Broadband Wireless Networks: Research Challenges and Opportunities

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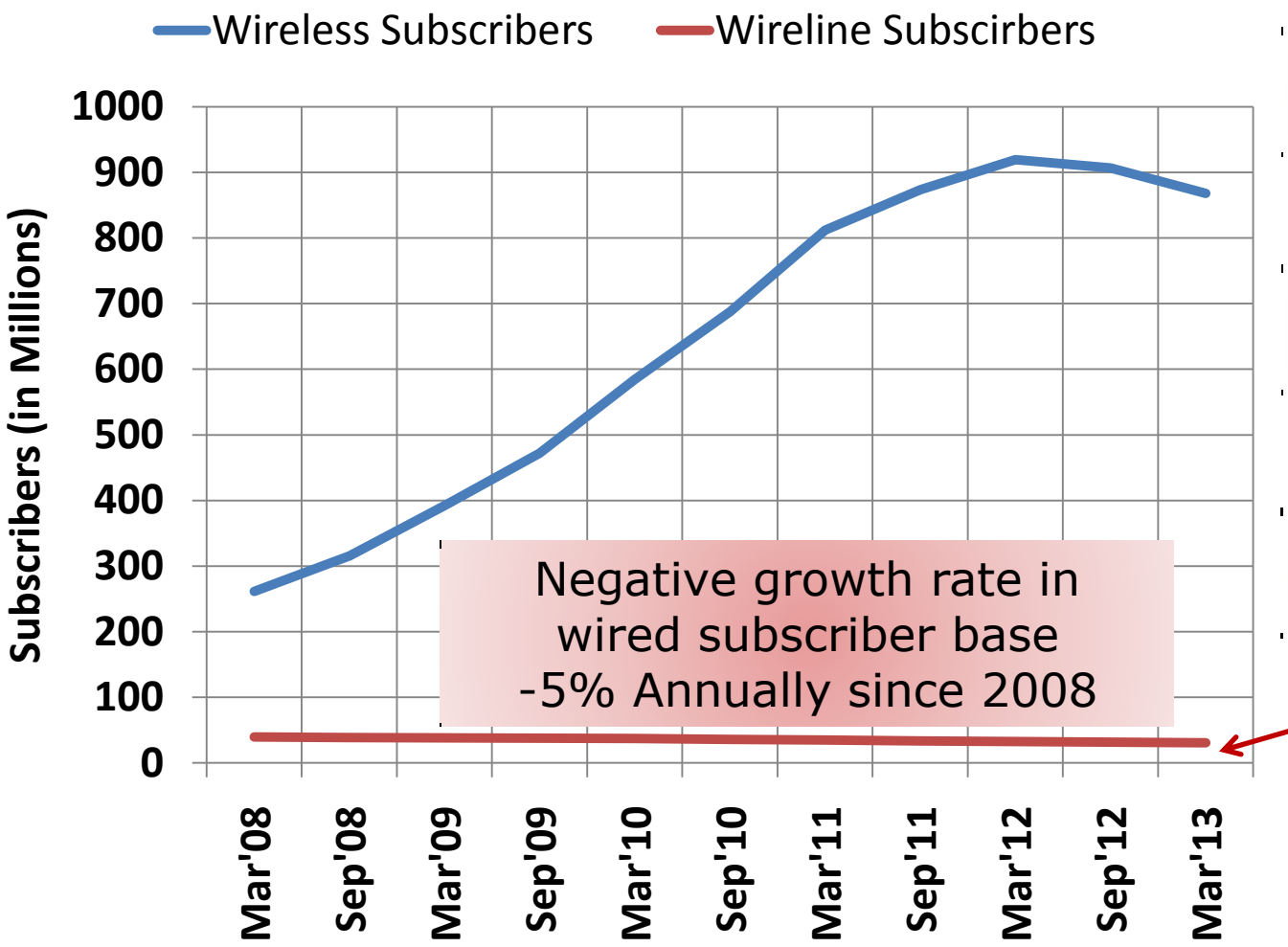
Outline

- Indian Scenario
- Broadband Access
- Rural Connectivity and Broadband
- Other possibilities? – TV White Space

Indian Scenario

Telecom in India: Subscriber Base

Subscriber Base



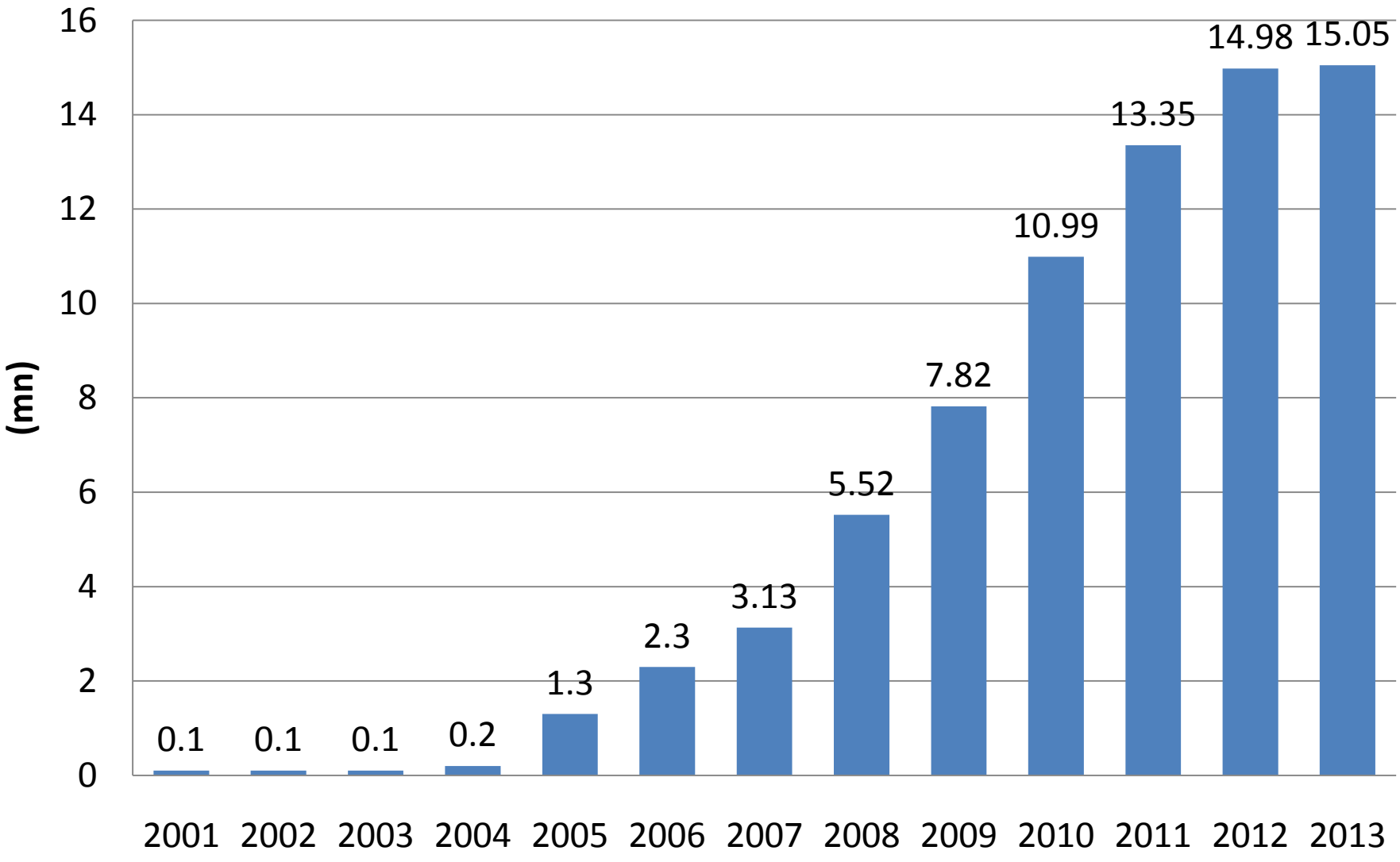
Wireless subscribers
850+ Million

Overall tele-density
73 (Mar '13)

