

3G Evolution



Chapter: 23

Performance of 3G Evolution

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3G Evolution - HSPA and LTE for Mobile Broadband

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Outline



- Performance Assessment
- Performance Comparison
- Performance Perspectives
 - End-User perspective
 - Operator perspective
 - Peak data rate
- LTE Performance Targets
- Performance Evaluation of 3G Evolution
 - Models and Assumptions
 - DL user throughput vs served traffic under typical urban prop.
 - DL user throughput vs served traffic under pedestrian A prop.
 - UL user throughput vs served traffic under typical urban prop.
 - UL user throughput vs served traffic under pedestrian A prop.
- LTE Spectrum efficiency

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Performance Assessment



- Computer simulations provide:
 - Evaluation of concepts not yet deployed
 - Full control over the environment
 - Well controlled experiments
- Computer simulation do NOT provide:
 - Full picture of the performance of the system
 - Complete environment in real life
- Still, a good picture of the system performance can be obtained

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Performance Comparison



- Performance measurements are meaningless without comparison
- However, there is no universal measure of performance for telecommunications systems
 - Users: Higher possible quality
 - Operators: Higher possible revenue

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End-User perspective

- The user experiences:
 - Quality of voice and/or video
 - Service Delay
- Typical measurements from user perspective
 - System and user throughput
 - Data rate
 - Latency

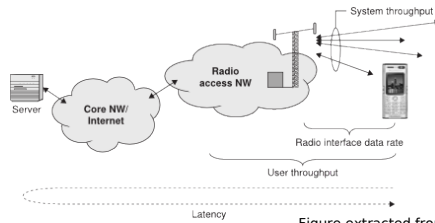


Figure extracted from "3G Evolution HSPA and LTE for ..."

Operator perspective

- The operator perceives
 - Deployment costs
 - Maintenance costs
 - Spectrum costs
- Operator has as a goal to achieve as high revenue as possible by:
 - Improving system throughput
 - Allocating as many users as possible
- A typical measure from operator perspective is spectrum efficiency [bps/Hz]

Performance in term of Peak Data Rate

- Minimum [Design Target]
 - 100Mbps DL and 50Mbps UL @ 20MHz BW
 - 5bps/Hz DL
 - 2.5bps/Hz UL
 - 2 Rx antennas 1 Tx antenna
- Expected
 - 150Mbps DL and 75Mbps UL @ 20MHz BW
 - 2x2 MIMO
 - 64QAM
 - Upto 300Mbps for 4x4 MIMO

LTE Performance Targets

Performance measure	DL target relative to baseline Rel6-HSDPA	UL target relative to baseline Rel-6 Enhanced UL
Average user throughput (per MHz)	3 - 4x	2 - 3x
Cell Edge user throughput (per MHz, 5th percentil)	2 - 3x	2 - 3x
Spectrum Efficiency (bps/Hz/site)	3 - 4x	2 - 3x
Coverage	Meet the above targets upto 5Km cell range	Meet the above targets upto 5Km cell range

Performance Evaluation of 3G Evolution



- Systems under evaluation:
 - LTE
 - Release 7 3GPP TR 25.913, 2x2 MIMO
 - Basic WCDMA
 - Release 6 Single stream and base-line rake receiver
 - Advanced WCDMA (HSPA)
 - 2x2 MIMO, 16QAM
- Models and Assumptions
 - Control-plane, user-plane protocols above PHY neglected
 - Simulation methodology is static (UEs randomly positioned)
 - Round-robin scheduling
 - Simulation over the average user and at the cell-edge

Models and Assumptions (1)



Traffic Models	
User distribution	Uniform, in average 10 users per sector
Terminal speed	0 km/h
Data generation	On-off with activity factor 5%, 10%, 20%, 40%, 60%, 80%, 100%
Radio network models	
Distance attenuation	$L = 35.3 + 37.6 \times \log(d)$, d = distance in meters
Shadow fading	Log-normal, 8 dB standard deviation
Multipath fading	3GPP Typical Urban and Pedestrian A
Cell layout	Hexagonal grid, 3-sector sites, 57 sectors in total
Cell radius	167 m (500 m inter-site distance)
System models	
Spectrum allocation	5 MHz for DL and 5 MHz for UL (FDD)
Base station and UE output power	20 W and 125 mW into antenna
Max antenna gain	15 dBi
Modulation and coding schemes	QPSK and 16QAM, Turbo coding according to WCDMA Release 6. Only QPSK for basic WCDMA uplink
Scheduling	Round robin in time domain

Figure extracted from "3G Evolution HSPA and LTE for ..."

