAP ESP Authoring perspective.
2. In the visual editor palette, in **Streams and Windows**, select **Compute** ().
3. Select a location in the diagram and click to add the shape.
4. Attach the compute object to the stream or window that provides input to this query.

   Attach compute objects to any stream, window, or Flex operator. Compute objects can have only one input. Any attempt to connect more than one input source is blocked.
5. Add columns:
   a. Click **Copy Columns from Input** () in the shape toolbar to copy input fields into the schema for this query.
   b. Add additional columns by clicking **Add Column Expression** in the shape toolbar.
   c. Edit a column expression by double-clicking to open the inline editor, by selecting one of the tabs in the Properties view, or by selecting an expression and pressing **Ctrl+F2** to edit it using the pop-up expression editor.

   > → Tip
   >
   > When entering column names and their datatypes, use **Tab** to easily move between cells in the table.
6. Add column expressions , as necessary.
7. Modify column expressions by selecting and modifying them directly, or by editing the corresponding fields in the Properties view.
8. Use the toggle option to designate the compute object as INPUT or OUTPUT. By default, computes are OUTPUT.

> Example
>
> You can also create compute queries in CCL, by using in-line expressions:

```
CREATE OUTPUT WINDOW Compute2 PRIMARY KEY DEDUCED KEEP 10 ROWS
AS
    SELECT
        InputWindow1.Column1 Column1 ,
        InputWindow1.Column2 + InputWindow1.Column3 theSum FROM InputWindow1 ;
```

6.10 Connecting a Stream to a Derived Window

Use a GROUP BY clause or the `nextval()` function to connect a stream to a derived window as part of a complex query.

A derived window is a stateful element that requires either an explicit or deduced primary key. When connecting a stream to a derived window, you assign a primary key by using either a GROUP BY clause or the `nextval()` function. Use the GROUP BY clause to aggregate column expressions from the stream to deduce a primary key when you compile the project in Studio. You cannot explicitly specify a primary key using the

GROUP BY clause. Use the `nextval()` function to assign an explicit primary key in the absence of a GROUP BY clause.

When using the GROUP BY clause, you should only use additive functions, such as `valueInserted()`, `sum()`, `avg()`, and `count()`, for all column expressions other than the GROUP BY columns. Additive functions allow the server to optimize the aggregation so that additional aggregation indexes are not maintained, which avoids unwanted memory consumption, as an aggregation index holds all of the records in memory. This improves the performance of the aggregation operation considerably. For more information, see Improving Aggregation Performance [page 335]. If using only additive functions is not an option, specify a retention policy other than KEEP ALL on the stream to limit the growth of the aggregation index.

In this section:

6.10.1 Connecting a Stream to a Derived Window Using the GROUP BY Clause

Use the GROUP BY clause to set a primary key for a derived window that is connected to a stream.

Procedure

1. Open a new or existing ESP project in Studio.
2. Connect a stream to a derived window.
3. In the derived window, click **Add Edit Group by Clause** ({ }).
4. Add the number of columns to group together. Click **OK**.

6.10.2 Connecting a Stream to a Derived Window Using nextval()

Use the `nextval()` function to set a primary key for a derived window that is connected to a stream.

Procedure

1. Open a new or existing ESP project in Studio.

2. Connect a stream to a derived window.
3. In the derived window under column expressions, right-click the wildcard and select **Delete Element**.
4. Select **Copy Columns from Input** to add the column expressions from the input window.
5. Click the dropdown menu for the derived window and select ▸ **Modify** ▸ **Edit Primary Keys** ▸.
6. In the dialog box, add a column as the primary key. Click **OK**.
7. Right-click the expression value for the primary key column and select **Edit Expression Value**.
8. Delete the expression value and replace it with `nextval()`. Click **OK**.

7 Exposing a Project as a Web Service

To expose a project as a Web service using one of the SAP Event Stream Processor Web Services providers, set the Web Service Enabled option to true in the project configuration (`.ccr`) file.

Prerequisites

- Start the Web Services Provider on which you are exposing the project.
- To run a project in a workspace other than the default, ensure that one or more connected workspaces are available.

Procedure

1. Select **File** > **Open** > **Project...** and open the project you want to run.
2. Double-click the project configuration file (`<project-name>.ccr`) to open the CCR Project Configuration editor.
3. Select the **Advanced** tab.
4. Choose a project deployment type from the Project Deployment Details window. The following table describes the project deployment type options:

Type	Description
Non-HA	Non-HA deployments create one project option item and one instance item as children under the project deployment item.
HA	HA deployments create one project option item and two instance items as children under the project deployment item. HA provides for hot project failover between instances.

5. Set the value of the Web Service Enabled option to **true** in the Project Deployment Details window.
6. Save the updated `ccr` file.
7. For the changes to take effect, choose one of the following:
   - Use Studio or `streamingclusteradmin` to stop and remove the project from the node, then redeploy (add) the project.
   - Restart the cluster on which the project runs.
8. To run the project, choose one of the following:
   - Click **Run ESP Project** ▶ in the main toolbar (in either the SAP ESP Authoring or the SAP ESP Run-Test perspective) to run the project in the default workspace.

- Click the dropdown arrow next to the Run Project tool and choose **Run ESP Project in Workspace**. Then select the workspace where this project will run.

The project runs and shows results in the SAP ESP Run-Test perspective.

8 Zero Data Loss

Zero data loss protects a project against data loss in the event of a client failure, server failure, or both. Achieving zero data loss requires a judicious use of log stores when you set up the project, as well as configuration of project options and clients that use guaranteed delivery (GD).

With zero data loss:

- SAP Event Stream Processor recovers streams or windows protected by one or more log stores to a consistent state as of the most recent checkpoint. (Any uncheckpointed data is lost and must be sent again by the publisher.)
- You can be confident you will not miss any events.
- Clients can minimize the number of duplicate events they receive by controlling how frequently they issue GD commits.
- Publishers can ensure that the data they publish is fully processed by the server and thereby reduce transmission of duplicates when the server restarts.
- You can optionally configure the server to control how frequently it issues automatic checkpoints and thus control how much uncheckpointed data is liable to be lost on a server failure.
- At the expense of performance, you can minimize (but not fully eliminate) the production of duplicate rows on server or subscriber restart by tweaking how frequently the server checkpoints data and how frequently GD subscribers issue GD commits.

In this section:

8.1 Guaranteed Delivery

Guaranteed delivery (GD) is a delivery mechanism that supports high availability. It ensures that data continues to be processed from a stream or window even if the SAP ESP server fails, the destination (third-party server) fails, or the destination does not respond for a period of time.

Guaranteed Delivery

Guaranteed delivery (GD) uses log stores to ensure that a GD subscriber registered with a GD stream or window receives all the data processed by that stream or window even if the client is not connected when the data is produced. GD is supported on streams and windows and each GD stream or window requires a GD log store.

You can specify GD support for a stream or window in the studio visual editor, or in CCL. A GD stream or window supports multiple GD subscribers as well as both GD and non-GD subscriptions.

To use GD:

- Assign a log store to every stream and window in the project that cannot be recovered by an upstream provider.
- Do at least one of the following:
  - Enable GD on any bindings for the project.
  - Enable GD on project adapters that support it.
  - Use the C++ SDK, the Java SDK, or the .NET SDK to configure publishers sending data to your project to retransmit any data for which they do not receive a commit confirmation.
  - Use the C++ SDK, the Java SDK, or the .NET SDK to set up GD subscriptions for client applications. For more information, see the instructions on subscribing with guaranteed delivery in the *SAP Event Stream Processor: SDK Guide*.

SAP Event Stream Processor projects that have at least one GD-enabled stream or window provide information on GD in two metadata streams:

- _ESP_Streams - tells you whether GD is enabled for the stream or window
- _ESP_GD_Sessions - lists active and inactive GD sessions, identifies the sequence number of the last event committed for each stream or window a GD session subscribes to and the last update time for an entry, and identifies the user associated with this session (that is, the user who initiated the subscription).

For details on these metadata streams, see the *SAP Event Stream Processor: Configuration and Administration Guide*.

You can subscribe to the metadata streams using the C++ SDK, the Java SDK, or the .NET SDK. You can also monitor the streams yourself using `streamingsubscribe` (see the *SAP Event Stream Processor: Utilities Guide*) or the Studio Server view. Event Stream Processor stores data from the _ESP_GD_Sessions metadata stream in a special metadata log store so it will be available after a crash.

You can subscribe to streams and windows configured for GD using adapters, bindings, the SDKs, or the subscribe tool.

Adapters

Enable guaranteed delivery on the adapters that support it and configure the GD adapter parameters. See the *SAP Event Stream Processor: Adapters Guide* for information on adapter support for GD.

Bindings

Enable GD on any project bindings to ensure that data is delivered to remote projects. See *Using Bindings to Connect CCL Projects* for more information on how to enable GD for project bindings.

SDKs

In the SDKs, set up GD subscriptions so each client can receive data and checkpoint messages from your project. The client, in turn, periodically responds to the project server with a commit message reporting the sequence number of the latest event the client has processed. The server need not save events once it knows that all GD clients have processed them, so it can free up their space for other uses. See the *SAP Event Stream Processor: SDK Guide* for more information.

Subscribe Tool

For testing or simple use cases, use the `streamingsubscribe` tool to subscribe in GD mode. See the *SAP Event Stream Processor: Utilities Guide* for details.

Consistent Recovery and Auto Checkpoint

Consistent recovery mode ensures that if the server restarts, it recovers the state of all streams and windows in a project to the last successful checkpoint state—provided you have followed the rules related to assigning streams and windows to log stores. Consistent recovery is achieved by checkpointing all log stores atomically. If any checkpoints fail (which happens, for example, when the server shuts downs in the middle of a checkpoint or there is not enough space in the log stores), Event Stream Processor rolls all the log stores back to the last successful checkpointed state.

Use the Auto Checkpoint project option to set the number of input transactions that trigger a checkpoint. Input transaction refers to records, transactions, or envelopes published to the server and currently in flight. More frequent checkpoints reduce the risk of data loss; less frequent checkpoints reduce the burden on system resources and may improve performance. Note that the frequency N you set with this option only ensures that a checkpoint happens at least every N transactions. Checkpoints might happen at other times if the system decides that it is necessary or if a publisher issues a commit when the server is running in consistent recovery mode.

Do not use Auto Checkpoint if a publisher is already configured to issue commits.

> **i Note**
>
> SAP does not recommend using consistent recovery mode in projects where active-active HA mode is also enabled. Because ESP is nondeterministic, enabling consistent recovery mode on the instances of an active-active project cannot be guaranteed to produce the same data in the primary and secondary instances if there is a failure.

Consistent recovery can be used with or without guaranteed delivery enabled. Consistent recovery protects data flowing into and through a project, while guaranteed delivery ensures that data flowing out of a project can be recovered. See *Consistent Recovery* and *Auto Checkpoint*for more information.

Recommendations for Guaranteed Delivery Subscribers

Follow these recommendations to reduce your chances of receiving duplicate rows or inconsistent data after a subscriber or server restart.

- To minimize data loss, enable consistent recovery and configure either:
    - The publisher to issue commits frequently. See the *SAP Event Stream Processor: SDK Guide* for more information.
    - The Auto Checkpoint project deployment option to control how frequently the client receives checkpoint messages.

  See the *SAP Event Stream Processor: Configuration and Administration Guide* for details on setting Auto Checkpoint and other project deployment options.
- Subscribe to a stream or window on which GD is enabled. You can identify GD-enabled streams and windows by using:
    - The `supports_gd` command in the `streamingprojectclient` utility. See the *SAP Event Stream Processor: Utilities Guide* for more information.
    - Commands in the SDKs. See the *SAP Event Stream Processor: SDK Guide* for more information.
    - The _ESP_Streams metadata window—look for streams that have a nonzero entry in the gd_support column. See the *SAP Event Stream Processor: Configuration and Administration Guide* for more information.
- Send data on to your client as it arrives or buffer it locally. Issue commits for only those messages for which you have received a checkpoint notification. If the client does not support commits, deliver only those messages that have been checkpointed by the server and cache the rest locally. This ensures that the client is always consistent with the server on a restart after a client or server failure.
- When the ESP server sends a checkpoint message, send a commit to the client or send the buffered rows followed by a commit.
- Issue a GD commit with the last committed sequence number to ensure that the server does not send the data again the next time the server or the subscription restarts. However, if the server does not shut down cleanly, it resends committed events that were not checkpointed.

Persistent Subscribe Pattern

In some situations, you can also use a persistent subscribe pattern (PSP), which is an older delivery mechanism for high availability.

If possible, use guaranteed delivery rather than persistent subscribe pattern. GD uses CPU and memory resources more efficiently and is more flexible from a development standpoint, because it does not force you to decide how many subscribers will be supported when you set it up. However, you might prefer PSP if you do not want the guaranteed delivery store to be a log store for performance reasons. Using a memory store allows recovery when the client restarts, but not when the project restarts.

For more information, see Adding a Persistent Subscribe Pattern [page 245].

In this section:

Adding a Persistent Subscribe Pattern [page 245]
Set up a persistent subscribe pattern (PSP) for any element in a project.

Parent topic: Zero Data Loss [page 240]

Related Information

Consistent Recovery [page 247]
Auto Checkpoint [page 248]
Achieving Zero Data Loss [page 249]

8.1.1 Adding Guaranteed Delivery

Configure guaranteed delivery (GD) in Studio for a stream or window to ensure that its output is delivered to subscribers.

Prerequisites

- Create at least one log store to be used as a GD log store, in which the guaranteed delivery stream or window stores its events and GD logs.
- In the CCR Project Configuration editor,
  - Make sure the Consistent Recovery project deployment option is enabled.
  - (Optional) Enable the Auto Checkpoint project deployment option.

> i Note
>
> If you already have a publisher attached to your project that is configured to issue commits, do not enable Auto Checkpoint.

Context

Set up a GD stream or window using a CREATE STREAM, CREATE WINDOW, or CREATE FLEX statement. Assign a GD log store to each GD-enabled stream or window. Do not create GD-enabled streams or windows inside modules—this is not supported because you cannot attach adapters or subscribe directly to elements in modules.

A stream or window configured for GD also supports non-GD subscriptions. Enabling GD does not significantly affect the stream or window's performance when it has no registered GD subscribers.

You can subscribe to streams and windows configured for GD using adapters, bindings, the SDKs, or the subscribe tool.

Procedure

1. Choose the stream or window to support GD.
2. (Optional) If a window that you want to support GD does not exist, create a new window:
   a. In the visual editor palette, in Streams and Windows, select an option to create a stream or window.
      - Streams that support GD include **Input Stream**, **Derived Stream**, and **Flex**.
      - Windows that support GD include **Input Window**, **Derived Window**, **Flex**, **Aggregate**, **Compute**, and **Join**.

   b. Select a location in the diagram and click to add the stream or window.
3. Select the new element and look at its Properties view. (If the Properties view is not visible, from the main menu select **Window** > **Show View** > **Properties**.)
4. In the Properties view:
   a. Select the **Properties** tab and click to check the **Supports Guaranteed Delivery** box.
   b. From the **Guaranteed Delivery Store** dropdown, select the log store you created for this element's GD logs.
   c. (For GD windows only) Select the **General** tab. In the **Store** field, enter the name of the log store you created for the GD window.

8.1.2 Adding a Persistent Subscribe Pattern

Set up a persistent subscribe pattern (PSP) for any element in a project.

Context

> **i Note**
>
> Whenever possible, use guaranteed delivery instead of PSP. See Guaranteed Delivery [page 241] for more information.

Set up PSP for each subscriber individually. Enabling PSP on a data stream or window creates two new elements:

- A log window (a Flex operator with a log store)
- A truncate window (also called the control window)

The data stream or window on which PSP is enabled and the truncate window plug into the log window. The PSP-enabled stream or window delivers data to the log window. The log window generates a sequence number, takes the opcode from the data, and places them at the beginning of each row of data. The log window sends this data to the output adapter that is attached to it. The adapter, taking advantage of guaranteed processing features on the subscribing system (where the data will be consumed), determines when to notify the truncate window that rows marked for deletion have been processed by the subscriber. When it receives this notification, the truncate window informs the log window that the data that has been processed and the log window removes the data from its log store.

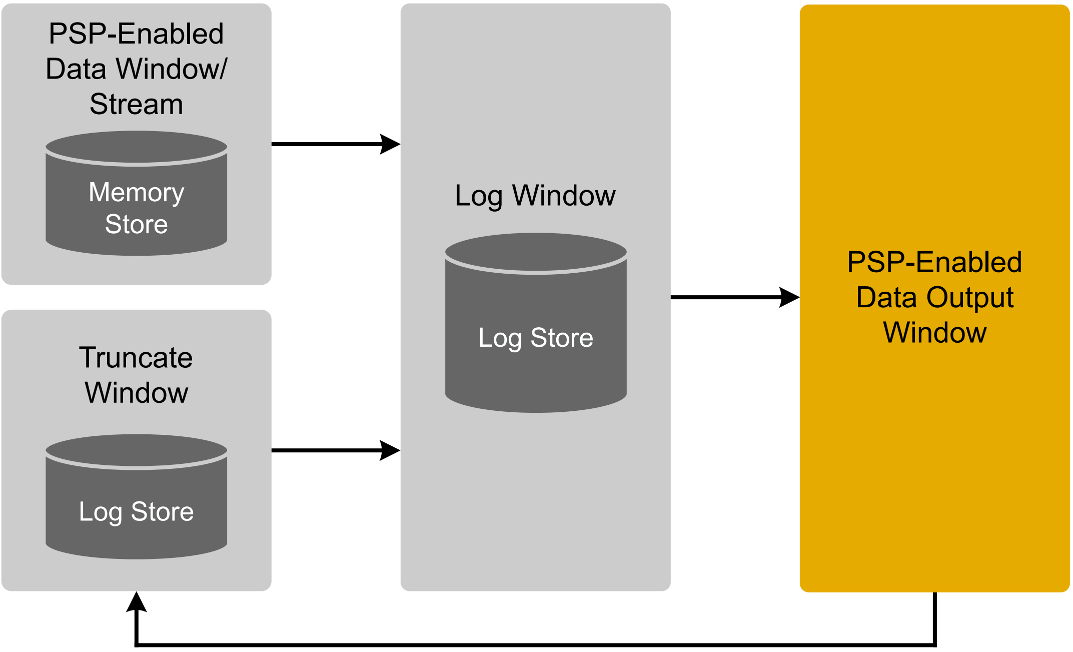

PSP-Enabled Data Window/ Stream
Memory Store
Truncate Window
Log Store
Log Window
Log Store
PSP-Enabled Data Output Window

Figure 11: Per-Subscriber PSP Overview

Input adapters support persistent subscribe pattern (PSP) using facilities provided by the data source. Output adapters use PSP directly.

> i Note
>
> The WebSphereMQ Input and Output adapters, all JMS Input and Output adapters, and the TIBCO Rendezvous adapter all support PSP. These adapters have specific, unique PSP and GD parameters. For more information, see the *SAP Event Stream Processor: Adapters Guide*.

Procedure

1. Open the project in the visual editor and choose the element to support PSP.
2. (Optional) If an element suitable for PSP does not exist, create a new one:
    a. In the visual editor palette, click a shape tool such as Streams and Windows.
    b. Click the shape (element) you want to create (**Input Stream**, for example).
    c. Select a location in the diagram and click to add the shape.
3. Right-click the shape and select **Modify** > **Add Persistent Subscribe Pattern**.
4. In the Select Store dialog, select either **Create New Store** or an existing store, then click **OK**.

    Studio creates two elements and attaches them to the shape you are configuring for PSP:
    - A Flex operator named `<-PSP-shape-name>_log<number>`.

- A truncate window named `<-PSP-shape-name>_truncate<number>`.

The new truncate window and the shape you are configuring for PSP connect automatically to the new Flex operator.

Next Steps

- To complete the PSP set-up, attach an appropriate output adapter to the Flex operator.
- Repeat the steps above to add more subscribers.

8.2 Consistent Recovery

Consistent recovery lets you set up a project that can recover its data if it is interrupted by a server or connection failure. This feature can restore all the streams and windows in a project to a consistent state after a server or connection failure.

Recovery consistency depends on guidelines for log stores:

- When consistent recovery is enabled, the server uses coordinated checkpoints to save data in log stores.
- When any log store fails to complete a checkpoint, all the log stores for that project roll back to their state as of the previous successful checkpoint. This rule ensures that even if a server or connection fails, all log stores in a project are consistent with one another. However, any input data that has not been checkpointed is not recovered upon restart.

Enabling consistent recovery has no effect if there are no log stores in the project. When you enable consistent recovery for a project, place the log stores on a shared drive where all the machines in the Event Stream Processor cluster can access them.

Enable consistent recovery in the project configuration (CCR file), either in Studio or by manually editing the CCR file. See *Project Configuration Files* in the *SAP Event Stream Processor: Configuration and Administration Guide*.

In consistent recovery mode, a project treats commits issued by publishers as checkpoint requests. When the publisher receives the return of a commit from the project, it can notify its source that the data in question has been processed.

All guaranteed delivery subscribers to a stream or window stored in a log store receive checkpoint notifications. GD subscribers can use this notification as an indication that it is safe to commit data in its target.

Consistent recovery works well with projects configured for cold failover if log stores are set up following the log store guidelines. When a project set for cold failover stops responding, the cluster restarts the project, typically on another host. Consistent recovery enables the restarted project to come back up to a consistent state corresponding to the last checkpoint.

> i Note
>
> Avoid using consistent recovery mode in projects where active-active HA mode is also enabled. Because ESP is nondeterministic, enabling consistent recovery mode on the instances of an active-active project cannot be guaranteed to produce the same data in the primary and secondary instances if there is a failure.

When consistent recovery is not enabled (which is the default state), the project does not ensure that all the log stores recover to the same point in time after a server failure. Some log stores may recover to a checkpoint state earlier in time than other log stores because the checkpoints across log stores are not treated as an atomic operation. When there is only one log store in the project, this is not an issue.

When you use consistent recovery, the recommendation that all input windows in a project and their direct or indirect dependents be placed in the same log store no longer applies. Instead, consider using multiple log stores placed on different disks to improve performance. Using multiple log stores is possible because consistent recovery ensures that all the log stores in the project are always consistent with each other.

Parent topic: Zero Data Loss [page 240]

Related Information

Guaranteed Delivery [page 241]
Auto Checkpoint [page 248]
Achieving Zero Data Loss [page 249]

8.3 Auto Checkpoint

Zero data loss relies on data being checkpointed (that is registered and saved in project log stores). Auto checkpoint lets you configure the checkpoint interval—the number of input transactions that triggers a checkpoint.

Checkpoints are triggered when:

- A publisher in a client application issues a commit (if the consistent recovery project option is enabled)
- The project server determines a checkpoint is required
- The project processes the number of transactions you specified in the auto checkpoint option
- The project shuts down cleanly
- The project restarts after an unexpected shutdown

Auto checkpoint lets you control how often log store checkpoints occur across all input streams and windows in the project. More frequent checkpoints mean less data is lost if the server crashes. At the maximum checkpoint frequency of every input transaction (value of 1), all input data is protected except the data from the last transaction, which might not be checkpointed before a crash. Here, input transaction refers to one record, one transaction, or one envelope published to the server and currently in flight. This applies to a single publisher; if there are multiple publishers, then the last transaction for every publisher that is in flight may be lost. When you set checkpoint frequency, you make a trade-off: with frequent checkpoints you can reduce the amount of data at risk, but performance and latency may suffer as a result. The alternative is to increase performance but risk a larger amount of data loss by setting infrequent checkpoints.

Setting auto checkpoint guarantees that a checkpoint occurs at least every `<N>` rows, where `<N>` is the checkpoint interval. The checkpoint itself may include more input rows because the system ensures that all inputs (other than the input stream that triggered the checkpoint) have consumed all the data in its input queues. The actual checkpoint may happen earlier than called for by the auto checkpoint interval if the system decides it is necessary.

When the server completes a checkpoint, it sends checkpoint messages to GD subscribers to notify them that all data up to the sequence number specified in the checkpoint message can be safely recovered by the server on restart.

Setting auto checkpoint has no effect if there are no log stores in the project. Auto checkpoint is not dependent on consistent recovery; use it with consistent recovery enabled or disabled.

> i Note
>
> You should only perform one of the following:
>
> - Enable auto checkpoint
> - Configure publishers sending data to the project to issue commits, which trigger checkpoints

Parent topic: Zero Data Loss [page 240]

Related Information

Guaranteed Delivery [page 241]
Consistent Recovery [page 247]
Achieving Zero Data Loss [page 249]

8.4 Achieving Zero Data Loss

A lost connection or a server crash can cause data produced by a project to be lost before it is delivered to a listening client. If you cannot afford to lose data, complete the following tasks to configure zero data loss:

Task	For Instructions, see...
Create a project with one or more guaranteed delivery streams or windows or add a GD stream or window to an existing project. You can do this in Studio or by adding CREATE STREAM, CREATE WINDOW, or CREATE FLEX statements to the project CCL file.	Adding Guaranteed Delivery [page 244] *SAP Event Stream Processor: CCL Reference*
Set up log stores for any streams or windows in the project that cannot be recovered by an upstream provider. Review the guidelines, restrictions, and sizing instructions for log stores to ensure that your project can accurately and completely recreate its data after a restart.	Creating a Log Store [page 186] and all subsections

Task	For Instructions, see...
Variables and CCLScript data structures (dictionaries, vectors, and event caches) do not persist in log stores and cannot be recovered after a failure. Use these structures with log stores only when: • You can provide logic to reconstruct the structures on restart. • Processing is not affected if the structures are missing after a restart. Data structures that are defined in DECLARE blocks may be fully or partially restored by the recovery process. However, achieving the desired recovery state after a project restart depends on the project's structure. For example, assume that there is an input window A that is assigned to a log store and window A has a retention policy of one hour. Flex operator B receives its input from A and contains data structures. The type of data structure, and the way it is configured, will affect how much data is recovered in the recovery process: • If Flex B has a dictionary that holds data for longer than an hour, the dictionary will be partially restored as Flex B receives rows from window A during the recovery process. • If Flex B has a dictionary that holds a last value received for every key value, and receives values more frequently than once per hour for every key value, the dictionary will be fully restored during the recovery process. • If Flex B has a five minute event cache that only holds records, the event cache will hold records that were replayed as a part of the recovery process in the last five minutes.	---
Enable guaranteed delivery on any bindings associated with GD-enabled streams or windows.	Adding Guaranteed Delivery [page 244]
Before you deploy the project, enable these options in the project configuration (CCR) file: • Failover • (Optional) Auto Checkpoint Note You should enable Auto Checkpoint only if you do not configure publishers of inbound data to trigger checkpoints by issuing commits. • Consistent Recovery Note You should not enable active-active HA mode for projects where consistent recovery is enabled. Active-active mode does not safeguard against data loss or data inconsistency when the project switches from the primary instance to the secondary.	*High Availability*, as well as the respective option topics, in the *SAP Event Stream Processor: Configuration and Administration Guide*.

