POMI 2010
Emergence of Mobile Internet & Enabling Technologies
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Intel’s Vision of Mobile Internet

Technology For Mobile Internet Connectivity

Transparent Affordable Internet Access Wherever* You Are

Wi-Fi + WiMAX = Mobile Internet

*WiMAX connectivity requires a WiMAX enabled device and subscription to a WiMAX broadband service. Availability of WiMAX is limited, check with your carrier for details on availability.
What is the killer application?*

Anything Internet Can Provide & More

* Third party brands and trademarks may be claimed as the property of others.
Key Ingredients for Mobile Internet Success

- True & affordable flat-rate charging
- Ubiquitous Connectivity
- Rational Roaming Charges
- Device Retail Model
- True Internet not Mini-Internets
- Open and PC-like Mobile Devices
### Users Desire “Mobile PC” Internet Experience

**Not a Mobile Phone Internet Experience**

The majority of churners generally leave after the first use of mobile data.

<table>
<thead>
<tr>
<th>Length of trial before churn</th>
<th>Percent of total mobile data churners**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Once</td>
<td>45</td>
</tr>
<tr>
<td>&lt;1 week</td>
<td>15</td>
</tr>
<tr>
<td>1-3 weeks</td>
<td>8</td>
</tr>
<tr>
<td>1 month</td>
<td>12</td>
</tr>
<tr>
<td>2-3 months</td>
<td>5</td>
</tr>
<tr>
<td>&gt;3 months</td>
<td>14</td>
</tr>
</tbody>
</table>

How can we better get users past the initial trial “hump”?

The main reason for churn was that their PC already met their needs.

<table>
<thead>
<tr>
<th>Reasons for churn</th>
<th>Percent churners in strong agreement**</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC met needs</td>
<td>61</td>
</tr>
<tr>
<td>Too expensive</td>
<td>58</td>
</tr>
<tr>
<td>No interest in content</td>
<td>38</td>
</tr>
<tr>
<td>Typing difficulty</td>
<td>33</td>
</tr>
<tr>
<td>Navigation difficulty</td>
<td>28</td>
</tr>
<tr>
<td>Slow speeds</td>
<td>26</td>
</tr>
<tr>
<td>Screen size</td>
<td>25</td>
</tr>
<tr>
<td>Ambiguous pricing</td>
<td>24</td>
</tr>
<tr>
<td>Difficult search</td>
<td>23</td>
</tr>
</tbody>
</table>

* North American consumer mobile subscribers

** Percent answering “top 2 box”

4G Devices - Intel View

- It’s not about phones
- Smaller PCs will be the primary access device
- A whole new class of Mobile Internet Devices (MIDs)
  - Small form factor
  - Good battery life
  - Mass market affordability
  - PC-like application processing power (service transparency)
  - Full-fledged Microsoft/MAC/Linux OS support (application transparency)
  - Always on experience
- Opportunity for Internet enabled consumer electronics (cameras, VoIP phones, portable music players, etc.)
Mobile Broadband Evolving to OFDM/MIMO + All-IP

Cellular (3GPP)
- 1G Analog
- 2G TDMA
- 3G CDMA
- LTE

Broadband Wireless (WiMAX)
- 802.16d
- 802.16e
- 802.16m

Wireless LAN (Wi-Fi)
- 802.11a/b/g
- 802.11n

OFDMA + MIMO
All-IP Core Network
## WiMAX Scales for Future Mobile Internet

Traffic Demands

<table>
<thead>
<tr>
<th>Technology</th>
<th>Peak Data Rate (Shared)*</th>
<th>Spectrum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Downlink</td>
<td>Uplink</td>
</tr>
<tr>
<td>1X-EVDO Rev B (hw upgrade) 10 MHz</td>
<td>14.7 Mbps</td>
<td>5.4 Mbps</td>
</tr>
<tr>
<td>HSPA (3GPP Release 7) 10 MHz</td>
<td>14 Mbps</td>
<td>5.8 Mbps</td>
</tr>
<tr>
<td>WiFi (802.11a/b/g) 20 MHz</td>
<td>54 Mbps</td>
<td></td>
</tr>
<tr>
<td>WiFi (802.11n, 3x3 40 MHz)</td>
<td>450 Mbps</td>
<td></td>
</tr>
<tr>
<td>Mobile WiMAX Release 1.0 (2x2 MIMO) 10 MHZ</td>
<td>72 Mbps</td>
<td></td>
</tr>
<tr>
<td>Mobile WiMAX Release 2.0 (4x4 MIMO) 20 MHZ</td>
<td>As much as 300 Mbps**</td>
<td></td>
</tr>
</tbody>
</table>

*Peak data rates are theoretical and assume zero path loss – similar to “100 Mbps Ethernet.” Data rates are calculated directly from the indicated air interface specification.

**IEEE 802.16m Systems Requirements Document sets 300 Mbps as the minimum peak data rate for the given configuration. Intel estimates rates could reach 400 Mbps.

**Rule of thumb: the actual capacity (Mbps per channel per sector) in a multi-cell environment for wireless technologies is ~ 20-30% of the peak theoretical data rate.
Backward Compatibility

- Definition: Ways to make new and legacy technologies share radio and/or core network resources

- Backward compatibility at air-interface level:
  - Allows new RAN to co-exists with the old one at the same frequency channel

- Backward compatibility at core network level:
  - Allows new RAN to share the same core network elements (e.g. gateways) with the legacy RAN
Evolution of Air-Interface Technologies

LTE is not an evolution of any 3GPP air-interface technology
The Good Old GSM
GPRS/EDGE has air-interface backward comparability with GSM
But requires a new packet core
3G has no air-interface backward comparability with 2G but UTRAN can interwork with legacy packet and circuit cores
LTE has no air-interface backward comparability with 2G/3G and requires a whole new evolved packet core (EPC).

