Frugal 5G Test-bed: A Case Study of Palghar Experiment

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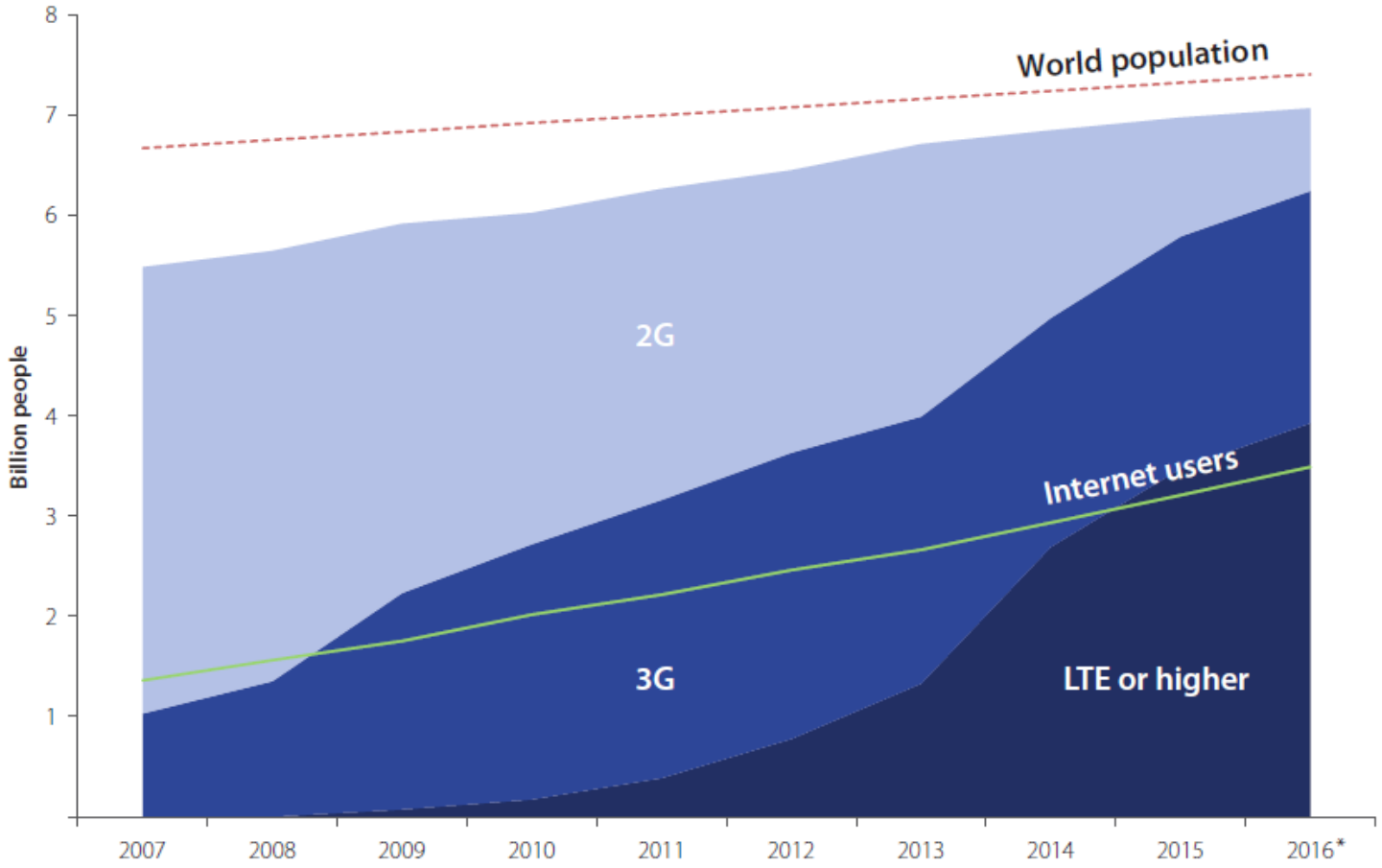
Outline of the Talk

- Broadband Status and Challenges in Connecting Rural India
- Rethinking 5G Requirements
- Potential Solution: TV UHF Band
- Test-bed 1: TV UHF Band Pilot Test-bed
- Test-bed 2: 25 Villages Palghar Project
- IEEE ComSoc Frugal 5G RRSA

