



# W3C's Standardization on WoT and 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

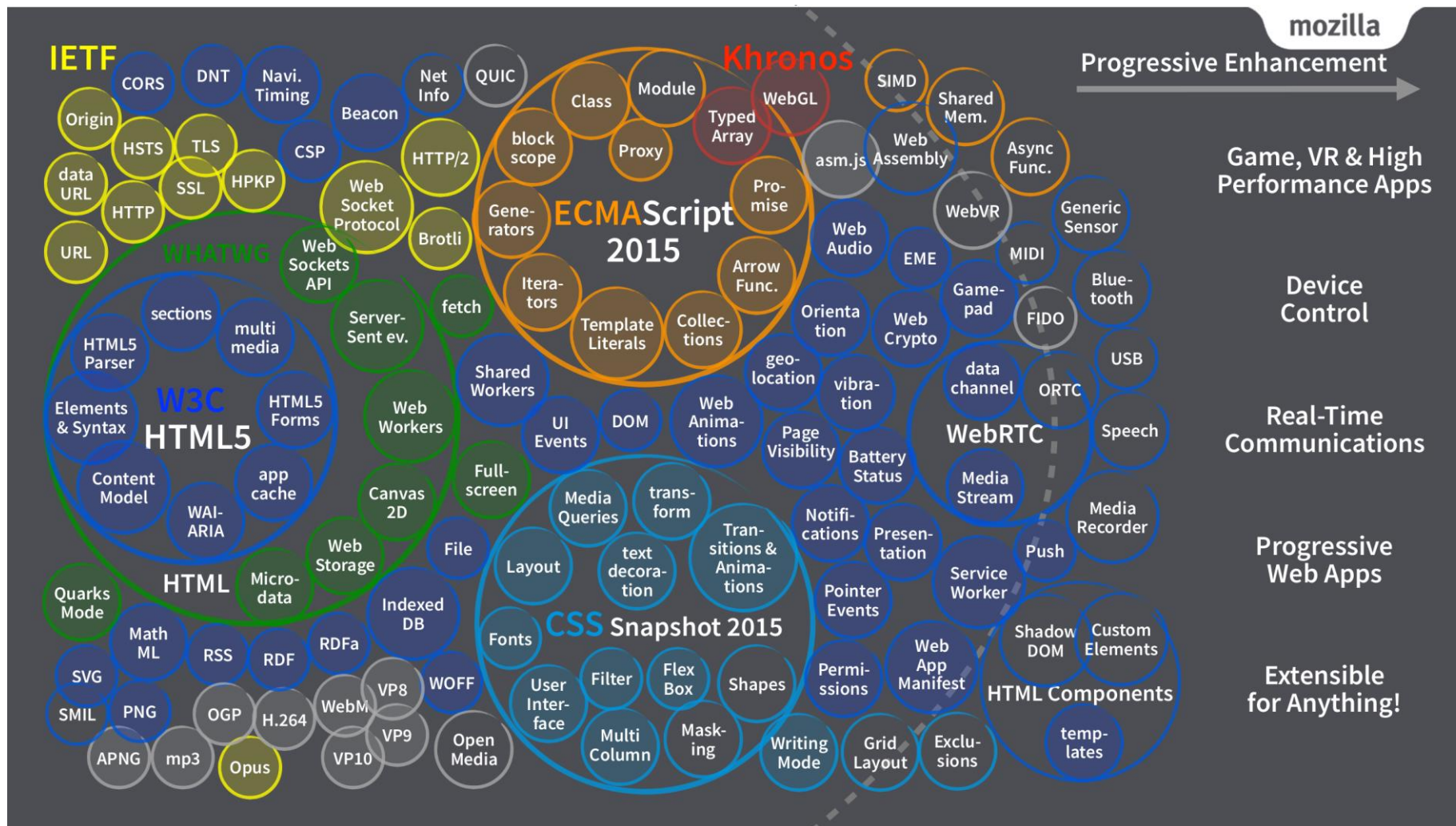
- Web technologies for various industries
- Web standardization by W3C
- WoT (Web of Things)
- Smart Cities

# Web technologies for various industries

# Web technology available everywhere



# Open Web Platform: HTML5 and related specs



(by Tomoya Asai from WebDINO; former Mozilla Japan (<http://webapi.link>))

# Familiar examples of HTML5 features

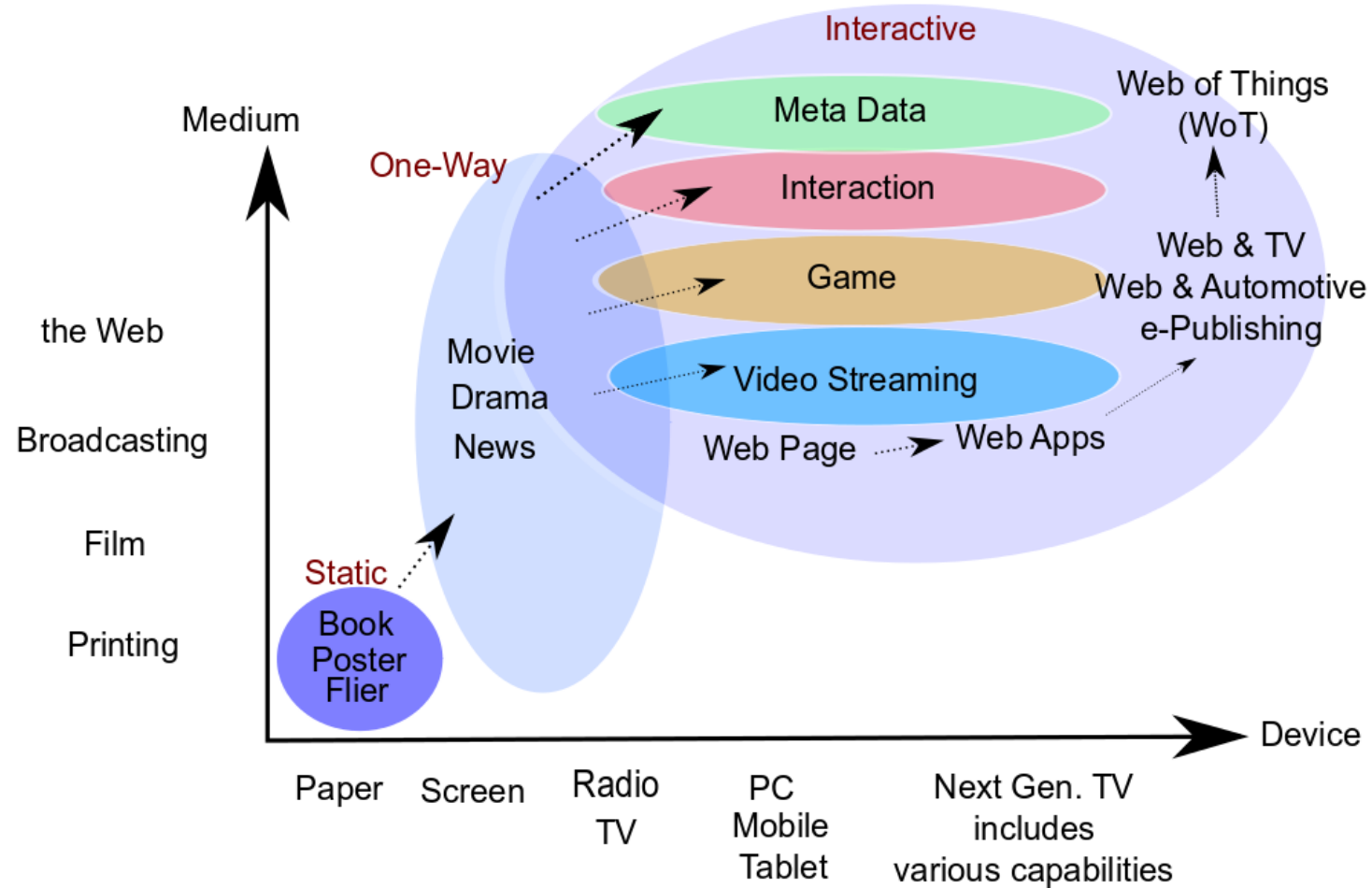
- **Video/Audio capability without plug-ins**
- **Duplex network connection using WebSocket**
- **2D/3D graphics using Canvas**
- **Local data storage**
- **Multi-processing using Worker**

## ◆ **Your friendly WebApps:**

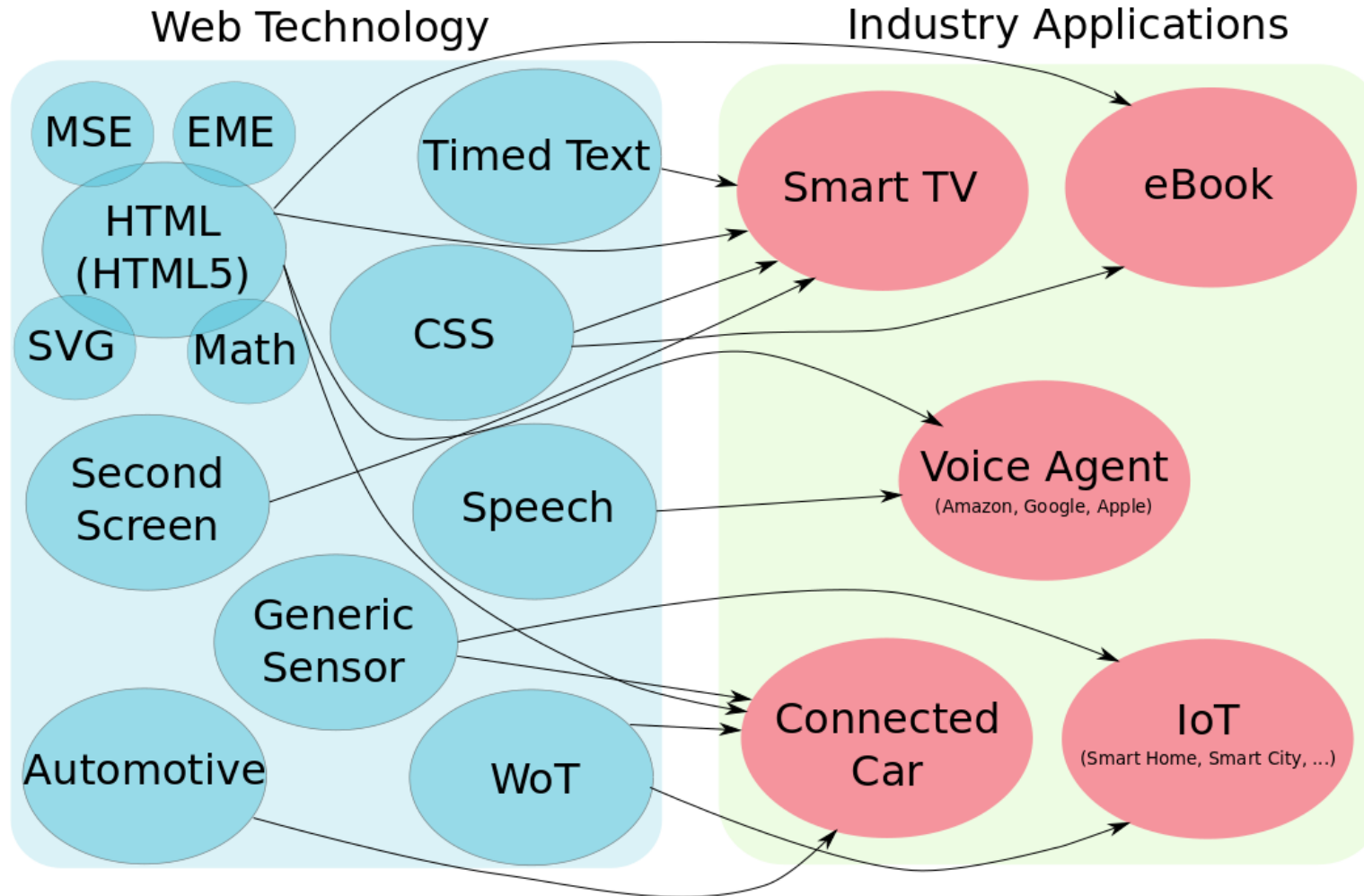
- **Google**
  - **Amazon**
  - **Facebook**
  - **Netflix**
- Etc.**

