Nomor 3GPP Newsletter – September 2007

Overview LTE PHY: Part 3 – LTE Performance

Authors: Eiko Seidel, Volker Pauli

PHY Performance

In part 3 of the LTE overview some capacity figures are being summarized based on analytical calculations and on simulations performed within RAN1. The performance figures do not include signaling overhead of control channels (PDCCH, PUCCH, BCH, SCH etc.) and do not consider latest decisions on specification.

Peak Data Rates

- Theoretical single user peak data rate.

Peak Data Rates

LTE should provide a significant increase of peak data rates
***Theoretical* peak data rate (calculated maximum)**
***Calculation* Assumptions**

- 20 MHz, 1200 sub carrier, code rate = 1, 64 QAM
- Overhead for CRC, BCH, and SCH (ca 1%) not deduced

Downlink		Uplink	
64QAM 2x2 MIMO	172.8Mbps	16QAM	57.6 Mbps
64QAM 4x4 MIMO	326.4Mbps	64QAM	86.4 Mbps

Source: 3GPP RAN WG1#49

LTE System Performance

Spectrum Efficiency

- Capacity figures that are normalized to UMTS Release 6 with Rx Diversity. Simulation results should not be taken for granted and be interpreted with care since LTE must fulfill the requirements that were set by the operators.

Capacity Figures

Capacity figures

Simulation based analysis
Simulation assumptions

- fully dynamic system level simulation (multi-cell)
- R1-070674: LTE PHY framework for performance verification by NGNM

Intersite Distance 1732m (case 3)	Spectrum Efficiency		Mean User Throughput		Cell-Edge User Throughput	
	bps/Hz/cell	x UTRA	bps/Hz/user	x UTRA	bps/Hz/user	x UTRA
UTRA DL baseline	0,52	1,0	0,05	1,0	0,02	1,0
LTE DL 2x2 SU-MIMO	1,56	3,0	0,16	3,0	0,04	2,3
UTRA UL baseline	0,316	1,0	0,032	1,0	0,0023	1,0
LTE UL 1x2 RxDiv	0,681	2,2	0,068	2,2	0,0044	2,0

Source: 3GPP RAN WG1#49

LTE System Performance

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5 MHz Bandwidth Intersite Distance 1732m (case 3)	Shared Cell Capacity	Mean User Throughput	Cell-Edge User Throughput
	kbps	kbps	kbps
UTRA DL baseline	2.600	250	100
LTE DL 2x2 SU-MIMO	7.800	800	200
UTRA UL baseline	1.580	160	11.5
LTE UL 1x2 RxDiv	3.405	340	22

Source: 3GPP RAN WG1#49

LTE System Performance

- In the case of LTE the low performance for a cell-edge user and the large difference between mean throughput and cell-edge throughput are remarkable. The simulations are performed without interference coordination or mitigation which should alleviate these problems.

VoIP Capacity

VoIP Capacity

Simulation based analysis

***Simulation* assumptions**

- fully dynamic system level simulation (multi-cell)
- Full rate AMR (12.2kbps), 50% VAF, 20ms frame length
- Outage defined as 95% coverage for 2% FER @ 50ms delay bound
- 5 MHz, 1x2 MIMO (receive diversity)

Open issues:

- VoIP scheduler design
- Control channel design
- VoIP optimization

Deployment scenario	Average VoIP Capacity (users/sector)	
	Downlink	Uplink
Case 1 (500m)	317	241
Case 3 (1732m)	289	123

Source: 3GPP RAN WG1#49

LTE System Performance

- Capacity of the uplink should be increase to increase overall number of users.

