Smart Cities Standardization within W3C

Web-based Digital Twins for Smart Cities

W3C Staff Contact for Web of Things and Media&Entertainment
W3C Project Specialist, Smart Cities Industry Champion
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27 Novemer 2022

ToC

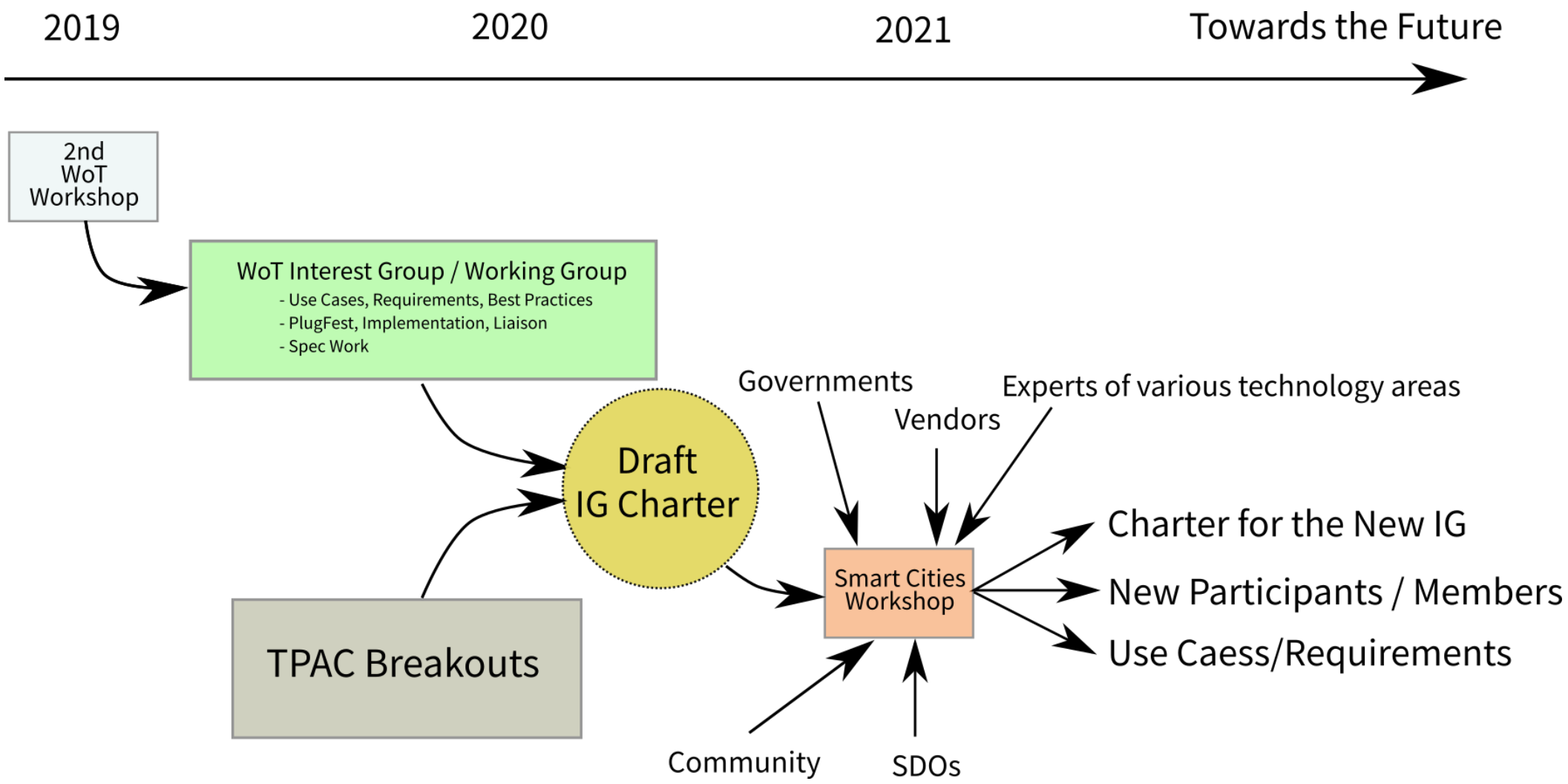
- Background: W3C Smart Cities Workshop
- What is already done by whom in which area?
- What is still missing for expected Web-based Smart Cities?
- How to continue the discussion to resolve the gaps?
- New discussion group at W3C!

Background:
W3C Smart Cities Workshop

Difficulties with Smart Cities

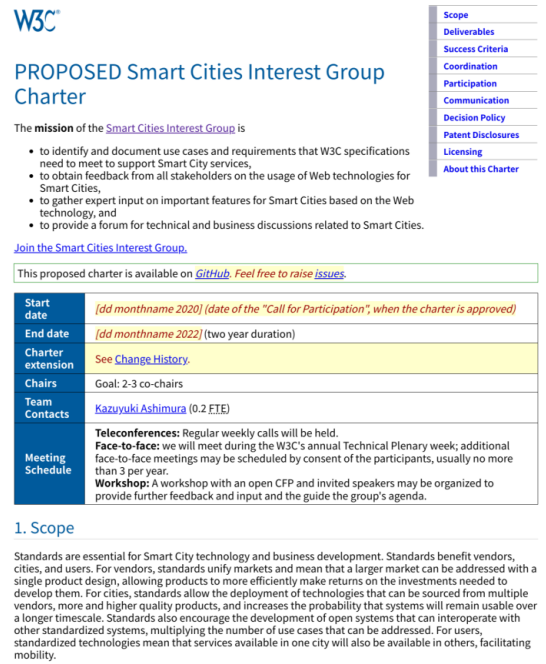
- "Smart Cities" consists of (too) many stakeholders (vendors, users, governments, …) and technologies (Web, IoT, Software, Hardware, …).
- So strong need:
  - To identify and document **use cases and requirements** that W3C specifications need to meet to support Smart City services and users,
  - To 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



W3C

PROPOSED Smart Cities Interest Group Charter

Scope
Deliverables
Success Criteria
Coordination
Participation
Communication
Decision Policy
Patent Disclosures
Licensing
About this Charter

The **mission** of the Smart Cities Interest Group is

- to identify and document use cases and requirements that W3C specifications need to meet to support Smart City services,
- to obtain feedback from all stakeholders on the usage of Web technologies for Smart Cities,
- to gather expert input on important features for Smart Cities based on the Web technology, and
- to provide a forum for technical and business discussions related to Smart Cities.

Join the Smart Cities Interest Group.

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 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

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

Structure of ECHONET Lite WebAPI

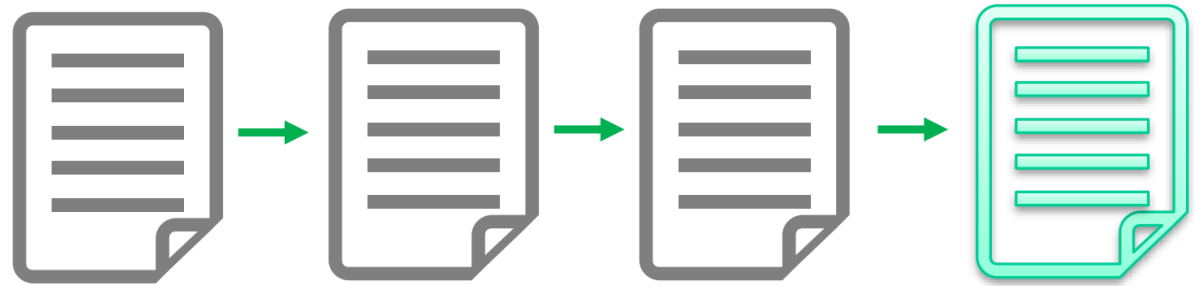
- ECHONET Lite Web API specification
  presents the scope of coverage (basic use cases), Web API model guidelines, and guidelines for mapping ECHONET Lite specifications to Web API
- ECHONET Lite Web API Device Descriptions
  specifies Device Description (data type and property resource specifications) 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.