# Web as platform for data transfer

- Independent from devices or OSs



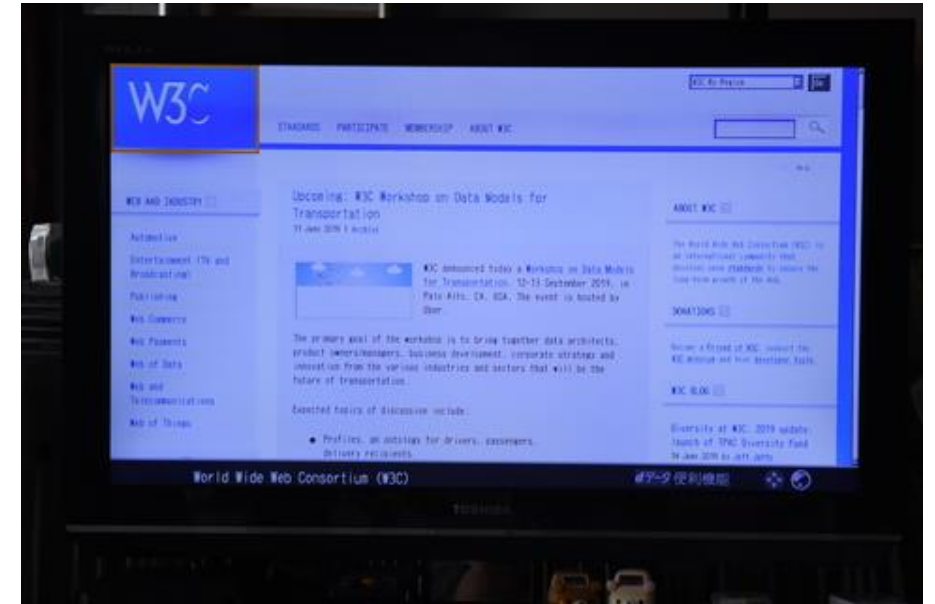
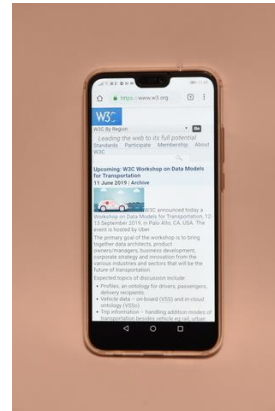
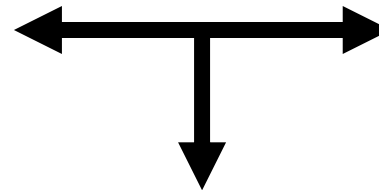
# Web standards applied to various industries





Broadcasting content from the tuner

Web content from the browser



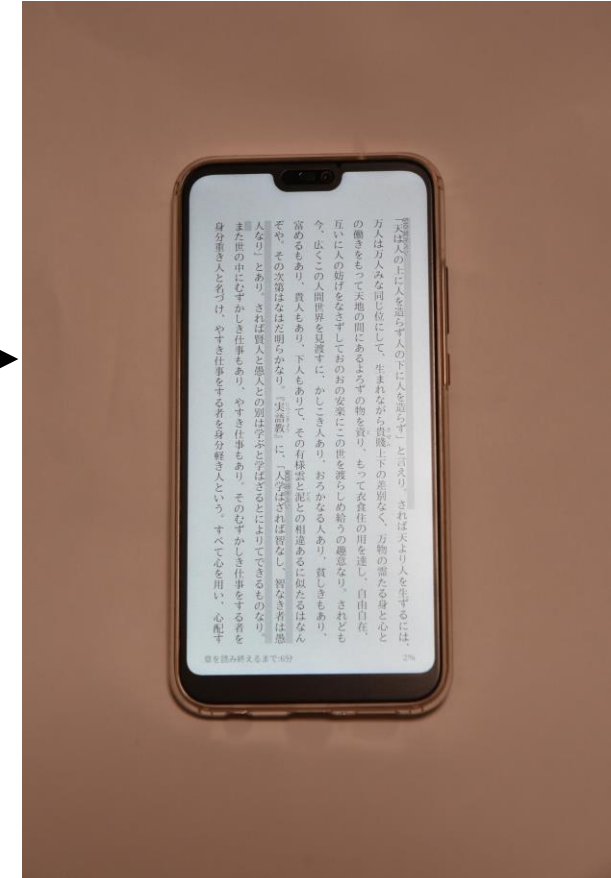
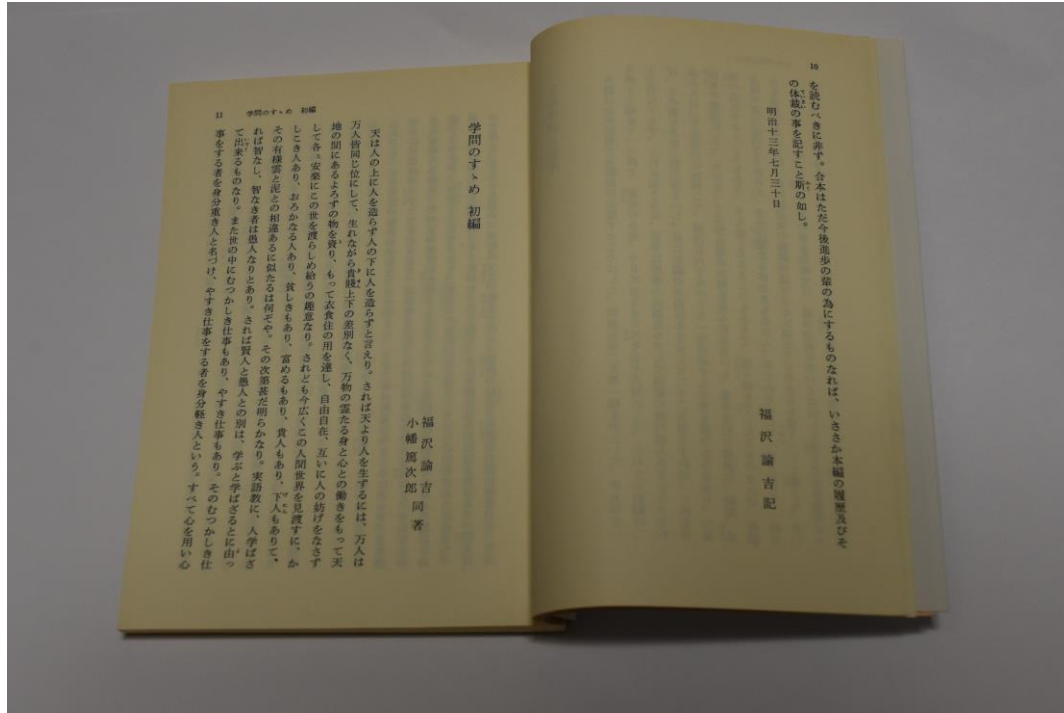
Smart collaboration using another browser on the smartphone

# Publishing

## — From paper books to E-Books

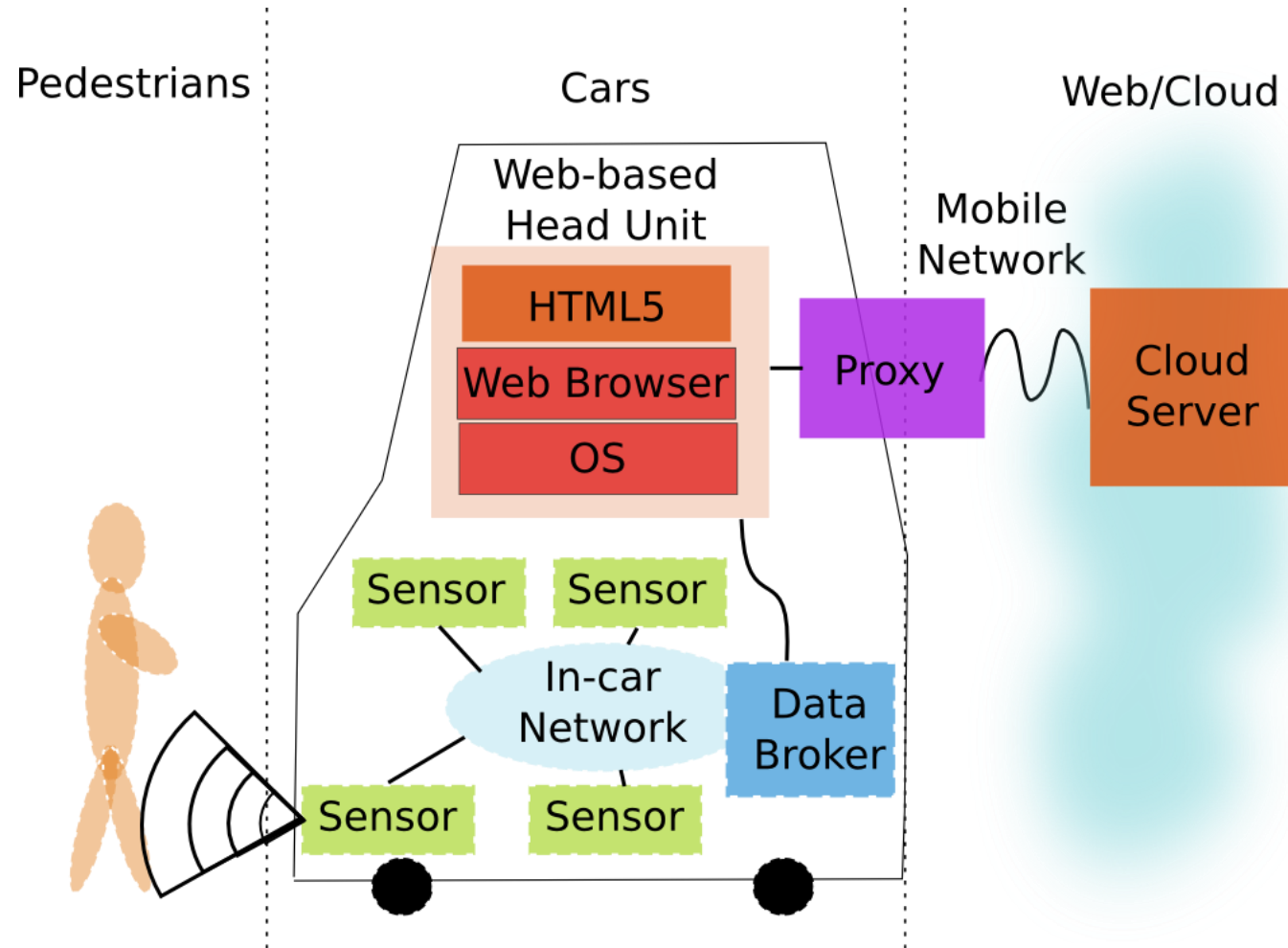
Paper books

E-Books (Web browser)



