

Planning a Wireless Network

Training materials for wireless trainers



The Abdus Salam
**International Centre
for Theoretical Physics**



Goals

- ▶ To understand why there is a need for planning a wireless network (or link) and how it can be performed effectively
- ▶ To know what kind of information is valuable to collect when performing a site survey and how to do it
- ▶ To learn about some free tools that can simplify link planning and “what if” simulations

Why plan a wireless network?

- ▶ Let us start with a list of cases when planning is not really needed and can be skipped (or well simplified):
 - ▶ very simple deployments: for example an Access Point to serve a conference room
 - ▶ repeated installation of the same equipment in multiple sites, all similar to each other
 - ▶ experiments or tests, meant to “play” with new or old equipment you have already purchased
- ▶ In all the situations above, you can just “*go and install the equipment*”, without having to follow a (somewhat long and/or complex) planning procedure.

How to plan a wireless network

- ▶ A simple step-by-step procedure is presented here, as a guide to organize your own planning and design in the most effective way.
- ▶ Remember that in a complex field like wireless networking, there is never a unique and perfect step-by-step procedure that can guarantee success: you will have to adapt your planning scheme to fit the local situation with its advantages and constraints.
- ▶ Proper planning takes time. Remember to allocate a reasonable amount of time to do your planning in advance and to start doing it, right from the beginning of your project.

Define your goals

I) Define your goals and characterize the desired output of your project, with measurable figures like:

- average usage (number of clients connected)
- average / peak throughput (overall / per user)
- latency and other network issues that can influence the services running on the network
- reliability (percentage of downtime)
- maintenance costs

Understand constraints

2) Understand which are the constraints and limitations, like for example:

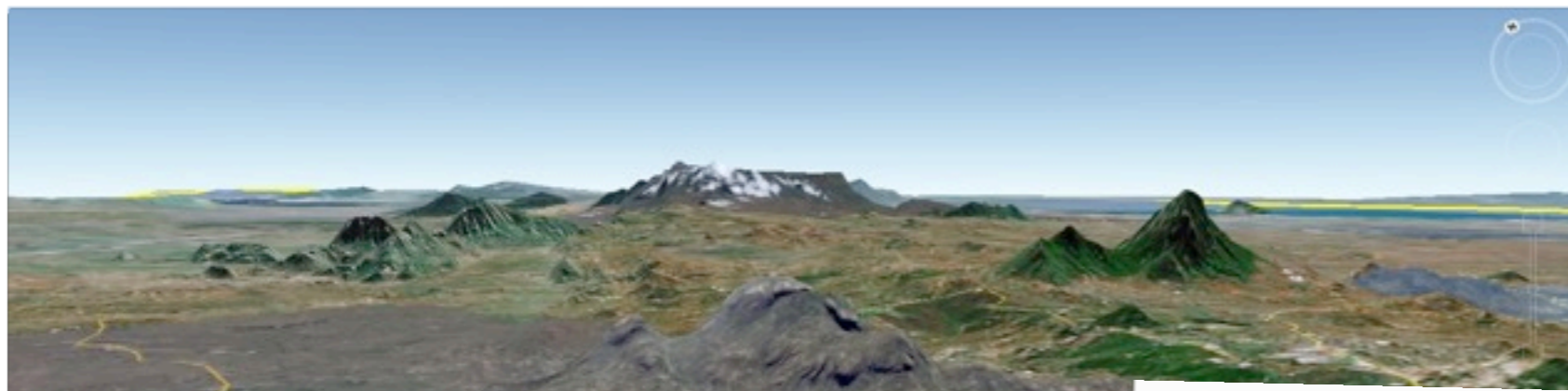
- local availability of equipment
- regulatory aspects (permits, fees, allowed frequencies and power, equipment homologation)
- limitations of the ISP
- access to sites and infrastructures
- availability of power (and its quality/reliability)
- human resources (for deployment/maintenance)
- financial constraints (budget)

Design and simulation

- 3) Feasibility check: **design** and **simulate** the architecture of your wireless network, considering aspects like:
- location of nodes and their access (maps...)
 - equipment to be deployed in each node
 - availability of antenna support structures
 - RF power link budget and Line-of-Sight clearance for each hop (with the help of Radio Mobile)
 - source of powering for each equipment
 - selection of frequency of operation for each hop
 - co-location and interference issues in each node

Google Earth

<http://earth.google.com/>



- ▶ Verify line-of-sight between locations
- ▶ Log precise GPS coordinates
- ▶ Terrain data is available nearly everywhere
- ▶ Building data is available in some cities

Link simulation with Radio Mobile

There are many programs that can be used to simulate radio links and base station coverage, some costing thousand of dollars.

