On the IoT, from A to Z

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InfoBlender HASLab Seminar

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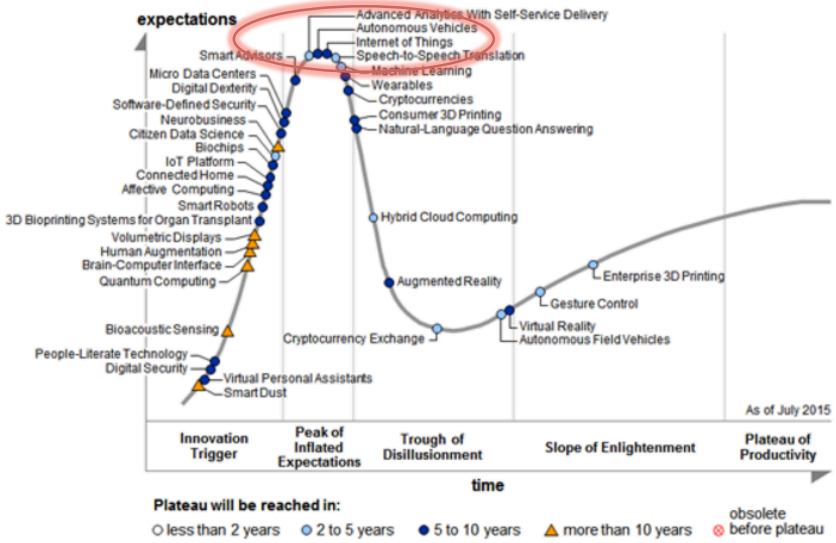


Source: Gartner (August 2015)

What is IoT?

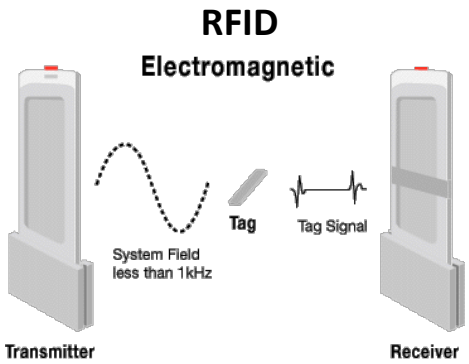
Internet of Things (IoT)

is the Internet of Things

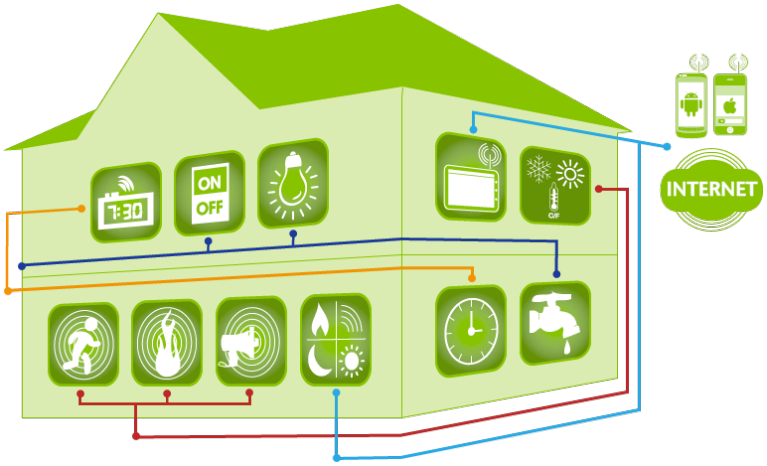
What the slides are about?

- To know what is IoT, how it works, and what are the challenges.
- Kind of survey, to identify the IoT parts that may fit your expertise or interests.

