Rural Community Wireless Mesh Network & TVWS Activities by intERLab/AIT

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ICTP School on Open Spectrum and Applications of White Spaces Technologies
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Outline

- Background : disaster emergency communication research @ intERLab

- TakNet: a rural community wireless mesh network

- ChiangRai MeshTV : A rural community wireless mesh network focused on community education.
  ISIF Grant Recipient 2014

- TVWS spectrum scanning in Tak

Indian Ocean Tsunami of 2004

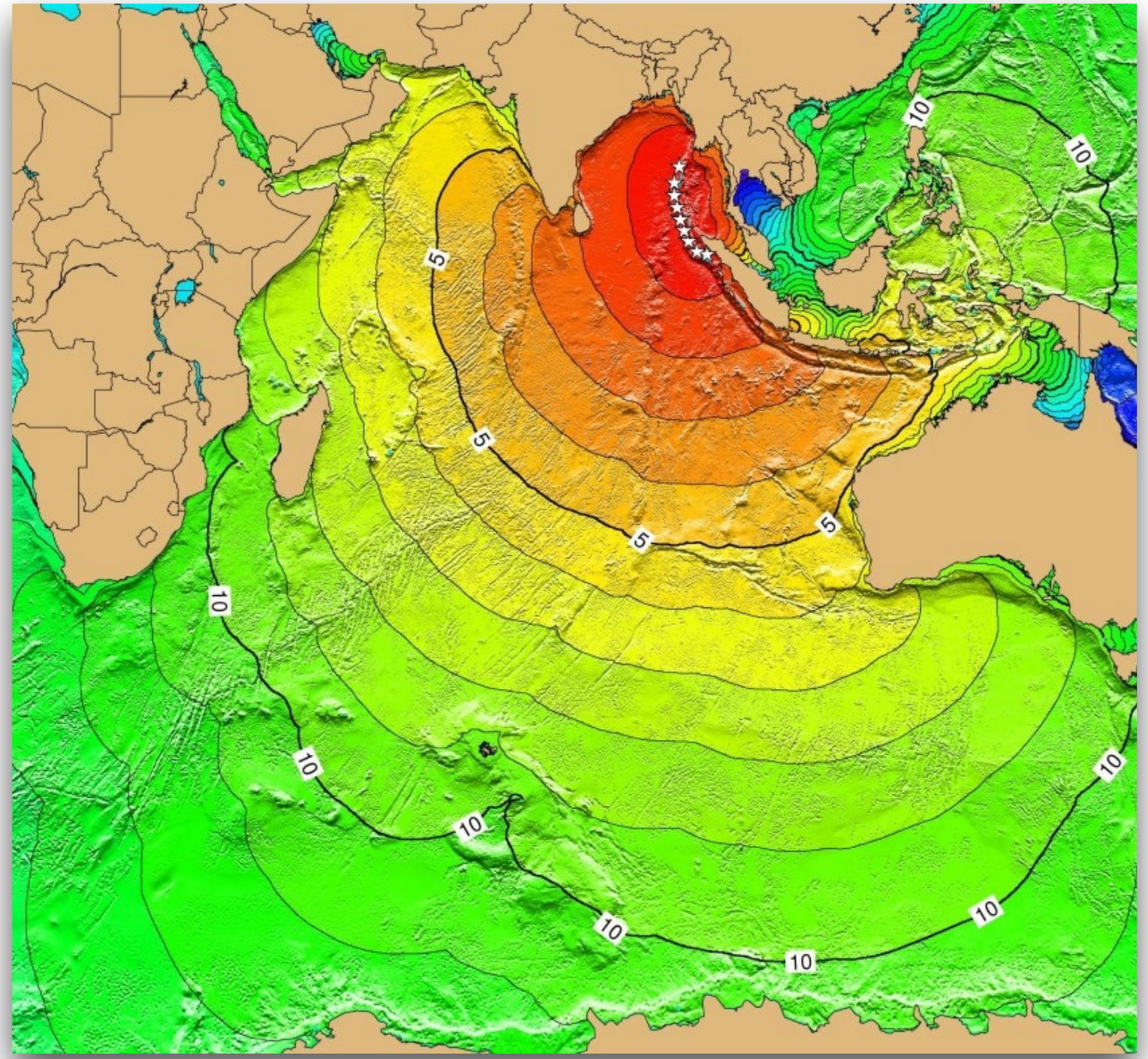


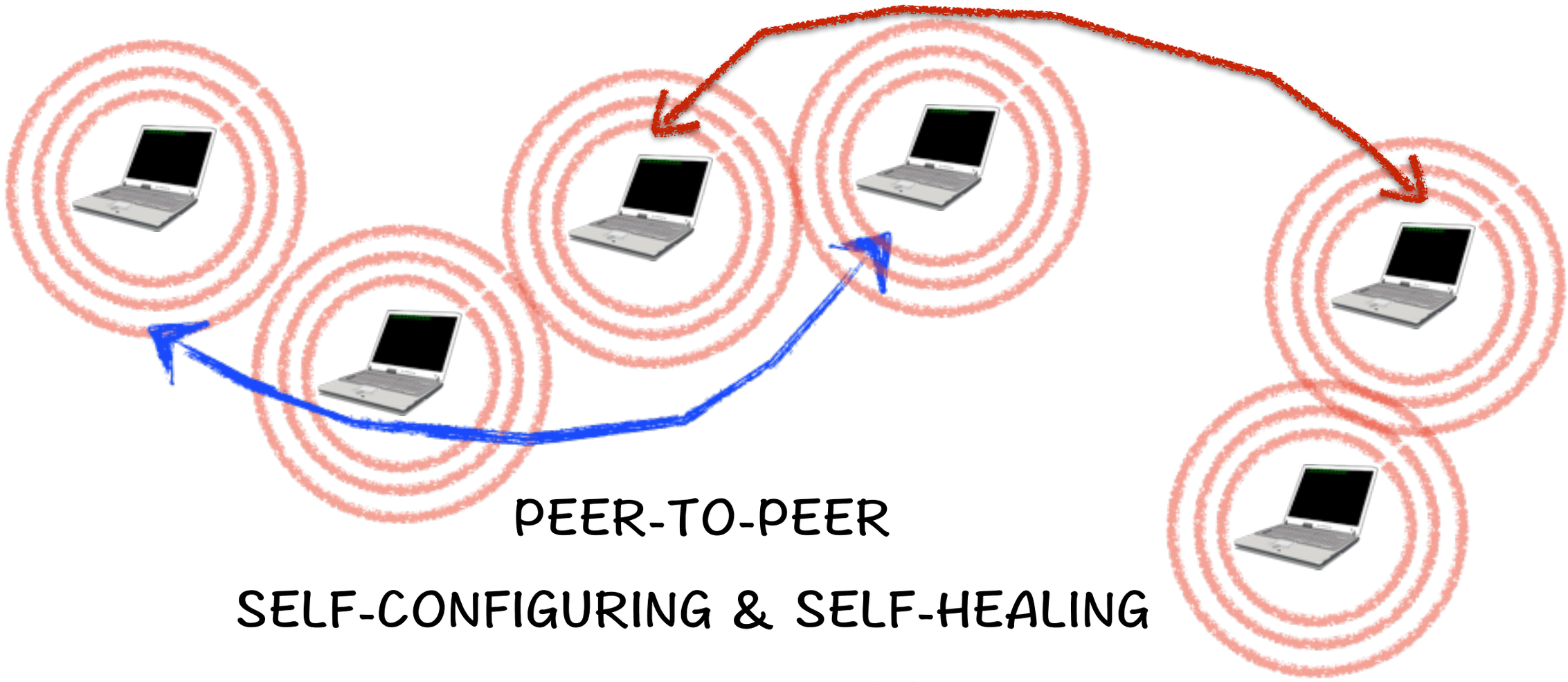
Image Source: NOAA

Disaster and communication infrastructure

A collapsed bridge can cut down fiber optics -- cutting communication to the whole region

Flood can disrupt electricity supply and destroy internet data centers

Characteristics of Mobile Ad hoc Networks (MANET)



PEER-TO-PEER

SELF-CONFIGURING & SELF-HEALING

ADAPTIVE TO TOPOLOGY CHANGES

MULTI-HOP, MULTI-PATH ROUTING

MULTIMEDIA CAPABILITIES

Commodity Devices

2006:
Large Notebooks

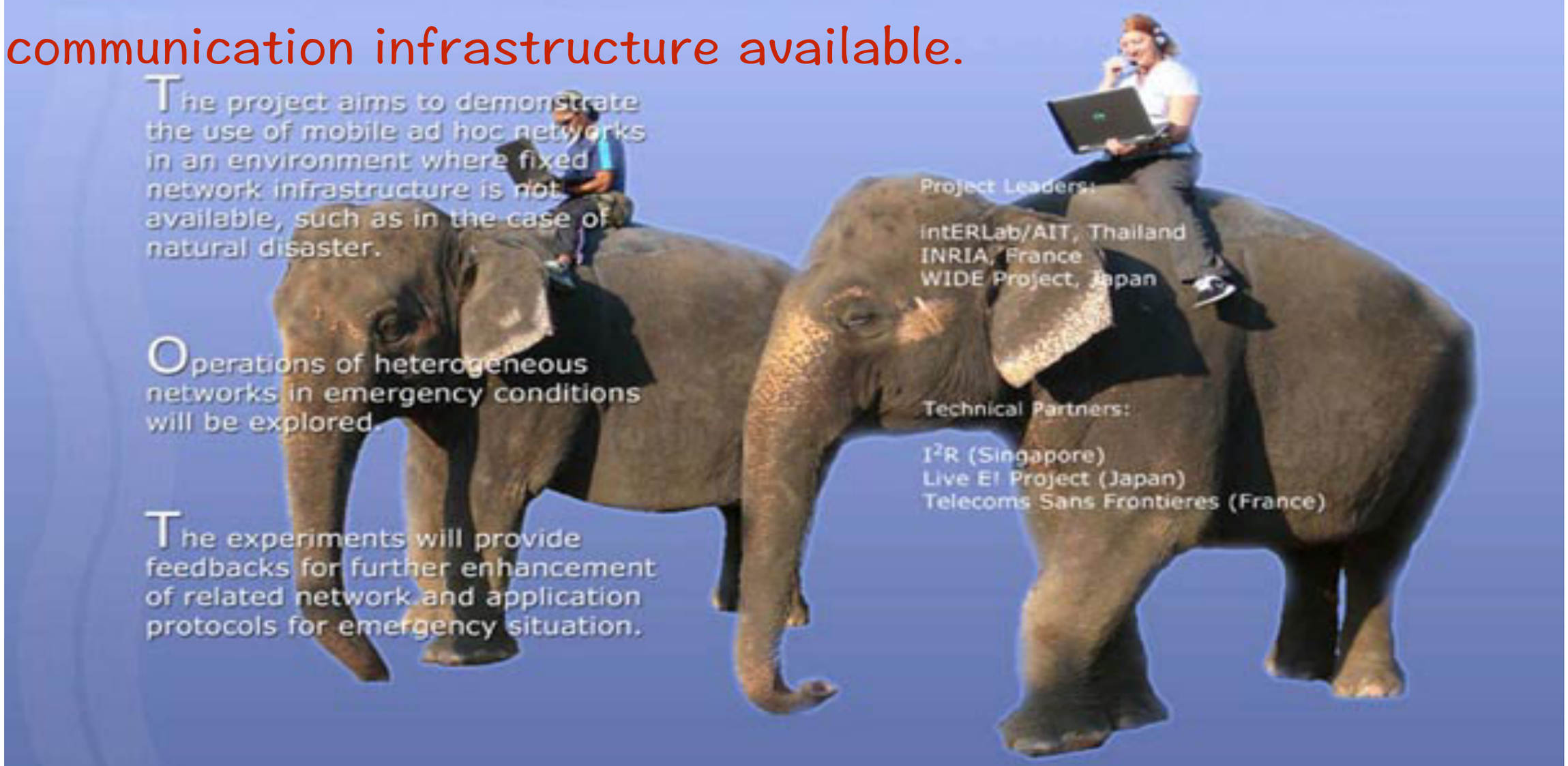
2008: Netbooks, and Bluetooth-enabled mobile phones

2011:
Tablets, Smartphones and Embedded systems

2013 - present:
Mobile routers

DUMBONET I (2006)

A multimedia emergency communication network for the situations where there is severely disabled, or no communication infrastructure available.



Digital Ubiquitous Mobile Broadband OLSR Network

a.k.a. "DUMBONET"

DUMBONET I
(December 2006)

IP Star
Satellite

IP Star
Uplink

IP Star Gateway

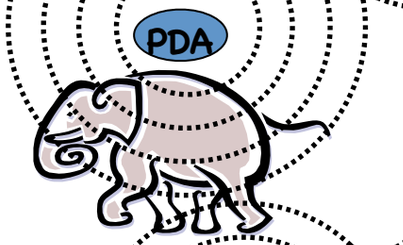
Terrestrial
Internet

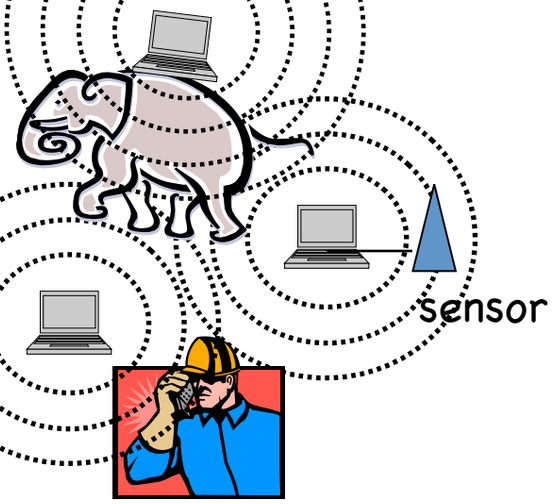
Simulated
Head Command
Center (AIT)

