HSPA+ and LTE Test Challenges for Multiformat UE Developers

Presented by: Jodi Zellmer, Agilent Technologies
Agenda

- Introduction
- FDD Technology Evolution
- Technology Overview
- Market Overview
- The Future for Multiformat UE Developers
- Conclusions
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HSPA+ and LTE: Living Together?

HSPA+ and LTE - exciting today

- Higher data throughput
- More applications

What about tomorrow?

HSPA+

LTE

HSPA
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3GPP Standards Evolution – FDD

- **Rel-99**
  - **W-CDMA**
  - DL: 384 kbps
  - UL: 384 kbps

- **Rel-5**
  - **HSDPA**
  - DL: 14.4 Mbps
  - UL: 384 kbps

- **Rel-6**
  - **HSUPA**
  - DL: 14.4 Mbps
  - UL: 5.8 Mbps

- **Rel-7**
  - **HSUPA+, MIMO**
  - DL: 28.8 Mbps
  - UL: 11 Mbps

- **Rel-8**
  - **DC-HSDPA**
  - DL: 42 Mbps
  - UL: 11 Mbps
  - LTE 2 x 2
  - 150 Mbps
  - 51 Mbps

- **Rel-9**
  - **DC+MIMO, DC-HSUPA**
  - DL: 84 Mbps
  - UL: 23 Mbps
  - LTE 4 x 4 MIMO
  - 303 Mbps
  - 86 Mbps

- **Rel-10**
  - **4C-HSDPA**
  - DL: 168 Mbps
  - UL: 23 Mbps
  - LTE-Advanced
  - 1.2 Gbps
  - 600 Mbps

- **Rel-11**
  - **HSPA+ Advanced**
  - DL: 336+ Mbps
  - UL: 46+ Mbps
  - LTE-Advanced
  - 1.2+ Gbps
  - 600+ Mbps
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HSPA and HSPA+ Overview

**WCDMA**
Wideband CDMA Rel-99
- DL 384 kbps
- UL 384 kbps

**HSPA**
High-speed packet access Rel-5 and Rel-6
- DL 14.4 Mbps
- UL 5.6 Mbps

**HSPA+**
Enhanced HSPA Rel-7
- DL 21 Mbps
- UL 11 Mbps

- HSDPA and HSUPA (DL and UL)
- 2 ms vs. 10 ms transmission times
- New DL modulation type: 16QAM
- UE Acknowledgements and CQI
- MAC real-time scheduling
- Flexible UL power grants

- New DL modulation type: 64QAM
- New UL modulation type: 16QAM
- DL flexible packet sizes
MIMO and Multi-Carrier Overview

MIMO
- Two DL data streams, 2 DL antennas
- Two UL antennas
- One 5 MHz channel

HSPA+ Rel-7
- Multiple input multiple output

Two to four carriers
- DC is two carriers
- Multiple 5 MHz channels
- DL and/or UL
- Multiple antennas not required

Technology | 3GPP | DL | UL |
--- | --- | --- | --- |
HSPA+ | R7 | 21 | |
MIMO | R7/8 | 42 | |
2C HSDPA | R9 | 42 | |
4C HSDPA | R10 | 84 | |
2C + MIMO | R9 | 84 | |
4C + MIMO | R10 | 168 | |
DC-HSUPA | R9 | 23 | |

HSPA+ Rel-7 to Rel-10
2 to 4 carriers

Mbps
HSPA+ Advanced: Overview

Five to eight carriers
- Up to 40 MHz aggregate bandwidth
- Downlink only
- Can be combined with MIMO

Multi-point transmission
- Data sent from multiple cells
- Requires multiple carriers
- UE must support Rx diversity
- Can be combined with MIMO

<table>
<thead>
<tr>
<th>Technology</th>
<th>3GPP</th>
<th>DL</th>
<th>UL</th>
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<tr>
<td>HSPA+ R7</td>
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<td>MIMO R7/8</td>
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<td>2C HSDPA R9</td>
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<td>4C HSDPA R10</td>
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<td>8C HSDPA R11</td>
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<td>8C + MIMO R11</td>
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<tr>
<td>DC-HSUPA R9</td>
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<td>23</td>
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</tr>
</tbody>
</table>

Mbps
**LTE Overview**

**Rel-8 and Rel-9**

**Long Term Evolution of UMTS**

- **RB** = 0.5 ms in 180 kHz

**DL OFDMA**

- **UL SC-FDMA**

**EPC is all-IP**

**Subcarriers**

- **MIMO**

**DL 100 to 303 Mbps**

- **UL 51 to 86 Mbps**

**EPC is all-IP**
**Enhanced MIMO**
- Up to 8x8 in the DL
- Up to 4x4 in the UL
- Multi-user MIMO (MU-MIMO)

**Carrier Aggregation**
- Component carriers (CCs)
- Use any existing bandwidth
- Up to 5 CCs in the DL and UL
- Can be combined with MIMO

