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Defragmenting the IoT
with the Web of Things

Enabling Open Markets of Services

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Activity lead for Web of Data

FIWARE Summit, Porto
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CREATE-IoT U4IoT ACTIVAGE PROJECT IoF 2020 INTERNET OF FOOD & FARM MONICA SYNCHRONICITY AUTOPILOT F-INTEROP

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Defragmenting the Internet of Things

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- The Internet of Things refers to connected sensors and actuators and the idea of digital twins
  - Huge potential across many application sectors
- But *highly* fragmented with myriad technologies and a lack of interoperability for devices and platforms
  - This imposes market friction and holds back the potential
- W3C is defining Web standards to unlock the potential for open markets for suppliers and consumers of services
  - Interoperability at the higher levels where the value is highest
- Web of Things (= web of digital twins)
  - Services decoupled from underlying communication technologies
  - Things as software objects with properties, actions and events
  - Linked Data as basis for describing things and their relationships
  - Interoperable discovery and composition of services

Green shoots in a parched environment

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Web of Things

- **Web of Things Workshop hosted by Siemens, Berlin, 2014**
  - W3C workshops as a way to bring stakeholders together to discuss a particular technical area
    - Is there broad agreement on what's needed?
    - Is it timely to start work on it?
    - Who would participate in such work?
- W3C Web of Things **Interest Group** launched in 2015, followed by the **Working Group** in 2017

Describe & Complement Existing IoT Systems

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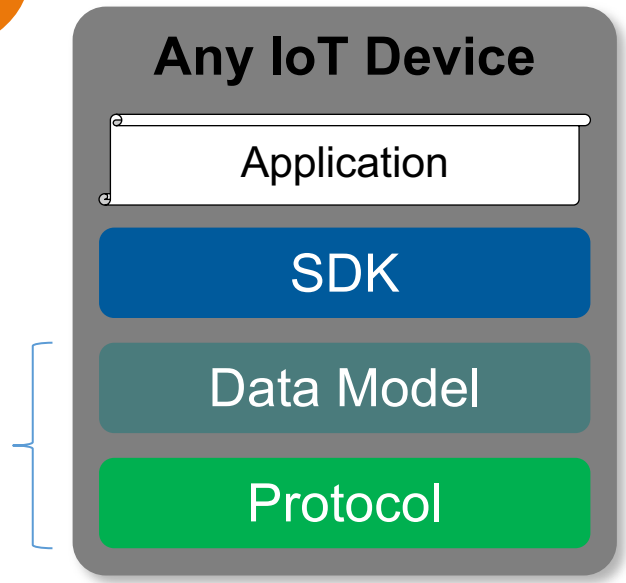
Provide **semantic metadata** that uniformly describes how to interact with Things

Implicit interaction model, typically not well documented



Define a **common runtime** for IoT applications that mimics Web development

Every SDK and library is different, so that app development is expensive

Capture each protocol once in a uniform template that describes how to configure common protocol stacks (e.g., CoAP or MQTT) to send the message expected by the Thing

The IoT has a plethora of protocols, often dialects due to custom options

With thanks to Matthias Kovatsch

W3C WoT Plans for next 12-18 months

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- Web of Things Working Group progressing work items to Candidate Recommendations
  - Thing descriptions and serialisation as JSON-LD 1.1
    - Programming language neutral description of things as objects
    - Work on application sector specific vocabularies is out of scope
  - Scripting API
    - Platform-independent application-facing API for Thing-to-Thing interaction and Thing lifecycle management
  - Declarative Protocols Bindings
    - For common protocols, e.g. HTTP, CoAP, WebSockets, MQTT
  - Security and Privacy Guidelines
    - How to enable end to end security across different IoT platforms
  - Short term charter extension may be needed to advance work items to CR
- Re-chartering the Web of Things Interest and Working Groups
  - Current charters expire at the end of 2018
  - Scope and objectives for future work is now under discussion

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Things and cloud instead of things to cloud

