Extending your wireless network

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Visualize Your Network

Introduction

This presentation focusses how you can extend your wireless network

- Why you would want to extend your wireless network wirelessly
- Terminology
- Description of each wireless mode and its behaviour
- Some regulatory requirements
- Limitations of each wireless mode
- Scenarios, possible solutions to different challenges
- FAQs
- Configuration examples
- Questions

Warnings!

- Wireless is susceptible to interference and outages
- Having coverage is not the same as having (high) throughput!
- Most wireless solutions to improve coverage via wireless connections will be bad for throughput

Why?

Two main reasons:

- Expand your Wi-Fi coverage over a larger area
- Extend your LAN to another (nearby) building or device

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Why

Expand your Wi-Fi coverage over a larger area

- There is no cabling (yet) near the spot where you want or need to place an AP to eliminate dead zones or increase coverage
- It is not possible to use an alternative for wireless such as:
  - PowerLine
  - Fiber
  - Ethernet

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Why

Extend your LAN to a building or device

- When it is not possible to put – or there is no - network cabling to the other building or device (w/o Wi-Fi interface)
- When you have no internet connection in the other building (for a VPN or remote access)
- When you need a bridged network instead of a routed VPN
- When you want a back-up link in case Internet goes down in one building
- When you need a network connection to there NOW!

The best wireless network is wired!

No need to elaborate on this…

Types of wireless connections

Besides IEEE 802.11 Wi-Fi there are may other devices sharing the same frequency spectrum (mostly on 2.4 GHz):

- Bluetooth
- Wireless (door) camera's using proprietary protocols
- Microwave ovens

There are also wireless connections using different frequencies:

- 6 GHz point to point
- 30 GHz point to point

We will focus mostly on using IEEE 802.11 on 2.4 and 5 GHz.

Terminology

Antennas

- Dipole
- Sector
- Panel
- Dish

Backhaul

Booster

(Range) extender

WPS

Wireless modes:

- Repeater
- Client bridge
- Client router
- WISP
- WDS
  - Bridge
  - AP
  - Station
- Mesh

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Terminology

Antenna

Dipole/omnidirectional

- All around, donut 360^0

Sector

- Pie slice $90\sim180^0$

Panel

- (Smaller) pie slice

Dish

- Small(est) pie slice

More dBi is smaller pie slice

Wi-Fi antennas do *not* (allow) boost(ing) output!

(Because) an EU regulation requires that when antennas with a higher gain are attached to an AP, the (maximum) transmit power sent to the antennas must be decreased (with the difference in gain with the old antennas) to stay within the allowed EIRP.

This causes a client (inside the covered (pie slice) or service) area to receive the same signal strength from any type of Wi-Fi AP with any type of antenna in the same place is always **limited by the same legal limit**.

When you make the pie slice smaller you may not make it higher to get the same weight (power).

Wi-Fi antennas *do* boost receive sensitivity!

(However) directional antennas have benefits:

1. Gain works both ways, the antenna will be able to pick up weaker client signals because of the higher gain. But only inside the area of coverage.
2. Directional sensitivity will lead to less or no interference from devices outside the area of coverage.
3. You can mount multiple antennas in the same location (pole or housing) and cover different (pie sliced) areas. And have a higher capacity in number of clients and/or throughput. This may require less cabling to cover an area.
4. Less power usage by an AP.

Antenna impact on receive sensitivity

Omni-directional antennas usually have a gain from 3 or 5 dBi.

Directional antennas come in different form factors with different gains:

- Sector antennas usually have a gain of 12 to 18 dB.
  See https://www.engeniustech.com/sector-antennas.html
- Panel antennas have gains of around 20 dB.
- Dish antennas has the highest gain (> 20dB), depending on the diameter of the dish.
- Other types of antennas, such as Yagi antennas also exist. Yagi's are perfect for VHF and UHF, but for Wi-Fi it is just very bulky.

Which antenna to choose?

It makes sense to select the right antenna for the job:

- Cover all-around: Omni-directional antenna
  - Up to 5 dBi
- Cover a sector: Sector or panel antenna
- Point to multi-point connection: Sector or panel antenna
  - 10~20 dBi depending on spread and distance
- Point to point connection: (Panel) or dish antenna
  - From 20 dBi

Backhaul (link)

- Wireless uplink connection
- Ideally a separate radio chain is used for backhaul
  - Needs separate radio, radio dedicated to backhaul
- Usually the same radio chain, same channel is used
  - Each shared link will half throughput
  - (One of the reasons wired is better)

Repeater, extender, booster

- You can a expect a repeater or booster to connect wirelessly to another AP and “repeat” the packets
  - On the same channel if the AP has a single radio (chain)
  - On another channel or band if the AP has a dual or triple radio
- Extenders usually (and boosters sometimes) have some wired network connection, but are inserted directly into a power socket
- These solutions are often vendor chipset agnostic (universal repeater)

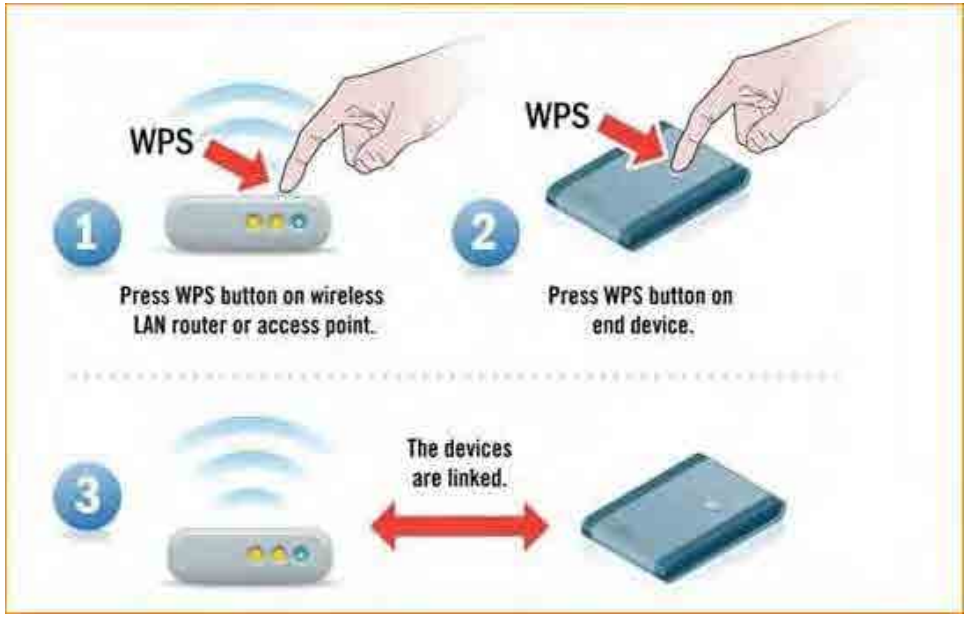
Repeater

Repeater is used to regenerate or replicate signals that are weakened or distorted by transmission over long distances and through areas with high levels of electromagnetic interference (EMI).

Repeater

Connect to the repeater and configure the SSID and security settings of the AP it needs to repeat. Or:

Use WPS (Wi-Fi Protected Setup) button



Wi-Fi PROTECTED SETUP

Client bridge (CB)

The device works as a client (station) of another AP.