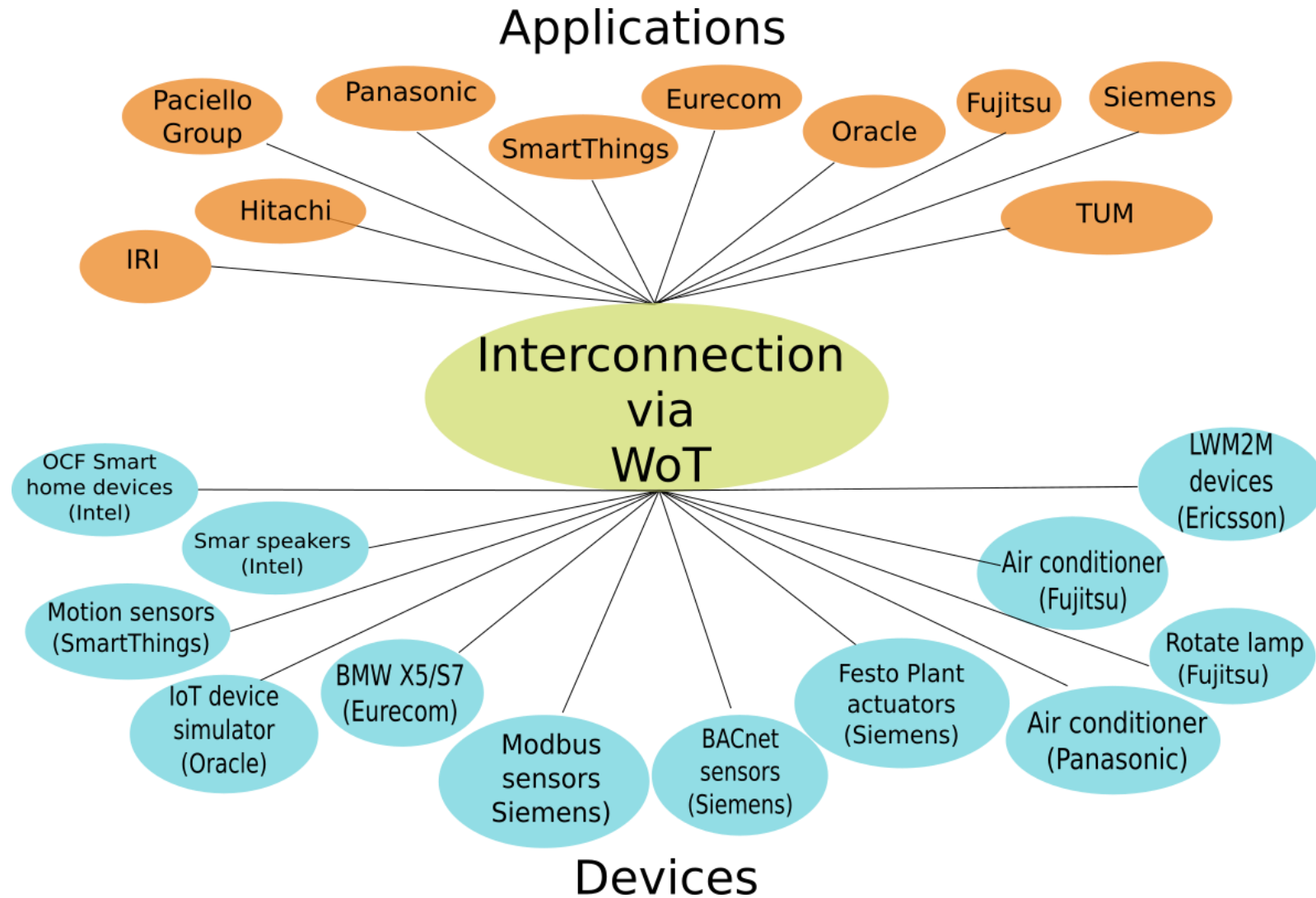
# Automotive

—Connected cars using the Web technology



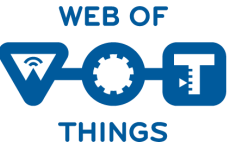
# And now for IoT

—WoT: IoT interconnection using the Web technology



# Web standardization by W3C

# W3C: The World Wide Web Consortium



Lead the Web to its full potential!

- Established in 1994 by the W3C Director, Tim Berners-Lee
- International consortium for Web's interoperability
- Generating W3C Recommendations, e.g., HTML5

**⇒ W3C is the one and only SDO tackling Web standards established by the Web inventor, Tim Berners-Lee!**

# 4 hosting organizations



US : MIT



Europe : ERCIM



Japan : **Keio university** (W3C/Keio Team established in 1996)



China : Beihang university

# Web standardization: One Web / Web for All



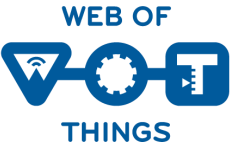
Standardization is very important for the Web because it interconnects everything!

- Interoperability
- Multilinguality
- Multi-Modality
- Accessibility

⇒ available at anytime, anywhere, for anyone



# W3C Members



- Global participation :
  - 459 organizations/companies (browser, Web service, CE, communications, publishing, etc.)
  - US/Canada : GAFA, Microsoft, IBM, Adobe, Airbnb, Akamai, Amex, Apache, AT&T, Cisco, Comcast, Federal Reserve Bank of Minneapolis, Intel, Mastercard, Mozilla, Netflix, OASIS, Oracle, Shopify, Thomson Reuters, Verizon, Visa, Walt Disney, Wikimedia, ...
  - Europe : BBC, CERN, Ericsson, Fraunhofer, GS1, JLR, SAP, Siemens, Viacom, Volkswagen, Volvo, ...
  - China : 360, Agora.io, Alibaba, Baidu, Beihang Univ., Beijing Haitai Fangyuan Technologies, Beijing Univ. of Posts and Telecom., Bilibili, China Mobile, CAS, Huawei, Tencent, Xiaomi, ...
  - Korea : ETRI, Gooroome, INCA, Inswave Systms, KETI, LG, Samsung, SCE Kora, SEAK
  - Japan: ACCESS, Alfasado, BPS, DSA, DDS, Dentsu, Design Inc., DCA, EdMuse, EBPAJ, FLUX, Fujitsu, FTL, Gardenia, Hitachi, Infours, Internet Academy, IRI, JPRS, JCB, Kadokawa, KDDI, Keio Univ., Kodansha, LINE, Media Do, Mitsubishi Electric, Mitsue-Links, NEC, Newphoria, NHK, NTT, Panasonic, Rakuten, Shueisha, SIVIRA, Softbank, Sony, JBA, Toshiba, Voyager Japan, Yahoo Japan

# W3C Groups

## — Working Groups and Interest Groups



- **Working Groups (43):**

Accessibility Education and Outreach, Accessibility Guidelines, Accessible Platform Architectures, Accessible Rich Internet Applications, Audio, Audiobooks, Automotive, Browser Testing and Tools, Cascading Style Sheet (CSS), Dataset Exchange, Decentralized Identifier, Devices and Sensors, Distributed Tracing, EPUB 3, GPU for the Web, HTML, Immersive Web, Internationalization, JSON-LD, Math, Media, MiniApps, Pointer Events, Portable Network Graphic (PNG), Second Screen, Service Workers, Spatial Data on the Web, SVG, Timed Text, Verifiable Credentials, Web Application Security, Web Applications, Web Authentication, Web Editing, Web Fonts, Web Machine Learning, Web of Things, Web Payments, Web Performance, Web Platform, Web Real-Time Communications, WebAssembly, WebTransport

- **Interest Groups (9):**

Chinese Web, Internationalization, Media and Entertainment, Patents and Standards, Privacy, WAI, Web & Networks, Web of Things, Web Payment Security

