IoT Payments and Security Breakout: Agenda

As proposed:

- An introduction to Web of Things WG deliverables
- IOT requirements for security and authentication
- Opportunities for payments for IOT services

Other:

- Sometimes-offline local networking (HTTPS local)
- WoT security review – see https://github.com/w3c/wot-security
- Use cases and requirements: WoT Architecture, WoT Security, …
- Proofs of concept and commercial engagement, ex AVS + Semantic search

Web of Things: Introduction

Michael McCool, Principal Engineer, Intel

W3C Web of Things WG Co-Chair

Web of Things: Goals

Support interoperability in IoT

…to enable an open “IoT service ecosystem” to develop

…by making use of well-developed web ecosystem

…without adding to the confusion of “too many standards”

Business Value of Interoperability

"Interoperability between IoT systems is critically important to capturing maximum value; on average, interoperability is required for 40% of potential value across IoT applications and by nearly 60% in some settings." [+$4.1B TAM by 2025]

McKinsey & Company, *The Internet of Things: Mapping the Value Beyond the Hype*, 2015

"Without question, the biggest obstacle facing widespread adoption of IoT and automation systems is interoperability. [...] What is needed is a standardized model to associate metadata with the existing […] identifiers."

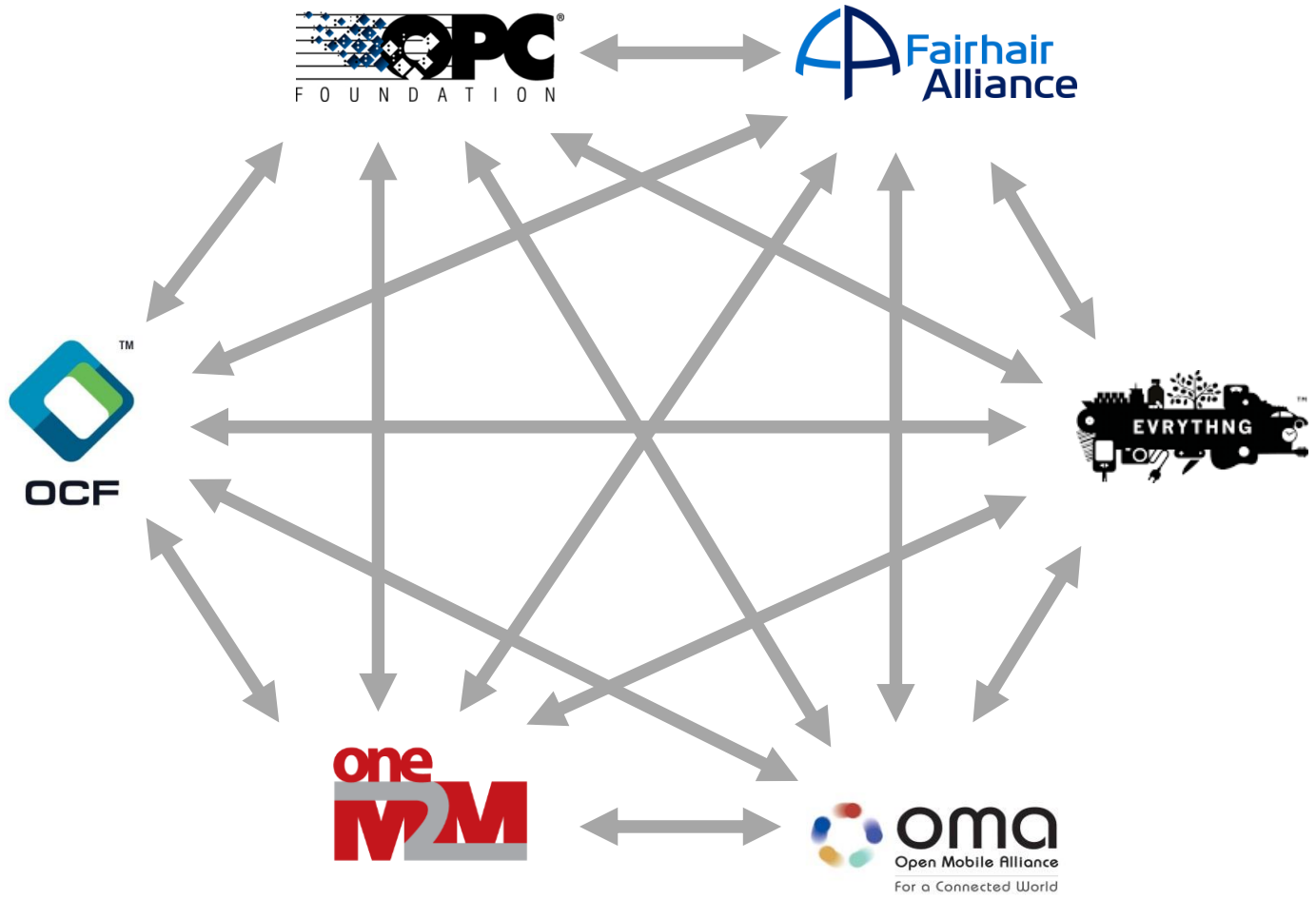
Embedded Computing Design, *Cross-Industry Semantic Interoperability*, 2017

Accelerate IoT Scaling by Supporting Interoperability

- *Interoperability* is the key to scaling IoT ecosystem
  - Maximize number of devices and services that can interoperate

    → quadratic: O(n^2)
  - Provide ecosystem that can compose devices and services flexibly

