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
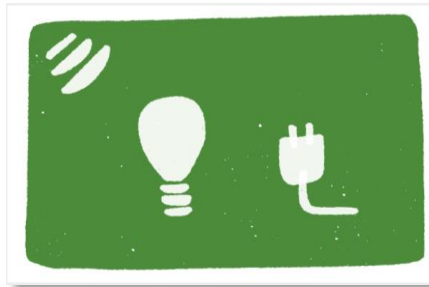
IoT Applications

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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

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- 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
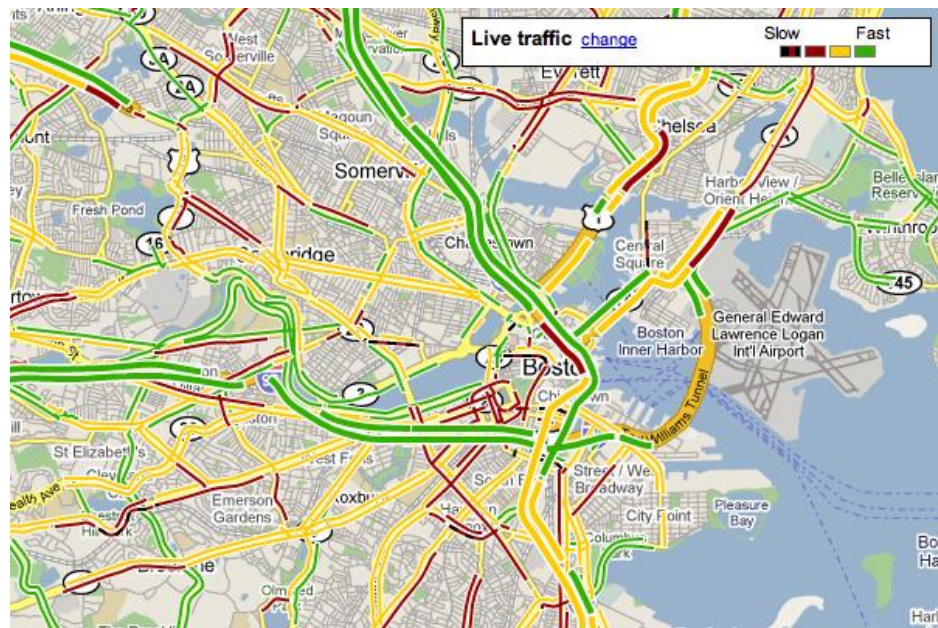
Managing Data Assets

- 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
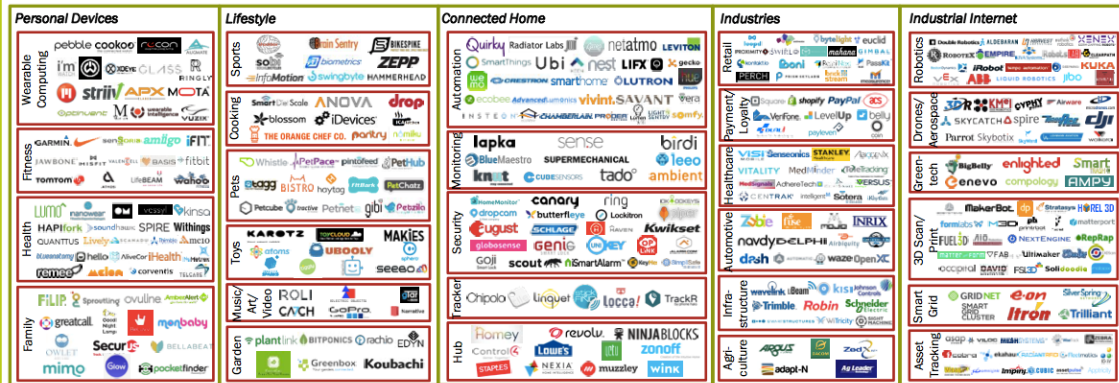- Note: Regulatory implications for monopoly control over data critical to society

