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Diploma Thesis

Analysis of LTE Access and Backhaul Link Performance

The International Telecommunication Union (ITU) has recently released a circular letter inviting submissions for candidate radio interface technologies for the terrestrial component of IMT-Advanced systems. New worldwide coordinated spectrum will be made available to such systems and ensure the evolution of mobile radio networks towards higher data rates. The ITU does not place any technical restrictions on the candidate systems, but imposes certain performance requirements that need to be fulfilled by the submitted candidate radio access technologies. Along with the circular letter the ITU has released a set of documents that describe the requirements and the evaluation methodology to be used to evaluate their fulfillment. Evaluation is to be made either analytically, by inspection or by simulation, both on link-level and system-level. ComNets participates in the CELTIC WINNER+ project which has registered as an external evaluation group with the ITU. The IMT-Advanced candidate systems that are evaluated by ComNets are proposed by the 3GPP group and the IEEE group. These candidates are known as the advanced 3GPP UMTS Long Term Evolution (LTE-A) or UMTS Release 10 and the candidate specification developed by the IEEE 802.16m group.

LTE targets high data rates beyond 100 Mbps, low delay and high spectral efficiency. This requires an efficient error control. Therefore since Release 8 the outer automatic repeat request (ARQ) of its radio link layer (RLC) is complemented by a Hybrid ARQ (HARQ) within the medium access (MAC) Layer to allow for fast and efficient retransmissions (see Figure 1). The access link lies between access point, the eNodeB (eNB), and the user equipment (UE). The self-backhauling feature of LTE is that an eNB is wirelessly connected to another eNB, the so called anchor eNB, instead of a wired connection to the evolved packet core (EPC). Release 9 introduced the concept of home eNBs. Together with the self-backhauling mechanism it becomes possible to connect home eNB via LTE and EPC to the Internet instead of using a digital subscriber line (DSL) of an Internet service provider.

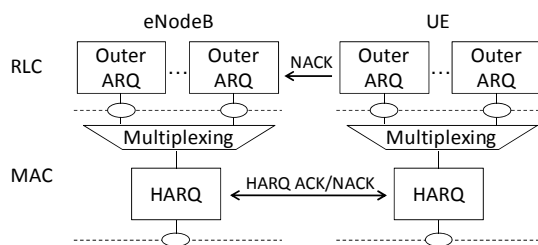


Figure 1: Hybrid ARQ and Outer ARQ

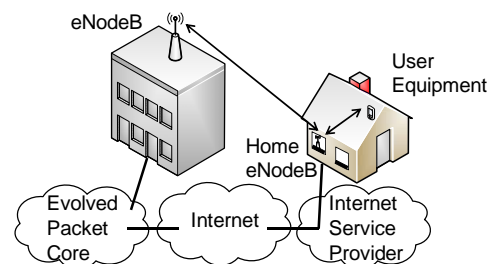


Figure 2: LTE Deployment.

In this work the delay introduced by the Outer ARQ and HARQ shall be evaluated analytically using Signal Flow Graphs (SFG) similar to [1]. In a first step the Outer ARQ and HARQ should be modeled independently. Afterwards these models shall be combined to give the delay distribution of a data transmission via the access link. Then the backhaul link should be modeled using DSL and the self-backhauling feature of LTE. Therefore, different self-backhauling concepts shall be described and investigated.

The following work items shall be handled:

- Describe the state of the art of LTE and its self-backhauling concepts.
- Provide a SFG model of the Outer ARQ and the HARQ using Matlab.
- Analyze the delay distribution of a multi-hop communication using DSL, LTE, LTE self-backhauling.
- Compare the different self-backhauling concepts based on the developed multi-hop model.
- Description of the obtained results
- Final presentation (two intermediate presentations)

Keywords: Signal Flow Graph, LTE, Hybrid ARQ, Matlab

- References:
- [1] *Transport Layer Delay Analysis in Wireless Networks using Signal Flow Graphs*, Gehlen, Walke, Proceedings of European Wireless 2007
 - [2] *Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (Release 8)*, 3rd Generation Partnership Project; Technical Specification Group Radio Access Network
 - [3] *Architecture aspects of Home NodeB and Home eNodeB (Release 9)*; 3rd Generation Partnership Project; Technical Specification Group Service and System Aspects