Broadband Scenario: Worldwide

Around half of the global population is unconnected

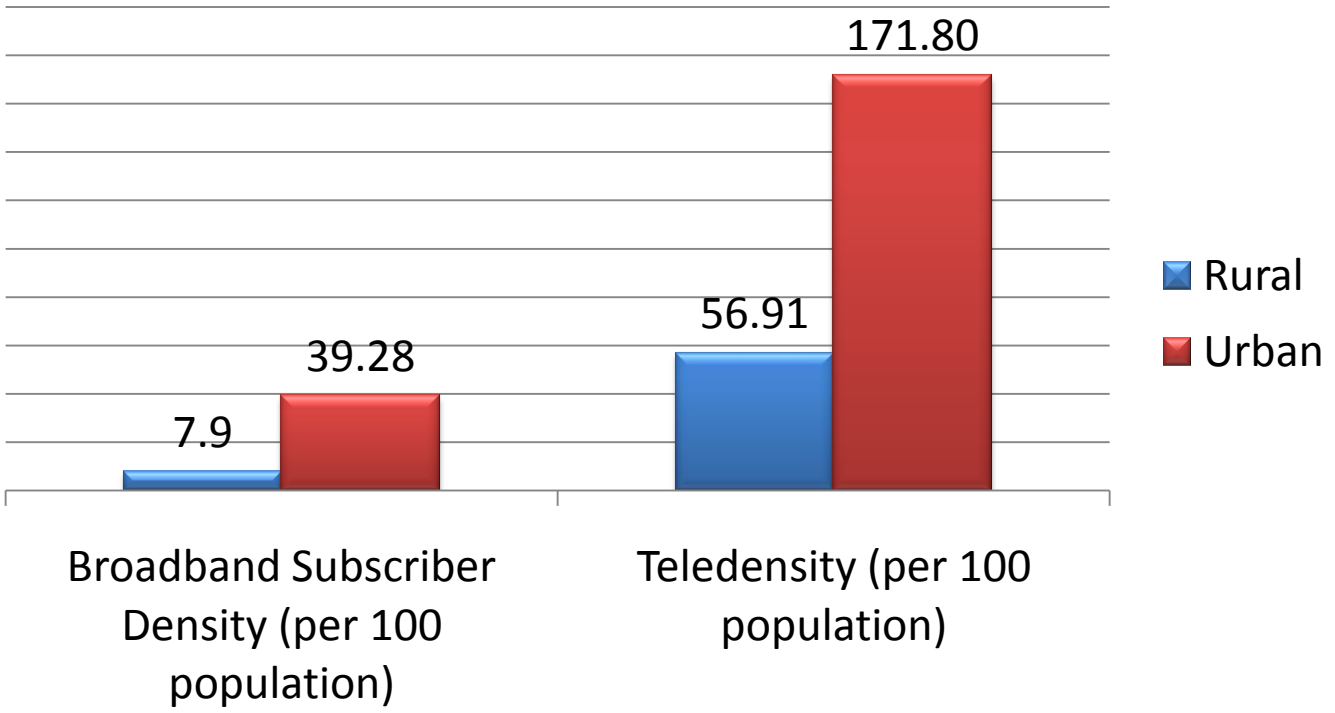


Source: International Telecommunication Union

Around 84% of global population lives in regions covered by wireless broadband (3G/4G) but the adoption rate is only 47%

Broadband Scenario: India

- In India, there are **276.52 million** broadband subscriptions in a population of about 1.34 billion
- Broadband penetration in rural areas is marginal



Source: TRAI, Cellular Operators Association of India (COAI)
(Statistics as on March 2017)

Challenges in Connecting Rural India

Low Average Revenue Per User (ARPU)