2nd largest telecom market globally

Source: **The Indian Telecom Services Performance Indicator Reports, TRAI**

The Indian Broadband Penetration



Source: **The Indian Telecom Services Performance Indicator Reports, TRAI**

Two Scenarios in Contrast

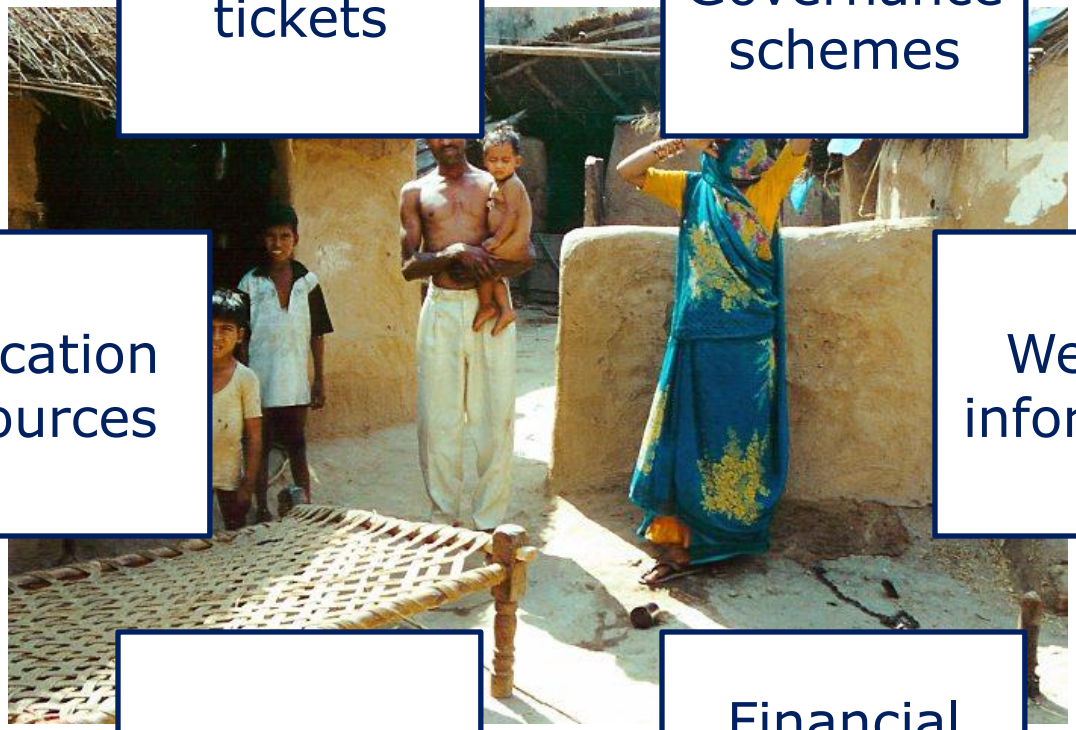
Images from Wikipedia: Mumbai (left); an Indian village (right)

Urban India or metro cities have optional access to broadband

Rural India, even though it contributes 50% to the GDP, has no access to broadband

This leads to or creates digital divide

The digital divide: What does it mean?



Railway tickets

E-Governance schemes

Education resources

Weather information

…

Financial services (banking)

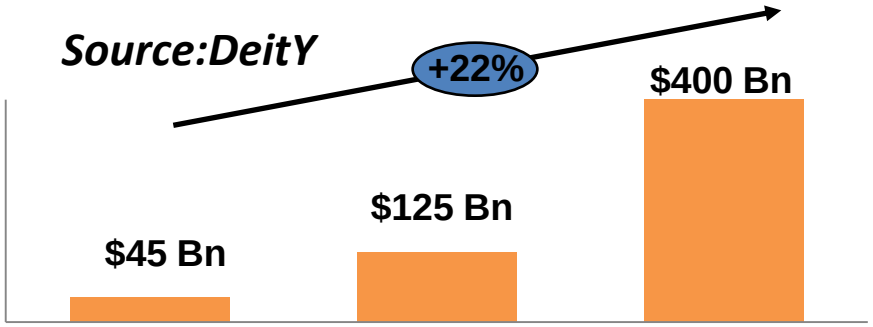
Indian Scenario – summarized.

- Rural teledensity is still 41 (against urban teledensity of 146)
- Broadband subscribers ~ 15.05 Million
- ARPU declining
  - 33% drop in ARPU from 2009 to 2011

Next Big Opportunity – Rural Connectivity & Broadband

Telecom Product Sector: A perspective

- India's electronics demand expected to grow exponentially at 22% per year
  - 30% semiconductor component



Electronics Systems Design & Manufacturing (ESDM) Demand, 2009-2020

- At current production levels of ~5% of demand, electronics import bill will outstrip oil import bill by 2020

Telecom Product Sector: A Perspective

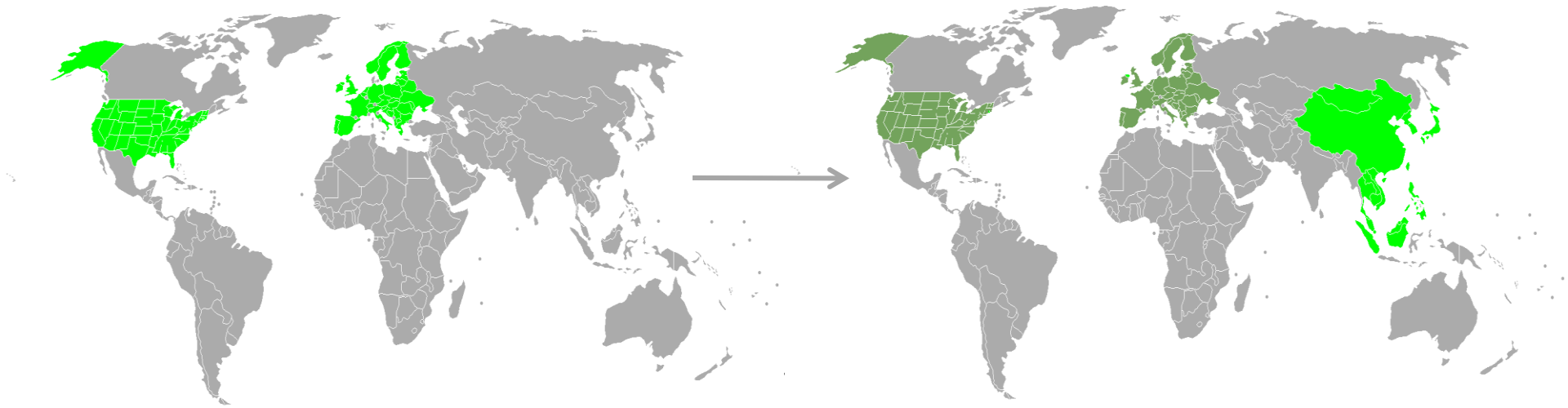
- Few telecom products made in India
  - Components are still 100% imports
  - High outflow of foreign currency $$
- No common interface to represent Indian industry and also Indian requirement
- Could not leverage 80's success- C-DoT
- Only country in the top telecom market with no umbrella body focusing
- Marginal value addition
  - In-significant contribution in IPRs, patents

India is not well-positioned for telecom product manufacturing

Global IPR Scenario

- Nations increasingly aware of IPR and use of IPR reserves to position trade policy
- China- a good example
- Balance of IPR shifting to Asia/Pacific
  - A… …ia Pacific (C…
  - Earlier almost 90% IPR held by Western world