IoT Landscape
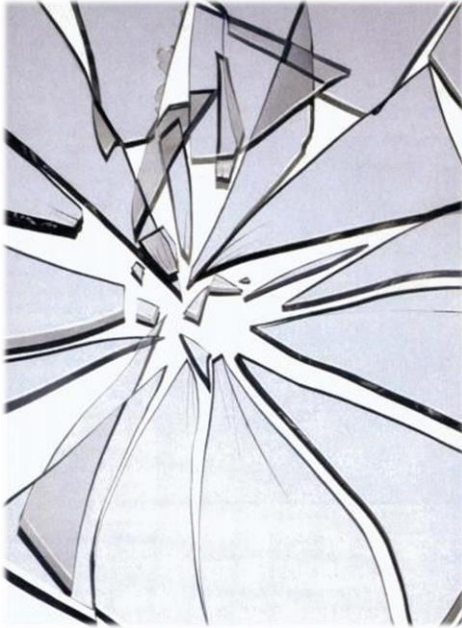
Many Standards Organizations

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
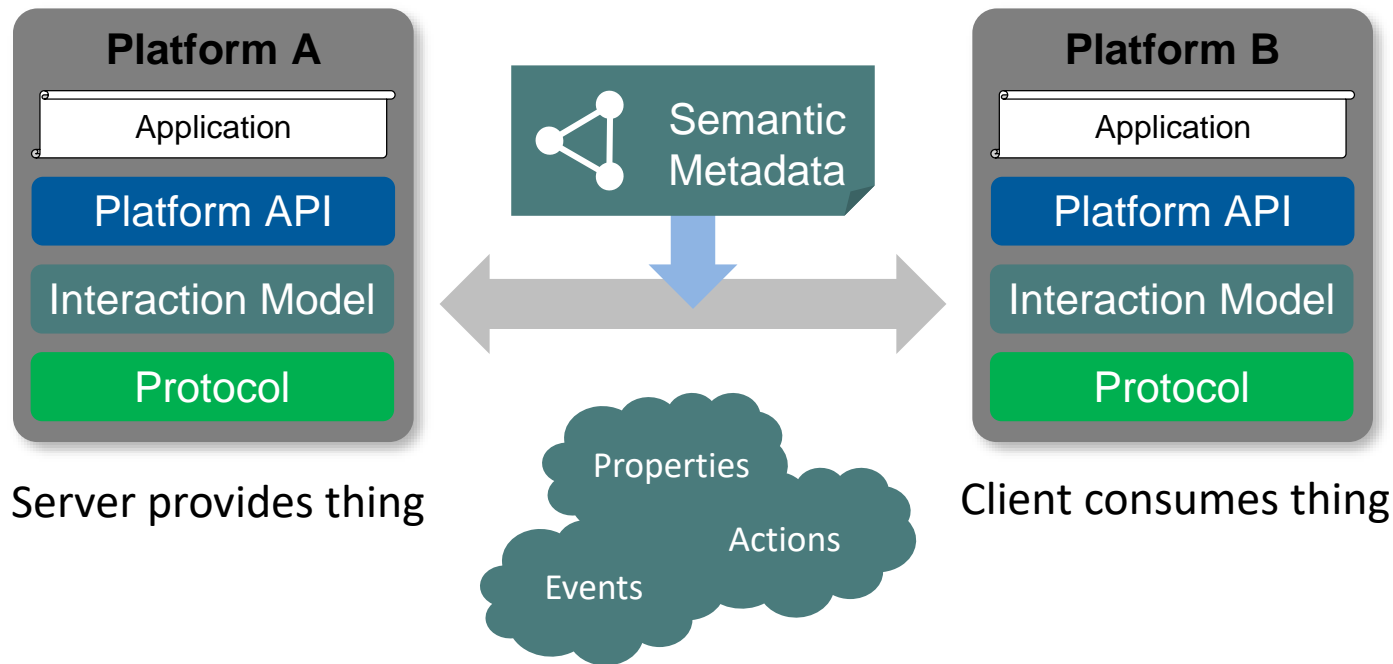
It's all about Things