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Strong Industry Support

FAST FACTS – January 5, 2012

Mobile broadband network deployments
- 424 commercial HSPA operators launched in 165 countries
- 304 networks support peak DL speed of at least 7.2 Mbps

HSPA+ is mainstream
- 211 HSPA+ network commitments; 152 HSPA+ networks launched
- GSA forecasts ~180 commercial HSPA+ networks by end 2011
- 49 commercial 42 Mbps DC-HSPA+ networks launched

LTE is the industry direction
- 285 operators investing in LTE; 49 commercial networks launched
- 226 network commitments in 76 countries + 59 pre-commitment trials

Mobile broadband business is profitable & growing
- Strong wireless data traffic and revenue growth with HSPA/HSPA+
systems consistently reported by operators around the world
- 822.4m WCDMA subs incl. 469m HSPA (2011), Informa Telecoms & Media

Global eco-system established
- Thousands of GSM user devices; unprecedented economies of scale
- Being repeated for HSPA
  - 3,227 devices launched (264 suppliers) - includes 182 HSPA+
- 62% devices support at least 7.2 Mbps peak DL
- 663 UMTS900 devices (supporting HSPA or HSPA+)
- 197 LTE user devices launched
  - includes 118 dual-mode HSPA/LTE devices

100% of WCDMA operators have launched HSPA

HSPA+ is mainstream

49 commercial LTE networks launched
- 45 = LTE FDD
- 3 = LTE TDD
- 1 = LTE FDD and TDD

GSA forecasts 119 commercial LTE networks by end 2012

197 LTE user devices launched
It’s All About Data Rates…Especially in the Downlink

<table>
<thead>
<tr>
<th>Bandwidth (MHz)</th>
<th>HSPA+</th>
<th>LTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 MHz</td>
<td>168 Mbps</td>
<td>172 Mbps</td>
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<tr>
<td>10 MHz</td>
<td>84 Mbps</td>
<td>73 Mbps</td>
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<td>5 MHz</td>
<td>42 Mbps</td>
<td>37 Mbps</td>
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</table>

Using 2x2 MIMO
LTE Wins - Later

Annual Handset Shipments by Technology

Source: Deutsche Bank, July 2011

- CDMA
- GSM
- WCDMA
- HSPA
- TD
- LTE
- WiMAX

Greater insight.
Greater confidence.

Accelerate next-generation wireless.
HSPA+ and LTE - Now

A wary truce?

Or a comfortable balance?

Either way, more challenges for wireless developers
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The Future for Device Developers

A successful multiple-technology device must balance cost and flexibility.

- **Cost**
  - Time to market
  - Consumer price

- **Flexibility**
  - Usage time
  - Inter-RAT
  - Voice quality
  - Faster data apps

Technologies:
- WCDMA
- WiFi
- GSM
- HSPA+
- LTE

Accelerate next-generation wireless.

Greater insight. Greater confidence.
So many tests, so little time…

Greater insight. Greater confidence.
Accelerate next-generation wireless.
Challenge: Data Throughput Validation
UE Functional and Performance Test

Graphical results are useful for observing throughput performance over time

But statistics are useful too, to observe the UE’s perceived channel quality

### DC-HSDPA Information

<table>
<thead>
<tr>
<th></th>
<th>Summary</th>
<th>Serving Cell</th>
<th>Secondary Serving Cell</th>
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</thead>
<tbody>
<tr>
<td>Block Error Ratio:</td>
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<td>0 %</td>
<td>0 %</td>
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<td>Throughput (kbps):</td>
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<td>Blocks Transmitted:</td>
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<td>ACKs Received:</td>
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<td>NACKs Received:</td>
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<td>Max Allowed CQI:</td>
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<td>Test Mode User Def TBS:</td>
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<td>PS Data User Def TBS:</td>
<td>7298</td>
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<tr>
<td>Last Sig Neas Pur Offs (dB):</td>
<td>6 1317011456</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Greater insight.
Greater confidence.

Accelerate next-generation wireless.
Challenge: Data Throughput Validation
Automated Test

Data rate decreases sharply for high cell power

Data rate drop-outs

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Challenge: Voice and Data Continuity Across Technologies

UE Design Validation - Inter-RAT Test

Many types of handovers defined between all technologies

LTE / 3G example
Challenge: Simultaneous UE Activities
UE Design Validation – Stress Test

- Failure caused by SMS buffer limitations in UE
- Failure caused by unique combination of activities
Challenges: Inter-RAT, Battery Drain, Inter-Operability
Operator Acceptance Test
Agilent: A Full Portfolio for the Wireless UE life-cycle

Fast, High-Performance Instruments

Results You Can Trust

8960 (E5515E)

Complete LTE R&D

New Power Unleashed for 2G / 3G / 3.5G R&D

EXT (E6607A)

Industry Benchmark for 2G/3G/3.5G

8960 (E5515C)

2G/3G/LTE DVT & RCT

PXT (E6621A)

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Next Generation Manufacturing

Anticipate — Accelerate — Achieve

Agilent Technologies

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Conclusions

Tomorrow: more mobile than fixed?

