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TV White Spaces

- **TV White Space** is a frequency allocated to broadcasting service but not used within certain region.
  - Never been used
  - Becomes free
- WS are also spaces wisely used: guard bands between channels, predictable white spaces in primary users.

How are White Spaces determined?

- Through **scanning process** and detection of no activity.
  - Largest known incumbents TV Stations (DB registered)
  - IEEE 802.22 suggests to detect incumbent for short time periods then change the channel.
- Caveat:
  - Scanning process gets complex considering: differences in transmission power, topography, antennas.

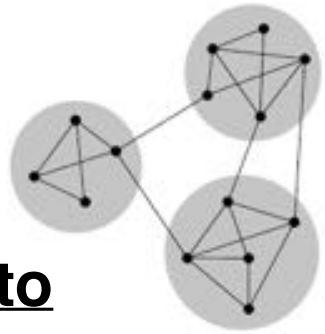
The awakening of TVWS

- **Spectrum crunch**
- **Disconnected communities**
  - > 60% of world population with no Internet connection
  - Access to fibre is very costly for rural
  - In emerging economies, there should be technologies to ease the connection for the digitally divided
  - Encourage innovative uses/ management of spectrum to advance in affordable access [A4AI]

From: www.technologyreview.com

Social Motivation

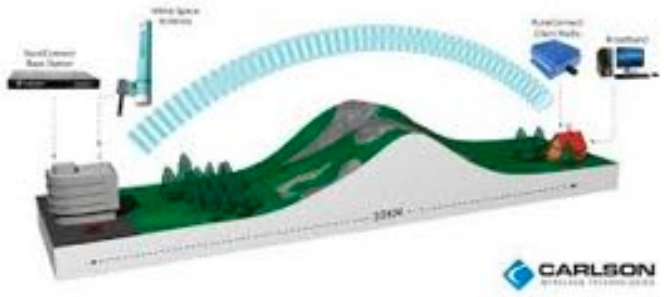
- Common agreement affordable wireless broadband Internet as ICTD principle
  - Closing the digital divide for rural and remote areas
- Allow people and governments to cooperate towards alternative network deployments.
  - Success stories include Community Networks in the ISM band and emerging deployments of TVWS in Africa.
- Incentivise the local production of content and services.



Provide a common ground for people and regulator to govern the free spectrum

Why using TVWS for alternative network deployments?

- More coverage area with the same (WiFi) power
- Need no line of sight
- Central system that controls the hidden terminal (and incumbent) problem and resource sharing
- Adaptation to specific conditions of the clients (distance, obstacles, erratic incumbents, channel bonding)
- Less susceptible to antennas misalignment (due to weather, geography)



Why automatic management of TVWS (in global south)?

- We want to encourage the accounting of the White Spaces in Developing Regions to persuade governments to exempt the license for Alternative Networks.
- Governments use static (manual) databases to account for primary users.
- Accounting for potential interferers: rogue users, unaccounted legal users, UHF mic, city services using trunking
- Other advantages:
  - Administration of indoor WS
  - Long distance, point to point links allowing: emergency communication, disaster relief.
  - Counter intuitive usage of cellular band in urban areas to off-load data from ADSL networks.

Which Stakeholders?

- In Alternative Network deployments, **communities** need to monitor spectrum to negotiate the use white spaces.
  - Communities should be allowed to know about the available spectrum to ease deployments
- The **regulator** interest on governing the spectrum and providing enough (computational) resources to process the crowd-sourced data.
  - Regionalisation of DBs should make the system scalable.
- Incentivise new business models to attract competition for backhaul connection

