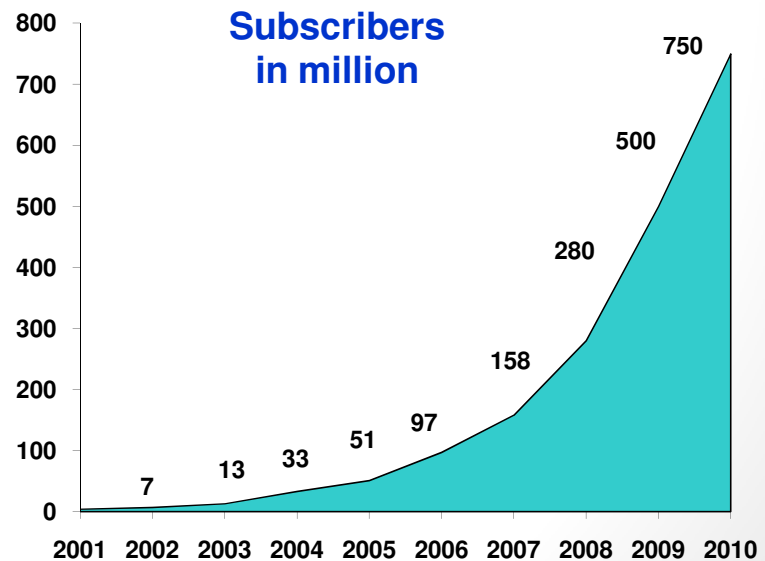


# What will it take to make India a Leader in Wireless Technology

Ashok Jhunjhunwala, IIT Madras  
ashok@tenet.res.in

# India's Telecom Story is now well known

- Growing at **15 million lines per month**
  - Largest telecom market in the world
- But India was **struggling** at under 10 million lines in 1994
  - Growing at **1 million per year**
- What happened?
  - Liberalization of Telecom
  - Wireless technology
    - Reduce CAPEX
    - Fast build-up
    - Low maintenance cost / OPEX
  - **Affordable tariff**



