CAPsMAN WiFi Layer1 / Layer2 Optimisation

Optimising CAPsMAN settings to improve performance and why

by Ron Touw

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Ron Touw

- 1970’s Trained to be a Naval Radio and Electronics Officer and learnt a lot of theory about RF and Marine Electronics
- 1980’s Entered into UK Government Service and learnt a lot about the **practical** application of RF
- Next 30+ years ‘playing’ with RF from 10kHz to 100GHz

Ron Touw

- 1997 - 1999 Saw the birth of point to point bridging by the likes of Breezom (now Alvarion)
- Early 2000's started to be more involved with WiFi being used by WISPs and troubleshooting interference problems mainly on 2.4GHz
- 20 years later, still mostly troubleshooting WiFi problems on… 2.4GHz 😛

Ron Touw

- Became MikroTik Consultant in 2008
- Became MikroTik Trainer #57 in 2009
- Head of Technical Training at LinITX
- Founding Member in 2017 of the MikroTik Training Bootcamp hosted at MikroTik's RouterOS Training Centre in Riga

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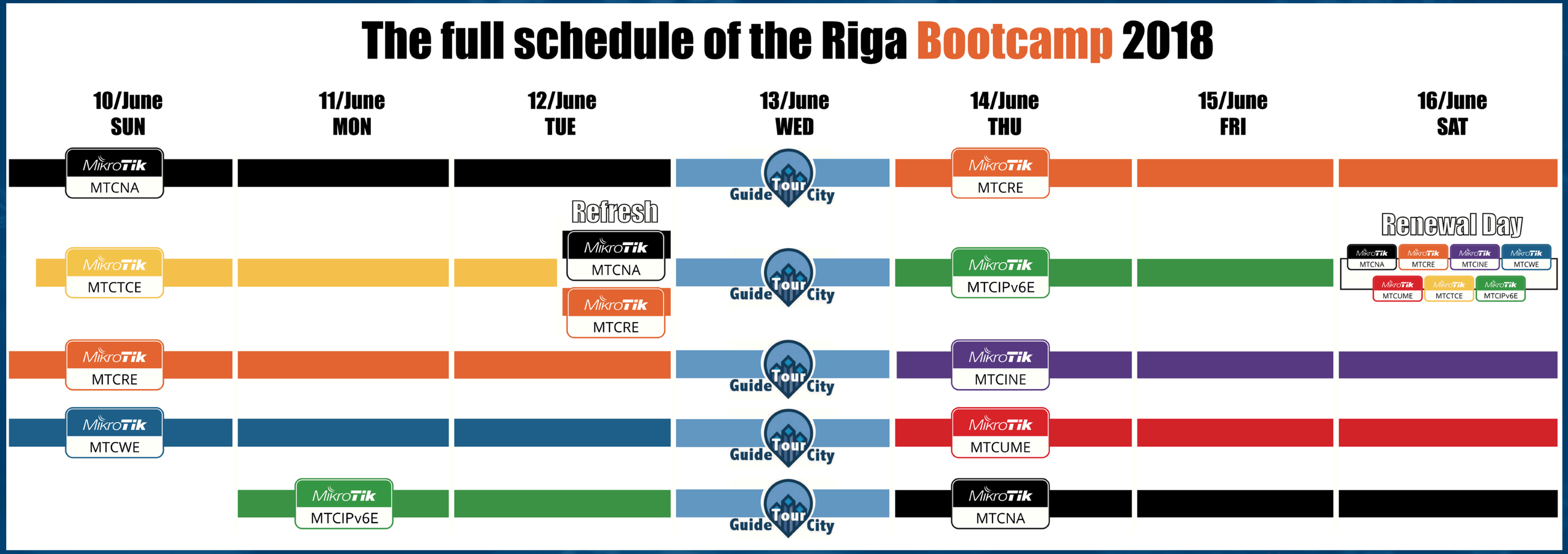

*Correct as of March 2018

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Optimising CAPsMAN settings to improve performance

But, more importantly - “Why is this even important?”

It’s only WiFi - it works!

- View of WiFi industry looking in from ‘outside’?
  - ‘Anyone can install WiFi - just stick a box in the house / office / garage / wherever you like’
  - ‘It just works, my one AP feeds the entire house!’
  - It’s all automatic, let it choose the best channel

It’s only WiFi - it works!

- Therefore the perception is that it must be really easy to cover the office / warehouse / school
  - Just throw loads more APs in!
  - Leave everything to default settings
- Reality is that the WiFi protocol was **designed** to go as slow as required to make it still work

Example of poor install, yet still works!

[redacted] [redacted]

Was staying at a hotel last night and could not believe how fast the Wi-Fi network was... went down for breakfast and while waiting for the elevator, I understood why. Got to love [redacted] networks!

2d • 24/03/2018 • 12:22

Common Mistakes

- Too few APs - massive gaps in coverage
- Too many APs - too much noise / interference
- APs set to maximum power - noise / interference
- 40MHz on 2.4GHz - no known clients support it
- 80MHz on 5GHz - poor coverage and more interference

Common Mistakes

- Running tests to speedtest.net in each area to test speed to internet
  - does not test JUST the internal network / AP only!
  - Also a risk you are not connected to the right AP being tested

Common Mistakes

- Looking at phone/tablet signal level and going for “4-5 bars” coverage everywhere
  - Most common mistake of all. Signal strength of APs is **not** the same as ‘quality’ or high throughput
  - Higher signal strengths of APs usually generates **poorer** performance not better

If WiFi is not placed under stress - does anyone notice?

- “Low density WiFi” (e.g. home, small office / hotel)
  - Usage more light / bursty in nature and limited by internet connection, not wireless connection
- “High density WiFi” (e.g. sports arena, concerts, theatres, Conferences, Schools, MikroTik MUM?)
  - If the WiFI is sub-par, now **everyone** complains!

Why is the WiFi ‘broken’?

- Cabling faults are easy to find
- WiFi faults are more hidden
  - RF is ‘invisible’
  - Far more difficult to diagnose without specialist tools

Interference

- Typical sources of 2.4GHz problems?
  - Interference - some non-802.11 devices
    - Bluetooth, Microwave Ovens, CCTV, ‘Video Senders’, RF based Motion Sensors, USB3.0, Zigbee, electrical switches, commutator motors.
  - Can be highly disruptive especially if ‘100% occupancy’

Interference

- Besides non-802.11 signals, what is the biggest ‘interferer’?
  - Plain ordinary ‘Congestion’
    - i.e. ’Co-Channel-Interference’ (CCI) from **other** 802.11a/b/g/n/ac devices!

Interference - CSMA/CA - A little theory

- WiFi devices use a system called Carrier Sense Multiple Access / Collision Avoidance (CSMA/CA) to determine if the channel is busy
- Carrier Sense uses a method of determining if the channel is available called Clear Channel Assessment (CCA)

Interference - CCA

- 802.11 uses two methods to assess the Channel occupancy and will wait until it has a clear channel before transmitting based on :-
  - Energy Detection (for non-802.11 signals)
  - Carrier Sense (where the signal **is** 802.11)

Interference - CCA Energy Detection

- Any non-decodable signal that is above the “ED threshold level” makes the channel marked as being “busy” / “in use”
  - ED threshold is set to be 20dB more than the level required to successfully decode an 802.11 header
  - If interference is 100% duty cycle - device will **never** transmit

Interference from motion alarm sensor - 100% occupancy

(WiFi Explorer Pro Screenshot)

Interference - CCA Carrier Sense

- CCA Carrier Sense decodes the signal's physical header at the start of each transmission and takes note of the transmitted duration field
  - Requires the signal to be 802.11 and for the physical header to be decoded without errors
  - Header contains transmission time
- Device will 'back off' and wait for that time

