Enabling Affordable/Rural Broadband in the 470-585MHz Spectrum Band

Abhay Karandikar

Electrical Engineering

Indian Institute of Technology Bombay, India

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

NFAP 2012

- **IND 36-**--Requirement of fixed and mobile services will be considered in 470-520MHz and 520-585MHz on case by case basis
- **IND 37-** Requirement of digital broadcasting including mobile TV will be considered in 585-698MHz subject to coordination on a case by case basis
- **IND 38-**IMT (BWA) will be considered in 698-806MHz subject to coordination on case by case basis

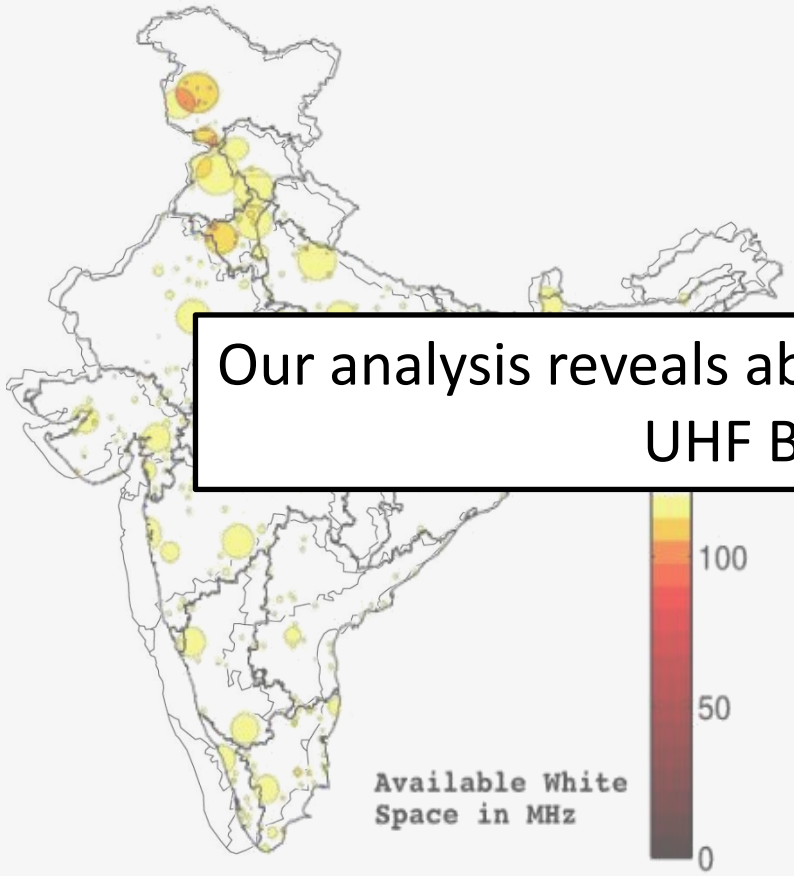
Terrestrial TV transmitter plan of India

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 (470-590MHz) Utilization in India



