IEEE Region 10 Symposium 2016
(IEEE TENSYMP 2016)

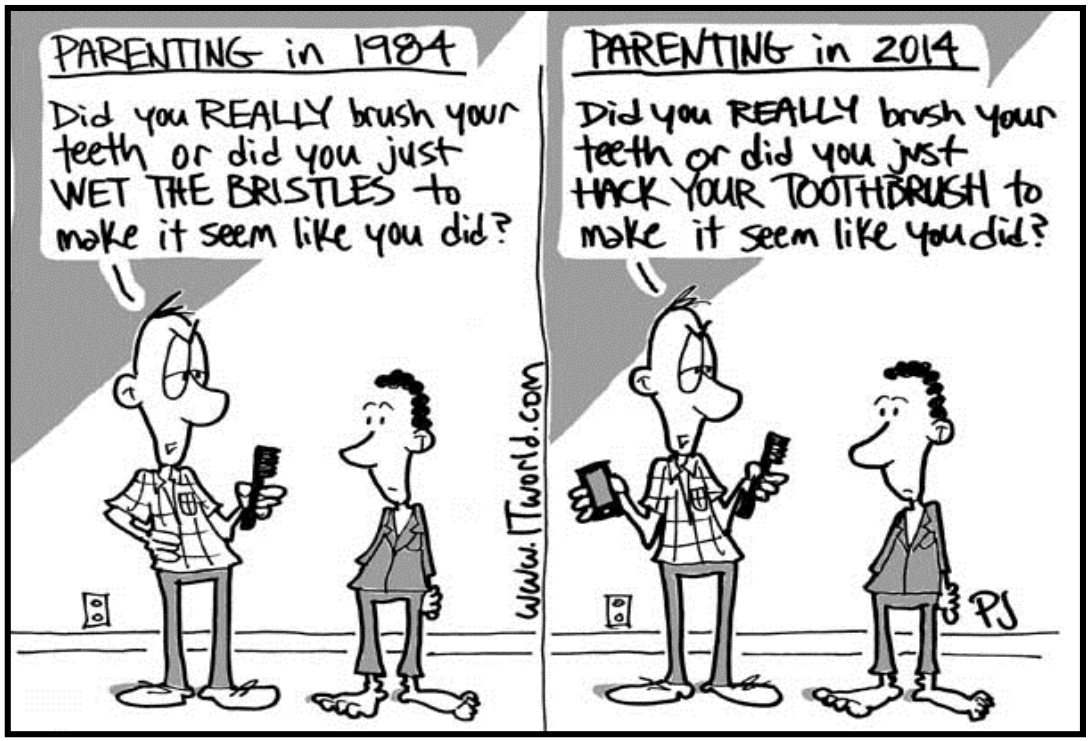
Fog Computing for Consumer Centric Internet of Things

Soumya Kanti Datta
Research Engineer, EURECOM, France
Email: soumya-kanti.datta@eurecom.fr

Roadmap

- Introduction
- From Cloud to Fog
- Fog Computing
- Connected Vehicle Scenarios
- Integration with IoT Standards
- Conclusion

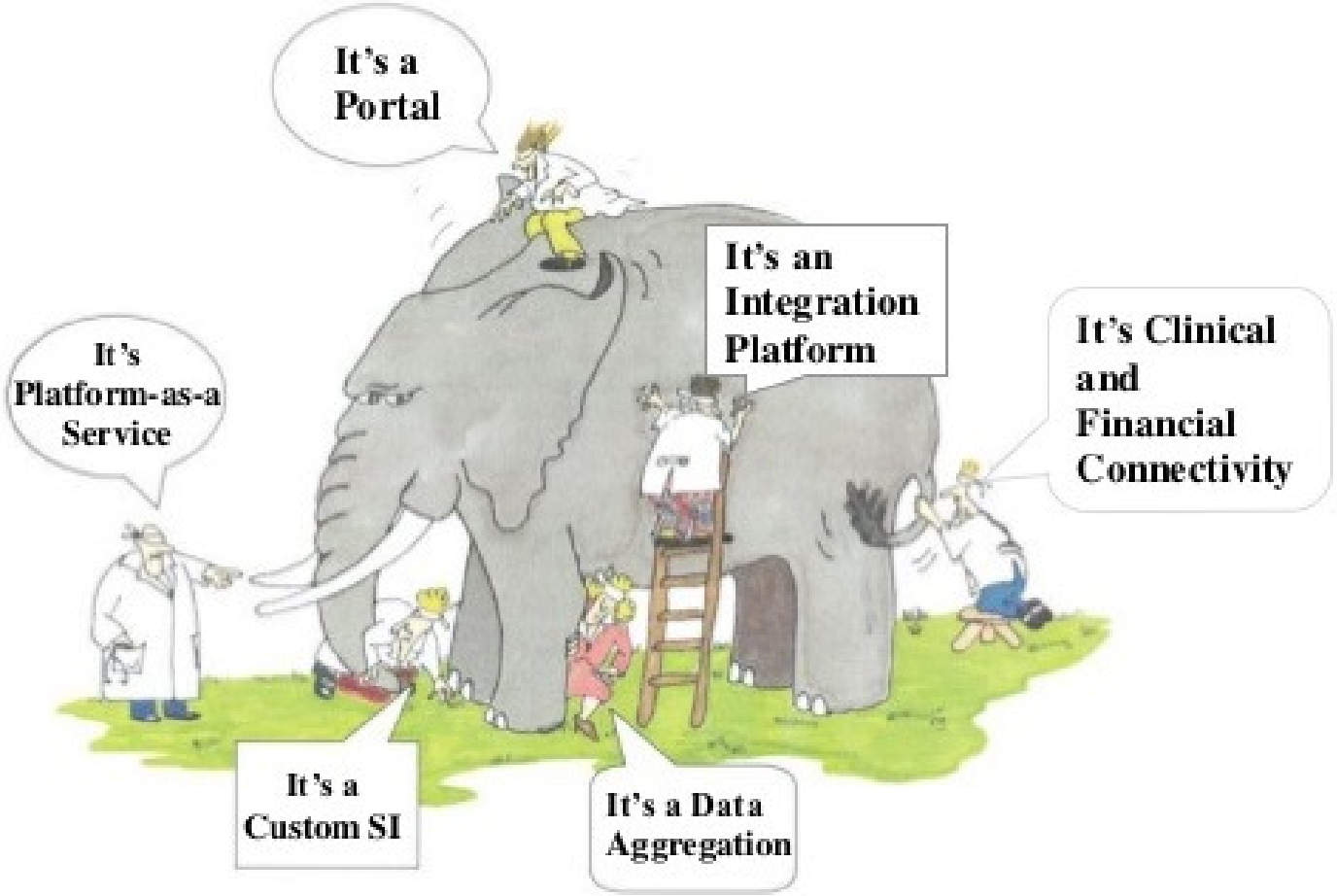
Connecting Things



Source: http://www.itworld.com/

Source: Roberto Minerva, "From M2M to Virtual Continuum", ICCE 2015, Las Vegas

What is IoT?

