Opportunities and Challenges for Broadband Wireless in India -Towards 5G

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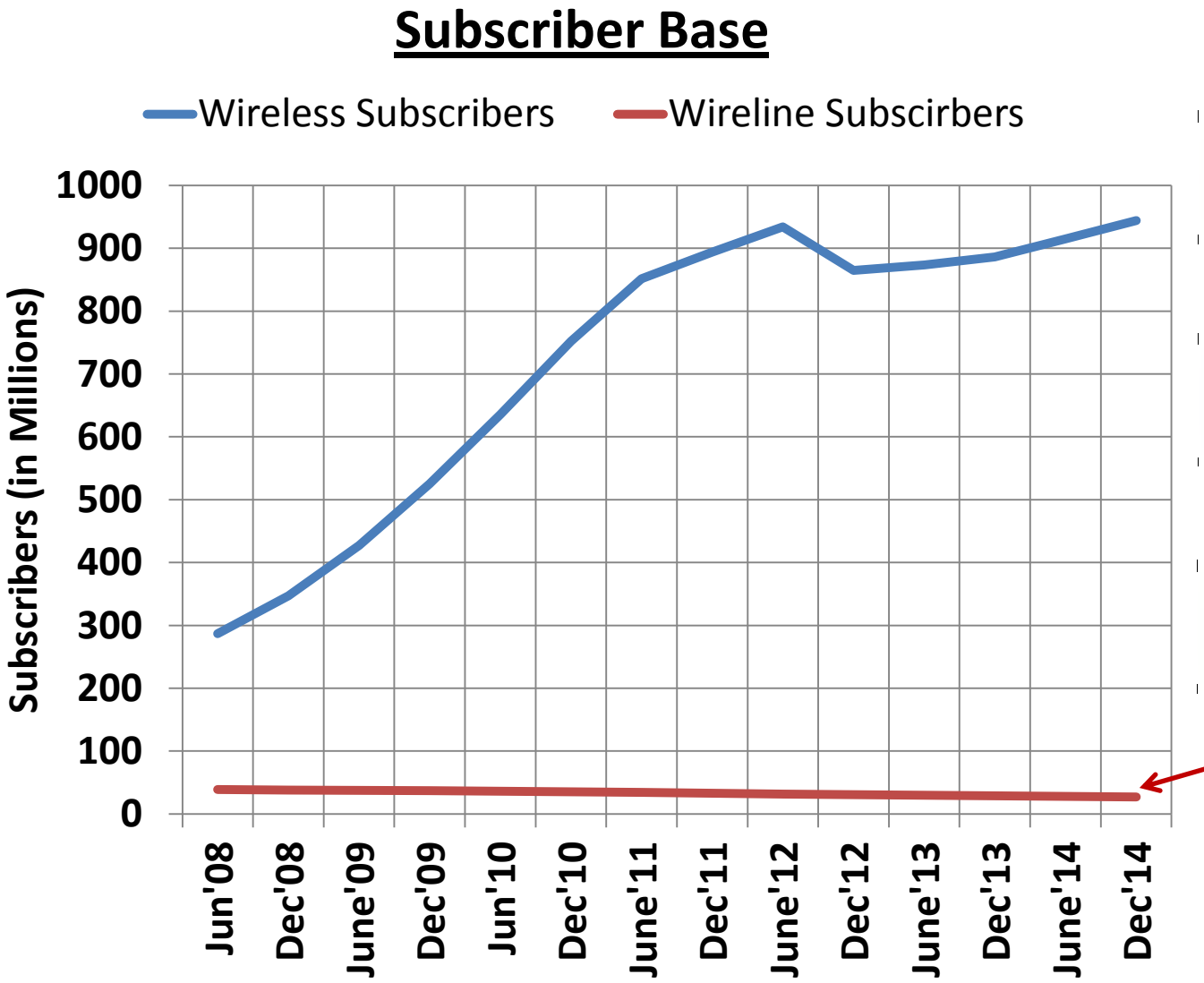
Telecom in India: Subscriber Base



Wireless subscribers
940+ Million

Overall tele-density
77 (Dec '14)

2nd largest telecom market globally

27 M

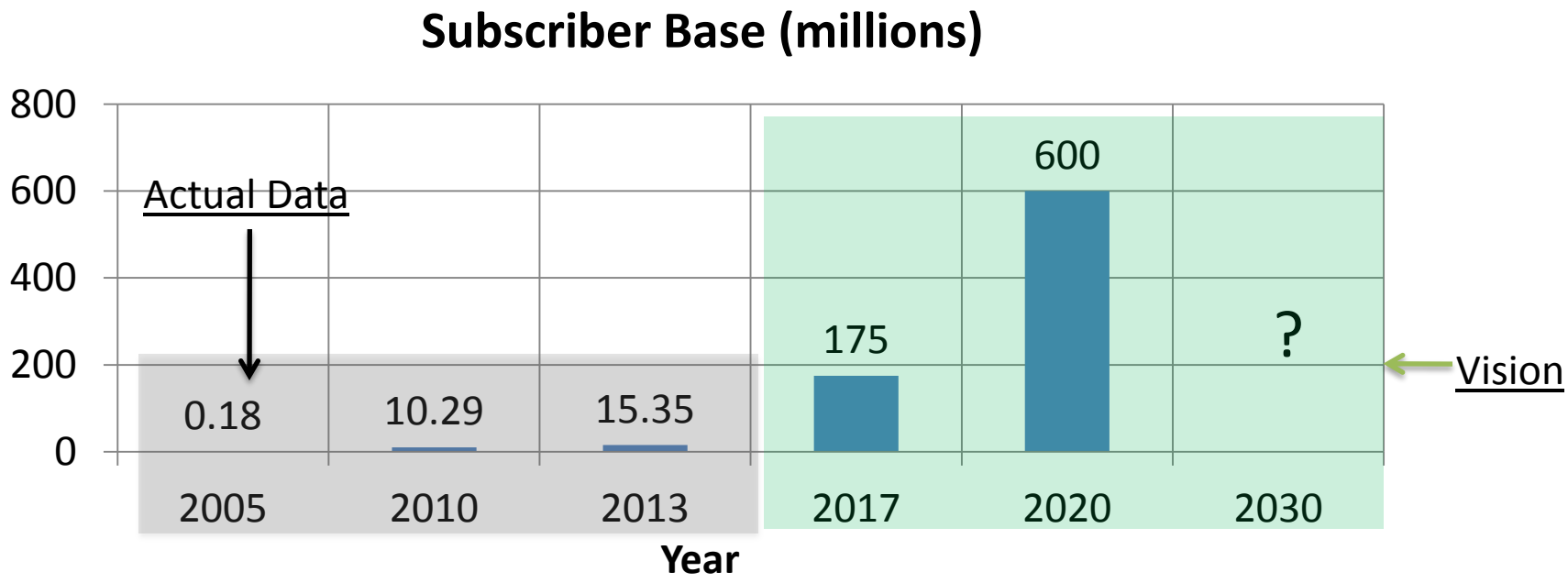
Source: The Indian Telecom Services Performance Indicator Reports, TRAI

