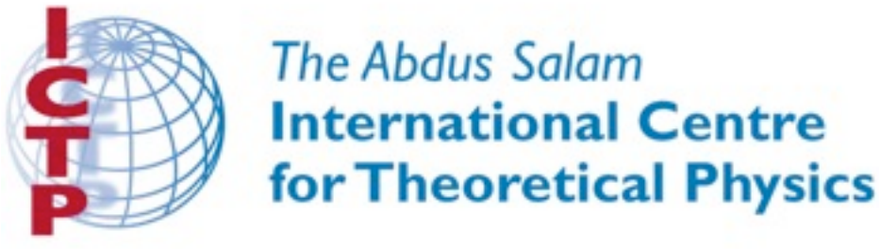
Why Wireless?

Training materials for wireless trainers



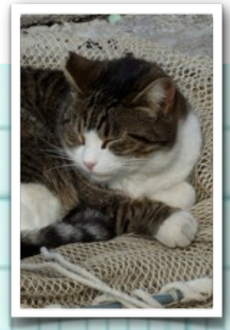
This talk provides a general introduction and a motivation to follow this 5-days training course on low-cost wireless networking.
It is intended to be the very first lecture and it has a duration of 15 minutes approx.
Version 0.1 by Carlo, @2009-11-25
Version 1.0 by Rob, @2009-11-27
Version 1.1 by Ermanno, @2010-1-31
Version 1.2 by Rob, @2010-2-23
Version 1.3 by Rob, @2010-03-03
Version 1.4 by Rob, @2010-03-11

Goals

- Understand why we use wireless, and how it fits into your existing network
- Realize the limits of what wireless can achieve
- See some examples of how wireless has been used to build real-world networks

What is wireless?



wavelength (meters)

town 10000 | 1000

house 100 | 10

man 1

cat 0,1

insect 0,01

seed 0,001

(Hertz) frequency

10^4 10^5 10^6 10^7 10^8 10^9 10^{10} 10^{11}

AM radio

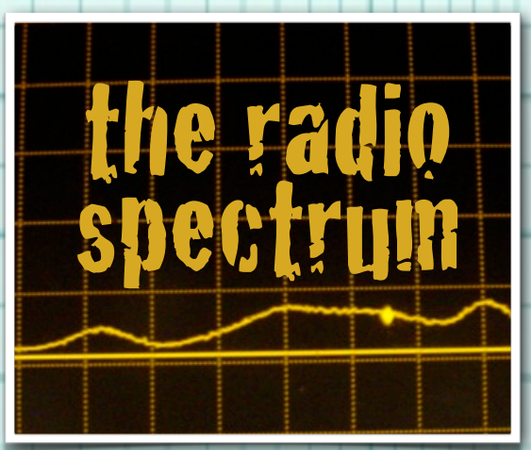
shortwaves

FM radio

GPS

WiFi

microwaves telecom links



links with submarines

radiohams

mobile phones

TV

radars

satellite TV

This picture represents some of the many different usages of the e.m. spectrum, from low frequency radio up to microwaves. It will be explained with greater detail later.

Now it is here to give you this message: ***wireless -in our meaning- is NOT mobile phones, is NOT microwaves telecom links, is 2.4GHz and 5GHz WiFi and that's all ;-)***

Low-cost wireless: history

- Commercially available starting from early '90s ("*Spread Spectrum*" ~10k$ per link)
- Standards ratified (802.11 "WiFi") since late '90s
- After standardization: big "boom", lower costs
- Widely adopted for indoor, SOHO, industry, academic, etc.
- Some commercial solutions have been developed and marketed up to medium-long distance (1-20 km)
- Today and tomorrow: ???

cost per link:
>10.000 US$ in 1992
<100 US$ in 2009

Talk about average prices and capabilities of equipment today compared to five years ago. Speculate about what is coming next.

Although microwave links have been widely deployed in many countries since the fifties, it is in the 90's when low cost technologies employing spread spectrum started to make a profound dent in prices for wireless links.

Specifics are intentionally left out of these notes because the technology changes so quickly.

Low-cost wireless: limits

- **1-5 km:** easy, reliable
- **5-20 km:** difficult, LoS required, QoS issues
- **20-100 km:** *experimentation*
- **>100 km:** *very difficult* (but possible)

- interference and co-location → need for planning
- regulations (ISM band) → need for planning
- variable costs (according to performance, reliability)

LoS: Line of Sight. The radio LoS is more stringent than the optical LoS.

QoS: Quality of Service. Refers to maximum latency, jitter, packet errors the most important parameters that affect the quality of communications.

Low-cost wireless: a few numbers

- Throughput: 1-54 Mbps (“old” standards), now higher
- Channels at 2.4 GHz: only 3 non-overlapping channels. Many more at 5 GHz (if available)
- TX power: < 600 mW
- power consumption: 0.3-10W (usually at 12 volts, PoE)
- Cost: range from 100US$ to 5.000US$ per link
- Users per base station: 20-50 max

PoE: Power over Ethernet. The provisioning of power using the same cable that transports data.

These are ballpark figures. Vendors will claim much better performance, but be wary!

Low-cost wireless: examples

- Wireless LANs:
  - indoor/outdoor network distribution among many clients
  - typical distance: 10 - 100 m
  - Point-to-Multipoint structure:
    - master station (access point, AP)
    - client station (Embedded miniPCI, PC card, USB device, wireless bridge)

Most laptops and PDA's will have embedded WiFi clients as well as many cellular phones and even some digital cameras.

