



Web-based Digital Twins for Smart Cities

W3C Staff Contact for Web of Things and Media&Entertainment

W3C Project Specialist, Smart Cities Industry Champion

Project Professor, Graduate School of Media and Governance, Keio University

Kazuyuki Ashimura

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ToC

- Background: W3C Smart Cities Workshop
- What is already done by whom in which area?
- What is still missing for expected Web-based Smart Cities?
- Who and how to lead the discussion to resolve the gaps?

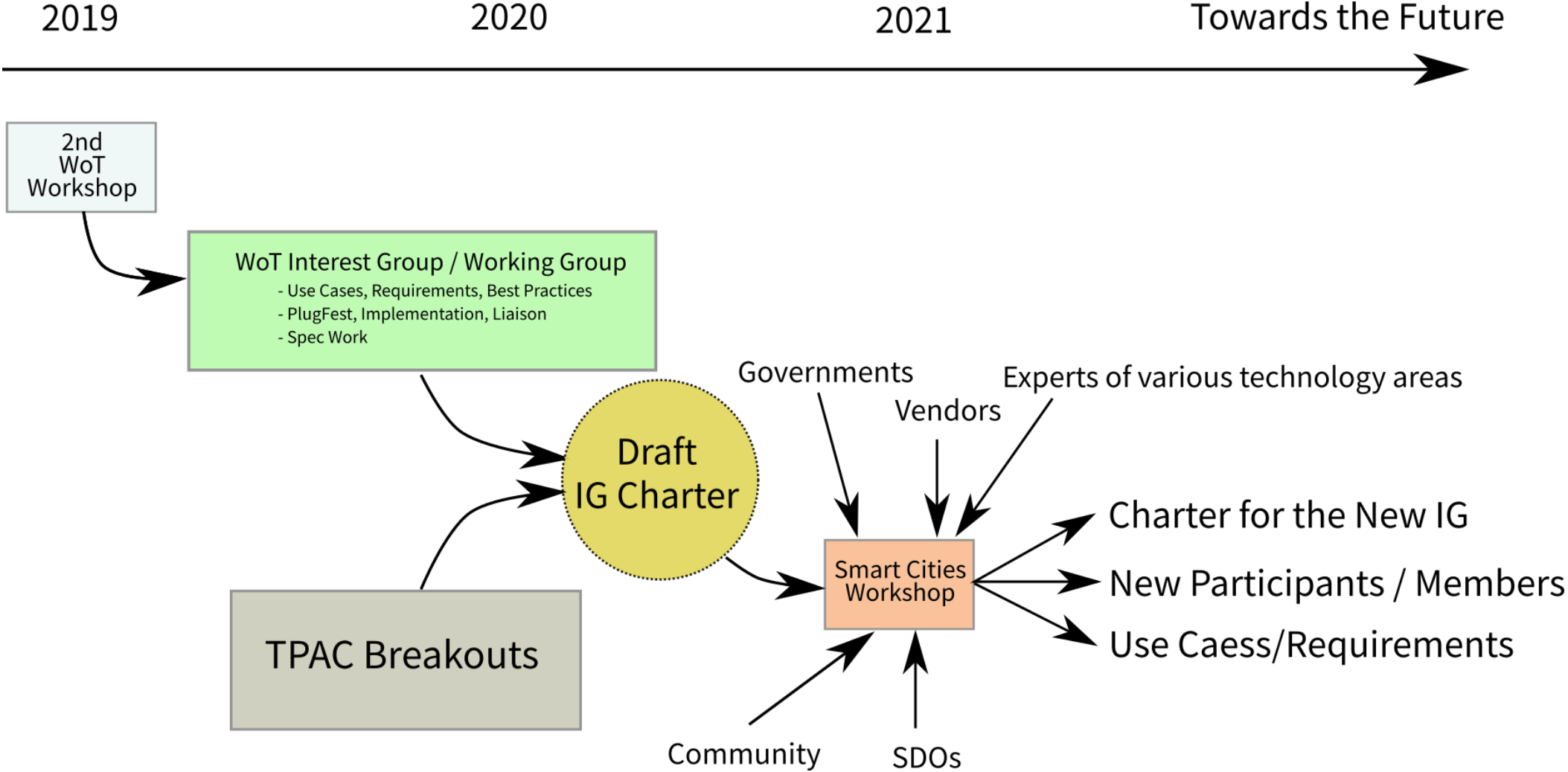
Background:

W3C Smart Cities Workshop

Difficulties with Smart Cities

- "Smart Cities" consists of (too) many stakeholders (vendors, users, governments, ...) and technologies (Web, IoT, Software, Hardware, ...).
- So strong need:
 - To identify and document **use cases and requirements** that W3C specifications need to meet to support Smart City services and users,
 - To obtain **feedback from all the stakeholders** on the usage of Web technologies for Smart Cities,
 - To gather **experts' input on important features** for Smart Cities based on Web technology, and
 - To provide a **forum for technical and business discussions** related to Smart Cities.

Smart Cities Discussion at W3C



W3C Smart Cities Workshop in 2021

- **Identify stakeholders** of Smart Cities standardization to drive the development of Web standards aligned with the real needs of Smart Cities
- **Clarify reasonable applications** for Smart Cities technologies we agree to build
- **See how to improve the draft Charter** for the potential Smart Cities Interest Group for further discussions

⇒ Workshop report:

<https://www.w3.org/2021/06/smartcities-workshop/report.html>

⇒ Draft Charter for a W3C Interest Group:

<https://w3c.github.io/wot/charters/smart-cities/smart-cities-ig-charter.html>



This proposed charter is available on [GitHub](#). *Feel free to raise issues.*

Start date	[dd monthname 2020] (date of the "Call for Participation", when the charter is approved)
End date	[dd monthname 2022] (two year duration)
Charter extension	See Change History .
Chairs	Goal: 2-3 co-chairs
Team Contacts	Kazuyuki Ashimura (0.2 FTE)
Meeting Schedule	Teleconferences: Regular weekly calls will be held. Face-to-face: we will meet during the W3C's annual Technical Plenary week; additional face-to-face meetings may be scheduled by consent of the participants, usually no more than 3 per year. Workshop: A workshop with an open CFP and invited speakers may be organized to provide further feedback and input and the guide the group's agenda.

1. Scope

Standards are essential for Smart City technology and business development. Standards benefit vendors, cities, and users. For vendors, standards unify markets and mean that a larger market can be addressed with a single product design, allowing products to more efficiently make returns on the investments needed to develop them. For cities, standards allow the deployment of technologies that can be sourced from multiple vendors, more and higher quality products, and increases the probability that systems will remain usable over a longer timescale. Standards also encourage the development of open systems that can interoperate with other standardized systems, multiplying the number of use cases that can be addressed. For users, standardized technologies mean that services available in one city will also be available in others, facilitating mobility.

Workshop Discussions – Use Cases

- [Heng QIAN: The Uniqueness of Smart City ICT](#)
- [Peter Lee: Smarter Suffolk \(UK\) case study](#)
- [Josh Lieberman: Socializing Urban Digital Twins](#)
- [Daihei Shiohama: Publishing WoT use case for Japan Smart Cities](#)

Workshop Discussions – Existing Standards

- Jerome Blum: ECLASS as a standardized Taxonomy, Terminology and Semantic for Smart Cities
- Clarissa Loureiro: Smart City Maturity Model for Developing Countries Scenarios

Workshop Discussions – Web-based Approach

- [Sebastian Kaebisch: Standardized Service Orchestration in Smart City](#)
- [Michael McCool: The Web of Things in the Smart City](#)
- [Andrea Cimmino: Shifting from smart cities to smart communities using Web technologies](#)
- [Jacqueline Lu: Transparency Interfaces for Everyday Places](#)
- [Dave McComb: Lessons Learned from Enterprise Ontologies to Smart Cities](#)

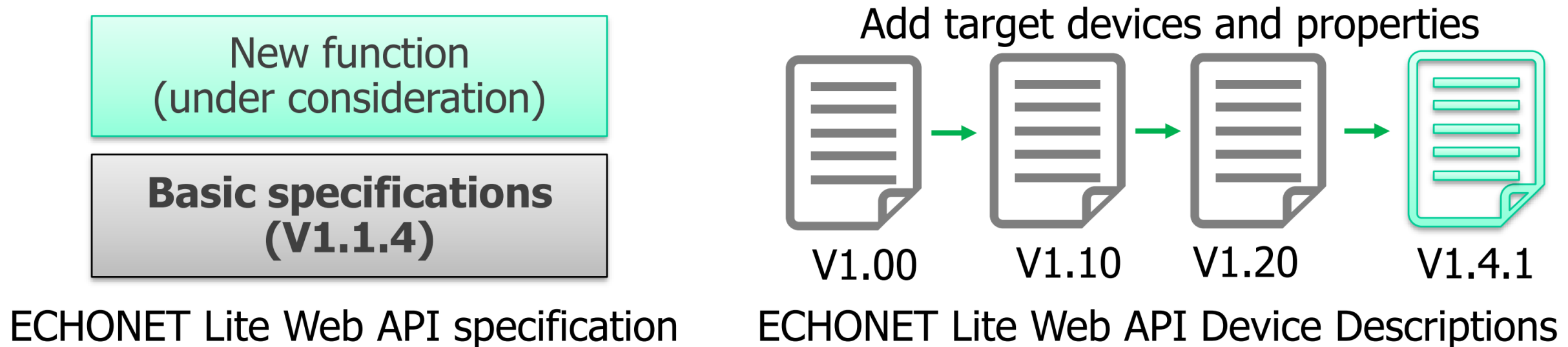
Workshop Discussions – Cross-cutting Issues

- [Sisay Chala, Otilia Werner-Kytölä: Privacy-Aware Information Base in the Context of Smart Cities](#)
- [Deborah Dahl: Intelligent User Interfaces to Smart Cities](#)
- [Baoping CHENG: Multimedia communication technology reshapes smart home life](#)
- [Kaz Ashimura: Data Governance for Smart Cities](#)

What is already done by whom in which area?

