Web of Things

Countering Fragmentation to
unlock the potential of the IoT

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W3C Staff Champion for the Web of Things

Internet of Things (IoT)

- “IoT” coined by Kevin Ashton in 1999
- Generally used for sensors and actuators that are connected in some way to the Internet
- Sensing and controlling physical **things** in conjunction with other data
- Enabling collection of vast amounts of data

IoT Applications

Smart Homes

Wearables

Healthcare

Power & Environment

Smart Cities

Manufacturing

And many many more application areas

Some IoT Benefits

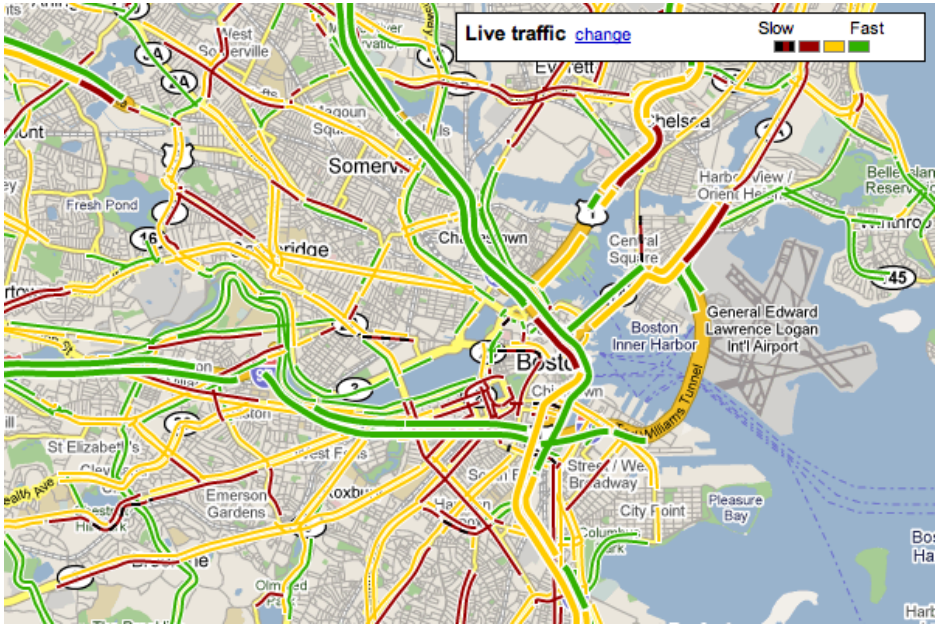
- Predictive maintenance, e.g. for railway networks, power stations, manufacturers, etc.
  - Reduced down time, enabling massive savings
  - Reduced maintenance costs compared to fixed schedule
  - Also valuable for consumers, e.g. cars, washing machines, etc.
- Analytics for cost savings and enhanced customer experience
  - Design improvements based upon statistics of use
- Better asset utilization for manufacturing lines
  - Purchasing and investment tied to accurate data measurements
  - Switching from mass production to mass customization
- Assistive living for people with physical or cognitive impairments

Data = Improvements in Wellbeing

- As people live longer, IoT sensors can help to improve their quality of live, and reduce costs of healthcare, freeing money for other purposes
- Anonymous datamining of healthcare records can improve effectiveness of medication and enable the development of new treatments

