Capturing LTE opportunity

May 2011
IEEE ComSoc / IST: 19as. Palestras sobre Comunicações Móveis
Agenda

- Why LTE?
- Operator approaches
- Network evolution
- NSN approach
- Summary
Motivation for LTE
The CSP view

- Traffic volume
- Network cost (existing technologies)
- Revenue
- Profitability
- Network cost (LTE)
- LTE reduces the cost/Mb
- LTE improves user experience

Source: Light Reading (adapted)
Motivation for LTE
Customer view: better broadband experience

- Broadband everywhere
  - LTE on low frequency bands, e.g. digital dividend
- Capacity for all
  - LTE on large frequency bands, e.g. 2.6GHz

High-Speed Broadband
- 10-20ms latency
- 173 Mbps peak data rate
WHY LTE?

Superior mobile broadband user experience

Throughput

- GSM: <1 Mbit
- HSPA: >42 Mbit
- LTE: 100 Mbit
- GSM: 150
- HSPA: 50
- LTE: 10ms

Industry commitment behind the ecosystem

- > 380 million LTE subscribers by 2015
  Forecast for LTE lead markets by Research and Markets
- 55+ LTE networks expected to be in commercial operation by end 2012
- 113 LTE network operator commitments in 46 countries

Technology convergence

- GSM
- WCDMA
- CDMA
- WiMAX
- TD-SCDMA
- FDD LTE
- LTE
- Advanced
- TD-LTE

Extensive range of radio spectrum support

- 22 different FDD frequency band options
- 9 different TDD frequency band options

Single operator may deploy both FDD+TDD LTE for maximum utilization of spectrum assets

+ new ones still being specified both for new band deployment and re-farming cases
LTE allows to use spectrum most efficiently
Low frequencies for coverage; large bands for capacity

<table>
<thead>
<tr>
<th>Band</th>
<th>MHz</th>
<th>Uplinks MHz</th>
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<td>1850-1910</td>
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<td>TDD</td>
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<td>1x194</td>
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<td>2496-2690</td>
<td>TDD</td>
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</tbody>
</table>

LTE is the best option for new spectrum
Agenda

Why LTE?

Operator approaches

Network evolution

NSN approach

Summary
What drives some of the early LTE-adopters?

Necessity to join the largest ecosystem: global standard of 3GPP

CDMA WiMAX TD-SCDMA → LTE

New spectrum allocations for more competitive broadband strategy

Immediate need for further mobile broadband capacity

traffic time

4G 3G 4G

Verizon, metroPCS, CLEAR, Yota, China Mobile

LightSquared, TeliaSonera, O2, T-Mobile, at&t, NTT Docomo

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Frequency band vs. early LTE market demand

