

# **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

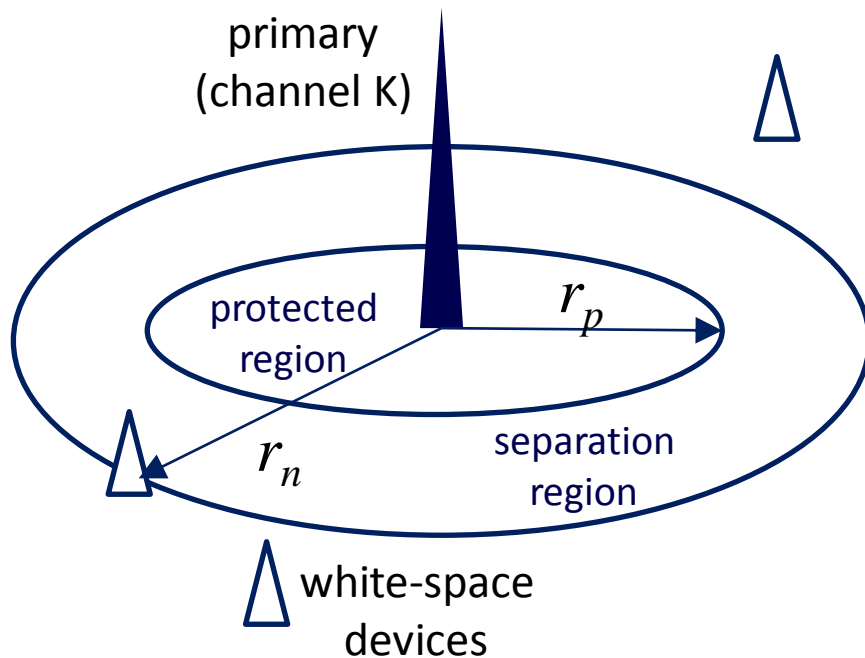
- ◇ We focus on the UHF Band-IV, i.e., 470-590MHz spectrum band

- ◇ 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]

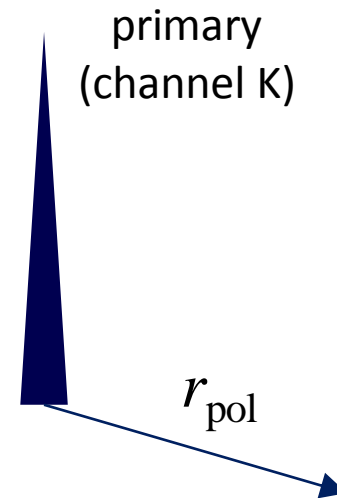
# The protection and pollution viewpoints



Min SINR at the primary receiver on edge of protected region should be  $\Delta$  [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  $\gamma$

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

# FCC rules for white space calculations

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

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

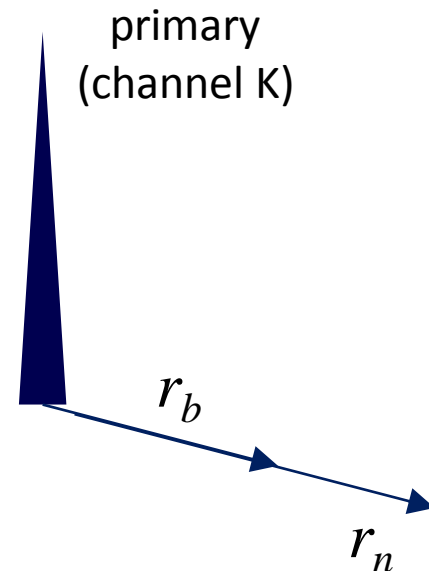
$P(\text{dBm})$  = transmit power in dBm