Data = Money

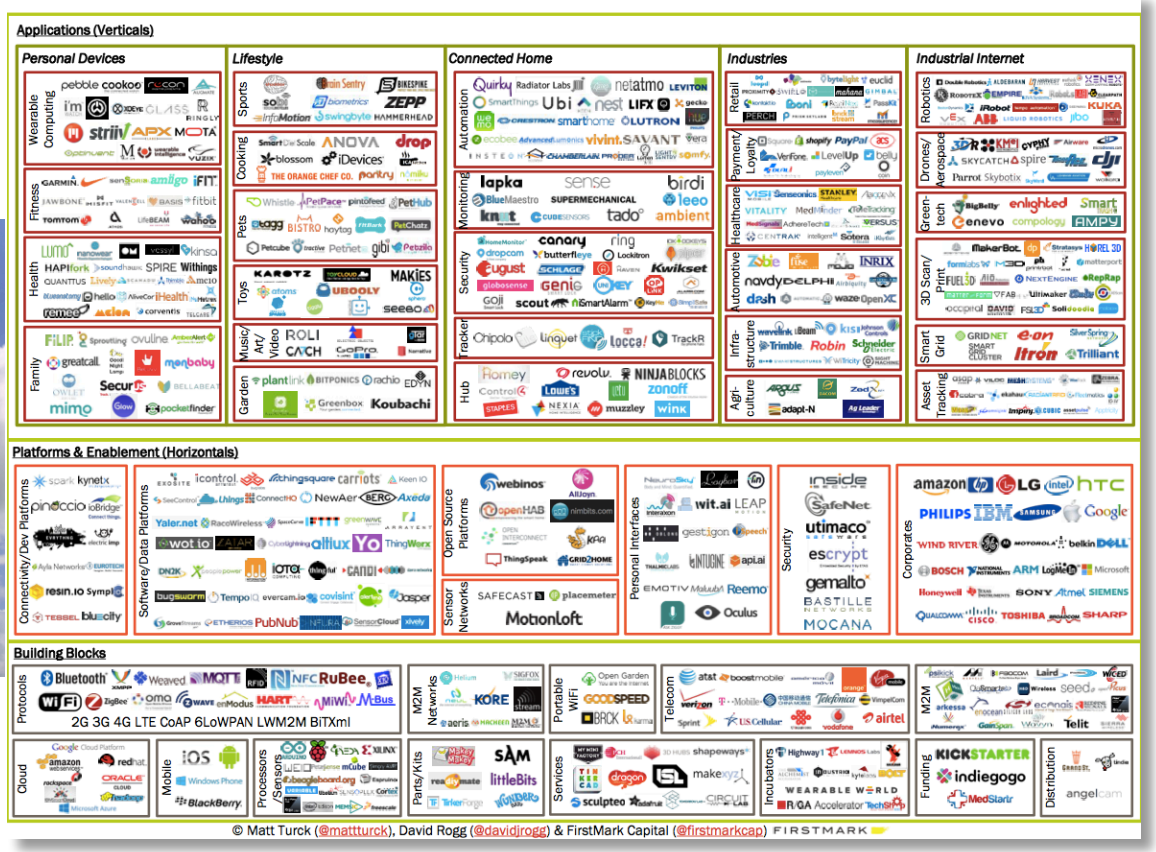
- Good quality data can be monetized
  - Everyone carries location sensors (smart phones)
  - Anonymous data collection
  - Drivers love live traffic data
  - Planners need traffic data for all kinds of purposes