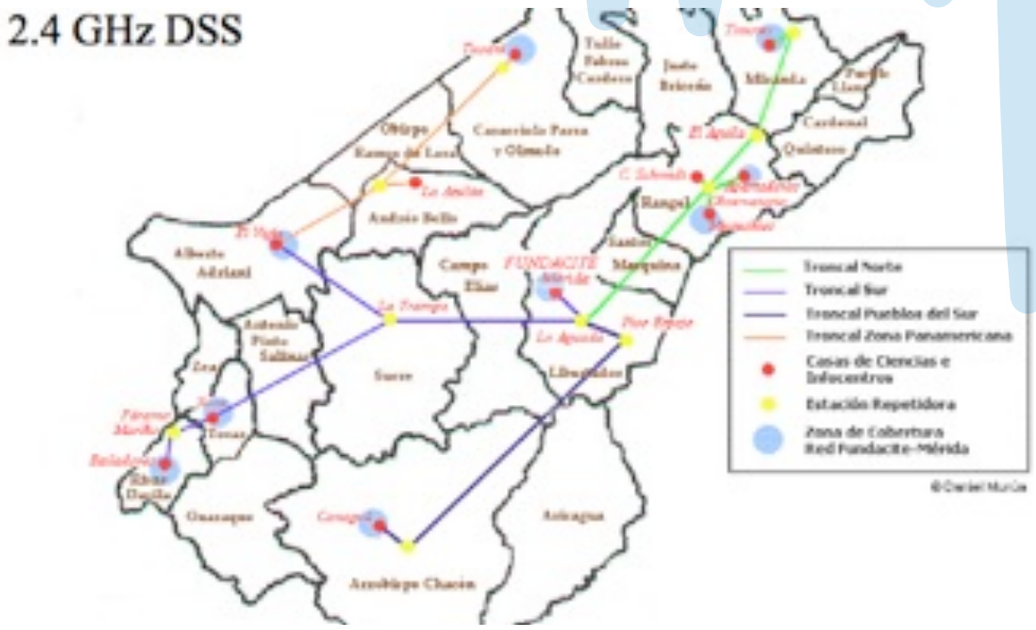
Low-cost wireless: examples

- Wireless Metropolitan Area Networks (MANs):
  - used by ISPs (Point-to-Multipoint)
  - typical distances: 1-10 km
  - a medium to large number of clients
  - coexistence problems (max. 3 non-overlapping channels)
  - line-of-sight, security issues, remote management

MAN: Metropolitan Area Network. A network that covers several kilometers.
ISP: Internet Service Provider
WISP: Wireless Internet Service Provider

Low-cost wireless: examples

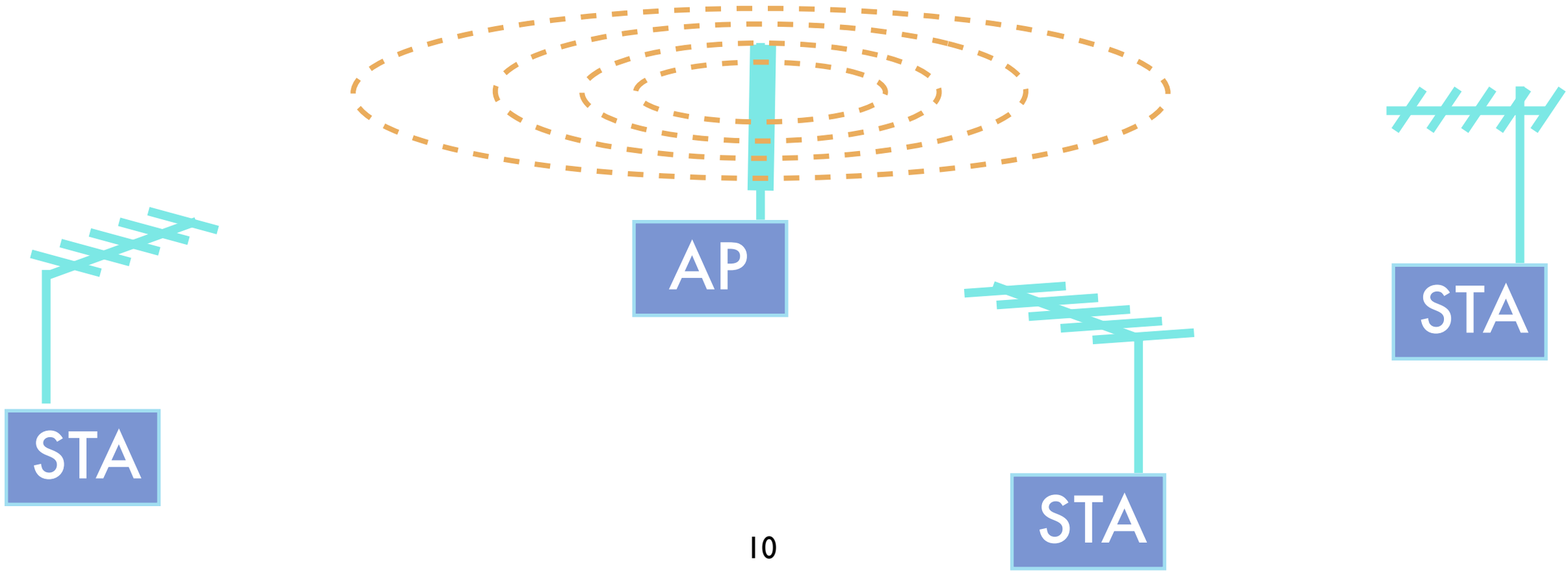
- Wireless MANs:
  - for private institutions/companies:
  - Point-to-Multipoint
  - Point-to-Point (larger distance, fewer coexistence problems)
  - line-of-sight, security issues
  - radio link planning and design



This example network was started in 1996 using spread spectrum, before the 802.11 standard was approved and it grew by using newer technologies as they became available.