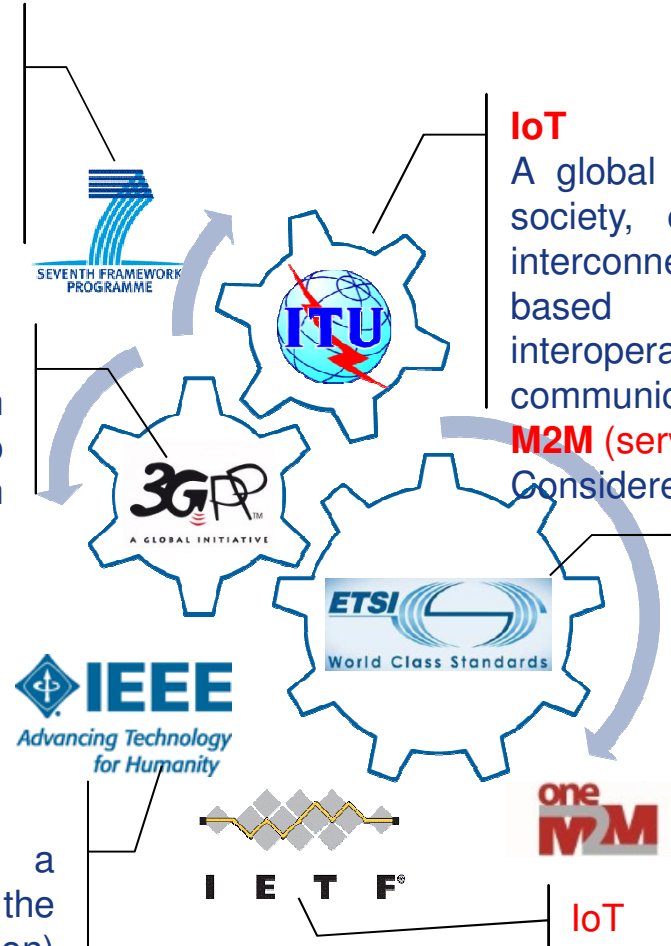


Source: IDC Health Insights

M2M/IoT Definitions

IoT
A global network infrastructure, linking physical and virtual objects through the exploitation of data capture and communication capabilities
[EU FP7 CASAGRAS]

MTC
A form of data communication which involves one or more entities that do not necessarily need human interaction



IoT
A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on, existing and evolving, interoperable information and communication technologies [ITU-T Y.2060]

M2M (service layer)
Considered as a key enabler for IoT

M2M

Communication between two or more entities that do not necessarily need any direct human intervention

M2M
Information exchange between a Subscriber station and a Server in the core network (through a base station) or between Subscriber station, which may be carried out without any human interaction [IEEE 802.16p]

IoT
a world-wide network of interconnected objects uniquely addressable, based on standard communication protocols
[draft-lee-iot-problem-statement-05.txt]

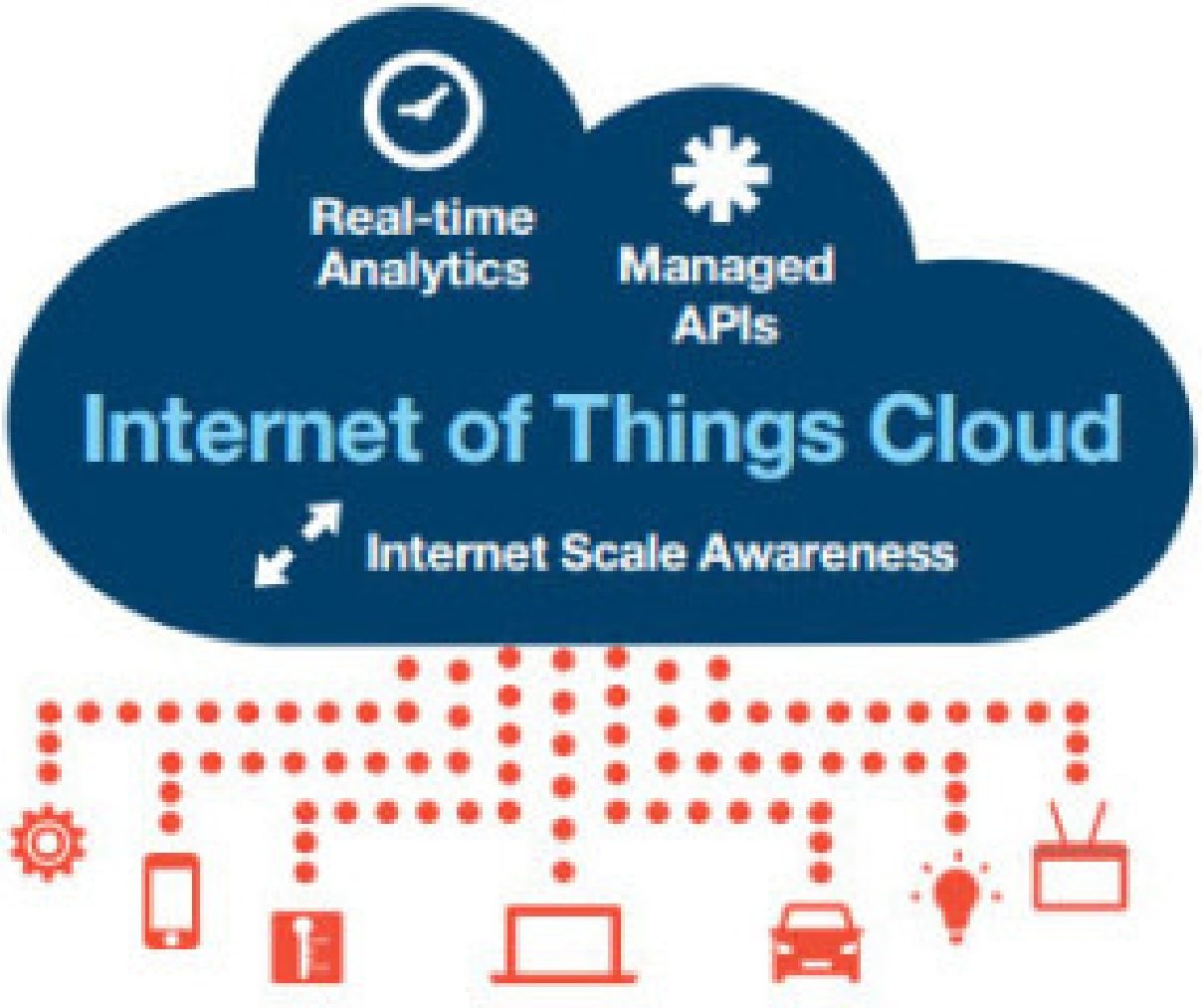
Contribute Your IoT Definition

Define IoT

Towards a Definition of the Internet of Things (IoT)

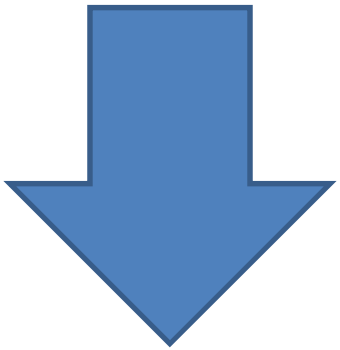
Source: IEEE IoT initiative, http://iot.ieee.org/definition.html

Current Trend in IoT



Cloud Based IoT Has Challenges

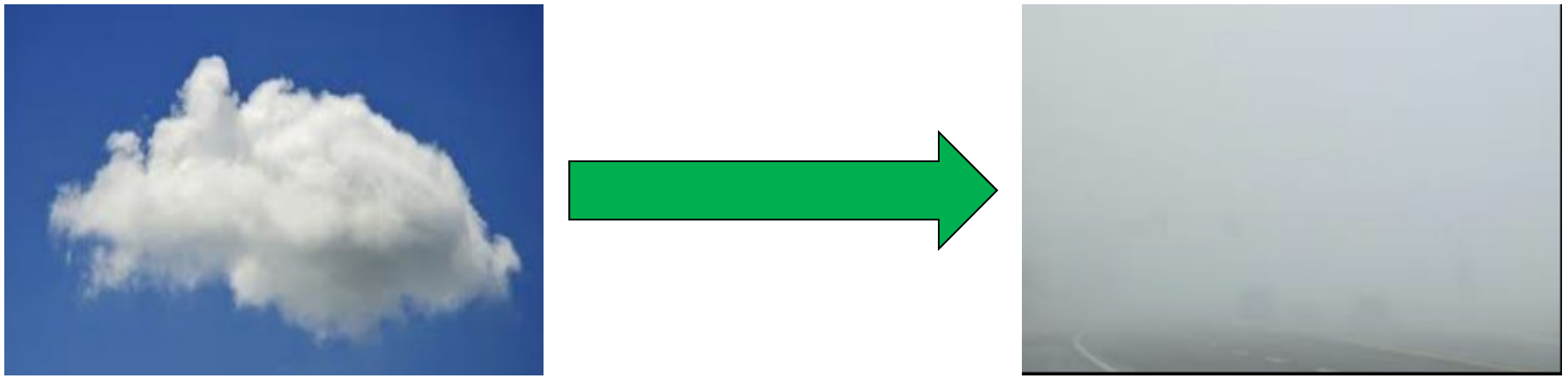
- Not suitable for
  - low latency applications
  - Real time data analysis
- How to support high degree of mobility



- What could be a suitable alternative?

