Challenges for Interoperability in the Industrial Internet of Things

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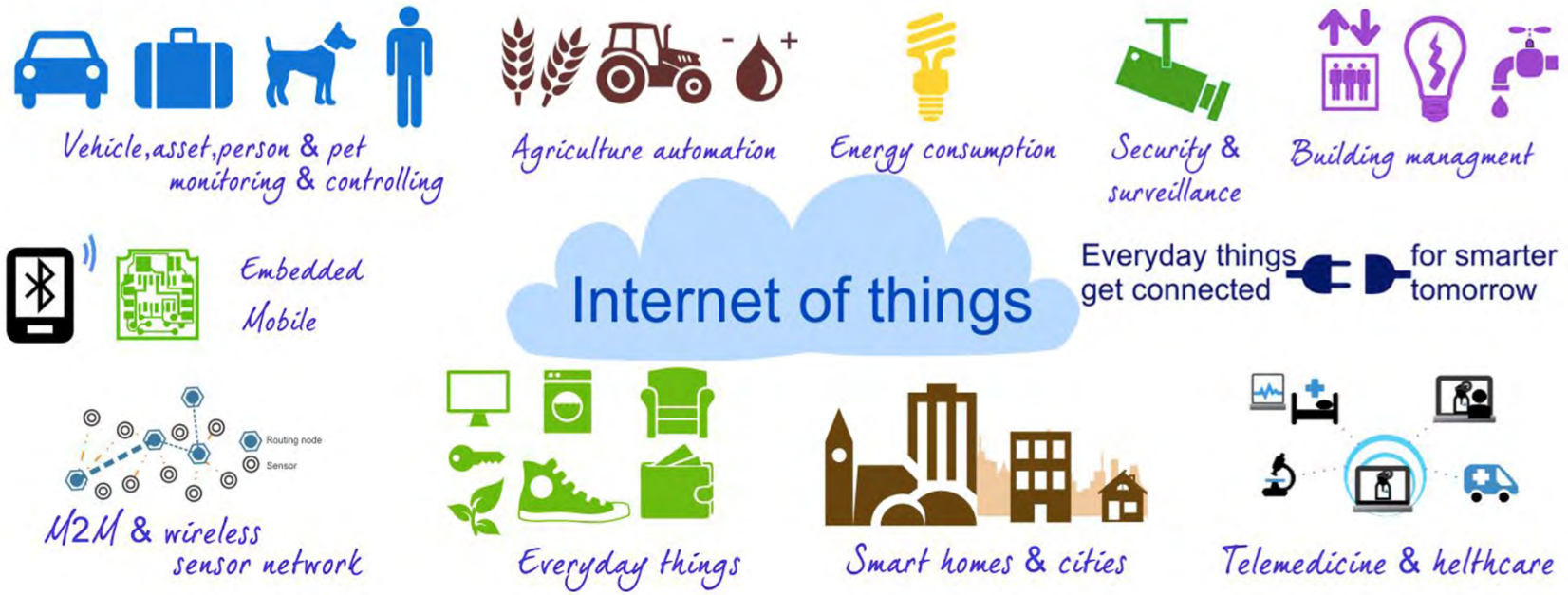
Outline

- Introduction and Challenges
- Internet of Things – Current Picture
- Approaches to Interoperability
- Conclusions

The Internet of Things

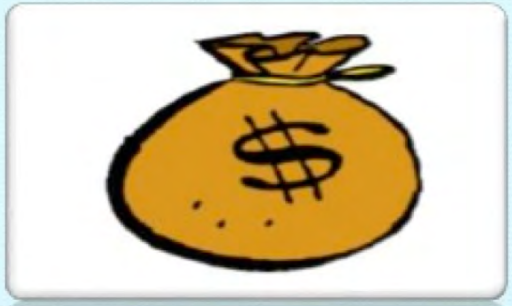
- Connection of large number of electronic, communicating devices – interfaced with “Things” – ultimately to the Internet
- Integration of devices functions with edge/cloud based systems
- Use of device data for wide range of services
  - Analytics, decision support
  - Control of objects via Internet



IoT - The Opportunity

Source: Mario Morales, I

internet of things Business Opportunity



- $1.7 Trillion by 2020 – IDC
- $7.1 Trillion – Gartner
- $10-15 Trillion just for Industrial Internet – GE
- $19 Trillion – Internet of Everything - Cisco

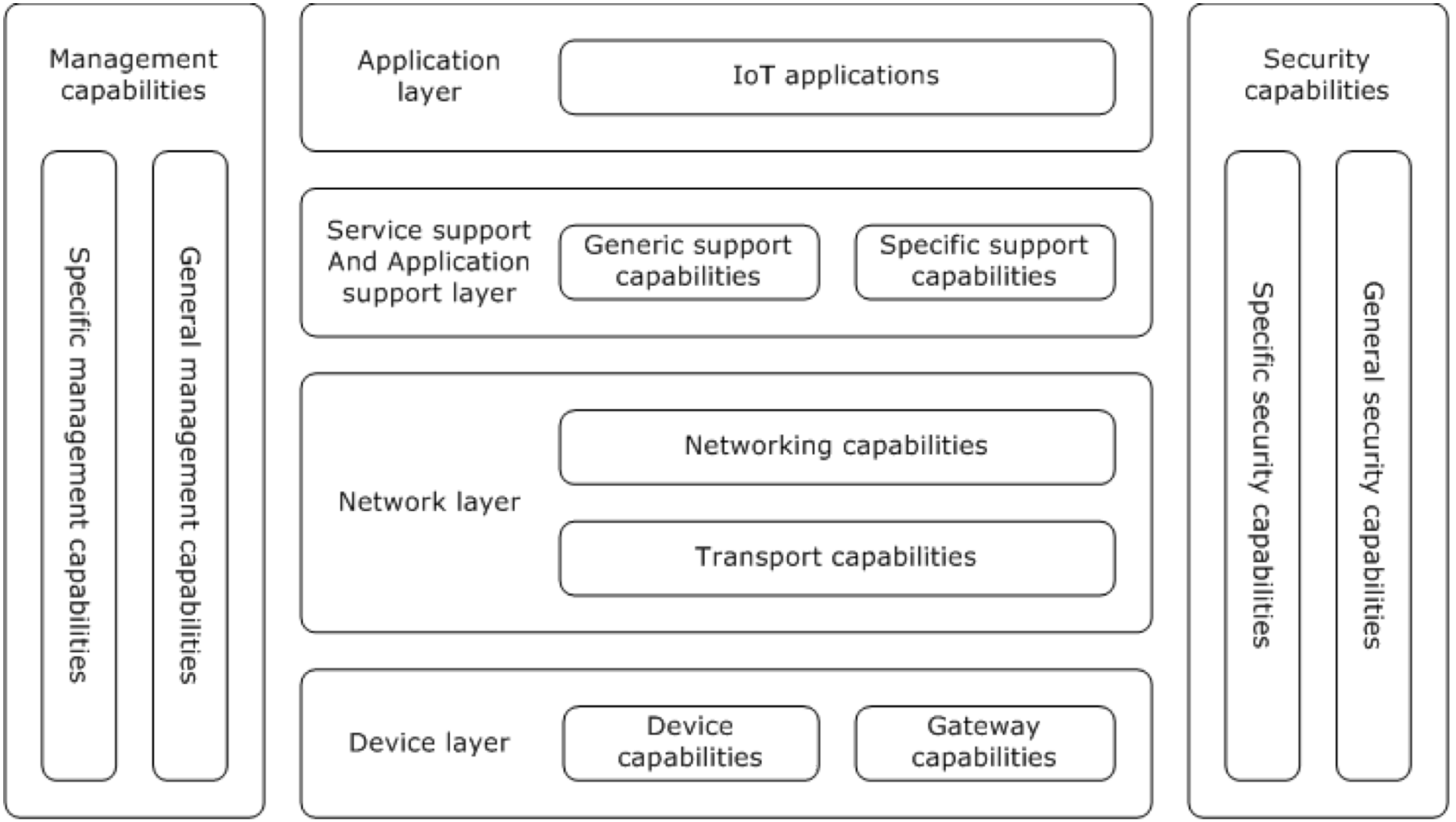
Ref: http://www.forbes.com/sites/gilpress/2014/08/22/internet-of-things-by-the-numbers-market-estimates-and-forecasts/