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

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Platform A

Application

Platform API

Interaction Model

Protocol

Semantic Metadata

Platform B

Application

Platform API

Interaction Model

Protocol

Server provides thing

Client consumes thing

Properties
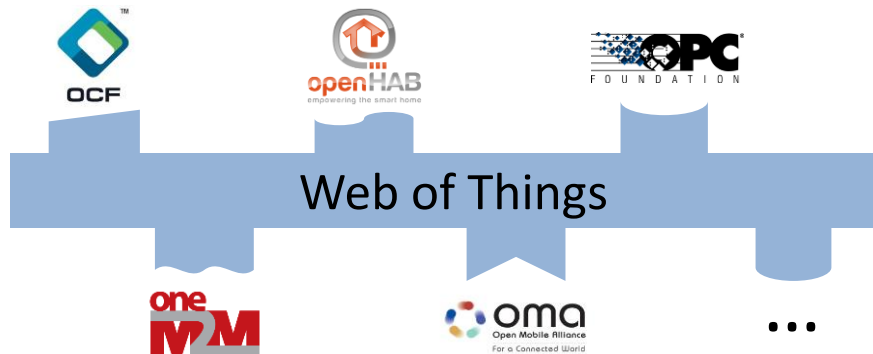
Actions

Events

Based upon Linked Data, available in JSON

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W3C as a key partner for the IoT

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

Web of Things

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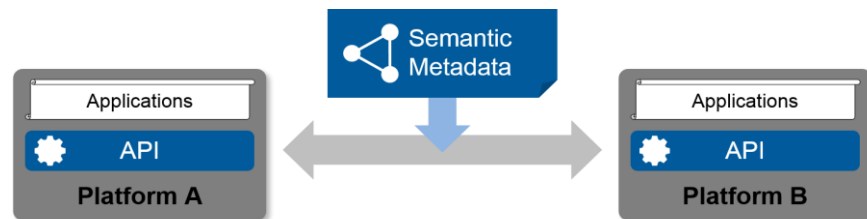
Metadata enables interoperability

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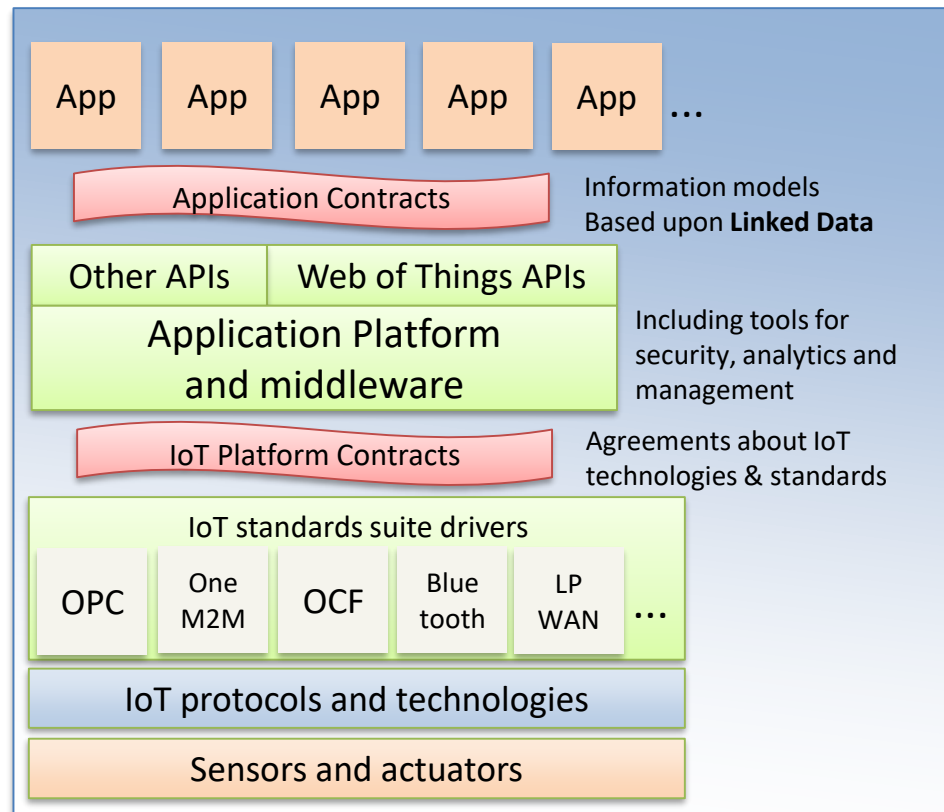- Describe the data models, semantics, and domain constraints