    →*combinatoric*: *n* choose *m* for services involving m sub-services



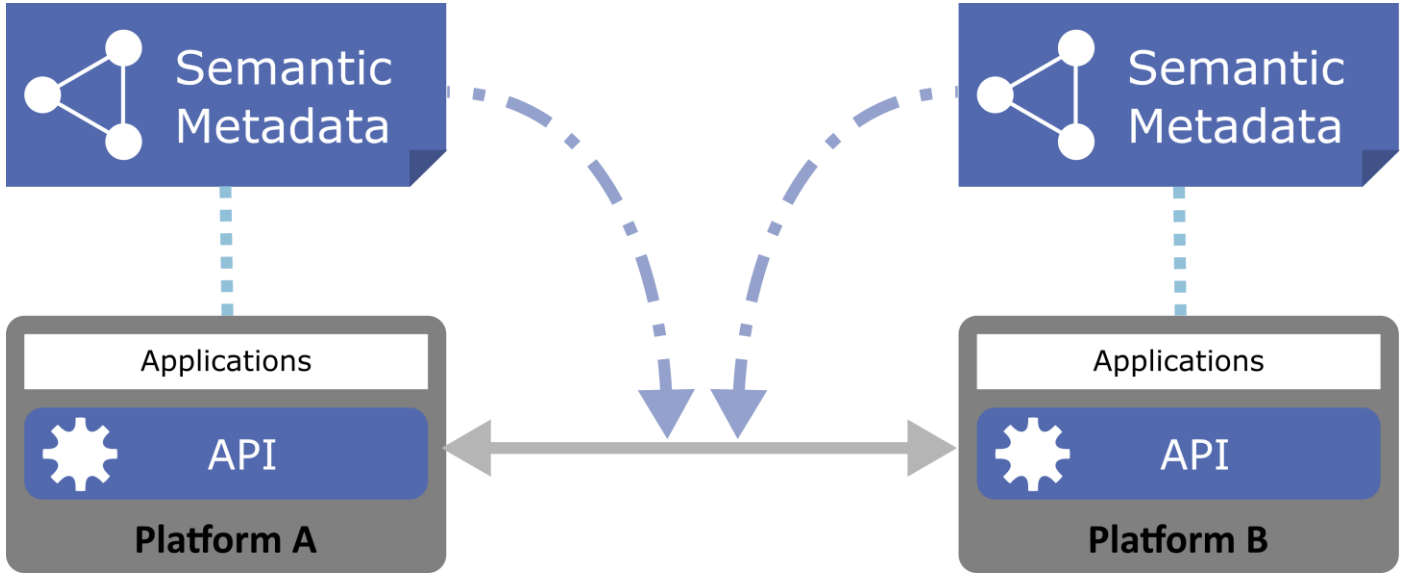
WoT Key Deliverable: Standardised Metadata

Metadata simplifies application development

- Decouples underlying protocols
- Enables automated tooling

Metadata enables interoperability

- Describe the interfaces exposed to applications
- Describe the communication and security requirements for accessing things
- Describe the data models, semantics, and domain constraints



TD Exampl

JSON-LD (Linked Data)

W3C WoT TD vocabulary

domain-specific vocabulary

JSON Schema

```
{
  "@context": [
    "http://w3c.github.io/wot/w3c-wot-td-context.jsonld",
    { "domain": "http://example.org/actuator#" }
  ],
  "@type": "Thing",
  "name": "MyLEDThing",
  "base": "coap://myled.example.com:5683/",
  "security": {
    "cat": "token:jwt",
    "alg": "HS256",
    "as": "https://authority-issuing.example.org"
  },
  "interactions": [
    {
      "@type": ["Property", "domain:onOffStatus"],
      "name": "status",
      "outputData": {"valueType": {"type": "boolean"}},
      "writable": true,
      "links": [
        {
          "href": "pwn"
```