O&R Repositories from a practical experience

Our Initial Scenario

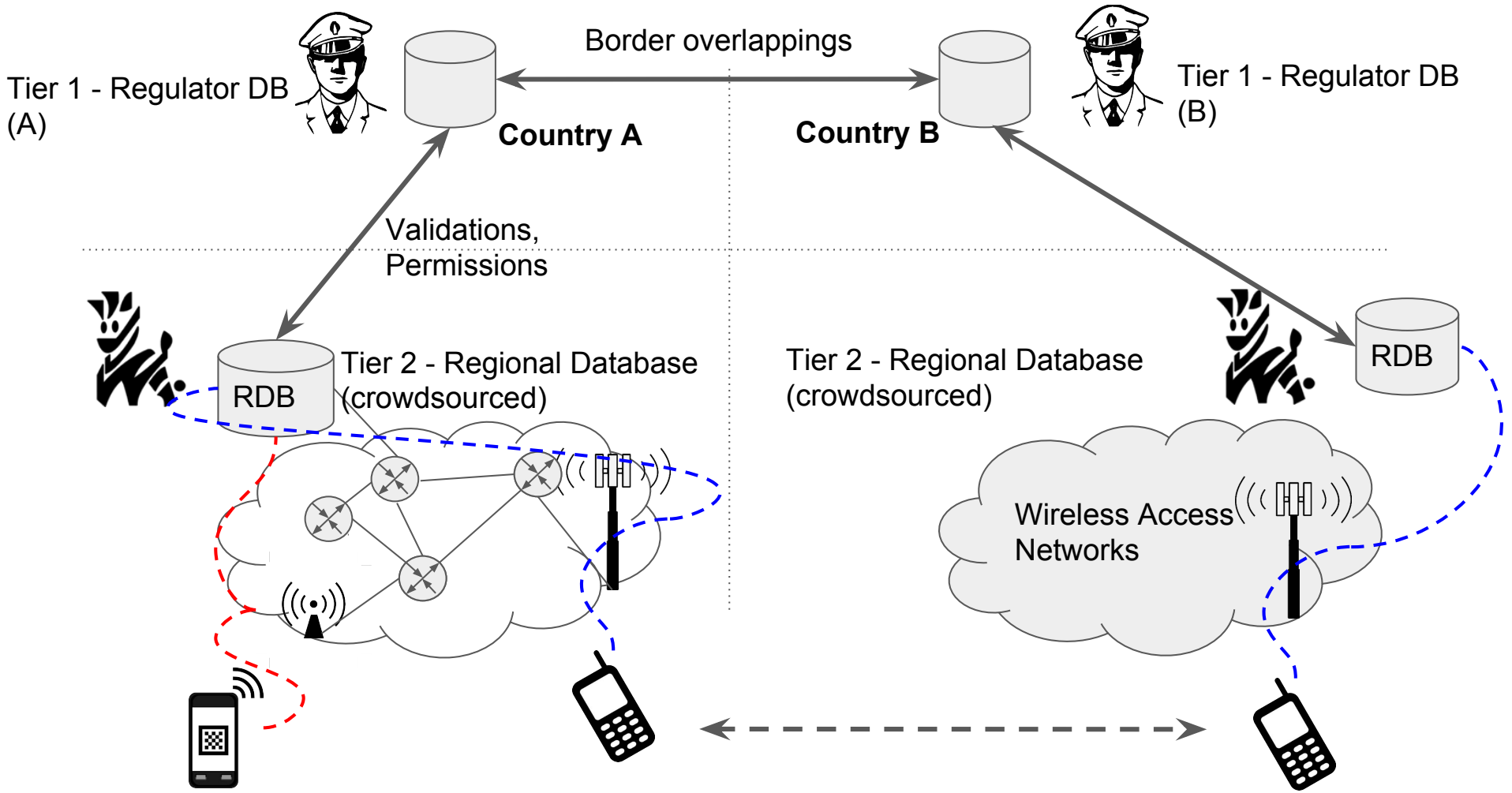
- Governments control spectrum management
- Communities have little or no information about free spectrum
  - We propose using low-cost equipment for collecting spectrum occupancy
  - We help in providing first rough view of the spectrum (e.g., Malawi)

