Hewlett Packard
Enterprise

Legacy Integration for Predictive Maintenance

HPE Edgeline IoT Systems &
Converged Edge Systems for enabling
Smart Manufacturing in Industrial IoT

Technical white paper

Contents

Executive Summary

HPE's new Edgeline IoT Systems and Converged Edge Systems and Aruba Networking products are being positioned to be the platforms of choice for the emerging intelligent edge in manufacturing plants. This document describes the context, fit and value of HPE hardware and third party partner software in enabling seamless OT & IT linkage in a manufacturing plant to transform existing infrastructure to gain maximum cost-efficiency. The benefits of this solution are that it will eliminate waste, improve productivity of employees, improve collaboration between the support staff, enable better process and machinery monitoring in the factory, and create a more secure production and supply chain environment. The combination of these will give a manufacturer better insight of how to best optimize their manufacturing process, decrease operational cost, improve resource management and increase revenue. In order to accomplish these goals data is leveraged from connected devices, people, and machinery in the factory. This information is gathered, aggregated, and processed on-site to generate actionable insight and enable greater control. The uses cases analyzed include asset tracking, location services, predictive maintenance, role-based networking, legacy device internetworking, remote diagnostics, scene analysis with heat map visualization, and off-site collaboration.

Background

Many manufacturers are unprepared for disruption in the manufacturing value-chain, specifically moving from a traditional product-centric business model to a service-centric one. According to recent research by Accenture, 88% of manufacturing executives do not fully understand the underlying business models of IoT, or the long-term implications on their industries. Only 40% indicated that they have developed a digital strategy for IoT.

With the rapid adoption of connected products and analytics capabilities to turn data into real business value, manufacturers increasingly expect more value and innovation from digitized business models. New entrants, including those with no physical assets, are stepping up to the challenge.

Manufacturing operations are increasingly using smart equipment, but the amount of data generated by automation systems, robots, NC machines, PLCs, digital gauges, cameras, sensors, wireless tools and others devices creates islands of data that can't easily be combined and analyzed, creating a challenge that traditional manufacturing systems were simply not designed for.

HPE has developed a four-stage Industrial IoT (IIoT) architecture to address these challenges faced by its manufacturing customers, to enable them to leverage the full potential of Industrial IoT (IIoT) and transform their manufacturing operations to a digital value chain operating model.
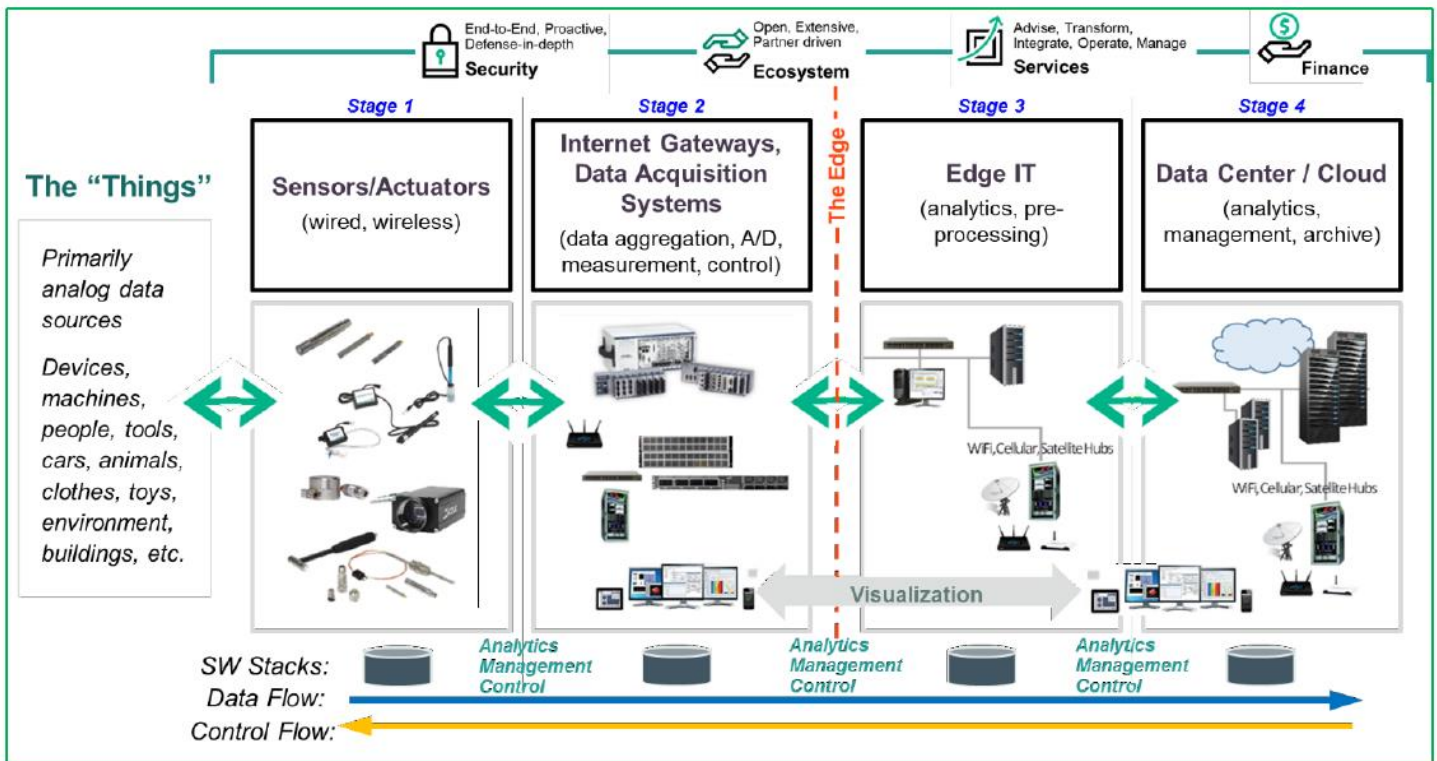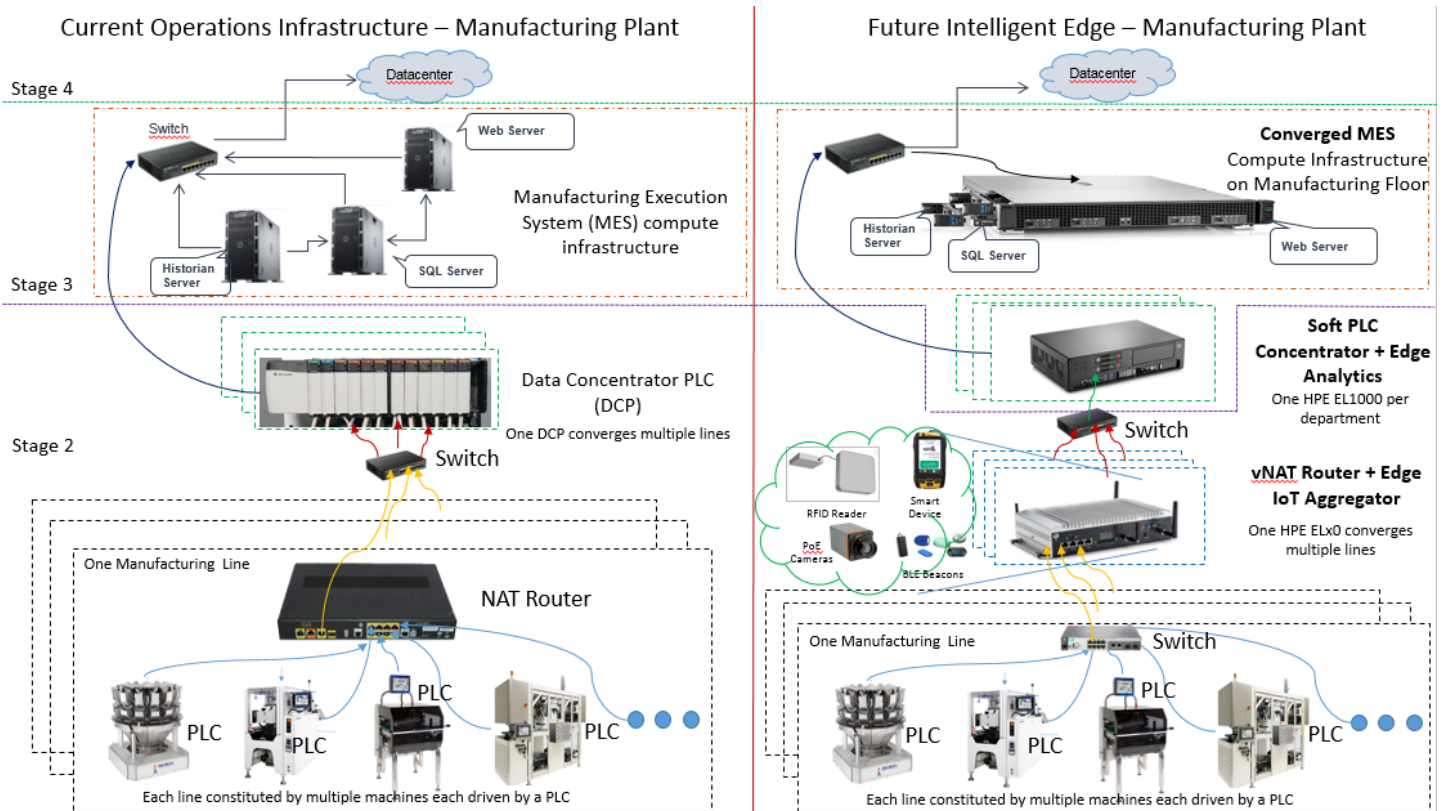
Figure 1. 4-stage Industrial IoT (IIoT) reference architecture