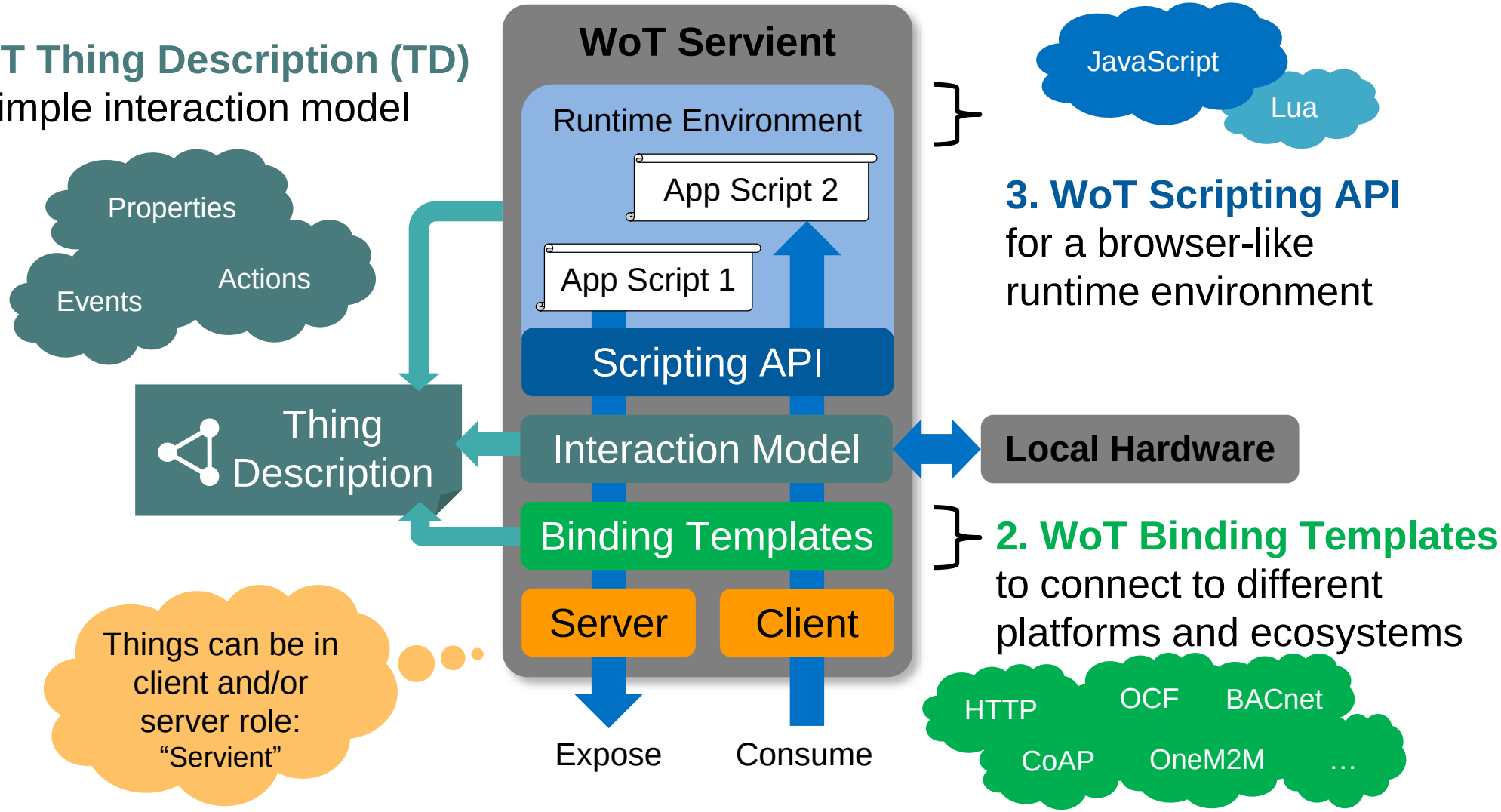

"interactions": [
{
"@type": ["Property", "domain:onOffStatus"],
"name": "status",
"outputData": {"valueType": {"type": "boolean"}},
"writable": true,
"links": [
{
"href": "pwr",
"mediaType": "application/exi"
},
{
"href": "http://mytemp.example.com:8080/status",
"mediaType": "application/json"
}
]
},
{
"@type": ["Action", "domain:fadeIn"],
"name": "fadeIn",
"inputData": {
"valueType": {"type": "integer"},
"domain:unit": "domain:ms"
},
"links": [
{
"href": "in",
"mediaType": "application/exi"
Property
Action

```
      "inputData" : {
        "valueType": {"type": "integer"},
        "domain:unit": "domain:ms"
      },
      "links": [
        {
          "href": "out",
          "mediaType": "application/exi"
        },
        {
          "href": "http://mytemp.example.com:8080/out",
          "mediaType": "application/json"
        }
      ]
    },
    {
      "@type": ["Event", "domain:alert"],
      "name": "criticalCondition",
      "outputData": {"valueType": {"type": "string"}},
      "links": [
        {
          "href": "ev",
          "mediaType": "application/exi"
        }
      ]
    }
  ]
}
```

Event
(sources, sinks, …)

WoT: Additional Deliverables/Architecture

1. WoT Thing Description (TD)
with simple interaction model



3. WoT Scripting API
for a browser-like runtime environment

2. WoT Binding Templates
to connect to different platforms and ecosystems

Security and Privacy Implications

Risks

- Accessible metadata raises the risk of scanning and inferencing attacks
- Bridging multiple systems may allow a vulnerability in one system to be used as a vector to attack another system that trusts it

Opportunities

- Endpoint adaptation (convert payloads at secure endpoint) rather than bridge-by-bridge adaptation (convert at multiple insecure bridges)
- Metadata can be used to analyze security of entire system (converse of scanning for attack) and assign trust

