M2M Communications and Internet of Things for Smart Cities

Soumya Kanti Datta
Mobile Communications Dept.
Email: Soumya-Kanti.Datta@eurecom.fr
WHAT IS EURECOM

- A graduate school & research centre in communication systems located in French Riviera
- A consortium with a private status (EIG) that brings together:
  - 7 academic partners
  - 8 industrial partners
  - 1 institutional partner
- Three Departments
  - Communication and Computer Security
  - Multimedia
  - Mobile Communications
Roadmap

- Introduction to IoT & Smart City
- Three Fundamental Operations in IoT
- Uniform Data Exchange with Objects
- Managing Connected Objects
- M2M Data Processing for Smart City Applications
- Conclusion
What is Internet of Things (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

[ITU-T Y.2060]

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

[IEEE 802.16p]

**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 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

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

**IoT**
a world-wide network of interconnected objects uniquely addressable, based on standard communication protocols

[draft-lee-iot-problem-statement-05.txt]
**IoT ecosystem**

- **To achieve the IoT ecosystem**
  - Things (sensors, actuators, RFID tags) need to be connected to **software**
  - Things need to be made available to be used together as a **system**

- **M2M architecture and protocols address the first item**

- **Second item is a challenge**

- **IoT applications**
  - Home automation
  - E-Health
  - Intelligent transportation system
How IoT is changing our surroundings

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

Source: market-intel.info
Smart City Initiatives: Motivations

- Urban population is expected to grow by an estimated 2.3 billion in the next 40 years, having almost 70% of the world population living in cities by 2050. [1]

- This poses diverse challenges
  - public safety, transportation management, waste disposal, noise, air and water pollution and more

- Smart City – a promising solution
  - To provide advanced services to the citizens
  - Enabled by Information and Communication Technologies (ICT).
  - Drives competitiveness, sustainability and improves quality of life.

Smart Cities

- Smart city mainly focuses on applying the next-generation information technology to all walks of life, embedding sensors and actuators to [2]
  - Smart homes
  - Health-care centres
  - Smart power grids
  - Roads & transportation systems
  - Water systems
  - Oil and gas pipelines

- Internet of Things (IoT) and Machine-to-Machine (M2M) communication are seen as the enablers of such initiatives.

- IBM Smarter Planet Initiative [3]

---


Libelium Smart World Infographic

Libelium Smart World

- **Air Pollution**
  - Control of CO₂, emissions of factories, pollution emitted by cars and toxic gases generated in farms.

- **Forest Fire Detection**
  - Monitoring of combustion gases and greenpine fire conditions to define alert zones.

- **Wine Quality Enhancing**
  - Monitoring soil, moisture and trunk diameter in vineyards to control the amount of sugar in grapes and grapevine health.

- **Offspring Care**
  - Control of growing conditions of the offspring in animal farms to ensure its survival and health.

- **Sportsmen Care**
  - Vital signs monitoring in high performance centers and fields.

- **Structural Health**
  - Monitoring of vibrations and material conditions in buildings, bridges and historical monuments.

- **Quality of Shipment Conditions**
  - Monitoring of vibrations, strakes, container openings or cold chain maintenance for insurance purposes.

- **Smartphones Detection**
  - Detect iPhone and Android devices and in general any device which works with WiFi or Bluetooth interfaces.

- **Perimeter Access Control**
  - Access control to restricted areas and detection of people in non-authorized sterile.

- **Electromagnetic Levels**
  - Measurements of the energy radiated by cell stations and and WiFi routers.

- **Traffic Congestion**
  - Monitoring of vehicles and pedestrian influence to optimize driving and walking routes.

- **Radiation Levels**
  - Distributed measurement of radiation levels in nuclear power stations surrounding to generate leakages alerts.

- **Smart Roads**
  - Warning messages and diversions according to climate conditions and unexpected events like accidents or traffic jams.

- **Smart Lighting**
  - Intelligent and weather adaptive lighting in street lights.

- **Intelligent Shopping**
  - Getting advice in the point of sale according to customer habits, preferences, presence of allergens components, for them or existing data.

- **Noise Urban Maps**
  - Sound monitoring in bar areas and center zones in real time.

- **Water Quality**
  - Study of water suitability in rivers and the sea for fauna and viability for drinkable use.