The core of the HPE solution rests in bringing compute, mobility and communications to the plant floor, in a secure and ruggedized industrial design format, to facilitate the analysis of real-time streaming data close to the source for just-in-time management and control of operations processes.

HPE's IIoT offering consists of an open standards-based end-to-end IIoT solution that leverages capabilities of an ecosystem of partners, and is augmented with end-to-end security, services and financing.

Figure 2. Simplified view of current operations infrastructure and future HPE Intelligent Edge for manufacturing

Figure 2 shows the operations monitoring infrastructure in a typical manufacturing plant (left hand side). At the lowest layer are custom OEM made machines typically driven by one or more Programmable Logic Controllers (PLCs). These PLCs run custom ladder logic/state machines to drive and manage the machine's operation in real-time. A microcontroller (part of the PLC unit) generally runs the network stack and makes its state registers/memory-space accessible via Modbus over TCP-IP or other legacy serial bus for monitoring purposes (potentially OPC/UA compliant). Tens of such legacy machines/devices (and PLCs) constitute a single manufacturing line and several such lines form the heart of a typical manufacturing plant. Individual machines and lines of machines are typically monitored by a Manufacturing Execution System (MES) for shopfloor optimization – correlating machine and material usage – to improve production output. For simplicity, equipment in each line is often identical - including identical IP addresses, statically configured by the equipment manufacturer. A manufacturing line may be composed of 8-10 machines or more depending on the complexity of the operation and each plant may have 10-20 lines of one type.

These device specific network addresses are translated (NATed) per line into a factory-wide routeable/accessible IP addresses by physical NAT routers (one per line). These IP addresses are next accessed by a Data Concentrator PLC (DCP) (via intermediate line switch) which polls individual PLC's in different lines (typically by function) to create a uniform aggregated memory space of PLC state. Further upstream (typically in a LAN room on the floor) a historian (data store) running on an x86 machine polls several such DCPs on the floor and aggregates their PLC Tags (metadata) and real-time value for diagnosing and monitoring the efficiency of individual machines, lines or a series of lines. MES equipment might also include other SQL database(s), webservers and provisioning equipment to complete the local compute infrastructure on the factory floor. Compute equipment that traditionally resides in the datacenter typically only accesses the historian data (non-real-time) to correlate efficiency across factories or lines between factories.

The future intelligent edge infrastructure for Industrial IoT being pioneered by HPE incorporates: HPE Edgeline IoT Systems (EL10/20) taking the place of existing NAT routers (for multiple lines), HPE EL1000 Converged Edge System across multiple types of lines aggregating and analyzing acquired data on-site and one or more EL4000 servers creating a converged MES infrastructure. The right hand side of Figure 2 shows such an infrastructure – their functionality has been nominally correlated to the 4-stage IIoT architecture described earlier. The key advantages of an x86 based system as edge IoT data aggregator are the following:

1. Ability to incorporate one or more of a plethora of "smart sensors" – PoE Cameras, RFID readers, BLE sensors, temperature/vibration/humidity sensors etc. to simultaneously instrument the machines or production process for greater insight

2. Run in-situ condition monitoring & alarming

3. Perform edge analytics

4. Converge the routing function of physical NAT routers on one device.

Early on-site analytics of both legacy machine data as well as "smart sensor" data can be performed in-situ at a multi-line level. Likewise the introduction of an EL1000 at the DCP level will allow the following:

1. Performance data concentration function via software (softPLC)

2. Generation of actionable insight across all lines combining legacy and smart sensor data with an edge analytics stack (including machine learning for predictive maintenance)

3. Provide the ability to push data via a 3G/4G network into a cloud service (such as Microsoft Azure or GE Predix).

Finally, the introduction of an HPE EL4000 at the MES layer allows the convergence of multiple independent servers (historian, MySQL etc.) on a single machine for continuing execution of MES infrastructure and historical data capture.

The rest of this paper describes the solution hardware & software ecosystem that constitute the edge aggregator & analytics stages (stages 2 & 3 only), followed by specific use cases that can be enabled through the use of foundational and third party software running on these devices at each stage. This demonstrates HPE's ability in enabling Operations & Information Technology transformation through ruggedized infrastructure and IIoT workload optimized systems architecture.
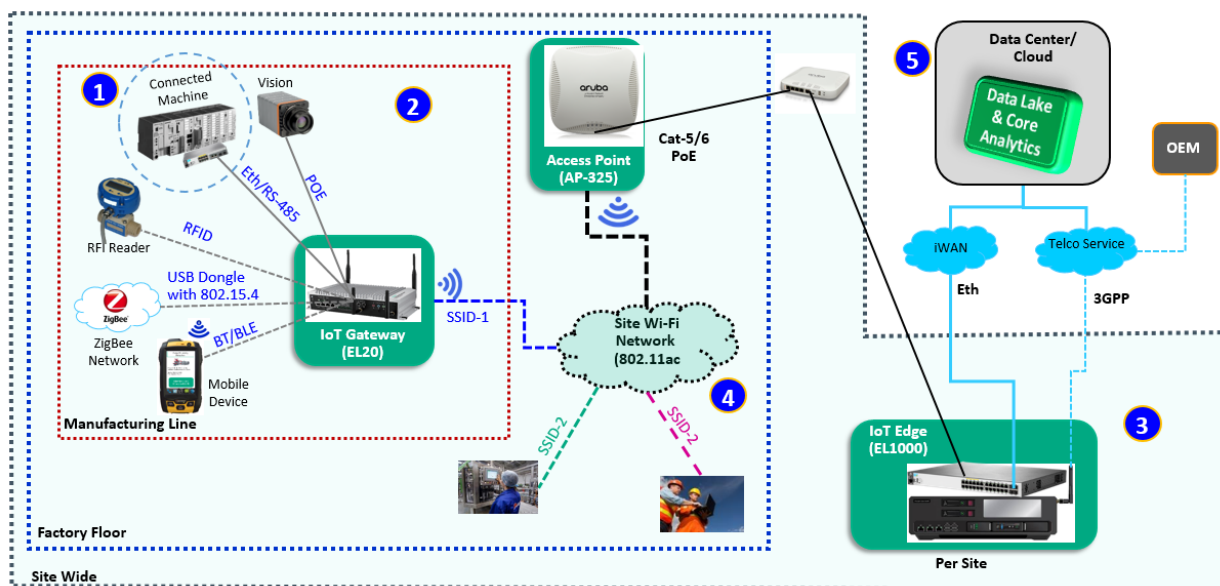
Solution Components & Overview

Figure 3. Hardware components for IIoT Intelligent Edge

Hardware components

This solution utilizes the HPE Edgeline family of products as the foundation for an edge data management solution. The need to quickly analyze and drive business decisions based on real-time data accentuates the need for edge computing. HPE has created unique systems that are purpose-built for converging real-time data acquisition, enterprise-class computing, and remote manageability. HPE Edgeline systems are energy-efficient, ruggedized platforms with a broad range of network connectivity and data acquisition options to accommodate even the most complex industrial applications. Chassis type, number of servers, number of CPU cores, memory, and storage can all be tailored to site requirements.

The specific Edgeline, Aruba and third party products used in this solution are described below.

