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Telecommunications Consulting

Master’s Thesis:

Future Potential of High Speed Uplink Packet Access in Existing 3G Networks

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Outline of Presentation

- Objectives of the Thesis
- Introduction to WCDMA Enhanced Uplink
- Research Methodology
- Case Study: EUL potential in a live 3G Network
- Conclusions

Thesis Objectives

- To find out what is HSUPA e.g. EUL in general
- What kind of performance is achievable when implementing EUL in the existing NWs?
- How will the EUL implementation affect to NW dimensioning from coverage point of view
- General goal: to be able to benchmark EUL suitability of different operators' NWs.

Introduction to WCDMA Enhanced Uplink

- Recently first HSDPA services launched, bringing the downlink bitrates to a completely new level. A throughput of 3.6 Mbps is the current *defacto* speed.
- To ensure that the uplink will not become a bottleneck for future data services, 3GPP has standardized a new technology called Enhanced Uplink (EUL) in the latest standard release 6.
- EUL is often referred as HSUPA to underline that it belongs to the same “family” with the HSDPA. The family is often called simply HSPA.
- With the help of **shortened transmission time interval** (TTI), fast **Hybrid-ARQ,** fast **Node B based scheduling** and **multicode transmission** the UL bitrates will reach 1.4 Mbps in the early phase and even 5.4 Mbps is specified in future evolution.

Impacts of the Enhancements

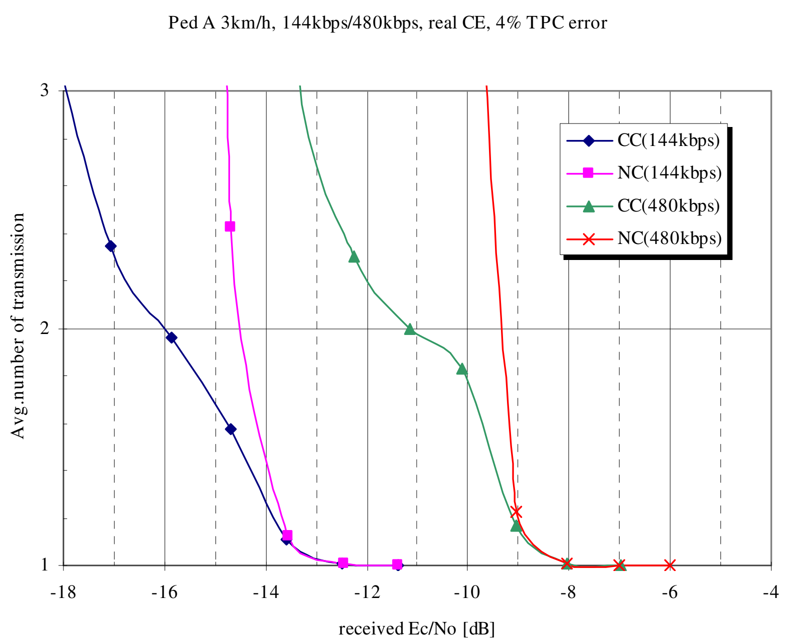
- Shorter TTI to provide the other functionalities with the means to operate accurate enough.
- Fast Node B scheduling to bring the *network brains* closer to the "battle field". R99 UL scheduler located in RNC. Due to the BS scheduler the EUL can allocate the resources faster and more accurately.
- Hybrid-ARQ to introduce extended coverage and capacity by *early termination gain.*
- Multicode transmission to introduce more dynamics to the bitrates. In R99 networks the maximum 384 kbps reached rather easily.

