

— Introduction —

# The Future Internet Cloud: Computing, Networking and Mobility

Dana Petcu<sup>1</sup>, Alex Galis<sup>2</sup>, and Stamatis Karnouskos<sup>3</sup>

<sup>1</sup> West University of Timișoara, Romania  
`petcu@info.uvt.ro`

<sup>2</sup> University College London, United Kingdom  
`a.galis@ucl.ac.uk`

<sup>3</sup> SAP Research, Germany  
`stamatis.karnouskos@sap.com`

## Introduction

Cloud computing has received tremendous attention the last years, both in academia as well as in industry, especially with the deployment of multiple commercially available solutions that foster the basis for a variety of value-added services. In the Future Internet era, the cloud will still have a considerable impact on the way the new infrastructures will be used by the Future Internet envisioned applications. However this attention is moving fast beyond from purely computing-oriented focus (although this will expand), towards covering networking and mobility.

The Future Internet Architecture will integrate the Cloud computing paradigm to a new level encompassing several aspects such as the Cloud of Things, Software Defined Networking, Fog Computing etc. Considerable research efforts are already devoted today to ensure that the amalgamation between new revolutionary network technologies and the Cloud computing is properly exploited in context like data deluge.

Clouds in the Future Internet are expected to come in various forms depending on their stakeholders' needs. Sophisticated capabilities will significantly expand what we today classify under "computing" and for instance real-time analytics on big data will empower a new generation of services and applications. To this direction networking and information exchange will be further enhanced and cross-layer interactions among the billions of interconnected devices, systems and services will be assisted by the Future Internet Cloud paradigm. In that era, mobility will be of key importance and will be supported both in terms of mobile users and their devices, as well as seamless transcoding of sessions among different systems of varying capabilities. The Future Internet Cloud is seen at the heart of the service offering and empowerment in the Future Internet vision.

## Challenges

In the Future Internet Cloud, the main concerns raised today will still be a challenge, e.g., aspects related to security, trust, privacy, interoperability and portability. As the Future Internet will stretch the Cloud infrastructure, other aspects such as quality of service, high performance guarantees, dependability, value-added services, data management, analytics, etc. will still need to be addressed in order to assist industry embracement of the Future Internet solutions.

Of special importance is of course the support of the billions of mobile users and the respective apps running in the increasingly heterogeneous devices. Hence the integration with the Internet of Things (an amalgamation described as Cloud of Things) as well as offering value added services on huge amounts of data (Big Data), will foster key challenges that need to be addressed. All these will need to be done with new approaches that guarantee adherence to concerns on security and privacy as well as to industry requirements for lifecycle management of the data and the services.

Networking and efficient interaction with the cloud and its services, as well as cross-cloud interaction (federation of cloud infrastructures) and development of value added services on top will be of pivotal importance. Adding also the seamless provision of service to the mostly mobile devices and users, as well as support for mobility in emerging application areas e.g., smart cities needs to be tackled. Considering also the global sustainability goals, green cloud computing in the Future Internet needs also to be efficiently addressed in a cooperative holistic way.

## Contributions

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

- The chapter *"Open the Way to Future Networks – a viewpoint framework from ITU-T"* focuses on the Future Network objectives and design goals for further developing technologies and systems. The chapter points out the results and future plans stemming from the initial standardization work performed by ITU-T as well as recommendations for standardization bodies in order to support the Future Networks development.
- The chapter *"The NEBULA Future Internet Architecture: A Mid-Course Report"* is presenting an architecture intended to provide secure and resilient networking to support present and future applications of cloud computing. To this end, reliable routing, data-center interconnections, data plane with policy enforcements, and a control plane for network configuration are investigated.
- The chapter *"Towards a Secure Network Virtualization Architecture for the Future Internet"* analyses different architecture proposals for the Future Internet and subsequently presents an architecture design that fills those gaps

by means of virtualization techniques working together with the overlay network concept. The notion of Virtual Group Networks, which group physical and abstract mobile entities, and focus on the demands in terms of security and network capabilities is introduced.

- The chapter *"Seeding the Cloud: An Innovative Approach to Grow Trust in Cloud Based Infrastructures"* tackles the issues of security, trust and privacy in the cloud. It introduces a network of secure elements (software and hardware elements connected locally with or in pieces of equipment), defining a minimal trusted computing base and allowing an end-to-end virtual security chain from the user to the server where the services are executed or data is stored.
- In the chapter *"Cloud-based Evaluation Framework for Big Data"* a discussion on the challenges that arise when doing benchmarking on big data is depicted. The problem of bringing the algorithms to the data in the Cloud is analysed in conjunction with the particular use cases of segmentation and retrieval of three-dimensional medical images.
- The chapter *"Resource Optimisation in IoT Cloud Systems by using Match-making and self-Management Principles"* a proposal to annotate data of monitored cloud performance and user profiles and adapt the management systems to use shared infrastructures and resources to enable efficient deployment of Internet-of-Things services and applications is depicted.
- The chapter *"Contrail: Distributed Application Deployment under SLA in Federated Heterogeneous Clouds"* addresses the challenges of offering reliable Cloud services and how to ensure quality of service and of protection in a federation of Cloud providers. Moreover, a deployment service, for distributed applications, that allows interoperability among the Cloud sites participating to the federation is investigated.
- The experimental studies presented in chapter *"Optimizing Service Ecosystems in the Cloud"* are related to the optimization of service compositions. The service ecosystem is emulated in a multi-site federated Cloud and the study subjects are two optimization models.

## Conclusions

In the Future Internet, the Cloud is playing a pivotal role. There are several open challenges, some of which are addressed in the chapters presented in this section. However, significant research is remaining in order to support effectively the Future Internet envisioned applications as well as their infrastructure requirements such as computation (including analytics), mobility and networking.