Technologies for Broadband Wireless

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Content

- Main Wireless Technologies
  - CDMA, HSPA, LTE
  - WiMAX and WiFi

- Selecting the right technology
  - Frequency
  - Coverage and Capacity
  - Low Cost Infrastructure
Main Wireless Technologies

Cellular Access
- 3GPP / 3GPP2
- GSM/GPRS/EDGE
- UMTS / HSPA/HSPA+
- CDMA 20001xEvDO RevA, RevB
- UMTS –TDD, TD-SCDMA
- LTE

Wireless Access
- IEEE Standards
  - WiFi (IEEE 802.11 a,b,g,n)
  - WiMAX (IEEE 802.16 d,e)
- Short range
  - Flash OFDM (Flarion)
  - WiBro (South Korea)
  - iBurst (ArrayComm)

Broadcasting
- DVB-H, DVB-SH
- T-DMB, S-DMB
- Media Flo

Short range
- UWB
- RFID
- Bluetooth
Worldwide Cellular Market

- **3G/3G+ statistics:**
  - 287 Million UMTS/HSPA subscribers (4Q 2008, source: GSA [www.gsacom.com](http://www.gsacom.com))
  - 112 Million CDMA 2000 1xEVDO subscribers (4Q 2008, source: CDG [www.cdg.org](http://www.cdg.org))
CDMA 2000 1xEVDO RevA

- **3GPP2** standard
- Evolution of CDMA2000 1xRTT
- Can evolve to multicarrier EvDO or EVDO RevB
- Deployed in 800/1900MHz and in 450MHz
- 1.25MHz bandwidth

<table>
<thead>
<tr>
<th>IS-95 B CDMA One</th>
<th>CDMA 2000 1xRTT</th>
<th>CDMA 2000 1xEV-DO Rel. 0</th>
<th>CDMA 2000 1xEV-DO Rev. A</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Peak Data Rate</strong></td>
<td>153.6 (307) kbps</td>
<td><strong>UpLink:</strong> 153.6 kbps</td>
<td><strong>UL:</strong> 1.8 Mbps</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>DownLink:</strong> 2.4 Mbps</td>
<td><strong>DL:</strong> 3.1 Mbps</td>
</tr>
<tr>
<td><strong>Typical Data Rate</strong></td>
<td>60-100 kbps</td>
<td><strong>UL:</strong> 70-90 kbps</td>
<td><strong>UL:</strong> 300-400 kbps</td>
</tr>
<tr>
<td>(source cdg.org)</td>
<td></td>
<td><strong>DL:</strong> 300-700 kbps</td>
<td><strong>DL:</strong> 450-800 kbps</td>
</tr>
</tbody>
</table>
CDMA 2000 1xEVDO RevA

April 2009 (Source: CDG [www.cdg.org]):

- Networks:
  - 106 1xEvDO Rel0 commercial networks and 40 in deployment 538 1xEvDO Rel0 devices
  - 62 1xEvDO RevA commercial networks (16 CDMA 450) and 37 in deployment (18 CDMA 450)
  - 16 1xEvDO RevA CDMA 450 commercial networks and 18 in deployment

- Devices:
  - 118 1xEvDO RevA devices
  - 13 1xEVDO RevA CDMA 450 devices
HSPA: HSDPA/HSUPA

- 3GPP standard (Release 5 and 6)
- Evolution of UMTS W-CDMA
  - Usage of Adaptive Modulation & Coding, H-ARQ, Fast Scheduling, 2ms/10ms Transmission Time Interval
- Can evolve to HSPA+
- Deployed in 2100 and 850/900MHz
- 5MHz bandwidth, can support voice and data on the same carrier

<table>
<thead>
<tr>
<th>Peak Data Rate</th>
<th>UL: 128/384 kbps</th>
<th>UL: 1.4/2/5.7 Mbps</th>
<th>UL: up to 11.5 Mbps</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DL: 1.8/3.6/7.2/10.8 (14.4) Mbps</td>
<td>DL: up to 43 Mbps</td>
<td></td>
</tr>
</tbody>
</table>
Higher Order Modulation and MIMO significantly increase the theoretical peak rates