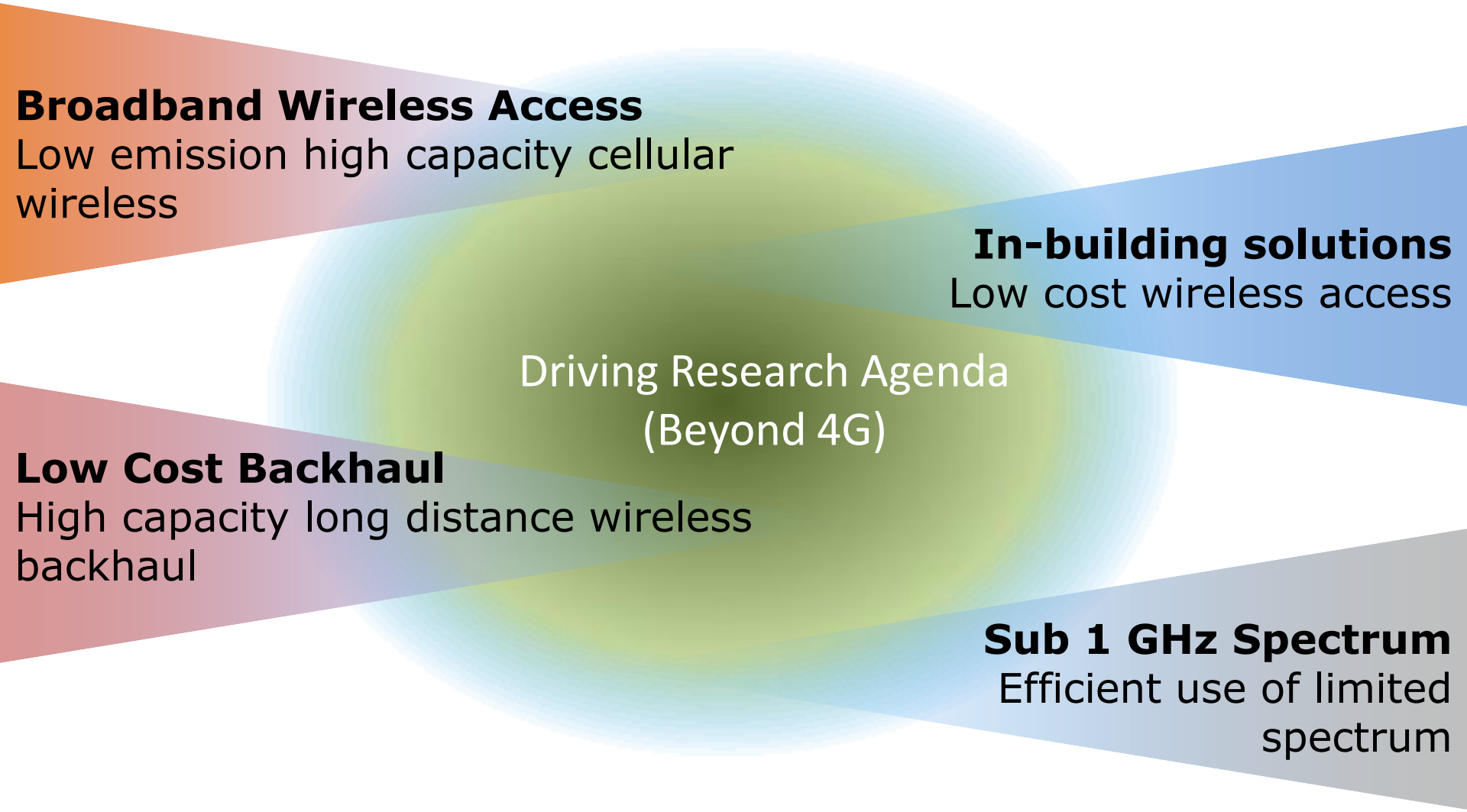
TD-SCDMA ⟶ TD-LTE Evolution



Indian Presence

- Modest (practically nil till recently)
  - CeWIT, IIT Bombay and Tejas Networks among few exceptions
- Indian presence in major wireless standards bodies 3GPP, 3GPP2 meagre
  - Requires participant to be a member of a partner SDO of 3GPP/3GPP2 to participate
  - With no India SDO participation Indian entities have become members of ETSI or TIA to participate
    - Not a scalable model

Driving Research Agenda beyond 4G for India



Broadband Access

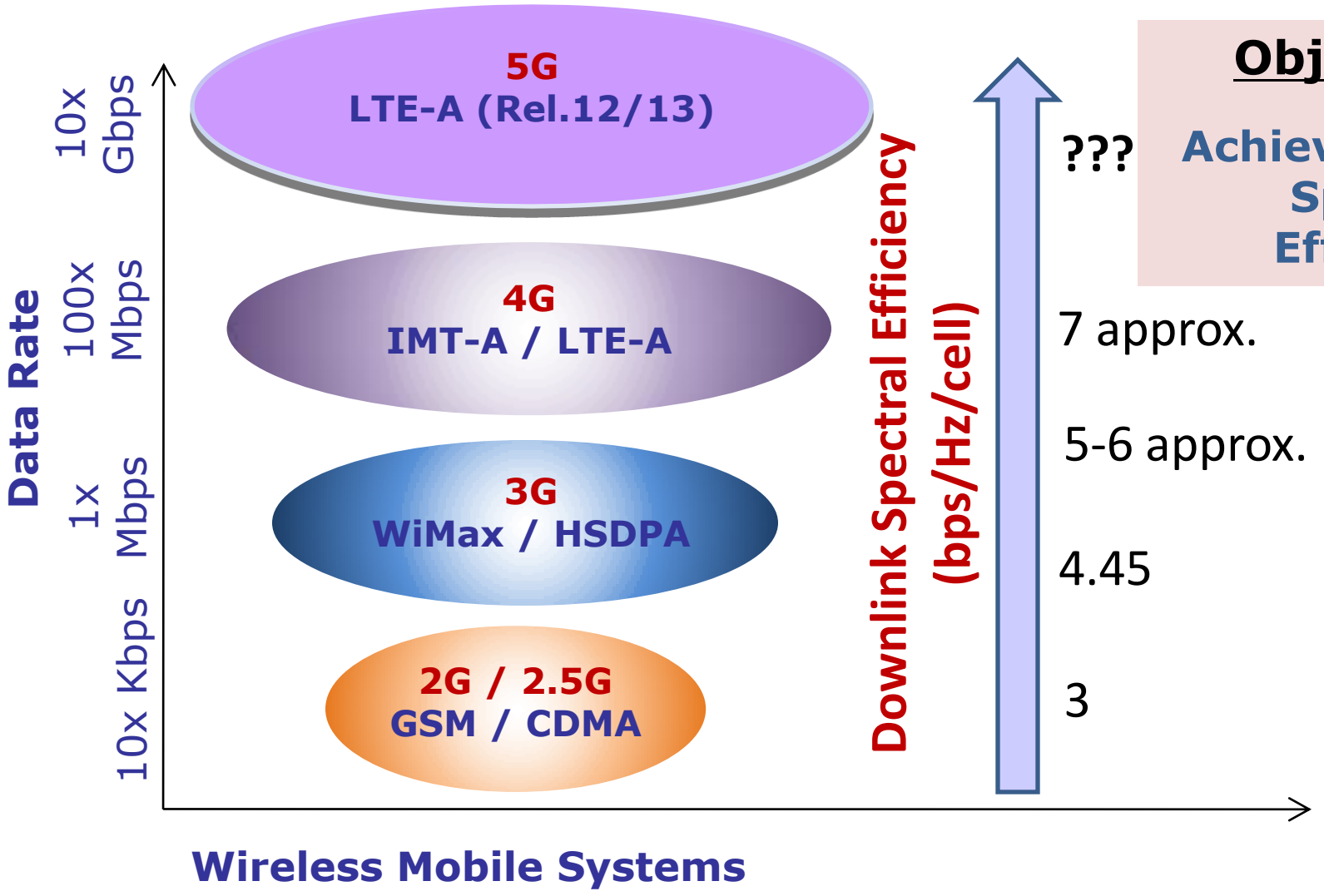
Broadband through Wireless?

- Assuming population density >15K per sq km
- 1K users /sq km, and 2 Mbps demand per user
- Very high capacity required: 2 Gbps/sq km
  - Assuming 2-3 cells/ sq km, we need about 1 Gbps per cell

Even with 100 MHz per cell ~ 10 bps/Hz/cell

Moreover, with increasing power levels, emission levels are also increasing

Stepping towards 5G Systems (Rel.12/13 of LTE-A)