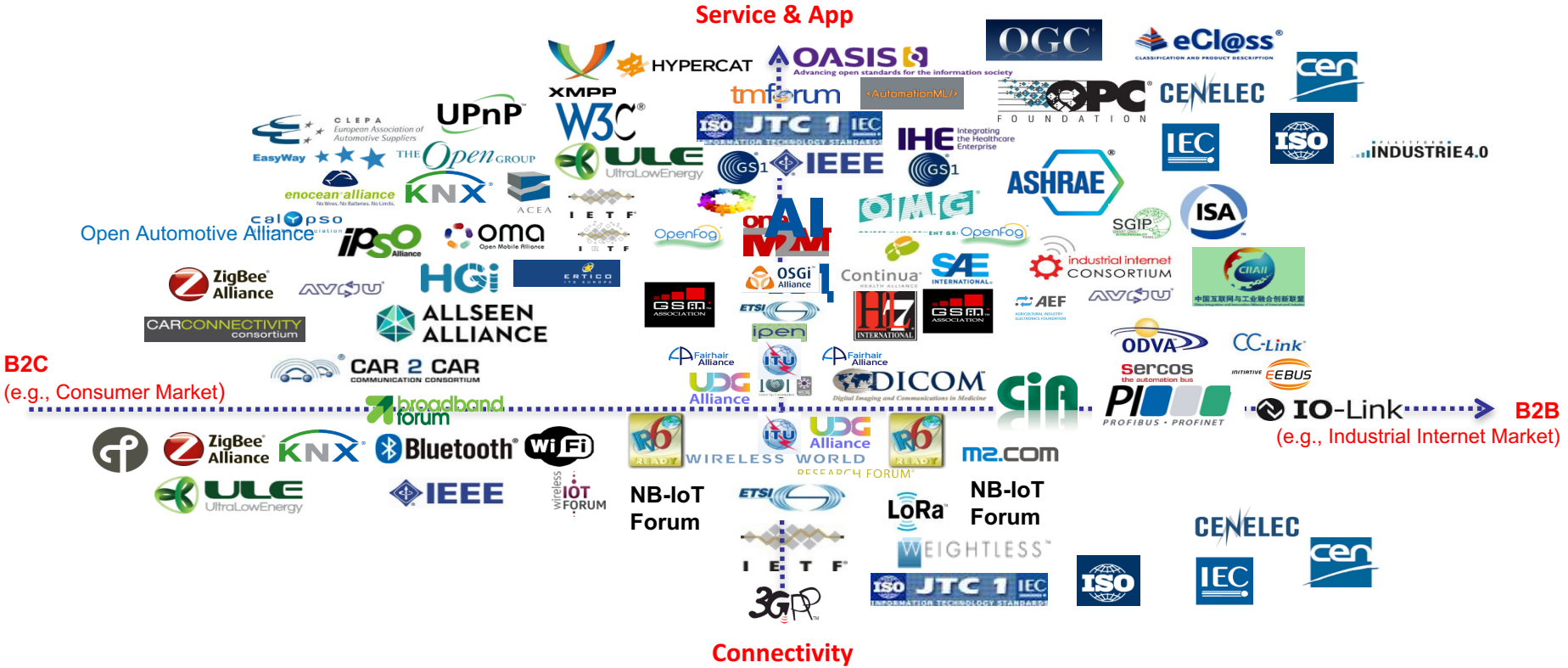
Managing Data Assets

- Rather than hoarding data, companies can seek a financial return on their data assets
- Either by licensing use of their data for direct use by others
- Or by providing a service that others can make use of
- Note: Regulatory implications for monopoly control over data critical to society

IoT Landscape

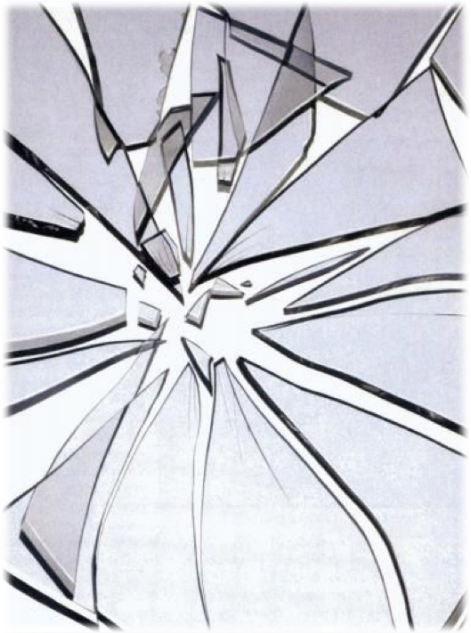


Many Standards Organizations



Source: AIOTI WG3 (IoT Standardisation) – Release 2.6

The IoT is Fragmented*



- Lots of incompatible platforms, standards and technologies
  - Even when using the same protocols
    - E.g. OCF and oneM2M both use CoAP, but are incompatible
- This is holding back the market potential by
  - Increasing the costs and complexity for developers
  - Increasing the risks for both investors and customers
  - Making it harder to realize the value of data

* CES 2017 – large number of incompatible smart home offerings with little chance of commercial success

Just how much do I need to learn?