Field
Satellite
Access

MANET
OLSR

PDA





sensor

Simulated Disaster
Area 1

Field
Satellite
Access

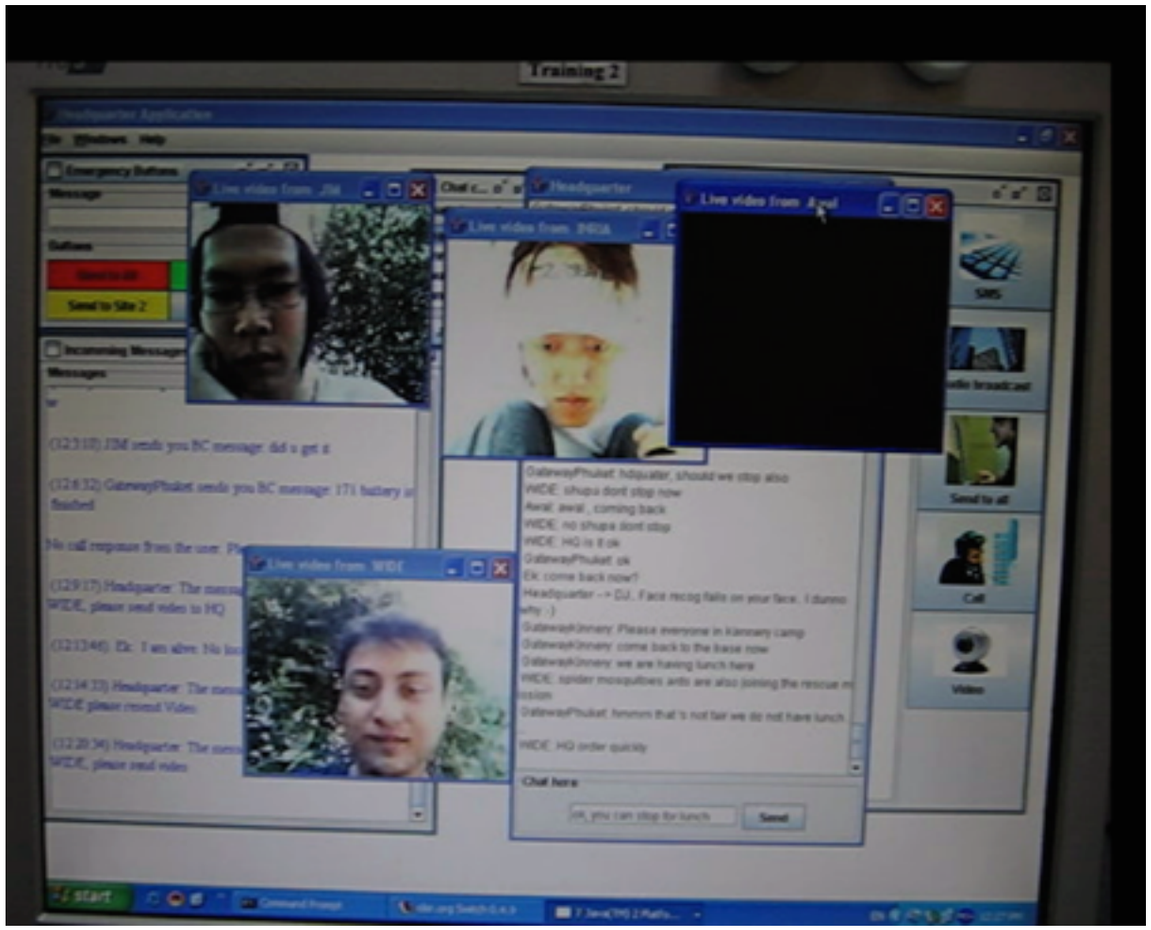
MANET
OLSR

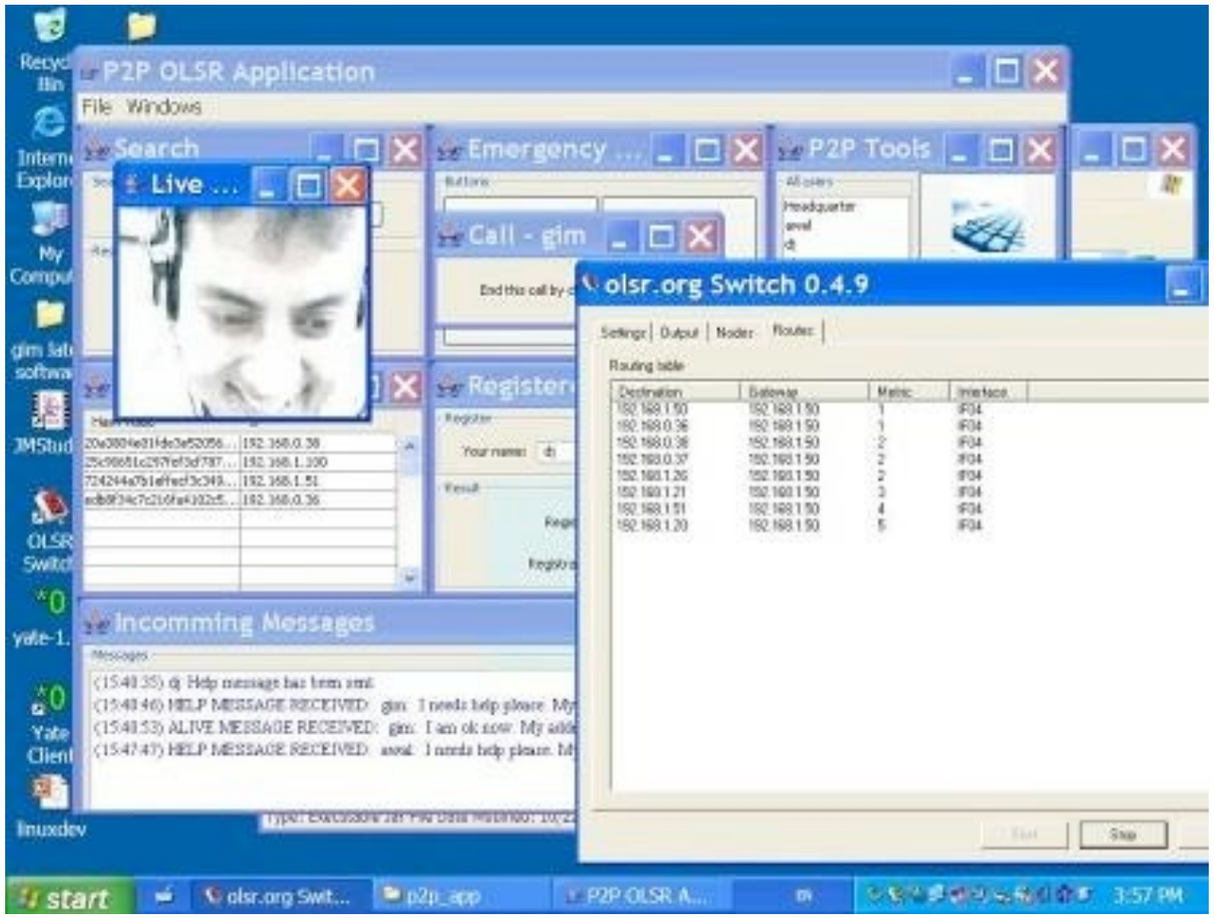
PDA

Simulated Disaster
Area 2

Features of DUMBONET I

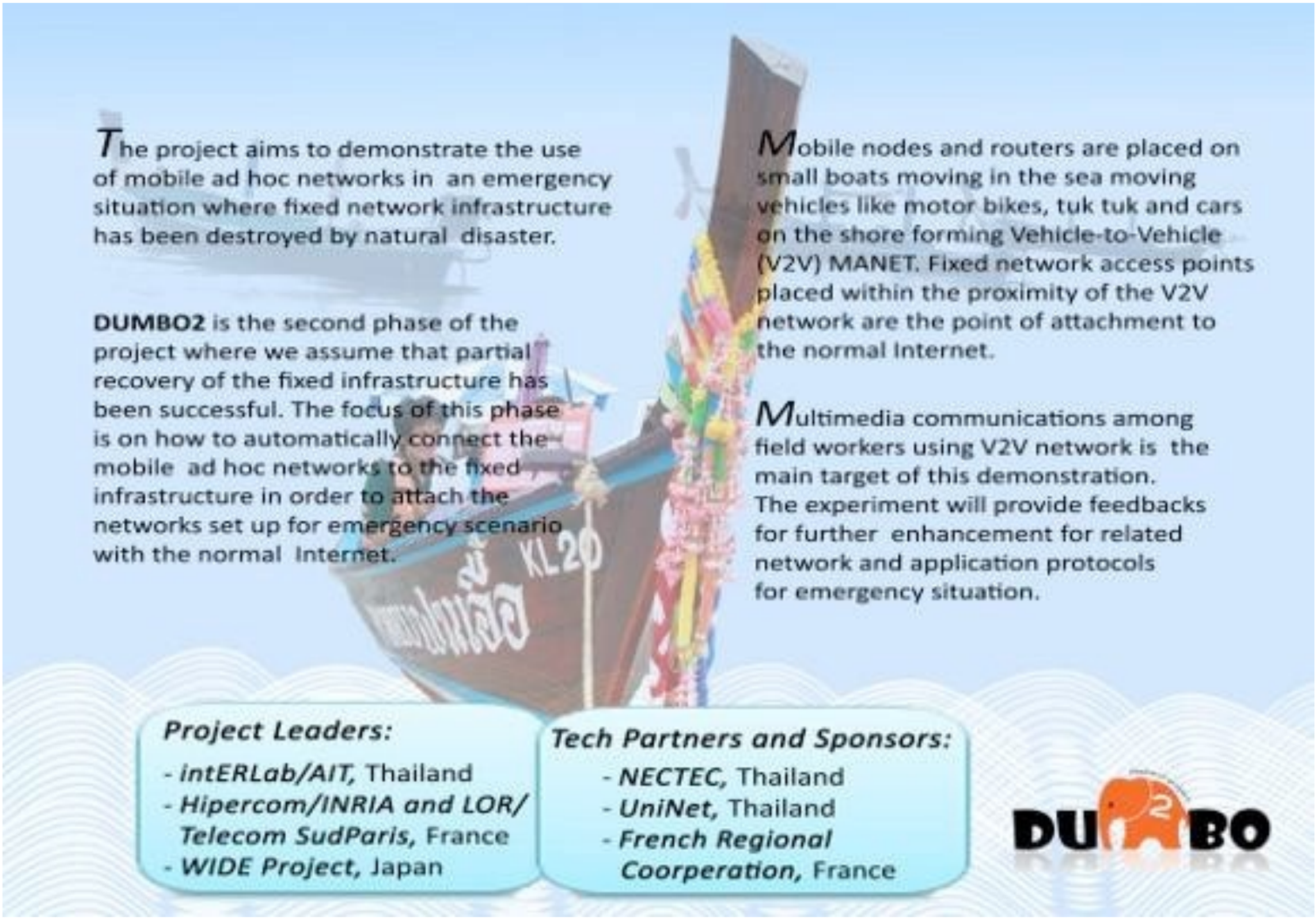
- Interactive Video, Voice, and Instant Messaging
  - very important for situational awareness
- Peer-to-Peer Paradigm



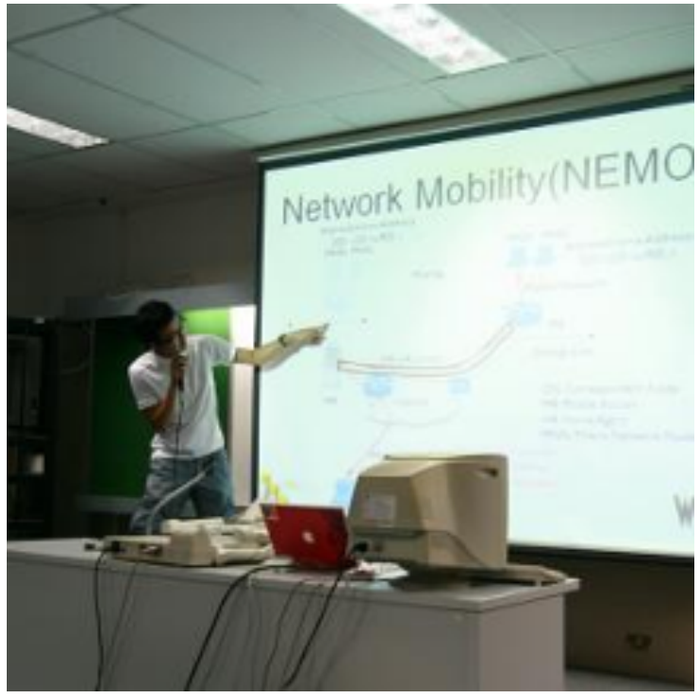


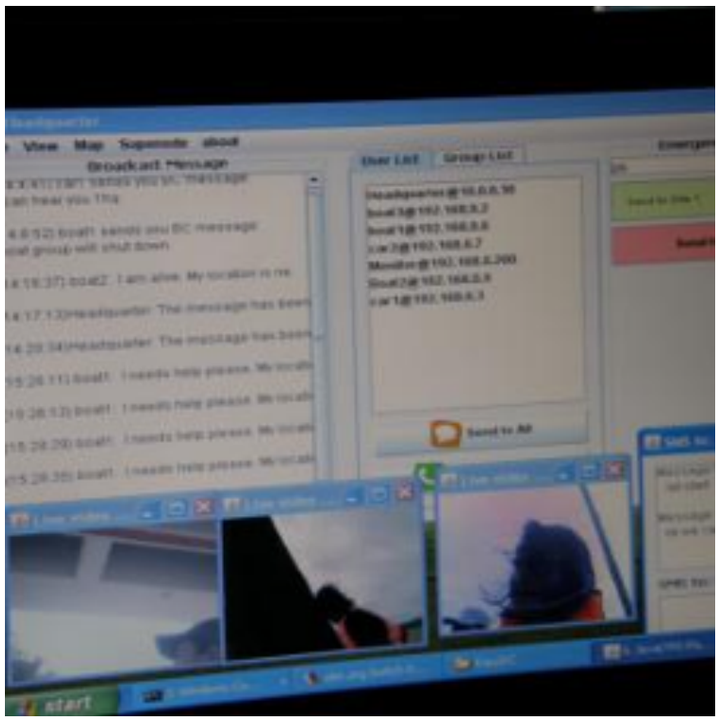
DUMBONET test in 2006

DUMBONET II (2008) : Connecting the vehicles

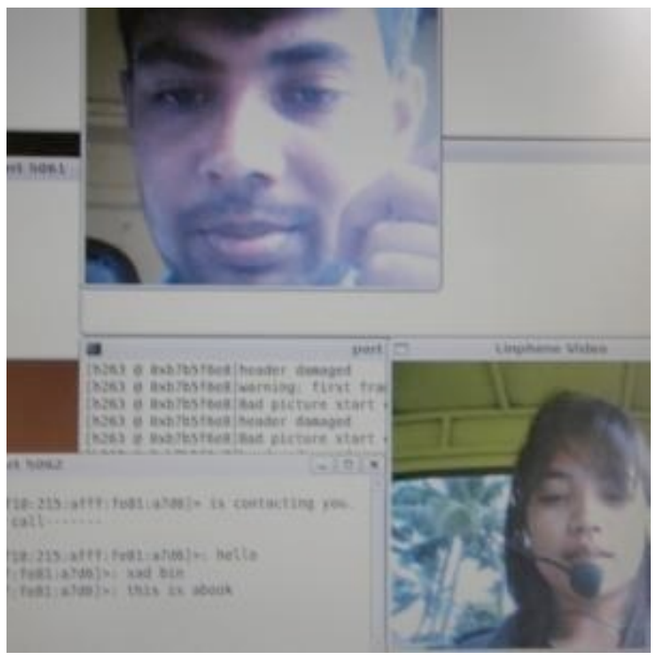


DUMBONET II : Connecting the vehicles





DUMBONET II : Connecting the vehicles



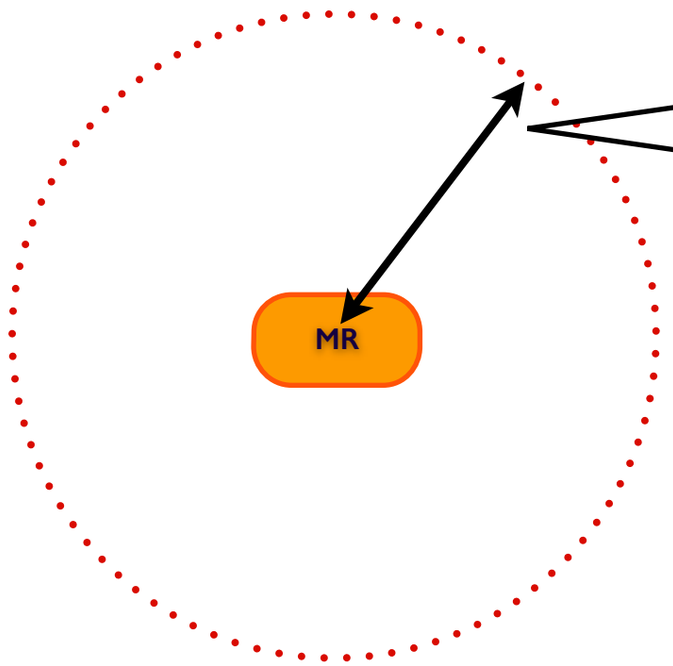
DUMBONET III (2010) : Challenged Networks

Khao-Yai (~Grand Mountains) National Park, Thailand

- Trail in a dense tropical rainforest (~ 3 KM)
- Highly 'challenged' environment:
  - Trees and terrain disrupt our WiFi, CB, and GSM signals
  - Even GPS signal oftentimes cannot get through dense tree leaves

How to enable multimedia emergency communication in highly challenged and disruptive environments?