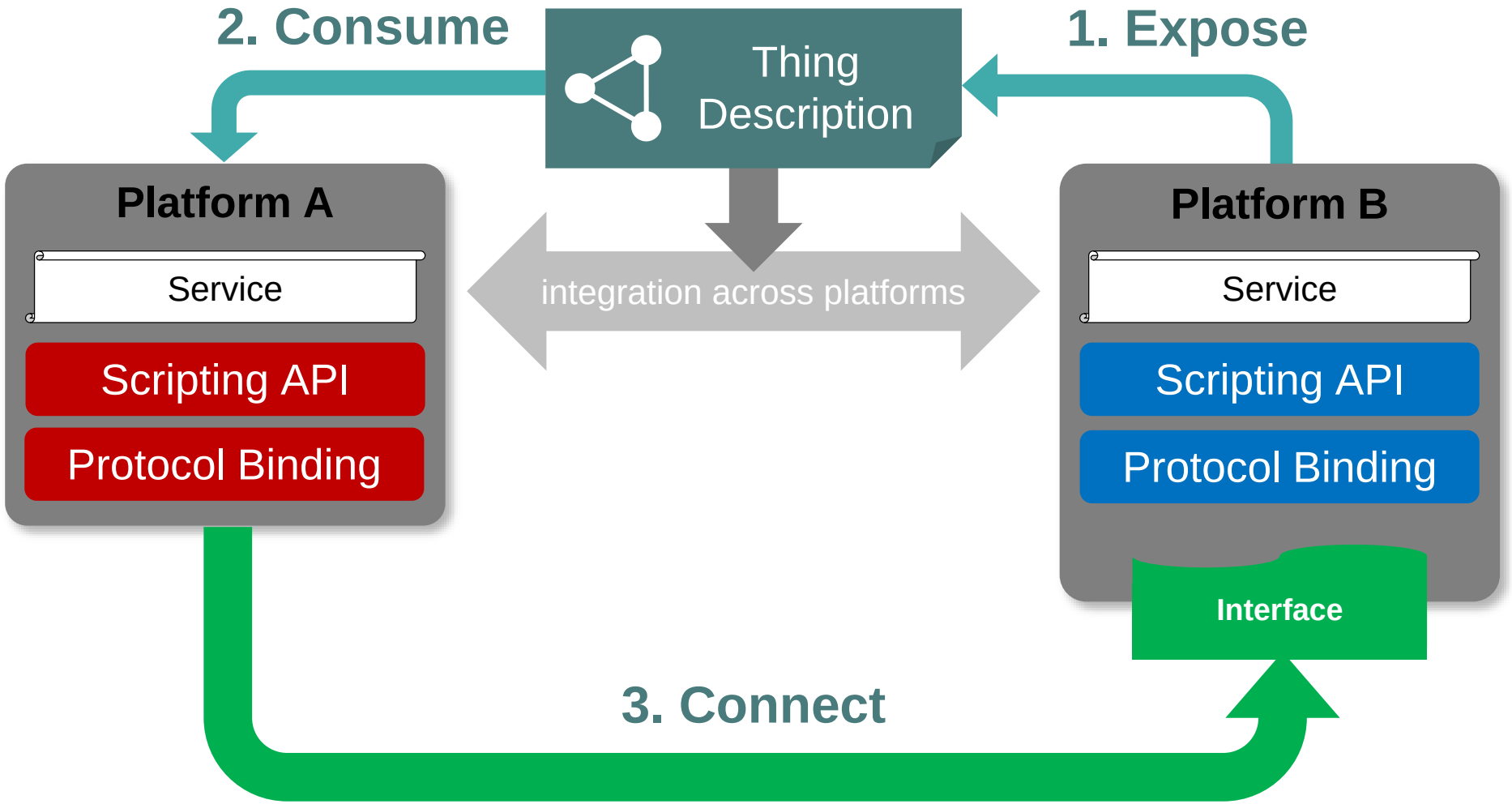
Summary

- Main W3C WoT deliverable and differentiator:
  - What: Universal metadata format (“Thing Description”) for IoT services (“Things”) and associated common Thing abstraction
  - ***Why: Enables interoperability with accelerates IoT market growth and opportunities***
- Complementary to other standards efforts
  - OpenFog for standard ambient services and orchestration
  - OCF, oneM2M, Fairhair, AWS IoT, etc. for device models
  - CoAP, HTTP, MQTT, etc. for low-level communication protocols

Other Relevant Breakouts

- HTTPS Local – Harbour A, 2-3
- WoT Plugfest – Grand Pen F&G, 1-3

WoT: Approach Summary



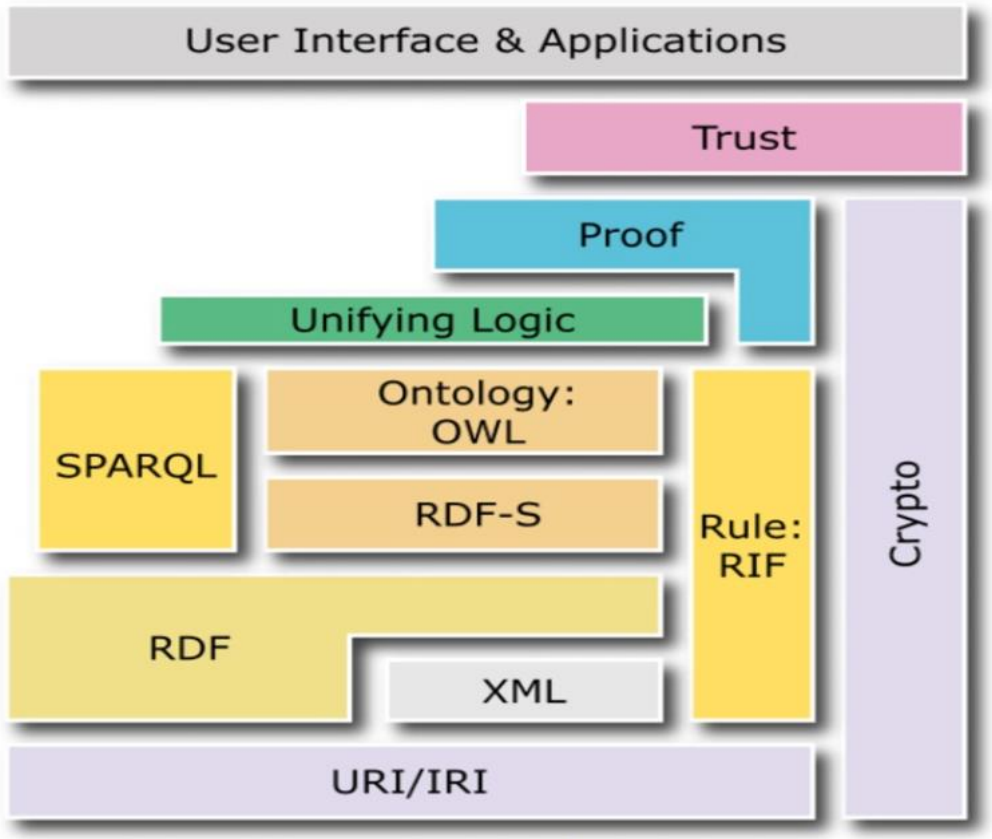
WoT: Related W3C Standards

- RDF: Resource Description Framework
  - General mechanisms for defining data semantics and vocabularies
  - Useful for working with metadata
- SSNO: Semantic Sensor Network Ontology
  - Vocabularies (ontologies) and semantics for sensor data
- JSON-LD: JSON (JavaScript Object Notation) Linked Data
  - Mechanism for encoding RDF in JSON, used for Thing Description serialization
- See also:
  - iot.schema.org: Vocabularies and semantics for IoT, defined using RDF

Linked Data and Semantic Interoperability

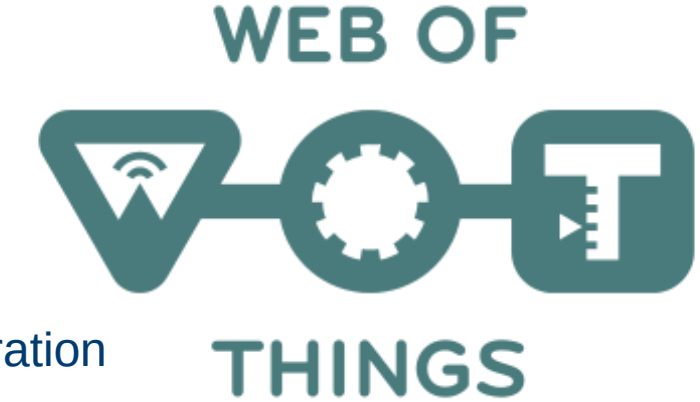
Well-defined semantics ensure that platforms share the same meaning for the data they exchange

- → Discovery based upon properties and relationships
  - → Search engines that can index the Web of Things
- → Verify consistency and interoperability
  - → Design service compositions based upon knowledge of which services are compatible
- → Reuse existing domain knowledge
  - → Using iot.schema.org, SSNO, SAREF, etc.