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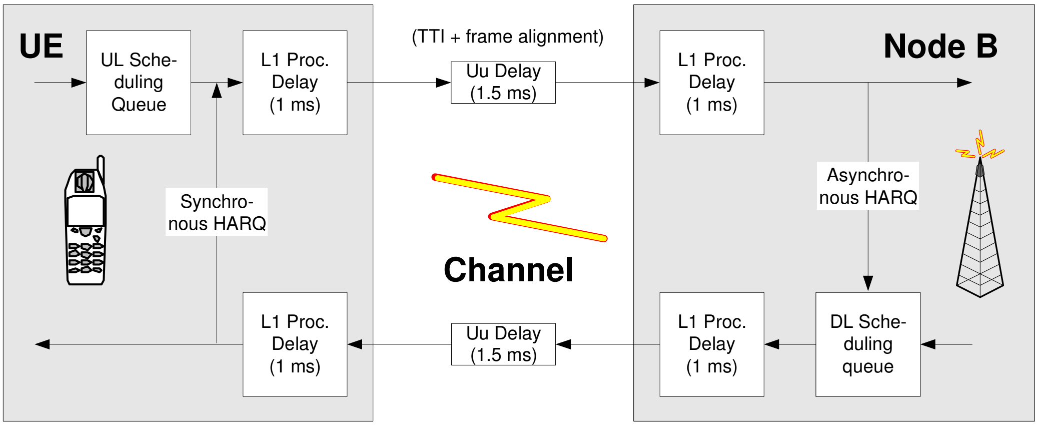
Protocol Performance

U-Plane Latency

- Simple architecture



- E-UTRAN one-way delay = 3.5 ms in theory
- HARQ retransmission will take 5ms round-trip time. In the last meetings the number of HARQ processes was discussed with several companies proposing the use of 8 HARQ processes in up- and downlink. This would increase the round-trip time to 8ms.
- Nevertheless queuing delay, scheduling delay in UL (request – grant) for different QoS requirements and so on will need to be added.
- RLC retransmission can take much longer once HARQ fails. The details on how often status reports are being sent is currently under discussion.

IDLE-to-ACTIVE Transitions

- Requirement for IDLE to ACTIVE transition until first data packet is received was 100 ms
- Control-plane establishment latency
  - Used for initial access or IDLE to ACTIVE transition; Consists of UL RACH, DL Timing Advance/Grant, RRC connection UL request/DL setup/UL complete messages ...
  - 47.5 ms + 2 x TS1c = e.g. **57.5 ms** for TS1c = 5 ms (TS1c = delay on S1 control-plane interface)
- User-plane establishment latency
  - 13.5 ms + TS1u = e.g. **16.5 ms** for TS1u = 3 ms (TS1u = delay on S1 user-plane interface)
- The 100 ms requirement is fulfilled
  - **57.5 ms** + **16.5 ms** = **74 ms**

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LTE Use Case Example

- The standard does not limit the number of users. With an UE ID of 16 bit length up to 65.536 users can be supported. Nevertheless, control overhead (e.g. for cell updates) will render such a large number inefficient. Similarly, network resources on S1 will have to be allocated continuously and Node B complexity will increase (e.g. for storing the context of all UEs).
- Network capabilities and configuration are implementation-specific issues and up to the manufacturer and operator. Below is an exemplary calculation based on traffic models for a 10 MHz bandwidth.
- Overall UEs in the cell
  - up to 7.000 per cell
  - ACTIVE and IDLE UEs. All of them should first register to the network.
- UEs in RRC_CONNCTED (Active)
  - 800 ... 1300 per cell
  - There is little overhead involved in having a large number of users ACTIVE. There should not be any signaling going on (no power control as in CDMA!). After some time of inactivity (time will be configured by the network) they will just lose UL synchronization and need to synchronize via contention based or non-contention based RACH procedure.
- Idle-to-Active transitions
  - 1000 ... 2000 per h per cell
  - One reason to go to IDLE may be a cell change. In IDLE mode the location will only be known at cell level and network signaling will be saved since the UE context does not need to be forwarded to each Node B.

The next newsletter ...

We will catch up with the latest progress in 3GPP RAN standardization and will introduce recent work and study items that have been agreed on for UMTS Release 8.

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