Task	For Instructions, see...
Enable guaranteed delivery on the project's adapters. i Note Some adapters do not support guaranteed delivery. See the *Adapter Summary* in the *SAP Event Stream Processor: Adapters Guide* for information on GD support.	*SAP Event Stream Processor: Adapters Guide* for GD-specific adapter properties.
If auto checkpoint is not enabled, configure publishers sending data to your project to issue commits to trigger server checkpoints. When the commit call returns, the publisher knows that the server has checkpointed the data. i Note When a project receives data from more than one publisher, a commit issued by one publisher triggers checkpointing of data sent by all publishers. Configure publishers to retransmit any data for which they do not receive a commit confirmation.	*SAP Event Stream Processor: SDK Guide*
Set up guaranteed delivery subscriptions for client applications that consume data from your project. To confirm that subscribers have received and processed data, configure them to send GD commit calls in response to checkpoint notifications.	*SAP Event Stream Processor: SDK Guide*

Parent topic: Zero Data Loss [page 240]

Related Information

Guaranteed Delivery [page 241]
Consistent Recovery [page 247]
Auto Checkpoint [page 248]

9 SAP PowerDesigner for Event Stream Processor

SAP Event Stream Processor users create and manipulate the Streaming Schema using SAP PowerDesigner®.

PowerDesigner is a powerful modeling tool. SAP Event Stream Processor users can use it to develop physical data models as well as the logical data models that define the Streaming Schema.

In this section:

9.1 Getting Started

SAP PowerDesigner® is a tool for creating and manipulating Streaming Schema. Optionally, it can be used with physical data models.

This section is intended for database and application development staff, and for SAP Professional Services representatives, customer IT support, and other technical personnel who set up and administer PowerDesigner. It includes information you need to understand, model, and modify logical schema definitions and physical database structure when developing schema.

In this section:

9.1.1 Data Modeling Scenarios

Integrated modeling supports efficient schema definition and database design, and consistent production deployments.

Use the Streaming Schema and extensions to:

- Model schema in the Streaming Schema model, a PowerDesigner logical data model.
- Convert Streaming Schema logical data models to SAP HANA, SAP ASE, or SAP IQ physical data models.
- Convert existing SAP HANA, SAP ASE, and SAP IQ physical data models to Streaming Schema logical data models.
- Import schema definitions defined in a CCL file into Streaming Schema models.
- Export schema definitions from Streaming Schema models into a CCL file.
- Validate a model using custom checks for Streaming Schema, in addition to the standard PowerDesigner checks.
- Analyze the impact of changes to schema, a model, or a database table on all components in the integrated model.

The corresponding adapter (SAP IQ, HANA, ASE) schema must match the SAP IQ, HANA, and ASE database schema for all tables in which data is inserted. After you make changes, you can use PowerDesigner to produce a set of data definition language (DDL) statements directly from the physical data models (SAP IQ, HANA, and ASE). PowerDesigner saves the DDL in a SQL script that you can run to generate the tables and other objects for the target databases.

DDL generation does not require use of the extended modeling feature.

9.1.2 Sample PowerDesigner Project

A sample project supports integrated modeling.

You can install a PowerDesigner sample project that includes:

- A sample Streaming Schema logical model.
- SAP IQ, SAP HANA, and SAP ASE physical data models.

In this section:

Opening the Sample Project [page 254]
    Open the sample model from the sample project.

9.1.2.1 Opening the Sample Project

Open the sample model from the sample project.

Procedure

1. Choose ▶ **Start** > **Programs** > **Sybase** > **PowerDesigner 16** .
2. In the Welcome dialog, under Getting started, choose **Open Model or Project**.

   If you are not a first-time user, you may see different options in the Welcome dialog, based on your previous work in PowerDesigner.
3. Browse to the sample project in `%PowerDesigner 16%\Examples\Streaming\Streaming.prj` and choose **Open**.

   PowerDesigner opens a workspace for the Streaming Schema sample project.
4. Double-click the **Streaming** project (💼).
   The sample project opens with the sample Streaming Schema model, SAP IQ model, SAP ASE model, SAP HANA model, and the Model Relationship Diagram in the Browser view.

9.1.3 Learning More About PowerDesigner

For more information on using PowerDesigner, press **F1** to open the online help, or see the PowerDesigner online product documentation.

9.2 Data Model

PowerDesigner includes a logical data model for Streaming Schema and three physical data models for the SAP IQ, SAP HANA, and SAP ASE databases.

The indexes for both physical data models are database-specific and are defined individually. You can open, view, modify, and extend the data models using PowerDesigner.

In this section:

Streaming Schema Logical Data Model [page 255]
    The Streaming Schema model represents market data in a logical data model independent of any data store.

[Finding an Object in a Diagram [page 255]]
Locate any object with a symbol in a diagram or among several diagrams. Objects without graphical symbols, such as domains, are not shown in diagrams.

[Data Model Tables [page 256]]
The following table lists all data model tables in the Market Data diagrams with their code names and descriptions.

[Extensions [page 257]]
Extensions (`.xem` files) provide a means to customize and extend PowerDesigner metaclasses, parameters, and generation. Use extended models to store additional information, or to change model behavior.

9.2.1 Streaming Schema Logical Data Model

The Streaming Schema model represents market data in a logical data model independent of any data store.

The Streaming Schema logical model represents the building of schema and the databases parsing schema and storing them.

The Streaming Schema model contains a definition for each schema. The schema definitions are contained in the Market Data diagram in the sample Streaming Schema model. Adding schema to the diagram is optional.

To create a new Streaming Schema model, you can:

- Create it from scratch using the Streaming Schema Model category.
- Create it from scratch using the `StreamingSchema.xem` file to extend the model during or after creation.
- Generate it from an SAP IQ, SAP HANA, or SAP ASE physical data model.

9.2.2 Finding an Object in a Diagram

Locate any object with a symbol in a diagram or among several diagrams. Objects without graphical symbols, such as domains, are not shown in diagrams.

Procedure

Right-click an object in the Browser and select **Find in Diagram**.

9.2.3 Data Model Tables

The following table lists all data model tables in the Market Data diagrams with their code names and descriptions.

Table name	Code	Description
Bond History	BOND_HISTORY	Stores bond historical data, one record per each trading date. The data includes daily price and yield values (open/close, high/low), trade volume (number of bonds traded), and so on, for each bond.
Bond Quote	BOND_QUOTE	Stores real-time (intraday) quote data. Each quote record includes a yield, bid/ask price, and size (in other words, a number of bonds offered at a bid/ask price).
Bond Trade	BOND_TRADE	Stores real-time (intraday) trade data. Each trade record includes a bond's price and yield and a transaction's size (number of bonds traded).
Dividend Event	DIVIDEND_EVENT	Stores information on a dividend payment event when a shareholder receives a certain payment for each share of stock owned. The dividend amount is commonly defined as a certain percentage of a share price but can also be specified as a monetary amount. The Monetary or Percentage Indicator (MOP_INDICATOR) column indicates how the dividend amount is defined.
Index History	INDEX_HISTORY	Stores the index’s historical data, one record per each trading date. The data includes the index’s daily values (open/close, high/low) and trade volume.
Index Intraday	INDEX_INTRADAY	Stores the index’s real-time (intraday) data that shows its value movements during a trading day. Each data point includes an index value and trade volume.
Mutual Fund History	MUTL_FUND_HIST	Stores the historical data for a mutual fund, one record per each trading date. The data includes a trade date and price.
Option History	OPTION_HISTORY	Stores the options historical data, one record per each trading date. The data includes options daily price (open/close, high/low), trade volume (number of contracts traded), and so on.
Option Quote	OPTION_QUOTE	Stores the options real-time (intraday) quote data. Each quote record includes a bid/ask price, size (number of contracts offered at a bid/ask price), and so on.

Table name	Code	Description
Option Trade	OPTION_TRADE	Stores the options real-time (intraday) trade data. Each trade record includes a trade's price, size (number of contracts traded), and so on.
Split Event	SPLIT_EVENT	Stores information on a stock split event when the number of outstanding shares of a company's stock is increased and the price per share is simultaneously decreased so that proportionate equity of each shareholder remains the same. The split is characterized by a split factor; a factor of 0.5 indicates that the number of shares is increased two times and that the share price is decreased two times. In a less common reverse split, the number of shares is decreased and the price per share is increased in a similar manner; a split factor of 2 indicates that the number of shares is decreased two times and that the share price is increased two times.
Stock History	STOCK_HISTORY	Stores the stock historical data, one record per each trading date. The data includes stocks daily prices (open/close, high/low) and trade volume (number of shares traded).
Stock Quote	STOCK_QUOTE	Stores the stocks' real-time (intraday) quote data. Each quote record includes a bid/ask price and corresponding size values (in other words, a number of shares offered at bid/ask price).
Stock Trade	STOCK_TRADE	Stores the stocks' real-time (intraday) trade data. Each trade record includes a transaction's price and size (in other words, a number of shares traded).

9.2.4 Extensions

Extensions (`.xem` files) provide a means to customize and extend PowerDesigner metaclasses, parameters, and generation. Use extended models to store additional information, or to change model behavior.

PowerDesigner provides four `.xem` files:

- `StreamingSchema.xem` – extensions for an logical data model. Contains rules and code that let you model Streaming Schema in a PowerDesigner logical data model.
- `IQ.xem` – extensions for a physical data model. Contains only transformation rules needed to convert a Streaming Schema definition to an SAP IQ table definition, in an SAP IQ model.
- `ASE.xem` – extensions for a physical data model. Contains only transformation rules needed to convert a Streaming Schema definition to an ASE table definition, in an ASE model.

- `HANA.xem` – extensions for a physical data model. Contains only transformation rules needed to convert a Streaming Schema definition to an SAP HANA table definition, in an SAP HANA model.

When you use the models provided with PowerDesigner, the extensions are present. When you create a new model using the Streaming Schema model category set, extensions are applied automatically.

When you create a new model without using the Streaming Schema model categories, or when you have an existing model, you can extend it using the PowerDesigner tools and Streaming extension files.

In this section:

9.2.4.1 Category Set

You can set the Streaming category set to create any Streaming model type.

The Streaming model category set includes Streaming Schema, SAP IQ, SAP HANA, and SAP ASE categories. To create new models from this category set, enable the categories in PowerDesigner. You can either merge the Streaming categories with others that you use, or change PowerDesigner to use only the Streaming categories.

Once you set up the Streaming category set, you can create any Streaming model type and extend it with the appropriate extension.

The `Streaming.mcc` file, installed with the extensions, defines the Streaming categories.

9.2.4.2 Schema Definitions

A schema definition in the Streaming Schema model represents a data stream in SAP Event Stream Processor.

The sample Streaming Schema model contains a schema definition for each market data table. You can customize any schema definition, or create a new one.

To create a new schema in the Streaming Schema model, you can either:

- Create a schema in PowerDesigner, and then generate a CCL file from it, or;
- Import schema definitions that are defined in a CCL file.

Each schema definition contains:

- Identifiers, which associate schemas with columns that are keys in the associated table.
- Attributes, which associate schemas with a destination column name in the SAP IQ, SAP HANA, and SAP ASE databases with length and precision where appropriate, lookup table and column information for columns that are foreign keys, and descriptive notes.

In this section:

9.2.4.2.1 Sample Schema Definition List

Sample schema definitions correspond to the Market Data diagram provided with PowerDesigner. While each schema appears in the SAP IQ, SAP HANA, and SAP ASE Market Data diagram, not every table in that diagram is a schema.

- Bond History
- Bond Quote
- Bond Trade
- Dividend Event
- Index History
- Index Intraday
- Mutual Fund History
- Option History
- Option Quote
- Option Trade
- Split Event
- Stock History
- Stock Quote
- Stock Trade

9.2.4.3 Impact and Lineage Analysis

PowerDesigner provides powerful tools for analyzing the dependencies between model objects.

When you perform an action on a model object, in a single operation you can produce both:

Impact Analysis	to analyze the effect of the action on the objects that depend on the initial object.
Lineage Analysis	to identify the objects that influence the initial object.

These tools can help you answer questions such as:

- If I change the precision on a column in my SAP ASE model which I generated from the streaming schema model, what table columns in my SAP IQ or SAP HANA model must also change, and what schema are affected?
- Which schema fields influence each column in my SAP ASE, SAP HANA, and SAP IQ models?
- If I delete a column from my SAP IQ model, what is the impact on tables and columns in my SAP ASE and SAP IQ models, and what schema definitions must change in my streaming schema model?

9.3 Extended Model Setup

Your installer automatically sets up the use of extensions.

To apply extensions automatically to new models, set up and use the Streaming Schema model category set.

To integrate existing PDMs with the Streaming model, extend the models by attaching the appropriate extension file.

In this section:

9.3.1 Extending an Existing Model

Attach extensions to any SAP IQ, SAP HANA, or SAP ASE physical data model, or to a logical data model that was generated from the Streaming physical data model but not extended.

Procedure

1. Open the model you want to extend.
2. From the PowerDesigner main menu, choose ▶ **Model** ▶ **Extended Model Definitions** ▶.

> → Tip
>
> If **Extended Model Definitions** is not in the menu, make sure that the extensions file is unzipped in the folder where PowerDesigner is installed.

3. Click **Import an Extended Model Definition** .

   A list shows available extensions that have not been applied to this model.
4. Select the correct model extension and choose **OK**.
   For example, to extend an ASE physical data model, choose **ASE**.
5. In the **List of Extended Model Definitions** dialog, choose **OK** to extend the model.

Results

PowerDesigner applies the Streaming extensions to the model. No other changes are made. For example, a generic logical data model is not transformed to a Streaming Schema model simply by adding the extensions.

9.3.2 Setting Up the Model Category Set File

Set up PowerDesigner to use the Streaming category set for new models.

Context

PowerDesigner can display only one set of categories in the New Model dialog. While not required, using the Streaming category makes it easier to develop models for use with SAP Event Stream Processor.

Procedure

- Decide which option you want to use to create new models:

Option	Action required
Only the installed Streaming category set	Change categories
Streaming category set merged with existing categories	Merge Streaming categories
Neither	Manually extend any models

In this section:

Merging Categories [page 262]
When you create a new model using categories, you can see the existing categories, as well as the three standard Streaming categories. You can merge existing model categories with the Streaming category.

Changing the Default Category [page 262]
Change the default category to the Streaming category, so that you can create new Streaming models.

9.3.2.1 Merging Categories

When you create a new model using categories, you can see the existing categories, as well as the three standard Streaming categories. You can merge existing model categories with the Streaming category.

Procedure

1. Choose ▶ **Tools** ▶ **Resources** ▶ **Model Category Sets** ▶.
2. From the list in the dialog, select the set you want to add to the Streaming category.
3. Click the **Merge** button in the toolbar.
4. Select **Streaming** from the list and choose **OK**.

9.3.2.2 Changing the Default Category

Change the default category to the Streaming category, so that you can create new Streaming models.

Procedure

1. From the PowerDesigner main menu, choose ▶ **Tools** ▶ **General Options** ▶.
2. Under Category, select **Model Creation**.
3. In the Model Creation frame, with **Enable categories** checked, select a default category set.
4. Click **OK**.

9.3.3 Setting Datatypes for a Streaming Schema

Manually set the datatype attribute for a Streaming Schema definition if the Streaming Datatype column in the Attributes tab of a Streaming Schema definition is empty or shows the wrong values.

Context

You may need to set datatypes for a logical data model you generate from a physical data model, if the generation process cannot determine how to convert the database datatype to a Streaming datatype. Datatypes for the shipped sample model are set correctly and no further adjustments are necessary.

Procedure

1. Right-click a schema definition and choose **Properties**.
2. Click the **Attributes** tab and review values in the Streaming Datatype column.

   For example, in the sample model, the Bond Quote Attributes shows the following datatypes:

Attribute Name	Streaming Datatype
Instrument	`string`
Quote Date	`seconddate`
Quote Sequence Number	`integer`
Quote Time	`msdate`
Ask Price	`money(4)`
Ask Size	`integer`
Bid Price	`money(4)`
Bid Size	`integer`
Yield	`money(2)`

   If values are missing or incorrect, continue with steps 3 - 5.

3. Click **Customize Columns and Filter** (**Ctrl+U**).
4. If needed, adjust columns available for viewing:
   a. Unselect **Data Type**, **Length**, and **Precision**.
   b. Select:

      Name
      Streaming Datatype
      Length
      Precision
      Mandatory
      Primary Identifier
      Displayed (selected by default)
5. Use the controls below the list to adjust the order so that **Primary Identifier** and **Displayed** are the last two checkboxes.

Results

Performing this task once corrects the datatypes for all schema definitions.

9.4 Streaming Schema Model Development

Develop schema using the PowerDesigner extensions.

You can:

- Explore the sample model
- Create a schema model using categories, or by creating and extending a logical data model
- Add schema to models
- Validate your schema with built-in checks, as well as custom ones
- Import defined schema definitions into a Streaming Schema model from CCL files
- Export schema definitions from the Streaming Schema model into CCL files

In this section:

9.4.1 Exploring the Sample Model

Review the sample model from the sample project.

Prerequisites

Install the sample model and complete the extended model setup.

Procedure

1. Start PowerDesigner and open the sample project with the sample model.
2. To open any of the models, either:
   - Double-click the model in the Model Relationship Diagram, or,
   - In the Browser tree, double-click the model, or right-click and choose **Open** or **Open as read-only**.

   > i Note
   >
   > Do not save changes to the installed sample model. Save it to another folder so that a new version of the model and project are created.

3. To display the sample schema definitions in the Streaming Schema model, expand the navigation buttons in the Browser tree.
4. To see more information on a schema definition:
   - Right-click the schema definition, an identifier, or an attribute in the tree view and choose **Properties**, or,
   - Right-click the schema definition in the tree view and choose **Find in Diagram**.

   Explore the SAP IQ, SAP HANA, and SAP ASE models in the same way.

9.4.2 Creating a Streaming Schema Model

Create a new Streaming Schema model using the Streaming Schema category, either by creating a logical model and extending it, or by generating it from an SAP IQ, SAP HANA, or SAP ASE model that has been extended.

In this section:

9.4.2.1 Creating a Model Using Categories

Use PowerDesigner to create and automatically extend any Streaming Schema model type.

Prerequisites

Designate the Streaming Schema set as the default category.

Procedure

1. Choose ▶ **File** ▶ **New Model** ▶.
2. In the New Model dialog, select **Categories**, and choose a category item:
   - **Streaming Schema**
   - **SAP IQ**
   - **ASE**
   - **HANA**
3. Enter a model name.
4. Click **OK**.

9.4.2.2 Creating a Logical Data Model

Create a logical data model and add extensions to it.

Procedure

1. Choose ▶ **File** ▶ **New Model** ▶.
2. In the New Model dialog, select **Model types** and **Logical Data Model**.
3. Enter a model name.
4. Click the **Select Extensions** button to the right of the Extensions box.

   A dialog shows currently loaded extensions. You can apply extensions when you create the model or later.
5. Select **Streaming Schema**, then select whether to share or copy:

Option	Description
Share the extended model definitions	PowerDesigner always uses the contents of the `.xem` file. If the contents of the `.xem` file change, the model sees those changes. For example, if a future version of Streaming Schema includes a new version of the file, models that share it sees those changes immediately.
Copy the extended model definitions	Copies the contents of the `.xem` file into the model. The model uses its local copy instead of the file on disk.

6. Click **OK**

   With either approach, use other extensions besides the shipped Streaming Schema extensions by creating your own `.xem` file. Although it is possible to do this by adding to the `StreamingSchema.xem` file, SAP does not recommend this.

9.4.2.3 Adding Schema Definition

Add a schema definition by creating it, importing schema definitions in a CCL file, or generating it from an SAP IQ, SAP HANA, or SAP ASE table.

In this section:

Creating Schema from the Schema Definitions Container [page 267]
  Create a new schema definition with initial properties.

Creating Schema with the Entity Tool [page 268]
  Create schema from the diagram.

Creating a Schema from the Streaming Schema Container [page 268]
  Create a new schema definition with initial properties.

Generating Schema from an SAP IQ, SAP HANA, or SAP ASE Table [page 268]
  Follow the same steps as when generating a Streaming Schema model, selecting a single table to generate.

9.4.2.3.1 Creating Schema from the Schema Definitions Container

Create a new schema definition with initial properties.

Procedure

1. Open the PowerDesigner model.
2. In the Browser tree, right-click the Streaming Schema container and choose **New**.
3. Complete the information in the **General** tab or other tabs.

   You can complete schema definition properties at any time before generating the physical models.

4. Click **OK** to save the schema definition.

9.4.2.3.2 Creating Schema with the Entity Tool

Create schema from the diagram.

Procedure

1. Open the PowerDesigner model.
2. In the diagram, click the **Entity** tool ▦.

   A new, empty schema definition appears in the diagram, and in the Browser tree when expanded.
3. Right-click the diagram and choose **Properties**.
4. Add attributes and identifiers in the properties sheet.

9.4.2.3.3 Creating a Schema from the Streaming Schema Container

Create a new schema definition with initial properties.

Procedure

1. Right-click the Streaming Schema container and choose ▶ **New** ▶ **Streaming Schema** ◀.
2. Complete the information in the **General** tab or other tabs.

   You can complete schema definition properties at any time before generating the physical models.
3. Click **OK** to save the schema definition.

9.4.2.3.4 Generating Schema from an SAP IQ, SAP HANA, or SAP ASE Table

Follow the same steps as when generating a Streaming Schema model, selecting a single table to generate.

9.4.2.4 Defining Schema Properties

Define schema details in the properties sheet.

Prerequisites

Add the schema definition to the Streaming Schema model.

Procedure

1. Open the Streaming Schema Properties sheet from the Browser tree or the diagram.
2. Edit fields on the **General**, **Attributes**, and **Identifiers** tabs.
3. (Optional) Right-click an attribute to open the Attribute Properties sheet.
4. (Optional) In the Attribute Properties sheet, choose **More** to see extended property details.
5. Click **Apply** to apply changes.
6. Click **OK** when done.

In this section:

General Tab Properties [page 270]
View information about the Name and Comment properties of a schema definition on the General tab of the Schema Definition Properties sheet.

Attributes Tab Properties [page 270]
The Attributes tab of the Schema Definition Properties sheet lets you quickly set information for all fields of a Streaming Schema.

Adding an Attribute to Schema [page 271]
Add fields to schema by adding attributes to the schema definition.

Identifiers [page 271]
An identifier is a column or combination of columns that uniquely defines a specific Streaming Schema.

Defining Identifiers [page 272]
Define identifiers to indicate which schema attributes become keys in the destination table.

9.4.2.4.1 General Tab Properties

View information about the Name and Comment properties of a schema definition on the General tab of the Schema Definition Properties sheet.

Property	Description
Name	Text that identifies the object's purpose for non-technical users, for example, Stock Quote. This element is used for descriptive purposes only, and can contain any string.
Comment	An optional comment field. This is stored only in the model, not in the schema.

9.4.2.4.2 Attributes Tab Properties

The Attributes tab of the Schema Definition Properties sheet lets you quickly set information for all fields of a Streaming Schema.

Property	Description
Name	Name of the field. The value can contain any string. This element is used for descriptive purposes only.
Code	By default the code is generated from the name by applying the naming conventions specified in the model options. To decouple name-code synchronization, click to release the = button to the right of the Code field.
ESP Datatype	Select from the list of supported ESP datatypes. For information on ESP datatypes, see Datatypes [page 101].
Data Type (Internal PowerDesigner datatype)	Select from the list of supported datatypes. For information on PowerDesigner datatypes, see related information in *PowerDesigner>Data Modeling*.
Length	Required for money and decimal data. Limited to precision 34. Precision must be the same on SAP IQ and SAP ASE. Not used for other datatypes.
Precision	Required for money and decimal data. Not used for other datatypes.
Domain	Specifies a domain which defines the datatype and related data characteristics for the schema attribute. It may also indicate check parameters, and business rules. Select a domain from the list, or click the Ellipsis button to create a new domain in the List of Domains.

Attribute Properties Sheet

Each field in a schema definition has its own Properties sheet.

In the Attribute Properties Sheet, you can:

- View or edit the same information as in the Attributes tab of the Schema Definition Properties sheet
- Specify validation checks for an attribute
- View attribute dependencies
- View impact and lineage analyses for an attribute

9.4.2.4.3 Adding an Attribute to Schema

Add fields to schema by adding attributes to the schema definition.

Procedure

1. In the schema definition to which you are adding an attribute, do any of the following:
    - From the schema definition, right-click and choose **New**. This opens the Attribute Properties sheet.
    - From the Attributes tab in the Streaming SchemaProperties sheet, type information in the row below the last attribute.
    - From the Attributes tab in the Streaming Schema Properties sheet, click the **Insert a Row**, **Add a Row**, or **Add Attributes** or **Replicate Attributes** toolbar button from other schema definitions.