Metadata simplifies application development

- Decouples underlying protocols
- Enables automated tooling

Web of Things

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- 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

App App App App App ...

Application Contracts

Other APIs | Web of Things APIs

Application Platform and middleware

IoT Platform Contracts

IoT standards suite drivers

OPC | One M2M | OCF | Blue tooth | LP WAN | ...

IoT protocols and technologies

Sensors and actuators

Information models
Based upon **Linked Data**

Including tools for security, analytics and management

Agreements about IoT technologies & standards

Web of Things Groups

- 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

Osaka F2F, 2017

Web of Things

Liaisons

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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

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- 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

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- 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
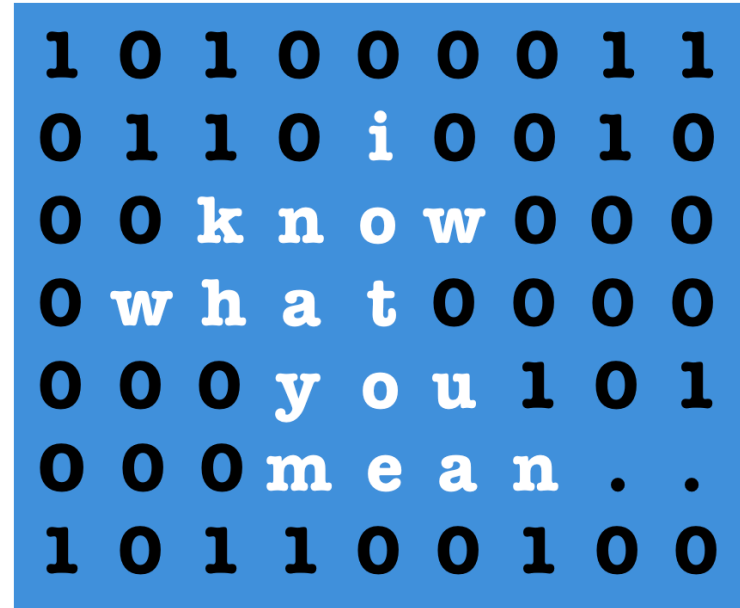
Web of Things & Linked Data

- 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

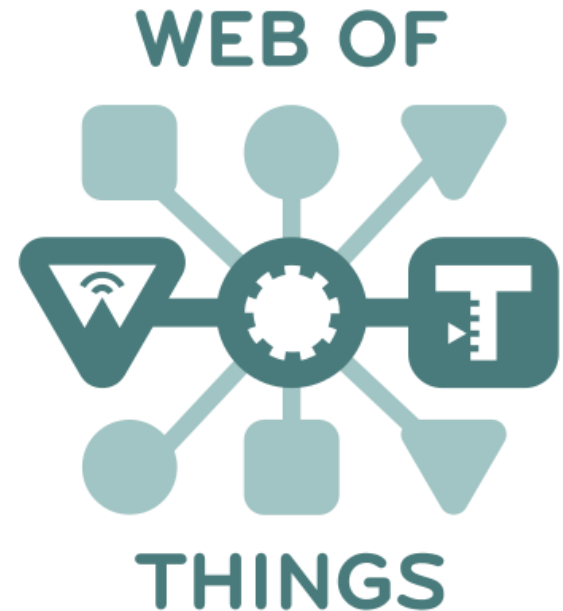Linked Data makes it easy to combine distributed sources of information

UK Companies House Linked Data Service

Getting Involved

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- 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>

WEB OF

THINGS

Demo