Unavailability of Fiber Backhaul

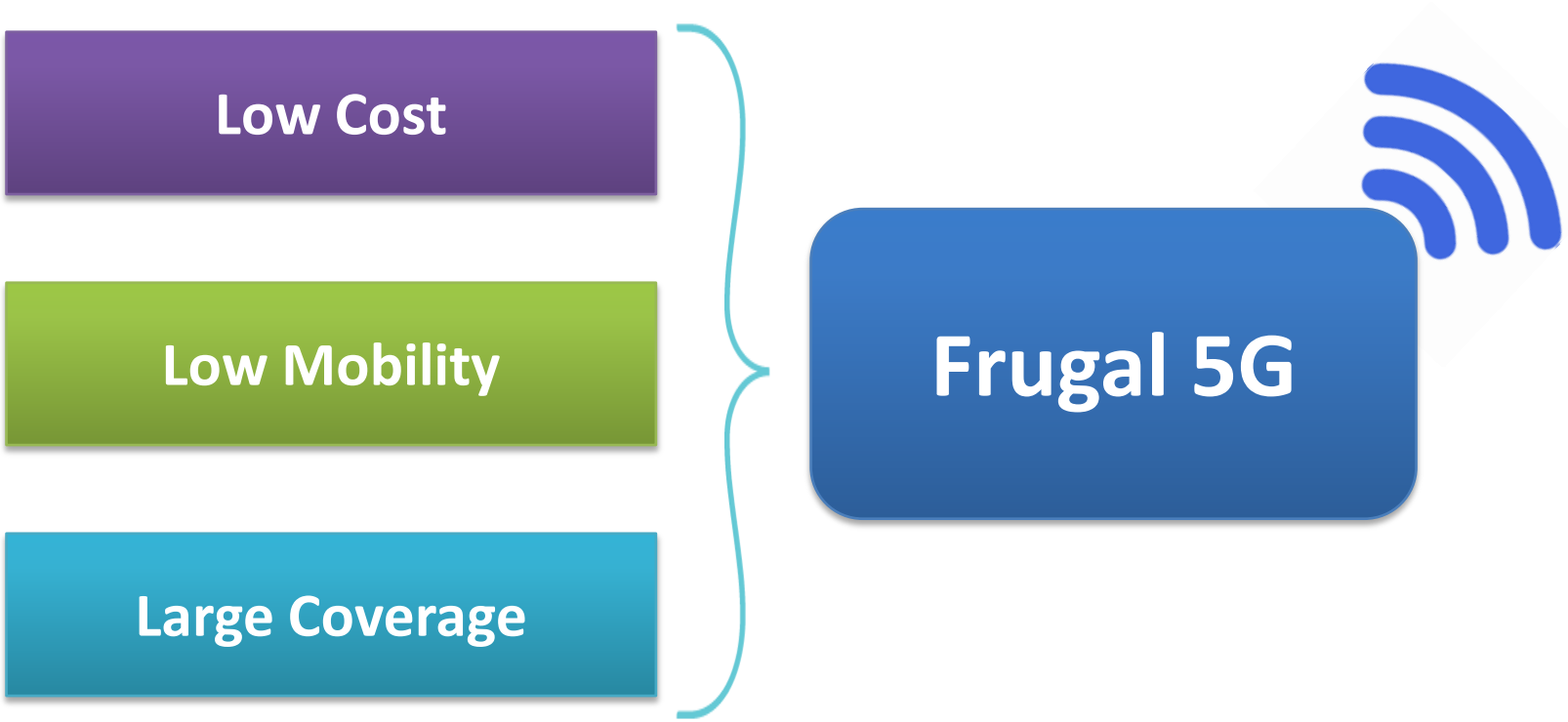
Intermitant Availability of Electricity

Rethinking 5G Requirements

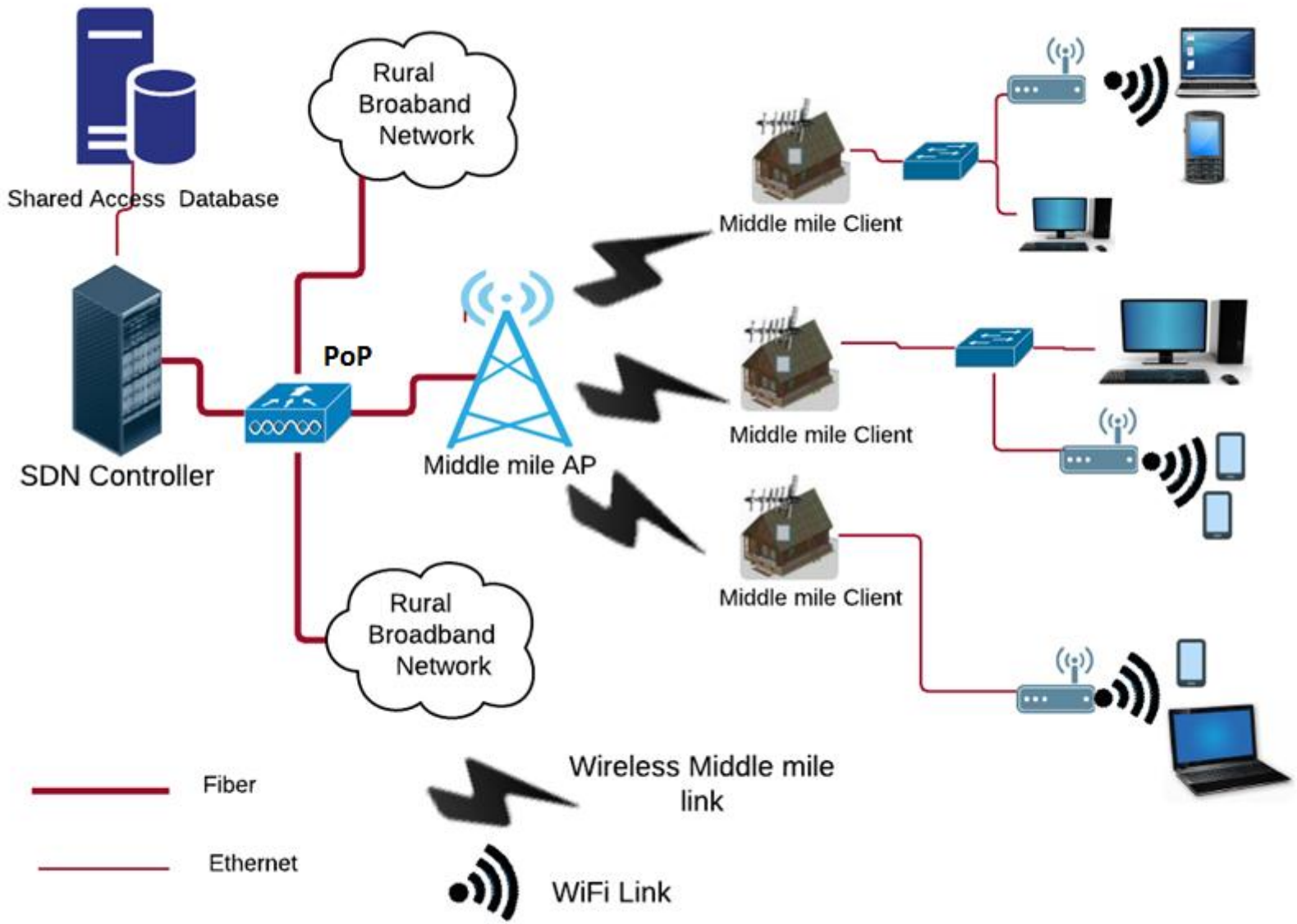
- Low cost solutions
  - Low Device costs
    - Simpler Hardware and RF Design reducing the device costs
  - Low cost Connectivity / backhaul solutions
    - Using wireless backhaul/middle mile instead of fiber
  - Lower spectrum cost
    - Efficient usage of spectrum
    - Using network sharing options to share spectrum across Radio Access Technologies (RATs) across operators
- Limited mobility support
  - Mobility is required but not very high speed
  - Fixed primary access is the key