    Before replicating attributes, read *Object Replications* in the *PowerDesigner Core Features Guide*.
2. Edit information in the Attributes Properties sheet or row as needed.

9.4.2.4.4 Identifiers

An identifier is a column or combination of columns that uniquely defines a specific Streaming Schema.

Identifiers in the Streaming Schema model become keys on tables in the SAP IQ, SAP HANA, and SAP ASE physical models.

Each Streaming Schema can have at most one primary identifier, which becomes the primary key in the generated table.

When an identifier has multiple attributes, the primary key in the destination table is composed of multiple columns. For example, in the sample model, the Dividend Event schema has one identifier. Attributes for this primary identifier are Instrument and Disbursed Date. Thus the primary key for the Dividend Event table is composed of both the Instrument and Disbursed Date columns.

9.4.2.4.5 Defining Identifiers

Define identifiers to indicate which schema attributes become keys in the destination table.

Procedure

1. Choose one of the following:
   - Right-click Streaming Schema and choose **New** > **Identifier**.
   - (Primary identifiers only) On the Streaming Schema Properties sheet, select the **Attributes** tab, and click the Primary Identifier column (the narrow column with the header **P**) for each attribute that is part of the primary identifier. Skip the remaining steps.

     > **i Note**
     >
     > In the Streaming Schema Properties **Attributes** tab, a checkmark in the **P** column indicates a primary identifier.

2. Select the **General** tab in the Identifier Properties sheet:
   a. (Optional) Set the identifier name.
   b. For a primary key, select **Primary Identifier**.
3. On the **Attributes** tab in the Identifier Properties sheet, enter the fields that identify the schema.

9.4.3 Validating a Model

Check the validity of your model after schema changes, and before generating schema templates, code, or a physical model. You can check the validity of a model at any time.

Procedure

1. (Optional) Select diagrams for the schema you want to validate.
2. Choose **Tools** > **Check Model (F4)**.
3. In the **Options** tab of Check Model Parameters, expand the containers and choose validation checks.

   The **Options** tab lists checks to be performed with symbols indicating their severity.
   - Do not disable any ESP-specific checks.
   - (Default and recommended) Disable **Existence of relationship or entity link** under **Entity**.
4. In the **Selection** tab, navigate to the Streaming Schema subtab and select schema definitions to check:
   - Select or unselect check boxes.
   - Choose a named selection.
   - If you selected schema in your diagram before starting the model check, you can select them for checking by clicking **Use Graphical Selection** () in the Selection tab toolbar.

5. Click **OK**.

Next Steps

Review results in the **Check Model** subtab in the status bar. It lists the checks made, and any errors or warnings.

Correct any errors. No automatic corrections are provided.

In this section:

PowerDesigner Validity Checks [page 273]
Standard PowerDesigner checks determine if a model is internally consistent and correct.

Custom Checks for Streaming Schema Extensions [page 273]
The Streaming Schema extension offers many custom checks.

9.4.3.1 PowerDesigner Validity Checks

Standard PowerDesigner checks determine if a model is internally consistent and correct.

For example:

- Each Streaming Schema name must be unique.
- Each object name in the Streaming Schema model must be unique.
- Each field must have an assigned ESP datatype.

For descriptions of standard PowerDesigner checks, see *Working with Data Models > Checking a Data Model* in the PowerDesigner *Data Modeling* guide.

9.4.3.2 Custom Checks for Streaming Schema Extensions

The Streaming Schema extension offers many custom checks.

Checks for Each Schema

Custom checks under the Schema Definition type validate values in the **General** tab of the Schema Properties sheet.

Option	Description
NameIsValid	Validates that names of Streaming Schema are valid java identifiers.

Checks for Each Field in a Schema

Custom checks for fields are under the Entity Attribute type. They validate values in the Attributes tab of the Streaming Schema Properties sheet.

Option	Description
FieldNameIsValid	Validates that field names are valid java identifiers.
StreamingDatatypeExists	Validates that the datatype is specified.
UniqueDestColumnName	Validates that DestColumnName is unique within that schema.

9.4.4 Importing a CCL File

Import the defined schema definitions in a CCL file into a Streaming Schema model.

Prerequisites

You have added the Everyone user to the PowerDesigner folder and have granted this user read and write permissions.

Procedure

1. Open the PowerDesigner model.
2. In the **Browser** tree, right-click the Streaming Schema container and choose **Import CCL File...**.
3. Navigate to the CCL file you wish to import.
4. Click **OK** to import the schema definitions defined in the CCL file.

> i Note
>
> A warning message appears if the CCL file schema definitions are not valid. Resolve the errors before importing the CCL file. Navigate to the `User/Appdata/Roaming/PowerDesigner/StreamingCompiler/compiledOutput.log` file to view the errors.

Results

The schema defined in the CCL file is imported into the Streaming Schema model.

9.4.5 Exporting a CCL File

Export all the defined schema from the Streaming Schema model into a CCL file for compiling and further analysis.

Procedure

1. Open the PowerDesigner model.
2. In the **Browser** tree, right-click the Streaming Schema container and choose **Export CCL File...**.
3. Navigate to the CCL file you wish to export to.
4. Click **OK** to export the schema definitions.

Results

The schema defined in the Streaming Schema model is exported as a CCL file.

9.5 Model Generation

Model generation with the Streaming Schema models is a critical step in ensuring the integrity of your production environment.

To generate data models, you can perform one of the following tasks:

- Generate SAP IQ, HANA, and ASE physical data models from the Streaming Schema model.
- Generate a Streaming Schema logical data model from the SAP IQ, HANA, or ASE physical data model.

Each generation process relies on transformation rules for that model type, which are defined in the Streaming Schema extensions for PowerDesigner.

In this section:

Update an existing Streaming Schema logical data model from either SAP IQ, HANA, or ASE physical data models.

9.5.1 Generating a new SAP IQ, HANA, or ASE Model from a Streaming Schema Model

Generate either an SAP IQ, HANA, or ASE physical data model from a Streaming Schema logical data model.

Procedure

1. Open the Streaming Schema model.
2. From the PowerDesigner main menu, choose ▸ **Tools** ▸ **Generate Physical Data Model** ▸.
3. In the **General** tab of the PDM Generation Options dialog, choose **Generate new Physical Data Model**.
4. For a new model, choose the target DBMS and the appropriate Name and Code.
   - For HANA, choose:

Field	Value
DBMS	**SAP HANA Database 1.0**
Name	Keep the default, StreamingSchema, or enter another name.
Code	Auto-generated from Name. For example, when Name is StreamingSchema, Code is StreamingSchema.

   - For ASE, choose:

Field	Value
DBMS	**SAP Adaptive Server Enterprise 15.7**
Name	Keep the default, StreamingSchema_1 (the name of the container), or enter another name.
Code	Auto-generated from Name. For example, when Name is StreamingSchema_1, Code is StreamingSchema_1.

   - For IQ, choose:

Field	Value
DBMS	**SAP IQ 15.X** i Note Use latest version of SAP IQ available.

Field	Value
Name	Keep the default, StreamingSchema_1 (the name of the container), or enter another name.
Code	Auto-generated from Name. For example, when Name is StreamingSchema_1, Code is StreamingSchema_1.

5. Click the **Detail** tab.
6. (Optional) Choose **Check model** and **Save generation dependencies**.
7. Ensure that **Enable transformations** is selected.
8. Click the **Extensions** tab and ensure that the appropriate extension is selected:
   - **ASE** when generating a new SAP ASE model
   - **IQ** when generating a new SAP IQ model
   - **HANA** when generating a new SAP HANA model
9. On the **Pre-generation** and **Post-generation** tabs, ensure that all transformation rules are selected.

   The post-generation tab appears only for new models.
10. On the **Selection** tab, select **StreamingSchema** to create tables for SAP IQ, SAP HANA, or SAP ASE, and choose **OK**.

Next Steps

After generation, check indexes, set physical options, and add foreign keys as needed.

In this section:

Checking Indexes [page 277]
PowerDesigner creates default indexes. Add, edit, or remove them as needed.

Setting Physical Options [page 278]
Set physical options for each table as needed for your SAP IQ or SAP ASE database.

Adding Foreign Keys [page 278]
Add foreign-key relationships to physical data models.

9.5.1.1 Checking Indexes

PowerDesigner creates default indexes. Add, edit, or remove them as needed.

Procedure

1. Open the new or updated physical data model.
2. For each table, right-click the table and choose **Properties**.

3. In the **Indexes** tab, edit indexes as needed for your data and performance requirements.

9.5.1.2 Setting Physical Options

Set physical options for each table as needed for your SAP IQ or SAP ASE database.

Procedure

1. Right-click the table and choose **Properties**.
2. Define any options needed:
   - (SAP ASE only) In the **Physical Options (Common)** tab, choose from the physical options most commonly set for the object.
   - In the **Physical Options** tab, choose from all available options.
   - (SAP ASE only) In the **Partitions** tab, set partitioning options for selected columns.

   For more information on partitioning, see the SAP ASE and SAP IQ documentation sets.

9.5.1.3 Adding Foreign Keys

Add foreign-key relationships to physical data models.

Procedure

1. Add tables to the physical data model that are not in your Market Data diagram and that contain lookup columns for foreign keys.

   New SAP ASE, SAP HANA, and SAP IQ models generated from a Streaming Schema model contain only market data tables.
2. Right-click the table and choose **Properties** or **Keys**.
3. Add foreign-key relationships to tables that are not in the Market Data diagram.

9.5.2 Generating a New Streaming Schema Model from an SAP IQ, HANA, or ASE Model

Generate a new Streaming Schema logical data model from either SAP IQ, HANA, or ASE physical data models.

Procedure

1. Open the **IQ**, **HANA**, or **ASE** model.
2. From the PowerDesigner main menu, choose **Tools** > **Generate Logical Data Model**.
3. In the **General** tab of the LDM Generation Options dialog, choose **Generate new Logical Data Model**.
4. Specify a **Name**.
   Code is autogenerated from the name.
5. On the **Detail** tab, choose Options:
   - (Optional) Check model
   - (Optional) Save generation dependencies
   - (Optional) Convert names into codes
   - (Required) Enable transformations
6. On the **Extensions** tab, choose **StreamingSchema**.
7. On the **Selection** tab, choose tables from which to generate schema.
8. Click **OK**.

9.5.3 Updating an Existing SAP IQ, HANA, or ASE Model from a Streaming Schema Model

Update either an SAP IQ, HANA, or ASE physical data model from a Streaming Schema logical data model.

Procedure

1. Open the Streaming Schema model.
2. From the PowerDesigner main menu, choose **Tools** > **Generate Physical Data Model**.
3. In the **General** tab of the PDM Generation Options dialog, choose **Update existing Physical Data Model**.
4. Select the model and leave **Preserve Modifications** selected.
5. Click the **Detail** tab.
6. (Optional) Choose **Check model** and **Save generation dependencies**.
7. Ensure that **Enable transformations** is selected.
8. In the Merge Models dialog, confirm the updates you want, and click **OK**.

Next Steps

After generation, check indexes, set physical options, and add foreign keys as needed.

9.5.4 Updating an Existing Streaming Schema Model from an SAP IQ, HANA, or ASE Model

Update an existing Streaming Schema logical data model from either SAP IQ, HANA, or ASE physical data models.

Procedure

1. Open either the **IQ**, **HANA**, or **ASE** model.
2. From the PowerDesigner main menu, choose **Tools** > **Generate Logical Data Model**.
3. In the **General** tab of the LDM Generation Options dialog, choose **Update existing Logical Data Model**.
4. Select the model and leave **Preserve Modifications** selected.
5. On the **Detail** tab, choose Options:
   - (Optional) Check model
   - (Optional) Save generation dependencies
   - (Optional) Convert names into codes
   - (Required) Enable transformations
6. On the **Selection** tab, choose tables from which to generate schema.
7. Click **OK**.

9.6 Impact and Lineage Analysis

With impact and lineage analysis, you can determine the full impact of changes to any object in the integrated model.

Impact analysis shows the effect of an action on the objects that depend on the initial object.

Lineage analysis identifies the objects that influence the initial object.

You can perform these analyses on:

- A schema definition or any of its properties in the Streaming Schema logical data model
- A table or column in the SAP ASE, HANA, or IQ physical data model

The results shows the effect of a change throughout the logical and physical data models.

In this section:

Launching an Impact and Lineage Analysis [page 281]
: Analyze the impact of a change to your model from the Impact and Lineage Analysis dialog box.

Generating an Analysis Diagram [page 282]
: Generate an analysis diagram to view the impact or lineage analysis in graphical form.

Reviewing an Impact and Lineage Analysis [page 283]
: Review the analysis in the preview or the impact and lineage model diagram.

Sample Analysis for a Schema Definition [page 283]
: The sample analysis for a schema definition shows that the Bond History schema in the Streaming Schema model was used to generate the `BOND_HISTORY` tables in the SAP HANA, ASE, and IQ models.

Sample Analysis for a Table [page 283]
: The sample analysis for a table shows that the STOCK_QUOTE table was generated from the Stock Quote schema definition in the Streaming Schema model.

9.6.1 Launching an Impact and Lineage Analysis

Analyze the impact of a change to your model from the Impact and Lineage Analysis dialog box.

Context

The Impact and Lineage Analysis dialog lets you review your analysis through:

- A preview – displays the impact and lineage analysis in a tree form. See *PowerDesigner Core Features Guide > Reviewing an Analysis in Preview*.
- An impact analysis model (IAM) – displays the impact and lineage analysis in a diagram. See *PowerDesigner Core Features Guide > Reviewing an Analysis in an IAM Model*.

Procedure

1. Open an impact and lineage analysis in any of these ways:
   - Select an object in the Browser or in the diagram and press **Ctrl** + **F11**.
   - Select one or more objects in the diagram and select ▶ **Tools** ▶ **Impact and Lineage Analysis** ◀.
   - Right-click an object symbol in the diagram and select ▶ **Edit** ▶ **Impact and Lineage Analysis** ◀.
   - Right-click an object entry in the Browser and select **Impact and Lineage Analysis**.
   - (When deleting an object) Click **Impact** on the Confirm Deletion dialog box.
   - Open an object's property sheet, click the **Dependencies** tab, then click **Impact Analysis** .
2. (Optional) Enter a name for your analysis result. This becomes the name of the generated model.
3. Select an impact rule set for your analysis. Choose one of these predefined rule sets:
   - Conceptual Impact Analysis – restrict the analysis to objects impacted by modeling changes on the initial object, such as a modification on a requirement definition.

- Data Impact Analysis – identify the use, if any, of a value contained in the initial object.
- Delete Impact Analysis – (default when deleting an object) restrict the analysis to objects that are directly impacted by the deletion of the initial object.
- Global Impact Analysis – (default when not deleting an object) identify all the objects that depend on the initial object.
- None – no impact rule set is selected.

4. Select a lineage rule set for your analysis. Choose one of these predefined rule sets:
   - Conceptual Lineage Analysis – justify the modeling existence of the initial object, and ensure it fulfills a well-identified need.
   - Data Lineage Analysis – identify the origin of the value contained in the initial object.
   - Global Lineage Analysis – (default when not deleting an object) identify all the objects that influence the initial object.
   - None – (default when deleting an object) no lineage rule set is selected.
5. (Optional) Click the **Properties** tool next to each rule set to review it. See *PowerDesigner Core Features Guide > Editing analysis rules*.

Results

The analysis appears in the **Impact and Lineage** tab of the dialog box. See *PowerDesigner Core Features Guide > Reviewing an Analysis in Preview*.

> i Note
>
> You can click the **Select Path** tool to change the default folder for analysis rule sets, or click the **List of Rule Sets** tool to open the **List of Impact and Lineage Analysis Rule Sets** window, and review a specific rule.

9.6.2 Generating an Analysis Diagram

Generate an analysis diagram to view the impact or lineage analysis in graphical form.

Prerequisites

Launch an impact or lineage analysis.

Procedure

1. In the Impact and Lineage Analysis dialog, click **Generate Diagram** to view a graphical form of the analysis in its default diagram.

2. (Optional) Save (**Ctrl+S**) the diagram as an impact analysis model (IAM).

   See *PowerDesigner Core Features Guide* > *Reviewing an Analysis in an IAM Model*.

9.6.3 Reviewing an Impact and Lineage Analysis

Review the analysis in the preview or the impact and lineage model diagram.

Procedure

1. Review the impact of the action and the lineage of the entity in the preview.
2. In the preview **List** tab, save the analysis in RTF or CSV format, or print.
3. You can refine your analysis by removing or adding initial objects, changing the analysis rule sets to be used, and customizing actions.
4. If you have generated an IAM, you can customize the display preferences and model options, print the model, and compare it with another IAM.
5. Watch for a red dot on an object icon in a generated model.

   When you generate a model to another model or create an external shortcut, you create cross-model dependencies, which are taken into account during impact and lineage analysis.

   When an object belonging to an unavailable related model is encountered, a red dot appears on the object icon and the analysis is interrupted. To continue, open the related model by right-clicking the object in the IAM Browser or in the preview, and selecting **Open Model**.

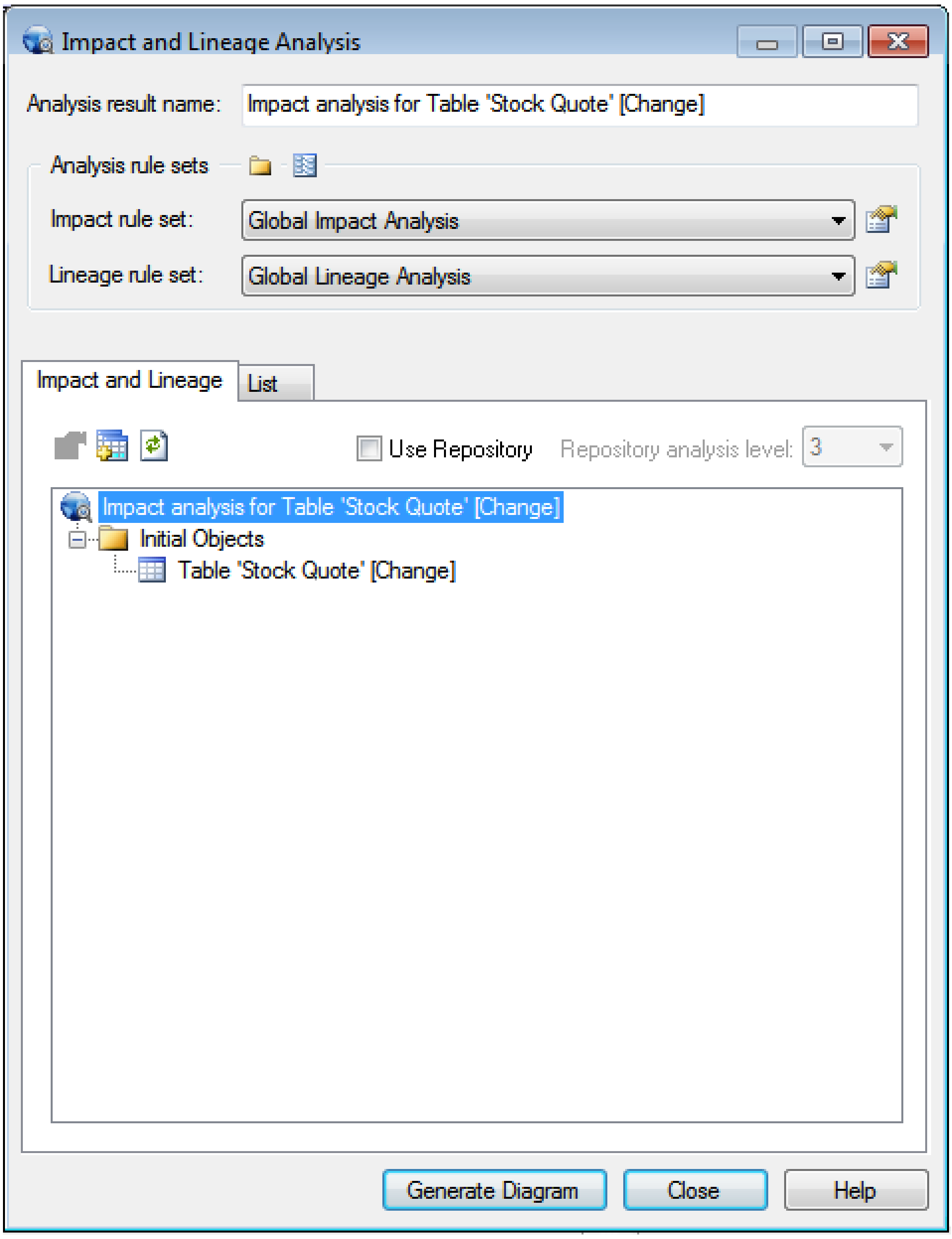
9.6.4 Sample Analysis for a Schema Definition

The sample analysis for a schema definition shows that the Bond History schema in the Streaming Schema model was used to generate the `BOND_HISTORY` tables in the SAP HANA, ASE, and IQ models.

9.6.5 Sample Analysis for a Table

The sample analysis for a table shows that the STOCK_QUOTE table was generated from the Stock Quote schema definition in the Streaming Schema model.

Outgoing References shows foreign-key relationships. Streaming Schema definitions become Market Data diagram tables when generated to a PDM.



Analysis result name: Impact analysis for Table 'Stock Quote' [Change]

Impact rule set: Global Impact Analysis

Lineage rule set: Global Lineage Analysis

□ Use Repository

Repository analysis level: 3

Impact analysis for Table 'Stock Quote' [Change]
- Initial Objects
  - Table 'Stock Quote' [Change]

Figure 12: Impact and Lineage Analysis for STOCK_QUOTE Table in ASE

9.7 DDL Script Generation

The data models for the SAP IQ, HANA, and ASE databases target different databases; however, they share an almost identical structure. Modify data models by creating additional tables or columns to suit your business environment.

The corresponding adapter (SAP IQ, HANA, ASE) schema must match the SAP IQ, HANA, and ASE database schema for all tables in which data is inserted. After you make changes, use PowerDesigner to produce a set of data definition language (DDL) statements directly from the physical data model (SAP IQ, HANA, and ASE). PowerDesigner saves the DDL statements in a SQL script to generate the tables and other objects for the target databases.

In this section:

9.7.1 Generating Database Schema with PowerDesigner

PowerDesigner includes all of the necessary resources to generate a set of DDL statements in SQL scripts directly from the PowerDesigner data models. Run these scripts to generate a schema for your SAP IQ, HANA, and ASE databases.

Procedure

1. In PowerDesigner, open the data model.
2. Change the default database user.
3. Generate the script that creates a schema for the new database.
4. Log in to the database and run the script.

In this section:

9.7.1.1 Changing the Default Database User

Overwrite the default database owner for the SAP IQ, HANA, or ASE database with a name specific to your environment.

Context

In the database, the user who creates an object (table, view, stored procedure, and so on) owns that object and is automatically granted all permissions on it. Overwriting the default user name globally changes ownership of database objects from the default owner to the new owner.

Procedure

1. Start PowerDesigner.
2. Select **File** > **Open** and choose the database that you want to change the default owner of (`IQ.pdm`, `HANA.pdm`, or `ASE.pdm`).
3. Select **Model** > **Users and Roles** > **Users** .
4. In the Name and Code columns, change the default user to the new database user.
5. Click **OK**.

9.7.2 Generating DDL Scripts

Generate DDL scripts directly from the SAP IQ, HANA, or ASE data model. PowerDesigner saves the results in a SQL script that you can use to generate the tables and other objects in the target database.

Context

Use the model file of the database for which you wish to generate DDL scripts. For example, to generate DDL for the SAP ASE database, use the ASE model. When you have the model open, do not change the target database as doing so results in the loss of index information.

By default, the `ASE.pdm` data model includes only those indexes that support the sample queries. The statements that create these indexes are included in the DDL scripts, which means the indexes supplied with the model are created automatically when you run the corresponding DDL scripts.

You can add or remove indexes from the ASE data model. See the SAP ASE product documentation for details on SAP ASE indexes.

Procedure

1. Select ▶ **Database** ▶ **Generate Database** ▶.
2. Browse to the directory where you want to store the script. Click **OK**.
3. Enter a name for the SQL script.
4. On the **Options** tab, verify that the options are set correctly:

Object	**Options**
Domain	Create User-Defined Data Type
Table	Create Table
Column	User Data Type
Key	Create Primary Key Inside
Index	○ Create Index ○ Index Filter Foreign Key ○ Index Filter Alternate Key ○ Index Filter Cluster ○ Index Filter Others

5. Click the **Selection** tab.
6. Choose the database owner.
7. On the **Tables** tab, click **Select All**.
8. On the **Domains** tab, choose the database owner, click **Select All**, click **Apply**, then click **OK**.

   PowerDesigner checks the model for any errors, builds a result list, and generates the DDL. The Result dialog appears, which identifies the name and location of the generated file.
9. (Optional) Click **Edit** to view the generated script.

   The Result List dialog appears in the background and may include several warnings, for example, `"Existence of index"` and `"Existence of reference".` You can safely ignore these warnings.
10. Close the Result List dialog, then exit PowerDesigner.
11. PowerDesigner prompts:
    - To save the current workspace, click **No**.
    - To save the (modified) model, click **Yes** or **No**.

Results

- PowerDesigner prompts: To save the current workspace, click **No**.
- If PowerDesigner prompts you to save the model, click **Yes** to save the modified model. Otherwise, click **No**.

9.7.3 Executing DDL Scripts for the SAP IQ Database

Execute the DDL script in Interactive SQL and create database objects in the SAP IQ database.

Prerequisites

Start the SAP IQ database server if it is not running.

Procedure

1. In a command prompt, change to the directory that contains the database files and enter:

   ```
   start_iq -n <server-name> @<config-file>.cfg <database-name>.db.
   ```

   Use the `-n` switch to name the server, either in the configuration file or on the command line when you start the server.