However…

- Rural tele-density is still 46 (against urban teledensity of 148)
- Broadband subscribers at 85.74 million (Dec 2014)

National Policy and Vision

- TRAI Roadmap for National Broadband Plan



  - Metros may have higher penetrations as compared to national average
- National Telecom Policy
  - Broadband definition: 2 Mbps

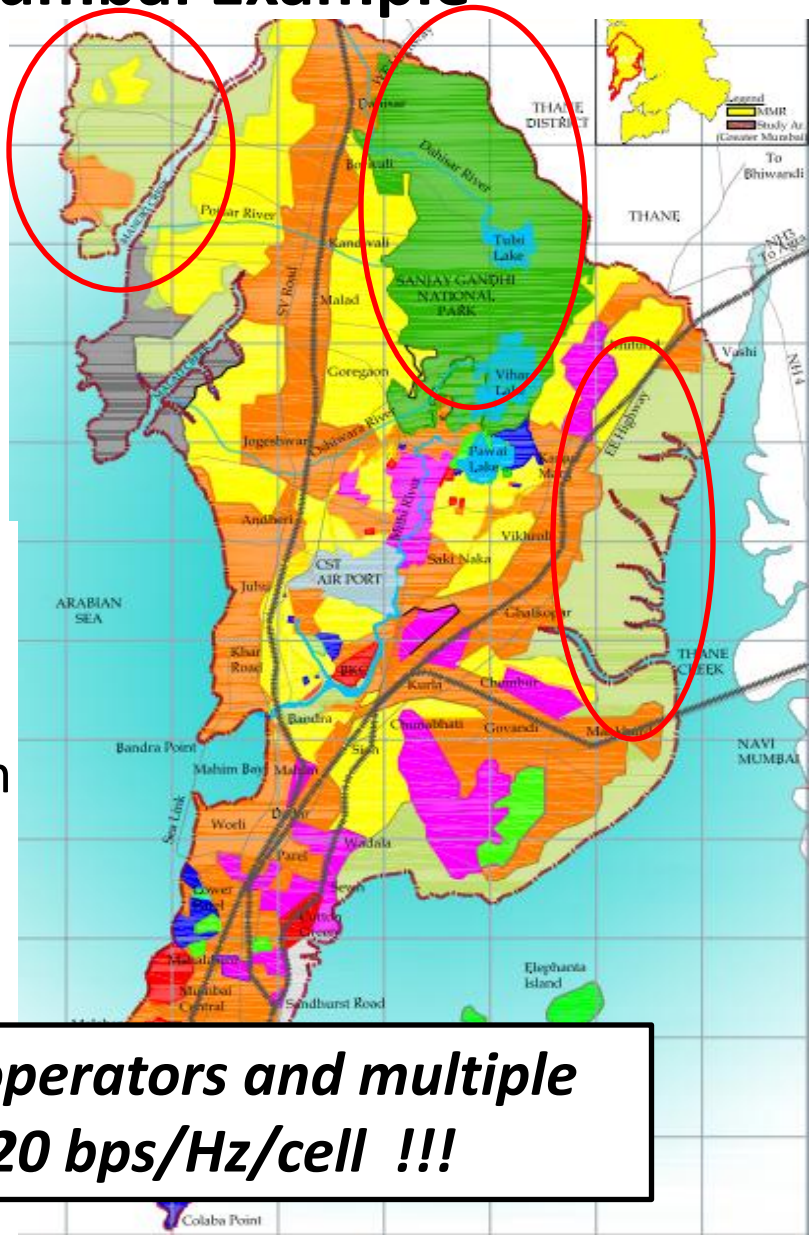
Traffic Growth in India – 5G?

- India needs primary broadband connectivity to 250 M homes, for 250 GB/month at 2 Mbps
- Translates to 100 Exabytes per month for India alone which is 8x the expected global mobile traffic by 2017!!

Future Wireless Broadband Demand

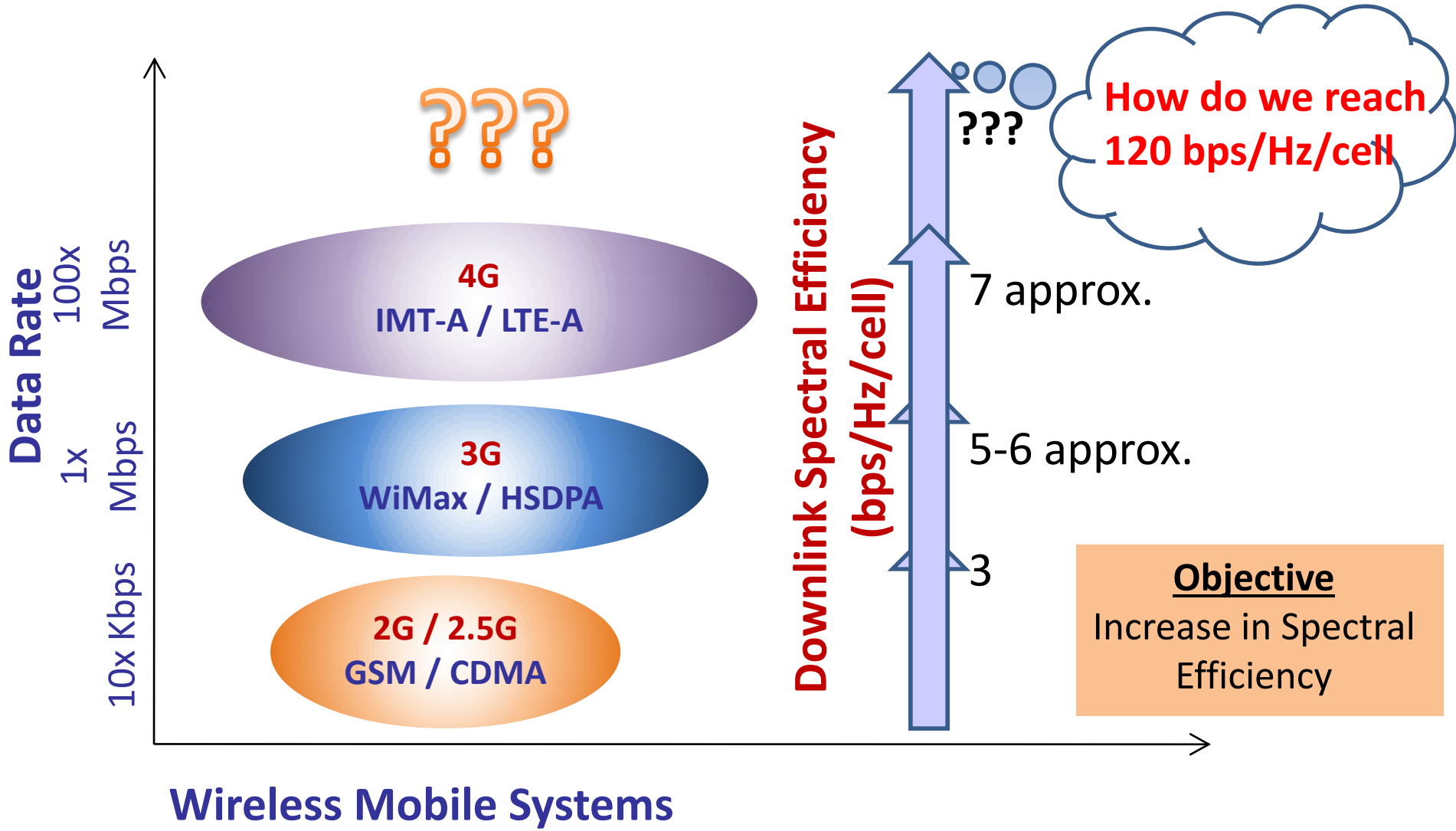
Broadband through Wireless – Mumbai Example