# W3C groups

## — Business Groups and Community Groups



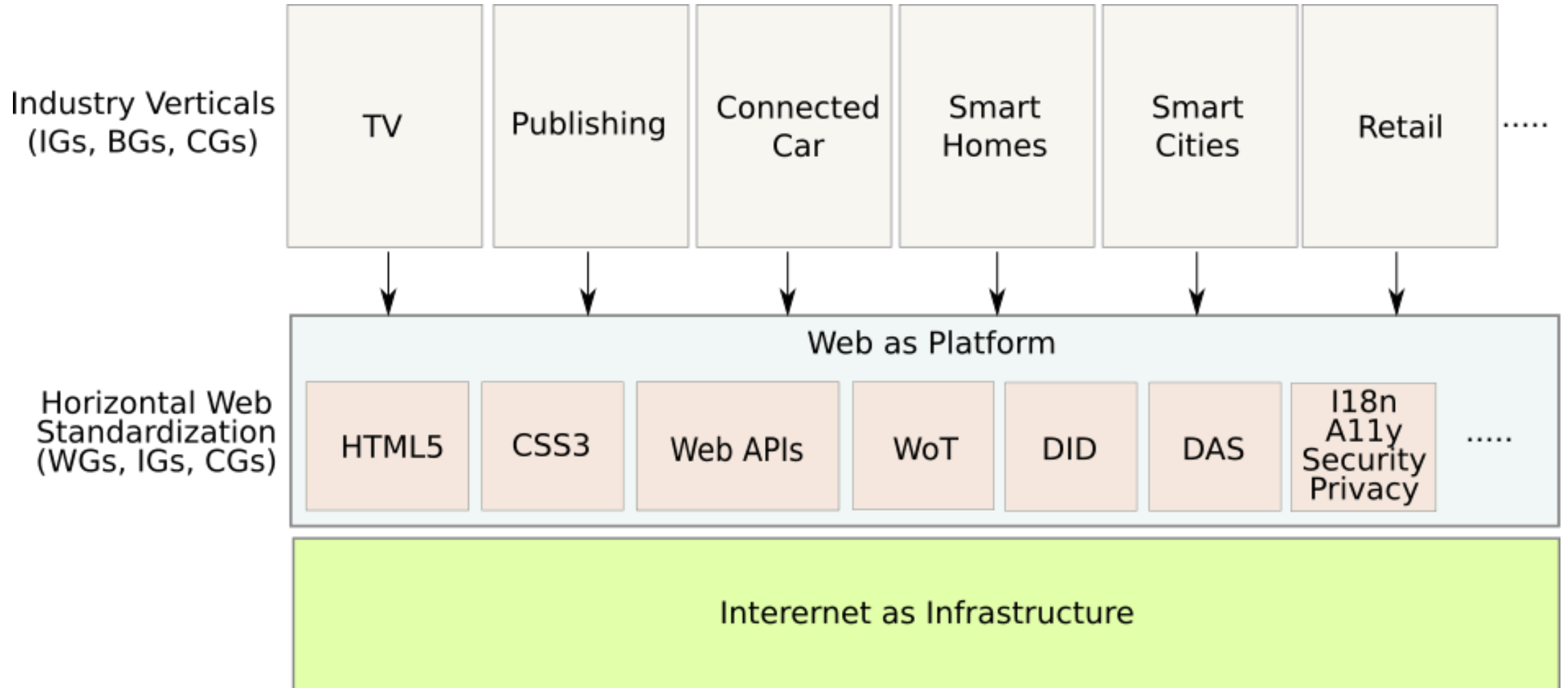
- **Business Groups (3):**

Automotive and Transportation, Improving Web Advertising, Publishing

- **Community Groups (366):**

AI KR, Algorithmic Modelling, Automotive Ontology, Big Data, Blockchain, Bullet Chatting, Cloud Computing, Color on the Web, Credentials, EPUB 3, HTTPS in Local Network, Machine Learning for the Web, MiniApps Ecosystem, Revising W3C Process, Schema.org, Speech API, Web Platform Incubator (WICG), ...