More LTE, still HSPA+

Optimal test efficiency

More data applications

Flexible
Repeatable
Reliable

TEST

Anticipate  Accelerate  Achieve

References

4G Mobile Broadband Evolution: 3GPP Release 10 and Beyond, February 2011, 4G Americas, [http://www.4gamericas.org/documents/4G%20Americas_3GPP_Rel-10_Beyond_2.1.11%20.pdf](http://www.4gamericas.org/documents/4G%20Americas_3GPP_Rel-10_Beyond_2.1.11%20.pdf)

Overview of 3GPP Release 10 V0.1.3 (2012-01), 3GPP, [http://www.3gpp.org/ftp/Information/WORK_PLAN/Description_Releases/Rel-10_description_20120124.zip](http://www.3gpp.org/ftp/Information/WORK_PLAN/Description_Releases/Rel-10_description_20120124.zip)

Overview of 3GPP Release 11 V0.0.9 (2012-01), 3GPP, [http://www.3gpp.org/ftp/Information/WORK_PLAN/Description_Releases/Rel-11_description_20120124.zip](http://www.3gpp.org/ftp/Information/WORK_PLAN/Description_Releases/Rel-11_description_20120124.zip)


Agilent Product References

E5515E (8960) and E6703H W-CDMA/HSPA lab application software with 42 Mbps DC-HSDPA throughput
www.agilent.com/find/e5515e
www.agilent.com/find/e6703h

E6621A PXT combined with 8960 for reliable inter-RAT handovers between all technologies
www.agilent.com/find/pxt

Interactive functional test (IFT) software for stress tests with simultaneous UE activities and operator acceptance tests
www.agilent.com/find/ift
Enabling Market Drivers – HSPA+ Advanced

Existing HSPA Network

LTE Spectrum

HSPA+ Advanced Network

More data

Less voice

Simple upgrades

Less battery drain

Greater insight.
Greater confidence.

Anticipate  Accelerate  Achieve

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Enabling Market Drivers – LTE-Advanced

Existing LTE Network

LTE-Advanced Network

Mobile performance like fixed Internet

Higher data rates

More user capacity

Greater insight.
Greater confidence.

Accelerate next-generation wireless.
Benefits and Goals from 3GPP

### HSPA+ (Rel-7, 8, 9, 10)

<table>
<thead>
<tr>
<th>Benefit</th>
<th>MC</th>
<th>MIMO</th>
<th>CPC</th>
<th>ECF</th>
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<tr>
<td>Improved spectral efficiency</td>
<td>X</td>
<td>X</td>
<td></td>
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</tr>
<tr>
<td>More capacity</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher data rates</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved user experience</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Improved battery life</td>
<td>X</td>
<td>X</td>
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</tbody>
</table>

### HSPA+ Advanced (Rel-11)

<table>
<thead>
<tr>
<th>Benefit</th>
<th>RxD</th>
<th>LB</th>
<th>MP</th>
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</thead>
<tbody>
<tr>
<td>Improved spectral efficiency</td>
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<td></td>
</tr>
<tr>
<td>More capacity when needed</td>
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<td>X</td>
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<tr>
<td>Enhanced user experience</td>
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<td></td>
<td>X</td>
</tr>
</tbody>
</table>

### LTE (Rel-8, 9)

- Competitive 3G system
- IP-only data traffic
- 4x increased spectral efficiency
- 10x users per cell
- DL / UL data rates: > 100 Mbps / 50 Mbps
- Latency comparable with fixed broadband Internet
- Interworking with other radio access systems
- Flexible frequency band allocations

### LTE-Advanced (Rel-10)

- Align with the requirements of IMT-Advanced
- Global functionality and roaming
- Interworking with other radio access systems
- Enhanced peak data rates: 100 Mbps for high mobility and 1 Gbps for low mobility

MC: Multi-carrier, CPC: Continuous Packet Connectivity, ECF: Enhanced CELL_FACH, RxD: 4 Receiver Diversity, LB: Load Balancing between NodeBs, MP: Multipoint transmission
Deployment Challenges

HSPA+ Advanced

- Continuous add-ons to improve existing technologies sometimes result in more complex technical implementation due to the need for backwards compatibility with existing network behavior
- Several improvements beyond HSPA are required before data rates comparable to LTE are achievable
- Existing backhaul can limit actual data rates

LTE-Advanced

- Capital to build new infrastructure
- Spectrum bundles > 10 MHz
- Learning curve for a new technology
- Interworking with existing technologies (i.e. inter-RAT handovers)
Market Predictions

HSPA+ and LTE

Past  Now  Future

HSPA+  LTE