From Cloud to Fog

- Witnessing a Paradigm Shift
- But why?
- What are the enablers?

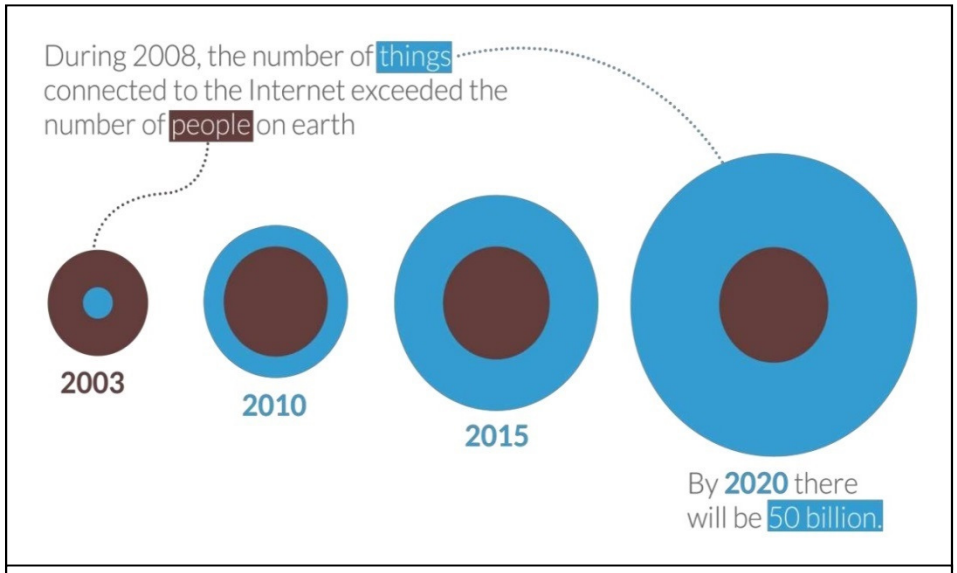


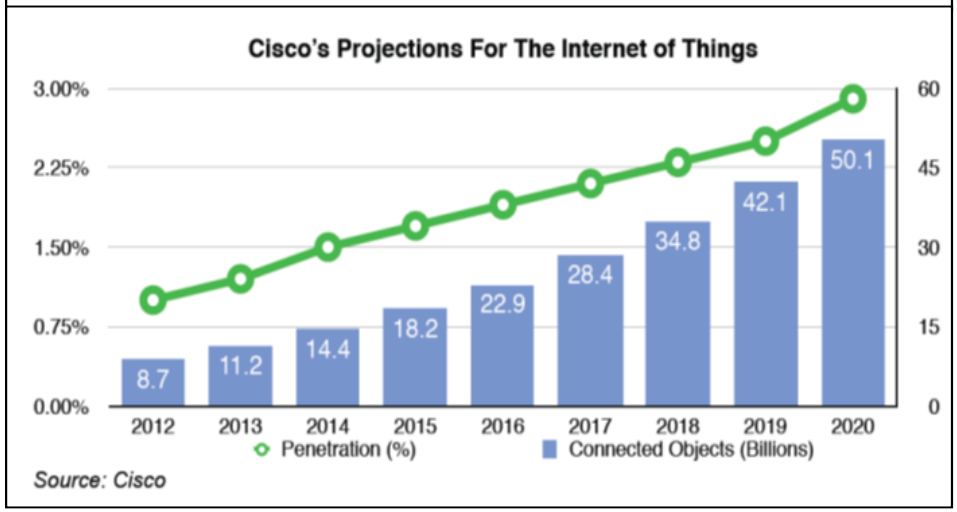
Source: Datta, S.K.; Bonnet, C.; Haerri, J., "Fog Computing architecture to enable consumer centric Internet of Things services," in *Consumer Electronics (ISCE), 2015 IEEE International Symposium on*, pp.1-2, 24-26 June 2015

Roadmap

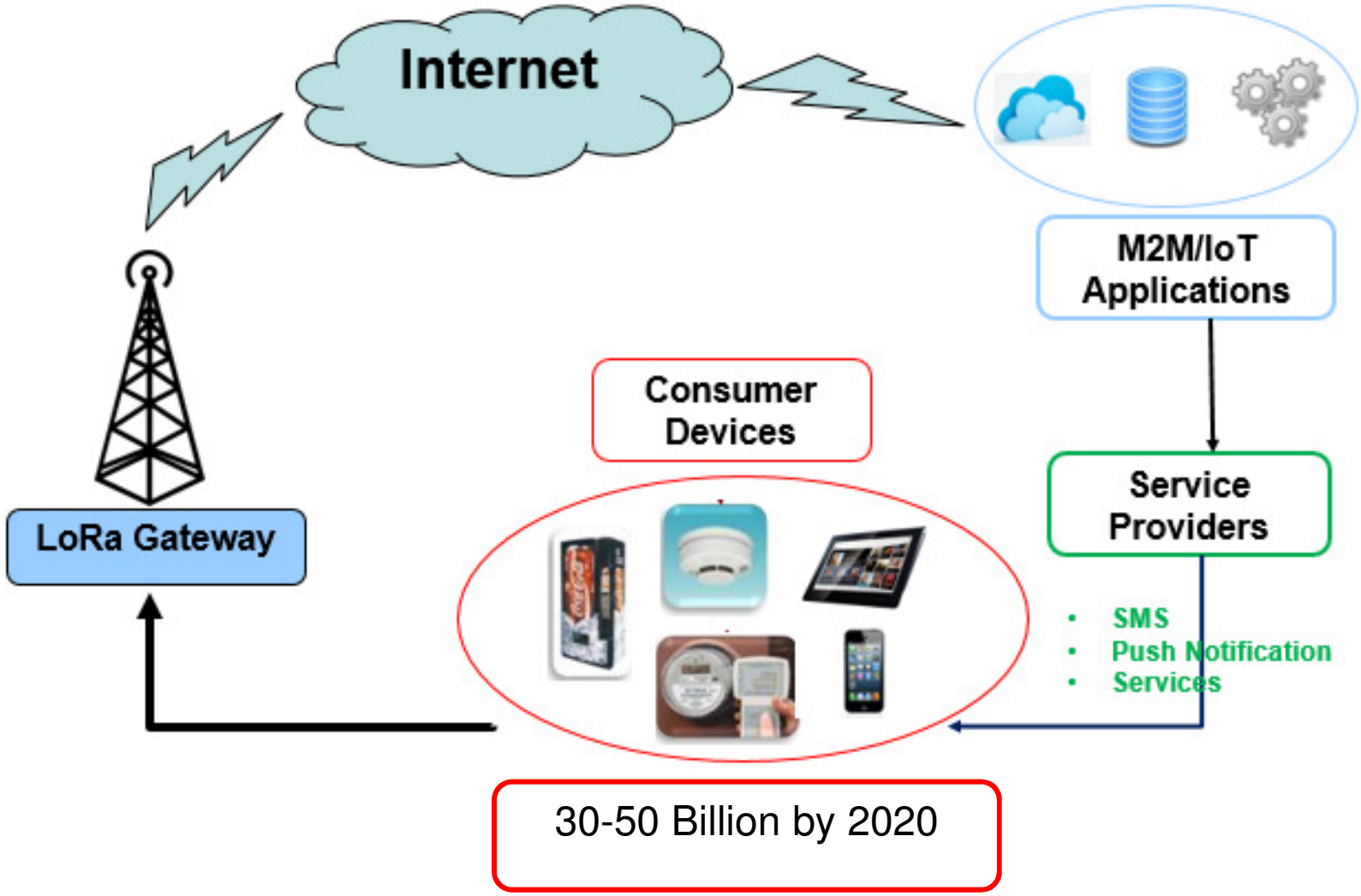
- Introduction
- From Cloud to Fog
- Fog Computing
- Connected Vehicle Scenarios
- Integration with IoT Standards
- Conclusion

