ITU-T Workshop on Bridging the Standardization Gap and Interactive Training Session
(Cyberjaya, Malaysia, 29 June – 1 July 2010)

Business Experience in Implementation of WiMAX

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- IMT-Advanced Standardization
- Mobile WiMAX
  - Introduction of Mobile WiMAX
  - Deployment Issues
- Summary
IMT-Advanced Standardization
Mobile Data Explosion

Source: Cisco Visual Networking Index

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Evolution Path in Standardization toward IMT-Advanced

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- LTE: Long Term Evolution
- UMB: Ultra Mobile Broadband

1G: AMPS
2G: GSM
3G: CDMA, GSM, WCDMA, HSDPA/HSUPA, CDMA2000/Ev-DV/DO
3G Ev.: CDMA2000/CDMA2100, WiBro/M-WiMAX
LTE: WiBro/M-WiMAX
UMB: WiBro/M-WiMAX, IEEE 802.16m
LTE-A: IEEE 802.16m, IEEE 802.16n
802.11 VHT: IEEE 802.11 VHT

- LTE: Long Term Evolution
- UMB: Ultra Mobile Broadband
IMT-Advanced

- Official name of 4G defined by ITU-R SG5 WP8F [TG8/1('85)→WP8F('00)→WP5D('08)]

- Key features
  - Worldwide commonality
  - Service compatibility
  - Interworking capability
  - High-quality mobile service
  - Worldwide usability of user equipment
  - User-friendly applications, services and equipment
  - Worldwide roaming capability
  - Enhanced peak data rates

- Candidate RIT
  - 3GPP LTE-Advanced, IEEE 802.16m
IMT-Advanced Standardization Schedule

Steps in radio interface development process:

- **Step 1**: Issuance of the circular letter
- **Step 2**: Development of candidate RITs and SRITs
- **Step 3**: Reception of the RIT and SRIT submissions and acknowledgement of receipt
- **Step 4**: Evaluation of candidate RITs and SRITs by evaluation groups
- **Step 5**: Review and coordination of outside evaluation activities
- **Step 6**: Review to assess compliance with minimum requirements
- **Step 7**: Consideration of evaluation results, consensus building and decision
- **Step 8**: Development of radio interface Recommendation(s)

Critical milestones in radio interface development process:

- (0): Issue an invitation to propose RITs
- (1): ITU proposed cut off for submission of candidate RIT proposals
- (2): Cut off for evaluation report to ITU
- (3): WP 5D decides framework and key characteristics of IMT-Advanced RITs and SRITs
- (4): WP 5D completes development of radio interface specification Recommendations

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Spectrum Identification for IMT at WRC

No distinction of IMT-2000 & IMT-Advanced in the use of frequency
IMT-Advanced Standardization Progress

- Issuance of Circular Letter (2008. 2)
- Minimum requirements (2008. 6)
- Technology Description Template : ITU-R Report M.2133
- Compliance Template : ITU-R Report M.2134
- Evaluation guideline : ITU-R Report M.2135
- WP5D 6th meeting(2009. 10)
- Six IMT-Advanced Candidate Proposals submission

<table>
<thead>
<tr>
<th>Candidate Proposals</th>
<th>Proponent</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEEE 802.16m</td>
<td>IEEE</td>
<td>IEEE 802.16m (TDD/FDD)</td>
</tr>
<tr>
<td></td>
<td>Japan</td>
<td>IEEE Technology excluding IPR</td>
</tr>
<tr>
<td></td>
<td>Korea</td>
<td>IEEE Technology excluding IPR</td>
</tr>
<tr>
<td>LTE-Advanced</td>
<td>3GPP (39 members)</td>
<td>LTE Release10&amp;Beyond (TDD/FDD)</td>
</tr>
<tr>
<td></td>
<td>Japan</td>
<td>LTE Release10&amp;Beyond (TDD/FDD)</td>
</tr>
<tr>
<td></td>
<td>China</td>
<td>LTE Release10&amp;Beyond (TDD)</td>
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</table>