IoT Use-Cases (naïve)



IoT Use-Cases (moderate)

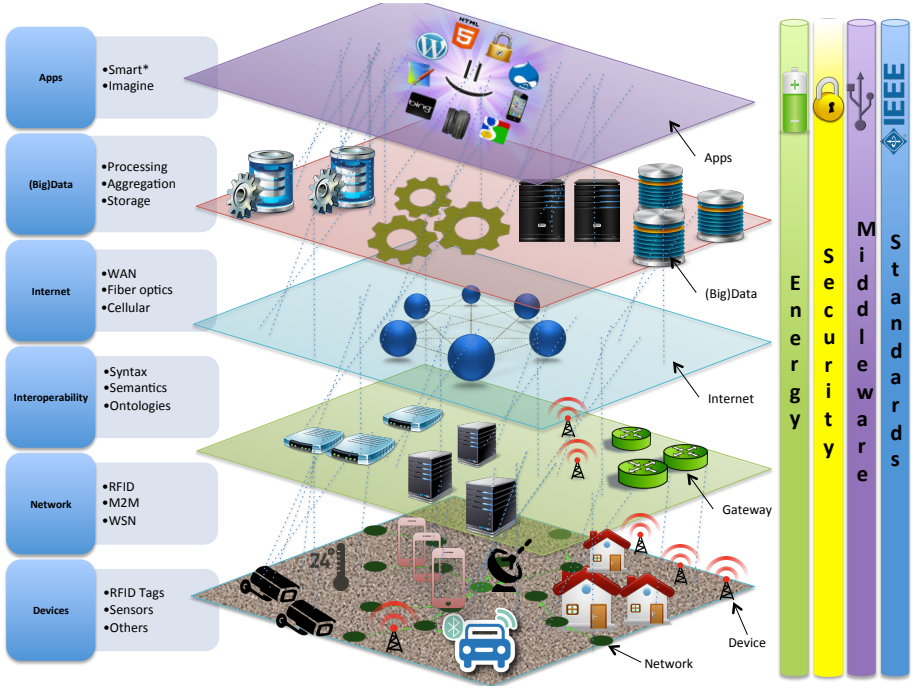


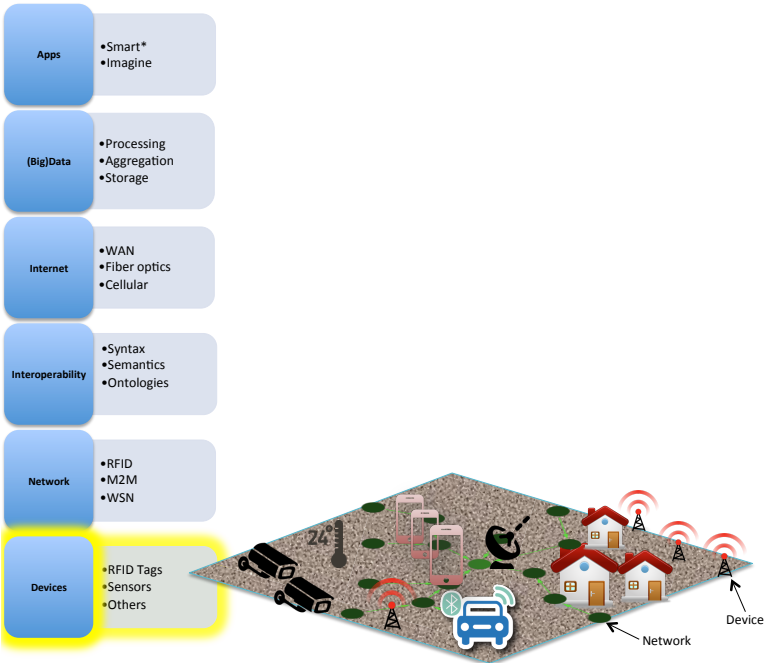
IoT Use-Cases (complex)

IoT Use-Cases (Extreme)

Go crazy

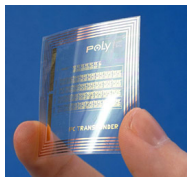
Dust sensors

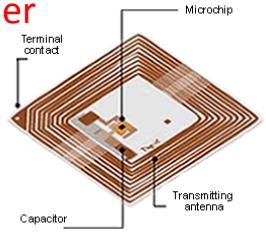




Devices: RFID Tags

- RFID: **R**adio **F**requency **Id**entification
- RFID Tag: small object, often powerless, and very cheap (passive) device with a unique identifier.
- Requires an expensive RFID reader
  - See details later