- So many protocols, e.g.

  CoAP, MQTT, AMQP, HTTP, WebSockets, ZigBee, Z-wave, Thread, Bluetooth, LPWAN, KNX, EnOcean, DALI, LwM2M, LoRaWAN, Weightless, BACnet, HART, HostLink, EtherCat, ModBus, PROFINET, Profibus, BSAP, MelsecNet, DirectNet, 6LoWPAN, 6TiSCH, DASH7, X10, HomePlug, mDNS, SSDP, ….

Countering Fragmentation with the Web of Things

- **Making it much easier for developers**
  - Focus on how to interact with things as software objects with properties, actions and events
  - Avoid the need to learn the details of each IoT standards suite and protocols
- **Making it easier to discover, compose and sell services, independently of how they are implemented**
  - Enabling open markets of services on the scale of the World Wide Web

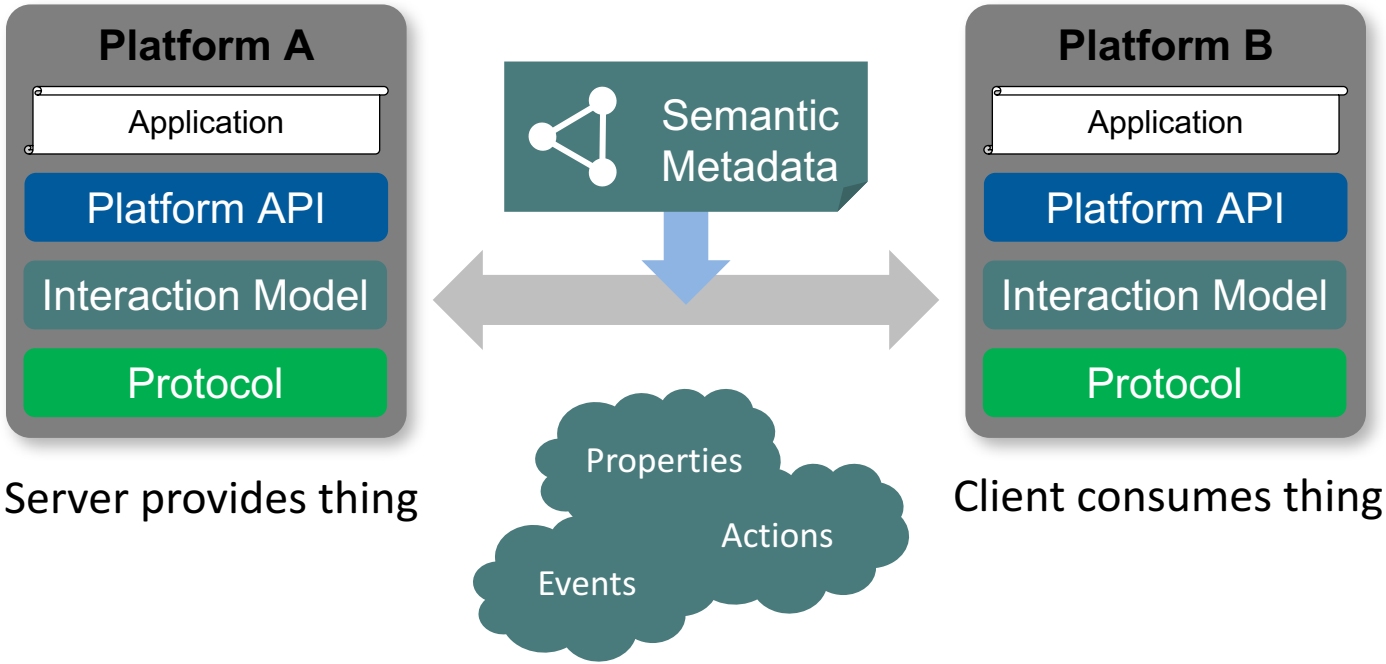
It’s all about Things

Providing a web of machine interpretable descriptions of things

- Things have **properties**
  - The temperature of this room
  - The state of a light switch (on or off)
  - Stream of electrocardiogram readings
- Things have **actions**
  - Fade lamp from daylight to a warm sunset
- Things have **events**
  - The door has just been opened
  - The battery is getting very low and needs replacing
- Things have **metadata**
  - Which room is this sensor in?
  - What is the vendor’s serial number for this device?