- **HPE EL10:** The HPE Edgeline EL10 IoT System is an entry level price/performance optimized ruggedized compute solution for very light weight data aggregation, acquisition and analytics. It is completely fanless and is designed to operate in industrial environments such as manufacturing, smart cities, or oil and gas. This device is configured with an Intel® E3286 dual-core Atom CPU, 4 GB RAM, 32 GB SSD storage and Wi-Fi connectivity.

Figure 4: HPE Edgeline EL10 IoT System

- **HPE EL20:** The HPE Edgeline EL20 IoT System is a mid-level ruggedized compute solution designed for light data aggregation and acquisition. This Edgeline device delivers a performance solution that comes optimally configured with an Intel® i5 CPU, 8 GB RAM, 64 GB SDD Storage, Wi-Fi connectivity and an expansive I/O selection including four-port Power over Ethernet (PoE) plus 1 x 8 bit digital input/output (DIO).

Figure 5. HPE Edgeline EL20 IoT System

- **EL1000:** This rugged, compact Converged Edge System is designed specifically for harsh environments, providing data center-level capabilities at the edge that delivers immediate insight from IoT data. It can carry datacenter class compute cartridges with Intel Xeon x86 processors, perform unique integration of precision data capture and control and is managed with data center class security and systems management software. In addition it can carry wireless and 3GPP data cards for backhaul traffic. Deep edge compute capabilities will

enable businesses to make real-time decisions, adding value to their operational processes that result in better business outcomes.

Figure 6. HPE Edgeline EL1000 Converged Edge System

- **Aruba Access Point:** High performance and high density 802.11ac 320 series wireless AP that supports multi-user MIMO (MU-MIMO) and 4 spatial access point streams (4SS). It provides simultaneous data transmission to multiple devices, maximizing data throughput and improving network efficiency - 5 GHz (1,733 Mbps max rate) and 2.4 GHz (800 Mbps max rate) radios, each with 4x4 MIMO support and a total of eight integrated omni-directional down-tilt antennae.

Figure 7. Aruba 802.11ac wireless access point

- **Aruba Controller:** 7005 Mobility Controller is a compact, fanless entry-level branch platform that can be powered by a power-over-Ethernet (PoE) switch. This piece of hardware is meant to manage various other Aruba Access Points making for an easy deployment of a complex network.

Figure 8: Aruba 7005 Mobility Controller

- **HPE ProLiant m510 server cartridge:** HPE ProLiant m510 server cartridge is designed to enhance the performance of many general purpose workloads. The ProLiant m510 server cartridge has one Intel® Xeon® D-1548 (8-core) or D-1587 (16-core) with up to 128GB of ECC protected memory, dual 10Gb Ethernet along with up to 2 (1TB NVMe each) M.2 flash storage modules, and up to (1) 240GB SATA M.2 for local OS booting. This is used as the compute engine for the EL1000 system described earlier.

Figure 9. HPE ProLiant m510 server cartridge

- **Zebra™ FX9500 RFID Reader:** This is a standalone RFID reader with exceptionally high RF sensitivity and the ability to interface multiple external RFID antennae across longer read ranges for a large distribution center or yard management applications, and higher throughput rates for high volume reading and densely packed goods situations. This was chosen as a representative stand-alone third party external RFID reader. For more information, please visit www.zebra.com/fx9500

Figure 10. Zebra FX9500 Fixed RFID Reader

- **RFID Antennas: Zebra AN480 & AN620 RF Antennae** are used in conjunction with the FX9500 to scan for RFID tags.

Figure 11. External RFID Antenna

Software components

This solution leverages a wide range of software products and tools to achieve the desired goals. These software elements enable the collection, processing, analysis and historical logging of data in a real time environment. The software comes from multiple vendors and has been validated on the Edgeline product family.

The specific software components used for this solution are described below.

- **Kepware KEPServerEX:** Connects disparate devices and applications, from plant control systems to enterprise information systems. Communications platform that provides a single source of industrial automation data to all applications. The platform design allows users to connect, manage, monitor, and control diverse automation devices and software applications through one intuitive user interface. More information about KepServerEX can be found here: https://www.kepware.com/en-us/products/kepserverex/
- **HPE Secure Data:** SecureData is an HPE Security Platform that is used to encrypt sensitive user data in order to keep employees as well as the company safe from any malicious behavior.
- **PTC ThingWorx:** The PTC ThingWorx IoT technology platform is used to analyze and visualize data from the manufacturing plant. The incoming data is processed and analyzed so that anomalies can be detected in real time. Dashboards are used to provide visualization of the results, enabling the user to better understand what is happening in the plant. Beyond the visualization aspect, Thingworx is used for machine learning alongside data analytics to enable a predictive maintenance capability. More information about ThingWorx can be found here: www.ThingWorx.com

- **Apache NiFi:** A graphical programming (Layer 7) tool/message bus used to manage data streams between various components of the solution. It provides messaging and connectivity including node to node movement and store-forward capabilities, dynamic transformation and routing. It enables the smooth integration of traffic from legacy machines (PLCs) and newly added sensors (RFID, Zigbee, BLE, PoE) – acting as the glue layer. More information about NiFi can be found here: https://nifi.apache.org/
- **MySQL Database:** A database used for storage and queried to give visual representation of certain aspects of the solution.
- **Aruba Clearpass:** ClearPass profiling classifies all mobile and IoT devices to define smart policies that determine access to wired and wireless networks, automatically granting or denying user access privileges based on device type, ownership status, or operating system. (from site with reference at end). More information about Aruba Clearpass can be found here: http://www.arubanetworks.com/products/security/network-access-control/
- **IDOL MediaServer:** MediaServer, as part of the Intelligent Data Operating Layer (IDOL) stack, offers rich media analytics (video, audio streams or recorded media) such as face detection/recognition, object recognition, and scene analysis. These capabilities can be used for product-line monitoring and personnel monitoring in IIoT. More information about IDOL MediaServer can be found here: http://www.hpe.com/software/richmedia
- **HPE MyRoom VRG:** A SaaS platform for rich media collaboration, webinars, e-learning and remote customer support. It offers clients on multiple platforms including on wearable Android devices. MyRoom VRG allows for remote visualization of equipment requiring maintenance by subject matter experts. More information on MyRoom VRG can be found here: http://www.myroom.hpe.com/VRG

The following diagrams depict how the software is deployed on the EL10, EL20 and EL1000.
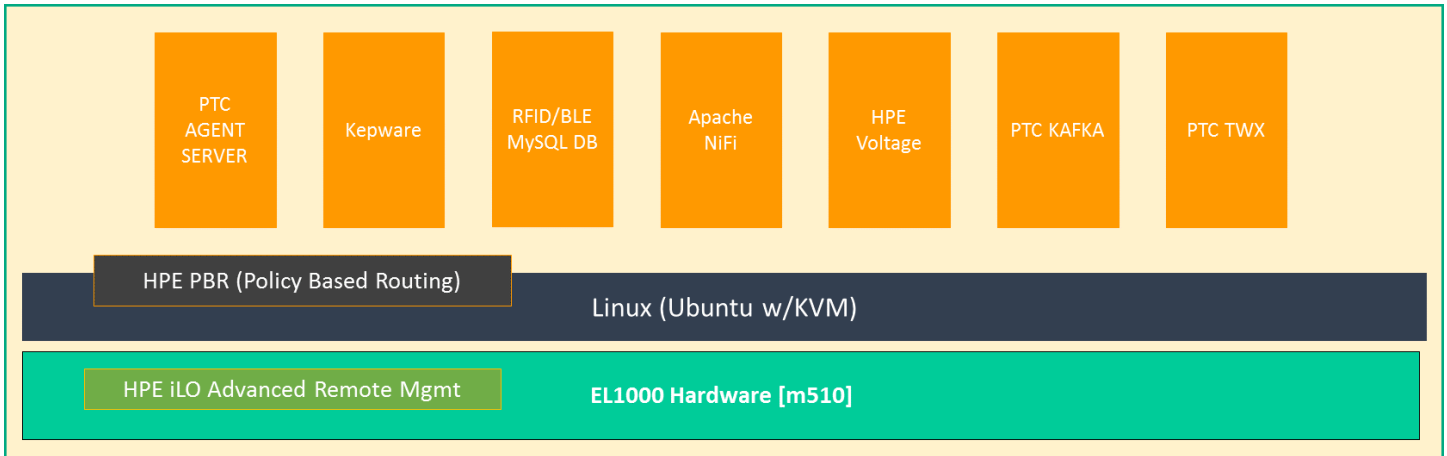