Objective

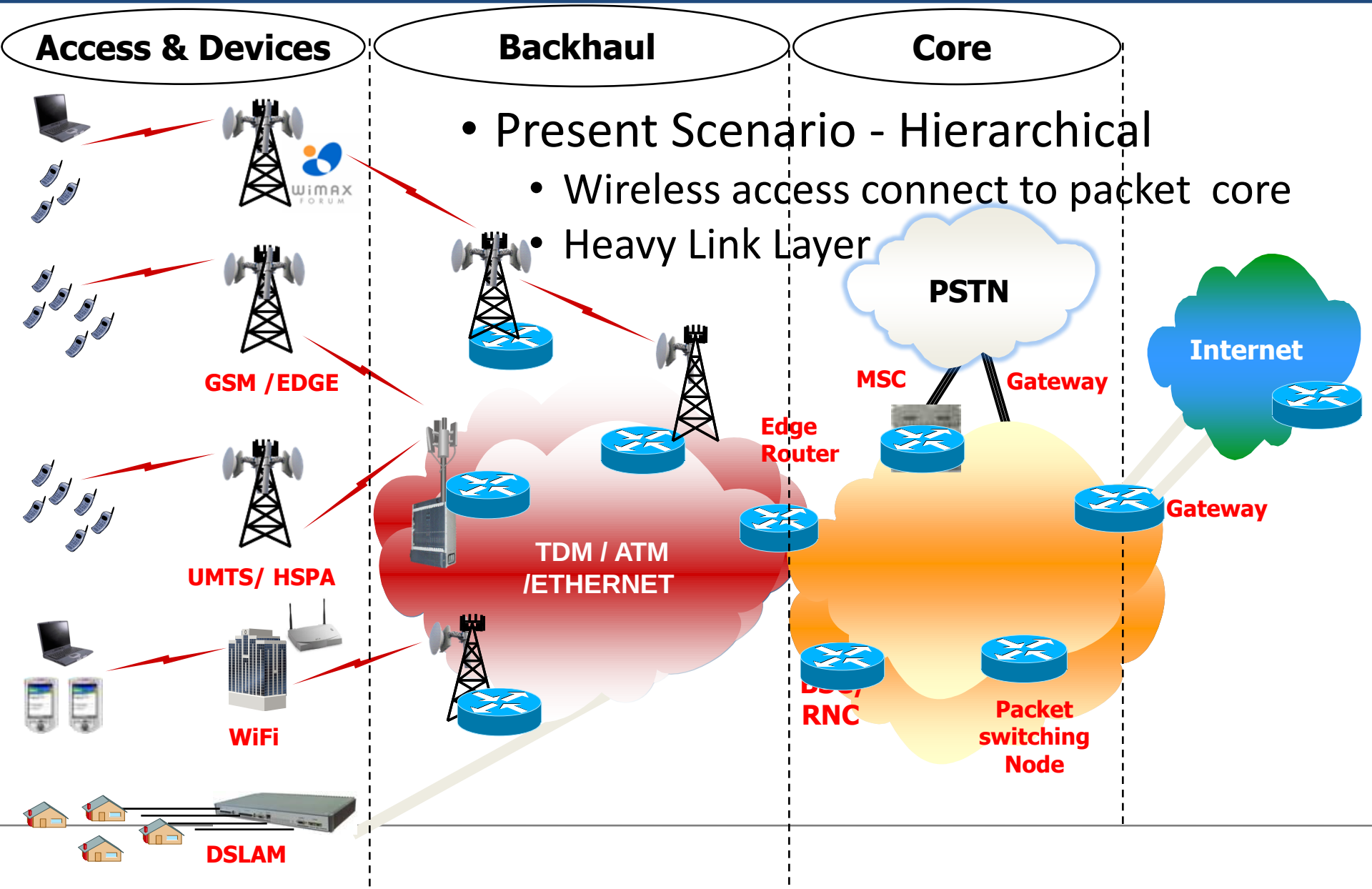
Achieve higher Spectral Efficiency

Spectrum Availability in India

700 MHz band	2.3 – 2.4 GHz	2.5 – 2.69 GHz
• 698 – 806 MHz • 108 MHz is likely to be reframed	• 40 MHz already auctioned • 60 MHz can be re-farmed from captive users and govt agencies	• 80 MHz can be re-farmed (currently with Department of Space)

250 MHz expected to be released over 3 years
(Requirement is about 500 MHz of spectrum)

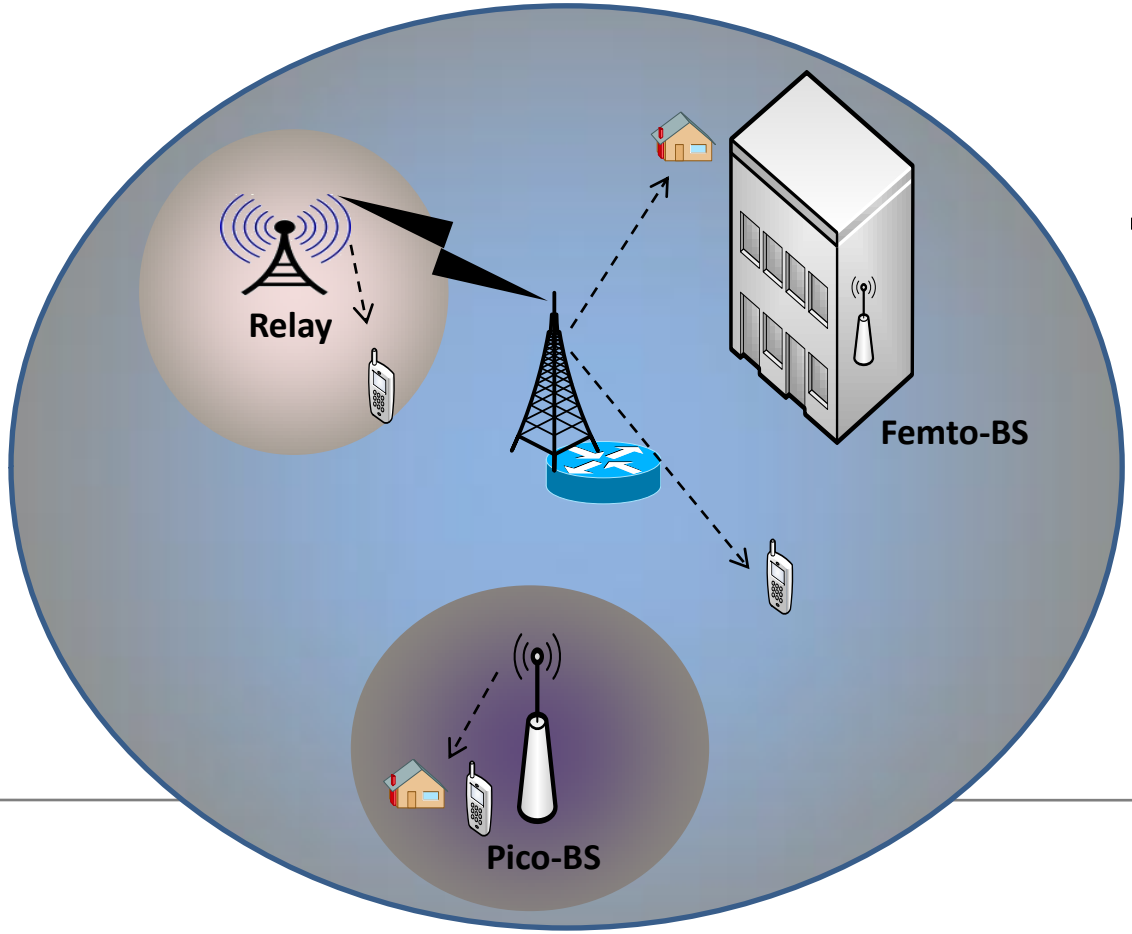
Today's Cellular Architecture

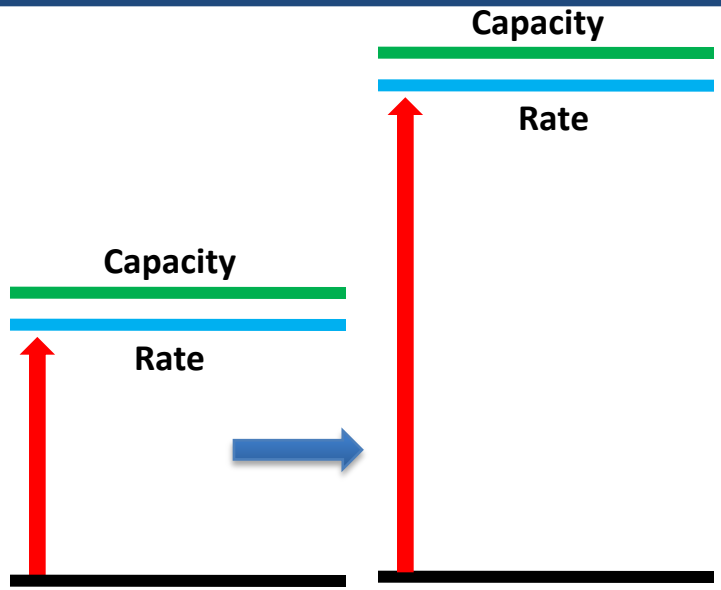


Heterogeneous Network

Features

- Low-power nodes- Pico and Femto
- Shared resources
- Macro BS provide umbrella coverage
- Capacity and/or coverage improvement

