« PoWLAN » : Polar Wireless LAN

European MUM Prague 2015

UNDER THE POLE
UNDERWATER POLAR EXPLORATION

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Overview

- Corporate presentation and UTP II Mission
- Tech Challenges
- Solution
- Feedback

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Who am I ?

- Thomas Mignien
  thomas@alsatis-labs.com
- Alsatis Labs, Toulouse, France
- Not a trainer, but
- A MikroTik daily user since 10 years

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Affiliated companies

ALSATIS	WISP	WiFi WiMax LTE Satellite
BLOOSURF (USA)	WISP	WiFi WiMax LTE Satellite
ALSETT	Engineering Training Consulting	Mobile Networks 2G/3G/LTE/M2M
ALSATIS Labs	R&D	Wireless SDN/NFV (ONF Member)

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UTP II – Under The Pole

- http://www.discoverygreenland.com/

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UTP II – Under The Pole - Objectives

- Exploration
  - Bring back unpublished images of submarine environment.
  - Polar bears, arctic foxes, wolves, reindeers
  - Seals, walruses, narwhals, belugas, boreal whales, orcas, Greenland sharks, endemic fauna and flora, plankton, micro-organisms…
  - Fjords, giant icebergs, glaciers fronts, coastal and open sea ice floe, continental cliffs and continental shelf…

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UTP II – Under The Pole - Objectives

- Sciences
  - List polar submarine biodiversity encountered during a complete seasonal cycle, between surface and 130m depth.
  - Study relations between atmosphere, ice and ocean.
  - Study human behaviour and its physiological adaptation to extreme conditions.
- Testify
  - Bring a testimony on current climate changes, local stakes and challenges that society must take up
  - Make new generations sensitive and stimulate them

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Tech Challenges

Goal of the project

« To create a prototype of a wireless system that allows many applications in an outdoor environment »

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Tech Challenges

Goal of the project

« To create a usable prototype of a wireless system that allows many unknown applications in a hostile outdoor environment »

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Tech Challenges

- Usability
- Applications
- Environment

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Tech Challenges : Usability

- Mission Staff
  - A staff composition targeted for the main scientific mission purpose
  - Neither Telecommunication nor Network engineer on board
  - Staff is wearing thick mittens or gloves when outside
- No pylons or towers
- Electrical power is a scarce resource

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Tech Challenges : Usability

- The system has to be easy to be deployed
  - Transportable
  - No screws and bolts
  - No cables to crimp
  - Easy-to-point antennas
  - Zero configuration
  - System status easy to perceive
  - Wireless link presence and quality feedback

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Tech Challenges : Applications

- No predetermined application
- Outdoor WLAN is not a well known technology for this kind of mission :
  - VHF and walkie talkies
  - Iridium Internet and Voice access
- But some ideas and opportunities are emerging

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Tech Challenges : Applications

- Emerging ideas :
  - To create a WiFi cell around the base-camp :
    - a boat jailed in the frozen sea in winter
    - the boat has two masts that are “easy” to climb
    - in order to create a communication cell for PC/Tablets/Smartphones

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Tech Challenges : Applications

- Emerging ideas :
  - To create long distance wireless links :
    - To support some remote and short duration missions
    - Having a local WiFi cell there, linked to the base-camp
    - To be able to create an autonomous relay site to get around any obstruction of the line-of-sight
    - Or to get a better Internet access in the base-camp from a remote town

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Tech Challenges : Applications

- Emerging ideas :
  - To transmit some videos and telemetry :
    - From IP Cameras
    - From WiFi capable drones
    - From Underwater Robots
      - Data is currently transported to the surface along the power and control cable using PLC
      - Already IP/Ethernet compatible
  - Many other applications to imagine...

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Tech Challenges : Environment

- Cold
  - Air temperature around -40°C in winter
  - Lower apparent temperature for bodies due to wind and humidity
- Wind
  - Storms
  - Blizzard
- Water
  - Melting ice
  - Rain and Snow
  - Sea (salty)
- Darkness
  - No Sun in winter

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Tech Challenges : Budget !

