

# IMT Advanced Technical Requirements -- An India Perspective

Centre of Excellence in Wireless Technology ( **CEWiT** )

*Presented by:* **K. Giridhar, CEWiT & IIT Madras**

Prepared along with Members of the Broadband Wireless Consortium of India ( **BWCI** )

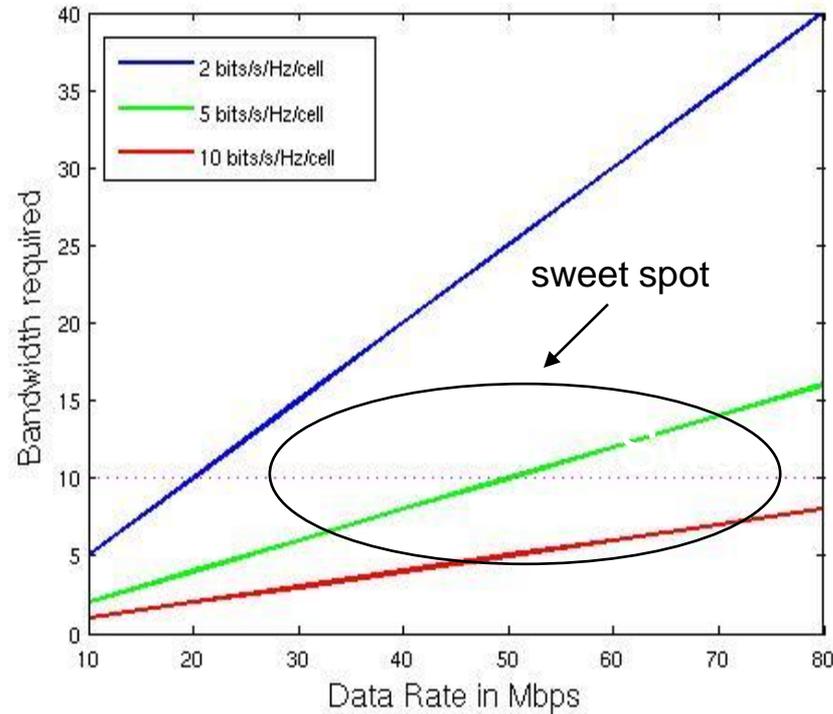
# User Requirements – Indian Perspective

- Based on the unified views expressed by the various cellular operators of India
  - Broadband Wireless Consortium of India (**BWCI**)
  - A strategic initiative of Centre of Excellence in Wireless Technology (**CEWiT**)
- BWCI has enunciated the service and technology requirements for India which IMT-A should address
  - please also see <http://www.cewit.org.in/docms/ibwsi.pdf>
- Requirements reflect the fact that wireless access will be the *only* way by which broadband can reach **100million+** Indian users!

## Indian Scenario – contd.

- Serve about 900 subscribers/cell/per operator that covers different market segments
- Cell radius varying between 100m and 20 Km
- Provide broadband services with limited spectrum *per* operator
  - FDD 10+10=20MHz per operator
  - TDD with 20MHz per operator (with sync between operators)
- Nearly 85% of the subscribers will be nomadic and indoors
- Need a minimum *useful* capacity per cell (per operator) of about 100 Mbps DL, and 40 Mbps UL

# Usage and Capacity



Example: With a FDD bandwidth of 10+10 MHz, spectral efficiency required is:

DL  $\rightarrow 100/10 = 10$  bits/sec/Hz/cell

UL  $\rightarrow 40/10 = 4$  bits/sec/Hz/cell

} Avg.  $\sim 7$  to  $8$  bits/sec/Hz/cell

# What should LTE-A / IMT-A Provide?

- 802.16e and LTE are expected to provide 2.5-3.0 bits/sec/Hz/cell
- Increasing this to 7-8 and eventually to 10 bits/sec/Hz/cell will be a major challenge !
- LTE-A should address this challenge while ensuring a highly power efficient, cost-effective, ubiquitous, broadband access
- LTE-A will create new technologies, services, and applications
- Focus on → PHY & MAC, and Network Architecture

# New Technologies for LTE-A

- New Preamble design
- Efficient pilot allocation
  - Especially for multiple-antenna modes
- Enable robust, low bit-rate links
  - This is very useful for UL → using diversity-spaced SC-FDMA schemes
- Enable “interference free” estimation of
  - Signal & channel parameters
  - Location

# New Technologies – contd. 1

- Methods for inter-cell interference management
  - Co-operative radio resource management & scheduling
  - Base-station co-operation on UL and DL
- UE Relaying and Femto Cells
  - Virtual MIMO techniques
  - Network coding

And all these at very low cost – ARPU of \$5 to \$7!