Low-cost wireless: P2MP MANs

- Point-to-Multipoint
- Star topology, one AP, many stations
- Omnidirectional antenna for AP
- Directional antennas for stations



AP: Access Point. Mediates all the communications.
STA: Station. Is the client that can only connect to other clients by means of the AP.
This is the most common topology. The AP uses an omnidirectional antenna for wide coverage but limited gain. The STA can use directional antennas for improved gain and therefore range.

Low-cost wireless: planning

- Distance, obstacles, power budget
- Site survey, antenna installation
- Detect and mitigate interference
- Powering and protection
- Grounding and bonding
- Security (theft/vandalism)
- Network Layer (TCP/IP)

It is possible to build a very inexpensive long distance radio link with off–the–shelf devices and low cost antennas, but good planning is needed!

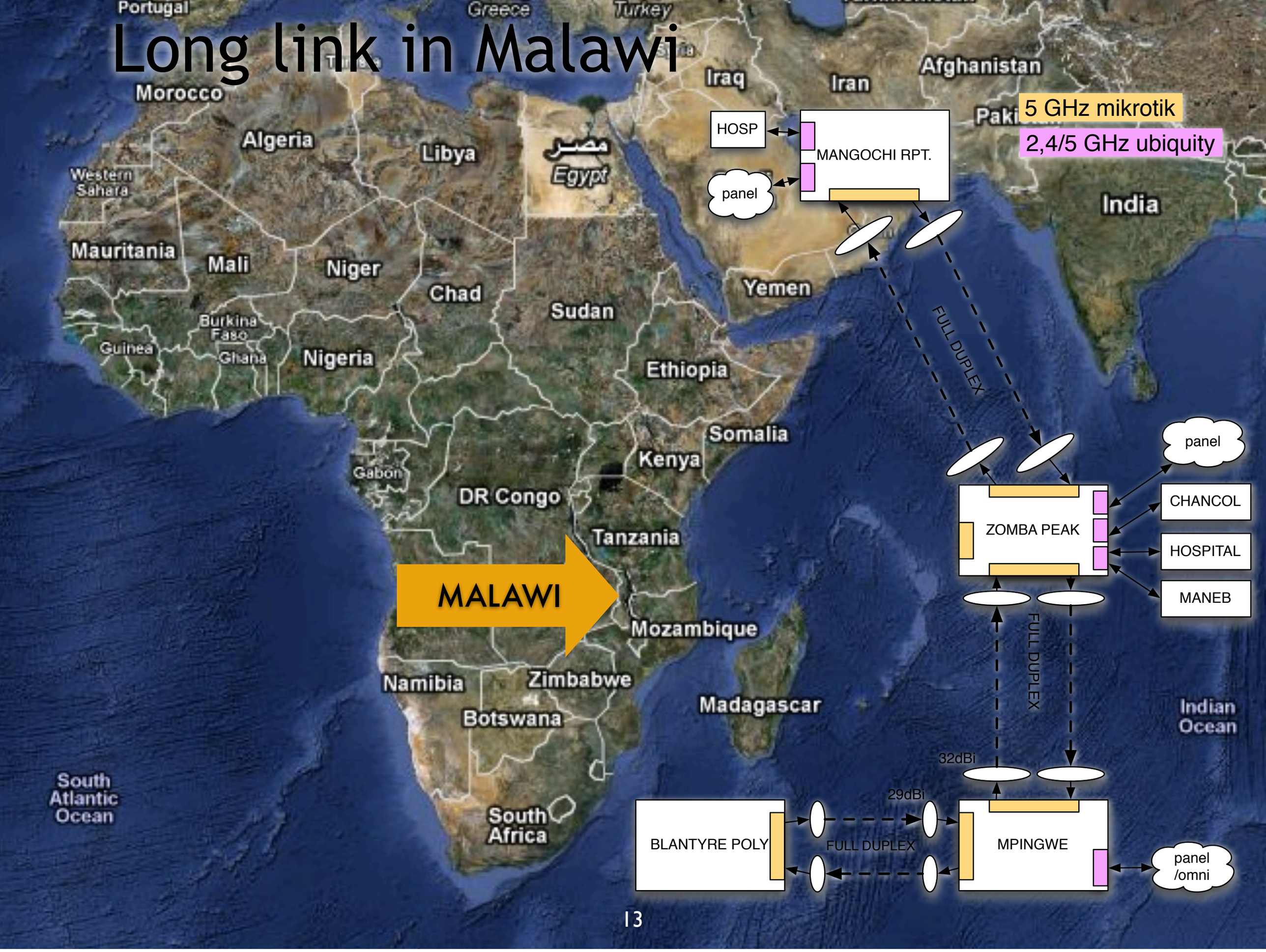
A thorough understanding of all these issue is paramount for a successful installation.

Low-cost wireless: long links

- From our field experiences, what is possible?
  - 2006: (Venezuela, 279km, World record for WiFi link)
  - 2007-8: Installation of a Test Bed link: 130km @2.4 + 5GHz (to study and compare the technologies)
  - 2006-8: Malawi (50+100 km @5GHz, throughput 20Mbps full duplex, double link for redundancy)

Let's analyze the last case, to show you what is it possible!