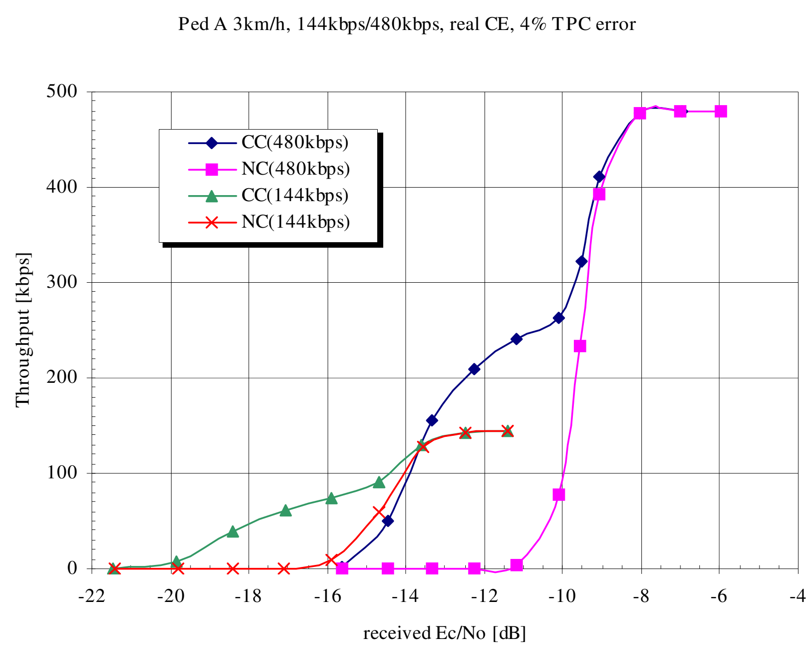
HARQ: Early Termination Gain

Two strategies to provide a bitrate:

1. Use enough transmit power to achieve certain BLER
2. Use X times higher bit rate, allow X retransmissions and bargain from the BLER of the 1st transmission by using the same P_{TX}

=> In average, X retransmission are not needed, thus energy cost per bit is reduced. This is called ”*Early termination Gain*”. Now, what's the price we pay?





HSUPA Principles: Why not go for a 16QAM?

Compared to QPSK, 16QAM doubles the bit rate. In other words, it introduces a 3 dB gain in throughput. Still, in the receiving end, the required P_{RX} is more than doubled, thus the energy cost per bit is increased.

UL is power controlled with 70 dB dynamic range, to avoid the *near-far problem*. No such free lunch as with HSDPA.

Going for 16QAM would degrade the the overall cell throughput, instead HSUPA utilizes multicode transmission.

