

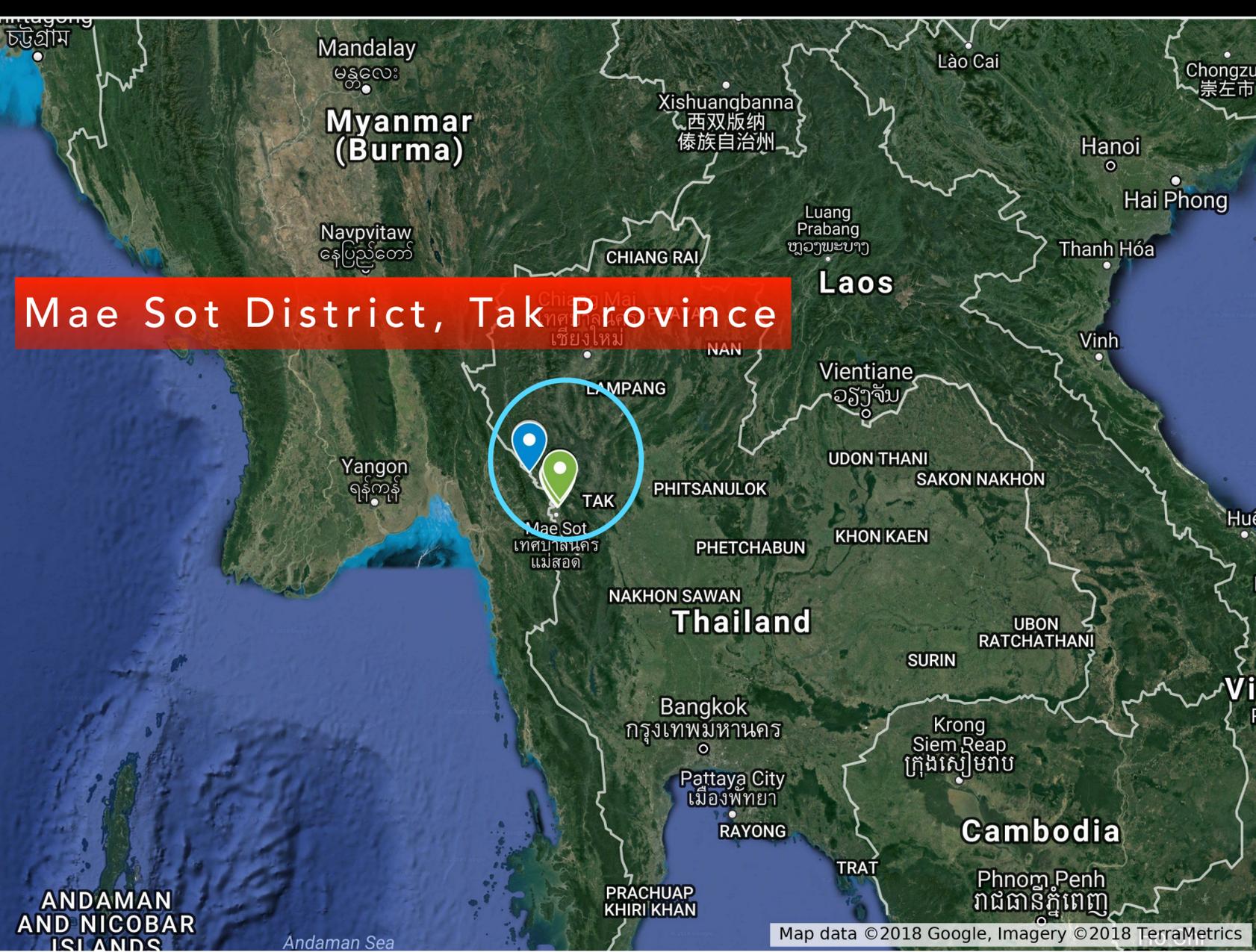
TakNet: A Community Network with TVWS Experiments

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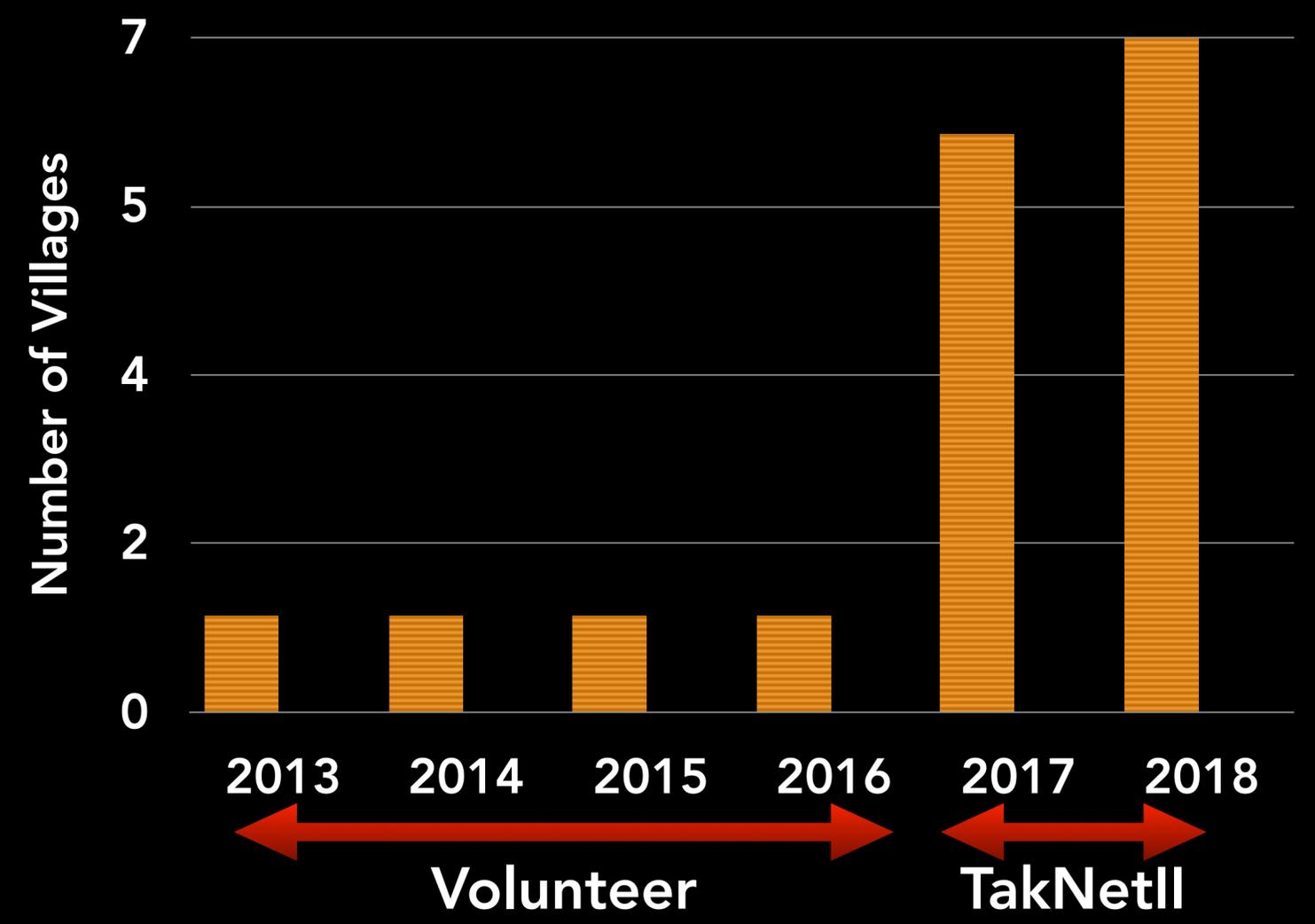