- Budget... Budget... Budget...
- In fact...
- May be the most difficult *technical* challenge !

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But, there are fortunately some solutions !

Who said MikroTik ??

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Solution : choices

- Why MikroTik ?
  - RouterOS : Swiss Army Knife
  - Cost effective
  - Some products are rugged
  - Well known to us

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Solution : choices

- Which WiFi band ?
  - 2.4GHz / 20MHz / 802.11bgn
  - To stay compatible with most of the terminals (PC, smartphones, tablets, drones, whatever...)
  - Not in an urban area with plenty of noisy WiFi devices

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Solution : choices

- Which kind of antennas ?
  - Integrated as much as possible
  - To create 360° WiFi cells for base-camps
    - Omni directional
    - Low or intermediate gain in order to keep an acceptable vertical aperture
  - To create long distance links
    - Directional
    - Intermediate gain in order to :
      - Deploy easily
      - Keep an acceptable size for transportation
      - To permit to create directed cells

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Solution : choices

- MikroTik product : Omni directional
  - Metal 2SHPn
  - Specs
    - 2.4Ghz Integrated AP/Backbone/CPE
    - 1600 mW TX power, N-male connector
    - 6dBi Omni antenna
    - Rugged and Waterproof
- Additional 54cm 9dBi Omni antenna without electrical tilt

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Solution : choices

- MikroTik product : Directional
  - SXTG-2HnD
  - Specs
    - 2.4Ghz Integrated
    - 1600 mW TX power,
    - 60° sector 2×2 MIMO 10dBi antenna
    - ~~*Rugged*~~ and ~~*Waterproof*~~ :(

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Solution : choices

	Pros	Cons
METAL SHP 	• Rugged • Waterproof • Low consumption • LEDs and Beeps • Can be attached using Velcro bands	• To replace the cable means to cut and crimp a new RJ45 connector (while wearing gloves) • Operating temperature > -30°C • SISO
SXT 	• Low consumption • LEDs and Beeps • Can be attached using Velcro bands • MIMO 2×2 • Cable can be easily replaced	• Plastic, not rugged • Holes and moving parts, not waterproof **FEAR :((** • Operating temperature > -30°C

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Let's have a break

What's the best and efficient method the staff have found to *gently* remove the ice of the deck and material every morning ?

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Answer A

Hot air blower ?

or

Answer B

De-icing fluid ?