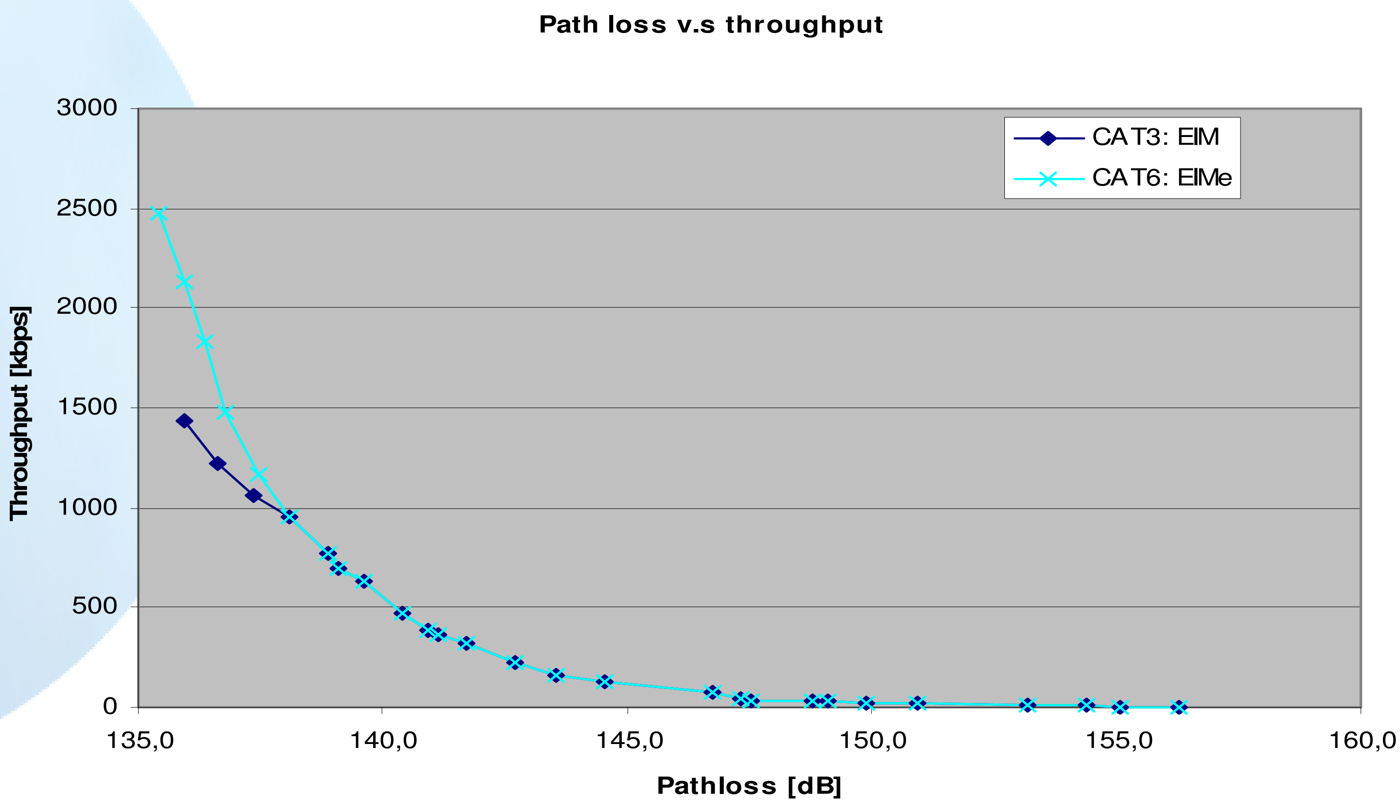
At max: 2*SF4 +2*SF2 used with BPSK => 5.44 Mbps

Research Methodology

- To come up with an answer to presented questions, a model from a typical WCDMA cell with EUL capabilities was developed.
- Model was based on typical WCDMA R99 link budget analysis.
- To model the EUL capabilities, theoretical analyses, simulations, and when better information wasn't available, educated guesses were applied.
- To push the analysis to a more realistic level, a case study with measurements from a live 3G network was carried out.