- Population density – 21k/sq.km
- Approx 34% wet land and forests
- Actual population density
  ~ 90-100k/sq.km. in some areas
  or even more
- 25k households / sq.km
- Assume 100% households have broadband
- 2Mbps per household
- Very high capacity required: 50 Gbps/sq km
  - Assuming 3-4 cells/ sq km (radius less than 500m)
  - We need about 12 Gbps per cell



With 100 MHz per cell (multiple operators and multiple technologies) ~ whopping 120 bps/Hz/cell !!!

Evolution of Wireless Systems



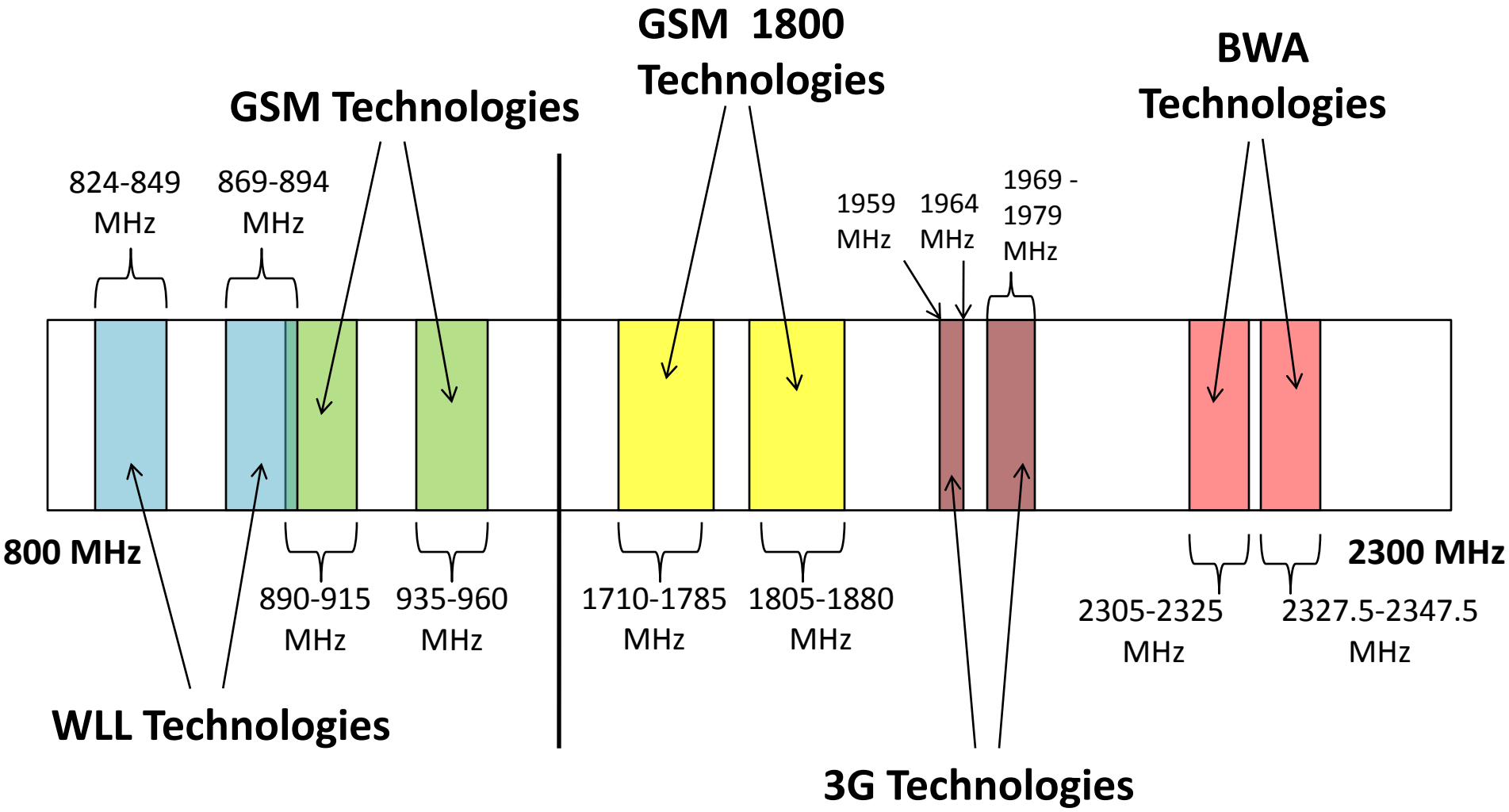
What does India need for 5G?

- Can we avoid new BTS roll outs?
  - We have 740,000 BTSes (all macro) already in India
  - We have 3,700 BTSes in Mumbai alone!!
- Can we avoid need for new/more spectrum
  - Cost is transferred to end-customer
  - Makes the solution unaffordable
- Do we need to support high-speed mobility (300 km/h)?
  - Traffic crawls in cities; 80 km/h on highways
- Do we need not address multiple device connectivity?
  - Crying need is for primary broadband connectivity

We need a focussed and cost-effective solution!

