INNOSOC Case Study

(selected for Zagreb 2016; extended version)

Case Study title:

Seamless Connectivity for a Digital Life

Keywords: 5G networks; Internet of Things (IoT); sensor networks; enhanced Telecom Operations Map (eTOM), business processes

H2020 challenge addressed by the Case Study: Europe in a changing world - inclusive, innovative and reflective societies

Introduction to the Case Study

It is well known that **5G wireless networks** will bring solutions for many challenges which are typical for the recent mobile networks, such as constantly growing demands for **higher data rates**, tighter requirements for **quality** of the provided services, requirement for **everywhere and anytime coverage**, low **delay and latency**, need for low **energy consumption** as well as low **cost for a bit** of transmitted information. In order to address all these challenges 5G networks most probably will be implemented with multilayer and heterogenic structure consisting of macro-, micro- and femto-cells, relays and ad hoc subnetworks to communicate across different devices and users with diverse requirements for quality of service (QoS). Using such a complex infrastructure the main concern will be the problem for more effective intra- and inter-cell interference control. This problem is an integral part of a more general task for power control in wireless networks. The definition and solution of this task in the context of an optimization problem with specific cost function will result in the substantial increase of spectral and energy efficiency in 5G wireless networks.

In order to gain the full benefits of those **technical innovations**, telecommunication companies require flexible production models, streamlined operations and end-to-end management of customer requirements. There is a high risk that technical changes on the network layer result in silo-oriented processes and applications on the **business side** [4]. In this context, the industry organization TM Forum offers a reference model for standardized business processes that is called **"enhanced Telecom Operations Map" (eTOM)** [6]. The International Telecommunication Union (ITU) has confirmed eTOM as a *de facto standard* for business processes and the eTOM is used by most telecommunication companies worldwide. Applying the eTOM to 5G wireless networks is an important requirement.

Five INNOSOC students, supervised by two INNOSOC lecturers, will collaborate on answering how combining technical and business perspective of the design, launch, and operations of 5G

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wireless networks can provide seamless communication services to customers. These activities will be conducted as a part of the ERASMUS+ blended mobility and will be finalized during INNOSOC Zagreb 2016 workshop in late April 2016.

How this Case Study is related to the selected H2020 challenge?

A great number of physical devices will be connected to 5G networks realizing the vision of the **Internet of Things (IoT)** [1], **Internet of Nano Things (IoNT**) [2] and even **Internet of Bio-Nano Things (IoBNT)** [3]. Monitoring and control systems that communicate through networks and enable smart homes are amongst the common examples.

There are variety of areas and environments where IoT can play an important role and improve the **quality of human life**. These applications include transportation, healthcare, industrial automation, and emergency response to natural and man-made disasters. The IoT transforms the **connected objects** into **smart devices** by using ubiquitous and pervasive computing, cloud technology, routing protocols and cooperative transmission. In addition, management and operations of those communication services is a challenge for telecommunication companies. An important objective is to overcome silo-oriented structures in order to offer an end-to-end management of seamless communication services [4].

How this Case Study is related to the INNOSOC project?

The key **innovations** expected in 5G wireless networks will be in several areas. First, the basic challenge of a **full duplex radio transmission** should be addressed. All recent standards for wireless networks work in half-duplex mode. The potential full-duplex radio systems can double the bandwidth and as a result can almost double the throughput. Alternatively, keeping the same throughput radio systems can save bandwidth which is crucial for applications where the frequency spectrum is scarce.

Next area for innovative solutions is the **inter-cell interference control**. Nowadays it is a common agreement that 5G networks will have a heavy heterogeneous structure. They will consist of macro-, micro- and femto-cells and will need an intensive coordination during data transmission. In such environments inter-cell interference control calls for new methods for coordination and interference cancelation. Most of recent approaches for inter-cell interference control exploit the spectral characteristics of transmitted signals and schedule different frequency ranges and time slots, in this way minimizing the interference. Basic problem for these approaches is how to manage the existing transmission resources in a fair manner according to the QoS requirements of each customer. Foreseen innovative solutions can be found in the field of Game Theory, Artificial Intelligence and Expert Systems.

Furthermore, **management of communication networks and services** and their impact on internal structures of telecommunication companies is an important question of information systems management. Solutions can be found in the field of reference modelling in general and specific work in the telecommunications industry.

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Questions that need answers during the Case Study development

- Which are the most popular methods for uplink and downlink transmission in current wireless networks?
- What are the new approaches enabling full-duplex radio transmission?
- Which are the most popular methods for the inter-cell interference control in current wireless networks?
- What are the new approaches enabling a fair resource management?
- What is the impact of these new technologies on the business processes and organizations?
- What could be an end-to-end process (e.g., Order-to-Payment) for offering seamless connectivity services?
- How could a reference models like eTOM support this task? What are additional requirements that are not supported by this reference model?