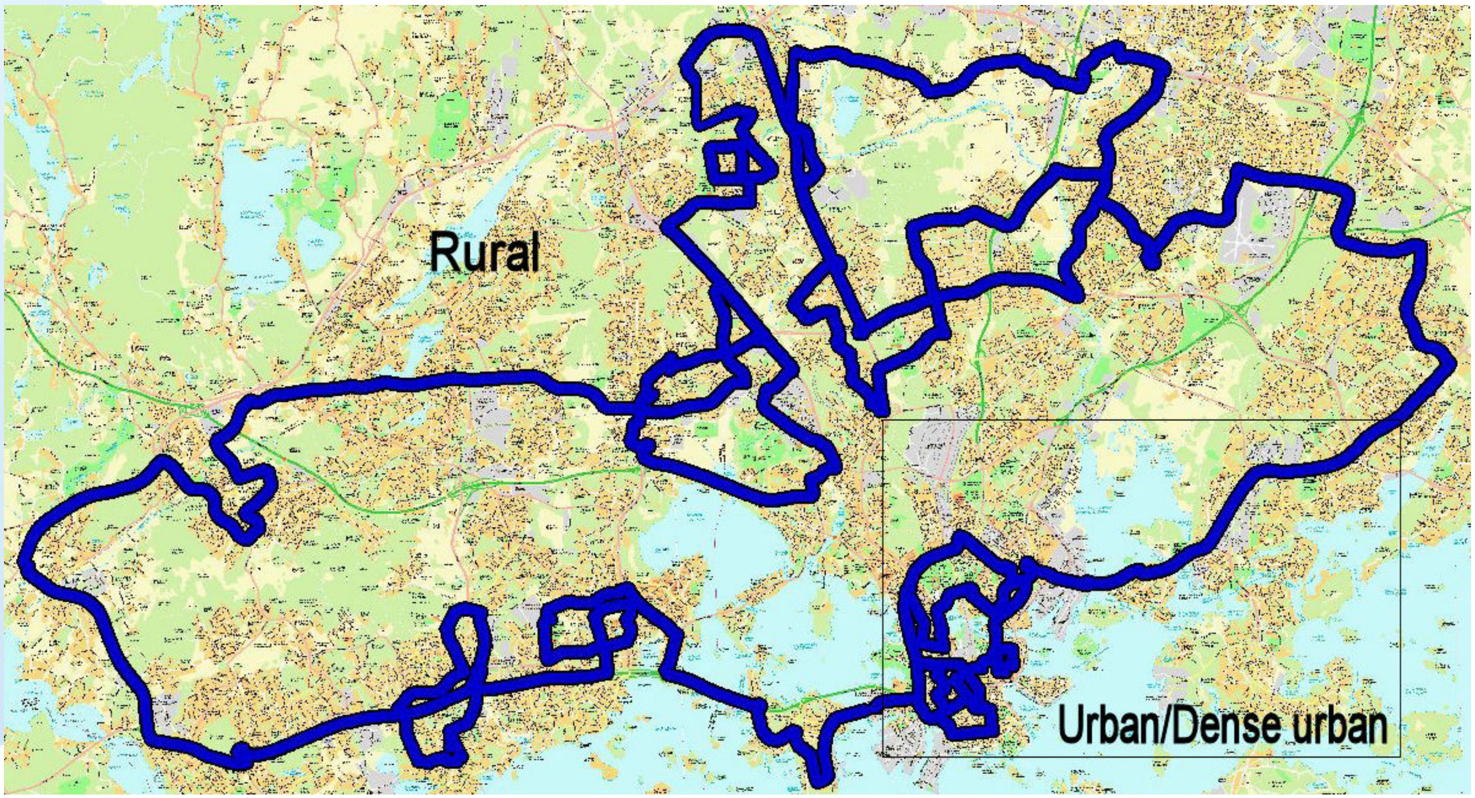
Modelling the EUL Capabilities

The investigation was limited to consern two cases: an early phase implementation and a future UE with all the ”bells and whistles”