http://www.zebra-rfo.org

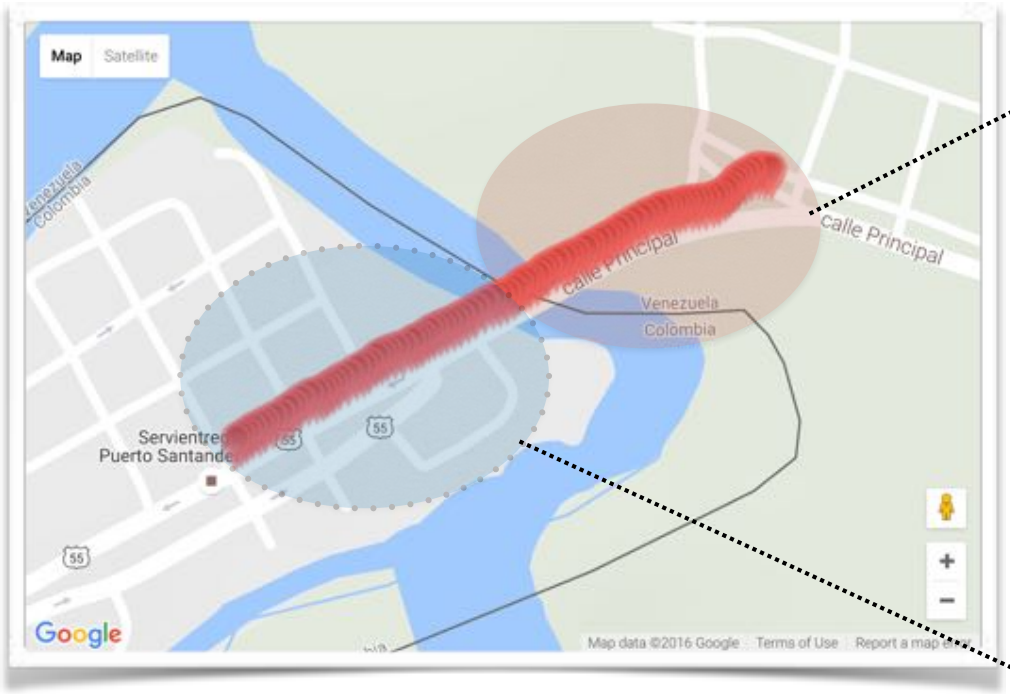
collecting spectrum fingerprints

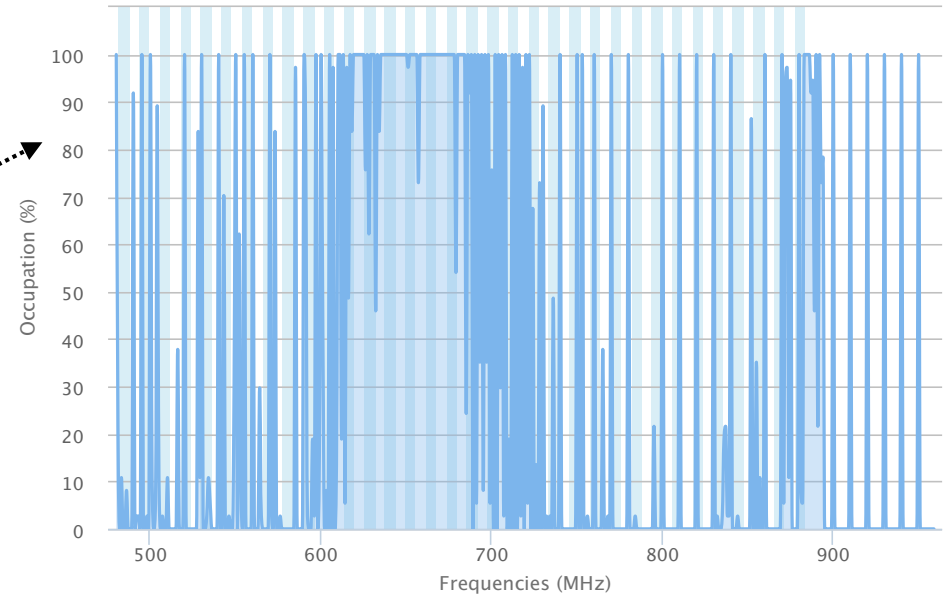
- ZFRO is basic building block for regionalised repositories
  - Independent spectrum collections from communities.
  - Localised databases for the efficient use of the spectrum.
- Stores spectrum dynamics coming from different stakeholders, with social networking capabilities, it allows:
  - Separation of the areas of interest: urban, sub urban, rural.
  - Proposes a uniform simple data format (and compact)
  - Deals with mid-size scale data storage
  - Offers different perspectives on the same set of data