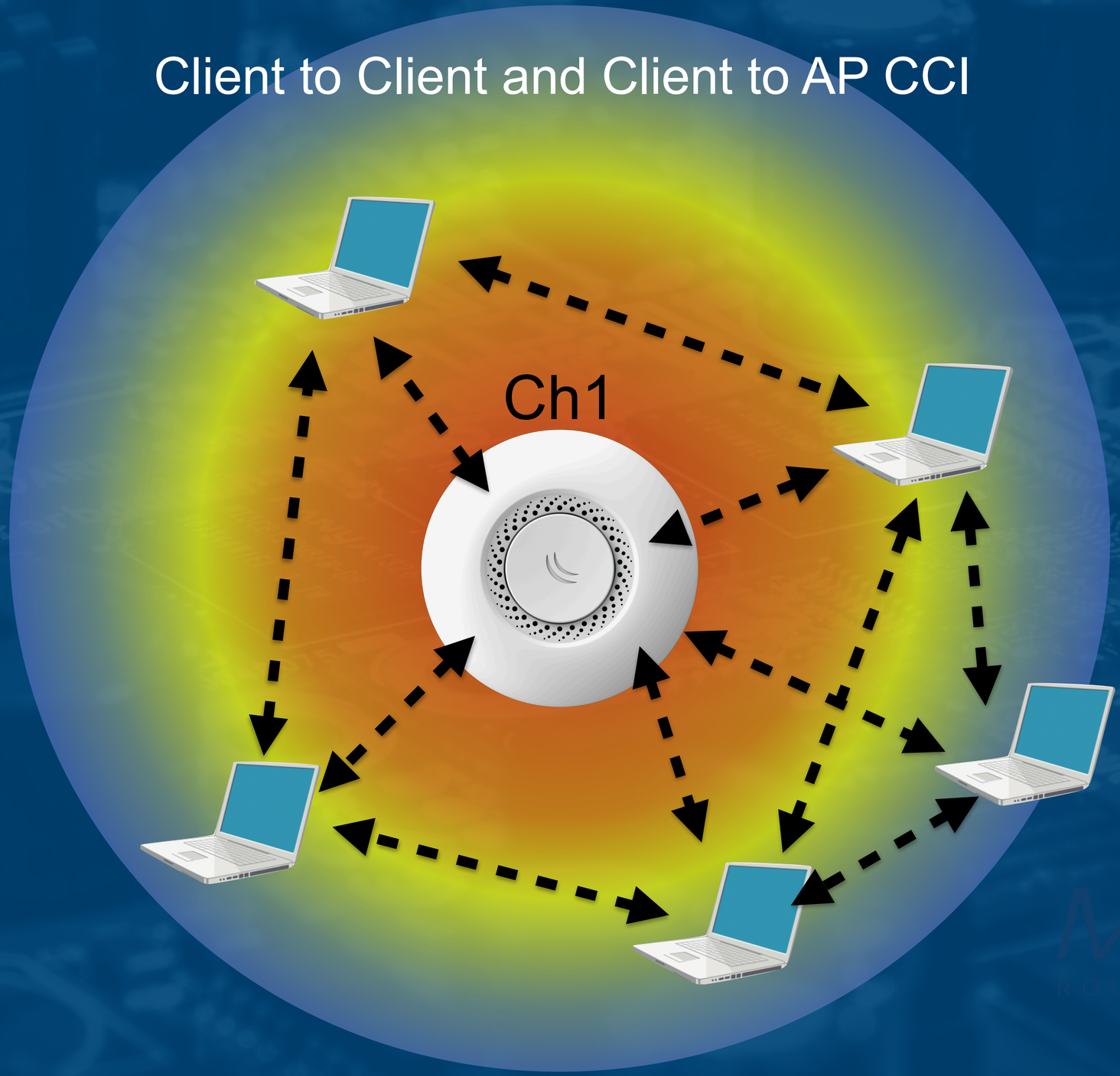
Interference - CCA Carrier Sense

- Regardless of which system used (Carrier Sense or Energy Detection) station will wait and not transmit until the chanel is clear
- Busier the channel, the slower the throughput
- So what consumes ‘airtime’ on an 802.11 network?

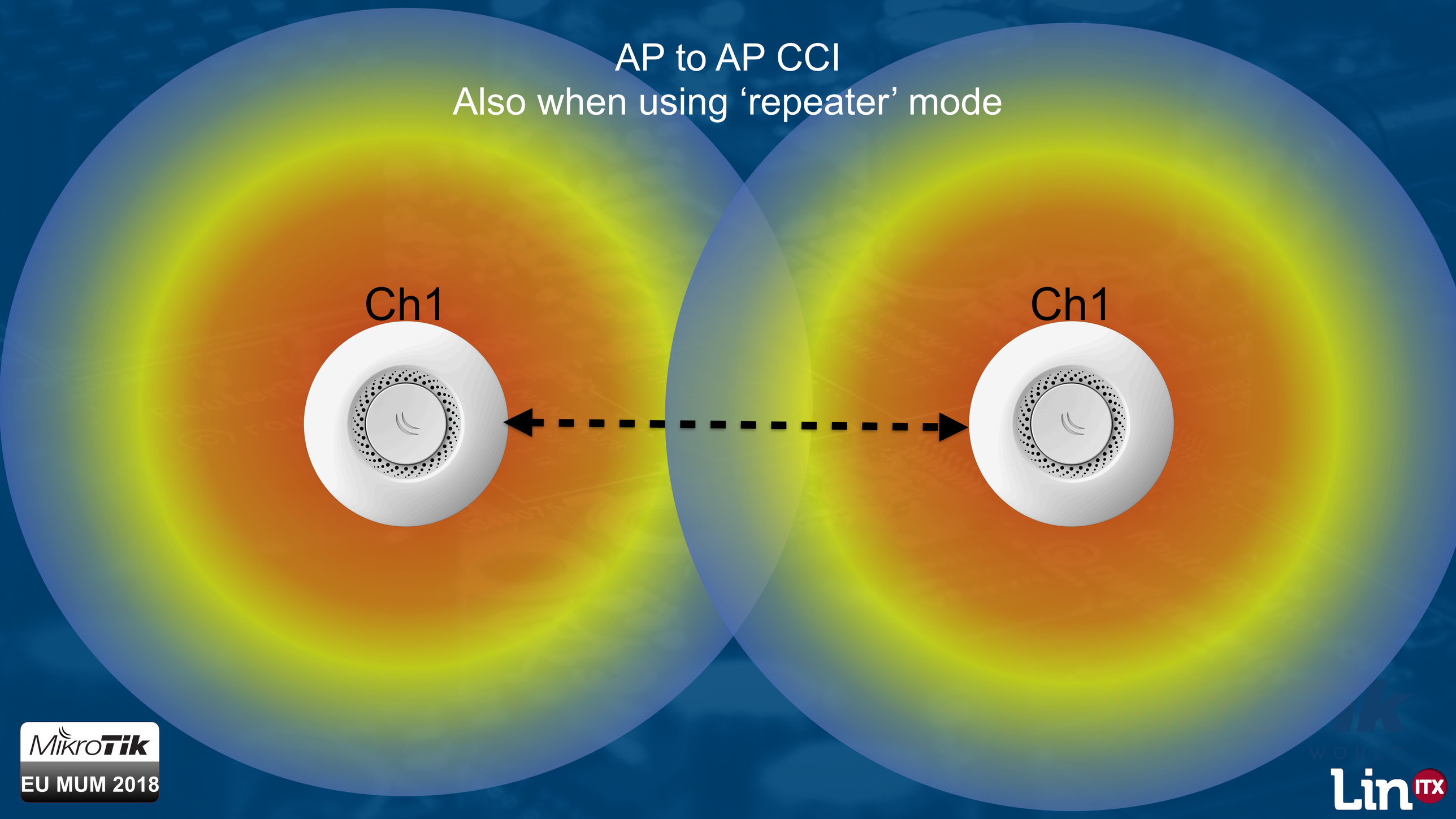
Interference - Contention Types

- Three major types of 802.11 based contention
  - Clients all contending for one AP’s airtime
  - APs contending with other APs
  - Clients connected to different APs but contending with each other for airtime