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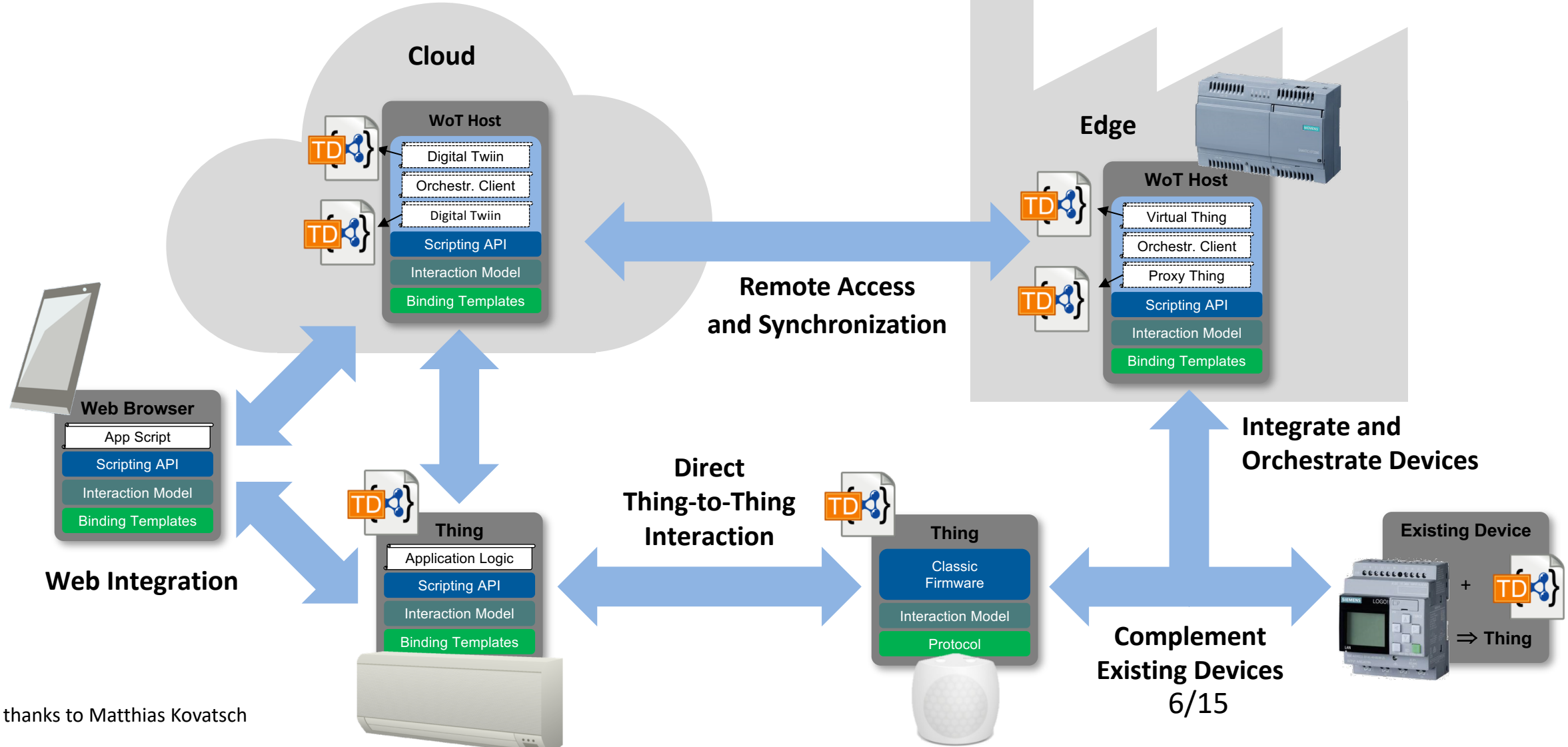

With thanks to Matthias Kovatsch

Web Architecture as Key to Interoperability

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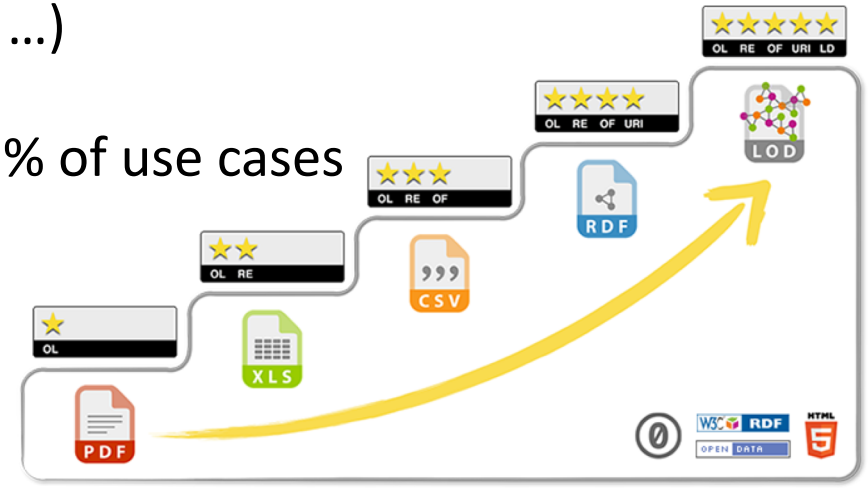
- Web Architecture is based upon three core aspects
  - URIs as addresses for resources
  - Standard data formats, such as HTML, which embed links to other resources
  - Standard protocols for retrieving resources such as HTTP
- For the IoT this translates to
  - URIs for naming things
  - Linked Data as the basis for describing things (JSON-LD, Turtle, …)
    - Dereference thing URIs to obtain thing descriptions
  - Standard protocols such as HTTP and WebSockets that fulfil 99% of use cases
    - Gateways at the network edge to address myriad IoT protocols
- Interoperability star rating
  - Let's be inspired by Tim Berners-Lee's star rating for data!