References

[1] Ala Al-Fuqaha, Mohsen Guizani, Mehdi Mohammadi, Mohammed Aledhari, and Moussa Ayyash, Internet of Things: A Survey on Enabling Technologies, Protocols, and Applications, IEEE COMMUNICATION SURVEYS & TUTORIALS, VOL. 17, NO. 4, FOURTH QUARTER 2015, pp. 2347-2376.
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[6] Czarnecki C, Winkelmann A, Spiliopoulou M (2013) Reference Process Flows for Telecommunication Companies. An Extension of the eTOM Model. Bus Inf Syst Eng. Volume 5, Issue 2, pp 83-96.

Knowledge and skills needed for developing the Case Study

(P: prerequisite; D: desirable, but not necessary)

- Basics of data transmission (P)
- Optimization methods (D)
- Basics of information systems design (D)
- Business process management (D)

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Figures describing this Case Study

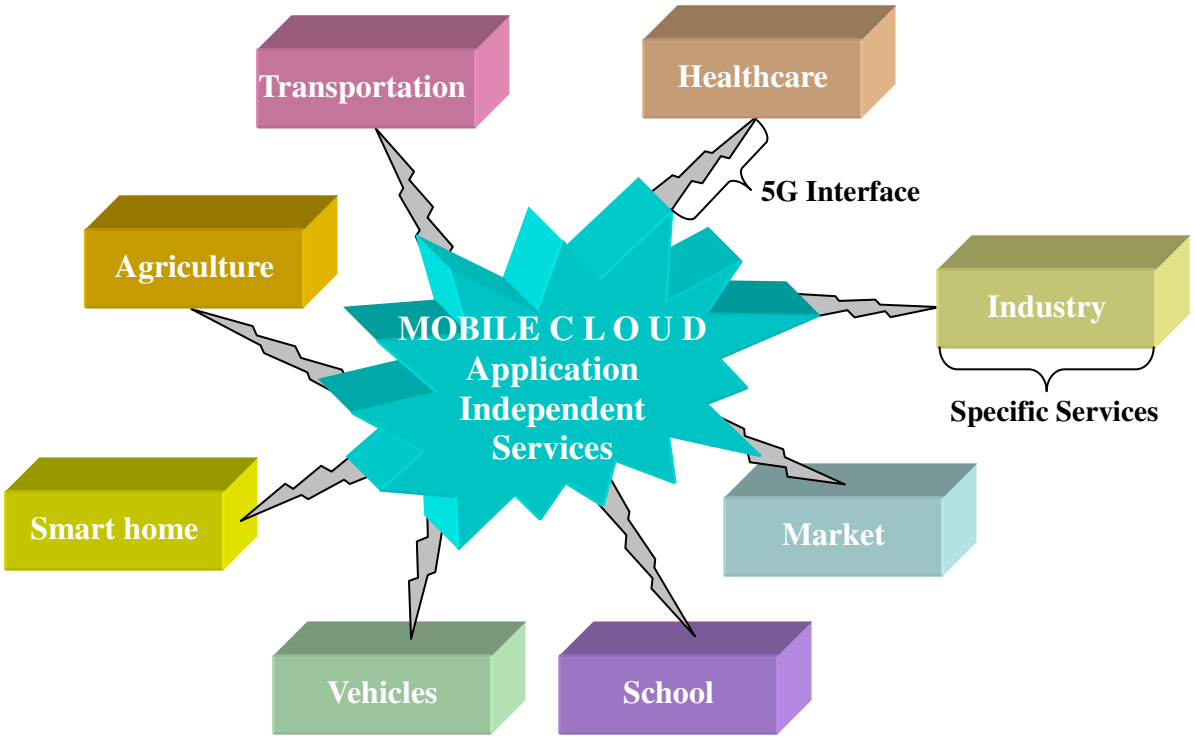

Figure 1. 5G networks enabling the vision for IoT, IoNT and IoBNT.