By using a link simulator, you can save considerable time. If a link is proven to be impossible in simulation, there is no need to perform a site survey at all.

Radio Mobile is a free program developed for radio amateurs by Roger Coudè that is based on the well known Longley-Rice Irregular Terrain Model and predicts radio propagation from 20 MHz to 20 GHz making use of several sets of freely available Digital Elevation Maps.

Site survey

4) Site survey: **inspection** of every relevant site, evaluating its positive and negative aspects like:

- accessibility to the site and inside the structure
- electrical power provisioning, grounding
- survey of the e.m. spectrum and its usage (to select the best operating channels to use)
- Line-of-Sight clearance towards other nodes
- pre-existing structures for antenna mounting
- arrange for practical considerations before the actual installation (required personnel, keys, ladders, etc)
- document everything with notes and pictures, take precise measurements where possible, take GPS coordinates and elevation data

Bring with you:

- ▶ Notebook and pen
- ▶ Map of the area of interest
- ▶ Compass, GPS (if available)
- ▶ Binoculars or small telescope
- ▶ Harness and climbing gear
- ▶ Digital camera
- ▶ Measuring tape



Often overlooked tips

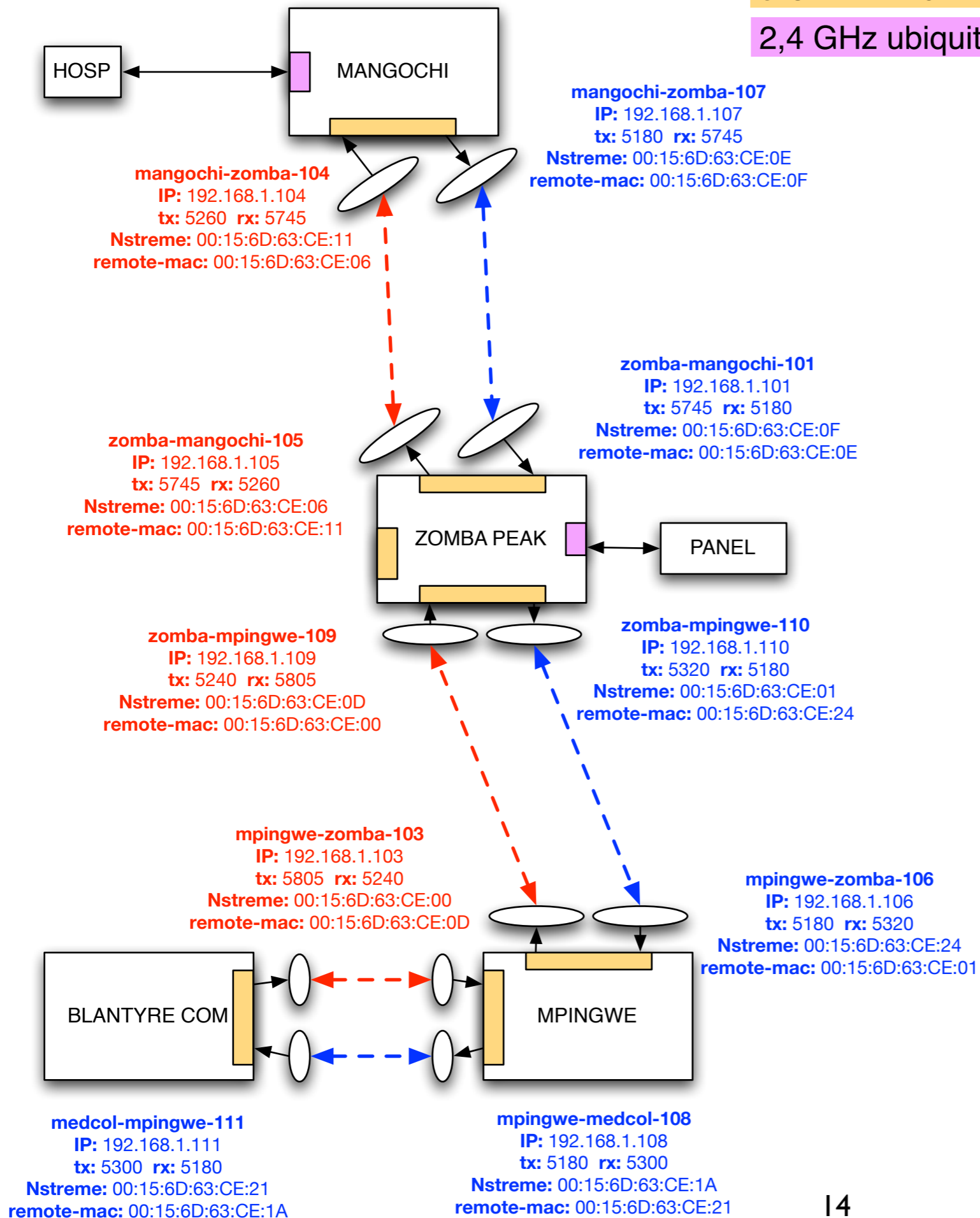
- ▶ For very long distance links, it can be difficult to spot the remote end. In the daytime, mirrors can be used to reflect light and make the other end easier to spot. At night, spot lights or strobe lights can help.
- ▶ A tethered balloon can also help locate the remote end of a link, as well as to estimate the necessary tower elevation needed to overcome any obstacles.
- ▶ Mobile phone coverage is not universal. Bring a pair of radios when working in remote places (especially for antenna alignment).
- ▶ Umbrellas can help shield glare on laptop screens on a sunny day.
- ▶ Safety first: wear gloves, helmet and harness when climbing towers.
- ▶ Don't forget about the weather: wear a hat, sunglasses, and sun screen when appropriate.

