The Internet of Things: What's next?

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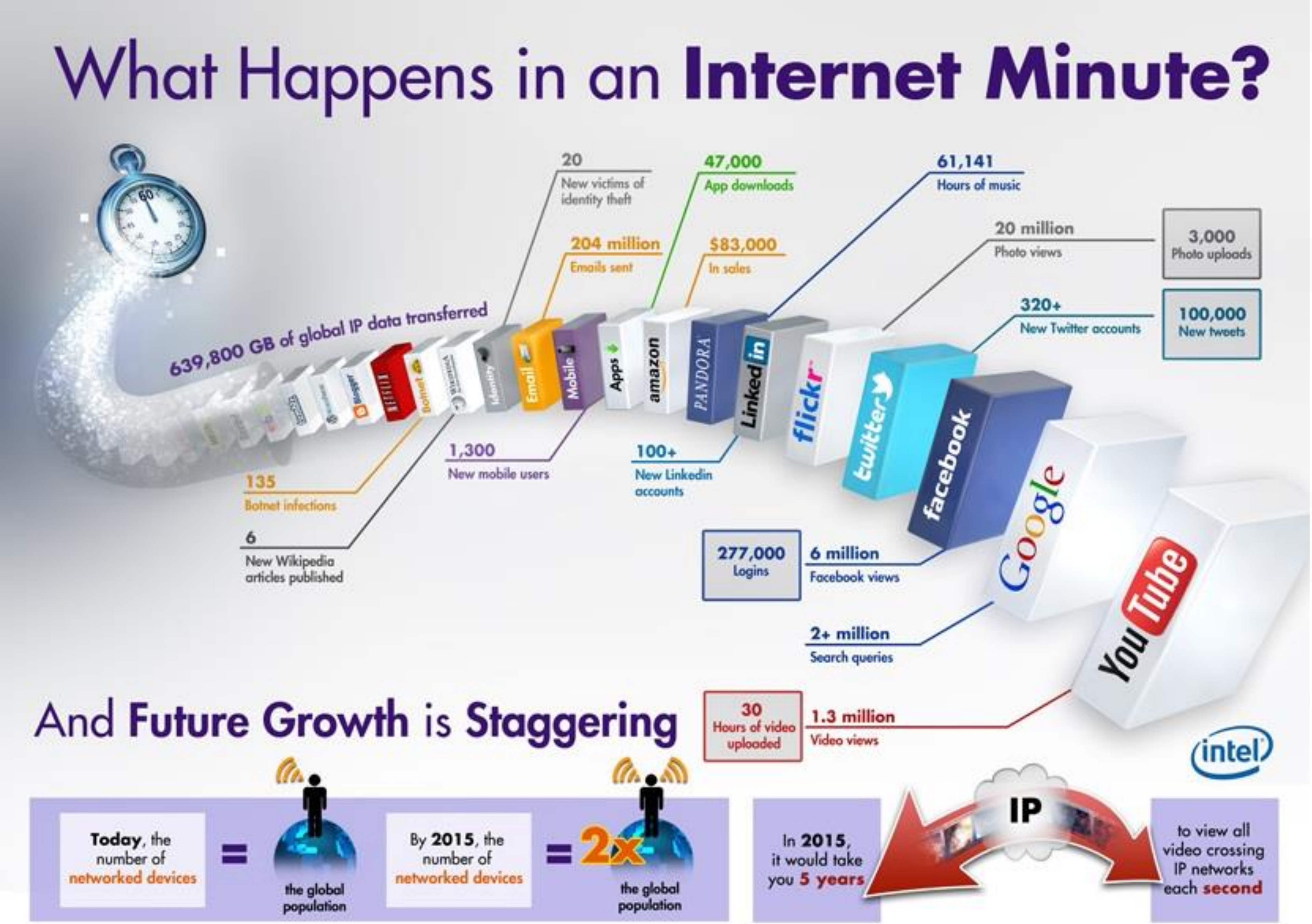
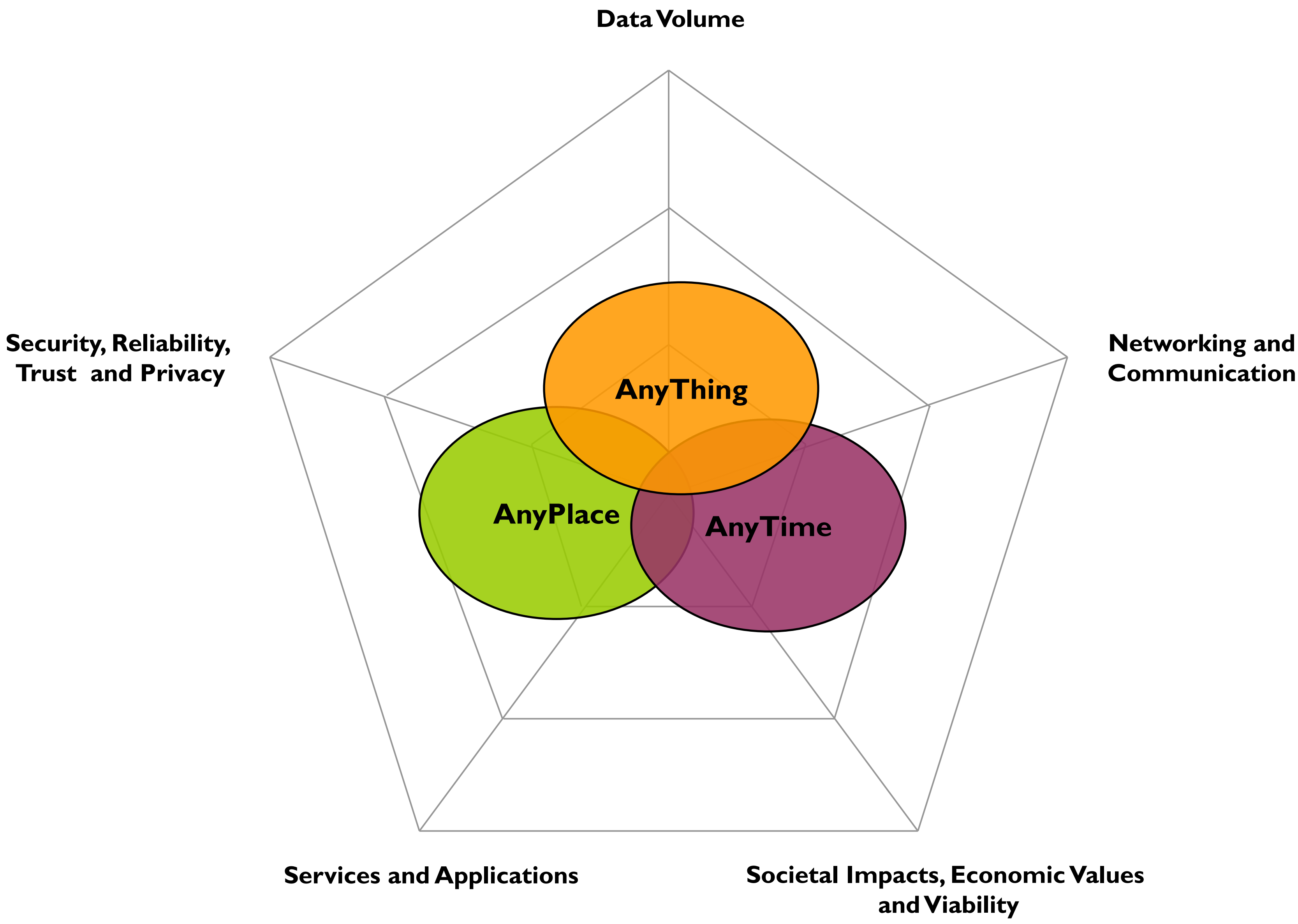
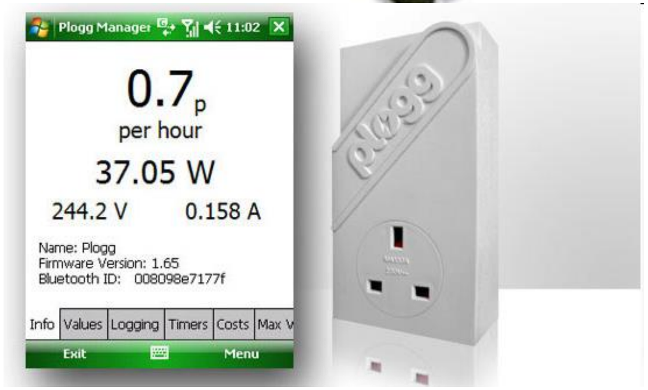