TakNet: Last meters access solution

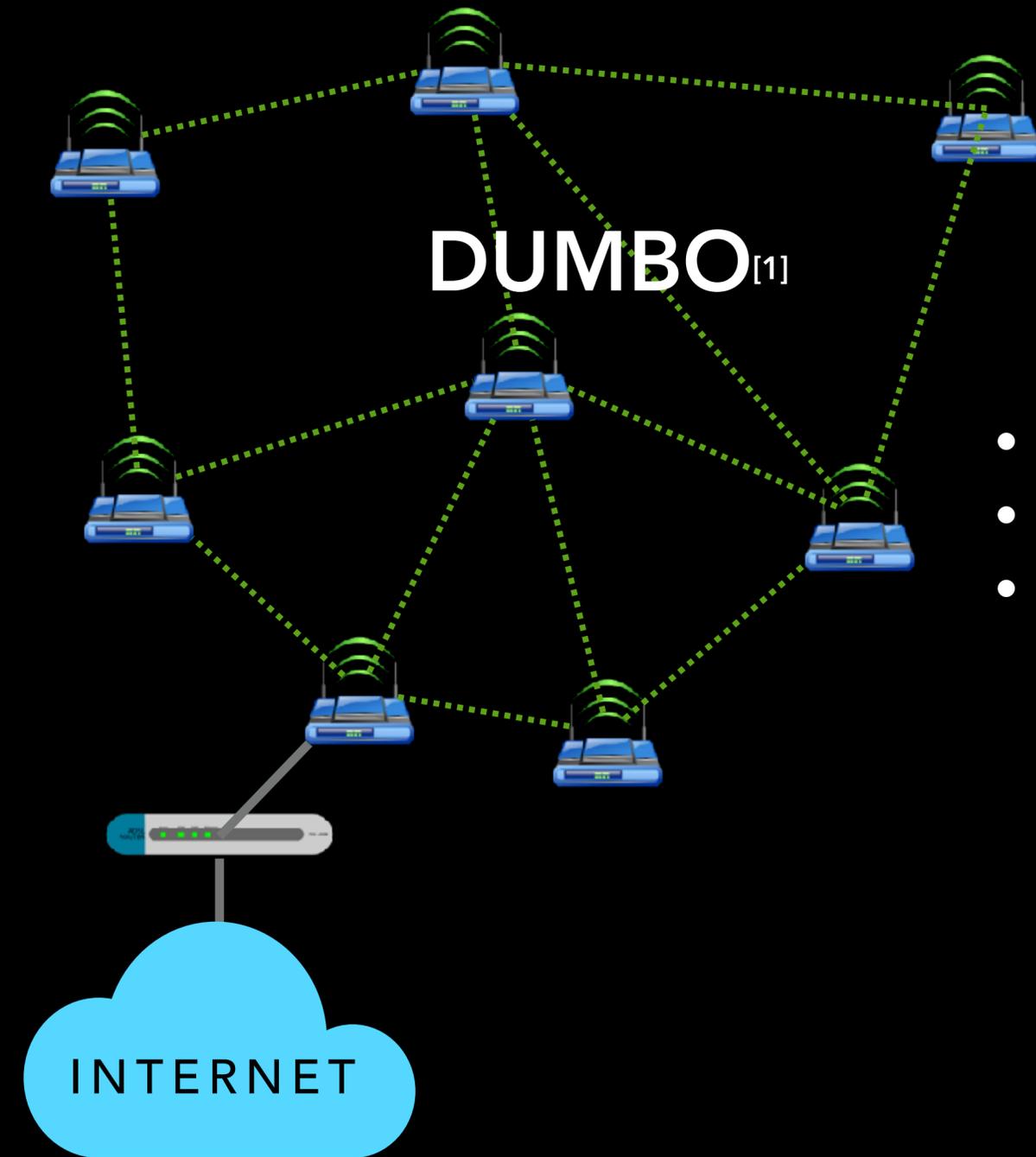
17 remote communities

200+ deployed nodes

1000+ residents using our network



Our Technologies



TPLink MR3040

- Coverage: 50-60 m
- WiFi 2.4 GHz
- Usage: Portable, Apply to emergency situation



TPLink AC1750

- Coverage: 100 m
- WiFi 2.4/5 GHz
- Usage: Static and Indoor



Unifi Outdoor AP

- Coverage: upto 200 m
- WiFi 2.4/5 GHz
- Usage: Outdoor, Link to GW



Raspberry Pi

- Micro Server
- Running local services (e.g., chat, VoD)



Wok

- DIY p2p antenna
- Extend the connectivity

[1] Kanchanasut, K., Tunpan, A., Awal M.A., Das, D.K., Wongsardsakul, T. and Tsuchimoto, Y., "DUMBONET: A Multimedia Communication System for Collaborative Emergency Response Operation in Disaster-affected Areas, International Journal of Emergency Management, Inderscience, Vol. 4, No. 4, pp. 670 – 681, 2007.

Extending the network coverage?



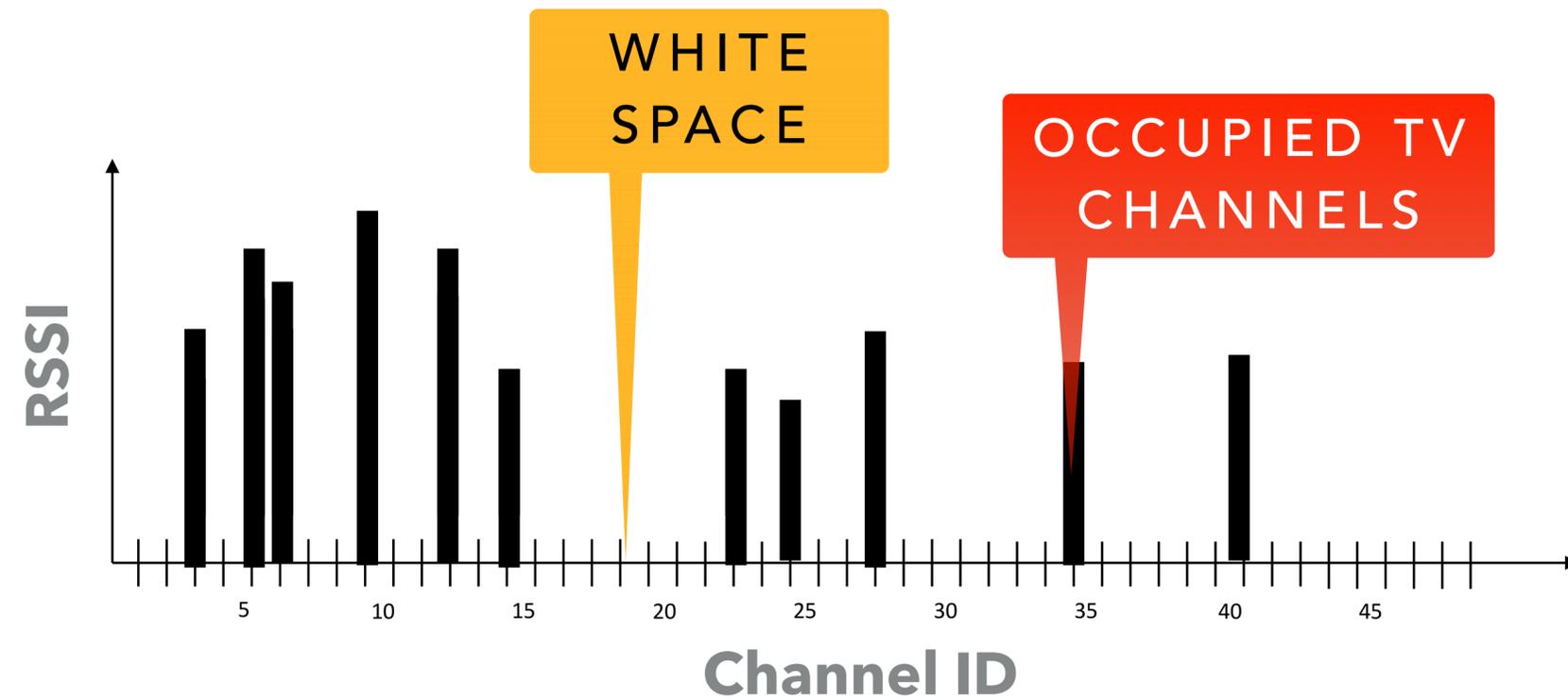
Some houses were abandon

- WiFi signal (Mesh) is not sufficient
- Too much multi hop (3 hops max)
- NLOS



TVWS (TV White Spaces) solution

Utilising the excellence radio characteristics of TV spectrum to provide digital broadband communication



- Support NLOS with better throughput and low latency
- Long distance propagation (10 - 20 km)
- Point to Multipoint communication (Up to 12 client nodes¹)

- ▶ The part of spectrum that is unused by the primary (licensed users) at specific location and time
- ▶ Plenty of spectrum allocated to TV broadcasting is currently idle, specially in rural areas of developing countries.

