Planning a Wireless Network

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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

1) 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/
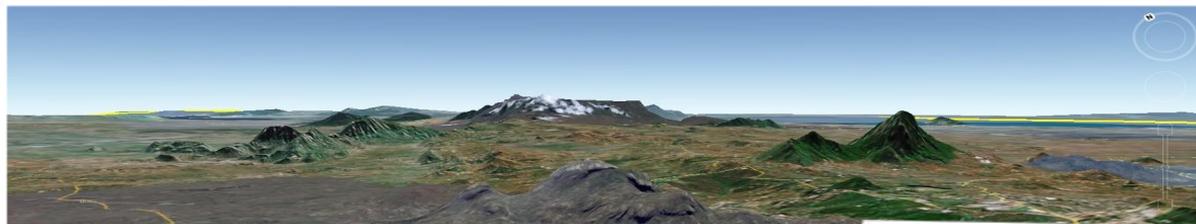
‣ Verify line-of-sight between locations

‣ Log precise GPS coordinates

‣ Terrain data is available nearly everywhere

‣ Building data is available in some cities

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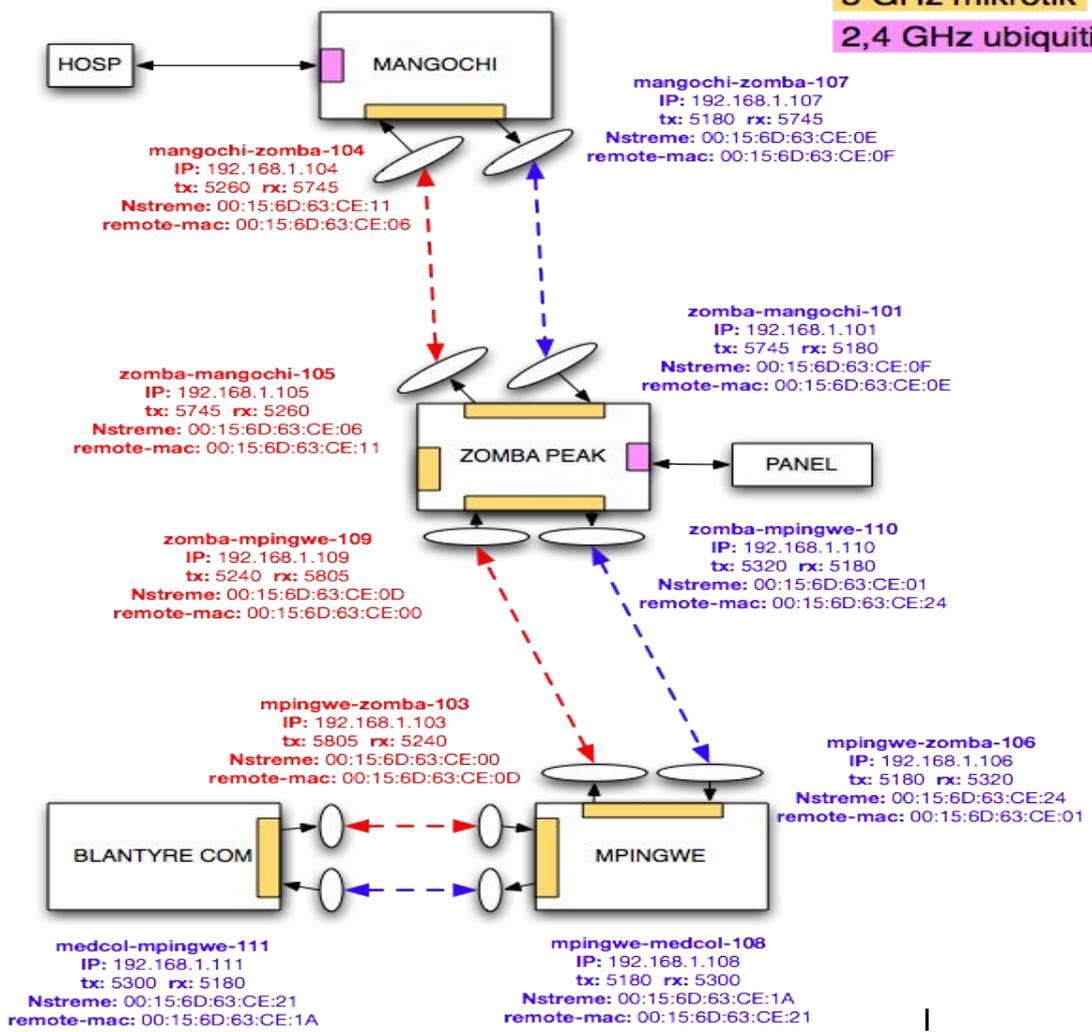
Here is an example of a network plan, with IP and MAC addresses, host names, locations, interconnections, operating bands, and frequency choices.

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

- 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

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).

First window (Mpimgwe Hill → Zomba Peak):

Azimuth=21.5° Elev. angle=0.395° Clearance at 13.98km Worst Fresnel=9.3F1 Distance=54.81km
PathLoss=152.2dB E field=63.2dBµV/m Rx level=-65.2dBm Rx level=123.03µV Rx Relative=41.8dB
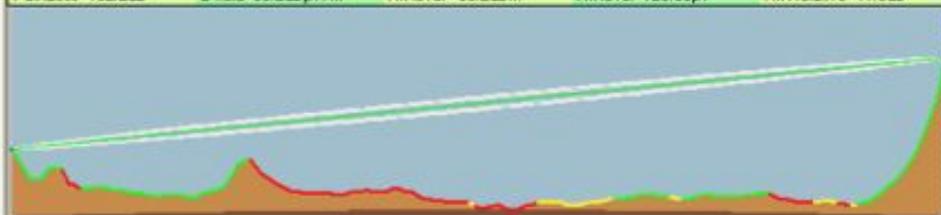
Transmitter

S9+20

Mpimgwe 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 +
Radiated power	EIRP=2.24 kW	ERP=1.37 kW
Antenna height (m)	10	Apply

Receiver

S9+20

Zomba Peak

Net

Mpimgwe - Zomba

Second window (Mtaja → Mangochi repeater):

Azimuth=325.4° Elev. angle=-0.508° Obstruction at 1.83km Worst Fresnel=1.3F1 Distance=56.50km
PathLoss=177.5dB E field=31.0dBµV/m Rx level=-90.5dBm Rx level=6.71µV Rx Relative=16.5dB
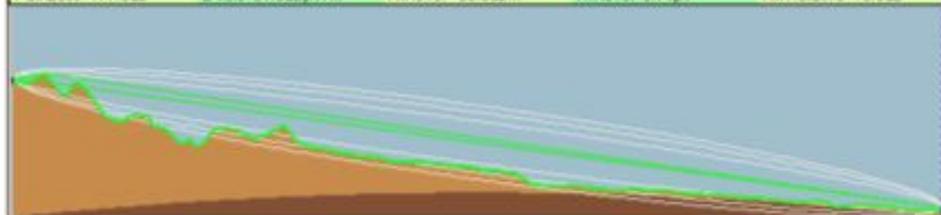
Transmitter

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 +
Radiated power	EIRP=2.24 kW	ERP=1.37 kW
Antenna height (m)	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 +
Line loss	0.5 dB	
Rx sensitivity	1 µV	-107 dBm
Antenna height (m)	10	Apply

Net

Mtaja - Mangochi

Frequency (MHz)

Minimum	Maximum	
2400	2500	Apply

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 BotRf or 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/