Huge Volume of Devices





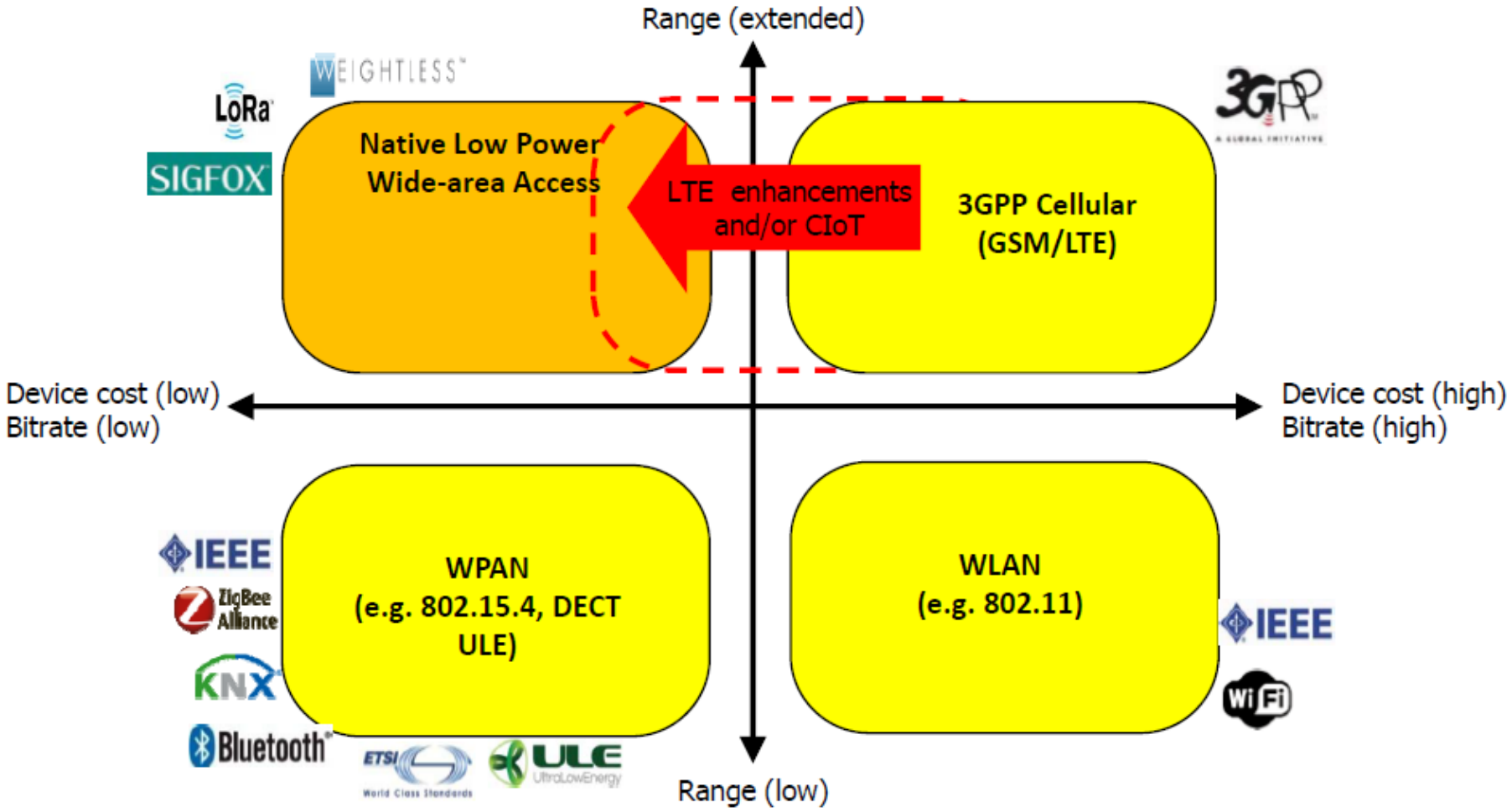
Edge of Network



A Closer Look at Edge Devices

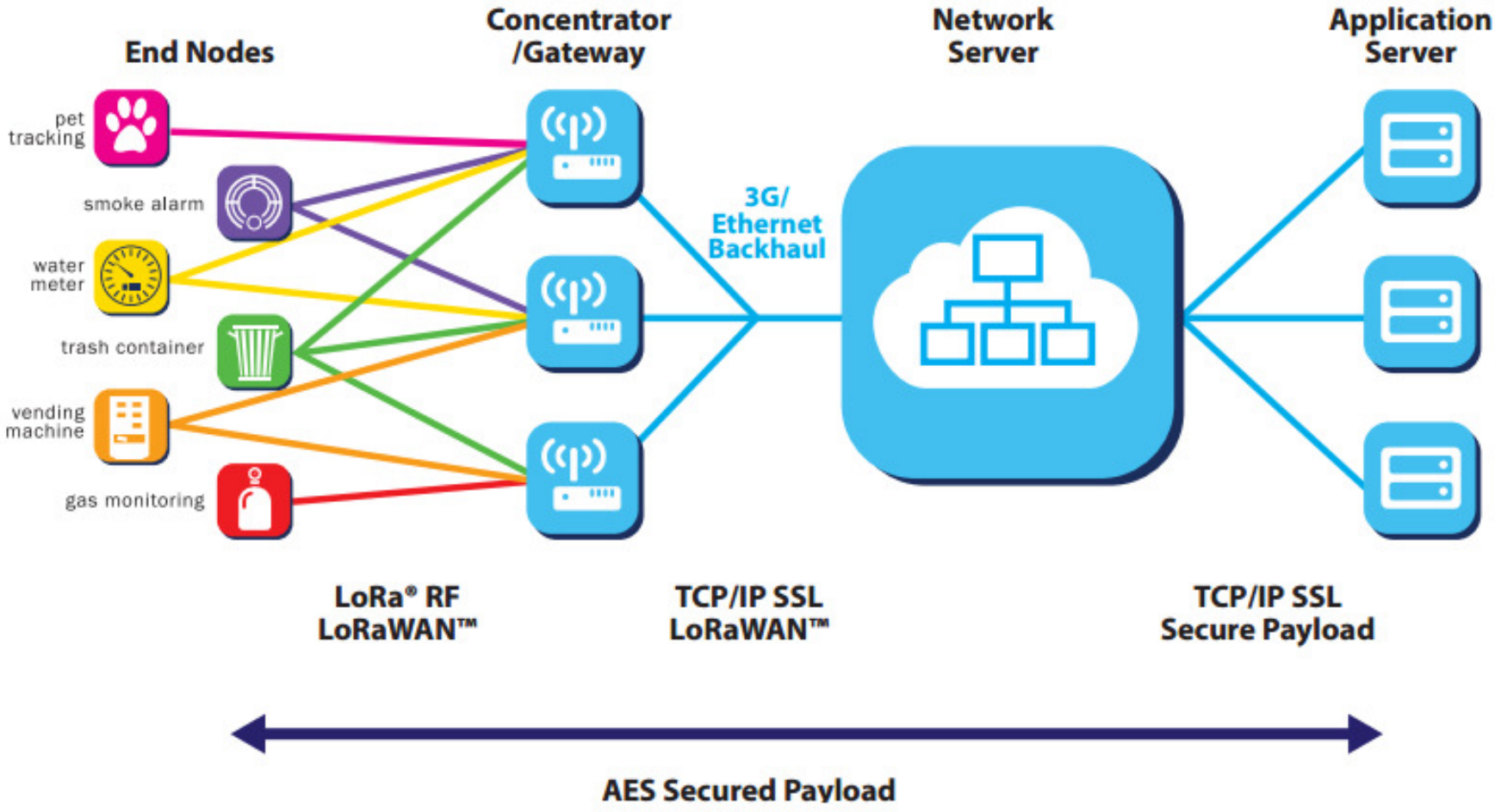
- Nature
  - Powerful as well as constrained devices
  - Dense
  - Highly distributed
  - Mobile as well as static
- Some applications need
  - Real time operation with very low latency and high QoS
    - Highly autonomous and interactive driving

Network Access Technologies



Source: Omar Elloumi, ETSI M2M Workshop 2015

Communication as an Enabler



Source: LoRa Alliance Whitepaper

Other Ingredients

Lightweight software development platform

- E.g. Python based Flask framework for web services.
- AndroJena, an Android library for Apache Jena Framework for semantic web computation.