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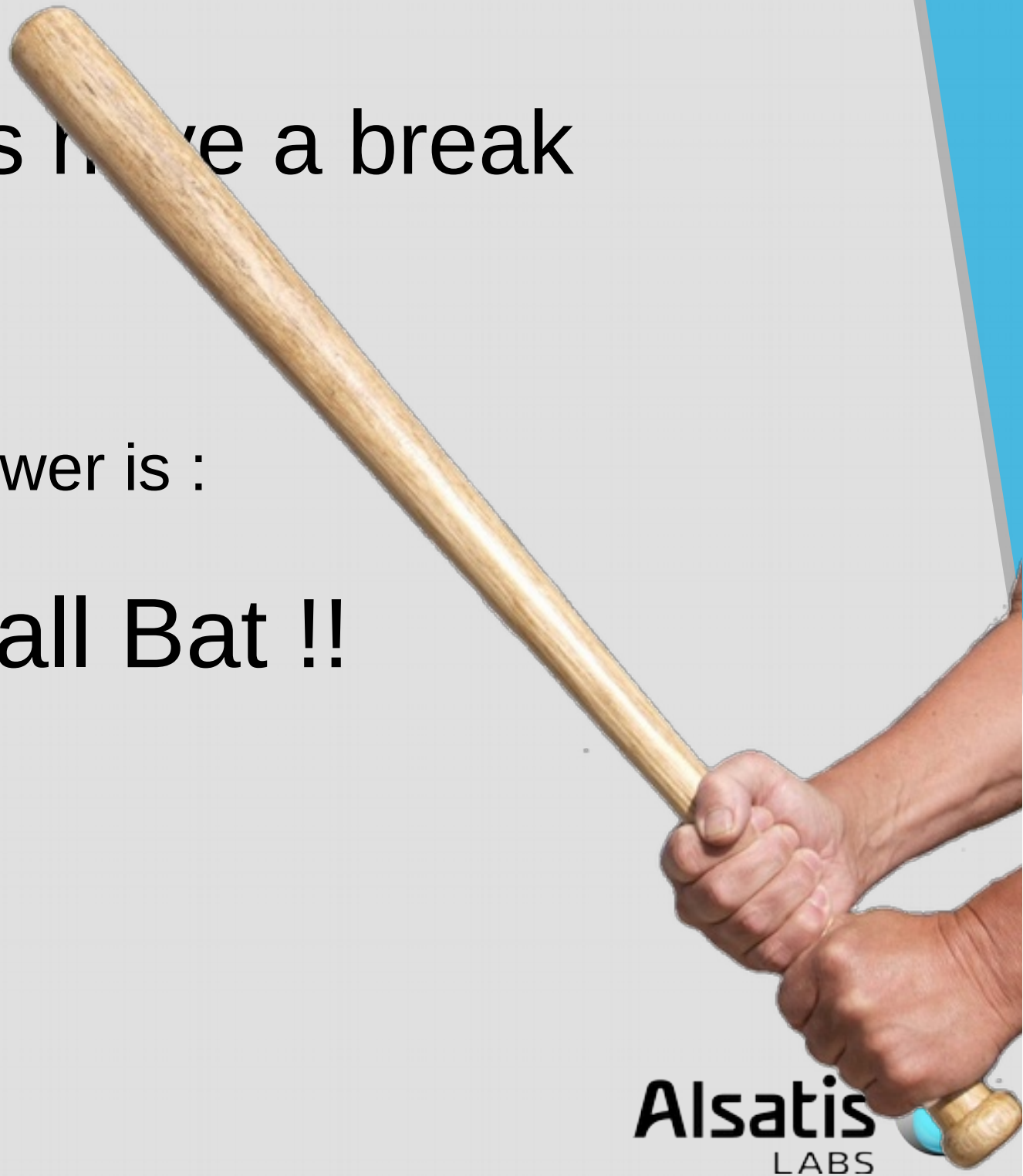
Correct answer is :

The Baseball Bat !!



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Let's h..ve a break

VS

FEAR Again...

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Let's be confident

1. We plan some spare :

- 2 P2P links max = 4 SXT, we send 5 units
- 1 Omni cell = 1 METAL 2SHPn, we send 2 units

2. We explain the staff not to install the SXTs upside down...

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Let's be confident

MikroTik staff told me last year (MUM2014/IT) that SXT is rain proof, serious tests have been conducted...

Configuration

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Solution : configuration

- The units must simultaneous act as :
  - WiFi Access Point for the terminals
  - P2P links between nodes

We choose to use WDS

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Solution : configuration

- The network must be as much transparent as possible
  - We don't know which application will be used
  - Using IP L3 could prevent some application to run :
    - L2 non IP protocols (discovery, …)
    - Broadcast or Multicast (video cameras, telemetry, robots/drones)
  - Using L3 means having multiple IP subnets to manage
    - Some devices have static IP addresses (no DHCP)
    - We can't change the device IP address during a mission
- We want a zero-conf solution for the staff

We choose to use a L2 topology

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Solution : configuration

- L2 topology can be done :
  - Natively
    - Attaching Ethernet interface to a bridge
    - Attaching Wireless interfaces (AP and WDS) to this bridge
  - Encapsulating using EoIP or VPLS and use a bridge
    - Could be funny, but EoIP config is static, and VPLS also needs static config (BGP links and RR, loopbacks, …)