Final design

- 5) Final design of your wireless network, using the relevant information acquired during the site survey:
- final choice of equipment for every node
 - recalculation of power budget for every hop
 - detailed plans for antenna mounting and the running of all RF/ethernet/power/grounding cables
 - frequency plan
 - network topology and architecture, IP addressing scheme

5 GHz mikrotik

2,4 GHz ubiquiti



Here is an example of a network plan, with IP and MAC addresses, host names, locations, interconnections, operating bands, and frequency choices.

Pre-deployment

- 6) Final steps before deployment (not the night before ;-):
- draft a timing scheme for all purchases, transportation and deployment of equipment
 - plan in advance the allocation of human resources: who is going where and when, to do what (and inform them in advance!)
 - configure and test all equipment before leaving the lab (run a full simulation of the network whenever is possible)
 - prepare a checklist of all equipment/tools/supplies you will need at each site
 - label all devices with relevant information like passwords, IP addresses, port names, etc...

Deployment

7) Deployment:

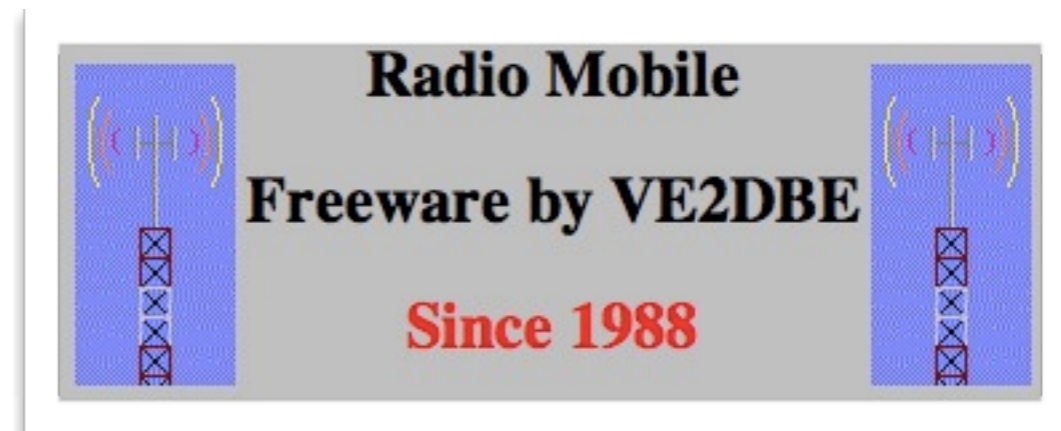
- install all equipment, antennas and cabling
- fine-tune the antenna alignment with a signal generator and signal strength meter (if available)
- test the power supplies and ethernet cables
- check if the radios are working
- check if the links are established
- fine-tune the antenna alignment using the readings of the receivers (if not done before at point 2)
- do performance tests on each individual link and on the complete network
- weatherproof all outdoor connectors and enclosures, tighten all antenna mounting brackets

Post-deployment

- 8) Post-deployment tasks (to be done on-site during the installation or immediately after the installation):
- document the actual configuration of all devices
 - revise the schemes of the running of RF, ethernet, power and grounding cables (with diagrams), documenting any difference from the original planning
 - record the RF signal strength at every receiver, for future comparison and reference
 - devise a maintenance schedule for visiting each site

Link simulations with Radio Mobile

Radio Mobile runs in Windows but it can be used in Linux or MAC by means of emulators.