ECHONET

- ECHONET Lite Web API specification presents the scope of coverage (basic use cases), Web API model guidelines, and guidelines for mapping ECHONET Lite specifications to Web API
- ECHONET Lite Web API Device Descriptions specifies Device Description (data type and property resource specifications) for each device (e.g. Air conditioner, Storage battery, Fuel cell, Photovoltaic system, Electric vehicle charger / discharger, Smart meter, Lighting)
- ECHONET Lite Web API referred to the early draft version of W3C WoT.



Sharing information on the study of new features

To enhance features for enabling requirements of realworld applications

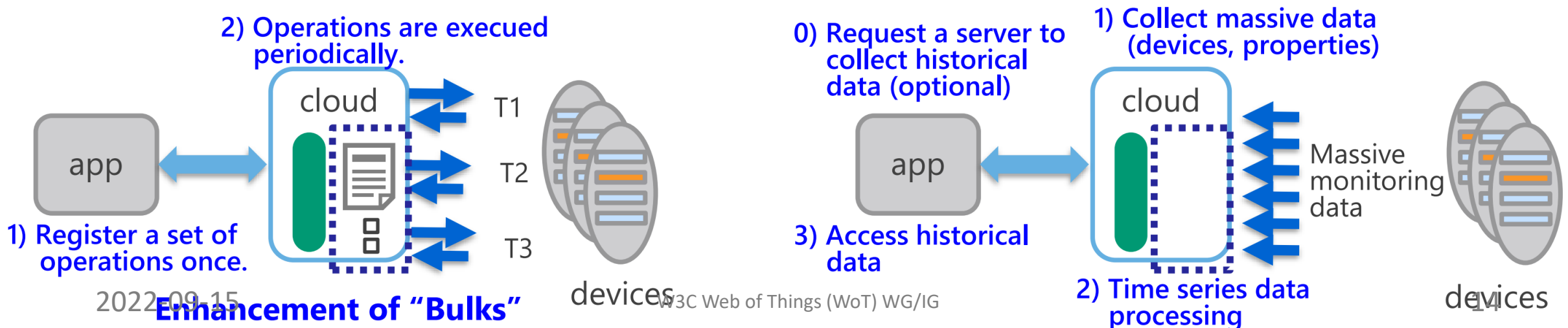
❖ Reserving the execution of a set of operations and executing the reservation

- Need to register and execute a set of operations that are done repeatedly in a server
 - Need to reuse the set of operations registered in a server. (“Bulks” defined in ECHONET Lite Web API is for this functionality.)
 - **Need to execute a set of operations at specified intervals periodically.**

❖ Historical data processing

- Need to provide Web API client with aggregated historical data.

❖ Authentication and authorization cooperation between servers



IEC SC3D

IEC SC3D: Methodology and products ontology

2022-09-14 W3C/WoT

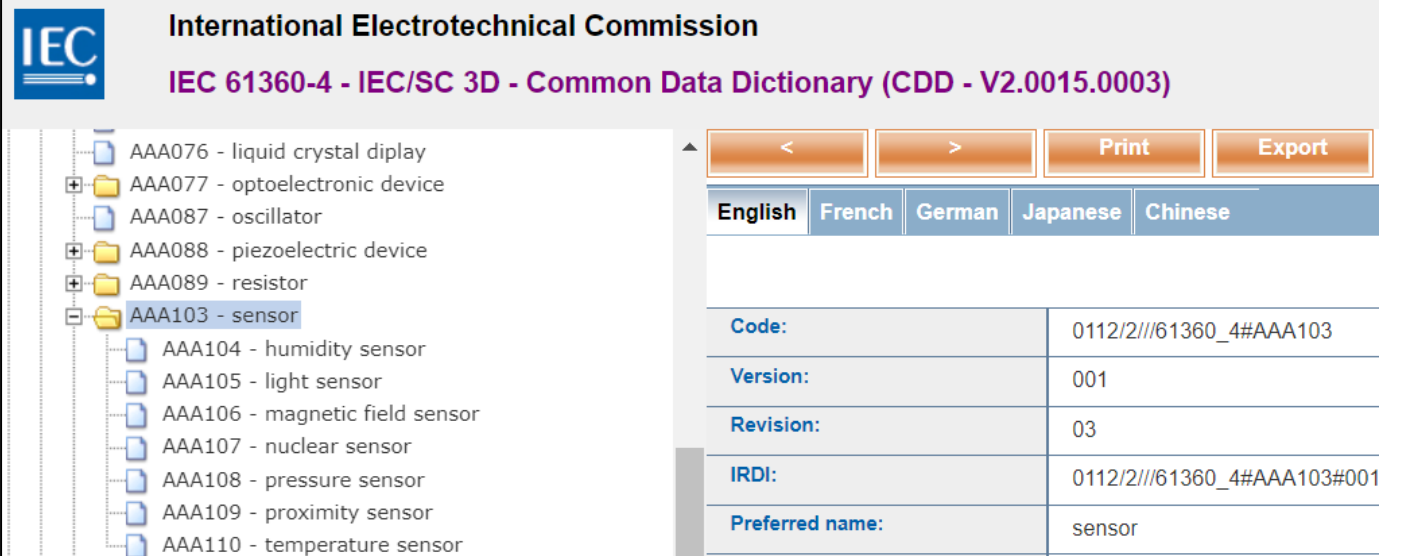
SC 3D Classes, Properties and Identification of products - Common Data Dictionary (CDD)

SC 3D Scope

Standardization for representation of technical information along the life cycle of a product including service, device, system, software or plant, covering rules, principles and methods associated with the machine sensible representation of the technical information. This refers to:

- definition, structuring and identification of classes and properties
- structural design of product data dictionaries and ontologies
- consistent methodology for the purpose of structuring technical information and its exchange
- support for the design of classes and properties in all domains/industries and their publication in IEC Common Data Dictionary (IEC CDD)
- maintenance and quality control of the IEC Common Data Dictionary (IEC CDD)
- Supporting semantic interoperability

Horizontal function related to the methodology, design, architecture and interface for supporting product data dictionaries.



International Electrotechnical Commission
IEC 61360-4 - IEC/SC 3D - Common Data Dictionary (CDD - V2.0015.0003)

AAA076 - liquid crystal display
AAA077 - optoelectronic device
AAA087 - oscillator
AAA088 - piezoelectric device
AAA089 - resistor
AAA103 - sensor
AAA104 - humidity sensor
AAA105 - light sensor
AAA106 - magnetic field sensor
AAA107 - nuclear sensor
AAA108 - pressure sensor
AAA109 - proximity sensor
AAA110 - temperature sensor