In-expensive yet powerful things

- Raspberry Pi, Arduino, M2M Gateways.
- LoRa Devices (cost ~ $5).

Open source philosophy

- Open source operating systems, APIs and firmware.
- Developer community.

Use Cases of Fog

- Video analytics
- Location based services
- Internet of Things
- Augmented reality
- Data caching and optimized local content distribution

- New Mobile Edge Computing (MEC) industry standards and deployment of MEC platforms will act as enablers for new revenue streams to operators, vendors, data analytics and platform providers.

Source: http://www.etsi.org/technologies-clusters/technologies/mobile-edge-computing

Roadmap

- Introduction
- From Cloud to Fog
- Fog Computing
- Connected Vehicle Scenarios
- Integration with IoT Standards
- Conclusion

Fog Computing

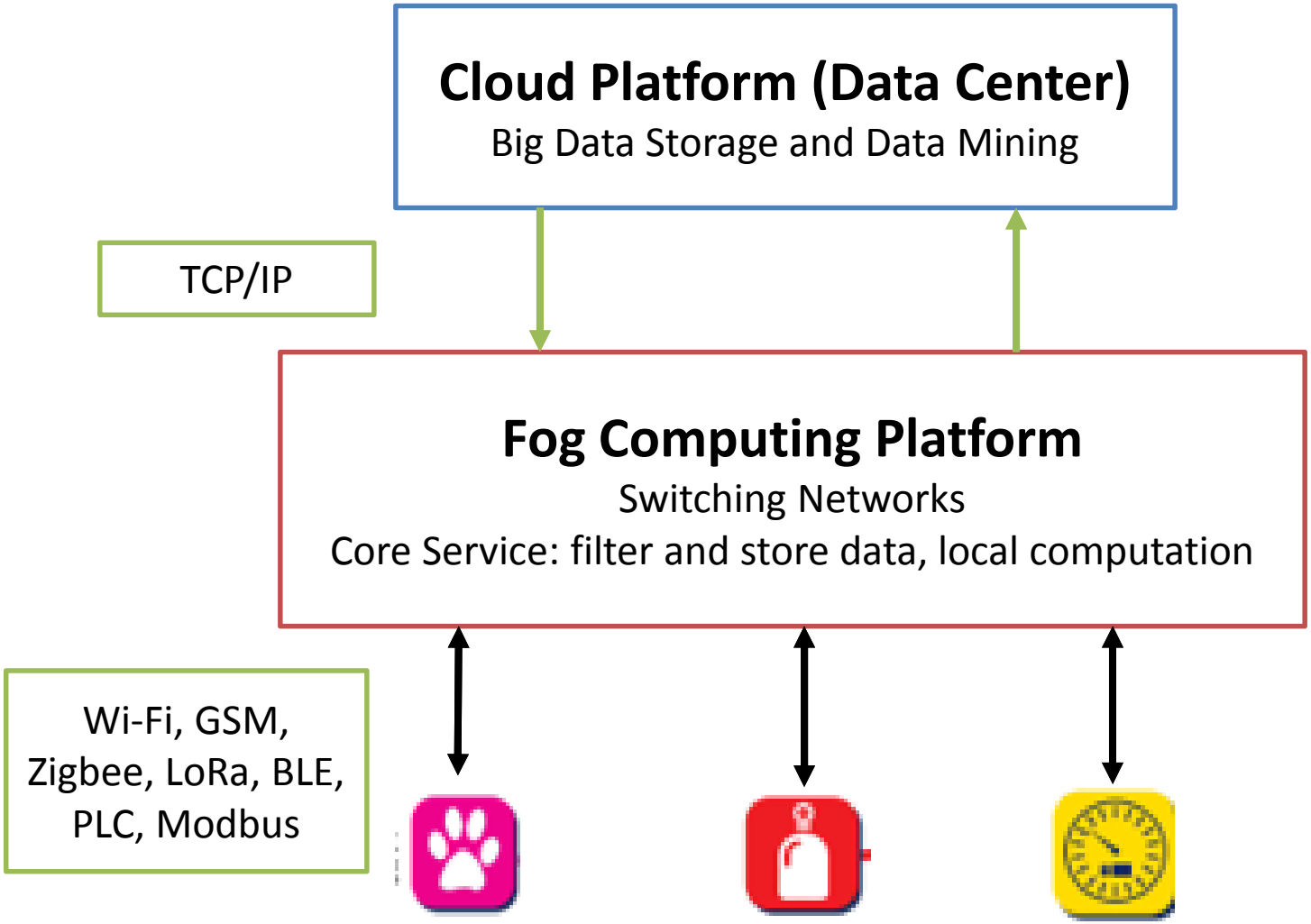
- Main characteristics
  - Proximity to end-users, dense geographical distribution
  - Open platform, Support for high mobility
- Value addition
  - Provide consumer centric services with reduce latency and improved QoS

Benefits of Fog Computing

- Operate IoT service from edge of networks
  - Access points, set top boxes, Road Side Units and M2M gateways.
- Real time operations
  - Reduced latency, improved QoS, real time data analysis with actuation results in superior user experience.
- Promotes distributed architecture
  - Dense geographic coverage
  - Promotes fault tolerance, reliability and scalability.
- Saves Bandwidth

Source: Datta, S.K.; Bonnet, C.; Haerri, J., "Fog Computing architecture to enable consumer centric Internet of Things services," in *Consumer Electronics (ISCE), 2015 IEEE International Symposium on*, pp.1-2, 24-26 June 2015

Core Services of MEC



Local Data Processing

- Need to support
  - Filtering and aggregating data based on some policies.
  - Localized analysis with real time data and exchange valuable information with consumers and/or cloud.
  - Remove redundant and invalid data.
- Fog plays an important role in deciding
  - Content: what should it upload to the cloud
  - Data format: how to represent the content
  - Time: when to send the content

Summarizing Fog Computing

- It offers application developers and content providers
  - Local computation capabilities
  - IT service environment at the edge of the mobile network.
- This environment is characterized by
  - ultra-low latency
  - high bandwidth
  - real-time access to radio network information that can be leveraged by applications.