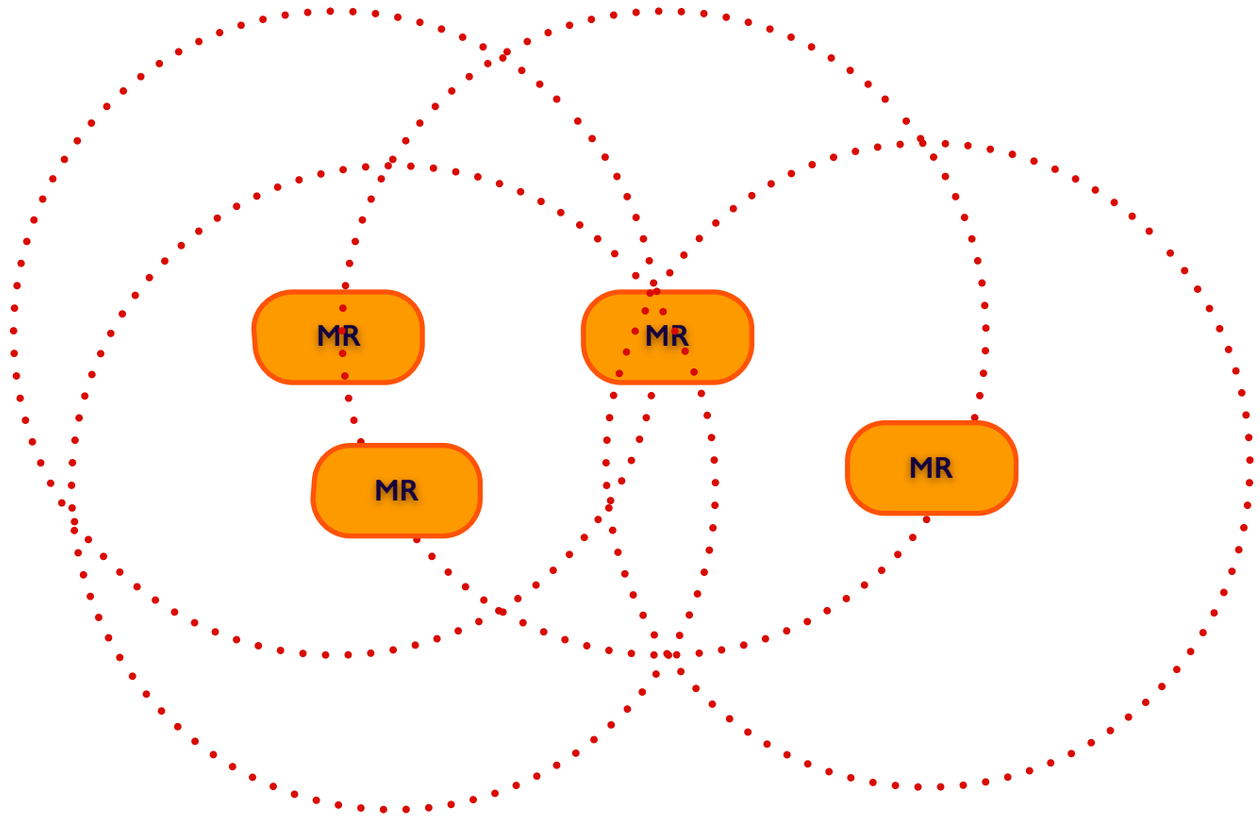
DUMBONET IV (2013): Mobile Routers (MR)



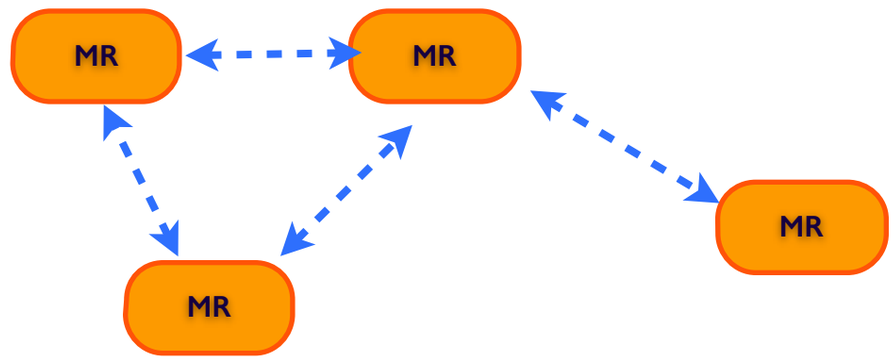
- Approximately 100 - 150 meters of coverage radius.
- Shorter distance means a more stable and reliable link
- Built-in battery allows ~ 4 hours operation.
- We have replaced the factory firmware and specially customized the configuration parameters for emergency network operations

Coverage vs. Link Views

Coverage View



Connectivity (Link) View

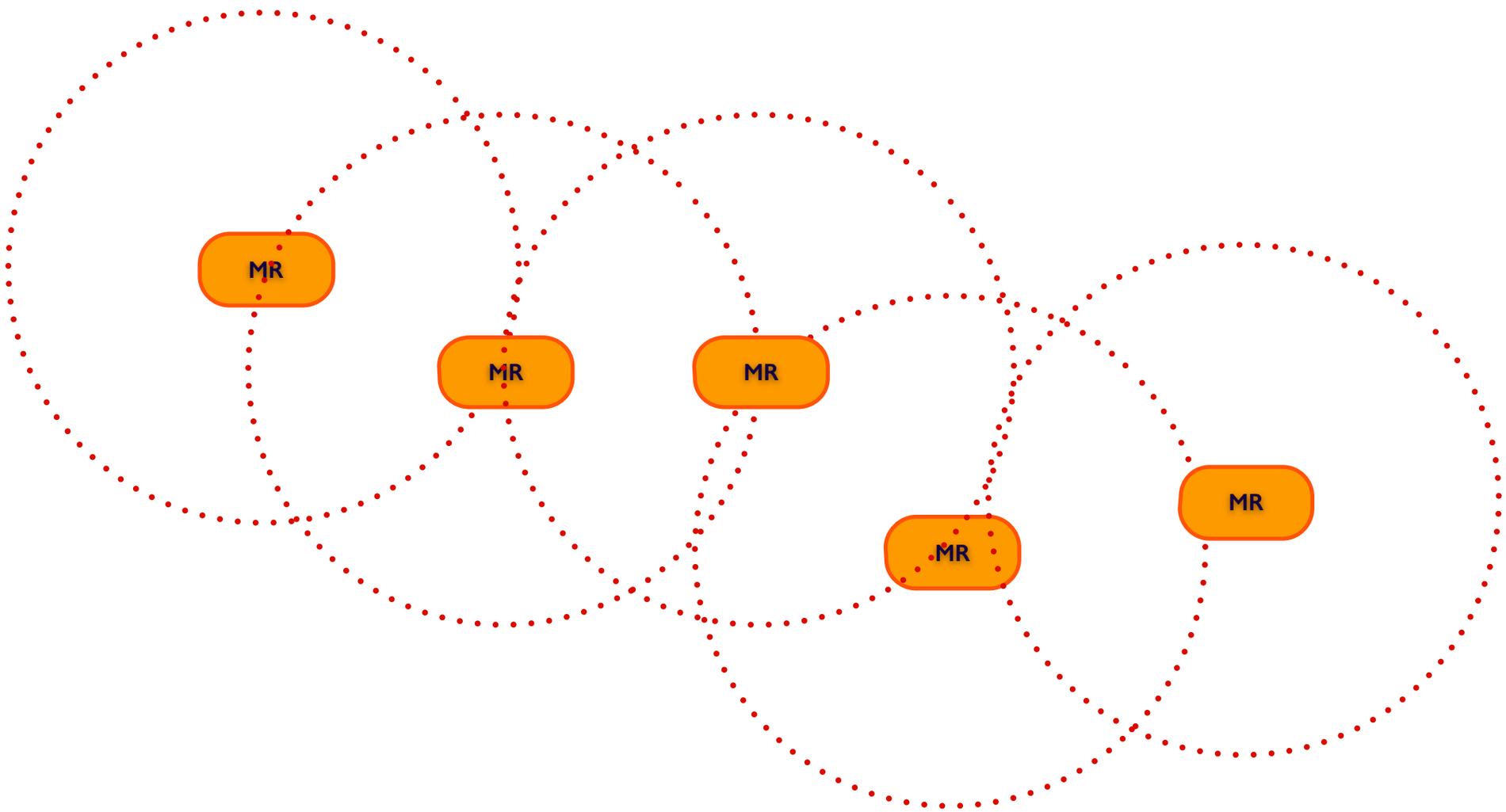


is one DUMBONET hop (wireless)

Maximum distance between any two farthest routers should not exceed 4 wireless hops

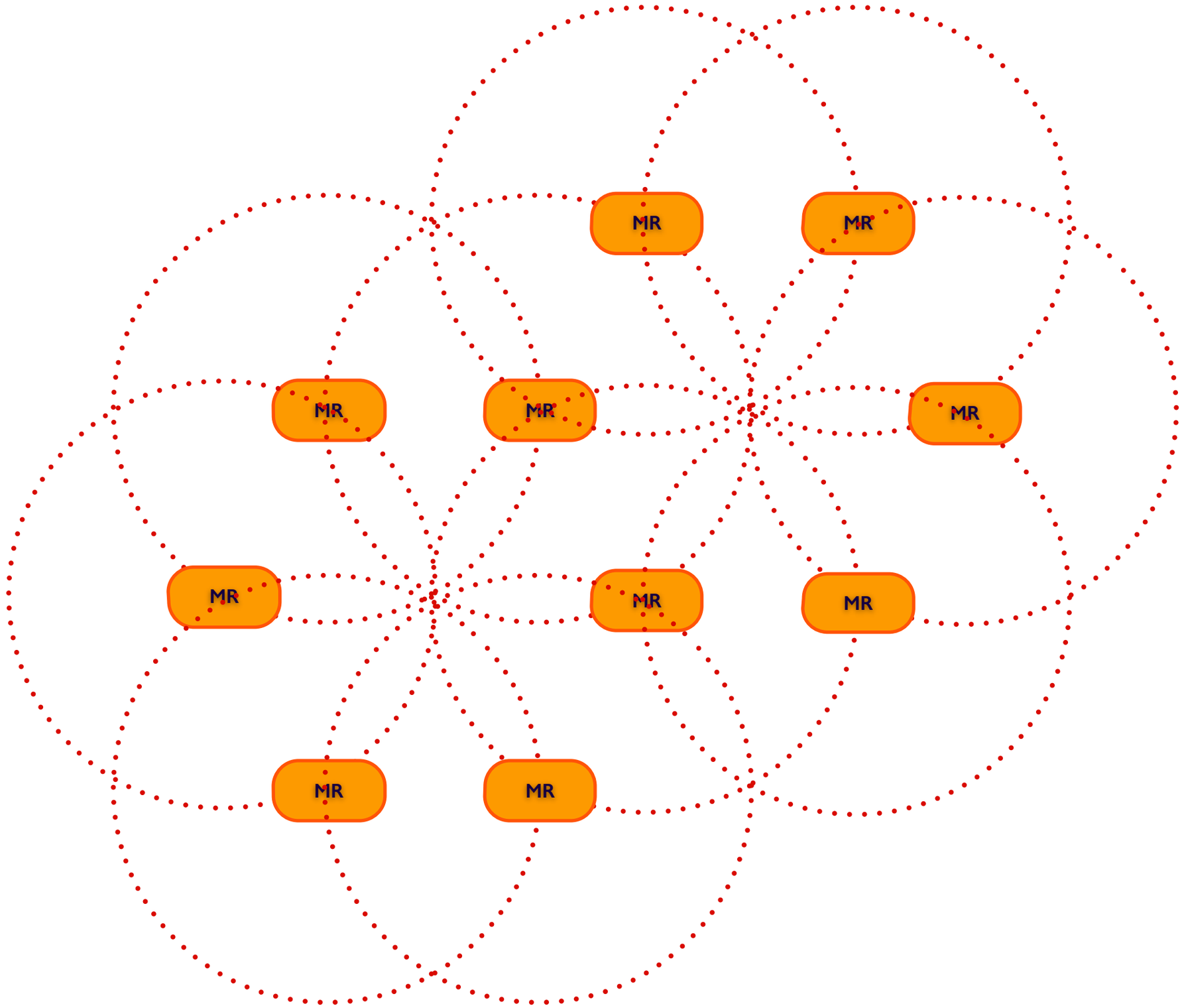
Example of Sparse Topology :

The sparse topology offers a reasonably wider or farer coverage in a specific direction. But if the nodes spread too far, the network might break into several segments



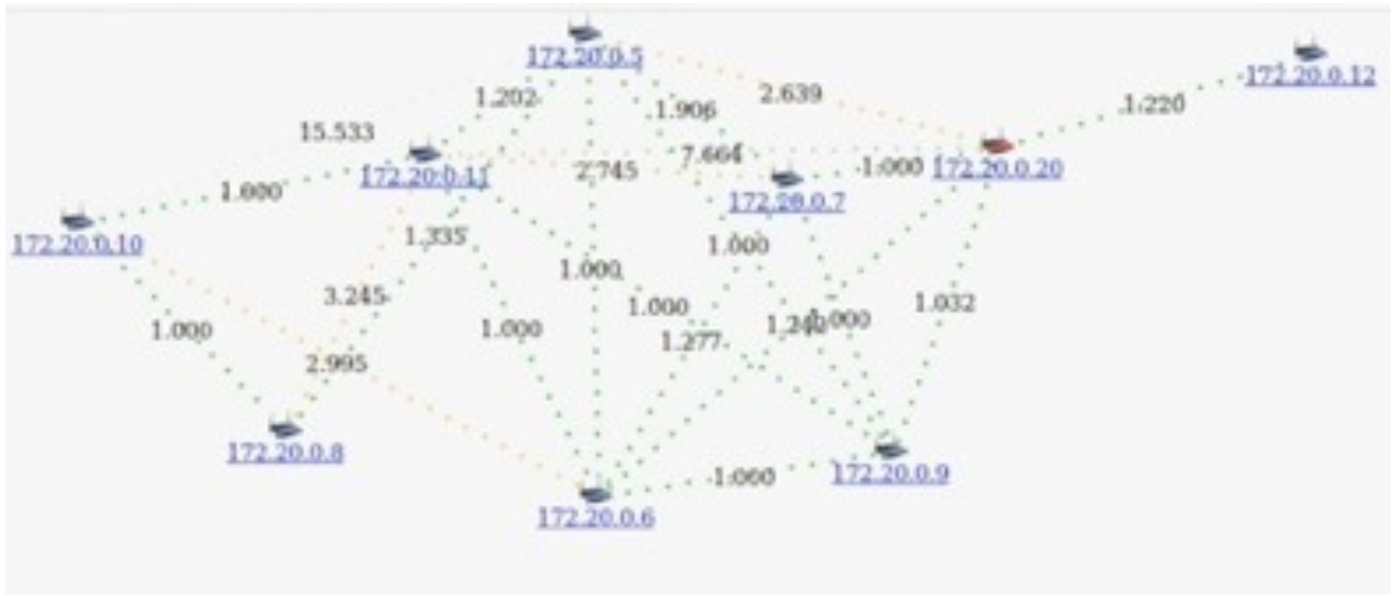
Example of Dense Topology :