Rethinking 5G Requirements (Contd.)

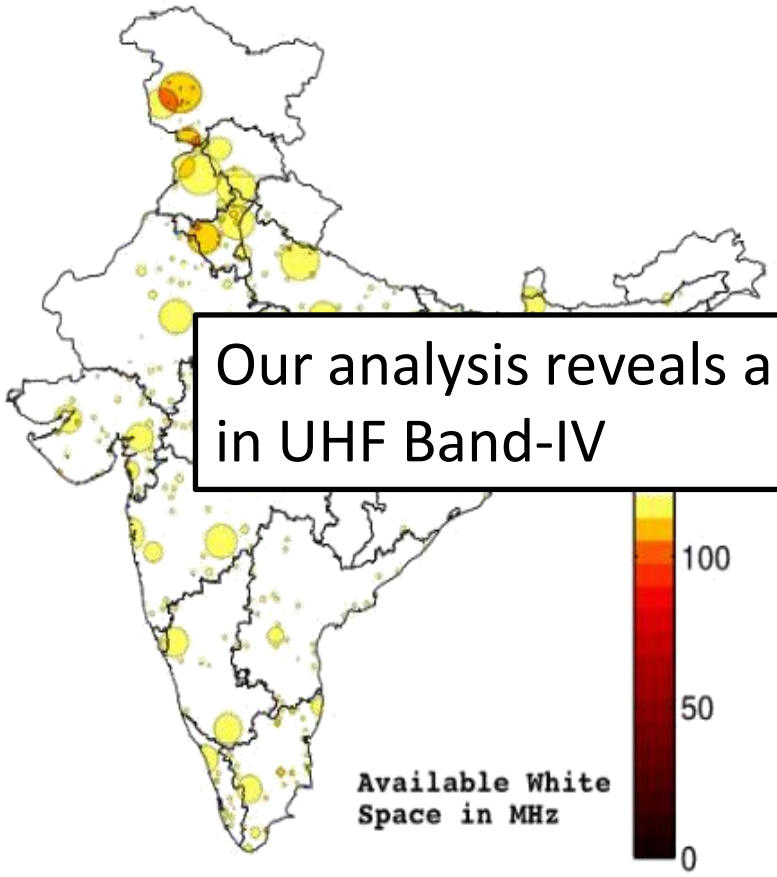
- Energy efficient solutions
  - Lowering system energy consumption
  - Support for operation in power saving mode
  - To enable working off non-conventional energy sources
- Large coverage area support
  - Support for large cells to reduce CAPEX and OPEX
- Less stringent availability requirements