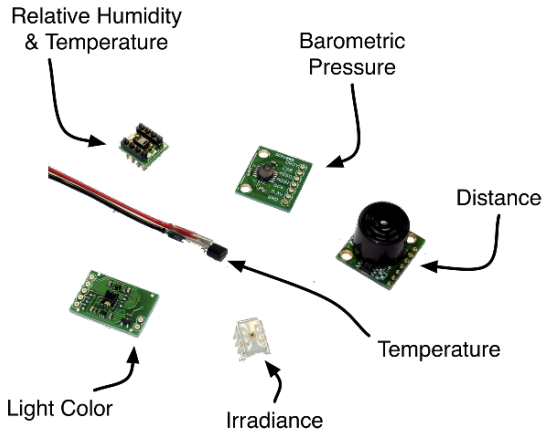




Devices: Sensors

- Categories:
  - Sensor: physical parameter→ electrical output.
    - E.g., temperature, humidity, motion sensors
  - Transducer: energy → energy
    - E.g., microphones
  - Actuator: electrical signal → physical output
    - E.g., speakers, LED, etc.
- Properties: active, powered, memory …

Devices: Sensors



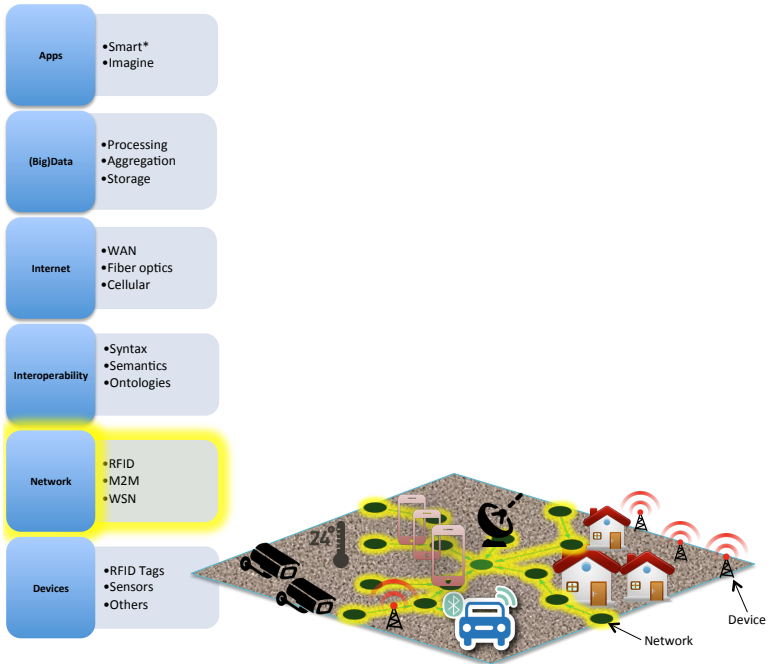
Devices: Others

- Motes
  - Autonomous nodes with power, CPU, memory, connection…
  - Several sensors can be plugged in.
  - E.g., Arduino, Waspmote..

- Smarter machines
  - Smartphones, computers, vehicules...
- Even more sensing
  - Internet traffic, human (social networks), ...

Devices: Challenges

Not only energy, size, price, security, standards



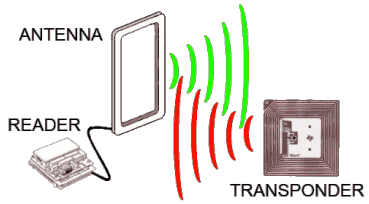
Network

We address these:

- RFID: Radio Frequency Identification
  - Single hop, passive, unidirectional, unpowered
- M2M: Machine to Machine
  - Single hop, active, bi-directional, mains power
- WSN Wireless Sensor Networks
  - Multi hop, active, unidirectional, battery

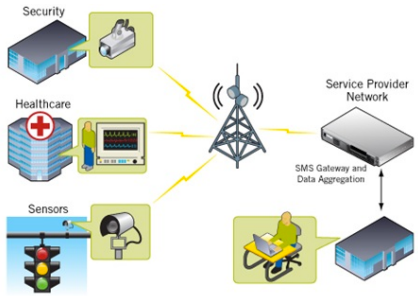
Network: RFID

- RFID communication requires an RFID Reader & Tag
  - **Reader**: a high powered and expensive (active) device that beams energy to a tag.
  - **Tag**: small, often powerless, and very cheap (passive) device with a unique identifier.
  - **Reader+Tag**: near-field communication (NFC)
    - E.g, share contact details via two new smartphones.
- Communication via Radio waves
  - LF(kHz), HF(MHz), UHF(GHz)
- Range: 3 cms to few meters
  - Useful for security