- Currently, all commercial mobile LTE devices are multimode (GSM/WCDMA and/or CDMA)
- Initial LTE deployments in 9 FDD bands and 2 TDD bands
- Device availability driven by market demand per use case, early operators are driving devices which include the LTE bands needed for the operator’s specific spectrum assets
<table>
<thead>
<tr>
<th>Devices for diverse service use cases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Maximum mobility mobile broadband</strong></td>
</tr>
<tr>
<td>• Internet experience on-the-move with high capacity throughput</td>
</tr>
<tr>
<td>• Coverage expected everywhere</td>
</tr>
<tr>
<td>• Laptops and tablets connected with USB-sticks, data cards, mobile hotspots or phones as modems</td>
</tr>
<tr>
<td>• LTE + 3G multimode devices</td>
</tr>
<tr>
<td><strong>2. Home and city level mobile BB “hotzone”</strong></td>
</tr>
<tr>
<td>• Needs to match today’s home Internet experience or exceed it</td>
</tr>
<tr>
<td>• Coverage and mobility needs less demanding as in number 1</td>
</tr>
<tr>
<td>• Home use case especially relevant for rural/suburban</td>
</tr>
<tr>
<td>• May include also operator branded VoIP</td>
</tr>
<tr>
<td>• Can use single mode LTE devices</td>
</tr>
<tr>
<td><strong>3. Handsets and smart phones</strong></td>
</tr>
<tr>
<td>• Voice is critical</td>
</tr>
<tr>
<td>• Internet experience becoming more important day-by-day (drives adding LTE)</td>
</tr>
<tr>
<td>• Coverage, mobility and service quality expected everywhere</td>
</tr>
<tr>
<td>• International and national roaming</td>
</tr>
<tr>
<td>• LTE + 3G/2G multimode devices</td>
</tr>
<tr>
<td><strong>4. Consumer electronics</strong></td>
</tr>
<tr>
<td>• Paradigm shift: focus on application specific service, not on data subscription (e.g. Kindle)</td>
</tr>
<tr>
<td>• Depending on device type different mobility requirements</td>
</tr>
<tr>
<td>• Wide variety of devices, but still emerging (e.g. e-book readers, game consoles, navigators, cameras)</td>
</tr>
<tr>
<td><strong>5. Machine-to-machine</strong></td>
</tr>
<tr>
<td>• Wide range of services for different industry verticals</td>
</tr>
<tr>
<td>• Depending on M2M use case different mobility requirements (e.g. fixed wireless surveillance cameras, transport logistics)</td>
</tr>
<tr>
<td>• Most major operators are active in M2M and LTE opens new opportunities</td>
</tr>
</tbody>
</table>
Early LTE service offering

1. Maximum mobility mobile broadband
   - LTE will typically start from this domain
   - Better end-user experience in LTE coverage areas + nomadic mobility to 3G/2G

2. Home and city level mobile BB "hotzone"
   - Specifically in rural and suburban areas
   - LTE could become a true alternative for wireline Internet

3. Handsets and smart phones
   - Primarily CDMA-operators will drive early high-end "velcro" smartphones with LTE data (HSPA+ competition with higher peak rate phones)
   - LTE VoIP + mass market later in the pipeline

4. Consumer electronics
   - Lots of potential in this space
   - A number of non-technical issues need to be addressed

5. Machine-to-machine
   - Lots of potential in this space
   - A number of non-technical issues need to be addressed

German digital dividend auction winners
Agenda

Why LTE?

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Summary
LTE / SAE* is specified for efficient mobile broadband

**Improved Radio Principles**
- Peak data rates [Mbps] 173 DL, 58 UL
- Scalable bandwidth: 1.4, 3, 5, 10, 15, 20 MHz
- Short latency: 10 – 20 ms
- 90% commonalities for LTE-FDD and TD-LTE

**RF Modulation**
- OFDMA in DL
- SC-FDMA in UL

**Flat All-IP architecture**
- 2-node architecture
- IP routable transport architecture

* SAE = System Architecture Evolution
## Initial LTE Terminal Categories

<table>
<thead>
<tr>
<th>Class 1</th>
<th>Class 2</th>
<th>Class 3</th>
<th>Class 4</th>
<th>Class 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peakrate DL/UL</td>
<td>10/5 Mbps</td>
<td>50/25 Mbps</td>
<td>100/50 Mbps</td>
<td>150/50 Mbps</td>
</tr>
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<td>RF Bandwidth</td>
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<td>20 MHz</td>
<td>20 MHz</td>
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<tr>
<td>Modulation DL</td>
<td>64 QAM</td>
<td>64 QAM</td>
<td>64 QAM</td>
<td>64 QAM</td>
</tr>
<tr>
<td>Modulation UL</td>
<td>16 QAM</td>
<td>16 QAM</td>
<td>16 QAM</td>
<td>16 QAM</td>
</tr>
<tr>
<td>Rx diversity</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>MIMO DL</td>
<td>optional</td>
<td>2 x 2</td>
<td>2 x 2</td>
<td>2 x 2</td>
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</table>
Evolution paths to LTE
3GPP operator examples