Figure 12. Software stack for the EL1000 (each orange box represents a virtual machine)
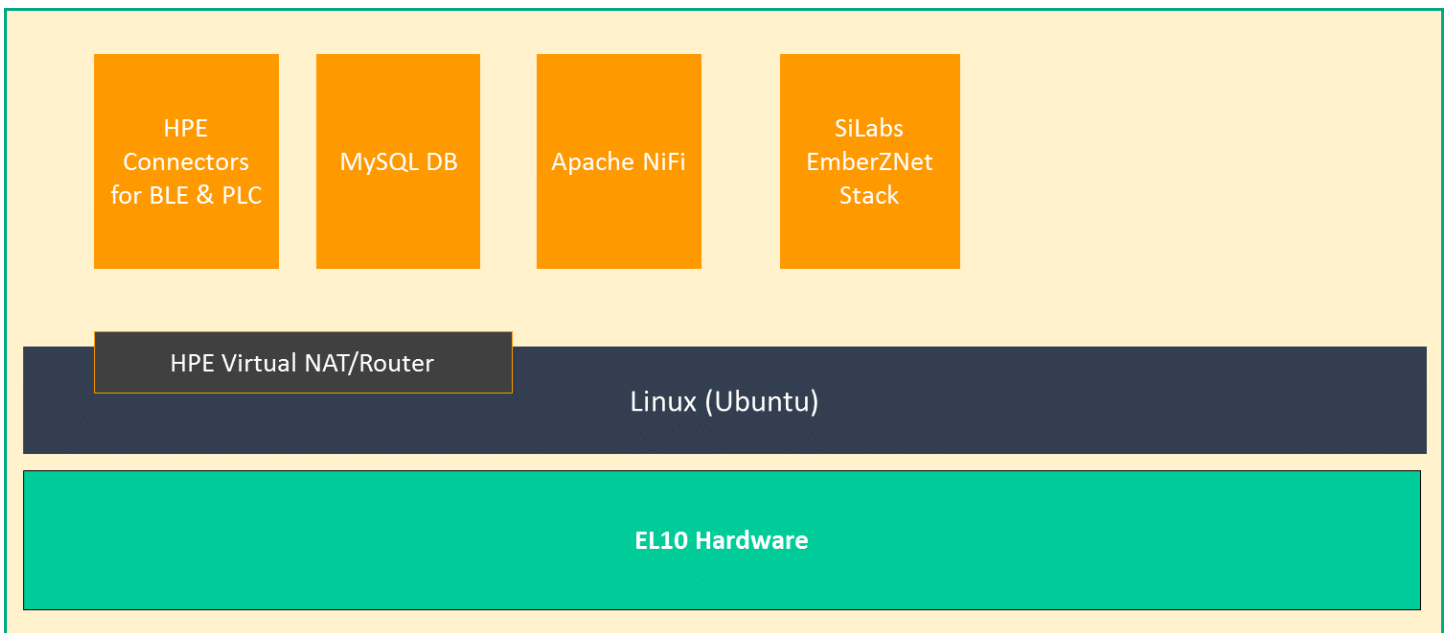

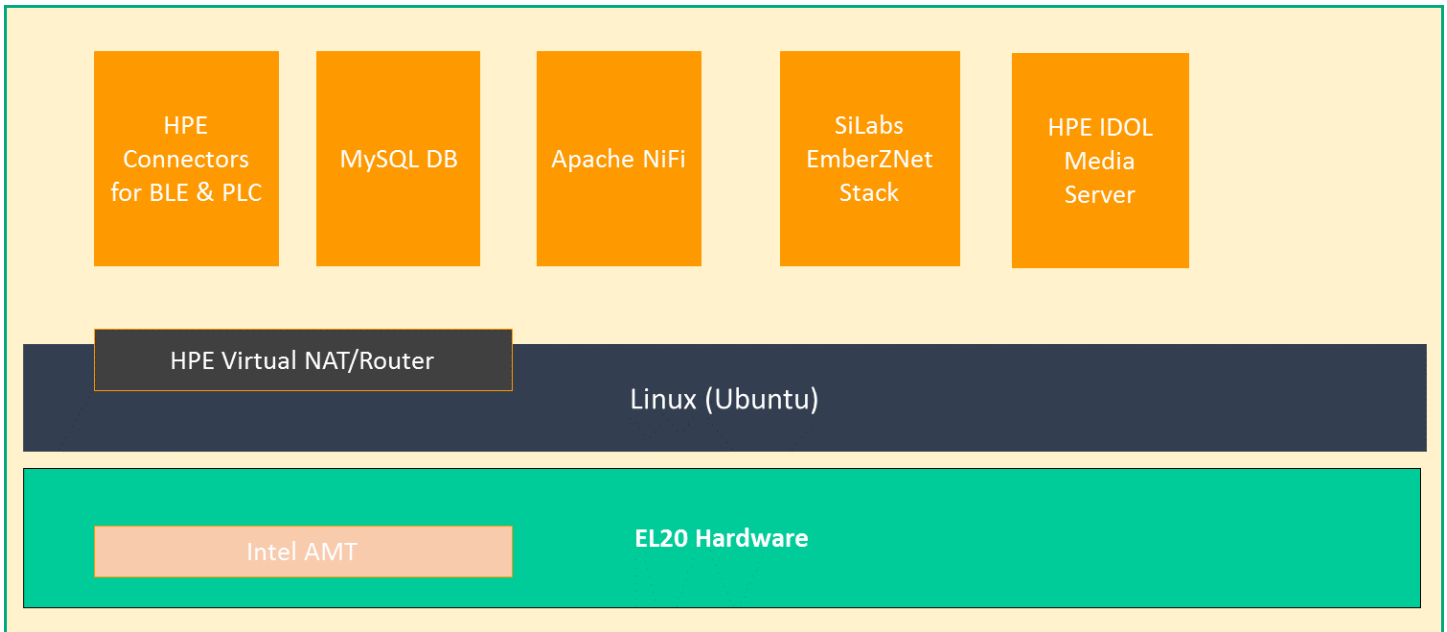**Figure 13.** Software stack for the EL10

Figure 14. Software stack for the EL20
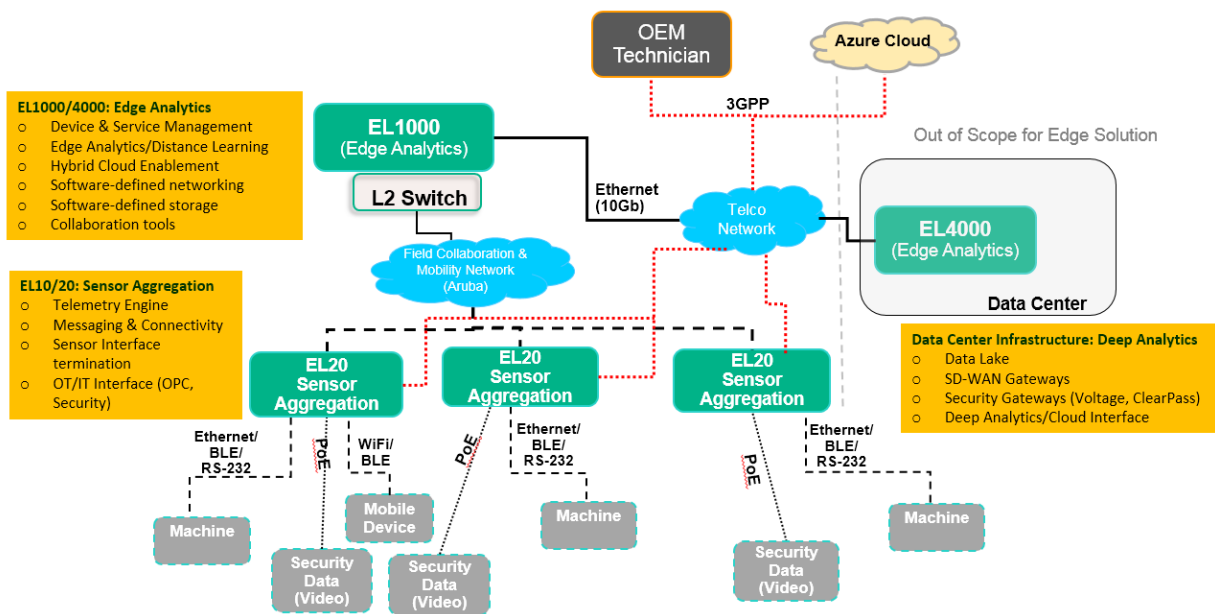
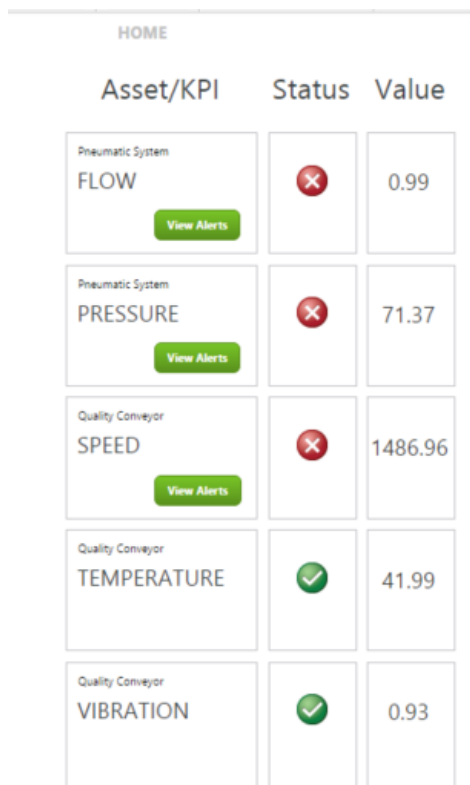# Specific Use cases addressed