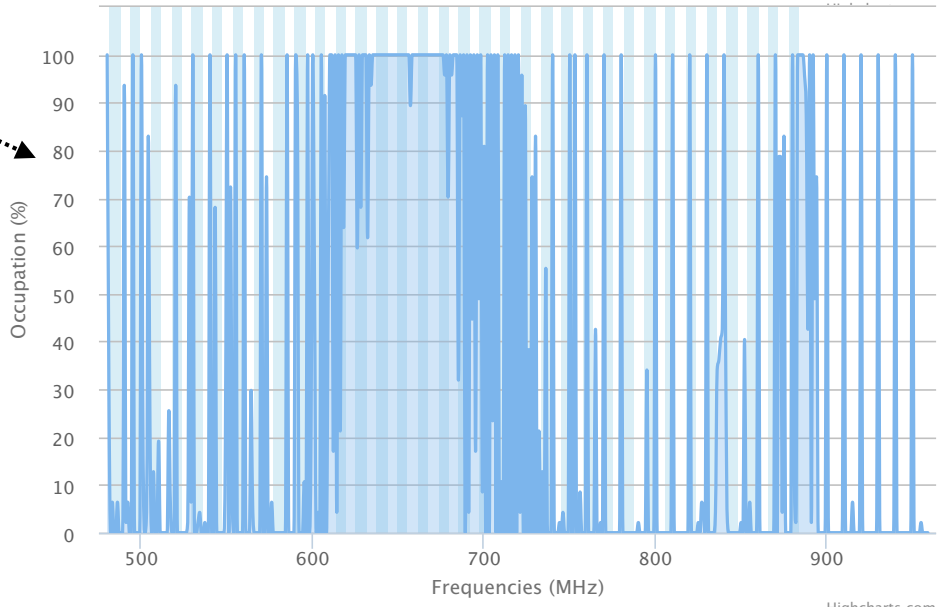
Strawman Architecture for spectrum governance



