Developing Applications for the Internet of Things: Requirements and Platforms

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“We have things. We have the internet. That’s a start.”
Internet of Things

Connecting the world
PROBLEMS

PROBLEMS EVERYWHERE
The Internet of Things (IoT) is the network of physical objects or "things" embedded with electronics, software, sensors, and connectivity to enable objects to collect and exchange data. The Internet of Things allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration between the physical world and computer-based systems, and resulting in improved efficiency, accuracy and economic benefit.

Internet of Things (IoT)

In the IoT vision, physical objects (things)

• are endowed with sensors and actuators, capture environmental variables and react to external stimuli
• can be addressable, controlled, and monitored through Internet
• can communicate with other physical and/or virtual resources
50 billion devices and objects will be connected to the Internet by 2020. In the next years, the Internet of Everything will generate $19 trillion of value.

John Chambers – Cisco’s CEO (Las Vegas, January 7, 2014)
https://trends.google.com/trends/explore?date=today%205-y&q=internet%20of%20things,iot&hl=en_US
Internet of Things (IoT)

Google Search (June 2018)

internet of things

About 2,180,000,000 results (0.49 seconds)

Google Scholar (June 2018)

internet of things

About 3,220,000 results (0.06 sec)
Why IoT?

Need for more data

Need for control

Need for automation

Need for making the things faster

Internet of Things
IoT applications
The wide dissemination of IoT has the potential of significantly impacting people’s lives in several application domains:

- Smart cities
- Environment
- Energy
- Logistics
- Industry
- Domotics
- Retail and services
- Health
Concerns and challenges
Concerns and challenges

The problem

• Collecting data from sensors is not enough

• Developing systems is not enough
Concerns and challenges

Integration is the key
Concerns and challenges

Key elements in IoT are

• interconnecting devices and systems (and also people)
• securely collecting data at real-time from multiple sources
• making reliable decisions through data processing and analysis
• providing integration platforms
• supporting application development as well as transparency
Concerns and challenges

High heterogeneity due to the diversity of physical devices in terms of
• Hardware
• Software
• Protocols
• Data formats
IoT seems to be a simple idea, but it is somewhat hard to implement.
Middleware for IoT

Promising solution to the high heterogeneity
Middleware for IoT

Application A

Application B

Application N

API

middleware (distributed services)

network connectivity and gateways

Thing A

Thing B

Thing N
Middleware for IoT

Middleware

- Defined as a software layer between physical nodes (sensors, actuators, things) and logical nodes (applications/users), connected through the network
- Provides high level interfaces and common services to ease the development of applications
- Promote transparency in terms of
  - Distribution/location
  - Heterogeneity
    (manufacturers, computing architectures, runtime environments, protocols)
Middleware for IoT

Software layer residing between applications/users and the underlying infrastructure (communication, processing, sensing)
Middleware for IoT

• Solution to the high heterogeneity of IoT environments
• Key element to promote interoperability
• Scalability to handle the increasing number of integrated devices
• Abstraction over underlying services and physical devices towards easing the development of IoT applications
Requirements IoT middleware platforms
In the IoT context, middleware platforms must meet a set of requirements aimed to cope with the needs of applications and users as well as address challenges arisen in this scenario:

- Interoperability
- Device discovery and management
- Context-awareness
- Scalability
- Management of large volumes of data
- Security and privacy
- Dynamic adaptation
- Development support
Middleware for IoT: Requirements

Interoperability to integrate heterogeneous physical devices and services in multiple levels

- **Lower level**: integration of physical devices
- **Intermediate level**: integration of data provided by devices
- **Upper level**: aggregation and transformation of data provided by devices with no knowledge about them or the underlying networking environment
Middleware for IoT: Requirements

Device discovery and management

• Information about location and state of devices
• Dynamic discovery of many existing resources and services
• Remote control
Middleware for IoT: Requirements

Context-awareness

- Gathering information about the environment at any time and adapting behaviors accordingly

- Quality of Context (QoC) information (e.g., precision, accuracy, up-to-dateness, etc.) can be used as means of
  - filtering out data
  - ranking which information can be used
  - better supporting decision-making actions
Middleware for IoT: Requirements

**Scalability** to deal with the **huge amount** of physical devices, exchanged information, and requests

- with minimal or no degradation in Quality of Service (QoS)
Middleware for IoT: Requirements

Management of large volumes of data

- **Massive data** produced from several devices and transmitted over the network
- **Efficient** data collection, storage, integration, analysis, and visualization

- **The 5Vs of Big Data**
  - **Volume** (scale) of data
  - **Velocity** of data [analysis]
  - **Variety** of data [formats]
  - **Veracity** (uncertainty) of data
  - **Value** of data
Middleware for IoT: Requirements

Security and privacy regarding devices themselves and their data

• Confidentiality
• Integrity
• Availability
• Vulnerability
Middleware for IoT: Requirements

Dynamic adaptation
- Network topology often dynamic
  - Devices may enter and leave the environment without any previous planning
  - Opportunism
- Seamless adaptation of application behavior according to device (un)availability, context changes, etc.
Middleware for IoT: Requirements

Development support

• Need for well-defined interfaces, development tools, and programming models to ease application development and integration
  o Revisit Software Engineering practices for IoT
Other issues

Human in the loop

• How to incorporate human beings and physiologic, psychologic, and behavioral aspects that can influence computer systems?

• How to autonomously react to actions of human beings on the environment (with or without computer systems)?
Other issues

Need for **efficient solutions** as physical devices are typically limited in terms of:

- energy
- processing
- storage
- communication
Other issues

Diversity of existing platforms for IoT
## Other issues

### Diversity of existing platforms for IoT

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<th>Platform</th>
<th>Interoperability</th>
<th>Discovery and management</th>
<th>Context-awareness</th>
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FIWARE is an open source cloud platform with a collaborative and mature ecosystem of developers, innovation Hubs, accelerators, cities and more than 1000 SMEs and startups.

The FIWARE platform provides a rather simple yet powerful set of APIs (Application Programming Interfaces) that ease the development of Smart Applications in multiple vertical sectors. The specifications of these APIs are public and royalty-free. Besides, an open source reference implementation of each of the FIWARE components is publicly available so that multiple FIWARE providers can emerge faster in the market with a low-cost proposition.
FIWARE

**Generic Enablers (GEs)**

- Generic componentes described by an open specification and API
- Released with a reference implementation
- Available at the FIWARE Catalogue ([https://catalogue.fiware.org/](https://catalogue.fiware.org/))
Integrating different GEs to develop applications
Domain-Specific Enablers (DSEs)

- Components developed by the community, following FIWARE specifications
- Aimed to meet specific requirements of application domains
- Can make use of other existing GEs and/or DSEs
FIWARE MARKET PLACE

Powered by FIWARE
- Solutions
- Platforms

FIWARE-Ready Technologies
- IoT Devices
- Software Enablers

FIWARE services
- Training and coaching
- Consultancy and integration services

http://marketplace.fiware.org/
The Internet of Things has the potential to change the world, just as the Internet did. Maybe even more so.

Kevin Ashton – Cofundador do Auto-ID Labs (MIT, EUA)
Developing Applications for the Internet of Things: Requirements and Platforms

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