Source: 3GPP TS 23.401/402
WiMAX Network Architecture

Simple flat all-IP network
ASN Functional Decomposition

ASN Control Functions

ASN GW
- PMIP Client
- AAA Client
- Authenticator
- Service Flow Authenticator
- Location Register
- Idle-Mode & Paging Control
- DHCP Proxy/Relay
- Security Key Distributor

Data Path Function/FA

BS
- Service Flow Management
- Security Key Receiver
- Base Station
- RRC
- Authentication Relay
- Handover Function

ASN Data-Path Functions
LTE and WiMAX interworking with legacy 2G/3G systems identically using the new evolved packet core (EPC)
<table>
<thead>
<tr>
<th></th>
<th>Air-interface backward compatibility</th>
<th>Core network backward compatibility</th>
<th>Interworking with legacy systems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2.5G (GPRS/EDGE)</strong></td>
<td>With GSM</td>
<td>Requires new packet core</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>3G (WCDMA, HSPA)</strong></td>
<td>None with GSM</td>
<td>Reuses 2G/2.5G core networks</td>
<td>Done via legacy 2G/2.5G core</td>
</tr>
<tr>
<td><strong>E-UTRAN (LTE)</strong></td>
<td>None with 2G or 3G</td>
<td>Requires new evolved packet core (EPC)</td>
<td>Possible via EPC</td>
</tr>
<tr>
<td><strong>WiMAX</strong></td>
<td>None with 2G or 3G</td>
<td>Requires new evolved packet core (EPC)</td>
<td>Possible via EPC</td>
</tr>
</tbody>
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WiMAX + Wi-Fi for Mobile Internet

- **Wi-Fi** -> best solution for local area connectivity
  - With up to 450 Mbps throughput, MIMO-enabled 802.11n enables new local area applications
  - Wi-Fi hotspots easy to find in most places

- **Mobile WiMAX** -> metropolitan-wide broadband coverage
  - Offers service providers 3x the latest HSPA (3G) capacity today*
  - Potential to scale to over 20x the capacity of today’s HSPA via more antennas over time**

** IEEE 802.16m System Requirements Document.
Flatter Network Architecture

LTE/EPC

SGi
S4
S3
S1-MME
PCRF
S7
S6a
HSS
S10
UE
GERAN
UTRAN
SGSN
MME
“LTE-Uu”
S1-U
S1-MME
S3
S4
S11
S10
S6a
S5
S7
Sg

LTE
-EPC
MME
S1-U
Operator’s IP Services (e.g. IMS, PSS etc.)

WiMAX

MS
BS
ASN
AAA
R1
R6
R3-AAA
R3-MIP
HA
(Optional)
Internet & Operator Service

Telecom vs. Internet Network Architecture

* SAE/LTE diagram source: 3GPP
** WiMAX diagram source: WiMAX Forum Network Spec Release 1.0.
LTE/SAE User Plane and Data Flow -> Identical to 3G Legacy

Many Layers, Proprietary Protocols

WiMAX User Plane and Data Flow

Simple. Few protocols. Easy-to-implement. All IETF protocols. Few device requirements

* LTE/SAE diagram source: 3GPP
** WiMAX diagram source: WiMAX Forum Network Spec Release 1.0.
**Beyond Access Opportunity**

- **Old Model: Walled Garden**
  - Advantage: complete control for the operator
  - Disadvantage: few applications, no leveraging of creative Internet application

- **Broadband Model: Open Internet (Dumb Pipe)**
  - Advantage: access to all applications over the internet
  - Disadvantage: operator revenues limited to access

- **Mobile WiMAX Model: Smart Pipe (Internet+)**
  - Mobile operators partner with content and application providers to deliver enhanced mobile services
  - Advantage: user transparent quality access to Internet applications, opportunity for shared revenue on contents
  - Win-Win!
Walled Garden Service Approach (IMS)

Source: 3GPP TS 23.002

Highly complex infrastructure
Internet+ Model

Mobile WiMAX Operator
- Large subscriber base
- Real-time knowledge of user’s presence
- Location
- Billing relationship
- Device Capability
- Control of data pipe

Internet Application Provider
- Unlimited application media
- Only major source of data traffic
- Substantial & phenomenal growth
- Control of data content

Win-Win for Mobile WiMAX operator and Internet application provider
WiMAX Universal Service Interface (USI)

- SP provides information and capability to be used for value added Internet services (e.g. QoS, location based service)
- iASP & WiMAX operator share revenue
- Simple Internet-friendly interfaces
Closing Statements

- Mobile Internet is driving the need for mobile broadband
- Mobile broadband solutions all have the same ingredients (OFDMA/MIMO, all-IP networks). Following physics law, they will have similar performance
- Emerging mobile broadband technologies require all new packet core network and the legacy networks are not reusable
- There is no backward compatibility of emerging mobile broadband air-interfaces with legacy (2G/3G) air-interfaces
- Identical interworking is possible with the legacy 2G/3G systems regardless of the mobile broadband technology of choice
- Available today, WiMAX/WiFi offer a cost-effective solution for enabling ubiquitous mobile Internet that can interwork with legacy 2G/3G systems
Thanks for listening...