Mesh-Network for Rural Broadband Coverage Using TV White Spaces in India

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WP5A – Seminar on Cognitive Radio Systems and the use of White Spaces

Organization

- How much TV white space is there in India?
- Ongoing study of mesh-network for affordable/rural broadband coverage

Terrestrial TV spectrum allocation in India

- Government's national broadcaster named Doordarshan holds all of the terrestrial TV broadcasting license
- The frequency allocation plan (NFAP) of UHF TV band and onwards is as follows:

Frequency band	Services
470-585	FIXED, MOBILE, BROADCASTING
585-610	FIXED, MOBILE, BROADCASTING, RADIO NAVIGATION, RADIO ASTRONOMY
610-890	FIXED, MOBILE, BROADCASTING, RADIO ASTRONOMY

TV transmitter plan of Doordarshan

On record, there are 1415 TV transmitters operating in India

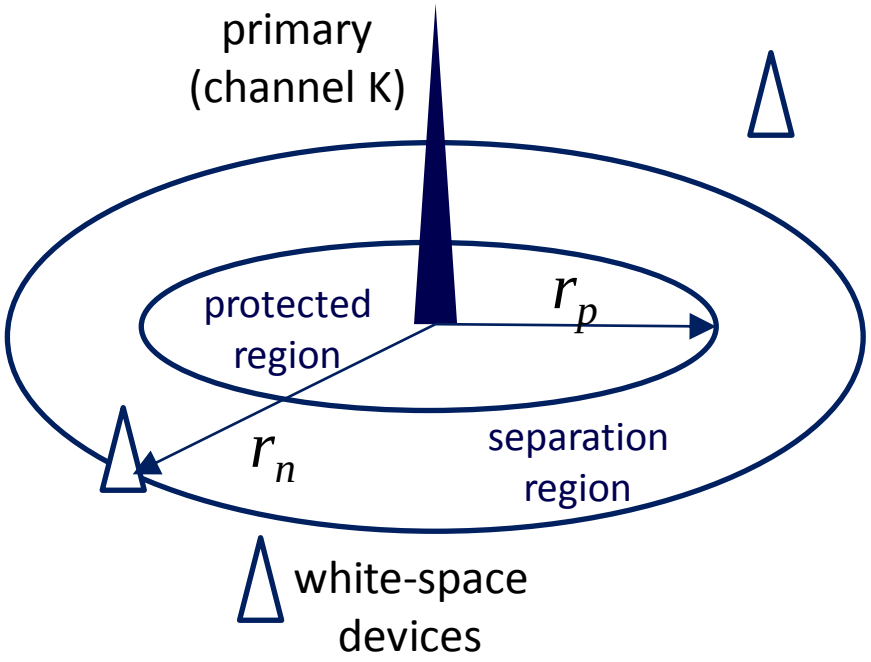
- UHF Band-IV (470-590MHz)
  - **Fifteen channels** of 8 MHz each — **373 transmitters** across all India
- VHF-I Band (54-68MHz)
  - **Two channels** of 7 MHz each — **8 transmitters** across all India
- VHF-III Band (174-230MHz)
  - **Eight channels** of 8MHz each — **1034 transmitters** across all India

- We focus on the UHF Band-IV, i.e., 470-590MHz spectrum band
- Use of microphones is very limited in India

TV white space assessment methods

- The protection and pollution viewpoints **[Mishra and Sahai'2009]**
- The FCC regulations **[FCC'Nov2008]**