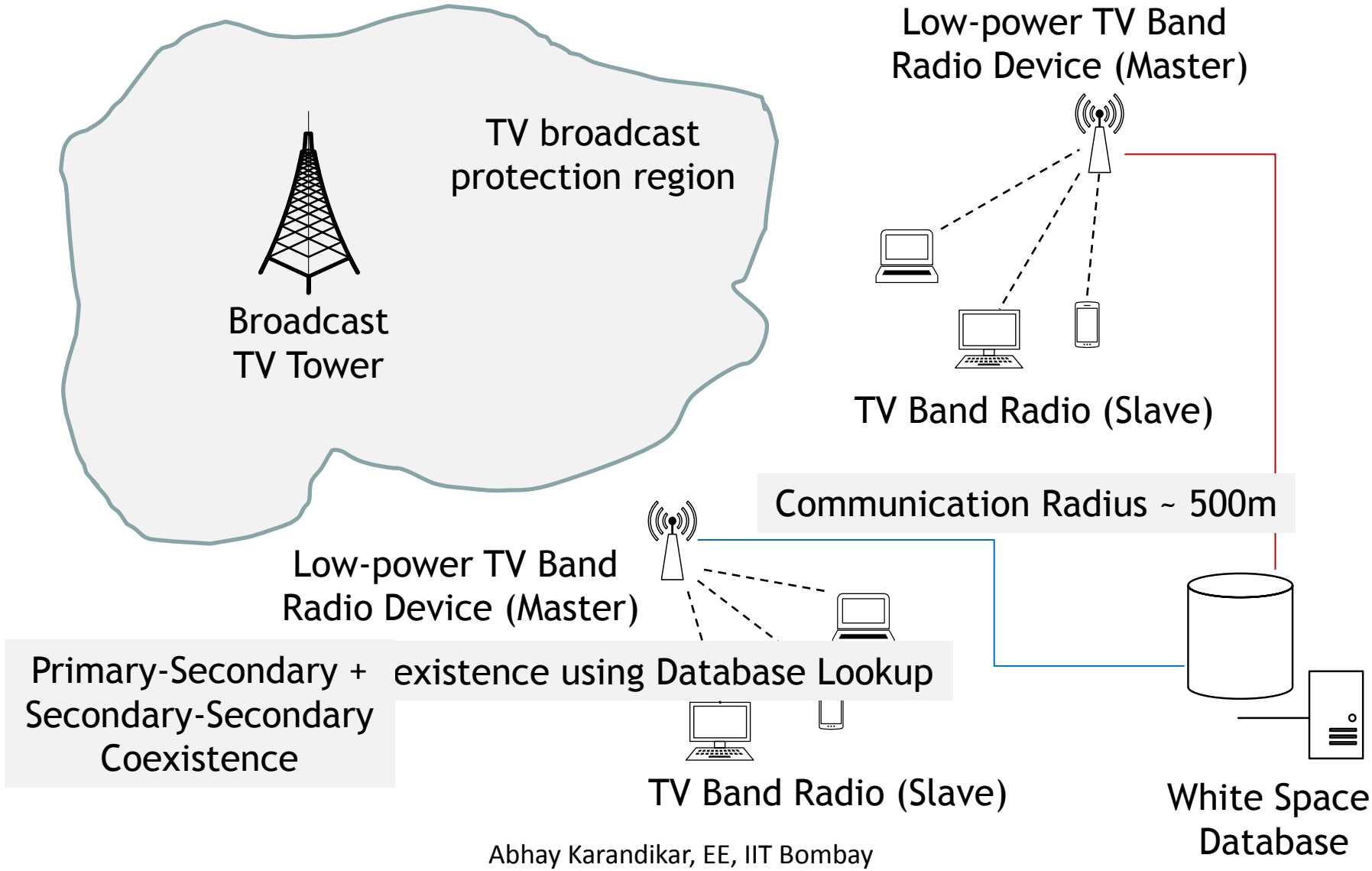
Our analysis reveals about 100MHz unused in UHF Band-IV

* 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

US / UK TV White Space Utilization



TV White Space Device: Features

- Every TV Band master device has
  - Geo-location (GPS)
  - Database look-up via the backhaul connectivity
  - Channel co-ordination with database (primary-secondary)
- Secondary-Secondary coexistence
  - IEEE 802.11af: CSMA-CA
  - IEEE 802.22: Self-coexistence using CPE (Coexistence Beacon Protocol:CBP)

Issues with IEEE 802.11af / IEEE 802.22

- Every TV Band master device needs
  - Geo-location (GPS)
  - Database look-up via the backhaul connectivity
  - Channel co-ordination with database (primary-secondary)
  - Channel co-ordination with peers (secondary-secondary)
- Multi-hop TV Band device need
  - Both master and slave functionality
  - Repeater / mesh-node of TV band can not radiate till its upstream master has authorization from the database

Indian Scenario: 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 Device: Features (US/UK v/s India)