Source: Intel, 2012

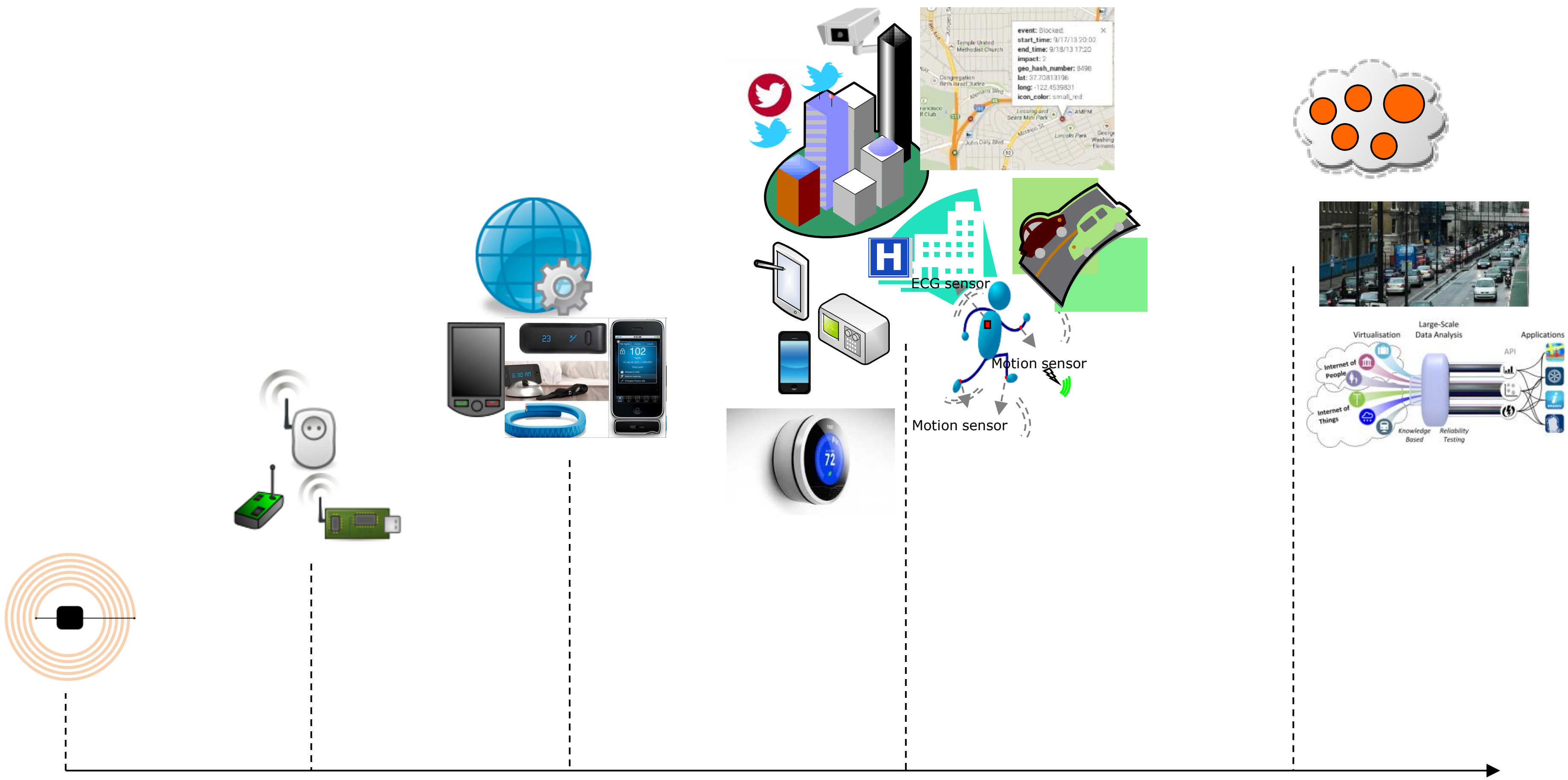

Data Volume
Networking and Communication
Societal Impacts, Economic Values and Viability
Services and Applications
Security, Reliability, Trust and Privacy
AnyThing
AnyPlace
AnyTime