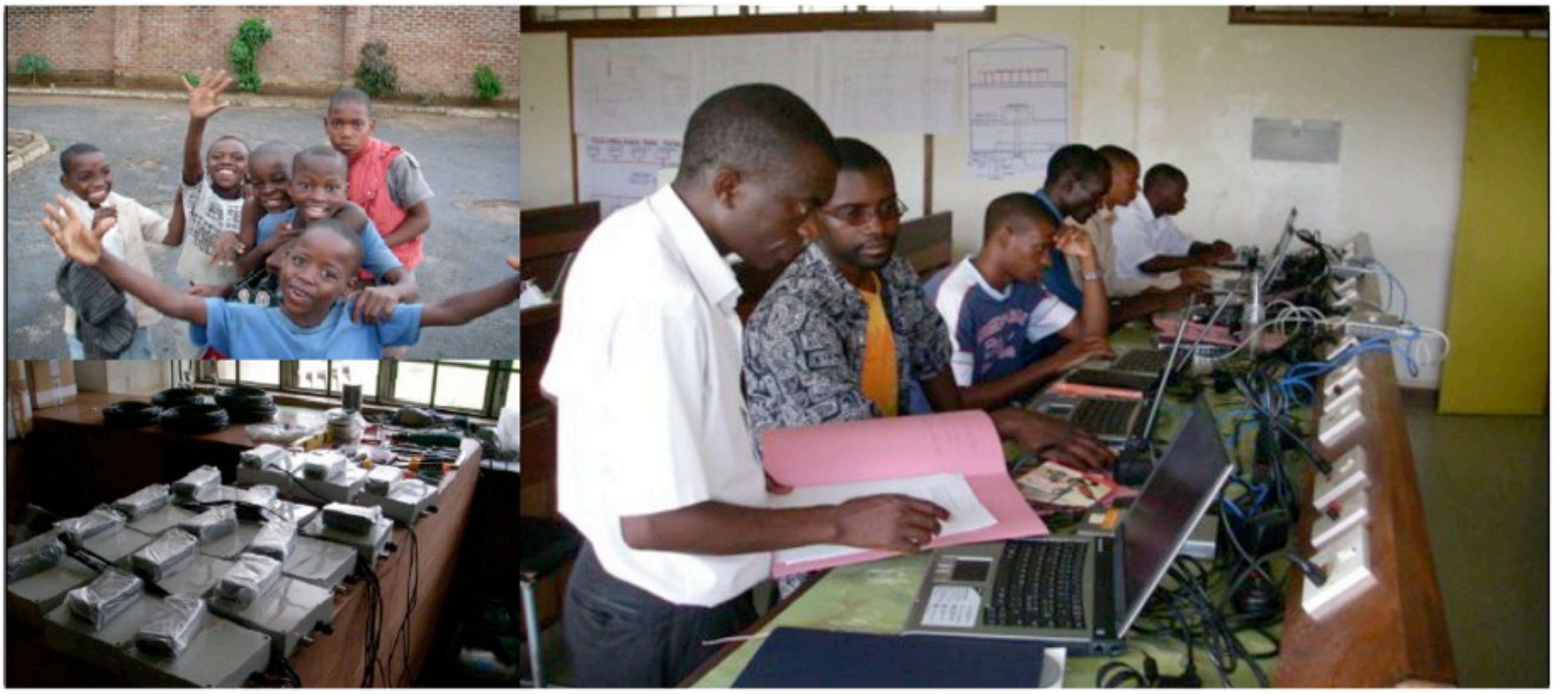
Long link in Malawi



This installation was in Malawi, in cooperation with the Blantyre Polytechnic and the Blantyre College of Medicine.

Long link in Malawi: goal

- Set the goal: to install a modern communication network to support health provisioning in hospitals and universities across Malawi



Long link in Malawi: where

- 3 hospitals in 3 different towns (distance by road ~200 km)