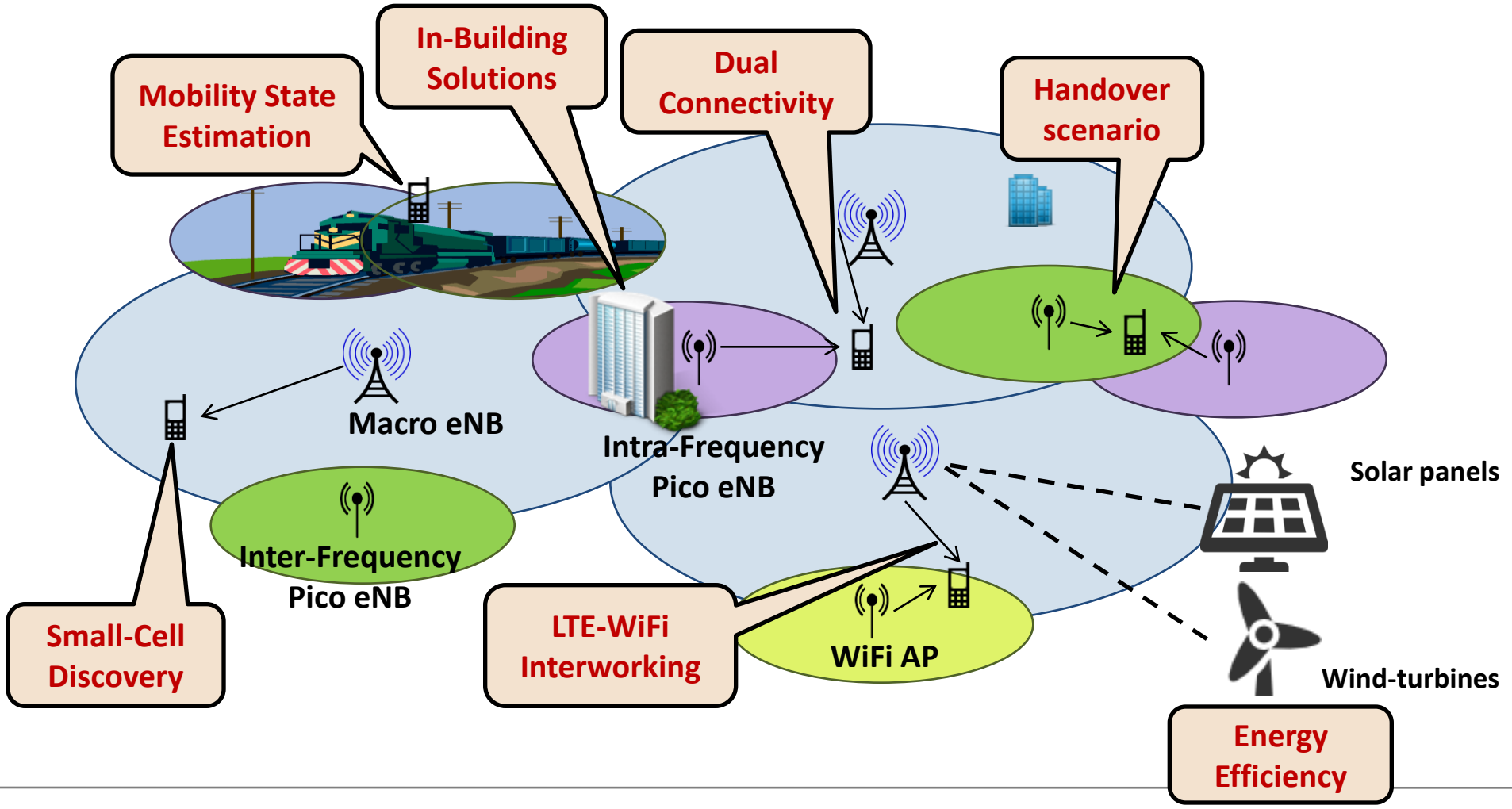




Challenges

- Backhaul – Major challenge for small cells
- Requires a mix of fiber and wireless

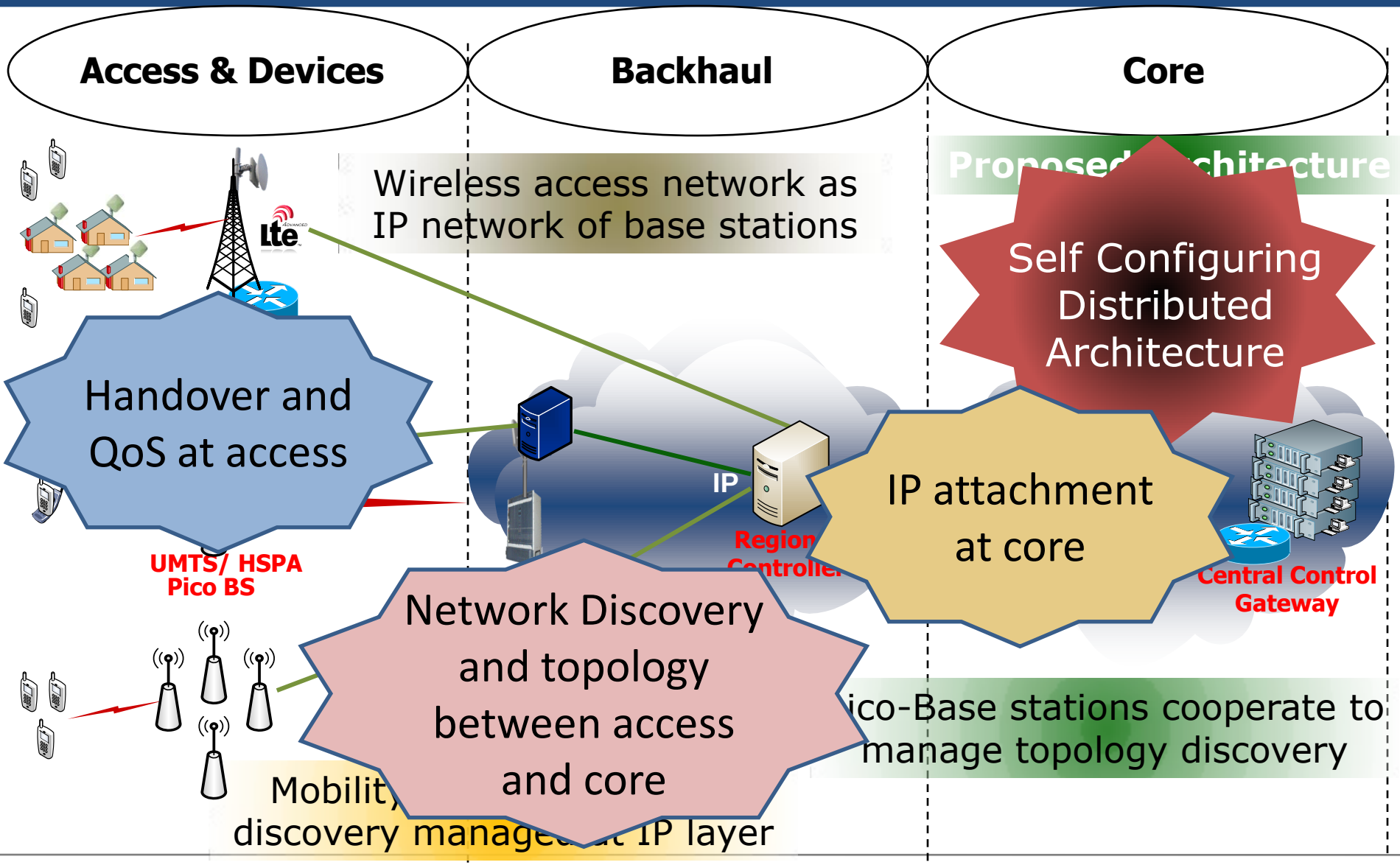
Research Issues



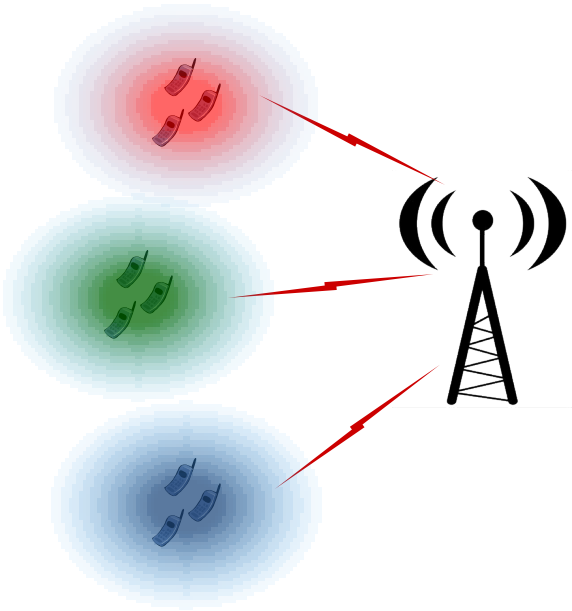
Today's Cellular Networks

- Current cellular networks (LTE, LTE-Advanced) are highly centralized
- Control passes hierarchically from access to core
- Handoffs, interference management, resource allocation are Layer 2 functions
- IP used only in data plane