New function
(under consideration)

Basic specifications (V1.1.4)

ECHONET Lite Web API specification

Add target devices and properties

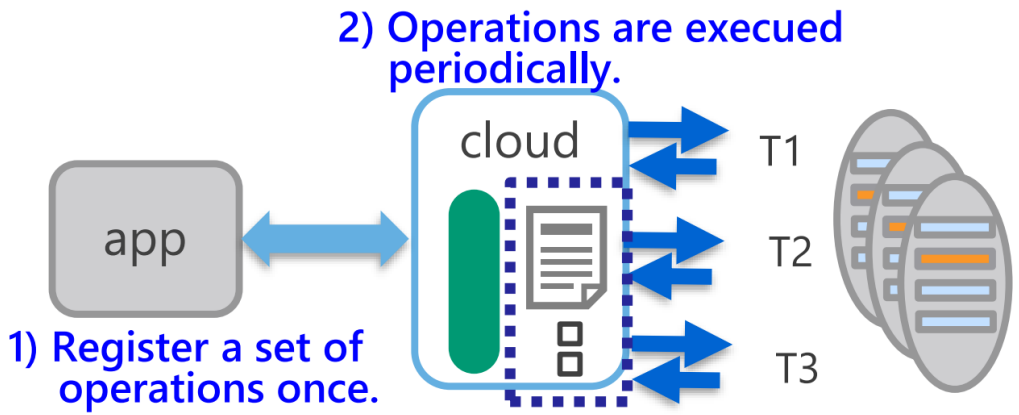


ECHONET Lite Web API Device Descriptions

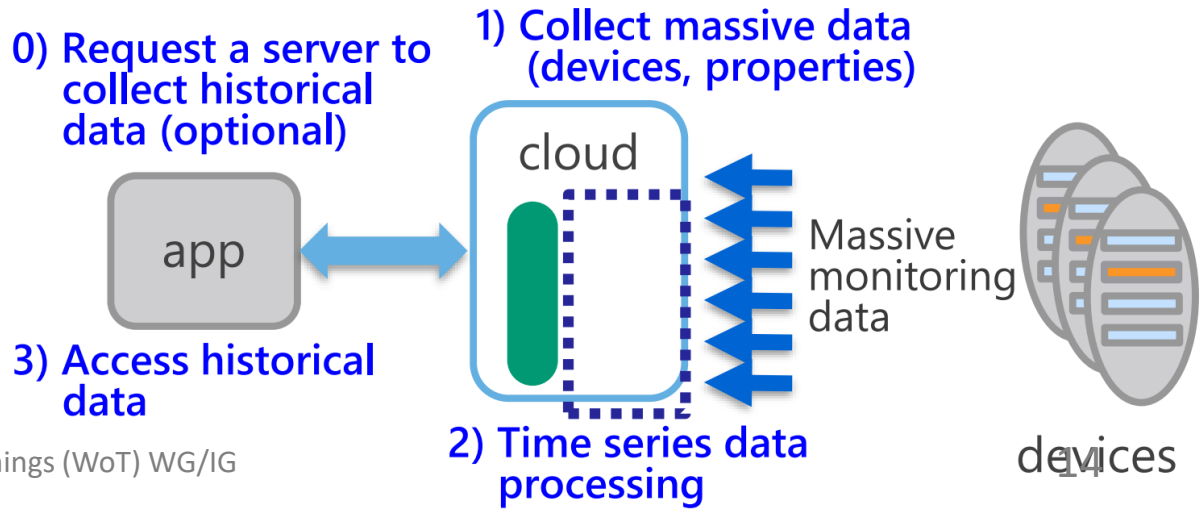
Sharing information on the study of new features

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**



Enhancement of “Bulks”



IEC SC3D

IEC SC3D: Methodology and products ontology

2022-09-14 W3C/WoT

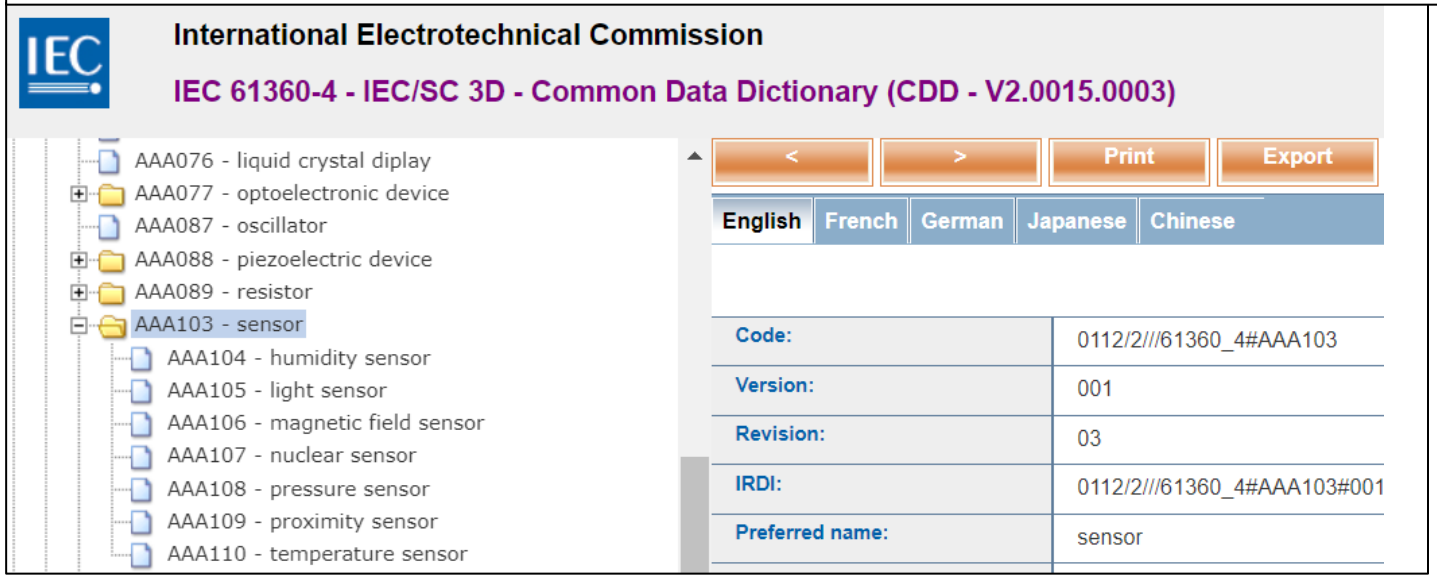
SC 3D Classes, Properties and Identification of products - Common Data Dictionary (CDD)

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.



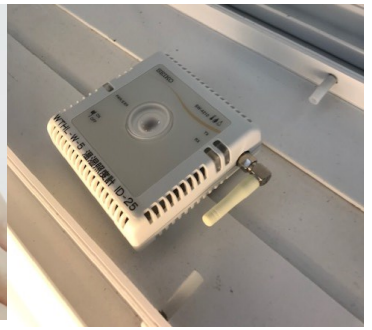
1. Machine-interoperable methodology
2. Available for all ISO, IEC products and systems
3. Standardized product ontology DB
   - https://cdd.iec.ch/