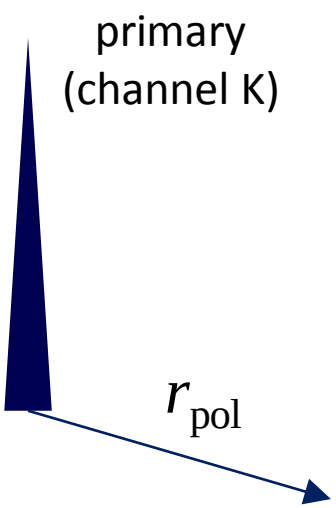
The protection and pollution viewpoints



Min SINR at the primary receiver on edge of protected region should be Δ **[Misra-Sahai'2009]**

$$P_t - PL(r_p) - N_0 = \Delta + \Psi$$

$$P_S - PL(r_n - r_p) = \Psi$$



Min SINR at the secondary receiver on edge of separation region should be γ

$$P_t - PL(r_{\text{pol}}) = N_0 + \gamma$$

FCC rules for white space calculations

The FCC specifies a formula for transmit power using electric field:

$$P(\text{dBm}) = E(\text{dBu}) - 130.8 + 20 \log_{10} (1230/(f_H + f_L))$$

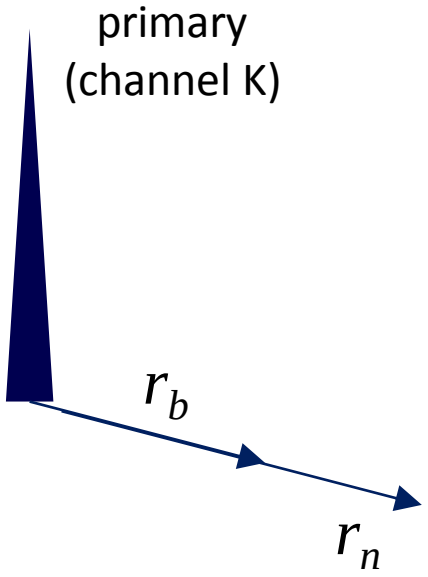
$P(\text{dBm})$ = transmit power in dBm

$E(\text{dBu})$ = electric-field strength in dBu

f_H, f_L = upper and lower frequency limits

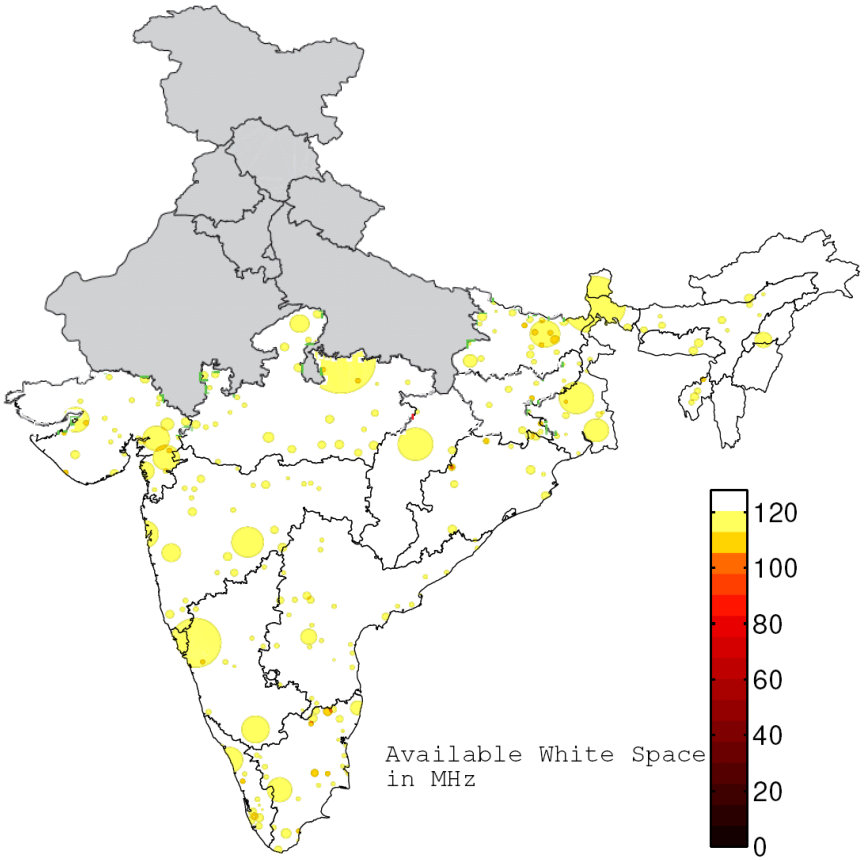
r_b = distance where $E(r_b)$ is 41dBu

r_n = no-talk distance; secondary interference is 18dBu at r_b



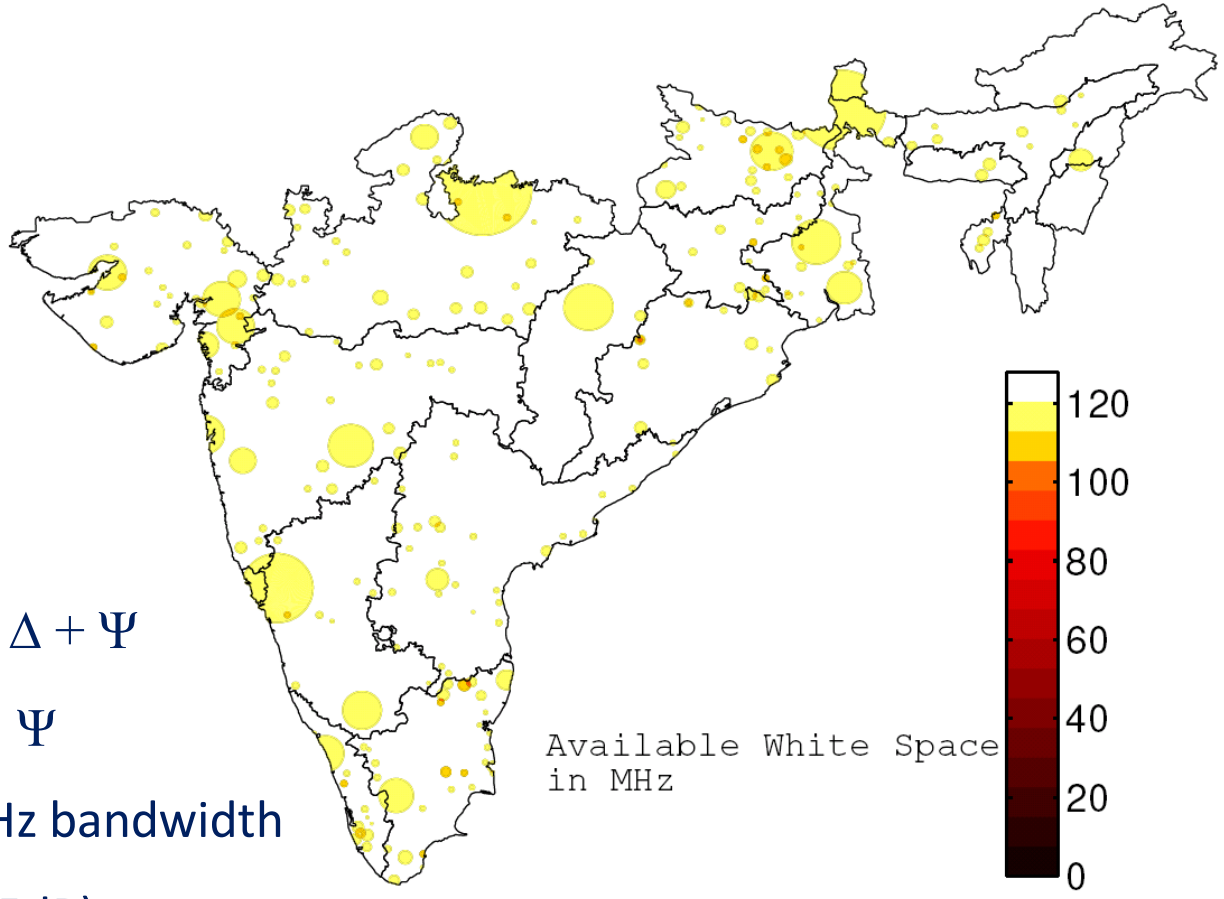
All these calculations require propagation models and we use existing models discussed in the Indian context **[Prasad-Ahmad'1997, Hata'1980]**

