Overview of Web of Things (WoT)

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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 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
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:
  - 457 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, Shogakukan, 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, 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,

● 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 (361):
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

Various applications

- Vendor A's LED
- Vendor B's LED
- Vendor C's LED

id
Properties
Actions
Events
SwitchStatus
TemperatureAlarm

Industry-specific vocabulary defined by iotschema.org, etc.

Vocabulary defined by the Thing Description itself
PlugFest: Proof-of-Concept for interconnectivity

Interconnection via WoT

Applications
- Paciello Group
- Panasonic
- Eurecom
- Oracle
- Fujitsu
- Siemens
- SmartThings
- Hitachi
- TUM
- IRI

Devices
- OCF Smart home devices (Intel)
- Smar speakers (Intel)
- Motion sensors (SmartThings)
- IoT device simulator (Oracle)
- BMW X5/S7 (Eurecom)
- Modbus sensors (Siemens)
- BACnet sensors (Siemens)
- Festo Plant actuators (Siemens)
- Air conditioner (Fujitsu)
- Rotate lamp (Fujitsu)
- Air conditioner (Panasonic)
- LWM2M devices (Ericsson)
WoT connects various IoT platforms with the Web
Integrating various IoT standards using the Web
WoT participants within W3C
Liaison with related SDOs

- INDUTRIE 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/](https://www.w3.org/TR/2020/REC-wot-architecture-20200409/) (REC)
  - Ver 1.1: [https://www.w3.org/TR/2020/WD-wot-architecture11-20201124/](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/](https://www.w3.org/TR/2020/REC-wot-thing-description-20200409/) (REC)
  - Ver 1.1: [https://www.w3.org/TR/2021/WD-wot-thing-description11-20210607/](https://www.w3.org/TR/2021/WD-wot-thing-description11-20210607/) (WD)

- WoT Discovery: [https://www.w3.org/TR/2021/WD-wot-discovery-20210602/](https://www.w3.org/TR/2021/WD-wot-discovery-20210602/) (WD)

- WoT Profile: [https://www.w3.org/TR/2020/WD-wot-profile-20201124/](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/](https://www.w3.org/TR/2020/NOTE-wot-scripting-api-20201124/)

- Binding Templates: WG Note
  - [https://www.w3.org/TR/2020/NOTE-wot-binding-templates-20200130/](https://www.w3.org/TR/2020/NOTE-wot-binding-templates-20200130/)

- Security&Privacy Guidelines: WG Note
  - [https://www.w3.org/TR/2019/NOTE-wot-security-20191106/](https://www.w3.org/TR/2019/NOTE-wot-security-20191106/)

- Use Cases: IG Note
  - [https://www.w3.org/TR/2021/NOTE-wot-usecases-20210518/](https://www.w3.org/TR/2021/NOTE-wot-usecases-20210518/)
Demo at TPAC2019 in Fukuoka

- TPAC (Technical Plenary & 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
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
  - Geolocational
  - 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
Extracting requirements from all the use cases — collaboration with industries and SDOs
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
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
- ...
Need for 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.
**Goals 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](https://www.w3.org/2021/06/smartcities-workshop/report.html)

⇒ Draft Charter for a W3C Interest Group:  
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!