Intra tier example



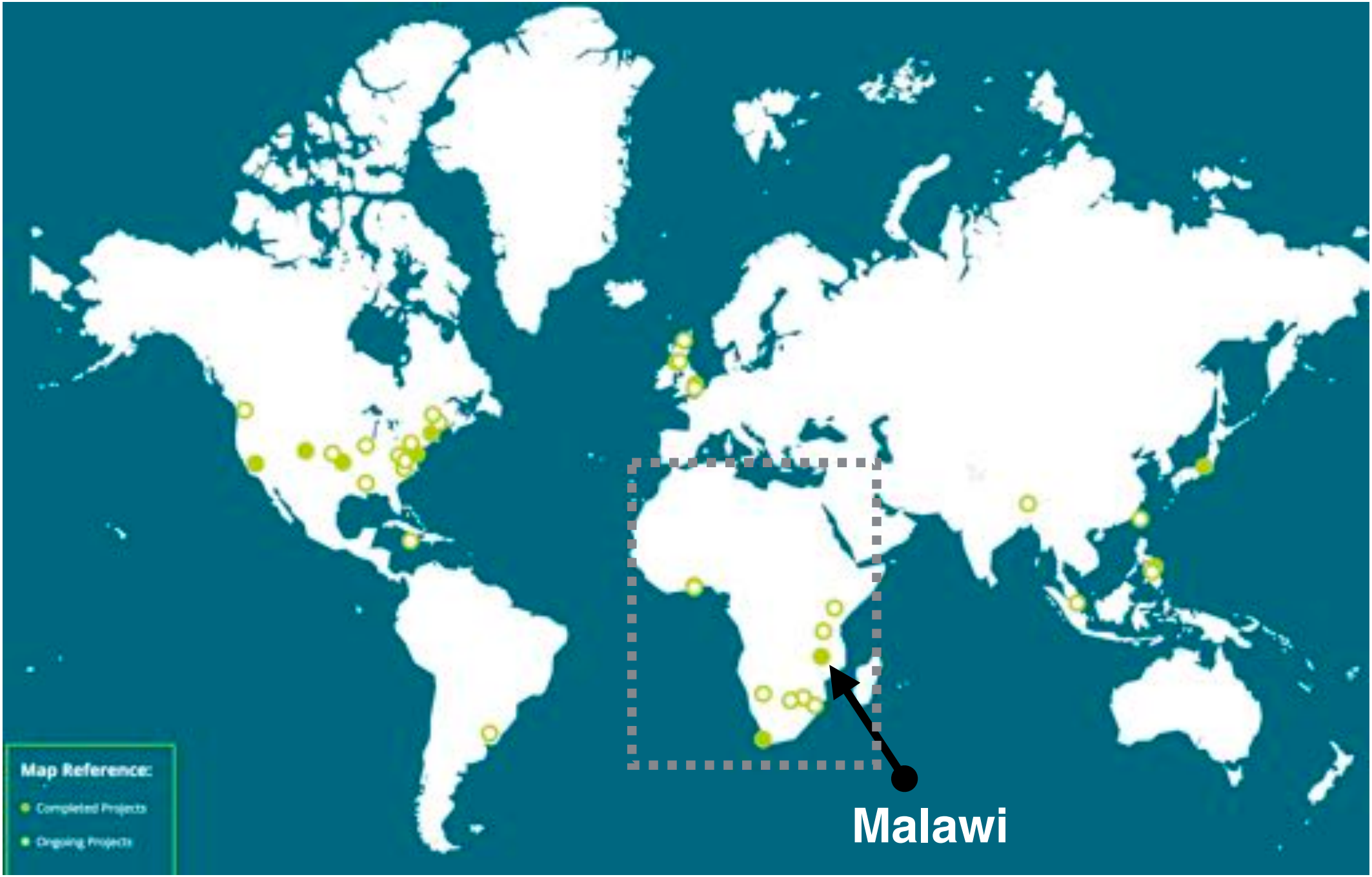


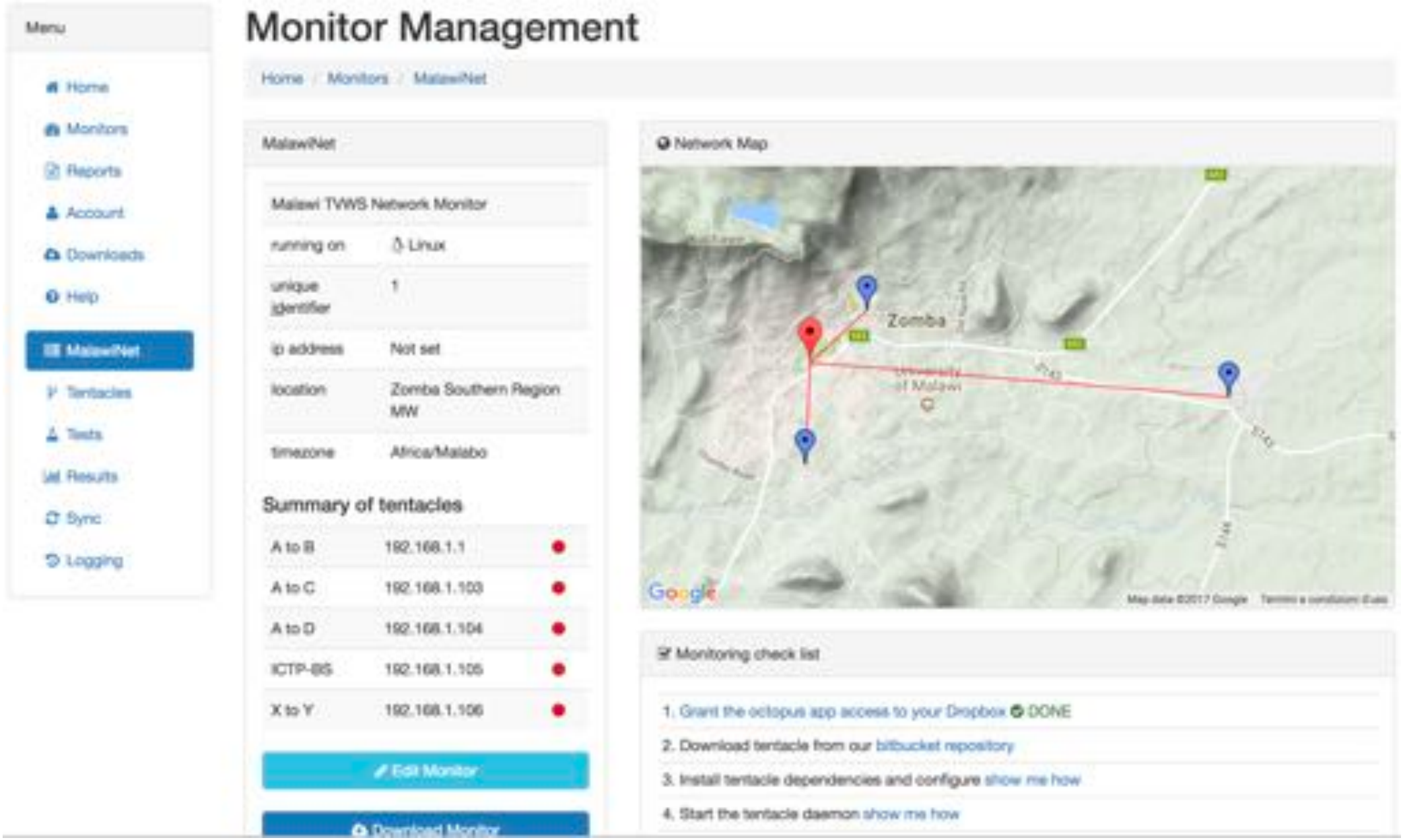


Venezuela - Colombia border crowded semi-urban area with overlapping operators

Existent initiatives

- Centralised system initiatives:
  - Google Spectrum Database
  - Microsoft Spectrum Observatory
  - Using centralised repositories (e.g., communicating with OFCOM DBs) [Holland]
- Proposals for spectrum regulation into layers (dynamic channel/frequency selection), helps in dealing with scalability
  - FCC encourages the design of 3-tiered architectures in the context of 5G. [Chan]
- IETF efforts providing protocols to access White Spaces RFC 7545 and RFC 6953.