Dr. Lan YAMASHITA/ IEC SC3D Chair

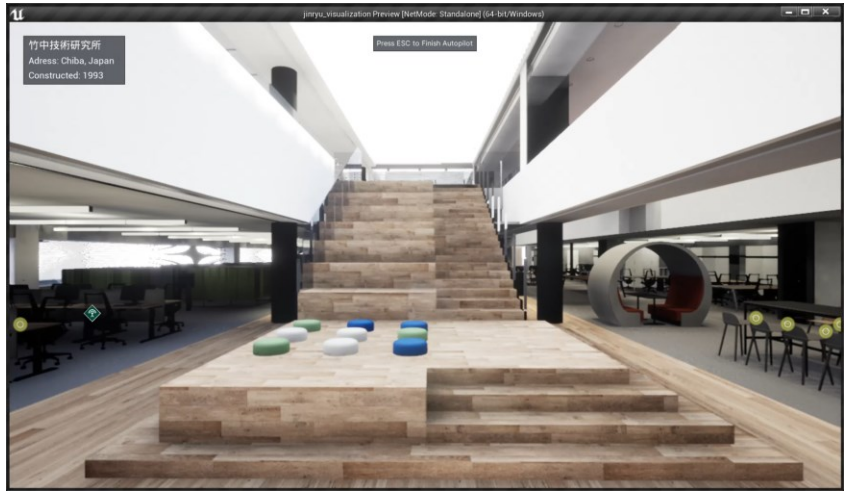
IPA DADC

Use case : Smart Building（1）

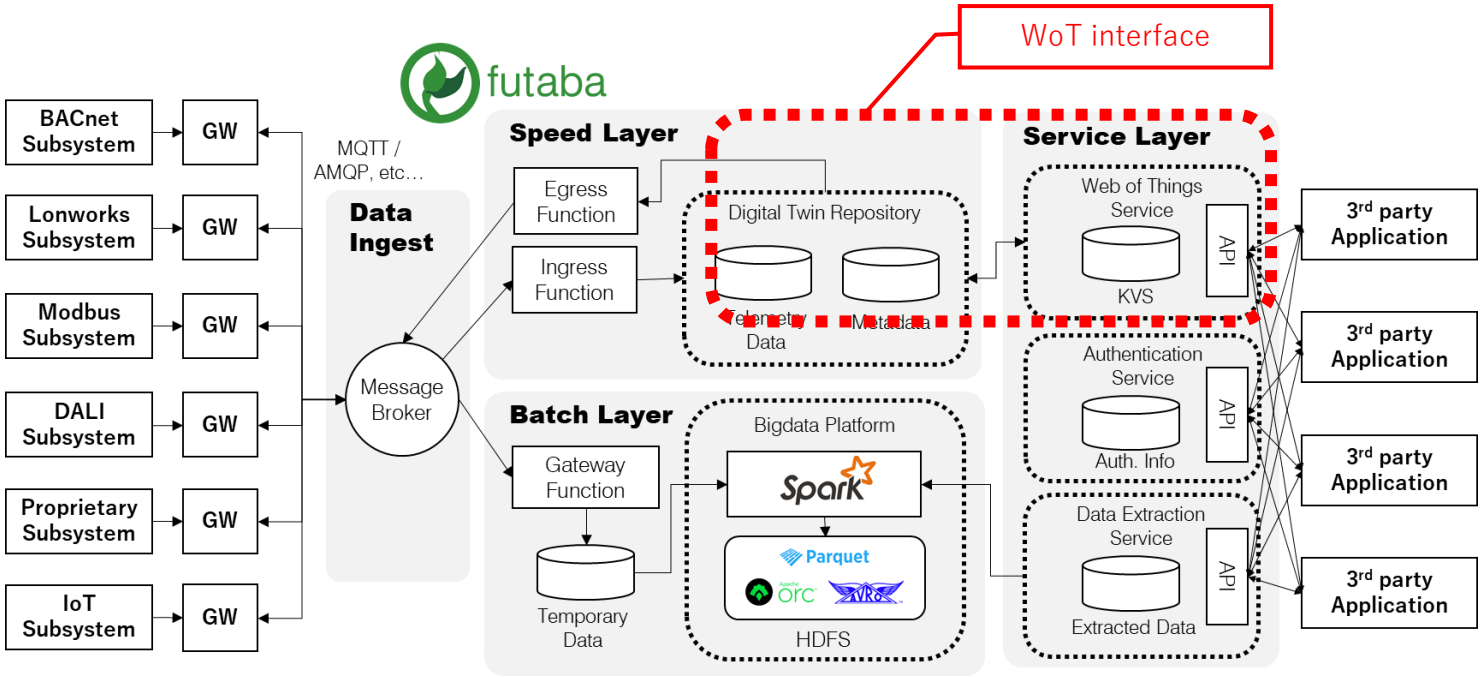
1. Takenaka Corporation has developed a data platform for smart buildings using WoT.
2. Based on the lambda architecture which is a best practice for real-time data processing.
3. WoT is used to implement data models and APIs.
4. It is the foundation for many services such as energy management, AI control,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



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

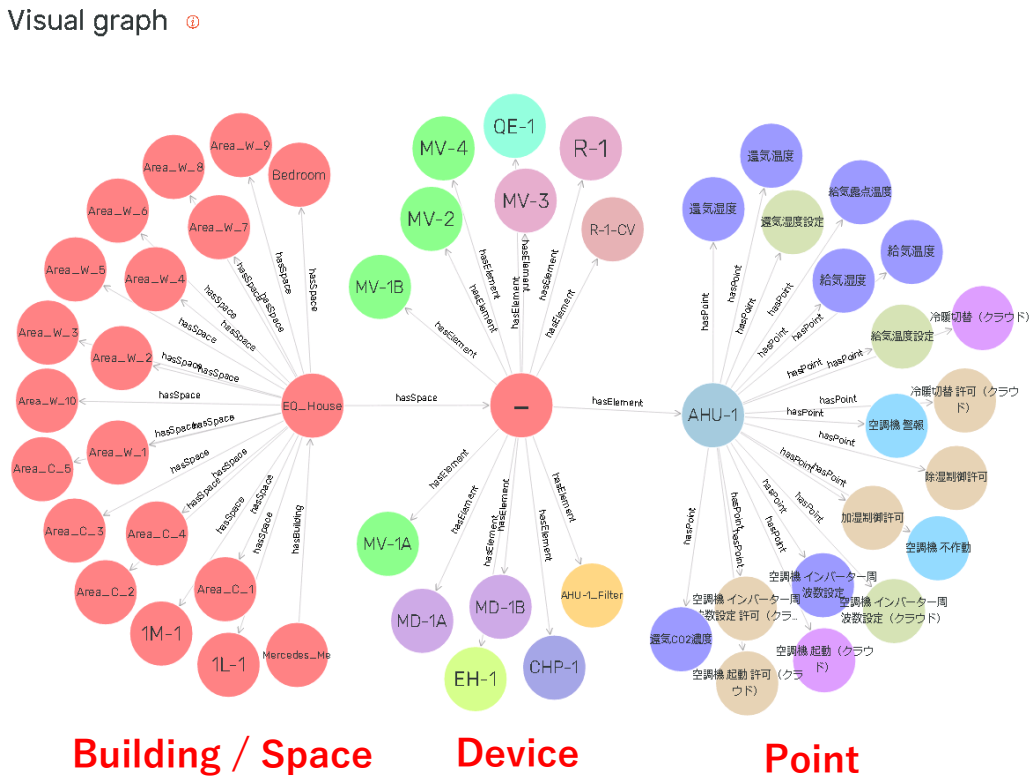


Digital Twin Application



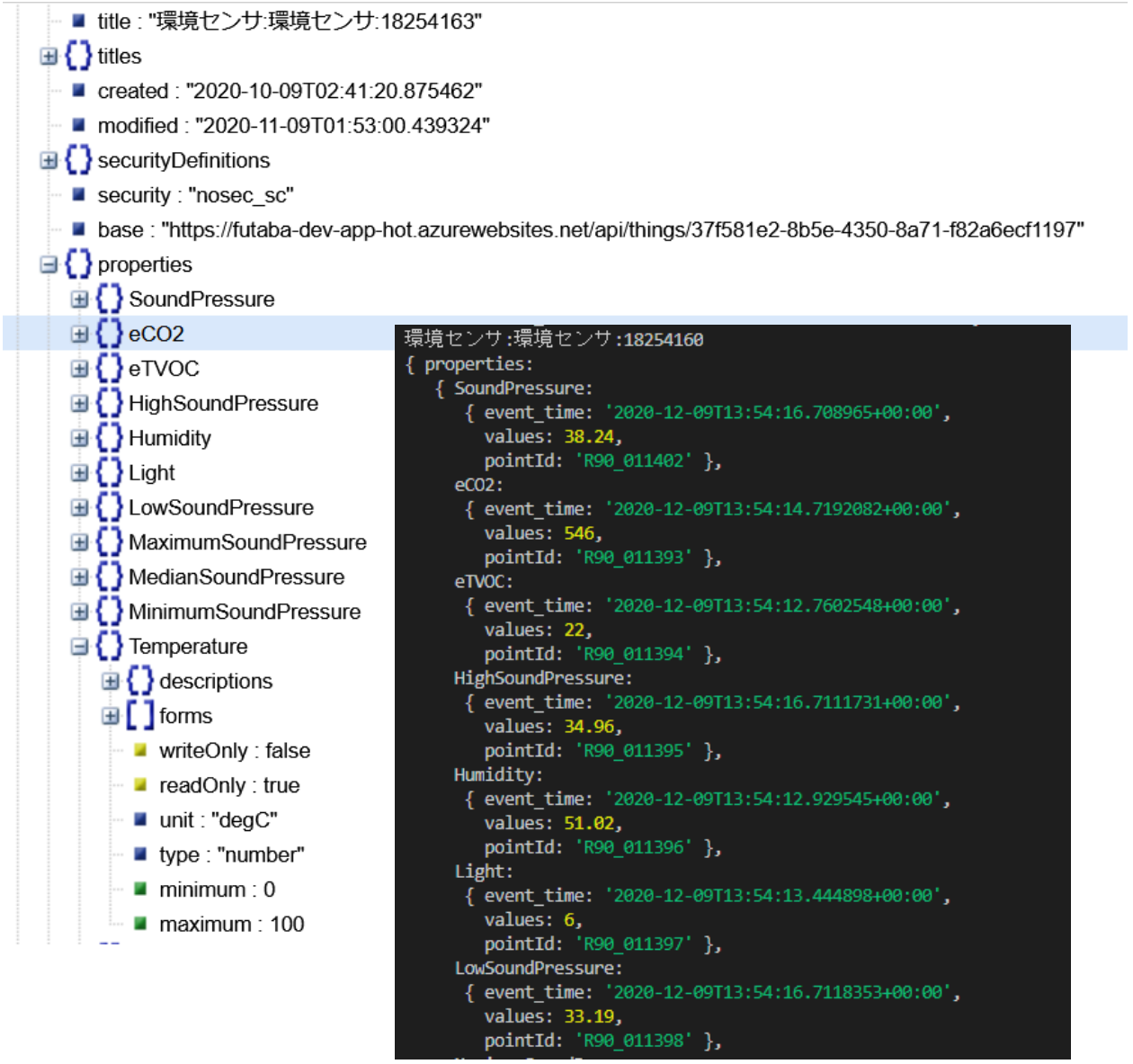
Use case : Smart Building（2）

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.