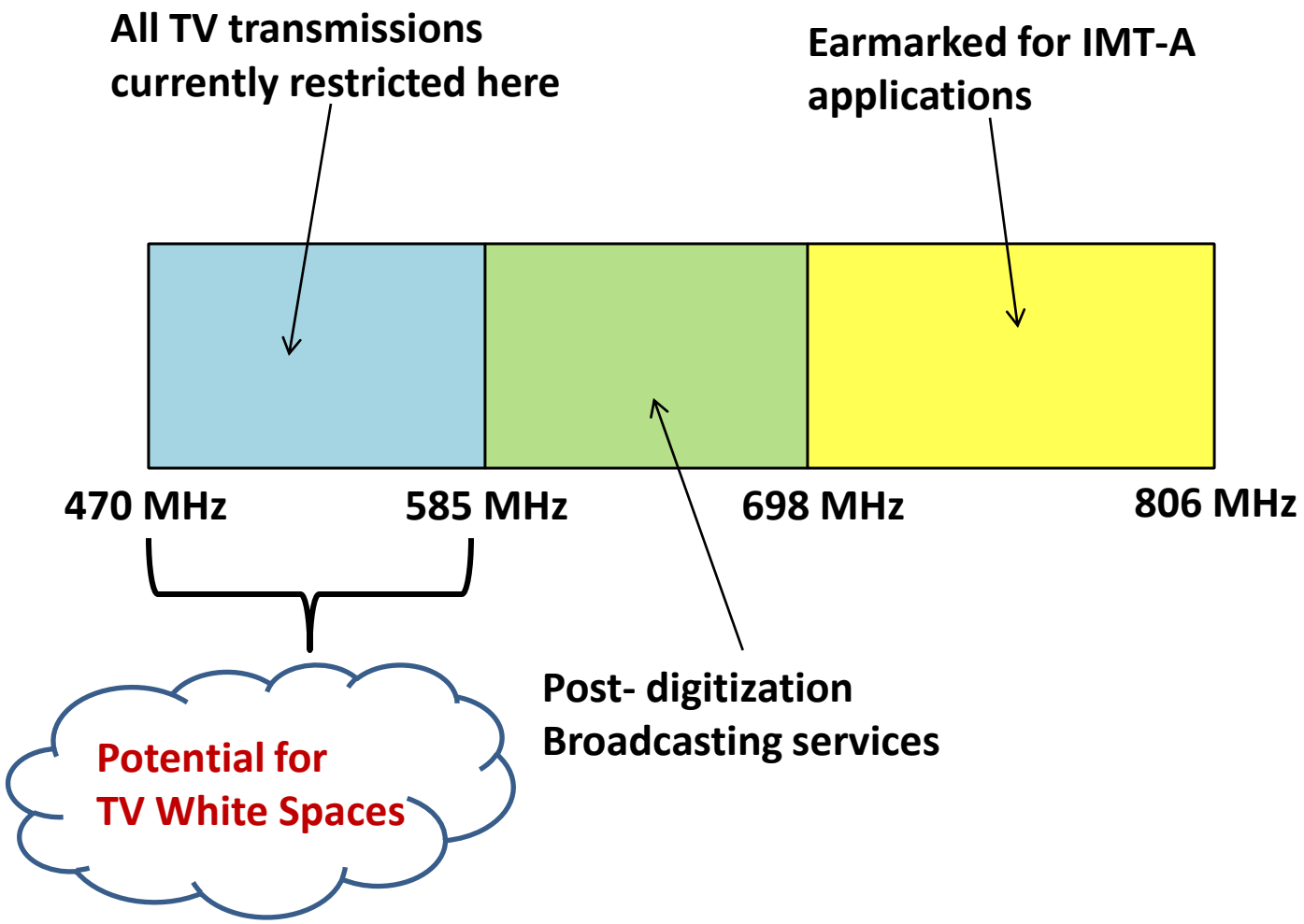
Spectrum Landscape in Indian Telecom Market

800 – 900 MHz and 1700 – 2300 MHz band



Spectrum Landscape in Indian Telecom Market

470 – 806 MHz band



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)

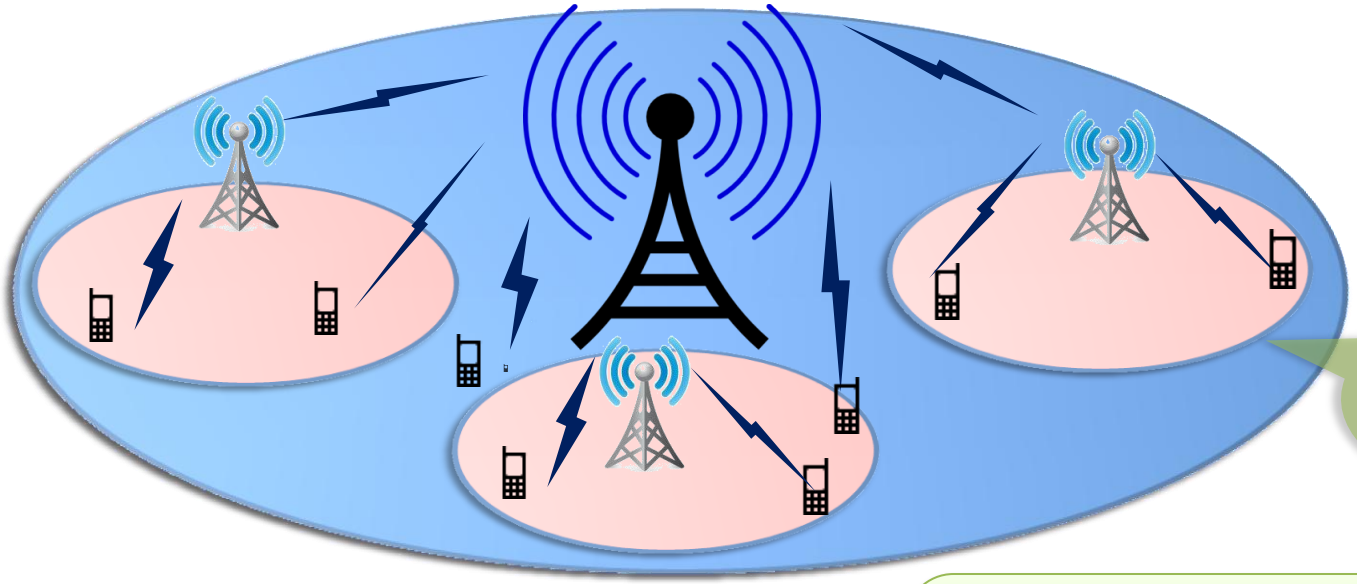
250 MHz expected to be released over 3 years (Requirement is about 500 MHz of spectrum)