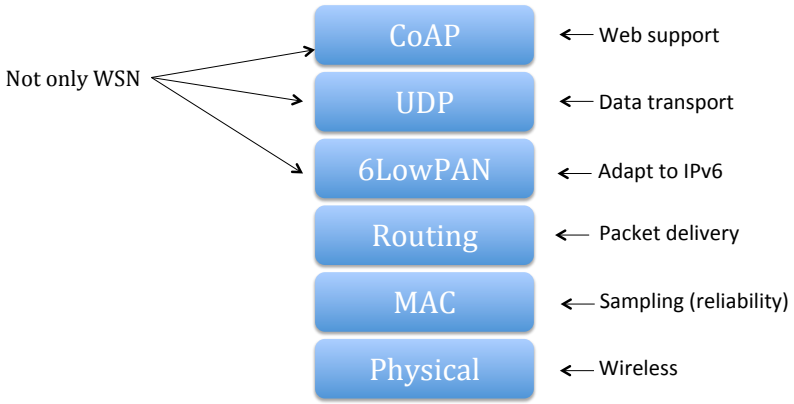
Network: M2M

- Machine to Machine network (e.g., via WIFI router).
  - Often conventional networks are used
- Machines are often fixed, and not energy constrained (use mains power)
- Simple topology: master-slave, star…
- Examples:
  - Smart Cities:
    - Smart lights, traffic monitors..
  - Smart home:
    - Smart meters, cameras, ..



Network: Wireless Sensor Network (WSN)

The IoT stack



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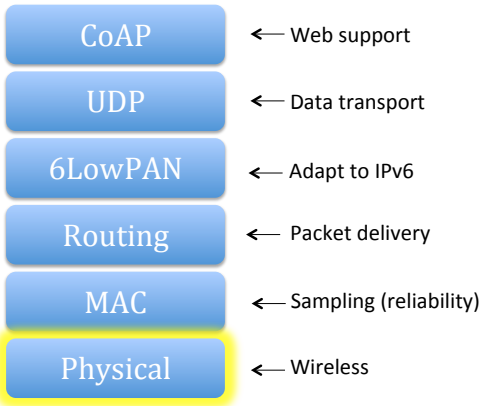
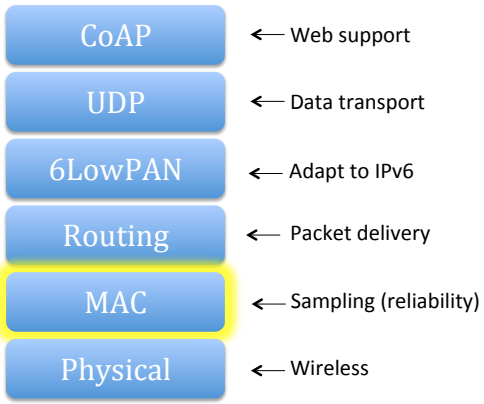


Network: WSN (Physical layer)

- Provides **wireless** communication between devices.
- Majority of WSN wireless technologies operate in an ISM band (no licensing is needed)
  - Short range:
    - WIFI: 50m, 1Gbps
    - BLE (Bluetooth Low-Energy): 150m, 1Mbps
    - Others: Zigbee, NFC, Zwave
  - Long range:
    - Cellular: 200KM, 10Mbps
    - Sigfox: 3-50KM (Rural), 1Kbps
  - Medium range:
    - LoRaWAN: (urban), Neul (urban), Sigfox (rural)

Network: Wireless Sensor Network (WSN)

The IoT stack



Network: WSN (MAC layer)