Things have relationships to other things, hence the “web” of things

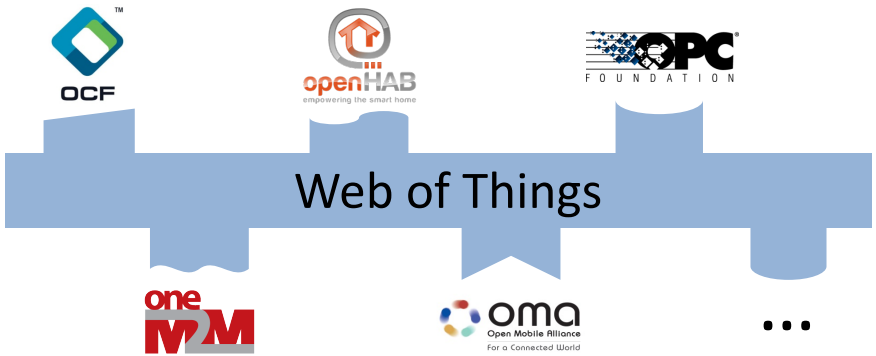
Simple, Common Interaction Model



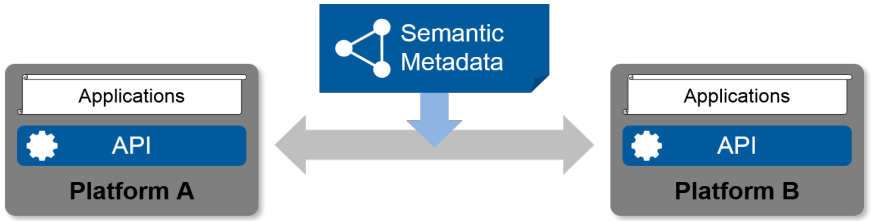
Based upon Linked Data, available in JSON

W3C as a key partner for the IoT

Building upon W3C's strengths with web scale interoperability – open web standards for APIs & metadata



interconnecting existing Internet of Things platforms and complementing available standards, to reduce costs, reduce risks and boost market opportunities