Small Cells

Macro Cell

Macro Cells

- Cover radius of 500m to 1km
- High transmit power (46dBm / 40W)
- Low spectral efficiency

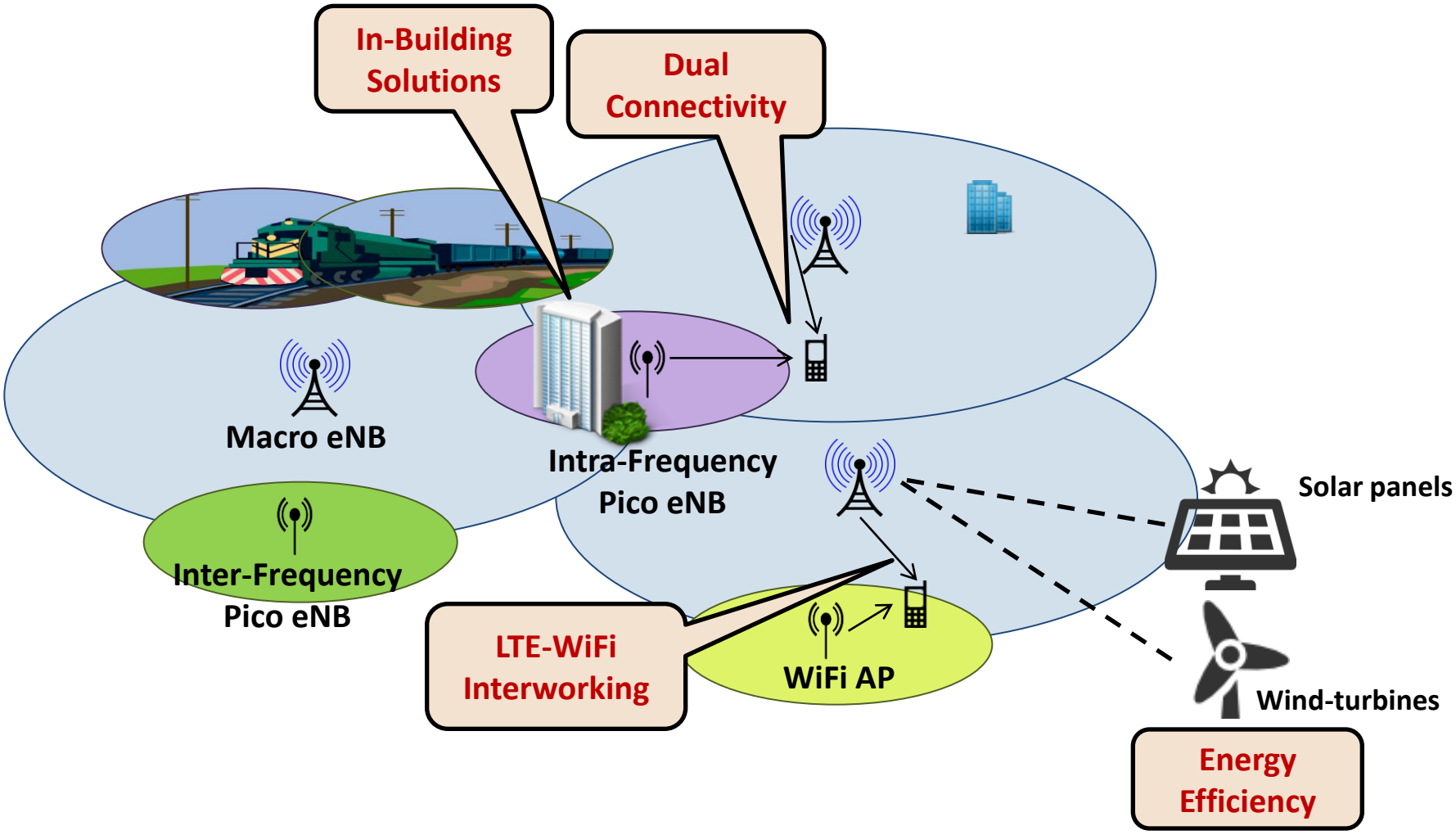


Small Cell

Small Cells

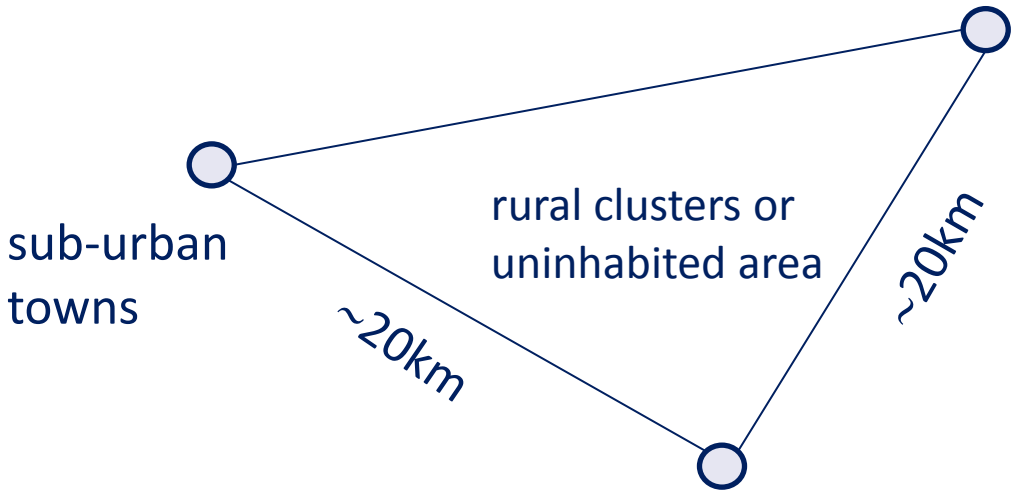
- Cover very small radius (< 100m)
- Lower Transmit Power! (30dBm/1W)
- High Spectral Capacity

HetNet - Densification



Key Problem in Rural Broadband Coverage

- Broadband coverage in rural areas is desirable but it is difficult due to cost and low return on investment
- Recently, Government of India has announced a National optical fiber network (NOFN) to link all sub-urban towns with optical connectivity

