Analysis of an Adaptive Switching Point for LTE TDD by Dynamic System-Level Simulations

Christian Backfrieder [a], Gerald Ostermayer [b]

[a] FH OÖ Forschungs & Entwicklungs GmbH, A-4232 Hagenberg, AUSTRIA
[b] University of Applied Sciences Upper Austria, A-4232 Hagenberg, AUSTRIA

ABSTRACT:
This paper introduces an LTE system level simulator and presents investigations of scenarios with differently balanced traffic emergence between uplink and downlink as well as inhomogeneous distribution of link direction asymmetry. In the time division duplex (TDD) mode of LTE, duplexing is implemented by different switching configurations between uplink and downlink, which offer varying capacity distributions, from a downlink-heavy configuration with 90 percent of the capacity in downlink direction to uplink heavy configurations with 60 percent uplink. We utilize the available capacity perfectly by adjusting the link configuration appropriately to traffic emergence. Performance gains when selecting a configuration appropriate to the arising traffic compared to usage of a static configuration with equally distributed capacity are investigated. In case of different configurations, additional interference can occur in neighbored cells due to distinct communication direction at the same time. We clarify the differences between these scenarios and quantify the gains and losses when the switching point between uplink and downlink is variable.

1 PROBLEM DESCRIPTION

Radio resource management is a very important part in mobile cellular networks when looking at the overall performance of the system. This work focuses on the TDD mode of LTE, where the same frequency band is used for uplink and downlink transmission. Figure 1 shows an example for bandwidth usage with inhomogeneous arrangement between uplink and downlink users. The upper part shows a fixed switching point, i.e. the same amount of bandwidth available for both downlink and uplink traffic. In the lower part, the advantage of TDD is utilized, where the available bandwidth amount is spread unequal between the two link directions. As a result, the unused part is minimized and bandwidth utilization can be increased in case of a disbalance between uplink and downlink user equipments (UE).

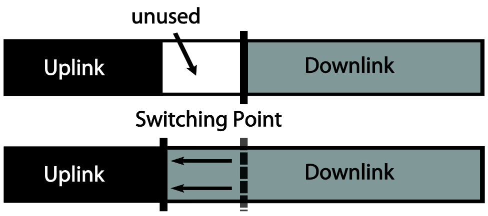

Figure 1. Dynamic switching point

Since the traffic emergence can vary from cell to cell, it is suggestive that different cells use different link configurations out of the defined set from the LTE standard. Preferably, these configurations match the user's behavior as good as possible and provide appropriate resources depending on the current traffic situation. For the scope of this paper, simulation results are specifically related to time division duplex (TDD). In case of asymmetric traffic emergence, a key advantage of LTE TDD is the possibility to select an appropriate link duplex configuration out of a predefined set. The duplex switching point is simply changed, and capacity is moved from downlink to uplink or reverse as desired. The goal of this study is to investigate to what extent the usage of different, potentially interfering link duplex configurations influence the throughput of the cells.

2 SIMULATION RESULTS AND CONCLUSION

The simulation scenario is set up for an urban environment with traffic emergence distributed asymmetric between uplink and downlink. We chose 75% downlink users compared to 25% uplink users. For this investigation, the presented scenario was simulated three times, where each column of the figure represents a single simulation run. The difference between the simulations is the duplex configuration that is chosen for the cell with asymmetric traffic emergence. The average cell throughput as well as the average throughput for single users are taken into account and depicted in the following diagram in figure 3. Columns of the same color represent a single simulation, for which the traffic was set up symmetric (black column) and asymmetric (white and grey columns). The simulations record throughput per user in detail. Through assignment of user to cells the cell throughput can be determined exactly. This is separated between downlink and uplink (left and right part of the diagram). This indicates the effects on cell and user throughput if the link configuration is adapted appropriately.

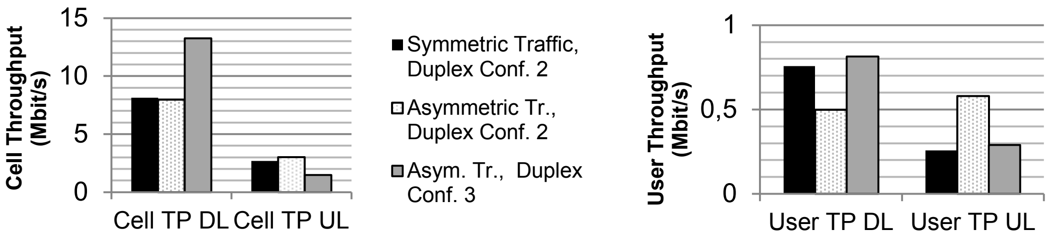

Figure 2. Cell and user throughput comparison

In the left diagram of the figure one can see that in case of an asymmetric traffic, but with selection of a configuration with equal distribution of downlink and uplink timeslots, the throughput stays roughly equal. The reason is that the scheduler always assigns the whole bandwidth, independent of the number of users to which it is separated. When comparing this simulation with a duplex configuration fitting to the traffic emergence (grey column), a distinct increase of cell throughput can be observed. This is due to the higher amount of timeslots for downlink of duplex configuration 3. The contrary effect arises in the cell throughput in uplink direction, which decreases because of less uplink resources. The essential result of this simulation becomes visible in the right part of figure 3. If traffic with a communication direction distribution contrary to the current link duplex configuration emerges, a considerable drop of throughput of single users is the result (white column). As soon as the network recognizes this disbalance and chooses an appropriate duplex configuration (in this case configuration three, grey column), the average user throughput rises again approximately to the original level. A better balanced user throughput is highly beneficial for operators due to higher efficiency and usage of the entirely available resources, the possibility to adjust the capacities to current traffic emergence as well as for keeping the data rate of single users approximately constant. This can be achieved by applying our approach without changing any hardware requirements to existing mobile LTE networks.

BIBLIOGRAPHY

[1] Kulcsar, J.R. (2009): Qualitätsevaluierung repräsentativer Werte für das Interface zwischen Link-Level- und System-Level-Simulatoren in Mobilkommunikationssystemen. Master's thesis, Fachhochschule Hagenberg, Austria

[2] Ikuno, J.C., M. Wrulich, and M. Rupp (2010): System level simulation of LTE networks. In Proc. 2010 IEEE 71st Vehicular Technology Conference: VTC2010-Spring, Taipei

[3] Andersen, J.B., T.S. Rappaport, and S. Yoshida (1995): Propagation measurements and models for wireless communications channels. Comm. Mag.

[4] Berg, J.E. (1995): A recursive method for street microcell path loss calculations. In Personal, Indoor and Mobile Radio Communications.

[5] Osterkorn, C.H. (2004): Untersuchung von Slow Fading Modellen im Mobilfunk. Master's thesis, Fachhochschule Hagenberg, Austria

[6] Ha, T.T. (2010): Theory and Design of Digital Communication Systems, Cambridge University Press, p. 615

[7] ETSI: Universal Mobile Telecommunications System (UMTS) (1998); Selection procedures for the choice of radio transmission technologies of the UMTS. Techn. rep., ETSI, 1998. TR 101 112 V3.2.0