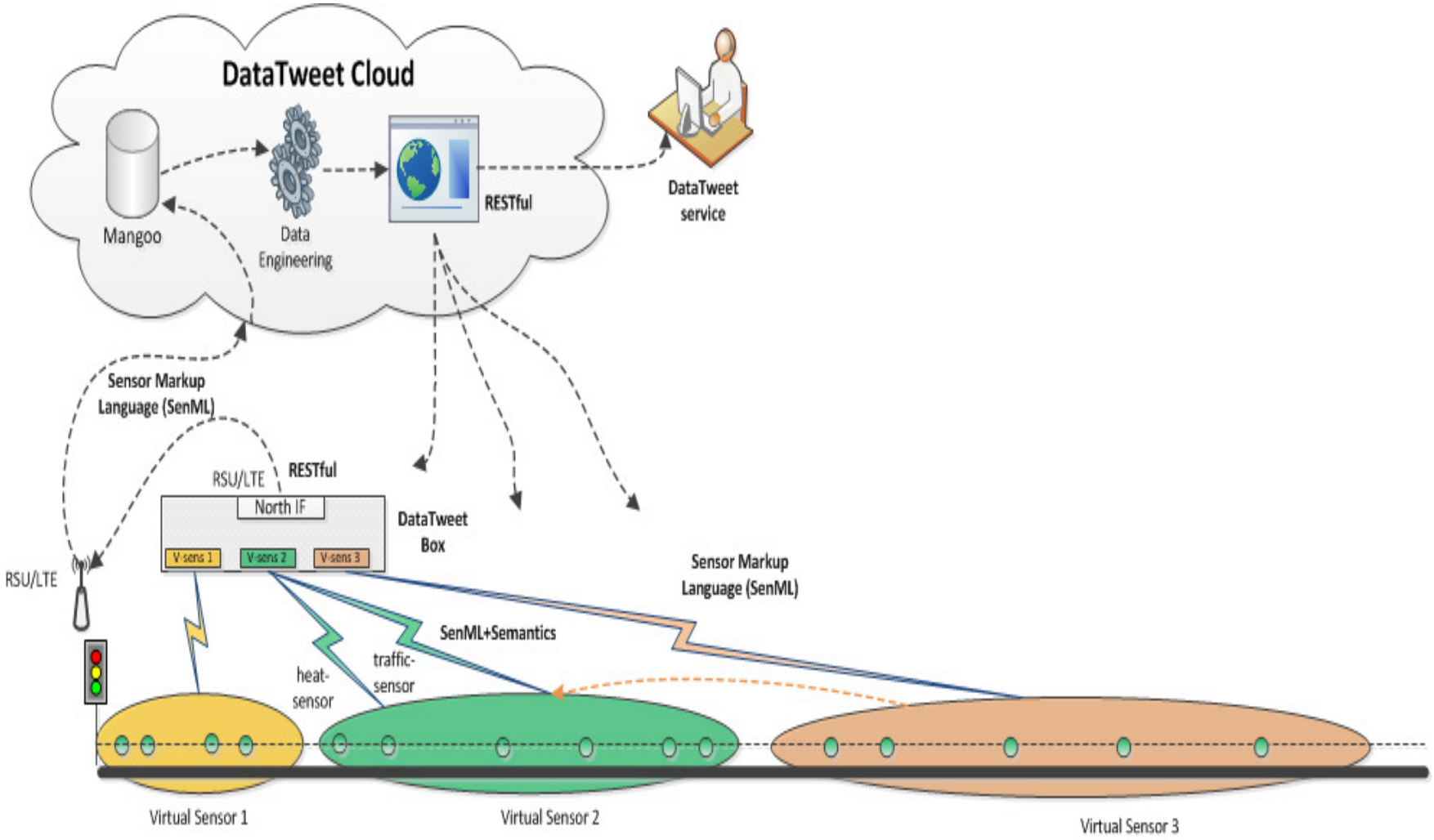
Roadmap

- Introduction
- From Cloud to Fog
- Fog Computing
- Connected Vehicle Scenarios
- Integration with IoT Standards
- Conclusion

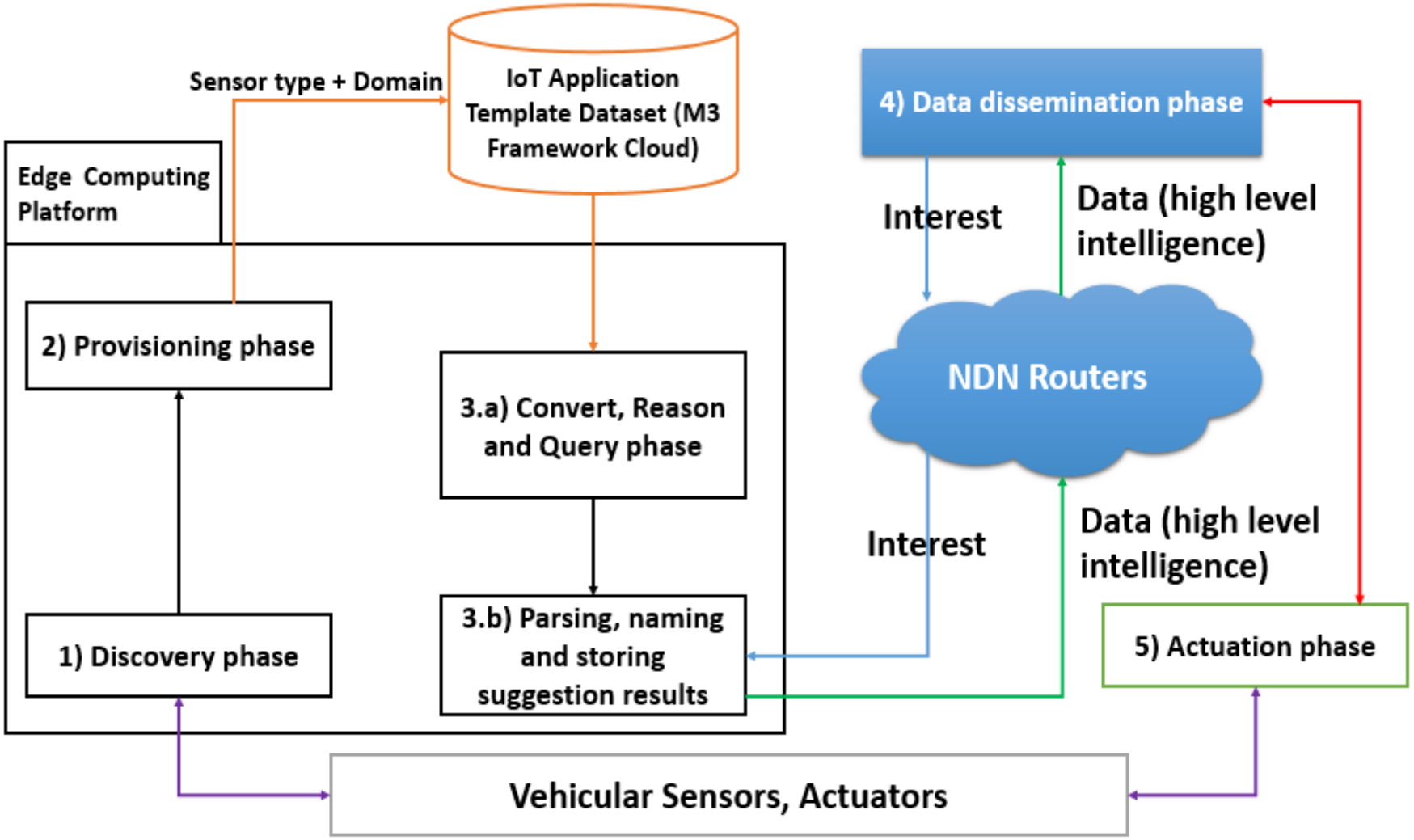
Connected Vehicles Scenarios

- Connected vehicles services comprise of -
  - Traffic and public safety
  - Real time traffic analysis
  - Support for high mobility
  - Location awareness
  - infotainment
  - Wide spread geographic distribution
- Such requirements make Fog computing platform ideal choice.