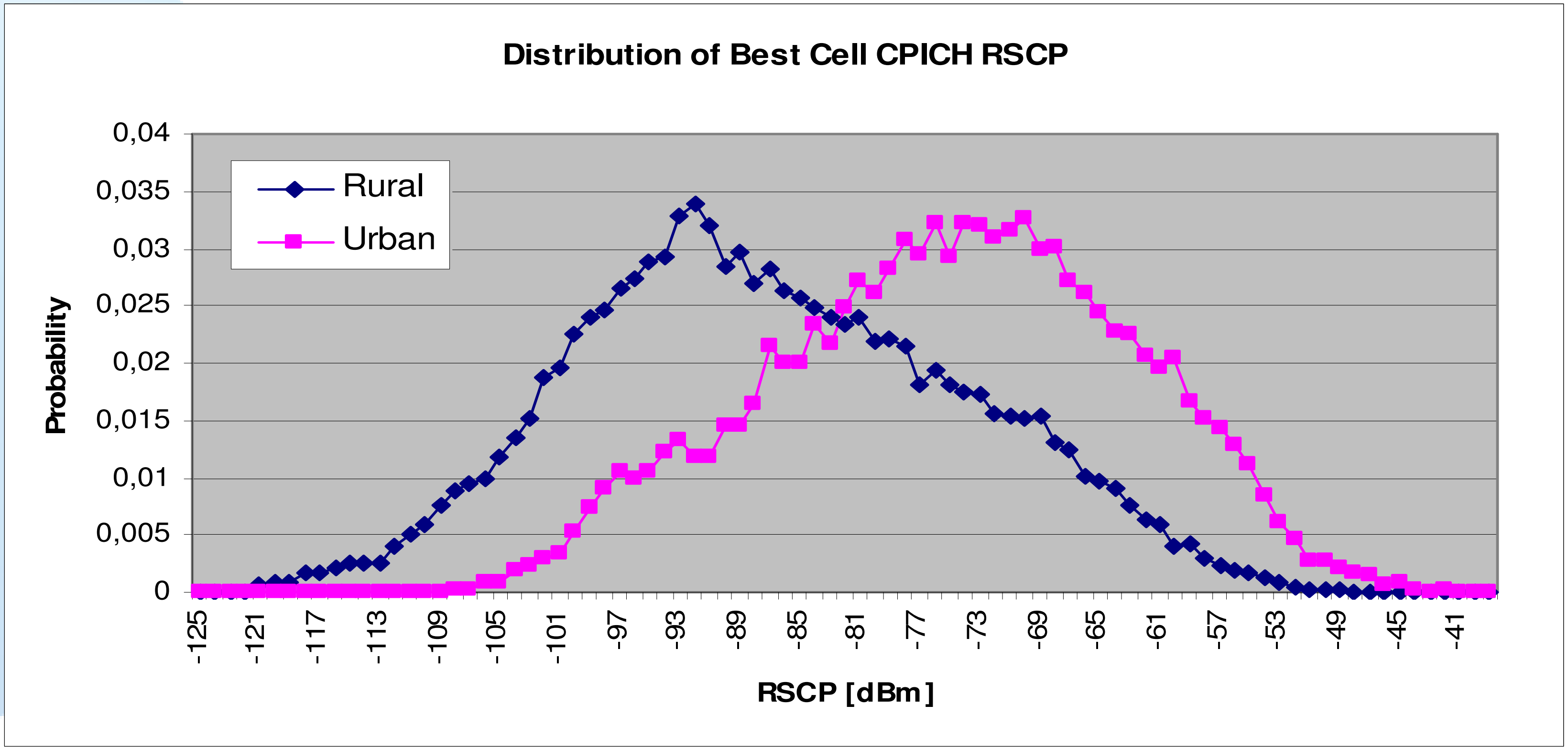
Case Study: A Metropolitan Area 3G Network (1)

For the case study a NW audit from a real 3G NW of a Finnish telecom operator was carried out. The area was furthermore divided into two sections, a rural part and urban part.