Building / Space　Device　Point

Space Graph / Data Model



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 AWI 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

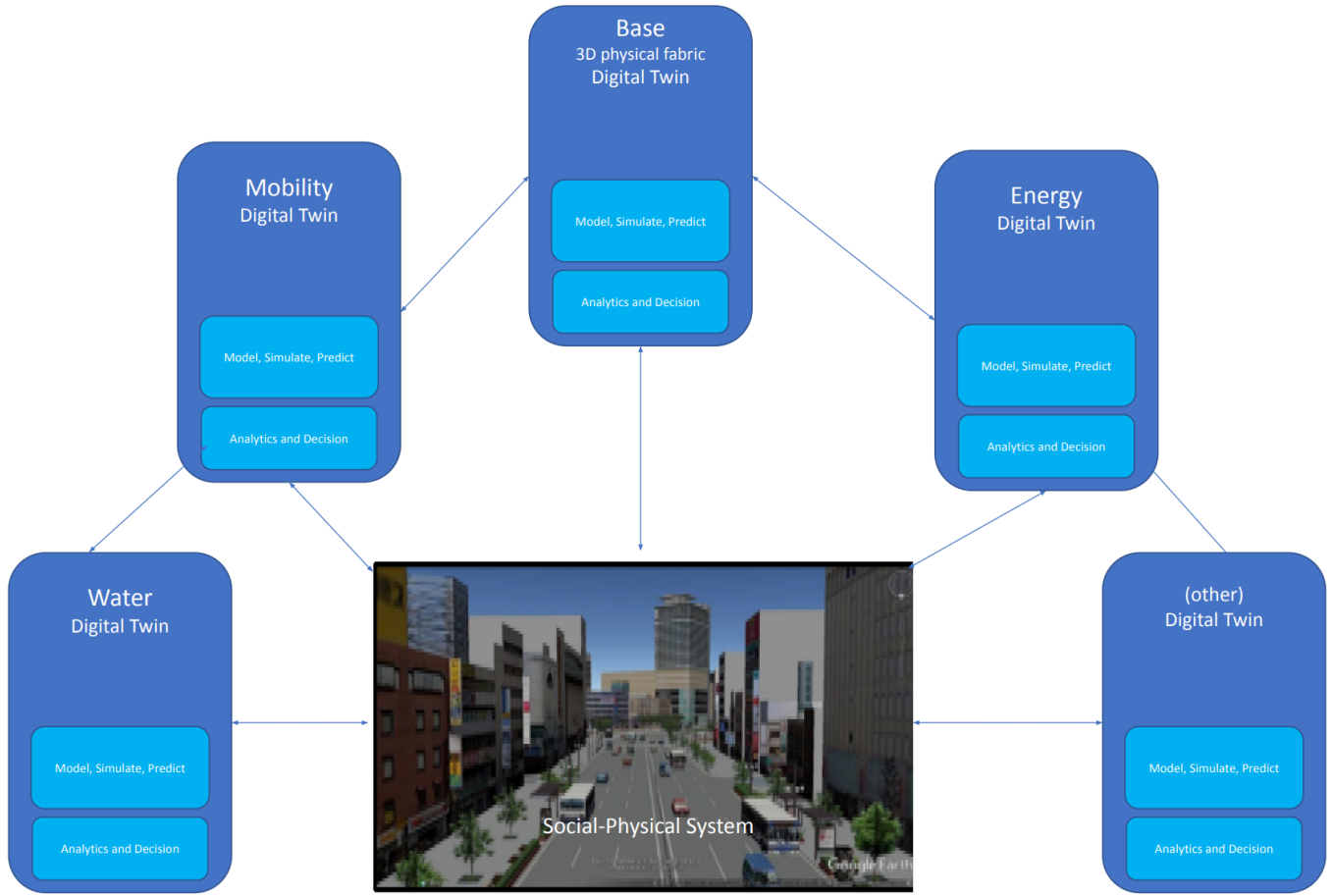
- AI and data context
  - Artificial Intelligence of Things: CG-AIoT activities
  - FG-AI4A (Digital Agriculture)
  - AI and Data Commons, Project Resilience
  - UN - data and digital transformation strategies