US/UK

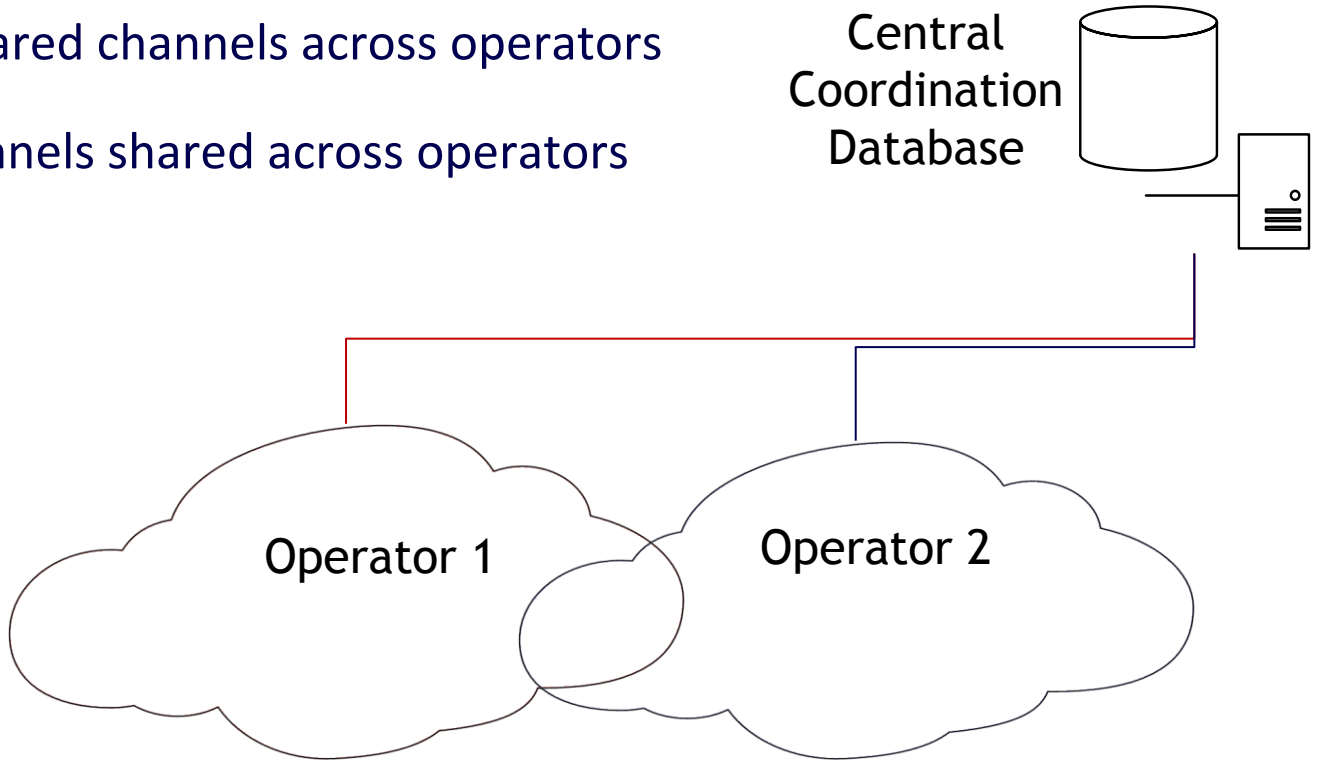
- ~~Every TV Band master device has~~
  - ~~Geo-location (GPS)~~
  - ~~Database look-up via the backhaul connectivity~~
  - ~~Channel co-ordination with database (primary-secondary)~~
- ~~Secondary-Secondary coexistence~~
  - ~~IEEE 802.11af: CSMA-CA~~
  - ~~IEEE 802.22: Self-coexistence using CPE (Coexistence Beacon Protocol:CBP)~~

India

- Every TV Band master device
  - Optional GPS
  - Database lookup via Gateway controller
  - No Primary-Secondary coexistence issue
- Secondary-Secondary coexistence
  - Via Database
  - Via Coordination protocols to be standardized