⇒ We keep it simple, and use a WDS native L2 topology

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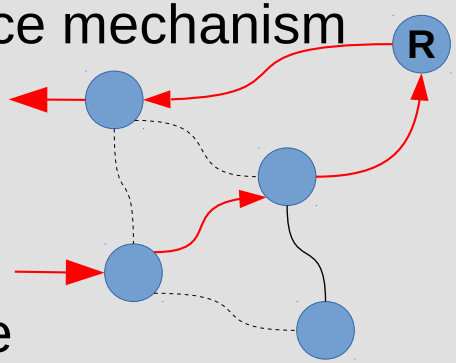
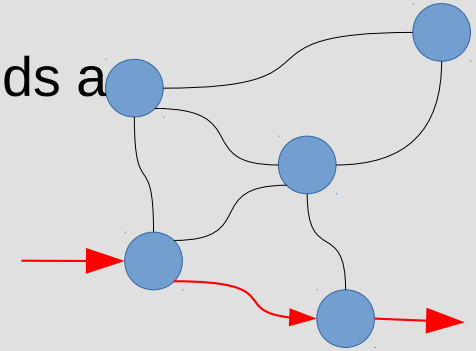
Solution : configuration

- L2 topology implies to implement a loop avoidance mechanism
  - Spanning Tree : STP or RSTP
    - Elects a Root
    - Disable ports to create a loop-free tree
    - Non-optimal paths between leaves of the tree
    - Adding a node can cause a new root to be elected, and a new tree to be calculated



  - HWMP+
    - RouterOS specific
    - Elects a path for each destination MAC address and holds a Forwarding Database (FDB)
    - Path selection is based on interface type and WDS link quality
    - No elected root



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Solution : configuration

- We want zero-config, just Plug'n Play
- We don't want to adjust priorities to force a specific node to become root
- We want optimal paths between terminals

We choose HWMP+ to build a mesh

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HWMP+ Mesh Config

```
/interface mesh
add hwmp-prep-lifetime=30s name=mesh1 reoptimize-paths=yes auto-
mac=no\  admin-mac=[/interface ethernet get ether1 mac-address]

/interface mesh port
add interface=ether1 mesh=mesh1 port-type=ethernet
add interface=wlan1 mesh=mesh1 port-type=wireless

/interface wireless
set [ find default-name=wlan1 ] disabled=no mode=ap-bridge ssid=UTP\
  wds-default-bridge=mesh1 wds-mode=dynamic-mesh
```

- *Reoptimize-paths* is enabled because the topology is subject to potential changes
- *The admin-mac* is defined from the ether1 interface to avoid mesh1 to have a changing MAC when some interface state changes
- ether1, wlan1 and dynamic wds links participate as ports in the HWMP+ mesh

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Solution : configuration

- We want zero-config, just Plug'n Play
- We need a DHCP server somewhere !
- We don't know which devices will participate to the mesh !

→ We put a DHCP server on every node

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IP and DHCP Config

```
/ip address
add address=10.0.0.XX/8 interface=mesh1

/ip pool
add name=utp ranges=10.0.XX.100-10.0.XX.200

/ip dhcp-server
add address-pool=utp interface=mesh1 name=utp authoritative=after-2sec-delay\
      disabled=no

/ip dhcp-server network
add address=10.0.0.0/8 netmask=8
```

- XX is different on each node (unique ID)
- All IP belong to the 10/8 subnet (nodes and terminals)
- Each node distributes IPs in non-overlapping sub-ranges
- DHCP servers are not authoritative immediately : there might be a central and master DHCP server outside the mesh
- Non-DHCP devices are statically configured with a 10.A.B.C/8 IP where A>0