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

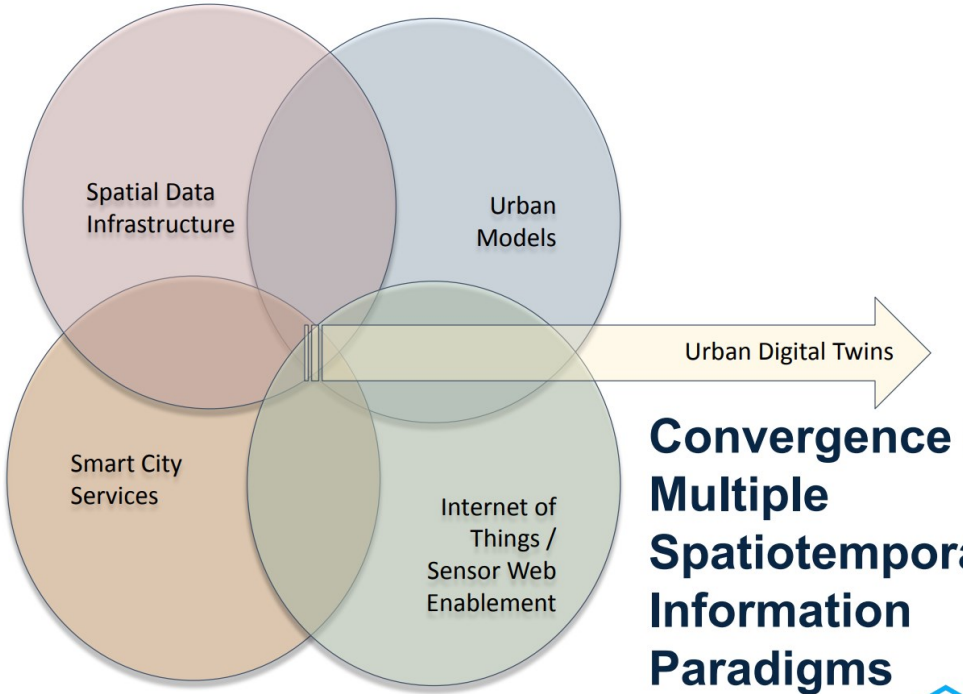
Open Geospatial Consortium

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

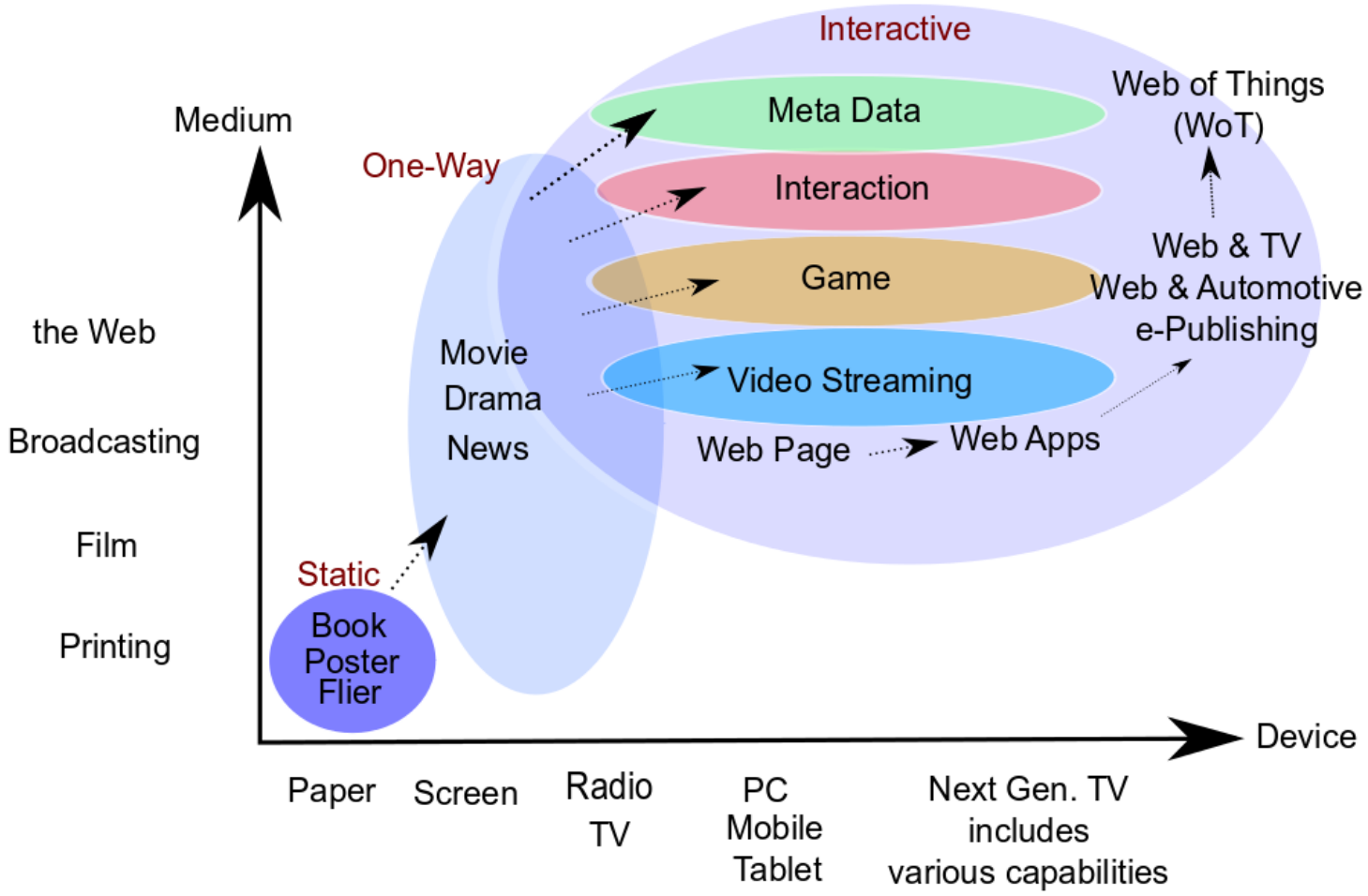


Convergence of Multiple Spatiotemporal Information Paradigms

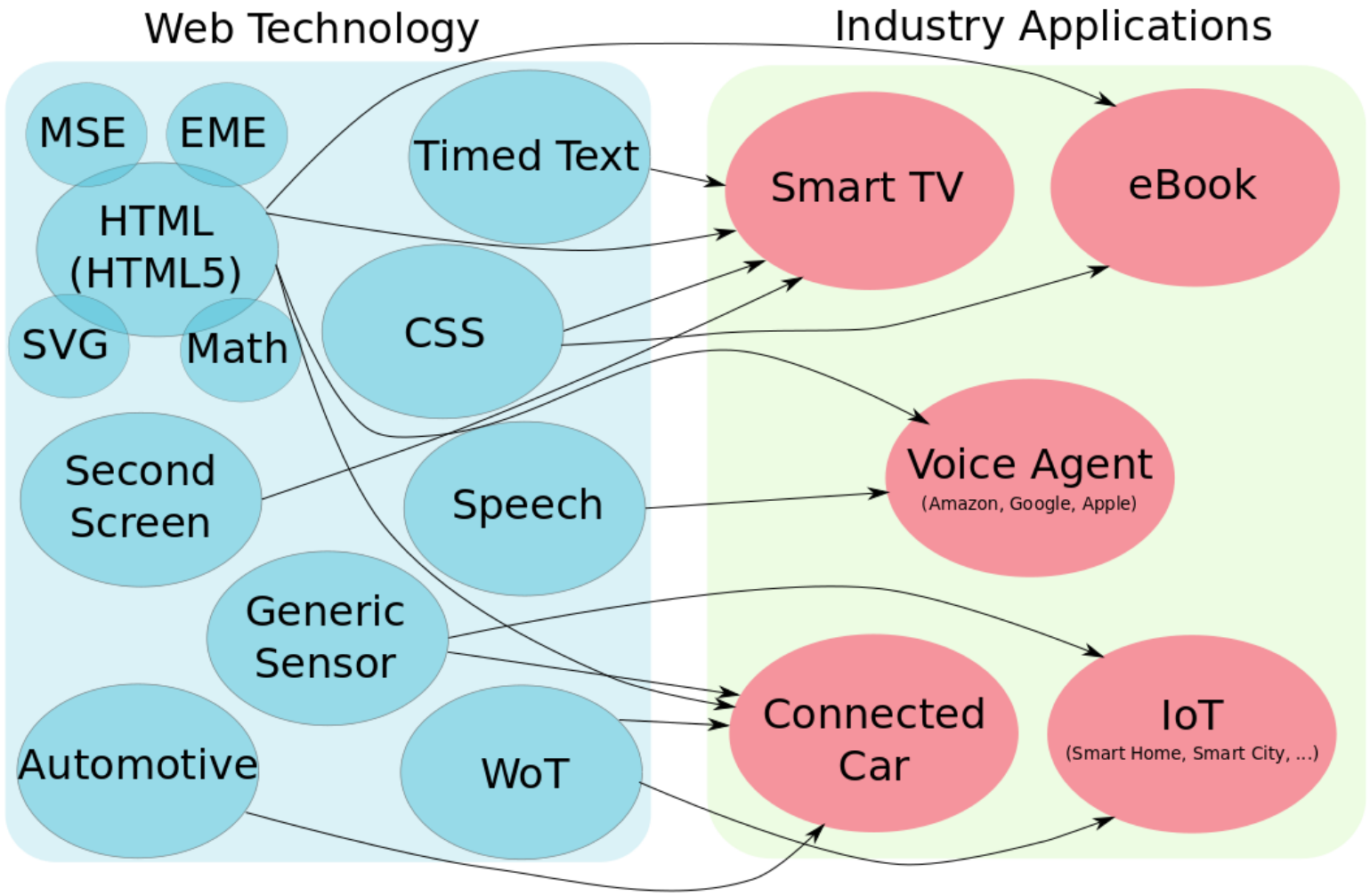
Open Geospatial Consortium

W3C

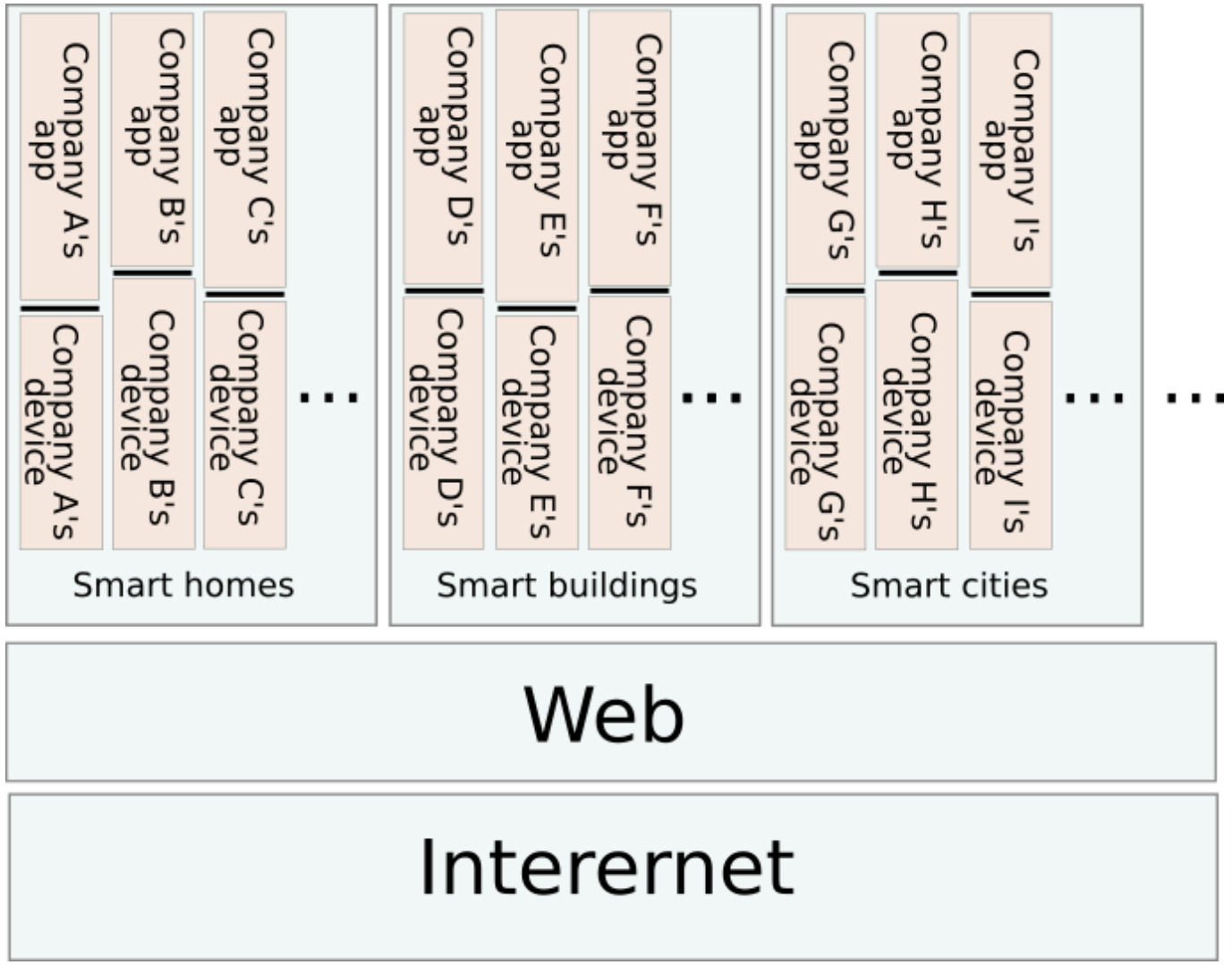
Web as platform for data transfer
- Independent from devices or OSs