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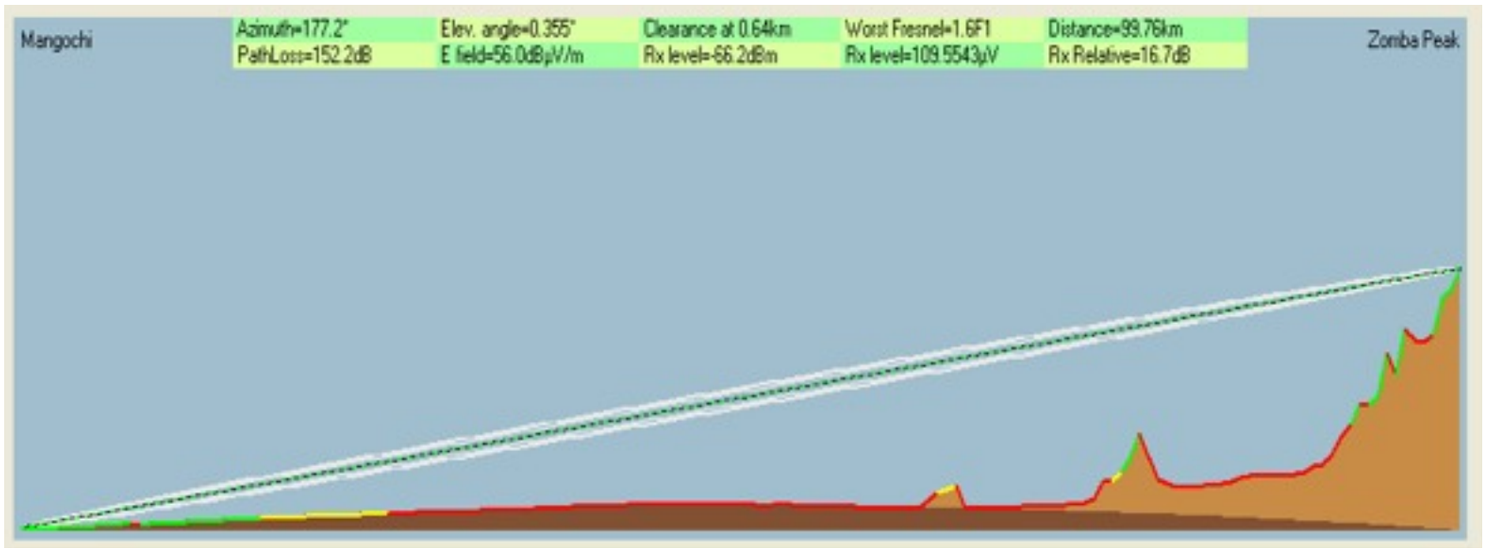
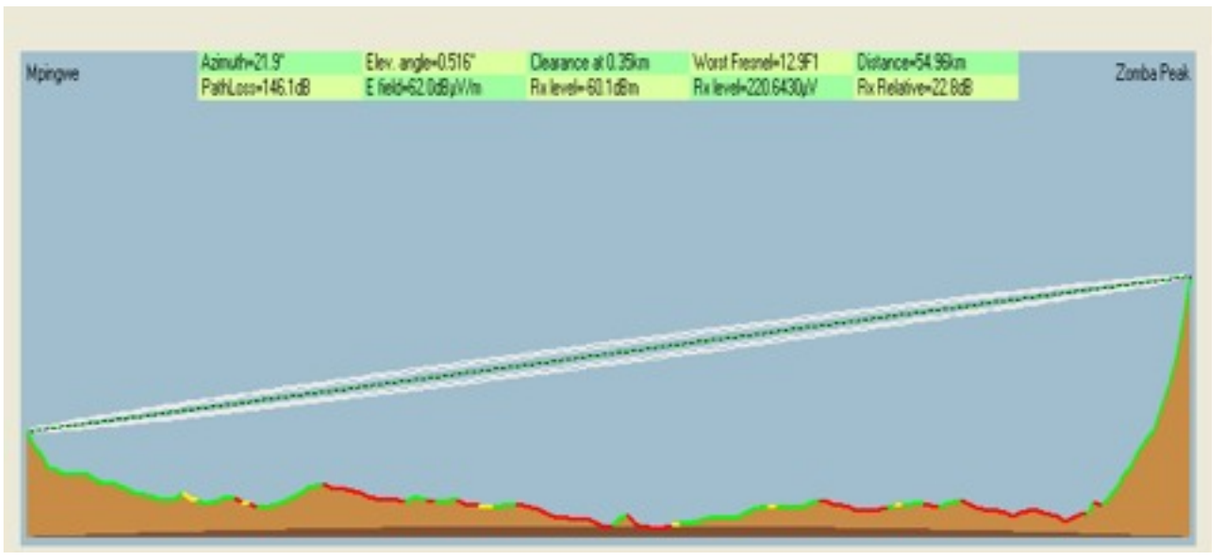
The preliminary plan indicated that a link from Blantyre > Zomba > Mangochi might be possible. But it was not completely certain that the site on Zomba peak would have clean line of sight to Mangochi. The backup plan was to use an additional hop at Ulongwe to avoid any obstacles in Zomba.

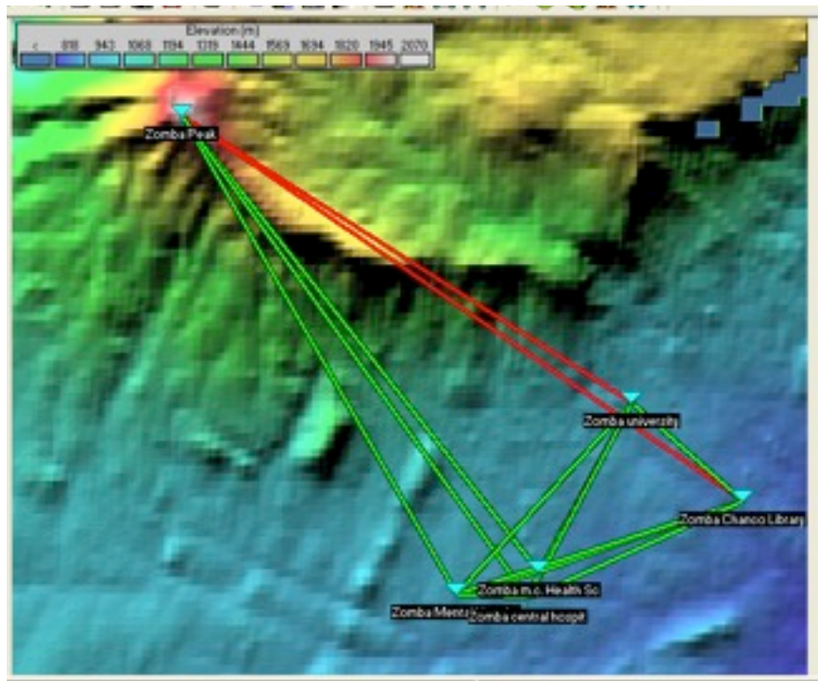
Fortunately, the path was clear and a direct 100+km link from Zomba > Mangochi was possible. But this was impossible to verify before people could physically inspect the site.