Sensor devices are becoming widely available

- Programmable devices
- Off-the-shelf gadgets/tools



Internet of Things: The story so far



RFID based solutions

Wireless Sensor and Actuator networks , solutions for communication technologies, energy efficiency, routing, …

Smart Devices/ Web-enabled Apps/Services, initial products, vertical applications, early concepts and demos, …

Physical-Cyber-Social Systems, Linked-data, semantics, M2M, More products, more heterogeneity, solutions for control and monitoring, …

Future: Cloud, Big (IoT) Data Analytics, Interoperability, Enhanced Cellular/Wireless Com. for IoT, Real-world operational use-cases and Industry and B2B services/applications, more Standards…

Speed of light?

Image source: The Brain with David Eagleman, BBC

Data in the IoT

- Data is collected by sensory devices and also crowd sensing resources.
- It is time and location dependent.
- It can be noisy and the quality can vary.
- It is often continuous - streaming data.

- There are several important issues such as:
  - Device/network management
  - Actuation and feedback (command and control)
  - Service and entity descriptions.

IoT data- challenges

- Multi-modal, distributed and heterogeneous
- Noisy and incomplete
- Time and location dependent
- Dynamic and varies in quality
- Crowdsourced data can be unreliable
- Requires (near-) real-time analysis
- Privacy and security are important issues
- Data can be biased- we need to know our data!

P. Barnaghi, A. Sheth, C. Henson, "From data to actionable knowledge: Big Data Challenges in the Web of Things," IEEE Intelligent Systems, vol.28 , issue.6, Dec 2013.

Device/Data interoperability

The slide adapted from the IoT talk given by Jan Holler of Ericsson at IoT Week 2015 in Lisbon.

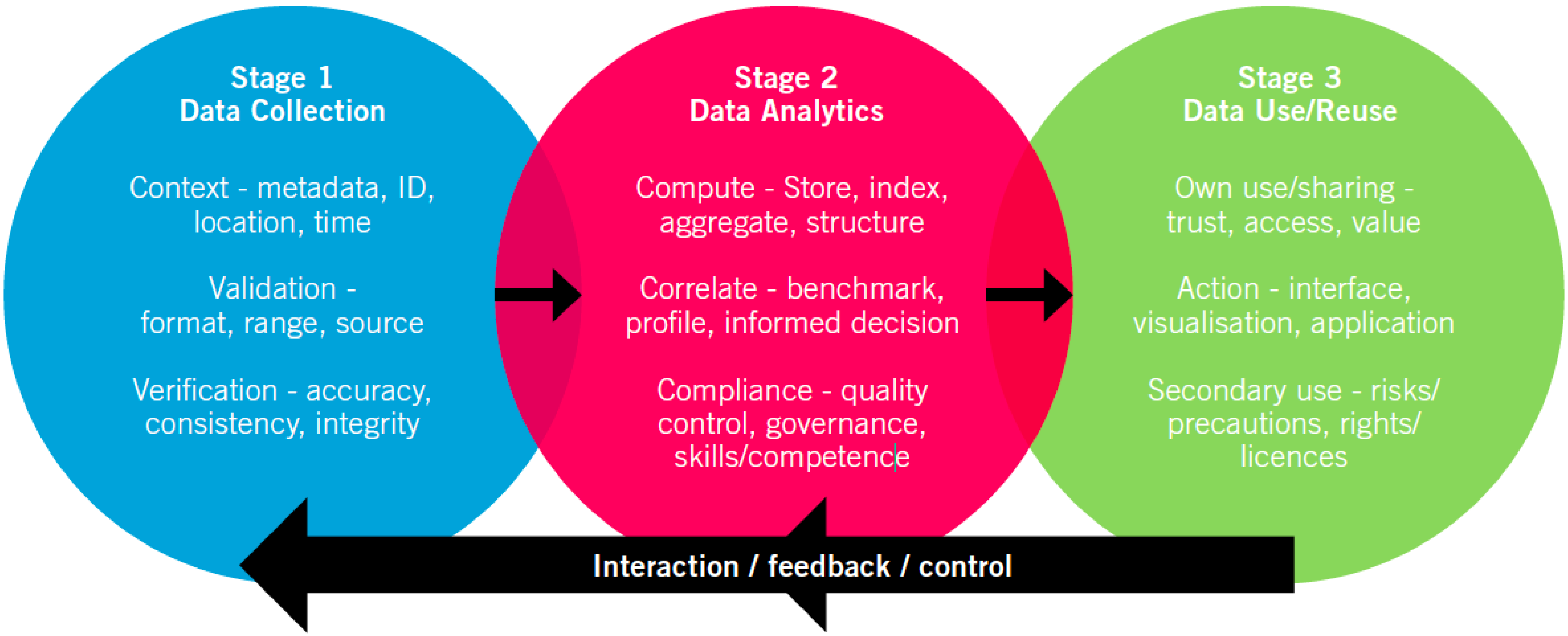
There are several good models and description frameworks;

The problem is that having good models and developing ontologies are not enough.

Semantic descriptions are intermediary solutions, not the end product.