# Layers of the W3C standardization groups



# WoT (Web of Things)

# Various IoT platforms



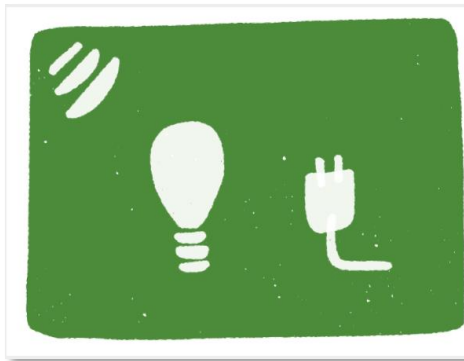
Smart Homes



Wearables



Healthcare



Power & Environment

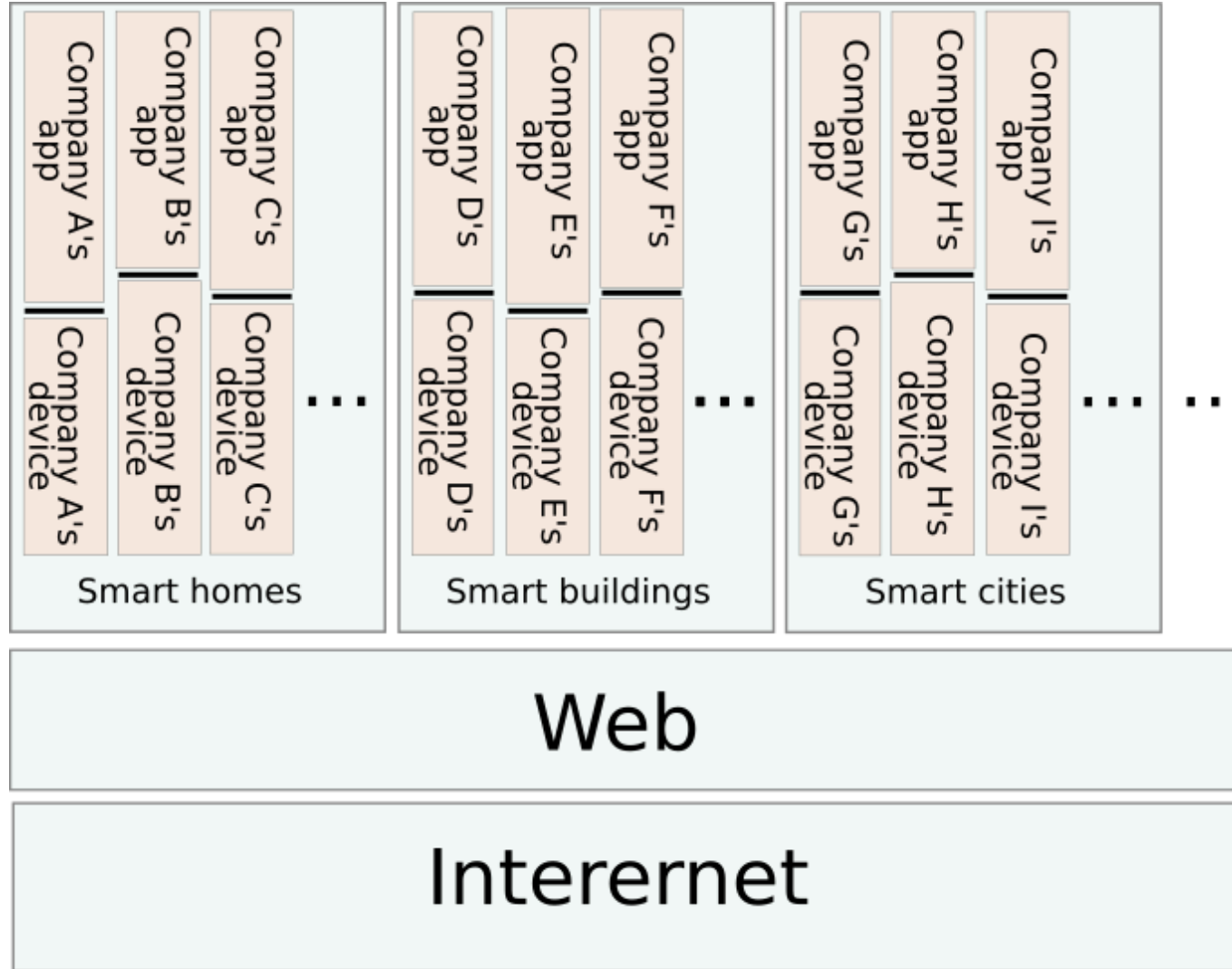


Smart Cities



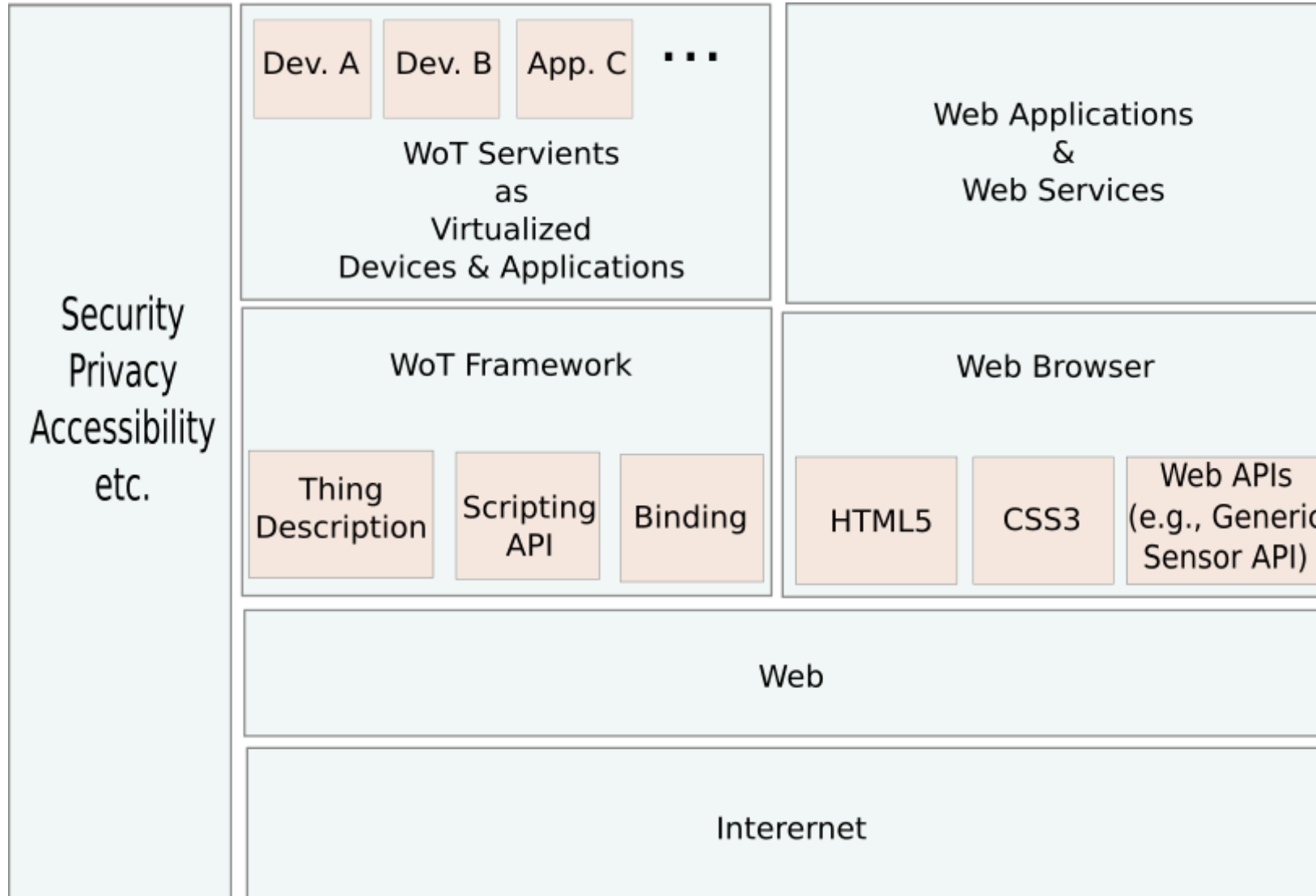
Manufacturing

# Problems of IoT silos



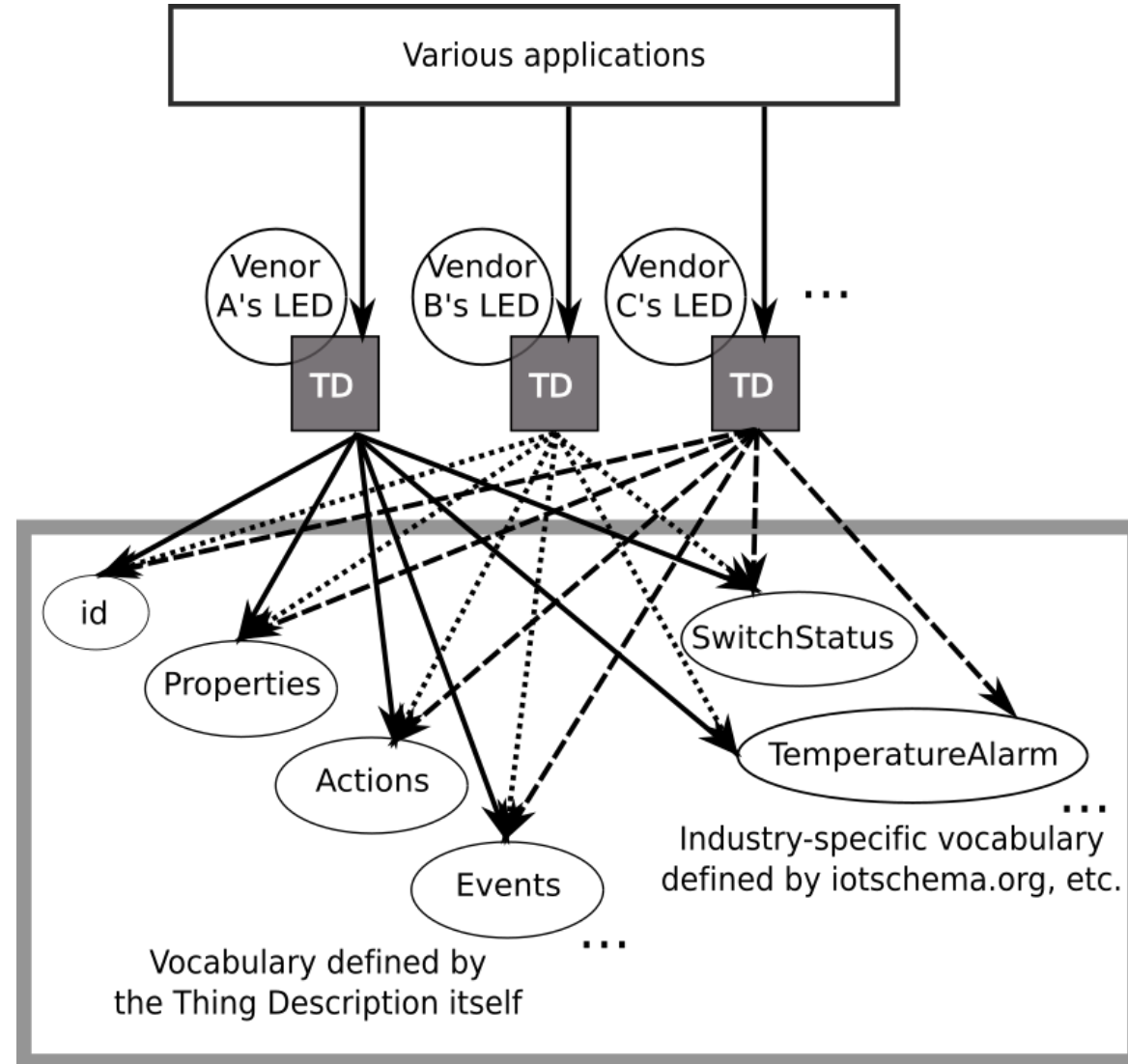
# WoT: IoT interconnection using the Web

- Web as the platform for data transfer

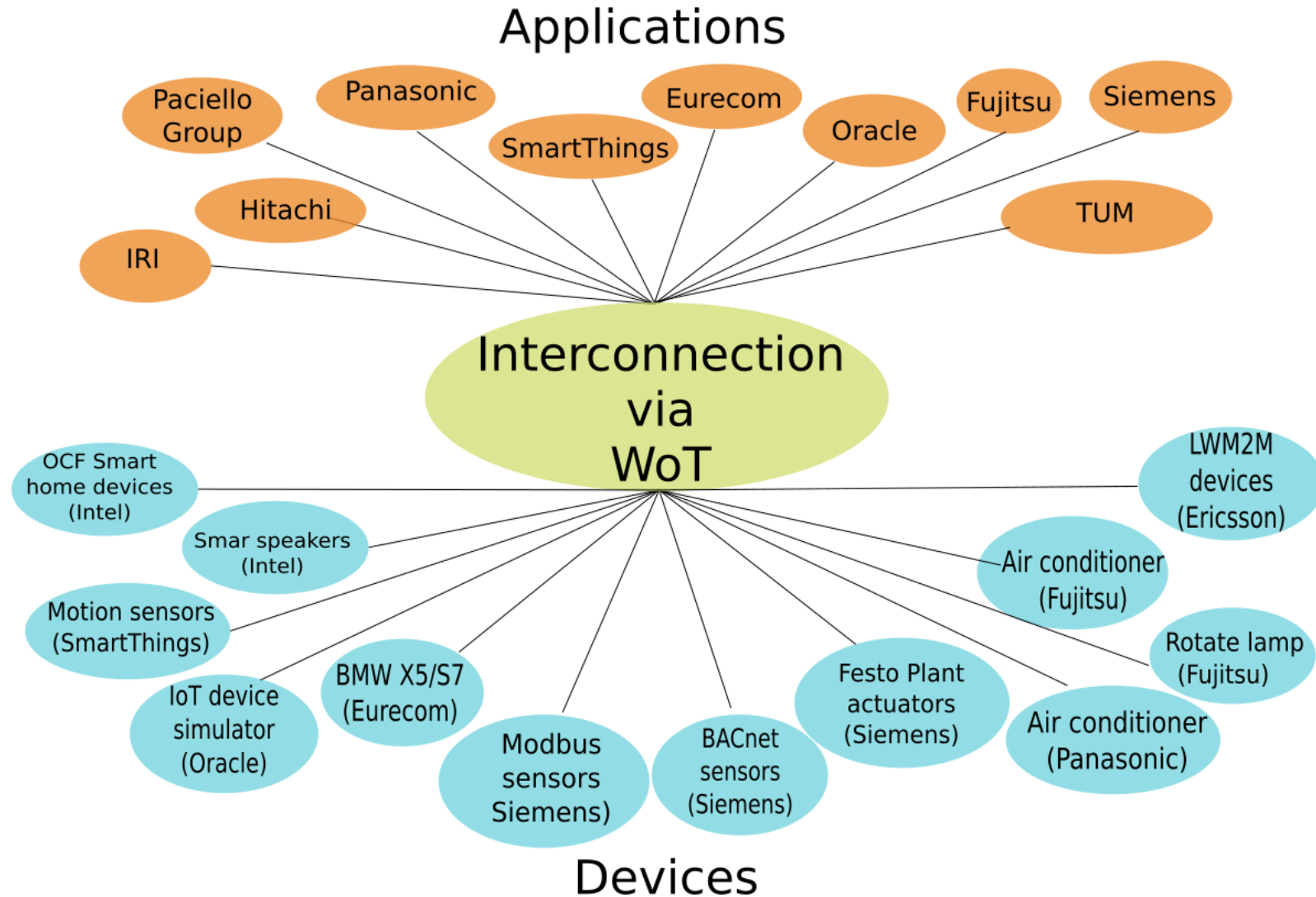




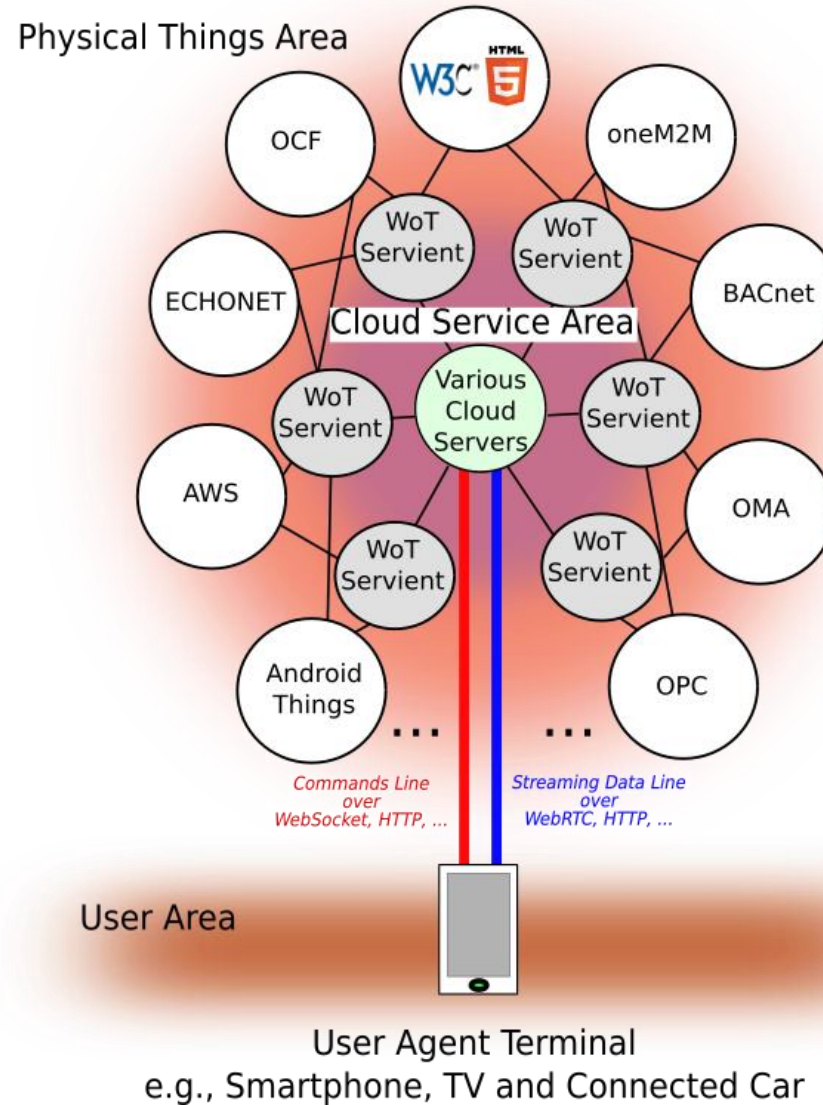
# Unified vocabulary references by Thing Description



# PlugFest: Proof-of-Concept for interconnectivity



# WoT connects various IoT platforms with the Web



Like this 😊

Integrating various IoT standards using the Web



# WoT participants within W3C



# Liaison with related SDOs

- INDUSTRIE 4.0
- Industrial Internet Consortium
- Open Connectivity Foundation
- OPC Foundation
- IETF/IRTF
- oneM2M
- AIOTI
- Etc.