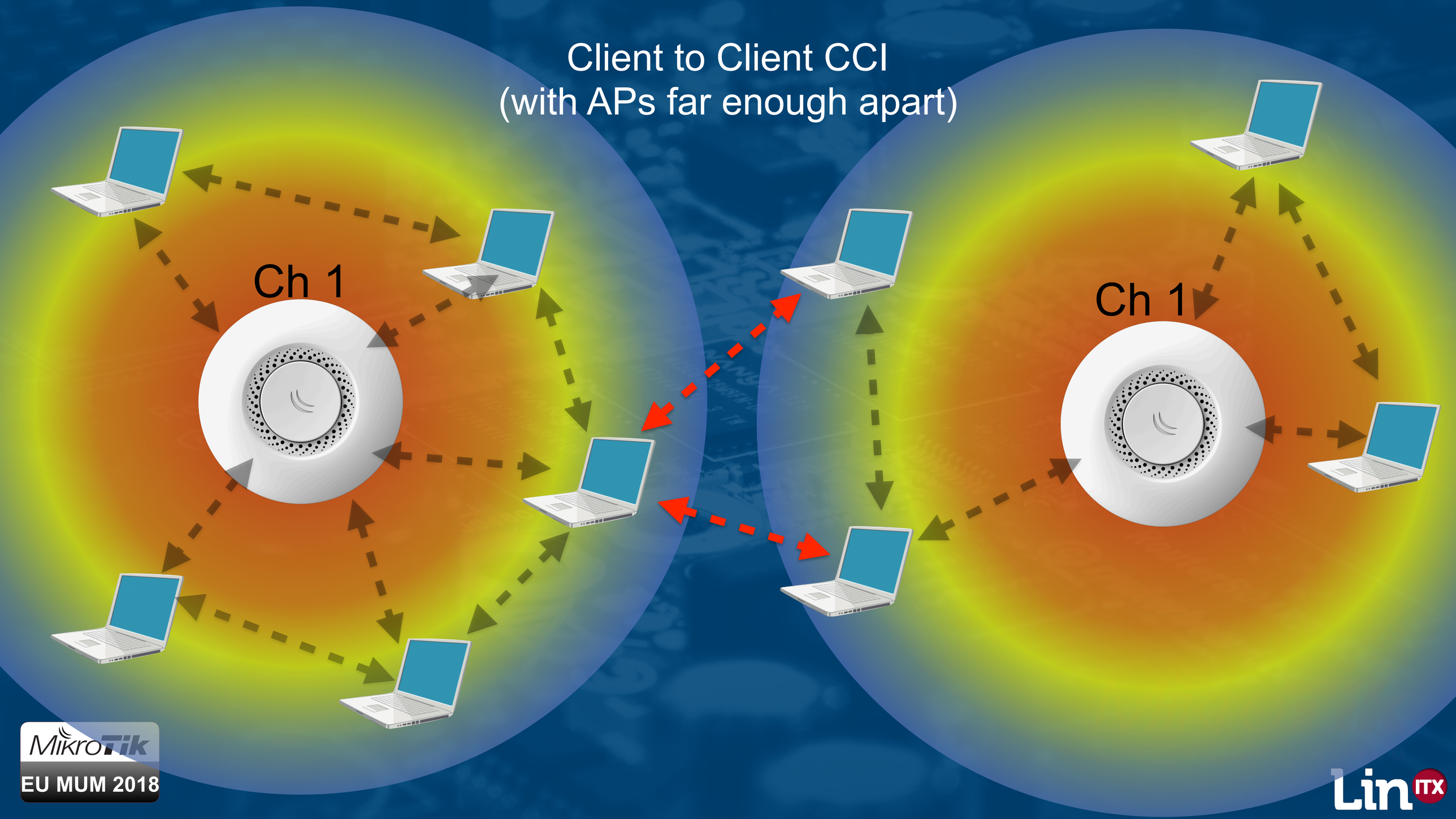
Client to Client and Client to AP CCI



AP to AP CCI
Also when using ‘repeater’ mode



Client to Client CCI
(with APs far enough apart)



Airtime - CSMA/CA

- AP to AP CCI is more common than you think
  - APs will usually be able to ‘see’ each other better than client to clients can (as the APs are often higher up and mounted on the same horizontal plane)
  - Clients will be shielded more from each other by people and/or building

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Airtime - CSMA/CA

- Therefore important to keep ‘same channel APs’ as isolated from each other as possible
  - Use the building to shield between them
  - Use directional antennas?
- Also bear in mind the potential of Co-channel interference with clients half way between two APs on same channel!

CCI or ACI - which is preferred?

- 802.11 is designed to cope with CCI - better called ‘channel contention’ or ‘congestion’ than noise / non 802.11 interference
- Very important to use non-overlapping channels
- Overlapping channels will be seen as non 802.11 noise / interference

Airtime - CSMA/CA

- Two very active APs on the same channel, will force them to both back off and send beacons late (or even give up altogether and miss a beacon),
- Thus each AP will reduce user throughout until the other AP is quiet. Especially with ‘repeaters’
  - Two APs on the same channel is effectively having a **very** large cell on one channel

Airtime - Beacons

- Access points have to send out beacons
- Beacons contain data such as SSID, RadioName and advertised features / extensions
- Each SSID requires a **separate** beacon
- Beacons are sent at the **slowest** basic rate

Airtime - Beacons

- Therefore more SSIDs equals more time consumed
  - Starving time from clients
- Beacons can be configured to be sent at higher data rates, therefore less time consumed
  - Increasing airtime for clients

Airtime - Probes

- Client will always send probe requests at their slowest data rate (e.g. 6Mbps)
- AP will reply with Probe Response at the AP's lowest data rate (perhaps 24Mbps)
- Client will ACK with AP's lowest data rate 24Mbps
- But the initial Client probe will always be at 6Mbps :(

2.4GHz vs. 5GHz

2.4GHz vs. 5GHz

- Majority of clients now support both bands
- More channels on 5GHz, less interference
- Therefore need to encourage clients to use 5GHz

Enough of the Theory!
Time for Solutions :)

Or why it is important - now learn what to do about it :)

Design Solutions?

- Try to avoid using too many SSIDs
- No more than 4-6 SSIDs per physical interface
  - The lower the number of SSIDs the better
- Turn off WPS as the WPS ‘Information Element’ increases the size of all transmitted beacons

Design Solutions?

- Try to avoid using 802.11b if possible
- Reduce Tx power on 2.4GHz to encourage clients to connect to the stronger 5GHz signal instead
- consider using two SSIDs to use human psychology
  - On 2.4GHz use “Slow Internet” ?
  - On 5GHz use “Fast Internet” ?

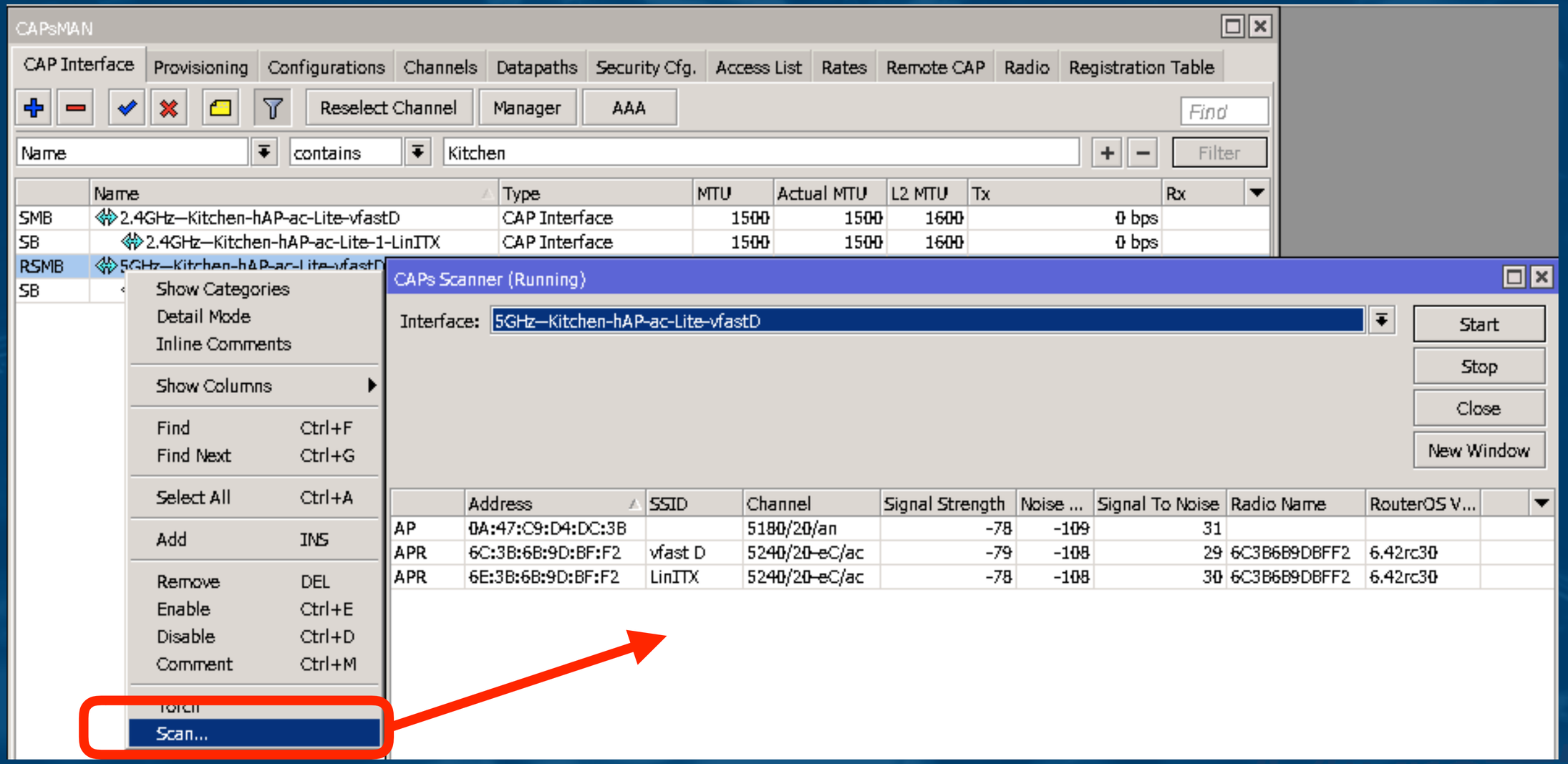
Design Solutions?