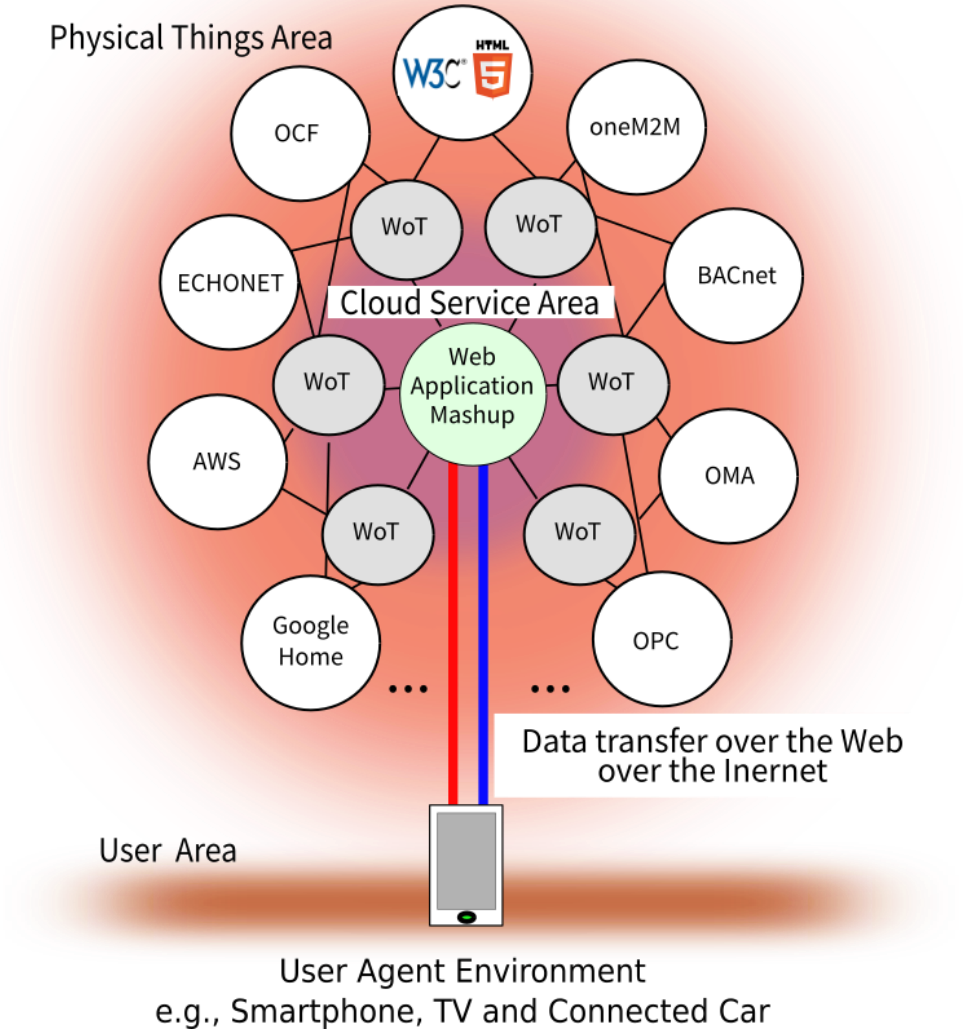
Web standards applied to various industries



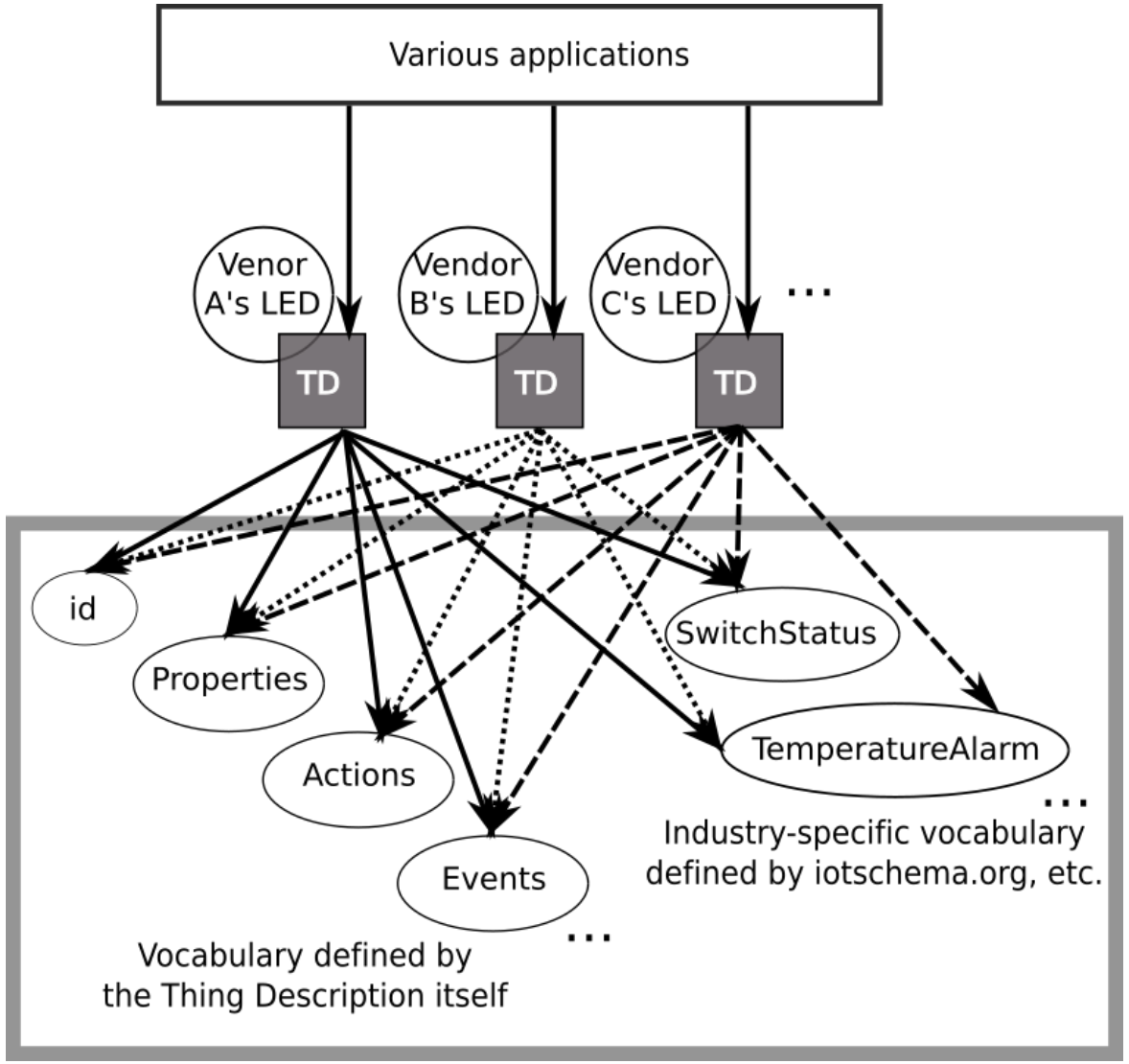
Problems of IoT silos



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/VF
  - Geolocation

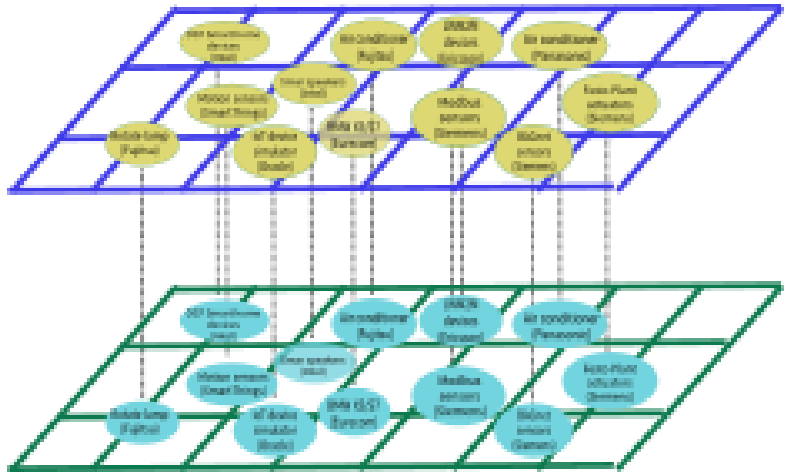
What is still missing
for expected Web-based Smart Cities?

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

How to continue the discussion to resolve the gaps?