   > i Note
   >
   > If you specify `-n <server-name>` without a `<database-name>`, you connect to the default database on the current server. If you specify `-n <database-name>` without a `<server-name>`, you connect to the specified database on the current server.
2. Enter `dbisql`.
3. Enter the correct user ID, password, and server information.
4. Open the generated DDL script for SAP IQ and click **Execute SQL Statement** on the toolbar.

9.7.4 Executing DDL Scripts for the SAP HANA Database

Execute the DDL script using hdbsql and create database objects in the SAP HANA database.

Prerequisites

Start the SAP HANA database server if it is not running.

Procedure

- In a command prompt, enter:

```
hdbsql -n <host>:<port> -u <user> -p <password> -I <script-file>
```

9.7.5 Executing DDL Scripts for the SAP ASE Database

Execute the DDL script in Interactive SQL and create database objects in the SAP ASE database.

Prerequisites

Start the SAP ASE server if it is not running.

Procedure

1. In a command prompt, enter:

```
isql -S <server-name> -U <user-name> -P <password> -i <ase-ddl.sql-file> -o
<log-file>
```

2. PowerDesigner prompts:
   - To save the current workspace. Click **No**
   - To save the (modified) model. Click **Yes** or **No**.
3. Check the log file for errors.

10 Appendix: Tutorial for Building and Testing a Project in Studio

Walk through this hands-on tutorial to create, compile, and test a simple project in the Studio. This is a great way of getting started in and familiar with Studio and SAP Event Stream Processor.

Context

The portfolio valuation sample project demonstrates how you can easily define streams and windows by attaching a previously configured adapter and discovering its schema, or by manually defining a window and its schema. It shows you how to define continuous queries—aggregations, joins, and more—using the visual tools in the SAP ESP Authoring perspective.

After you build the project, the tutorial shows you how to compile, run, and test the project you have created using tools in the SAP ESP Run-Test perspective.

1. About the Portfolio Valuation Sample Project [page 291]
   The portfolio valuation project that you build in this tutorial applies current prices to a portfolio of investments to compute the value of each investment and of the portfolio. It uses simple queries to aggregate and join data from two input windows, then outputs the refined data into SAP HANA using an output adapter.
2. Creating the Project [page 295]
   In Studio, define a new set of processing instructions for event data.
3. Editing a Project Diagram [page 296]
   Edit projects in the visual editor by adding shapes from the palette to the project diagram, connecting them, and completing the configuration of each shape.
4. Adding an Input Adapter [page 297]
   Attach an adapter by inserting it in the diagram, connecting it to a stream or window, and setting properties.
5. Discovering a Schema [page 299]
   In Studio, use the **Schema Discovery** button in the adapter shape to discover and automatically create a schema based on the format of the data from the adapter.
6. Adding an Input Window Manually [page 301]
   In Studio, add an input window to the diagram in the sample project `my_portfolio_valuation`.
7. Creating an Aggregate as a Simple Query [page 302]
   In Studio, add an aggregate simple query to the sample diagram to create a volume weighted average price (VWAP).
8. Creating a Join as a Simple Query [page 304]
   Add a join to the sample project. A join combines events from two or more inputs to create a single stream or window. It is similar to a join in SQL.
9. Preparing Data for Output [page 308]
   Add a new aggregate to finalize the data and prepare it for output into SAP HANA.

10. Adding an Output Adapter for SAP HANA [page 309]
    Create an SAP HANA service definition, and insert and configure an SAP HANA Output adapter using the Studio.
11. Preparing to Compile [page 310]
    Clean up the diagram by removing unused elements.
12. Compiling the Project and Viewing Problems [page 312]
    Compile a project in Studio before running it to check for errors and make corrections. Use the Problems view to view error details.
13. Deploying the Sample Project [page 313]
    Run the project and watch it open in the SAP ESP Run-Test perspective.
14. Loading Data into the Sample Project [page 314]
    Test the sample project by loading reference data into the Positions window.
15. Testing the Project with Recorded Data [page 315]
    Play back the previously recorded price feed data, and view the continuous portfolio valuations in the sample project.
16. Sample Project with Modules [page 317]
    This variation of the portfolio valuation project provides a complex, real-world example. The project uses a defined module with a named schema to easily scale out the application in a very high volume deployment. The SAP HANA Output adapter is not included in this module.

10.1 About the Portfolio Valuation Sample Project

The portfolio valuation project that you build in this tutorial applies current prices to a portfolio of investments to compute the value of each investment and of the portfolio. It uses simple queries to aggregate and join data from two input windows, then outputs the refined data into SAP HANA using an output adapter.

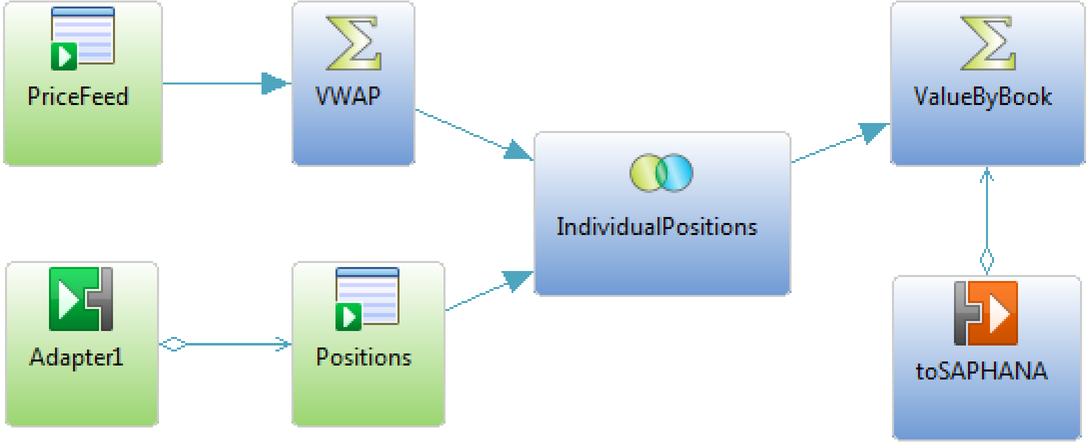
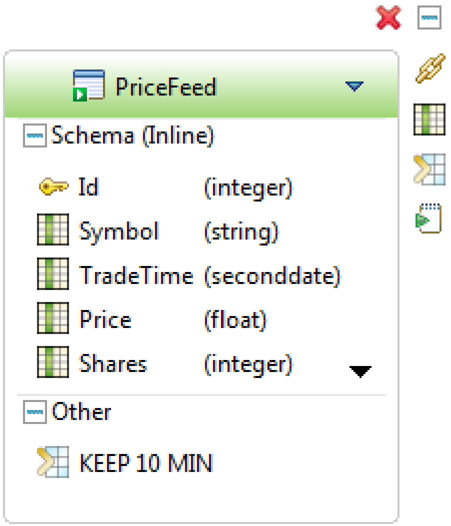
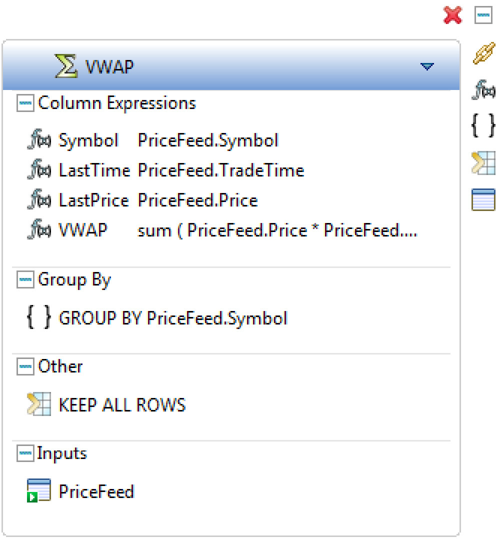


Figure 13: Portfolio Valuation Sample Diagram (Iconic Mode)

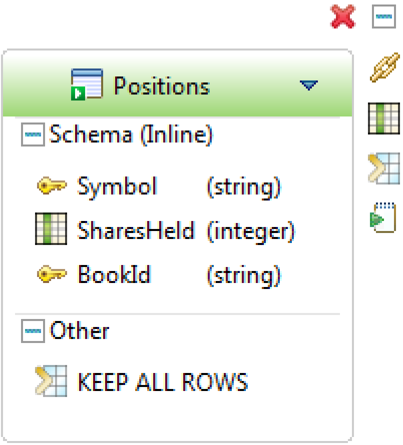
The portfolio valuation project consists of various elements, any of which you can create either in the visual editor, or by manually writing CCL code.

<table>
<tr><th>CCL Element</th><th>Diagram Element</th></tr>
<tr><td>Receives a stream of prices in an input window called PriceFeed. The schema for this window has five columns: Id, Symbol, Price, Shares, and TradeTime. The window uses the Id field as a primary key, and is set to keep the last 10 minutes of price events:
<pre>
CREATE INPUT WINDOW PriceFeed
SCHEMA
 (Id integer ,
   Symbol string ,
   TradeTime seconddate ,
   Price float ,
   Shares integer)
PRIMARY KEY (Id)
KEEP 10 MIN ;
</pre></td><td>
PriceFeed
Schema (Inline)
Id (integer)
Symbol (string)
TradeTime (seconddate)
Price (float)
Shares (integer)
Other
KEEP 10 MIN</td></tr>
<tr><td>Applies an aggregate simple query to create a 10-minute moving average—a volume weighted average price (VWAP). With the VWAP, you can see the value of positions based on the average price, rather than see the value of your positions change with every small price movement. The VWAP formula is calculated as:
<pre>
/**@SIMPLEQUERY=AGGREGATE*/
CREATE OUTPUT WINDOW VWAP
PRIMARY KEY DEDUCED
KEEP ALL ROWS
 AS
 SELECT
     PriceFeed.Symbol Symbol ,
     PriceFeed.TradeTime LastTime ,
     PriceFeed.Price LastPrice ,
     sum (PriceFeed.Price *
PriceFeed.Shares) /
      sum (PriceFeed.Shares) VWAP
 FROM PriceFeed
 GROUP BY PriceFeed.Symbol ;
</pre></td><td>
VWAP
Column Expressions
Symbol PriceFeed.Symbol
LastTime PriceFeed.TradeTime
LastPrice PriceFeed.Price
VWAP sum (PriceFeed.Price * PriceFeed....
Group By
{ } GROUP BY PriceFeed.Symbol
Other
KEEP ALL ROWS
Inputs
PriceFeed</td></tr>
</table>

CCL Element | **Diagram Element**

Reads data from another input window, Positions, with three columns: BookId, Symbol, and SharesHeld:

```
CREATE INPUT WINDOW Positions
  SCHEMA
   ( BookId string ,
     Symbol string ,
     SharesHeld integer )
  PRIMARY KEY ( BookId, Symbol) KEEP ALL
ROWS ;
```



Positions

Schema (Inline)

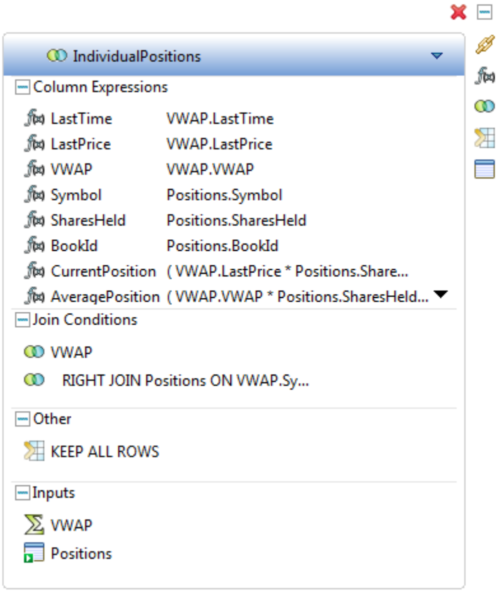
Symbol	(string)
SharesHeld	(integer)
BookId	(string)

Other

KEEP ALL ROWS

Applies a join simple query, joining the market price (from the VWAP aggregate) to your holdings (Positions), so that you can see the value of your position in each stock:

```
/**@SIMPLEQUERY=JOIN*/
CREATE OUTPUT WINDOW IndividualPositions
PRIMARY KEY DEDUCED
KEEP ALL ROWS
 AS
 SELECT
   VWAP.LastTime LastTime ,
   VWAP.LastPrice LastPrice ,
   VWAP.VWAP VWAP ,
   Positions.BookId BookId ,
   Positions.Symbol Symbol ,
   Positions.SharesHeld SharesHeld ,
   VWAP.LastPrice *
     Positions.SharesHeld CurrentPosition ,
   VWAP.VWAP *
     Positions.SharesHeld AveragePosition
 FROM VWAP RIGHT JOIN Positions ON
VWAP.Symbol = Positions.Symbol ;
```



IndividualPositions

Column Expressions

LastTime	VWAP.LastTime
LastPrice	VWAP.LastPrice
VWAP	VWAP.VWAP
Symbol	Positions.Symbol
SharesHeld	Positions.SharesHeld
BookId	Positions.BookId
CurrentPosition	(VWAP.LastPrice * Positions.Share...
AveragePosition	(VWAP.VWAP * Positions.SharesHeld...

Join Conditions

VWAP

RIGHT JOIN Positions ON VWAP.Sy...

Other

KEEP ALL ROWS

Inputs

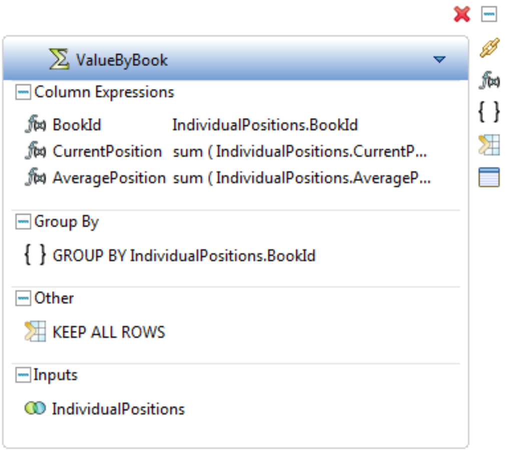
VWAP

Positions

CCL Element | **Diagram Element**

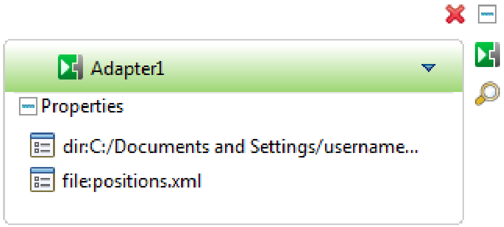
Applies one more aggregation to show the total value of each "book." This aggregate, ValueByBook, groups current and average values for individual positions into different "books." Each book may comprise a set of investment portfolios or funds. In the CCL, a GROUP BY clause performs the aggregation:

```
/**@SIMPLEQUERY=AGGREGATE*/
CREATE OUTPUT WINDOW ValueByBook
PRIMARY KEY DEDUCED
KEEP ALL ROWS
 AS
  SELECT
     IndividualPositions.BookId BookId ,
     sum
( IndividualPositions.CurrentPosition )
           CurrentPosition ,
     sum
( IndividualPositions.AveragePosition )
           AveragePosition
  FROM IndividualPositions
  GROUP BY IndividualPositions.BookId ;
```



ValueByBook
Column Expressions
BookId IndividualPositions.BookId
CurrentPosition sum (IndividualPositions.CurrentP...
AveragePosition sum (IndividualPositions.AverageP...
Group By
{ } GROUP BY IndividualPositions.BookId
Other
KEEP ALL ROWS
Inputs
IndividualPositions

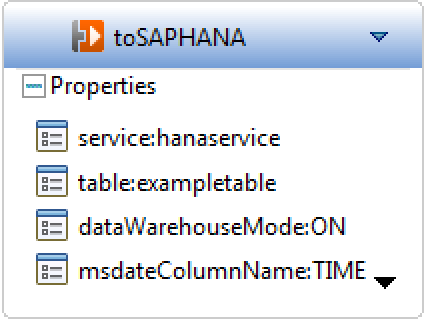
```
ATTACH INPUT ADAPTER Adapter1
TYPE toolkit_file_xmllist_input
TO
Positions
PROPERTIES dir =
'C:/Documents and Settings/<username>/My
Documents/
    SybaseESP/5.1/workspace/exampledata' ,
file = 'positions.xml' ;
```



Adapter1
Properties
dir:C:/Documents and Settings/username...
file:positions.xml

Attaches an output adapter to output the processed data to an SAP HANA table. This adapter requires an existing connection to SAP HANA, which is created using the SAP HANA service from the Data Services view. See *Adding a Connection to an SAP HANA Database* in the *SAP Event Stream Processor: Configuration and Administration Guide* for detailed instructions on creating the service.

```
ATTACH OUTPUT ADAPTER toSAPHANA TYPE
hana_out
TO ValueByBook
PROPERTIES service = 'hanaservice' ,
table = 'exampletable' ,
dataWarehouseMode = 'ON' ,
msdateColumnName = 'TIME' ;
```



toSAPHANA
Properties
service:hanaservice
table:exampletable
dataWarehouseMode:ON
msdateColumnName:TIME

Column Alias in Expressions

Each expression defines a unique name or alias for the column.

In the portfolio valuation sample project, a derived window called VWAP takes input from an input stream (PriceFeed) with columns Symbol, Price and TradeTime, and it includes an aggregate expression. Columns aliases for this derived window (created in visual editor as an aggregate simple query) are the following:

Alias	Column Expression
Symbol	PriceFeed.Symbol
LastPrice	PriceFeed.Price
VWAP	(sum ((PriceFeed.Price * CAST (FLOAT , PriceFeed.Shares))) / CAST (float , sum (PriceFeed.Shares)))
LastTime	PriceFeed.TradeTime

Parent topic: Appendix: Tutorial for Building and Testing a Project in Studio [page 290]

Next task: Creating the Project [page 295]

Related Information

Sample Project with Modules [page 317]

10.2 Creating the Project

In Studio, define a new set of processing instructions for event data.

Prerequisites

Start the SAP Event Stream Processor Studio.

Procedure

1. Select ▶ **File** ▶ **New** ▶ **ESP Project...** ▶.
2. For the purposes of this tutorial, in the **Name** field, enter `my_portfolio_valuation`.
3. In the **Directory** field, accept the default location or browse to a directory in which to store the new project folder.
creates three files in the named directory:

`<project-name>.ccl`	contains the CCL code.
`<project-name>.cclnotation`	contains the diagram that corresponds to the `.ccl` file.
`<project-name>.ccr`	contains the project configuration.

For example, for a project directory named "trades," smart data streaming creates a `trades.ccl`, `trades.cclnotation`, and `trades.ccr` file in the `trades` directory.

4. Click **Finish** to create the project files.
   The new project opens in the visual editor with one input stream, NEWSTREAM, and an inline schema ready for editing.

Task overview: Appendix: Tutorial for Building and Testing a Project in Studio [page 290]

Previous: About the Portfolio Valuation Sample Project [page 291]

Next task: Editing a Project Diagram [page 296]

Related Information

Creating or Modifying an ESP Project [page 74]

10.3 Editing a Project Diagram

Edit projects in the visual editor by adding shapes from the palette to the project diagram, connecting them, and completing the configuration of each shape.

Procedure

1. If the sample project diagram is not already open in the visual editor, open it now:
   a. In SAP ESP Authoring perspective, from project explorer, open the sample project, my_portfolio_valuation.
   b. Navigate to the `.cclnotation` file in your project folder and double-click `my_portfolio_valuation.cclnotation`.
2. Click in the diagram to begin editing using the palette.

   > → Tip
   >
   > To make the visual editor window full-screen, double-click the `<name>`**:Diagram** tab at the top. Double-click again to revert.

3. Select the input stream element NEWSTREAM that was added automatically when you created the project, right-click, and choose **Delete Element**.
   To run the sample project with example data, delete this element from the project before compiling.
   - **Delete Element** – removes the element from the project.
   - **Delete from Diagram** – removes the element from the diagram, but retains it in the project. When you run the project, everything in the project runs, even elements that are not on the diagram.

4. (Optional) To toggle between the visual editor and the text editor, choose **Switch to Text** or **Switch to Visual** (**F6**).

> **i Note**
>
> The visual editor, like other graphical user interfaces, offers several ways to accomplish most tasks, although this guide may not list all of them. For example, in many contexts you can carry out an action by:
>
> - Clicking a button or other icon in a shape, or on the main toolbar
> - Using a shortcut key
> - Double-clicking an element to open it
> - Right-clicking to select from the context menu
> - Selecting from the main menu bar
> - Editing element values in the properties view

Task overview: Appendix: Tutorial for Building and Testing a Project in Studio [page 290]

Previous task: Creating the Project [page 295]

Next task: Adding an Input Adapter [page 297]

10.4 Adding an Input Adapter

Attach an adapter by inserting it in the diagram, connecting it to a stream or window, and setting properties.

Context

This tutorial shows you how to insert an adapter, enable it for schema discovery, then generate and attach the input window and its schema automatically. This is the best practice for creating a schema when using an adapter that supports schema discovery.

Alternatively, SAP Event Stream Processor allows you to create the stream or window and then attach an adapter. Use this method for adapters that do not support schema discovery, or to explicitly create an inline schema for input streams or windows.

Procedure

1. For this example, from within the SAP ESP Authoring perspective, open the **Input Adapters** compartment in the palette (to the right of the diagram) and select the **File/Hadoop Event XML Input** adapter, which reads data from an XML file.

2. Click the adapter in the palette, then click in the diagram.
   The adapter shape is inserted but its border is red, indicating it is not complete, until you define its properties and attach it to a stream or window.
3. In the adapter shape toolbar hovering outside the shape, click **Edit Properties** ( ) .
4. (Optional) In the Adapter Properties dialog, change **Name** to identify your adapter.
5. Configure the adapter for schema discovery:

   Required properties are in red.

   > **i Note**
   >
   > Leave **Use named property set** unchecked, as this option does not allow you to discover the schema for this adapter.

   a. Click in the Value column for Directory and click the Browse button (...).
   b. Click the Browse button in the Directory dialog to select the folder with the data files you want the adapter to read. Click OK.
      For this example, specify the absolute path to the sample data installed with the product.

Property	Value
Directory	`<ESP-workspace-install-path>\exampledata` Windows default: `C:\Documents and Settings\<username>\My Documents\SybaseESP\5.1\workspace\exampledata` Linux and Solaris default: `<your-home-directory>/SybaseESP/5.1/workspace/exampledata`

   c. Enter a wildcard (*) in the Value column for File (in Directory). Click **OK**.
6. Click **OK**, then press **Ctrl+S** to save.

Next Steps

Import the schema and create a connected input stream or window with the same schema as the data file.

Task overview: Appendix: Tutorial for Building and Testing a Project in Studio [page 290]

Previous task: Editing a Project Diagram [page 296]

Next task: Discovering a Schema [page 299]

Related Information

Adapters [page 28]

10.5 Discovering a Schema

In Studio, use the **Schema Discovery** button in the adapter shape to discover and automatically create a schema based on the format of the data from the adapter.

Prerequisites

Add the adapter to the diagram and set its properties.

Context

Rather than manually creating a new schema in your ESP project, use schema discovery to discover and automatically create a schema, stream, or window based on the format of the data from the datasource to which your adapter connects. In this tutorial, you discover the schema for the PriceFeed input window from the File/Hadoop Event XML Input adapter, which corresponds to the schema of the source file.

Each adapter that supports schema discovery has unique properties that enable schema discovery. For a list of adapters that support schema discovery and which properties to configure, see Adapter Support for Schema Discovery [page 87].

Procedure

1. From within the SAP ESP Authoring perspective, click **Schema Discovery** on the adapter toolbar. Studio displays a Progress Information box and looks for the configuration.
   - If the schema is configured properly and one or more data sets are found, a Schema Discovery: Select Schema dialog appears where you can view and select a schema.
   - If the schema is not successfully discovered, an error message appears stating that no schema was discovered for the adapter. You can:
     - Check that the adapter properties are configured for schema discovery.
     - Check Adapter Support for Schema Discovery [page 87] to see if the adapter supports schema discovery.
2. Select the schema you need.

   You can expand the data set to view the schema.

For this example, select **positions.xml**, then click **Next**.

3. In the Schema Discovery: Create Element dialog, choose **Create new input window (with inline schema)**.

   This option creates and attaches a new window to the adapter, creates an inline schema for the window, and populates the window with the schema discovered from the adapter. When the adapter is not yet attached to a stream or window, other options are the following:

Option	Description
Create a new input stream (with inline schema)	Creates and attaches a new stream to the adapter, creates an inline schema for the stream, and populates the stream with the schema discovered from the adapter.
Create a new input stream (with attached schema)	Creates and attaches a new stream to the adapter, creates and attaches a new named schema to the stream, and populates the stream with the schema discovered from the adapter.
Create a new input window (with attached schema)	Creates and attaches a new window to the adapter, creates and attaches a new named schema to the window, and populates the window with the schema discovered from the adapter.
Create new named schema	Creates a new named schema and populates it with the schema discovered from the adapter.

4. Click **Finish**.
   - The new input window appears with the default name positions_xml_window1, and is automatically connected to the File/Hadoop Event XML Input adapter.
   - The adapter file property is set. The red warning border disappears, indicating that the element is now valid.
5. In the schema compartment of the input window, click the **Toggle Key** buttons for the BookId and Symbol columns to specify the primary key.

   The key button indicates primary key columns. With the primary key, the shape becomes valid.
6. Set a keep policy in the input window:

   a. Click **Set Keep Policy**.

   b. In the Edit Keep Policy dialog, choose **All Rows**, and click **OK**.
7. Click the input window **Edit** button and name it `positions`, using lower case letters.

Next Steps

Create another input window, PriceFeed. Either:

- Create the PriceFeed input window manually, following steps in the next task, or,
- Insert another File/Hadoop Event XML Input adapter and configure it for schema discovery.
  This time, when you discover the schema, choose `pricefeed.xml` in the `exampledata` directory. Name the input window PriceFeed, click the Id column to make it the primary key, and set the keep policy to `10 MIN`.