North-zone data not yet available



- So far, with significant efforts, we have been able to obtain the data for all zones except North in India
- The results will **omit** the North zone for this reason

TV white space assessment: protection view



Recall

$$P_t - PL(r_p) - N_0 = \Delta + \Psi$$

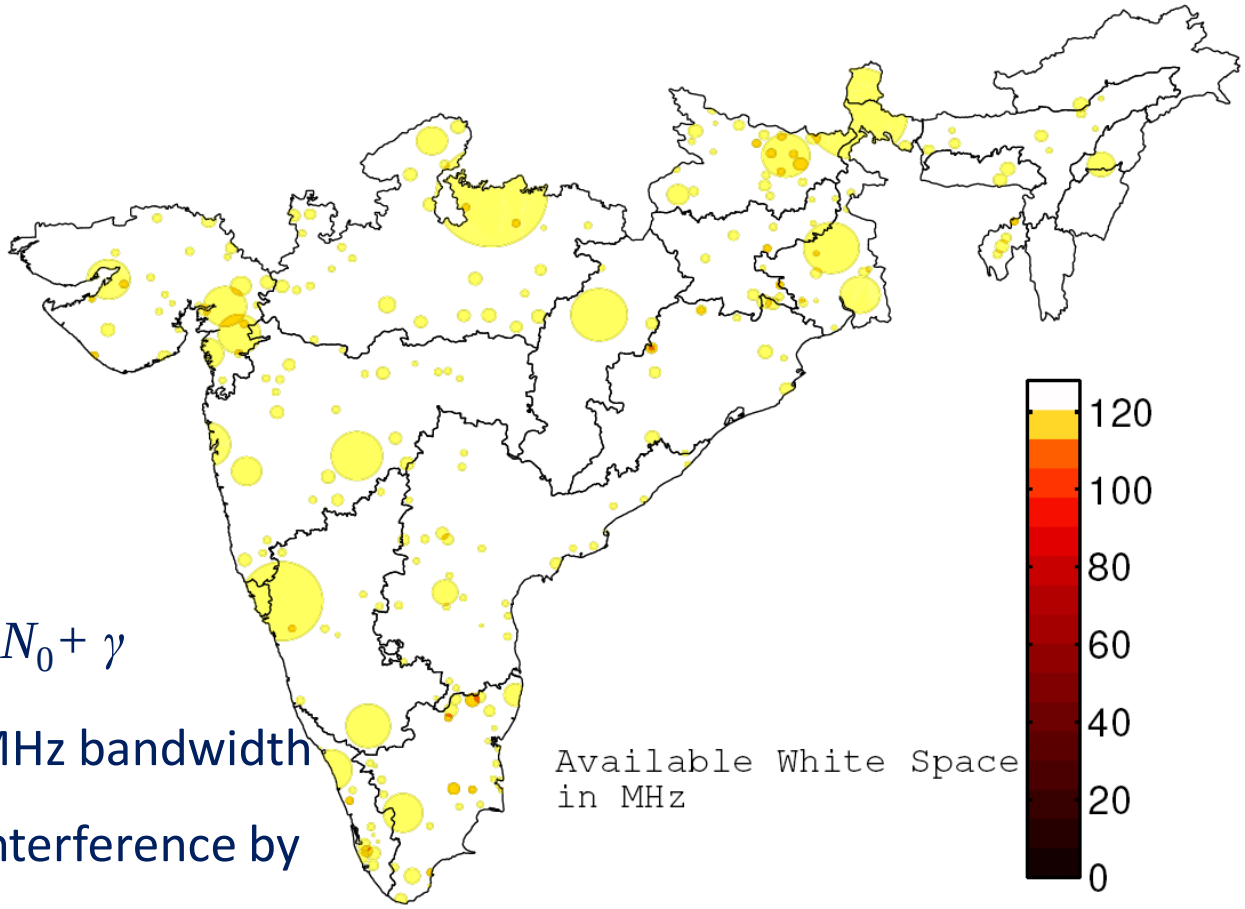
$$P_S - PL(r_n - r_p) = \Psi$$

N_0 = -105dBm for 8MHz bandwidth

Δ = SINR threshold (45dB)