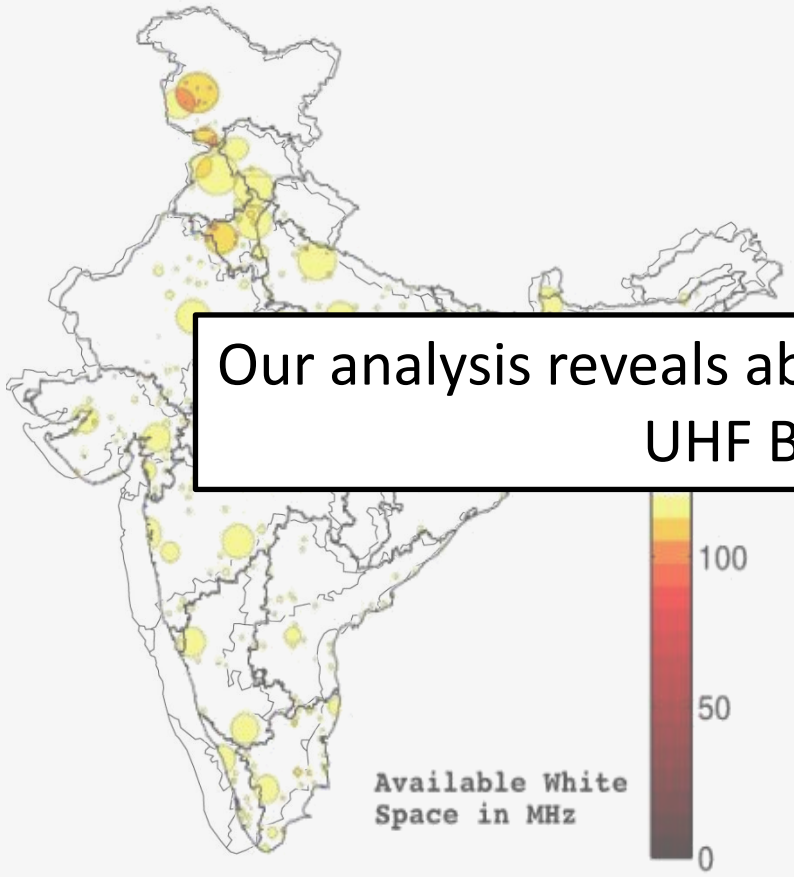


It is a challenge to provide an affordable broadband to sparsely populated rural areas due to backhaul considerations

Terrestrial TV Transmitter Plan of India

- On record, there are 1415 Terrestrial TV transmitters operating in India only by Doordarshan
  - UHF Band-IV (470-590MHz)
    - **Fifteen** channels of 8 MHz each — **373** transmitters across all India
  - VHF-I Band (54-68MHz)
    - **Two** channels of 7 MHz each — **8** transmitters across all India
  - VHF-III Band (174-230MHz)
    - **Eight** channels of 8MHz each — **1034** transmitters across all India
- We focus on the UHF Band-IV, i.e., 470-590MHz spectrum band
- Use of microphones is very limited in India

UHF Band-IV (470-590 MHz) Utilization in India



Our analysis reveals about 100MHz unused in UHF Band-IV

* Using protection/pollution viewpoint [Mishra-Sahai'09]

Band Characteristics

1. Primary user: Doordarshan 373 transmitters overall
2. 15 channels of 8MHz each
3. at least 12 annels are always available
4. Better propagation characteristics than existing unlicensed band
5. Potential for providing affordable rural broadband

Terrestrial TV Spectrum Allocations

Region 1 (Europe, Africa, Russia, Middle East)	Region 2 (Americas, Pacific)	Region 3 (India - Asia, Oceania)
470-790 Broadcasting	470-512 Broadcasting, Fixed, Mobile	470-585 Fixed, Mobile, Broadcasting
	512-608 Broadcasting	

- Government's national broadcaster named Doordarshan holds all of the terrestrial TV broadcasting license
- ITU Regulations for Region 3 (applies to India) allows use of 470-585 MHz for

  "Fixed, Mobile, and Broadcasting" as Primary Services

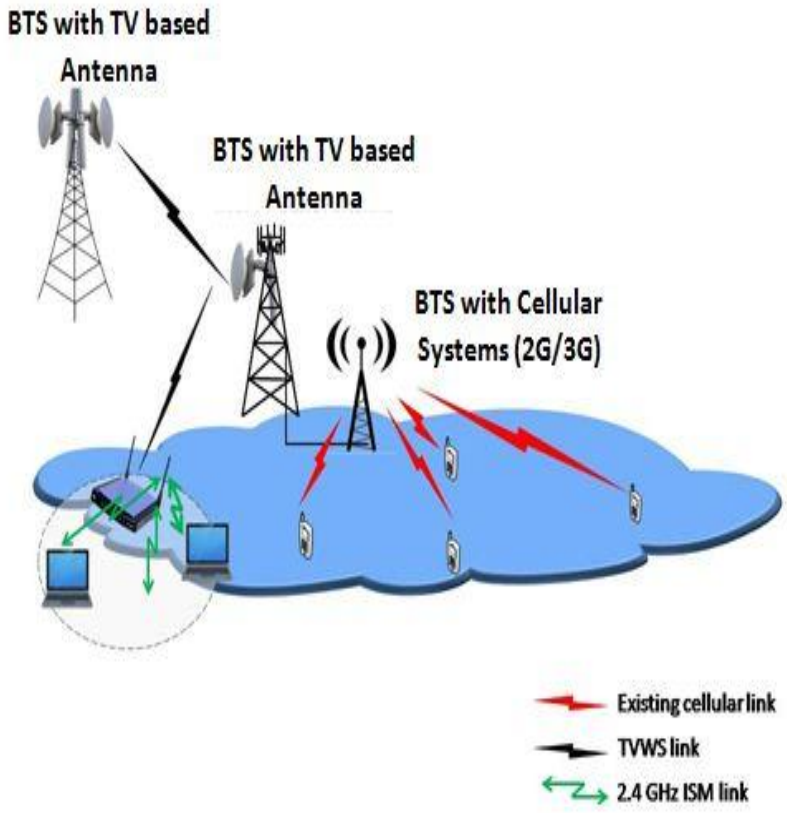
Our Proposal for Rural Broadband using UHF-IV