Figure 15. Key use-cases demonstrated at Sensor Aggregation (Stage 2), Edge Analytics (Stage 3) & Datacenter Deep Analytics (Stage 3) layers

Predictive Maintenance

An important part of manufacturing a product is making sure that equipment is running in the most efficient form possible and minimizing down time when machines need to be repaired to ensure maximum production output. Through this solution the customer has the ability to monitor their factory machinery and are given insight about when their equipment will fail. This gives the advantage of being able to perform maintenance only when something is wrong, instead of wasting money on preventative maintenance that may or may not need to be performed.

This valuable piece of the solution is achieved using four different virtual machines consisting of KEPServerEX, Kafka, an agent server, and ThingWorx. These four virtual machines are loaded on the m510 server cartridge inside of the EL1000. For this solution a PLC is used to control and monitor devices. The PLC is sending information to KEPServerEXwhere it is aggregated appropriately. ThingWorx then pulls that data from KEPServerEX and then pushes that information into Kafka, which is being monitored by the agent server. The agent server works together with ThingWorx to perform the analytics on the data being sent from the PLC.

Through the use of a ThingWorx mashup this information is output into graphs, health, and a numerical value for the current data. The potential for machine failure can also be displayed if desired, enabling predictive use of the machine if critical operations are in progress. If desired, alerts can be sent out to specific people in charge of specific machines or areas of the production floor, in addition to remote tunnels for technicians, and links to MyRoom VRG. With this information it is easy to plan maintenance on machines to minimize production downtime, and alert the appropriate people of issues at hand.

Figure 16. Operational data displayed using ThingWorx

The above diagram provides a representative depiction of the user interface for the Predictive Maintenance function. Status will change from green to red if an anomaly is detected.
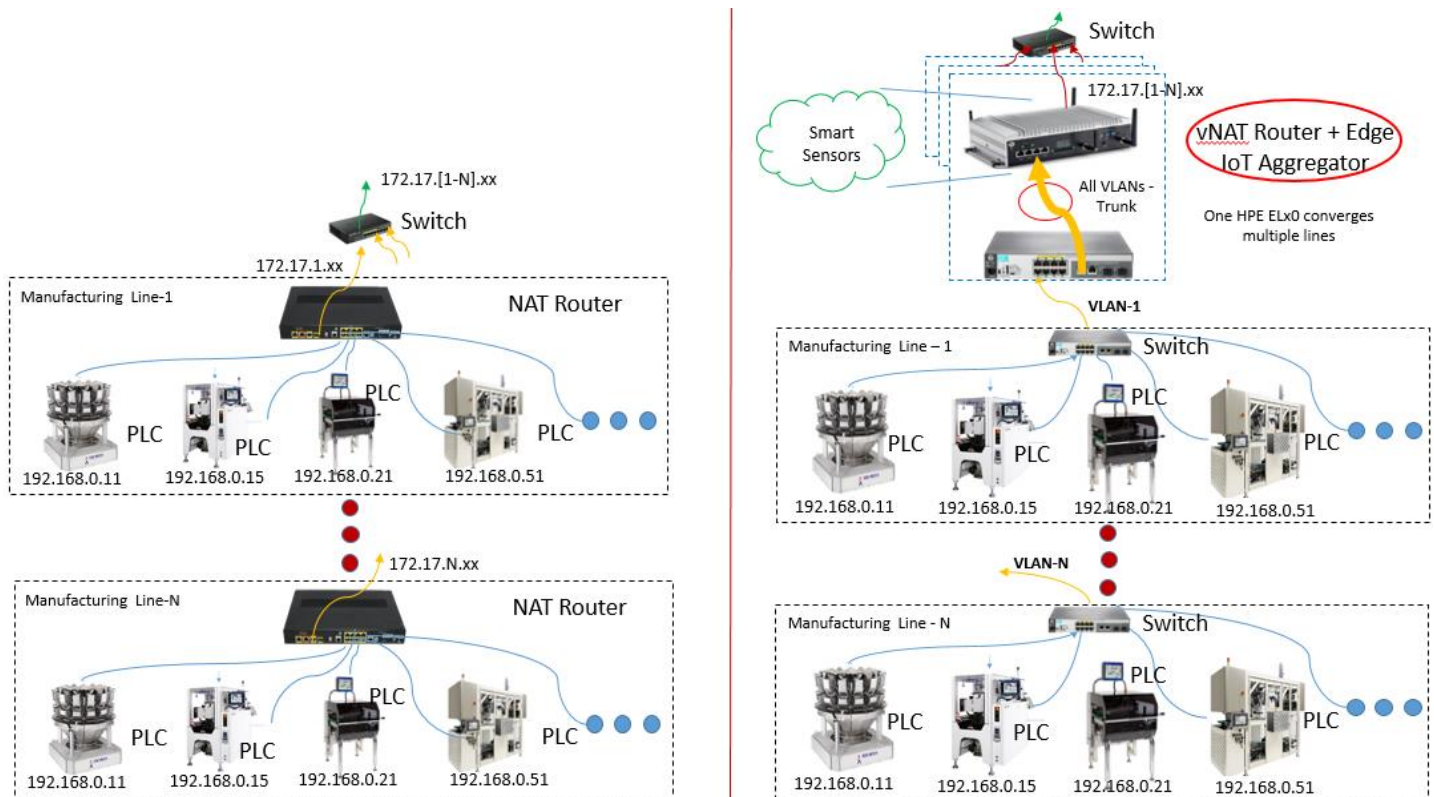
Legacy Interworking

Similar to the predictive maintenance and analytics portion of this solution, monitoring a machine on the factory floor is important to make sure that operations are running smoothly and nothing is out of sync. The ability to monitor machines gives the user the ability to find inefficiencies and possible faults in the production line before they cause a large and expensive problem.

The data flow for Legacy Interworking follows the same path as described earlier in the Predictive Maintenance and Analytics section about how information is passed from the PLC into a ThingWorx mashup. This process can be run on the same EL1000 with an m510 server cartridge installed. It functions exactly the same way without the analytics portions examining the data to report anomalies.