Ψ = fading margin 0.1dB-1dB

TV white space assessment: pollution view



Recall

$$P_t - PL(r_{\text{pol}}) = N_0 + \gamma$$

N_0 = -105dBm for 8MHz bandwidth

γ = max. tolerable interference by secondary 5dB-15dB

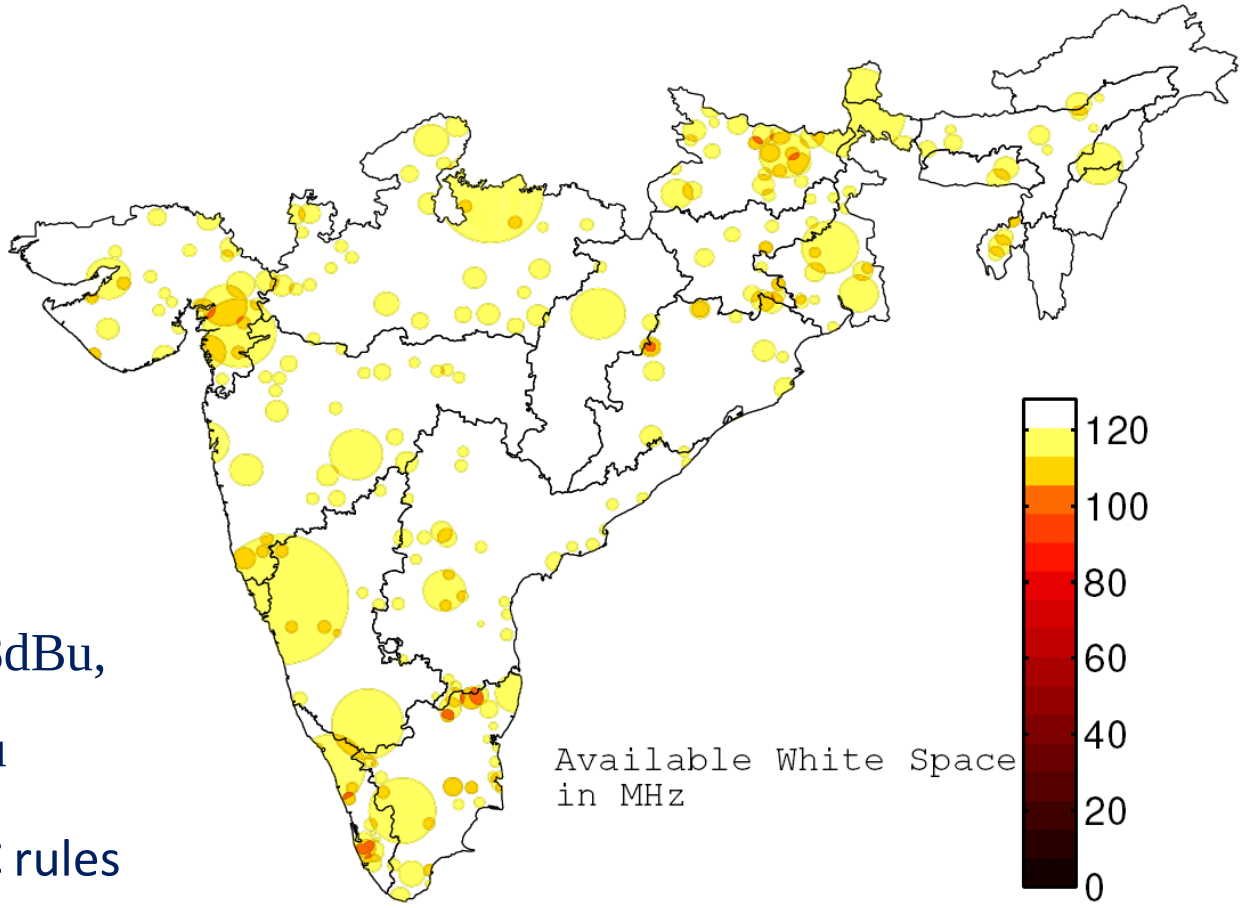
TV white space assessment: FCC rules

Recall

$$E_S(r_n - r_b) = 18\text{dBu},$$

$$E_P(r_b) = 41\text{dBu}$$

P_S = specified by FCC rules



Key observations

- Per unit area, a minimum of **14 out of 15 channels** is always available as TV white space!
- At any place, a minimum of **12 out of 15** channels are almost always available as TV white space
- These results hold for various values of γ = 5dB-15dB, Ψ = 0.1dB-1dB and $E(r_b)$ was fixed at 41dBu for the FCC rule calculations