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Open question: complementing or subsuming existing IoT frameworks?

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- Enabling open markets for suppliers and consumers of services
  - Discovery based upon thing metadata (objects, semantics, context)
  - Design and deploy service compositions
  - Centralised marketplaces and ***much larger*** distributed marketplaces
- Duplicating the success of the Open Web of Pages
  - Exponential growth over many years and now over 2 billion websites
- Focus is on the Internet ***not*** the network edge!
  - Use gateways to strengthen security and decouple myriad IoT protocols
  - Use HTTP and WebSockets for Things supplied and consumed over the Internet as part of the Open Web of Things
  - Avoid need for developers to provide complex protocol binding information
- Web of Things as major simplification for Internet based services
  - Replacing siloed standards and isolated proprietary ecosystems

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Adaptation to Variation in Devices

- Manufacturers seek to differentiate their products from their competitors
- Manufacturers often offer customers a choice from a product range
  - Low end models offering just the basic features
  - More expensive models offering extra features
- Web of Things applications that can adapt to variations in device capabilities and how these are exposed as thing properties, actions and events
- Based upon semantic descriptions of things and the context in which they are used
  - Linked from thing descriptions that describe the object model (properties, actions, events)
  - Involves the need for domain specific vocabularies
- A very good reason for learning how to use semantic technologies!

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Semantic Interoperability

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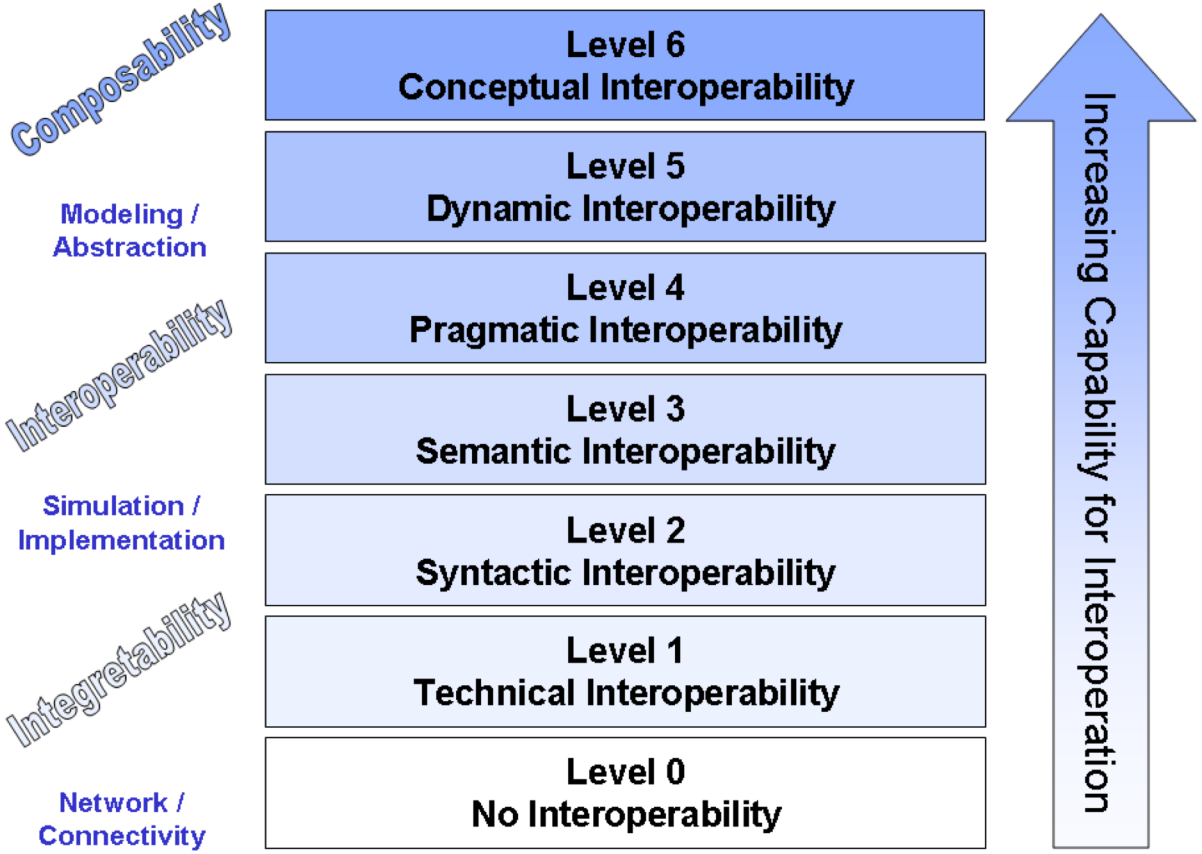
- Interoperability can be defined at multiple layers of abstraction
  - Physical, Network, Transport protocols, data formats and encodings, and higher layers
- The Web of Things enables semantic interoperability
  - Agreement on the meaning of data as well as its format and type
  - A temperature measurement of the engine block in degrees Celsius
- Important for composability of services
  - e.g. identifying need for conversion of units of measure