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Performance optimization

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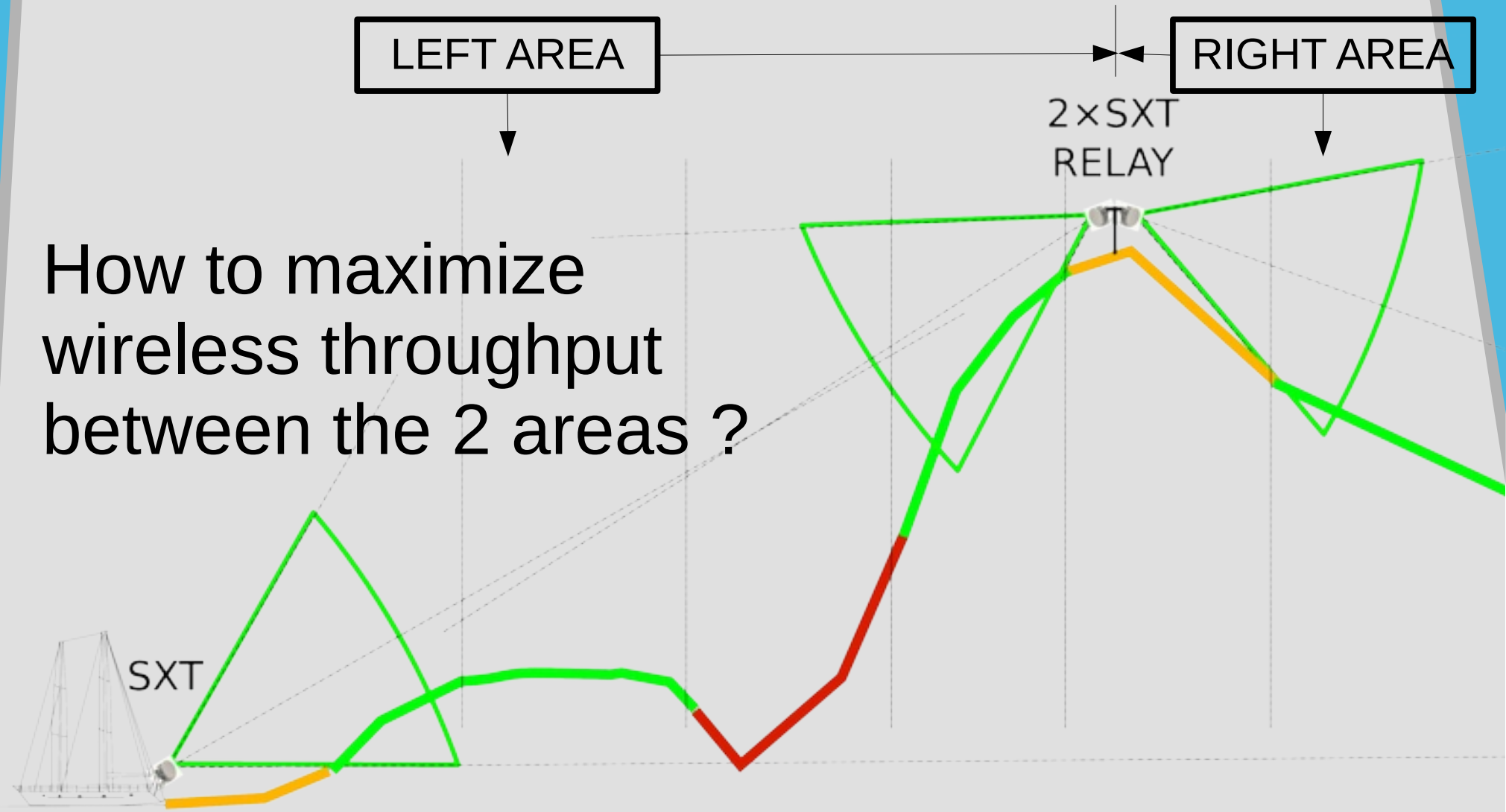
Configuration : Performance



How to maximize wireless throughput between the 2 areas ?

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Configuration : Performances

- How to maximize wireless throughput between the 2 areas ?