Most of the UHF-Band spectrum at most of the places in India is white space

A hypothetical channel allocation algorithm

- Using interference avoidance by spatial reuse of frequencies, an algorithm can be used to find the **smallest number** of channels needed for existing TV coverage in India
- We find that **typically 3** and in the worst-case **4 channels** are sufficient to provide existing TV coverage spread over 15 UHF channels!

11 out of 15 channels (>70%) can be freed by reassignment of TV channel frequencies in India

Organization

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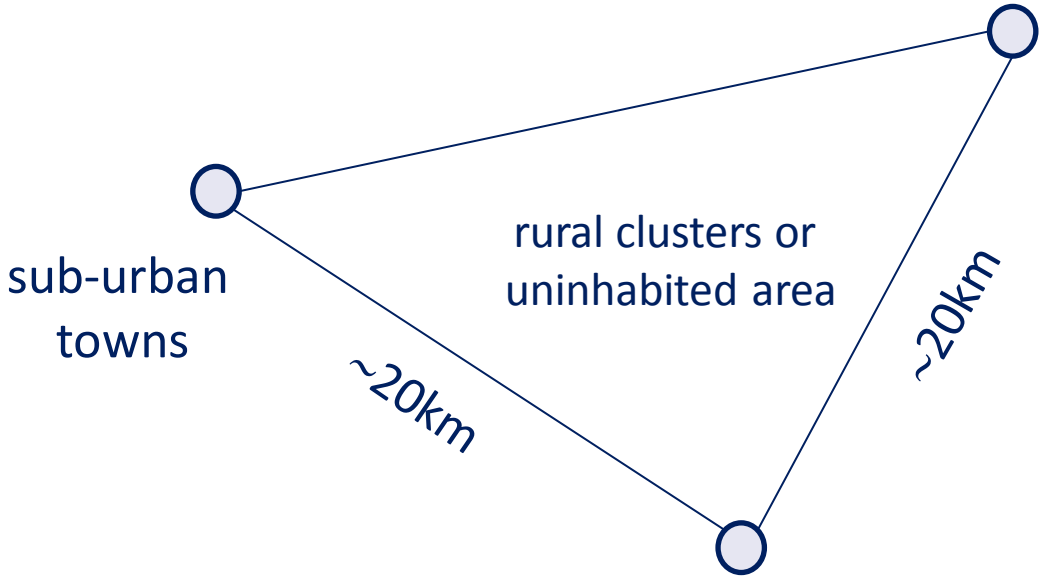
- Ongoing study of mesh-network for affordable/rural broadband coverage