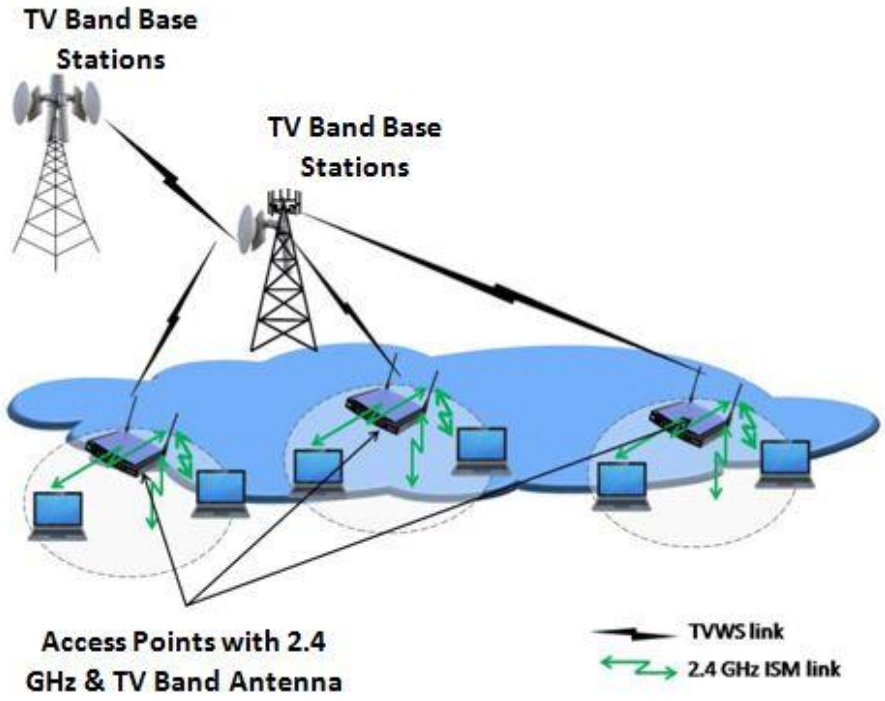
- Recently, Government of India has announced a National Optical Fiber Network (NOFN) to link all Gram Panchayats with optical connectivity.
- Leveraging on the NOFN of Government of India, we envisage the use of (currently under-utilized) UHF Band-IV to provide affordable broadband in (rural) India
- Summary statistics of NOFN / Gram Panchayats

Number of Blocks (NOFN Phase-I)	6,382
Number of Gram Panchayats (NOFN Phase I/II)	2,50,000
Number of Villages	6,38,619
Avg. number of Gram Panchayats per block	40
Avg. number of Villages per Gram Panchayat	2.56
Avg. number of Hamlets per Village	4