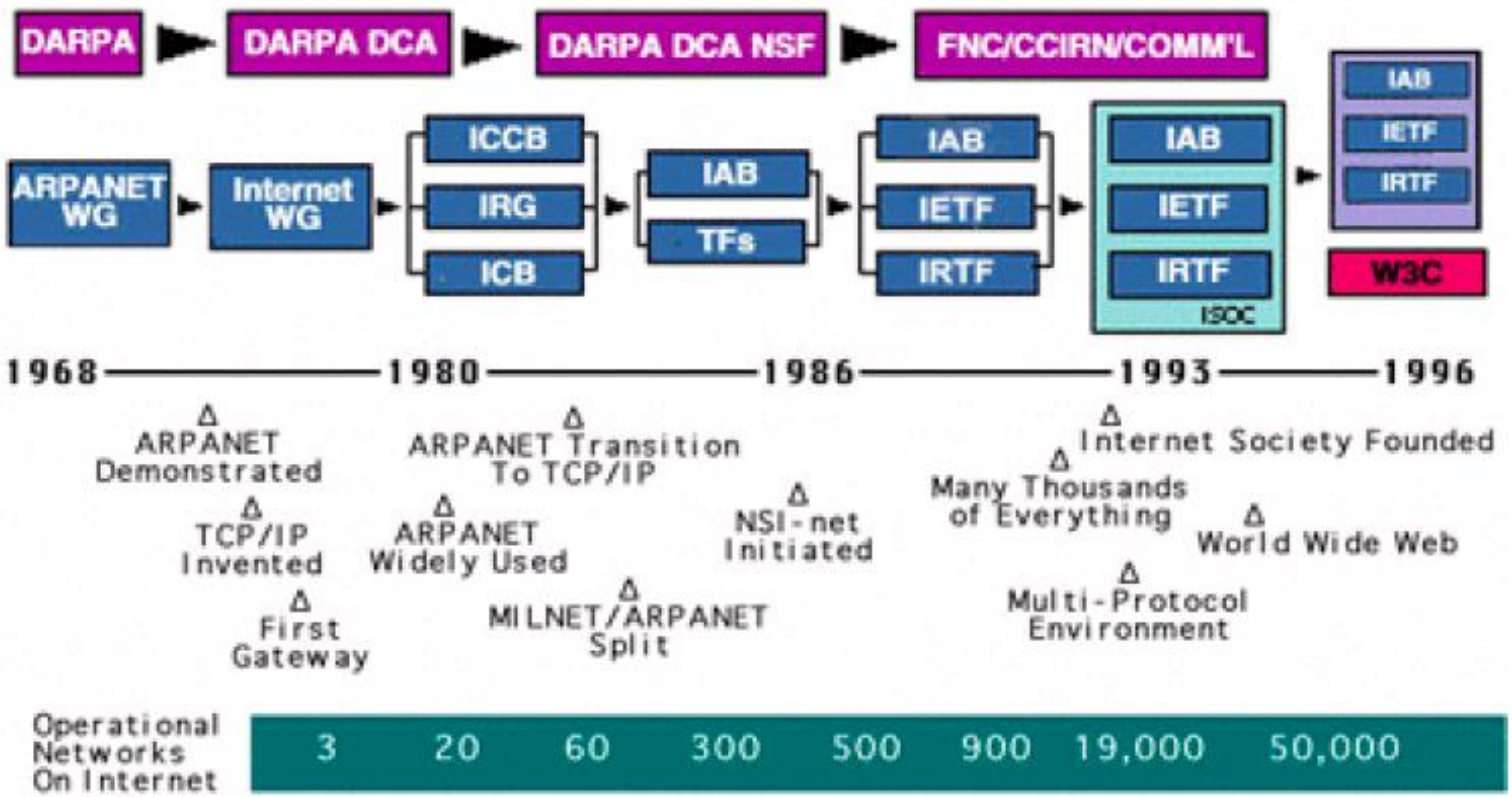
They should be transparent to the end-user and probably to the data producer as well.

Data Lifecycle



Source: **The IET Technical Report**, Digital Technology Adoption in the Smart Built Environment: Challenges and opportunities of data driven systems for building, community and city-scale applications, http://www.theiet.org/sectors/built-environment/resources/digital-technology.cfm

The old Internet timeline

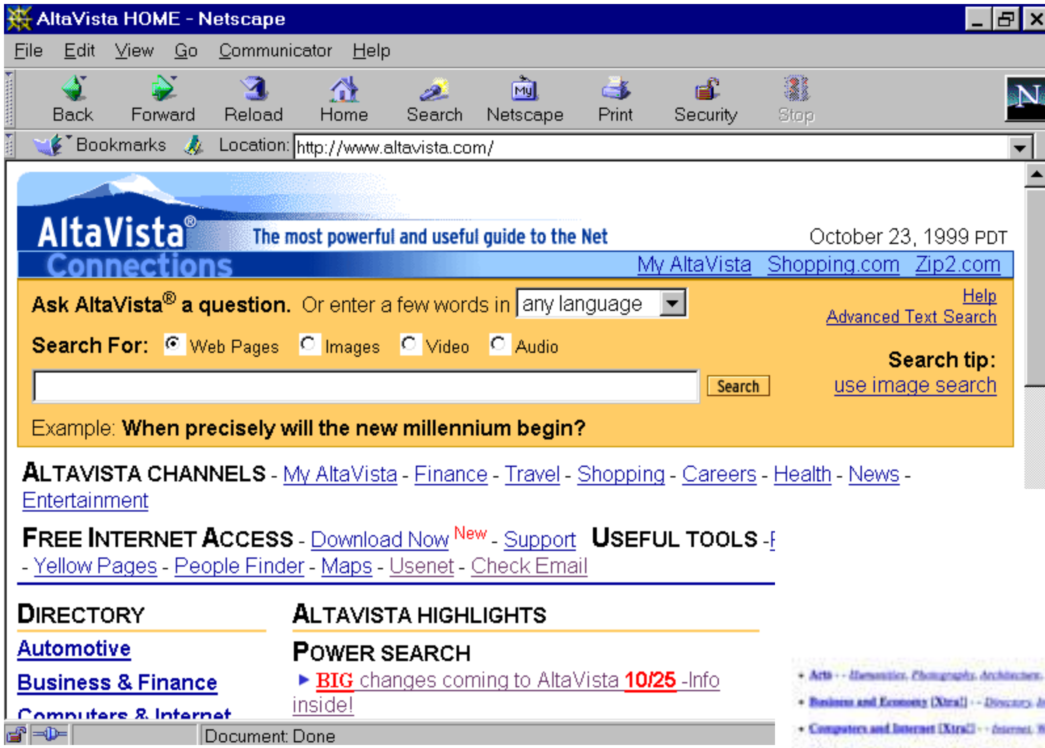


Connectivity and information exchange was (and is) the main motivation behind the Internet; but Content and Services are now the key elements;