Low Cost
Low Mobility
Large Coverage
Frugal 5G

Frugal 5G – Envisioned Architecture



Potential Solution: TV UHF Band



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

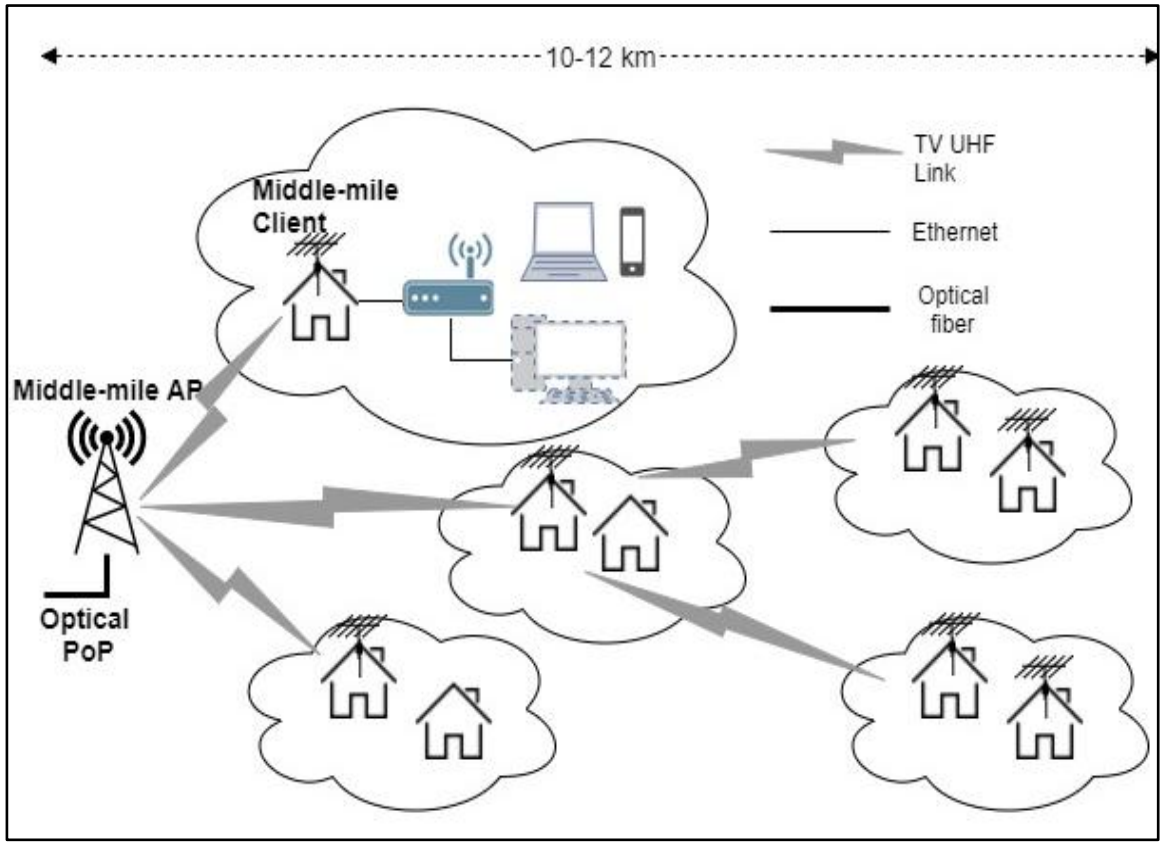
* Using protection/pollution viewpoint [Mishra-Sahai'09]

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

Middle-Mile Network

- Optical fiber terminates a few km away from villages
- Extension of optical PoP to the villages
- End users access the broadband through Wi-Fi Access Points
- Wi-Fi APs connected through a **middle mile network** in TV UHF band

