Future Mobile Standardization

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Ongoing LTE Commercialization

- 351 Operators in 104 Countries are investing in LTE
- 105 LTE Commercial LTE Networks Launched in 48 Countries

[Source: GSA, Global Mobile Suppliers Alliance, 2012.10]
LTE: Fast Market Growth

- 100 LTE Commercial Launches within 3 years of the first launch
  - WCDMA took longer than 4 year for 100 commercial launches
- 100M LTE Subscribers within 3.3 year expected

[Source: DoCoMo, 2012.11]

[Source: Samsung, 4G World Key Note Speech, 2012.10]
Timely LTE devices for early market development

- 1st Pre-Commercial LTE Dongle (GT-B3710, for TeliaSonera, Dec 2009)
- 1st Commercial LTE Dongle (GT-B3730, for TeliaSonera, Jun 2010)
- 1st LTE Handset (SCH-R900, for Metro PCS, Sep 2010)
3GPP Technologies

- 3GPP has developed GSM, UMTS, HSPA and LTE standards
- WCDMA/HSPA is known as 3G, LTE/LTE-A is known as 4G mobile technologies
3GPP as the global standards body

- **3GPP is a Partnership Project**
  - 6 Regional standards organizations and 13 Market representing partners
  - 390 individual member companies from 39 countries

![Graph showing participation by region with Asia at 40%, EMEA at 41%, and Americas at 19% with June 2012 data]

![Image of 6 Organizational Partners and 13 Market Representative Partners]
3GPP Technology Roadmap

- 3GPP technologies are based on CDMA and OFDMA technologies
  - WCDMA and HDPA are based on CDMA
  - LTE is based on OFDMA
3GPP Core Network Evolution

- 3GPP Network has evolved from 4 tier architecture to 3 tier architecture
### 3GPP WCDMA/HSPA Evolution

- AMC and HARQ are the key technologies for HSDPA & HSUPA
- MIMO, 64 QAM and multi-carrier are the key technologies for HSPA & HSPA+

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<td>Rel-5</td>
<td>Rel-6</td>
<td>Rel-7</td>
<td>Rel-8</td>
<td>Rel-9</td>
<td>Rel-10</td>
<td>Rel-11</td>
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**Rel-99 WCDMA**
- DL: WCDMA (5MHz) 2Mbps
- UL: WCDMA 768 kbps

**Rel-5 HSDPA**
- DL: HSDPA AMC, HARQ 14 Mbps
- UL: NA 768 kbps

**Rel-4 WCDMA**
- DL: TD-SCDMA 2Mbps
- UL: TD-SCDMA 768 kbps

**Rel-6 HSDUA**
- DL: MBMS 14 Mbps
- UL: HSUPA HARQ, AMC 5.7Mbps

**Rel-7 HSPA**
- DL: 2x2 MIMO or 64 QAM 28 Mbps
- UL: 16 QAM 11.5 Mbps

**Rel-8 HSPA+**
- DL: 2x2 MIMO/64QAM or 2-carriers (10MHz) 42 Mbps
- UL: NA 11.5 Mbps

**Rel-9 HSPA+**
- DL: MIMO/64QAM/10MHz Dual band Dual-cell 84 Mbps
- UL: 2-carriers (10MHz) 23 Mbps

**Rel-10 HSPA+**
- DL: 4-Carriers (20MHz) 168 Mbps
- UL: NA 23 Mbps

**Rel-11 HSPA+**
- DL: 8-Carrier 336 Mbps
- UL: MIMO with 64QAM
# 3GPP LTE Evolution

- For Rel-8/9 LTE, OFDMA and 4x4 MIMO/64 QAM enables high peak data rate
- For Rel-10 LTE-A, 8x8 MIMO and Carrier Aggregation are the key technologies
- For Rel-11 LTE-A, CoMP improves cell capacity rather than peak data rate

<table>
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<th>Year</th>
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**Rel-8 LTE**
- DL: OFDMA, 20MHz
  - 4x4 MIMO, 64QAM
  - **300 Mbps**
- UL: SC-FDMA, 20MHz
  - 64QAM
  - **75 Mbps**

**Rel-9 LTE**
- DL: e-Dual Layer
  - 300 Mbps
- UL: NA
  - **75 Mbps**

**Rel-10 LTE-Advanced**
- DL: 8x8 MIMO, CA (100MHz), MU-MIMO, HetNet
  - **1 Gbps (3Gbps)**
- UL: 4x4 MIMO, CA (100 MHz)
  - **500 Mbps (1.5Gbps)**

**Rel-11 LTE-A**
- DL: CoMP, ePDCCH
  - Hetnet enhanc.
  - **1 Gbps (3Gbps)**
- UL: NA
  - **500 Mbps (1.5Gbps)**

CA: Carrier Aggregation, CoMP: Coordinated Multi-Point Operation
Direction of Evolution