Shared Access

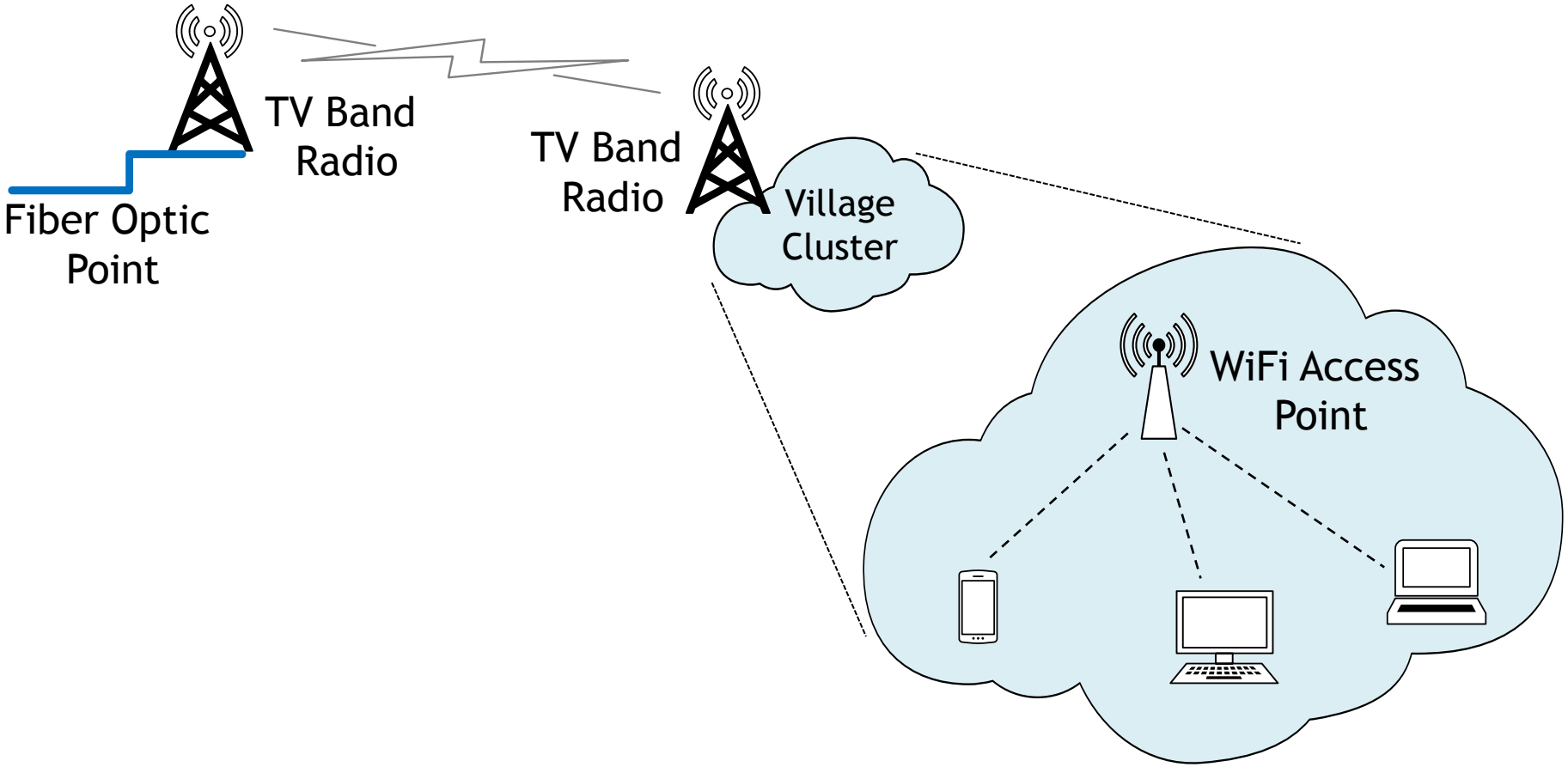
- Registered Shared Access (RSA)
  - Orthogonal channels across operators
  - Few shared channels across operators
  - All channels shared across operators