It provides all sort of details for point to point links, including expected signal level at any point along the path, including diffraction losses due to obstacles.

Automatically builds a profile between two points in the digital map showing Fresnel Zone and Earth Curvature Clearance, as well as required antenna heights and it is a wonderful tool for exploring “what if?” scenarios.



Transmitter

S9+20

Mpimwe Hill

Role	Master
Tx system name	System 1
Tx power	10 W 40 dBm
Line loss	0.5 dB
Antenna gain	24 dBi 21.85 dBd <input type="checkbox"/> +
Radiated power	EIRP=2.24 kW ERP=1.37 kW
Antenna height (m)	<input type="text" value="10"/> Apply

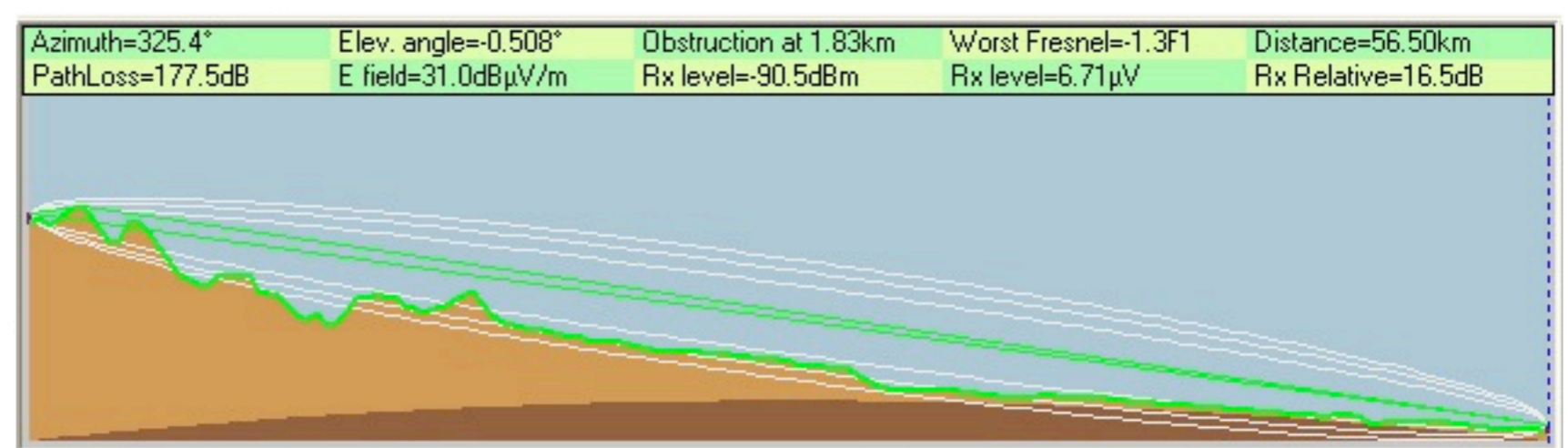
Net

Mpimwe - Zomba

Receiver

S9+20

Zomba Peak



Transmitter

S7

Mtaja

Role	Master
Tx system name	System 1
Tx power	10 W 40 dBm
Line loss	0.5 dB
Antenna gain	24 dBi 21.85 dBd <input type="checkbox"/> +
Radiated power	EIRP=2.24 kW ERP=1.37 kW
Antenna height (m)	<input type="text" value="10"/> Apply

Receiver

S7

Mangochi repeater

Role	Slave
Rx system name	System 1
Required E Field	14.49 dEμV/m
Antenna gain	24 dBi 21.85 dBd <input type="checkbox"/> +
Line loss	0.5 dB
Rx sensitivity	1 μV -107 dBm
Antenna height (m)	<input type="text" value="10"/> Apply