- If you *have* to use 2.4GHz - Ch's 1, 6, 11 **ONLY**
- On 5GHz consider that some clients do not support DFS channels and also that APs on DFS channels may go offline
  - Therefore ensure there are always some non-DFS channel APs nearby (Channels 36-48)

Surveying Tip to measure AP to AP CCI

- Measure signal levels of *other* APs on all APs to determine if AP to AP co-channel interference is present
  - Look for other AP levels around -80dBm or less
  - CAPsMAN now allows background scanning :)

Measuring other AP signal levels



Background Scan on remote CAP

Measuring other AP signal levels on same channel

Channel	Signal St...	Noise Floor	Signal To Noise
2412/20/gn(18dBm)	-85	-105	20
2412/20/gn(18dBm)	-87	-105	18
2412/20/gn(18dBm)	-87	-105	18

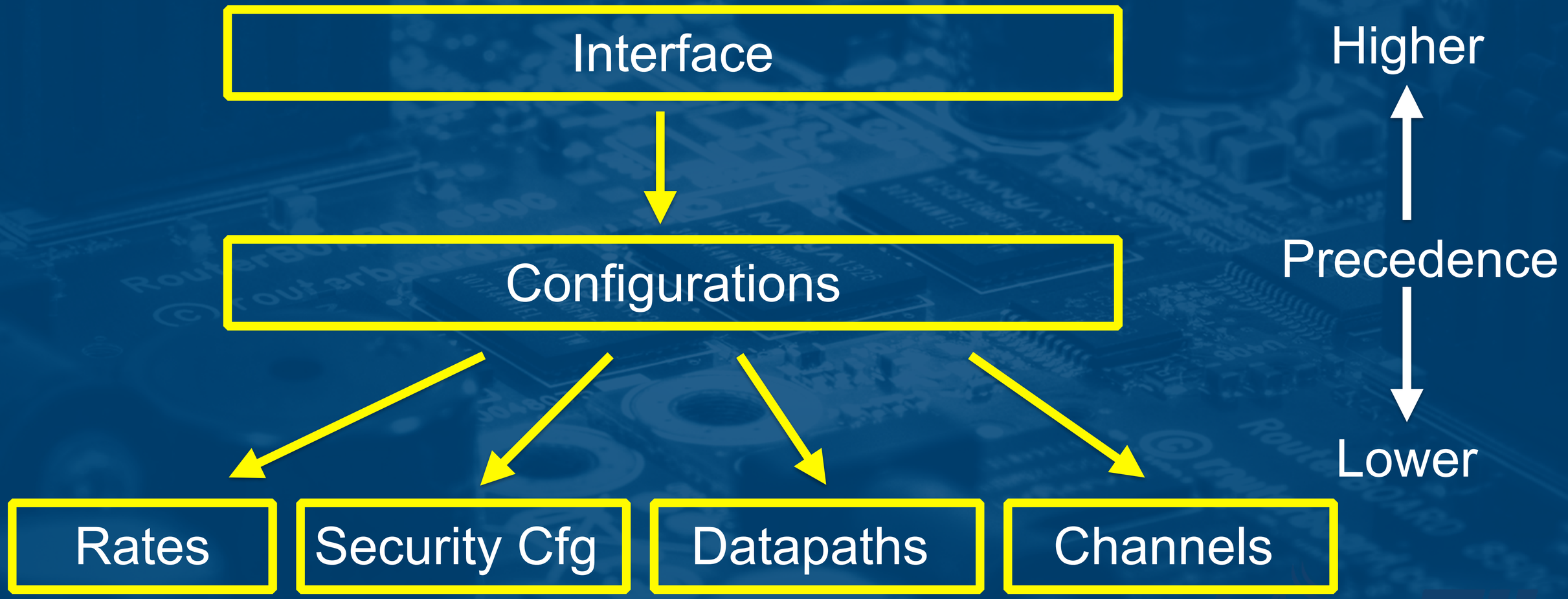
Check signal levels of all other APs on the same channel as that AP

Ensure other co-channel APs' signal levels are as low as possible (>-80dBm)

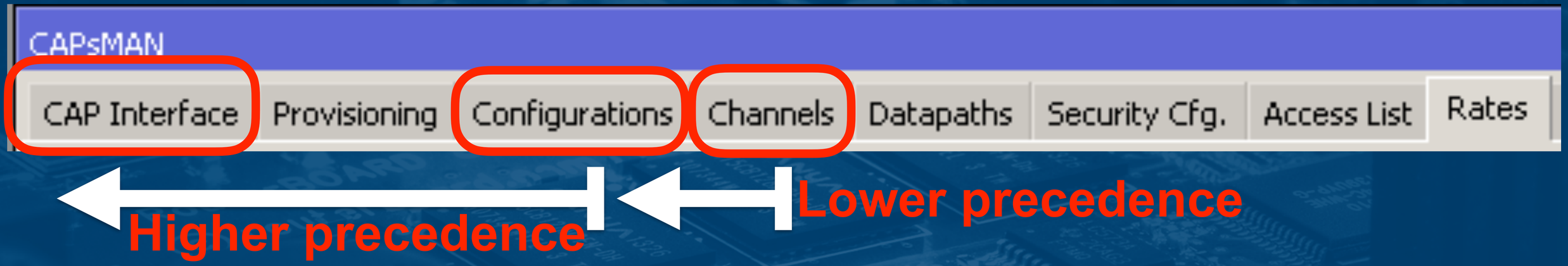
Improving Beacons and Probes - Data rates

- Beacons and probes transmitted at lowest basic rate
- So, raise the data rate of the lowest basic rate!
- Not recommended to go above 24Mbps!
  - 12Mbps is usually well supported by most clients
- Test connectivity and roaming with **customer's devices** not your own!