  ➡ We make use of 2 radio frequencies to alternate

- We still want zero-config
  - Either we make some conditional frequency-toggle bootup scripts
  - Either we split the devices in 2 groups

  ➡ We choose to split the devices in 2 groups, to make documentation, to explain, and to put labels on the units

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Configuration : Performances

- We provide :
  - 5 SXT units : labeled S*n* : S for sector
  - 2 Metal SHP units : labeled O*n* : O for omni

- Numbering
  - Odd *n* numbers for the 2412MHz frequency
    → O1, S1, S3, S5 are configured on the 2412MHz frequency

  - Even *n* numbers for the 2462MHz frequency
    → O2, S2, S4 are configured on the 2462MHz frequency

- An “Even” wireless mesh can be connected to an “Odd” wireless mesh using an Ethernet cable : example on the 2×SXT Relay

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Additional wireless tweaks

- Enable encryption

```
/interface wireless security-profiles
add authentication-types=wpa2-psk mode=dynamic-keys name=utp
wpa2-pre-shared-key=more_beer_at_mum_please

/interface wireless
set [ find default-name=wlan1 ] security-profile=utp
```

- Enable ANI and Compression

```
set [ find default-name=wlan1 ] compression=yes\
  adaptive-noise-immunity=ap-and-client-mode
```

- Enable 2×2 MIMO (SXT only)

```
set [ find default-name=wlan1 ] \
  ht-txchains=0,1 ht-rxchains=0,1
```

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When weird things happen

- When co-located in the lab, O1 and O2 are still able to establish a WDS a link !
  - O1 runs on 2412MHz
  - O2 runs on 2462MHz
  - Harmonics ???
- The WDS link is established, but the traffic can't flow through it
- Some poisoning entries in the HWMP+ FDB

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When weird things happen

- Solution : we use the Wireless Areas feature

```
# Define Area and restrict connections
/interface wireless
set [ find default-name=wlan1 ] area=AREA_2412 \
     default-authentication=no

# We only connect and create WDS links with same area APs
/interface wireless connect-list
add area-prefix=AREA_2412 interface=wlan1

# Allow any terminal to connect to the AP
/interface wireless access-list
add
```

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Visual and audio feedback

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Visual and audio feedback

- We want to give some information about
  - Wireless link quality
  - Ethernet port status if possible
- SXT and Metal SHP have LEDs and a buzzer
  - 5 visible signal LEDs
  - 1 visible user LED on the Metal SHP
  - LEDs and buzzer are usable within scripts

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Visual and audio feedback

- User LED (Metal SHP)
  - For the Ethernet link status

```
/system leds add type=interface-status disabled=no
interface=ether1 leds=user-led
```

- Signal LEDs and beeps
  - Only the WDS links must be taken into account
  - We calculate an average SNR of the WDS links
  - We map it on a 0 to 5 scale
  - The value is displayed with the LED signal scale
  - The value is enumerated with beeps

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“set-leds” script

Var init

Sum SNR APs only (WDS)

Average none=-250

Map to 0..5 scale

Define LEDs states

Emit beeps count

```
:local leds ;
:local signal ;
:local count 0 ;
:local avg 0;
:local total 0;
:foreach item in=[/interface wireless registration-table find ap=yes] do={
    :set count ($count + 1) ;
    :set signal [/interface wireless registration-table get $item signal-to-noise] ;
    :set total ($total + $signal) ;
} ;
:if ($count > 0) do={
    :set avg ($total / $count)
} else={
    :set avg -250
} ;

:if ($avg < 10) do={
    :set leds 0
} else={
    :if ($avg > 50) do={:set leds 5} else={:set leds ($signal / 10 )}
} ;

:local beeps 0;
:for counter=i from=1 to=5 do={
    :local state "no";
    :if ($leds >= $i) do={:set state "yes" ; :set beeps $i}  ; [:parse (":led led$i=$state")]
}
:if ($beeps > 0) do={
    :for counter=i from=1 to=$beeps do={
        :beep length=100ms frequency=4000;
        :delay 200ms;
    }
}
```

Visual and audio feedback

- Schedule the “set-leds” scripts every 20s

```
/system scheduler
add interval=20s name=update-leds \
    on-event=set-leds \
    start-time=startup
```

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Power

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Solution : Power

- Existing power sources
  - On-board batteries in the base-camp boat provide 24VDC
    - Great to power on a Routerboard unit
  - An engine generator is launched when needed
    - AC only devices or adapters
    - Recharge on-board batteries
- We need some power to take outside to run our mesh nodes
  - Easy to transport
  - Easy to use