“Digital Twins” as the Key Concept



During the discussions at:

- WoT standardization
- Smart Cities workshop
- Follow-up discussions at TPAC meetings

Proposal:

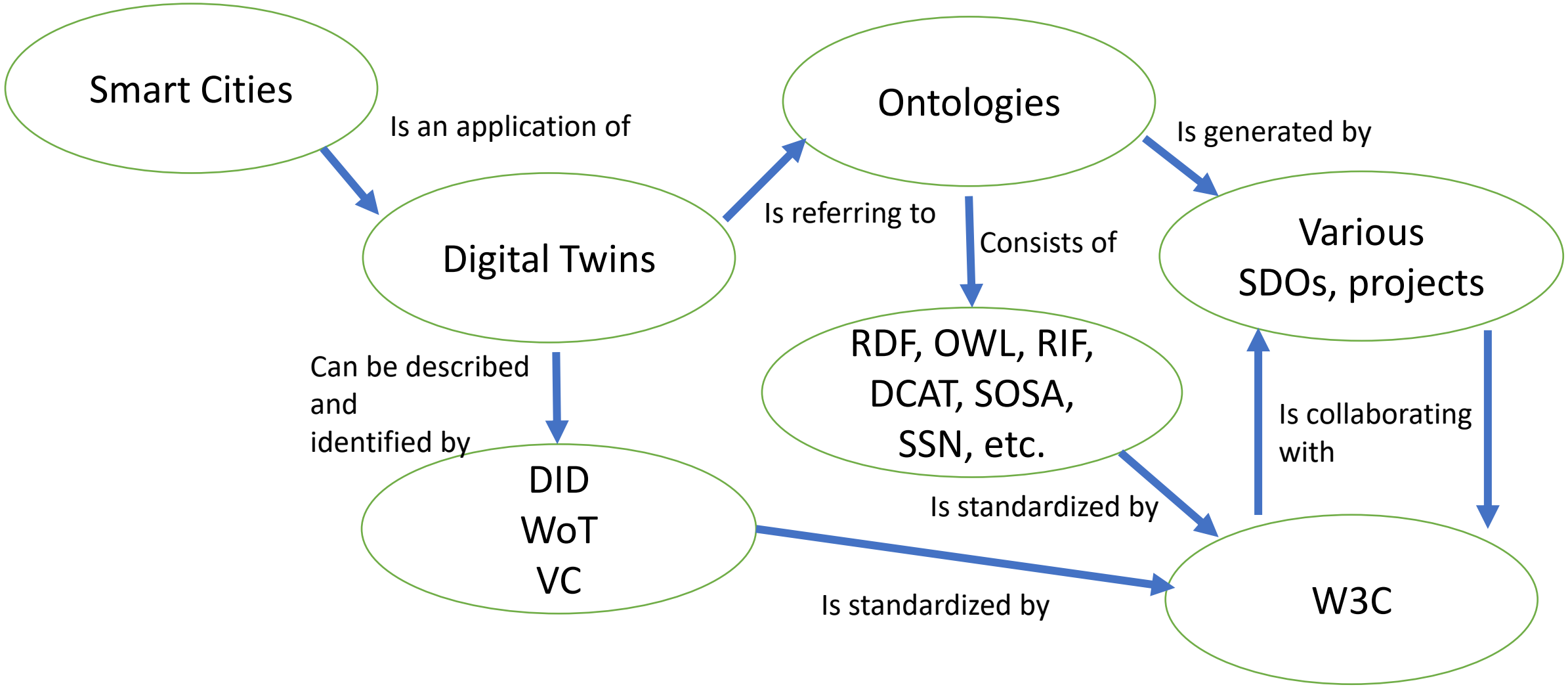
Let’s start with “Web-based Digital Twin”
as the initial target!

Also, Need for Standardized Vocabulary

- Definition and References
- Ontology standards are provided by W3C:
  - RDF and RDF Schemas
  - Web Ontology Language (OWL)
  - Rule Interchange Format (RIF)
  - Data Catalog Vocabulary (DCAT)
- Proposal:
  - Let’s have collative discussions at W3C as a hub to clarify what ’s done and what’s missing!

Smart Cities, Digital Twins, Ontologies and W3C

— in an Ontology style ☺



Note: Metaverse is an example of “Digital Twins”

- hypothetical iteration of the Internet
  - as a single, universal, and immersive virtual worl
  - that is facilitated by the use of
    - virtual reality (VR) and augmented reality (AR) headsets

(Wikipedia)

New Discussion Group at W3C

W3C Web-based Digital Twins for Smart Cities IG

To Establish a W3C Interest Group

- Discussion at W3C TPAC2023 Meeting in Sevilla (13 September 2023)
- Attendees including:
  - SDOs: ECHONET, IEC SC3D, IEC SyC Smart Energy, IPA DADC
  - W3C Members: Intel, Hitachi, NHK, KADOKAWA, Kodansha, Media Do, Siemens, Yahoo! Japan, Fundacion CTIC, Conexxus, GS1, Digitaal Vlaanderen, INRIA, Gooloomee, Fraunhofer, Internet Research Intstitute
- Draft Charter (Planning Document):
  - https://w3c.github.io/smartcities-workshop/draft-charter/index.html

Mission of the Group

- to identify and document use cases and requirements that W3C specifications need to meet to support various services within Smart Cities,
- to obtain feedback from all stakeholders on the usage of Web technologies for those services,
- to gather expert input on important features for those services based on the Web technology, and
- to provide a forum for technical and business discussions related to those services.

⇒ Key points:

- Involve actual stakeholders from not only SDOs but countries and local governments
- Multi-vendor mash-up for various industries, vendors and products
- Data governance to protect privacy and data trust

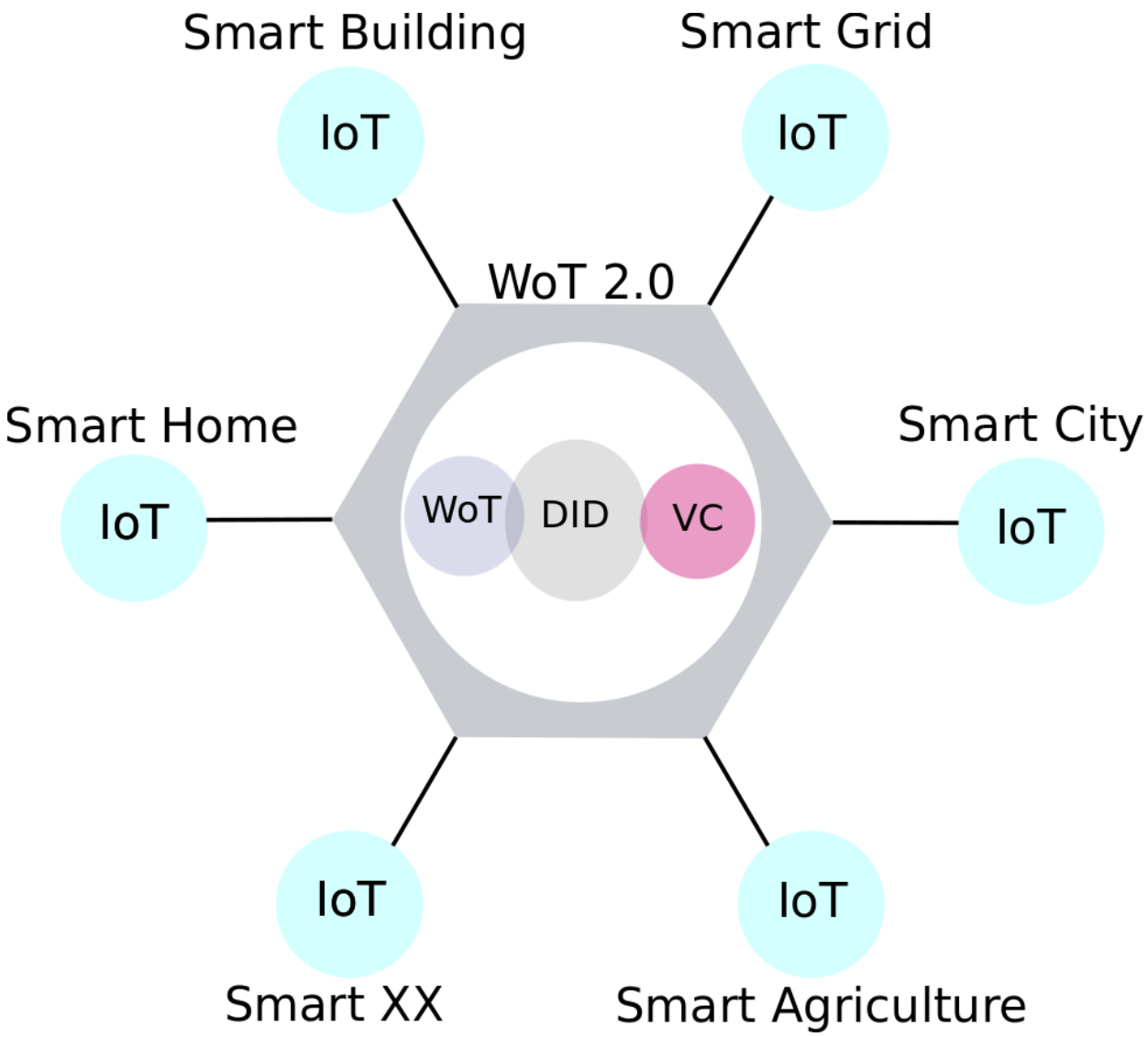
Need to define “Web-based Digital Twins”

- Google’s comment: Define or remove "digital twins" #17
  - Not objecting to create the IG itself
- W3C Web of Things WG’s definition as the basis:

> A digital twin is type of Virtual Thing that resides on a cloud or edge node. Digital Twins may be used to represent and provide a network interface for real-world devices which may not be continuously online (see also Shadows), may be able to run simulations of new applications and services before they get deployed to the real devices, may be able to maintain a history of past state or behaviour, and may be able to predict future state or behaviour. Digital Twins typically have more functionality than simple Shadows.