## IMT Advanced Technical Requirements -- An India Perspective

# Additional Details

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# Market segmentation and user density

- Dense Urban (Case: Mumbai)
  - 70% of 16M people  
In area of 600 sq Km  
~3733 households per sq km  
Assuming 5 per household  
~ 50% wireless internet subscribers  
~ 1866 wireless internet/sq km
  - cell radius = 0.75 km  
~ 3300 subscribers/cell
  - Assuming 5 competitive operators  
in each area  
=> 660 subscribers/operator/cell
- Urban (Case: Pune)
  - 70% of 4.2M people  
In area of 400 sq Km  
~1470 households per sq km  
Assuming 5 per household  
~ 60% wireless internet subscribers  
~ 882 wireless internet/sq km
  - cell radius = 1 km  
~ 2800 subscribers/cell
  - Assuming 5 competitive operators  
in each area  
=> ~560 subscribers/operator/cell

Technology must have sufficient coverage (up to 3 km) within regulatory constraints without capacity loss— else, subscribers/cell will need to be adjusted.

# Market segmentation and user density

- Suburban

- ~400 households per sq km
- ~ 70% wireless internet subscribers
- ~ 280 wireless internet/sq km
- cell radius = 1-3 km (use 2 km)
- ~ 3516 subscribers/cell

Assuming 5 competitive operators  
in each area  
=> ~700  
subscribers/operator/cell

- Rural

- 600000 villages
- cell radius ~ 15 km => 150 villages
- each village has ~ 5 households who would take internet and ~5 public access/kiosks
- ~ 1500 subscribers/cell
  
- 2 or 3 operators
- ~500-750 subscribers/operator/cell
- Capacity may reduce with this coverage, but this may be okay in rural context

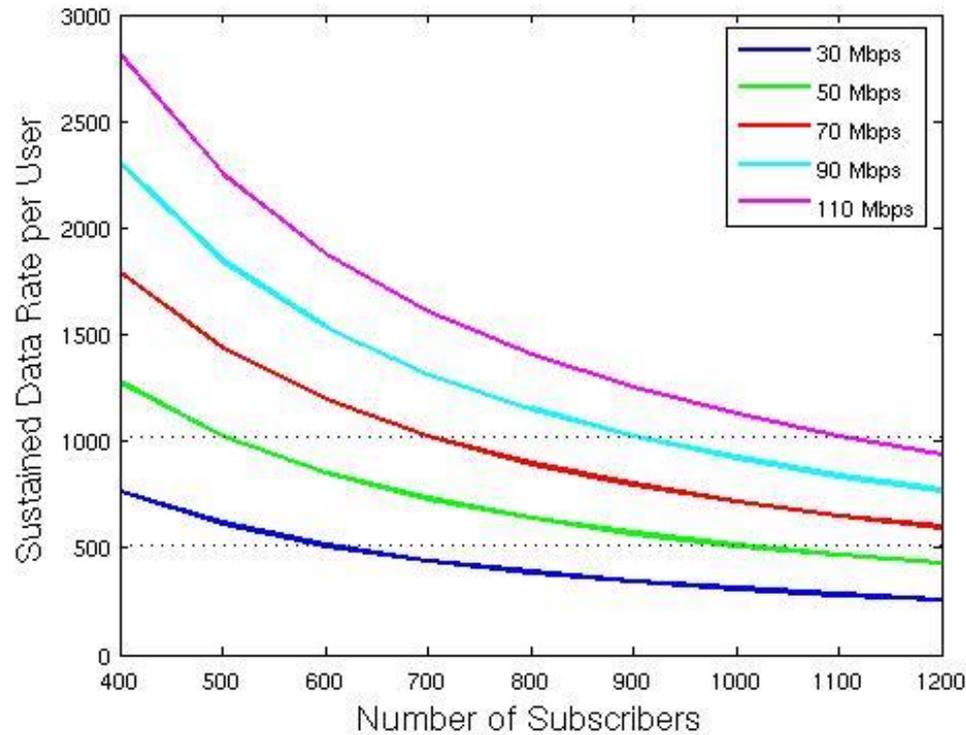
# Usage and Capacity

- One usage model in a cell for an operator:
  - About 33% of the subscribers are assumed to be connected
  - Any connected subscriber is assumed to be active (sending or receiving data at a sustained rate) for about 33% of the time
  - The above translates to about 10% of the subscribers being connected and active at any time

# Usage and Capacity

- What is the sustained (average) throughput an operator with fixed capacity can provide?
- How many subscribers can an operator with fixed capacity support?
- How much spectrum does an operator need?