# Standardization status

## - REC Track documents (=W3C Specs)

- WoT Architecture:
  - Ver 1.0: <https://www.w3.org/TR/2020/REC-wot-architecture-20200409/> (REC)
  - Ver 1.1: <https://www.w3.org/TR/2020/WD-wot-architecture11-20201124/> (FPWD)
- WoT Thing Description (TD):
  - Ver 1.0: <https://www.w3.org/TR/2020/REC-wot-thing-description-20200409/> (REC)
  - Ver 1.1: <https://www.w3.org/TR/2020/WD-wot-thing-description11-20210607/> (WD)
- WoT Discovery: <https://www.w3.org/TR/2020/WD-wot-discovery-20210602/> (WD)
- WoT Profile: <https://www.w3.org/TR/2020/WD-wot-profile-20201124/> (FPWD)

# Standardization Status

## - Group Notes

- WoT Scripting API: WG Note
  - <https://www.w3.org/TR/2020/NOTE-wot-scripting-api-20201124/>
- Security&Privacy Guidelines: WG Note
  - <https://www.w3.org/TR/2019/NOTE-wot-security-20191106/>
- Binding Templates: WG Note
  - <https://www.w3.org/TR/2020/NOTE-wot-binding-templates-20200130/>
- Use Cases: IG Note
  - <https://www.w3.org/TR/2021/NOTE-wot-usecases-20210518/>



# Demo at TPAC2019 in Fukuoka

- TPAC (Technical Prenary & Advisory Committee Meetings)



- Oracle: Cloud services, Digital twin simulator
- Siemens: Electric car charger
- Panasonic: Air conditioner, Robot cleaner, Bulletin board, LED lamps
- NHK: HybridCast app on TV
- Fujitsu: Proxy server, Smart meter, LED lamp, Air conditioner, Battery, Window blinds
- Mozilla: WebThing lamp
- Hitachi: NodeRED app
- Intel: Webcam, Amazon Echo

# Demo at virtual TPAC2020

- TPAC held as a virtual remote event using Zoom and WebEx
  - PlugFest demo also held as a virtual event
  - VPN service using SoftEther to emulate the local network for all the participants
  - mDNS-based device discovery service using LinkSmart
- Participants
  - Virtual local net using SoftEther VPN
    - Fujitsu: Proxy service, Various sensors (acceleration, brightness, proximity, PIR, temperature, humidity, air pressure)
    - Hitachi: LED connected to Raspberry Pi, NodeRED app
    - NHK: Hybridcast emulator, Hybridcast Connect app, smartphone, haptic device
    - RIOT OS: BLE prototype
  - Outside the virtual net (connected via proxies)
    - TUM: Remote Lab (belt conveyer, HUE LED, IR sensor, Robot arms, Coffee machines)
    - Siemens: Multi-language counter, Coffee machines, TestThing (including geolocation information), browser UI
    - Intel: Proxy server, Webcam, Speech synthesis (Amazon Echo)
    - UNIBO: WoT Farm emulator (virtual sensors and sprinklers)
  - TPAC Breakout demo
    - Slides: <https://www.w3.org/2020/10/27-wot-breakout/2020-10-WoT-Breakout.pptx>
    - Minutes: <https://www.w3.org/2020/10/27-wot-breakout-minutes.html>

# Demo at Virtual TPAC2021

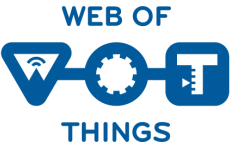
Similar setting as TPAC2020

- Remote PlugFest:
  - SoftEther VPN
  - LinkSmart
- Participants
  - Virtual local network (VPN)
    - ECHONET: LED, Air conditioner, Temp. sensor, Illuminance sensor
    - Fujitsu: Proxy service, Sensors (acceleration, illuminance, proximity, motion, temp., humidity, pressure)
    - Hitachi: Raspberry Pi + LEDs, NodeRED
    - NHK: Hybridcast emulator, Virtual devices (Smart speaker, Smart display, Smart cuttingboard)
    - RIOT OS: BLE prototype
  - Internet (via proxy)
    - TUM: Remote Lab (Belt conveyer, HUE LED, IR sensor, Robot arm, Coffee machine)
    - Siemens: Directory service, Multi-language counter, Coffee machine, TestThing, Solar panel, Brower UI
    - Intel: Proxy server, Webcam, Speech synth. (Amazon Echo)
    - UNIBO: WoT Farm emulator (Sensor and Sprinkler)

# Expected use cases for the future apps

# WoT 1.1 Use Cases

## — Multi-vendor integration



- So far...

- ◆ Just part of the discussion for the WoT specifications by the WoT WG

- However, since this year...

- ◆ Getting inputs/ideas from the WoT IG participants as well as the WoT WG participants
- ◆ and even from the outside of the W3C 😊

Working area:

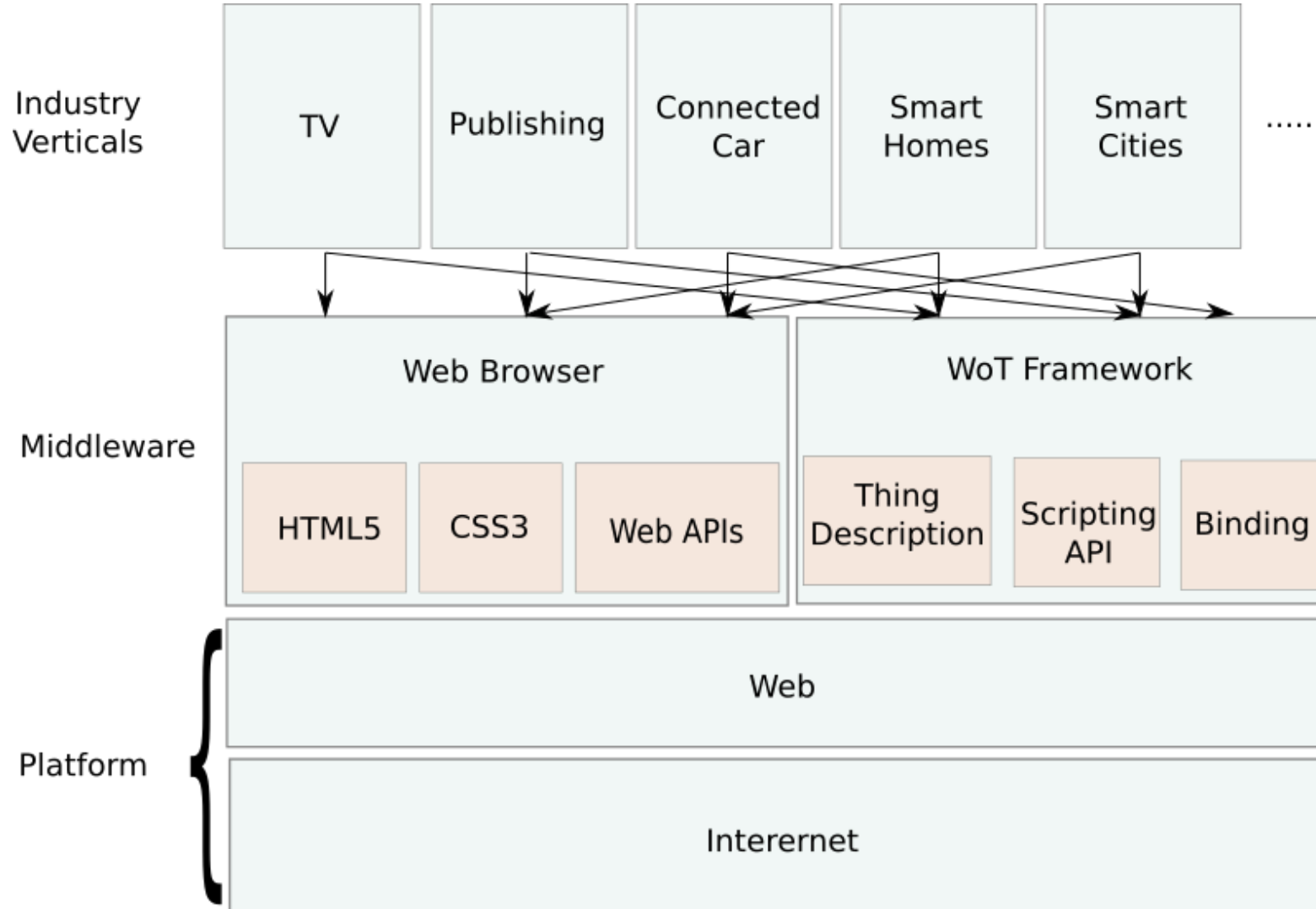
<https://github.com/w3c/wot-architecture/tree/master/USE-CASES>

Consolidated document on Use cases and Requirements:

<https://w3c.github.io/wot-usecases/>

# WoT Positioning

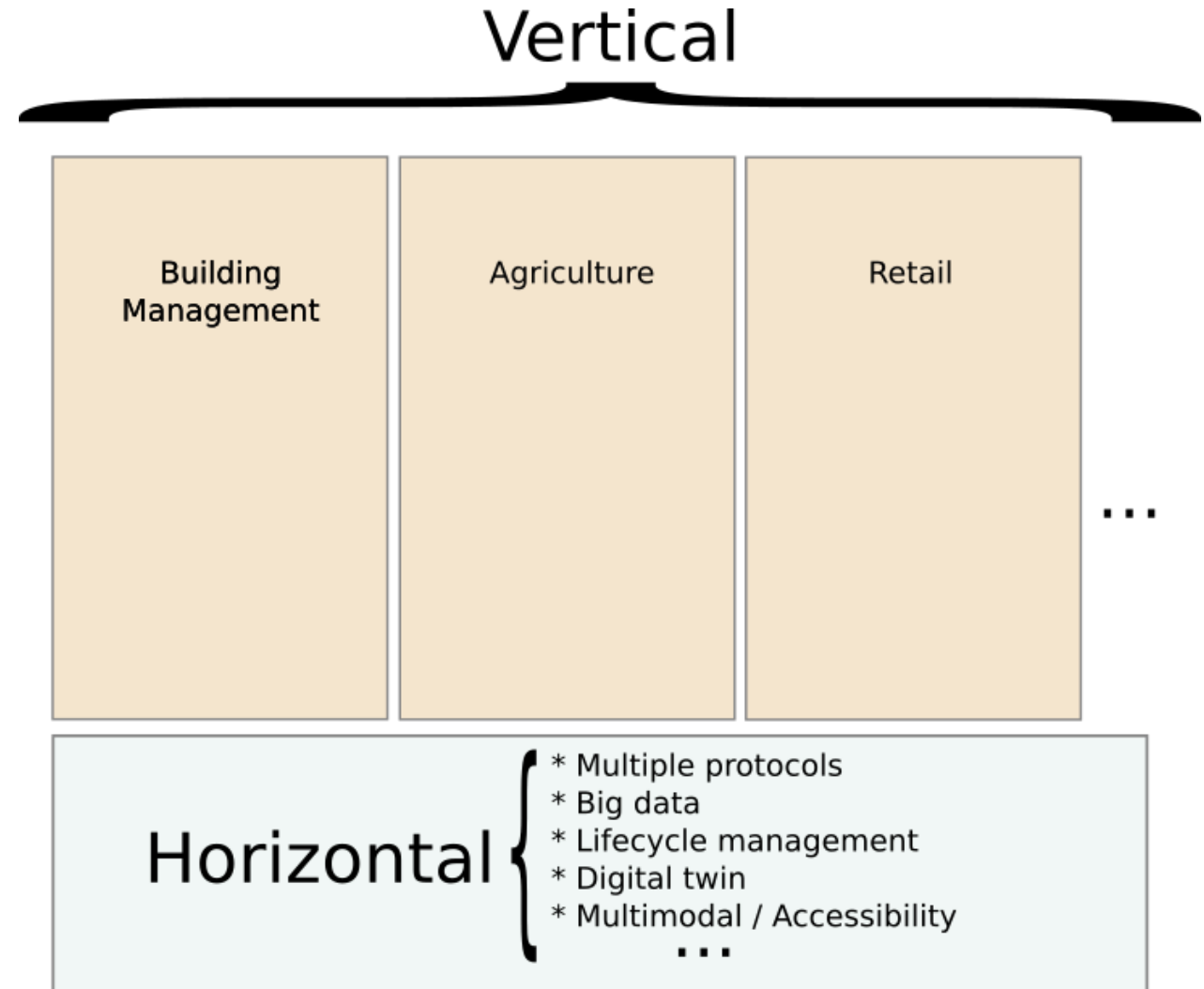
— Middleware for IoT purposes based on the Web platform!