(https://www.w3.org/TR/wot-architecture11/)

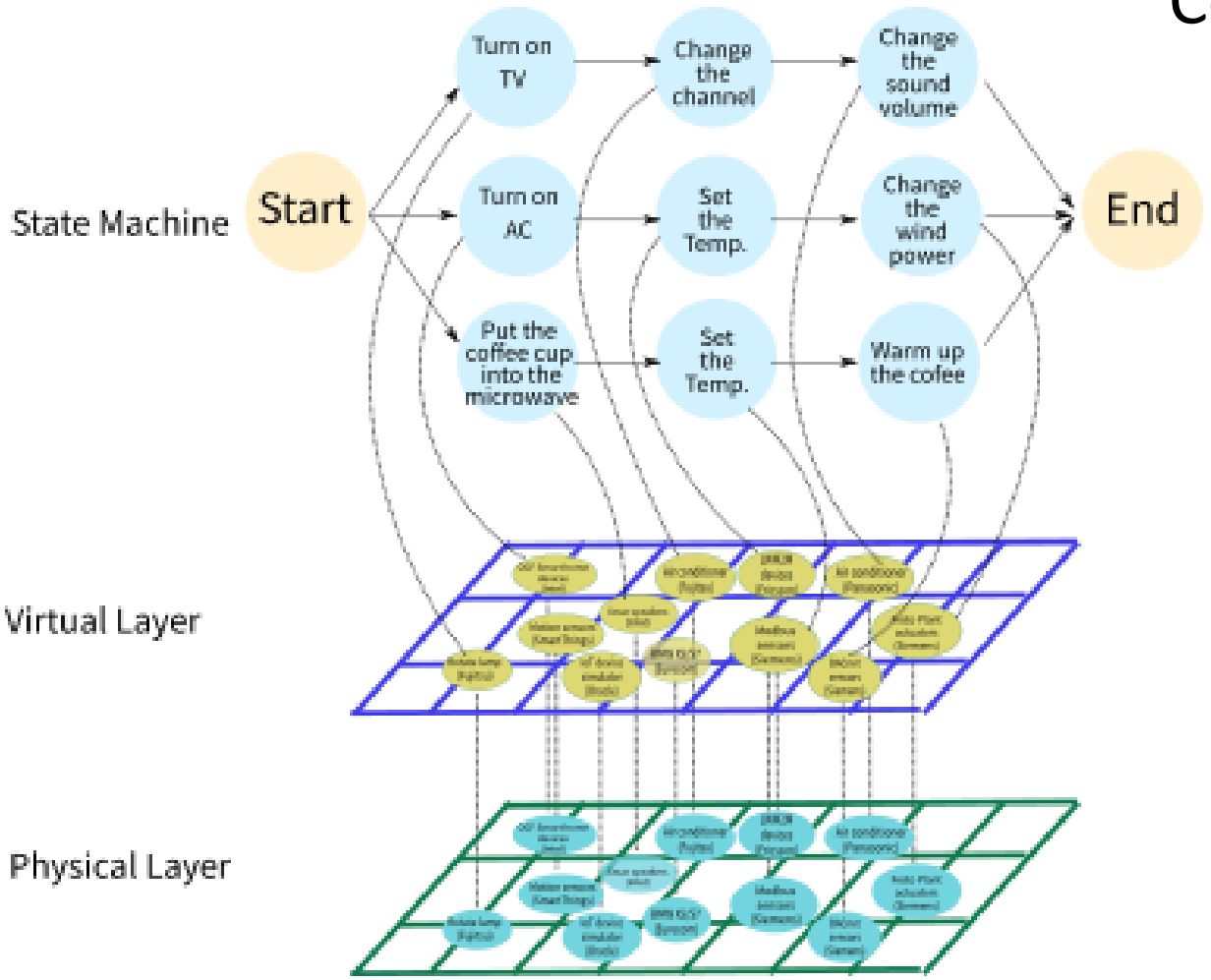
A Possible Framework for Web-based Digital Twins



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

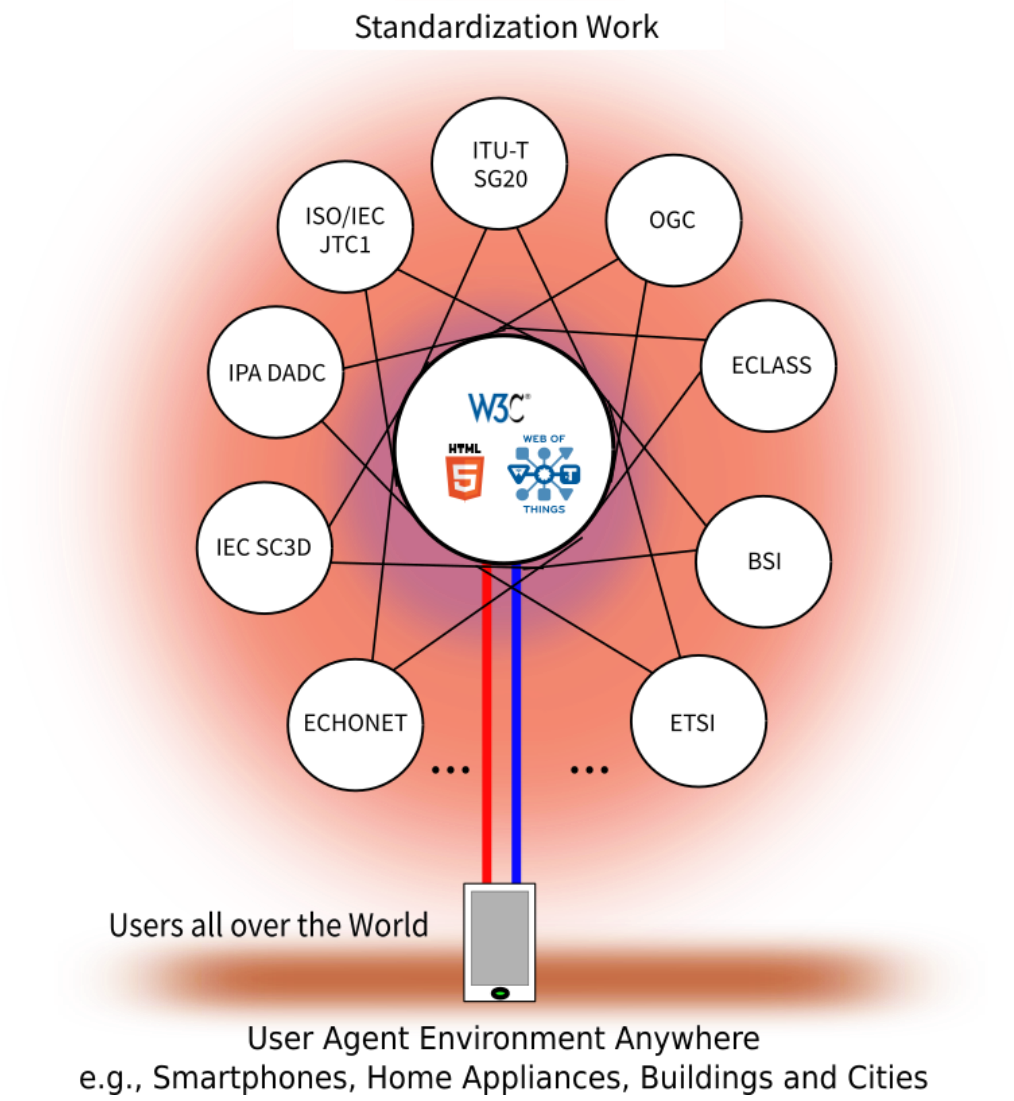
Web-based Digital Twins w/ State Machine



Control virtual devices using State Machine

- Synchronize multiple devices and services based on the user's need dynamically
- Integration of various devices and modalities
- E.g., speech interface and gesture interface within cars

Collaborative Discussions by related SDOs at W3C!



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

Thank you!

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