However …

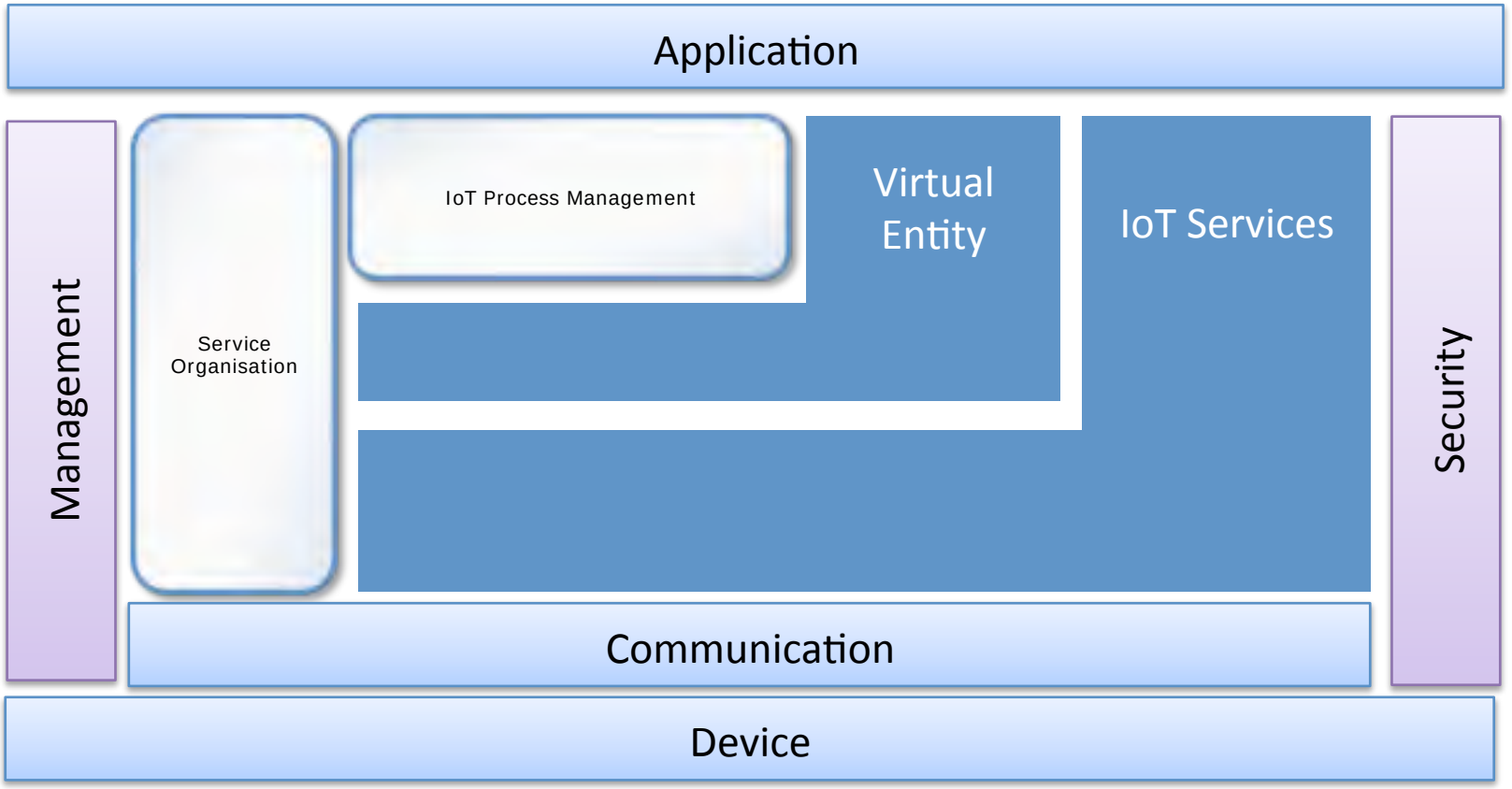
- Many
  - Communication and networking standards – not all IP based
  - IoT Reference Models
  - IoT Software Platforms
- But also many other challenges (just some of them)
  - Spectrum availability and interference
  - Wireless device co-existence problems
  - Power and energy management
  - Addressing
  - Data formats and semantics
  - Data rates and volumes
  - Edge versus cloud processing
  - Deployment and commissioning
  - Privacy & security
- Have been leading to **Interoperability** Issues
  - The Internet of Things Silos

IoT Reference Models

ITU-T Y.2060 IoT Reference Model



IoT Architecture – EU FP7 IoT-A project



IoT World Forum Reference Model

Levels

7 **Collaboration & Processes**
(Involving People & Business Processes)

6 **Application**
(Reporting, Analytics, Control)

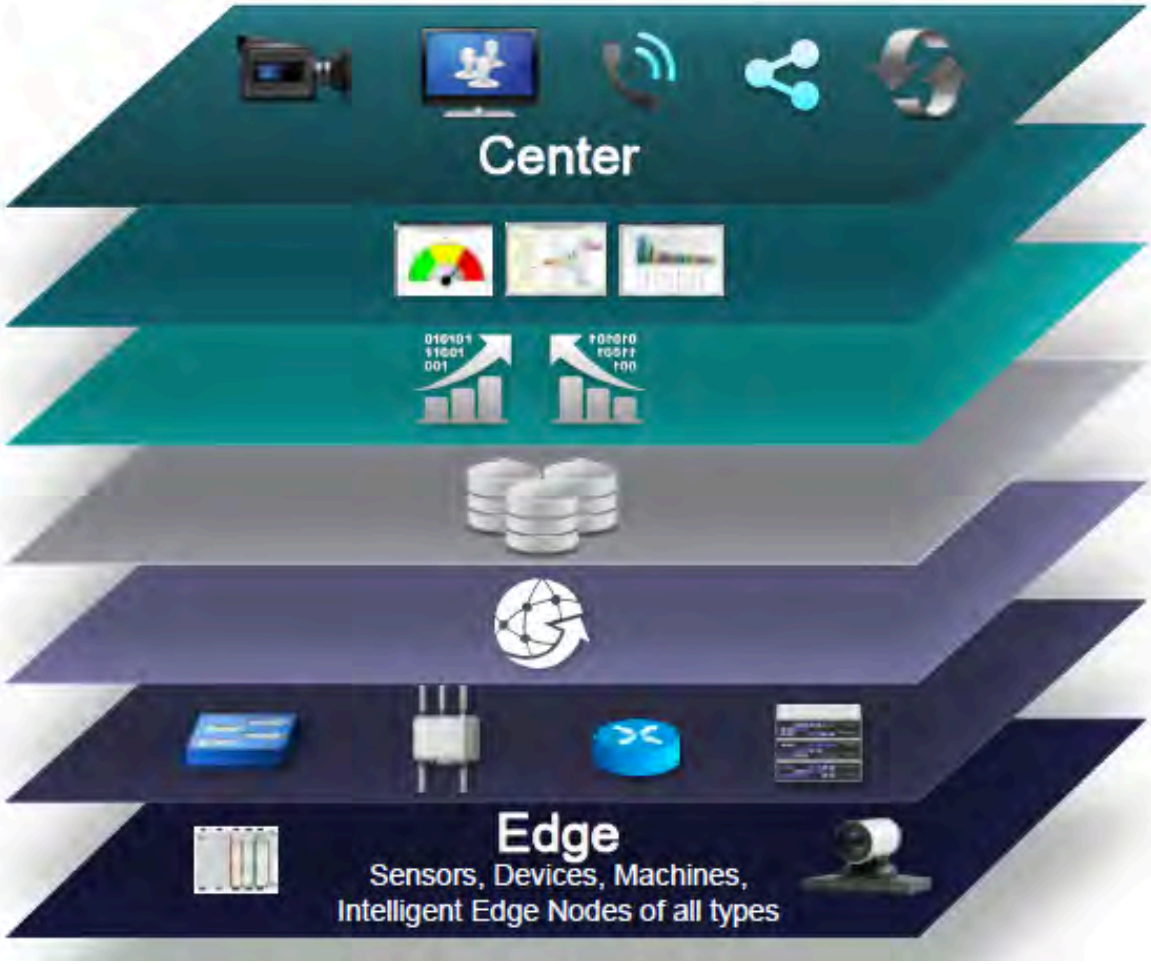
5 **Data Abstraction**
(Aggregation & Access)