Legacy interworking provides a mechanism for connecting to existing sensors and controllers while at the same time providing newer sensors that enhance the IoT environment. In this project, two methods of connecting to existing sensors and controllers were presented:
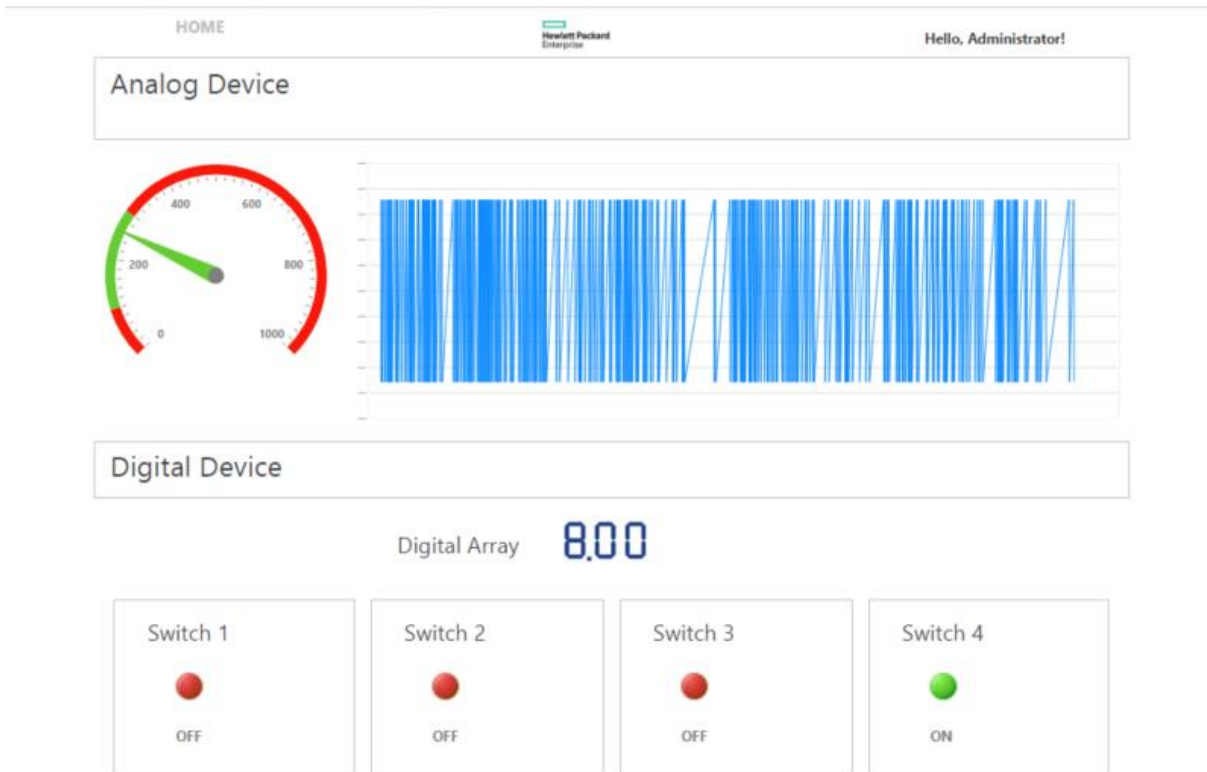
- Utilizing KEPServerEX to connect to various sensors and controllers, using the various communications protocols involved, and then making the collected data available upwards.
- Utilizing open source Modbus libraries for C and Python, which allow direct interfacing to the existing sensors and controllers via serial port or Ethernet port. In this project, the Python libraries were used to interface to the controller on its serial port via the Modbus protocol. The access to the controller was conducted simultaneously via the serial port using the Modbus library and via the Ethernet port using the KEPServerEX.

Figure 17. Converged Virtual NAT Routing on HPE EL20 to transform device specific IPs into a global scheme

A patent-pending Virtual NATing scheme was also implemented on HPE Edgeline IoT Systems (HPE EL10/20) to subsume and converge the function of multiple physical NAT routers. The resulting L2/L3 vNAT router allows a single ELx0 and one managed Aruba switch to collapse a maze of physical NAT routers in a cost-efficient and software configurable manner – using kernel resource virtualization primitives, VLAN tagging and Linux IP Namespaces (which are underlying technology behind containers).

This provides the ability for an ELx0 device to displace existing NAT Routers while simultaneously enabling the interface and aggregation of "smart sensor" data with legacy data to enable the intelligent edge. This makes innovative use of core features of the Linux kernel to disambiguate between potentially conflicting (and unchangeable) IP addresses between different lines. This is fulfilling the role of the Edgeline IoT System as a router or a pass-through device without disrupting the existing configuration, but still providing the foundation ($ savings) for green field implementations of new sensors/smart-machinery.

Figure 18. SCADA front-end for legacy device monitoring using a Thingworx Mashup

Figure 18 shows a sample representation of what the user interface would look like for legacy interworking. This shows a digital readout of a physical device, giving the status of the various hardware on the device. It is utilizing Kepware™ KEPServerEX to connect, access and control different PLC devices.

This portion of the solution leverages Kepware KEPServerEX and PTC ThingWorx software running on the EL1000 as depicted in Figure 12.

Remote Diagnostics
In some cases specialized skills of subject matter experts may be required to diagnose and fix problems that occur within a production environment, but a person with the skills may not be available onsite. A remote user may utilize this portion of the solution to tunnel into an affected machine, enabling them to have access and to run diagnostics software against to the available data to examine the issue may be and determine how to solve it.

The remote tunneling feature is built upon the Thingworx Edge Microserver. The Edge Microserver software runs on a remote Linux machine connected to the control network, communicating with the Thingworx platform. The Linux machine is running a VNC server (a protocol to enable remote desktop interaction), and the Edge Microserver is set to forward the VNC port. When a request is made via the web interface, a Java applet is launched, contacting the Edge Microserver. The Microserver starts a remote tunneling session and displays the connection information to the user, who points their VNC client to the specific IP and port combination.

This portion of the solution leverages PTC ThingWorx software running on the EL1000 as depicted in Figure 12.
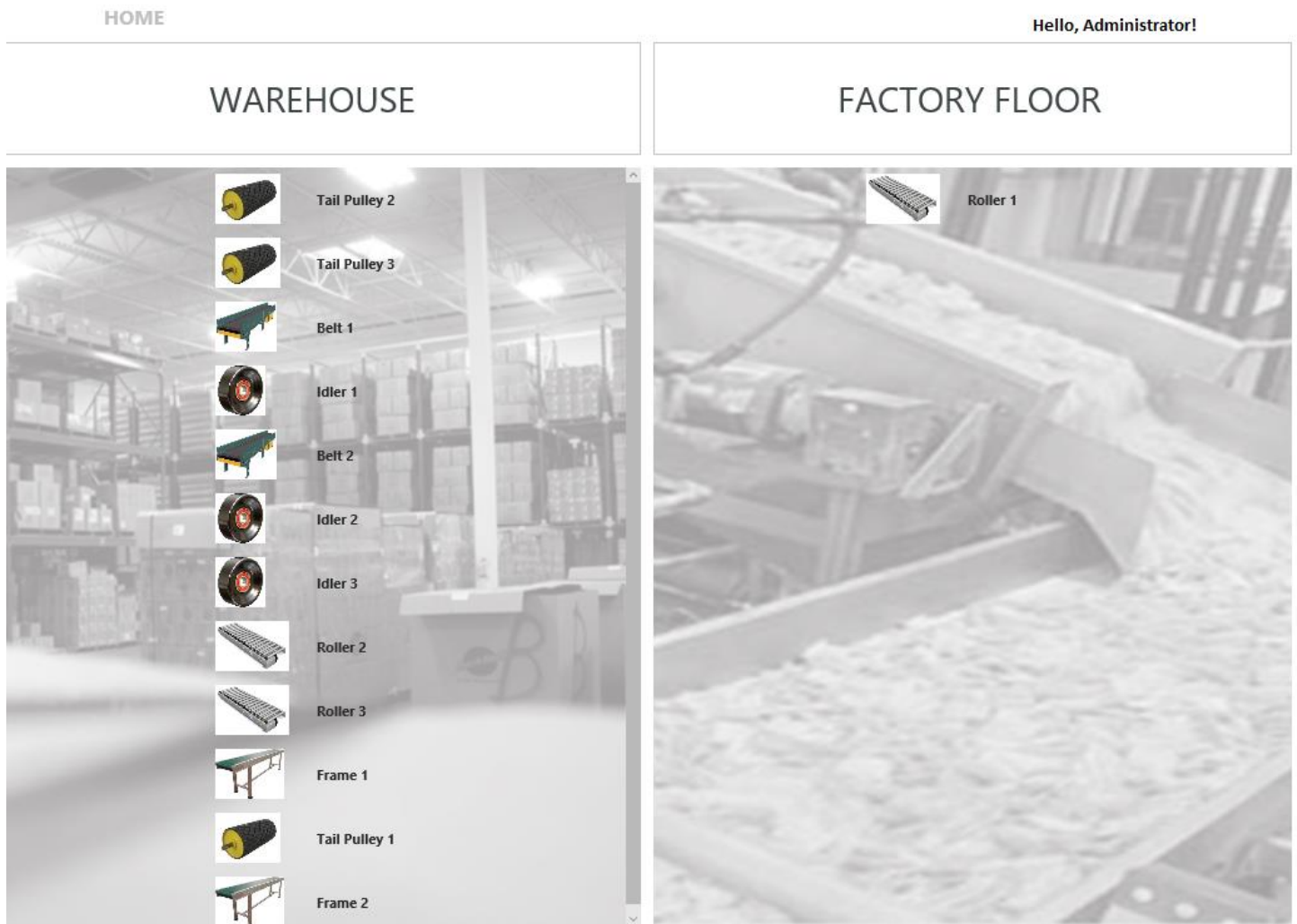
RFID Asset Tracking

The ability to know where assets lie in a factory provides multiple advantages. This technology allows for the tracking of the manufactured product from the very moment it comes off the line until it reaches the mode of transportation. Having this knowledge eliminates misplaced goods. It also prevents an employee from wasting time trying to find out when the finished goods are possibly misplaced.