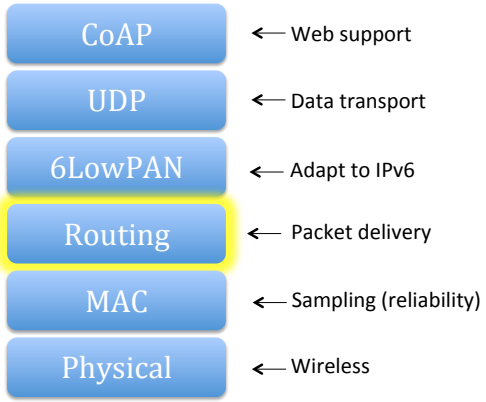
- MAC layer: when to speak and when to listen
- Why matters?
  - Reliability: wireless uses a shared medium
    - Different signals interfere (interference)
    - Reflected signals interfere (multi-path fading)
- Solution: sampling and/or hopping
  - Time slices (TDMA)
  - Frequency slices (FDMA)
  - Code slices (CDMA)

Network: WSN (MAC layer)

- Challenges and tradeoffs:
  - Cheap clocks are not perfect (re-schedule)
  - Power consumption – sleep more
  - Response time – sleep less
- Even more challenging:
  - Centralized?
    - Controller is not always reachable
    - Single point of failure
  - Distributed?
    - How to coordinate?
    - Listening is too expensive, when to sleep?!
    - Protocols: MAC, S-MAC, X-MAC

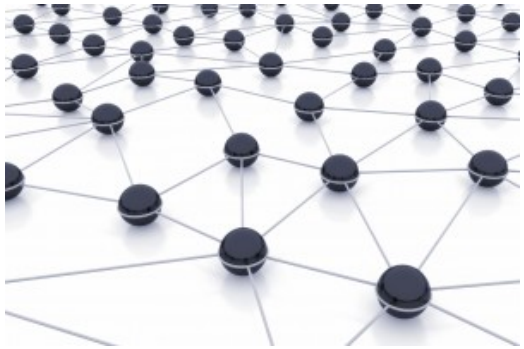
Network: Wireless Sensor Network (WSN)

The IoT stack



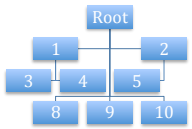
Network: WSN (Routing layer)

- How packets should be sent from a source to a destination
- Problem: often mesh network→ Dynamic neighborhood

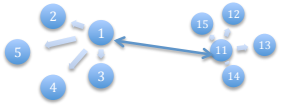


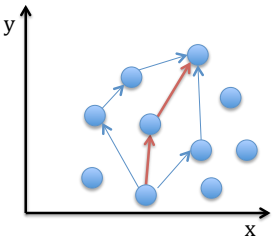
Network: WSN (Routing layer)

- Approaches
  - Build a Tree



  - Impose a hierarchy





  - Use geographic info.
    - GPS (5-50m accuracy), Infrared, Radio
    - Next-hop, lowest-cost path, or flooding (LAR, DREAM, GRID)

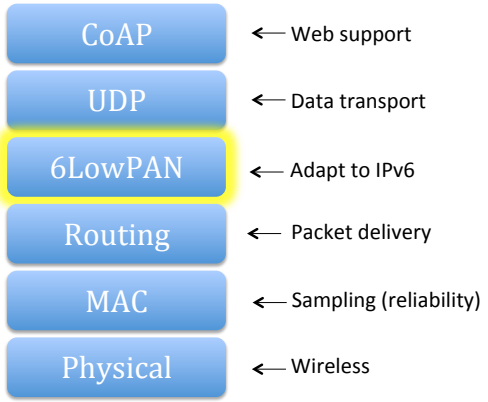
Network: WSN (Routing layer)

- Challenges:
  - Energy: discovery/probe, load balance
  - Failures and mobility
  - Limited resources (small buffers)
- "Best" approach?
  - depends on application needs!