4 **Data Accumulation**
(Storage)

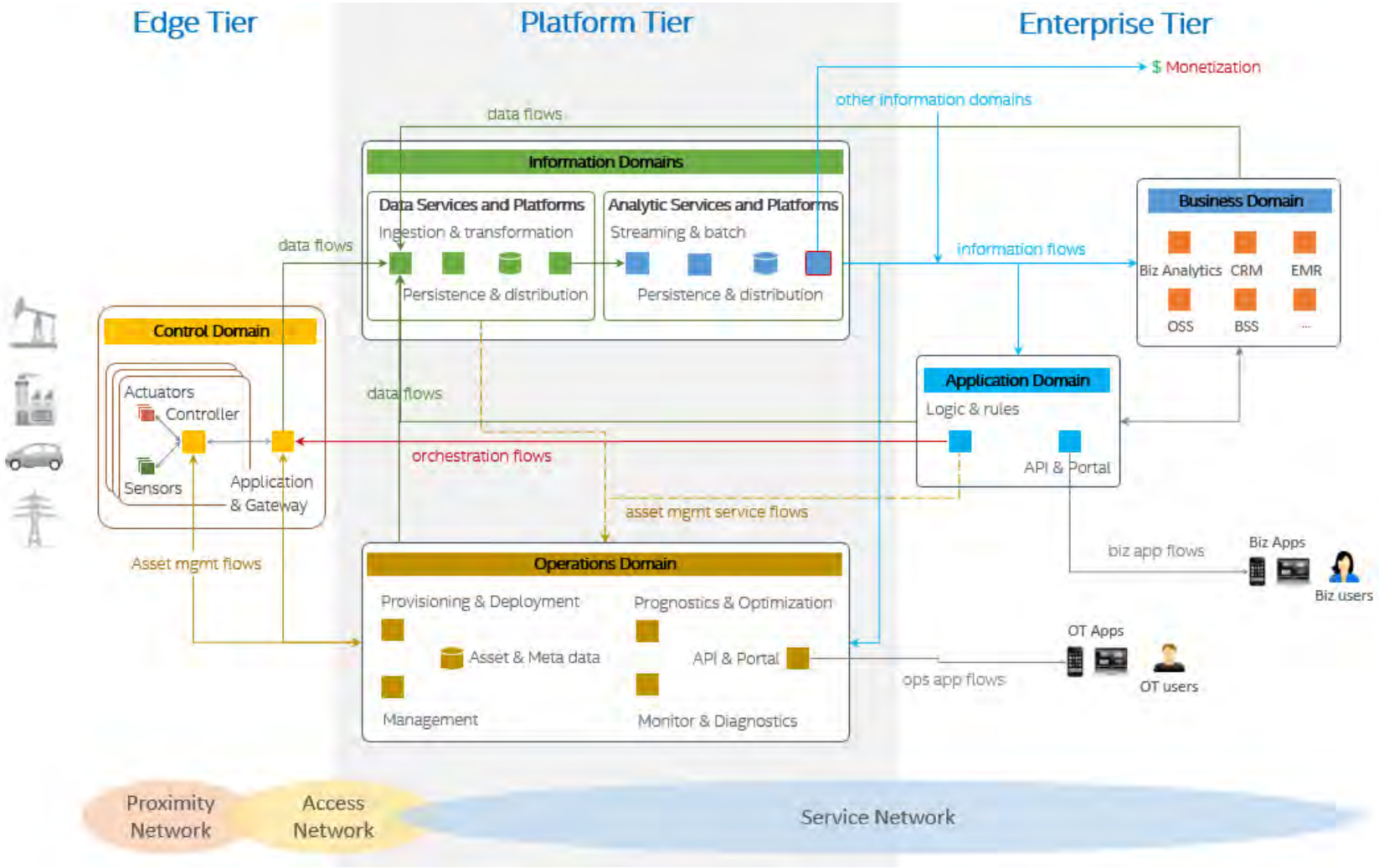
3 **Edge Computing**
(Data Element Analysis & Transformation)

2 **Connectivity**
(Communication & Processing Units)

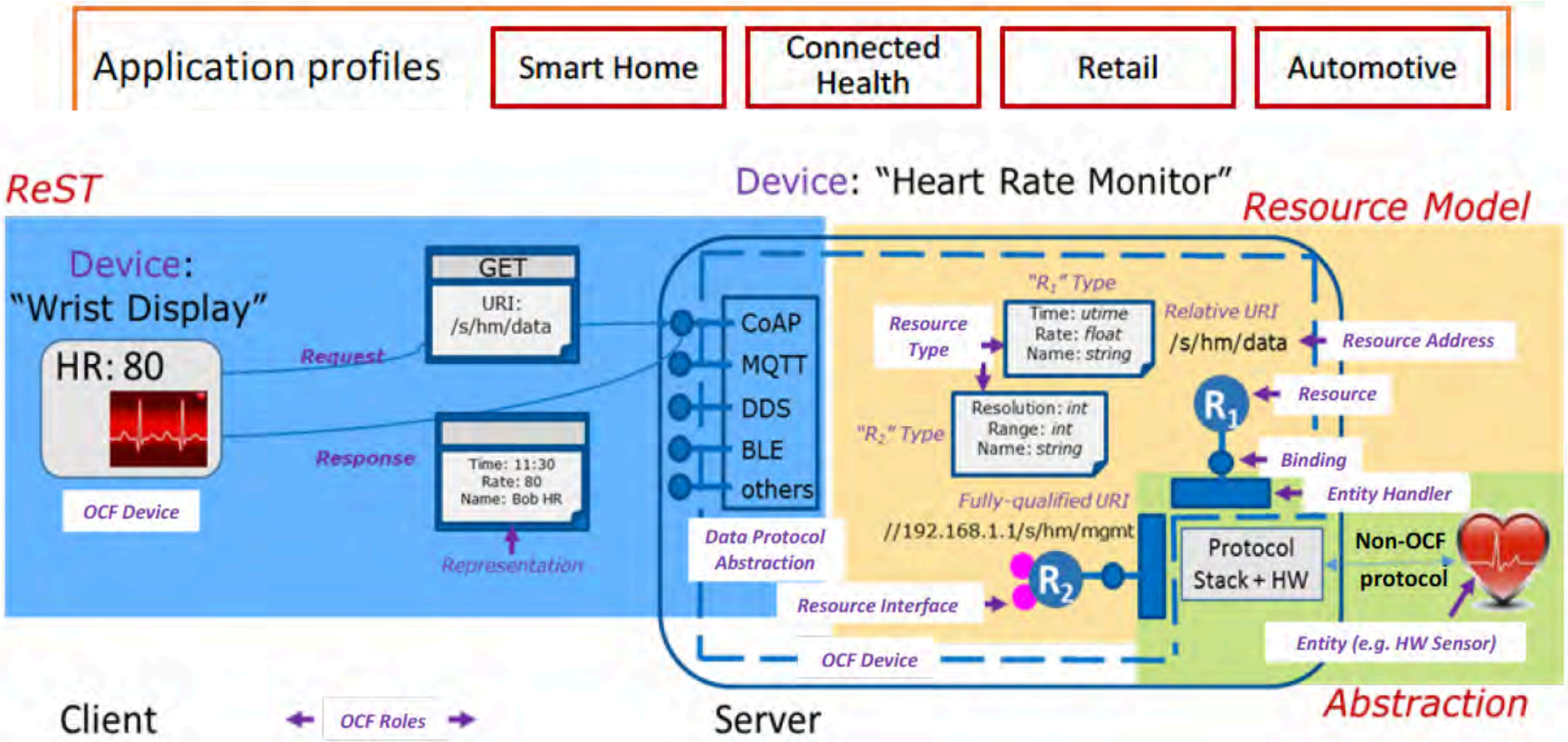
1 **Physical Devices & Controllers**
(The "Things" in IoT)