Turnitsa, C.D. (2005). Extending the Levels of Conceptual Interoperability Model. Proceedings IEEE Summer Computer Simulation Conference, IEEE CS Press

Interoperability Testing: Web of Things

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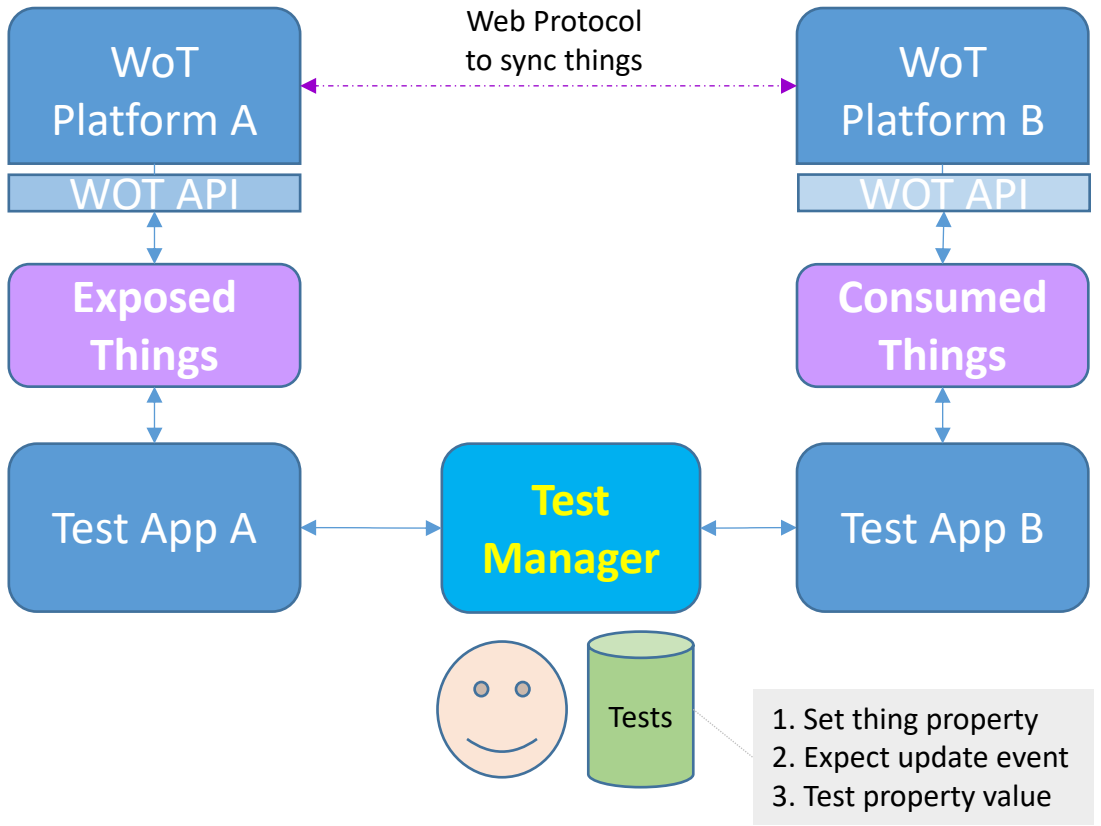
- Test interoperability between Web of Things platforms
  - Testing at WoT API level, ***not*** protocol level
  - Suite of things to cover thing description specification
- Platform A hosts application that exposes suite of test things
- Platform B hosts application that consumes suite of test things
- Design these things as test harnesses that connect to **F-INTEROP** test manager via separate communication channel
  - e.g. WebSockets as convenient protocol with reliable bi-directional asynchronous messaging using JSON messages
  - Web page as user interface for test management
  - Things use Web of Things API to invoke and monitor test results on behalf of test manager
  - Web app as a lightweight alternative to F-INTEROP?