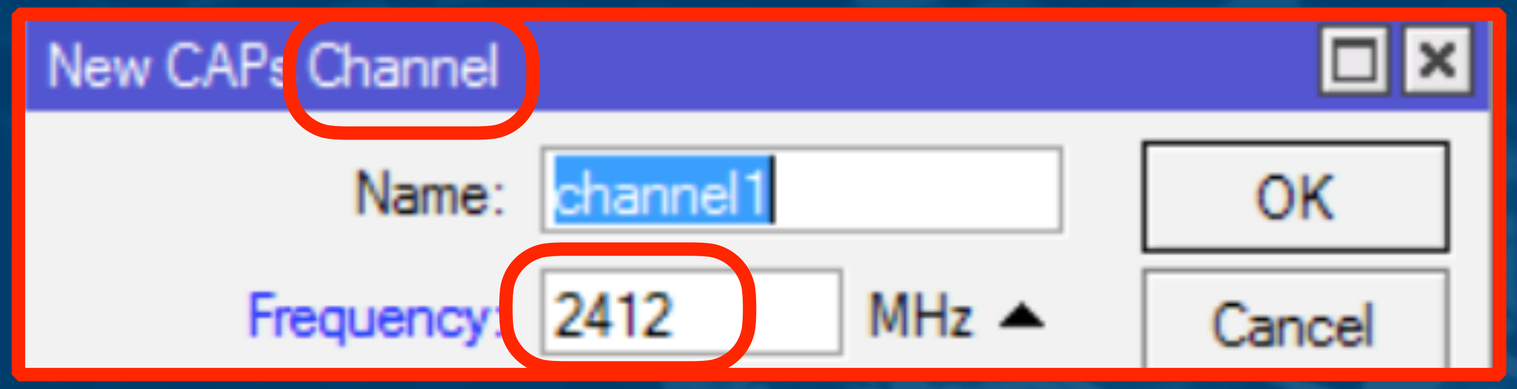
CAPsMAN Configuration Overview



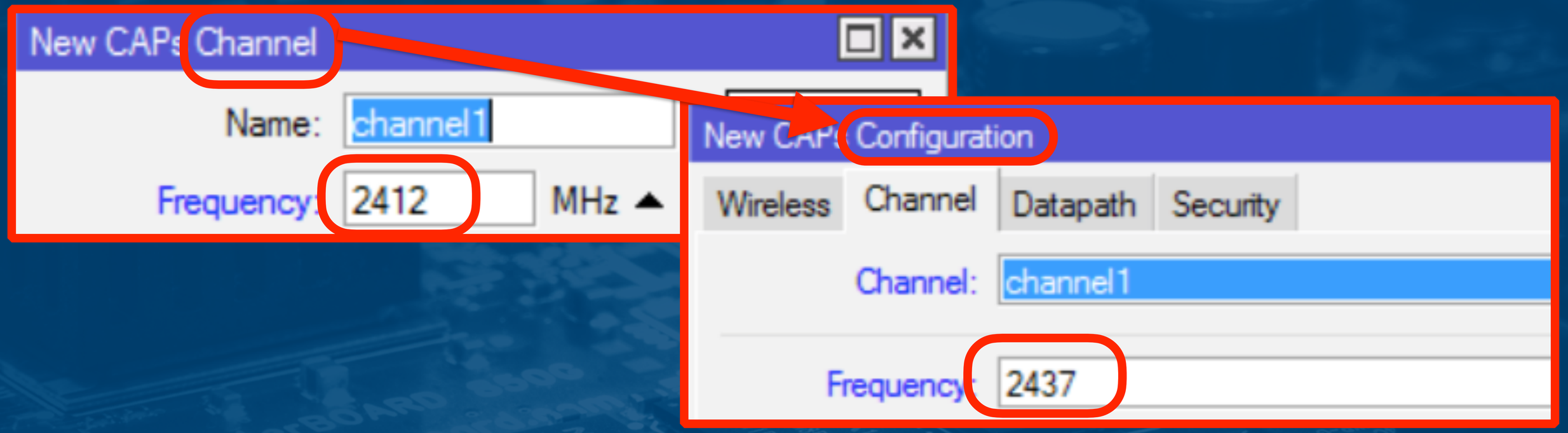
CAPsMAN Configuration Override - Frequency



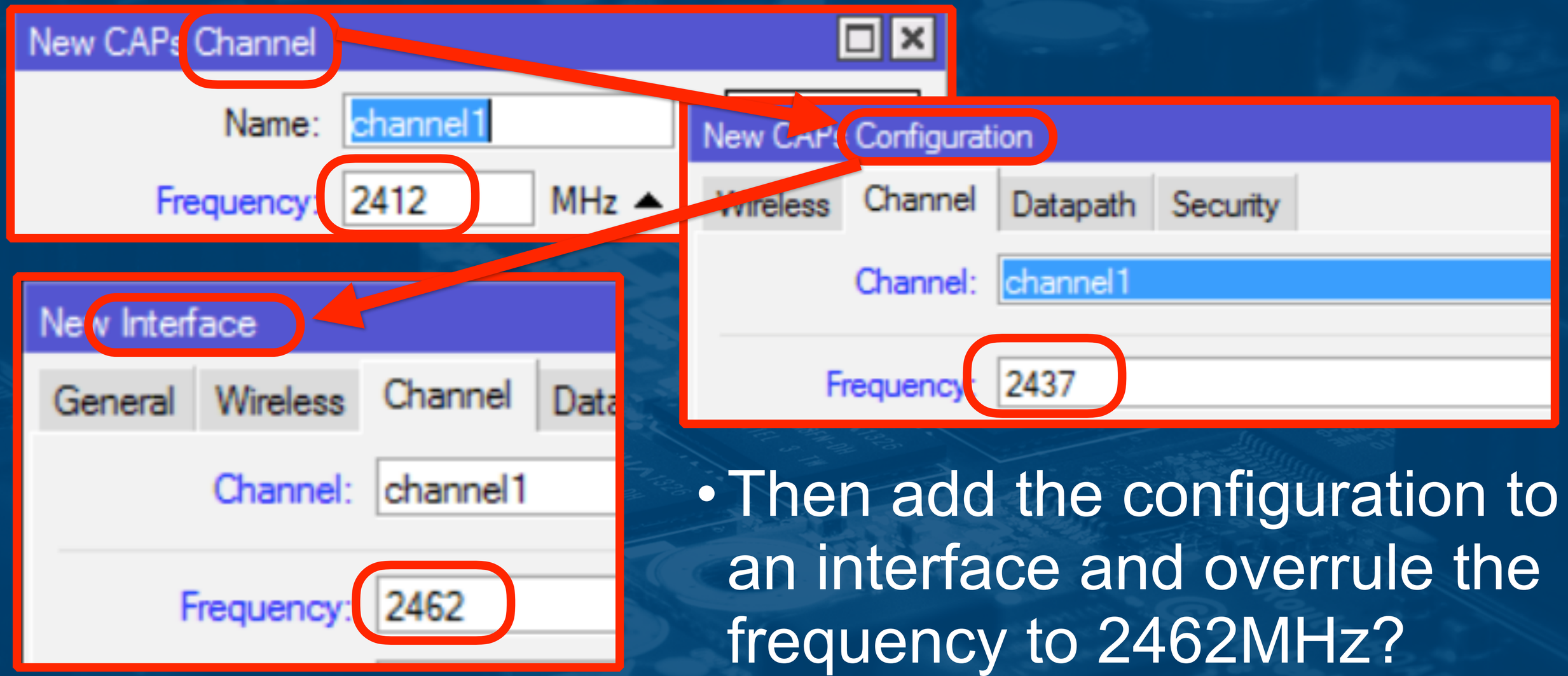
- Changing any setting at a ‘higher’ level (on the left) overrules the same lower settings (on the right)



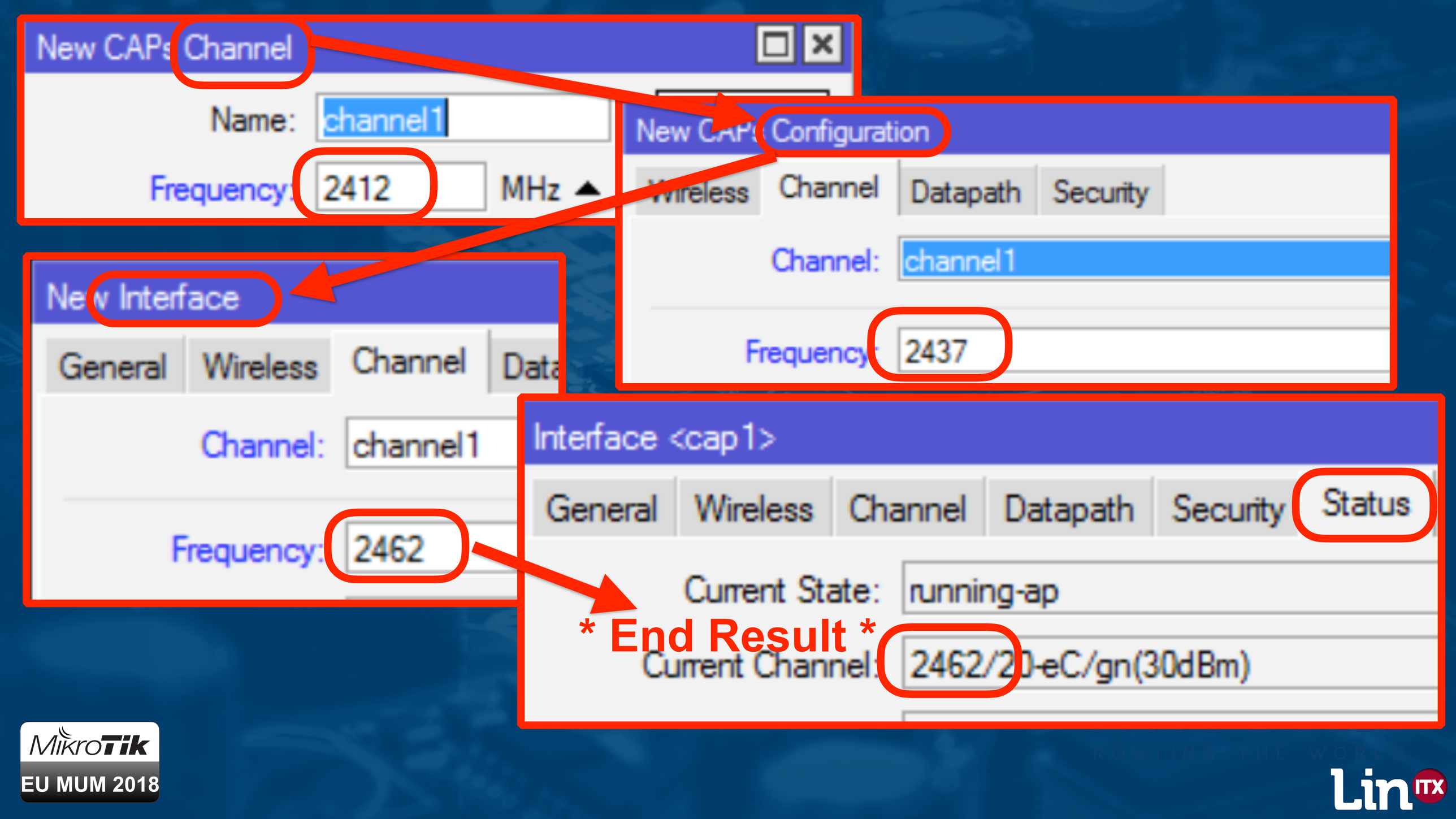
- For example, create a new channel definition with a frequency of 2412MHz