- **Potentially skip HSPA+, Early LTE**
  - TeliaSonera, DoCoMo
  - Progression: 2G → WCDMA/HSPA → HSPA+ → LTE

- **First HSPA+, then LTE**
  - AT&T, USA, Elisa, Finland
  - Progression: 2G → WCDMA/HSPA → HSPA+ → LTE

- **Aggressive HSPA+**
  - T-Mobile, USA, Softbank, Japan
  - Progression: 2G → WCDMA/HSPA → HSPA+ → DC-HSPA → LTE
Evolution paths to LTE
3GPP2 operator examples

- **Continue EVDO, Aggressive LTE plan**
  - CDMA
  - EV-DO
  - EV-DO eHRPD
  - Verizon, USA
  - LG U+, South-Korea

- **Continue CDMA, Aggressive HSPA+**
  - CDMA
  - EV-DO
  - HSPA / HSPA+
  - Bell & Telus, Canada

- **Continue EVDO, Aggressive WiMAX**
  - CDMA
  - EV-DO
  - WiMAX
  - Sprint/Clearwire, USA
Evolution paths to LTE
TD-LTE specific operator examples

**Evolve TD-SCDMA path**
- China Mobile
  - 2G → TD/SCDMA → TD-LTE

**First HSPA, then TD-LTE**
- India – most of BWA Spectrum holders
  - (single-carrier WCDMA/HSPA, plus TD-LTE)
  - 2G → WCDMA/HSPA → TD-LTE

**TD-LTE greenfield**
- Reliance Industries (India)
  - → TD-LTE
Flat LTE Architecture

- Direct evolution from Direct Tunnel usage
- Transmission delay time can be shortened by reducing the number of relay nodes
- Introduction of new services such as VoIP (real-time) etc.

**HSPA R6**
- GGSN
- SGSN
- RNC
- Node-B

**HSPA R7**
- GGSN
- SGSN
- RNC
- Node-B

**I-HSPA R7**
- GGSN
- SGSN
- Node-B

**LTE R8**
- S/P-GW / GGSN
- MME/SGSN
- eNode-B

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* = control plane

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Smooth LTE-introduction 10 step “check list”

1. Device capabilities
   - network support should be aligned with device LTE capabilities

2. Radio Access
   - New band deployment vs. refarming
   - antenna plant arrangements (including 2*2 MIMO)
   - Synchronization reference

3. Mobile transport
   - Transport data scalability, SLAs
   - Ethernet for every LTE BTS cell site
   - Network topology changes (X2-links between BTS-sites)
   - LTE traffic security (esp. BTS-sites)

4. EPC
   - Need for 4D scalability
   - Location of MME, SGW, PGW
   - 2G/3G/4G Packet Core evolution
   - Scalable Internet connectivity
   - IP address scalability

5. E2E interworking (device, radio, core)
   - LTE-WCDMA/HSPA
   - LTE-GSM
   - LTE-CDMA2000
   - LTE-WiMAX

6. OSS-domain
   - SON capabilities
   - E2E-mgmt (e.g. QoS, customer experience)

7. Subscriber management
   - LTE subscriber profiles
   - USIM cards, EIR, roaming

8. Charging
   - LTE charging and billing

9. PCRF
   - LTE policy control

10. SMS, Voice
    - SMS-support
    - Voice options

Confidential
<table>
<thead>
<tr>
<th>Agenda Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Why LTE?</td>
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<tr>
<td>Operator approaches</td>
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<td>Network evolution</td>
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<tr>
<td>NSN approach</td>
</tr>
<tr>
<td>Summary</td>
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</tbody>
</table>
Nokia Siemens Networks
We drive the commercialization of LTE

- First to ship LTE-capable, commercial base stations (Sept. 2008)
- Shipments to more than 200 operators worldwide

The LTE era has started with Nokia Siemens Networks.
### World’s 1st
- **LTE demo 160Mbps Nov.2006**
- **SON Plug and Play**