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

$f_H, f_L$  = upper and lower frequency limits

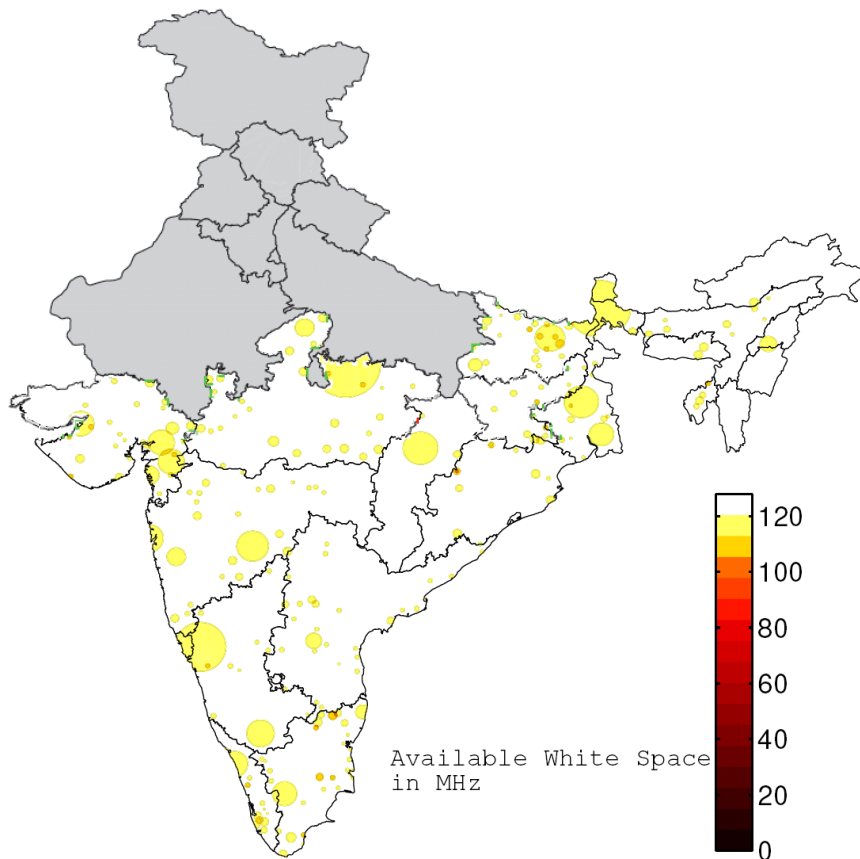
$r_b$  = distance where  $E(r_b)$  is 41dBu

$r_n$  = 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**]