Another aspect of asset tracking is the ability to track items such as tools or machine parts. This is important to the prevention of costly tools used for repairs being misplaced. It also gives insight as to where a certain piece of machinery is, such as if it was taken off the line to be replaced or repaired.

This process is achieved through the use of RFID tags, an RFID reader, a few scripts, a MySQL database, a small C# program, and PTC's ThingWorx. RFID tags are placed on the assets that are to be tracked and each tag has a unique identifier. The MySQL database is populated with this list of tags and the parts with which they are associated. An RFID reader is equipped with multiple antenna that pick up the tags as they pass by. In order to ensure an accurate assessment of the location of assets, these antenna will be placed at choke points such as doors or hallways narrow enough to pick up the tag. Through the use of the scripts and the C# program, the database is populated and queried to see which tag has passed by which antenna. This reveals the location of the asset.

ThingWorx has the ability to visually represent information in what is called a mashup. A mashup takes data and information that is pulled from a specific location (in this case a MySQL database) and makes it more appealing to the eye, as well as a little easier to understand, through visualization tools.

A ThingWorx mashup is created with the various different areas of the factory floor such as the warehouse, factory floor, inventory, etc. Each associated tag is assigned an image to show what it is. The C# program associates tags with the receiving antenna and the combination of these two things will reveal where the asset sits on the floor. The mashup shows the image that the tag is associated with in the location on the factory floor, which gives a completely visualized picture of the factory and its assets.

Figure 19. Asset tracking between multiple zones

Above is a sample of what the user interface would look like for this portion of the solution. Each area shows a different zone. The icons in each area represent an item that the user would want to be tracking. As each item passes to a different area, the tag is picked up by the RFID reader, and the icon is moved to the new location in the interface.

This portion of the solution leverages the RFID/BLE, MySQL DB and PTC ThingWorx software running on the EL1000 as depicted in Figure 12. HPE Connectors for BLE/RFID (shown in Figure 13 and Figure 14) acquire the data acquire data from the corresponding sensors and pass it on via the Apache NiFi data transformation layer to PTC ThingWorx.

Indoor Location-Based Services

Location services have many important uses. Employees can be located in relation to specific areas. This allows verification of employee locations, which would discourage employees from being inefficient and wasting time in areas they need not be in.

Another use case for this solution involves directing technicians or unfamiliar employees to a specific location. This is beneficial as it allows someone with no previous knowledge of the factory lay out to find a machine with minimal effort and less wasted time.

BLE location services also allow elimination of potential accidents with transportation vehicles, such as forklifts, due to bumping into expensive machinery by killing the vehicle if it gets into too close of a proximity with said machinery.

In order to achieve these goals in the environment BLE beacons, an EL20, a MySQL database, NiFi, a script and ThingWorx are utilized. The BLE beacons put out a constant signal level. The signal level received from the beacons determine their distance. This signal strength is referred to as received signal strength indicator (RSSI). The back end of this portion of the solution uses NiFi to execute a script. This script accesses the Bluetooth adapter inside of the EL20, looks at a specific beacon, obtains the RSSI information, and puts the information into the MySQL database. The database is accessed and queried in a similar process to the RFID process.

This information is piped into another ThingWorx mashup and reveals the beacon's distance from specific areas. An array of these EL20s could be used to map out an entire factory floor as mentioned above, and a script could be written with a triangulation formula to implement the navigation aspect of the solution.

| > 8 ft | 4-8 ft | 2-4 ft | < 1 ft |

Aruba Beacon

Aruba on Pump

Estimote Beacon

Kontakt Beacon

Figure 20. Beacon use for location based services

Above is a sample representation of how indoor location based services would look through the user interface. This part of the solution used BLE beacon, placed at various distances. This gives the user the ability to locate how far away from the EL20 the desired device is.
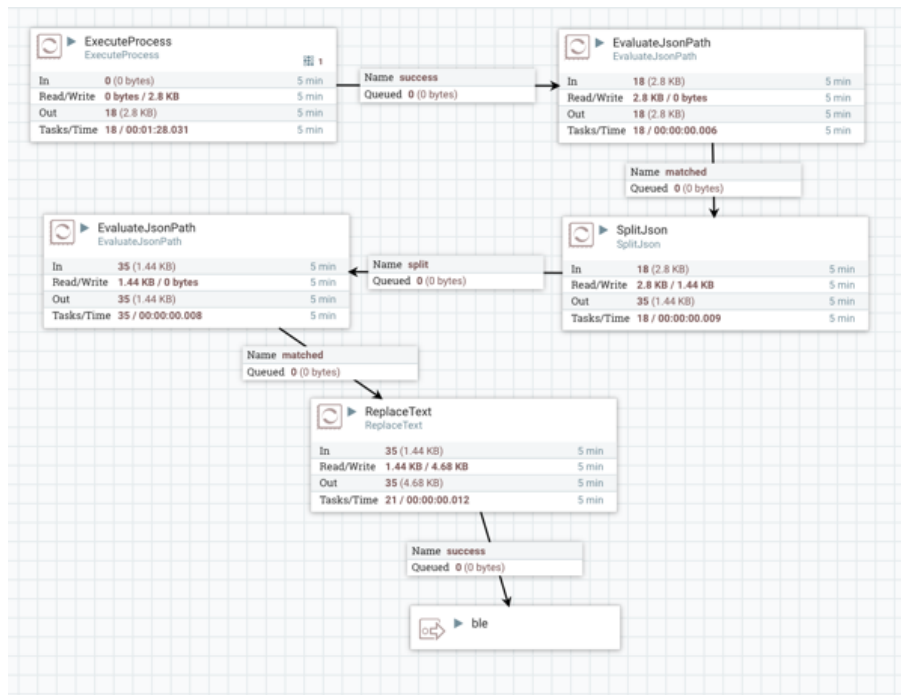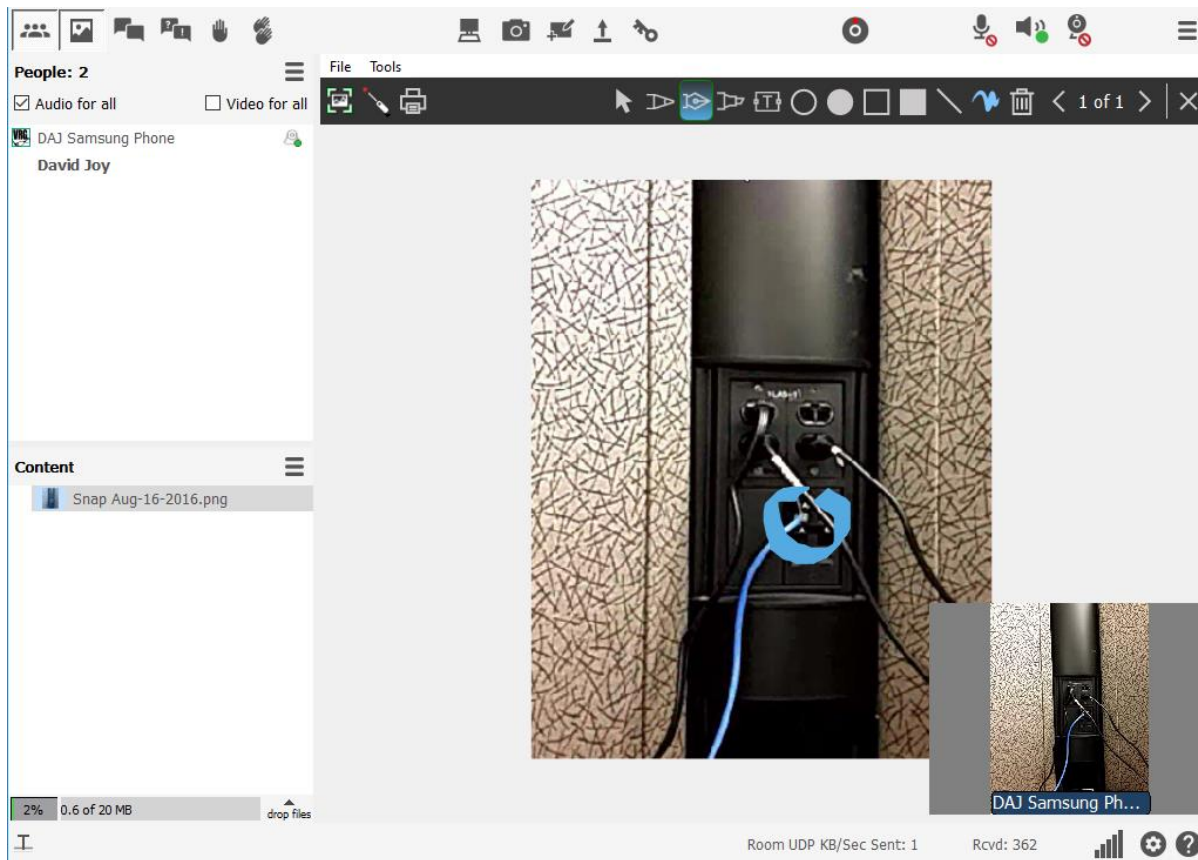
Figure 21. Data transformation services for BLE utilizing NiFi for location based services