W3C has a rich suite of related standards

Web of Things: Resources and Links



W3C: World Wide Web Consortium: https://www.w3.org

Web of Things Interest Group: https://www.w3.org/WoT/IG/

- Charter: Leverage web standards and technology to enable IoT interoperation
- Web architecture: https://www.w3.org/standards/webarch/

Web of Things Working Group in the W3C to develop standard recommendations:

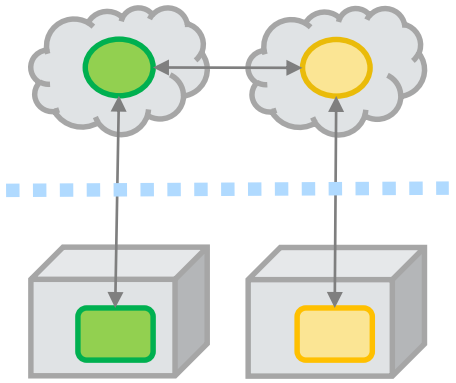
- https://www.w3.org/2016/09/wot-wg-charter.html
- Co-chairs: Matthias Kovatsch (Siemens), Kazuo Kajimoto (Panasonic), Michael McCool (Intel)
- White paper on WoT architecture: http://w3c.github.io/wot/charters/wot-white-paper-2016.html

WoT current practices: http://w3c.github.io/wot/current-practices/wot-practices.html

IoT Evolution: Towards an Ambient IoT Ecosystem

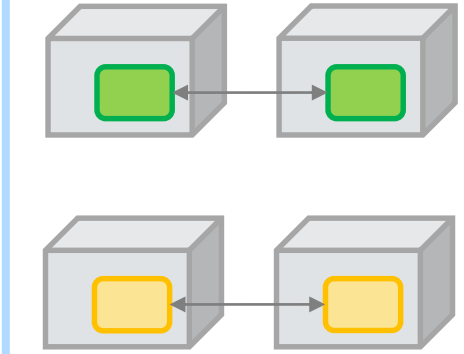
Cloud Supported IoT Devices

IoT devices connect to semi-independent cloud services



Locally Networked IoT Devices

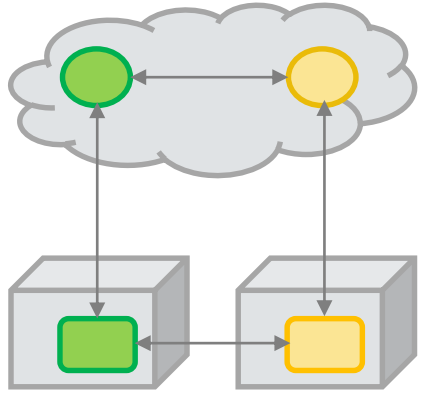
IoT devices connect to others in isolated ecosystems



2016/2017

Fog Supported IoT Devices

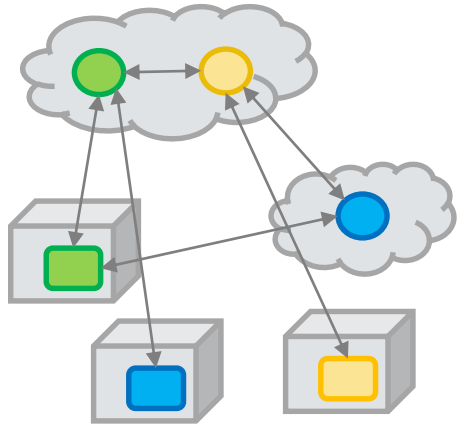
IoT devices can discover and connect to local “fog services” that facilitate interop.



2018/2019

Ambient Service Ecosystem Computing

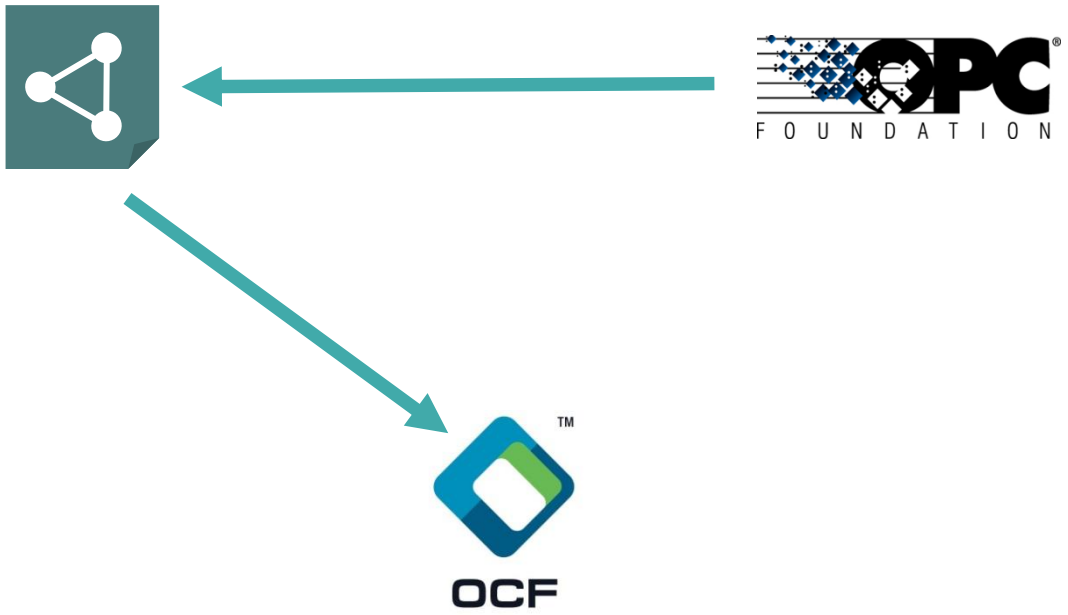
Services composed from dynamically discovered devices and services



