— Introduction —
The Future Internet of Things

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Introduction

Internet of Things is seen as a key part of the Future Internet vision which will enable real-time interaction with the physical environment. Billions of connected heterogeneous devices, sensing and actuating the physical environment in which they are embedded, and interacting among them or with remote users comprise the foundation of IoT.

More sophisticated approaches go beyond simple communication integration and target more complex interactions where collaboration of devices and systems is taking place. The cross-layer interaction and cooperation is pursued (i) at machine-to-machine (M2M) level where the machines cooperate with each other (machine focused interactions), as well as (ii) at machine-to-business (M2B) level where machines cooperate also with network-based services and business systems (business service focus).

As the Future Internet will be a very complex system of systems, the Internet of Things is expected to enable approaches that tame that complexity via real-time fine-grained monitoring, analytics-assisted decision making, and timely management. To do so, it will have to highly depend on the Future Internet infrastructure and envisioned capabilities in an open and collaborative way. This collaborative way of interactions is expected to lead to emergent behaviours in the Future Internet that, at the end, will better serve the end-users.

Challenges

Realizing the vision of Future Internet of Things requires tackling numerous challenges spanning a range of domains from the technical ones, to the social, design, economics etc. domain, or new area like smart cities. At the same time

the traditional issues such as security, trust, privacy, openness, user-friendliness and rapid development still have to be supported.

Connectivity will remain in Future Internet a key aspect. However, the major focus is shifted towards supporting interoperable interactions at multiple layers and among various Internet of Things empowered services, and at the same time support legacy systems. The latter includes also aspects of migration of the current partially networked infrastructure to a fully-connected open system in the Future Internet era. Additionally, complexity management, crowdsourcing, real-time analytics, knowledge capturing and communication, simulation are only some indicative aspects that will need to be investigated as they will impact the next generation of Future Internet enabled applications.

Designing software solutions for the Future Internet of Things, and analysing the impact (e.g. of malfunctions) at system-wide level can be assisted by big data analytics. A new generation of data explorative of tools, as well as sophisticated algorithms considering context specific information at several levels on very large scale systems will need to be designed, developed and piloted. Extracting and understanding the business relevant information under temporal constraints and being able to effectively built in solutions that utilize the monitor-analyse-decide-manage approach for a multitude of domains is challenging.

The high heterogeneity of systems, models, quality of data and associated information, uncertainties as well as complex system-wide interactions, will need to be investigated to identify business opportunities and realize a business benefit. Supporting effectively all stakeholders in the Future Internet Era is a key challenge that we will have to deal with. This implies new business models, information exchange and business collaborations that create added value for all participating stakeholders and that will open new business opportunities.

Contributions

Chapters contained in this book that address some of the aforementioned challenges include:

- The chapter *"Test-Enabled Architecture for IoT Service Creation and Provisioning"* targets the service creation and testing in the Future Internet of Things environment. An architecture design is investigated that extends the existing IoT reference architecture and enables a test-driven, semantics-oriented management of the entire service lifecycle. Future Internet of things challenges addressed include integration, service creating and semantic-enabled interaction.
- The chapter *"A Cognitive Management Framework for Empowering the Internet of Things"* presents a framework that has the ability to dynamically adapt its behaviour, through self-management functionality, taking into account information and knowledge (obtained through machine learning) on the situation (e.g., internal status and status of environment), as well as policies (designating objectives, constraints, rules, etc.). Several Future Internet

of Things challenges such as integration, collaboration, self-X, reliability and efficiency are addressed.

– The chapter *"SmartSantander: Internet of Things Research and Innovation through citizen participation"* shows the applicability of the Future Internet of Things in urban environments. The two examined services i.e., participatory sensing and augmented reality, address challenges towards the added-value and business effect of the Future Internet of Things.

– The chapter *"IoT6 – Moving to an IPv6-based future IoT"* investigates the design and development of a highly scalable IPv6-based Service-Oriented Architecture to achieve interoperability, mobility, cloud computing integration and intelligence distribution among heterogeneous smart things components, applications and services, taking advantage of the IPv6 features. The domain of building automation is chosen to show the feasibility of the approach. The challenges addressed include integration, service-driven interaction, openness and empowerment of applications and services in IPv6 Future Internet of Things era.

– The chapter *"Building modular middlewares for the Internet of Things with OSGi"* investigated how to develop intelligent infrastructures combining various devices through the network by fully utilizing the capabilities of OSGi for development of modular, fine-grained and loosely coupled Java applications. Challenges of the Future Internet of Things addressed include scalability, integration, lifecycle management etc.

Conclusions

The Internet of Things is an integral part of the Future Internet vision. There are numerous challenges that need to be tackled that spawn several domains. Some of the chapters presented in this book go towards depicting how a subset of these challenges can be addressed. It is clear however, that we are still at the dawn of an the Future Internet of Things era and significant research efforts need to be investigated in a well balanced way in order to make sure that the benefits expected can be harvested.