Better robustness



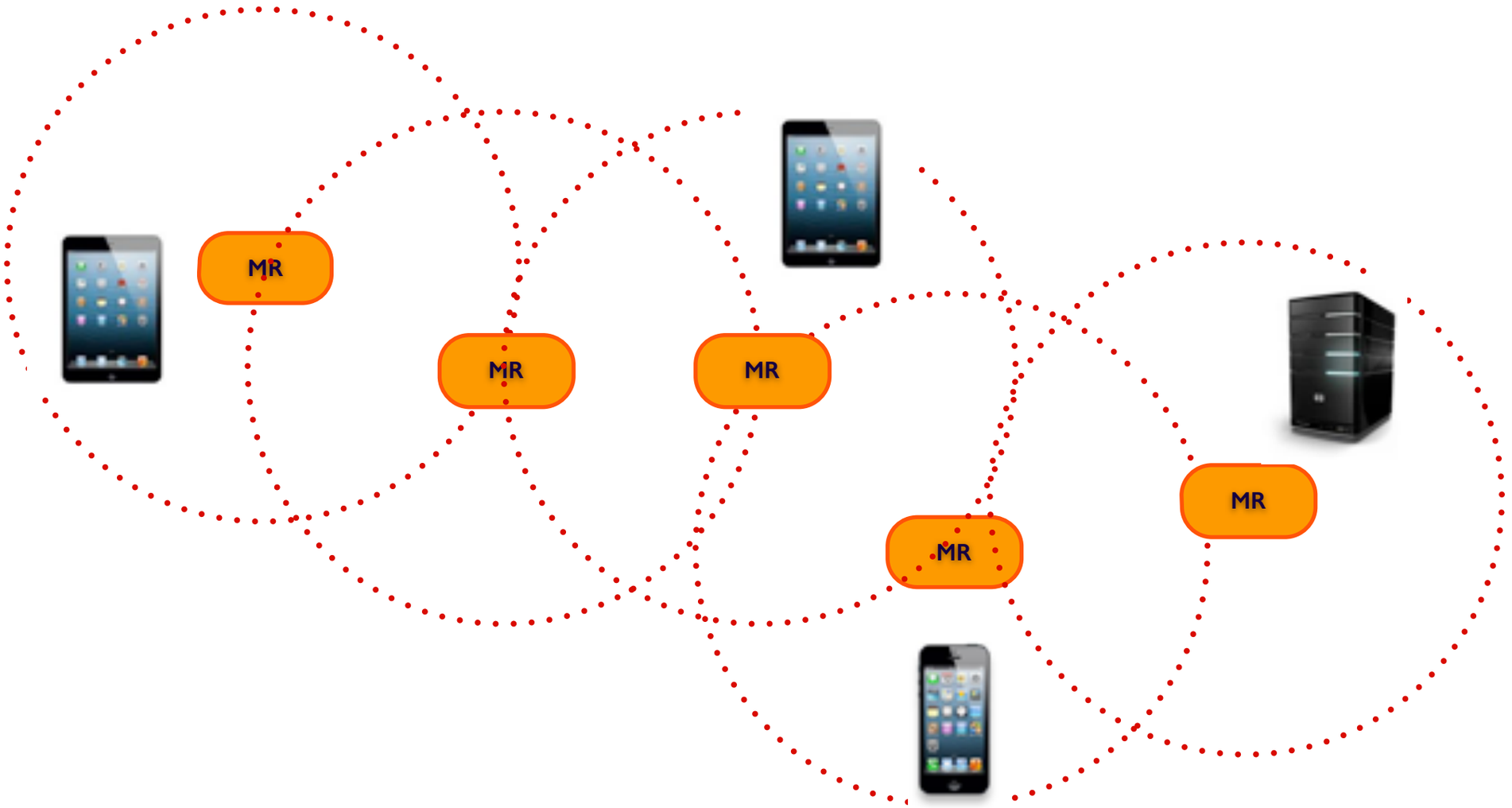
4 simple steps to operate DUMBONET

1. Install the mobile routers in their designated places
2. Connect each router to a power supply or install a fully charged battery
3. Switch the routers to "ON" and wait
4. When the indicator lights start to blink, it's done: The DUMBONET emergency network is formed.

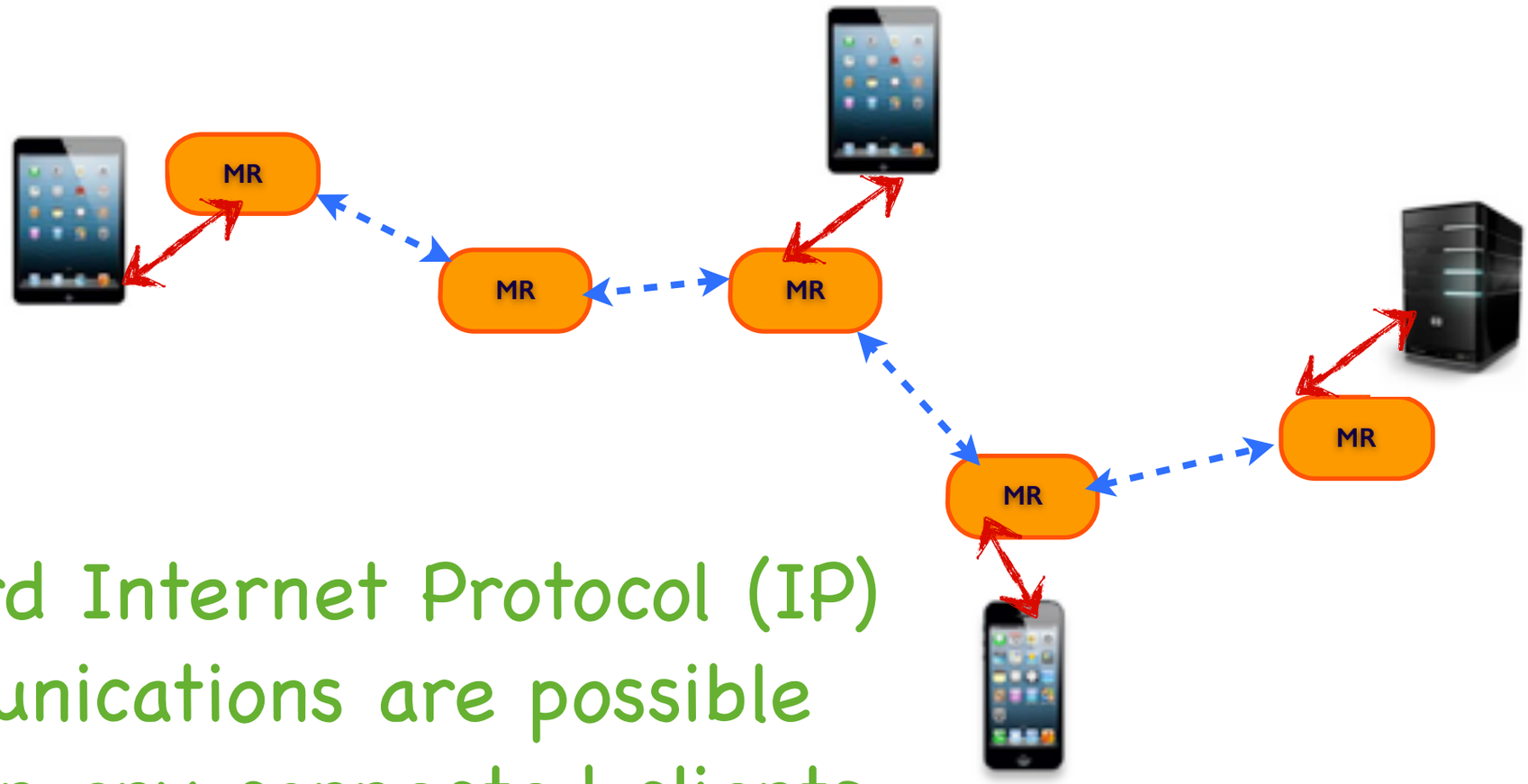


How to connect the clients :

Put the clients in the covered area and connect to the nearest DUMBONET MR as normal Wi-Fi clients



The Link View :



Standard Internet Protocol (IP) communications are possible between any connected clients and computers.

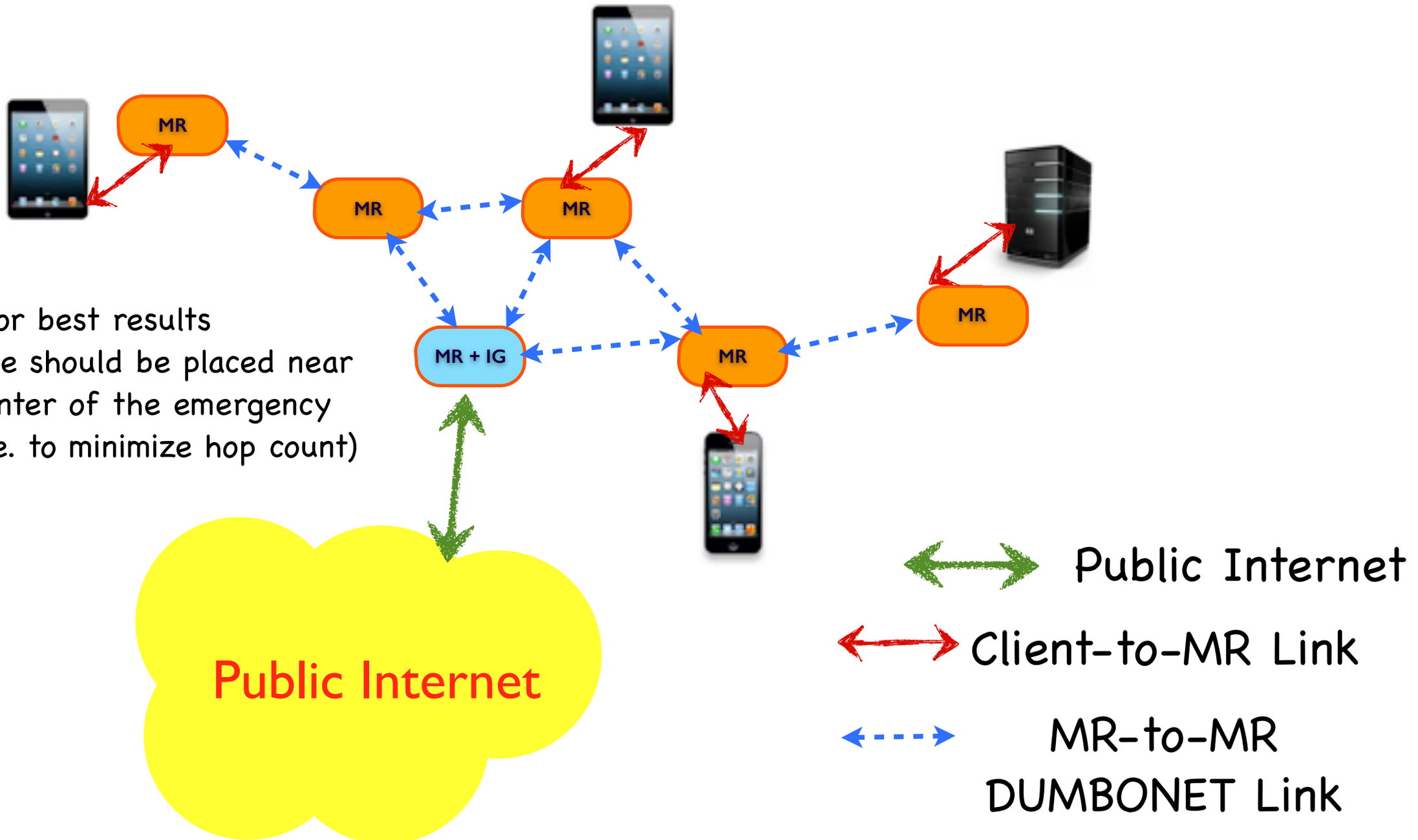
Think of this as our own "intranet"

Client-to-MR Link

MR-to-MR DUMBONET Link

Internet Gateway (IG) in DUMBONET

One DUMBONET node can be specially configured to connect to the public Internet (e.g. via Ethernet cable or 3G/4G cellular).
Add the IG node and then every client can access the public Internet.



For best results
the IG node should be placed near
to the center of the emergency
network (i.e. to minimize hop count)

TakNet (2013)

A rural community wireless mesh network

Motivations

- **IT IS IMPORTANT TO HAVE EMERGENCY NETWORKS READY WHEN A DISASTER STRIKES !!**

- **PEOPLE SHOULD KNOW KNOW HOW TO USE THE EMERGENCY NETWORKS, PREFERABLY THROUGH OTHER DAILY ACTIVITIES**

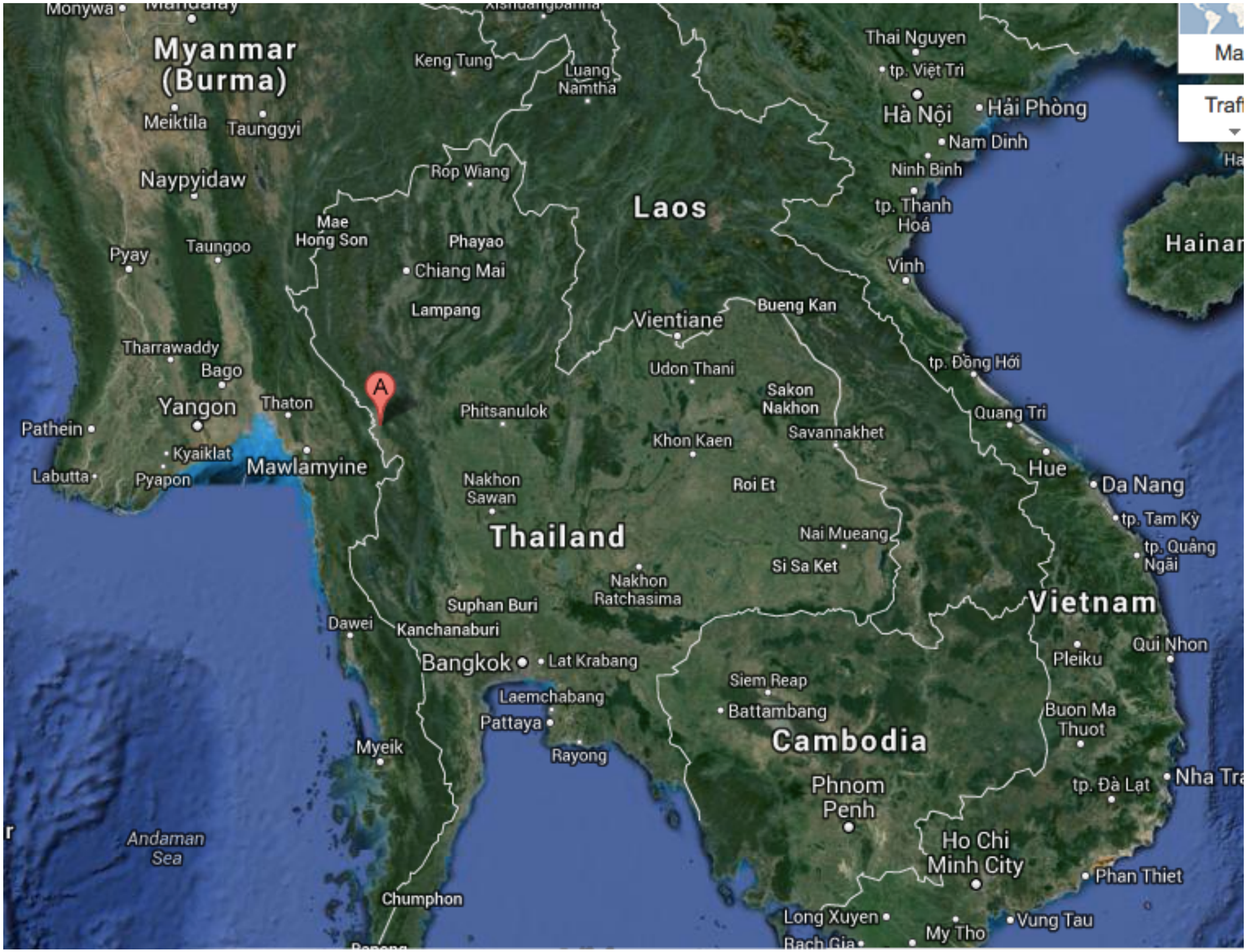
- **HENCE:**

  - **Rural community disaster preparedness**

  - **ICT literacy in rural areas**

  - **DUMBONET mobile routers can be adapted to serve these purposes.**

Testbed Location : Thai Samakhi Village, Mae Sot District, Tak Province, THAILAND



Mobile Routers in TakNet

- Very low-cost (~ US$ 60 - 70)
- Wi-Fi 802.11n 2.4GHz Max150Mbps
- 16 GB USB flash storage for community applications and video files
- Low-powered, max 5W < US$ 0.70 per month
- Optional battery, for 4 - 5 hours of operations
- Flashed with OpenWRT Linux firmware and configured with OLSR
- Selectable options on community application services
  - voice over IP
  - video on demand
  - social networking in community wireless mesh network