TV White Space for Middle Mile Connectivity

Middle-Mile Mesh Network in TV White Spaces

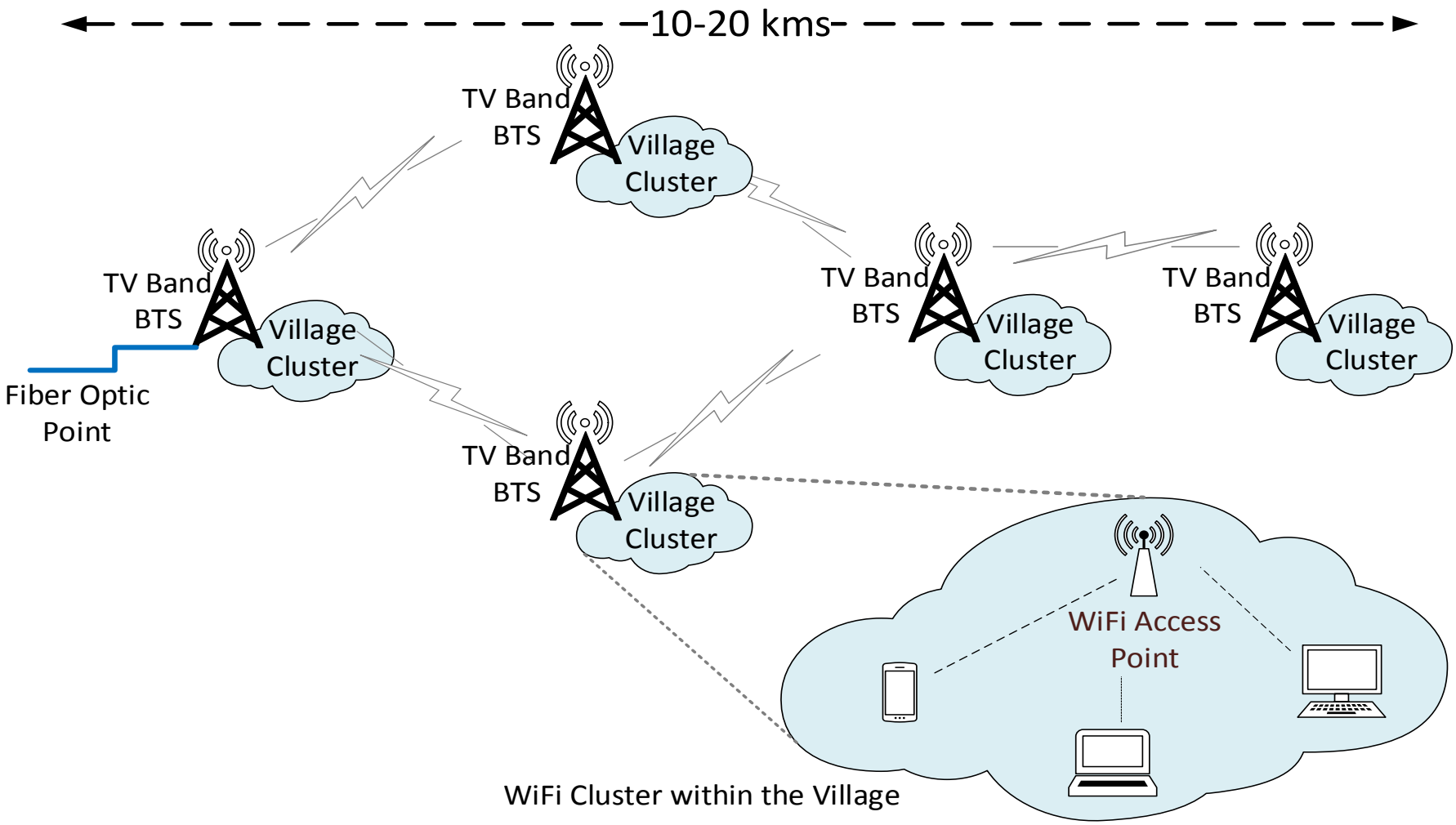




TVWS Network Architecture

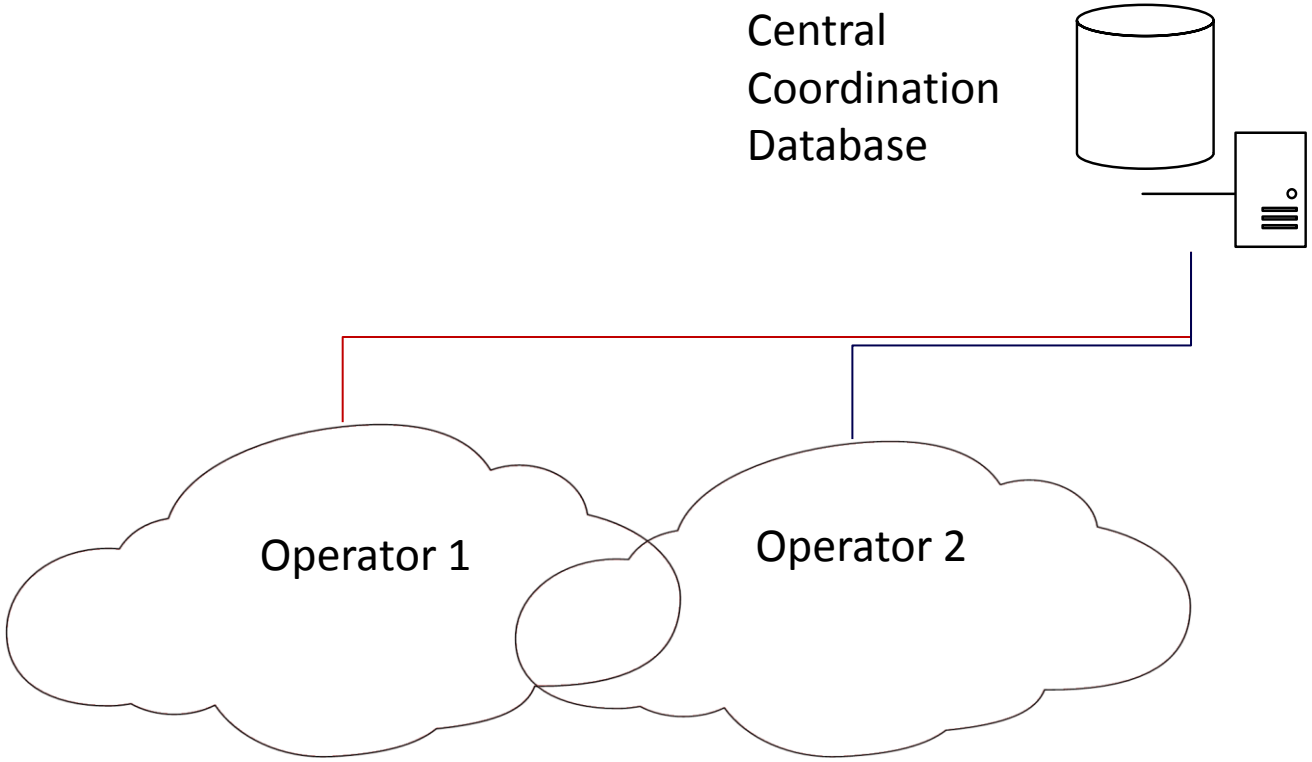
Wide band in Sub-1 GHz band significantly reduces deployment and operating costs as fewer towers required for coverage and relay

Middle-Mile Mesh-Network in UHF Band IV

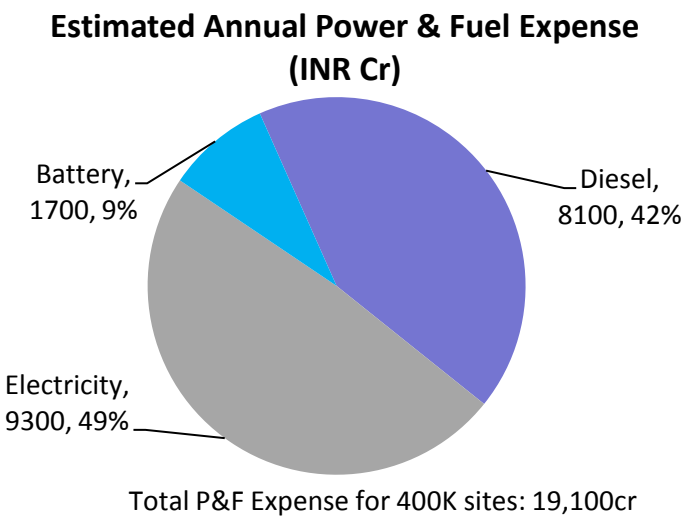


Shared Access

- Registered Shared Access (RSA)
  - Orthogonal channels across operators
  - Few shared channels across operators
  - All channels shared across operators

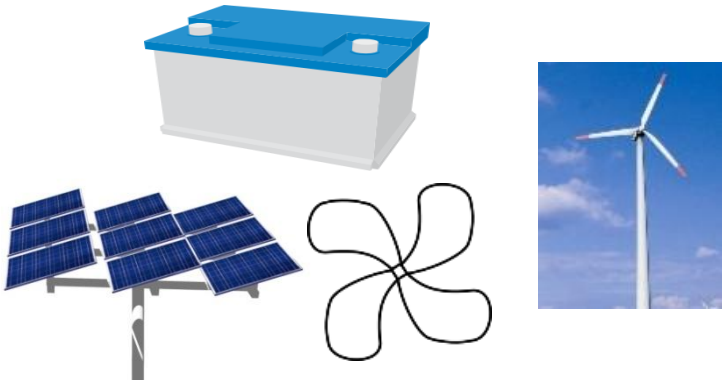


Background to Energy Problem



- DoT Guidelines on Green Telecom
  - 50% of rural towers and 33% urban towers to be provided by hybrid power by 2015
  - Declaration of carbon footprint (6months)
  - Use of Diesel Consumption is not a choice
  - Deploying Renewable Energy technologies

- The industry has been experimenting with several initiatives like Solar, Lithium batteries etc
- New technologies unable to check escalating energy costs



Industry and Operational Innovation

- Field challenges like diesel pilferage and Lack of engineering capabilities on field key bottlenecks for improving operational inefficiencies

~~Engineering Capabilities on field~~

Team of IIT Bombay engineers spent 1.5 years at TICET working on **OPEX Optimization** in Indian Telecom Industry

- Analyzed industry efforts towards energy cost reduction and upcoming technologies
- Collaborated with the industry to understand the ground realities of cell tower operations across circles

•Have patents and several Publications in this field
•Company incubated to commercialize technologies developed for improving Energy Efficiency in telecom network

Summary

- Mobile data traffic expected to grow exponentially
  - Spectrum requirement will grow exponentially
  - Energy cost will also go
- Primary Broadband and Rural connectivity are the crying need
  - Need a different approach for 5G !

Thank You!