TVWS Project

- ▶ **Duration: 2017 – 2019**
- ▶ **A grant from the National Broadcasting and Telecommunication Commission (NBTC) office**
- ▶ **License: 470 – 790 MHz**
- ▶ **First TVWS trail in Thailand**
- ▶ **Carry out TVWS spectrum measurements to build WSDB**

How much White Spaces ?

EQUIPMENTS



Spectrum Analyser: RFExploer (Low cost and portable)

Measurement tools: A laptop/RPI with RFestatic (ICTP) to record the spectrum measurement

MEASUREMENT SETUP



Frequency range	510 - 790 MHz (THA - UHF TV channels)
Signal bw	8 MHz (ETSI)
Resolution bw	500 kHz
Location	Outdoor vs Indoor
Antenna height	1m (ground level) vs 15 m (Roof top)

Which channel is white space?

- **Fixed Threshold**

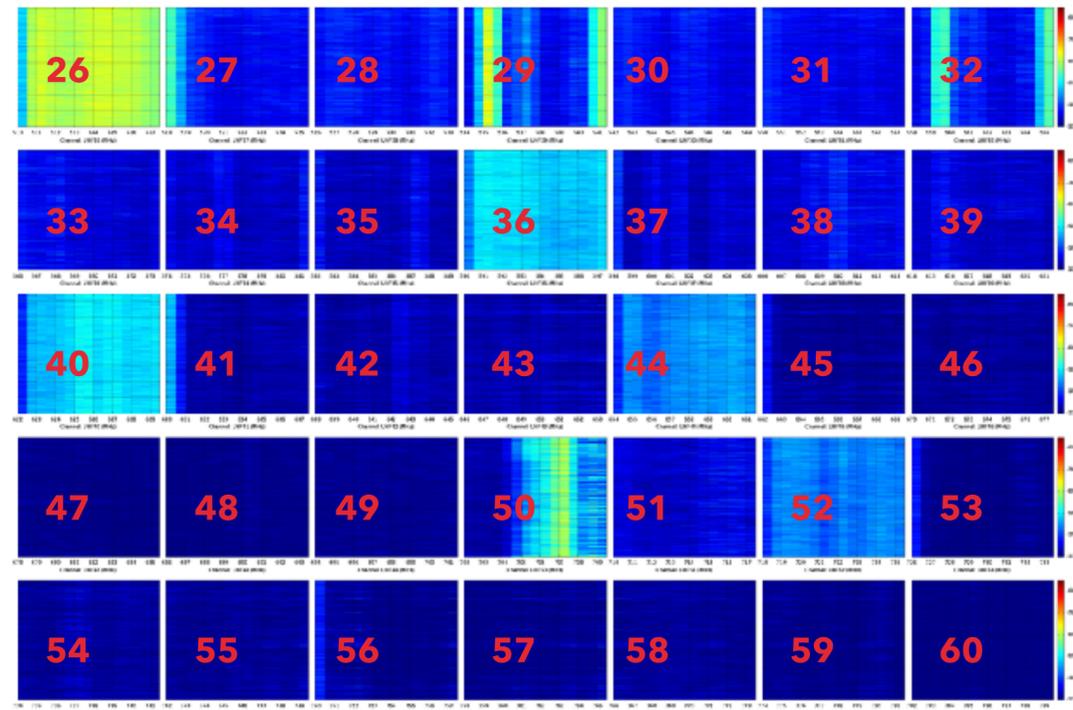
- Threshold (TH):

- -114 dBm (FCC recommended)
- -100 dBm (Rule of thumb - commonly used in literature^[3])

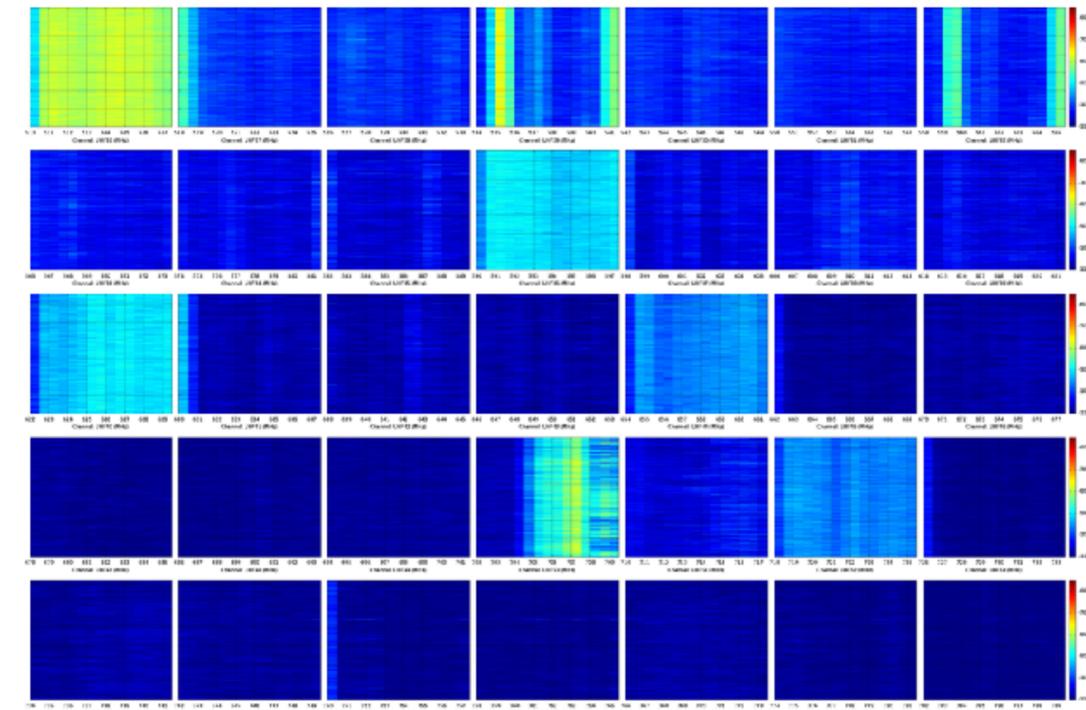
- Occupancy

- Threshold (TH_o)

- 80% (again Rule of thumb)