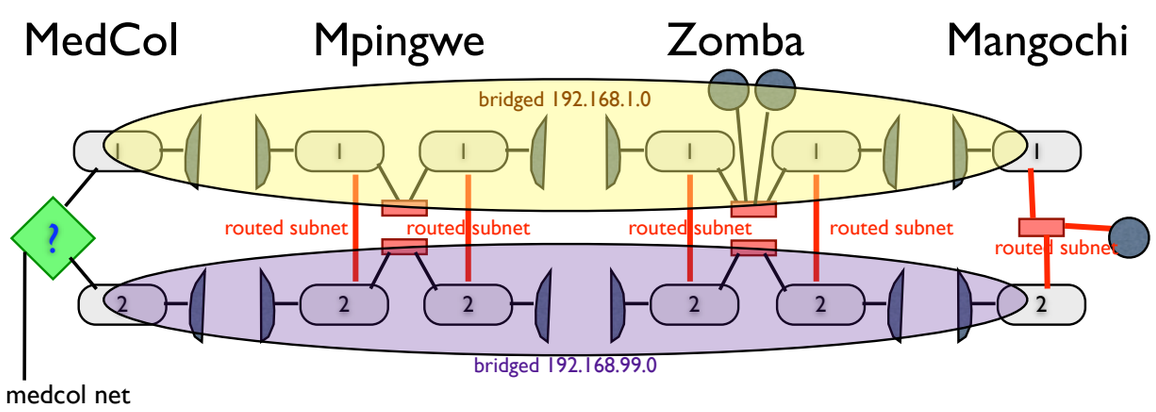
Long link in Malawi: planning

- design the network, plan the survey, setup and test activities









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Due to logistical constraints, we spent extra time planning the links, including backup plans in case a site might turn out to be unusable.

Long link in Malawi: towers

- thanks to a local operator, we had access to towers

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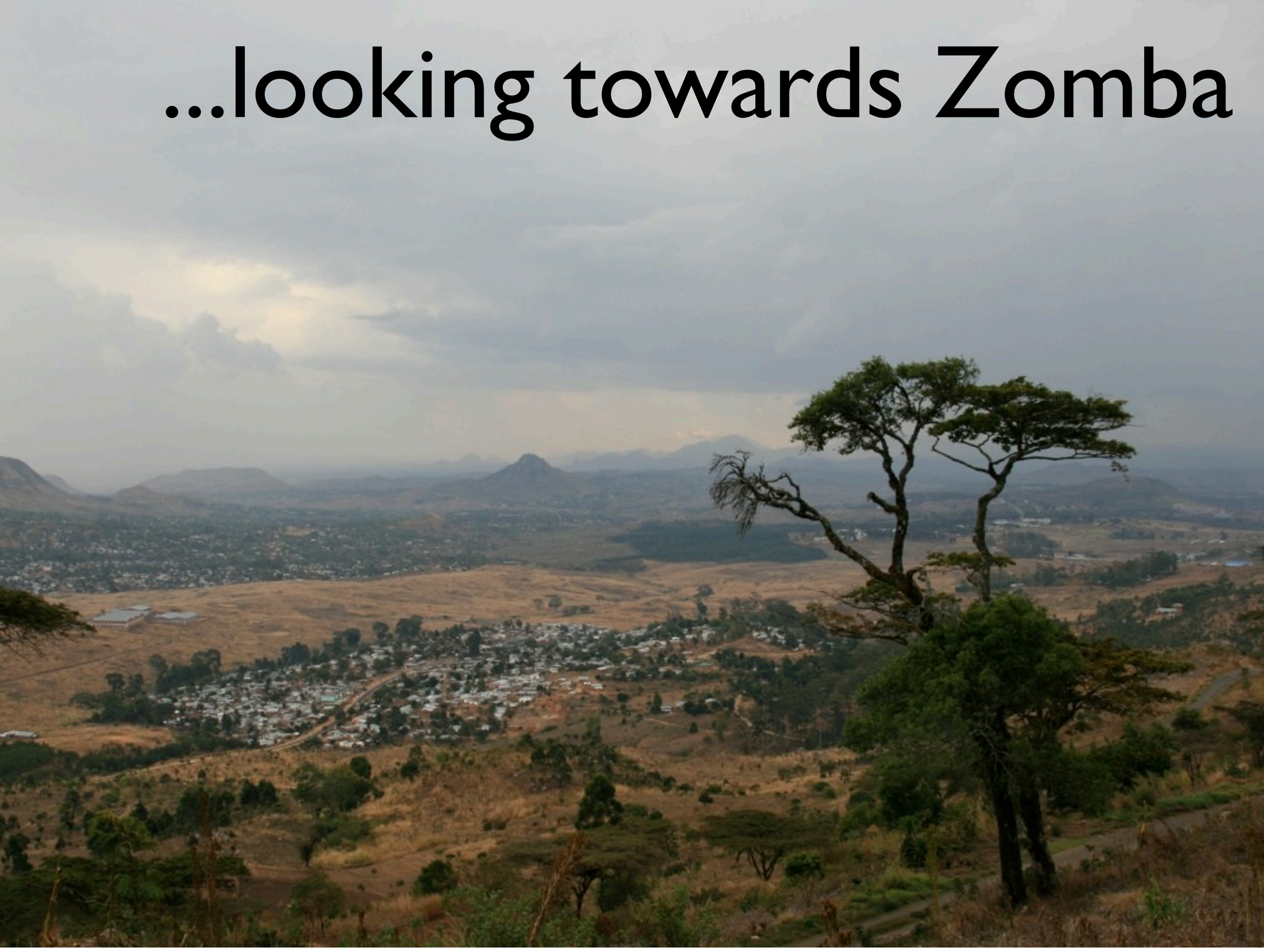
Having access to physical structures like these, as well as grid power, helped us build this network with a small team in just two weeks.

Mpingwe

The shortest hop was 7 km to Mpingwe hill, just above Blantyre. While this was the shortest link, it was also the most challenging due to the presence of many other local operators. There is a huge amount of interference on this hill, since it is the nearest sizable hill to the highly populated city of Blantyre.

