Overview of the Internet of Things

{adapted based on "Things in 2020" Roadmap for the Future by EU INFSO D.4 NETWORKED ENTERPRISE & RFID}

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The Internet of Things (IoT) (1)

- Any object will have a unique way of identification in the coming future
  - "Unique Address"
- Addressable continuum of computers, sensors, actuators, mobile phones
  - Any thing or object around us
- Objects will be able to:
  - Exchange information
  - Actively process information
    - Predefined schemes, which may or may not be deterministic

The Internet of Things (IoT) (2)

- Internet of Things (IoT) Definitions:
  - "Things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts"
  - "Interconnected objects having an active role in what might be called the Future Internet"

The Internet of Things (IoT) (3)

- Things able to transport themselves
  - Consulting global positioning system sensors on its way
  - Instructing conveyor belts for its routing
  - Consulting logistics information databases and decide themselves upon the best route to their destinations;
  - Alternatively the things may consult an external entity like their customers before making decisions that will increase cost or cause delays
- Result:
  - Fully automated supply networks
  - Autonomous warehouses
  - Customers will monitor entirely the transport route from the point an object or product leaves the manufacturer

Energy and Communication Concern

- All devices will need to harvest their own energy
- In environments where there will be no fixed access point:
  - Extensive ad-hoc networks routing information towards the infrastructure or their destination node in the formed network
  - Sensors will be placed everywhere, even when the infrastructure is weak or absent, and even if the sensors are mobile.

What about addressing?

- Already today many tags operate with a 128 bits address field
- Allows:
  - 340282366920938463463374607431768211456 (≈ 3.4 × 1038) unique identifiers
  - More than a trillion unique addresses for every square centimetre on the earth

Wider technological trends for IoT (1)

- "exaflood" or "data deluge":
  - Explosion of the amount of data collected and exchanged
- Business forecast:
  - Indicate that in the year 2015 more than 220 Exabaytes of data will be stored
- Need by all the actors to re-think current networking and storage architectures:
  - Novel ways and mechanisms to find, fetch, and transmit data
  - Explosion in the number of devices collecting and exchanging information as envisioned as the IoT becomes a reality

Wider technological trends for IoT (2)

- Energy required to operate the intelligent devices will dramatically decreased
- Many data centres have reached the maximum level of energy consumption and the acquisition of new devices has necessarily to follow the dismissal of old ones
- Search for a zero level of entropy where the device or system will have to harvest its own energy

Wider technological trends for IoT (3)

- "Miniaturisation" of devices is also taking place amazingly fast
  - Single-electron transistor is getting closer
- Autonomic resources:
  - Systems must show self-* properties, such as self-management, self-healing and self-configuration

IoT Technology Enablers (1)

- Energy:
  - New and more efficient and compact energy storage like batteries, fuel cells, and printed/polymer batteries etc;
  - New energy generation devices coupling energy transmission methods or energy harvesting using energy conversion

IoT Technology Enablers (2)

- Intelligence:
  - Context awareness and inter-machine communication
  - Integration of memory and processing power
  - Capacity of resisting harsh environments
  - Development of ultra low power processors/microcontrollers cores designed specifically for mobile IoT devices
  - New class of simple and affordable IoT-centric smart systems

IoT Technology Enablers (3)

- Communication:
  - New, smart multi frequency band antennas, integrated on-chip and made of new materials
  - On-chip antennas optimised for size, cost and efficiency, and could come in various forms like coil on chip, printed antennas, embedded antennas, and multiple antenna using different substrates and 3D structures
  - Modulation schemes and transmission speed are also important issues to be tackled allowing multi-frequency energy efficient communication protocols and transmission rates.
  - Methods of effectively managing power consumption at different levels of the network design are needed, from network routing down to the architecture of individual devices.

IoT Technology Enablers (4)

- Integration:
  - Integration of smart devices into packaging, or better, into the products themselves will allow a significant cost saving and increase the eco-friendliness of products
  - System-in-Package (SiP) technology allows flexible and 3D integration of different elements such as antennas, sensors, active and passive components into the packaging, improving performance and reducing the tag cost.
  - RFID inlays with a strap coupling structure are used to connect the integrated circuit chip and antenna in order to produce a variety of shapes and sizes of labels, instead of direct mounting.

IoT Technology Enablers (5)

- Interoperability:
  - Two different devices might not be interoperable, even if they are following the same standard.
  - Future tags must integrate different communication standards and protocols that operate at different frequencies and allow different architectures, centralised or distributed

IoT Technology Enablers (6)

- Standards
  - Open standards are key enablers for the success of the Internet of things, as it is for any kind of machine to machine communication
  - The unique addresses follow two standards today, Ubiquitous ID and EPC Global, and there is quite a big variance in the frequencies used according to the country and the manufacturer.
  - Sustainable fully global, energy efficient communication standards that are security and privacy centred and are using compatible or identical protocols at different frequencies are therefore needed.

IoT Technology Enablers (7)

- Manufacturing:
  - Lower costs to less than one cent per tag
  - Production must reach extremely high volumes
  - The whole production process must have a very limited impact on the environment

Main Barriers (1)

- Governance:
  - Without an authority, similar to the one that is governing Internet, there are high chances that it will be impossible to have a truly global "internet of things"
  - Keep governance as generic as possible, as having one authority per field will certainly lead to overlap, confusion and competition between standards
  - E.g., EPC Global architecture has a "single point of failure and control" architecture where a single company, VeriSign, has the records of all the numbers, and can track where any object is.

Main Barriers (2)

- Privacy and Security:
  - Guarantee privacy and the security of the customers in order to have a widespread adoption of any object identification system
  - Public acceptance for the internet of things will happen only when the strong security solutions are in place.
  - Hybrid security mechanisms that for example combine hardware security with key diversification to deliver superior security that makes attacks significantly more difficult or even impossible
  - Range of issues related to the identity of people
    - Dealt with in politics and legislation