- Apply channel setting to new configuration but then maybe ‘overrule’ the frequency on the configuration with 2437MHz?



- Then add the configuration to an interface and overrule the frequency to 2462MHz?

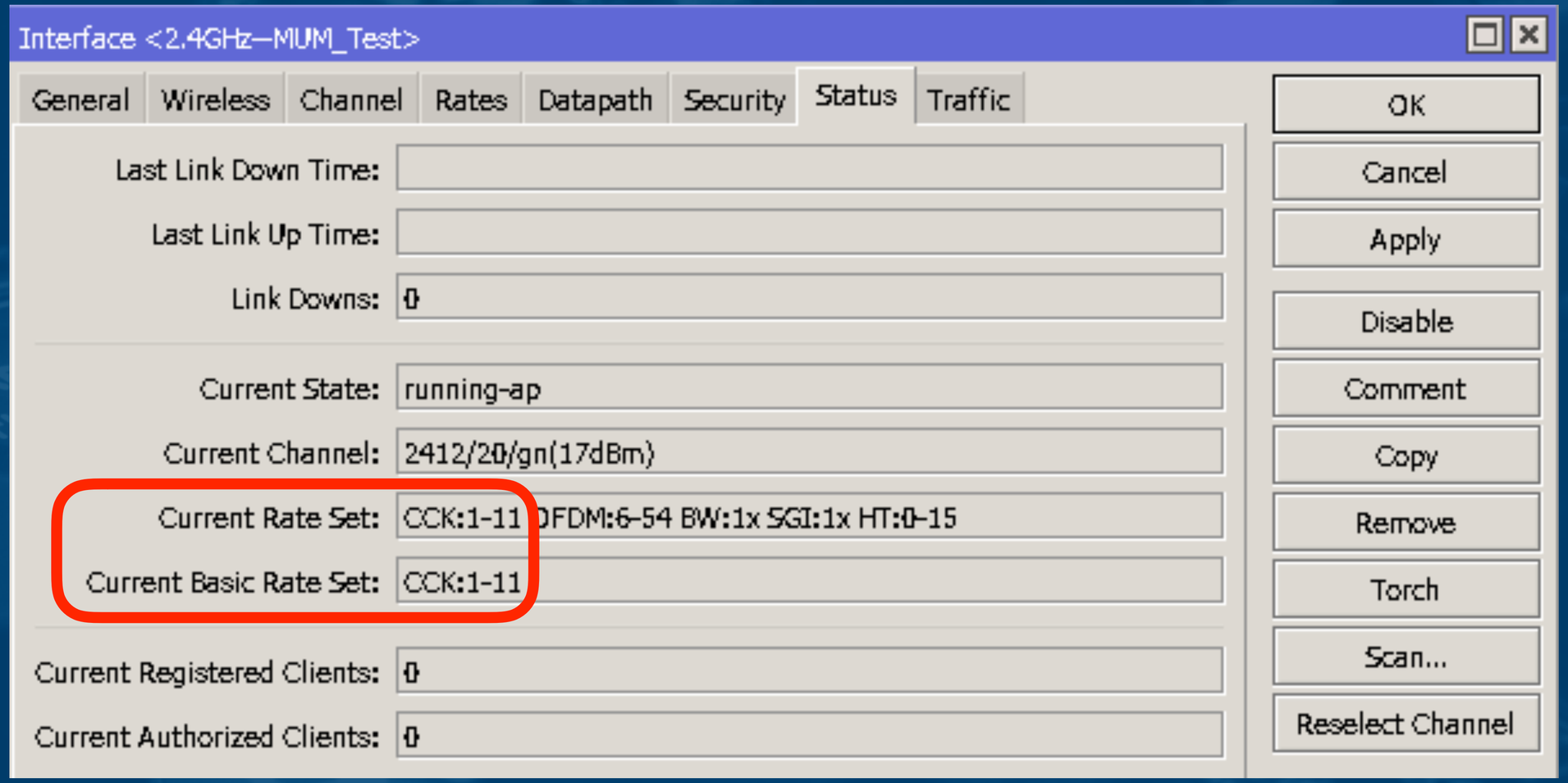

New CAP Channel
Name: channel1
Frequency: 2412 MHz
New CAP Configuration
Wireless Channel Datapath Security
Channel: channel1
Frequency: 2437
New Interface
General Wireless Channel Data
Channel: channel1
Frequency: 2462
Interface <cap1>
General Wireless Channel Datapath Security Status
Current State: running-ap
* End Result *
Current Channel: 2462/20-eC/gn(30dBm)

Removing 802.11b

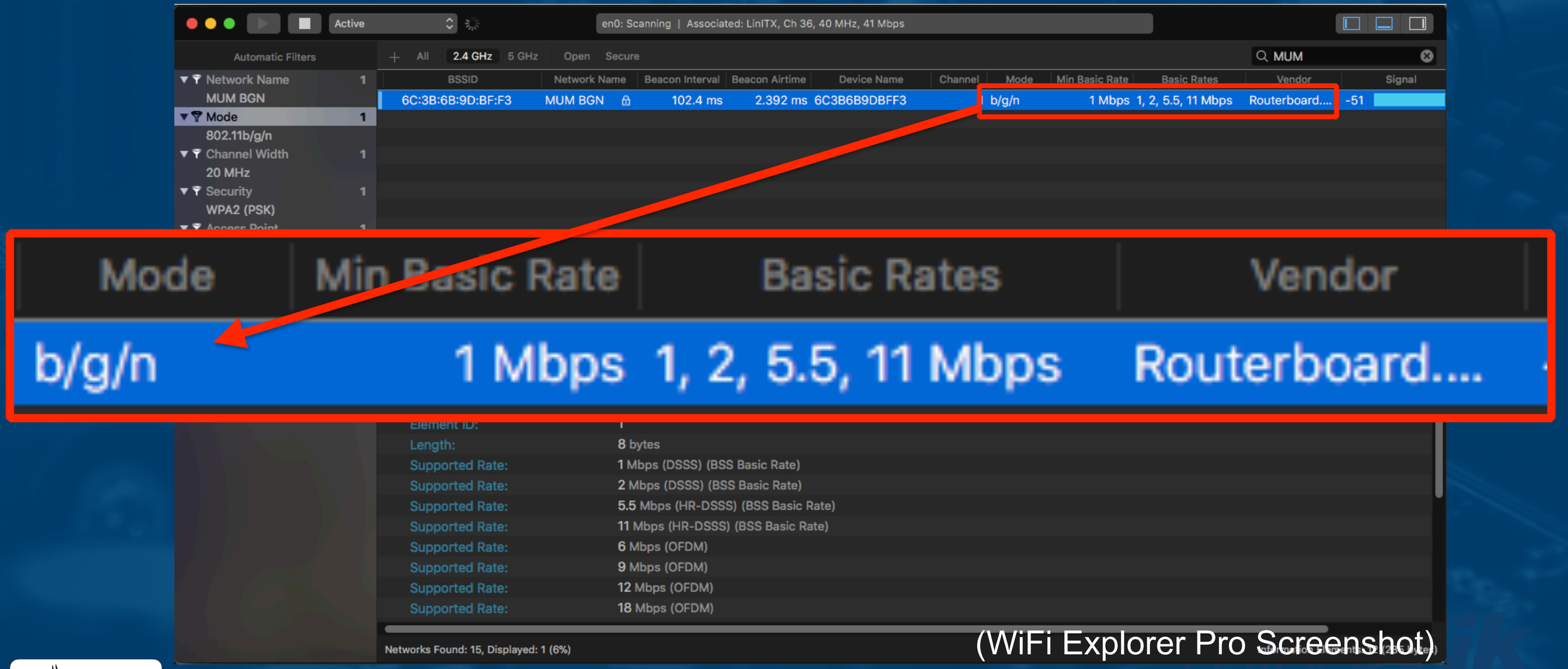
- First major improvement to speed up the wireless network is to remove all support 802.11b