### World’s 1st
- **LTE call**
- **LTE handover**
- **LTE voice + SMS**
- **100Mbps class3 call**

### World’s 1st
- **On commercial hardware and software**
- **Compliant with commercial standards baseline (March 2009)**
- **Working together with leading device vendors**

### World’s 1st
- **Pre-LTE**
- **Unique flat architecture for HSPA+**
- **15+ references**

### World’s 1st
- **Leader in direct tunnel**
- **90+ projects**
- **50+ live**

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**Nokia Siemens Networks**

**We drive the commercialization of LTE with a unique holistic approach**

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**IEEE ComSoc / IST: 19as. Palestras sobre Comunicações Móveis**
Nokia Siemens Networks
We ensure e2e interoperability with our unique holistic approach

1/2010
Record data speed 100Mbps

11/2009
End-to-end interoperability tested

11/2009
Industry first chipset

10/2009
Testing with 4 vendors

9/2009
LTE call on March 2009 baseline
Nokia Siemens Networks Flexi Multiradio BTS
Best LTE user-experience most efficiently delivered

Winner: Best Technology Advance 2009

Winner 2009: Green Network Hardware and Infrastructure

Juniper Research
Gold Award Winner 2010: Green Infrastructure

Excellent performance in commercial LTE network

- Software Defined Radio (same modules for all technologies)
- Smallest & most compact BTS
- Highest energy-efficiency
- Weatherproof outdoor & indoor
- All-IP – all integrated, incl. wirespeed IPSec
Nokia Siemens Networks Flexi NS and Flexi NG
Best LTE user-experience most efficiently delivered

Flexi NG
- GGSN & S/P-GW
- Highest efficiency with 4D scaling
  - Leading throughput: 360 Gbit/s
  - Leading session density: 21.6M
  - Leading signaling capacity: 108k trs/s
- Leading service intelligence

Flexi NS
- SGSN & MME
- Evolution of field proven SGSN
- Leading signaling capacity: 22 k trs/s

Simultaneous 2G/3G/LTE operation
- ATCA based platforms

Leading in all LTE relevant criteria

“EPC product platform will need to scale control-plane capacity, and specially that the transaction rate (i.e. signaling capacity) of the platform will be the key to system performance”

Heavy Reading (11/2009) on Evolved Packet Core

In commercial LTE network
Nokia Siemens Networks - leading the LTE market with 37 commercial LTE customers

- TeliaSonera
  - Finland
- TELIA
  - Sweden
- telenor
  - Denmark
- TELE2
  - Sweden
- elisa
  - Estonia
- verizon wireless
  - USA
- LightSquared
  - USA
- Deutsche Telekom
  - Germany
- TeliaSonera
  - Denmark
- emt
  - Estonia
- SK telecom
  - South Korea
- USA
  - IMS/SDM
- USA
  - Saudi Arabia
- O2
  - Spain
- Telefonica
  - Italy
- Telecom Italia
  - Italy
- LG U+
  - South Korea
- SK telecom
  - South Korea
- LG U+
  - South Korea
- NTT Docomo
  - Japan
- KDDI
  - Japan
- Saudi Arabia
  - Zain
- Bahrain
  - Zain
- Japan

- 30 LTE radio deals
- 18 LTE EPC deals
- 9 commercially launched LTE Networks
Nokia Siemens Networks’ unique position in LTE

Unique efficient delivery of best customer experience

Unique track record in LTE world’s firsts, commercial deals and live networks

Unique global end-to-end approach

Smart

Holistic

Proven

LTE by Nokia Siemens Networks
Agenda

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Summary

- Strong market momentum around mobile broadband
- Mobile broadband is a growing business for operators
- Planning and implementing seamless 2G/3G/4G evolution is vital
- LTE timing depends on spectrum licences, competition and targeted end-user offering
- NSN is well positioned mobile broadband and LTE e2e solution provider and partner for operators with a proven track record