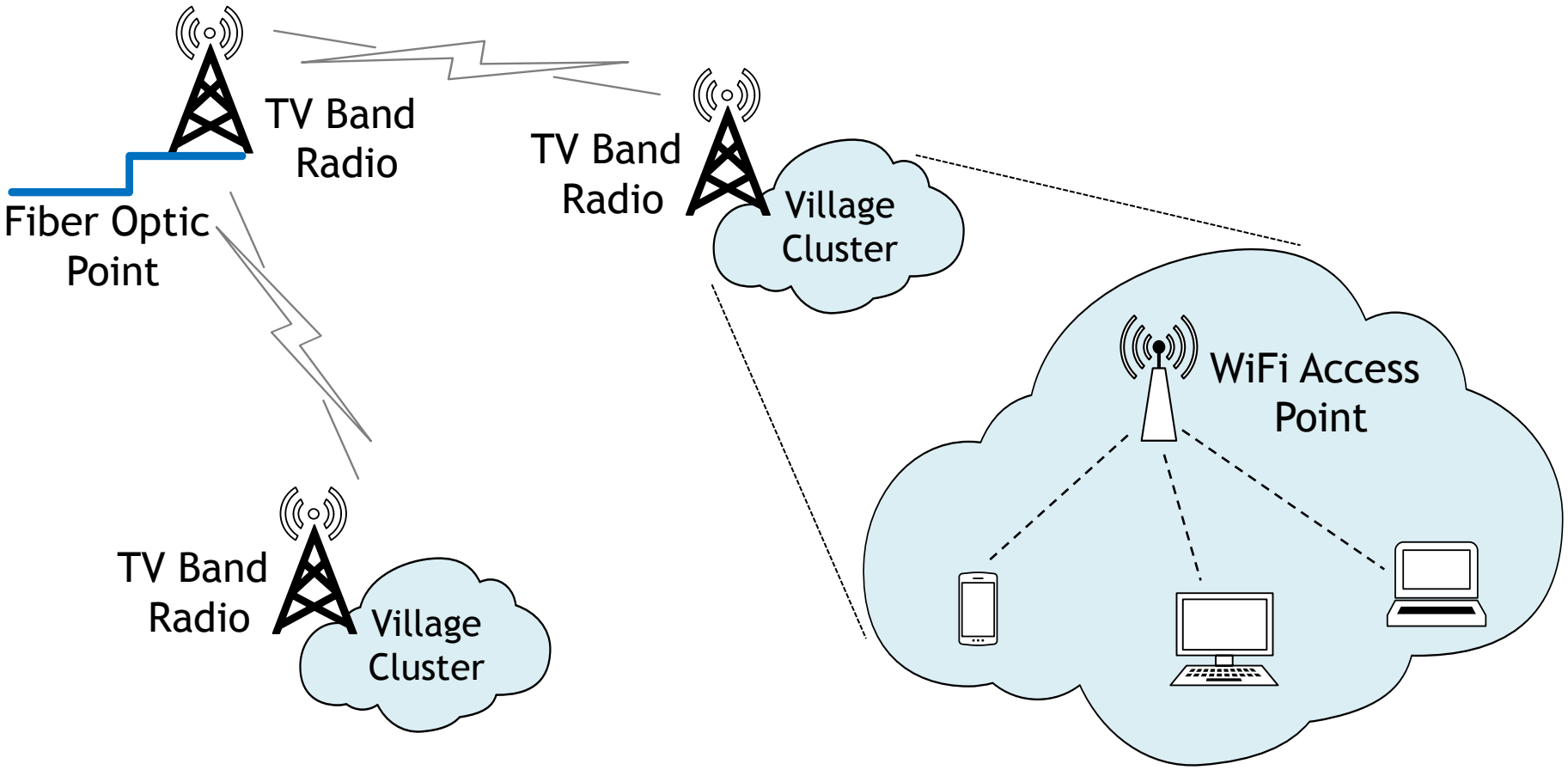
WRC-15 Position from India

- 470-585 MHz spectrum currently in use by very few TV transmitters
- Allow part of the spectrum to be reserved for fixed services to be available in a shared license mode (Registered Shared Access)
- Allow part of the spectrum to be used for PPDR services?