Task overview: Appendix: Tutorial for Building and Testing a Project in Studio [page 290]

Previous task: Adding an Input Adapter [page 297]

Next task: Adding an Input Window Manually [page 301]

10.6 Adding an Input Window Manually

In Studio, add an input window to the diagram in the sample project `my_portfolio_valuation`.

Context

These steps let you create an input window directly, and define the schema, without importing a schema.

If you used the input adapter to discover the schema and generated both input windows automatically, skip these steps and go directly to the next task.

Procedure

1. From within the SAP ESP Authoring perspective, in the visual editor, in the palette to the right of the diagram, open the **Streams and Windows** compartment.
2. Click **Input Window**.
3. Click in an empty area in the diagram where you want to insert the input window.
   The input window object is added to the project. The red border indicates that it needs more definition to be valid.
4. To set the name of the input window, either:
   - In iconic mode, click once to select the shape, then click again to edit the name.
   - In verbose mode, click the edit icon next to the name.

   For this example, enter the name `PriceFeed`.
5. Click the "plus" sign to expand the shape to verbose mode, if necessary, and click **Add Column** () on the toolbar in the input window, to add each new column.

   > → Tip
   >
   > Hover over any icon to see its name.

   A new column is created with a default name, and default datatype of integer.
6. Specify additional columns.
   a. Double-click each column name to edit it.
   b. Double-click each datatype to select the correct datatype.

   For this example, enter these column names and datatypes:

Id	integer
Symbol	string
TradeTime	seconddate
Price	float
Shares	integer

7. Click the ▦ button for the Id column to toggle it to the Key symbol.

   Input windows require a primary key.

   The Id column is now the primary key for the PriceFeed input window. The red warning border disappears, indicating that the element is now valid.
8. Create a retention window.
   a. Click **Set Keep Policy** ▦.
   b. In the Edit Keep Policy dialog, select **Time**, and enter `10 MIN` in the text box. Click **OK**.

   The default policy is to keep all rows of incoming data.

   This step defines a KEEP clause, and retains all price events received in the last 10 minutes. Without a KEEP clause, the PriceFeed window would grow infinitely large. See Retention Policies [page 23].
9. Save (**Ctrl+S**).
   This saves changes to both the `.cclnotation` file (the diagram) and the `.ccl` file (the CCL).

Results

The input window and its schema (or deduced schema) are in the diagram.

Task overview: Appendix: Tutorial for Building and Testing a Project in Studio [page 290]

Previous task: Discovering a Schema [page 299]

Next task: Creating an Aggregate as a Simple Query [page 302]

10.7 Creating an Aggregate as a Simple Query

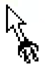
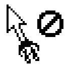
In Studio, add an aggregate simple query to the sample diagram to create a volume weighted average price (VWAP).

Context

An aggregate query groups events that have common values, and computes summary statistics for the group.

Procedure

1. From within the SAP ESP Authoring perspective, in the visual editor palette, in **Streams and Windows**, click Σ **Aggregate**.
2. Click in the diagram to create the object.
3. Change the default name, Aggregate1, to VWAP.
4. Connect PriceFeed to the VWAP aggregate:
   a. Click the **Connector** tool in the palette.
   b. Click the **PriceFeed** input window, then click the **VWAP** aggregate.
   Click the shape that produces the output first, then the shape that receives the data, to indicate the direction of data flow. Watch for visual indicators that show you when the connection is valid:

Indicator	Meaning
	Connection is allowed
	Connection is not allowed

5. Enter column expressions:
   a. Click **Add Column Expressions** (), then **Copy Columns from Input** () in the shape toolbar to select the columns to copy into the schema for the aggregate window.
   For this example, copy these columns:
      - PriceFeed.Symbol
      - PriceFeed.TradeTime
      - PriceFeed.Price
   b. Edit column names to clarify that these columns will hold the most recent price and time for the group:
      - Change TradeTime to LastTime
      - Change Price to LastPrice
   c. Add additional columns by clicking **Add Column Expression** in the shape toolbar.

   For this example, add another column and edit its name to `VWAP`.
6. Edit a column expression by double-clicking to open the inline editor, by selecting one of the tabs in the Properties view, or by selecting an expression and pressing **Ctrl+F2** to edit it using the pop-up expression editor.
   For this example, edit the VWAP column expression to:

```
sum ( PriceFeed.Price *
PriceFeed.Shares ) /
sum ( PriceFeed.Shares )
```

7. Click **Add Group Clause** (**{ }**) to edit the grouping of columns in the aggregate object.

> **i Note**
>
> The aggregate shape must have exactly one GROUP BY expression.

For this example, select **PriceFeed.Symbol** as the grouping column.

The red warning border disappears, indicating that the element is now valid.

8. Set a keep policy in the input window:
   a. Click **Set Keep Policy** .
   b. In the Edit Keep Policy dialog, choose **All Rows**, and click **OK**.

Results

By default, the aggregate is created as output, which allows external applications to subscribe to or query it, and allows you to view it using the Stream View in the SAP ESP Run-Test perspective.

Task overview: Appendix: Tutorial for Building and Testing a Project in Studio [page 290]

Previous task: Adding an Input Window Manually [page 301]

Next task: Creating a Join as a Simple Query [page 304]

10.8 Creating a Join as a Simple Query

Add a join to the sample project. A join combines events from two or more inputs to create a single stream or window. It is similar to a join in SQL.

Context

Event Stream Processor supports inner joins, left and right outer joins, and full outer joins, with join syntax comparable to SQL ANSI join syntax and comma-separated syntax. For more information, see Joins [page 210].

Procedure

1. From within the SAP ESP Authoring perspective, in the visual editor palette, in **Streams and Windows**, select **Join**.

   If necessary, close the compartments below **Streams and Windows**, or use the arrow below the compartment, so that **Join** is visible.
2. Click in the diagram to create the object.
   For this example, name the the join object `IndividualPositions`.

3. Using the connector tool, connect the join object to the appropriate stream or window.

   Attach join objects to any stream, window, or Flex operator. Join objects have multiple inputs, but only one output.

   > i Note
   >
   > Streams, windows, or keyed streams can participate in a join. Only one stream can participate in a join at a time.

   For this example, connect the VWAP aggregate object and the Positions input window to the IndividualPositions join object, in that order.

   > → Tip
   >
   > To add multiple connections, **Shift+click** while holding the **Connector** tool. To return to normal selection, press **Esc** or click the **Select** tool in the palette to release it.

4. Click **Add Column Expressions** (), then **Copy Columns** () in the join shape toolbar and select columns to copy.

   > → Tip
   >
   > If you get an error, or do not see all columns from both inputs listed, reconnect the new join element to the Positions or VWAP shapes as needed.

   For this example, choose **Select All**, then clear the check box on **VWAP.Symbol** so that you do not get the symbol field twice.

5. Click **Add Column Expressions** ().
   For this example add two columns: CurrentPosition and AveragePosition.

6. To modify column expressions, do one of the following:

   - Double-click on the expression to open the inline editor, and either type directly or press **Ctrl+Space** for syntax completion assistance, to pick from column names and functions, or,
   - Press **Ctrl+F2** to open the expression editor. Press **Ctrl+Space** to display the available input columns and built-in functions, or enter the desired expression manually, or,
   - Modify the expression in the Properties view.

   For this example, create these Column Expressions:

   - CurrentPosition: `( VWAP.LastPrice * positions.SharesHeld )`
   - AveragePosition: `( VWAP.VWAP * positions.SharesHeld )`

7. In the Join Conditions compartment of the join shape, set up the join conditions.
   If you connected the join to the VWAP and Positions inputs, in that order, there are now two elements in the Join Conditions compartment. The first defines the leftmost element for the join. If you connected to VWAP first, the first element (left side of the join) is VWAP. For this example, configure the second join element.

   a. Double-click the second join element to open the Edit Join Expression dialog.

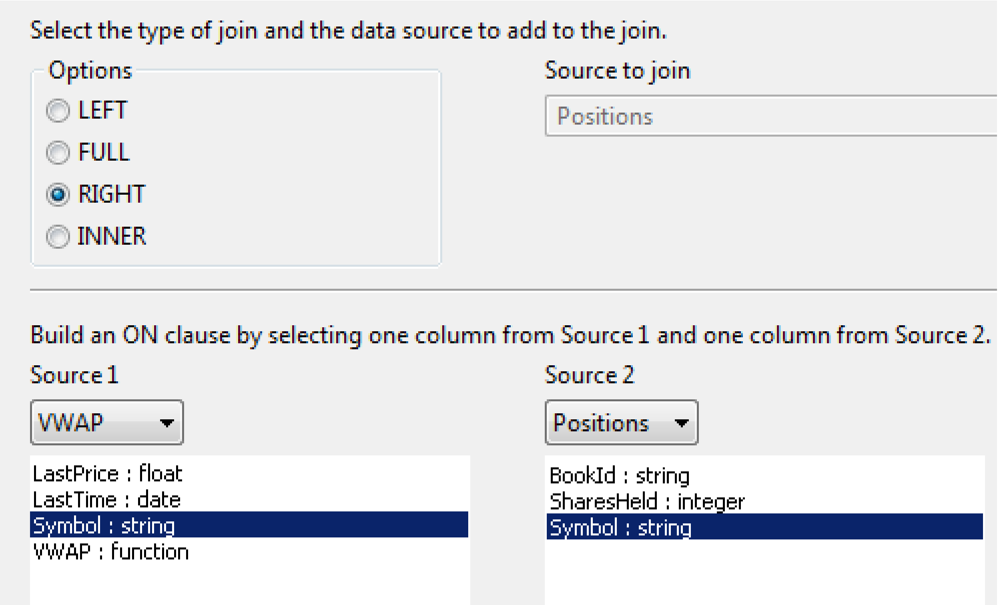
   b. Choose a join type.
      For this example, use **RIGHT**, which is a right outer join. You want RIGHT because VWAP is the first, or left input, and Positions is the second, or right input. You only want your positions in the output; you do not need prices for symbols that are not held in the portfolio.

   c. Select the columns to join on.

You cannot edit join constraints manually in the visual editor.

For this example:.

- As Source 1, ensure that **VWAP** is in the dropdown, and select the option starting with **Symbol:** as the column.
- As Source 2, ensure that **Positions** is in the dropdown, and select the option starting with **Symbol:** as the column.



Select the type of join and the data source to add to the join.

Options

○ LEFT
○ FULL
● RIGHT
○ INNER

Source to join: Positions

Build an ON clause by selecting one column from Source 1 and one column from Source 2.

Source 1: VWAP

LastPrice : float
LastTime : date
Symbol : string
VWAP : function

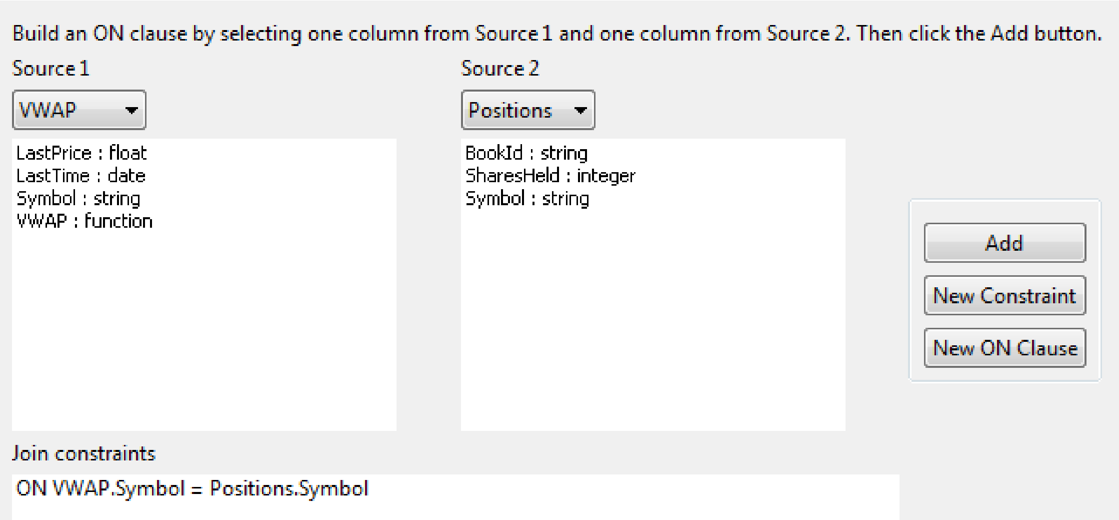
Source 2: Positions

BookId : string
SharesHeld : integer
Symbol : string

d. Click **Add**. If a message displays indicating that datatypes for the selected columns should match, click **Yes** to continue.
The columns chosen appear in Join Constraints, where you now see:

```
ON VWAP.Symbol=positions.Symbol
```

The dialog shows:



Build an ON clause by selecting one column from Source 1 and one column from Source 2. Then click the Add button.

Source 1: VWAP

LastPrice : float
LastTime : date
Symbol : string
VWAP : function

Source 2: Positions

BookId : string
SharesHeld : integer
Symbol : string

Join constraints

ON VWAP.Symbol = Positions.Symbol

e. Click **OK**.

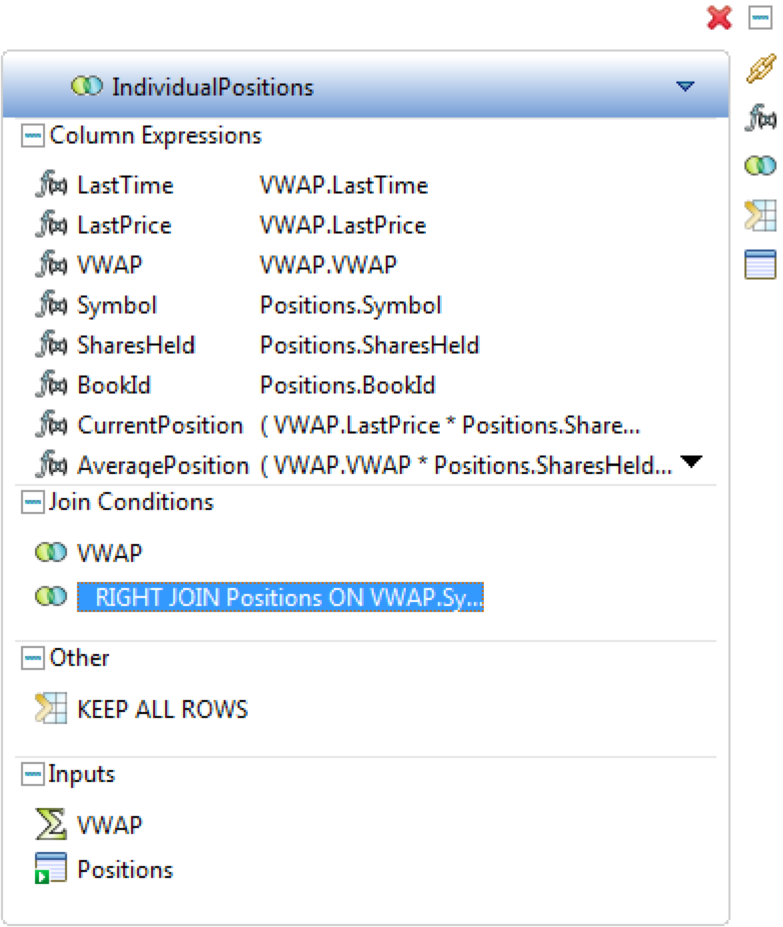
8. Set a keep policy in the input window:

   a. Click **Set Keep Policy** .
   b. In the Edit Keep Policy dialog, choose **All Rows**, and click **OK**.

9. In the join shape, click (Toggle Type to OUTPUT). If this option is not available, the shape is already set to OUTPUT.

Results

The IndividualPositions join shape now shows the completed join, as shown in the figure.



IndividualPositions

Column Expressions

LastTime	VWAP.LastTime
LastPrice	VWAP.LastPrice
VWAP	VWAP.VWAP
Symbol	Positions.Symbol
SharesHeld	Positions.SharesHeld
BookId	Positions.BookId
CurrentPosition	(VWAP.LastPrice * Positions.Share...
AveragePosition	(VWAP.VWAP * Positions.SharesHeld...

Join Conditions

VWAP

RIGHT JOIN Positions ON VWAP.Sy...

Other

KEEP ALL ROWS

Inputs

VWAP

Positions

Task overview: Appendix: Tutorial for Building and Testing a Project in Studio [page 290]

Previous task: Creating an Aggregate as a Simple Query [page 302]

Next task: Preparing Data for Output [page 308]

10.9 Preparing Data for Output

Add a new aggregate to finalize the data and prepare it for output into SAP HANA.

Context

If you do not have SAP HANA installed, complete these steps, then move on to Preparing to Compile [page 310].

In the SAP ESP Authoring perspective:

Create an additional Aggregate Simple Query Σ and name it ValueByBook.

Procedure

1. Connect the IndividualPositions join object to it.
2. Click **Copy Columns** (▦) in the shape toolbar and copy columns BookId, CurrentPosition, and AveragePosition.
3. Set column expressions:
   - `BookId IndividualPositions.BookId`
   - `CurrentPosition sum ( IndividualPositions.CurrentPosition )`
   - `AveragePosition sum ( IndividualPositions.AveragePosition )`

   > → Tip
   >
   > Use the inline editor. Double-click on the column expression, and use the **Home** and **End** keys to quickly edit the expression.
4. Add the GROUP BY clause (**{ }**) `IndividualPositions.BookId`.
5. Toggle to OUTPUT if the shape is not set as OUTPUT already.

Next Steps

Set up a connection and add an output adapter to deposit data into an SAP HANA studio table. If you do not have SAP HANA installed, skip to Preparing to Compile [page 310].

Task overview: Appendix: Tutorial for Building and Testing a Project in Studio [page 290]

Previous task: Creating a Join as a Simple Query [page 304]

Next task: Adding an Output Adapter for SAP HANA [page 309]

10.10 Adding an Output Adapter for SAP HANA

Create an SAP HANA service definition, and insert and configure an SAP HANA Output adapter using the Studio.

Prerequisites

- You have installed the SAP HANA client driver on the same machine as Studio and set up an SAP HANA database.
- You have created a connection to the server through the SAP ESP Run-Test perspective server view.

> i Note
>
> The server that you connect to must be version 5.1 SPS 10 or newer. If you connect to an older version, the option to create a HANA service does not appear in the Data Services view.

Context

If you do not have SAP HANA installed, skip this task and move on to Preparing to Compile [page 310].

Procedure

1. In the data services view, right-click on the SAP ESP server and select **Discover**.
2. In the data services view, right-click on the SAP ESP server and select **Discover**.
3. Select the new database service. In the Properties view, set the **Name** parameter to `hanaservice`.

   This service name is the value you specify to components, such as the SAP ESP Authoring HANA Output adapter, that access external databases.
4. From the **Driver** dropdown list, select **streamingdbodbc64_lib** or **streamingdbodbc_lib**.
5. Set the **User** parameter to the username that you want to use when communicating with SAP HANA.
6. Set the **Password** parameter to the password for your user name.
7. Select **Connection to HANA database** to set this database service as a HANA service entry.

8. Click anywhere outside the Properties view to save your work.
9. Open the **Output Adapters** compartment in the palette and choose **HANA Output**. This adapter uses multiple parallel ODBC connections to load information from ESP into the SAP HANA server.
    a. Add the adapter to the diagram and name it `toSAPHANA`.
    b. Click **Edit Properties** (). Fill in those property values in red:
        - Set **Database Service Name** to `hanaservice`.
        - Set **Target Database Table Name** to the required SAP HANA table. In this example, you will not be configuring the project from the SAP HANA side, so enter `exampletable` in the value field.
    c. Click **OK**, then press **Ctrl+S** to save.

Task overview: Appendix: Tutorial for Building and Testing a Project in Studio [page 290]

Previous task: Preparing Data for Output [page 308]

Next task: Preparing to Compile [page 310]

Related Information

Adapters [page 28]

10.11 Preparing to Compile

Clean up the diagram by removing unused elements.

Procedure

1. Delete any unused elements from the project so that you can run it.
   For example, if you have not done so, remove the unused input stream element NEWSTREAM that was added automatically when you created the project.
2. (Optional) Toggle to Iconic mode or Verbose mode:
    - Click the Toggle Image button in the upper left corner of a shape, or,
    - Click the All Iconic or All Verbose button in the toolbar.
3. (Optional) Click Layout Left to Right to line up shapes.
4. (Optional) To close the diagram, press **Ctrl+W** or **Ctrl+F4**, or click the **X** on the tab at the top of the editor .

Results

The completed diagram should look like this figure in Verbose mode. You may need to open some compartments and click ⊟ again to see details for all elements.

> **i Note**
>
> Even though it does not appear below, if you added the SAP HANA Output adapter to the project, the adapter is also visible in the diagram.

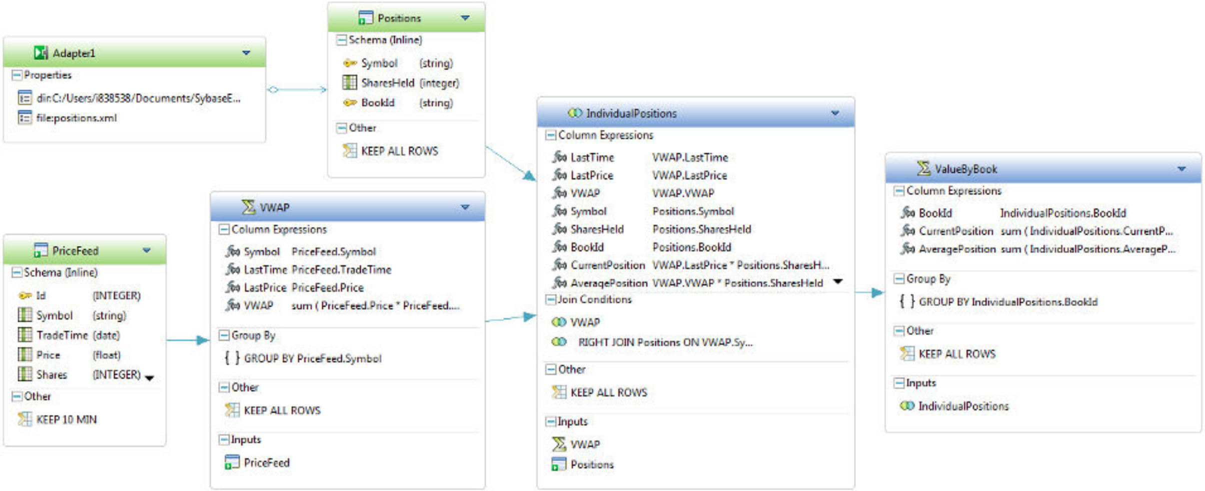


Figure 14: Completed Sample Portfolio Valuation Diagram

Next Steps

Compile the project and check for errors.

Task overview: Appendix: Tutorial for Building and Testing a Project in Studio [page 290]

Previous task: Adding an Output Adapter for SAP HANA [page 309]

Next task: Compiling the Project and Viewing Problems [page 312]

10.12 Compiling the Project and Viewing Problems

Compile a project in Studio before running it to check for errors and make corrections. Use the Problems view to view error details.

Procedure

1. To compile the project, either:
   - Click the **Compile Project** 010 button in the main toolbar, or,
   - Press **F7**.

   The project compiles and reports any errors found. Compilation errors are displayed in the Problems or Console view, depending on the type of error.
2. Click on a problem in the Problems view, or expand the group to see individual errors.

   By default, the Problems view is at the bottom of the screen, and problems are grouped by severity.

   Error details appear in the Problems view and in the status bar at the bottom left side of the screen.

   > → Tip
   >
   > If you double-click on a problem in the Problems view while the project is open in the visual editor, the text editor opens read-only to show you where the problem is. To fix the problem, either:
   > - Return to the visual editor and fix it there, or,
   > - Close both the visual editor and text editor for the project, and then reopen the project in the text editor.
3. If the error message is too long to show the entire message, click it to read the full text in the status bar at the bottom of the Studio window.
4. Right-click an item to choose from the context menu:

Option	Action
Go to	Highlight the problem in the .ccl file. The text editor opens in read-only mode.
Copy	Copy error details to the clipboard. When you exit Studio, the contents of problems view are removed. Use this option to save off errors.
Show in	Display details in Properties view.
Quick Fix	(Disabled)
Properties	Display details in a dialog box.

5. (Optional) Click the View dropdown menu to see more options.
6. Click the **Console** tab to view compiler results.

Task overview: Appendix: Tutorial for Building and Testing a Project in Studio [page 290]

Previous task: Preparing to Compile [page 310]

Next task: Deploying the Sample Project [page 313]

10.13 Deploying the Sample Project

Run the project and watch it open in the SAP ESP Run-Test perspective.

Prerequisites

Make sure the project compiles without errors. Correct any problems before you run the project.

Procedure

1. With the diagram open in the visual editor in the SAP ESP Authoring perspective, click ▶ in the main toolbar.

   > **i Note**
   >
   > If you are prompted for a user name and password for the local cluster, first change the default system-generated credentials. See *Troubleshooting > Prompted for Local Cluster Password* in the *SAP Event Stream Processor: Configuration and Administration Guide* for more information.

2. Review the running project in SAP ESP Run-Test perspective.

Task overview: Appendix: Tutorial for Building and Testing a Project in Studio [page 290]

Previous task: Compiling the Project and Viewing Problems [page 312]

Next task: Loading Data into the Sample Project [page 314]

10.14 Loading Data into the Sample Project

Test the sample project by loading reference data into the Positions window.

Context

If your project has the File/Hadoop Event XML Input adapter attached to the Positions input window, data is loaded automatically when you start the project. If you removed or omitted the adapter, use this alternative process to load the sample data.