Metadata enables interoperability

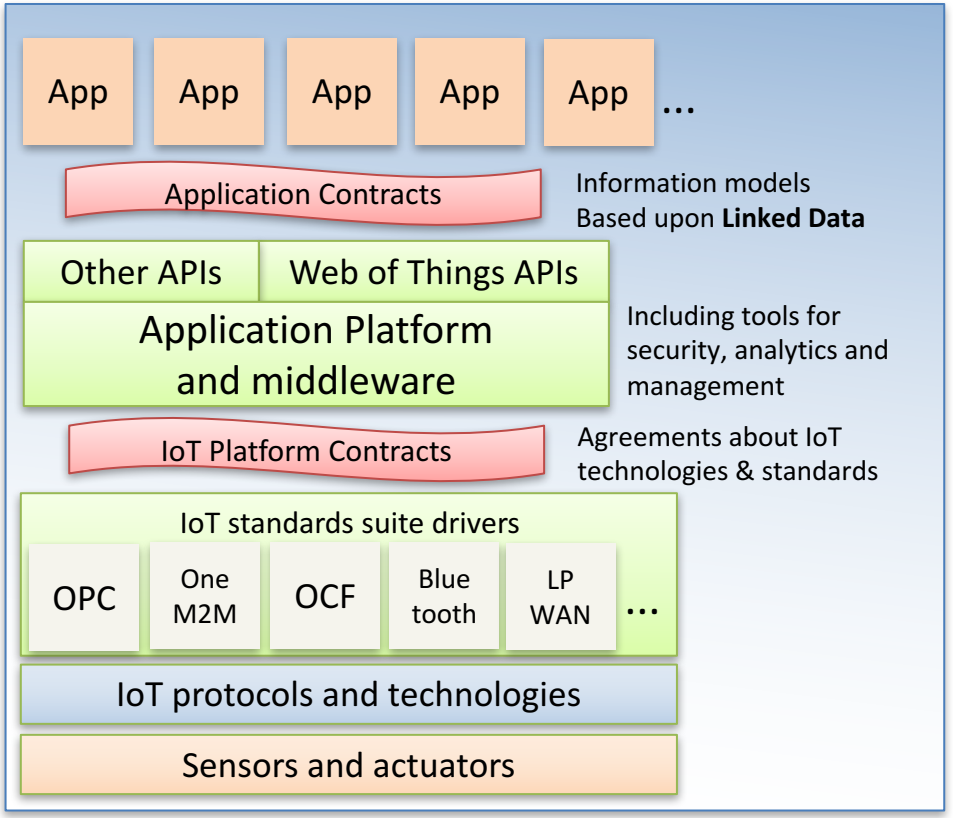
- Describe the interfaces exposed to applications
- Describe the communication and security requirements for accessing things
- Describe the data models, semantics, and domain constraints

Metadata simplifies application development

- Decouples underlying protocols
- Enables automated tooling

Web of Things

- An **abstraction layer** over heterogeneous IoT standards, communication patterns, protocols and data formats
- Applications interact with **software objects** for things that represent physical or abstract entities, e.g. sensors, actuators, virtual devices, cloud services, etc.
  - Each thing has a URI for its application contract
- Analogous to the role played by the Internet as an abstraction layer for networks and networking technology that has enabled trillions of dollars of services world wide
- Web of things application platforms can be located at the network edge, in the fog, in the cloud, peer to peer or a combination thereof



Web of Things Groups

https://www.w3.org/WoT/

- Web of things Interest Group
  - Launched early 2015
  - Pre-standardization actvities
    - Use cases and requirements
    - Experimental specs & Plugfests
    - Liaisons with external groups
    - Test frameworks
- Web of things Working Group
  - Launched early 2017
  - Cross domain vocabulary for thing descriptions
  - Serialization as JSON
  - Application APIs
  - Security review with help from other groups
    - Security metadata and cross platform approaches building on top of IoT platform security

Beijing F2F, 2016

Web of Things

Liaisons

Reaching out to industry alliances and SDO's to drive convergence to unleash the potential

- Open Connectivity Foundation
- oneM2M
- Industrial Internet Consortium
- Plattform Industrie 4.0
  Especially the "semantics" subgroup
- OPC Foundation
- IETF/IRTF
- Industrial Internet Consortium
- AIOTI
- IoT Security Foundation
- Schema.org
- etc.