IP based HetNet Architecture



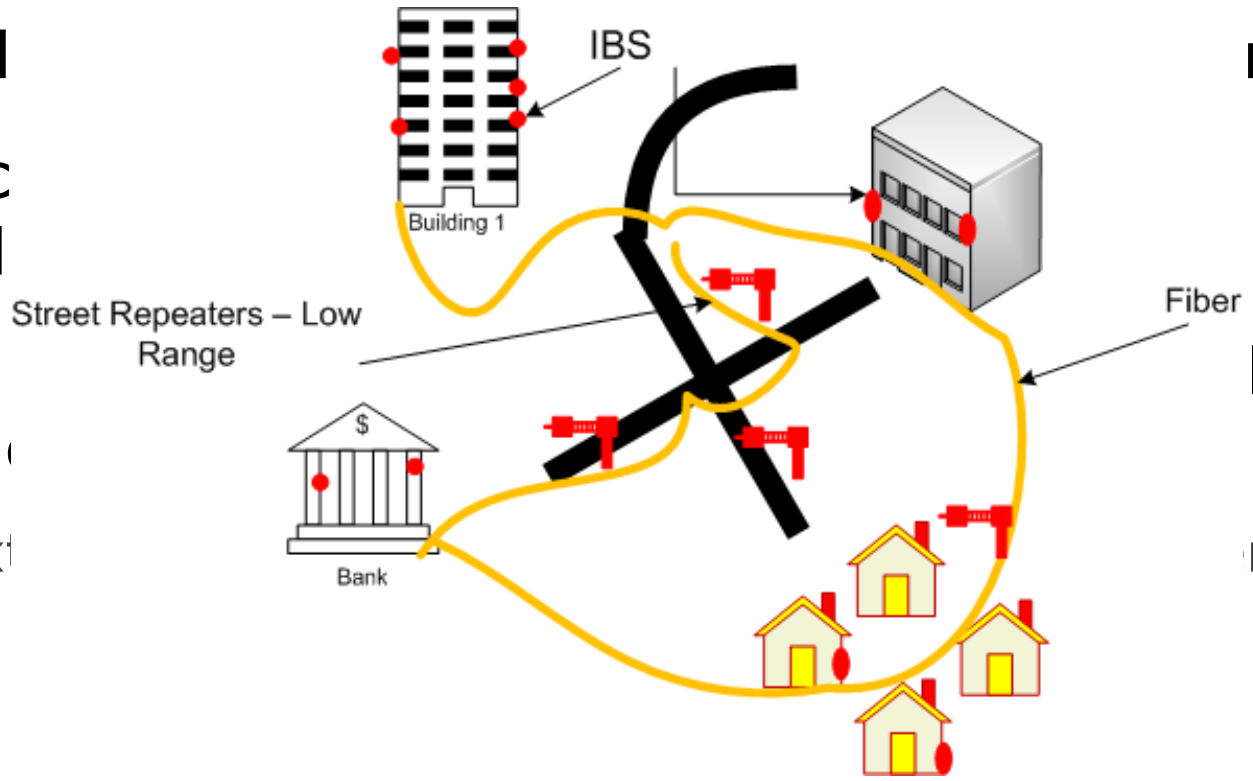
Virtual Radio Access Networks



- Active Infrastructure Sharing
  - Reduce BoM for RF equipment
  - Improve energy efficiency
  - Optimize backhaul infrastructure
  - Load share ‘roaming’ between operators
- Technical Features
  - Intelligent switching to route and bill the user’s traffic
  - Spectrum management
  - Interference management

In Building (Wireless) Solutions - IBS

- Operator-agnostic IBS based on transceivers deployed tens of meters apart
  - These connected to the equipment of various operators at the building's gateway.
- Outd reets
- Spec can be used
- Pico long a singl
  - Ext rs.



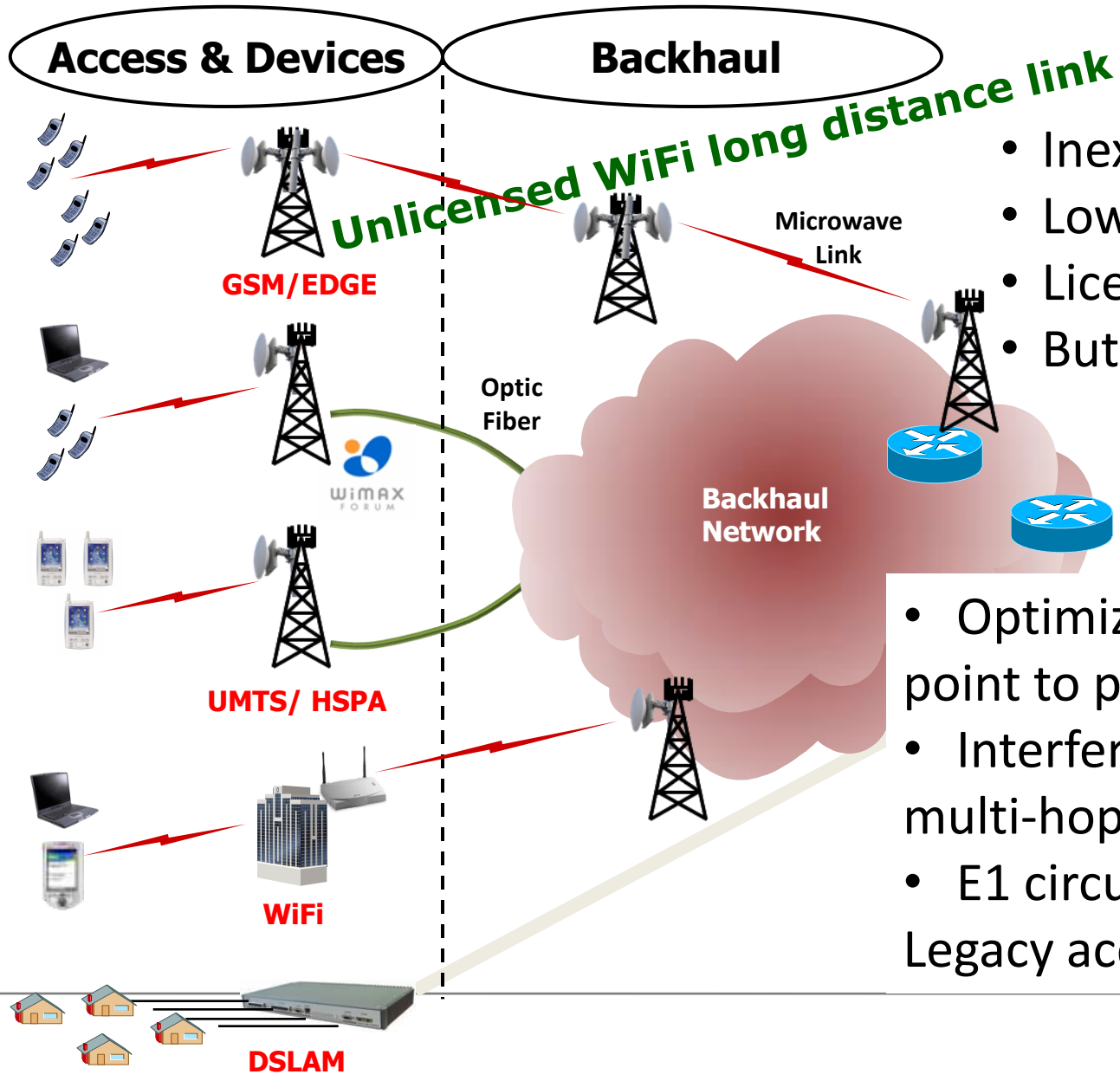
Rural Connectivity and Broadband

Providing Rural Wireless Connectivity

- Major challenge- backhaul network
  - Backhaul cost being significant percent of the network

Features	TVWS < 700 MHz	Microwave Backhaul < 6 GHz	Millimeter wave Backhaul 60-80 MHz	Fiber
Capacity	Medium	Medium	High	Very High
Distance	Long	Long	Short	Long
Deployment	NLOS, LOS, Mesh	LoS Point to Point	LoS Point to Point	Right of Way?
Cost	Low	High	High	Very High due to right of way

Unlicensed Radio Backhaul



Benefits

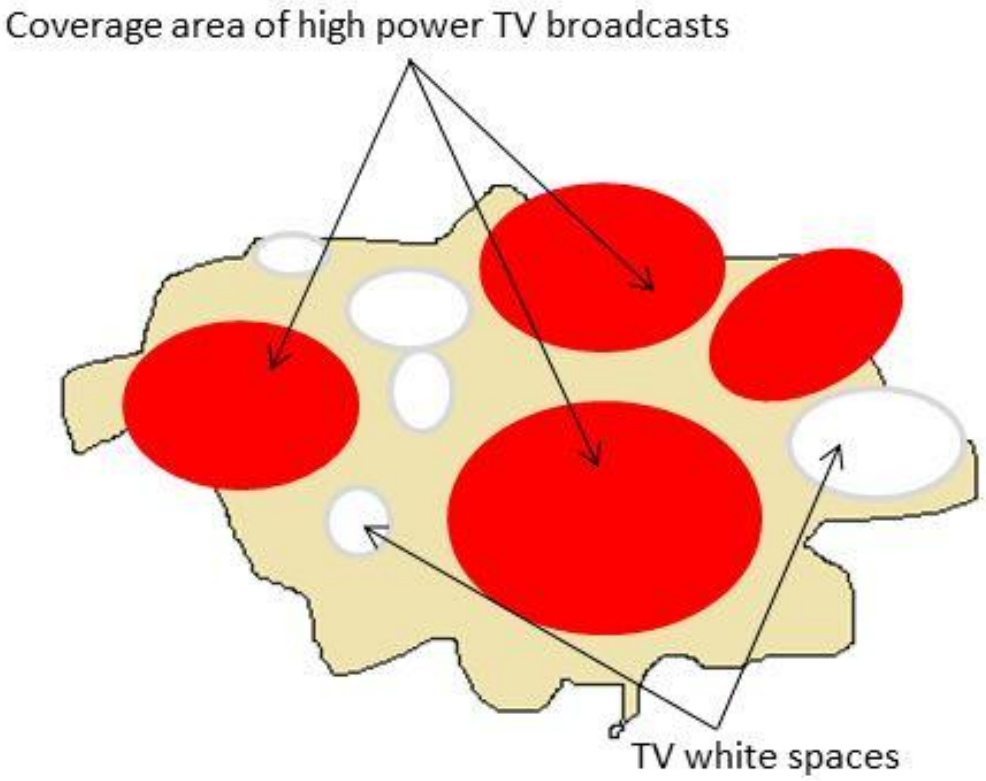
- Inexpensive radio (<$50)
- Low power (<10 W)
- License free band
- But designed for Indoor