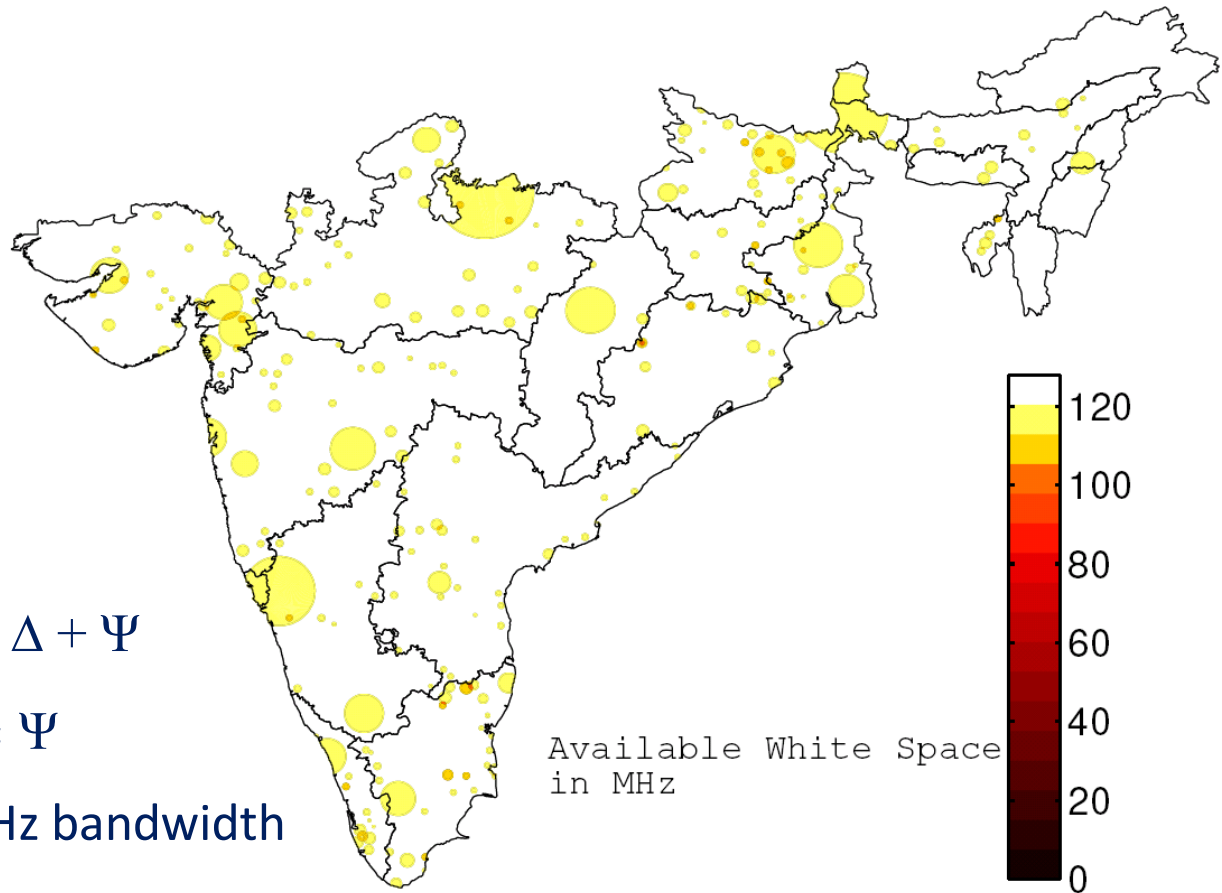
# North-zone data not yet available



- ◇ 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

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

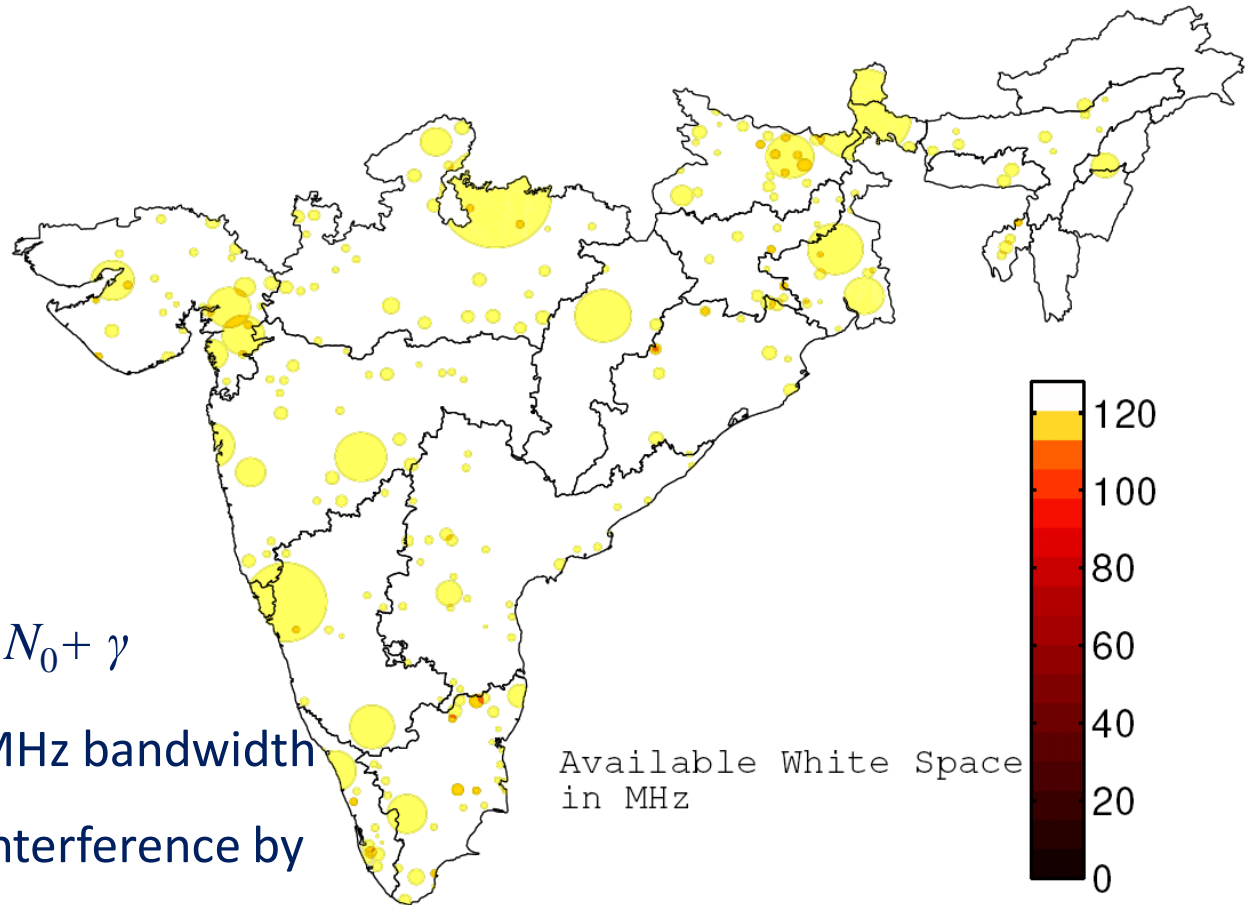
$$P_s - PL(r_n - r_p) = \Psi$$

$N_0 = -105\text{dBm}$  for 8MHz bandwidth

$\Delta = \text{SINR threshold (45dB)}$