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Opportunities for FIWARE

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- To take on a pivotal role in driving exponential growth of services through adoption of the Web of Things so that
  - FIWARE is to Web of Things as Apache HTTP is to Web of Pages
- Convergence on Linked Data as framework for semantics
  - FIWARE Context Broker in relation to Linked Data
    - Adding value to the Linked Data core standards
  - Discussion on NGSI-LD in respect to W3C & Linked Data
    - Coordination on messaging on work by each organisation
  - Plans for W3C Workshop on next steps for Linked Data
    - More details in a later slide

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Data Management and Governance

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- Data is increasingly of strategic importance to enterprises
- Need to connect data and metadata
  - Industry 4.0 and tracking components throughout lifecycle
  - Public health concerns and complex food supply chains
  - Ethical concerns about how consumer products are produced
  - Need to address evolving requirements for privacy
- Data governance: data quality, data models, metadata, security, trust, provenance and privacy
  - This calls for a consistent enterprise wide approach
- Enterprise knowledge graphs as the solution
  - Reality of data management across heterogeneous distributed systems
  - W3C's suite of standards for the Web of Data
    - Including work on dataset catalogues – DCAT-rev

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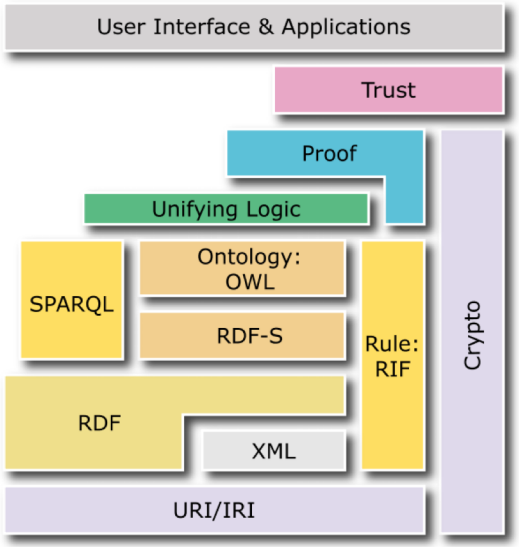
Learning from two decades of experience with RDF and Linked Data



- Plans for W3C Workshop late 2018 in Europe
- Identifying opportunities for new standards
  - Extending RDF to embrace Property Graphs
    - Annotations on relationships
    - Amazon's Blazegraph
  - Digitally signed RDF graphs – e.g. ontologies
    - Where you want to ensure graph hasn't been modified
  - Addressing scalability for communities with differing requirements
    - Context sensitive data mappings for vocabularies with overlapping semantics
  - Blending ideas from Cognitive Science, Sociology, …
    - Dealing with incomplete, uncertain and inconsistent knowledge
    - Unlocking the potential for machine reasoning with natural language
- What's needed to support Enterprise Knowledge Graphs?

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Thank You!

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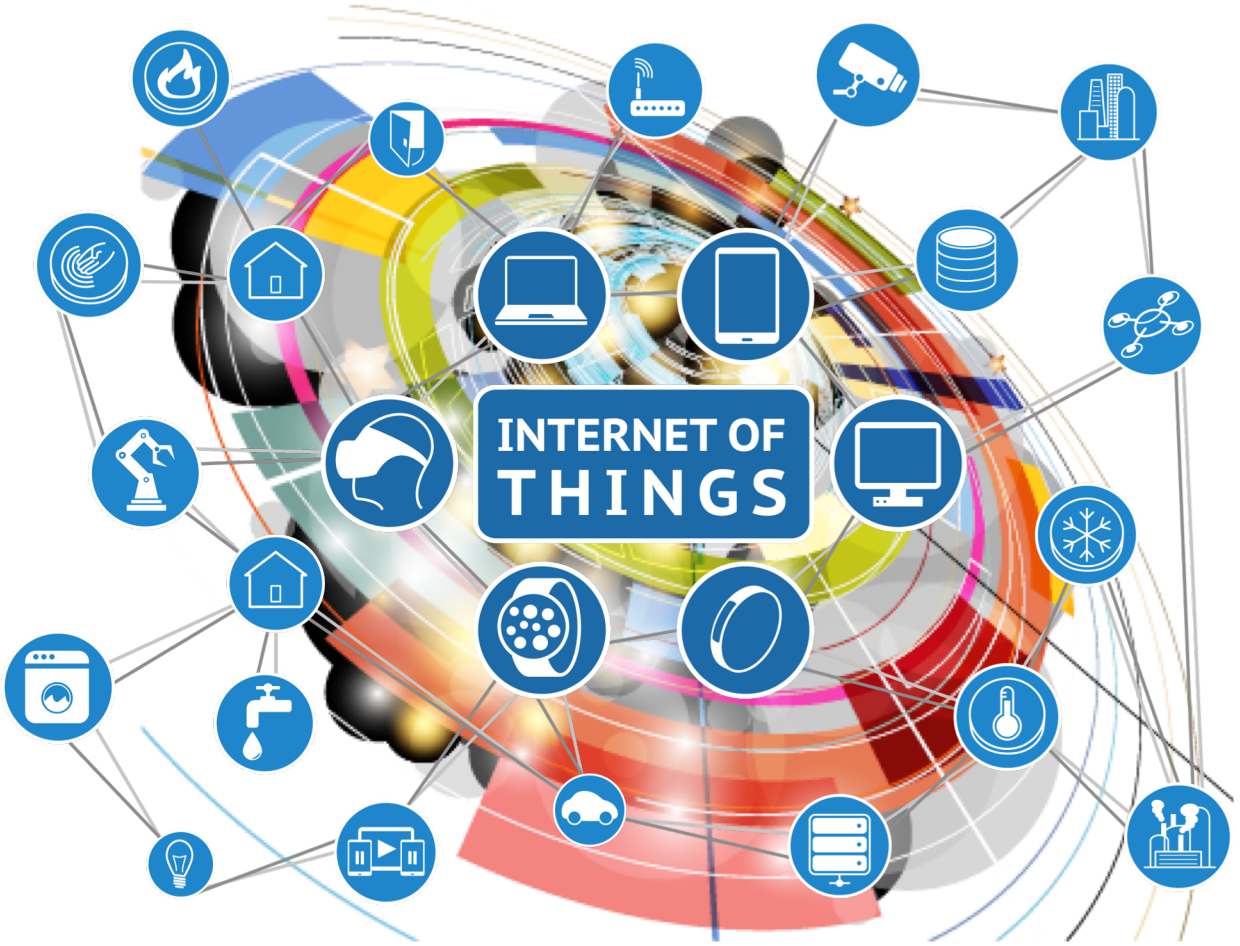