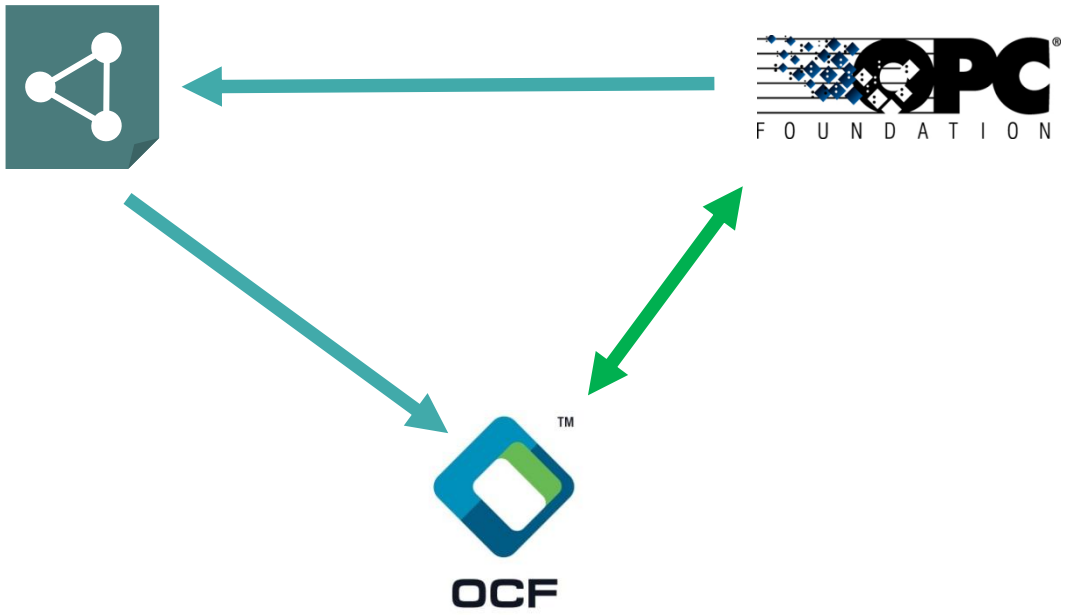
2020/2021

WoT Approach: 1. Expose Metadata

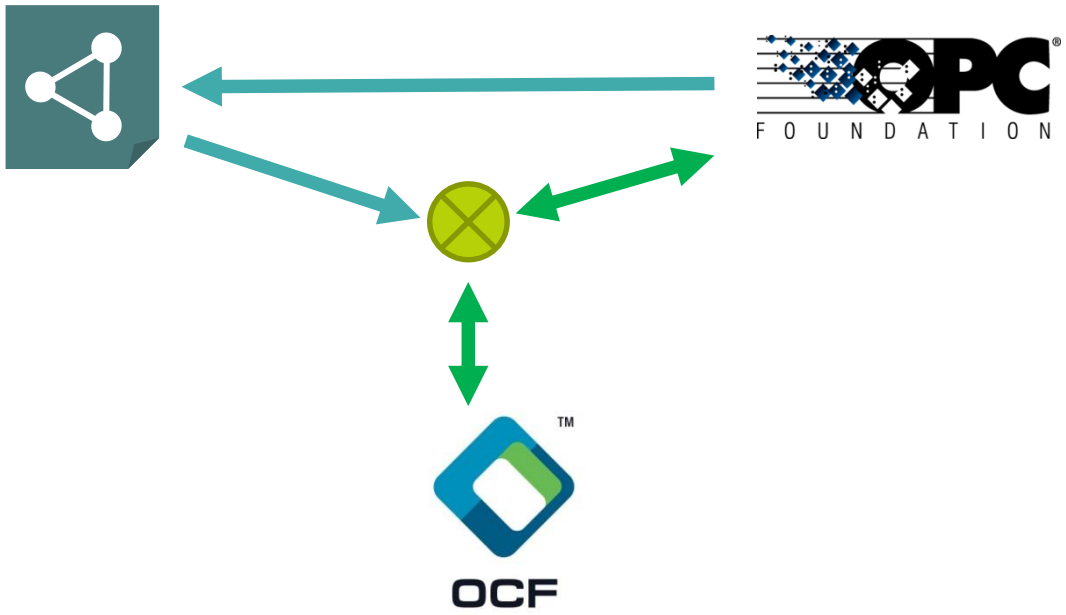
WoT Approach: 2. Consume Metadata



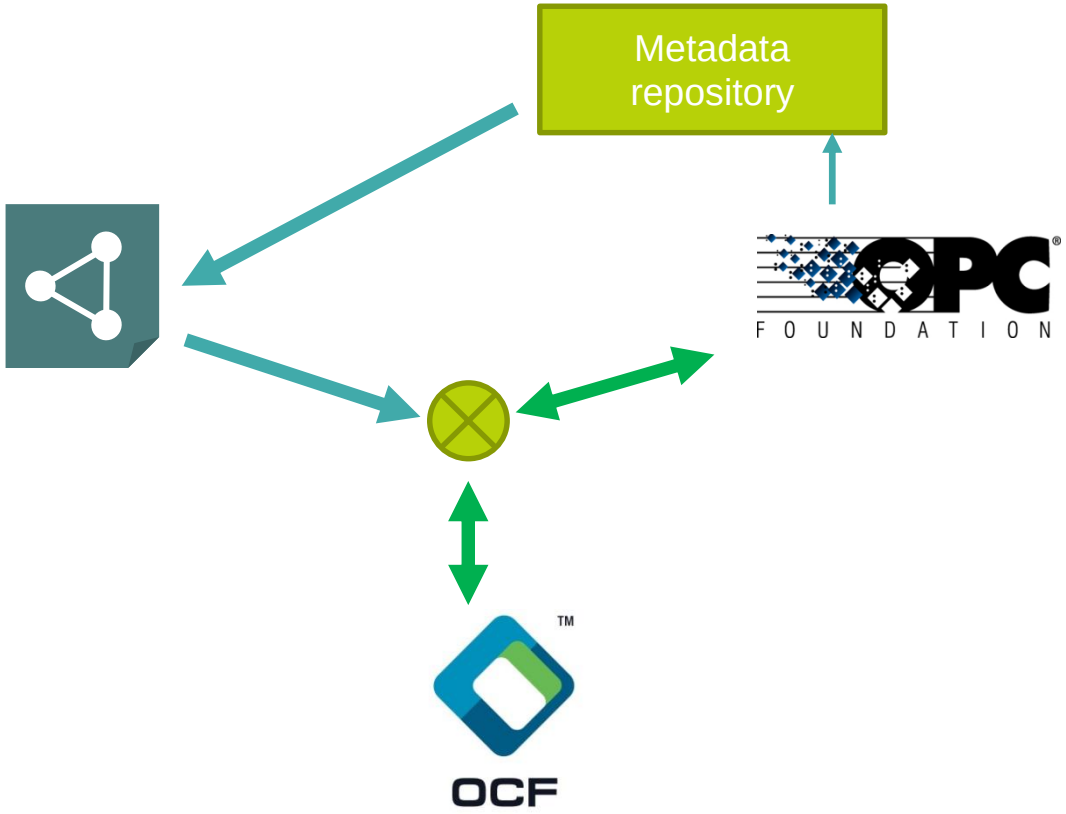
WoT Approach: 3a. Connect Directly



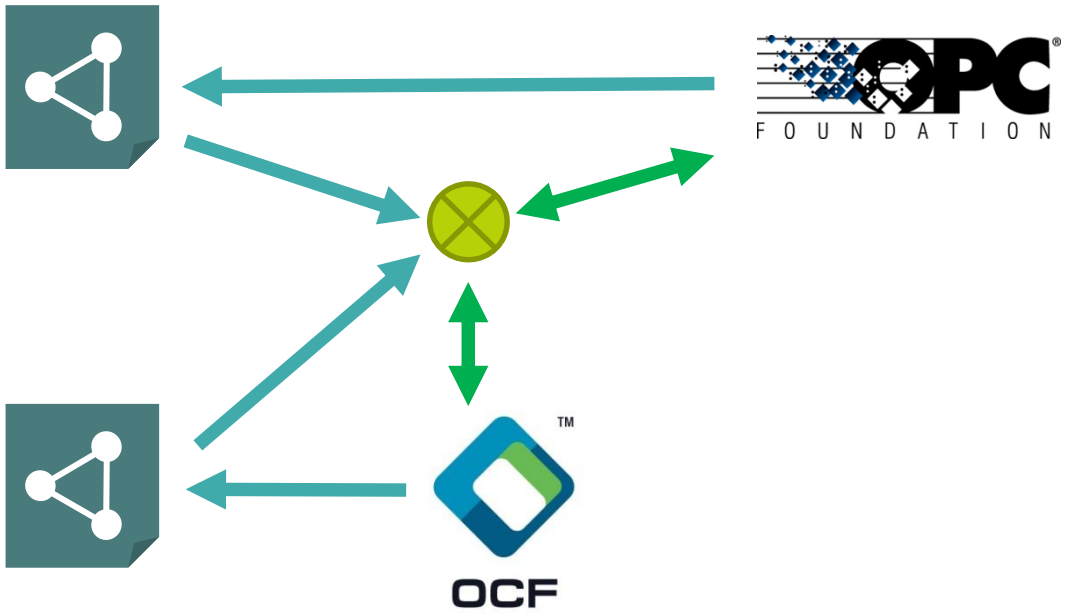
WoT Approach: 3b. Connect via a Bridge



WoT Approach: 3b. Connect via a Bridge



WoT Approach: 3c. Bidirectional Bridging



How to Build Bridges?

- One by One
  - Needs (roughly) N^2 bridges, and so N^2 effort for N standards
    - Still feasible if small N and if can outsource work, or streamline it somehow
- Using Common Intermediate
  - Equivalent to getting everyone to agree to one standard in the first place
    - May not even be feasible in theory
    - Legacy devices, incompatible regulatory environments, NIH, etc.
- Automation
  - Needs extra information about each interface: “metadata”
    - *This is the approach the WoT effort is trying to facilitate*