This interplay between layers (Physical-MAC-Routing) is very difficult to study

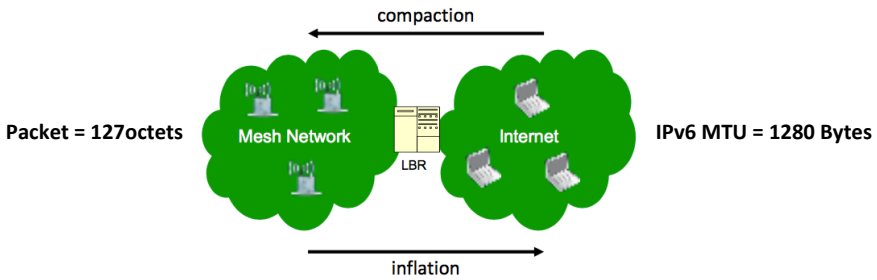
Network: Wireless Sensor Network (WSN)

The IoT stack



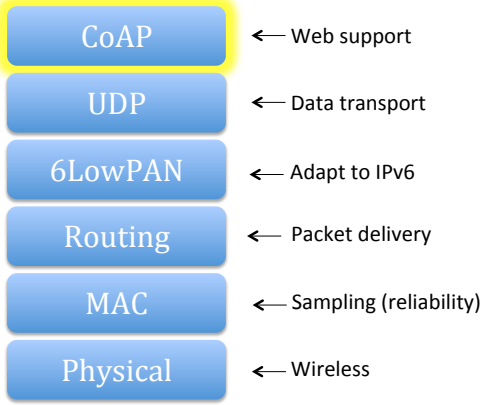
Network: 6LowPAN

- 6LowPAN: IPv**6** over **Low** power wireless **PAN**
- PAN: **P**ersonal **A**rea **N**etworks
- Adapts smart objects (e.g., using 6TOP) to IPv6



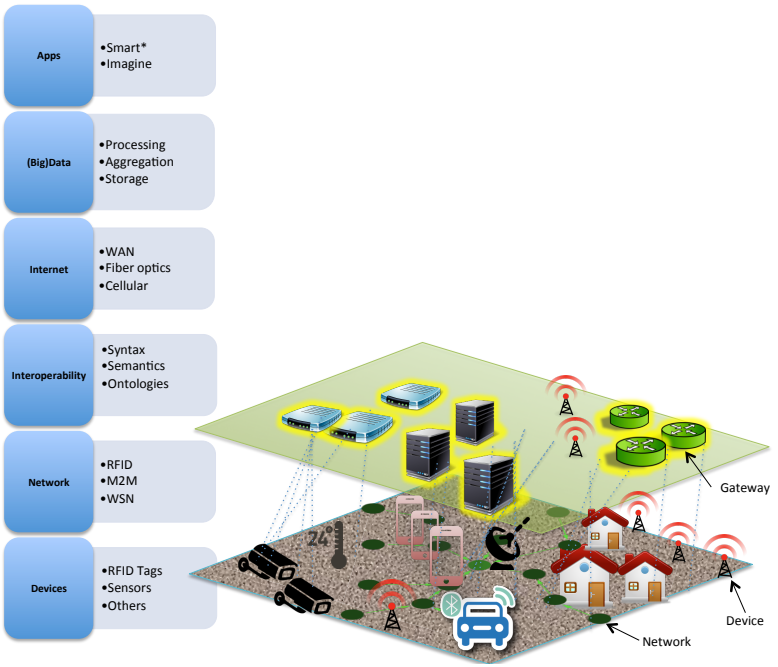
Network: Wireless Sensor Network (WSN)

The IoT stack



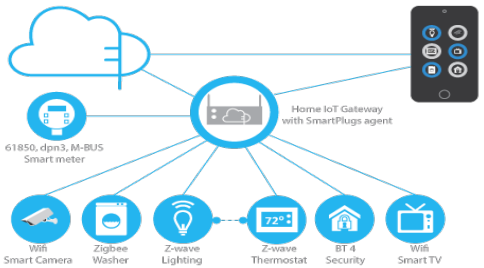
Network: CoAP

- CoAP: **Co**nstrained **A**pplication **P**rotocol (RFC 7252)
- Lightweight application layer web transfer protocol
  - Say HTTP for smart objects
- Why not HTTP?
  - **constrained** nodes
  - **constrained** networks
- Supports *REST (maybe SOAP?)* webservice model.



Network: Gateways

- Gateways are mainly interfaces between the IoT worlds and a more familiar world (Internet..)



- Gateways are not dummy machines
  - Memory, processing, storage, power, reliable, …

Continue on file Part 2