IoT Architecture for Connected Vehicles



Operational Phases



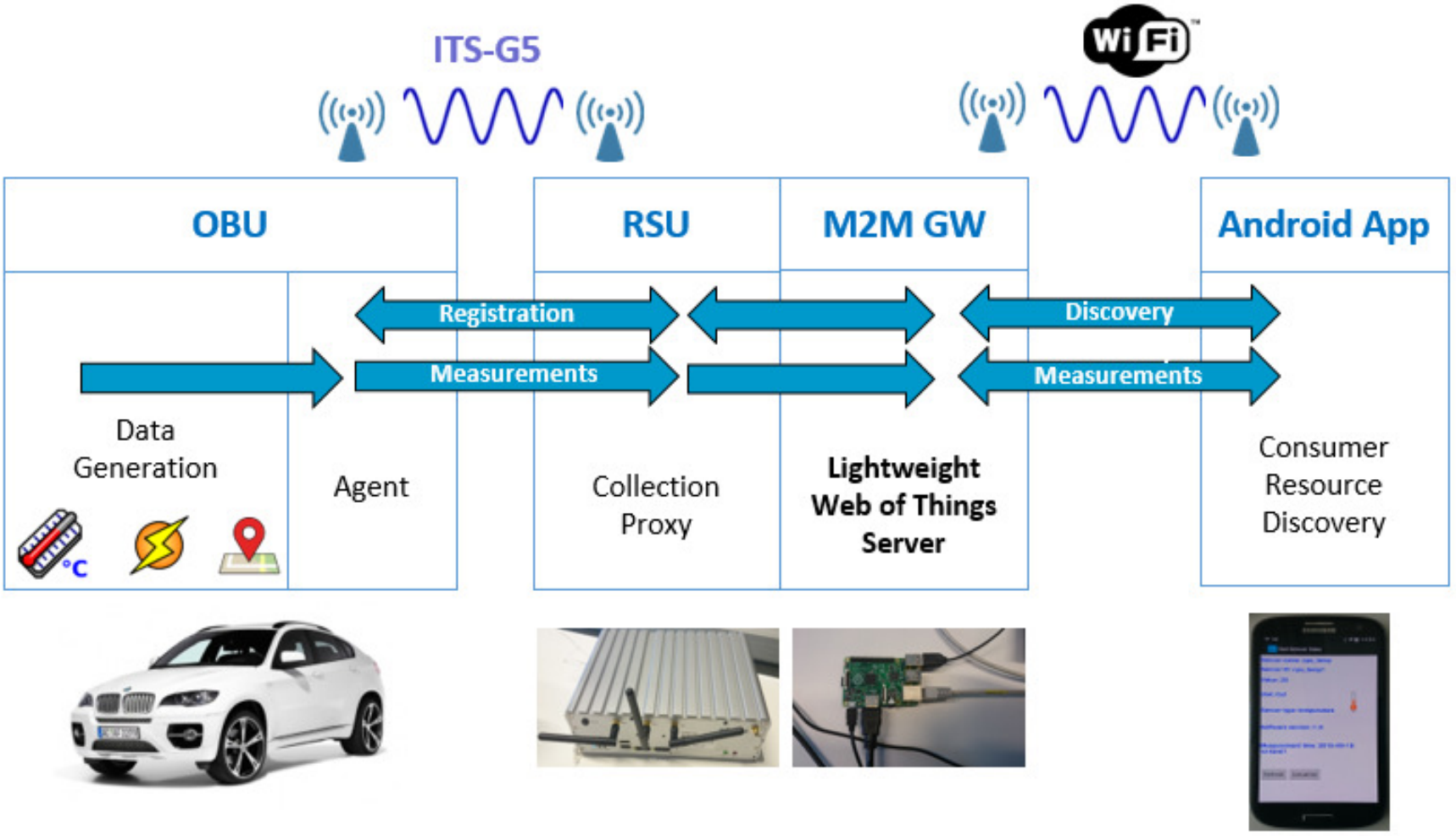
Three Main Functionalities

- Resource Discovery
- Management of connected vehicles
- Data analytics
  - Utilizing semantic web technologies
  - Dissemination of high level intelligence

Data Analytics

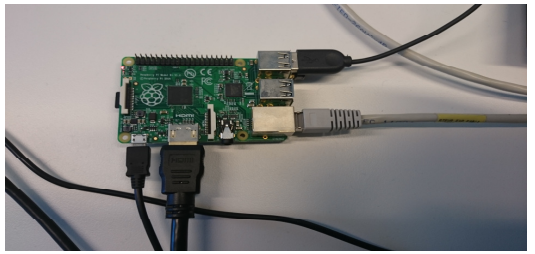
- Use of semantic reasoning
  - First step: Use Sensor Markup Language (SenML) to add side information to vehicular sensor data.
  - Second step: decorate the M2M data with additional semantic reasoning.
- Accomplished using Machine-to-Machine Measurement Framework.
  - Available at http://sensormeasurement.appspot.com/

Demonstration – A Fog Platform



Hardware Components

- Nexcomm VTC-6201 – 1x OBU (vehicle) and 1x RSU (base-station)
  - IEEE 802.11p radio (5.9GHz), GPS, Wi-Fi and Ethernet.
  - ITS-G5 stack protocols embedded.
- Raspberry Pi acting as M2M gateway
  - Supports Discovery, Registration and Data Collection
- Android phone acting as client



Software Components

- OBU and RSU
  - Ubuntu 12.04 with ITS-G5 stack protocols and DSRC logic interface.
  - Gpsd and ntpd for GPS data manipulation.
  - Data generation, Proxy and Agent modules implemented in C.
- M2M Gateway running Lightweight WoT server
  - SQLite database for sensor data storage.
  - Python language for developing the web services.
- Android Application
  - Consumer application