Procedure

1. From within the SAP ESP Run-Test perspective, in the server view, expand the **my_portfolio_valuation** project to show the list of windows and streams in the project.
2. Double-click the Positions input window to open it in stream view.
   Stream view is in the upper right-hand portion of the SAP ESP Run-Test perspective.
   - If your diagram has the File/Hadoop Event XML Input adapter connected to the Positions input window, stream view shows sample data for Positions, loaded automatically from the adapter.
   - If you removed the adapter, go to the next step to load the data manually.
3. Load positions data from a file into the Positions window.
   a. Go to file upload view.
   b. Click the Select Project button in the view toolbar. If you only have one project open in server view, no dialog appears and ESP automatically selects the project for you. Otherwise, select the **my_portfolio_valuation** project in the dialog, and click **OK**.
   c. Click the **Browse** button, navigate to your `...\SybaseESP\5.1\workspace\exampledata` folder, and select `positions.xml`.

      If you do not see the `positions.xml` file, try changing the file name extension filter in the lower right corner of the dialog to `*.xml`.
   d. Click **Open**.
   e. With `positions.xml` highlighted in File Upload view, click the **Upload** button.

   Watch the data flow in stream view, as Studio loads the three positions for Book1 and Book2.

Task overview: Appendix: Tutorial for Building and Testing a Project in Studio [page 290]

Previous task: Deploying the Sample Project [page 313]

Next task: Testing the Project with Recorded Data [page 315]

10.15 Testing the Project with Recorded Data

Play back the previously recorded price feed data, and view the continuous portfolio valuations in the sample project.

Procedure

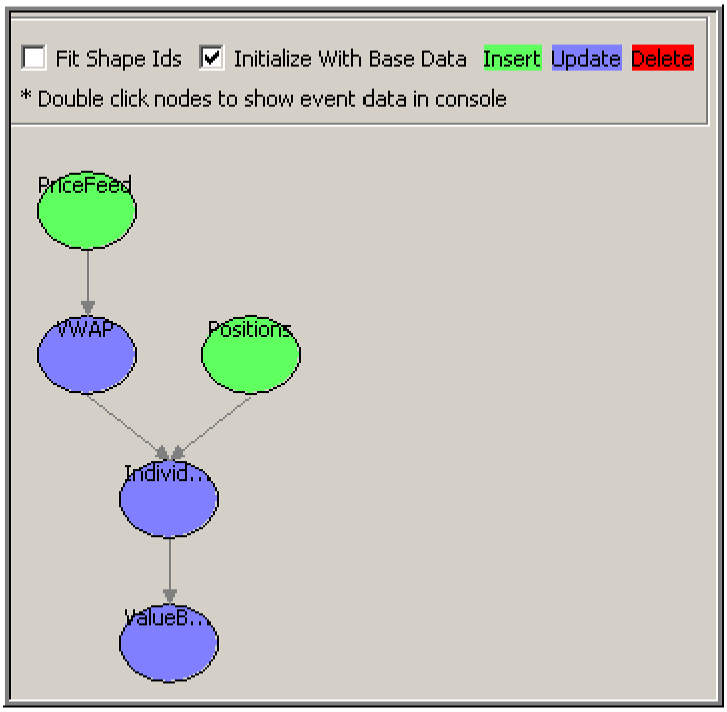
1. From within the SAP ESP Run-Test perspective, in the server view, double-click the IndividualPositions, VWAP, and ValueByBook output windows.

   In the server view list, a red arrow in the lower right corner of the window icon () indicates the output windows.
2. Click the **Playback** tab.
3. If necessary, click the **Select Project** button in the upper right corner of playback view.
   - If you only have one project running, studio selects it for you.
   - Otherwise, select the **my_portfolio_valuation** project in the dialog and click **OK**.
4. Click the **Select Playback File** button.
5. Navigate to your `<ESP-workspace-folder>\exampledata` folder, and select `pricefeed.xml`. Click **Open**.

   If you do not see the `pricefeed.xml` file, change the file name extension filter to `*.xml`.
6. In the playback view, in the playback mode frame, click the **rec/ms** button, then enter a **rec/ms** value of 1.

   A value of 1 plays back at a rate of 1000 records per second.
7. Click the green **Start Playback** button to start playback of the price feed.
8. While the data plays back, click each of the output windows in stream view to see the calculations revised in real-time.
9. (Optional) In the event tracer view, choose **Select Running Project**, and click **Initialize with Base Data**. In this example, Event Tracer shows the PriceFeed and Positions elements in green to indicate Insert operations. VWAP, IndividualPositions, and ValueByBook are in blue, indicating Updates. Colors change as different event types are processed.

   Double-click each node to watch event data in the Console.


□ Fit Shape Ids
☑ Initialize With Base Data
Insert
Update
Delete
* Double click nodes to show event data in console
PriceFeed
VWAP
Positions
Individ...
ValueB...

10. To stop the playback, click **Stop** 🟥.
11. When you are done testing the project, right-click it in server view and choose **Stop Project**.

    If you omit this step, the project stops when you exit Studio, but you may get an error.

    > → Tip
    >
    > If you see an error when you restart Studio, or when you try to open a `.ccl` file after running a project, there may be multiple instances of Studio trying to use the same Studio workspace location. If this occurs, close Studio and restart it.

Task overview: Appendix: Tutorial for Building and Testing a Project in Studio [page 290]

Previous task: Loading Data into the Sample Project [page 314]

Next: Sample Project with Modules [page 317]

Related Information

Project Execution and Testing [page 46]

10.16 Sample Project with Modules

This variation of the portfolio valuation project provides a complex, real-world example. The project uses a defined module with a named schema to easily scale out the application in a very high volume deployment. The SAP HANA Output adapter is not included in this module.

The module, `valuation.ccl`, computes the VWAP aggregate, and creates a join to the Positions window. The project uses the module to divide the moving data into smaller partitions, based on the first letter of the Symbol column. This strategy spreads the load out to more cores, thereby increasing throughput. By using modules, with very little coding you can easily double, quadruple, and so on, the number of partitions.

This example also implements the streaming tick data in PriceFeed as a stream rather than as an input window. Because keeping every tick would use a lot of memory, and because the state is never updated or queried, a stream is a more likely choice than a window in a real-world scenario for this event stream.

Example

Create Module valuation

The valuation module:

1. Defines the input stream TradesIn.
2. Defines a stream, Filter1, that filters TradesIn data into a substream based on the declared parameters `afrom` and `ato`.
3. Defines the input window Portfolio.
4. Defines the VWAP aggregate as an output window.
5. Defines another output window, ValueBySymbol, that performs a join similar to the join simple query in the simple PortfolioValuation project, with the addition of a `cast` for the `float` data.

```
CREATE MODULE valuation
IN TradesIn,Portfolio
OUT ValueBySymbol,   VWAP
BEGIN
    IMPORT 'import.ccl';

    DECLARE
        PARAMETER STRING afrom;
        PARAMETER STRING ato;
    END;

    CREATE INPUT STREAM TradesIn
       SCHEMA TradesSchema ;
    CREATE  STREAM Filter1  AS
       SELECT * FROM TradesIn
         WHERE substr(TradesIn.Symbol,1,1) >= afrom
               and substr(TradesIn.Symbol,1,1) <= ato
    ;
    CREATE INPUT WINDOW Portfolio
       SCHEMA PortfolioSchema
       PRIMARY KEY (BookId, Symbol);
    CREATE OUTPUT WINDOW VWAP
       PRIMARY KEY DEDUCED AS
       SELECT Filter1.Symbol Symbol ,
       (sum((Filter1.Price * cast(FLOAT ,Filter1.Shares))) /
          cast(FLOAT ,sum(Filter1.Shares)))
       AS VWAP,
       sum (Filter1.Shares ) Total_Shares ,
       valueinserted(Filter1.Price) LastPrice,
       valueinserted(Filter1.TradeTime) TradeTime
       FROM Filter1
       GROUP BY Filter1.Symbol ;
    CREATE OUTPUT WINDOW ValueBySymbol
        SCHEMA (BookId STRING, Symbol STRING, CurrentPosition FLOAT,
AveragePosition FLOAT)
        PRIMARY KEY (BookId, Symbol) AS
        SELECT
            Portfolio.BookId  AS BookId,
            Portfolio.Symbol  AS Symbol,
            (VWAP.LastPrice * cast(FLOAT ,Portfolio.SharesHeld))
                AS CurrentPosition,
            (VWAP.VWAP * cast(FLOAT ,Portfolio.SharesHeld))
                AS AveragePosition
            FROM Portfolio JOIN
              VWAP
                 ON Portfolio.Symbol = VWAP.Symbol;
END;
```

Example

Create Named Schema TradesSchema

```
CREATE SCHEMA  TradesSchema
    ( Id integer ,
    Symbol string ,
    TradeTime seconddate ,
    Price float ,
    Shares integer )  ;
```

Example

Create Named Schema PortfolioSchema

```
CREATE SCHEMA PortfolioSchema
    ( BookId string ,
    Symbol string ,
    SharesHeld integer ) ;
```

Example

Import and Load the valuation Module

In the parent scope, the valuation module is loaded three times, as Valuation1, Valuation2, and Valuation3.

1. The IN clause binds the input streams in the module to streams in the parent scope. TradesIn is bound to InputStream1, and Portfolio is bound to InputPositions.
2. The OUT clause binds the output window in the module, ValueBySymbol, with the three parameterized output windows, VbySym1, VbySym2, and VbySym3, and partitions the VWAP aggregate as VWAP1, VWAP2, and VWAP3.

InputStream1 Input stream based on the imported schema, TradesSchema.

InputPositions Input window based on the imported schema, PortfolioSchema.

UnionVWAP Output window created as a UNION of the partitioned VWAP aggregate.

```
IMPORT 'import.ccl';
IMPORT 'valuation.ccl';
DECLARE
    PARAMETER STRING afrom :='A';
    PARAMETER STRING ato := 'Z';
END;
CREATE INPUT STREAM InputStream1 SCHEMA TradesSchema  ;
CREATE INPUT WINDOW InputPositions
  SCHEMA PortfolioSchema PRIMARY KEY ( BookId , Symbol ) ;
  LOAD MODULE valuation as Valuation1
    in TradesIn = InputStream1, Portfolio = InputPositions
    OUT ValueBySymbol = VbySym1,  VWAP = VWAP1
    PARAMETERS afrom = 'A', ato = 'J'
    ;
  LOAD MODULE valuation as Valuation2
    in TradesIn = InputStream1, Portfolio = InputPositions
    OUT ValueBySymbol = VbySym2, VWAP = VWAP2
    PARAMETERS afrom = 'K', ato = 'Q'
    ;
  LOAD MODULE valuation as Valuation3
    in TradesIn = InputStream1, Portfolio = InputPositions
    OUT ValueBySymbol = VbySym3,  VWAP = VWAP3
    PARAMETERS afrom = 'R', ato = 'Z'
    ;
CREATE OUTPUT WINDOW UnionVWAP
 PRIMARY KEY DEDUCED
 AS SELECT * FROM VWAP1
    UNION SELECT * FROM VWAP3
    UNION SELECT * FROM VWAP2 ;
CREATE OUTPUT WINDOW ValueBySymbol
 PRIMARY KEY (BookId,Symbol)
 AS SELECT * FROM VbySym1
    UNION SELECT * FROM VbySym3
    UNION SELECT * FROM VbySym2 ;
// ----------------------------
//  stream ValueByBook
CREATE  OUTPUT  WINDOW ValueByBook
    SCHEMA (BookId STRING, CurrentPosition FLOAT, AveragePosition FLOAT)
     PRIMARY KEY DEDUCED AS
    SELECT ValueBySymbol.BookId AS BookId,
        sum(ValueBySymbol.CurrentPosition) AS CurrentPosition,
        sum(ValueBySymbol.AveragePosition) AS AveragePosition
    FROM ValueBySymbol
    GROUP BY ValueBySymbol.BookId;


ATTACH INPUT ADAPTER Adapter1 TYPE toolkit_file_xmllist_input TO InputStream1
GROUP nostartGroup
PROPERTIES
dir = '../exampledata' ,
file = 'pricefeed.xml' ,
pollingPeriod = 0 ,
xmllistSecondDateFormat = 'yyyy-MM-ddTHH:mm:ss' ,
xmllistMsDateFormat = 'yyyy-MM-ddTHH:mm:ss';
ATTACH INPUT ADAPTER Adapter2 TYPE toolkit_file_xmllist_input TO
InputPositions
PROPERTIES
dir = '../exampledata' ,
file = 'positions.xml' ,
pollingPeriod = 0 ,
xmllistSecondDateFormat = 'yyyy-MM-ddTHH:mm:ss' ,
xmllistMsDateFormat = 'yyyy-MM-ddTHH:mm:ss';
ADAPTER START GROUPS nostartGroup nostart   ;
```

Note

When sandboxing is enabled, edit the `dir` property. For example, change `dir='../exampledata` to `dir='<sandbox-base-directory>/exampledata'`. Otherwise, when sandboxing is enabled, the example does not compile properly and you receive an error message.

Parent topic: Appendix: Tutorial for Building and Testing a Project in Studio [page 290]

Previous task: Testing the Project with Recorded Data [page 315]

Related Information

About the Portfolio Valuation Sample Project [page 291]
Modularity [page 172]

11 Appendix: Performance and Tuning Tips

Optimizing performance in SAP Event Stream Processor requires tuning at the project level as well as at the infrastructure level (machine, OS, network configuration, and so on).

If you tune your projects to produce maximum throughput and minimum latency but do not configure your infrastructure to handle the throughput, you will see sub-optimal performance. Likewise, if you configure your infrastructure to handle maximum throughput but do not tune your projects, your performance suffers.

In this section:

Distributing Load through Parallelization [page 322]

To improve performance of large ESP projects, separate the data into smaller chunks that are processed within their own partitions. Processing on multiple partitions in parallel can improve performance over processing in one large partition.

Distributing Load through Modularization [page 326]

You can optimize performance by breaking projects into modules. This strategy spreads the load out to more cores, thereby increasing throughput.

Streaming Data Flow [page 326]

The throughput of the Event Stream Processor project depends on the throughput of the slowest component in the project.

Log Store Considerations [page 326]

The size and location of your log stores can impact performance.

Batch Processing [page 327]

When stream processing logic is relatively light, inter-stream communication can become a bottleneck. To avoid such bottlenecks, you can publish data to the ESP server in micro batches. Batching reduces the overhead of inter-stream communication and thus increases throughput at the expense of increased latency.

Main Memory Usage [page 327]

There are no SAP Event Stream Processor configuration settings that directly set up or control RAM usage on the machine. However, a reference from ESP counts records in the system, ensuring that only one copy of a record is present in memory, although multiple references to that record may exist in different streams.

Monitor Project Memory Usage [page 328]

When the ESP server is running at log level INFO and it is shut down cleanly, it reports the amount of memory consumed by various project components, adding this information to the ESP project log file. You can also generate this report on-demand without shutting down.

CPU Usage [page 334]

SAP Event Stream Processor automatically distributes its processing load across all the available CPUs on the machine. If the processing of a data stream seems slow, monitor each stream's CPU utilization using either the `streamingmonitor` utility from the command line or through SAP ESP Cockpit. If the monitoring tool shows one stream in the project using the CPU more than other streams, refine the project to ensure that the CPU is used evenly across the streams.

TCP Buffer and Window Sizes [page 334]

High throughput data transfers between clients and SAP Event Stream Processor rely on the proper tuning of the underlying operating system's TCP networking system.

Improving Aggregation Performance [page 335]
Aggregation functions typically require the server to iterate over every element in a group. For this reason, the performance of the aggregation operator is inversely proportional to the size of the group.

Switch from Decimal to Money Datatype [page 337]
Using the `money` datatype rather than the `decimal` datatype can improve the performance of a project.

Recompiling Projects [page 337]
Recompile existing projects that were compiled with earlier compiler versions to take advantage of the latest enhancements.

Improving Studio Performance [page 338]
When you have multiple projects running, Studio can slow down. You can improve performance by adjusting preferences in the SAP ESP Run-Test perspective.

11.1 Distributing Load through Parallelization

To improve performance of large ESP projects, separate the data into smaller chunks that are processed within their own partitions. Processing on multiple partitions in parallel can improve performance over processing in one large partition.

There are various ways to parallelize your ESP project.

1. Application-based Partitioning

You can send all incoming data to each of the input adapters within your ESP project, and then attach each of these adapters to a stream that filters a subset of the overall incoming data. The output adapters receive this data and output it to the external datasource.

Advantages:

- Improves performance and processes high volumes of data since having multiple streams processing subsets of the data divides the load on the processor.
- No need to create a custom adapter or do any custom coding aside from specifying the filtering.
- Allows for partitioning across cores, but this type of partioning is best suited across machines.

Disadvantages:

- Need to duplicate the input data feeding into the input adapters.

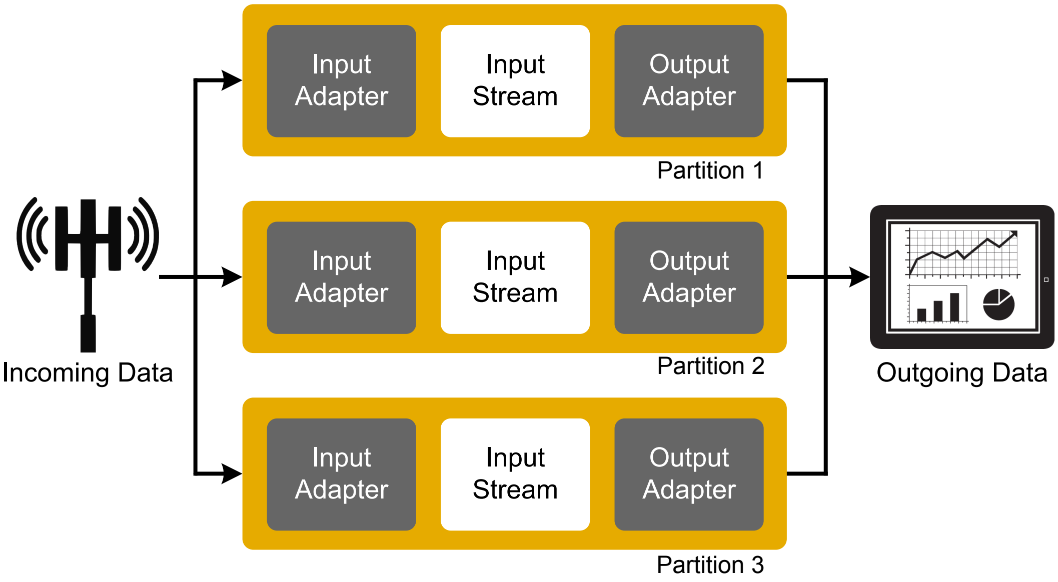


Figure 15: Application-based Partitioning

2. Partitioning Using a Custom Adapter

You can write a custom adapter to receive input data and publish it to various streams, keyed streams, or windows on separate machines. These streams or windows process and send this data to separate output adapters, which then publish it to the end datasource. The custom adapter is responsible for partitioning the input data in this scenario.

Advantages:

- Improves performance and processes high volumes of data by filtering incoming data across multiple machines.
- Adapters are customizeable to meet partitioning requirements.
- No need to duplicate any data.
- Allows for partitioning across cores, but this type of partioning is best suited across machines.

Disadvantages:

- Requires more effort in terms of coding because you create a custom adapter. You cannot currently partition the available adapters provided with Event Stream Processor.

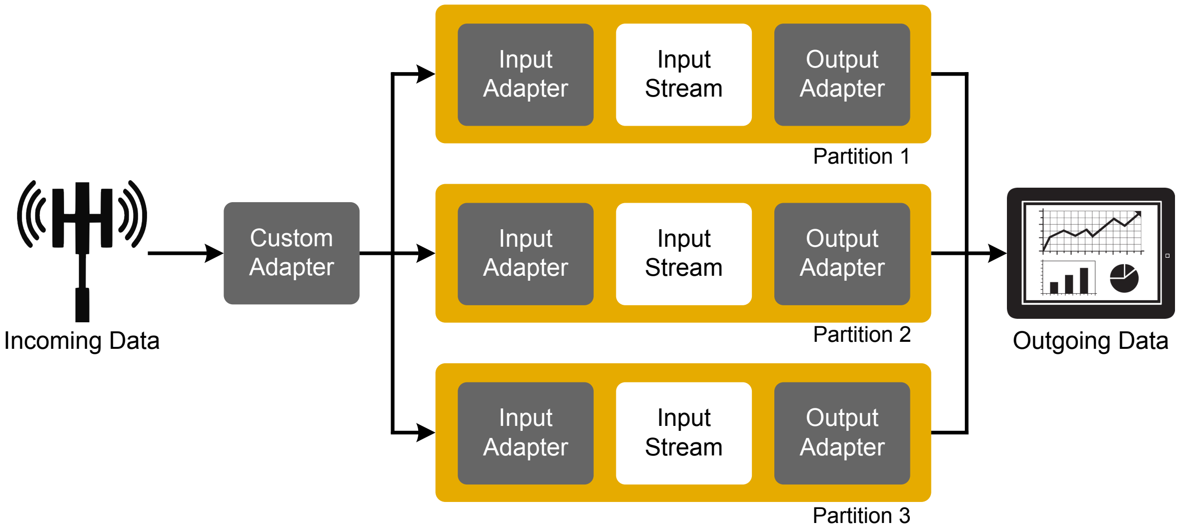


Figure 16: Partitioning Using a Custom Adapter

3. Partitioning Using a SPLITTER Statement

You can use the CCL SPLITTER object to subdivide input data based on specific criteria, and then a UNION statement to consolidate the data before sending it to the output adapter.

Advantages:

- More flexibility in the operations that you can perform on streams. For example, you first split the data, perform operations on the resulting streams, and then consolidate the data again.
- Allows for partitioning across cores.

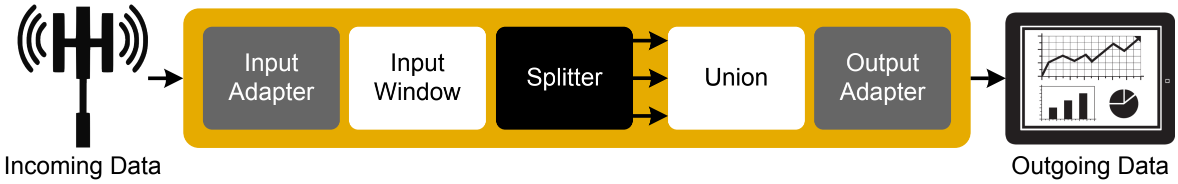


Figure 17: Partitioning Using SPLITTER and UNION Statements

Although the example in the illustration uses a single input adapter, you can use a SPLITTER when using multiple input adapters.

> **i Note**
>
> Using the JOIN object does not provide the same performance benefit as using the UNION. In fact, the JOIN operation can degrade performance considerably, so to optimize performance, parallelizing your project using the SPLITTER/UNION combination is recommended over using JOIN.

In both the cases, the number of parallel instances is limited to the throughput of the union and the SPLITTER, when used. In addition, the number of parallel instances depends on the number of available CPUs.

4. Automatic Partitioning

You can create multiple parallel instances of a given element (keyed stream, stream, window, module) and partition input data into these instance. Partitioning data this way results in higher performance as the workload is split across the parallel instances. If using this scenario, you can partition the CCL elements using CUSTOM, HASH, or ROUND ROBIN partitioning.

Advantages:

- Ideal for complex projects which perform computationally expensive operations, such as aggregation and joins.
- Easy to add to a project.
- Allows for partitioning across cores.

Disadvantage:

- Lacks the ability to order output.

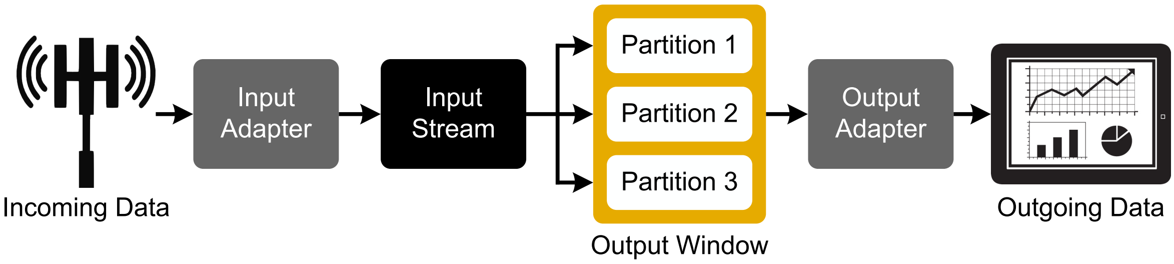


Figure 18: Automatic Partitioning

General Guidelines

Hash partitioning uses hash functions to partition data. The hash function determines which partition to place a row into based on the column names you specify as keys. These do not have to be primary keys. Round-robin partitioning distributes data evenly across partitions without any regard to the values.

Choose a type based on the calculations you are performing on the input data. For example, round-robin is sufficient for stateless operations like simple filters, but not for aggregation as this would produce differing results. Hash partitioning is necessary for grouping records together, but grouping may not evenly distribute the data across instances.

When implementing the scenarios above, use round-robin or key-based partitioning. Round-robin partitioning provides the most even distribution across the multiple parallel instances, but is recommended only for projects limited to insert operations (that is, no updates or deletes). For projects using insert, update, and delete operations, key-based partitioning is preferable. Any update or delete operation on a record should occur on the same path where the record was inserted, and only key-based partitioning can guarantee this. However, key-based partitioning can distribute load unevenly if the HASH function is not applied correctly, resulting in some partitions having a higher burden than others.

For an example of improving performance throughput using automatic partitioning, see *Performance Tuning Using Partitioning* in the *SAP Event Stream Processor: Examples Guide*.

For more information on the SPLITTER and UNION statements, see the *SAP Event Stream Processor: CCL Reference* and refer to the `splitter`, `Union`, and `RAP_splitter_examples` provided in your `Examples` folder.

11.2 Distributing Load through Modularization

You can optimize performance by breaking projects into modules. This strategy spreads the load out to more cores, thereby increasing throughput.

Use modules to double, quadruple, and so on, the number of partitions, with very little additional code. The more partitions you create, the more you distribute the load.