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Open Source Implementations

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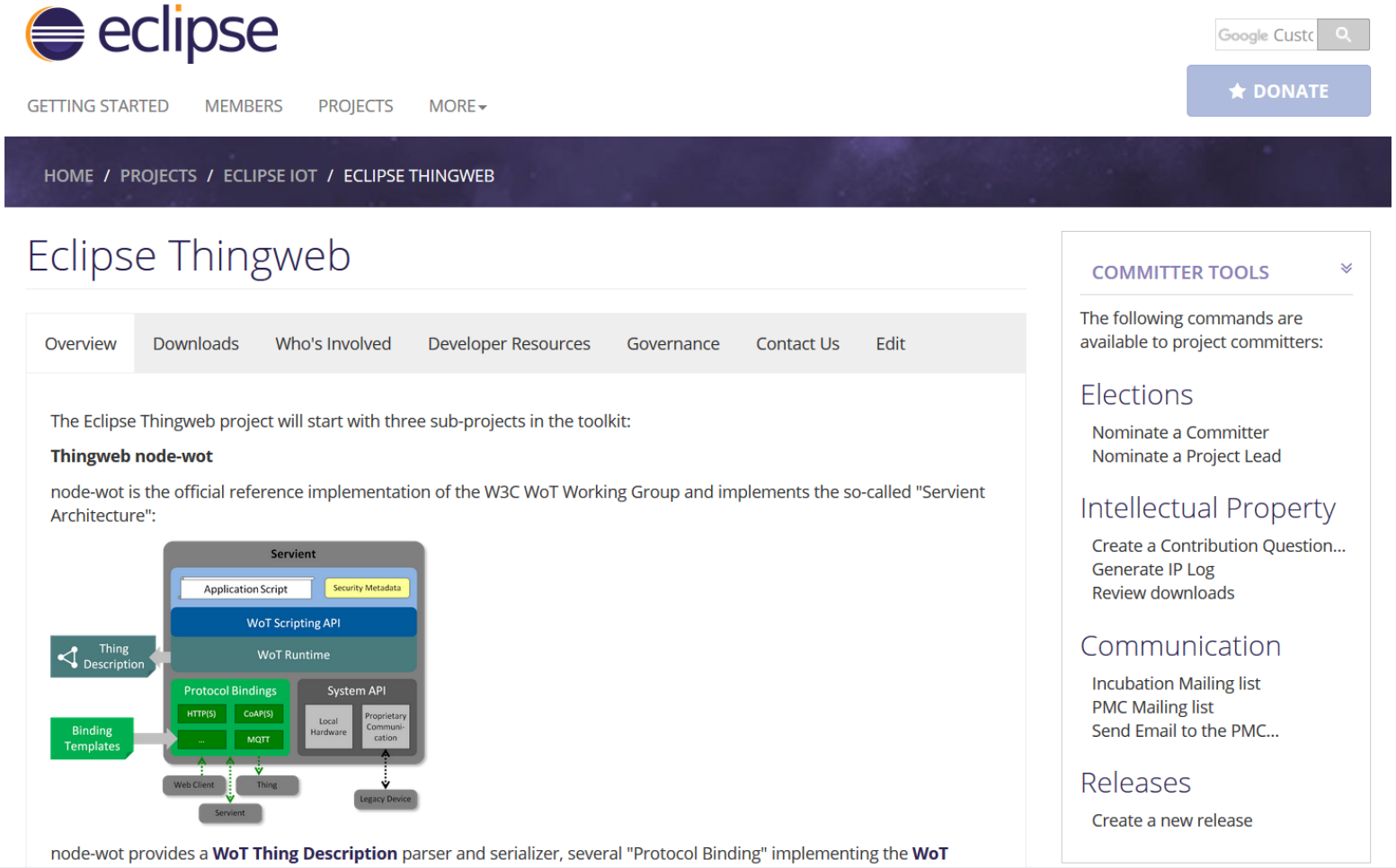
- Open-source W3C WoT reference implementation
  - node-wot (WoT Host)
    NodeJS + TypeScript
  - Thingweb Java (WoT Host)
    Java
  - Thingweb Directory
    Java + Apache Jena
  - Thingweb UI
    AngularJS
- More tools expected to follow
- https://github.com/thingweb