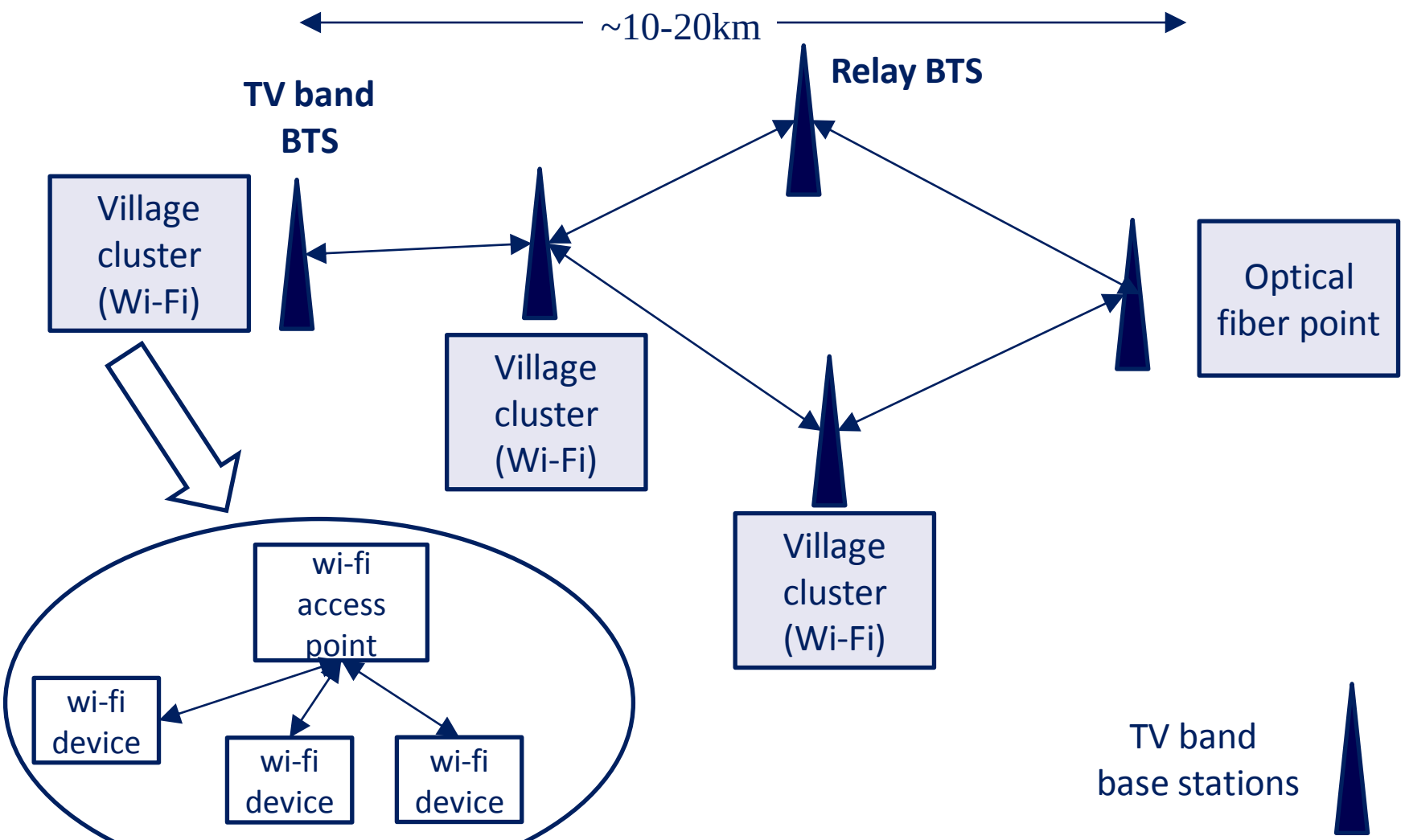
Key problem in broadband coverage

- 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

Middle-mile mesh-network in TV white spaces



Analysis to be done/test-beds to be deployed

- Throughput analysis with bandwidth for the mesh-network has to be done
- Interference management has to be figured out. In particular,
  - Co-channel interference or coexistence, power limits
  - Adjacent channel coexistence, frequency of operation
  - Spectral mask, out of band performance
- On-site test-beds to experimentally verify everything mentioned above

Conclusions in brief

- Lots of TV white space in India in the 470-590MHz band
- While it is in inception, we believe that a suitably designed mesh-network in the TV band will significantly address the lack of rural broadband coverage in India.

Acknowledgments

- This research is supported by the Ford Foundation
- Dr. José Costa, WP5A chairman, for inviting our presentation