# Categorization of the use cases

- collaborative work with related WGs and SDOs

- Vertical (Industry-dependent)
  - ◆ Devices and Sensors
  - ◆ Automotive
  - ◆ Media and Entertainment
  - ◆ Other SDOs
- Horizontal (Industry-independent)
  - ◆ Accessibility
  - ◆ Privacy
  - ◆ Security
  - ◆ Internationalization



# Use cases – Vertical ones

- TV industry
  - ◆ Media distribution
  - ◆ Multi-program collaboration
  - ◆ AR/VR
- Smart agriculture
  - ◆ Plastic greenhouse
  - ◆ Openfield management
  - ◆ Smart water management
- Smart building
  - ◆ Sensors
  - ◆ Maintenance
- Smart city
  - ◆ IoT mashup
  - ◆ Geolocation
  - ◆ Healthcare
- Others
  - ◆ Retail
  - ◆ Traffic
  - ◆ Smartgrid
  - ◆ Education
  - ◆ Medical care

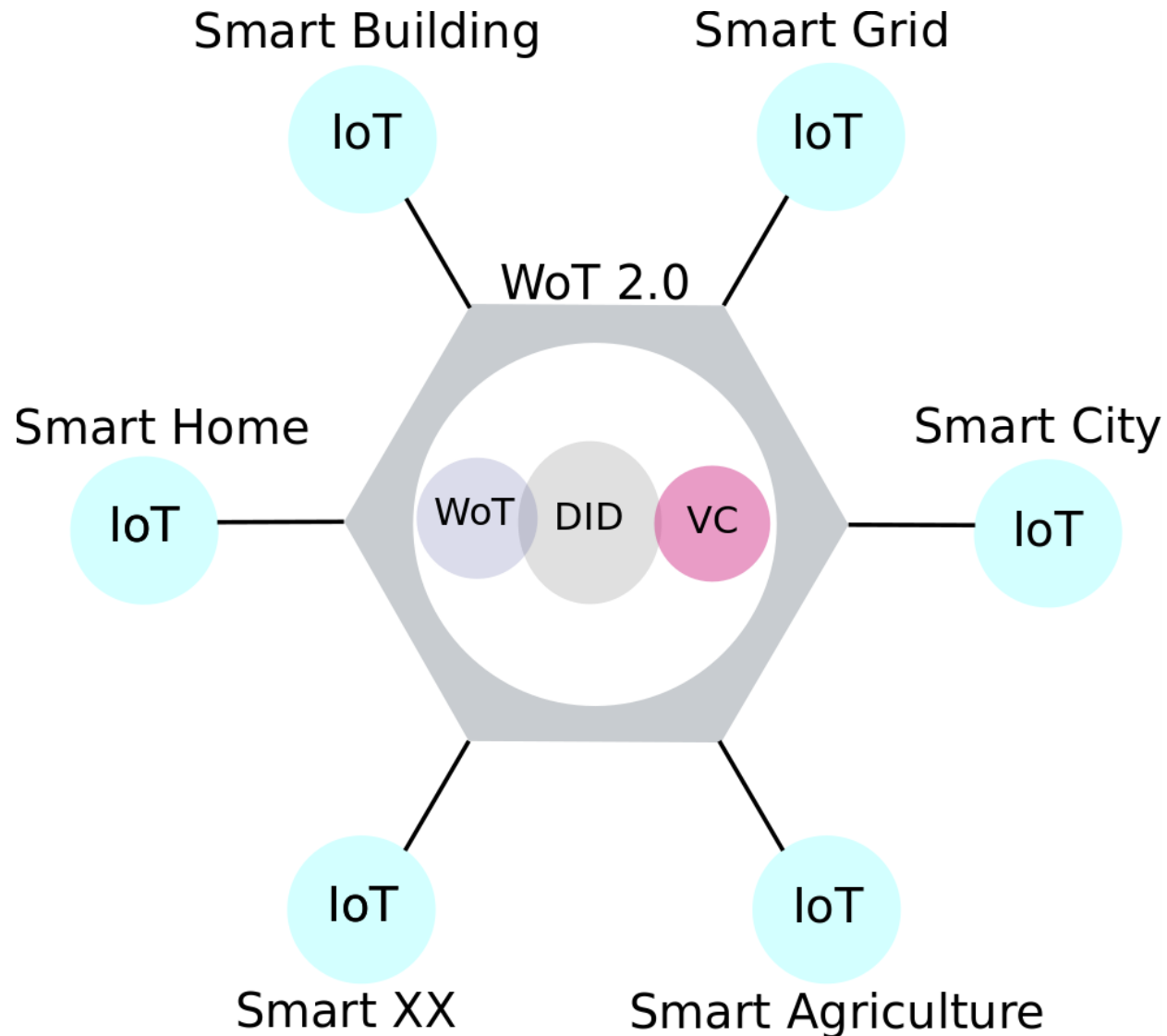


# Use cases – Horizontal ones

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



# Then towards WoT 2.0: 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

# Smart Cities

# Pros and Cons of Smart Cities...

- “Smart City” by Wikipedia: [https://en.wikipedia.org/wiki/Smart\\_city](https://en.wikipedia.org/wiki/Smart_city)
  - An urban area that uses **different types of electronic methods and sensors to collect data**.
  - Insights gained from that data are used to **manage assets, resources and services efficiently**; in return, that data is used to improve the operations across the city.
  - The smart city concept integrates **information and communication technology (ICT)**, and various physical **devices connected to the IoT (Internet of things)** network to optimize the efficiency of city operations and services and connect to citizens.
  - Smart city technology allows **city officials** to interact directly with both **community and city infrastructure** and to **monitor what is happening** in the city and how the city is evolving.

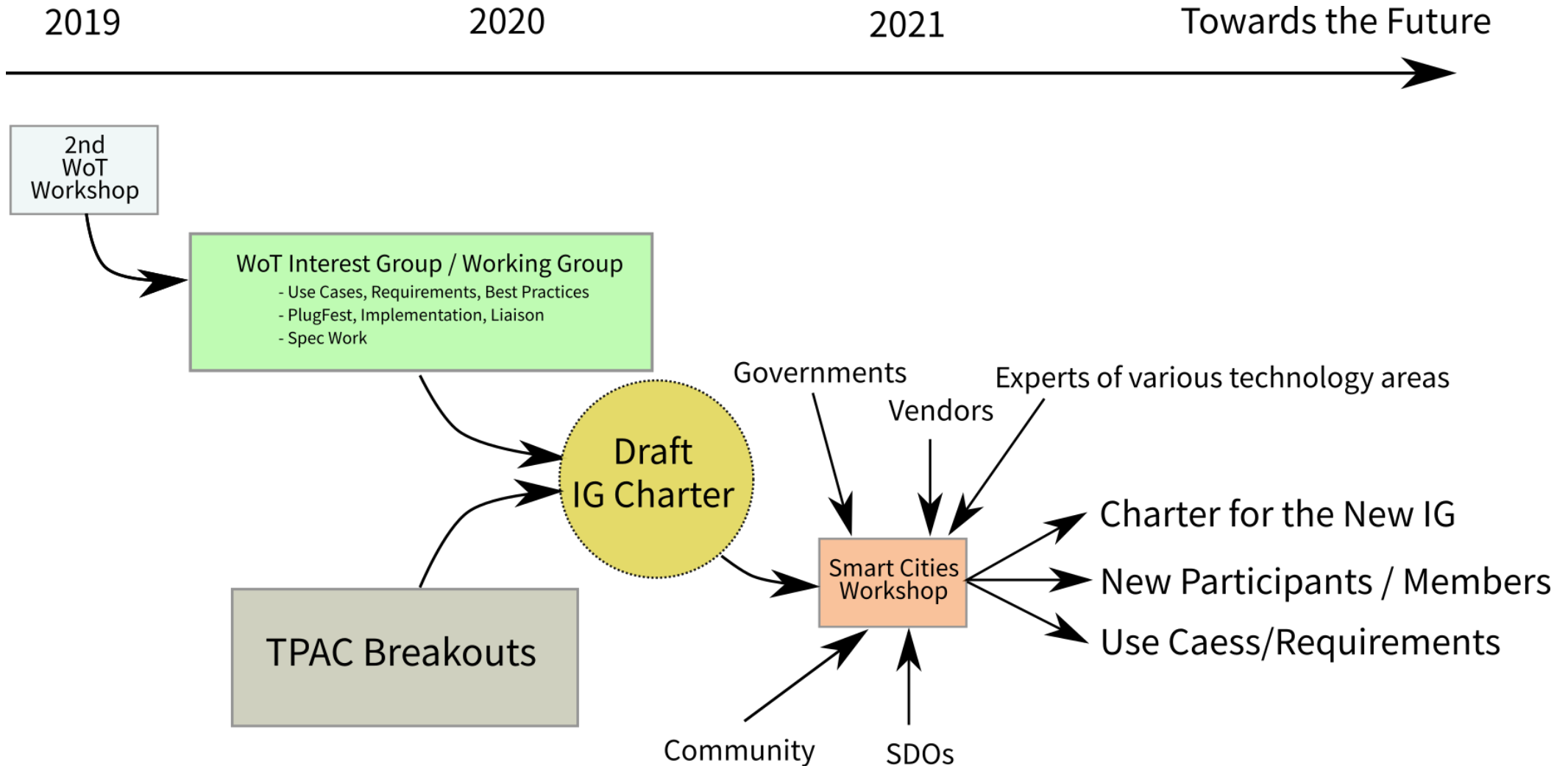
# Various Adoptions All Over the World

- Amsterdam
- Barcelona
- Columbus, Ohio
- Copenhagen
- Dubai
- Dublin
- Gdynia
- Isfahan
- Kyiv
- London
- Madrid
- Malta
- Manchester
- Milan
- Milton Keynes
- Moscow
- New Songdo City
- New York
- San Leandro
- Santa Cruz
- Santander
- Shanghai
- Singapore
- Stockholm
- Taipei
- Tokyo
- ...