Only provide data rate benefits for users in very good channel conditions (e.g. users in line of sight conditions with good C/I)

**HSPA+**

**Peak data rates achievable in Perfect RF Conditions**

- **HSUPA (BPSK)**
  - Uplink: 5.7 Mbps
- **HSDPA (16 QAM)**
  - Downlink: 14.4 Mbps
- **HSPA+ (64 QAM)**
  - Downlink: 28.8 Mbps
- **HSPA+ (16 QAM & 2x2 MIMO)**
  - Downlink: 43 Mbps
HSPA

- April 2009 (Source: 3G Americas www.3gamericas.org and GSA www.gsacom.com):
  - Networks:
    - 262 HSDPA commercial networks and 54 planned or in deployment
    - 77 HSUPA commercial networks and 92 planned or in deployment
    - 2 HSPA+ commercial networks and 19 commitments
    - 8 UMTS 900 commercial networks
  - Devices:
    - 1409 HSDPA devices
    - 242 HSUPA devices
    - 115 UMTS 900 HSPA devices
LTE

- Long Term Evolution (LTE) is 3GPP Evolution (Release 8)
- Based on OFDM (Orthogonal Frequency Division Multiplexing) and MIMO (Multiple Input Multiple Output) techniques
- To be deployed in various bands (700MHz, 900MHz, 2.1GHz, 2.6GHz)
- FDD and TDD mode
- Scaleable bandwidth: 1.4, 3, 5, 10, 15, 20MHz
- All IP network, simplified architecture (eNodeB and e Packet Core)
- Voice is offered through VoIP
- Evolution to LTE-Advanced already forecast (candidate for ITU IMT-Advanced solution)
LTE

- April 2009 (Source: GSA [www.gsacom.com](http://www.gsacom.com)):
  - 31 network operators have committed to LTE deployment
  - Service launch expected for 2010

- 3GPP2 CDMA operators committed to LTE
### LTE

- **Peak Data Rates:**

<table>
<thead>
<tr>
<th>Bandwidth</th>
<th>1.4MHz</th>
<th>3MHz</th>
<th>5MHz</th>
<th>10MHz</th>
<th>15MHz</th>
<th>20MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Uplink (16QAM)</strong></td>
<td>2.9Mbps</td>
<td>6.9Mbps</td>
<td><strong>11.5 Mbps</strong></td>
<td>27.6Mbps</td>
<td>41.5Mbps</td>
<td>55Mbps</td>
</tr>
<tr>
<td><strong>Downlink (64QAM, MIMO 2x2)</strong></td>
<td>10.4Mbps</td>
<td>26Mbps</td>
<td><strong>43 Mbps</strong></td>
<td>86Mbps</td>
<td>130Mbps</td>
<td>173Mbps</td>
</tr>
<tr>
<td><strong>Downlink (64QAM, MIMO 4x2)</strong></td>
<td>19.6Mbps</td>
<td>49 Mbps</td>
<td>81Mbps</td>
<td>163Mbps</td>
<td>245Mbps</td>
<td>326Mbps</td>
</tr>
</tbody>
</table>

In line with HSPA+ peak data rates
WiMAX

- IEEE 802.16d (fixed) and 16e (mobile)
- Based on **OFDM** (Orthogonal Frequency Division Multiplexing) and **MIMO** (Multiple Input Multiple Output) techniques
- Currently deployed in 2.3, 2.5, 3.5GHz
- **FDD** and **TDD** mode
- **All IP** network, simplified architecture
- Voice is offered through **VoIP**
- Evolution to 802.16m under standardization (candidate for ITU IMT-Advanced)
- April 2009 (source: WiMAX Forum [www.wimaxforum.org](http://www.wimaxforum.org))
  - 455 network deployments in 135 countries
## WiMAX vs 3GPP