TakNet Deployment Strategy

- Deployed by volunteers in March 2013
- Educational VoD service was introduced to the villagers
- A shared Internet Gateway node was added in May 2013
- Students and village people have been our enthusiastic users.
- Currently villagers are planning to share the cost of the shared Internet gateway

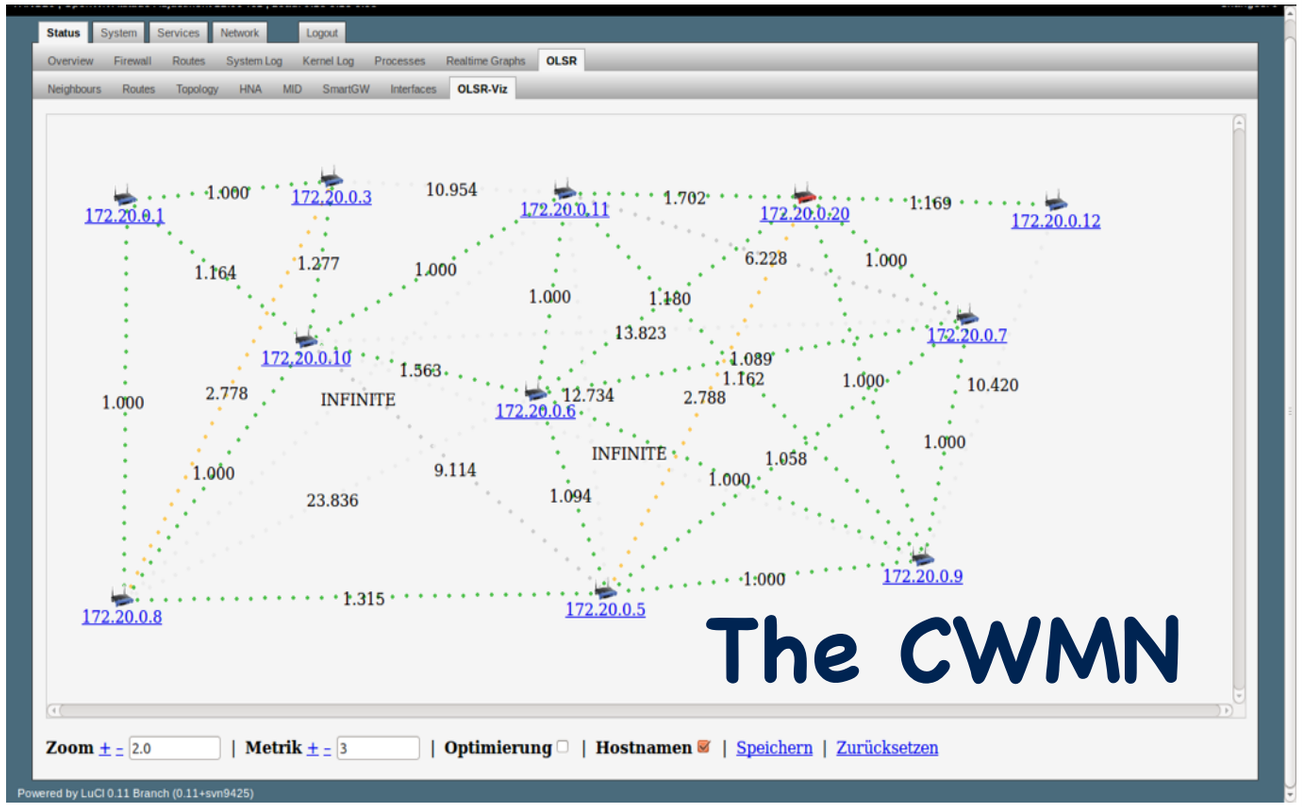
Network was planned, installed, and tested by volunteers


A custom-made
range extender


Quick and easy
installation


Easy to use
esp. on tablets

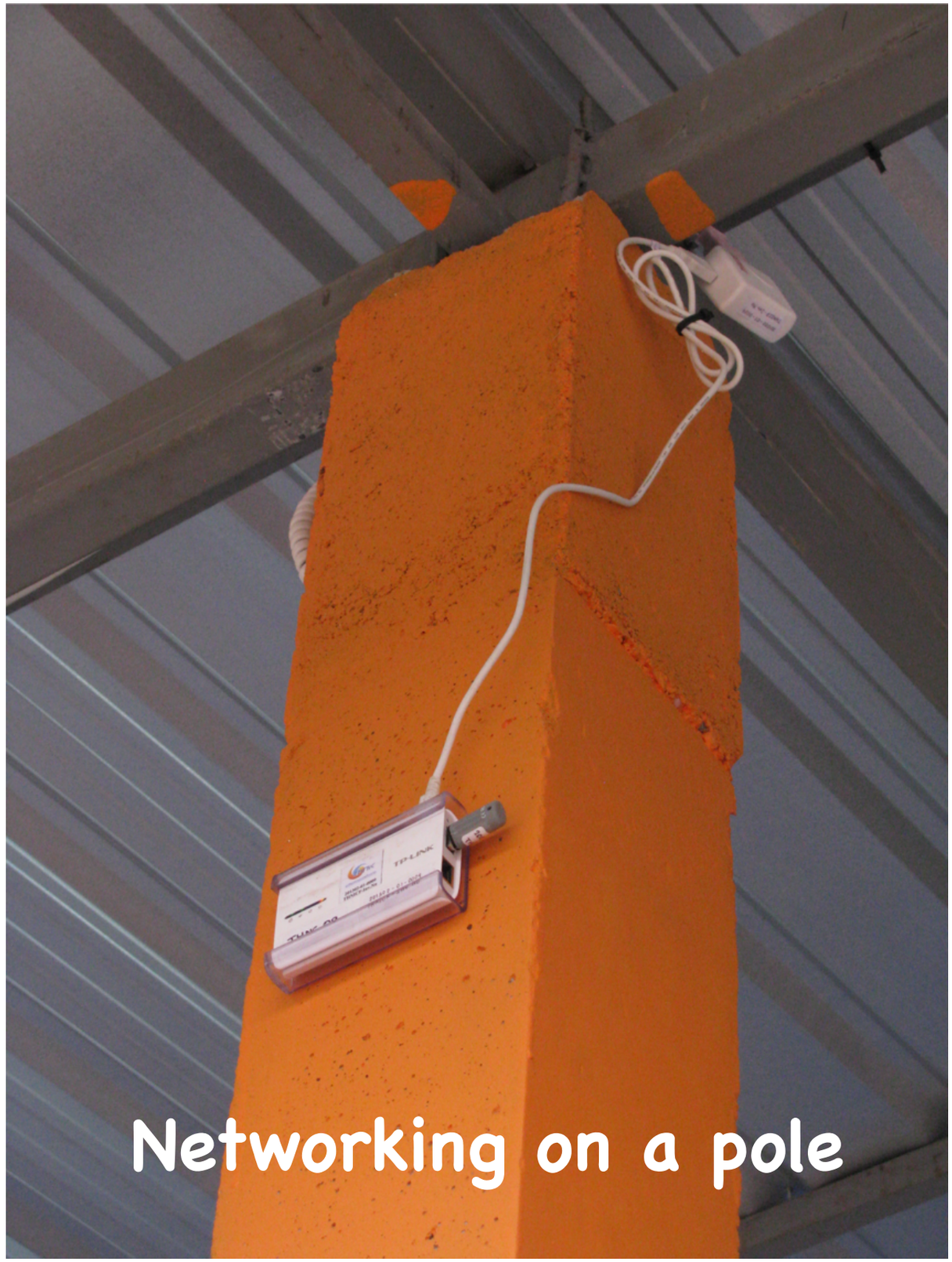

VoIP


Status
System
Services
Network
Logout
Overview
Firewall
Routes
System Log
Kernel Log
Processes
Realtime Graphs
OLSR
Neighbours
Routes
Topology
HNA
MID
SmartGW
Interfaces
OLSR-Viz
172.20.0.1
172.20.0.3
172.20.0.11
172.20.0.20
172.20.0.12
172.20.0.10
172.20.0.7
172.20.0.6
172.20.0.8
172.20.0.5
172.20.0.9
1.000
10.954
1.702
1.169
1.164
1.277
1.000
6.228
1.000
1.000
1.180
13.823
1.563
1.089
1.162
1.000
10.420
1.000
2.778
INFINITE
12.734
2.788
INFINITE
1.058
1.000
1.000
9.114
1.000
23.836
1.094
1.315
1.000
The CWMN
Zoom ± 2.0 | Metrik ± 3 | Optimierung | Hostnamen | Speichern | Zurücksetzen
Powered by LuCI 0.11 Branch (0.11+svn9425)


Video on Demand


For curious minds

A piece of contemporary art endorsed by Steve Song



Networking on a pole

Lessons Learned from TakNet

- Rural people, especially the youths, are more enthusiastic about technology and Internet.

- The number of ADSL ports available to the villagers are limited. Some households cannot have their ADSL yet. Cost of ADSL is still relatively high, when compared to villagers' incomes.

- Although 3G is available, 3G is volume-limited and much more expensive than ADSL.

TakNet expansion (January 2014)

A rural school wireless mesh network with an educational video-on-demand system

Networking problems in rural schools

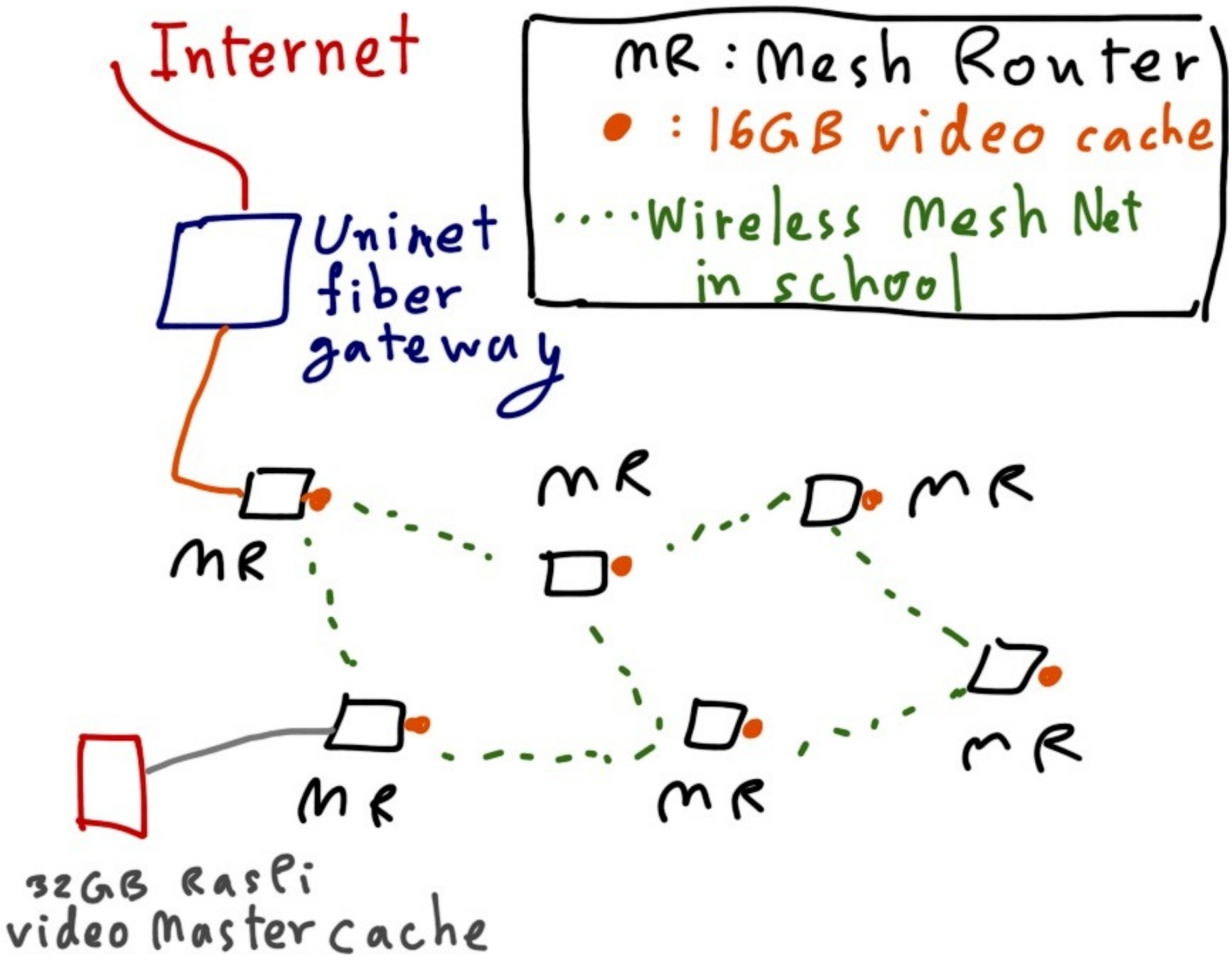
- Several hundreds students share a relatively slow internet gateway — many rural schools have < 10Mbps links
- Although some rural schools start to have fibre Internet connectivity provided by UNINET, the lack of quality EDU contents still plagues most schools.
- UNINET Fibre Internet and backbone could still easily be saturated, if hundreds of students simultaneously access high-bandwidth video contents.

Our proposed solution

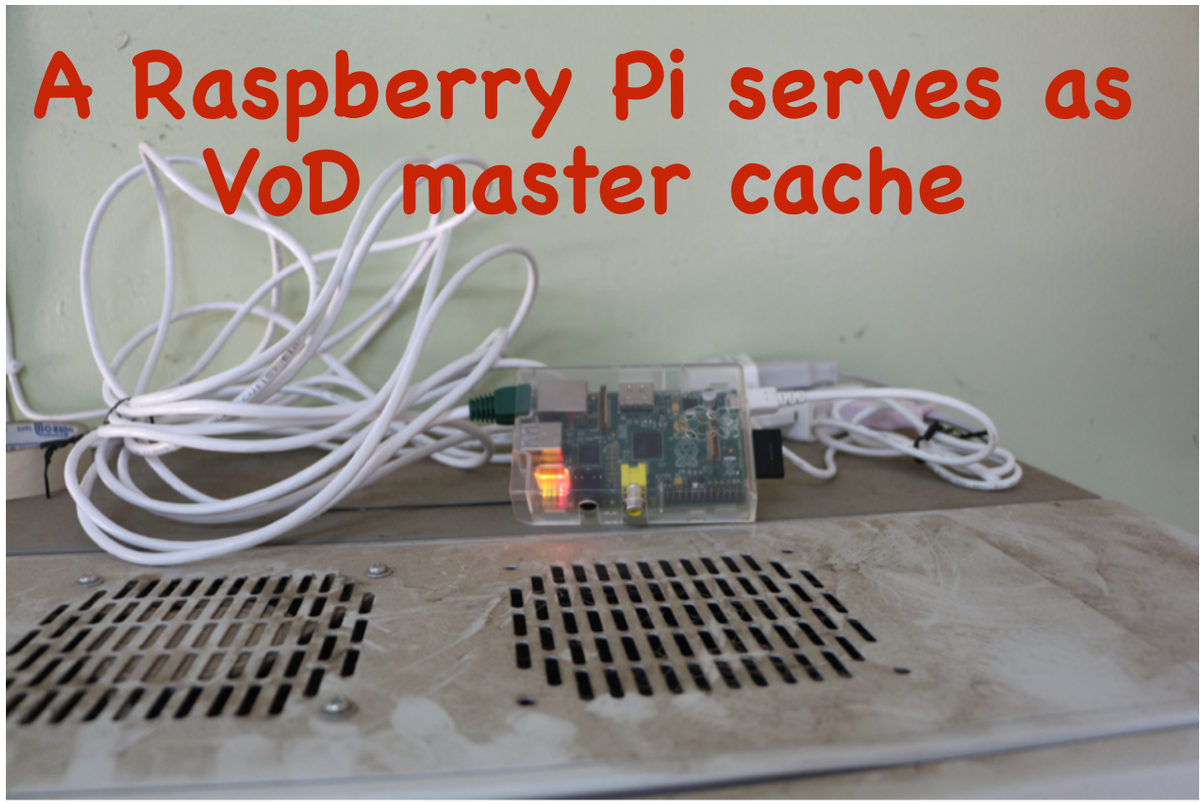
- We attempt to bring High-Definition (HD) Educational Video on Demand (VoD) experience to students in rural schools