Technical Innovation

- Optimized MAC for outdoor point to point link
- Interference management for multi-hop link
- E1 circuit emulation for Legacy access GSM/CDMA)

Other possibilities? – TV White Space

TV White Spaces, a potential antidote



- Analog TV channels are in sub-GHz band, which has better propagation characteristics than existing unlicensed bands
- Sparse television activity due to single broadcasting entity (Doordarshan)

Licensed but unused, good propagation characteristic, and low infrastructure cost spectrum available due to primary's inactivity

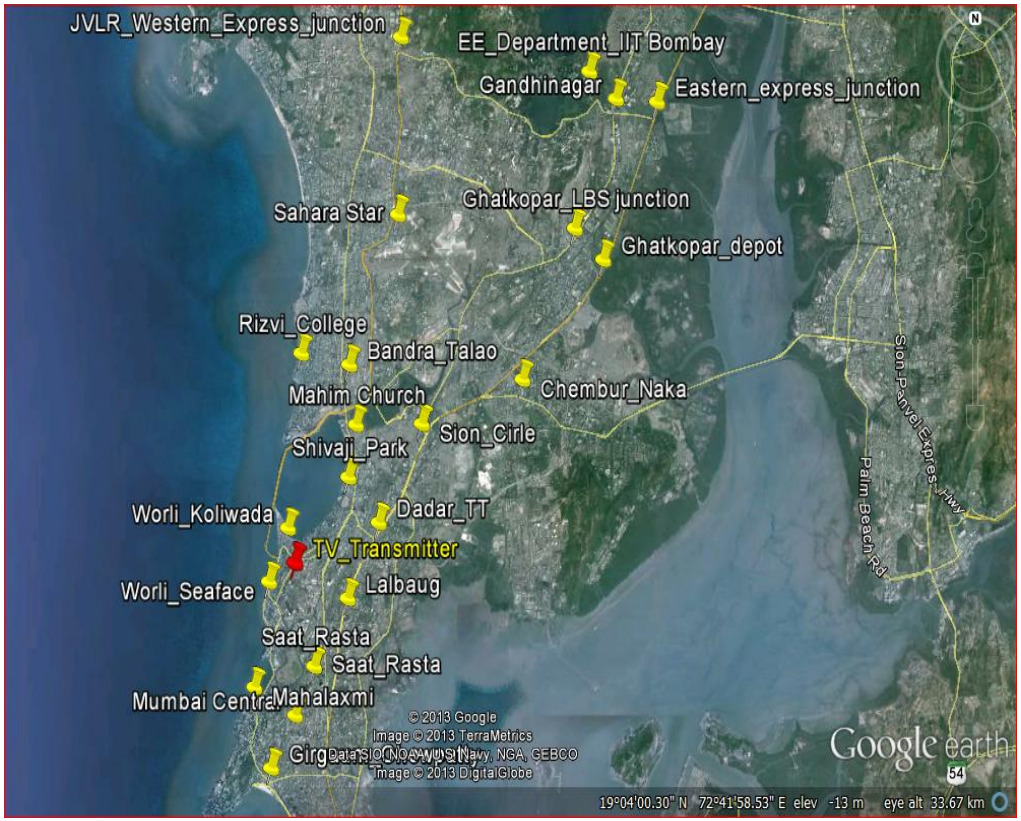
Indian TV Spectrum Usage

- Doordarshan is the only provider
  - 1145 Transmitters

Frequency Bands	No of transmitters
VHF Band I- 54-68 MHz and VHF Band II- 174-230 MHz	772
UHF Band IV- 470-582 MHz	373 (At most 2 channels each of 8 MHz)

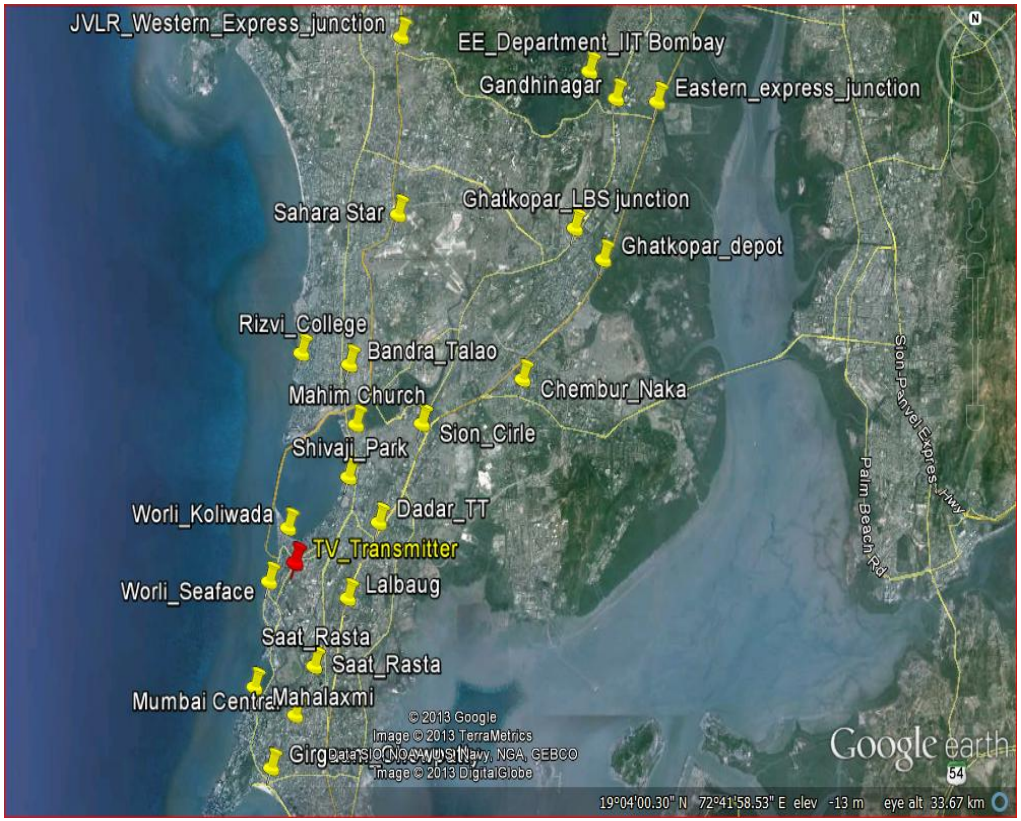
Measurements in Mumbai (Urban & Sub-Urban)

- Measurements carried out at 42 locations
- Two channels transmitted by Doordarshan (DD) terrestrial TV tower (DD-1 & DD-2)
- Channel 1 (182 MHz) & Channel 2(224 MHz) – Both in VHF Band
- **The bands 470-585 MHz, 585-698 MHz & 698-806MHz are presently unutilized.**