$\Psi = \text{fading margin 0.1dB-1dB}$

# TV white space assessment: pollution view



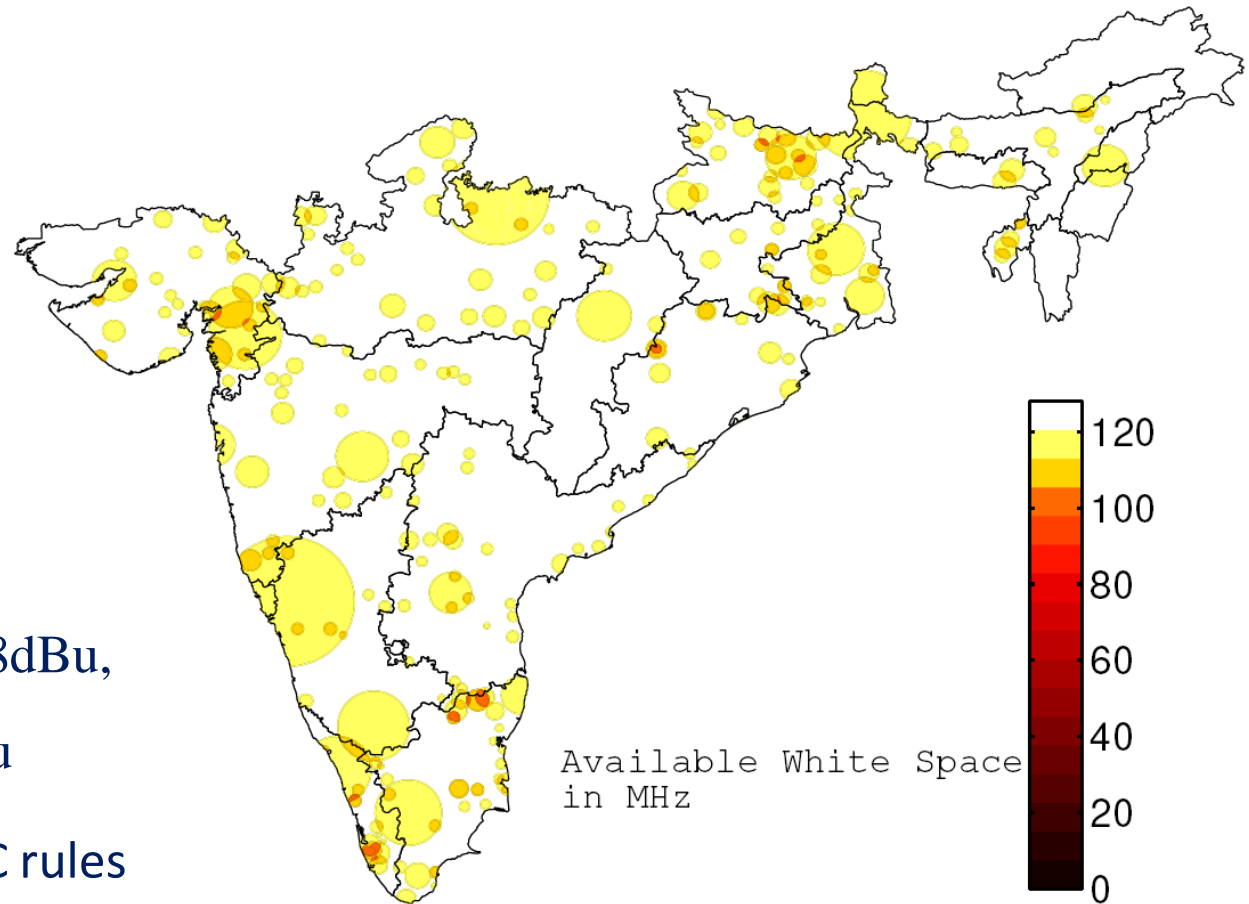
Recall

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

$N_0 = -105\text{dBm}$  for 8MHz bandwidth

$\gamma = \text{max. tolerable interference by secondary } 5\text{dB-}15\text{dB}$