# Need for a Standardization

- "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 stakeholders** on the usage of Web technologies for Smart Cities,
  - To gather **expert 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





# Goals and Deliverables of The Workshop

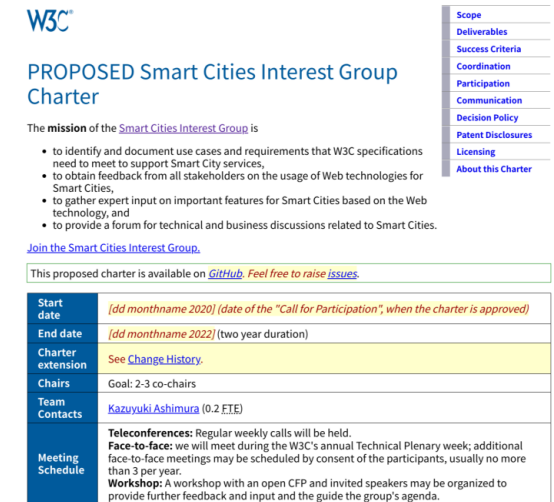
- **Identify stakeholders** of Smart Cities standardization to drive the development of Web standards aligned with the real needs of Smart Cities
- **Clarify reasonable applications** for Smart Cities technologies we agree to build
- **See how to improve the draft Charter** for the potential Smart Cities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



The screenshot shows the W3C PROPOSED Smart Cities Interest Group Charter page. It includes a table of contents on the right with items like Scope, Deliverables, Success Criteria, etc. The main content area starts with the mission of the Smart Cities Interest Group, followed by a list of goals: to identify and document use cases, to obtain feedback, to gather expert input, and to provide a forum for discussions. Below this is a table with metadata such as Start date, End date, Charter extension, Chairs, Team Contacts, and Meeting Schedule.

## 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.

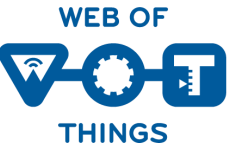
# Workshop Discussions – Use Cases

- [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



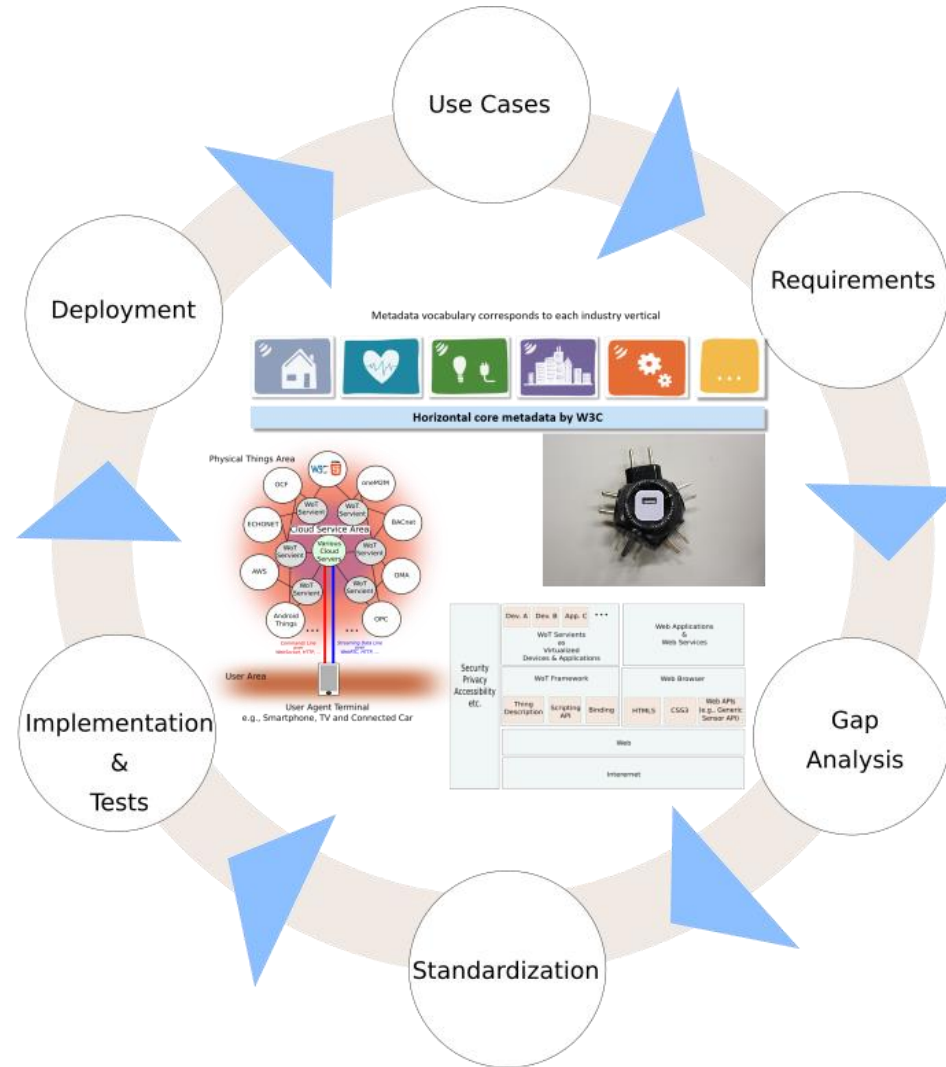
- [Sebastian Kaebisch: Standardized Service Orchestration in Smart City](#)
- [Michael McCool: The Web of Things in the Smart City](#)
- [Andrea Cimmino: Shifting from smart cities to smart communities using Web technologies](#)
- [Jacqueline Lu: Transparency Interfaces for Everyday Places](#)
- [Dave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

# W3C Standardization Cycle

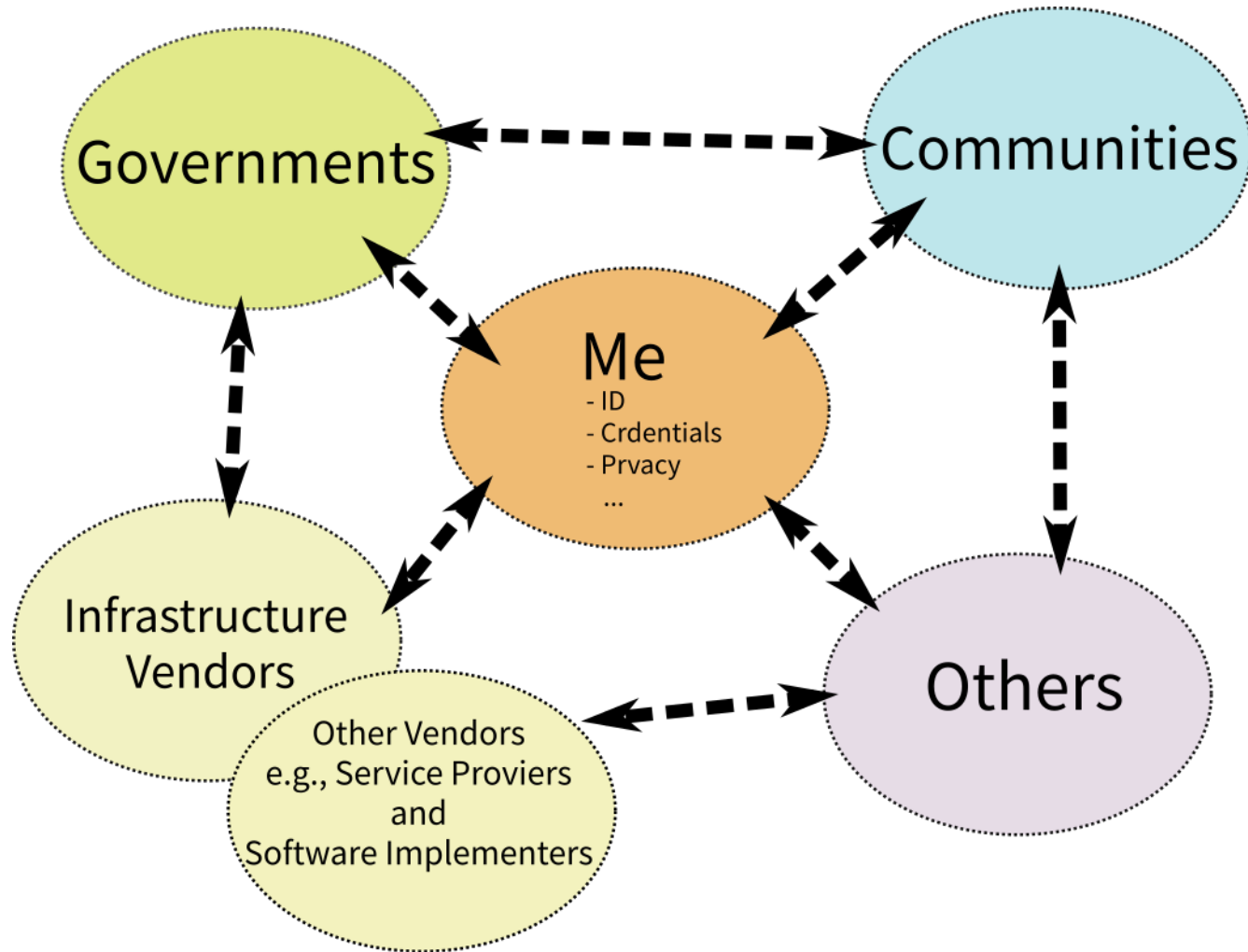
— based on industry use cases and implementations



# Criticism

- As a globalized business model is based on capital mobility, following a business-oriented model may result in a **losing long-term strategy**: "The 'spatial fix' inevitably means that mobile capital can often 'write its own deals' to come to town, only to move on when it receives a better deal elsewhere. This is no less true for the smart city than it was for the industrial, [or] manufacturing city."
- **The high level of big data collection and analytics has raised questions regarding surveillance in smart cities, particularly as it relates to predictive policing.**
- As of August 2018, the discussion on smart cities centres around the **usage and implementation of technology** rather than on the inhabitants of the cities and how they can be involved in the process.

# Data Governance for Smart Cities



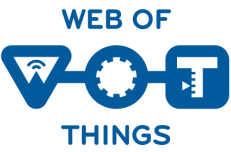
Data Transfer among various stakeholders

- Who
- What
- When
- How
- Need clarification based on concrete Use Cases by a dedicated IG 😊



# Please remember Web technology for whom?

- When / Where / For whom / How it works



- Various possible stakeholders and roles

- Governments?

- Content producers?

- Network providers?

- System developers?

- Hardware vendors?

- Infrastructure providers?

- Service providers?

- Users (=Everybody) ← **Most important stakeholders !**

# Thank you!

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