It may(!) request an IP on wireless from its WLAN MAC address.

It will work as a bridge between WLAN and LAN.

Depending on the implementation:

- It passes MAC addresses transparently.
- It may do “MAC address translation” hiding all MAC addresses of devices behind its own MAC.
  This implementation can cause issues if more than a single device is connected to the CB its LAN.

You need to check!

Because it connects to an AP its SSID it does not bridge VLANs.

Client bridge (CB)

In CB mode, the AP acts as “a wireless dongle” that connects to another AP to allow a system wireless access to the network. This mode requires you to connect the Ethernet port on your PC to the LAN port of the CB.

Client router (CR)

Like the client bridge but with some added twists:

- It will (by default) request an IP on wireless from its WLAN MAC address
- It will work as a (NAT) router between WLAN (or more appropriately) W**W**AN and LAN
- All devices connected in the LAN are hidden between the AP its WLAN IP and MAC address
- Often supports port forwarding from WWAN to LAN

Client router (CR)

In the CR mode, the CR its internal Dynamic Host Configuration Protocol (DHCP) server automatically allocates ranges of IP addresses to each LAN that will access the Internet through the CR.

Wireless ISP (WISP)

(Almost) the same as client router but with some added twists:

- Able to function as an AP (on a different SSID) at the same time
- Ideally (but seldom) using another radio chain

Terminology WISP and CR will often be confused or mixed up. Make sure what features you need and if it is supported by the AP model and firmware regardless how it is called by the vendor.

CR & WISP possible use

CR and WISP usually allow port forwarding from Wireless WAN to LAN like any router. This feature can be used to make devices reachable with the same factory fixed static IP/subnet and gateway.

WDS

- Wireless Distribution System
- Wirelessly transparent pass-trough of data packages
  - Preserves the MAC addresses of client frames
  - Preserves VLAN tags
- This a vendor and chipset specific solution
  - Assume it works only between APs with the same model and firmware
  - Test for compatibility between models

WDS (2)

- WDS-bridge
  - For point to point
  - For point to multi-point
  - You need to statically configure (hard-link) connecting devices
- WDS-AP
  - Function as an AP at the same time (use as AP optional)
  - WDS-AP can connect to WDS-AP
- WDS-station
  - Can connect to WDS-AP

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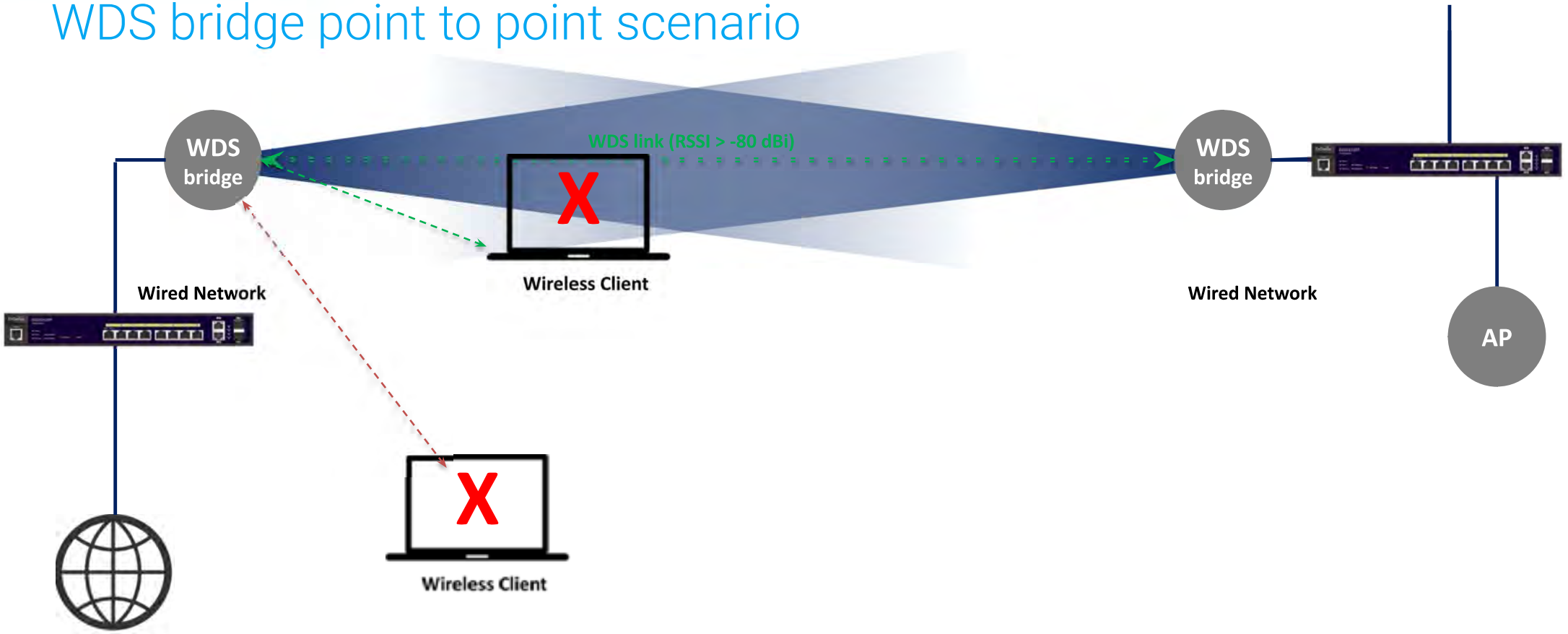
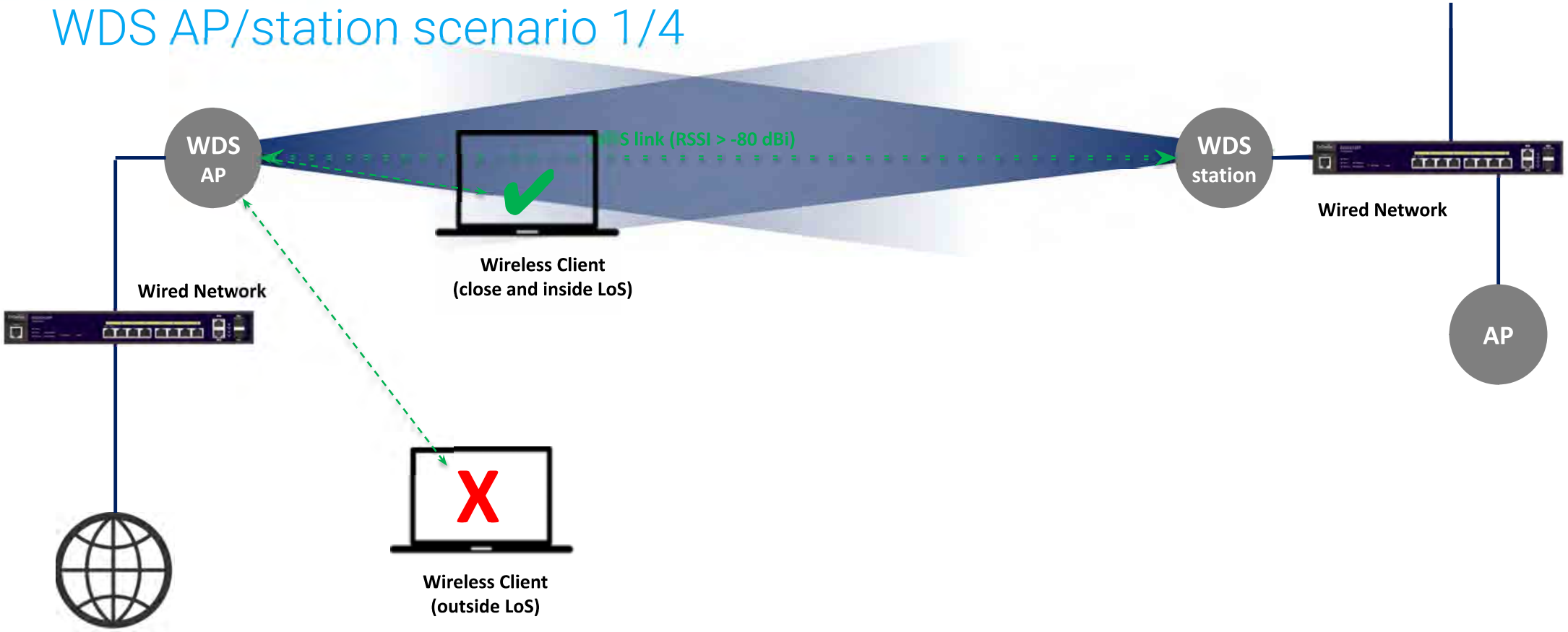
Extending your wireless network