Measurements in Pune

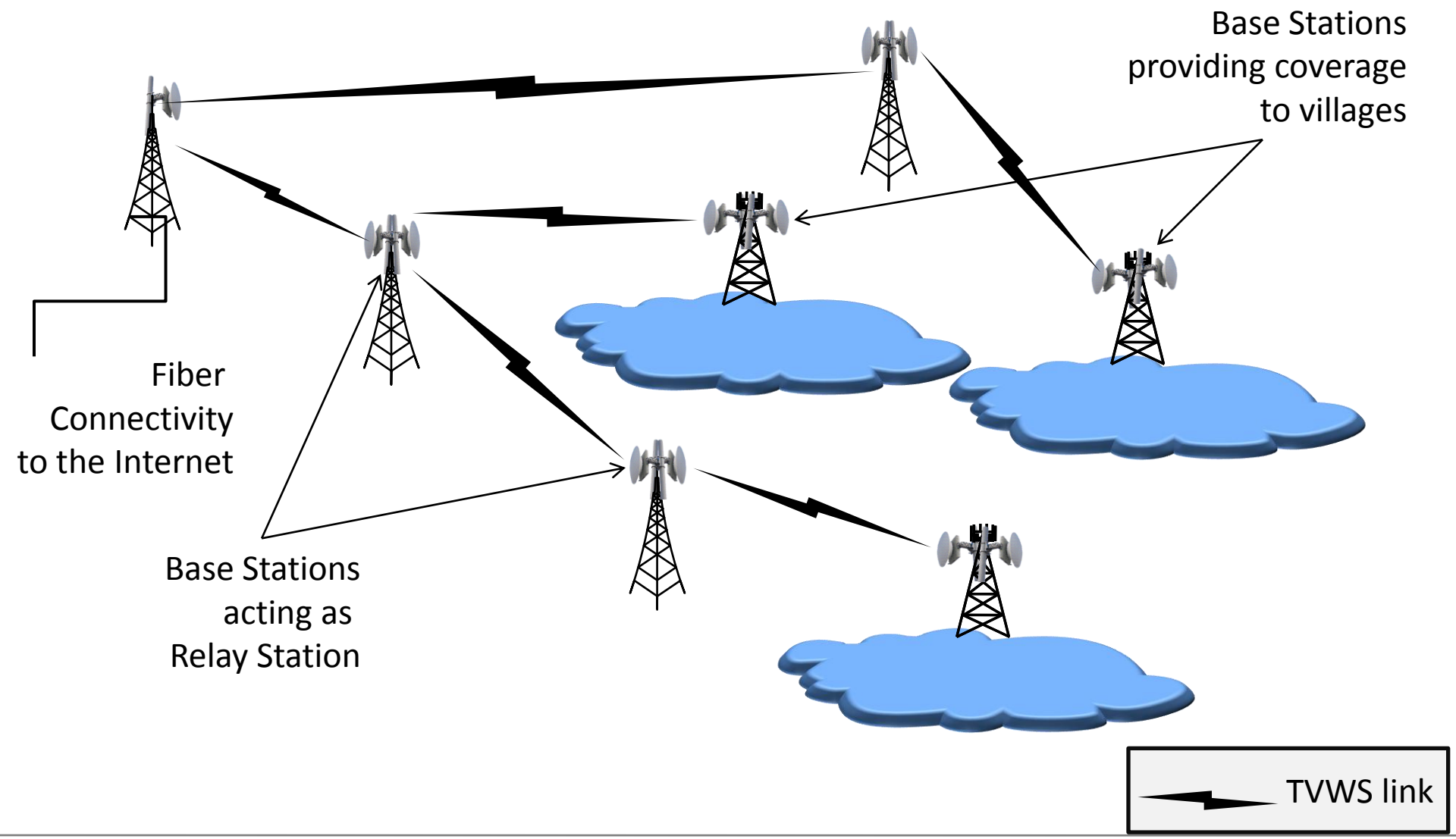
- Measurements carried out at 30 locations
- Two channels (DD 1 & DD 2) being transmitted at 175 MHz and 535 MHz respectively
- Only one channel in 470-585 MHz band
- **The bands 585-698 MHz & 698-806 MHz are presently unutilized.**



TV White Space's market potential for Broadband in India

- User devices must be extremely cheap
  - WiFi
- White space can be used for backhaul
  - Regulation on 470-585 MHz required urgently
  - Supporting WiFi access point
- Mobility not a major driver

Proposed Core TVWS Backhaul Network



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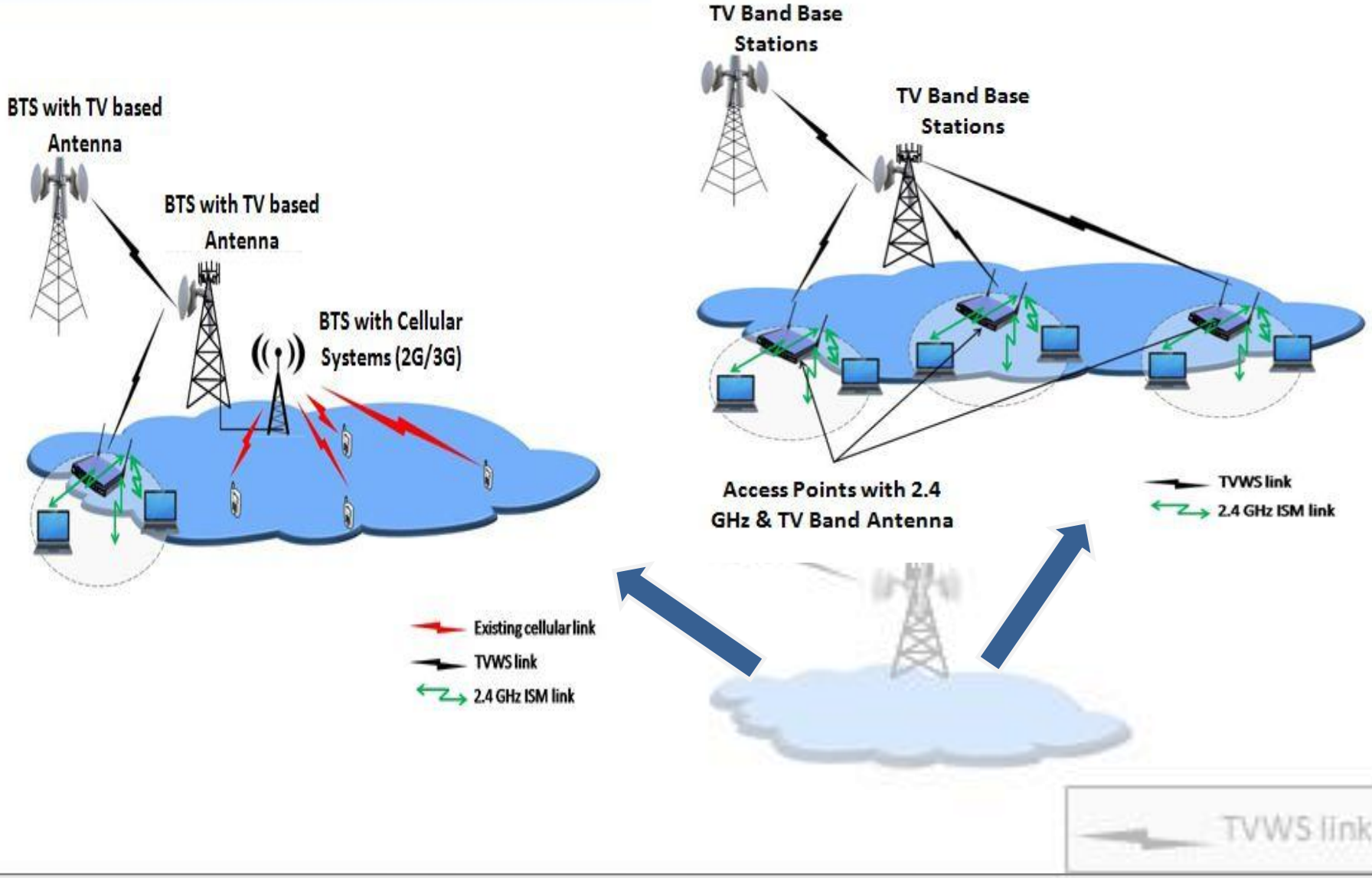

NFAP 2011

- Requirement of fixed and mobile services will be considered in 470 – 520 MHz and 520 – 585 MHz on case by case basis (IND36 in NFAP 2011)
- Requirement of digital broadcasting including mobile TV will be considered in 585 – 698 MHz subject to coordination on a case by case basis (IND37)
- IMT (BWA) will be considered in 698 – 806 MHz subject to coordination on case by case basis (IND38)

What we should do in sub-1 GHz ?

- Categorize licensing of sub-1GHz spectrum as:
  - Licensed (may follow market dynamics and spectrum auction)
  - Lightly licensed
  - Unlicensed
- Develop a Regulatory model based on the above licensing regimes
- We should facilitate deployments for low cost broadband technologies
  - Based on evolving standards such as 802.11af and 11ah (WiFi in 470-585 MHz band)
  - Make 5/10/15 MHz bandwidth unlicensed
- Develop Test-bed and conduct field trial
- Work towards frequency harmonization with rest of the word

Concluding Remarks

- India – one of the largest telecom market
- Indian requirements and IPR must get reflected into international standards
  - Significant opportunity to push our research into next generation wireless networks
  - This will catalyze manufacturing scenario in India
- Concerted efforts needed- academia and research labs need to address relevant research problems

Can we leverage & lead 4G+ and beyond?