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WoT Plugfests to Explore Ideas

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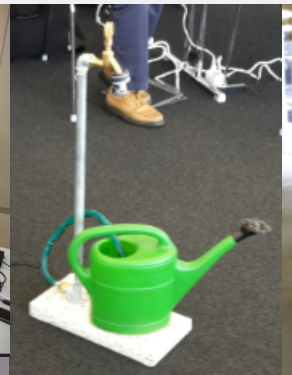


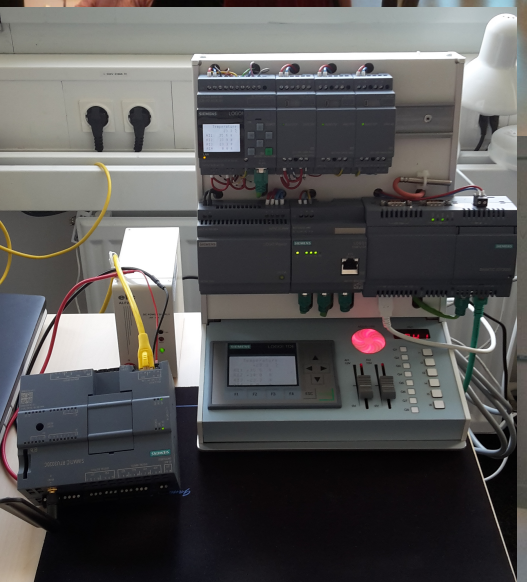
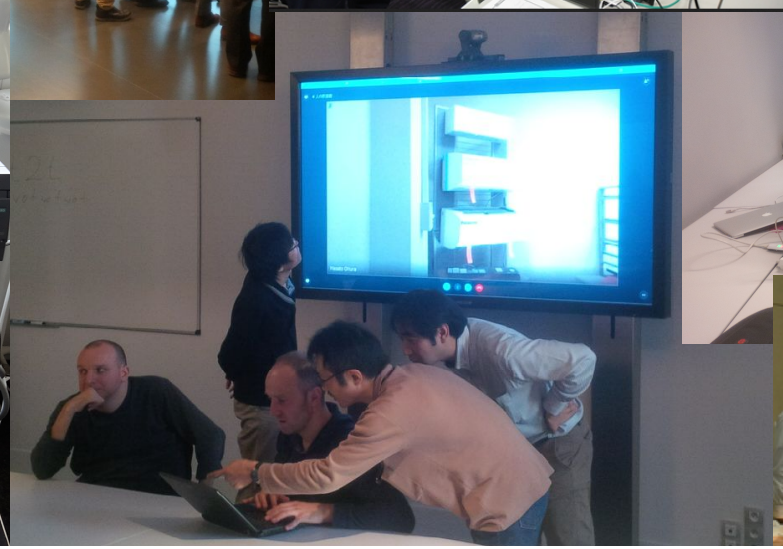
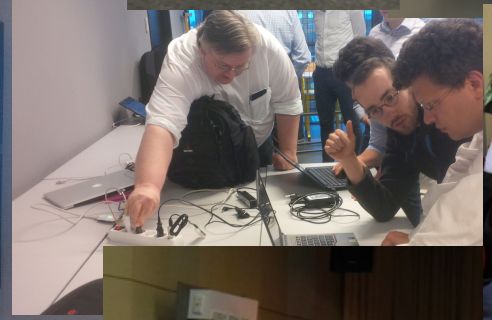
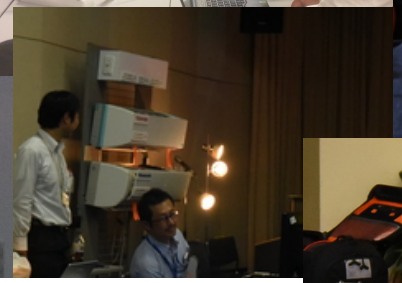