- Peak data rate is not the main goal for the evolution

Directions of evolution: “The Cube”

A set of radio access technologies is required to satisfy future requirements

- Spectrum efficiency
- Traffic offloading
- Network density

Spectrum extension
- Efficient use of higher spectrum bands

Required Performance

[Source: DOCOMO, RWS-120010, 3GPP RAN Workshop, 2012.6]
Main Challenges for the Future

- User QoE decrease and operator cost increase due to mobile traffic growth
- Operator revenue growth slows

1. **QoE Decrease**
   - Users experience network congestions

2. **COST Increase**
   - CAPEX Increase
   - OPEX Increase

3. **Revenue decoupling**

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- **Terabytes per Month**
  - **Global Mobile Data Traffic, 2010 to 2015**
  - 92% CAGR 2010-2015
  - Source: Cisco VNI Mobile, 2011

- **Traffic volume**
  - **Voice dominated**
    - Data dominated
  - Source: Light Reading (adapted)

- **Increase Revenue**
- **Decrease Cost**

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[Graph showing network congestion and traffic volume over time]
Mobile Traffic

- Major contribution to Mobile Traffic is from Video contents
- OTT providers are consuming the mobile video

**Who is using this?**

2011 Global Mobile Data BW Usage
[Source: Allot Communication 2011]
3GPP RAN Workshop in June

- TSG-RAN WS on Release 12 Onward, June 11-12, 2012 in Ljubljana, Slovenia
  - 250 participants, 43 presentations
Potential Rel-12/13 RAN WI/SI

Rel-11 Enhancements (15)

- Small cells (7)
  - HetNet Mobility
  - HeNB Part 3
  - LIPA/SIPTO local
- Enhanced antenna techniques (5)
  - Enhanced COMP
  - Further Enhanced DL MIMO
  - 8 Rx Perf. Requirement for UL
- Small data transport enhancements (3)
  - eDDA enhance
  - Small data tx optimise (SI)
- Others (14)
  - New Carrier Type
  - Flexible TDD mode
  - eMBMS enhance
  - Coverage Enhance
  - Next Gen SON (SI)
  - MTC enhancements
  -增值服务
  - MDT enhance
  - MDT extension (SI)

New Technologies (15)

- Small cell requirements (Study Item)
- Small cell enh: L1 (SI)
- Small cell enh: higher layer (SI)
- UL CA enhancements
- 3D-channel model (SI)
- Elevation Beamforming (SI)
- Full-Dimension MIMO (SI)
- MTC enhancements
- D2D proximity discovery (SI)
- Enhanced rcv
- Further Enhanced rcvrs (SI)
- Enh Interference Suppression (SI)
- LTE+UMTS
  - UMTS/LTE Aggregate (SI)
  - LTE/UMTS Iwk (SI)
- 3GPP/WIFI integration (SI)
- Push To Talk (SI)
Three Categories Rel-12 & 13 Features

Enhanced Small Cell
- Frequency separation btw macro and small cells with higher freq. band, e.g. 3.5 GHz
- Inter site CA
- Enhanced discovery / mobility
- Interference management
- Dynamic TDD

Multi-antenna/site technologies
- Inter-eNB CoMP
- 3D channel model
- Vertical beamforming
- FD-MIMO
- Enhanced MU-MIMO

Energy efficient communication
- Diverse traffic type support
- Machine Type Comm
- New Carrier Type
- VoLTE enhancement
- MDT/SON enhancement

Rel-12 & 13 (LTE-Beyond 4G)
Key Features of Rel-12 & 13

- **2009**
  - Rel-8/9
  - LTE

- **2012**
  - Rel-10/11
  - LTE-Advanced (4G)

- **2015**
  - Rel-12/13
  - LTE-Future (?) (Beyond-4G)

### Key Features of Rel-12 & 13

- **20MHz, OFDM**
- **SC-FDMA**
- **DL 4x4 MIMO**
- **SON, HeNB**
- **Carrier aggregation**
- **UL 4x4 MIMO**
- **DL/UL COMP**
- **HetNet**

1. Small Cell Enhancement
2. CoMP enhancement
3. FD-MIMO
4. Diverse Traffic support
1. Small Cell Enhancement

- High frequency band (> 3GHz) targeted for small cell enhancement
- Inter eNB Carrier Aggregation is a key solution

<table>
<thead>
<tr>
<th>E-UTRA Band</th>
<th>UL (MHz)</th>
<th>DL (MHz)</th>
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<tr>
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<td>3510 – 3590</td>
<td>FDD</td>
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<td>42</td>
<td>3400 – 3600</td>
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<td>TDD</td>
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<tr>
<td>43</td>
<td>3600 – 3800</td>
<td>3600 – 3800</td>
<td>TDD</td>
</tr>
</tbody>
</table>