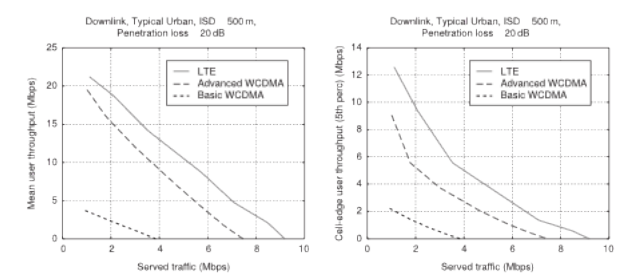
Models and Assumptions (2)



Basic WCDMA characteristics	
Transmission scheme	Single stream in DL and UL
Receiver	Two-branch antenna diversity with rake receiver, maximum ratio combining of all channel taps. 9 dB noise figure in UE, 5 dB in NodeB
Advanced WCDMA characteristics	
Transmission scheme	DL: 2 stream PARC UL: Single stream
Receiver	DL: GRAKE [29] with Successive Interference Cancellation UL: GRAKE with 2-branch receive diversity, soft handover with selection combining between sites
LTE characteristics	
Transmission scheme	DL: 2 stream PARC UL: Single stream
Receiver	DL: MMSE with Successive Interference Cancellation UL: MMSE with 2-branch receive diversity, soft handover with selection combining between sites

Figure extracted from "3G Evolution HSPA and LTE for ..."

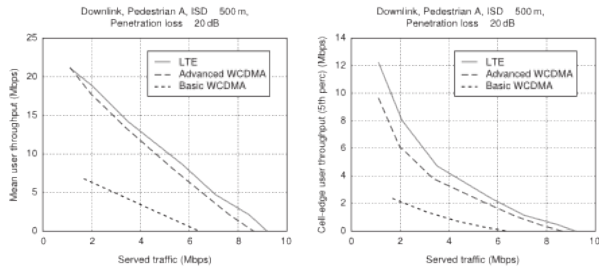
Downlink under typical urban propagation



Mean and cell-edge downlink user throughput vs. served traffic. Typical Urban propagation.

Figure extracted from "3G Evolution HSPA and LTE for ..."

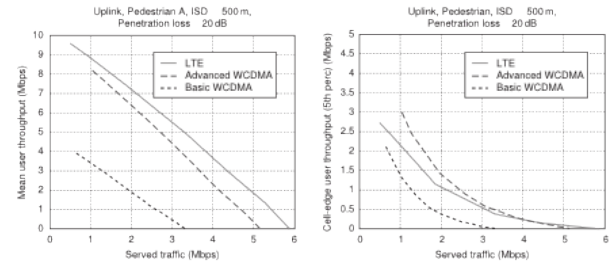
Downlink under pedestrian A propagation



Mean and cell-edge downlink user throughput vs. served traffic. Pedestrian A propagation.

Figure extracted from "3G Evolution HSPA and LTE for ..."

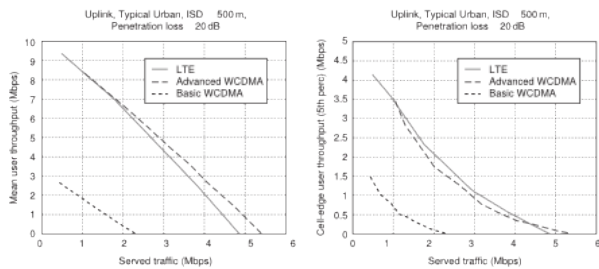
Uplink under pedestrian A propagation



Mean and cell-edge uplink user throughput vs. served traffic. Pedestrian A propagation.

Figure extracted from "3G Evolution HSPA and LTE for ..."

Uplink under typical urban propagation



Mean and cell-edge uplink user throughput vs. served traffic. Typical Urban propagation.

Figure extracted from "3G Evolution HSPA and LTE for ..."

LTE Spectrum Efficiency

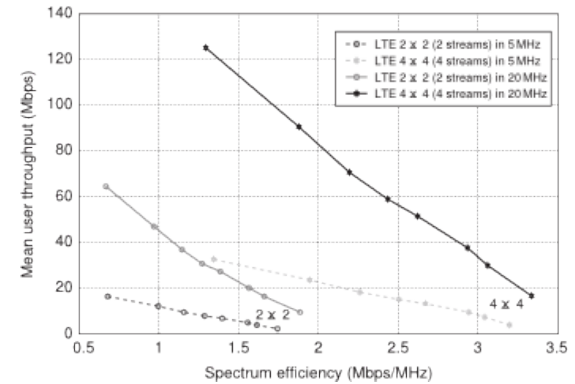


Figure extracted from "3G Evolution HSPA and LTE for ..."

Chapter summary



- There is no universal measurement for telecom systems
 - It can be seen from User perspective, Operator perspective, and more
- Performance measurements without comparison are meaningless
- From the simulations we see that LTE fulfills the target on user throughput and spectrum efficiency.
- A more advance WCDMA would result in simmlar performance than current LTE specification