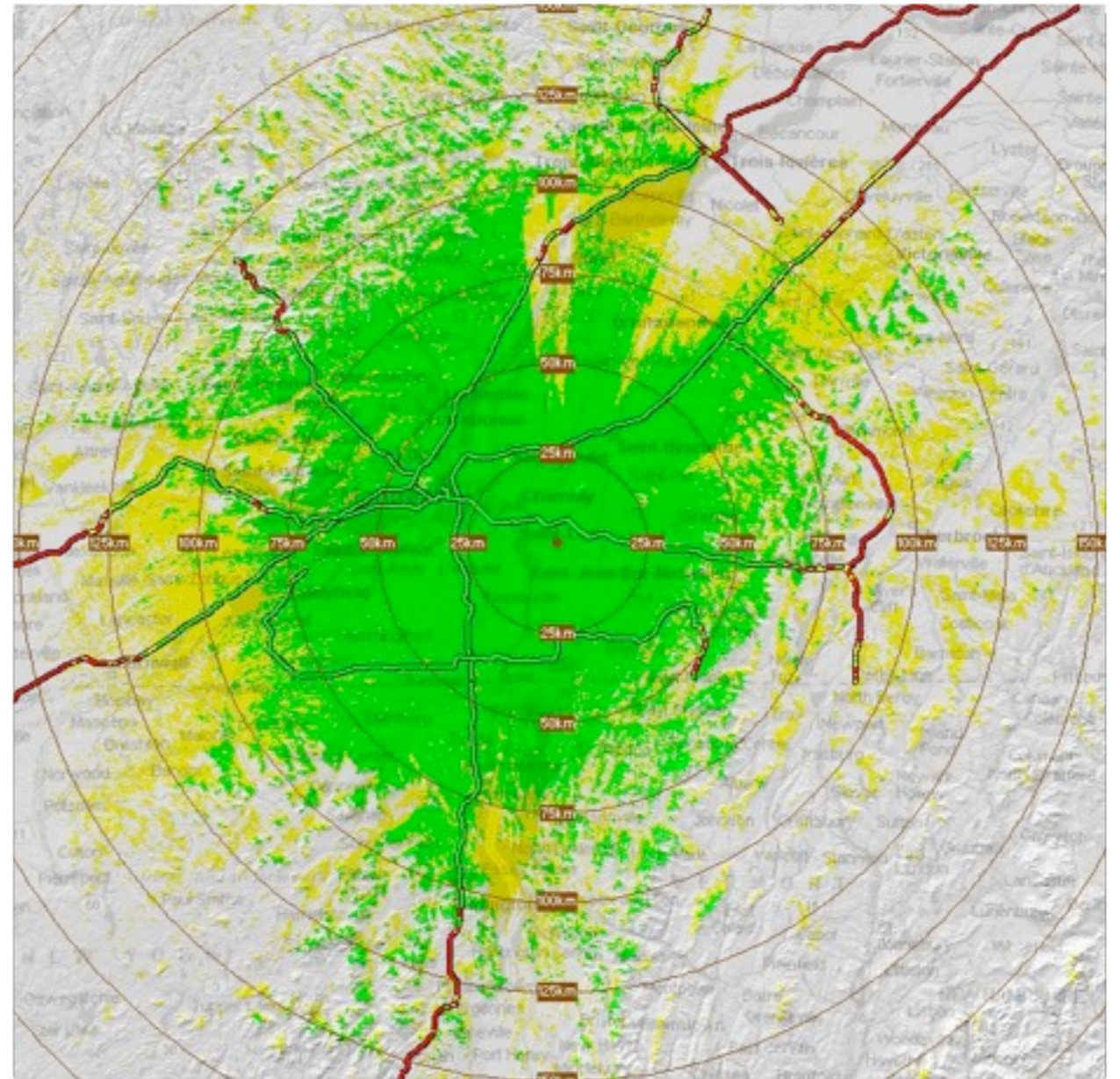
Net

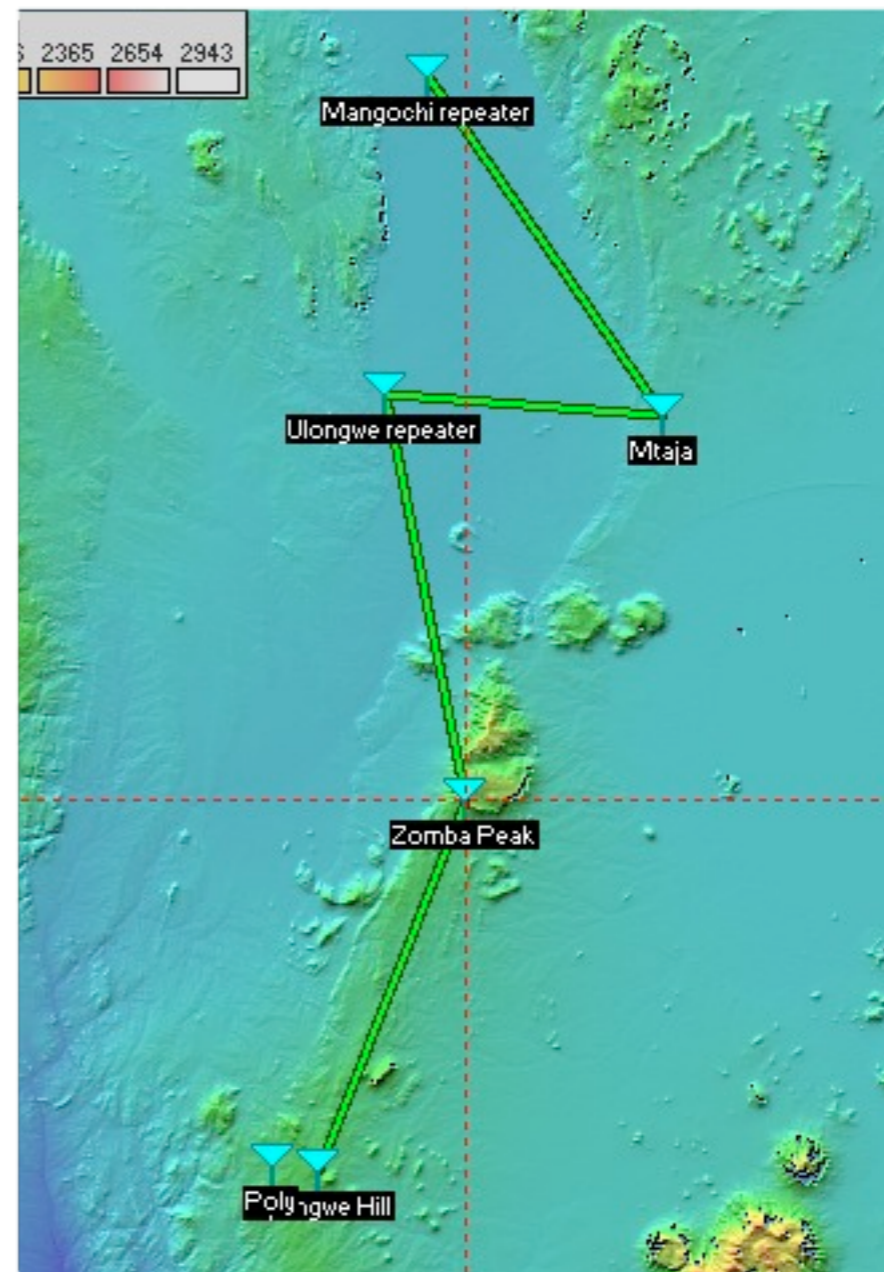
Mtaja - Mangochi

Frequency (MHz)	
Minimum	Maximum
<input type="text" value="2400"/>	<input type="text" value="2500"/>
<input type="button" value="Apply"/>	

For point to multipoint links, it will provide Base Station coverage areas (as shown), suggest convenient sites for base station placement, and allows changing the antenna pattern while assessing how it will affect coverage.

It works with true bearing but it will also provide the magnetic declination of the site so you can relate the compass reading with the map data.





Download Radio Mobile

Download Radio Mobile here:

<http://www.cplus.org/rmw/english1.html>

Instructions are provided there on how to get the digital elevations maps of the area of interest.

Digital elevation maps come in 1 degree longitude X degree latitude tiles so you might need to download a few tiles for your application.

Once you have downloaded the maps, you no longer need Internet access (unlike using Google Earth).

Conclusions

- Effort spent in planning will save ten times the effort in installation and maintenance.
- Configure and test all equipment “in the lab” before deploying it in the field.
- Keep good documentation of all configuration settings for all devices to assist in troubleshooting and expanding the network later.
- Don’t forget to account for maintenance in your planning (both financial and logistical)!
- Tools such as Radio Mobile can automate many parts of the network planning process.

Thank you for your attention

For more details about the topics presented in this lecture, please see the book ***Wireless Networking in the Developing World***, available as free download in many languages at:

<http://wndw.net/>