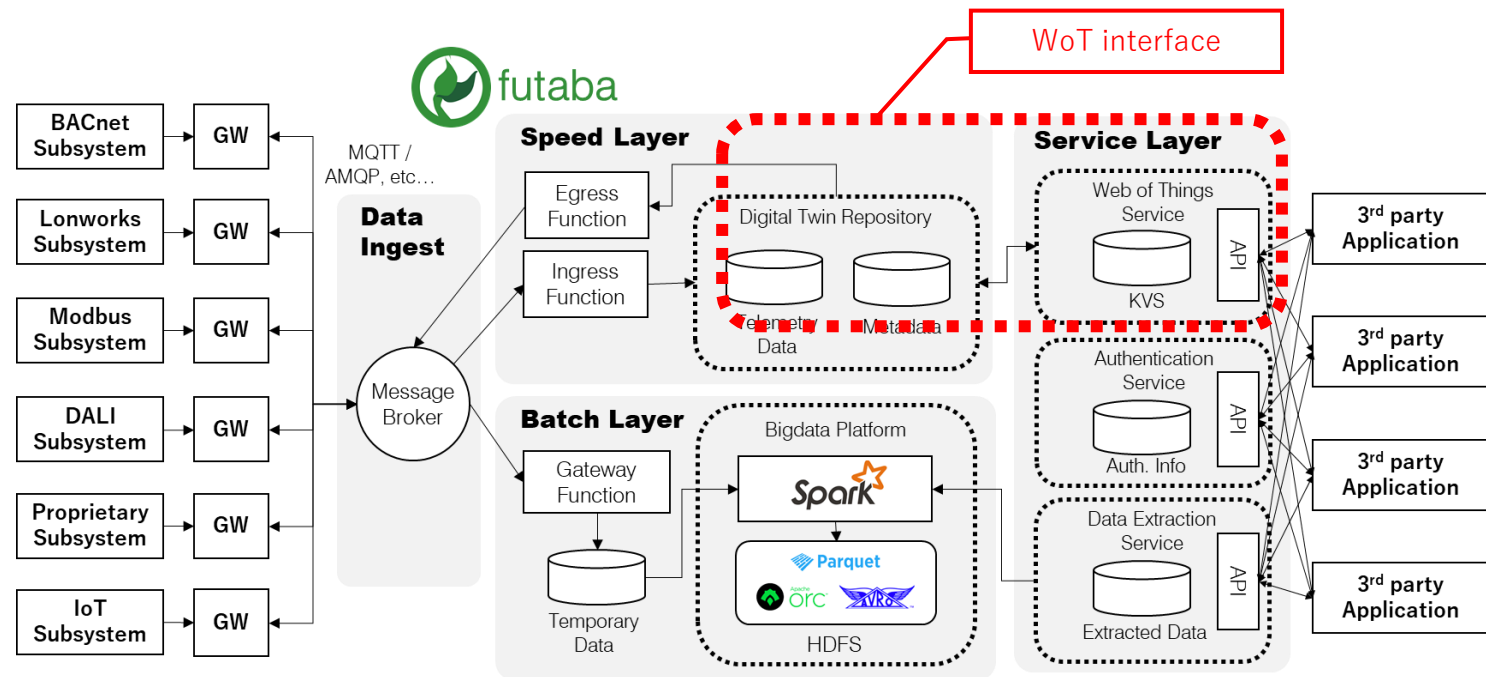
Code:	0112/2///61360_4#AAA103
Version:	001
Revision:	03
IRDI:	0112/2///61360_4#AAA103#001
Preferred name:	sensor

1. Machine-interoperable methodology
2. Available for all ISO, IEC products and systems
3. Standardized product ontology DB
 - <https://cdd.iec.ch/>

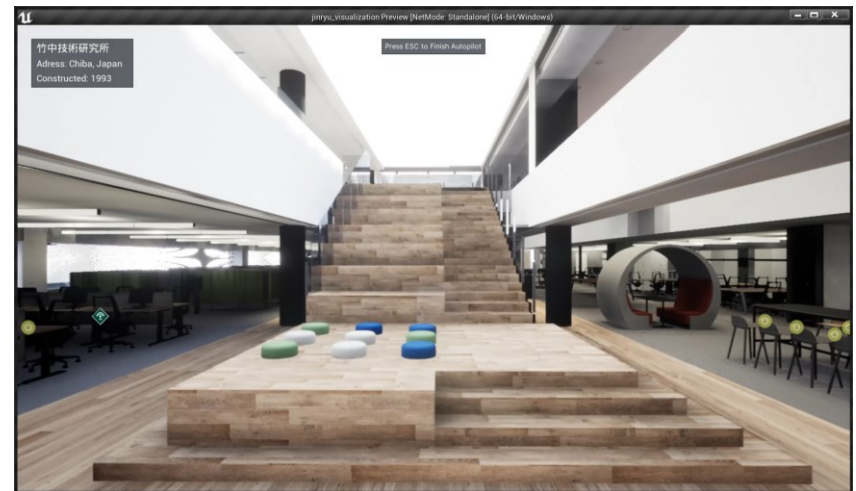
IPA DADC

Use case : Smart Building (1)

1. Takenaka Corporation has developed a data platform for smart buildings using WoT.
2. Based on the lambda architecture which is a best practice for real-time data processing.
3. WoT is used to implement data models and APIs.
4. It is the foundation for many services such as energy management, AI control, personal control and digital twin.



EQ House : Remote control by reinforcement learning
https://www.takenaka.co.jp/eq_house/

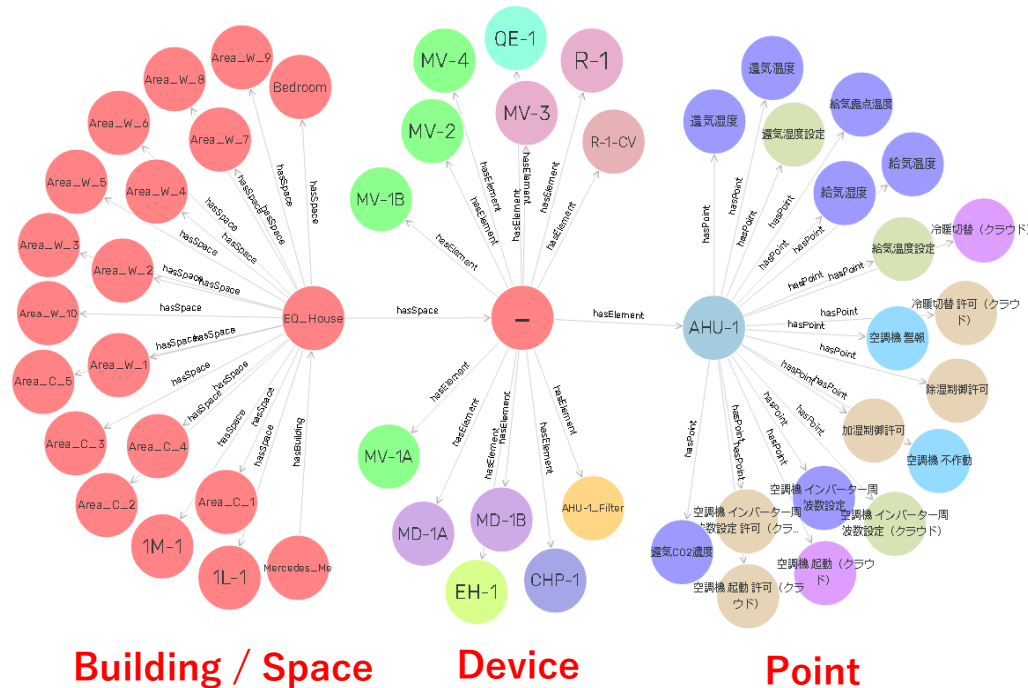


Digital Twin Application

Use case : Smart Building (2)

1. Must manage many devices and tons of associated measurement and control points.
2. It is impossible to write a TD for each device manually.
3. We must extend the original WoT API for batch property acquisition.

Visual graph



Space Graph / Data Model

- title : "環境センサ:環境センサ:18254163"
- ⊕ titles
- created : "2020-10-09T02:41:20.875462"
- modified : "2020-11-09T01:53:00.439324"
- ⊕ securityDefinitions
- security : "nosec_sc"
- base : "https://futaba-dev-app-hot.azurewebsites.net/api/things/37f581e2-8b5e-4350-8a71-f82a6ecf1197"
- ⊖ properties
- ⊕ SoundPressure
- ⊕ eCO2
- ⊕ eTVOC
- ⊕ HighSoundPressure
- ⊕ Humidity
- ⊕ Light
- ⊕ LowSoundPressure
- ⊕ MaximumSoundPressure
- ⊕ MedianSoundPressure
- ⊕ MinimumSoundPressure
- ⊖ Temperature
- ⊕ descriptions
- ⊕ forms
- writeOnly : false
- readOnly : true
- unit : "degC"
- type : "number"
- minimum : 0
- maximum : 100

環境センサ:環境センサ:18254160

```

{ properties:
  { SoundPressure:
    { event_time: '2020-12-09T13:54:16.708965+00:00',
      values: 38.24,
      pointId: 'R90_011402' },
    eCO2:
    { event_time: '2020-12-09T13:54:14.7192082+00:00',
      values: 546,
      pointId: 'R90_011393' },
    eTVOC:
    { event_time: '2020-12-09T13:54:12.7602548+00:00',
      values: 22,
      pointId: 'R90_011394' },
    HighSoundPressure:
    { event_time: '2020-12-09T13:54:16.7111731+00:00',
      values: 34.96,
      pointId: 'R90_011395' },
    Humidity:
    { event_time: '2020-12-09T13:54:12.929545+00:00',
      values: 51.02,
      pointId: 'R90_011396' },
    Light:
    { event_time: '2020-12-09T13:54:13.444898+00:00',
      values: 6,
      pointId: 'R90_011397' },
    LowSoundPressure:
    { event_time: '2020-12-09T13:54:16.7118353+00:00',
      values: 33.19,
      pointId: 'R90_011398' },
  }