Industrial Internet Consortium 3 Tier IoT Architecture



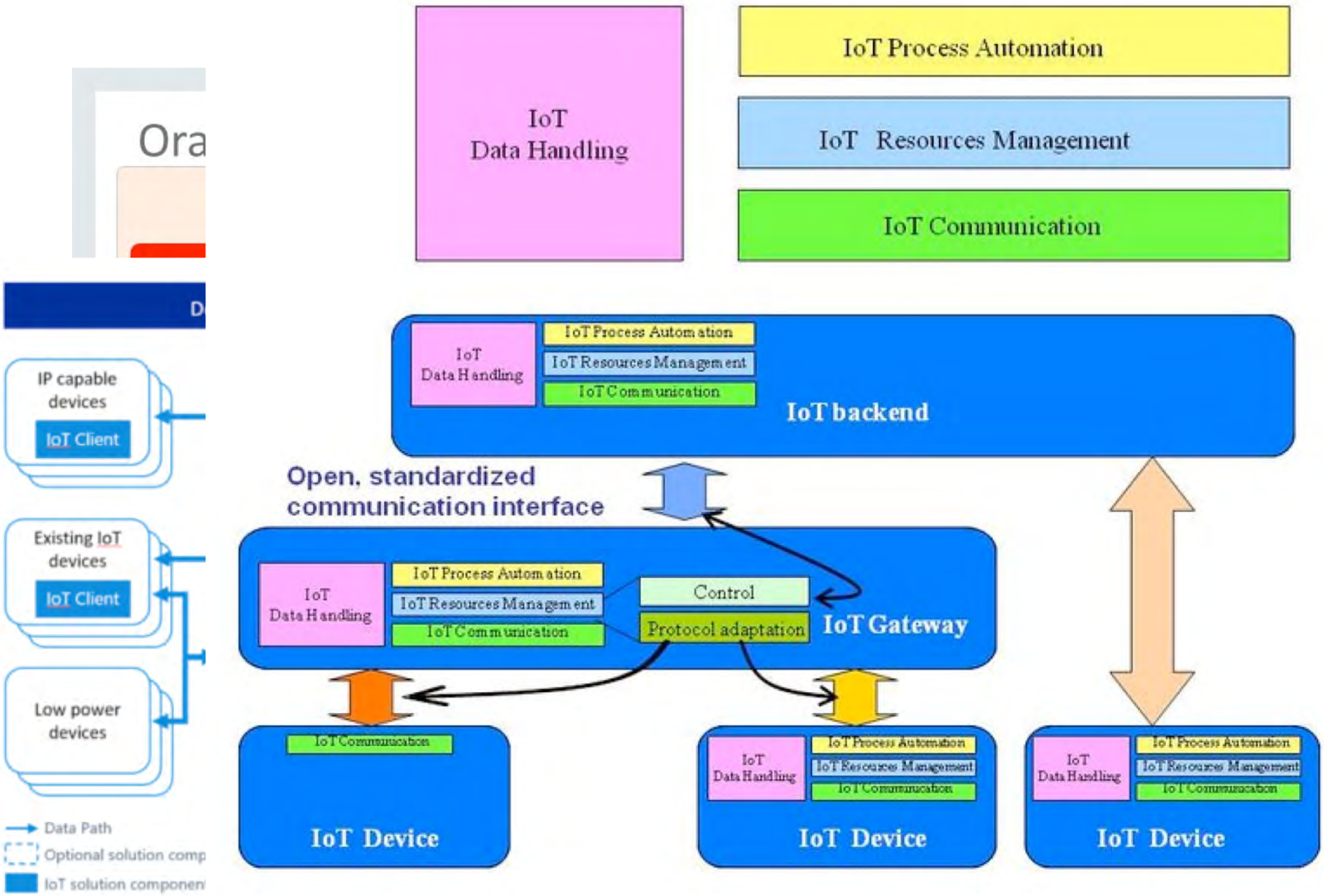
OCF Functional Reference Model



Other standards initiatives

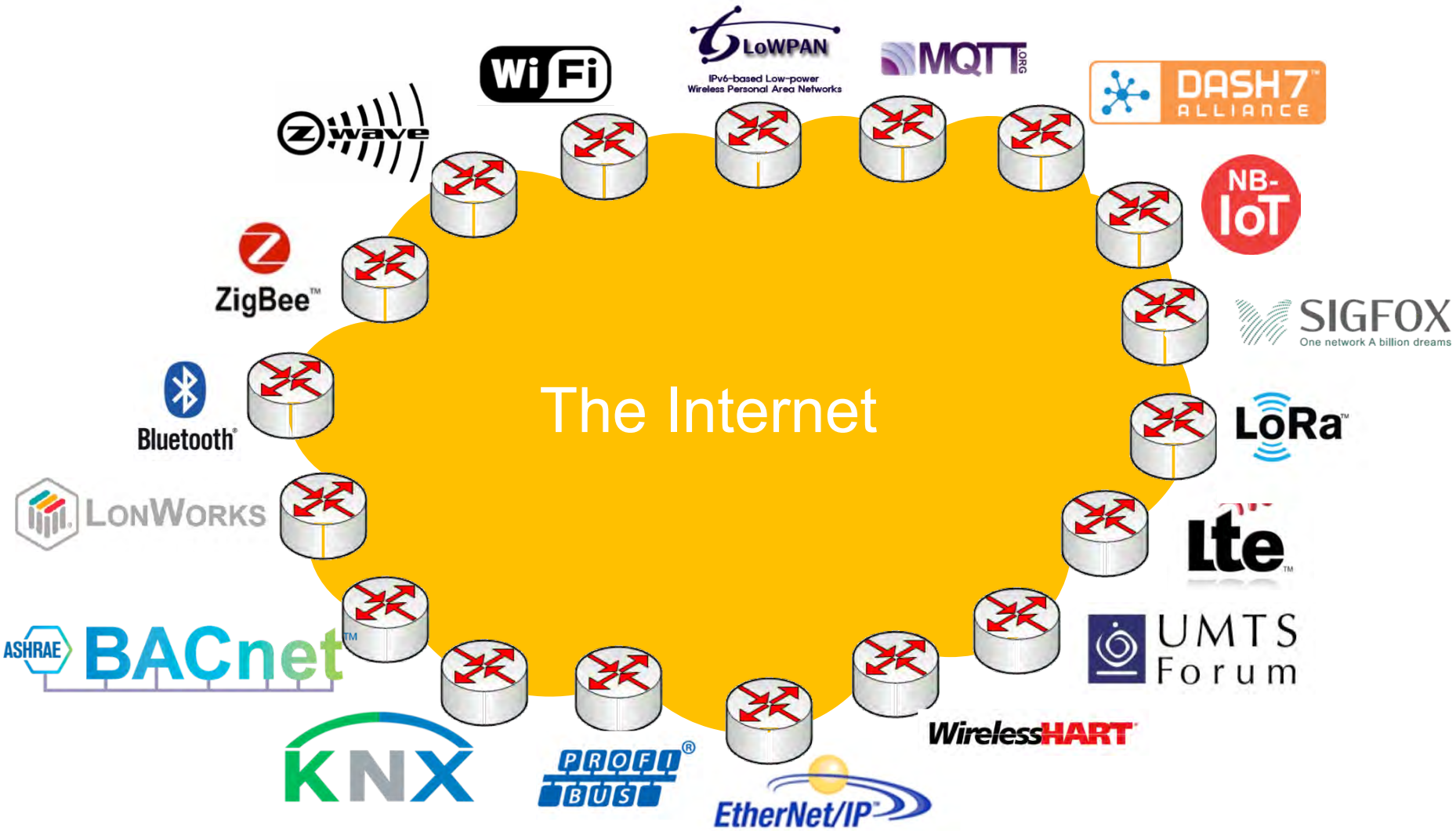
- ISO/IEC working Group JTC1/SC41
- oneM2M reference model
- ETSI M2M reference model

Individual organisations' reference models



IoT M2M Communications Technologies

Many M2M Communication Standards



Spectrum Availability & Fragmentation

- Limited unlicensed spectrum
- Multiple technologies need to co-exist

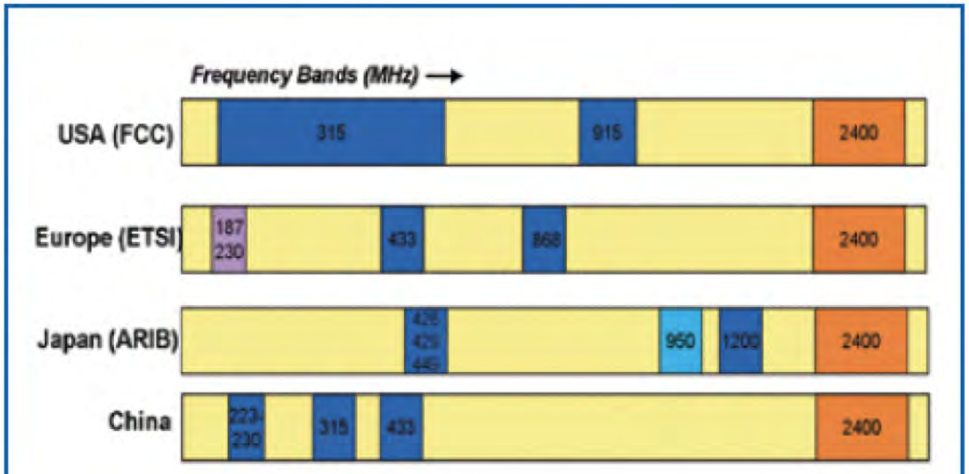
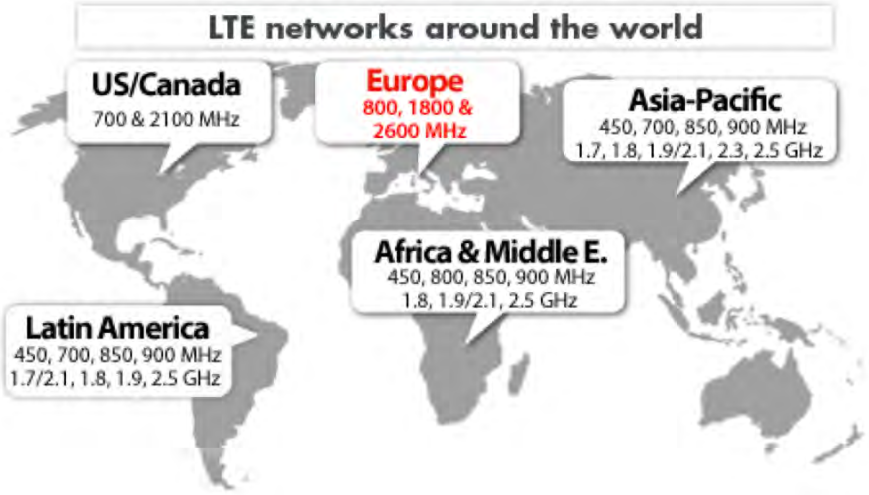


Figure 1: Unlicensed frequency bands (300 MHz to 3 GHz)[1]



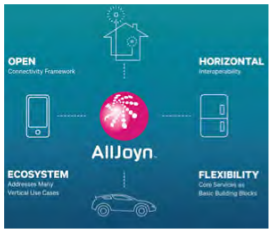
Data Standards and IoT Platforms

Data Format and Protocol Standards

Wide Range of IoT Platforms

xively by LogMeIn™

Intel & IoT



FI-WARE

carriots®