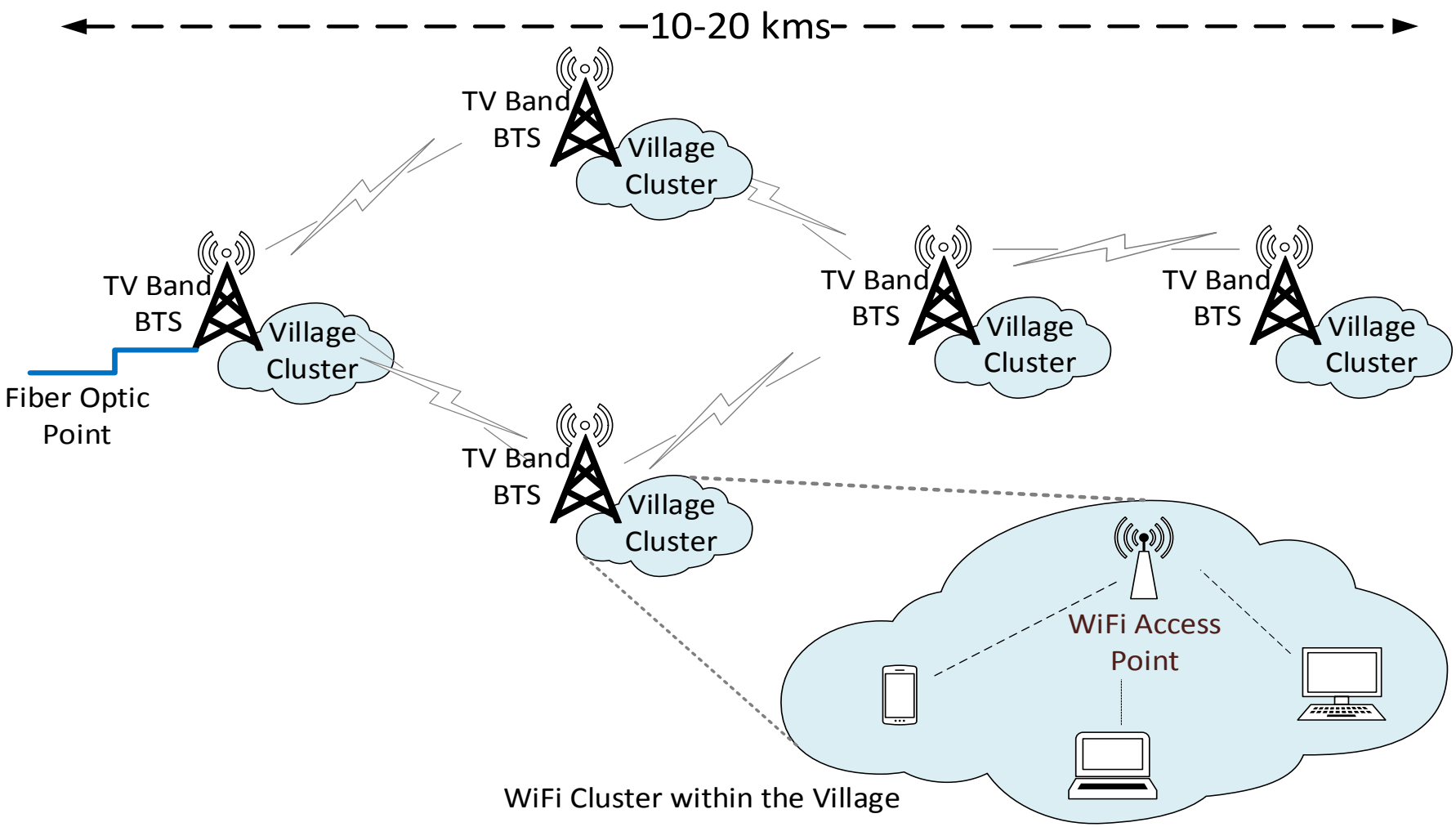
Topology 1: Middle-Mile Point-to-Point Network



Topology 2: Middle-Mile Point-to-MultiPoint Network



Topology 3: Middle-Mile Multi-Hop Network



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