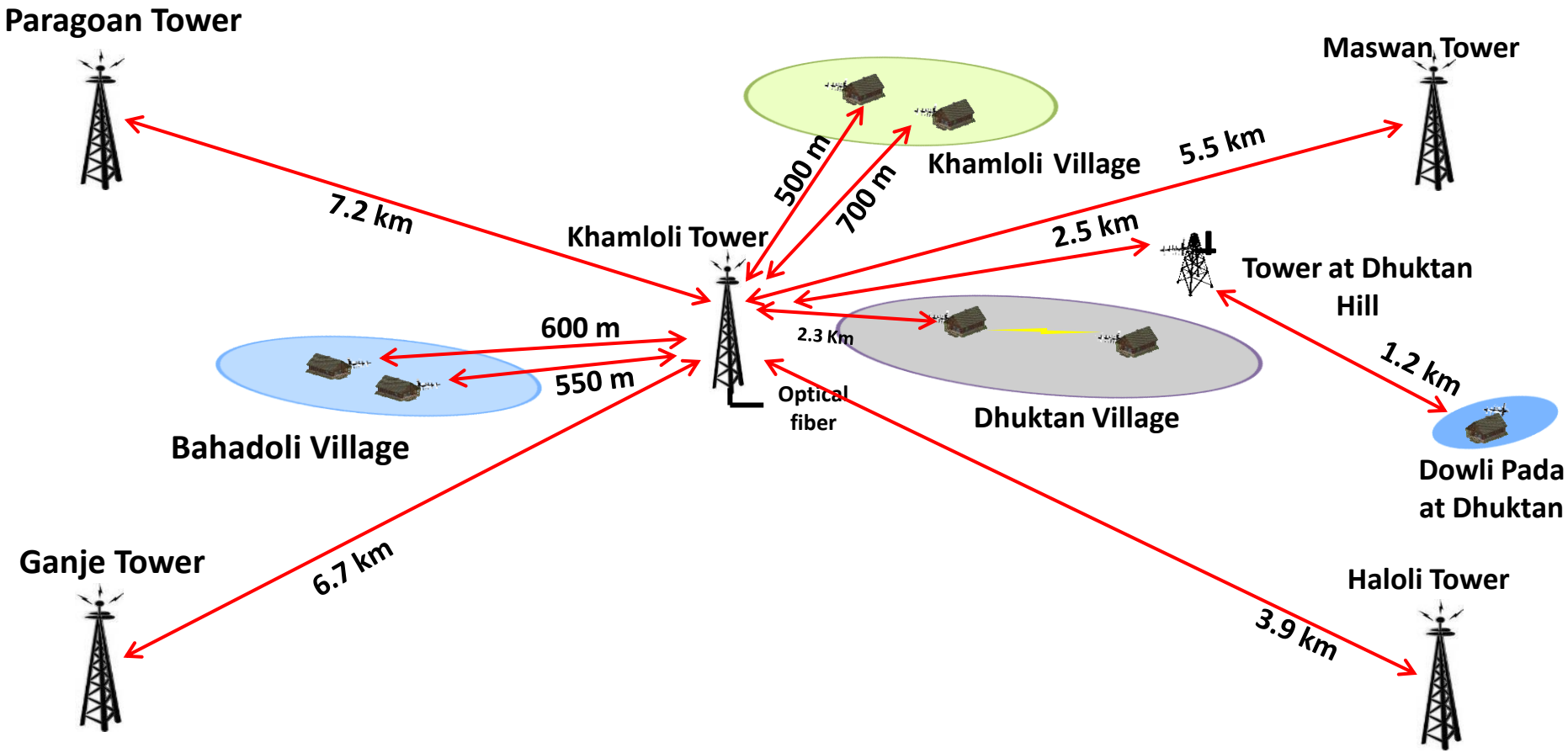


Testbed 1: TV UHF Band Pilot test-bed

- First TV White Space test-bed in India
- Situated in Palghar, Maharashtra
- Spanning an area of 25 sq. km., covering 7 villages
- Deployed 10 Wi-Fi APs and 3 GP kiosks, backhauled via TV UHF link
- A 20 Mbps leased line provisioned at the PoP
- TV UHF band device: Off-the-shelf Wi-Fi with 500 MHz RF

Objective: To test the feasibility of TV UHF band for providing connectivity in rural areas

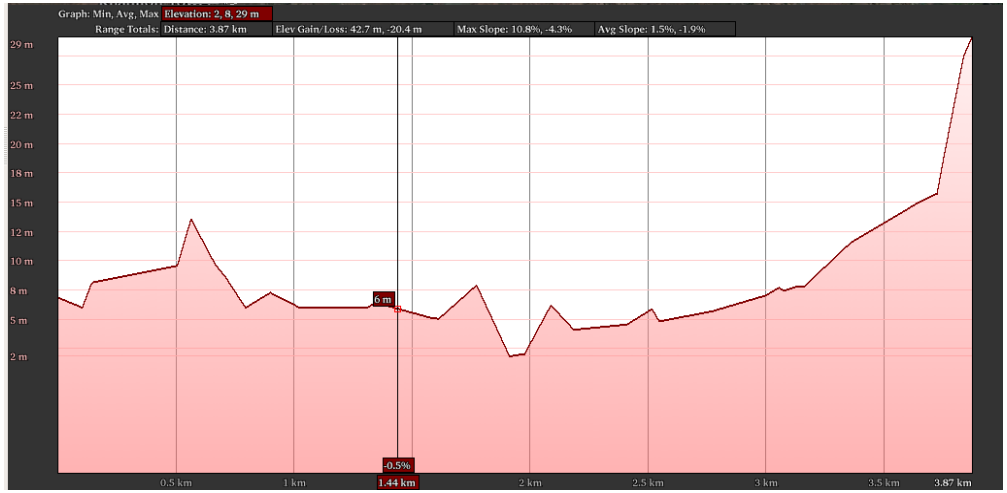
Network Topology of TV UHF Band Pilot at Palghar