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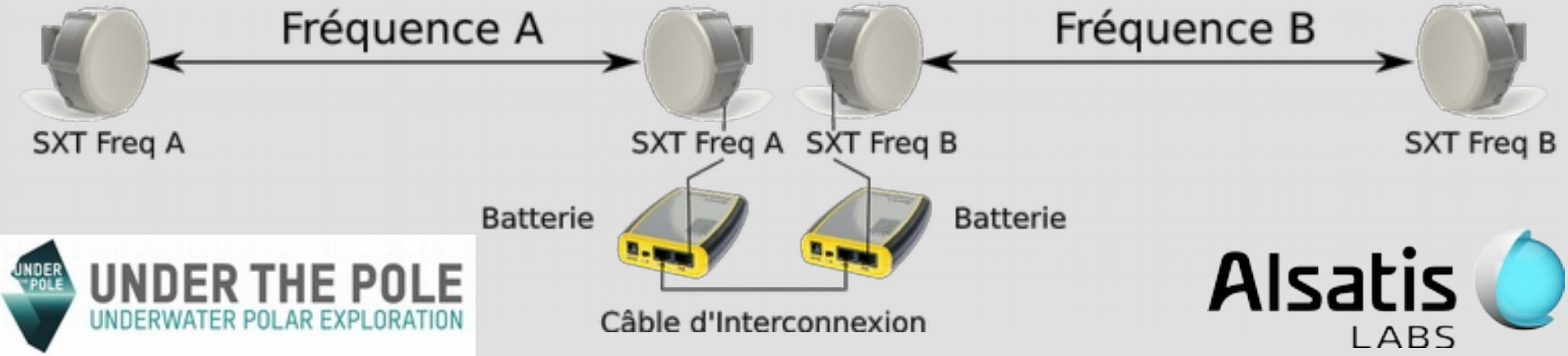
Solution : Power

- Smart Powerbank
  - Seen on MUM 2014 IT
  - Compact Li-Ion battery
  - RJ45 ports for PoE and easy inter-units patching
  - LEDs for remaining capacity level



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Solution : Power

- Some words about Li-Ion
  - Pros
    - Good capacity/volume or weight ratios
  - Cons
    - Capacity is degraded when temperature < 0°C
    - Need to be charged at positive temperature
- Problem mitigation
  - Give a lot of units (10 Smart Powerbank in the prototype package)
  - The batteries will be charged in the boat where temperature should stay above 0°C
  - Protect from cold during mission
    - In a jacket inside pocket when walking or standing by the devices
    - In a protective case

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Ethernet cables

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Solution : Ethernet cables

- Cables must resist to the environment
- Like the batteries, the problem comes from the temperature :
  - Not all the UV protected outdoor cables are compatible with -40°C temperature (specsheets)
  - Some of them are -40°C compatible for operations only, not installation/manipulation
  - Few references installable at -40°C … some at 1400€ for 1000ft !

We choose a “normal” -40°C compliant cable for operations, and warn the staff

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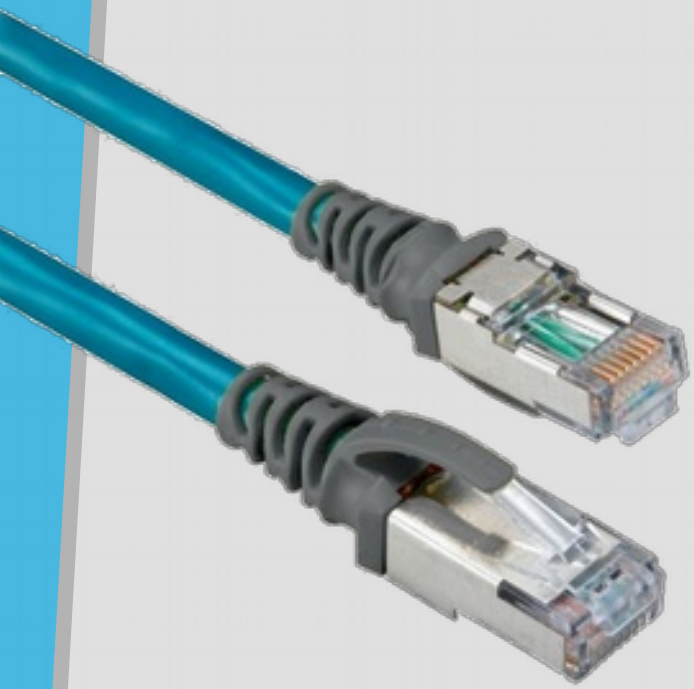
Solution : Ethernet cables