```

TD from data platform / actual values

ISO/IEC JTC1

JTC1/WG11 Projects

Project ID.	Topic	Status
ISO/IEC 30146:2019	Information technology — Smart city ICT indicators	Published
ISO/IEC 21972:2020	Information technology — Upper level ontology for smart city indicators	Published
ISO/IEC 30145-3:2020	Information technology — Smart City ICT reference framework — Part 3: Smart city engineering framework	Published
ISO/IEC 30145-2:2020	Information technology — Smart City ICT reference framework — Part 2: Smart city knowledge management framework	Published
ISO/IEC 30145-1:2021	Information technology — Smart City ICT reference framework — Part 1: Smart city business process framework	Published
ISO/IEC 24039:2022	Information technology — Smart city digital platform reference architecture — Data and service	Published
ISO/IEC DIS 5087-1	Information technology — City data model — Part 1: Foundation level concepts	DIS ballot closed and approved
ISO/IEC CD 5087-2	Information technology — City data model — Part 2: City level concepts	CD ballot closed
ISO/IEC AW1 5087-3	Information technology — City data model — Part 3: Service level concepts - Transportation planning	WD (collaboration with ISO/TC 204 is ongoing)
ISO/IEC CD 5153-1	Information Technology — City service platform for public health emergencies — Part 1: Overview and general requirements	CD ballot closed

Pre-research and gap analysis

- **Standards needs and roadmap analysis for smart city standards from the ICT aspects**
- **Data Use in Smart City**
- **City digital twin and operating system**
- **Unified Digital Infrastructure — ICT Reference Architecture**
- **City Knowledge Trustworthiness Evaluation**
- **Terminology-Ontology in Smart City System**
- **ICT support in Public Health Emergency**

ITU-T SG20

What is done by ITU-T so far

- SG20 – Lead group on IoT and Smart Cities & Communities
 - Core IoT solutions
- FG-DPM (Data Processing and Management)
 - DPM framework, blockchain-based data sharing
- Web of Things
 - Framework, architecture, WoT-based semantic mediation
- Data models (basic interoperability)
 - Semantics, things description, Web-based data model



What is still missing and to be done ?

- Smart cities ontology (semantic interoperability)
 - A common language and correlation
 - GOUI (Global Observatory for Urban Intelligence): ITU and IEEE Joint Collaboration
- Digital Twin for smart cities
 - Model Digital Twin of City or town, based on the weighting their priorities, as a unique Decision Support System
- AI and data context
 - Artificial Intelligence of Things: CG-AIoT activities
 - FG-AI4A (Digital Agriculture)
 - AI and Data Commons, Project Resilience
 - UN - data and digital transformation strategies

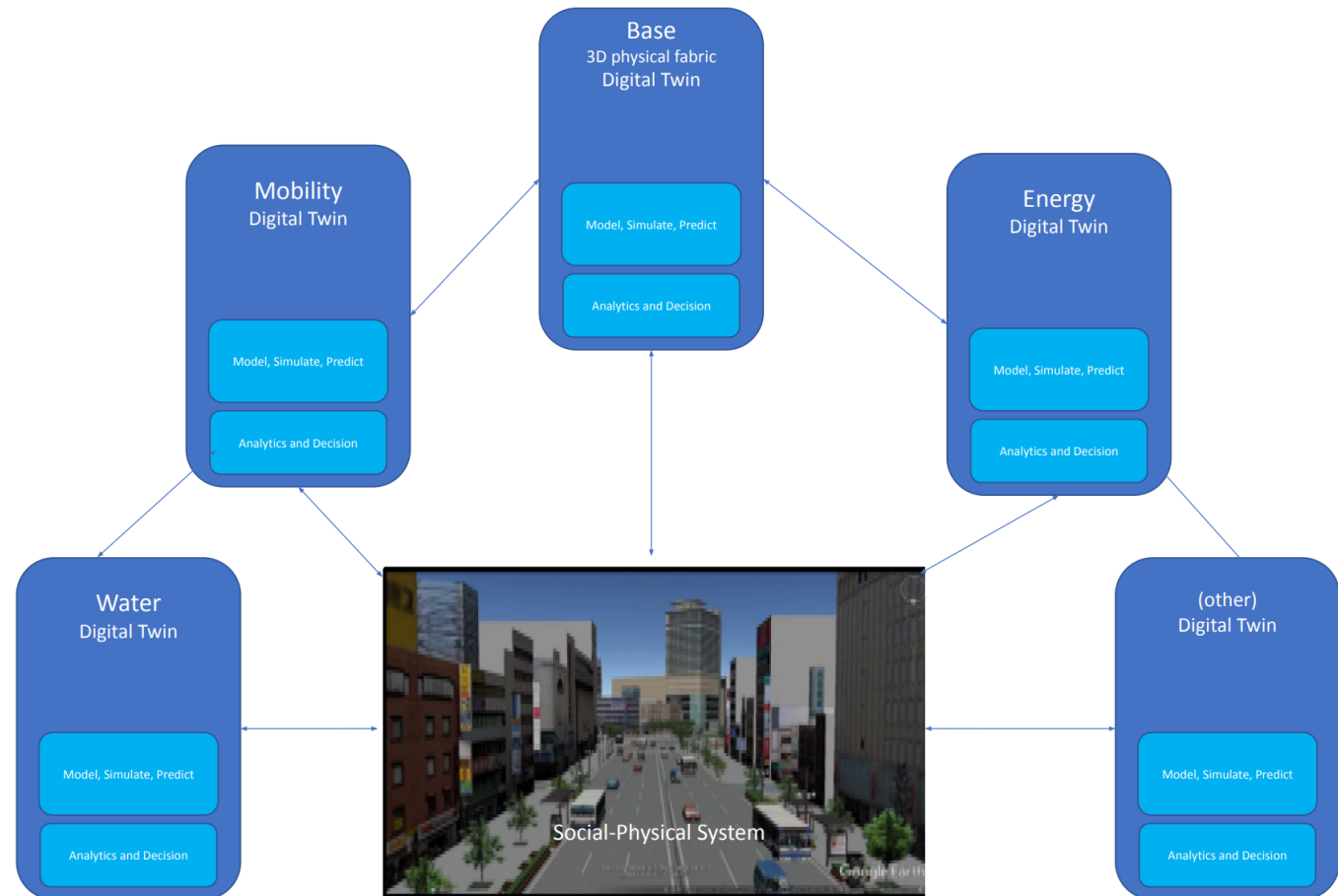


OGC

OGC Standards and Emerging Digital Twins

Tools for Representing and Observing Space

- *General Feature Model*
- *Simple Features*
- *CityGML - CityJSON*
- *3D Tiles - I3S*
- *WaterML*
- *GeoSciML*
- *MUDDI Underground Info*
- *OGC API Features*
- *Observations and Measurements*
- *SensorThings API*
- *OGC API Processes*
- *Moving Features*
- *GeoPose*
- *IMDF*
- *LAS*