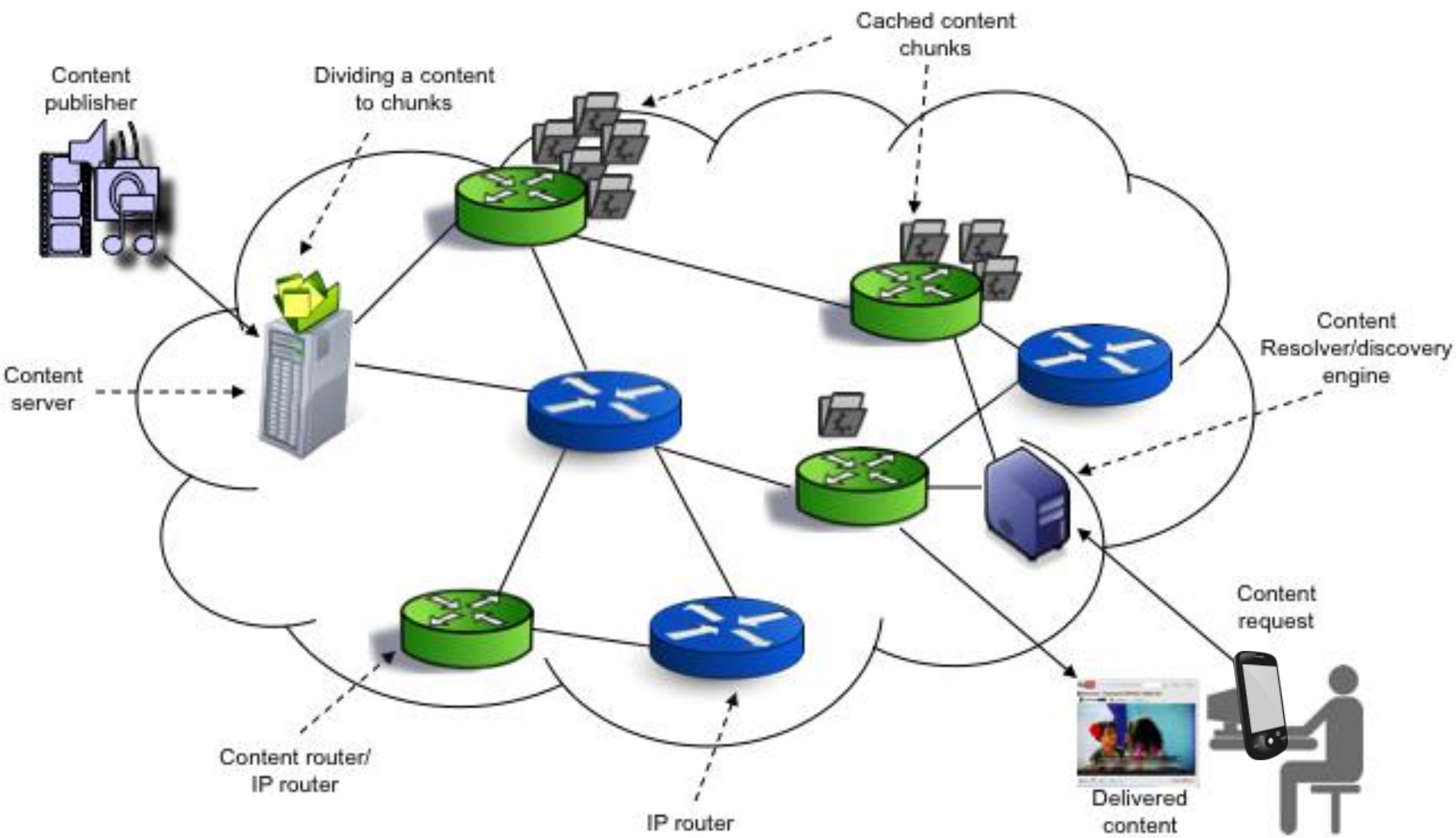
and all started growing rapidly by the introduction of the World Wide Web (and linked information and search and discovery services).

Early days of the web

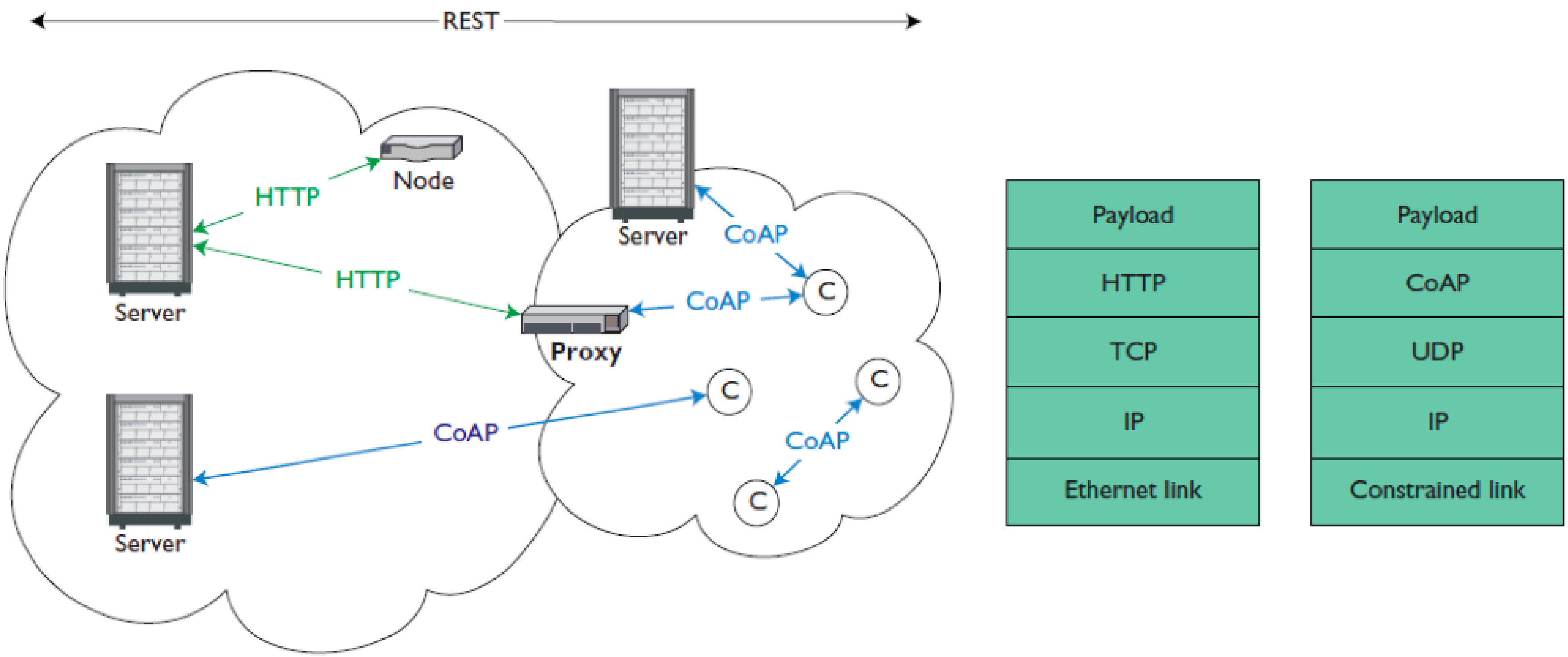
Search on the Internet/Web in the early days



