A Bridge to Broader IoT Ecosystems

ETSI IoT Week

Sophia Antipolis, France, Oct 2017
Where is the value potential of the IoT?

McKinsey, June 2015 – “The Internet of Things: mapping the value beyond the hype”

Aggregated value - $3.9 trillion to $11.1 trillion per year in 2025

- **Interoperability** is required to capture 40% of total value
- Less than 1% of data is currently used, mostly for alarms or real-time control
  - More can be used for optimisation and prediction
- Twice as much value from B2B applications than from consumer
- 40% of value in developing countries, 60% in developed countries

➢ Most of the potential value is in the **data and value added services** rather than the IoT devices and IoT communication technologies.

✔ **Open standards** are needed to overcome fragmentation, connect the silos and unlock the network effect for exponential growth
Problem: Application/Platform Silos

Internet of Things: Connectivity

- IEEE 802.15.4
- Ethernet
- Wi-Fi
- Bluetooth
- LoRa

OCF
oneM2M
OMA
OPC Foundation
Fairhair Alliance
W3C WoT Mission

Not to be yet another standard

Web of Things: “glue in-between”

Extend Web technologies to the IoT to complement IoT standards by being *descriptive* instead of prescriptive
W3C WoT Scope

WoT: cross-platform, cross-domain
Where is WoT Positioned?

Web of Things: Application Layer

Internet of Things: Connectivity

IEEE 802.15.4  Ethernet  Wi-Fi  Bluetooth  LoRa
W3C WoT Approach

learn how to interact with Thing

describe Thing

easy integration across platforms

complement

Platform A
- Application
- Platform API
- Data Model
- Protocol

Platform B
- Application
- Platform API
- Data Model
- Protocol

“WoT Interface”
W3C WoT Building Blocks

WoT Thing Description (TD) with simple interaction model

Properties
Events
Actions

Thing Description

WoT Servient

Runtime Environment
App Script 2

Scripting API

Interaction Model
App Script 1

Binding Templates

Server
Client

Expose
Consume

WoT Servient

Local Hardware

JavaScript
Lua

WoT Scripting API for browser-like runtime environment

WoT Binding Templates to connect to different platforms and ecosystems

HTTP
OCF
BACnet
CoAP
OneM2M

Things can be in client and/or server role: “Servient”
JSON-LD Serialization

```json
{
  "@context": [
    "http://w3c.github.io/wot/w3c-wot-td-context.jsonld",
    { "domain": "http://example.org/actuator#" }
  ],
  "@type": "Thing",
  "name": "MyLEDThing",
  "security": {
    "cat": "token:jwt",
    "alg": "HS256",
    "as": "https://authority-issuing.example.org"
  },
  "interaction": [
    { "@type": ["Action", "domain:fadeIn"],
      "name": "fadeIn",
      "inputData": {
        "type": "integer",
        "minimum": "0",
        "domain:unit": "domain:ms"
      }
    },
    { "href": "coaps://myled.example.com:5684/in",
      "mediaType": "application/exi",
      "REST:method": "POST"
    },
    { "href": "https://mytemp.example.com:8080/in",
      "mediaType": "application/json",
      "REST:method": "POST"
    }
  ]
}
```
Things as Objects with Descriptions

Every Thing has a URL that identifies the Thing, and links to its description.

The URL is used as an RDF node for semantic descriptions of Things and their relationships.

RDF: knowledge representation using binary graphs with labelled links between RDF nodes

Application platforms use Thing Descriptions to automatically create the objects for exposed and consumed Things.

RDF technology standard

Device

Sensors and actuators

Application Script that abstracts the device as a Thing

Properties

Actions

Events

Produced Thing as software object

Synchronisation across the Internet using Web protocols

Consumed Thing as software object

Properties

Actions

Events

Application Script that interacts with a consumed Thing

exposes

consumes

Application publishes

Thing Description

IoT technology standard
W3C WoT Architecture Patterns

Cloud

Servient
- Digital Twin
- Orchestr. Client
- Digital Twin

Scripting API
Interaction Model
Binding Templates

Gateway

Servient
- Virtual Thing
- Orchestr. Client
- Proxy Thing

Scripting API
Interaction Model
Binding Templates

Web Integration

Web Browser
- App Script
- Scripting API
- Interaction Model
- Binding Templates

Thing
- App Script
- Scripting API
- Interaction Model
- Protocol

Direct Thing-to-Thing Interaction

Thing
- Classic Firmware
- Interaction Model
- Protocol

Complement Existing Devices

Existing Device

+ 

⇒ Thing
W3C WoT Process

Interest Group (IG)
https://www.w3.org/2016/07/wot-ig-charter.html

- Started spring 2015
- 199 participants
- Informal work, outreach
- Explorative work, validation
- PlugFests with running code
- Liaisons and collaborations with other organizations and SDOs (+ “OpenDays”)