Measurement#1 10 Channels are busy

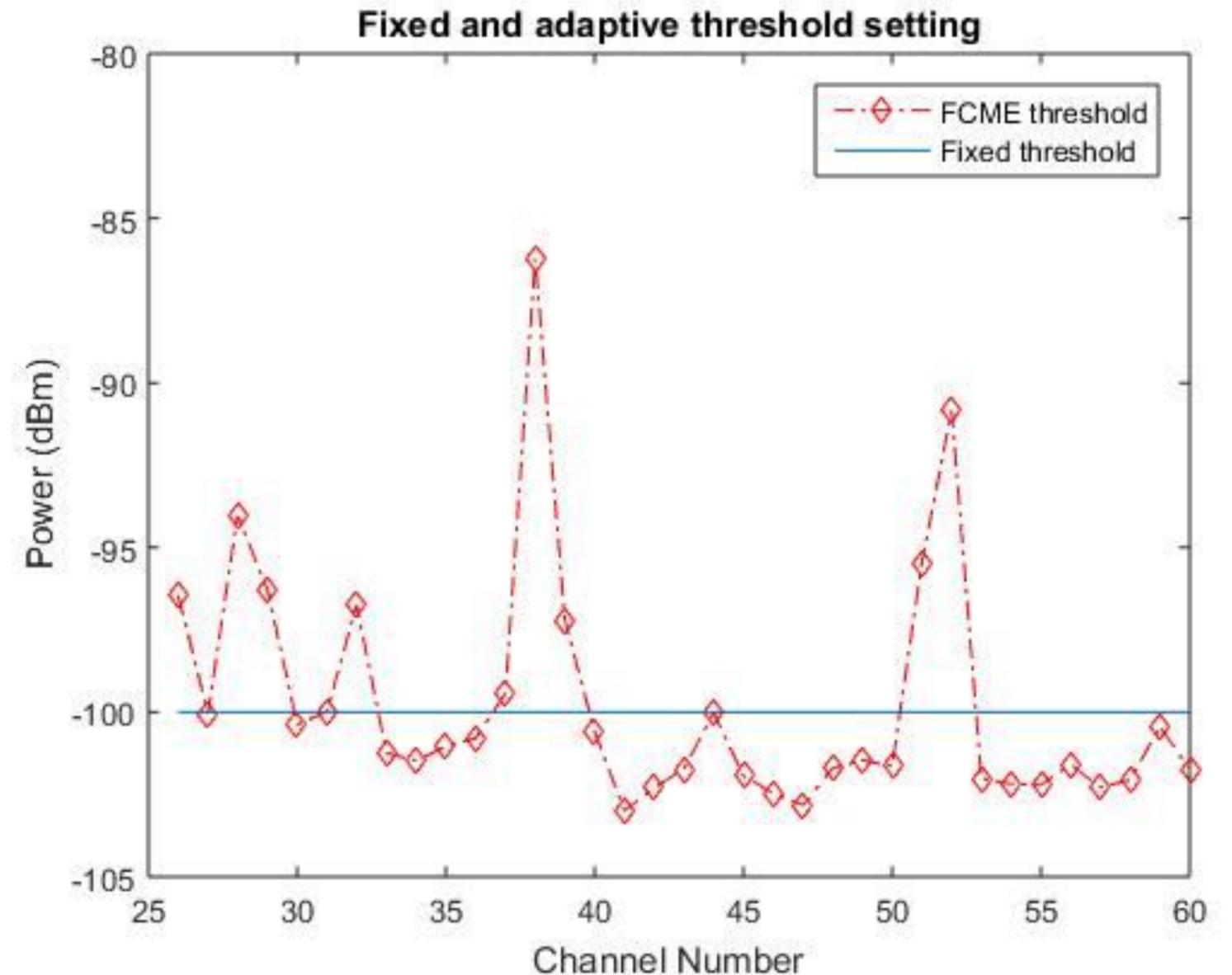


Measurement#2 14 Channels are busy

[3] Petty V. et. al., "Feasibility of Dynamic Spectrum Access in Underutilized Television Bands," DySPAN 2007

Adaptive Threshold Method

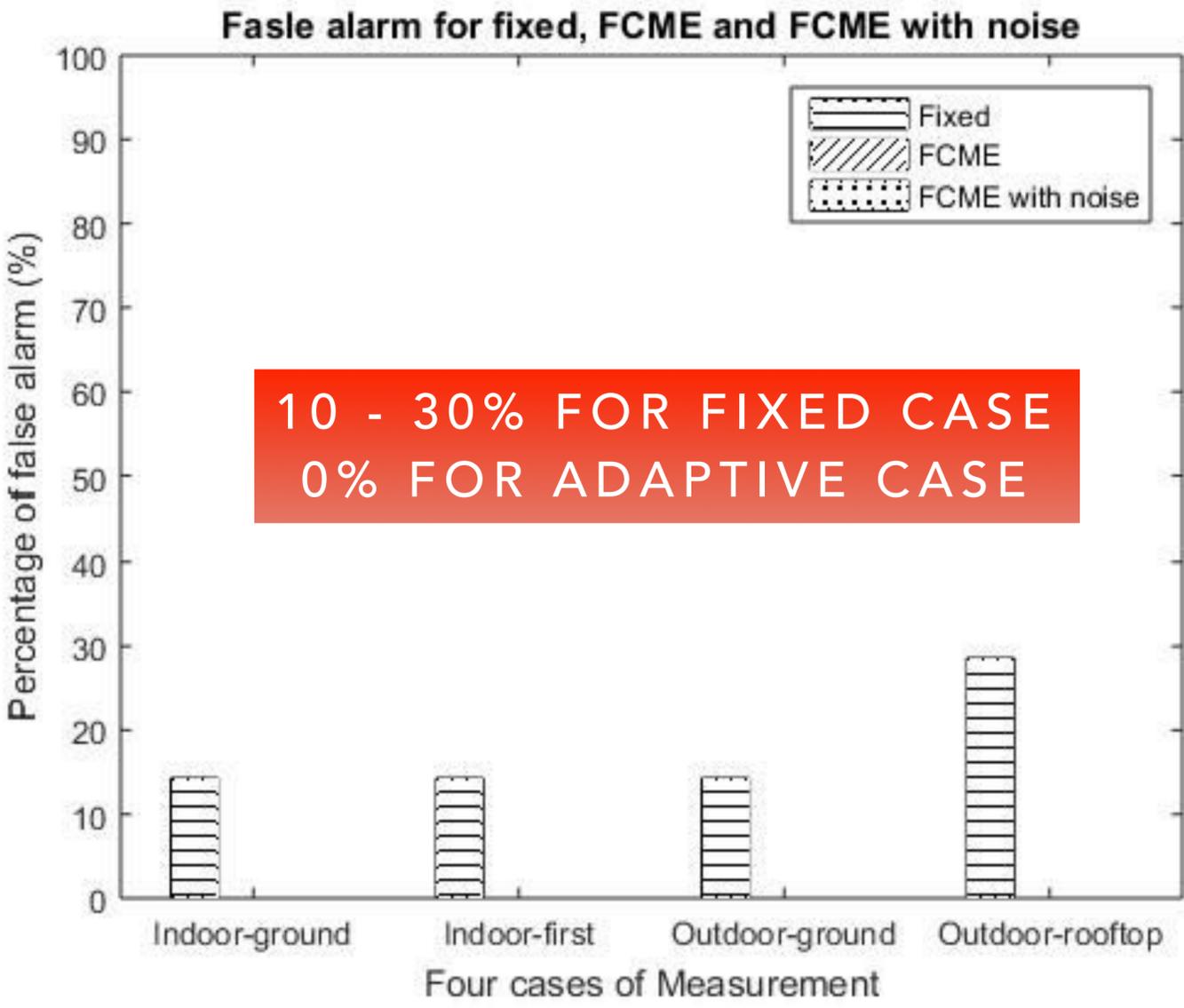
- Better support noise variance and fluctuation of power spectral density
 - Neyman-Pearson (NP)
 - Forward Consecutive Mean Excision (FCME)
 - Localization Algorithm Based on Double-Thresholding (LAD)
 - Noise Added FCME [2]
 - Noise Added LAD