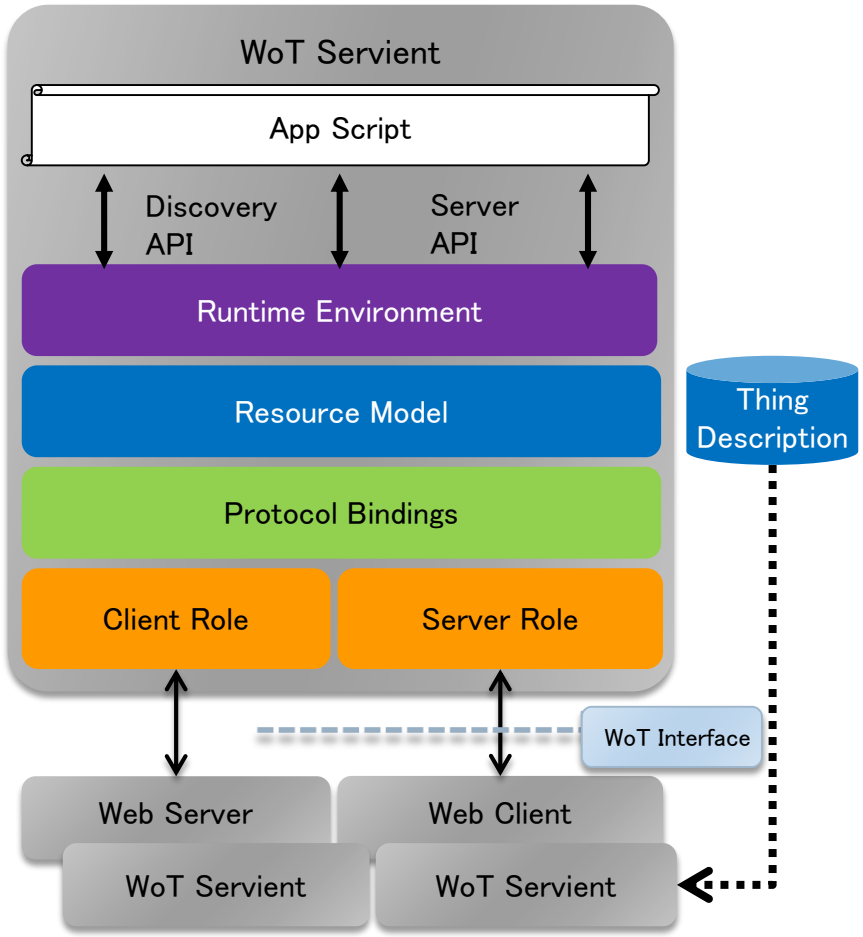
Anti-Recommendations

These are NOT recommended

1. Let the market sort it out [Null, do-nothing option] (Google vs. Apple vs….)
   - "Vertical" walled gardens will inhibit interoperability
   - Poor security across domains, slow growth
2. Crowd-sourcing (Microsoft's strategy for OCF bridging)
   - Still $O(N^2)$ work
   - "Many point solutions" limits ability to compose new services from existing ones
   - Poor security across bridges, slow growth
3. Build it and they will come
   - Intel does not have enough market influence on its own, NIH
   - CPU performance and hardware features alone are insufficient

Web of Things: Interest Group Members

Web of Things: Current Reference Architecture



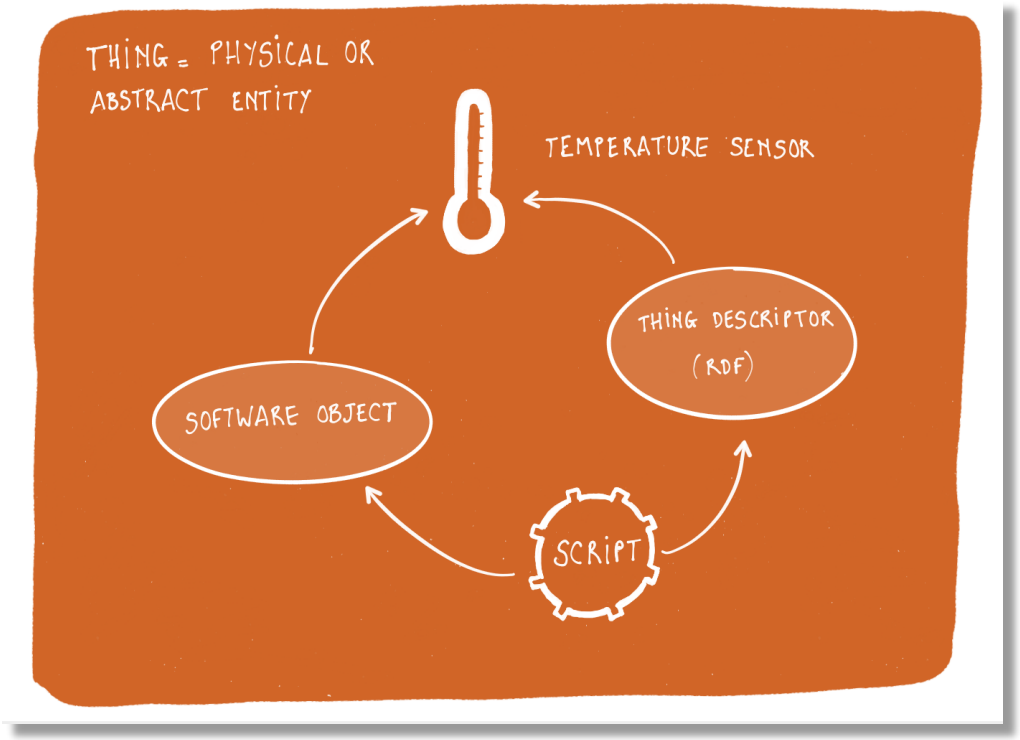
Things can simultaneously be both clients and servers

- "Servients"
- Use plugin "connectors" to specific protocols
- Can be different protocols on different connectors

Proposed WG deliverables to include

- **Thing Description** (TD) metadata format
- Language-independent "Scripting API"
- Protocol binding
  - –Map from abstract "interaction model" to concrete protocol
- Security management

Web of Things: Thing Abstraction



Applications act on "Things"

- Things are *software objects*
- Digital avatars representing physical or abstract entities (such as services)
- Have properties, support actions and events
- Can be local or remote

Metadata descriptions for every "Thing"

- Each Thing has a URI for its name
- URI provides access to its description
- Ontologies describe Things and their relationships
- Using W3C's Linked Data semantic framework

TODO

- POCs, Testbeds, implementations
  - AWS Alexa/WoT demo at TPAC and Re:Invent
  - Node-wot engagement with OTC (Zoltan, under Sakari)
  - OCF meta-data bridge
- Audience and Stakeholders
  - Who wants this and why? Who is engaged? Make a map.
  - CCG (DCG?):Amazon (Steve Berg is BDM), not IoTG
  - Google
- Explanation
  - Focus on TD and main value prop; use a Concrete example
  - Hide unnecessary detail
- Actions and Status
  - Provide information to support desired and necessary actions