- **Waste Management**
  - Detection of rubbish levels in containers to optimize the trash collection routes.

- **Vehicle Auto-diagnosis**
  - Information on vehicle conditions to send real time alarms to emergencies or provide advice in drives.

- **Item Location**
  - Search of individual items in big surfaces like warehouses or harbours.

Three Fundamental Operations

- **Collection of data**
  - Sensor oriented collection

- **Processing the data**
  - Semantic reasoning

- **Control**
  - Sensing based actuation
  - E.g. switching on fog lamp when fog is detected
Wait, it is not so simple

- **Heterogeneity**
  - Sensors belong to different domains
  - Sensors use various technologies to communicate
  - What about actuators?

- **Management of connected objects**
  - Concerns due to high mobility
  - Naming and addressing billions of objects
  - Discovery of objects

- **Processing**
  - Utilizing semantic web technologies?
  - Cloud computing vs. Mobile edge computing vs. M2M gateway
Uniform Data Exchange with Objects

- **Sensor Markup Language (SenML)**
  - Uniform way to exchange sensor “metadata”
    - Sensor measurement, name, id, unit, timestamp etc.

- **SenML extensions**
  - Uniform way to exchange actuator “metadata” [4]
  - Used to send commands to actuators
    - Switch on/off a light, reduce the speed of motor etc.

- **Advantage**
  - **Uniform mechanism to interact with both sensors and actuators**

---

Managing Connected Objects

- Ensuring flexibility, scalability and dynamicity
- Deploying millions of connected objects
- We have developed
  - CoRE Link based configuration for connected objects [5]
  - Lightweight and can be stored in home gateways
  - OMA Lightweight M2M Technical Specifications based API for connected object management

- Work on progress
  - Naming and addressing schemes
  - Automatic discovery of M2M devices and services
    - Offline map for smart tourism

Interacting with Legacy Objects

- Legacy objects can not be replaced overnight
- Including them into IoT based systems require [6]
  - An intermediate gateway or
  - A proxy of the legacy object
- This is to make the overall system aware of the intelligence of objects

- We deploy objects, interact in a standardized manner
- We get data
- But what can we do with the data
  - How to get meaning out of data
  - Understand the context
Data Processing for Smart City Applications

- Same sensor can be used in
  - Different contexts
  - Across different domains
  - E.g. – Accelerometer in smartphones can be used to judge road conditions as well as determining earthquakes

- Smart city comprises of several domains
  - There are rules associated with the knowledge of the each domain

- What if you want to build applications combining several domains
Semantic Reasoning

- **Use of semantic reasoning to enrich M2M data**
  - First step – SenML to add some side information
  - Second step – decorate the M2M data with additional semantic reasoning

- **Link the data with the meaning**
  - From the point of view of different domains
M3 Approach

- The M3 (Machine to Machine Measurement) approach
  - Enrich M2M data with semantic web technologies [7]
  - The M3 ontology: A hub for cross-domain ontologies and datasets
    - e-Health: weather, recipe, health
    - Smart city: weather, home automation, transport, vacation
    - STAC (security): sensor, cellular, web, mobile phone
  - LOR (Linked Open Rules): share and reuse domain rules

- M3 integrated in a semantic-based M2M architecture


Limitations in Current Standards

- **Existing standards (ETSI M2M, W3C SSN Ontology) lack** [8]
  - A common format or syntax to describe sensors, measurements, units and domains.
  - Interoperable and standardized domain knowledge (ontologies, datasets and rules).
  - Semantics components are not explicitly described in M2M architectures.
  - Uniform methods to interpret high level abstraction from M2M data.

Vision to Standardize the M3 Approach

- Describe sensor measurements in a uniform way
  - Utilize Sensor Markup Language and our proposed extensions.

- Standardize common domain ontologies for IoT domains
  - Tackles the interoperability issues related to combining cross domain knowledge.

- Already proposed to oneM2M MAS group.
Conclusion

- Shading lights on some fundamental and specific points of IoT and Smart City initiatives
  - Uniform way to exchange information
  - Managing billions of connected objects
  - Semantic reasoning to develop cross domain applications
  - Ability to react and control using actuators
  - Vision to improve standardization
Thank you!

- Email: soumya-kanti.datta@eurecom.fr
- Telephone: +33658194342
- Webpage: https://sites.google.com/site/skdunfolded