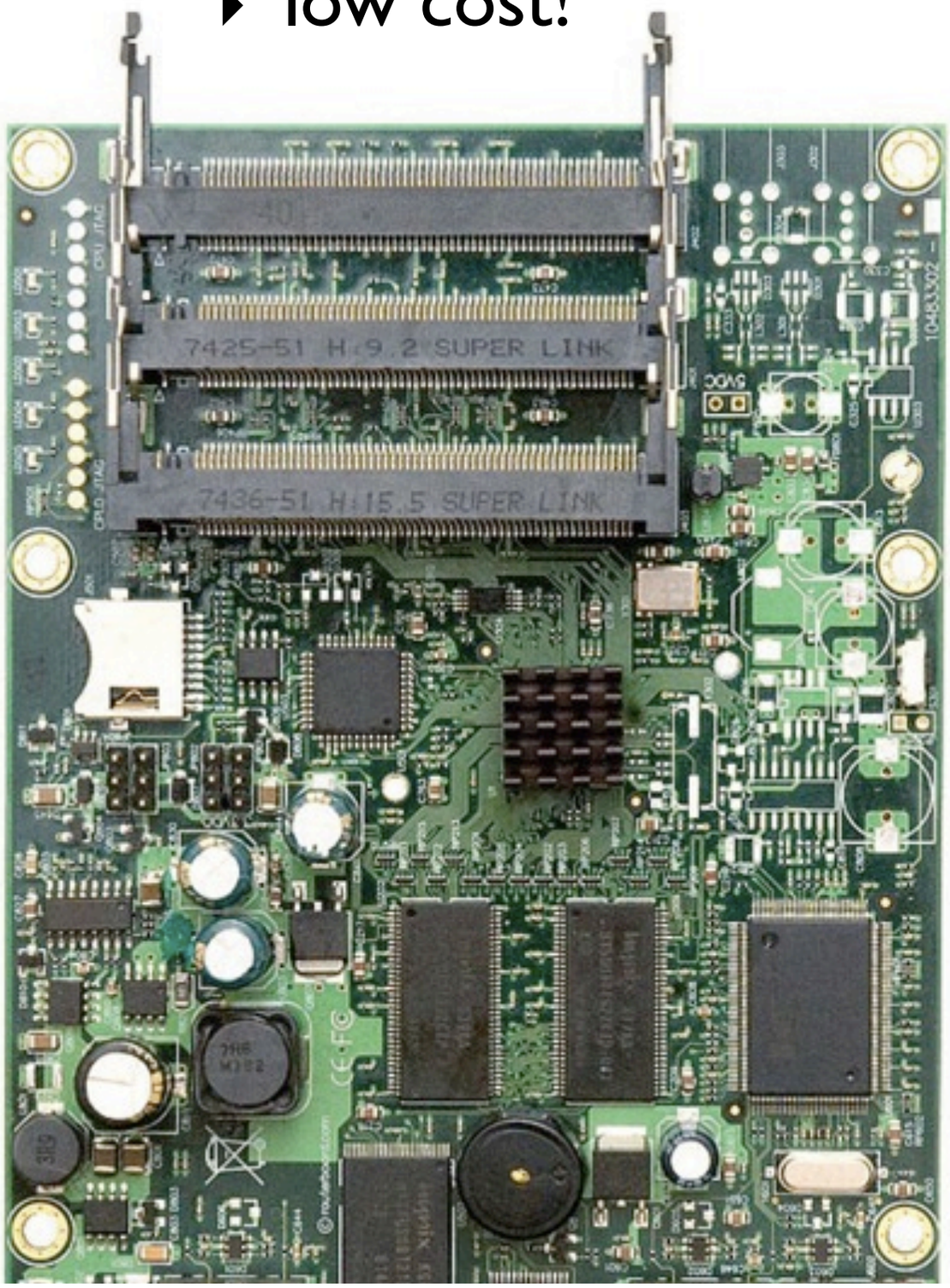
...looking towards Zomba



The link to Zomba was much more clear, but challenging in a different way: a 60 km hop to a 100 km hop is not trivial to engineer!

Long link in Malawi: equipment

- low cost!



Mikrotik RouterBOARD 433 with Atheros AR7161 680MHz Network CPU (overclock to 800MHz), 128MB DDR RAM, 3 10/100 ethernet ports with MDI/X, 3 miniPCI, microSD, 64MB NAND with RouterOS L5.

SAVE 17%

Supports POE on ether1: 10 to 28vdc on un pairs (no power over datalines), or 10-28vdc jack support. Overall dimensions: 150mm x (5.9in x 4.13in).

New product - in stock!

Details

SKU	RB/433AH
Quantity in stock	66 item(s) available
Weight	0.35 lbs
Documentation (PDF)	Brochure
Price:	**$149.00**