# 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  $\gamma = 5\text{dB}-15\text{dB}$ ,  $\Psi = 0.1\text{dB}-1\text{dB}$  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 assign 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!

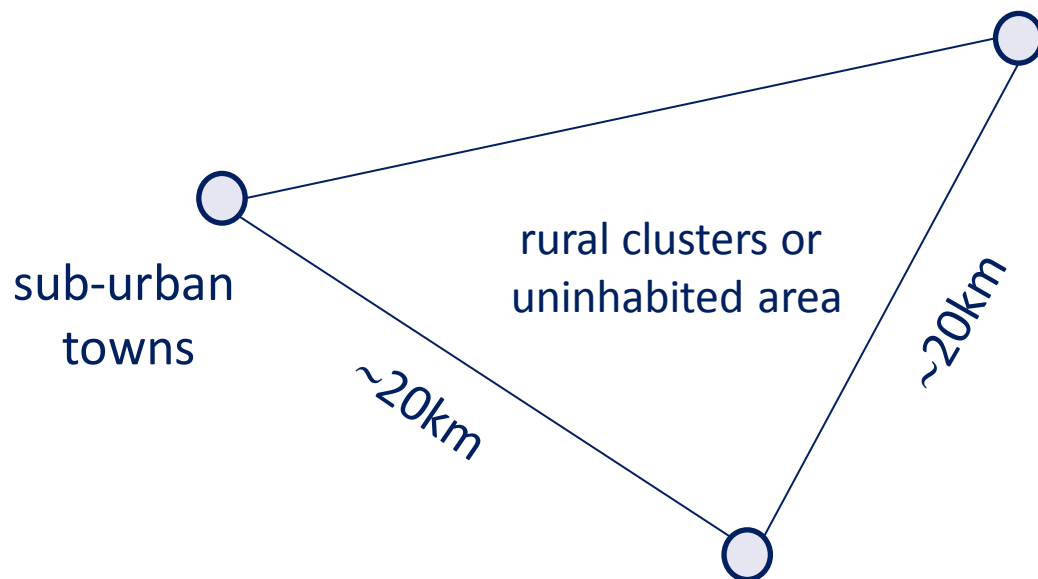
11 out of 15 channels (>70%) can be freed by  
reassignment of TV channel frequencies in India