ThingSpeak

IBM Watson IoT

MindSphere

Microsoft Azure IoT Platform

Couple Industry statements

- Interoperability has the potential to unlock more than $4 trillion per year in potential economic impact from IoT use by 2025, according to McKinsey & Co.
  - Of the total potential economic value the IoT enables, interoperability is required for 40% on average and for nearly 60% in some settings.
  - For example, on an oil rig that has 30,000 sensors, only 1% of the data are examined. That's because this information is used mostly to detect and control anomalies — not for optimization and prediction, which provide the greatest value.
- Gartner identified Interoperability as one of the top three challenges preventing IoT from reaching its full potential.

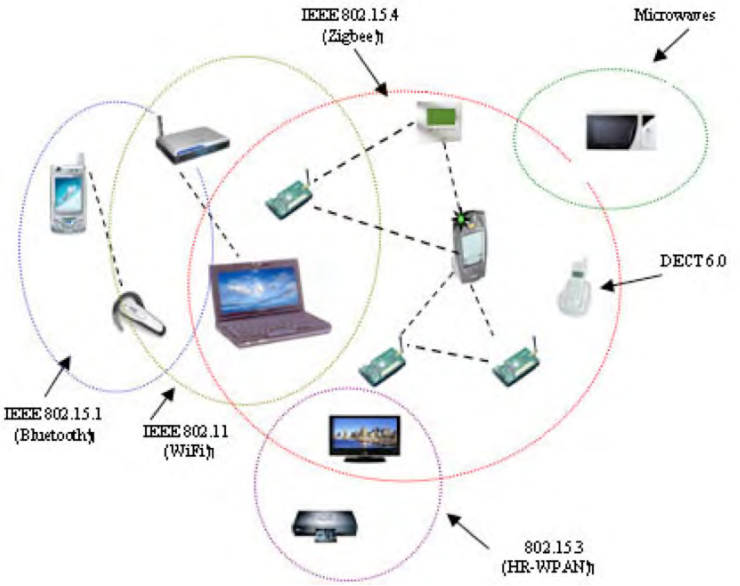
Some Approaches to Interoperability Solutions