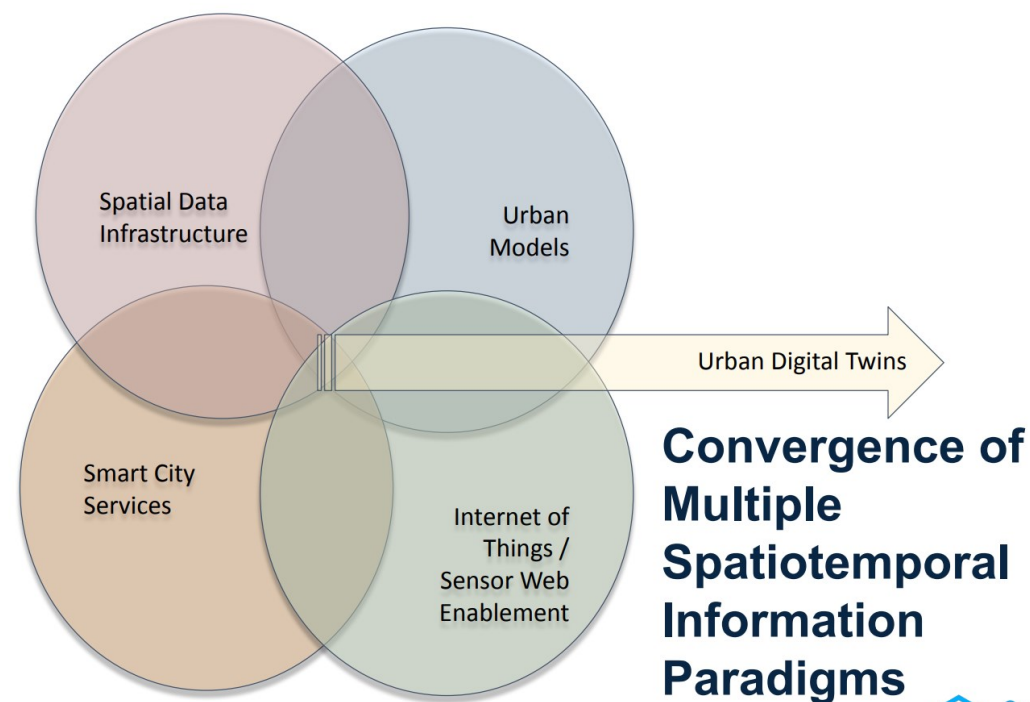
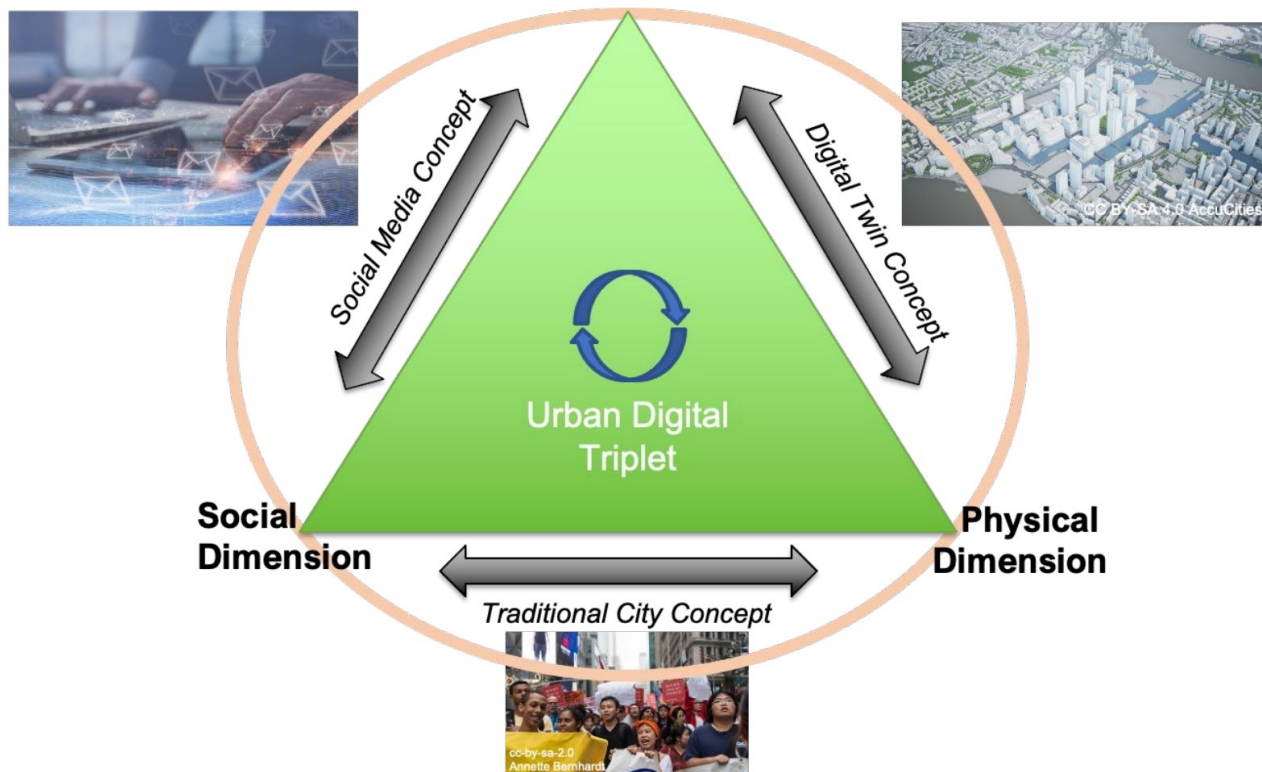
From thematic models through pairwise coordination towards a system-of-systems

OGC Innovation and Future Digital Twins

“Looks the Same, Behaves the Same, Is Not the Same”

- *Location Powers Urban Digital Twins <-> Urban Digital Twin Summit*
- *3D-IoT - Modern Spatial Data Infrastructure - Integrated Digital Built Environment*
- *Simulation, Prediction, Digital Twins in the Metaverse*

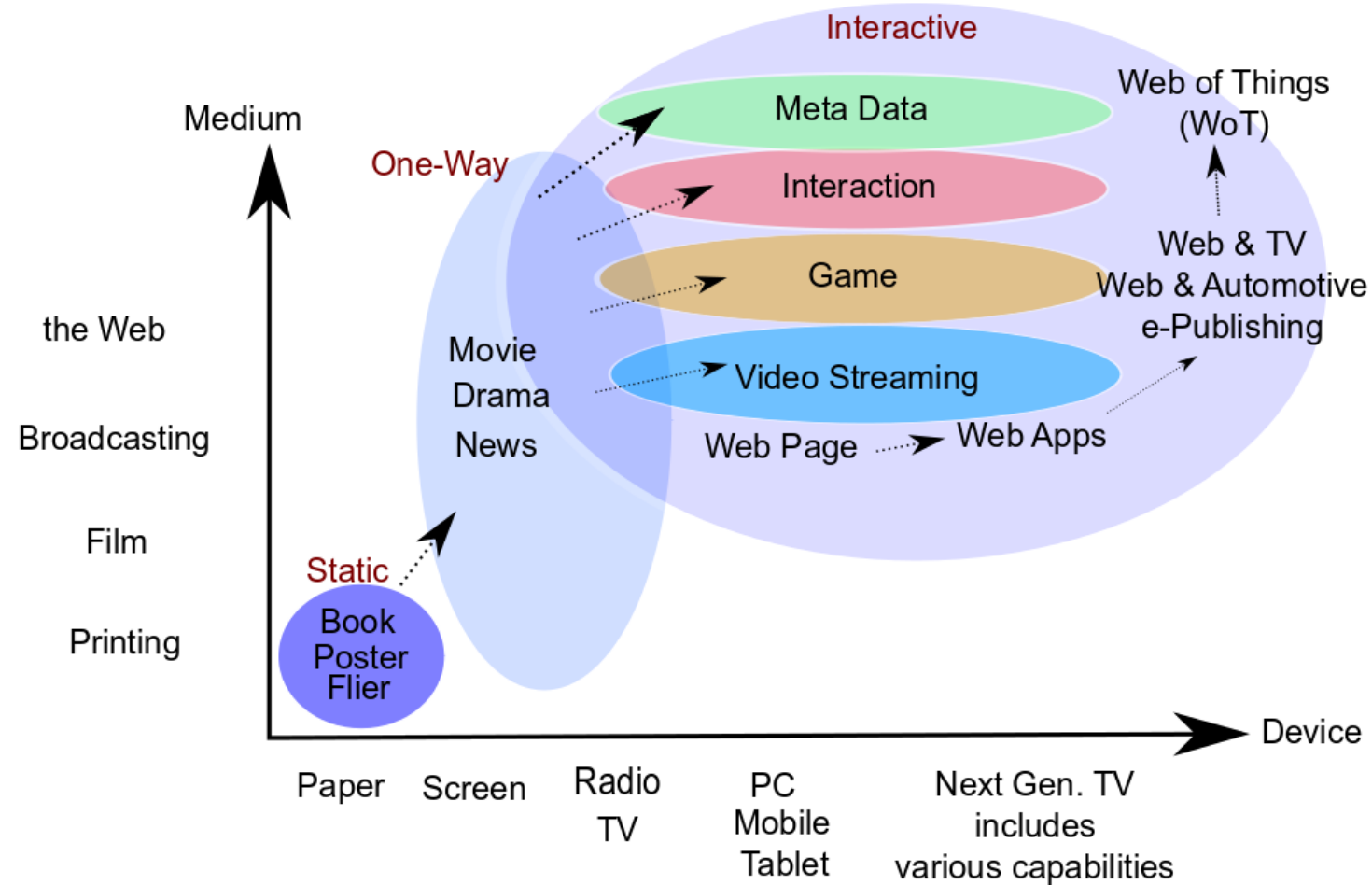
Nexus of Physical - Digital - Social Dimensions



