Ph.D. in Information Technology: Thesis Defense

July 16th, 2019

Room Seminari – 10.00 am

Özgür Umut AKGÜL – XXXI Cycle

"Real Time Trading of Mobile Resources in Beyond-5G Systems"

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Abstract:

5G is expected to offer download speeds as high as 1 GBps and latency lower than 1 ms. Although 5G networks are planned to be fully operational by 2020, the unprecedented technical and economic challenges still need to be solved. The biggest problem from a network operator's perspective is the tight profit margins. The lofty expectations from 5G connectivity lead to the need for enormous investments on infrastructure. However, many small operators simply do not possess the necessary revenue in order to deploy the required infrastructure, while the rich operators are unwilling to burden this extreme cost due to the very long return of investment duration. Moreover, 4G technology is reported to reach a fairly close to the Shannon capacity in the available spectrum, and the further improvements on the physical layer are very expensive with respect to the capacity gains. This techno-economic pressure is forcing mobile operators to make pivotal changes in their modus operandi. A simple solution is to extent the conventional infrastructure sharing agreements to cover the active network components, e.g. radio access network and the spectral resources, and decrease the total costs as well as increasing the spectral efficiency. From a regulatory perspective, the most reasonable scenario is the sharing of the resources brought by a neutral 3rd party, i.e. infrastructure provider. Despite the offered cost efficiency, the conventional sharing approaches rely on well-defined service level agreements that cover very long-time intervals (e.g. years) which cannot provide the envisioned flexibility and the efficiency in next generation networks.

While the aforesaid techno-economic pressure is forcing the operators to share their networks, the heterogeneity of the service types requires revolutionary changes in the network management. The 5G network is envisioned to host a multitude of services and devices with unique requirements and service priorities. The traditional solution of optimizing the complete network for a particular service type is no longer applicable due to the conflicting requirements posed by different services. A way out is to vertically group network resources, i.e. slicing the network, in order to create virtual dedicated networks per service. This way, each resource group (i.e. slice) can be customized to serve the respective service in the best possible way. The simplest form of this approach is slicing the network in a static manner, based on some statistical information. However, the conventional network provisioning techniques show that static resource allocation has a tendency towards over-provisioning the network, which causes the inefficient usage of scare spectral resources. Dynamic network slicing can increase efficiency yet enabling inter-service and inter-tenant priorities in a dynamic negotiation and resource allocation framework is still open in the literature.

In order to address the aforementioned challenges, the main research question in this PhD thesis revolves around how to achieve flexibility and efficiency in a shared mobile network. More specifically, this thesis targets answering the following research questions.

- How can the network resources dynamically and flexibly be shared in a multi-tenant network?
- How can the tenants differentiate their services in a shared infrastructure?
- What are the long- and short-term implications of anticipatory network sharing and resource trading?

The proposed dynamic negotiation and resource allocation framework proposes a novel service level agreement formulation that allows the operators to renegotiate their shared resources in very short time scales, i.e. in the order of seconds. Moreover, we demonstrate how to exploit anticipatory information regarding the users' achievable rates in order to improve the real time scheduling and resource trading. Lastly, we present a novel self-dimensioning algorithm in order to exploit the short-term observations on the traffic demand in order to fine-tune the network capacity. A number of simulations with both synthetic and real data have been performed in order to investigate the characteristic of the proposed framework.

PhD Committee:
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