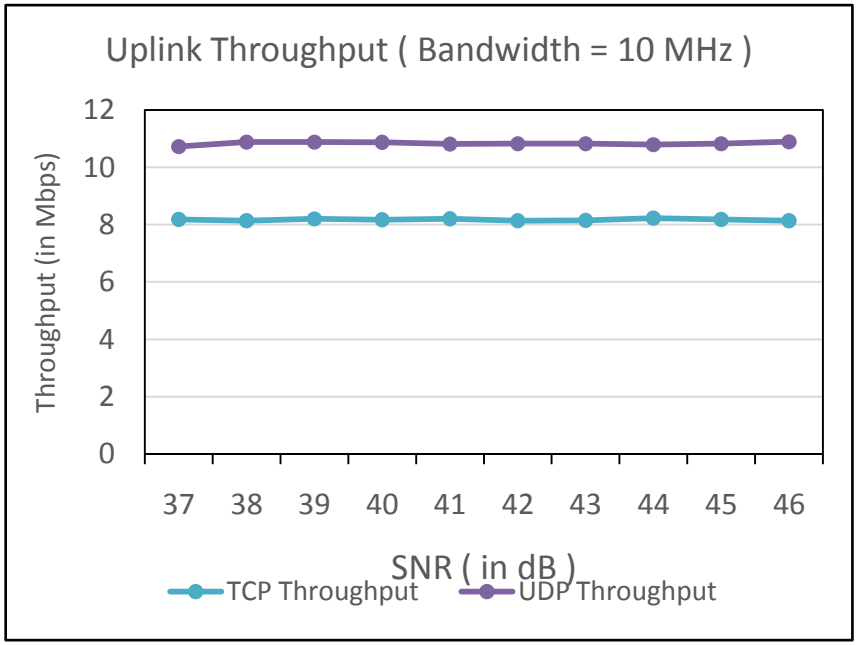
Test-bed Deployment in Palghar

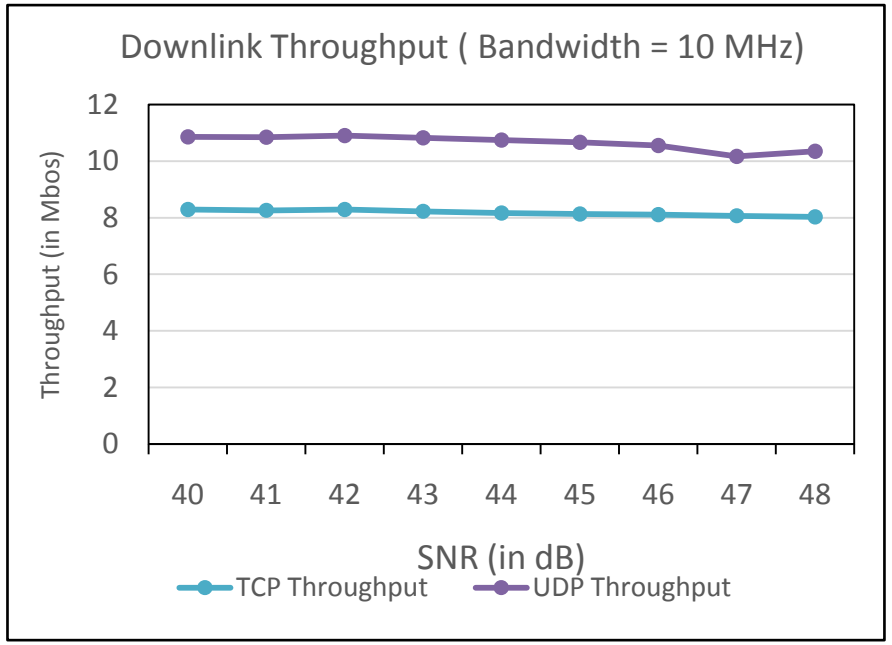
Results (Khamloli-Haloli Link)

Elevation profile



Type: Line of Sight link
Base Station: Khamloli (at 30m)
Client: Haloli (at 30m)
Distance between base station and client: 3.9 km





Impact Assessment

Time and Money Saved

$ 300 per Month

18 Miles per Activity

3 Hours per Activity

Beneficiaries

The villagers themselves who would be impacted through internet connectivity

Government to people and people to government

Internet access via Wi-Fi Hotspots

Learnings from the test-bed

- Need for a cost-effective technology solution
  - Reduction in cost of device
  - Use of renewable energy sources (solar energy)
  - Infrastructure sharing and reuse
- Need for a sustainable economic model based on partnerships
  - Involvement of community
  - Skill development of local youth
  - Viability gap funding from government and private organizations