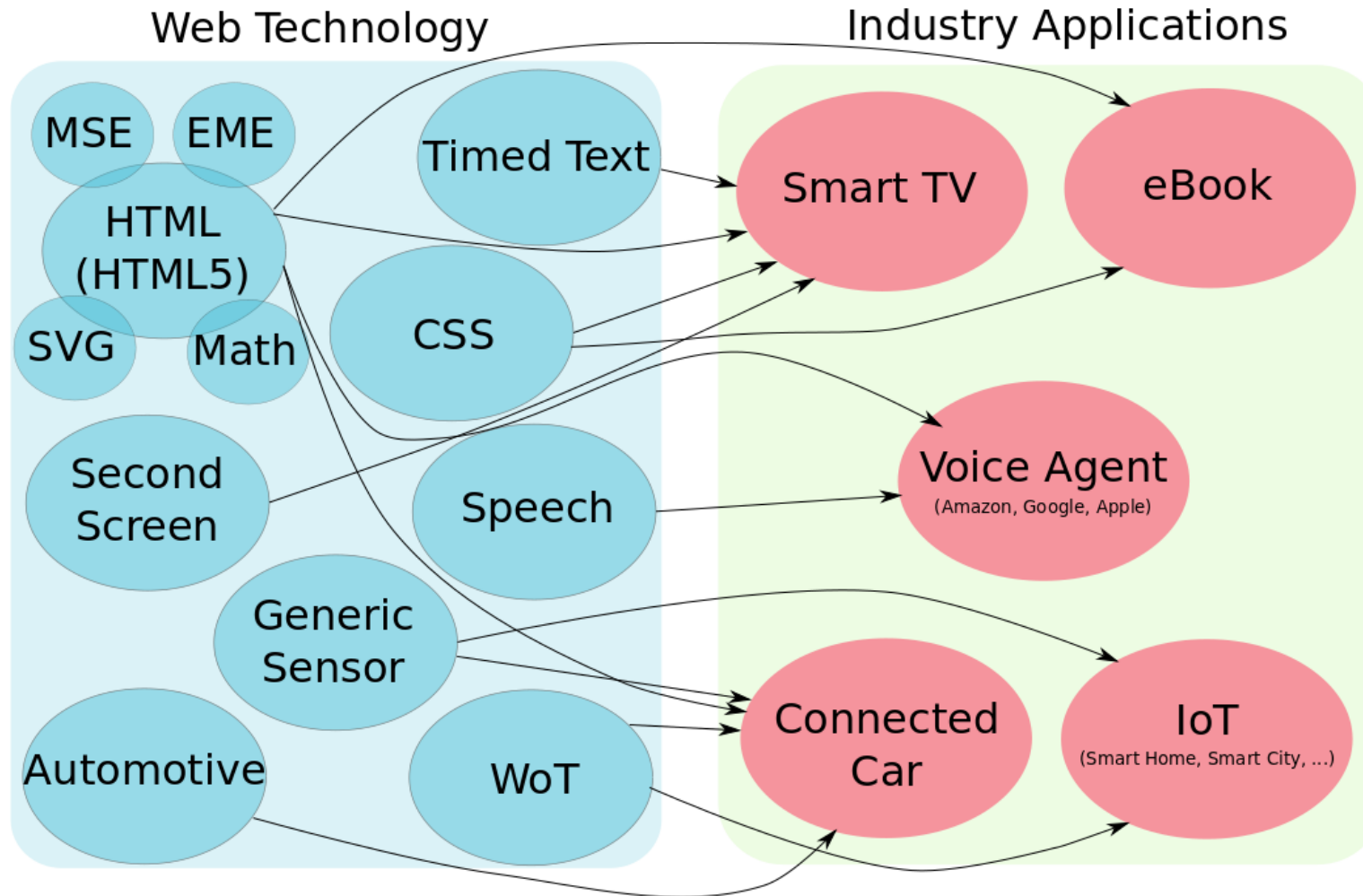
W3C

Web as platform for data transfer

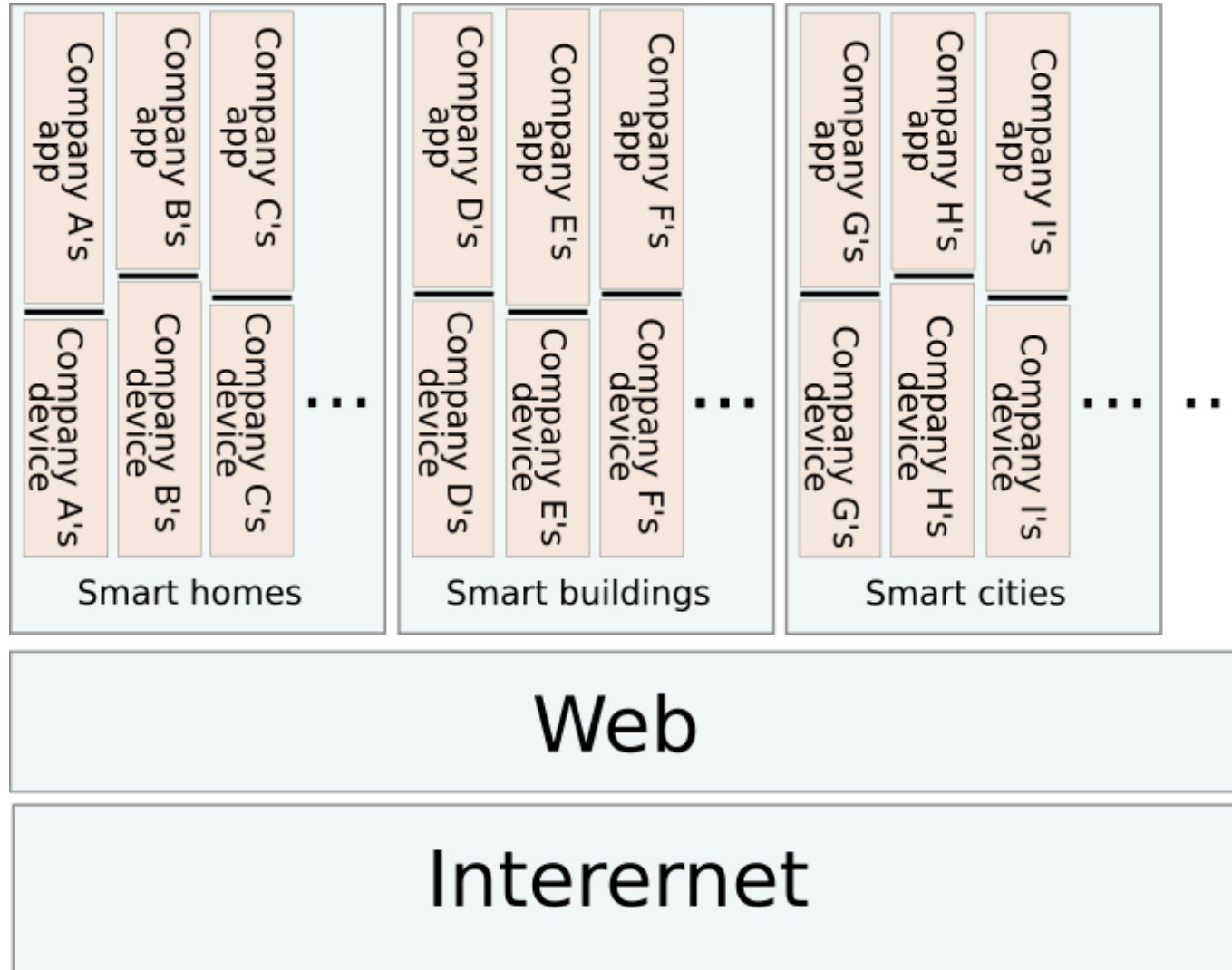
- Independent from devices or OSs



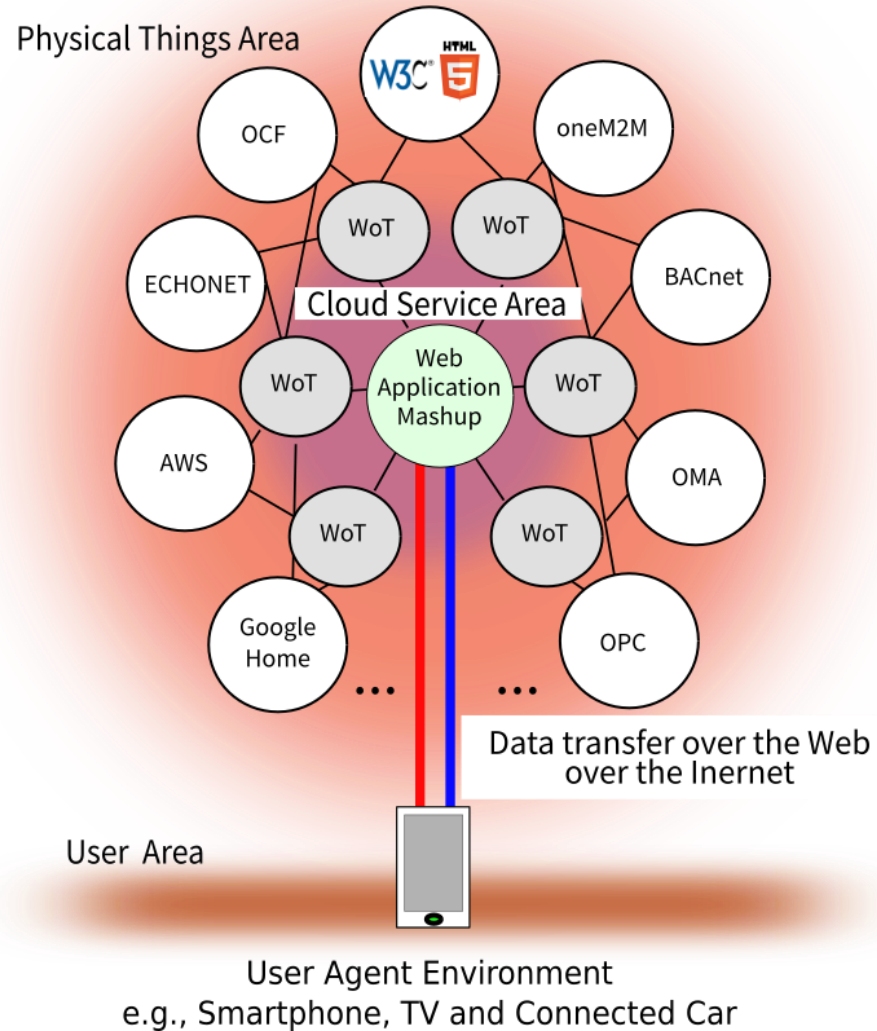
Web standards applied to various industries