Shown above is a sample of a flow file inside of NiFi that utilized BLE for location based services. First a python script is executed that interfaces with the beacons (ExecuteProcess NiFi processor), then the JSON is split into separate flow files based on beacon ID (EvaluateJSONPath, SplitJSON NiFi processors). That information is then formatted as a SQL query, and a query is executed on the MySQL database (ReplaceText processor).

This portion of the solution leverages the RFID/BLE, MySQL DB, Apache NiFi and PTC ThingWorx software running on the EL1000 as depicted in Figure 12 and HPE Connectors for BLE on the EL 10 and EL20 as shown in Figure 13 and Figure 14, respectively.

Remote Collaboration

With HPE Visual Remote Guidance for the Enterprise, your remote workers or customers may be guided by experts through issue resolution, significantly reducing time to repair, even for demanding technology issues. HPE Visual Remote Guidance creates an innovative service enabled through HPE MyRoom that facilitates faster issue resolution by staff, while collaborating virtually with a support engineer or expert. Live information sharing provides an intelligent, intuitive support experience. The support engineer or expert can see what the remote worker sees and does, and can provide real-time guidance, all through the wearable computing display, enabling convenient, hands-free interaction. This enables issues to be diagnosed and resolved accurately and more efficiently, which significantly increases the first-time repair rate and enables quick resolution, for fast return to productive operation. Additionally, live guidance during the repair leverages your engineers' accumulated expertise to dramatically shorten users' learning curve, enabling them to focus more on core tasks. Figure 22 shows an example of a remote display at the subject matter expert's end via an operator wearing a wearable glass (also running MyRoom VRG app)

Figure 22. HPE MyRoom collaboration between technicians

Above is a sample of what the user interface would look like. It shows two devices that are talking to one another. The blue circle in the middle is a sample of how a technician would be able to indicate to someone where a problem is located during their chat session.

Role-based Network authentication

In order to ensure data is protected, and only seen by appropriate users and machines, an Aruba Collaboration Network was created. This allows for each portion of data to be given its own data pipe, meaning that items from the sensor network wouldn't be clogging up the data from device control networks.

Two pieces of Aruba hardware - the Aruba 7005 Controller and the Aruba 350 Access Point, were used alongside Aruba Clearpass. The controller has access to various access points, broadcasting various SSIDs to which the user or machine would connect. Clearpass is utilized to set up user-type privileges. These privileges determine which specific VLAN a user or machine would be placed on. This network of VLANs allows for a more organized and secure way for data to be transmitted.

Edge Video analytics – Production Heatmap

This portion of the solution offers the ability to monitor and to track foot travel patterns in a given area. The idea is to stream live feeds from an array of Power-over-Ethernet (PoE) cameras to the Edgeline 20. The Media Server software on the EL20 analyzes the stream and detects pedestrians in the scene. Utilizing the data from the Media Server, a heat map can be created to graphically represent the pedestrian traveling pattern. The hot spots in the heat map show where people travel and gather most often. In a manufacturing factory floor scenario, this solution offers the ability to study employee movement and to help locate issues on the production line, such as employees constantly leaving assigned posts to attend the machines or to look for material.

The heat map demo used HPE's Media Server 11.1 analytical software, the Media Server Training Utility software, PostgreSQL database, Linux Ubuntu 16.01 OS, an EL20 IoT System, and an off-the-shelf Power-over-Ethernet camera. The Media Server performs the pedestrian detection and saves the resulting X-Y coordinates to a PostgreSQL database. The heat map application, written in JavaScript, HTML, and run on Firefox browser, sends POST calls to the PostgreSQL database. It then plots the X-Y points onto the scene live and changes the color based on density. On the hardware side, the Power-over-Ethernet camera is connected the POE ports with a CAT6 cable, which provides both power and communication to the camera. On the software side, the PostgreSQL database communicates to the Media Server through the ODBC drivers and an XML parser included in the Media Server. More detail on the software configuration can be found in the Media Server user manual. The Training Utility is for machine learning on object detection. Refer to the Training Utility user manual the training process. Finally, to start the pedestrian detection job on the Media Server, a POST request is sent to the Media Server. It then specifies the camera's IP address, the SQL database information, and the path to the job configuration file, which calls the training configuration file and enables the scene analysis for pedestrian detection.

Figure 23. Heat map indicating areas of pedestrian traffic

Figure 23 is an example of an area monitoring pedestrian traffic in an indoor environment. This heat map indicates where people have been traveling. Blue areas are the least traveled, green are slightly more traveled, yellow is more traveled, and red is the most traveled areas.

This portion of the solution leverages HPE IDOL Media Server and Postgres Database software running on the EL20 as depicted in Figure 14.

End-to-End Data Security

HPE SecureData software is used to provide end-to-end data protection, using Format Preserving Encryption and Secure Stateless Tokenization features. The starting point of data protection is in the EL20 and the entire system has respective access control and secure transport techniques. This is implemented as a processor at the NiFi layer in Figure 13 & Figure 14.

Summary

This paper shows how a combination of HPE Edgeline IoT systems, HPE Aruba networking equipment and strategic partner software stacks can be used in unison to deliver an edge-to-core stack for legacy and smart sensor aggregation, edge analytics without disrupting existing field operations but simultaneously providing an integrated digital value chain.

As depicted below, this is a mutlifaceted solution that combines legacy integration with new sensors to enable a wide range of capabilities. This results in new operational efficiencies that improve their bottom line.

Figure 24. Legacy integration with edge analytics components

"HPE is the world leader in the data center. We are creating not just a new product, but a **new product category**. For the first time in history, the new Edgeline EL1000 and EL4000 take proven datacenter class **function out to the edge, and converges** it with embedded data capture and control."

– Dr Tom Bradicich, VP & GM, HPE Servers & IoT Systems

Learn more at

- ProLiant m510 Server Cartridge - https://www.hpe.com/h20195/v2/getpdf.aspx/c05069171.pdf?ver=1
- Aruba Controller - http://www.arubanetworks.com/assets/ds/DS_7000Series.pdf
- Access Point - http://www.arubanetworks.com/assets/ds/DS_AP320Series.pdf
- Edgeline EL10 IoT System - https://www.hpe.com/sg/en/product-catalog/servers/edgeline-systems/pip.hpe-edgeline-el10-intelligent-gateway.1008670386.html
- Edgeline EL20 IoT System - http://www8.hp.com/us/en/products/server-edgeline/product-detail.html?oid=1008670391
- Edgeline EL1000 Converged Edge System - https://www.hpe.com/h20195/v2/GetPDF.aspx/4AA6-6095ENN.pdf
- FX9500 - https://www.zebra.com/us/en/products/rfid/rfid-readers/fx9500.html
- KEPServerEX- https://www.kepware.com/en-us/products/kepserverex/
- ThingWorx - http://www.ptc.com/internet-of-things/technology-platform-thingworx
- IDOL MediaServer - http://www.hpe.com/software/richmedia
- MyRoom VRG - http://www.myroom.hpe.com/VRG
- Clearpass - http://www.arubanetworks.com/products/security/network-access-control/

Hewlett Packard Enterprise