Data-centric networking



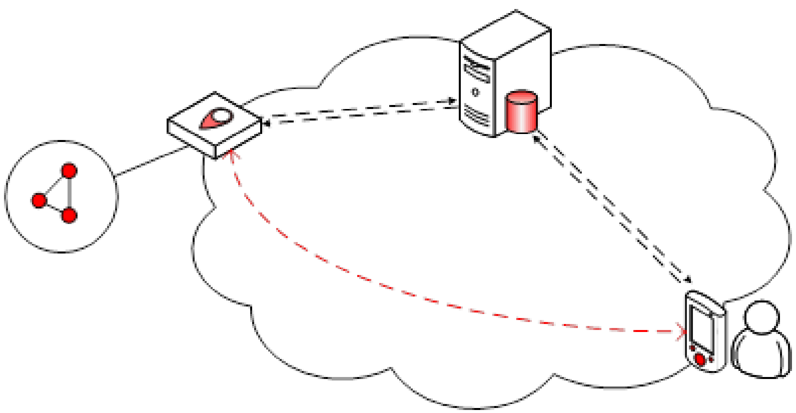
Protocols

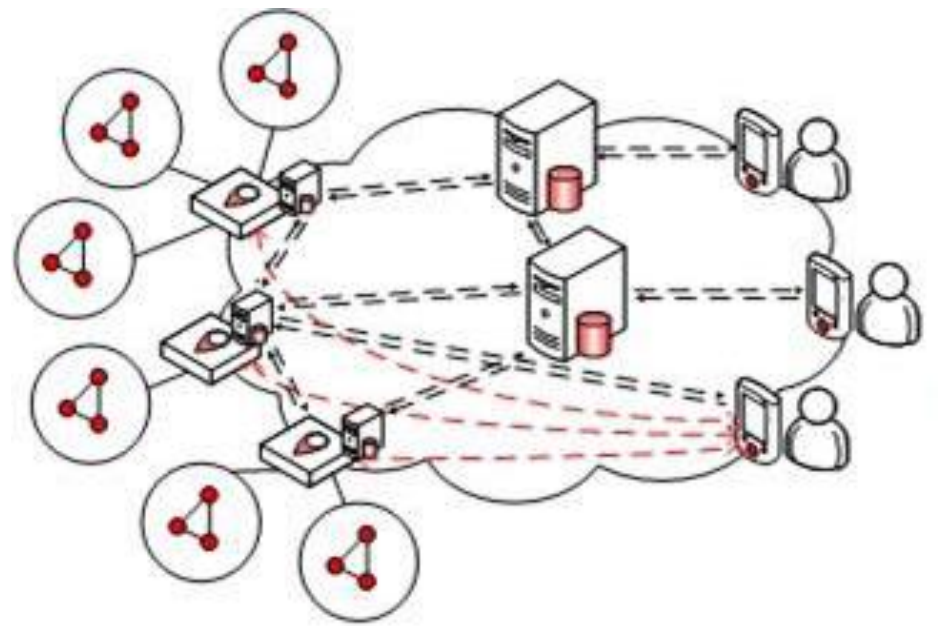


(a) Internet Constrained environments (b)