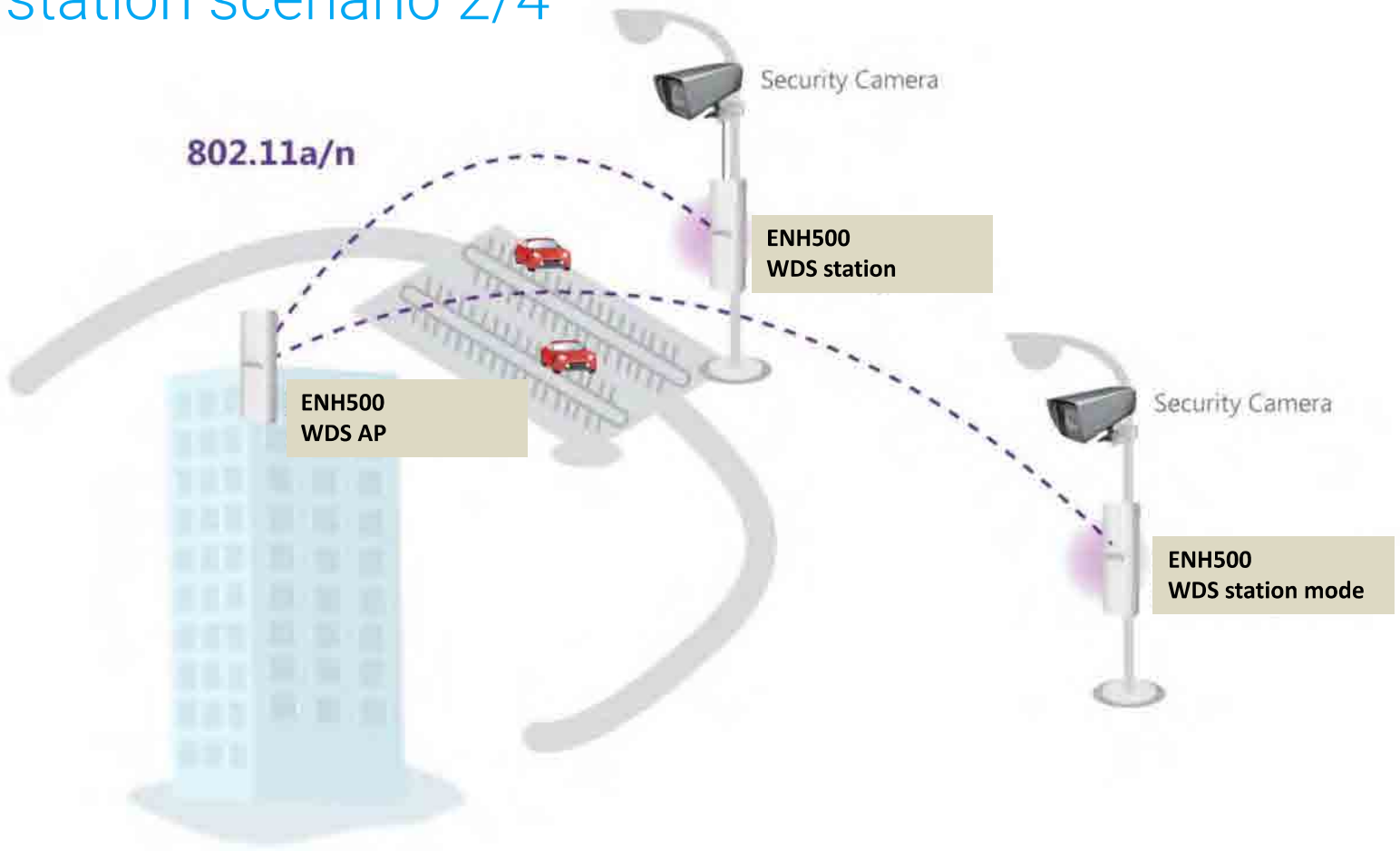
WDS bridge point to point scenario



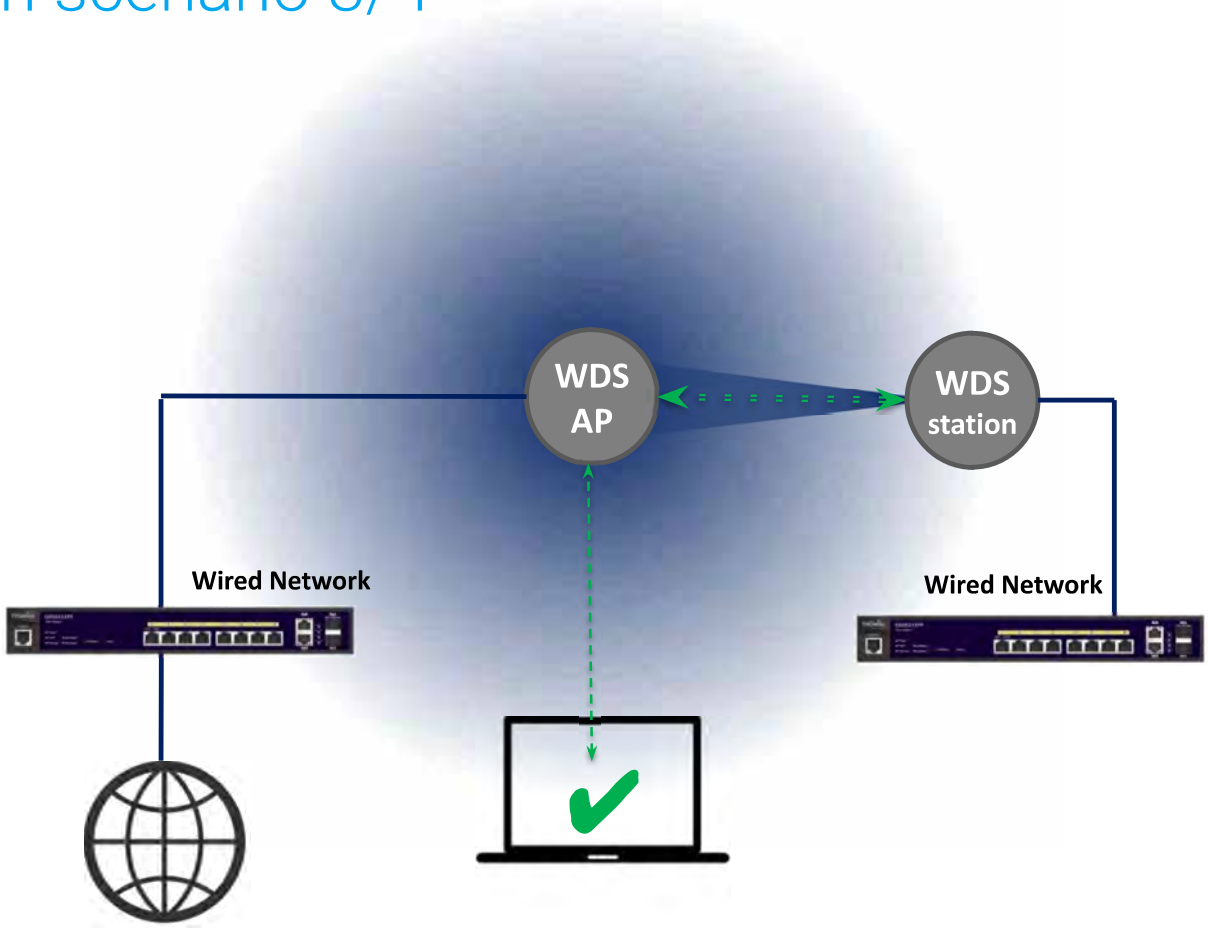
WDS AP/station scenario 1/4



WDS AP/station scenario 2/4



WDS AP/station scenario 3/4



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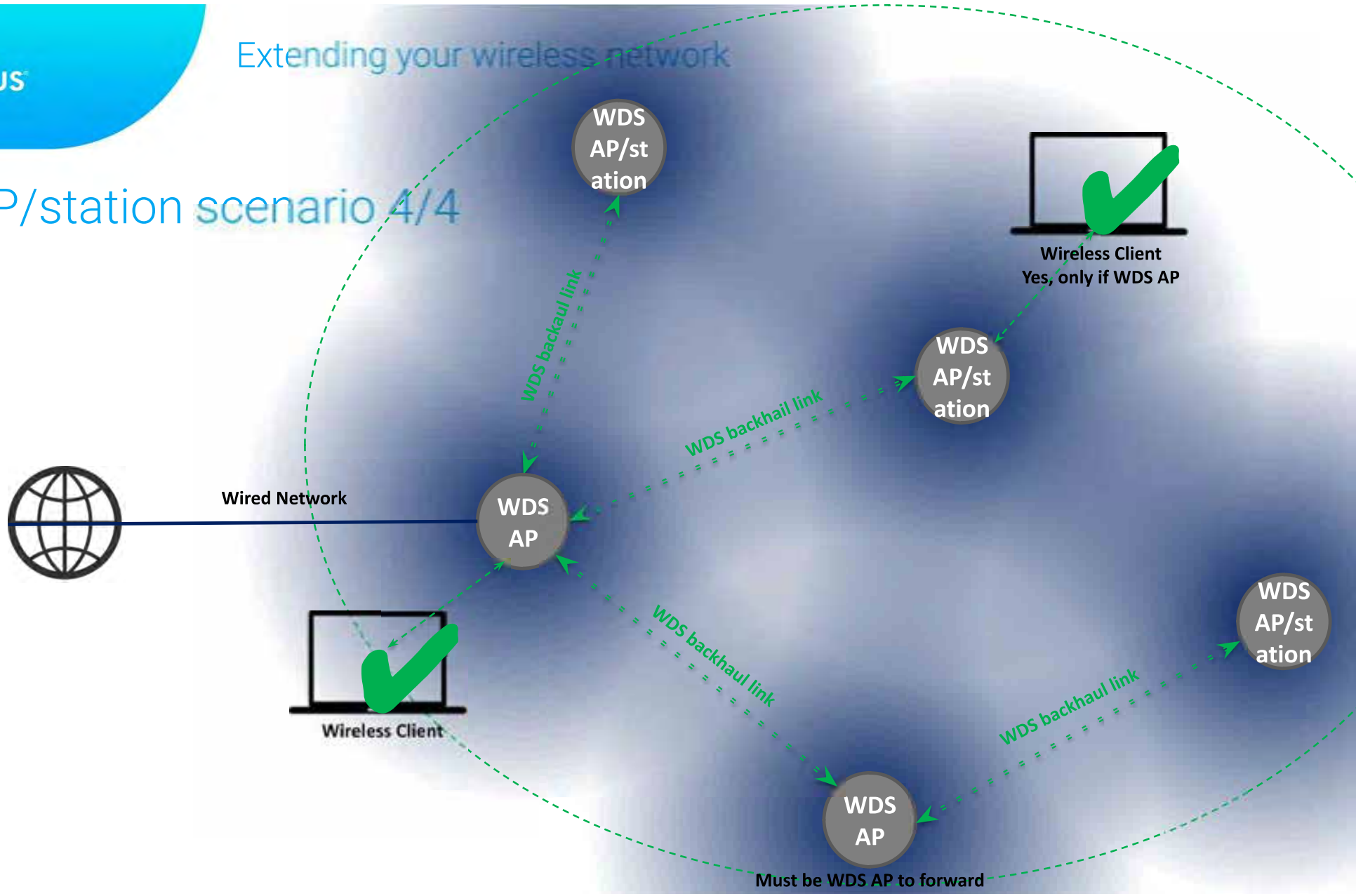
WDS AP/station scenario 4/4



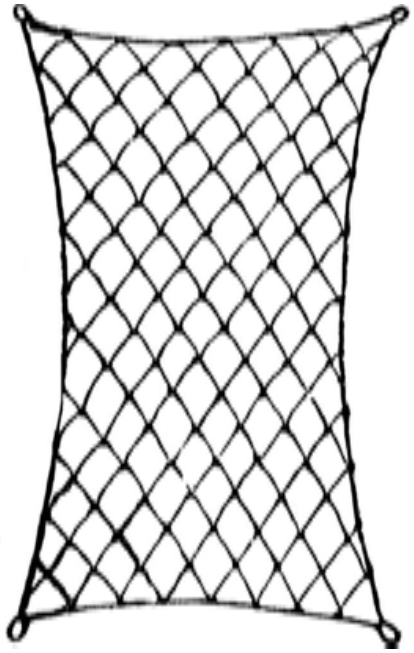
WDS Bridge or WDS AP/station?

5GHz outdoor APs may only use DFS channels.

When a DFS (radar detection) event happens it must switch. With WDS bridge (as implemented by EnGenius) a “fixed” channel is configured. And there is no leader and follower and after a DFS event the link may be lost because the APs do not sync on a new channel.