India has done well as a Design House today

# But it is not all about Telecom Service

# India is already a Design house

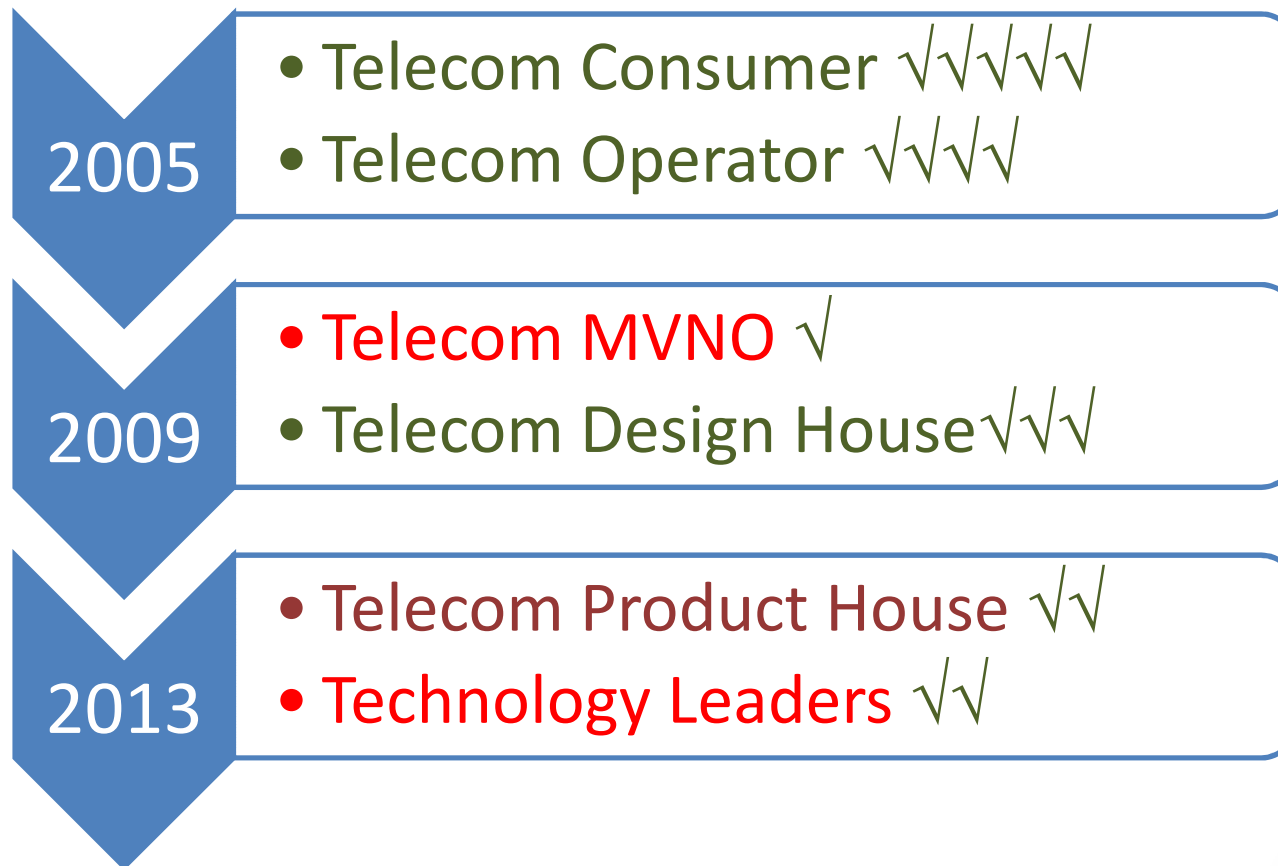
- **Systems**

- Telecom MNCs design in India
- Indian companies excel in providing **design** services
  - Sasken, Wipro Infosys, TCS, Tata LXI, Hughes, Tech-Mahindra
- Telecom **Start-ups** (Beceem and Telsima) sets their design teams
- Indian **Product** companies emerge (Tejas, Midas)

- **Semiconductors**

- More of semiconductor development in India by MNC
  - TI, ADI
- Indian **start-ups** emerging (Cosmic, Redpine)
- Multiple companies continue to provide design services

# India Amongst the Leaders



# India imports most systems today

- Except to a small extent from
  - Tejas Networks, Midas Communications, Telsima
    - who own IPR for their products
- We still pay IPR price for GSM (infrastructure / handset) even at this late stage of technology
  - Embedded in price of components, systems, software
  - Seriously impacts CAPEX investment requirements and bottom line for operators
- Typically four to five essential IPR in a standard can neutralize the royalty outflows from a country
  - Would still require business aspects to be sorted out

Short-term goal of making royalty outflow negligible

# What does it take for India to become Technology Leader

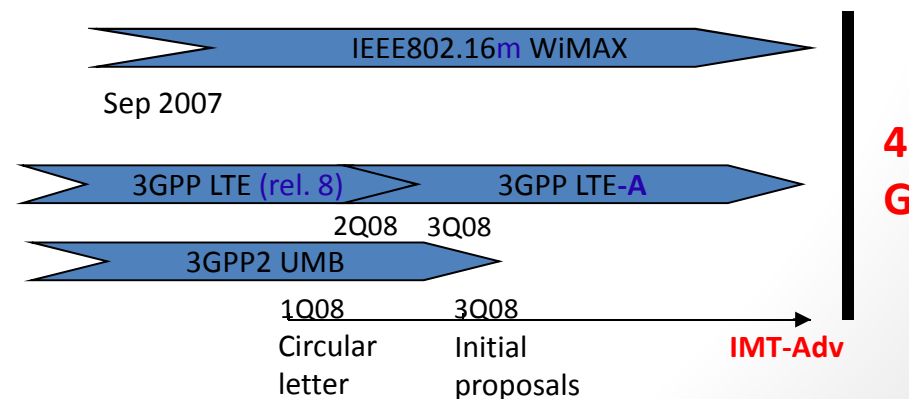
say in wireless area?

# Understand the niche for the nation

- What will industry need -- tomorrow and day after?
  - Who is defining the standards that they would use?
- Who all are driving the emerging standards?
  - What technologies are going into those standards?
  - What, if any, is the technology gap?
- Does India have special requirements?
  - Are those special requirements recognised?
  - Do technologies exist to full-fill these requirements?
    - Who is working on such technologies?
    - Are there scientists in India (or Indian Scientists abroad) who could take lead in fulfilling such requirements?
  - How do we get them to take a lead
    - And how does one get industry behind such efforts?
    - How does one get government behind such efforts?
    - And the funding required!