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## Preliminary Evaluation Reports
### WP5D 7th meeting (2010. 2)

- Candidate technologies **satisfy the minimum requirements** of ITU-R IMT-ADV

<table>
<thead>
<tr>
<th>Evaluation Groups</th>
<th>(Submission)</th>
<th>3GPP LTE-Advanced</th>
<th>IEEE 802.16m</th>
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<tr>
<td></td>
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<td>FDD</td>
<td>TDD</td>
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<tr>
<td>1. ARIB(Japan)</td>
<td>○</td>
<td>X</td>
<td>X</td>
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<tr>
<td>2. ATIS(USA)</td>
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<td></td>
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<tr>
<td>3. CEG(Canada)</td>
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<td>○</td>
<td>□</td>
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<tr>
<td>4. CEN(China)</td>
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<tr>
<td>5. RFEG(Russia)</td>
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<td></td>
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<tr>
<td>6. TDOE(India)</td>
<td>□</td>
<td>○</td>
<td>□</td>
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<tr>
<td>7. TR-45(USA)</td>
<td>□</td>
<td>○</td>
<td>□</td>
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<tr>
<td>8. TTA R767(Korea)</td>
<td>□</td>
<td>○</td>
<td>□</td>
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<tr>
<td>9. WCAI(USA)</td>
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<td></td>
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<tr>
<td>10. WFEG(WiMAX)</td>
<td>□</td>
<td></td>
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<tr>
<td>11. WINNER+(EU)</td>
<td>□</td>
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<tr>
<td>12. Argentina</td>
<td></td>
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<tr>
<td>13. Israel</td>
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<tr>
<td>14. FTTS(IU)</td>
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</tbody>
</table>

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Mobile WiMAX
Introduction
**Key features of M-WiMAX**

<table>
<thead>
<tr>
<th>Scalability</th>
<th>Scalable PHY for flexible channel bandwidth as global RF band allocation vary. Flexible Frequency re-use schemes for network planning.</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Data Rate</td>
<td>Larger MAC frames with low overhead, Adaptive Modulation, Advanced FEC, H-ARQ, Beamforming(AAS), Space-Time Transmit Diversity, MIMO</td>
</tr>
<tr>
<td>Mobility</td>
<td>Secure Handover, Optimized Hard Handover, Multicast, Broadcast, Paging, Power Management with Sleep and Idle Modes</td>
</tr>
<tr>
<td>Security</td>
<td>EAP authentication, Encryption with AES-CCM, CMAC Authentication, X.509 Certificates, Key Binding, Mutual Authentication, Device and User Authentication</td>
</tr>
</tbody>
</table>
Mobile WiMAX Deployment Issues
KT WiBro (Mobile WiMAX) Commercial Service Stage

Partial Commercial Service
- Shinchon
- Songpa
- Seocho
- Gangnam
- Bundang

Commercial Launch (June, 2006)

Full Commercial Service
- Seoul

Expansion (May, 2008)

Coverage Expansion
- Incheon
- Daegu
- Ulsan
- Busan
- Daejeon
- Gwangju

Network Upgrade (By end of year 2010)

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Operator’s General Requirements

- RFP consists of traffic assumption, price, training plan, system feature list, network architecture, O&M requirement, optimization, etc.

Operator’s requirements:
- Service plan
- Service contents
- Quality of service
## Coverage