With WDS APs the WDS station will always search all channels for the SSID on the WDS AP.

This is why WDS AP – WDS station is preferred.



Mesh

- Mesh like in nets or webs, APs at the nodes
- Wirelessly transparent pass-trough of data packages?
  - Preserves the MAC addresses of client frames!
  - Preserves VLAN tags?
- Which devices connect is determined dynamically
  - Self-healing (can become unstable)
- This a vendor and chipset specific solution
  - Assume it works only between APs with the same model and firmware
  - Test for compatibility between models

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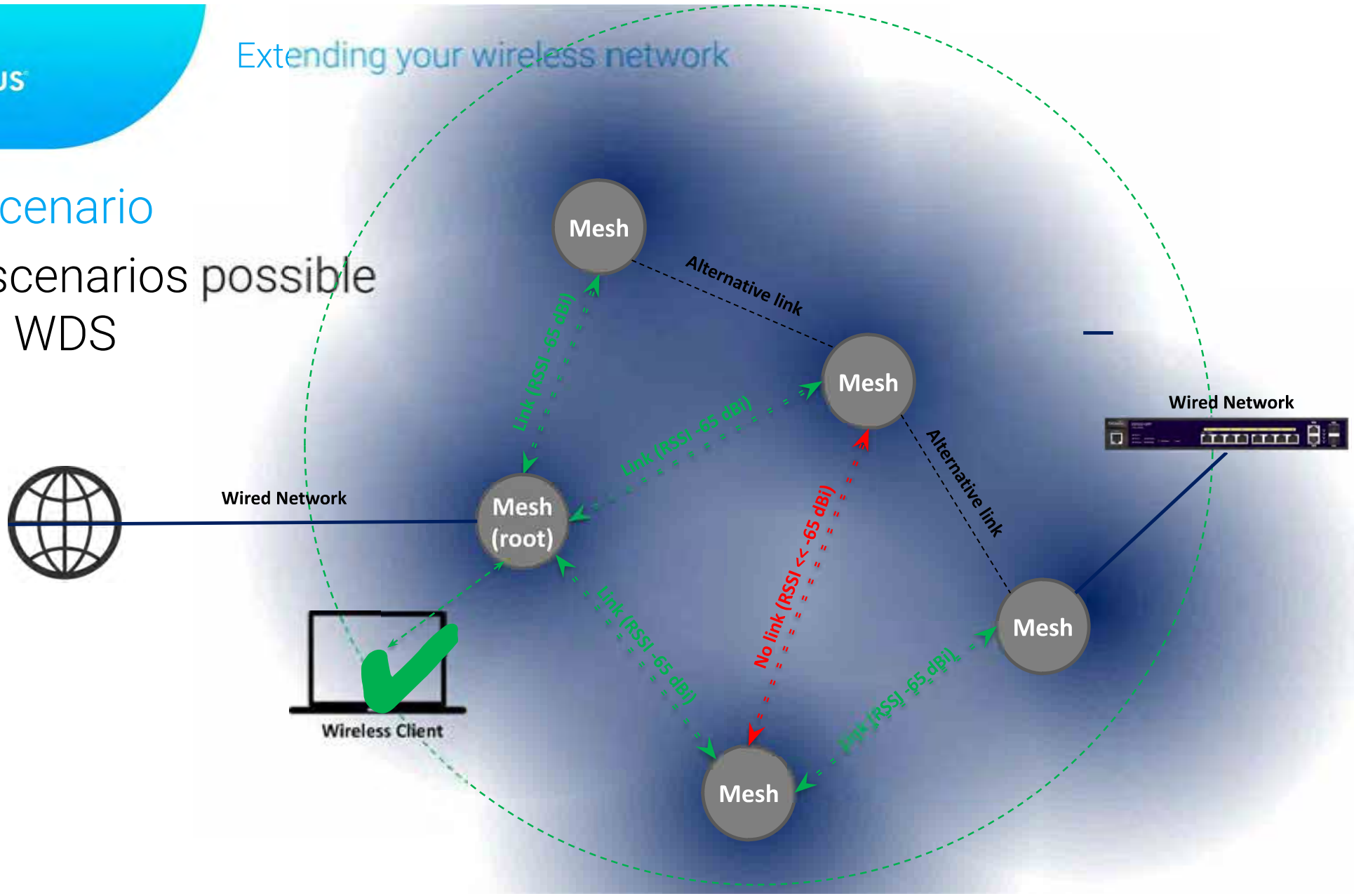
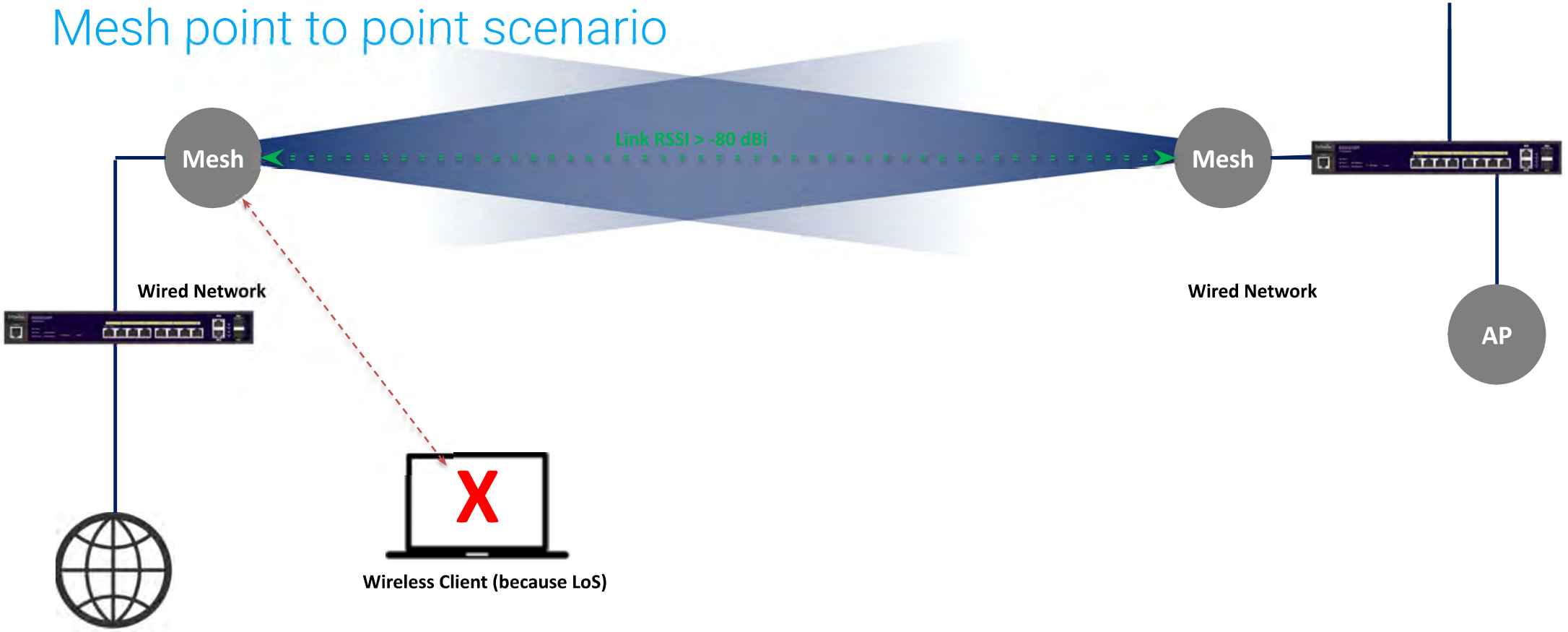
Mesh scenario