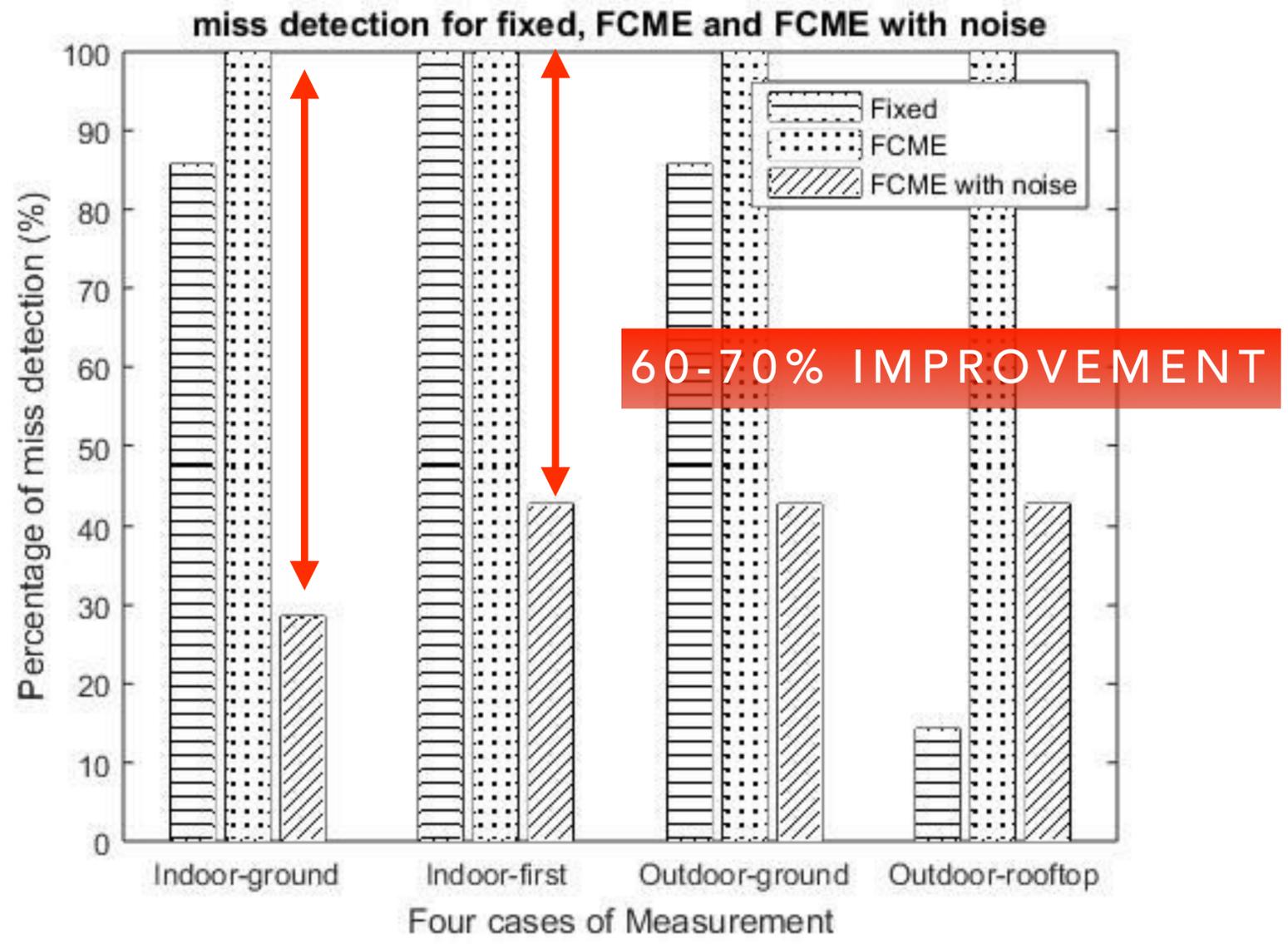
[2] Bipun Man Pati, Adisorn Lertsinsrubtavee, Attaphongse Taparugssanagorn,, Kanchana Kanchanasut, and Arjuna Sathiseelan, "Adaptive Threshold Setting for Determining Spectrum Occupancy in TV White Space," in Proc. the Annual ACM SIGCAS Conference on Computing and Sustainable Societies (COMPASS 2018), 2018.

FIXED vs Adaptive Thresholds

PROBABILITY OF FALSE ALARM



PROBABILITY OF MISS DETECTION

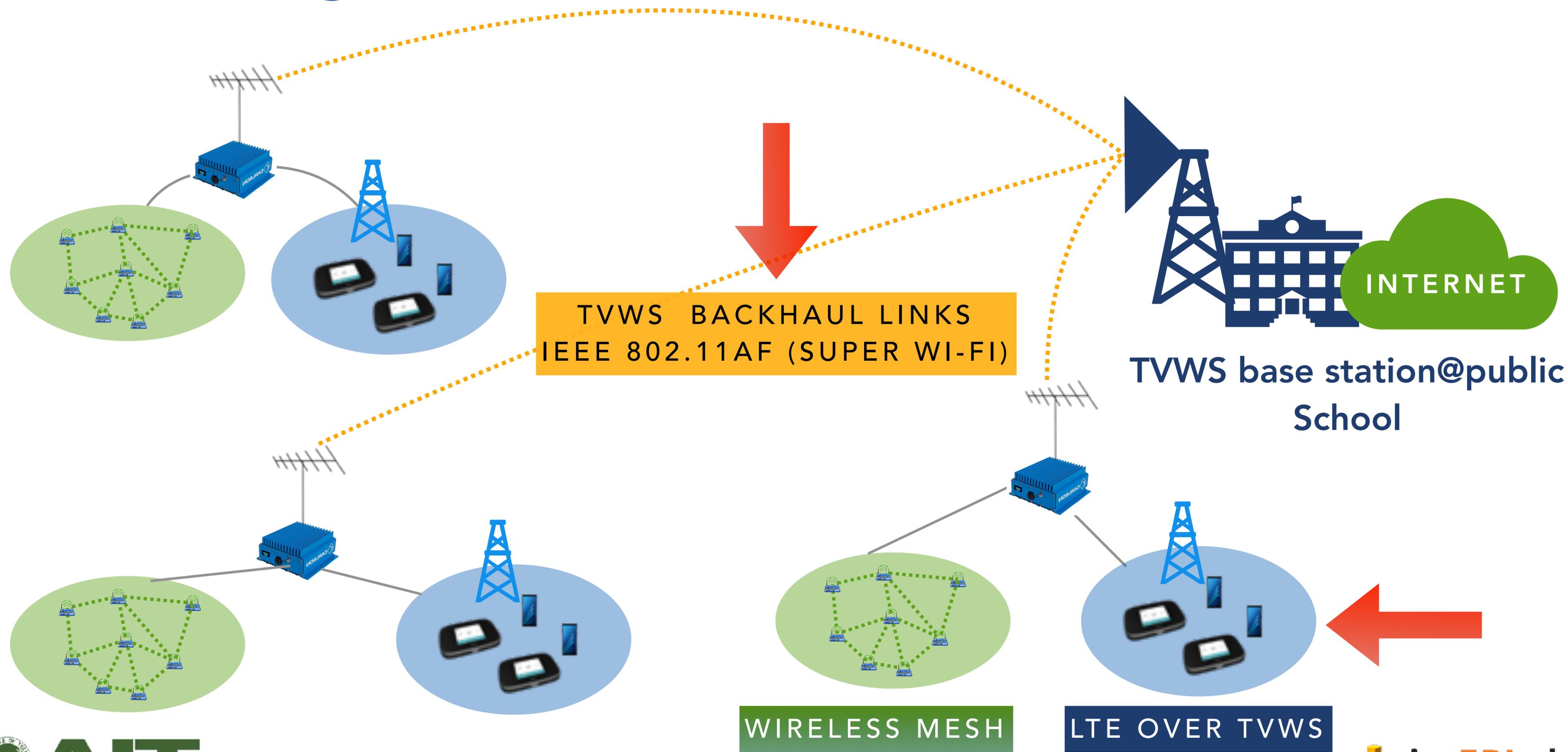


- The measurements were taken at AIT campus
- Ground truth: Spectrum Usage from national spectrum allocation report (regulator)

Our White Spaces;)

LOCATION	IDLE CHANNEL NUMBERS	TOTAL TVWS
AIT CAMPUS (45 KM FROM BKK)	27, 28, 30, 31, 33, 34, 35, 37, 38, 39, 41, 42, 43, 45, 46, 47, 48, 49, 50, 51, 53, 54, 55, 56, 57, 58, 59, 60	28
TAKNET	26, 27, 28, 29, 30, 32, 33, 34, 36, 37, 38, 40, 41, 42, 43, 44, 45, 46, 48, 49, 50, 52, 53, 54, 55, 56, 57, 58, 59, 60	30

Utilising TVWS over TakNet



TVWS BACKHAUL LINKS
IEEE 802.11AF (SUPER WI-FI)