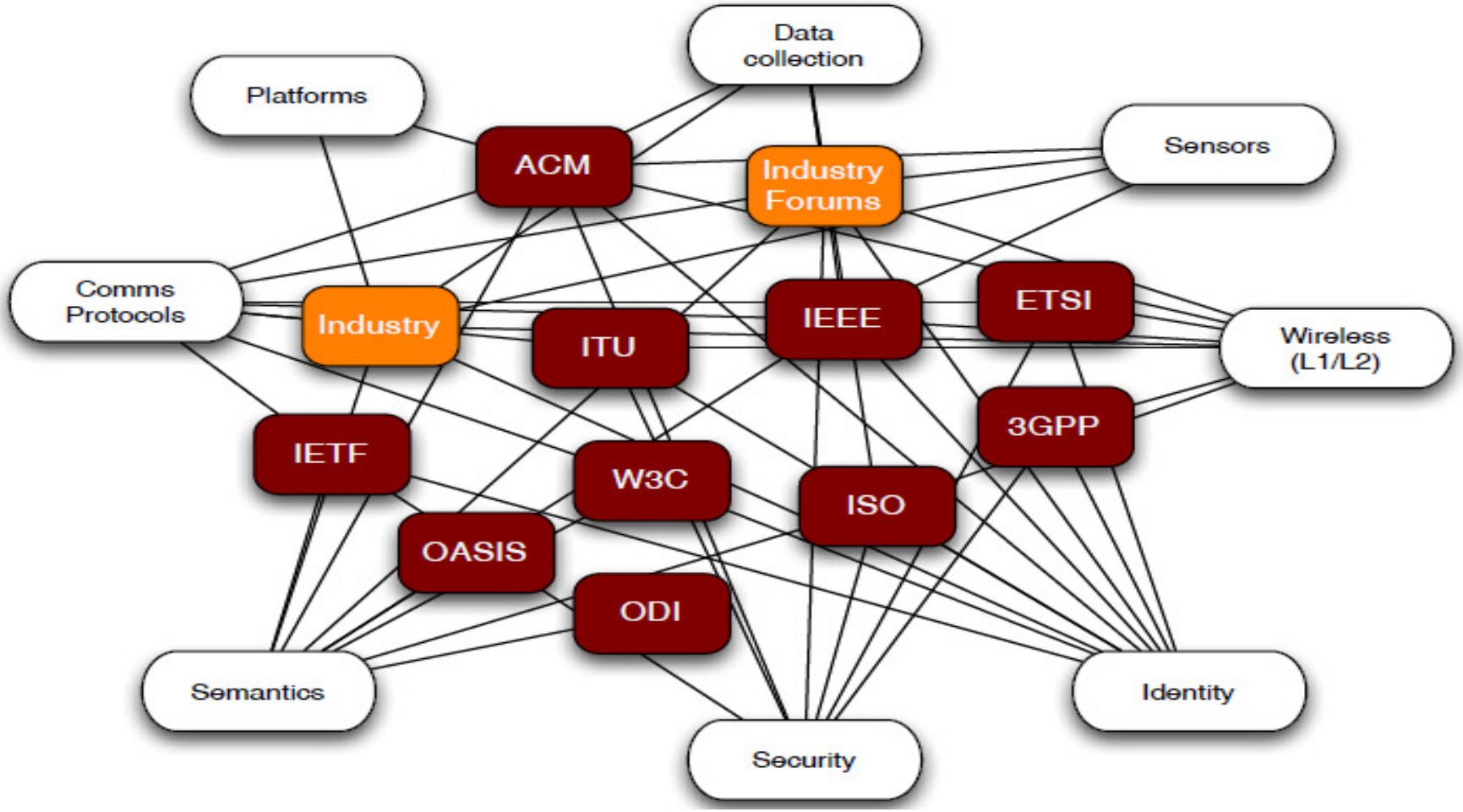
Demo Video

Roadmap

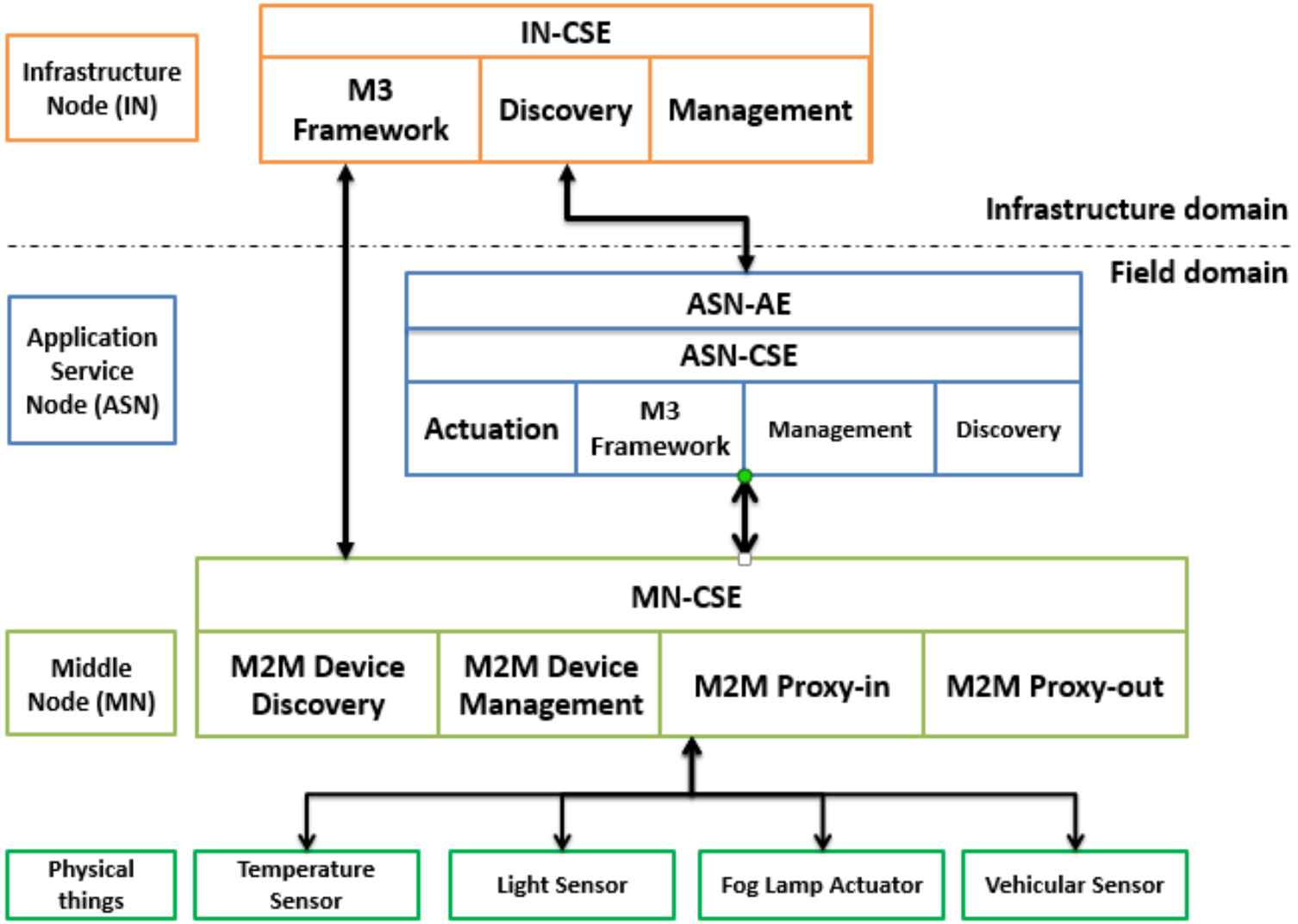
- Introduction
- From Cloud to Edge
- Mobile Edge Computing
- Connected Vehicle Scenarios
- Integration with IoT Standards
- Conclusion

SDOs and Alliances

IoT Standardization Activities



Integration into oneM2M Architecture

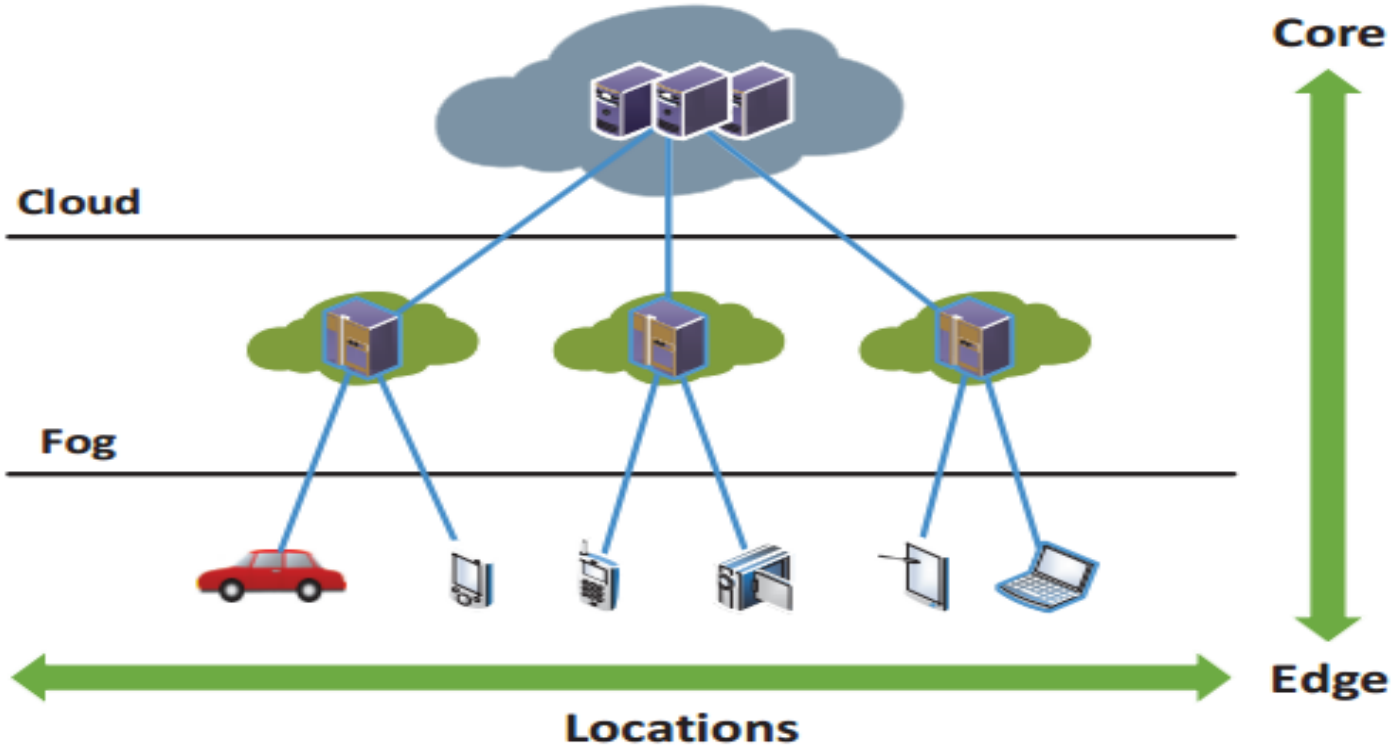


Roadmap

- Introduction
- From Cloud to Fog
- Fog Computing
- Connected Vehicle Scenarios
- Integration with IoT Standards
- Conclusion

Concluding Note

- Cloud and Fog will co-exist enabling consumer centric IoT services.




감사합니다
Natick
Grazie
Danke
Ευχαριστίες
Dalu
Obrigado
Thank You
Köszönöm
Tack
Спасибо
Dank
Gracias
谢谢
Merci
Seé
ありがとう

Q/A

- Email: soumya-Kanti.datta@eurecom.fr
- Twitter: @skdatta2010
- Webpage: https://sites.google.com/site/skdunfolded