# Wireless is the Key to Broadband Access

- Wireless got telephony to everyone in developing countries
  - Wired line infrastructure is too poor
- **Wireless** will get **Broadband** to everyone
  - Unlike the West, there is no wireline infrastructure for this!
    - GPRS / EDGE/ 3G-1x / EVDO available today
      - Increasing use of wireless Internet even in rural India
    - 3G (HSDPA), LTE and WiMax 802.16e (wireless auction)
      - But they struggle to provide 2-3 bps/Hz/cell
    - And eventually 4G technology: 802.16m and LTE-A



# To make India a leader in Wireless Technology

- India takes an initiative three years ago
  - to create a **public-private** organization  
*Center of Excellence in Wireless Technology*
    - Initially funded Government: industry = 2:1
      - To be Lead by Academia
      - Attract top R&D talent from around the world
      - Drive Research towards IPR creation
      - Create a cluster of Industrial R&D around it



*Broadband Wireless  
Consortium of India*

and CEWiT initiates set up of *Broadband Wireless Consortium of India (BWCI)*

- Telecom operators, Academia, Government / Regulators, Product Industry, Semiconductor Industry
- To define and drive R&D and standardization to make India leader in wireless technology

# CEWiT Objectives

- Bring together wireless **industry stake-holders**
  - align their pre-competitive R&D efforts
- Involve all IITs/IISc in the **IPR-driven research** effort
- Focus on Next Generation Standards
  - Feed *Indian requirements* and specifications in International wireless Standards bodies
  - Conduct *mission-oriented* research towards IPR for 4G
    - Focus on Indian requirements (high system capacity)
  - Early *technology trials* of Indian-made prototypes along with industry
  - Work with *regulators* to anticipate issues related to spectrum / licensing

# India's 4G Requirements

## ▶ CeWiT+Broadband Wireless Consortium of India (BWCI)

- Developed by Operators' subgroup of BWCI
- BWCI released document in Sept 2007
  - Highlights important points of departure from international requirements
- **Primary broadband** connection for the masses
  - Not just an additional mobility tool
- Need sustained **> 512 kbps per user**
- **At mobile phone cost point**

## ▶ Indian cellular ecosystem is different

- Urban cells ~ 200 – 800 m radius ; rural ~ 15 km
- Spectrum per operator tight ⇒ need **1:1 re-use**
- Severely **interference-limited**
- 85% users **nomadic** and **in-building** ⇒ coverage an issue

# Requirements derived out of business case for Broadband?

- Dense Urban (Case: Mumbai)
    - 70% of 16M people: 600 sq Km
    - ~3733 households per sq km
    - ~50% wireless internet subscribers
      - ~ 1866 wireless internet/sq km
    - cell radius = 0.75 km
      - ~ 3300 subscribers/cell
    - Assuming 5 competitive operators
      - 660 subscribers/operator/cell
  - Urban (Case: Pune)
    - 70% of 4.2M people: 400 sq Km
    - ~1470 households per sq km
    - ~ 60% wireless internet subscribers
      - ~ 882 wireless internet/sq km
    - cell radius = 1 km
      - ~ 2800 subscribers/cell
    - Assuming 5 competitive operators i
      - ~560 subscribers/operator/cell
- Typical scenarios evaluated by Indian operators (similar for rural)
  - Technology must have sufficient coverage (up to 3 km) within regulatory constraints without capacity loss