TVWS base station@public
School

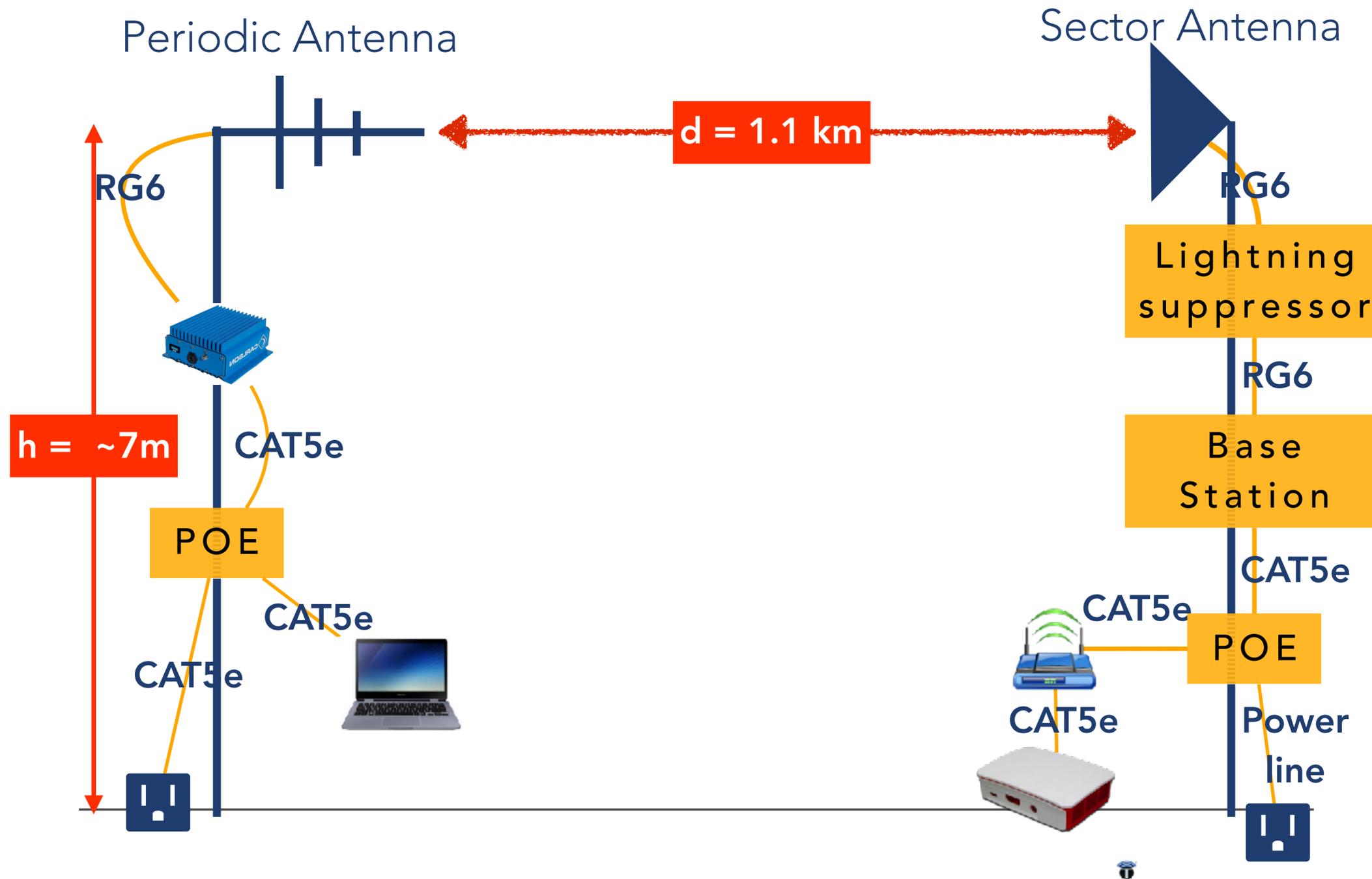
WIRELESS MESH

LTE OVER TVWS

Test them up!



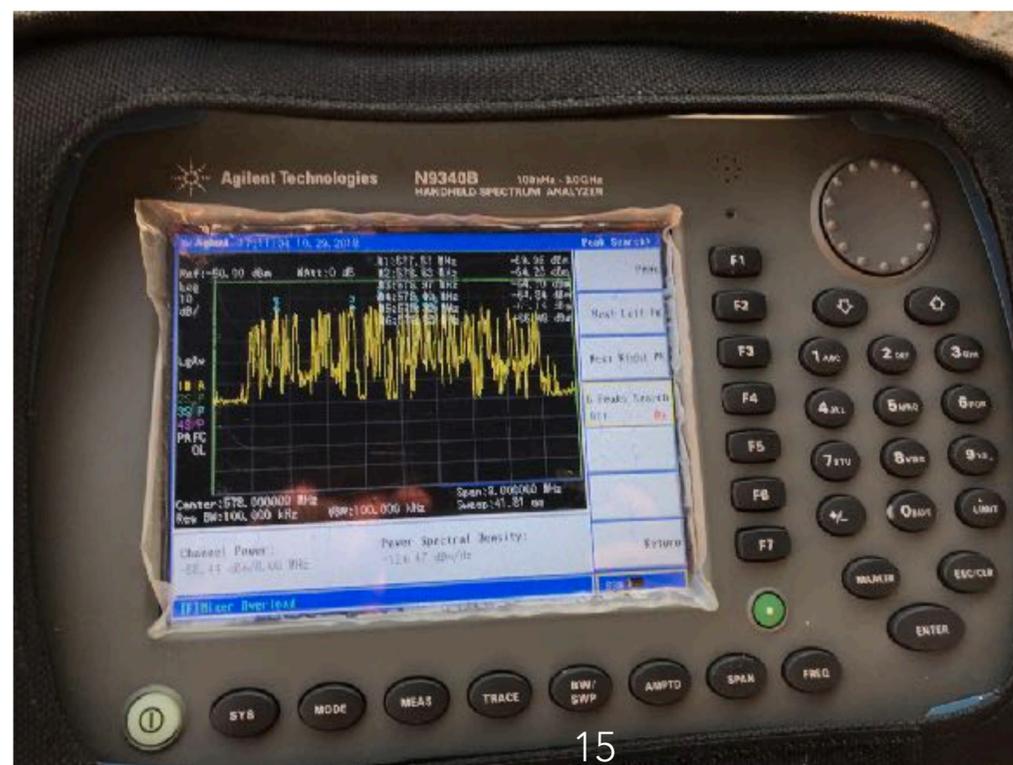
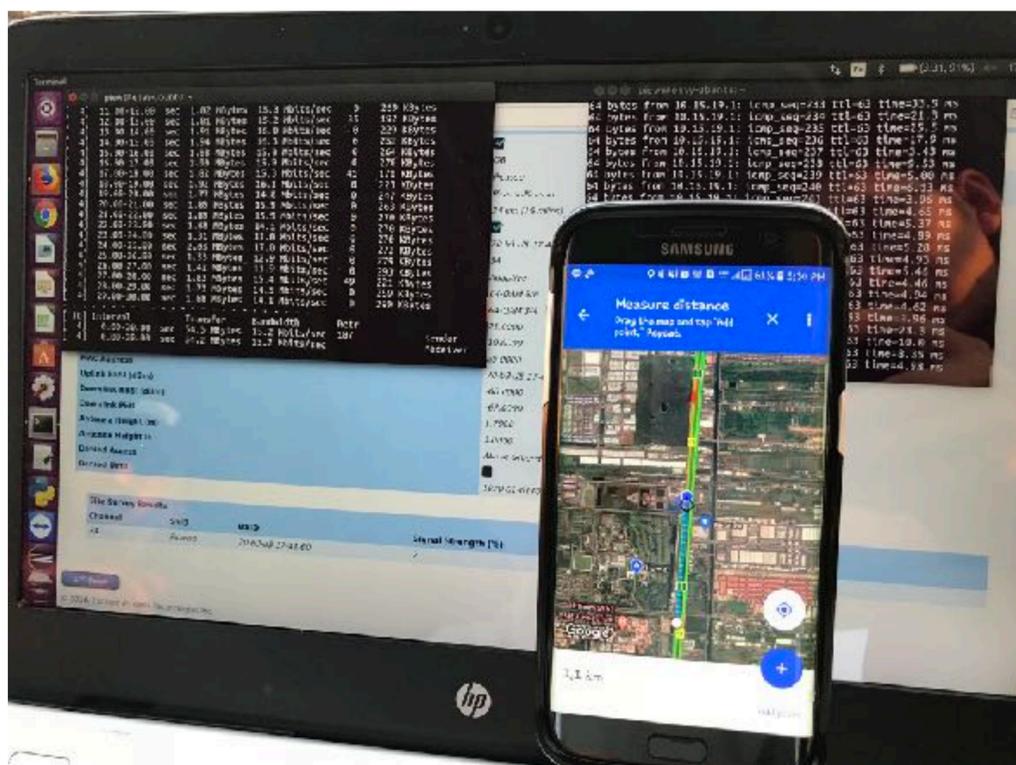
Network Configuration



Configuration

- Antenna height: $\sim 7\text{m}$
- Distance: 1.1 km with partial LOS
- Modulation: 64 QAM
- Frequency BW: 8 MHz
- Operating CH: 34 (574-582 MHz)
- Tx = 21 dBm
- Antenna gain = 10 dB