For more information see the *Modularity* section in the *SAP Event Stream Processor: Developer Guide*, and the *SAP Event Stream Processor: CCL Reference*.

11.3 Streaming Data Flow

The throughput of the Event Stream Processor project depends on the throughput of the slowest component in the project.

Each stream in ESP has an internal queue that holds up to 1024 messages; this queue is composed of multiple internal queues. The queue size is hard-coded and cannot be modified. An internal queue buffers data feeding a stream if that stream is unable to keep up with the inflowing data.

Consider an example where data flows from an input adapter, through streams A, B, and C, and then through an output adapter. If the destination target of the output adapter cannot handle the volume or frequency of messages being sent by the output adapter, the internal queue for the stream feeding the output destination fills up, and stream C cannot publish additional messages to it. As a result, the internal queue for stream C also fills up and stream B can no longer publish to it.

This continues up the chain until the input adapter can no longer publish messages to stream A. If, in the same example, the input adapter is slower than the other streams, messages will continue being published from stream to stream, but the throughput is constrained by the speed of the input adapter.

If your output destination is a database, you can batch the data for faster inserts and updates. Set the batch size for a database adapter in the data service for the cluster. For information on managing data services, see the *SAP Event Stream Processor: Configuration and Administration Guide*.

Batching data carries some risk of data loss because the database adapters run on an in-memory system. To minimize the risk of data loss, set the batch size to 1.

11.4 Log Store Considerations

The size and location of your log stores can impact performance.

Sizing the log stores correctly is important. A store that is too small requires more frequent cleaning cycles, which severely degrades performance. In the worst case, the log store can overflow and cause the processing to stop. A store that is too large also causes performance issues due to the larger memory and disk footprint. For detailed information on calculating the optimal log store size, see *Sizing a Log Store* in the *SAP Event Stream Processor: Developer Guide*.

When storing ESP data locally using log stores, use a high-speed storage device (for example, a raid array or SAN, preferably with a large dynamic RAM cache). Putting the backing files for log stores on single disk drives (whether SAS, SCSI, IDE, or SATA) always yields moderately low throughput.

> i Note
>
> On Solaris, putting log files in `/tmp` uses main memory.

11.5 Batch Processing

When stream processing logic is relatively light, inter-stream communication can become a bottleneck. To avoid such bottlenecks, you can publish data to the ESP server in micro batches. Batching reduces the overhead of inter-stream communication and thus increases throughput at the expense of increased latency.

ESP supports two modes of batching: envelopes and transactions.

- Envelopes – When you publish data to the server using the envelope option, the server sends the complete block of records to the source stream. The source stream processes the complete block of records before forwarding the ensuing results to the dependent streams in the graph, which in turn process all the records before forwarding them to their dependent streams. In envelope mode, each record in the envelope is treated atomically, so a failure in one record does not impact the processing of the other records in the block.
- Transactions – When you publish data to the server using the transaction option, processing is similar to envelope mode in that the source stream processes all of the records in the transaction block before forwarding the results to its dependent streams in the data graph. Transaction mode is more efficient than envelope mode, but there are some important semantic differences between the two. The key difference between the two modes is that in transaction mode, if one record in the transaction block fails, then all records in the transaction block are rejected, and none of the computed results are forwarded downstream. Another difference is that in transaction mode, all resultant rows produced by a stream, regardless of which row in the transaction block produced them, are coalesced on the key field. Consequently, the number of resulting rows may be somewhat unexpected.

In both cases the number of records to place in a micro batch depends on the nature of the model and needs to be evaluated by trial and error. Typically, the best performance is achieved when using a few tens of rows per batch to a few thousand rows per batch. While increasing the number of rows per batch may increase throughput, it also increases latency.

11.6 Main Memory Usage

There are no SAP Event Stream Processor configuration settings that directly set up or control RAM usage on the machine. However, a reference from ESP counts records in the system, ensuring that only one copy of a record is present in memory, although multiple references to that record may exist in different streams.

Memory usage is directly proportional to the number of records in a project. To limit the amount of memory the entire instance of ESP uses before it reports an out-of-memory condition, use the `ulimit` command to restrict the amount of memory available to each shell process.

11.7 Monitor Project Memory Usage

When the ESP server is running at log level INFO and it is shut down cleanly, it reports the amount of memory consumed by various project components, adding this information to the ESP project log file. You can also generate this report on-demand without shutting down.

The log level is a project configuration option on the **Advanced** tab of the Project Configuration editor in Studio. A report detailing project statistics is printed if the level is set at 6 when the ESP server shuts down.

The files generated by a project, including the project log file, are placed in the SAP project working directory. To change the log level at run time, use the `streamingprojectclient` tool and execute:

```
streamingprojectclient -p [<host>:]<port></workspace-name/project-name> -c
<username>:<password> "loglevel 6"
```

Alternatively, use the `streamingprojectclient` command `get_memory_usage all` to generate this report without having to set the log level or shut the project down. The report measures input and output streams, queues, adapters, and reference caches for their memory use. Use this data to identify memory usage bottlenecks, and fine tune your project layout to improve throughput.

> ℹ Note
>
> In some cases when using `get_memory_usage all`, some rows of data that are shared by components are subsequently recorded more than once in the report. Rows in a gateway queue, for example, are likely to be in a store, and possibly an input queue as well. Cross-referencing between component reports can help identify where select rows are recorded, but the overall report nonetheless serves to highlight where excessive memory is being used.

When looking for component-specific data, qualify the component type and name in the project being tracked. Component types include:

- gateway
- stream/window
- global
- reference cache

Component names include:

- all
- `<client-ID><client-name>`
- `<stream-name>`
- `<adapter-name>`
- `<reference-name>`

The following sample illustrates some of the memory usage statistics reported in the log file:

```
[SP-6-131039] (189.139) sp(21115) CompiledSourceStream(W1): Collecting
statistics (this could take awhile).
[SP-6-131040] (190.269) sp(21115) CompiledSourceStream(W1): Memory usage:
1,329,000,000 bytes in 3,000,000 records.
[SP-6-114012] (190.269) sp(21115) Platform(cepqplinux1)::run() -- cleaning up
CompiledAggregateStream(grpbyout).
[SP-6-131039] (191.065) sp(21115) CompiledAggregateStream(grpbyout): Collecting
statistics (this could take awhile).
```

```
[SP-6-124001] (191.065) sp(21115) CompiledAggregateStream(grpbyout)::Memory
usage: 1,545,000,000 bytes in aggregation index.
[SP-6-131039] (195.957) sp(21115) CompiledAggregateStream(grpbyout): Collecting
statistics (this could take awhile).
[SP-6-131040] (196.267) sp(21115) CompiledAggregateStream(grpbyout): Memory
usage: 1,020,000,000 bytes in 3,000,000 records.
[SP-6-114012] (196.267) sp(21115) Platform(cepqplinux1)::run() -- cleaning up
CompiledAggregateStream(grpbyout2).
[SP-6-131039] (197.038) sp(21115) CompiledAggregateStream(grpbyout2): Collecting
statistics (this could take awhile).
[SP-6-124001] (197.039) sp(21115) CompiledAggregateStream(grpbyout2)::Memory
usage: 1,545,000,000 bytes in aggregation index.
[SP-6-131039] (202.184) sp(21115) CompiledAggregateStream(grpbyout2): Collecting
statistics (this could take awhile).
[SP-6-131040] (202.496) sp(21115) CompiledAggregateStream(grpbyout2): Memory
usage: 1,122,000,000 bytes in 3,000,000 records.
[SP-6-114012] (202.496) sp(21115) Platform(cepqplinux1)::run() -- cleaning up
CompiledStream(coutputwin).
[SP-6-131039] (202.496) sp(21115) CompiledStream(coutputwin): Collecting
statistics (this could take awhile).
[SP-6-131040] (203.654) sp(21115) CompiledStream(coutputwin): Memory usage:
651,000,000 bytes in 3,000,000 records.
```

> Note
>
> While running this report, you may notice a degradation in performance until the report is complete.

In this section:

Gateway Memory Usage [page 329]
: Gateway establishes queues where it stores incoming data and, depending on the type of subscription, creates additional queues, indices, and stores for aggregation. When requesting a report for gateway, you can request data for all client connections, specify a client IP address, or specify an IP address and name pairing.

Stream and Window Memory Usage [page 330]
: When requesting a report for streams, request data for all streams in a project or a specific stream by name.

CCLScript Variables Memory Usage [page 332]
: When requesting information on CCLScript memory usage, specify your search for either global or local declare blocks.

Reference Cache Memory Usage [page 333]
: References can store information in potentially unlimited-size caches. When requesting a report for memory allocated to the reference cache, specify the reference name.

11.7.1 Gateway Memory Usage

Gateway establishes queues where it stores incoming data and, depending on the type of subscription, creates additional queues, indices, and stores for aggregation. When requesting a report for gateway, you can request data for all client connections, specify a client IP address, or specify an IP address and name pairing.

Use the *streamingprojectclient* `get_memory_usage` command to view all gateway clients:

```
get_memory_usage gateway
```

Use the *streamingprojectclient* `get_memory_usage` command to view gateway clients on a specific IP:

```
get_memory_usage <IP-Address>
```

Use the *streamingprojectclient* `get_memory_usage` command to view one specifed client:

```
get_memory_usage <IP-Address><Client-ID>
```

A gateway report includes the following:

```
<Client-IP><Client-ID>:
Input Queue:
<subscriber-queue-memory-size> bytes in <subscriber-queue-number-of-records>
records
Aggregation Indices:
<aggregation-index-memory-size> bytes
Order by Store:
<order-by-memory-size> bytes in <number-of-records> records
Output Queue:
<output-queue-memory-size> bytes in <output-queue-number-of-rows> rows
```

The following example illustrates the report when using a specified client IP address and client ID:

```
[SP-6-131096] (71.084) sp(14723) Gateway Client 10.7.168.66 (129) Memory usage:
[SP-6-131094] (71.084) sp(14723) Queue: 0 bytes in 0 records
[SP-6-131097] (71.084) sp(14723) Aggregation Indices: 12,902 bytes in 26 records
[SP-6-131098] (71.084) sp(14723) Result Set Store: 1,846 bytes in 26 records
[SP-6-131095] (71.084) sp(14723) Gateway Output Store: 0 bytes in 0 rows
```

Considerations for gateway memory usage:

- Queues: You can adjust the settings of your connection tool to alleviate any strain on the connection. Increase the amount of records your tool can consume, or send fewer records by filtering data into other streams and subscribing to those streams. See the *SAP Event Stream Processor: Configuration and Administration Guide* for infomation on project configurations.
- Aggregation Indices: This is a temporary index that is only stored when specified in the query to the client connection. This memory usage ends when the query is finished.
- Result Set Store: Like aggregation indices, this memory usage is temporary.
- Output Store: This is a concern only if the subscription is pulsed, where records are collected and delivered at set intervals. If the output store is holding onto too much data, lower the pulse subscribe interval. See the *SAP Event Stream Processor: Utilities Guide* for information on controlling the pulse rate.

11.7.2 Stream and Window Memory Usage

When requesting a report for streams, request data for all streams in a project or a specific stream by name.

There are different kinds of streams to monitor. Most allocate a temporary amount of memory to process rows, and some streams keep rows and other data for the entire project lifecycle. Streams can also have CCLScript local declare block variables of basic data types, records, dictionaries, vectors, xml values, and event caches.

Use the *streamingprojectclient* `get_memory_usage` command to view the memory usage for all streams:

```
streamingprojectclient get_memory_usage stream
```

Use the *streamingprojectclient* `get_memory_usage` command to view memory usage for a single stream:

```
streamingprojectclient get_memory_usage stream '<stream-name>'
```

A report includes the following:

```
<Stream-Name>:
Store:
<store-memory-size> bytes in <number-of-stored-rows> records stored
Input Queue:
<Input-Queue-memory-size> bytes in <number-of-queued-rows> records
Transaction Export Queue:
<Transaction-Queue-memory-size> bytes in <number-of-queued-rows> records
Aggregation Index:
<Aggregation-Index-memory-size> bytes in aggregation index
Guaranteed Delivery Store:
<GD-Store-memory-size> bytes in <number-of-stored-rows> records
```

Considerations for stream or window memory usage:

- Store: A log store that is too large can hinder performance due to larger disk and memory requirements. To reduce memory usage, consider adjusting your retention policy on the store to retain less data .

  > i Note
  >
  > Log stores that are too small can cause processing to stop due to overflow. They can also cause significant performance degradation due to frequent cleaning cycles. See *Creating a Log Store* in the *SAP Event Stream Processor: Developer Guide* for information regarding log store optimization.

- Input Queue: Examine other objects that are consuming messages from the stream, and determine if their queues are full. If a queue is not full, check the object feeding into it for potential bottlenecks. Reduce the messages coming into the stream by filtering and distributing the data through multiple streams.
- Transaction Export Queue: Huge transactions are the primary cause of excessive memory use. Avoid constructing a transaction with an excessive number of records. Determine if any secondary objects like tables are joined into the row without any equality conditions.
- Aggregation Index: If a stream feeds input to an aggregation window directly, the memory usage of the aggregation index increases without bound. To prevent such unbounded growth, insert an intermediate window between the stream and the aggregation window. Consider lowering the retention policy of the store or unnamed window that has the aggregation..

  > i Note
  >
  > There are advantages and disadvantages to changing the retention policy. See *Aggregation* in the *SAP Event Stream Processor: Developer Guide* for more information.

- GD Mode: A stream with guaranteed delivery (GD) mode enabled stores records until all rows are fully processed. If GD Mode is enabled, but not required, disable it.

Depending on which CCLScript variables exist in the stream, a report includes:

```
CCLScript Variables:
<Stream-Dictionary-size> in bytes
<Stream-Event-Cache-size> in bytes
<Stream-Vector-size> in bytes
<Stream-Records-size> in bytes
<Stream-XML-Values-size> in bytes
<Primitive-Variables-size> in bytes
```

Considerations for CCLScript local declare block variables:

- Multiple variables of the same type will not be grouped together.
- The size of your variables are dependent on their usage. For more information on declare block variables, consult the *CCL Statements* section of the *SAP Event Stream Processor: CCL Reference*.

The following example illustrates a report when tracking streams for memory usage:

```
SP-6-124001] (191.065) sp(21115) Log store: 3,692 bytes in 52 records
[SP-6-124001] (191.065) sp(21115) Input queue: 700,000 bytes in 46,100 records
[SP-6-124001] (191.065) sp(21115) Export queue 1,000,000 bytes in 67,040 records
[SP-6-124001] (191.065) sp(21115) Aggregation Index: 1,545,000,000 bytes in
aggregation index
[SP-6-124001] (191.065) sp(21115) GD Store: 0 bytes in 0 records
[SP-6-124001] (191.065) sp(21115) StreamDic1: 3 bytes
[SP-6-124001] (191.065) sp(21115) StreamEvent1: 28,668 bytes
[SP-6-124001] (191.065) sp(21115) StreamVec1: 19 bytes
[SP-6-124001] (191.065) sp(21115) StreamVec2: 78 bytes
[SP-6-124001] (191.065) sp(21115) StreamRec1: 111 bytes
[SP-6-124001] (191.065) sp(21115) StreamRec2: 111 bytes
[SP-6-124001] (191.065) sp(21115) StreamXml1: 72 bytes
[SP-6-124001] (191.065) sp(21115) Primitive Variables: 32 bytes
```

11.7.3 CCLScript Variables Memory Usage

When requesting information on CCLScript memory usage, specify your search for either global or local declare blocks.

CCLScript variables include basic datatypes, records, dictionaries, vectors, xml values, and event caches. These variables are declared in DECLARE statements, which help to define a project's computations and logic. Local declare blocks are used in regular and Flex streams, while global declare blocks are available to an entire project.

A report for CCLScript variables can include the following:

```
<Stream-Dictionary-size> in bytes
<Stream-Event-Cache-size> in bytes
<Stream-Vector-size> in bytes
<Stream-Records-size> in bytes
<Stream-XML-Values-size> in bytes
<Primitive-Variables-size> in bytes
```

Use the following *streamingprojectclient* commands to report CCLScript variables present in local streams or a single stream:

```
streamingprojectclient get memory usage stream
```

```
streamingprojectclient get_memory_usage stream '<stream-name>'
```

The following example illustrates the report when tracking CCLScript variable memory use in streams:

```
[SP-6-124001] (191.065) sp(21115) streamDic1: 3 bytes
[SP-6-124001] (191.065) sp(21115) streamEvent1: 28,668 bytes
[SP-6-124001] (191.065) sp(21115) streamVec1: 19 bytes
[SP-6-124001] (191.065) sp(21115) streamVec2: 59 bytes
[SP-6-124001] (191.065) sp(21115) streamVec3: 13 bytes
[SP-6-124001] (191.065) sp(21115) streamRec1: 111 bytes
```

```
[SP-6-124001] (191.065) sp(21115) streamXml1: 72 bytes
[SP-6-124001] (191.065) sp(21115) Primitive Variables: 32 bytes
```

> **Note**
>
> When using `stream` and `stream <stream-name>` keywords for your report, other components of the stream are reported. See *Stream and Window Memory Usage*.

Use the *streamingprojectclient* command to report CCLScript variables in global declare blocks:

```
streamingprojectclient get_memory_usage global
```

The following example illustrates the report when tracking CCLScript variables' memory use in global declare blocks:

```
[SP-6-124001] (191.065) sp(21115) globalDic1: 64 bytes
[SP-6-124001] (191.065) sp(21115) globalRec1: 111 bytes
[SP-6-124001] (191.065) sp(21115) globalRec2: 311 bytes
[SP-6-124001] (191.065) sp(21115) globalRec3: 245 bytes
[SP-6-124001] (191.065) sp(21115) globalVec1: 66 bytes
[SP-6-124001] (191.065) sp(21115) globalVec2: 78 bytes
[SP-6-124001] (191.065) sp(21115) globalXml1: 72 bytes
[SP-6-124001] (191.065) sp(21115) Primitive variables: 32 bytes
```

Considerations for CCLScript declare block variables:

- Multiple variables of the same type are not grouped together.
- The size of your variables are dependent on their usage. For more information on declare block variables, consult the CCL Statements section of *SAP Event Stream Processor: CCL Reference*.

11.7.4 Reference Cache Memory Usage

References can store information in potentially unlimited-size caches. When requesting a report for memory allocated to the reference cache, specify the reference name.

Use the *streamingprojectclient* `get_memory_usage` command to view the size of a reference cache:

```
get_memory_usage <reference-name>
```

A report includes the following:

```
<reference-name>:
<cache-size> bytes in <number-of-cached-queries> queries
```

Considerations for reference memory usage:

- Change the retention policy on your reference by lowering the `maxCacheSize` parameter. This is the only way to reduce memory consumption for this component.

  > **Note**
  >
  > There are significant advantages and disadvantages to adjusting this parameter. See *Reference Table Queries* in the *SAP Event Stream Processor: Developer Guide*.

11.8 CPU Usage

SAP Event Stream Processor automatically distributes its processing load across all the available CPUs on the machine. If the processing of a data stream seems slow, monitor each stream's CPU utilization using either the `streamingmonitor` utility from the command line or through SAP ESP Cockpit. If the monitoring tool shows one stream in the project using the CPU more than other streams, refine the project to ensure that the CPU is used evenly across the streams.

The queue depth is also a very important metric to monitor. Each stream is preceded by a queue of input records. All input to a given stream is placed in the input queue. If the stream processing logic cannot process the records as quickly as they arrive to the input queue, the input queue can grow to a maximum size of 1024 records. At that point, the queue stops accepting new records, which results in the automatic throttling of input streams. Since throttled streams require no CPU time, all CPU resources are distributed to the streams with the full queues, in effect performing a CPU resource load balance of the running project. When a stream's input queue is blocked, but the stream has managed to clear half of the pending records, the queue is unblocked, and input streams can proceed to supply the stream with more data.

If this inherent load balancing is insufficient to clear the input queue for any given stream, the backup of the queue can percolate upward causing blockages all the way up the dependency graph to the source stream. If your monitoring indicates growing or full queues on any stream or arc of streams in the directed graph, examine this collection of streams to determine the cause of the slow processing.

11.9 TCP Buffer and Window Sizes

High throughput data transfers between clients and SAP Event Stream Processor rely on the proper tuning of the underlying operating system's TCP networking system.

The data generated by clients for delivery to ESP does not always arrive at a uniform rate. Sometimes the delivery of data is bursty. In order to accommodate large bursts of network data, large TCP buffers, and TCP send/receive windows are useful. They allow a certain amount of elasticity, so the operating system can temporarily handle the burst of data by quickly placing it in a buffer, before handing it off to ESP for consumption.

If the TCP buffers are undersized, the client may see TCP blockages due to the advertised TCP window size going to zero as the TCP buffers on the ESP server fill up. To avoid this scenario, tune the TCP buffers and window sizes on the server on which ESP is running to between one and two times the maximum size that is in use on all client servers sending data to ESP.

For information and best practices for determining and setting TCP buffer and window sizes, consult the documentation provided with your operating system.

11.10 Improving Aggregation Performance

Aggregation functions typically require the server to iterate over every element in a group. For this reason, the performance of the aggregation operator is inversely proportional to the size of the group.

Aggregation functions can be used in a SELECT statement along with a GROUP BY clause, or over event caches in CCLScript inside UDFs and Flex operators.

For the `sum()`, `count()`, `avg()`, and `valueInserted()` aggregation functions, the server can perform additive optimization, where the function executes in constant time. In such cases, the time it takes to perform an operation is the same regardless of group size.

In a SELECT statement, the server performs additive optimization provided functions eligible for optimization are used in all values being selected, with the exception of the columns referenced in the GROUP BY clause.

The following SELECT statement is optimized for additive optimization since all non-GROUP BY columns (`name`, `counter`, and `summary`) only use additive aggregation functions (that is, `valueInserted()`, `sum()`, and `count()`).

```
CREATE OUTPUT WINDOW AggResult
    SCHEMA (id INTEGER, name STRING, counter INTEGER, summary FLOAT)
    PRIMARY KEY DEDUCED
AS
    SELECT BaseInput.intData_1 AS id,
        valueInserted(BaseInput.strData_1) AS name,
        count(BaseInput.intData_1) AS counter,
        sum(BaseInput.dblData_1) AS summary
FROM BaseInput
GROUP BY BaseInput.intData_1;
```

i Note

For optimal peformance, when selecting only the column in a SELECT statement with a GROUP BY clause, use the valueInserted function, where feasible.

The following SELECT statement is not optimized for additive optimization since one of the non-GROUP BY columns (`name`) directly selects a column which cannot be computed additively.

```
CREATE OUTPUT WINDOW AggResult
    SCHEMA (id INTEGER, name STRING, counter INTEGER, summary FLOAT)
    PRIMARY KEY DEDUCED
AS
    SELECT BaseInput.intData_1 AS id,
        BaseInput.strData_1 AS name,
        count(BaseInput.intData_1) AS counter,
        sum(BaseInput.dblData_1) AS summary
FROM BaseInput
GROUP BY BaseInput.intData_1;
```

When applying aggregation functions over an event cache, additive optimization is turned on when using the `sum()`, `count()`, `avg()`, or `valueInserted()` functions only in the ON clause of a Flex operator. The additive optimization does not apply when functions are used inside a UDF.

The following Flex stream computes the sum in the ON clause additively, since the `sum()` function is computed additively and the used EventCaches (e0,e1) are declared locally.

```
CREATE INPUT WINDOW In1
```

```
    SCHEMA (c1 INTEGER, c2 STRING, c3 INTEGER, summary FLOAT)
    PRIMARY KEY (c1, c2);
CREATE FLEX MyFlex
    IN In1
    OUT OUTPUT WINDOW FlexOut
    SCHEMA (c1 INTEGER, c2 INTEGER, c3 INTEGER, c4 INTEGER)
    PRIMARY KEY (c1, c2)
BEGIN
    declare
        eventCache(In1, coalesce) e0;
        eventCache(In1, coalesce) e1;
    end;
    ON In1 {
     {
        output setOpcode([c1=In1.c1;c2=In1.c2;|
c3=sum(e0.c1);c4=sum(e1.c3);],getOpcode(In1));
     }
    };
END;
```

The following Flex stream is not computed additively, since the `stddev()` function cannot be computed additively.

```
CREATE INPUT WINDOW In1
    SCHEMA (c1 INTEGER, c2 STRING, c3 INTEGER)
    PRIMARY KEY (c1, c2);
CREATE FLEX MyFlex
    IN In1
    OUT OUTPUT WINDOW FlexOut
    SCHEMA (c1 INTEGER, c2 INTEGER, c3 INTEGER, c4 FLOAT)
    PRIMARY KEY (c1, c2)
BEGIN
    declare
        eventCache(In1, coalesce) e0;
        eventCache(In1, coalesce) e1;
    end;
    ON In1 {
     {
        output setOpcode([c1=In1.c1;c2=In1.c2;|
c3=sum(e0.c1);c4=stddev(e1.c3);],getOpcode(In1));
     }
    };
END;
```

Another restriction is that additive optimizations are disabled when functions are used inside nonlinear statements (IF, WHILE, FOR, and CASE statements). To enable additive optimizations when using a function within a nonlinear statement, assign the result of the function to a variable outside of the statement. Then use the variable inside the nonlinear statement.

> **Note**
>
> The function used within the nonlinear statement must be from the set of functions eligible for additive optimization.

The following SELECT statement is not optimized for additive optimization since one of the expressions (CASE) in the SELECT list is a nonlinear expression:

```
CREATE OUTPUT WINDOW AggResult
    SCHEMA (id INTEGER, name STRING, counter INTEGER, summary FLOAT)
    PRIMARY KEY DEDUCED
AS
    SELECT BaseInput.intData_1 AS id,
        valueInserted(BaseInput.strData_1) AS name,
        CASE WHEN (count(BaseInput.intDATA_1) < 100) THEN 0 ELSE 1 END AS
counter,
        sum(BaseInput.dblData_1) AS summary
FROM BaseInput
GROUP BY BaseInput.intData_1;
```

11.11 Switch from Decimal to Money Datatype

Using the `money` datatype rather than the `decimal` datatype can improve the performance of a project.