Same scenarios possible as with WDS



Mesh point to point scenario



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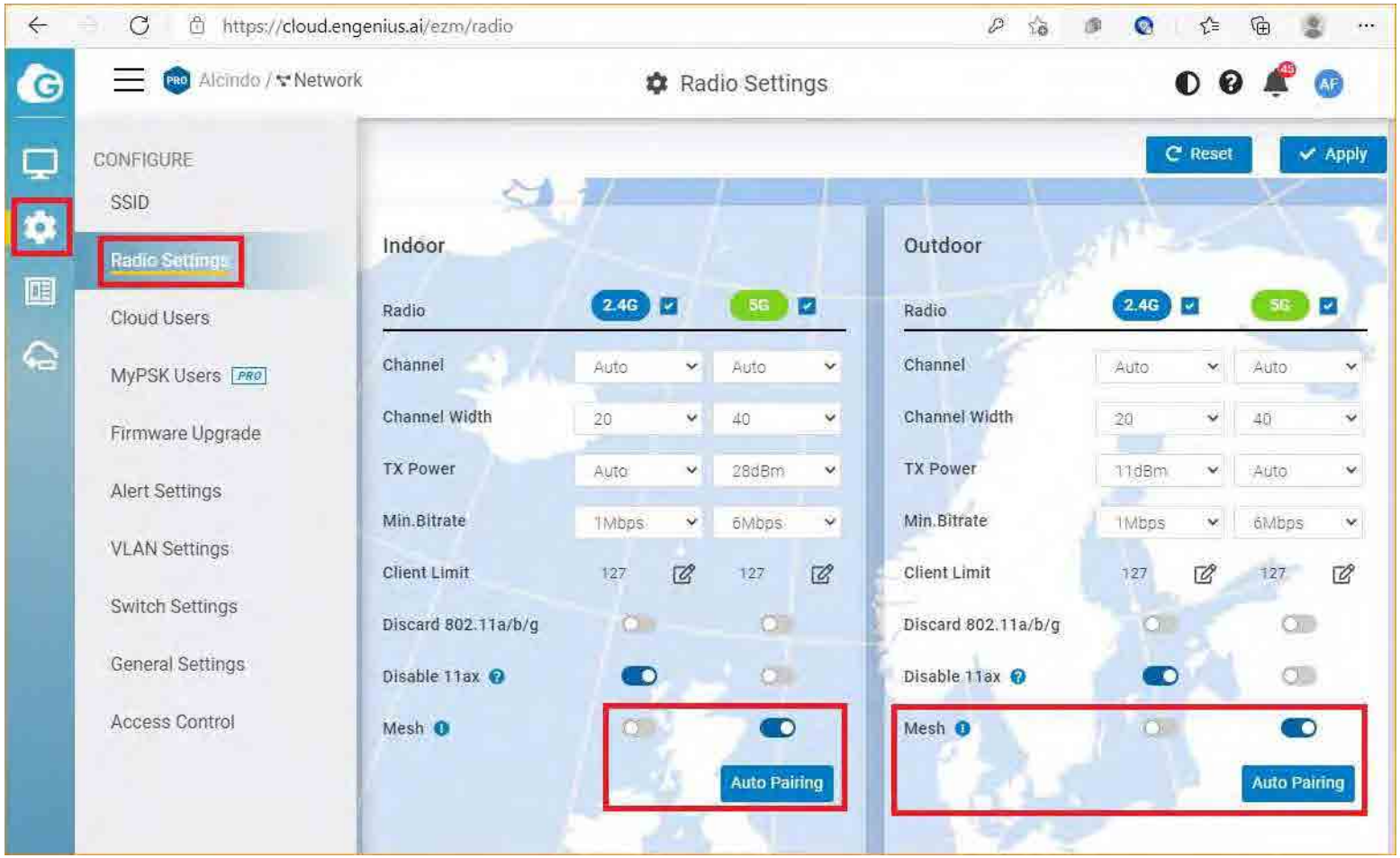
Configuration

Mesh in Cloud



WDS or mesh? (1/3)

- **Depends on personal preference**
- Depends on what is supported by available device
- Depends on requirement

WDS or mesh? (2/3)

- **Depends on available device**
  - Mesh:
    - All Cloud APs support (only) mesh
      - Cloud solution scalable
    - Some EWS-AP
      - EWS385AP only supports mesh in managed mode
    - ENH dual band models (ENH1350EXT)
    - ENS620EXT
  - WDS:
    - Supported by most EWS-AP, ENH, ENS, EnStation series
    - Not supported by Cloud APs

WDS or mesh? (3/3)

- **Depends on requirement**
  - Mesh
    - Indoor (requires fixed, non DFS channel?)
    - Auto-healing
    - Less scalable stand-alone
  - WDS
    - Outdoor (can use DFS channels)
    - Hard-links
    - Scalable without auto-healing
  - You can replace external antennas on –EXT models!

Which mode for each scenario

Scenario		Mode					
Transparent	VLANs	Repeater	CB	Mesh	WDS	CR	WISP
Yes	Yes	X	X	√	√	X	X
Yes	No	?	√?	√	√	X	X
No	No	X	X	X	X	NAT	NAT+AP
No	Yes	X	X	X	X	X	X

Supported operation modes per family (type)

Subject to change, check specifications, check release notes!

- CR mode of ENS202v2 is limited (no DHCP server)
- ezMaster is only able to configure APs in AP mode

	AP	NAT AP	Mesh AP	WDS AP	WDS sta	WDS bridge	CB	CR	WISP	Repeater
ENH (1350EXT)	√		√	√	√	√	X	X	X	X
ENS	√		620EXT	√	√	√	√	202v2*	X	620EXT/202EXTv2
EAP	√		√	√	√	√	X	X	X	√
EWS AP	√		most	√	most	most	X	X	X	330/385/550
ezMaster	√		X	X	X	X	X	X	X	X
ECW (Cloud)	√	√	√	X	X	X	X	X	X	X

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FAQ

WDS or mesh interoperability?