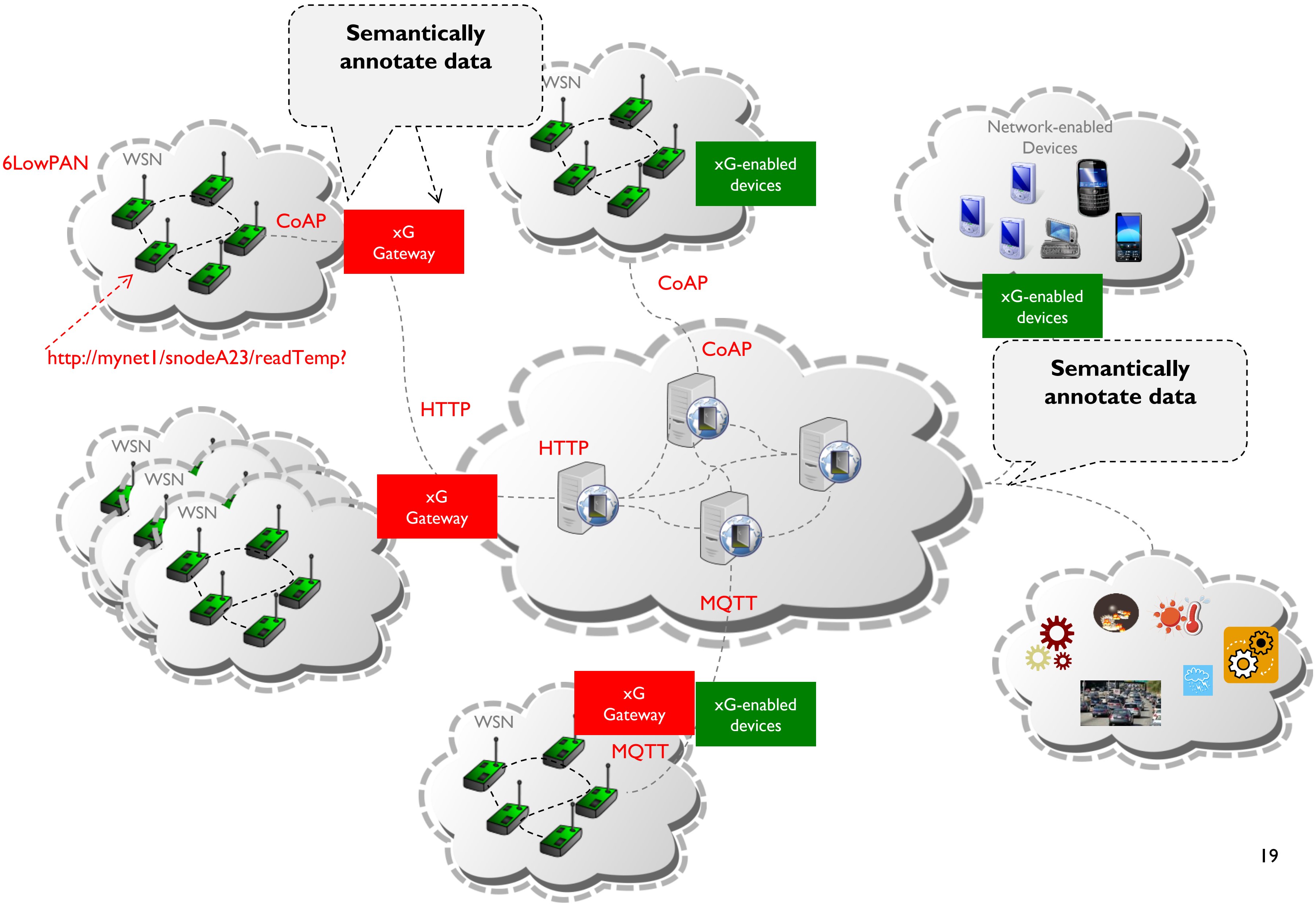
C. Bormann, A. P. Castellani, Z. Shelby, "CoAP: An Application Protocol for Billions of Tiny Internet Nodes," IEEE Internet Computing, vol. 16, no. 2, pp. 62-67, Feb. 2012, doi:10.1109/MIC.2012.29

Gateway Architecture





WoT/IoT over (future) communication networks



#1: Design for large-scale and provide tools and APIs.

#2: Think of who will use the data/services and how, when you design your models.

#3: Provide means to update and change/update the annotations.

Smart data collection

– Sooner or later we need to think whether we need to collect that data, how often we need to collect it and what volume.

– Intelligent data Processing (selective attention and information-extraction)

(image source: KRISTEN NICOLE, siliconangle.com)

#4: Create tools and open APIs for validation, evaluation, and interoperability testing.

#5: Consider quality of information and quality of service requirements when designing/deciding on your network and communication links.

#6: Link your data and descriptions to other existing resources.

#7: Define rules and/or best practices for providing the values for each attribute.

#8: Design or (re-)use solutions for smart data collection, processing and automated interactions.

Best Practices: an example (early draft)

W3C Editor's Draft

Spatial Data on the Web Best Practices

W3C Editor's Draft 18 December 2015

This version:
 http://w3c.github.io/sdw/bp/
Latest published version:
 http://www.w3.org/TR/sdw-bp/
Latest editor's draft:
 http://w3c.github.io/sdw/bp/

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Abstract

Status of This Document

This section describes the status of this document at the time of its publication. Other documents may supersede this document. A list of currer http://www.w3.org/TR/.

Spatial Data on the Web- Best Practices (early draft)

Best Practice 11: How to describe properties that change over time

Entities and their data should have versioning with time/location references

Why

Entities and their properties can change over time and this change can be related to spatial properties, for example when a spatial thing moves from one location to ano to be able to explicitly refer to a particular version of a spatial thing, or to infer which geometry is appropriate at a specific time, based on the versioning. To make this po the time and location that the data is captured and should retain a version history. This allows you to reference the most recent data as well as previous versions and to

Intended Outcome

Properties described in a dataset will include a time (and/or location) stamp and also versioning information to allow tracking of the changes and accessing the most up-

Possible Approach to Implementation

When entities and their properties can change over time, or are valid only at a given time, and this needs to be captured, it is important to specify a clear relationship be should explain in the defining specification and/or schema and temporal and/or spatial metadata should be provided to indicate when and where the data was captured.

For an example of how to version information about entities and their properties and retaining a version history, see `version:VersionedThing` and `version:Version` at http types.

It is also useful to incorporate information on how often the information might change: the frequency of update.

How much change is acceptable before the resources cannot be considered equivalent, and you should create a new resource instead of a new version of the same res (resources) that change over time.

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ISSUE

How to work with data that is such high volume (e.g. sensor data streams) that the data is discarded after a period of time?

EXAMPLE 12

Example(s) to be added; including:

- Linking crime data to a identified region; these regions change over time so we need to know which version of the region the data is applicable to.
- Australian hydrological catchment geometries (that vary as a result of a resurvey).

How to Test

...

Evidence

Relevant requirements: R-MachineToMachine, R-MovingFeatures, R-Streamable

#9: Design for different audience (data/service consumers, developers, providers) and think about real world applications and sustainability.

#10: Specify (and encourage others to do the same) data governance and privacy procedures, explain the ownership and re-use rules, and give control to the owners of data

Some of the technical challenges and research directions

Technical (and non-technical) Challenges

- Creating common models to represent, publish, and (re-)use and share IoT data.
  - Developing common protocols and standards,
- Providing best practices, demonstrators and open portals for IoT data/services.
- Provide governance, dependability, reliability, trust and security models.

Research challenges

- Transforming raw data to actionable-information.
  - Machine learning and data analytics for large-scale, multi-modal and dynamic (streaming data).
- Making data more accessible and discoverable.
- Energy and computationally efficient data collection, communication, aggregation and abstraction (for both edge and Cloud processing).
- Automated feedback and control mechanisms.