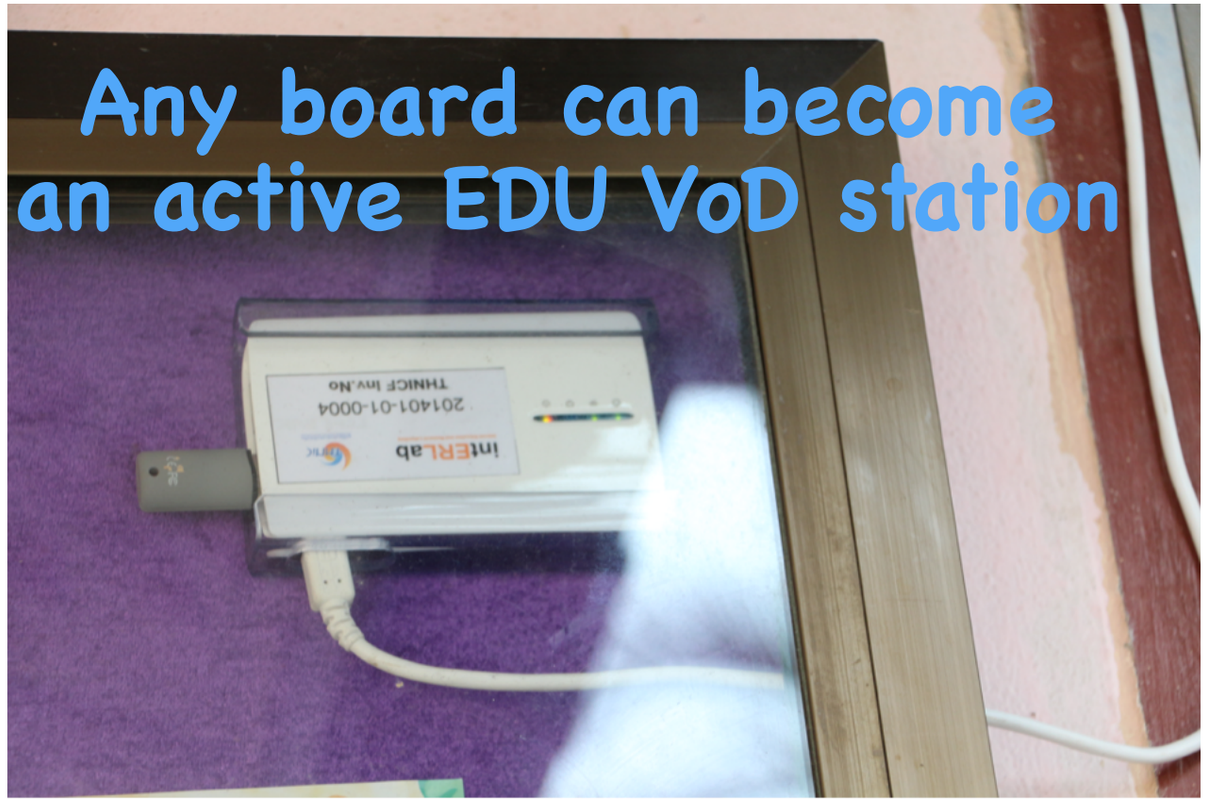
- VoD requires a significant amount of network bandwidth. Therefore, video caching and cache management prove very important!

TakNet : “Fiber to Mesh” concept



A school's installation of WMN nodes with EDU VoD

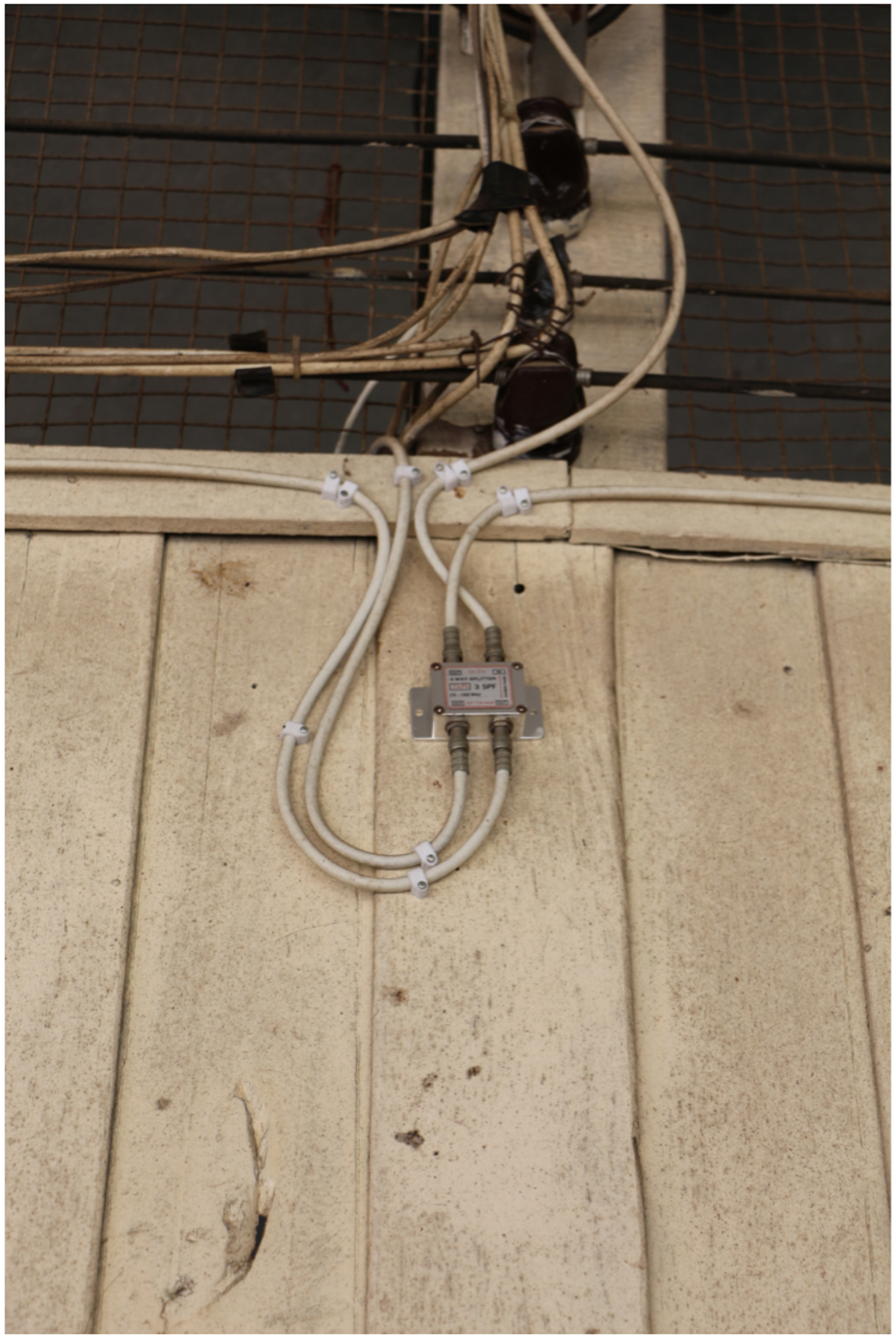

A Raspberry Pi serves as
VoD master cache


Any board can become
an active EDU VoD station
interLab
THNIC Inv.No
2014O1-01-0004

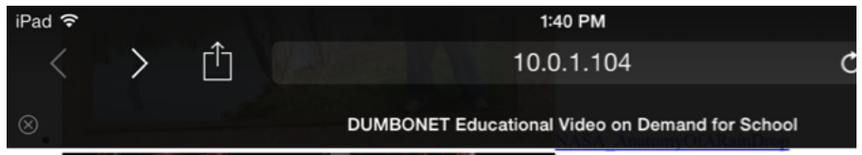

TOSHIBA
A timer reboots the router
every day for better
service availability


ประชาสัมพันธ์
13th
NANMEEBOOK
READING CLUB
Active citizen

The art of “old” vs. “new” video on demand systems



Samples of Cached EDU Videos



- NASA_AskAClimateScientist

- NASA_DeepSpaceNetwork

- NASA_EarthAtNight

- NASA_EarthFromOrbit

Welcome to the TakNet Educational Video-on-Demand System

delivered to you via the RuralSchool Wireless Mesh Network Project

ยินดีต้อนรับสู่ระบบวีดิทัศน์เพื่อการศึกษาผ่านเครือข่ายเมชไร้สาย

Music

- Bach_0

Rural Community or School

The Internet

Lesson Contents

Slow Gateway

Bottleneck

Contents

Contents

Contents

Contents

Contents

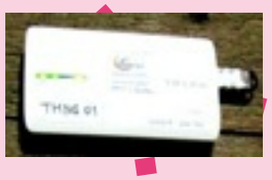
Contents

Alleviating the bottleneck problem (1)

The Internet

Slow Gateway

Content Distribution Node



Alleviating the bottleneck problem (2)

The Internet

Slow Gateway

Edu Contents

Edu Contents

mid night

Alleviating the bottleneck problem (3)

The Internet

Slow Gateway

Edu Contents

near dawn

Edu Contents

Edu Contents

Edu Contents

Edu Contents

Edu Contents

Edu Contents

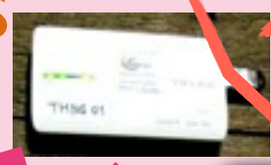
Alleviating the bottleneck problem (4)

The Internet

Slow Gateway

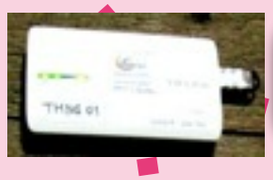
Edu Contents

school's hours

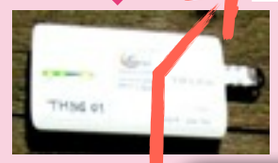


Edu Contents

Edu Contents

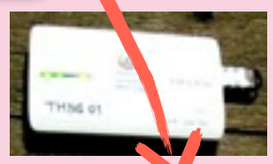


Edu Contents



Edu Contents

Edu Contents



Edu Contents

IntERLab
Internet Education and Research Laboratory

ChiangRai MeshTV

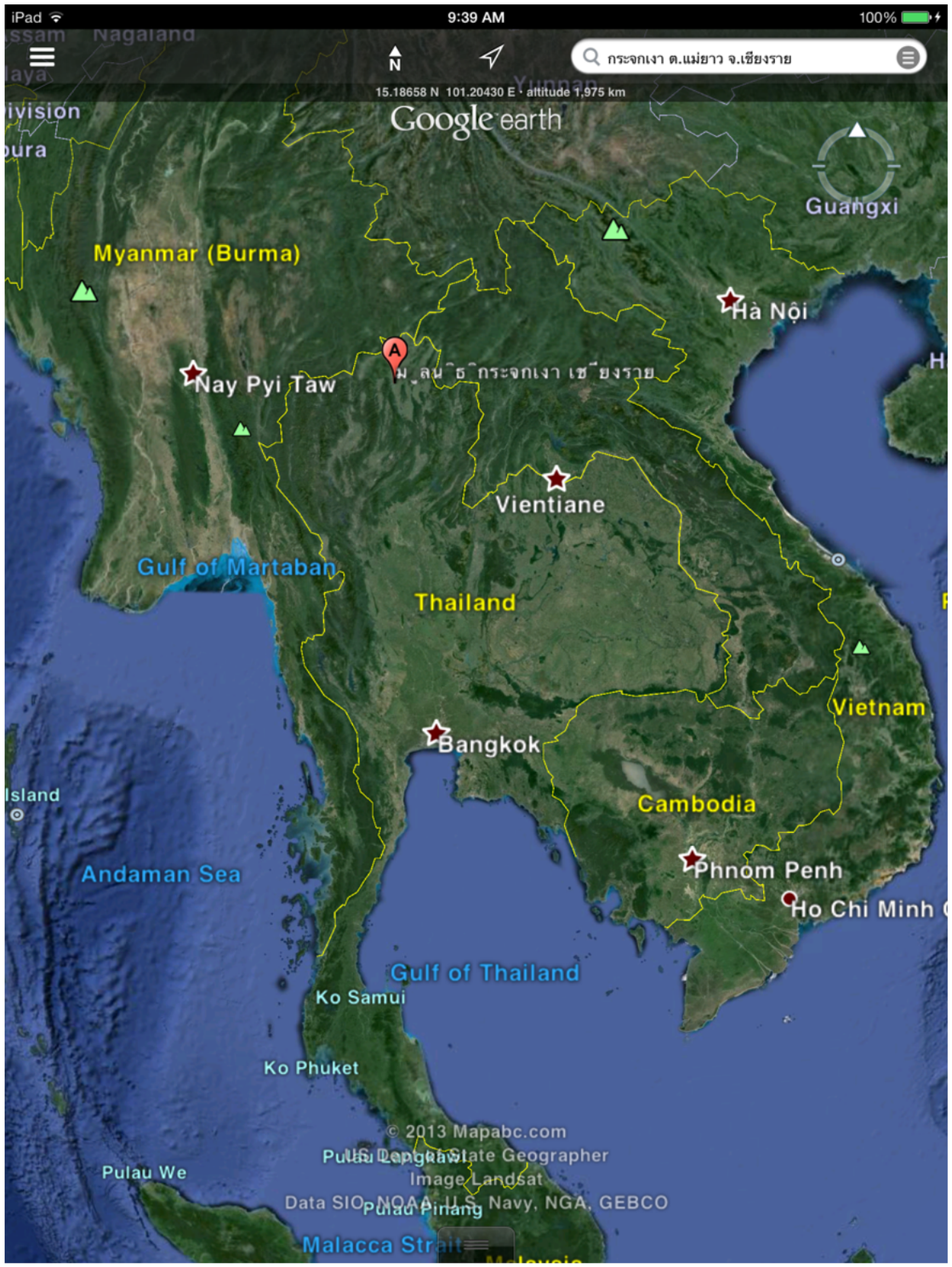
isif asia

มูลนิธิศูนย์สารสนเทศเครือข่ายไทย
THAI NETWORK INFORMATION CENTER FOUNDATION

มูลนิธิกระจกเงา
The Mirror Foundation

ISIF Grant 2014

Baan Huay Khom Ar Kha, ChiangRai



Hill-tribe village with very low ICT literacy -- Lack of internet access

Targets:

- Wireless Mesh Networking
- Video-on-Demand: a subset of YouTube videos which are creative commons or in public domain will be cached there
- Educational videos from the Mirror Foundation and other donations will be provided

Baan Huay Khom Ar Kha, ChiangRai

Survey and pre-deployment activities

Survey and pre-deployment activities

ChiangRai MeshTV plan

- Field deployment will begin 21 March 2014 (small lead team)

- Volunteers (~20 - 30 people) will arrive on 22 March 2014 and carry out node deployments in households.

- Training of villagers on 26 March 2014

- Follow ups and improvements around 6+ months

Some facts and thoughts around TVWS in Thailand

On regulatory issues

- Members of NBTC (the national regulator) just recently became aware of TVWS (~ mid 2013 : "TVWS" showed up in a post ITU meeting report)

- For the past few years, NBTC has pushed the new 60GHz (57 - 66 GHz) unlicensed band. It is near to reality.

- NBTC just announced the 24 winners of digital TV broadcasters.

- Unlicensed frequencies below 1Ghz is somewhat problematic !

Some of fully unlicensed conditions for Thailand (can import, export, operate)

(๘) เครื่องวิทยุคมนาคม คลื่นความถี่ ๓๐ - ๕๐ เมกะเฮิรตซ์ กำลังส่งไม่เกิน ๑๐ มิลลิวัตต์

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30 - 50 MHz, max tx power 10 mW

300 - 500 MHz, max tx power 10mW

2400 - 2500 MHz, max EIRP 100mW

Some of partially unlicensed conditions for Thailand (can operate, export, but not import)

(๓) เครื่องส่งสัญญาณภาพหรือภาพและเสียง คลื่นความถี่ ๕๑๐ - ๗๙๐ เมกะเฮิรตซ์ กำลังส่งไม่เกิน ๑๐ มิลลิวัตต์

510 - 790 MHz, max tx power 10 mW, limited to audio/video transmission only

In November 2013, Steve Song (NSRC) helped us conduct TVWS spectrum scanning in Tak to evaluate the potentials.