# Usage and Capacity



- At 30 Mbps, 600 subscribers/cell can be supported at sustained rate of 512 Kbps
- For 400 subscribers/cell, sustained rate ~ 1Mbps requires support for 40 Mbps

# Usage and Capacity

Application specific usage model: 900 subscribers/cell

| Application and Average Rate                             | % (No.) of Customers | Bit-rate (Up link)              | Bit-rate (Down link)            |
|--|----------------------|---------------------------------|---------------------------------|
| Internet Browsing @ 64 kbps DL / 16 kbps UL (avg. rates) | 50% (450)            | 450 X 16 kbps $\approx$ 7 Mbps  | 450 X 64 kbps $\approx$ 28 Mbps |
| Computing / Thin client @ 512 kbps DL / 256 kbps UL      | 10% (90)             | 90 X 256 kbps $\approx$ 22 Mbps | 90 X 512 kbps $\approx$ 45 Mbps |
| File transfer/Conferencing uploads @ 256 kbps            | 5% (45)              | 45 X 256 kbps $\approx$ 11 Mbps | Negligible                      |
| Trickle @ 30 kbps (e.g., radio)                          | 33% (300)            | Negligible                      | 300 X 30 kbps $\approx$ 9 Mbps  |
| Multicast video streaming @ 1Mbps DL                     | N/A                  | Negligible                      | N X 1 Mbps = N Mbps             |
| TOTAL bit-rate   | $\sim$ 900           | 40 Mbps                         | (82 + N) Mbps                   |

- Therefore, a technology with 1/1 reuse in every sector, and a spectral efficiency of 5 bits/s/Hz requires a TDD bandwidth of 10 MHz to serve the customers

# Broadband Services

- Basic: Internet access – browsing, email, MMS, Voice over IP
- Value-added services
  - VPN
  - Multi-media applications, Video streaming, Audio streaming
  - Video Broadcast (Mobile TV)
  - Games
  - Video phone, Video conferencing
  - Video mail
- Added advantage of mobility and easy portability
  - Commuters spend significant time on travel everyday!

# Throughput Requirements

- Current broadband offerings - 256 Kbps to 2 Mbps per user
  - Peak rates, not necessarily sustained
- Sustained throughput of 512 Kbps per user
  - Likely to become baseline offering
- Video streaming requires sustained rates 1 – 1.5 Mbps

# Performance Requirements

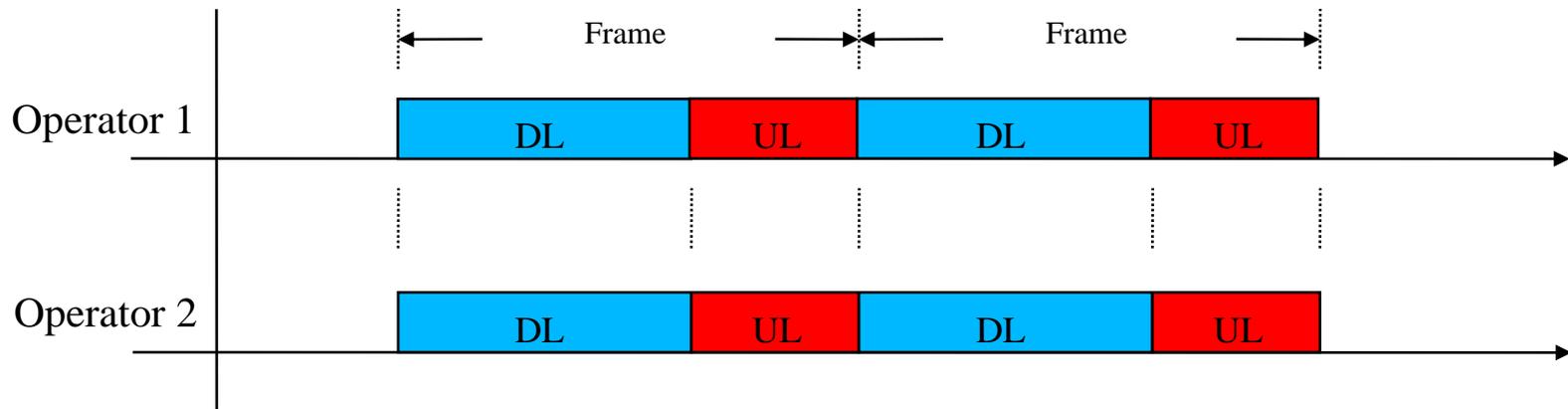
- Ability to provide sustained throughput
  - In low SNR and high interference conditions, different terrains
- Operate with low power
  - human safety and interference considerations, and battery life
- Improved spectral efficiency: More customers with less bandwidth
- Ability to provide wider and deeper coverage
- Ability to scale transmit power to address different market segments
- Seamless mobility handling (handovers)
  - preferably across multiple standards