Possible Solutions

- Multi-mode radios
- Interoperability frameworks
- Common APIs
- Common IoT Service layer
- Spectrum co-existence mechanisms
- Interoperable data formats
- Semantic interoperability

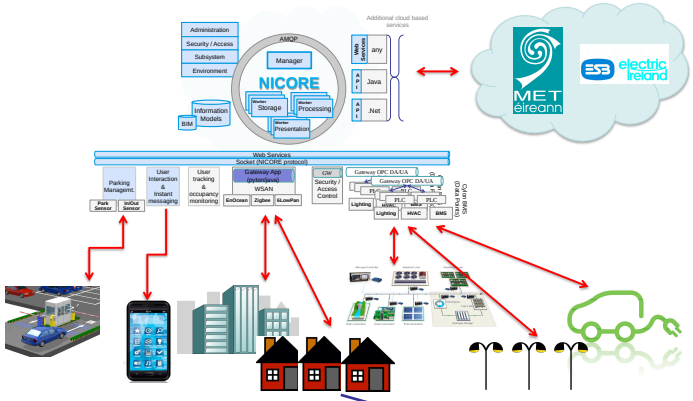
Radio Co-existence for IoT Devices

- Many wireless communications technologies
- Both, licensed and unlicensed band usage
- Co-existence critical, in particular in unlicensed spectrum
- Cognitive radio approaches
  - Sensing the environment
  - Building models of interference
  - Scheduling communication during periods of inactivity
  - Cooperation between MAC and applications layer