Before changes - 802.11b active (the theory)

- Default shows CCK:1-11 meaning 802.11b is active



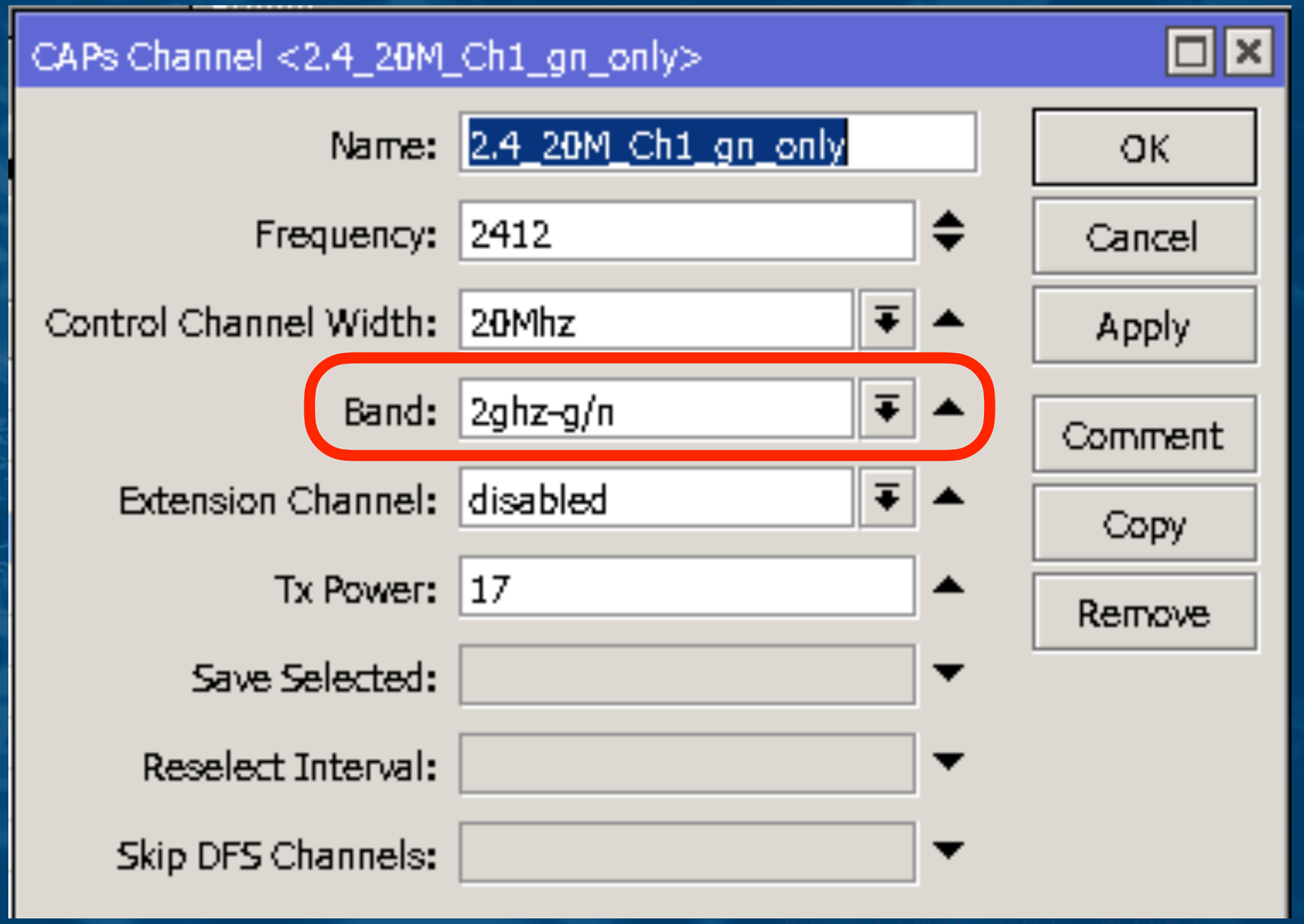
Before changes - 802.11b active (yes - reality!)



(WiFi Explorer Pro Screenshot)

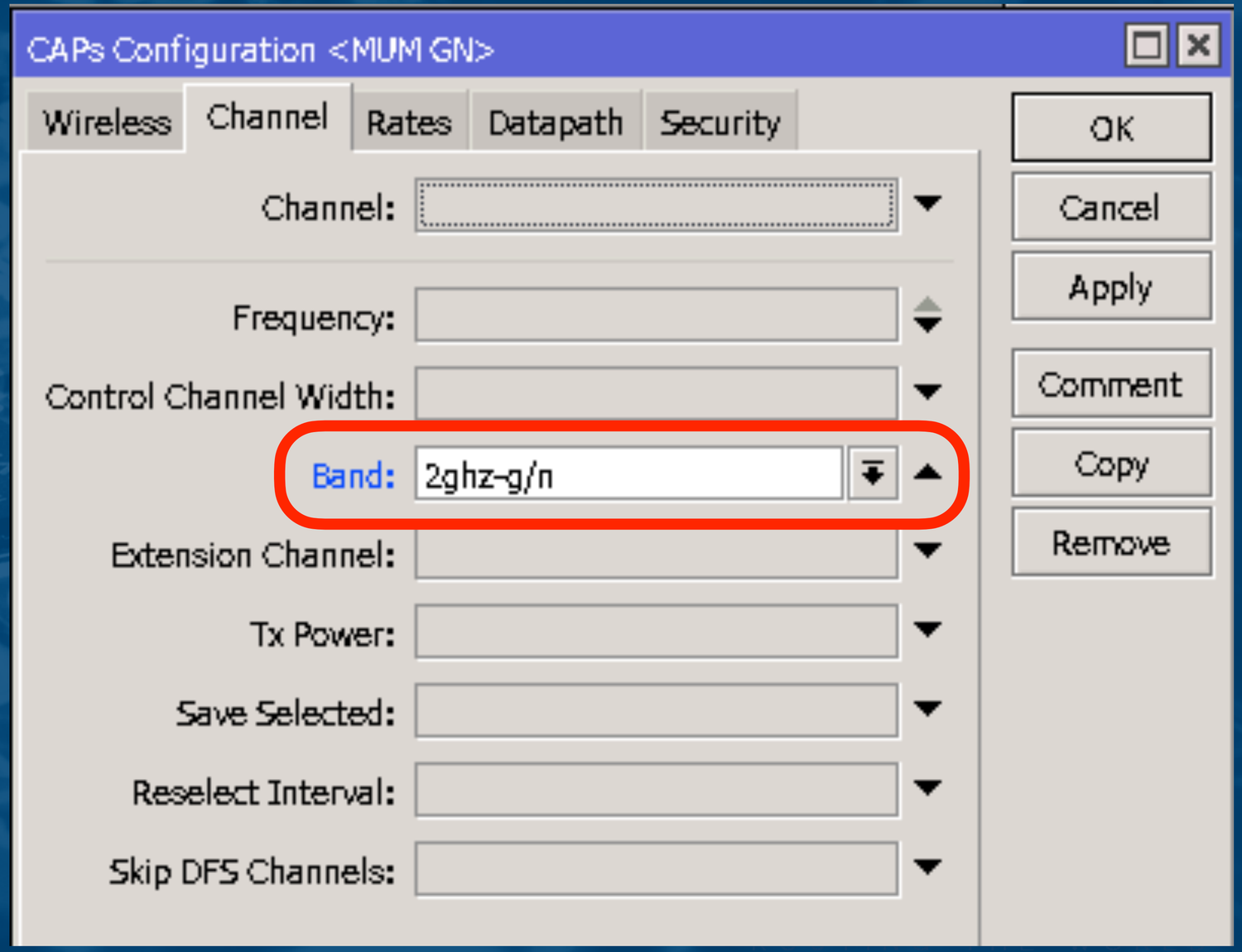
Removing 802.11b from 2.4GHz

- To remove 802.11b, one could create and use a channel setting the Band to ‘2ghz-g/n’