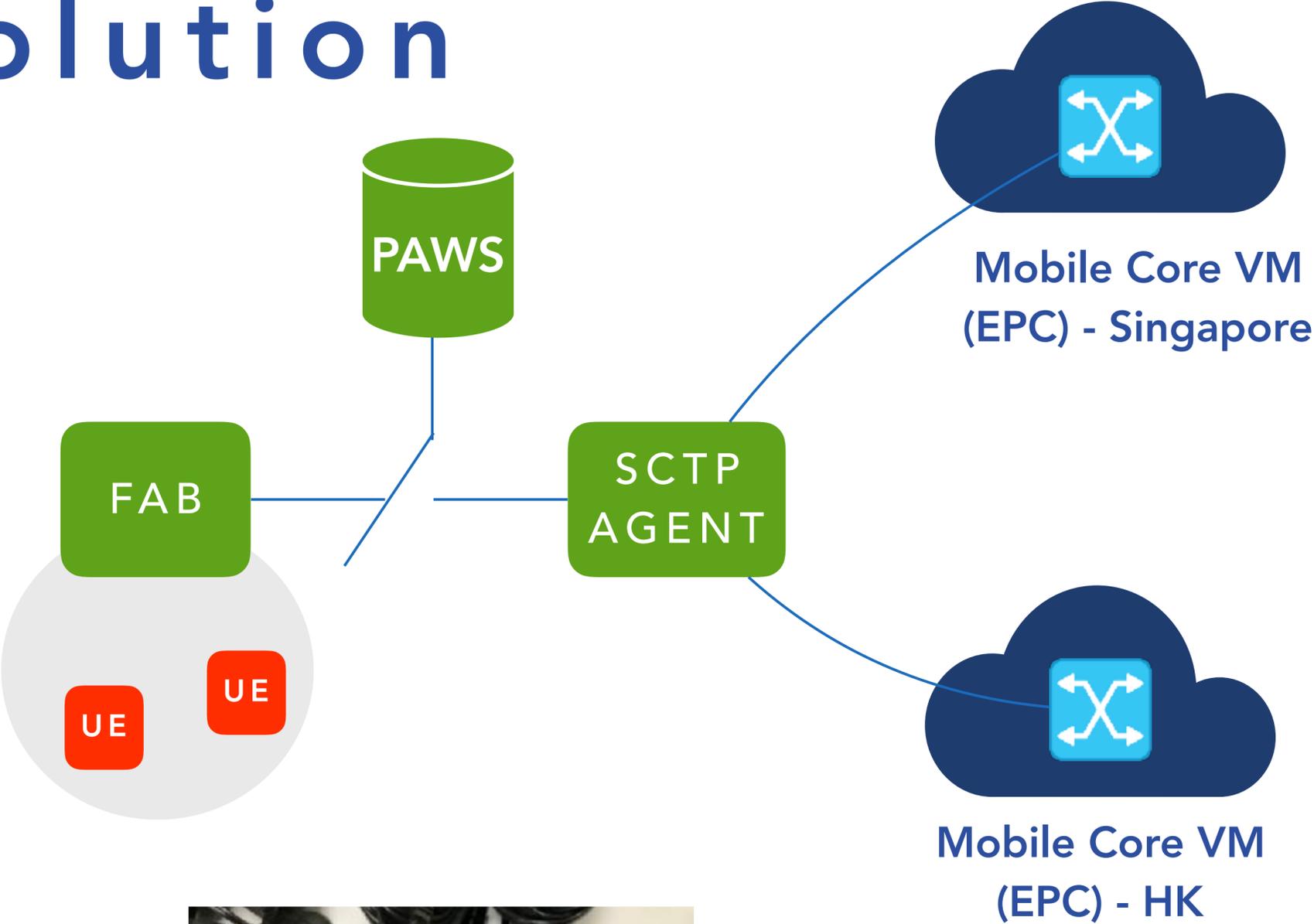
TVWS Backhaul: Performance Evaluation



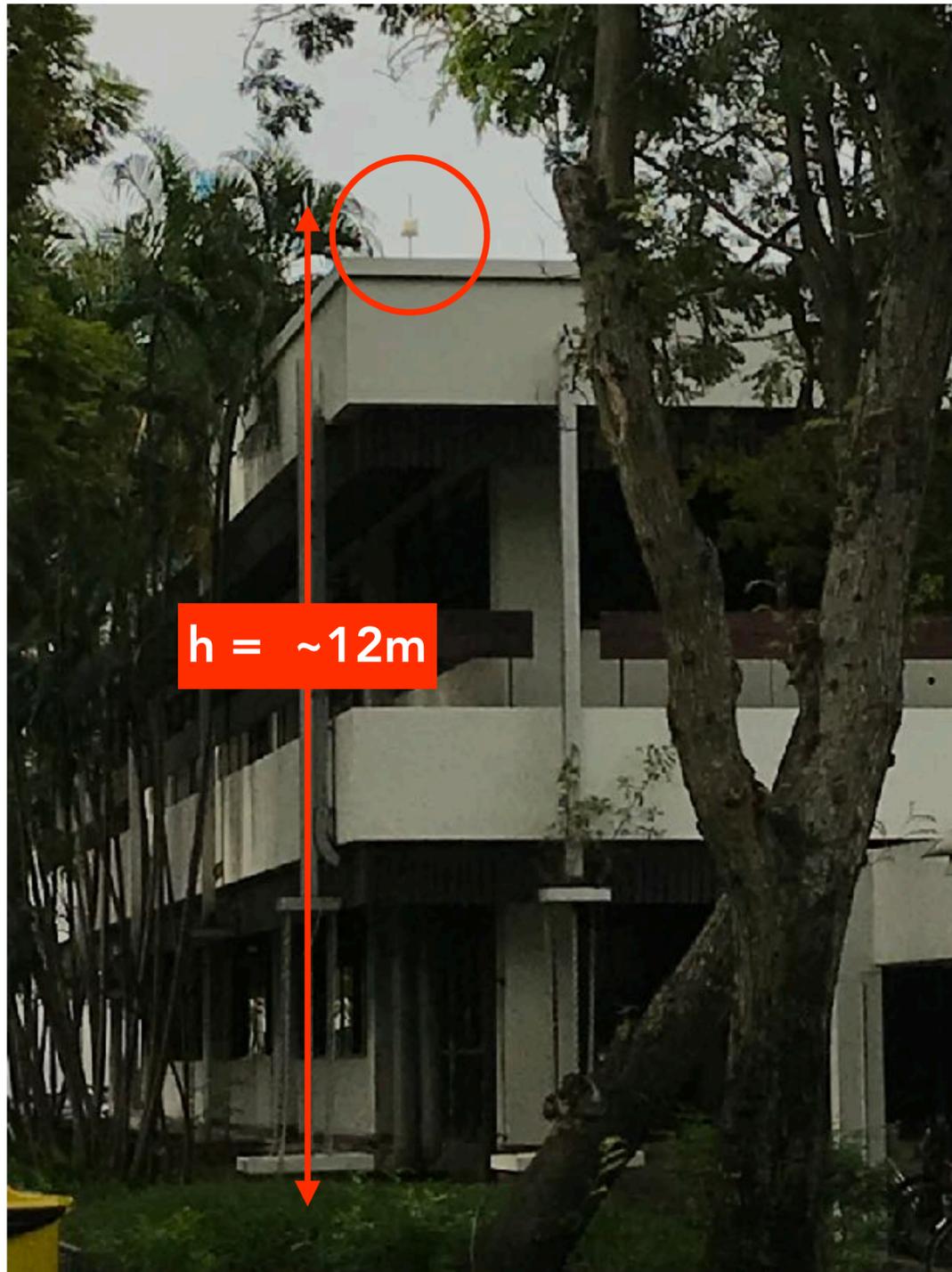
Performance
RSSI: - 51.5 dBm@ receiver side
Throughput: 15/10 (UL/DL)
Packet lost: 0%
RTT: ~5ms

LTE over TVWS Solution

- Collaborating with Microsoft research, UK
- Utilises the excellent radio characteristics of TVWS to cover the gap that CWMN could not support.