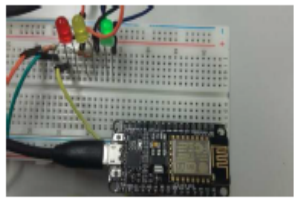

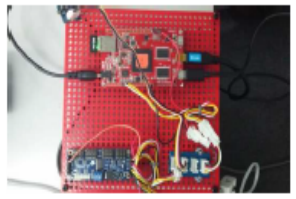

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W3C Liaisons – Web of Things as Neutral, Horizontal, Cross-domain Solution

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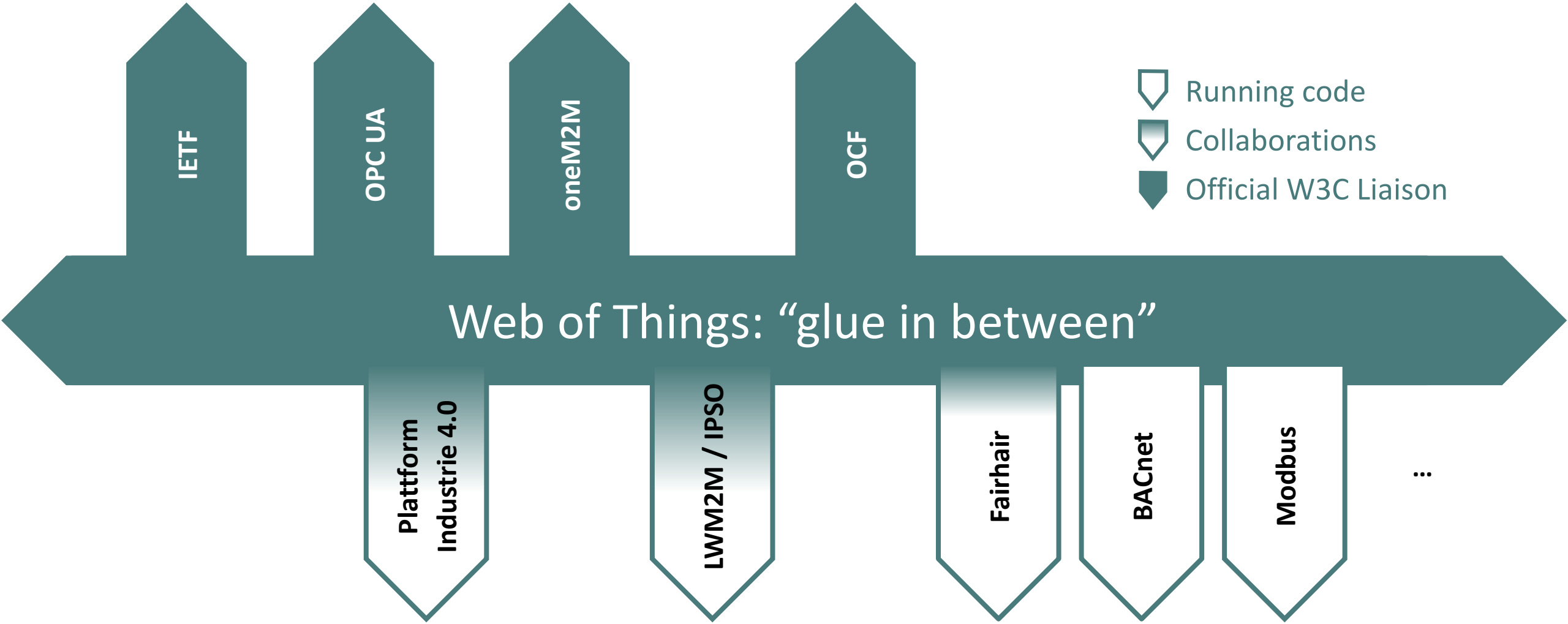

With thanks to Matthias Kovatsch

Who's Who

European Large-Scale Pilots Programme

- WoT WG Chairs
  - Matthias Kovatsch (Siemens), Kazuo Kajimoto (Panasonic), Michael McCool (Intel)
- WoT IG Chairs
  - Matthias Kovatsch (Siemens)
  - Yongjing Zhang (Huawei)
- Staff contacts
  - Kazuyuki Ashimura, Dave Raggett
- Web of Things Champion
  - Dave Raggett <dsr@w3.org>