# Feature Requirements

- High quality voice support is essential
- Backward compatibility to be ensured while evolving to LTE-A
- Ability to provide multiple services on the same access (Triple play)
- Products must have interoperability
- QoS and security features are very important
- Self-Install
- Lawful intercept facility must be provided for societal security

# Requirements of TDD standards

- TDD frames of all operators must be time synchronized (eg. via GPS etc.)
  - Avoids receiver saturation when bands of two operators are adjacent
  - TDD UL and DL frames must also be of same length and synchronized
  - Applies even if the operators use different TDD access technologies
  - Standards should have flexibility in
    - Frame duration with, say, 1 msec step
    - uplink/downlink ratio say, from 1:1 to 1:4



# Requirements on bands specified for emerging FDD standards

- FDD Systems -
  - When specifying FDD bands in new standards for a common application, preferable that bands for U/L and D/L directions across standards are harmonized
    - Keep all uplink bands together and downlink bands together – this eases deployment.
    - Where U/L and D/L bands of different standards are adjacent, mitigation methods such as filters, minimum site spacing, etc need to be implemented

# Technology Upgrade in existing Band of Operation (TDD)

- TDD Systems – Technology Upgrade
  - An operator licensed in a particular band should be enabled to evolve to a different technology (standard) in the same band
    - Flexible frame duration, uplink/downlink durations, and synchronization support required in the new standard
    - Same or lower out-of-band emission spectral density in the new standard
    - Same or lower in-band EIRP in the new standard

# Technology Upgrade in existing Band of Operation (FDD)

## FDD Systems – Technology Upgrade

- An operator licensed in a particular band should be enabled to evolve to a new technology (standard) in the same band
  - The new standard should have U/L and D/L band definitions in harmony with the old standards operating in the band and adjacent bands to the extent possible
  - Same or lower out-of-band emission spectral density should be achieved in the new standard as in the older ones.
  - Same or lower in-band EIRP should be defined in the new standard
- In case of existing U/L and D/L bands of different standards are adjacent, mitigation methods such as filters, minimum site spacing will be needed.

# For 3GPP RAN consideration

- LTE Advanced is expected to meet the following requirements
  - LTE-A should be able to scale *transmit power/link budget* to provide wider and deeper coverage to address different market segments.
  - LTE-A should support smaller cell sizes with radius as small as 100m, and should be able to provide consistent throughput in such high interference conditions.
  - LTE-A should support larger cell sizes with radius as high as 20 Km, or even more, and should be able to provide consistent throughput in low SNR (SINR) conditions.
  - LTE-A systems should have good indoor penetration.
  - LTE-A shall enable a graceful degradation in case of load and disaster conditions, and the network shall have enough re-configurability to allow continuous service when some of the eNBs become inoperative.

# For 3GPP RAN consideration

- LTE-A should be able to operate with low power for human safety and interference considerations, and long battery life.
- LTE-A should be able to offer a sustained throughput of 512 Kbps for at least 10% of the subscribers at any given time in diverse deployment scenarios without requirement for line-of-sight – in different terrains and foliage / built-up scenarios, and in different weather conditions.
  - LTE-A systems shall provide in TDD deployment, 140 Mbps (100 Mbps on DL + 40 Mbps on UL) per cell-site on a 10 MHz bandwidth.
- LTE-A should support seamless mobility handling (handovers), preferably across multiple standards / access technologies (fixed-mobile convergence).
  - One handheld for multiple standards (multi-mode) would be an attractive feature.

# For 3GPP RAN consideration

- Need for LTE-A to be such that service providers can upgrade seamlessly to the new technology in the bands that they are currently licensed, in a manner dictated by the growing market.
- In order to be deployed in new and existing TDD spectrum, LTE-A systems should
  - support flexible frame duration, with say, 1 ms step.
  - support uplink/downlink ratio, with say 1:1 to 1:4.
  - be time synchronized.
  - have same, or lower out-of-band emission spectral density as in existing TDD standards.
  - have same or lower in-band EIRP as in existing TDD standards.

# For 3GPP RAN consideration

- It is preferable that bands for uplink and downlink directions across the standards are harmonized for FDD mode of operation.
  - It is better to ensure that all the uplink bands are placed together and the downlink bands are placed together.
  - However, when different service providers employing standards whose downlink/uplink bands are adjacent require coexistent operation, mitigation methods such as the use of filters, and spatial separation between antennas, etc. need to be incorporated.
- In order to be deployed in existing FDD spectrum, LTE-A systems should
  - have uplink and downlink band definitions in harmony with the old standards operating in the band and adjacent bands to the extent possible.
  - have same, or lower out-of-band emission spectral density as in existing FDD standards.
  - have same, or lower in-band EIRP as in existing FDD standards.
- The customer terminal must be user self-installable