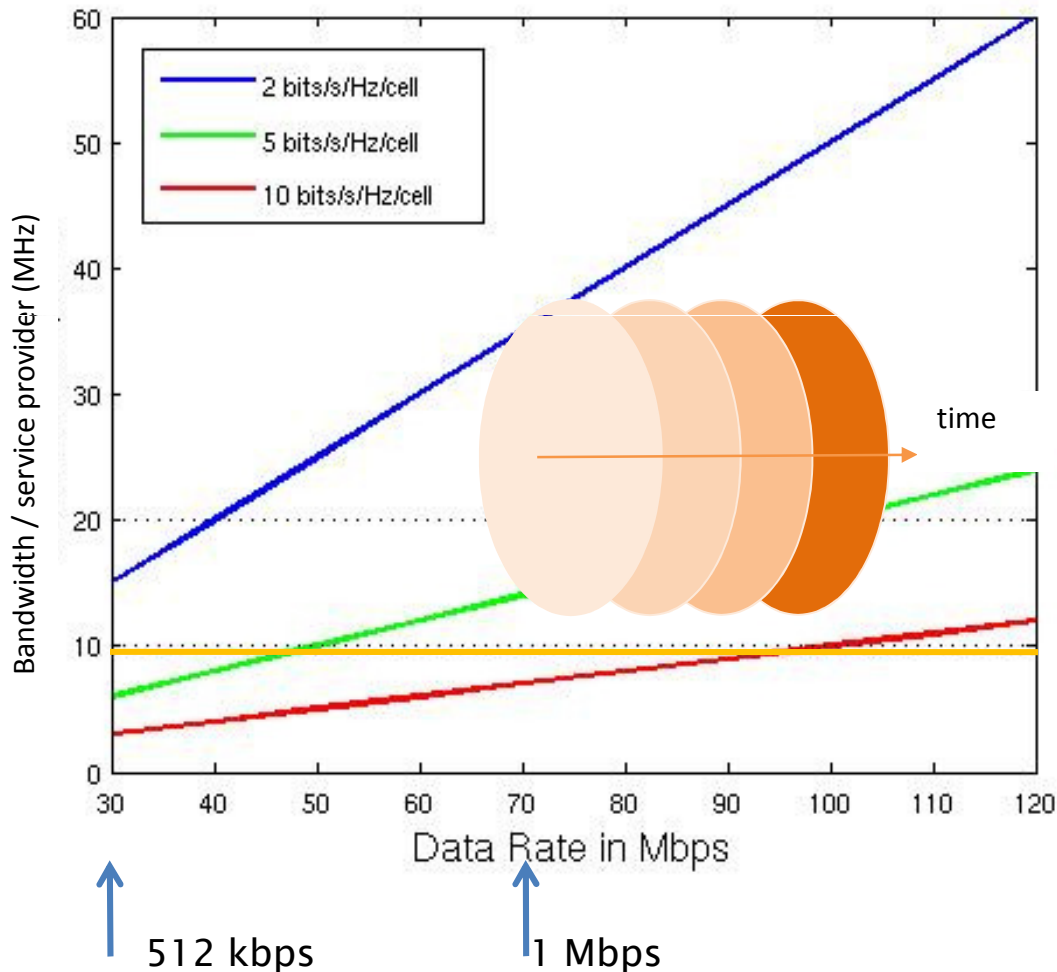
Wireless technology needs to support 500 to 800  
Broadband subscribers /operator / cell

# What enables a performance improvement today?

- How can one transmit more and more in a given spectrum: measure by bits per second per Hz per cell
  - reducing cell size of-course enables more reuse?
- What limits Radio Performance?
  - Attenuation: Amplification
  - Noise: better modulation and better error-coding techniques
  - Distortion: equalisation; adaptive equalisation
  - Near-far problem
  - Interference: sectorisation, power-control, channel coding
    - Can we reuse spectrum in each sector in each cell
  - Multi-path:
    - Equalisation to compensate fading
    - Spread-spectrum to take advantage: add signals from different path
    - OFDM: split channels and transmit as much as it can support using feedback
    - Utilising space-time diversity: MIMO
    - Comprehensive feedback for power control, coding, transmitting more where interference is less
      - Is feedback fast enough? What if traffic, channel, interference has changed during feedback?
- Does simulations reflect the real-world situation? Traffic assumptions

# India needs higher than 5 bps/Hz/cell

as operators unlikely to get more than 20 MHz



# India has small cell-size

- Need Special focus on cell-edge performance
  - As one attempts to get higher bps / Hz/cell
  - And at lowest possible costs
- India's focus on Physical layer lead by CeWIT and IITM
  - significant improvement in cell-edge performance
    - With modest complexity in terminal
    - Responsible for focus on nomadic, cell-edge user in LTE-A and 802.16m
- India's focus on Network performance and services lead by TCOE and IITB
  - Evolved IP Services
  - Layer 3 Radio Protocols
  - Packet Transport Networks and Evolution

# Improving Cell Edge Performance

- 2-D Phase Offset Diversity (2D POD) Scheme for 2/4-antenna BTSs
  - Better than existing Alamouti code for cell-edge in terms of receiver implementation
    - Can suppress interference from neighboring BTSs with no additional complexity
- Conjugate Data Repetition (CDR) + 2D POD for cell edge downlink data
  - Can suppress 1 - 4 interferers at 0 – 9 dB
  - Gives cell-edge performance much better than current target

# Some Key Proposals from India

- Inter-Cell Interference Cancellation (ICIC)
  - Low bit-rate, low latency links between neighboring BTSs used to implement **BTS co-operation**
  - Ensures 1:1 re-use for nomadic **cell-edge** users
- Better **preamble** for synchronization
- Orthogonal **pilots** with PN cover
- Pilot density reduction targeting **low-mobility** situation
  - Will result into higher payload
- **Relays** for Coverage extension as well as data rate enhancement