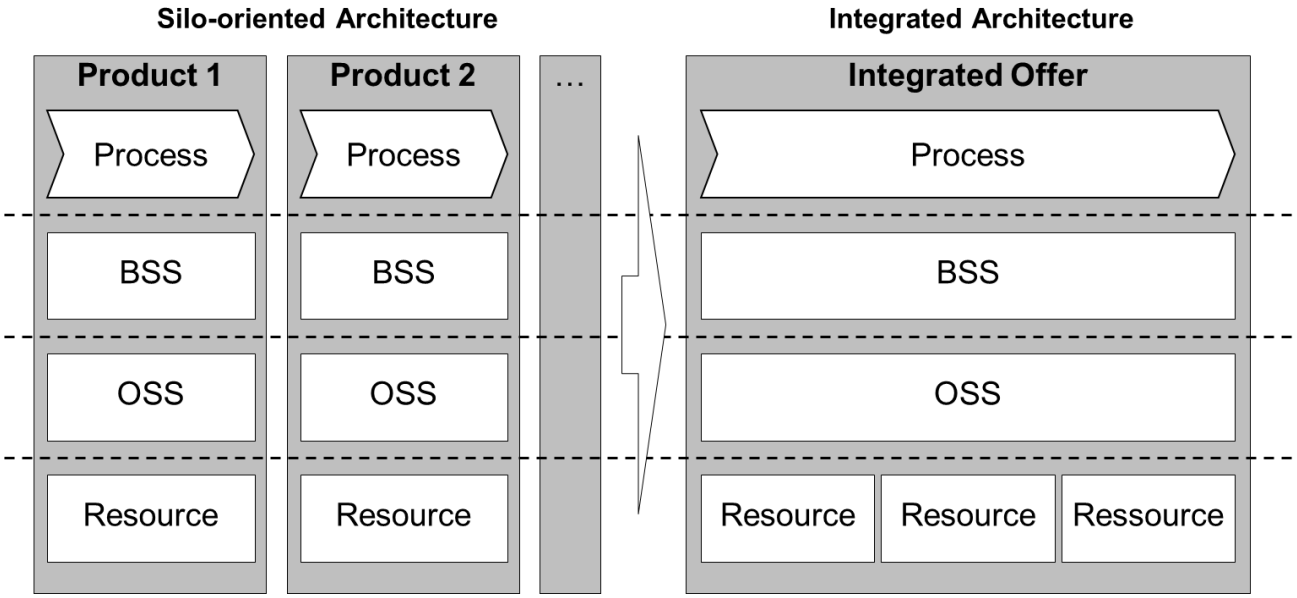

Figure 2. From a silo-oriented to an integrated architecture (according to [4])

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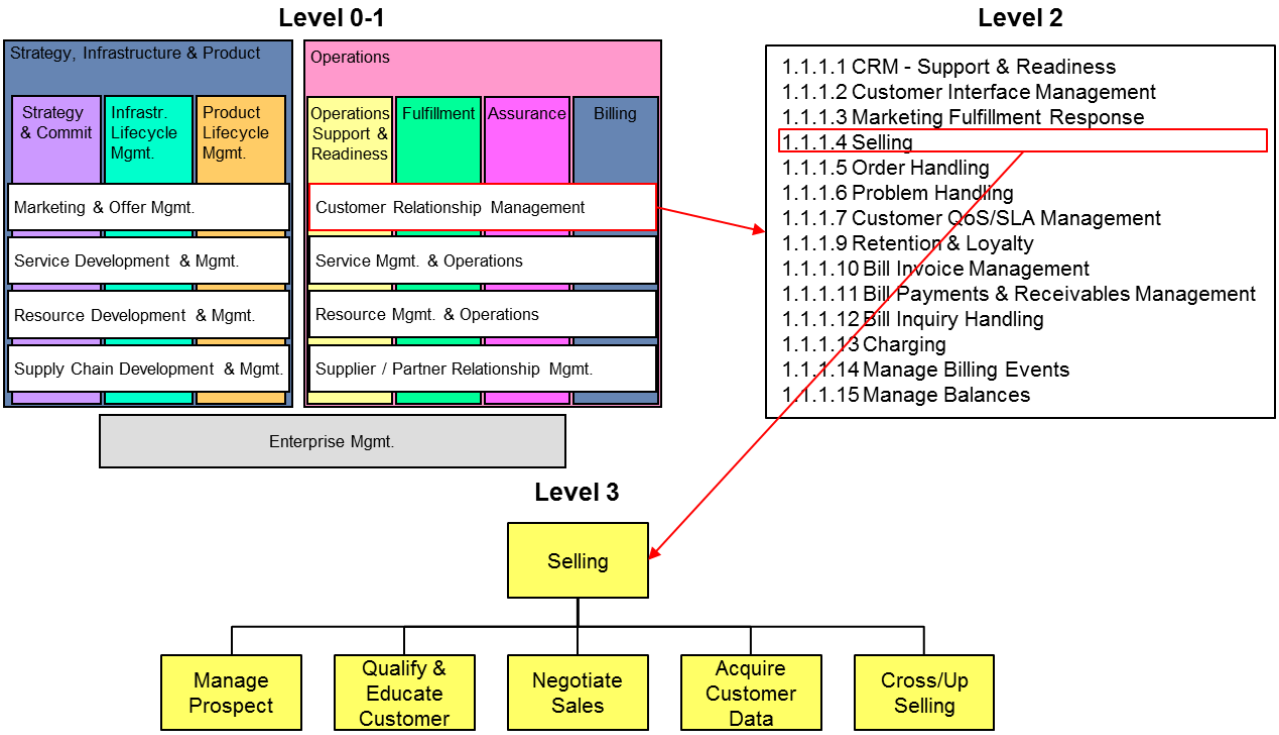

Figure 3. The eTOM is a collection of processes that can be decomposed on different levels of detail [6]

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