Map Reference:
Completed Projects
Ongoing Projects
Malawi

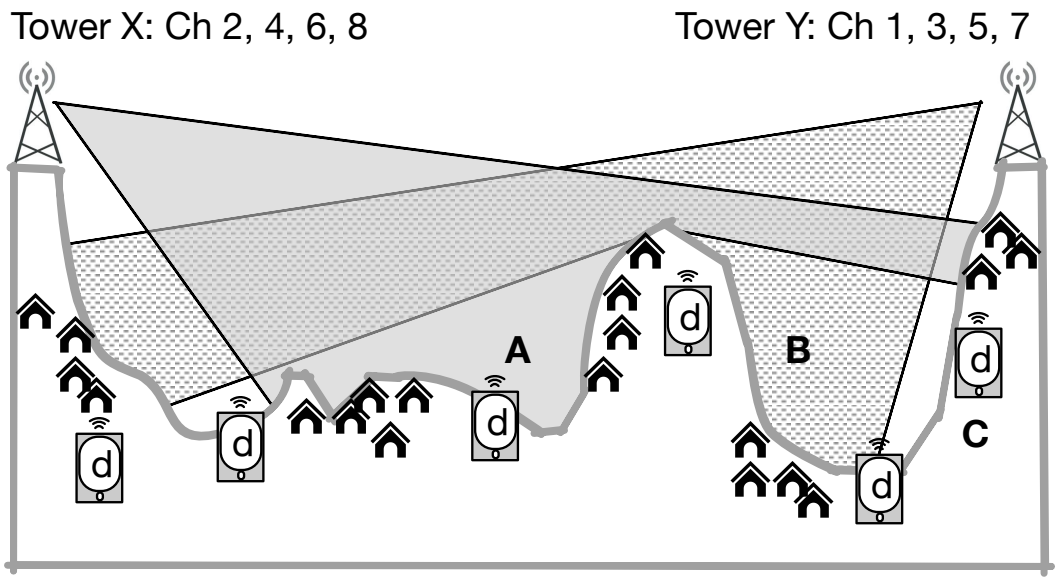

Menu
Home
Monitors
Reports
Account
Downloads
Help
MalawiNet
Tentacles
Tests
Results
Sync
Logging
Monitor Management
Home / Monitors / MalawiNet
MalawiNet
Malawi TWWS Network Monitor
running on
Linux
unique identifier
1
ip address
Not set
location
Zomba Southern Region MW
timezone
Africa/Malabo
Summary of tentacles
A to B
192.168.1.1
A to C
192.168.1.103
A to D
192.168.1.104
ICTP-B5
192.168.1.105
X to Y
192.168.1.106
Edit Monitor
Download Monitor
Network Map
Zomba
Monitoring check list
1. Grant the octopus app access to your Dropbox DONE
2. Download tentacle from our bitbucket repository
3. Install tentacle dependencies and configure show me how
4. Start the tentacle daemon show me how

Experimenting with monitoring tools

- There is not appropriate monitoring tools, due to high costs and size.
  - Mobile low-cost monitoring arises as a solution
  - But, many challenges arise as well.
    - **Appropriate representation, storage and assessment of a White Space**

Collection Workflow

- Detector approach using geo-location database for raw energy detection in the UHF band.



The WhispPi device

Trying to substitute an Agilent 8648C 20.000 US$ device!