- Connectors
  - Industrial or RJ45 ?



- Too many things to change or adapt for industrial connectors
  - SXT and Metal SHP
  - PoE and Smartpower Banks
- Industrial connectors are expensive and not compatible with our low budget
- How will behave the fragile latch clip of an RJ45 connector in the cold ?

Despite the risks, we stay with RJ45 connectors for this (usable) prototype

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Packaging and Protection

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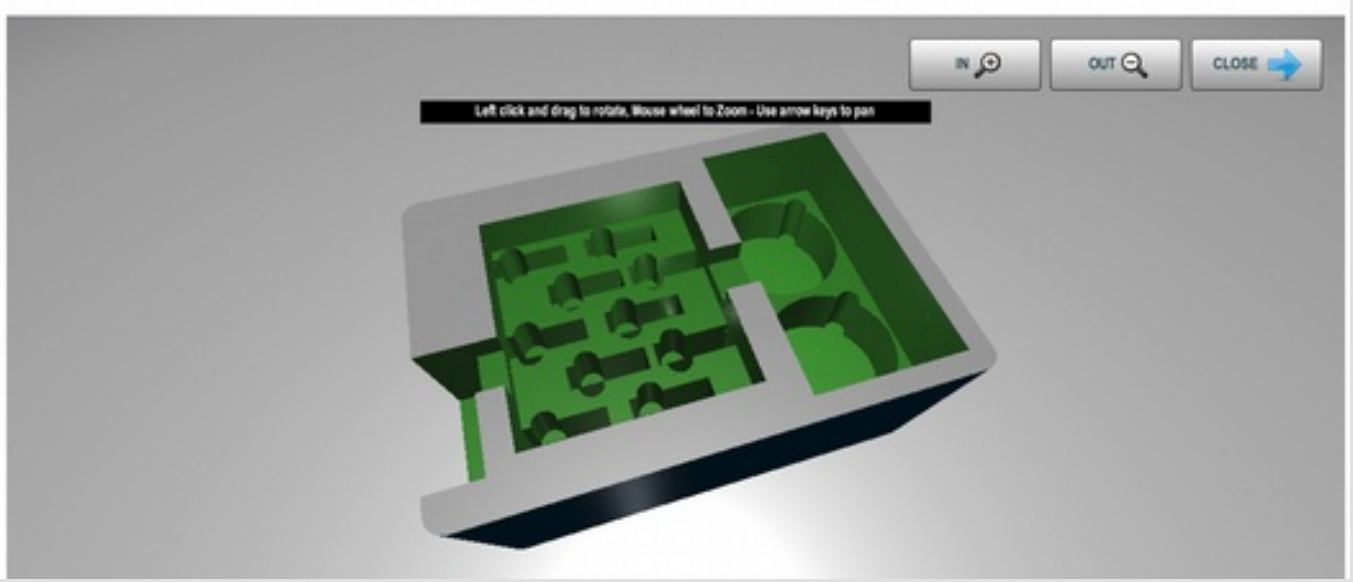
Solution : Packaging & Protection

- A case filled of foam has been designed :
  - To protect (a little the) batteries from the cold
  - To protect the devices during transportation



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Solution : Packaging & Protection

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Solution : Packaging & Protection

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First feedback

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Some good news received 3 days ago

They picked up two SXT units of the same frequency an succeeded to establish a 3km link between the boat jailed in ice and a small town.

Plug'n Play ;)

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