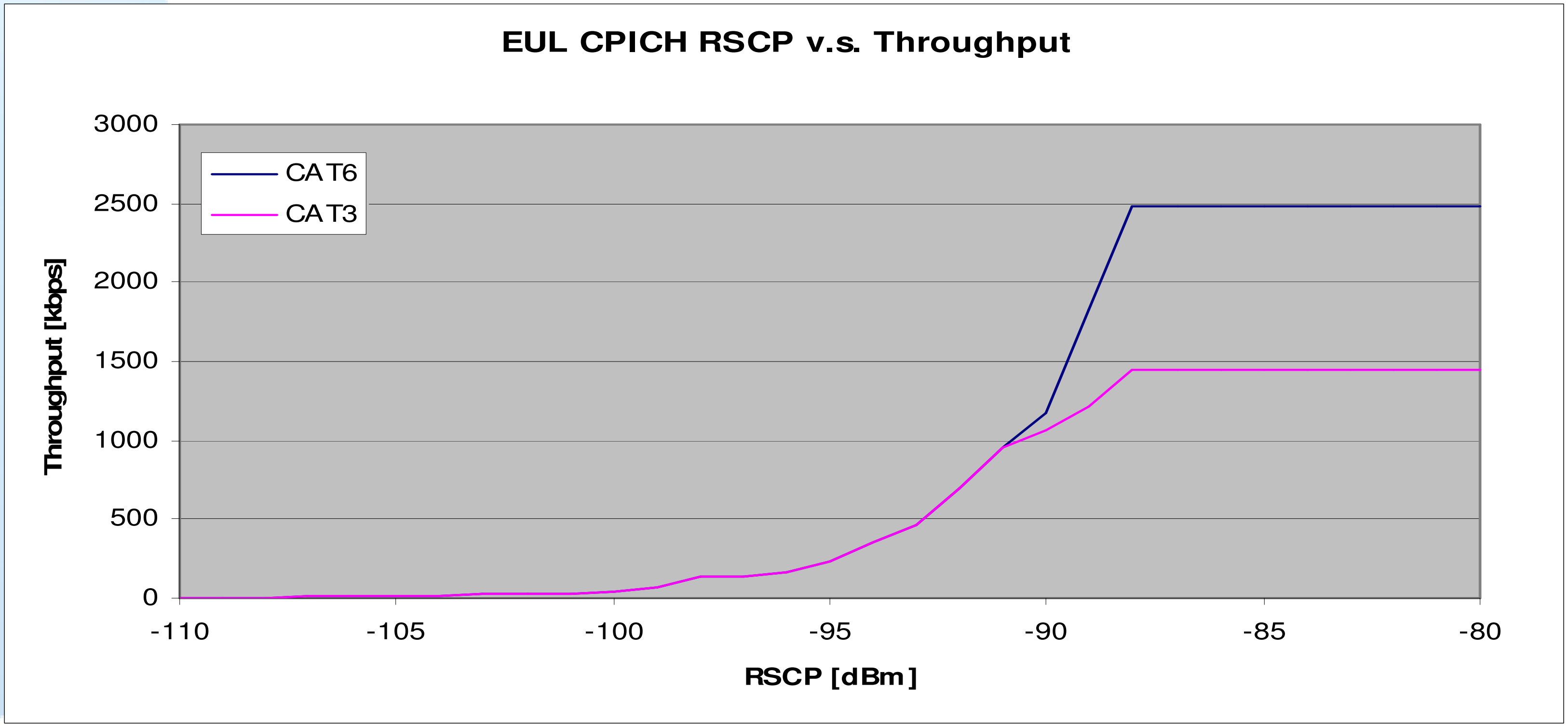
Case Study: A Metropolitan Area 3G Network (2)

The reason for dividing the target area into two sections was the significantly differing site densities. The figure below represents the measured distribution of the received code power (RSCP) of the Common Pilot Channel (CPICH) in both parts.