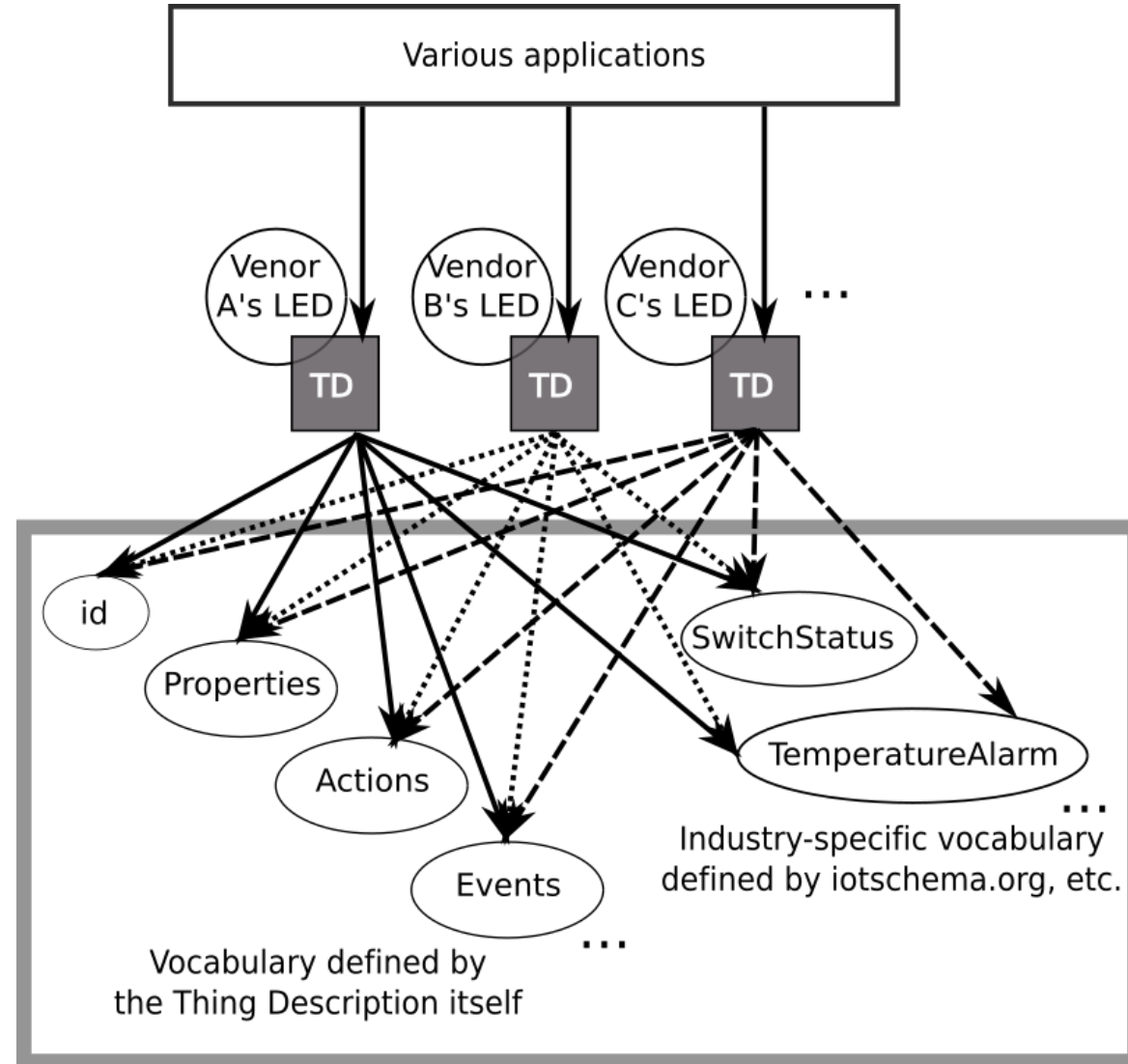
Problems of IoT silos



WoT: IoT Inter-connection using the Web



Unified vocabulary references by Thing Description



Use cases

- Vertical use cases

- ◆ TV industry
- ◆ Smart agriculture
- ◆ Smart buildings
- ◆ Smart cities
- ◆ Retail
- ◆ Traffic
- ◆ Smartgrid
- ◆ Education
- ◆ Medical care

- Horizontal use cases

- ◆ Digital twins
- ◆ Multi-protocol integration
- ◆ Big data
- ◆ Lifecycle management
- ◆ Multimodal interfaces (improved UX)
- ◆ AI & Machine learning
- ◆ Edge computing
- ◆ IoT orchestration
- ◆ AR/VR
- ◆ Geolocation

What is still missing
for expected Web-based Smart Cities?

Strong need for...

- Guidelines for real-world engineering
 - Device discovery
 - Inter-system binding
 - ID authentication and management
- Data transfer and distribution
 - Governance of data distribution - Security/Privacy
 - Semantic interoperability - Standard vocabulary
 - Catalog to start with the data search
- And more: e.g., Accessibility, Geolocation

Who and how to lead the discussion
to resolve the gaps?

“Digital Twins” as the Key Concept

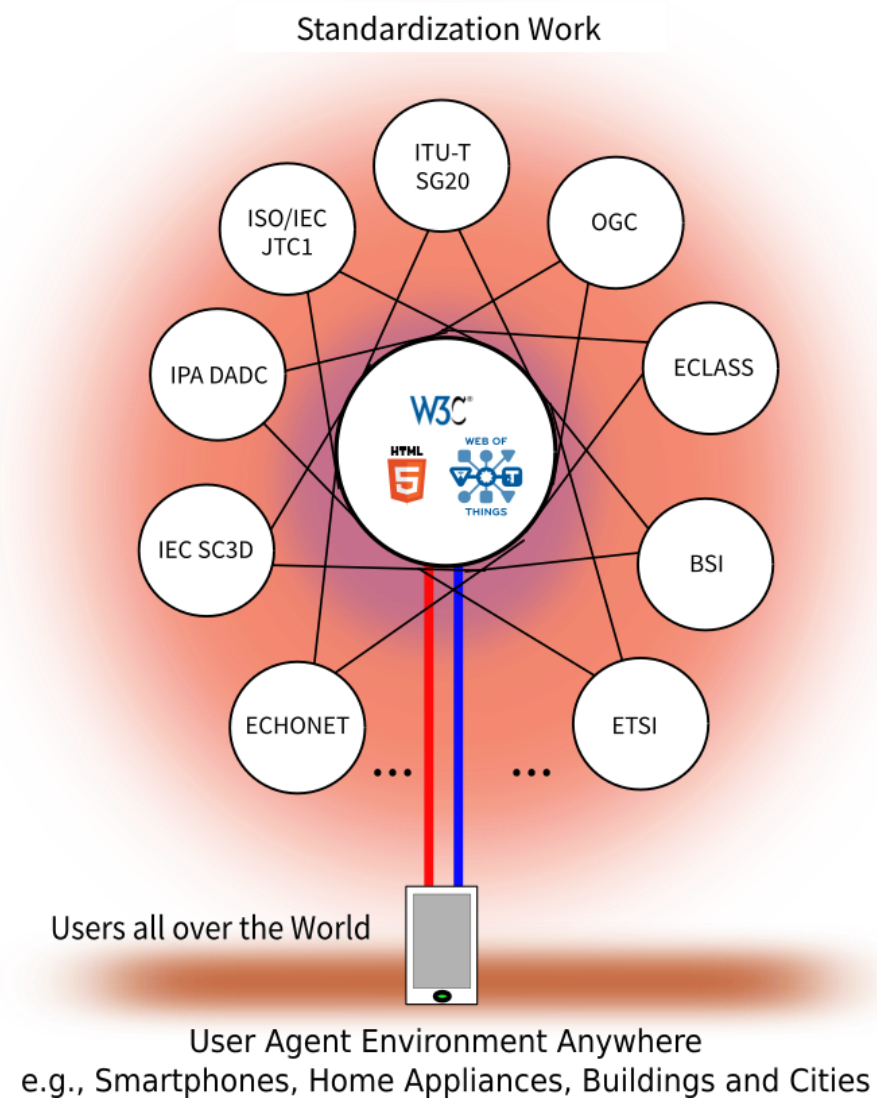
During various use case discussions:

- WoT standardization
- Smart Cities workshop
- Following discussions after the workshop

Proposal:

Let’s start with “Web-based Digital Twin”
as the initial target!