The `money` datatype cannot handle the full range of values that the `decimal` datatype can. Ensure that you do not expect any values outside of the `money` datatype's range before making this change.

11.12 Recompiling Projects

Recompile existing projects that were compiled with earlier compiler versions to take advantage of the latest enhancements.

Context

Enhancements to the compiler are made constantly to improve the performance of SAP Event Stream Processor projects.

Procedure

1. Back up the existing `.ccx` file for the project. By default, these files are in the `%STREAMING_HOME%\bin` folder on Windows machines and the `$STREAMING_HOME/bin` directory on Linux and Solaris machines.
2. Open SAP Event Stream Processor Studio, and compile the project. Refer to *Compiling a Streaming Project* in the *SAP Event Stream Processor: Developer Guide* for details.

11.13 Improving Studio Performance

When you have multiple projects running, Studio can slow down. You can improve performance by adjusting preferences in the SAP ESP Run-Test perspective.

Preference	Location	What to do	Result
Always start previously running run-test views on project start	**Window** > **Preferences** > **SAP Event Stream Processor** > **Run Test**	Disable	Prevents previously open views (such as Stream View) from re-opening automatically when you connect to a project.
Streamviewer pulsed subscribe interval (seconds) **Other pulsed subscribe interval (seconds)**	**Window** > **Preferences** > **SAP Event Stream Processor** > **Run Test**	Set to non-zero values	Groups stream updates to be released as often as prescribed, preventing them from occurring continuously.
Filter Meta-data Streams	Server View icon	Enable	Prevents metadata streams from loading with the input and output windows of a project in Server View.

12 Appendix: Recommendations for Project Portability

Guidelines on what you can do to move projects from one ESP installation to another without having to edit your CCL to work with the new environment, and therefore, avoid having to recompile your CCL.

Log Stores

For any log stores in your project, create a custom parameter and make its value the file name and path of your log store file. To change this value later, you can do so in the project configuration (ccr) file without having to make changes to your CCL and recompile. For example, if you wanted to create a parameter called `LogStoreFilepath`:

```
DECLARE
PARAMETER string LogStoreFilepath := '/<folder>/<folder>/<filename>'
END;
```

Then in the CREATE LOG STORE statement, specify your custom parameter name as the value for the `file name` property. For example:

```
CREATE LOG STORE storename
PROPERTIES
filename=LogStoreFilepath;
```

Adapter Property Sets

For any adapter properties that require file path values, use property sets instead of specifying values directly in CCL. This way, you can edit the property values in the project configuration (ccr) file instead of editing your CCL and having to recompile again.

Also, use an environment variable to specify the base directory of the adapter property file path. To ensure that your project works on both Windows and Unix platforms and does not require any changes when moving it to another machine, use forward slashes in your file paths. When specifying an environment variable, use the format %`<environment-variable-name>`% for Windows and ${`<environment-variable-name>`} for Unix..

Here is an example of a property set that uses an environment variable called `FOO`:

CCL:

```
ATTACH INPUT ADAPTER csvInputAdapter
TYPE toolkit_file_csv_input
TO NEWSTREAM
PROPERTIES propertyset = 'CSV File Input';
```

CCR:

```
<?xml version="1.0" encoding="UTF-8"?>
<Configuration xmlns="http://www.myserver.com/streaming/project_config/2010/08/">
  <Runtime>
    <AdaptersPropertySet>
        <PropertySet name="CSV File Input">
        <Property name="dir">${FOO}/Examples/exampledata/</Property>
        <Property name="file">csv_input.csv</Property>
      </PropertySet>
```

13 Appendix: Troubleshooting

Common techniques for troubleshooting issues you may encounter in Studio.

To help troubleshoot events and view Studio activity, refer to the Studio log file. The Studio log file resides in your workspace directory under `workspace/.metadata/.log`.

In this section:

Issue: In the SAP ESP Run-Test perspective, the Stream View does not show all rows of a running project.

Stream View Displays No Data [page 349]

Issue: When running a project that uses one or more file input adapters, Stream View does not show any data.

Stream View Shows Date Values in UTC or Local Time [page 349]

Issue: Stream View interprets date values as UTC or the local time zone, and you want to change this behavior.

An Unmanaged External Adapter Fails to Connect to a Project [page 350]

Issue: When starting an external adapter in unmanaged mode without editing its sample XML configuration file, the adapter fails to start.

A Studio Project Does Not Run, Reports Login Failure [page 350]

Issue: You are unable to run a project in a remote cluster and errors display.

Error Compiling CCL in PowerDesigner [page 351]

Issue: You receive the following error when importing CCL into a Streaming Schema model in PowerDesigner:

Cannot Add a Server Connection in Studio [page 351]

Issue: When working in Studio, you cannot add a server connection through the SAP ESP Run-Test perspective server view.

CCLScript Operations on Records Fail [page 351]

Issue: When you assign or get fields in a record, the operation fails.

Project Binding Fails to Connect [page 351]

Issue: Adding a binding between projects results in an error where the binding cannot connect to one of the projects.

Studio is Slow When Establishing a Server Connection [page 352]

Issue: You are working in Studio to establish an initial connection to a server that hosts projects, and the loading process is very slow.

A File Input Adapter Fails to Read Records From a File [page 352]

Issue: When using an adapter that reads input from a file, the adapter fails to successfully read and send records into the project.

SAP ESP Run-Test Runs Stale or Outdated Code [page 353]

Issue: When using the SAP ESP Run-Test to test a project, Studio runs a stale or outdated version.

Cannot Stop Project [page 354]

Issue: When your project is hanging and you attempt to stop it, the project status remains at "stopping", and the project and adapter processes keep running.

13.1 Cannot Publish or Subscribe to a Project that Seems to be Running

Issue: Your project appears to be running, but you cannot publish or subscribe to it.

Solution: If there is a single database server running the cluster database, and the server goes offline, you will not be able to connect to the cluster, particularly if authorization is enabled.

1. Check the status of the database server, and restart if necessary.
2. If necessary, restart the cluster database using the `dbstart` command.

> i Note
>
> If authorization is enabled on the cluster database, in the future, try running SQL Anywhere HA option for the cluster database.

3. If you cannot restart the cluster database,
    1. Manually terminate the projects and the cluster manager node using the Linux “kill” command or the Windows Task Manager.
    2. Restart the cluster database.
    3. Restart the cluster manager node.
    4. Restart all projects.

13.2 A Legacy Project Fails to Compile or Run

Issue: A legacy project does not compile or run. You might see an error saying there is no such adapter as platform_in or platform_out.

As of Event Stream Processor version 5.1.04, the Platform Input and Platform Output adapters are no longer installed.

Solution: If your project uses platform_in or platform_out to create stream or window bindings in the .ccl file, you must remove the bindings from the .ccl file and recreate them in the .ccr file.

1. Remove the ATTACH ADAPTER statements for the deprecated adapters from the project:
    - `ATTACH INPUT ADAPTER platform_in`
    - `ATTACH OUTPUT ADAPTER platform_out`

    In Studio, use either the visual editor (right-click the adapter element and select **Delete**) or the CCL text editor (delete the statement). The default location of the .ccl file on the Studio machine is `STREAMING_HOME/SybaseESP/5.1/workspace/<project-name>/<project-name>.ccl`.
2. Recreate each binding in the project configuration (.ccr) file. See the *SAP Event Stream Processor: Configuration and Administration Guide* for information on editing the project configuration. The default location of the .ccr file on the Studio machine is the same as the default location for the .ccr file.
3. If your old CCL file references adapter parameters that do not appear on the Bindings tab of the Project Configuration File editor in Studio, call technical support to report the problem.

13.3 Cannot Connect to Server from Studio

Issue: When trying to run a project, Studio returns a connection error.

When running a project, the following error message appears:

```
<Cannot connect to server>
```

This may be due to an invalid license key.

Solution: View the Studio log file.

1. Select **Help > About Studio**.
2. Click **Configuration Details**.
3. Click **Configuration**.
4. Click **View Error Log**.
5. If prompted, select a text editor to view the file.
6. Locate the error. If the log file entry indicates a problem with your license, refer to the information on licensing in the *SAP Event Stream Processor: Installation Guide* or the *SAP Event Stream Processor: Configuration and Administration Guide*.

13.4 Cannot Connect to the Cluster

Issue: When running a project, you cannot connect to the SAP Event Stream Processor cluster.

Solution: If there is a single database server running the cluster database, and the server goes offline, you cannot connect to the cluster, particularly if authorization is enabled. Check the status of the server and cluster database, and restart if necessary.

1. Check the status of the SAP Event Stream Processor server, and restart if necessary.
2. If necessary, restart the cluster database using the `dbstart` command.

   > Note
   >
   > If authorization is enabled on the cluster database, in the future, try running SQL Anywhere HA option for the cluster database.

3. If you cannot restart the cluster database,
   1. Manually terminate the projects and the cluster manager node using the Linux “kill” command or the Windows Task Manager.
   2. Restart the cluster database.
   3. Restart the cluster manager node.
   4. Restart all projects.

13.5 Cannot Connect to a Project on a Remote Cluster

Issue: From ESP Studio, when trying to connect to a running project on a remote cluster, the console reports an error.

For example:

```
Failed call to: https://<server-name>:38579/RPC2 (Failed to read server's
response: <server-name>)
```

Solution: Specify the fully qualified domain name for the STREAMING_HOSTNAME macro for the node, then connect to the remote cluster using the specified fully qualified domain name.

1. In SAP ESP Cockpit, edit the STREAMING_HOSTNAME macro for the node to include the fully qualified domain name for the cluster, which consists of `<hostname>.<domain>`. For example, `company1.sybase.com`.
2. Save your changes.
3. Restart the cluster node.
4. Add the ESP project to the cluster. Execute:

```
streamingclusteradmin --uri=esps://<hostname>.<domain>:<port> --
username=<username> --password=<password> --add_project --workspace-
name=<workspace-name> --project-name=<project-name> --ccx=<project-name>.ccx
--ccr=<project-name>.ccr
```

5. Start the ESP project. Execute:

```
streamingclusteradmin --uri=esps://<hostname>.<domain>:<port> --
username=<username> --password=<password> --start_project --workspace-
name=<workspace-name> --project-name=<project-name>
```

6. From the command line on a different server, connect to the running project. Execute:

```
$STREAMING_HOME/bin/streamingprojectclient -p <hostname>.<domain>:<port>/
<workspace-name>/<project-name> -c <username>:<password> [-e]
```

7. In ESP Studio, from within the SAP ESP Run-Test perspective in the Server View, set up a new server URL:
    1. In the Server View, right-click and select **New Server URL**.
    2. In the **Server Connection** dialog, specify the following:
        - The fully qualified domain name
        - The port number
        - The protocol
        - Whether or not the connection is SSL-enabled
        - Authentication type
8. Connect to the remote server.

13.6 Cannot Open a Project in Studio

Issue: Attempts to open a project fail and cause errors.

You encounter the following error:

```
Could not open the editor: Invalid thread access
```

This issue is caused by conflicts with previous environment variable settings, or by missing environment variables.

Solution: Set environment variables and start Studio using the command prompt.

1. From the command line, navigate to the ESP install directory. The default name of this directory is `/Streaming`.

2. Set the environment variables:

Operating System	Step
Windows	Run `STREAMING.bat`
UNIX	Source `STREAMING.csh`, `STREAMING.sh`, or `STREAMING.env`

3. Navigate to `<install-dir>/ESP-5_1/studio`.
4. Run `esp_studio.exe` to start Studio.

13.7 Changing Date Format for Playback

Issue: Unable to load or playback files containing dates in formats other than UTC.

The Studio playback tool assumes all dates and times are in UTC format.

Solution: Set a date mask to change the order of date and time values.

1. Open the SAP ESP Run-Test perspective.
2. In the Playback view, enter a date mask in the **XML/CSV datemask** field using the following format: `%Y-%m-%dT%H:%M:%S`
   Change the value order as necessary. See *Playback View* in the *SAP Event Stream Processor: Developer Guide* for more information.

You cannot change delimiters from within Studio. To learn how to specify a different delimiter from the command line, see *Server Executables* in the *SAP Event Stream Processor: Utilities Guide*.

13.8 An External Adapter Fails to Start

Issue: Your attempts to start an external adapter fail.

When attempting to run an external adapter an error message similar to the following appears:

```
Failed call to:https://<ESP-hostname>:61308/RPC2 (Failed to read server's
response: <ESP-hostname>) java.io.IOException: Failed call to:https://<ESP-
hostname>:61308/RPC2 (Failed to read server's response: <ESP-hostname>)
```

This error is an example of the Event Stream Processor server not being resolved.

Solution: Use the `ping` command to verify that the hostname of the server to which you are trying to connect can be resolved. If the hostname cannot be resolved:

1. Determine the IP address of the host on which the Event Stream Processor server is running. Run this command from that machine:

   ```
   nslookup <hostname>
   ```

2. Add the following line to `C:\Windows\System32\drivers\etc\hosts` (Windows) or `/etc/hosts` (UNIX):

   ```
   <ip-address-of-server-hostname>        <Server-hostname>
   ```

13.9 External Managed Adapters Do Not Start in Desired Order

Issue: When using multiple external managed adapters in a project, you cannot implicitly guarantee that they will start in the desired order.

Solution: To enforce a specific ordering of external managed adapters:

1. In your CCL project, use the ADAPTER START statement with the NOSTART clause to prevent the adapters from starting with the project. For more information and an example of usage, see the *ADAPTER START Statement* topic in the *SAP Event Stream Processor: CCL Reference*.
2. Use the `streamingprojectclient` utility to start the adapters in your desired order. You can use a script to automate the command calls, and add short delays as necessary to ensure that all adapters are called and started in your desired order.

13.10 Prompted for Local Cluster Password

Issue: While connecting to the Studio local cluster from a component outside of Studio (such as command line tools, external adapters, or custom applications), you are prompted for a password.

Solution: The Studio local cluster password is system-generated, by default. Change it to something of your choosing.

1. In Studio, open the SAP ESP Run-Test perspective.
2. In the Server View, stop any projects running in the local cluster.
3. Right-click the local cluster, and select **Disconnect Server**.
4. Right-click the local cluster, and select **Change Username and Password**.
5. Enter the new values for the local cluster user name and password.
   Make note of the new values as you will be prompted to enter them every time you connect to the local cluster with a component from outside of SAP ESP Run-Test perspective.
6. Right-click the local cluster, and select **Connect Server**.

13.11 Playback is Too Fast or Slow

Issue While using the playback tool in the SAP ESP Run-Test perspective, data plays back too fast or too slow.

By default, Studio runs projects in Full Rate mode. This playback mode is dependent on external factors, such as the computer running Studio.

Solution: Change the playback mode and adjust the playback rate.

1. Open the SAP ESP Run-Test perspective.
2. In the Playback view, select the **rec/ms** playback mode.
3. Set your preferred speed in the **rec/ms** field. For example, set your speed to 0.01 to run the project at a speed of 0.01 records per millisecond.
4. Run your project. If necessary, adjust the speed setting using the **At timestamp rate** slider. Using the slider allows you to change playback speed while the project is running, since the **rec/ms** setting can only be directly changed while a project is stopped.

13.12 Studio Crashes and You Are Unable to Restart It

Issue: The Studio workspace may have become corrupt.

Solution: Migrate your projects to a new workspace.

1. Rename the corrupt workspace by appending the string `_OLD` to its name.
2. Shut down and restart Studio. Upon restarting, Studio creates a new workspace folder.
3. In the SAP ESP Authoring perspective, import your projects into the new workspace. See *Importing Multiple Projects* or *Importing a Streaming Project into SAP HANA Studio* in the *SAP Event Stream Processor: Developer Guide* for detailed steps.

13.13 Stream View Causes Project to Run Slower

Issue: A project runs slower when streams or windows are open in the Stream View.

As Studio tries to keep up with the data flowing through the server, it blocks incoming data and slows down the project.

Solution: Enable lossy subcription. This option allows the Studio subscription to lose data if it is unable to keep up with the data flowing through the server.

1. Go to **Window** > **Preferences** > **SAP Event Stream Processor** > **Run Test**.
2. Select **Streamviewer lossy subscription**. Click **OK** to save.

13.14 Stream View Displays Partial Data

Issue: In the SAP ESP Run-Test perspective, the Stream View does not show all rows of a running project.

Solution: Increase the number of visible rows in the Stream View preferences.

> **i Note**
>
> Increasing the number of rows will also increase memory usage in Studio.

1. Open the SAP ESP Run-Test perspective.
2. In the top right corner of the Stream View, select **Set StreamViewer Number of Rows Displayed.** ▦.
3. Enter a new number of rows, then click **OK** to save.
4. (Optional) If your project has stopped running, re-run the project to see the new number of rows.

For more information on Stream View preferences, see the *Viewing a Stream* topic in the *SAP Event Stream Processor: Developer Guide*.

If Stream View does not show any data, the data may have already been processed. See Stream View Displays No Data [page 349] for more information.

13.15 Stream View Displays No Data

Issue: When running a project that uses one or more file input adapters, Stream View does not show any data.

File input adapters read data into projects at very high speeds. Streams are stateless and do not store any data, so by the time a user opens a stream in the viewer, all the input data has already been processed. Since the Stream View can only show new events since the time it was opened, there is nothing to see.

Solution: Manually load the data using the File Upload tool.

1. In the SAP ESP Authoring perspective, remove the ATTACH ADAPTER statement from the CCL, or delete the adapter using the visual editor.
2. Compile and run the project.
3. In the SAP ESP Run-Test perspective, open the necessary streams in Stream View.
4. Open the File Upload tool to manually load the data. For more information, see the *Uploading Data to the Server* topic in the *SAP Event Stream Processor: Developer Guide*.

If Stream View shows some data but the rest is missing, adjust your preferences to increase the number of visible rows. See Stream View Displays Partial Data [page 349] for more information.

13.16 Stream View Shows Date Values in UTC or Local Time

Issue: Stream View interprets date values as UTC or the local time zone, and you want to change this behavior.

Solution:

1. In Studio, choose ▶ **Window** ▶ **Preferences** ▶, then expand ▶ **SAP Event Stream Processor** ▶ **Run Test** ▶ and select **Manual Input Settings**.
2. Check the **Interpret Date values in Manual Input and Stream Viewer as UTC** option and select **Apply**.

13.17 An Unmanaged External Adapter Fails to Connect to a Project

Issue: When starting an external adapter in unmanaged mode without editing its sample XML configuration file, the adapter fails to start.

The external adapter may be unable to connect to the example workspace specified in the sample XML adapter configuration file if you have SSL enabled on the cluster, and the URI specified in the file uses `esp` instead of `esps`. The mismatch between the cluster and adapter configuration causes the adapter to fail to connect.

Solution: If SSL is enabled on the cluster on which you are attempting to run this adapter:

1. Open the adapter's XML configuration file in a notepad program and ensure the URI uses `esps` not `esp`.
2. If using one of the adapter examples provided with your installation, edit the `set_example_env.bat` or `set_example_env.sh` script file to specify:

   ```
   set ADAPTER_EXAMPLE_CLUSTER_NODE_PROTOCOL=esps
   ```

13.18 A Studio Project Does Not Run, Reports Login Failure

Issue: You are unable to run a project in a remote cluster and errors display.

```
Failed to connect to server "esp[s]://localhost:19011".
Reason: "Failed to login server"
```

Studio reports these errors when it has an SSL mismatch with the ESP server:

- either SSL is enabled on the server and the Studio connection definition for that server does not include SSL, or
- the connection definition does include SSL but SSL is not enabled on the server

Solution: Correct the connection definition in Studio. For details, see the *Configuring a Remote Cluster Connection* topic in the *SAP Event Stream Processor: Configuration and Administration Guide*.

13.19 Error Compiling CCL in PowerDesigner

Issue: You receive the following error when importing CCL into a Streaming Schema model in PowerDesigner:

```
There was an error in compiling the given CCL. Please check the log file.
```

This issue occurs on Windows 2008 R2 if PowerDesigner is installed in the system program folder. The default permission for this folder is ReadOnly, which prevents PowerDesigner from writing to this location.

Solution: Add the user Everyone to the PowerDesigner installation folder and grant this user read and write permissions.

13.20 Cannot Add a Server Connection in Studio

Issue: When working in Studio, you cannot add a server connection through the SAP ESP Run-Test perspective server view.

When adding a server connection, you receive the following error:

```
Invalid Cluster Manager Field, enter a valid Cluster Manager Value.
```

Solution: This error occurs when the value in the **Host Name** field is entered incorrectly.

To fix this issue, enter a valid host in the **Host Name** field, without the `esp` or `esps` prefix. For example, `myhostname`, but not `esps://myhostname`.

13.21 CCLScript Operations on Records Fail

Issue: When you assign or get fields in a record, the operation fails.

Solution: Initialize the record variable before assigning or getting individual fields.

13.22 Project Binding Fails to Connect

Issue: Adding a binding between projects results in an error where the binding cannot connect to one of the projects.

> i Note
>
> This functionality is not supported in streaming lite.

Prerequisites: Ensure that your hostname can be resolved to an IP address by DNS. If not, edit the /etc/hosts file to add the IP address and hostname for the streaming host to the file using the following format:

```
<ip-address> <streaming-hostname>
```

Solution: Configure ESP to connect to the server without a proxy. Normally, `no_proxy` uses domain names to allow host connections without a proxy. However, SAP ESP connects to the server without the use of a domain name, which means that the connection would use a proxy. To allow SAP ESP to connect without a proxy, add the server hostname without the domain name to `no_proxy`.

1. In your Linux environment, run `set|grep proxy`. This shows you what is currently on the `no_proxy` list.
2. Add your hostname to `no_proxy`. In your Linux .bashrc configuration file, add `export no_proxy=<hostname>,$no_proxy`.
3. Restart your projects.

13.23 Studio is Slow When Establishing a Server Connection

Issue: You are working in Studio to establish an initial connection to a server that hosts projects, and the loading process is very slow.

When Studio is not located on the same network as the server, connecting to the server may take longer. Accessing multiple projects at once on the server will further stall loading times. If you have enabled the Run-Test preference **Automatically reconnect to all projects when connecting to a server**, all of your projects will automatically connect when you access a server, causing this lag.

Solution: Change your SAP ESP Run-Test preferences so that projects do not automatically reconnect.

1. Go to ▶ **Window** ▶ **Preferences** ▶ **SAP Event Stream Processor** ▶ **Run Test** ▶.
2. Uncheck **Automatically reconnect to all projects when connecting to a server**. Click **OK** to save.
3. From the SAP ESP Run-Test perspective, right-click an individual project in the Server View to connect to or disconnect from that project.

13.24 A File Input Adapter Fails to Read Records From a File

Issue: When using an adapter that reads input from a file, the adapter fails to successfully read and send records into the project.

Solution 1: Change the Input Stream to an Input Window

One way to ensure a File Input adapter is successfully reading records from an input file is to change the stream it is feeding to an input window.

By using a window instead of a stream, you can view the records inside the window after they have been added, and ensure that they all appear correctly.

1. Delete the input stream element.
2. Create a new input window using the Studio visual editor or using the CREATE WINDOW statement.
3. Set a retention policy for the input window so that it keeps all rows. See *Specifying a Retention Policy* in the *SAP Event Stream Processor: Developer Guide* for more information.
4. Attach the input adapter to the input window.
5. Compile and run the project.
6. Set all of the column types in the input data file to `string`, to facilitate reading and avoid parsing errors.
7. In the SAP ESP Run-Test, in the server view, expand your project to show the list of windows and streams in the project.
8. Right-click the input window and select ▶ **Show in** ▶ **StreamViewer** ▶.

Viewing a stream is possible, but only after a project has started running. The records can also finish flowing through the stream in the time it takes to open the StreamViewer. Using an input window that retains all records as they are added makes troubleshooting file reading problems easier.

If the adapter correctly reads the input from the file, change the window back into a stream to prevent retention policy and out of memory errors, or configure an appropriate retention policy. See *Retention Policies* in the *SAP Event Stream Processor: Developer Guide* for more information.

Solution 2: Look in the .out Log File for Adapter Information and Errors

If the adapter still does not correctly read records from an input file, look in the `.out` file to find the full path to the directory where the adapter expects files to appear. See *Project Log Files* in the *SAP Event Stream Processor: Configuration and Administration Guide* for more information.

Correct the filepath for the adapter in the adapter's properties in Studio, or in the adapter's `.xml` file. See the appropriate configuration topic for your adapter in the *SAP Event Stream Processor: Adapters Guide* for more information.

13.25 SAP ESP Run-Test Runs Stale or Outdated Code

Issue: When using the SAP ESP Run-Test to test a project, Studio runs a stale or outdated version.

1. If the project is currently running, stop it.
2. Recompile the project in the SAP ESP Authoring.
3. In the SAP ESP Run-Test, in the Server View, right-click your project and select**Remove Project**.
4. Right-click your desired workspace and select **Load Project(s) into Workspace** to re-add your project's `.ccx` file.
5. Right-click the project and select **Start Project**.

13.26 Cannot Stop Project

Issue: When your project is hanging and you attempt to stop it, the project status remains at "stopping", and the project and adapter processes keep running.

Solution: Force the project to stop, which immediately shuts down all project and related processes. You can do this in one of two ways:

- Using the `streamingclusteradmin` utility, run the `--stop_project` command with the `timeout` option set to -1:

  ```
  $STREAMING_HOME/bin/streamingclusteradmin esp[s]://<host>:<port> --
  username=<username> --password=<password> --stop_project --workspace-
  name=<workspace> --project-name=<project> --timeout -1
  ```

- Using the ESP Studio, open the SAP ESP Run-Test perspective. In the stream view, right-click on the frozen project and select **Force Stop Project**.

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