Then, ICTP helped us analyze the results.

White Spaces Monitor

Ocupation threshold
[-120,-20]

Around thai smauckee ▸

-100

please select allocation of channel frequency

European Channels (8MHz) ▸

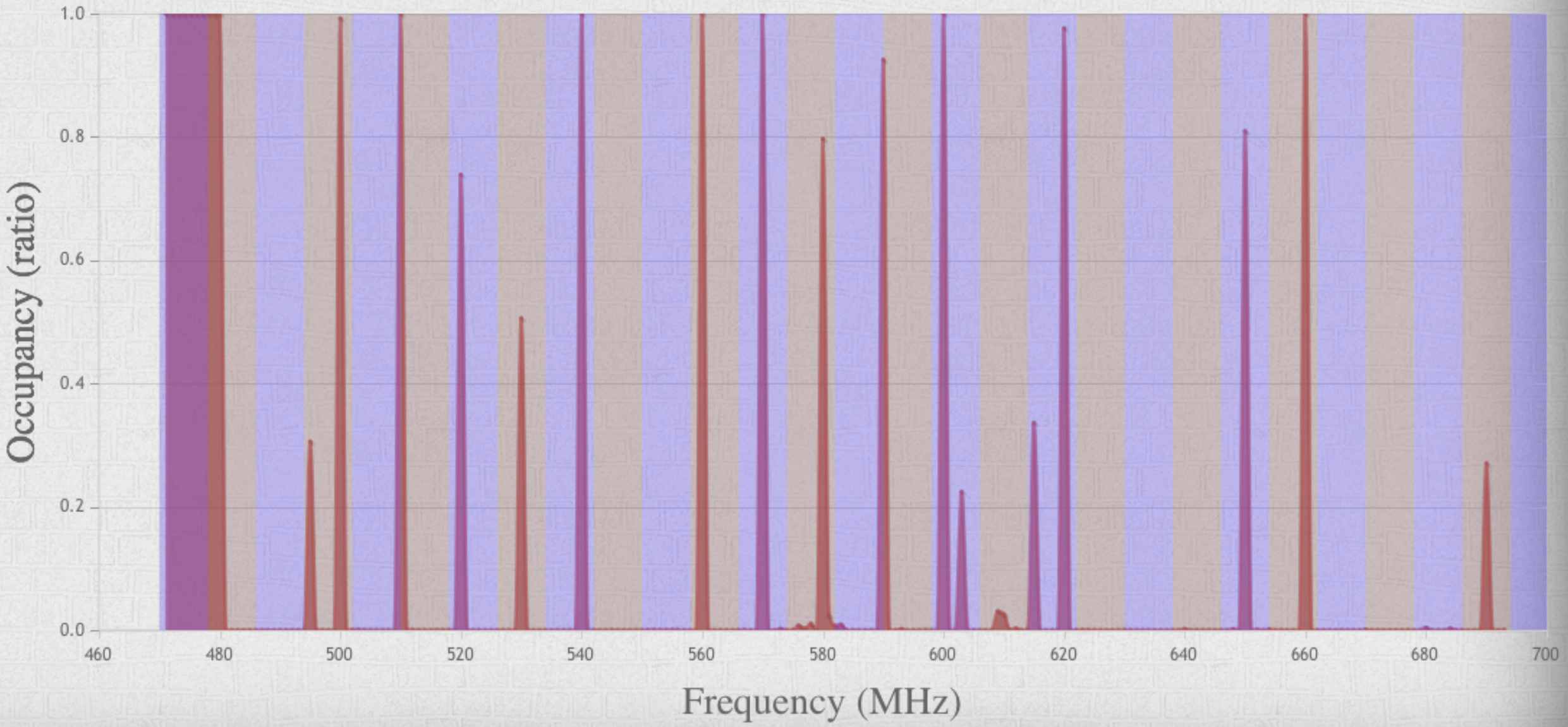
Calculate occupation

UNIVERSIDAD DE LOS ANDES VENEZUELA

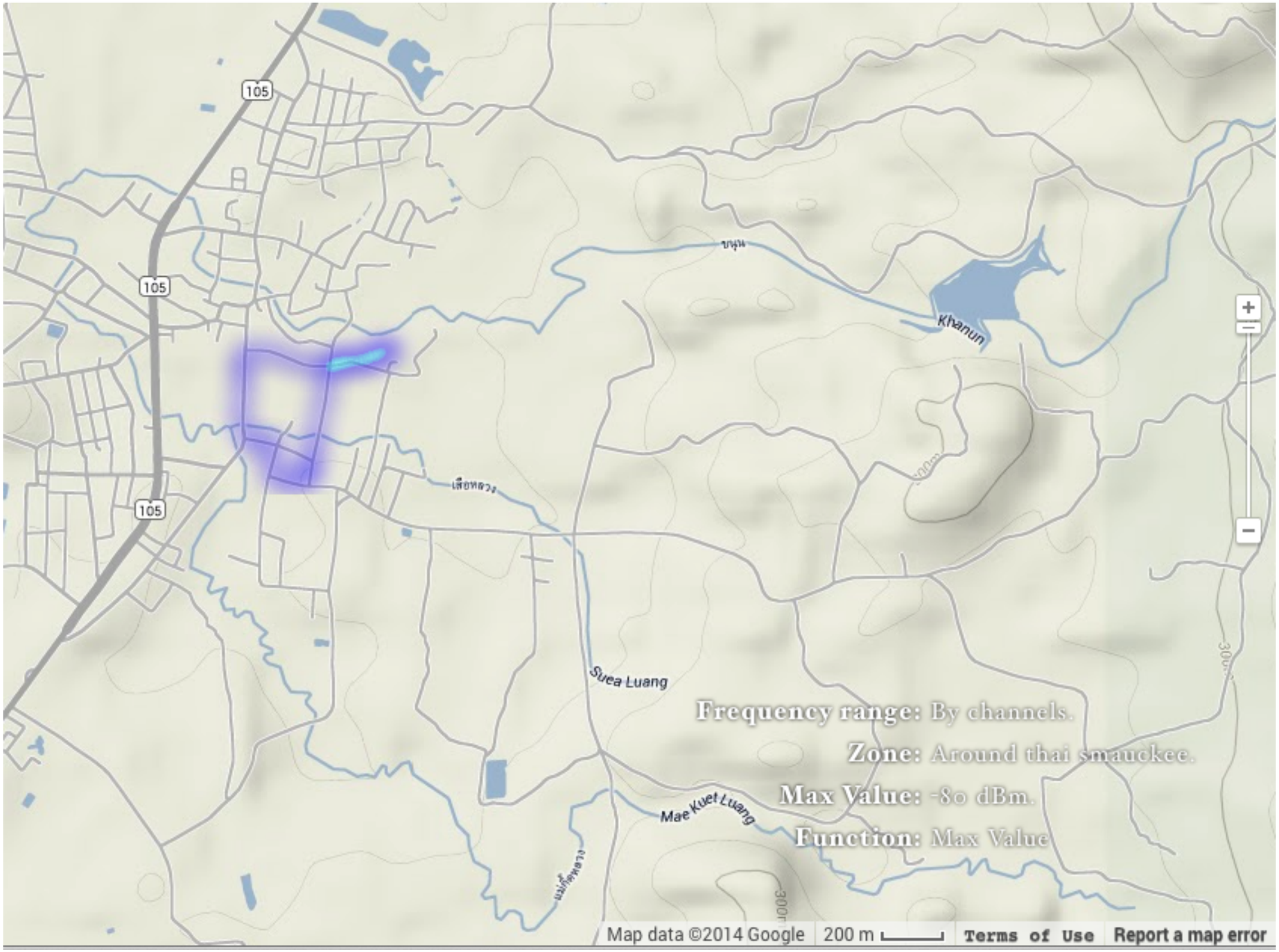
The Abdus Salam International Centre for Theoretical Physics

Occupation with threshold

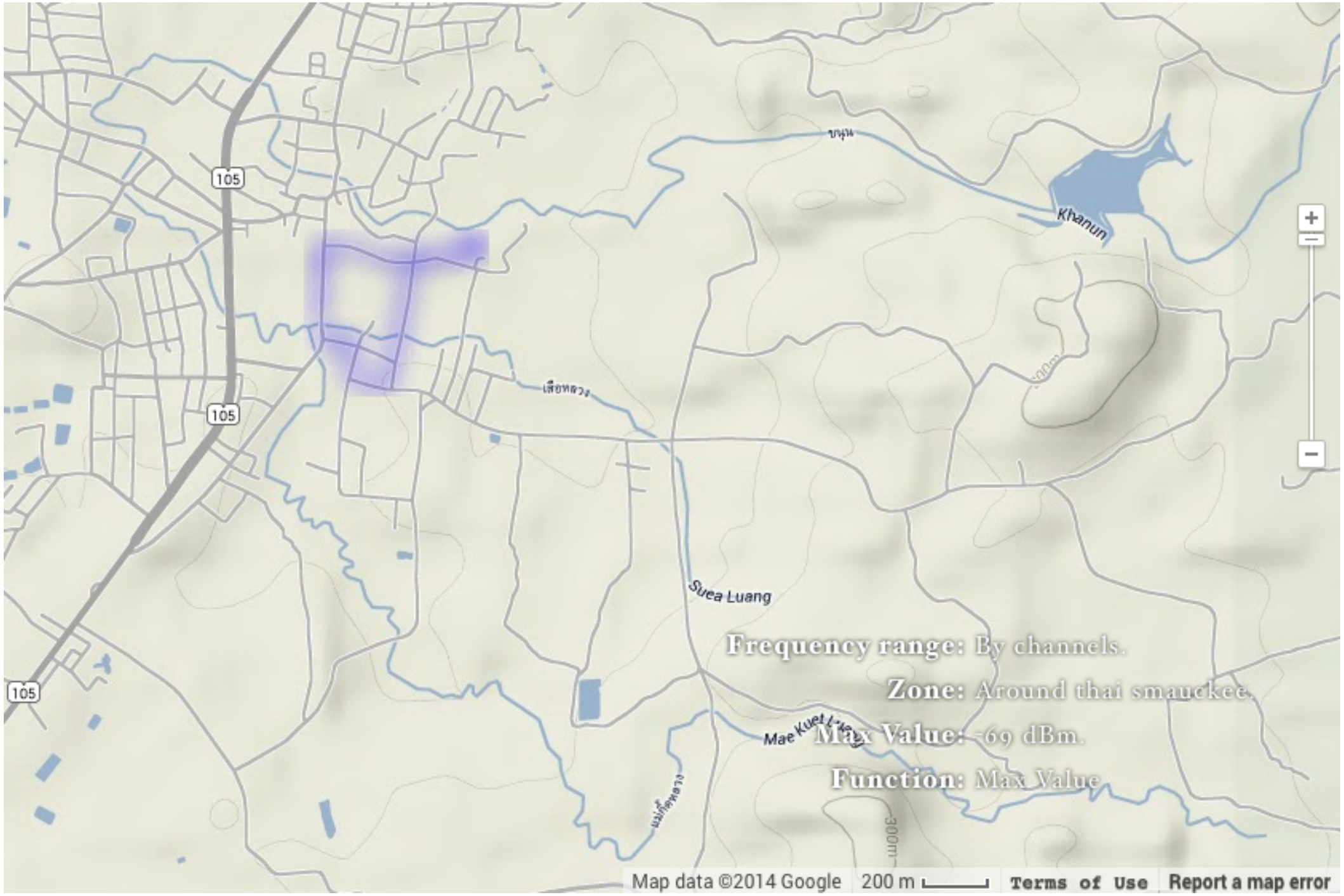
-100 dBm (Around thai smauckee)



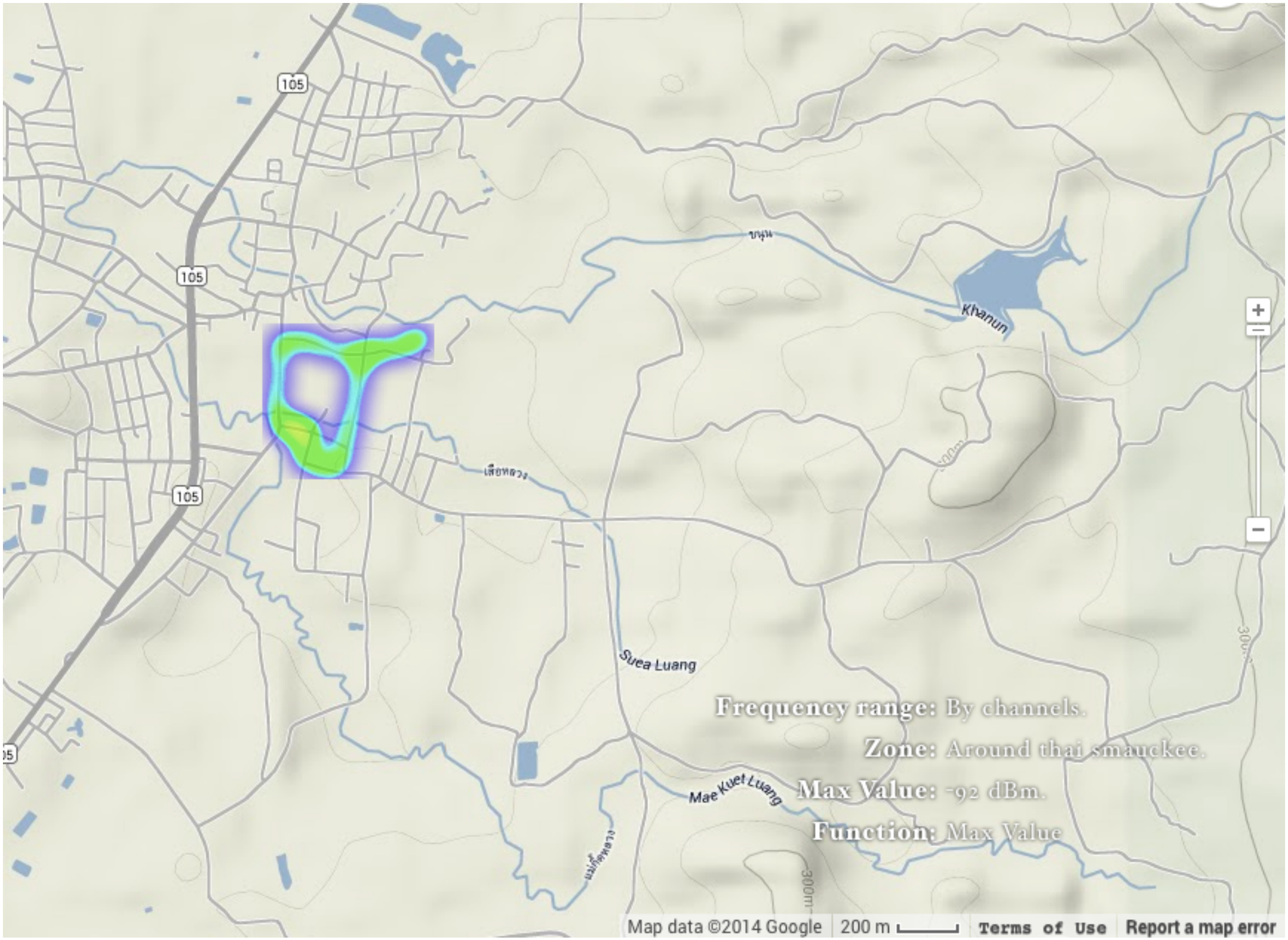
Ch 21 - 29 (470 - 542 MHz)



Ch 30 - 39 (542 - 622 MHz)



Ch 40 - 48 (622 - 694 MHz)



White Spaces Monitor

Ocupation threshold
[-120,-20]