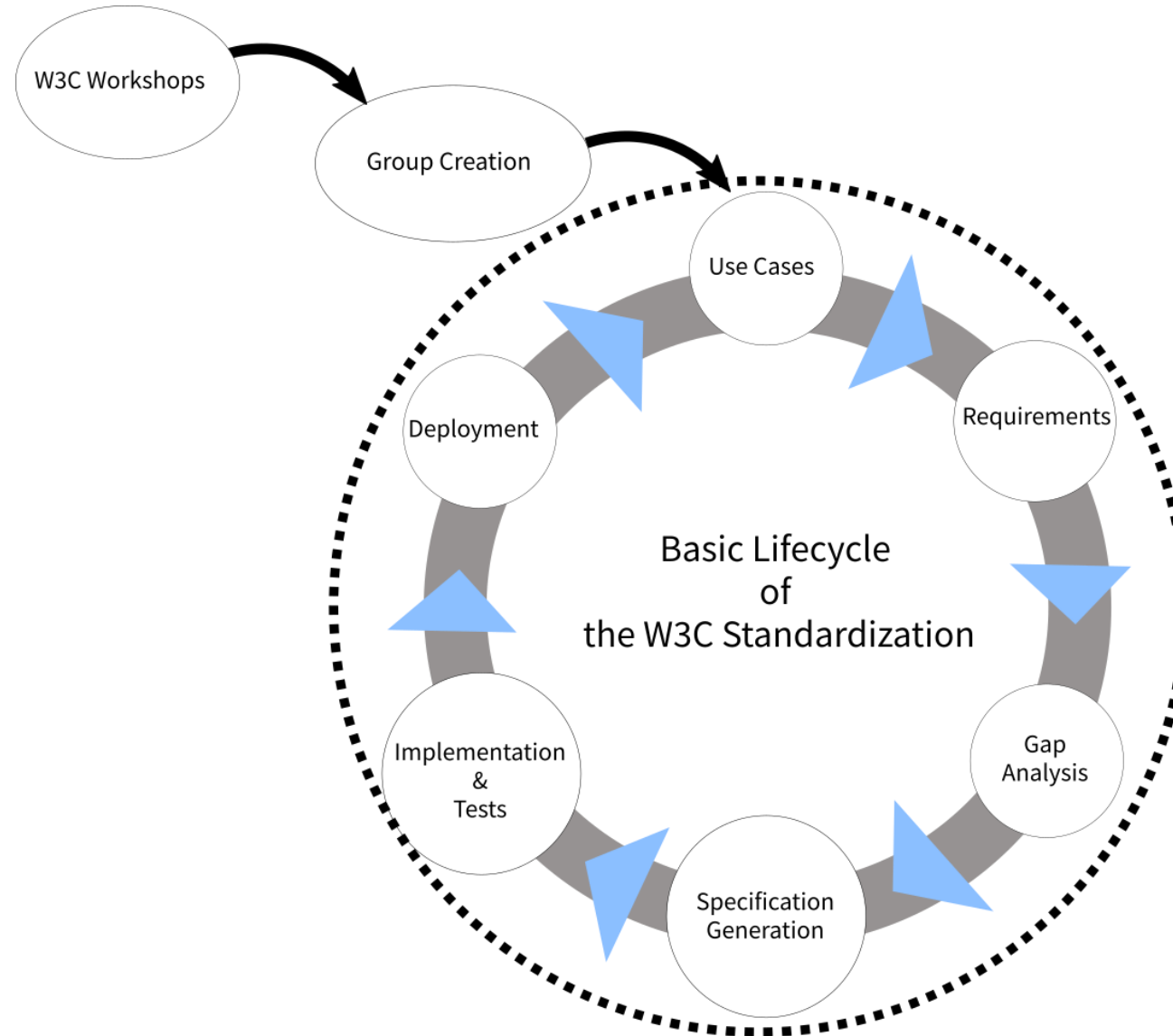
Collaborative Discussions by related SDOs!



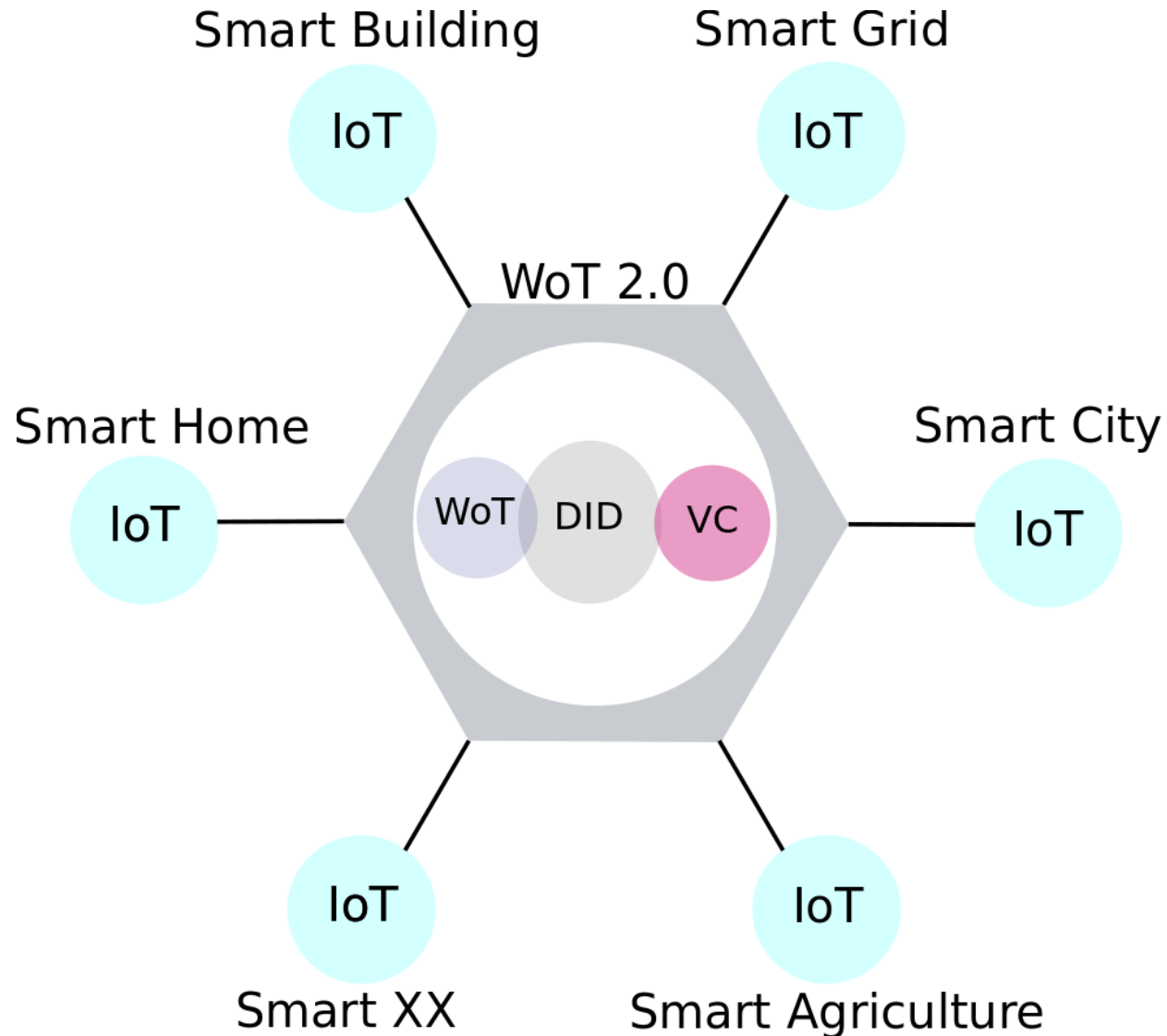
W3C as the central hub
for the collaborative discussion
on the “Web-based Digital Twins”

W3C Standardization Cycle and Next Steps

— based on industry needs and implementations



A Possible Future Framework: WoT + DID + VC



Managing devices and users using the DIDs:

- DID: Decentralized Identifiers
 - IDs for identify devices and users
 - Encrypted and distributed
 - Blockchain is a possible system platform
- WoT: Web of Things
 - Standard description for devices' capability and behavior
- VC: Verifiable Credentials
 - Standard description for users' credentials
 - Encrypted and self-sovereign

Thank you!

May the Web standards be
your companion helping you
improve the world!