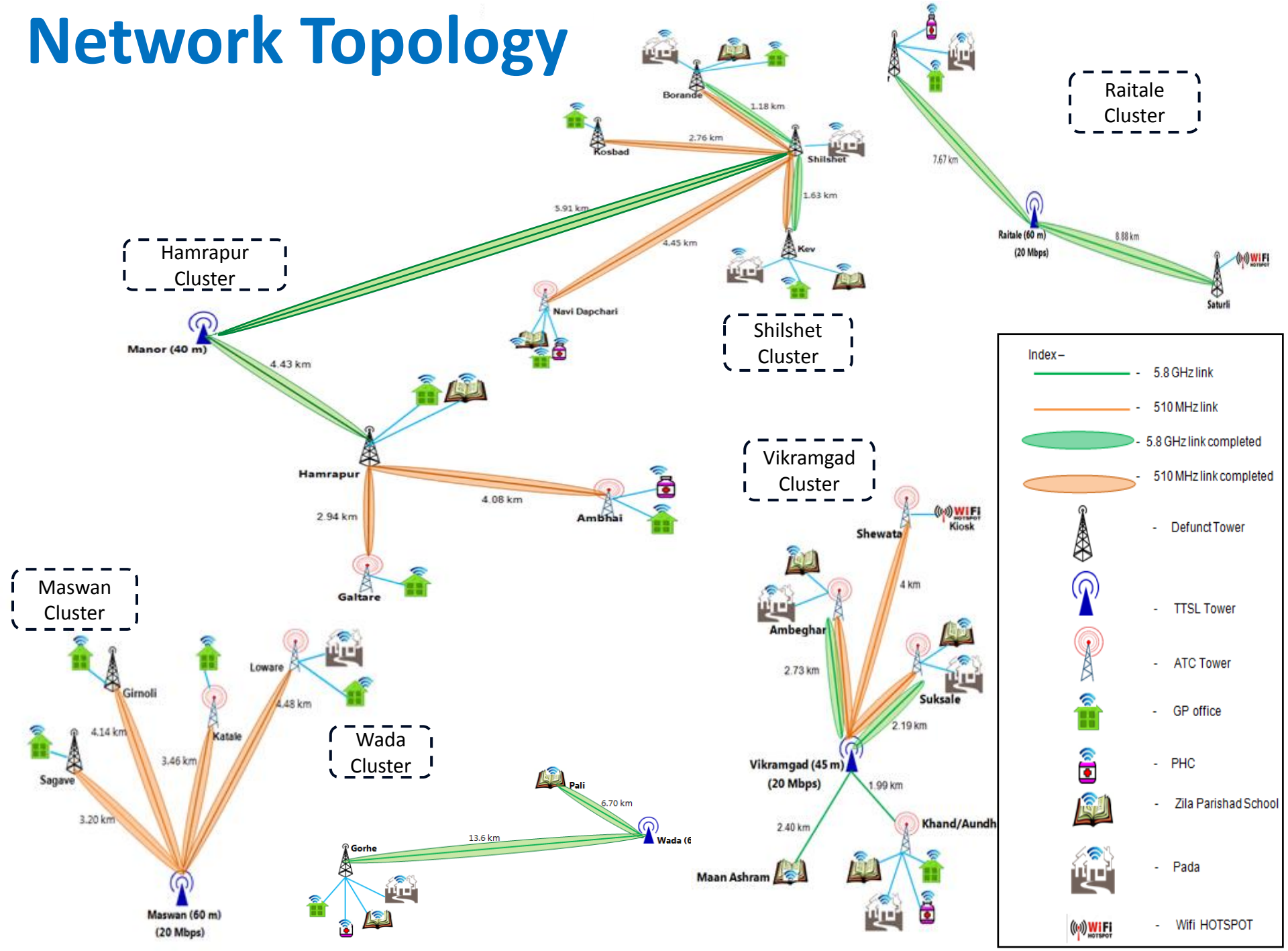
Test-bed 2: 25 Villages Palghar Project

- Situated in Palghar, Maharashtra
- Connecting 25 villages spanning over an area of approx. 350 sq. km.
- Consists of 6 clusters, each cluster having one optical PoP
- Total bandwidth provisioned is 116 Mbps
- 65 Wi-Fi APs serving GP offices, schools, Primary Health Care (PHC) centers, anganwadi and community centers
- Unlike Test-bed 1, this test-bed also uses Wi-Fi (5.8 GHz) link as backhaul

Objectives

1. **To study the feasibility of technology mix for a cost-effective solution**
2. **Development of a sustainable economic model**

Network Topology



Infrastructure Reuse and Sharing

- Use of 12 defunct towers in the test-bed
  - 10 - 15 meter heighted towers at GP location
  - Old towers strengthened for use
- In GPs without a defunct tower, 15 meter tower or 9 meter pole has been set up
- In some GPs, the roof is used or devices are clamped on to the GP walls.

Use of Solar Power

- All the towers/poles at GPs equipped with solar panels and 48 hour battery backups
- All the devices run on solar power making it less dependent on grid electricity

Village Level Entrepreneur at Work

Frugal 5G – IEEE ComSoc RRSA Study

- Study & analysis of existing wireless broadband technologies
  - IEEE 802.11 WLAN, IEEE 802.22 WRAN, 3GPP-UMTS, 3GPP-LTE
  - Gap analysis with respect to following requirements
    - Low Cost Solution
    - Reduced Energy Consumption
    - Low Mobility scenarios
    - Usage of non-conventional energy sources

Frugal 5G – RRSA Study Phase(Contd.)

- Usage of affordable Wireless middle-mile network to connect the core network to IEEE 802.11 based access network
  - TV UHF spectrum based solution
  - Mesh network in mmWave
- Dynamic spectrum sharing for multi-operator co-existence
- Scalable control and management of access and middle mile network
  - Software defined network (SDN) based control and management
  - A simplified IP based network architecture

Meet our Team

Thank you