RF explorer spectrum analyser

+

Raspberry Pi

+

USB GPS

+

convenient 4200 mAh battery

Low-cost devices for spectrum collection

ASCII 32/Arduino

WispPi

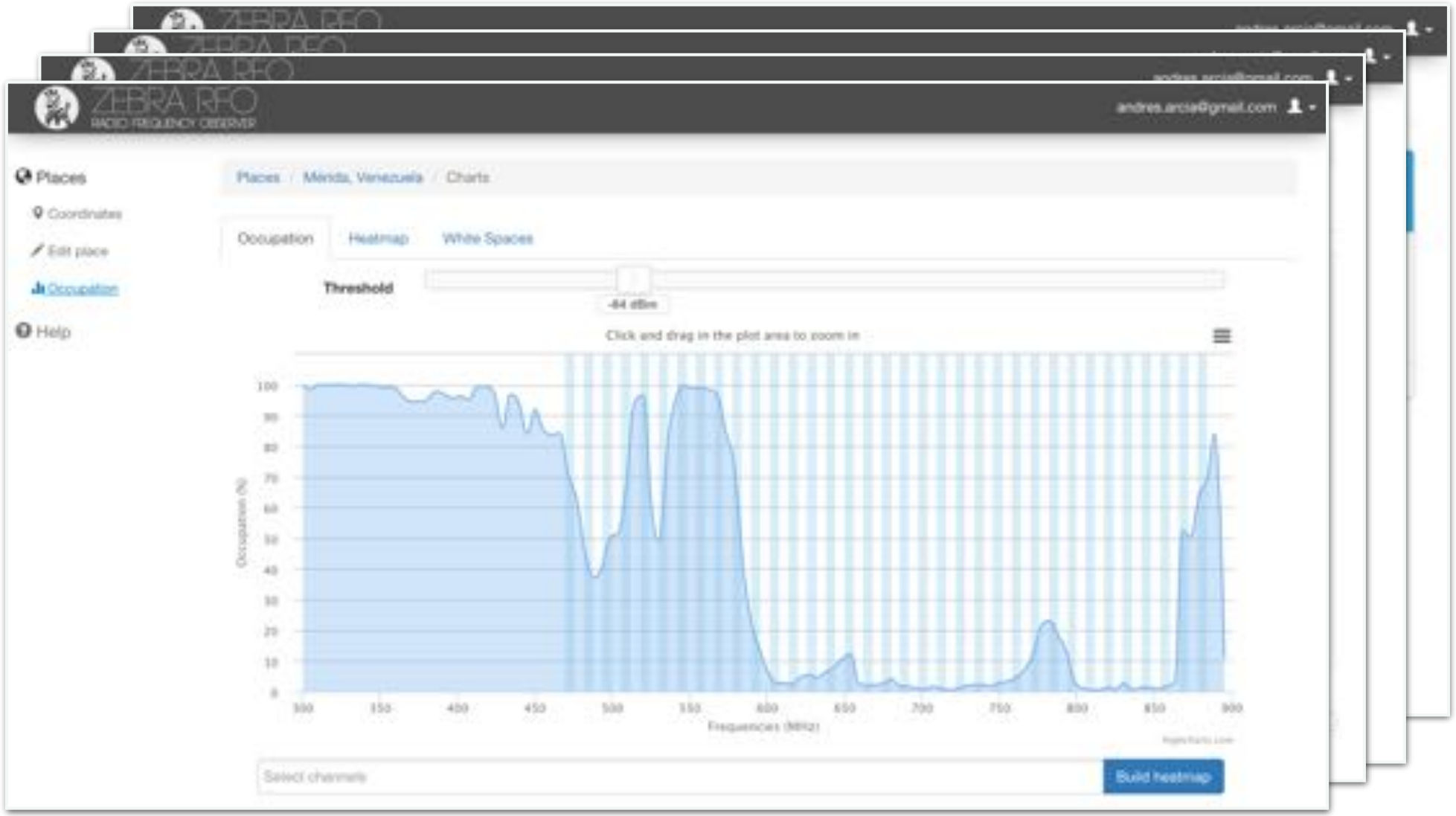
Android

- ASCII 32: High speed device, stand alone, less accurate.
- Android Interface to RF Explorer. High speed device.

From the data collection…

- Different speeds for mobile sampling
- Different sampling rates
- Heterogeneous devices (radio, antenna, storage capacity)
- Different formats for storing the data
- No means for assessing the White Spaces!

Regionalised Repositories



Preliminary Results

- 7 countries across the scale of A4AI report
- between 39% and 86% of WS in urban areas.
- couple of developed regions showing between 74% and 86% of WS.

Takeaways

- Initial results report high number of White Spaces thus encouraging the implementation of ORSR for communities in emerging regions (or wherever exists digital divide).
- Based on empirical evidence we propose a two-tier architecture for spectrum occupancy (communities must be the collectors, governments the curators).
- From collection workflow, rezoning and curation of spectrum are the most expensive tasks.
- Assessing white spaces should be a cooperative task (involving communities) from which governments and private companies could benefit.

Thank you.
Questions?