Working Group (WG)
https://www.w3.org/2016/12/wot-wg-2016.html

- Started December 2016
- 100 participants
- Normative standardization
- Work on deliverables
- W3C Patent Policy for royalty-free standards
- Member organizations and Invited Experts
W3C WoT Progress

• 2014: Stakeholders identified at W3C Workshop
• 2015: IG started to identify initial building blocks
  – Current Practices documented
    (http://w3c.github.io/wot/current-practices/wot-practices.html)
  – Practical evaluation in “PlugFests”
• 2016/17: WG chartered until end of 2018
  – Editor’s Drafts available
  – 3 First Public Working Drafts published in Sep. 2017
  – Candidate Recommendations end of 2018…
• 2019: WG re-chartering for next building blocks
  – IG is continuously exploring and identifying
W3C WoT Online Resources

• W3C WoT Wiki (IG+WG organizational information)
  – https://www.w3.org/WoT/IG/wiki/Main_Page

• W3C WoT Interest Group
  – https://www.w3.org/2016/07/wot-ig-charter.html (charter)
  – https://lists.w3.org/Archives/Public/public-wot-ig/ (subscribe to mailing list)
  – https://github.com/w3c/wot (technical proposals)

• W3C WoT Working Group
  – https://www.w3.org/2016/12/wot-wg-2016.html (charter)
  – https://www.w3.org/WoT/WG/ (dashboard)

• W3C WoT Editor’s Drafts
  – https://w3c.github.io/wot-architecture/ FPWD!
  – https://w3c.github.io/wot-thing-description/ FPWD!
  – https://w3c.github.io/wot-scripting-api/ FPWD!
  – https://w3c.github.io/wot-binding-templates/
Opportunities for Reuse/Integration

• Royalty-free Web standards
• Technological building blocks
  – Non-prescriptive: take what you need
  – Open source reference implementation
    https://github.com/thingweb/node-wot
• Extension points
  – Semantic vocabulary → iot.schema.org, oneM2M, ...
  – Binding Templates → Web, CoRE, OCF, oneM2M, ...
  – Libraries on top of Scripting API → individual Members
W3C WoT Liaisons

• Active
  – OCF
  – OneM2M
  – OPC Foundation

• Potential
  – OpenFog
  – OMA LWM2M / IPSO Alliance
  – EchoNet
  – Fairhair Alliance
W3C - oneM2M Collaboration

• **Common ground** of Semantic Interoperability for IoT
  – Standards, tools and expertise on **Semantic Web** (RDF/OWL/SPARQL) as the **building blocks** of oneM2M semantic features (ontology management, semantic query/discovery, ...)
    • Importance of machine interpretable descriptions rather than relying on informal documentation that may diverge over time
    • Discovering Things based upon their capabilities and context of use
    • Inferring knowledge of Things and environments
    • Designing compositions of services that can be proven to interoperate
    • Addressing inevitability of change, especially across uncoupled or weakly coupled communities
  – **Well-aligned semantic models** between WoT and oneM2M Base Ontology and Smart Device Template as the solid base of interoperability (see next pages)

• **Ongoing Work Item** “oneM2M-WoT Interworking”
The core concepts in each model are well mapped.
Well-aligned base of Semantic Interoperability

WoT TD & oneM2M/HGI SDT Mapping

The WoT TD Core Model

oneM2M SDT

- Event more direct mapping observed.
Added value of WoT to oneM2M

• A descriptive & semantic framework (TD) bridging with many other IoT ecosystems in an easier way
• A close and natural engagement with Web developers who are more familiar with Web technologies like the Scripting API
Bridging to Broader IoT Ecosystems

• Exposing the “WoT i/f” to oneM2M systems
  – WoT services/data (described in WoT TD) can be consumed by oneM2M applications
  – oneM2M IPE design can be simplified based on the common description of TD (works as BO but more generic)
Bridging to Broader IoT Ecosystems

- Exposing the oneM2M i/f to WoT-compatible systems
  - oneM2M services/data can be consumed by WoT Servients (as if they “speak” oneM2M protocol according to TD)
  - oneM2M protocol bindings can be described in a **machine-understandable** way using WoT TD Binding Template (automated interworking becomes possible)
Take-away

• WoT is not yet another *prescriptive* standard but a *descriptive* tool for bridging the IoT ecosystems

• **TD** is the heart of WoT

• Common ground of *semantic interoperability* shows promising interworking solution between WoT and oneM2M

• Work to be further progressed on both sides via **closer collaboration**
Thank you!!!