- **Preferably use same models with same firmware version**
- **Test!** (Regardless of the information below)
- Cloud ECW
  - Only support mesh
  - All models interoperable (5GHz between indoor and outdoor not allowed)
- EAP/EWS/ENH1350EXT/ENS620EXT
  - All models interoperable for mesh (if supported) and WDS
- ENH1350EXT / ENS620EXT / ENS500ACv# / ENH500ACv# / EnStation5/AC
  - All models interoperable for WDS (with EnJet disabled)
- ENH1350EXT / ENS620EXT / ENS500ACv# / ENH500ACv# / EnStation5/AC / ENH1350EXT / ENS620EXT
  - All models interoperable for WDS (with EnJet disabled)

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Test

Mesh IOP and VLAN transparency

Router
192.168.1.254/24 (U)
DHCP server GW

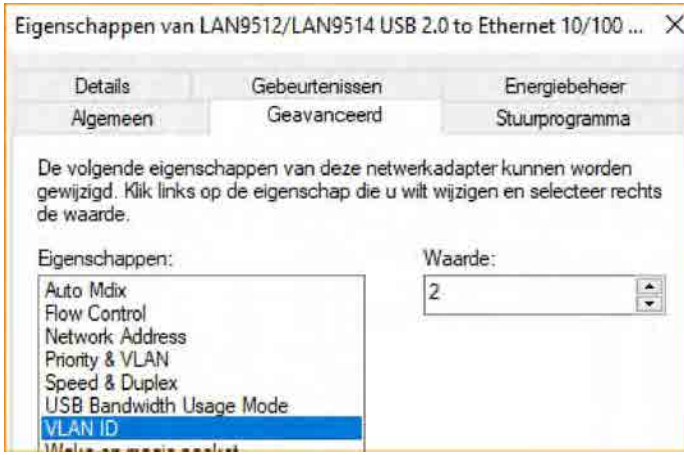
Switch (pass VLAN tags)

ENH1350EXT
5GHz Ch 36 “mesh point”
(No VLANs or SSIDs configured)

Raspberry Pi
192.168.1.2/24 (U)
192.168.2.254 VLAN2(T) DHCP server & GW

ENS620EXT
5GHz Ch 36 “mesh point”
(No VLANs or SSIDs configured)

Laptop
VLAN2 DHCP client



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Test

Mesh IOP and VLAN transparency

Router
192.168.1.254/24 (U)
DHCP server GW

Switch (pass VLAN tags)

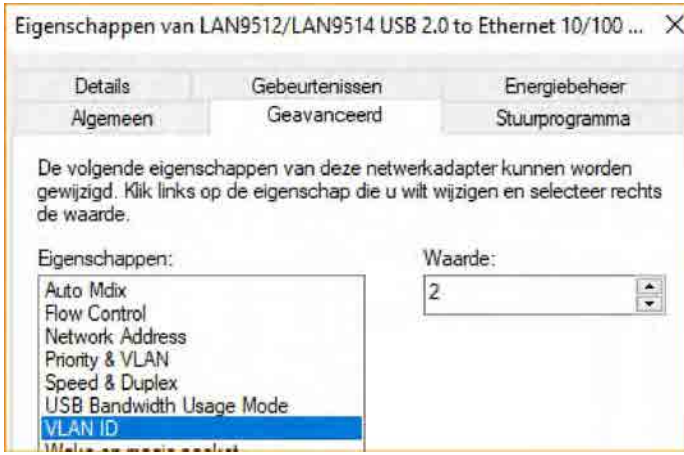
Raspberry Pi
192.168.1.2/24 (U)
192.168.2.254 VLAN2(T) DHCP server & GW

ENS620EXT
2.4GHz Ch 13 “mesh point”
(No VLANs or SSIDs configured)

EWS357AP
2.4GHz Ch 13 “mesh AP”
(No VLANs or SSIDs configured)

Laptop
VLAN2 DHCP client

ENH1350EXT
2.4GHz Ch 13 “mesh AP”
(No VLANs or SSIDs configured)



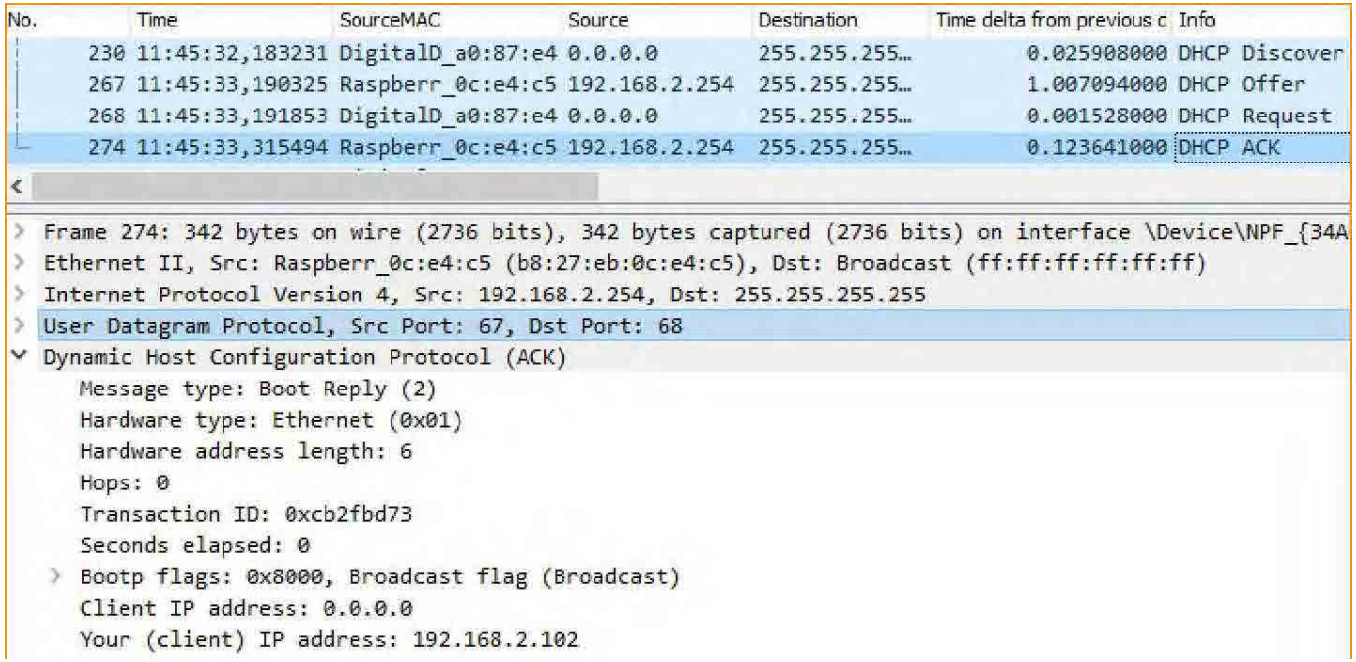
Status

Mesh Status	Enabled
Mesh Interface	2.4GHz
Mesh ID	12345678
Mesh Channel	13
Mesh Type	Root Node

Mesh Device List

Node	MAC Address	IP Address
EWS357AP	8E:DC:96:78:[illegible]	192.168.1.15
ENH1350EXT	8E:DC:96:[illegible]	192.168.1.13