Centara to meet hall ▸

-100

please select allocation of channel frequency

European Channels (8MHz) ▸

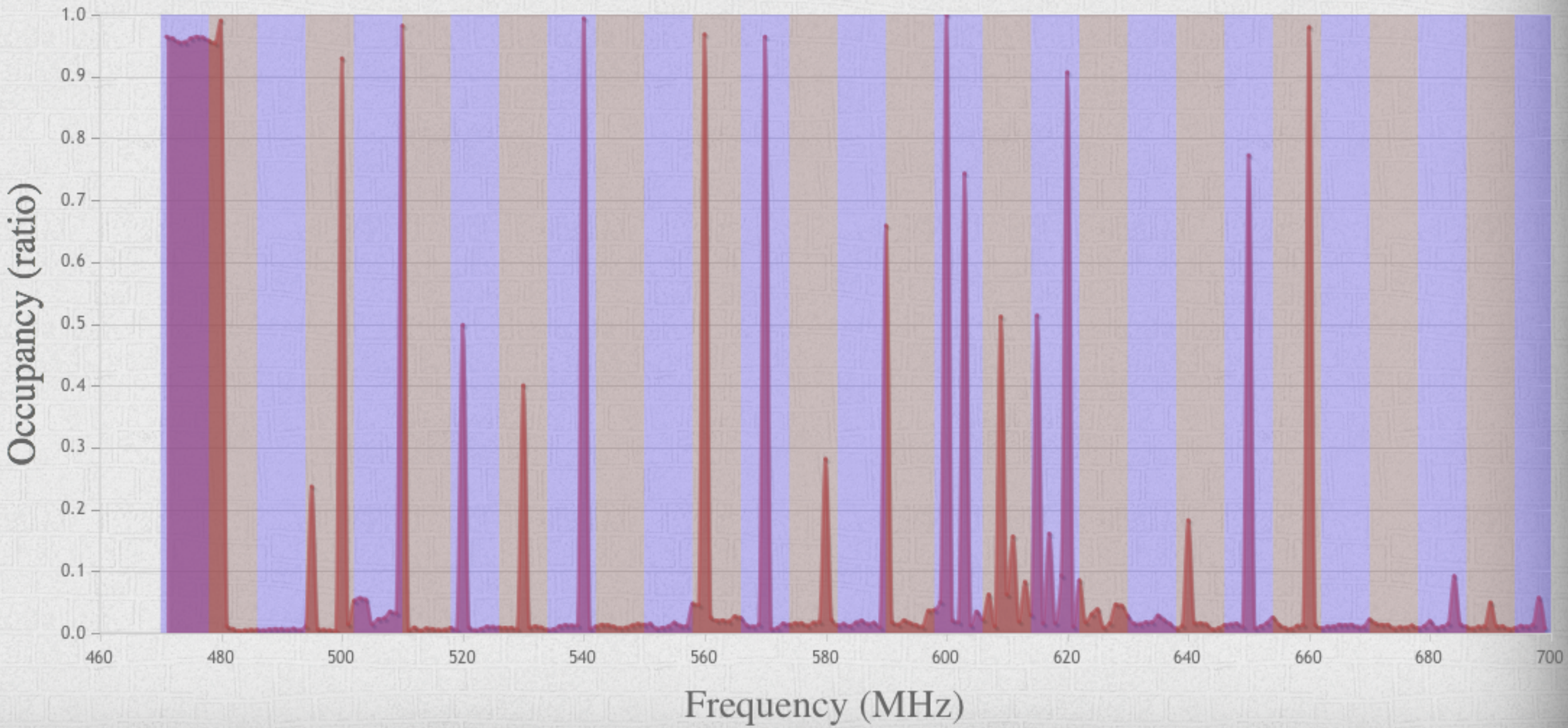
Calculate occupation

UNIVERSIDAD DE LOS ANDES VENEZUELA

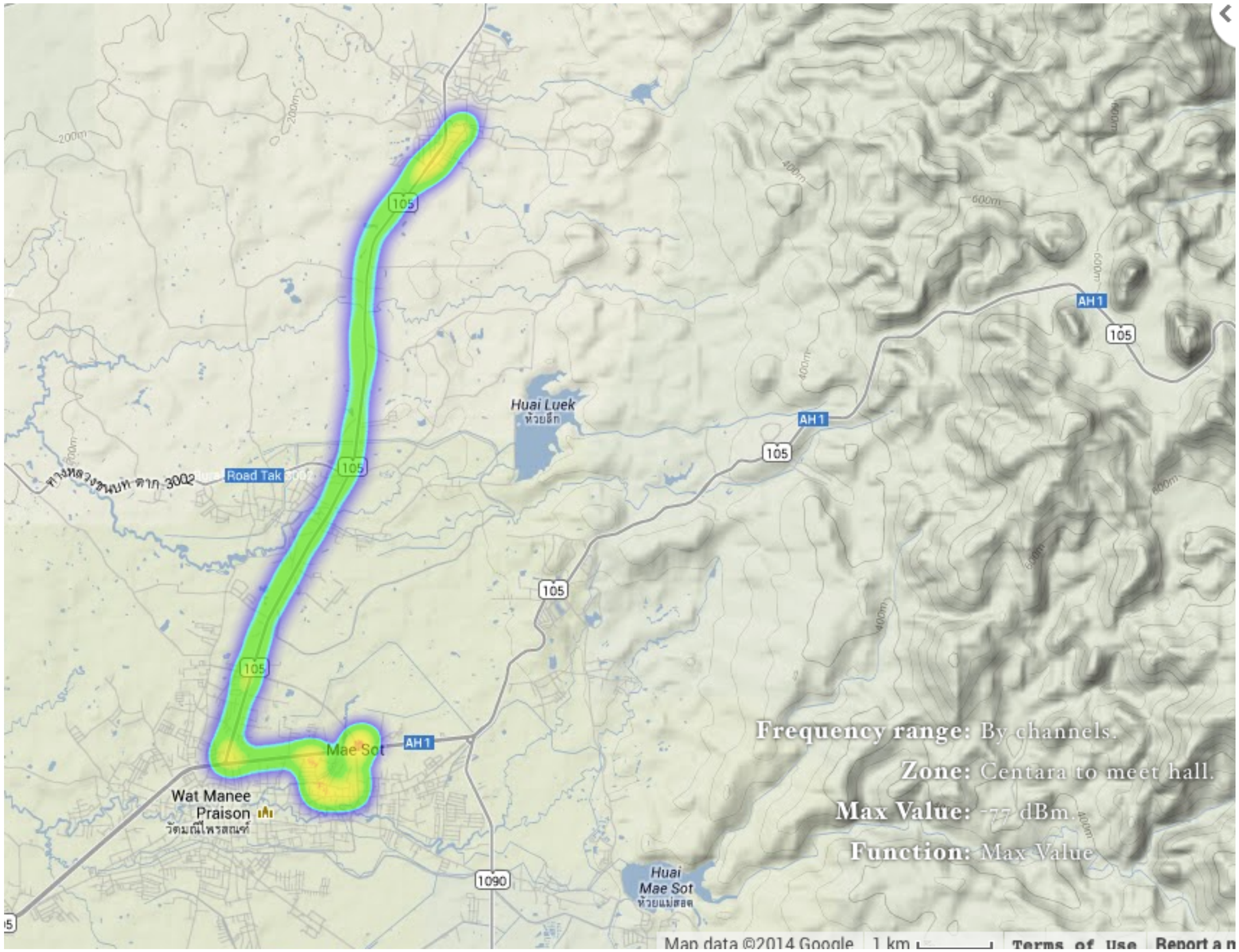
The Abdus Salam International Centre for Theoretical Physics

Occupation with threshold

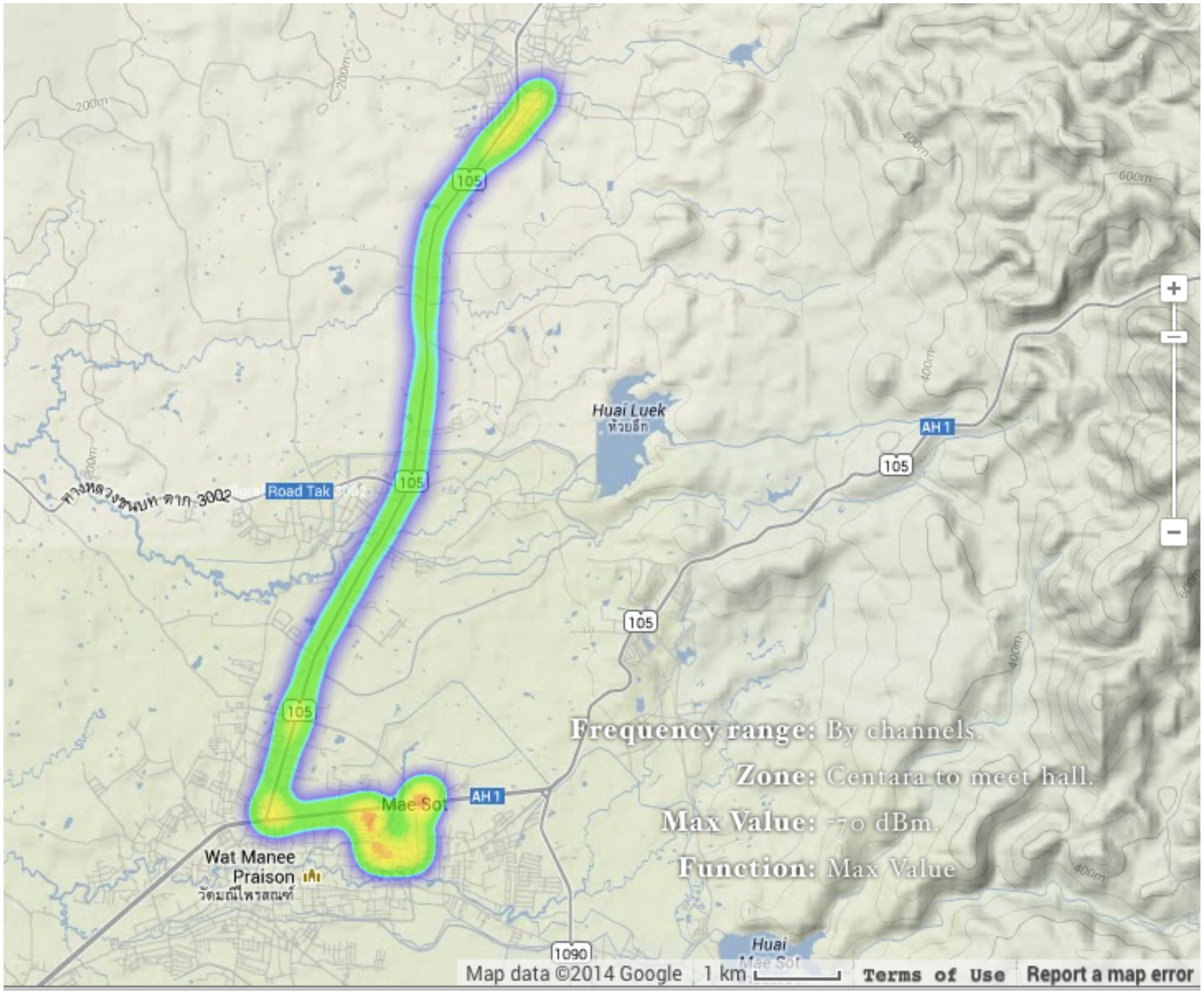
-100 dBm (Centara to meet hall)



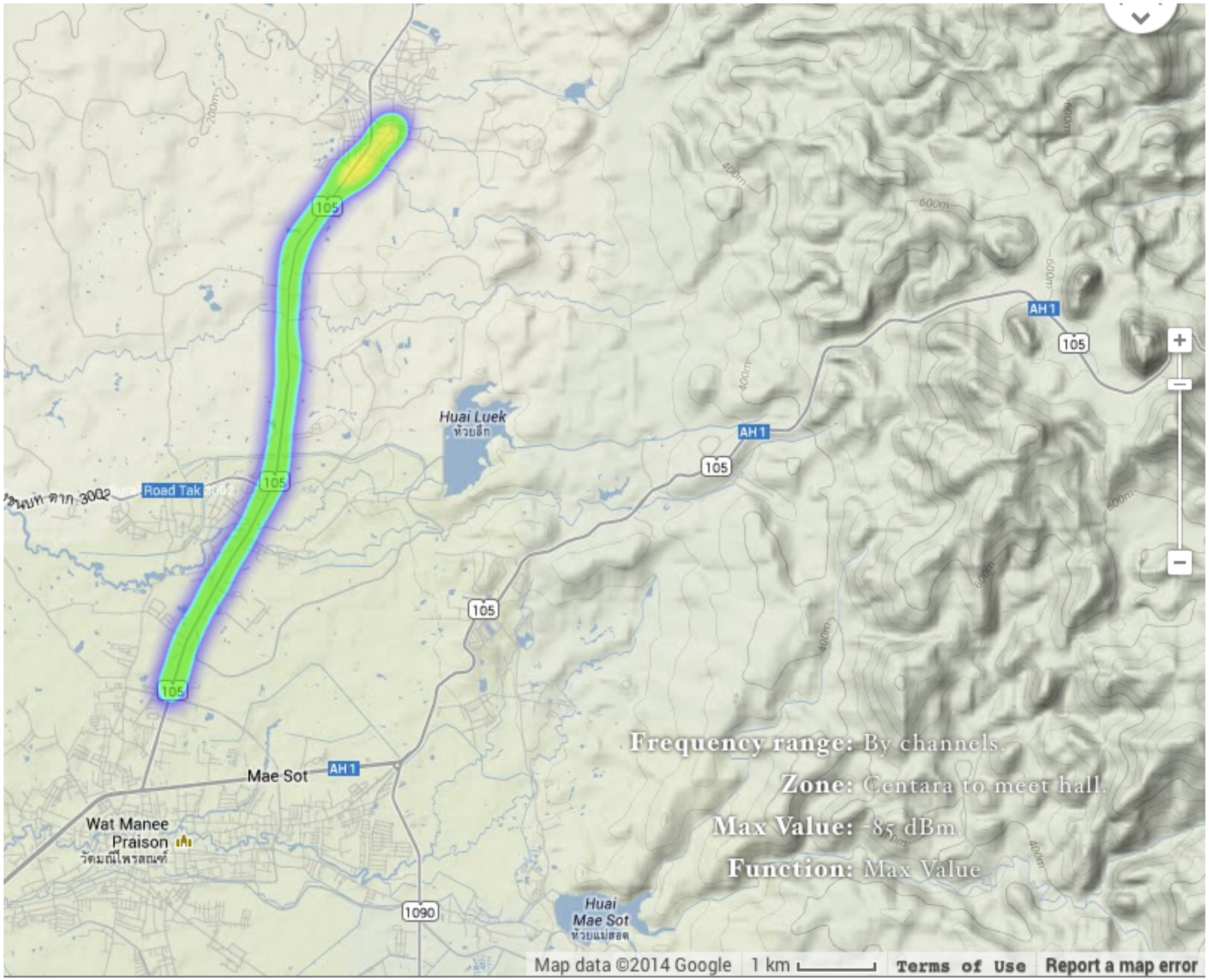
Ch 21 - 29 (470 - 542 MHz)



Ch 30 - 39 (542 - 622 MHz)



Ch 40 - 49 (622 - 702 MHz)



still, note that

- The results are preliminary. More digital TV channels will soon pop up later. Rescanning will be required from time to time.

- This area is a Thai-Myanmar border area. We do not know frequency bands being utilized in Myanmar.

- The measurements were done both while on vehicle and on foot. Different number of samples may “bias” the shown results.

Summary

- We have been working on rural community wireless mesh networks which can be deployed using low-cost devices since 2013.
- Present focus is on community applications & cloud services
- We are looking for wireless 'backbone' which would be within the regulatory limits for 'unlicensed' uses
- We have conducted TVWS spectrum scan and believe in TVWS potentials
- We invite technology partners to help us with TVWS testbed equipments.

Thank you — Q&A

Contact E-mail: atunpan@ait.asia