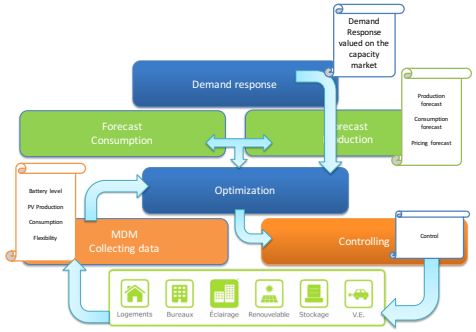


FP7 COOPERaTE Project

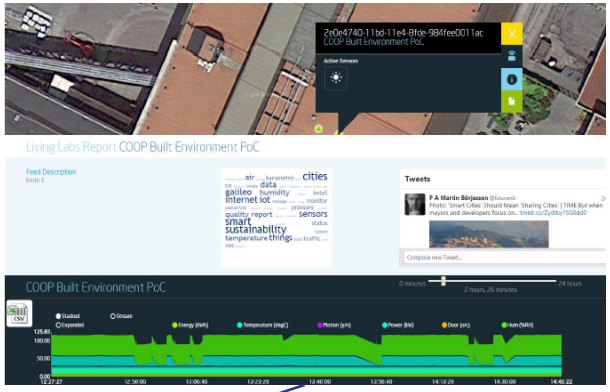
CIT NICORE IoT Platform

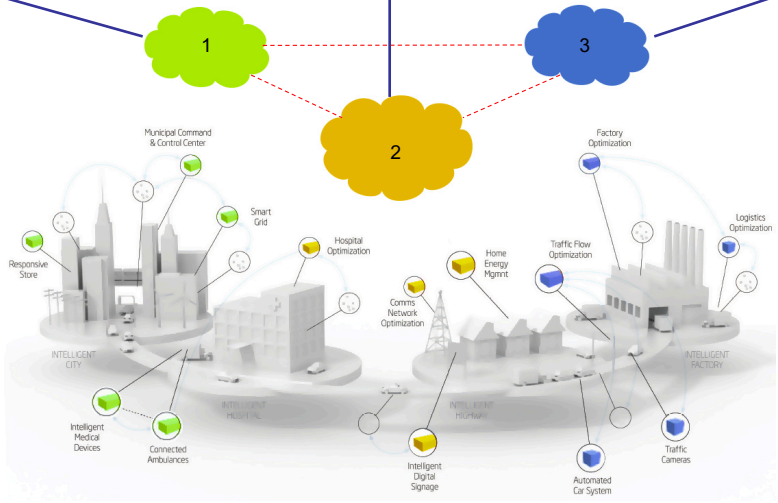


Embix UrbanPower



Intel E2E IoT Platform





http://www.cooperate-fp7.eu/

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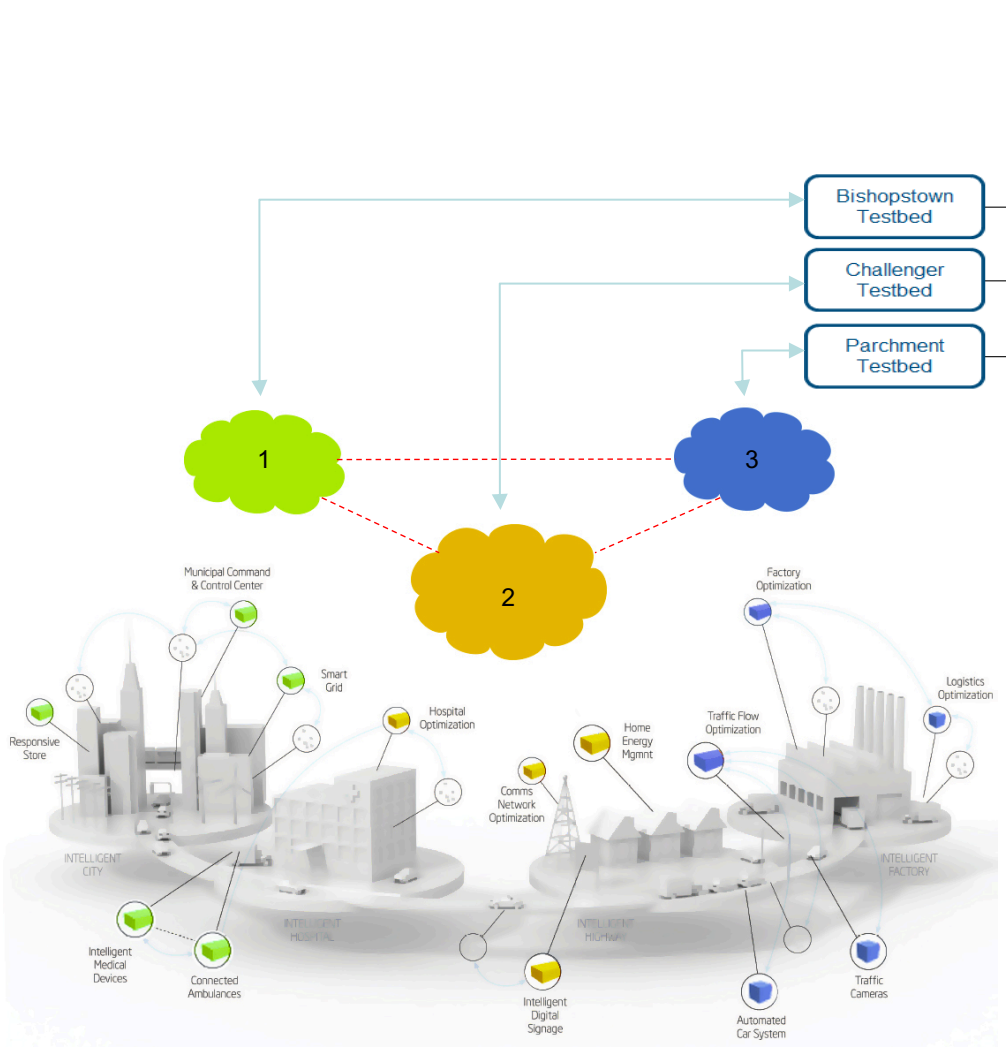
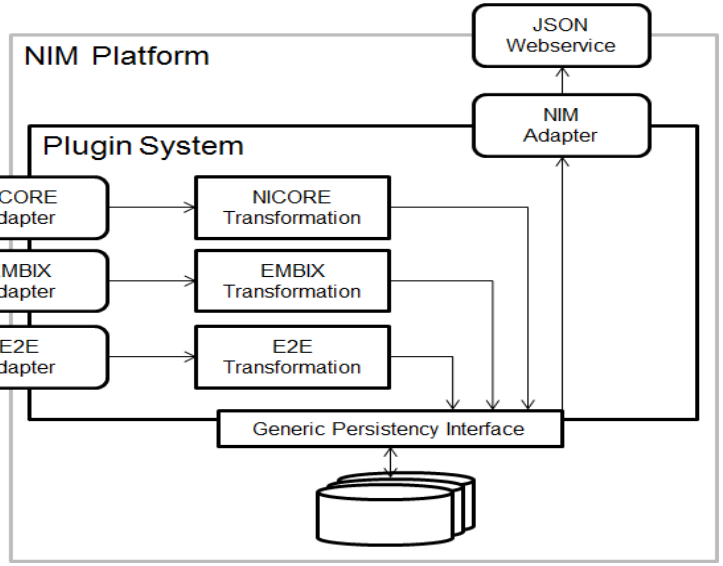
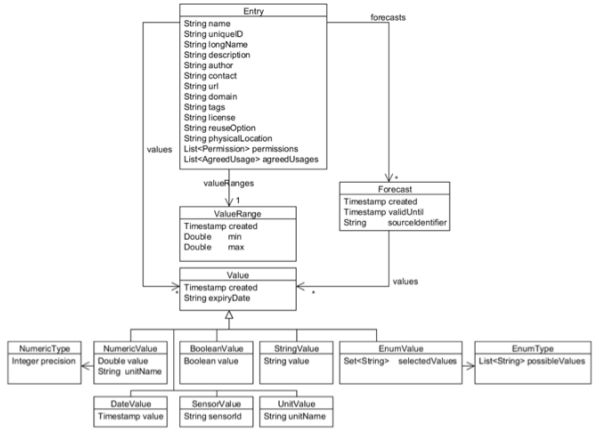
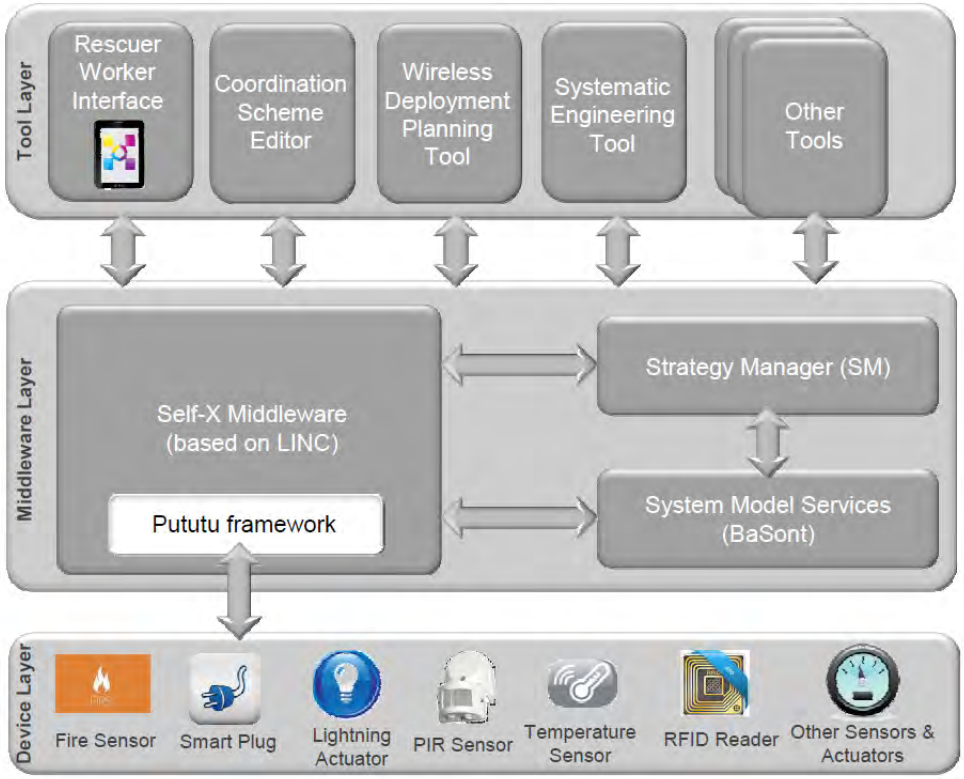
COOPERaTE Systems of Systems Approach