# Organization

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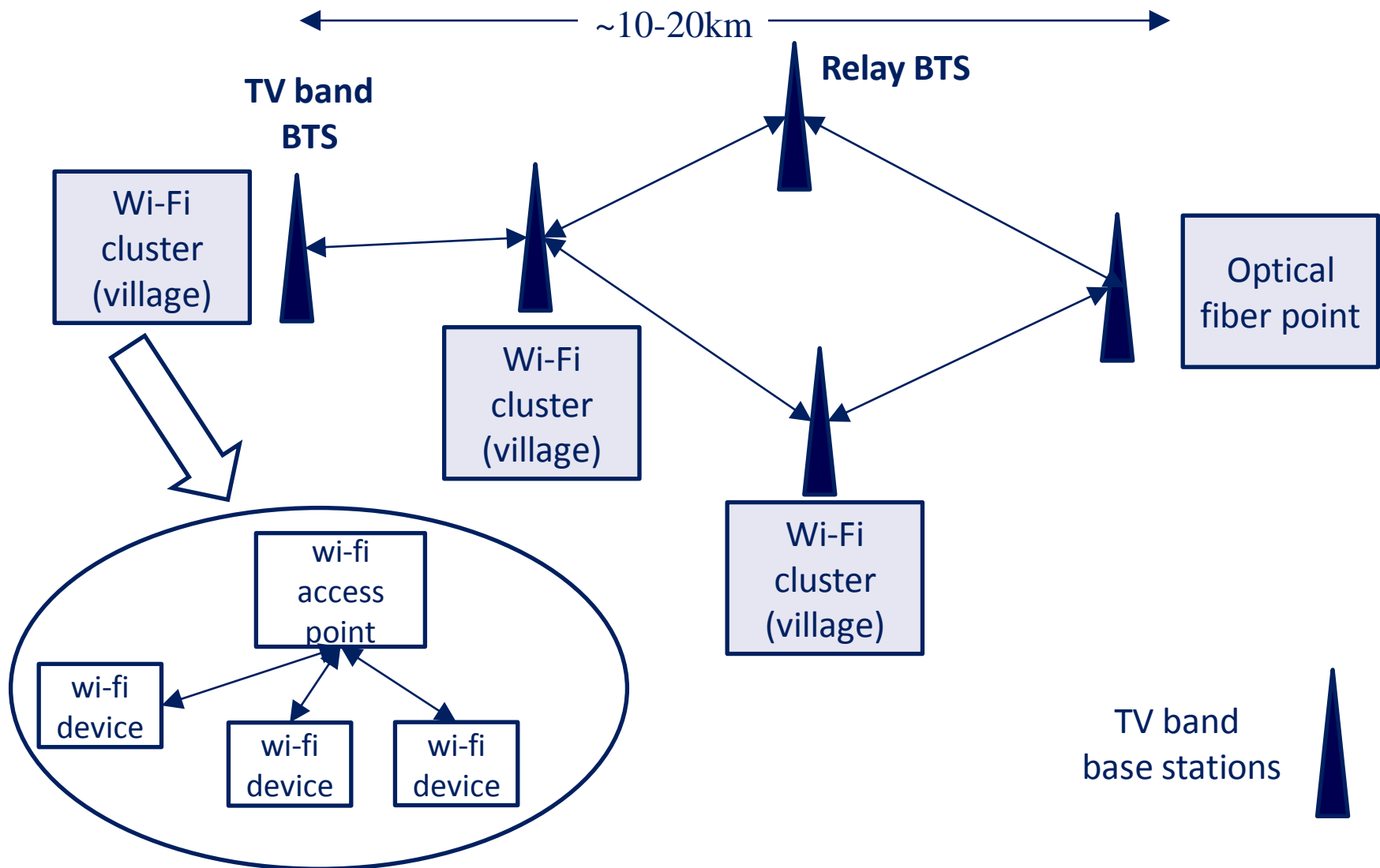
# Key problem in broadband coverage

- ◇ 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