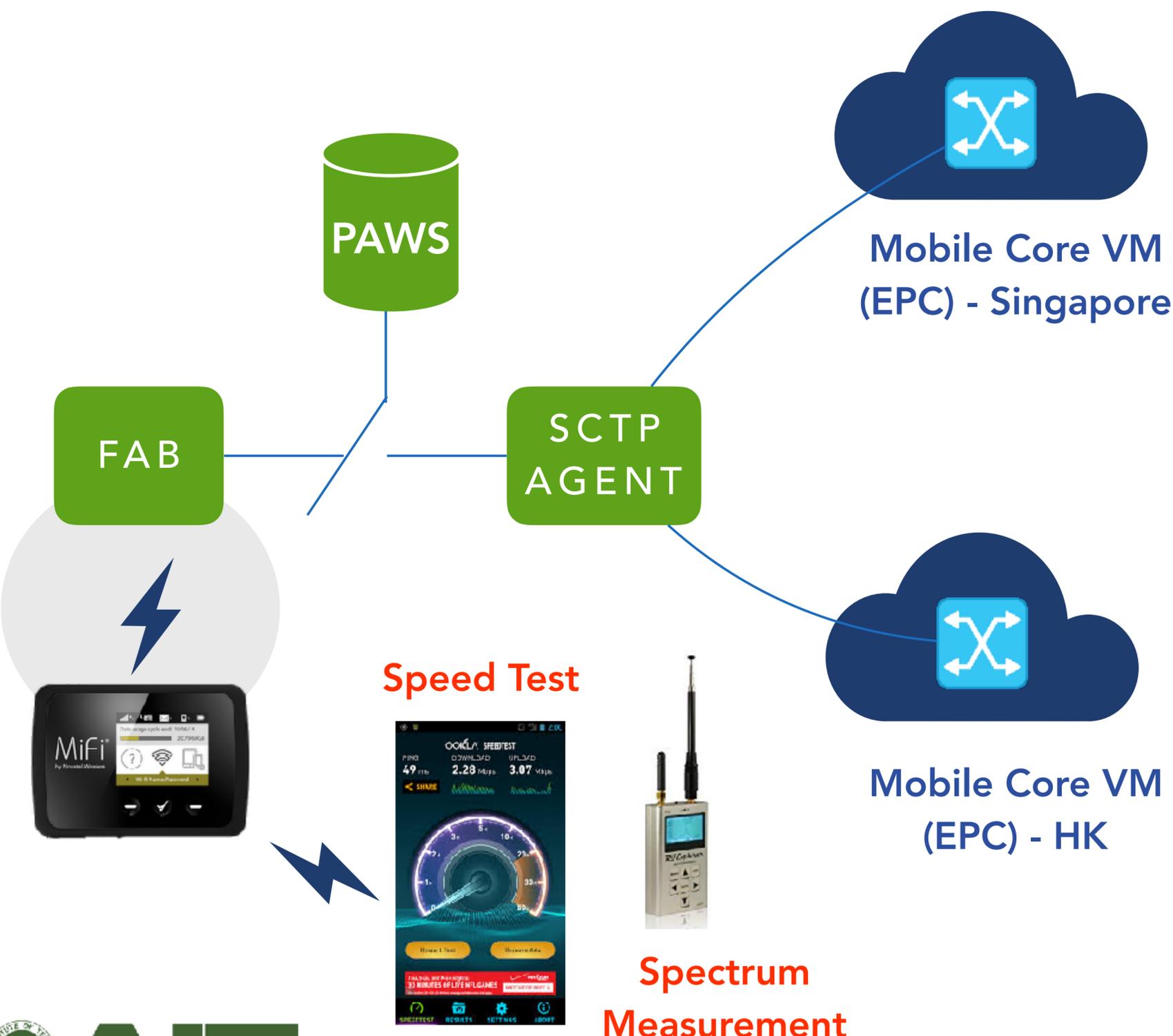


LTE over TVWS: Testing in AIT



- LTE small cell on the UHF 746 MHz
- Channel BW: 5 MHz
- maximum 16 active users
- Coverage area ~500 m.
- Strong signal even inside the buildings

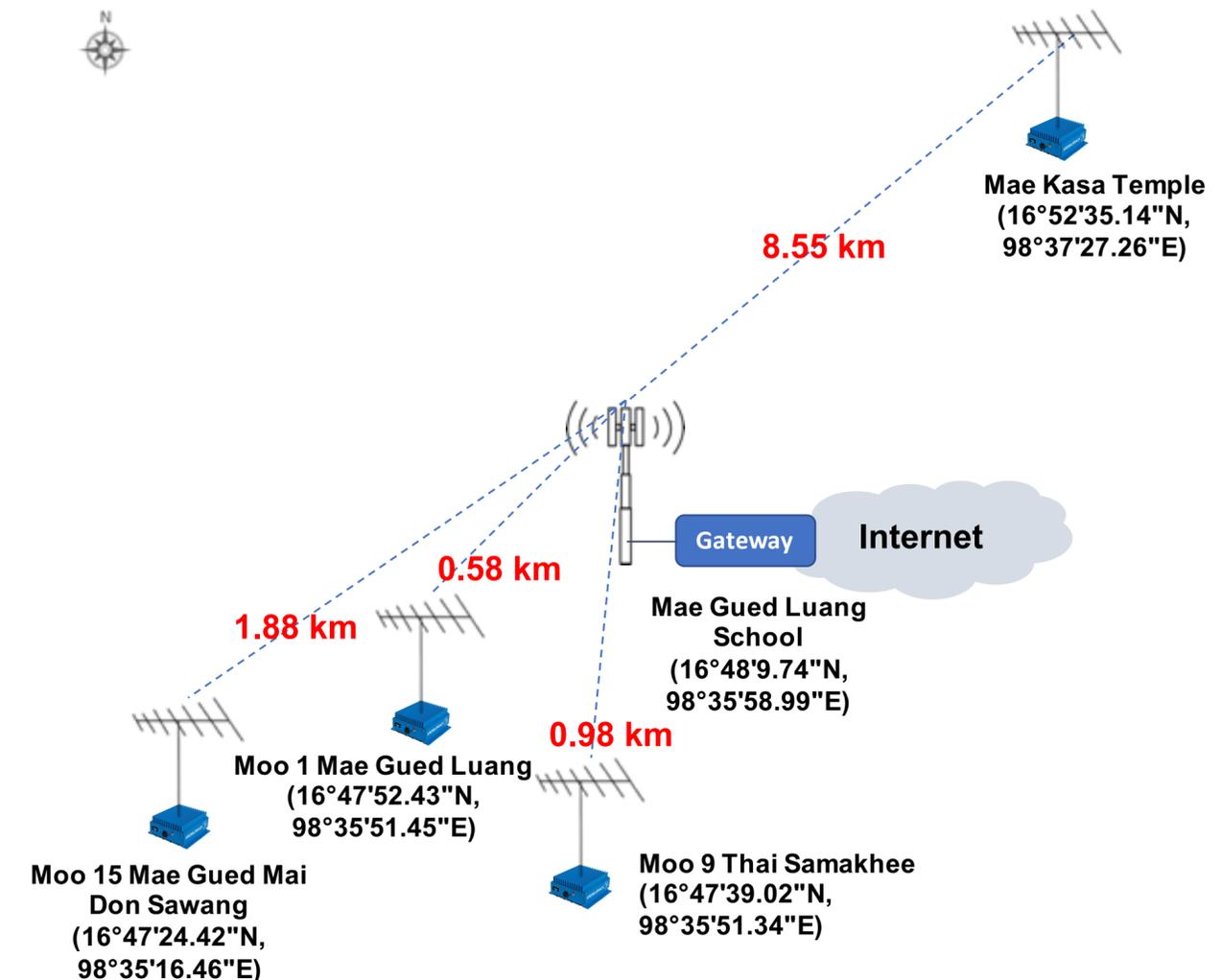
LTE over TVWS: Performance Evaluation



Server's location	PING (ms)	DOWNLOAD (Mbps)	UPLOAD (Mbps)
BKK	140.67	15.71	1.73
HK	98.67	15.85	2.1

Next Step...

- Preparing for a real deployment in TakNet
 - 1 TVWS base station - 4 TVWS client stations for new TakNet backhaul
 - 3 LTE small cells for network access integrating with TVWS backhaul
 - Lots of network measurement
- Exploring other methods for adaptive threshold
 - Machine learning
- Keep expanding TakNet ;)



Our Team



Kanchana



Mongkol



Apinun



Atthaphongse



Nunthaphat



Preechai



Nisararat



Adisorn

Internet Education
and
Research Laboratory

Thank you !





THANK YOU
Q&A