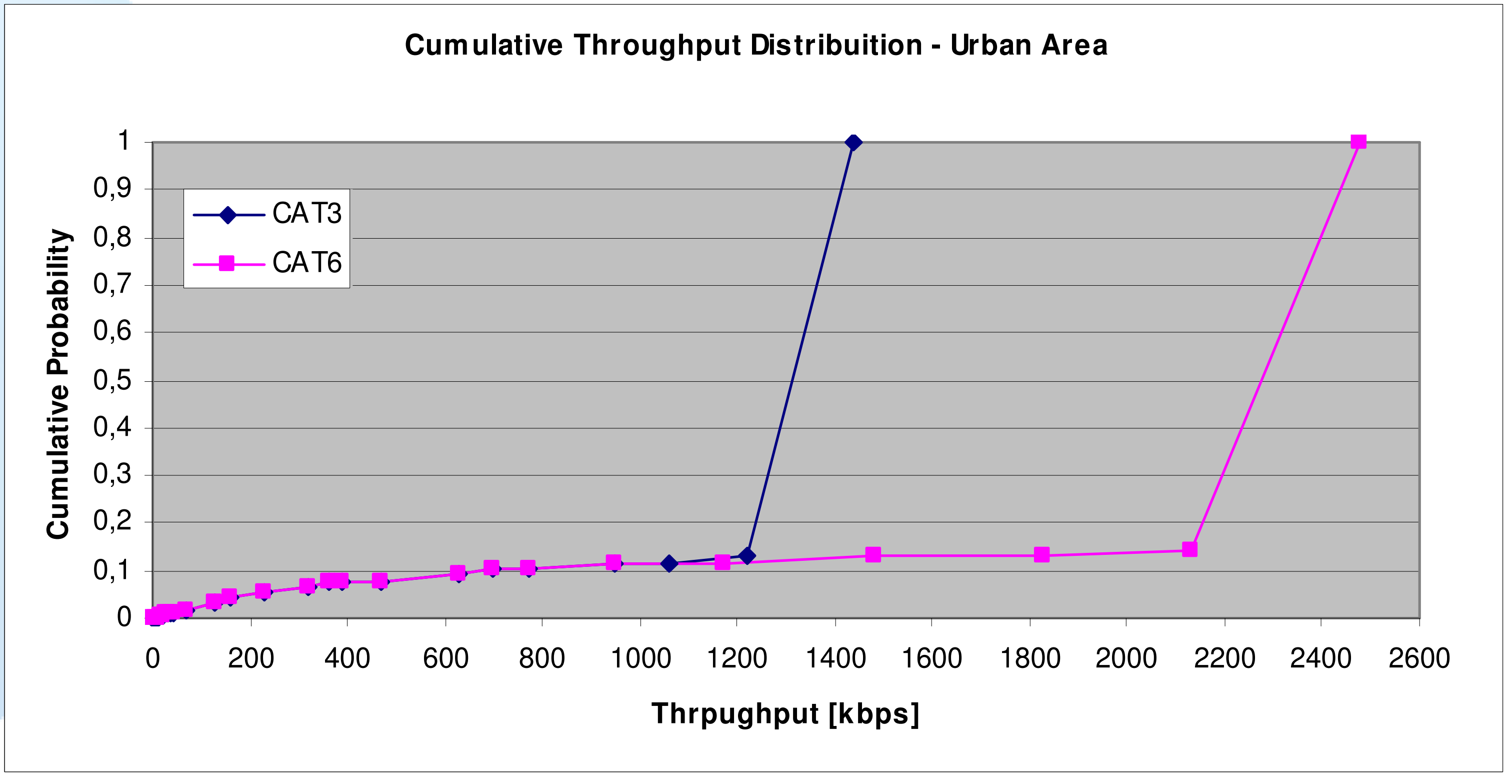
Case Study: A Metropolitan Area 3G Network (3)

CPICH RSCP was converted to UL path loss with the knowledge of CPICH transmit power and the general difference between the free space pathloss of UL and DL. The latter was furthermore mapped to corresponding EUL throughputs of CAT3 and CAT6 UEs.



Case Study: A Metropolitan Area 3G Network (4)

The case study pointed out that at least in the urban part of target area the site density is sufficient for the high bitrates of EUL. Some parts of the rural area suffered from coverage issues, thus the performance will be lower as well. The figure below presents the CDF of UE limited EUL throughput in the urban part of the target area.



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Summary

The overall storyline of the thesis was organized in five chapters answering following questions:

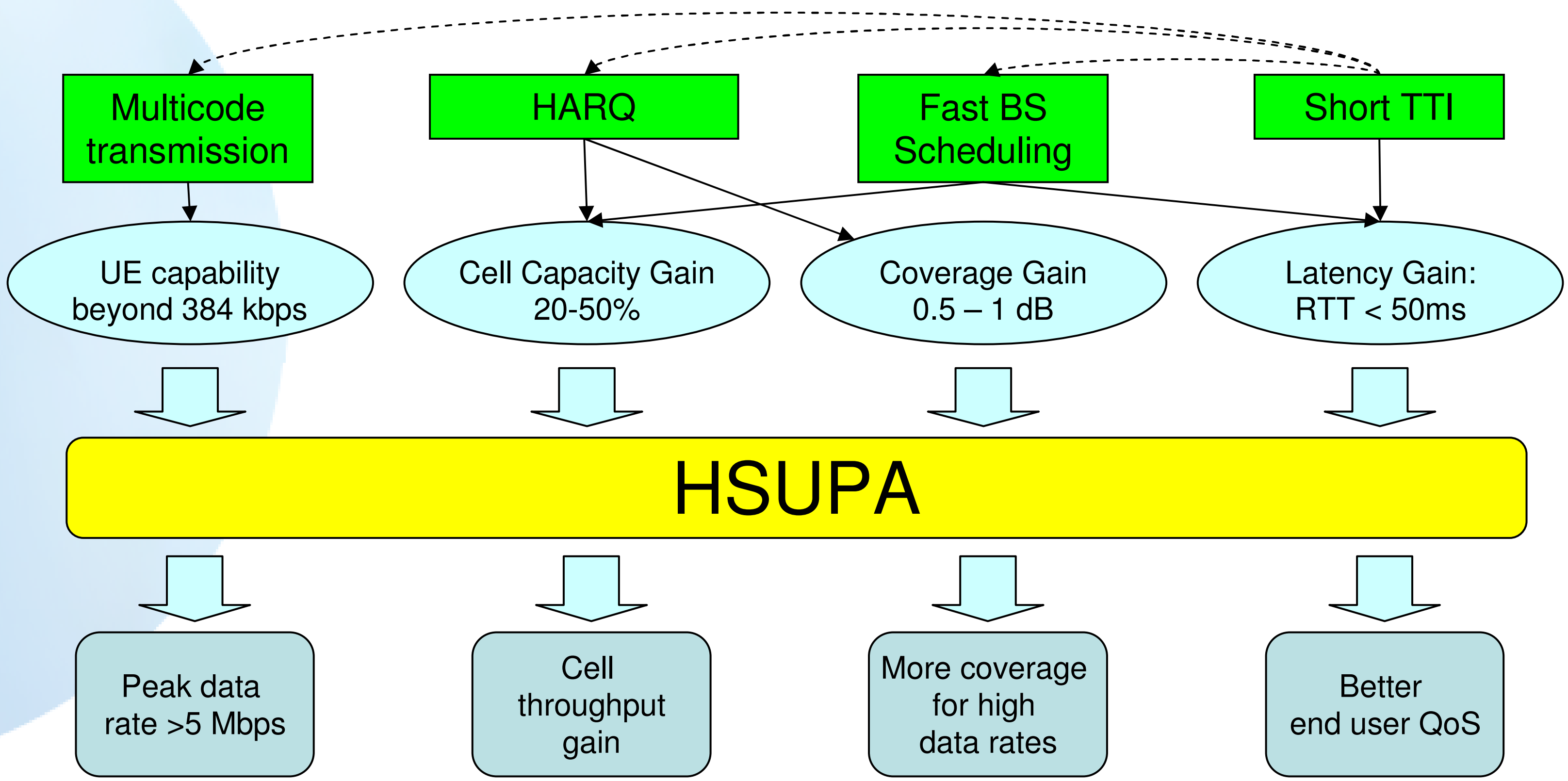
1. Why is the whole thesis done, what are we trying to figure out?
2. What is EUL, how does it compare to existing WCDMA uplink?
3. How do the improvements of EUL impact to performance?
4. What are the circumstances and surroundings in which a certain EUL throughput can be achieved?
5. How do the analysis of chapter four compare to the circumstances in real life 3G networks?

Results and Conclusions (1)

- The general goal for the thesis was fulfilled: We now know what kind of NW density is needed to provide certain EUL data rates in a typical 3G NW.
- It was also found out that although bitrates of even 5.4 Mbps is specified for EUL, in normal circumstances only 2.5 Mbps will be achievable even with the most advanced Ues. The latter is due to the noise rise limitations of WCDMA UL.
- The case study showed that the largest part of the investigated NW is ready for providing the highest bitrates of early phase EUL evolution. In other words, at least from the coverage point of view, the maximum data rate of a CAT3 UE, e.g.1.4 Mbps, should be achieved rather easily in concurrent 3G NWs.

Results and Conclusions (2)

Another fact definitely attracting the operators is that with only software updates the existing network can have extended capacity, coverage and improved user level QoS. Hence rapid market penetration can be expected. The most optimistic sources even state that real services would be launched already during this year.



End of Presentation

Questions?