**Maximum coverage based on IEEE 802.16e**

<table>
<thead>
<tr>
<th>BW (MHz)</th>
<th>3.5</th>
<th>5</th>
<th>10</th>
<th>8.75</th>
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<tbody>
<tr>
<td>Effective symbols</td>
<td>33</td>
<td>47</td>
<td>47</td>
<td>42</td>
</tr>
<tr>
<td>Unallocated Frame Duration (TTG+RTG)</td>
<td>248.0</td>
<td>165.7</td>
<td>165.7</td>
<td>161.6</td>
</tr>
<tr>
<td>RTG (μs)</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>74.4</td>
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<tr>
<td>TTG (μs)</td>
<td>188</td>
<td>105.71</td>
<td>105.71</td>
<td>87.20</td>
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<tr>
<td>RTD (μs) = TTG – SSRTG</td>
<td>138.0</td>
<td>55.7</td>
<td>55.7</td>
<td>37.2</td>
</tr>
<tr>
<td>Maximum Range (km)</td>
<td>20.7</td>
<td>8.36</td>
<td>8.36</td>
<td>5.58</td>
</tr>
</tbody>
</table>

*RTD: round trip delay BS to MS, TTG: Tx to Rx transition gap at BS, RTG: Rx to Tx transition gap at BS*

*SSRTG: mobile station receive to transmit transition gap*

**KT coverage criteria**

- Minimum supportable TP per user: 512kbps(DL), 128kbps(UL)
- RSSI ≥ -75dBm
- CINR ≥ 5dB

**KT BS coverage in Seoul: 300 ~ 400 m**
- About 500 BSs excluding subway BS in Seoul
Coverage: Link budget

Link budget
- An assessment of the losses and gains that occur on a link between transmitter and receiver
- To predict cell coverage

Link budget analysis process
- MAPL(dB) = Tx_EIRP – Rx_sensitivity + sum of (gains & losses)
  - Tx_EIRP: Max Tx power per traffic channel + Tx ant. gain – cable loss
  - Rx_sensitivity: Required minimum received signal power at Rx

* MAPL : Maximum Allowable Path Loss
Coverage? Remote RF Unit

Repeater Solution

BS + RARi

MHU

Coxial Cable (Analog IF)

Optic cable (Digital IF)

RRF Solution

BS Baseband

Optic cable (Base Band I/Q)

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Coverage? Indoor Solution

Indoor Repeater solution

Mobile WiMAX Femtocell, Picocell and Microcell solution

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Fast Link Adaptation

- Adaptive Modulation on a burst by burst basis
  - Each subscriber operates at the data rate corresponding to its link quality

- MCS table: MCS level transition criterion
- Outer loop power control: efficiency improvement at user throughput
Handover Process

- Handover in M-WiMAX: Hard handover
- Handover Process
  - Cell reselection
    - Receiving neighbor BS information (MOB_NBR-ADV)
    - Scanning neighbor BSs
  - HO decision & Initiation
    - Handover decision from Serving BS to Target BS
  - Synchronization to Target BS Downlink
  - Ranging
    - Handover RNG processing for synchronization to target BS uplink
    - Handover optimization process
  - Termination of MS context in serving BS
- Inter-sector, Inter-BS, Inter-ACR Handover
Performance Evaluation

Simulation components

- Link Level Model
- System Level Model
- Propagation and Channel Model
- Traffic Model
- Antenna Pattern

Simulation

- Simulation Framework
- Simulation Methodology
- Simulation Procedure

Evaluation Criteria

- Fairness Criterion
- Performance Metrics

Simulation Results and Evaluation Report
Performance Evaluation

Link level simulation

To probe the characteristics of a point-to-point link

Result

- Link performance curves (as a function of received SNR)

- Link-level simulation results for AWGN channel

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Performance Evaluation
System level simulation

- To evaluate the overall performance of a whole system
- Result: System throughput
- Snap time simulation ⇔ Full motion simulation

SINR distribution (MIMO)

Average system throughput

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Summary

IMT-Advanced standards establishment
- Scheduled to be early 2011 through the expert evaluation process
- 2 Candidate RITs: LTE-Advanced, IEEE 802.16m
- Now evaluation stage
  - Candidate RITs satisfy the minimum requirements

Mobile WiMAX
- Flat architecture due to All-IP services
- Deployment issues
  - Coverage
  - Fast link adaptation
  - Handover
  - Performance evaluation
Thank You

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Q & A