Collaboration on demos, testing, security, Web of Things drivers, …

End to End Security

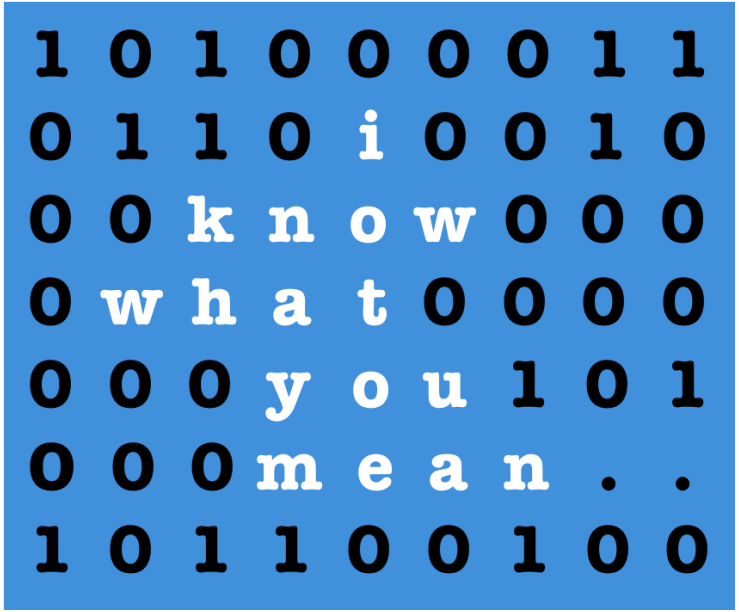
- Securing the Web of things
  - Security, Safety, Privacy, Resilience
- Building upon existing security standards
  - IETF, IoT Security Foundation, IIC, etc.
  - IoT platforms, e.g. OCF, oneM2M, OPC, …
- What additional security standards are needed for end to end security across different IoT platforms?
  - How to (re) bootstrap trust?
  - How to deal with insecure devices?

Discovery & Installation

- Discovering things near me
  - Bluetooth Beacons and Bluetooth peering
  - NFC, QR codes, IR and audio chirps
  - LAN with mDNS, UPnP, etc.
- Registering with home hub or a cloud based service
  - IoT device discovers hub or vice versa
- Websites that embed metadata on apps & services
  - For discovery by search engines
- Browser API for installing app on home hub or cloud
  - Browser dialog to request user consent

Semantic Interoperability

- Ensuring that communicating parties share the same meaning, e.g.
    - A temperature sensor that reports in Celsius.
  - Machine interpretable descriptions linked from interaction models
  - Support for discovery, composition, validation, and adaptation to variations in devices from different vendors
  - Need for lightweight vocabularies that make it easy for companies to describe their specific devices



Web of Things & Linked Data

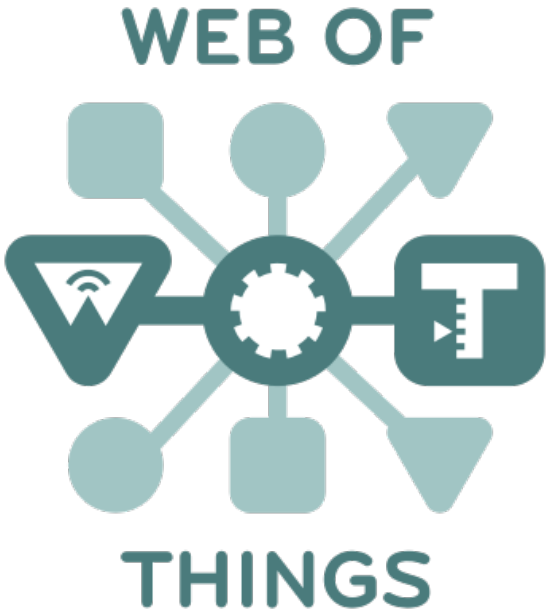
- A *lingua franca* for data and metadata
  - Basis for relating data and metadata in different formats and data models
- Concepts and their relationships are given globally unique identifiers using Web addresses
- These addresses can be used to obtain further information enabling a Web of Linked Data
- W3C has a wealth of experience in developing semantic technology standards
  - Existing standards, e.g. **OWL** ontology language, **SPARQL** query language (analogous to SQL)
  - Current work e.g. on **shape rules** for validation
  - Future work on the **Cognitive Web** for AI systems that think more like we do

Linked Data makes it easy to combine distributed sources of information

UK Companies House Linked Data Service

Getting Involved

- Opportunities to join Web of Things Interest and Working Groups
  - Participate in one or more task forces
    - Thing descriptions, APIs, Security, Linked Data & Semantic Processing, Testing, Liaisons
  - Contribute to use cases and requirements
  - Contribute to technical specifications
- For more information please contact
  - Dave Raggett <dsr@w3.org>,
  - Yingying Chen <yingying@w3.org>
  - Kazuyuki Ashimura <kaz@w3.org>



Demo