# CeWiT's Achievements so far

- takes India's Broadband Wireless Requirements into 4G standard bodies
  - Both LTE-A as well as 802.16m
  - Has six essential and 6 other IPRs accepted in the 802.16m standards
    - Many in LTE-A under consideration
- CeWiT and TCOE were evaluators of standards for IMT-A (of ITU)
  - Year long process where claims of all standards were validated, strengths and shortfalls documented
- At the same time
  - Creating industrial infrastructure around itself
  - Jointly Building Hardware Software Blocks for 4G standards
  - Conducting field trials and evaluations
  - Connecting Indian academia to Design / Manufacturing Industries

# BWA Technology choices & performance

Technology	DL Spectral Eff. (bps/Hz/sector)	UL Spectral Eff. (bps/Hz/sector)	Availability
HSPA Rel 6*	0.53	0.33	today
HSPA Rel 8**	1.51	NA	soon
DO Rev B***	1.0	NA	today
DO Rev C	Target: Rev B x 2,	no published results yet	2011?, standard in progress
TD LTE (2x2)*	1.64	0.81	2011?
LTE (4x2)* (assume same for TDD)	1.93	NA	Late 2011?
WiMAX 16e* (2x2)	1.15	0.62	today
<b>WiMAX 16e+# (2x2)</b>	<b>1.6</b>	<b>1.05</b>	Dec 10 soft-upgrade
WiMAX 16e+# (4x2)	1.85	NA	2011?
<b>WiMAX 16e+i (2x2)\$</b>	<b>2.23</b>	<b>1.05</b>	Dec 10 soft-upgrade

Sources: \*NGMN Ph2 Report 2008; \*\*Ericsson; \*\*\*Motorola, IEEE Globecom2007; #Wimax Forum 2009; \$CEWiT 2010

**802.16m or LTE-A being examined by IMT as 4G standards: Availability 2012**

15 October 2010

( 20 )

# CEWiT's key contribution to 802.16m based on its IPR

- **Open Loop Region** (no closed loop MIMO adaptation)
  - SINR stable: get the data rate you expected when you fed back SINR
- Best-Band **Scheduling based on stable post-processing SINR**
  - Till now, best-band scheduling was to exploit varying channel conditions
  - Now, exploit (stable) interference variation across bands too
  - receiver processing cancels some of the interference
- Conjugate Data Repetition (**CDR**) with associated Collision Free Pilots (**CoFIP**)
  - Can cancel 3 or more interferers
- Net Impact
  - Full-blown spectrum **reuse 1 possible**
    - No "fractional" reuse (FFR), etc
  - Ideally suited for **Indian** scenario
  - Very good performance with **2x2** configuration itself
    - 40% lower infrastructure cost than 4x2

# 16e+i proposal

- **Fast forward CEWiT contributions** into 16e+ to create 16e+i
  - Part 1: Open Loop Region with best-band scheduling - possible with **software changes only** in BTS and terminal
    - BTS software change only in scheduler, can be done anytime
    - Can time release along with WiMAX Open-Retail 1a/1b in Dec 2010
  - Part 2: CDR and CoFIP - requires minor PHY hardware change in terminal
    - Can time it with Open-retail 1c whenever next tape-out is done
- 16e+i is **backward compatible** with 16e/16e+
  - Legacy terminals will work
  - Can roam into 16e/16e+ networks

# 16e+i Advantage

- Spectral efficiency of **2.23 bps/Hz** on DL in Phase 1 itself
  - Both SINR stability and channel estimation errors in high interference scenario addressed
- UL of 16e+ already good
- VoIP performance of 16e+ already good (not as good in 16e)
  - Performance of 16e+i **50% better than TD LTE, HSPA, DO Rev C**
    - all with 2x2 configuration itself
  - Performance of 16e+i **better than TD LTE 4x2 configuration** also
    - TD LTE performance in any case doubtful due to SINR fluctuation
- **16e+i can actually make 4G a reality**
  - No other technology comes close
    - Cost effective: 2x2 configuration (much cheaper than 4 x 2 configuration)
    - Mature platforms: Roaming possible in US, Japan
- **Based on Indian IPR**
  - Will result in India becoming leading voice in WF and 802.16
    - development of India-based vendor ecosystem

# What does it take to obtain Technology Leadership?

- Quality Faculty: 100
  - Research Scholars: 300
- Industry: 10
  - R&D personnel: 300
- State funding per year: Rs 20C
- Complete Coordination of Government, industry (COAI and AUSPI) and CEWiT efforts