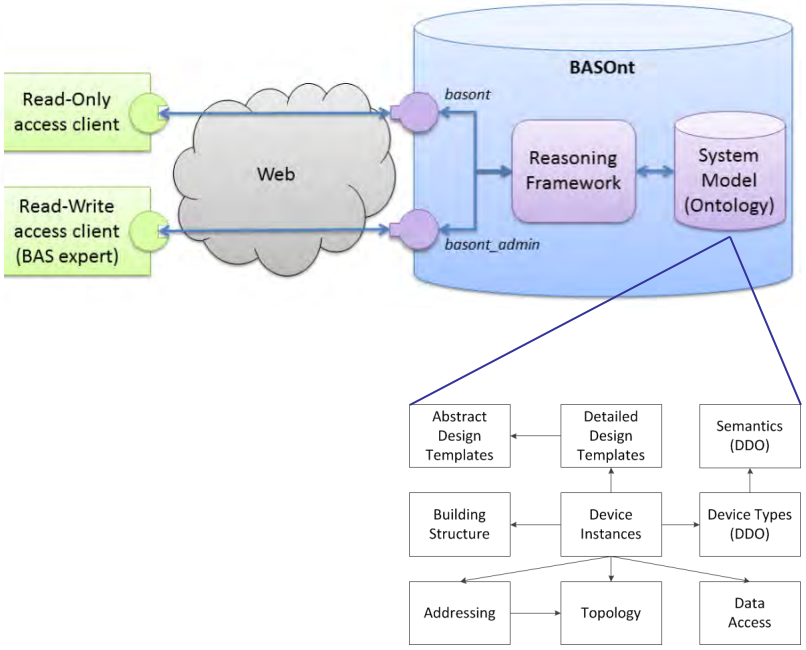




FP7 SCUBA Project

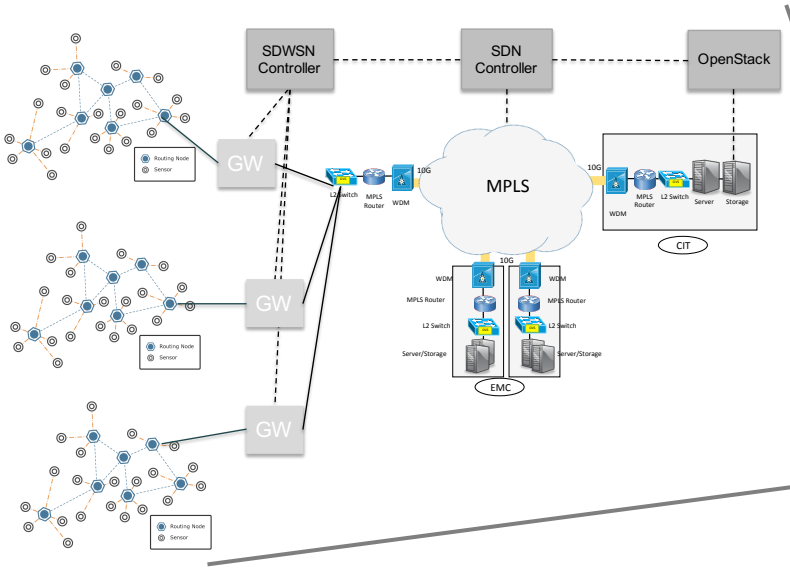


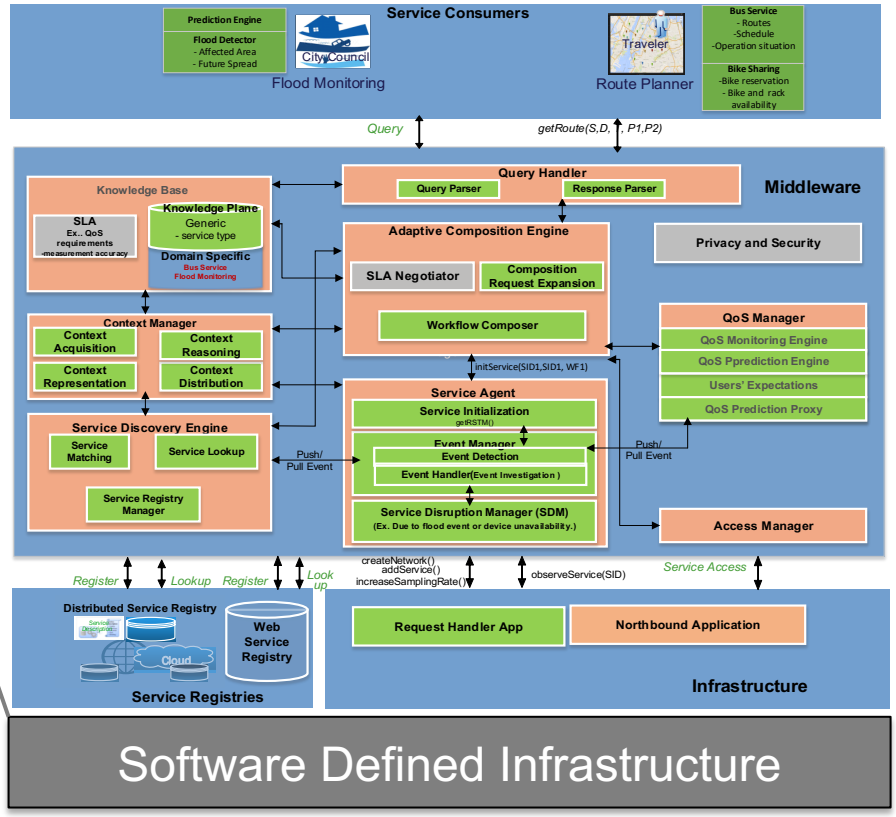
- Architecture for Cooperative Building Automation
- Trying to solve interoperability in BAS
- BASOnt data model for interoperability



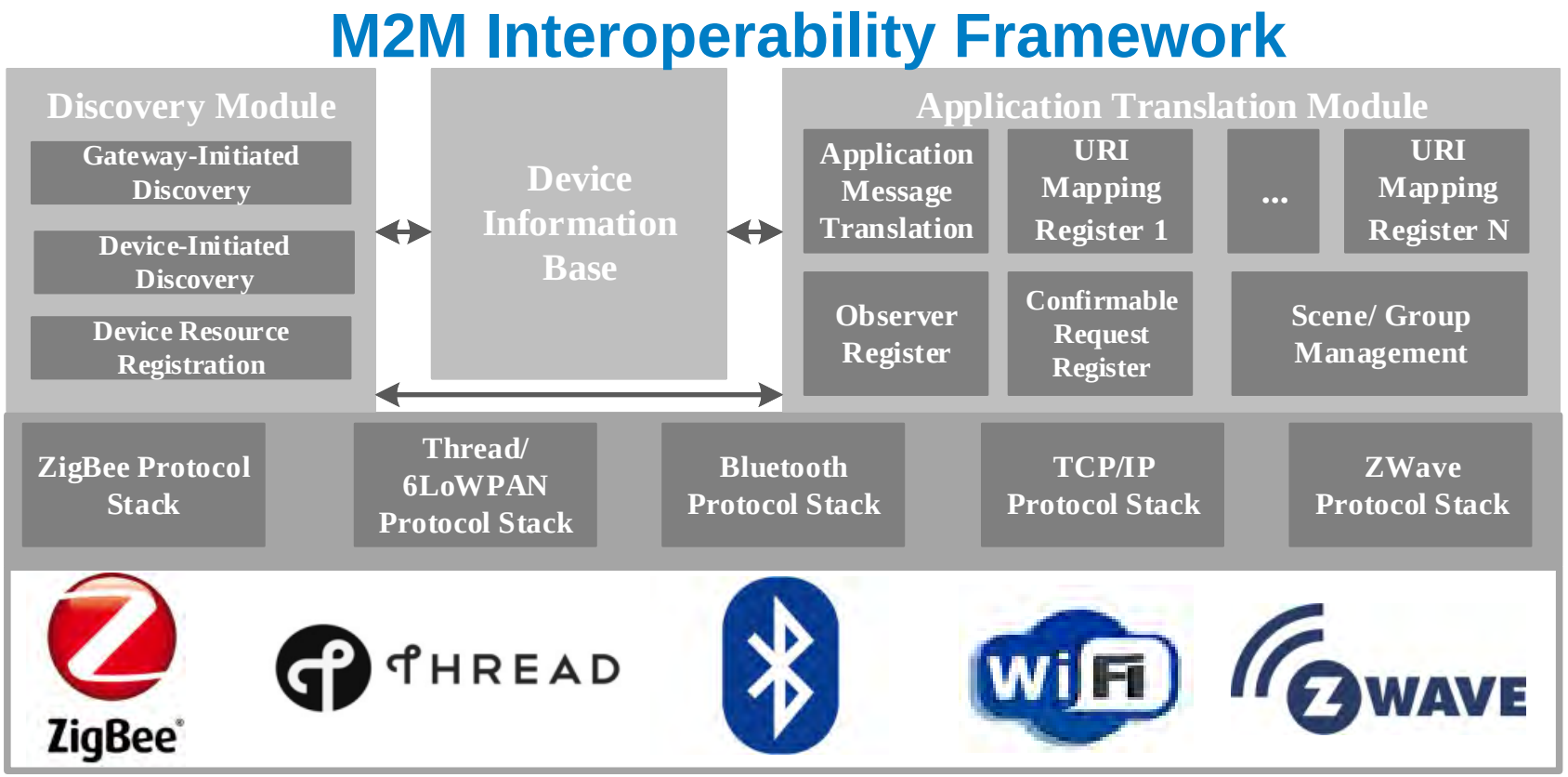
SURF – Software Defined Embedded Networks

- Software Defined IoT edge infrastructure
- edgeSDN can help with solving interoperability issues
  - Reconfiguration of protocol infrastructure
  - Embedding interoperable networks





Modular Interoperability Layer



Patent Application: EP17206239

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Conclusions

- Interoperability emerging as a key problem in Internet of Things
- (Too) Many architectures, platforms, devices, and M2M protocols
- Current trends leading to Internet of Things Silos
- Solutions requires Interoperability at least at
  - Communications layer
  - Data and model layer

  however, scalability issues exist
- Open service architectures and interfaces, composition and cooperation
- Effective end to end security needed

Questions ?

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