<table>
<thead>
<tr>
<th></th>
<th>EDGE</th>
<th>HSPA</th>
<th>WiMAX</th>
<th>LTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market Maturity</td>
<td>😃</td>
<td>😃</td>
<td>😒</td>
<td>😒</td>
</tr>
<tr>
<td>VoIP support</td>
<td>😒</td>
<td>😖</td>
<td>😃</td>
<td>😃</td>
</tr>
<tr>
<td>Mobility</td>
<td>😃</td>
<td>😃</td>
<td>😒</td>
<td>😃</td>
</tr>
<tr>
<td>User data rate</td>
<td>😒</td>
<td>😃</td>
<td>😃</td>
<td>😃</td>
</tr>
<tr>
<td>Coverage</td>
<td>😃</td>
<td>😃</td>
<td>😒</td>
<td>😃</td>
</tr>
<tr>
<td>Capacity</td>
<td>😒</td>
<td>😃</td>
<td>😃</td>
<td>😃</td>
</tr>
</tbody>
</table>
WiFi

- **IEEE 802.11 standards**
- Deployed in **2.4 GHz and 5 GHz non licensed bands**
- **Wireless Local Area Networks:**
  - Low coverage, hotspots
  - Nomadism
- Peak rate: 11 to 54Mbps
- WiFi mesh networks
Choice of the right technology

- The choice of the best technology depends on various factors:
  - **Spectrum** (frequency, bandwidth, cost of licence) available
  - **Terminal** and equipment availability
  - **Services** to be offered (contents, data rates, VoIP, mobility)
  - Required **coverage and traffic** to be supported
  - Market share (**economy of scale**) and **maturity** of the technology
  - Possible **evolutions** and **upgrades** of the technology
  - **Interoperability** with existing technology
  - Network **architecture** and **backhauling** solution
  - Total Cost of Ownership (**CAPEX, OPEX**)
### Frequency

Available bands according to technology:

<table>
<thead>
<tr>
<th>Technology</th>
<th>Channel bandwidth (MHz)</th>
<th>450</th>
<th>700</th>
<th>800/900</th>
<th>1800/1900</th>
<th>2100</th>
<th>2600</th>
<th>3500</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDGE</td>
<td>0.2</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HSPA</td>
<td>5</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CDMA2000 1x EvDO</td>
<td>1.25</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WiMAX</td>
<td>(1.25)/3.5/5/7/10/(20)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>LTE</td>
<td>1.4/3/5/10/15/20</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
Coverage

- Link budget analysis enable to assess the **cell range** of the different systems according to their own receiver performances and the frequency used for deployment
- The coverage is extremely related to the **frequency**
  - The higher frequency,
  - The lower cell range,
  - The higher number of sites
- WiMAX is unfavoured by its high frequency (2.5, 3.5GHz)
  - Working to expand to 700MHz
- The coverage can be enhanced by using outdoor CPEs or antenna techniques (Receive Diversity, Adaptive Antennas)
  - Benefits to be assessed by CAPEX analysis
- The coverage analysis must be linked with a capacity analysis
The capacity analysis must be performed according to each deployment scenario and marketing objectives:

- Density of subscribers
- Voice/Data traffic demand: voice or data centric
- Data rate offer: 128kbps, 256kbps, 512kbps, >1Mbps

Some trends:

- CDMA 450 will be more suitable for low density rural areas with low data rate offer (coverage-limited scenarios)
- EDGE/HSPA/CDMA EvDO are suitable for medium cases and when mobility is required
- WiMAX and LTE will be more suitable for high data-oriented DSL like offers (capacity-limited scenarios)
Low cost infrastructure

- Trends of the infrastructure supplier industry:
  - Propose solutions to reduce CAPEX and OPEX
    - Coverage/Capacity enhancement solutions to reduce the required number of sites
      - Antenna techniques
      - AMR low rates for Voice, VoIP
      - Outdoor CPEs
    - Propose solutions adapted to low cost deployment
      - Reduce the power consumption
      - Solar equipment
      - Multi-technology, software upgrade and Software Defined Radio (SDR) equipment
  - Simplify network architecture and go for flat IP
Conclusion

- Various technologies are available to offer broadband wireless: EDGE, WiFi, CDMA2000 1xEVDO, HSPA, WiMAX

- LTE is coming based on the same technology than WiMAX (OFDM and MIMO)

- The choice of the right technology depends on various factors such as the available frequency, the market scale of the technology, its performances compared to the coverage and the traffic needs
Thank you!

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