Issues in Small Cell Enhancement
- Overhead due to frequent cell change
- Inter-frequency mobility
- Power consumption due to cell discovery
- Need to consider non-ideal backhaul

Small cell in 3.5GHz
- Existing cellular band (coverage, mobility)
- High frequency band (> 3GHz) (high data rate, traffic offloading)

Macro-Pico Inter-eNB CA
- f1
- Macro eNB
- f2
- Pico eNB
- Data rate

Architecture for Macro-Pico
- MME
- S-GW
- Control
- Data
- Anchor to macro
- Big pipe from small cell
2. CoMP Enhancement

- CoMP enhancement for Inter-eNB CoMP with non-ideal backhaul
- Centralized Scheduler is the key feature to enable Inter-eNB CoMP

Rel-12

- Scenario 1: Intra-eNB CoMP in homogeneous deployment
- **Scenario 2:** Inter-eNB CoMP in homogeneous deployment
- **Scenario 3:** Inter-cell CoMP in heterogeneous deployment
- Scenario 4: Distributed antenna system with shared cell ID

Central Scheduler

CQI, SRS measurements, load info, etc..

RB allocation, SRS resource partition

Key Features of Rel-12 & 13
3. Full Dimension MIMO (1/2)

- Full Dimension MIMO (FD-MIMO) is a promising technology for Macro cell capacity improvement.

**Full Dimension MIMO with 2D AAS**

1) 2D Active Antenna Array (AAA) & up to 64* Tx antenna ports at eNB
2) MU-MIMO with 10s of UEs

* For 2.5GHz carrier frequency. More antenna ports possible for higher frequency.

**Macro capacity gain**

![Graph showing macro capacity gain with 2D AAS and FD-MIMO eNB](image)

- **Average throughput (b/s/Hz)**: x4.3, x4.49
- **5%-tile throughput (b/s/Hz)**: x6.9, x9.12

![Diagram showing transceiver array panel](image)

AAS: Active Antenna System
Full Dimension MIMO (FD-MIMO) is the next step of Vertical Beamforming.
Expected Performance gain from Rel-12 & 13

Key Features of Rel-12 & 13

- Spectrum Extension
- Capacity
- Network density
- Spectrum Efficiency

- Rel-8/9 LTE
- Rel-10/11 LTE-A
- Rel-12/13 (LTE-B4G)
- Over 6 GHz (?)

- Rel-14/15

Performance gains:
- x 3.53 (FD-MIMO)
- x 1.14 (MU-MIMO)
- x 4.33 (HetNet/CoMP)

- 2 GHz (100MHz)
- 800/900 MHz (70MHz)
- 1.8GHz (40MHz)
- 2.3/2.5 GHz (120 MHz)
- 3.5 GHz (200MHz)
- Over 6 GHz (?)
3GPP SA Workshop in December

- TSG-SA WS on Release 12 Prioritization, December 10, 2012 in Barcelona, Spain
  - 26 presentations are submitted
3GPP SA Workshop

- Key Features for Network Evolution will be indentified

**QoE Improvement**

**Cost Reduction / Revenue Increase**

**Improve for Delivery of Applications**
(Better understanding of application and network)

1. User Plane Congestion management (UPCON)

**Features for New Market Potential**
(New service enabler)

2. Machine Type and other mobile data applications Comm. Enhancements

**Increase Available Bandwidth**
(Better offloading / Reduce backhaul usage)

3. WLAN Network Selection for 3GPP Terminals

4. LIPA Mobility and SIPTO at the Local Network
3GPP SA Workshop

- QoE improvement by considering network status at application/service

- RAN congestion status notification to UE/AF
- RAN/PGW selects flows to be controlled
- Traffic Control by application/service based on the notification
A new NGMN Project for Network evolution

- Mobile Video Traffic Optimization is one of the most important projects in NGMN

NGMN Partner Forum

- NGMN TG1 Project Start
- Requirement draft
- White paper Draft
- Final Revision Deliverable

Proposal

2012.11 2013.01 2013.03 2013.06 2013.09 2013.12

<EPS Video Traffic Optimization>

QoE-guaranteed

Best Effort

QoE-aware Scheduling (e.g. deadline)

Free Contents

Premium Contents

<Video Delivery Protocol Enhancement>

Video Transport Protocol: DASH, MMT

Media Adaptation

RAN Info (bit rate, congestion info)

Device Info (Screen-size, Resolution)
Summary

- Many promising technologies have been identified in 3GPP
- Operator and consumer benefit should be carefully considered when new technologies are introduced for Beyond 4G