Research challenges (continued)

- Integration and combination of Physical-Cyber-Social data.

- Use of data for automated interactions and autonomous services in different domains.

- Resource-aware and context-aware security, privacy and trust solutions.

In conclusion

- IoT information engineering is different from common models of web data and/or other types of big data.
- Data collection in the IoT comes at the cost of bandwidth, network, energy and other resources.
- Data collection, delivery and processing is also depended on multiple layers of the network.
- We need more resource-aware data analytics methods and cross-layer optimisations (*Deep IoT*).
- The solutions should work across different systems and multiple platforms (*Ecosystem of systems*).
- Data sources are more than physical (sensory) observation.
- The IoT requires integration and processing of physical-cyber-social data.
- The extracted insights and information should be converted to a feedback and/or actionable information.

Other challenges and topics that I didn't talk about

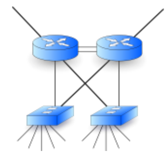
Security

Privacy

Trust, resilience and reliability

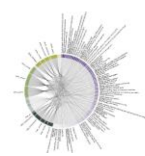
Noise and incomplete data

Cloud and distributed computing



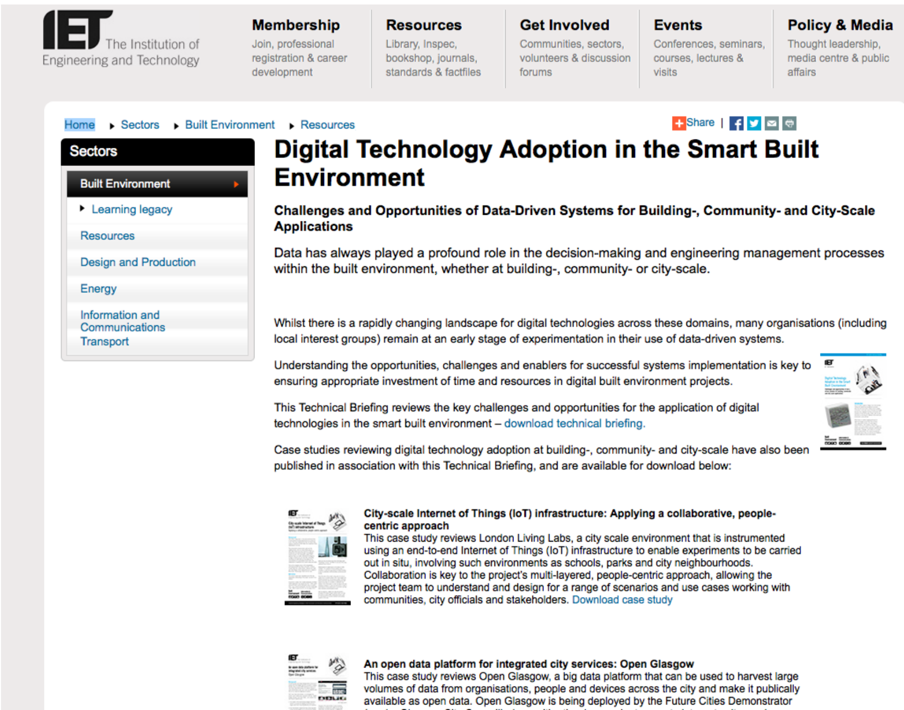
Networks, test-beds and mobility

Mobile computing



Applications and use-case scenarios

IET sector briefing report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Digital Technology Adoption in the Smart Built Environment

Challenges and Opportunities of Data-Driven Systems for Building-, Community- and City-Scale Applications

Data has always played a profound role in the decision-making and engineering management processes within the built environment, whether at building-, community- or city-scale.

Whilst there is a rapidly changing landscape for digital technologies across these domains, many organisations (including local interest groups) remain at an early stage of experimentation in their use of data-driven systems.

Understanding the opportunities, challenges and enablers for successful systems implementation is key to ensuring appropriate investment of time and resources in digital built environment projects.

This Technical Briefing reviews the key challenges and opportunities for the application of digital technologies in the smart built environment – download technical briefing.

Case studies reviewing digital technology adoption at building-, community- and city-scale have also been published in association with this Technical Briefing, and are available for download below:

City-scale Internet of Things (IoT) infrastructure: Applying a collaborative, people-centric approach
This case study reviews London Living Labs, a city scale environment that is instrumented using an end-to-end Internet of Things (IoT) infrastructure to enable experiments to be carried out in situ, involving such environments as schools, parks and city neighbourhoods. Collaboration is key to the project's multi-layered, people-centric approach, allowing the project team to understand and design for a range of scenarios and use cases working with communities, city officials and stakeholders. Download case study

An open data platform for integrated city services: Open Glasgow
This case study reviews Open Glasgow, a big data platform that can be used to harvest large volumes of data from organisations, people and devices across the city and make it publically available as open data. Open Glasgow is being deployed by the Future Cities Demonstrator


IET Sector Technical Briefing

The Institution of Engineering and Technology

Digital Technology Adoption in the Smart Built Environment

Challenges and opportunities of data-driven systems for building, community and city-scale applications

Introduction

Data has always played an integral role in the decision-making and engineering management processes within the built environment, whether at the building-, community- or city-scale; and as information technology becomes more integrated into those environments, the importance of data will escalate; indeed, data has been described as now being the 'lifeblood' of the smart built environment, as we shall see.

Whilst there is a rapidly-changing landscape for digital technologies across these three domains, many organisations remain at an early stage of experimentation in their adoption of data-driven systems. One of the purposes of this Technical Briefing is to provide entry points for those seeking to understand the opportunities, challenges, and enablers for successful systems implementation: this is key to ensuring that appropriate levels of time and resources are invested in successful digital built environment projects.

IET Standards   Built Environment   Information & Communications   www.theiet.org/sectors

Available at: http://www.theiet.org/sectors/built-environment/resources/digital-technology.cfm

Useful information:

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November 2015

http://www.raeng.org.uk/publications/reports/connecting-data-driving-productivity

Q&A

– Thank you.

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