VLAN transparency



No.	Time	SourceMAC	Source	Destination	Time delta from previous c	Info
230	11:45:32,183231	DigitalD_a0:87:e4	0.0.0.0	255.255.255…	0.025908000	DHCP Discover
267	11:45:33,190325	Raspberr_0c:e4:c5	192.168.2.254	255.255.255…	1.007094000	DHCP Offer
268	11:45:33,191853	DigitalD_a0:87:e4	0.0.0.0	255.255.255…	0.001528000	DHCP Request
274	11:45:33,315494	Raspberr_0c:e4:c5	192.168.2.254	255.255.255…	0.123641000	DHCP ACK

```
> Frame 274: 342 bytes on wire (2736 bits), 342 bytes captured (2736 bits) on interface \Device\NPF_{34A
> Ethernet II, Src: Raspberr_0c:e4:c5 (b8:27:eb:0c:e4:c5), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
> Internet Protocol Version 4, Src: 192.168.2.254, Dst: 255.255.255.255
> User Datagram Protocol, Src Port: 67, Dst Port: 68
v Dynamic Host Configuration Protocol (ACK)
    Message type: Boot Reply (2)
    Hardware type: Ethernet (0x01)
    Hardware address length: 6
    Hops: 0
    Transaction ID: 0xcb2fbd73
    Seconds elapsed: 0
  > Bootp flags: 0x8000, Broadcast flag (Broadcast)
    Client IP address: 0.0.0.0
    Your (client) IP address: 192.168.2.102
```

Supported operation modes

ENS220EXT

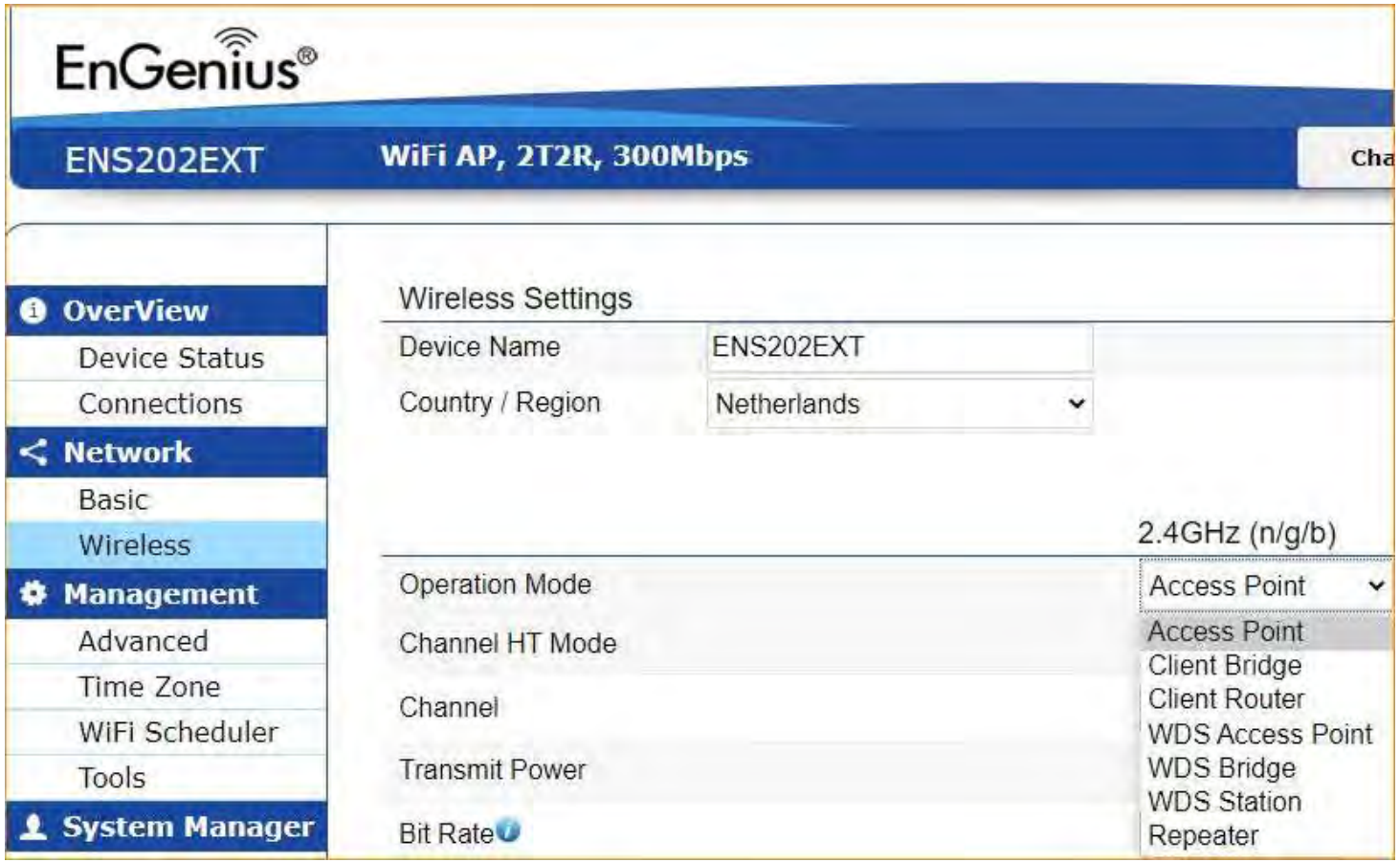
Only 2.4 GHz

Missing:

- Mesh
- WISP

Client router limited:

- No DHCP server



Why can I not see my WDS APs in ezMaster?

Circumstances:

- ezMaster is used for management of APs

Cause:

- ezMaster only supports APs in AP mode.

Solution:

- Configure via the device webGUI

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FAQ

Why can I not bridge with new EnStationACv2/ENH500v2/ENS500v2?

Circumstances:

- Have replaced a broken device by new “EnJet” model

Cause:

- EnJet is enabled (in some firmwares by default)

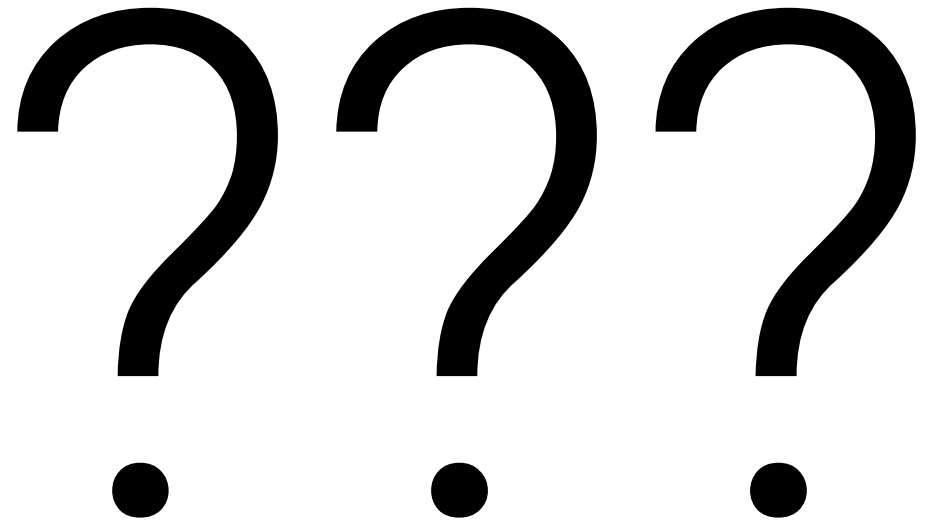
Solution:

- Disable EnJet on the new device

Summary answers to FAQs

- Yes, mesh transparently pass MAC addresses and VLAN tags
- Yes, WDS transparently pass MAC addresses and VLAN tags (when management VLAN is not configured)
- Yes, mesh will pass packets to the LAN port of the remote AP
- Yes, you can replace antennas on –EXT models

Questions?



The end

TY