Options

Quantity 1

Quantity:	10-19 Items	20-59 Items
Price:	$144.00	$140.00

Add to cart Add to wish list

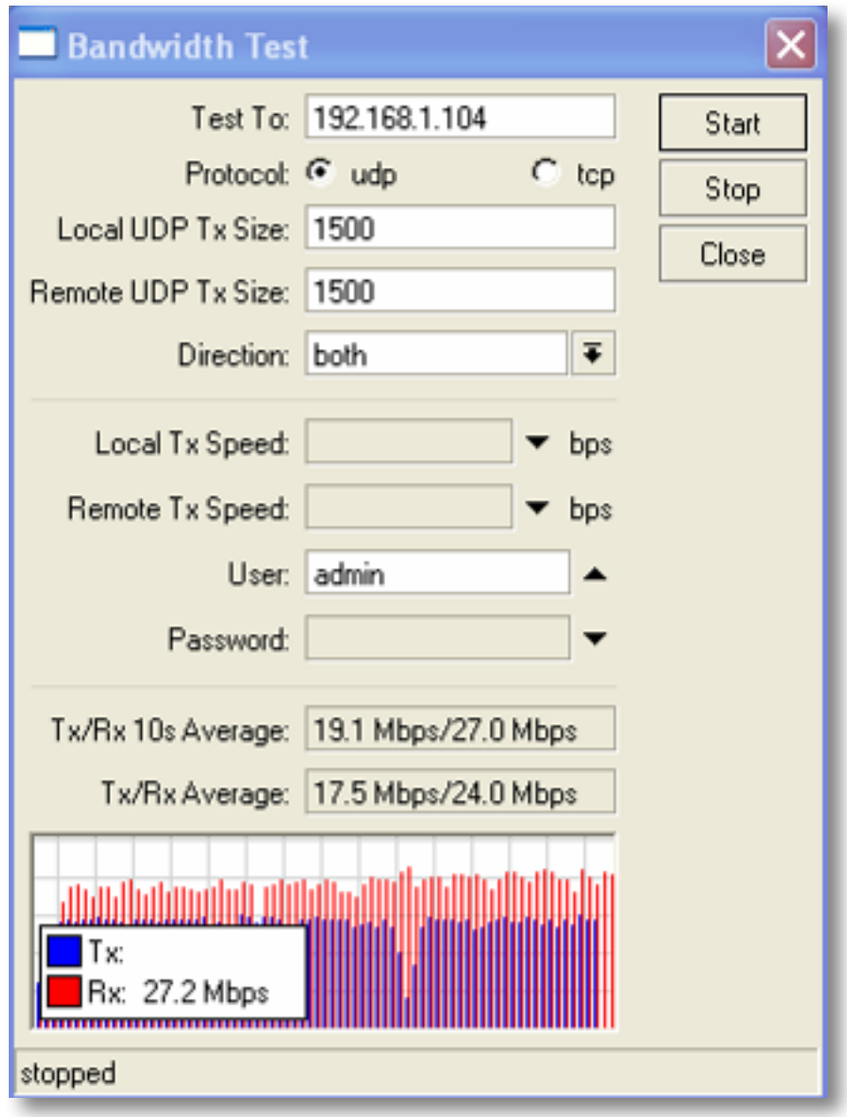
243,96€

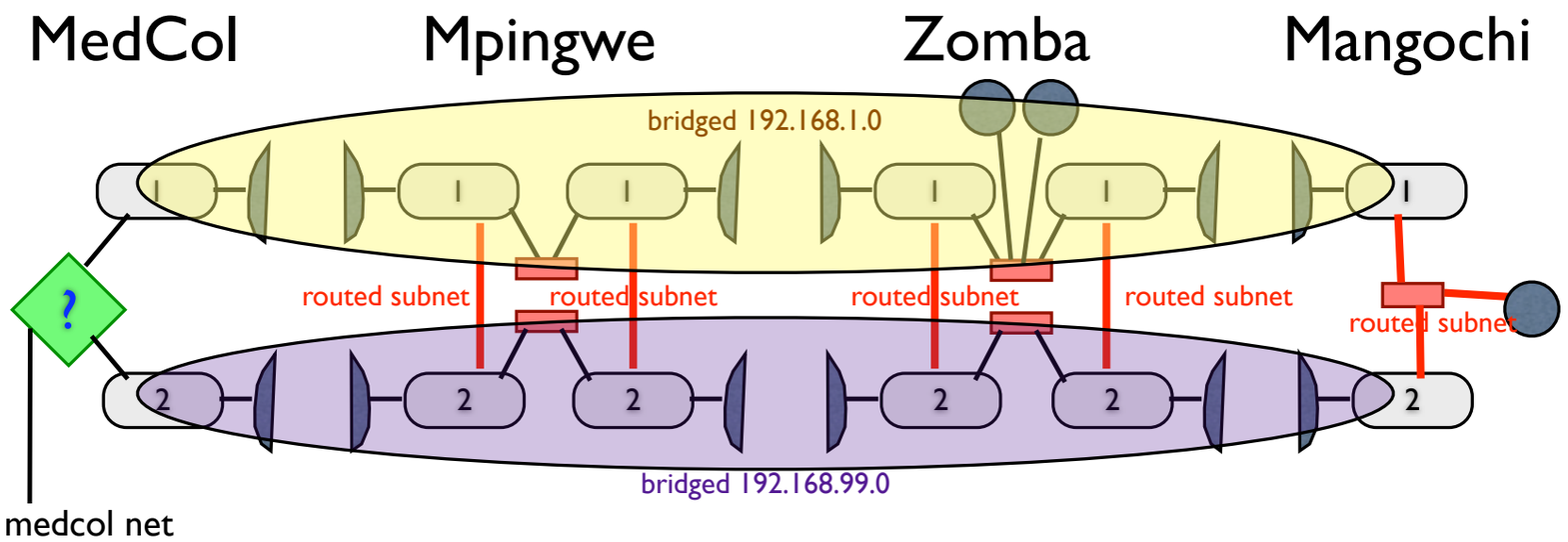
Order or Qty		Price
> 500€	5+	**239,08€**
> 1000€	10+	**234,20€**
> 2000€	20+	**229,32€**
> 5000€	50+	**224,44€**
> 10000€	100+	**219,56€**

The final cost of the equipment for this project was about $1000 for each link.

Long link in Malawi: results

- > 20 Mbps full duplex for each link
- Two independent links from Blantyre through Mpingwe, Zomba, and all the way to Mangochi.





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 a free download in many languages:

http://wndw.net/