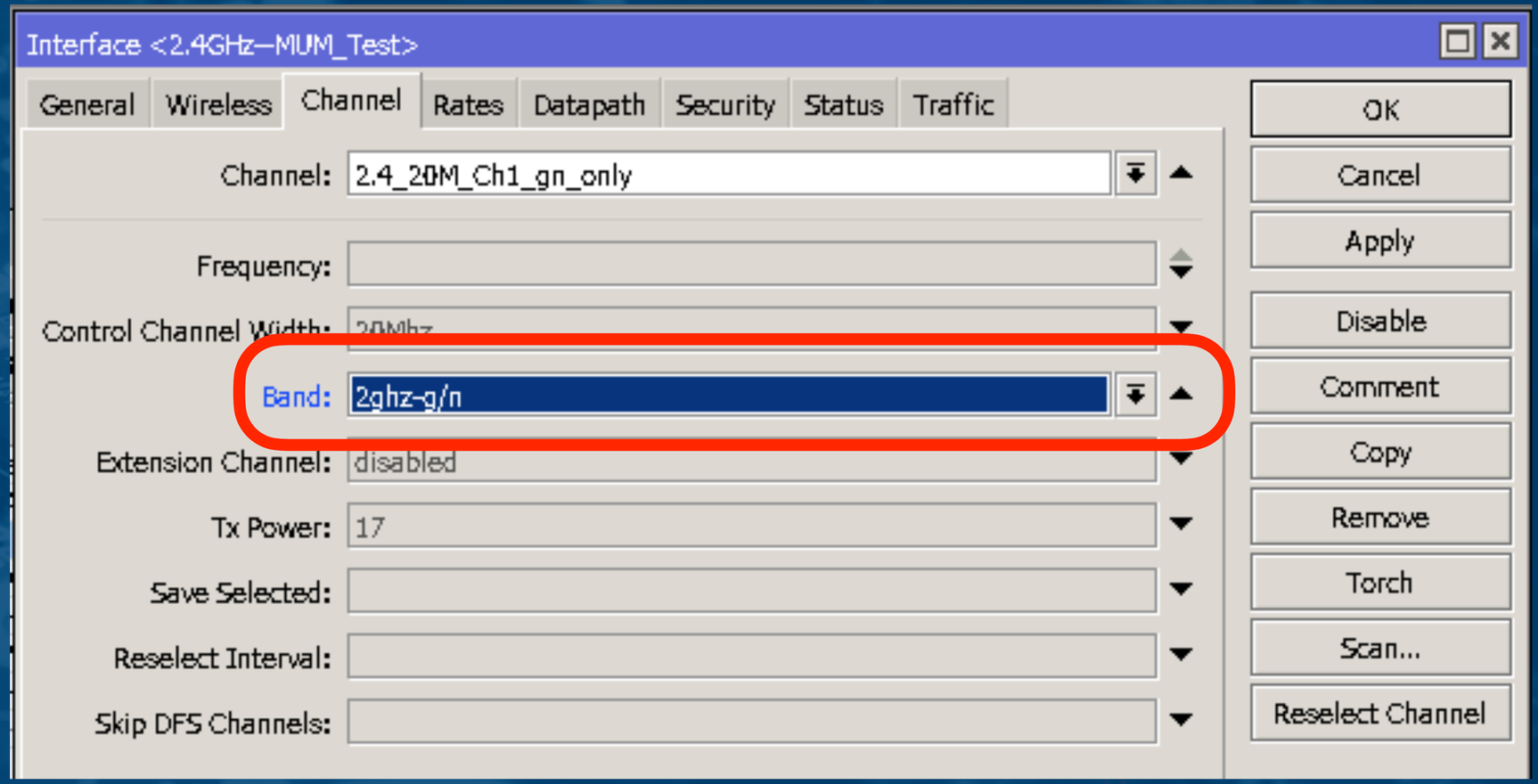
Removing 802.11b from 2.4GHz

- Or, set Band to ‘2ghz-g/n’ on the Channel tab on Configuration



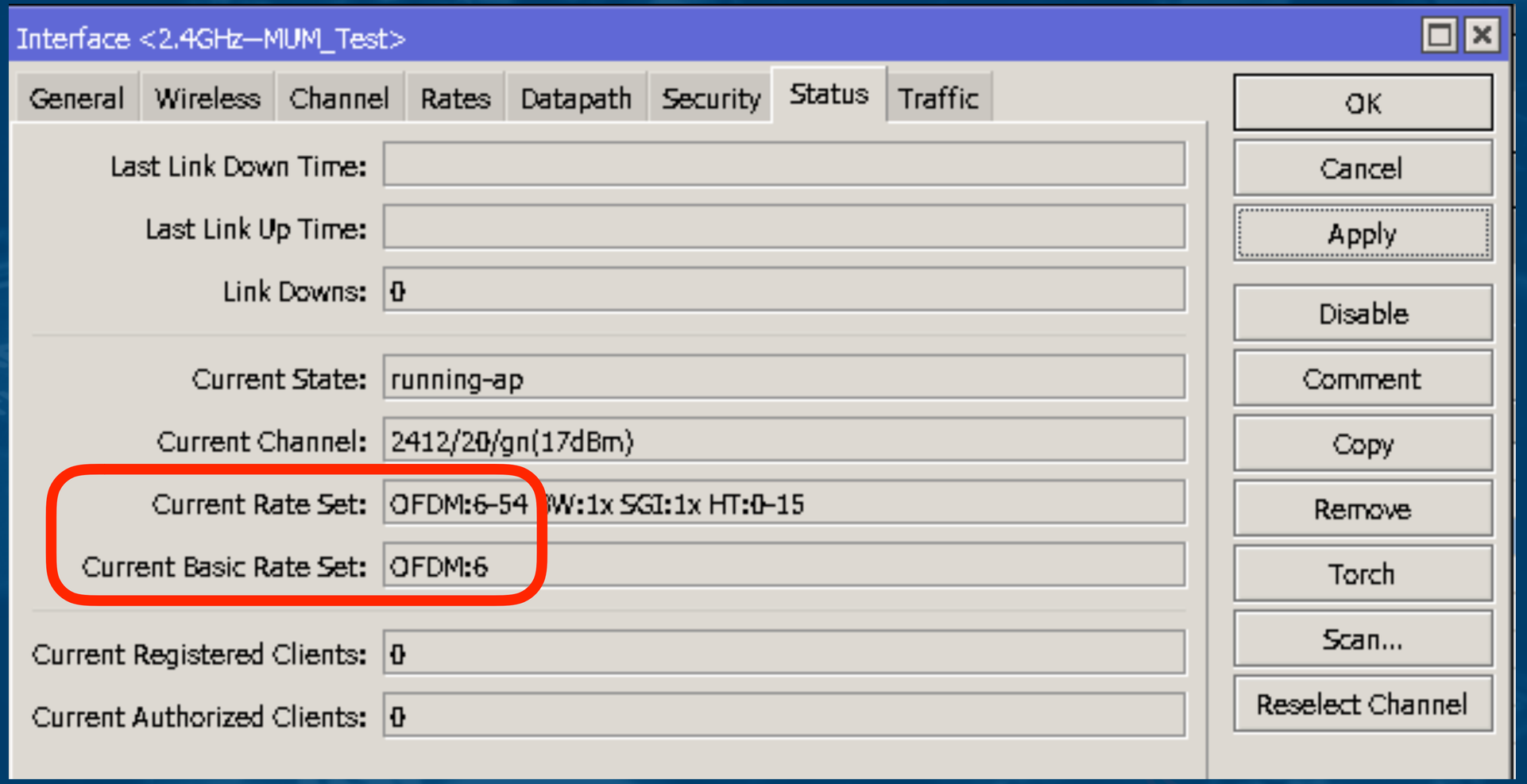
Removing 802.11b from 2.4GHz

- Or, set Band to ‘2ghz-g/n’ on the Channel tab on Interface

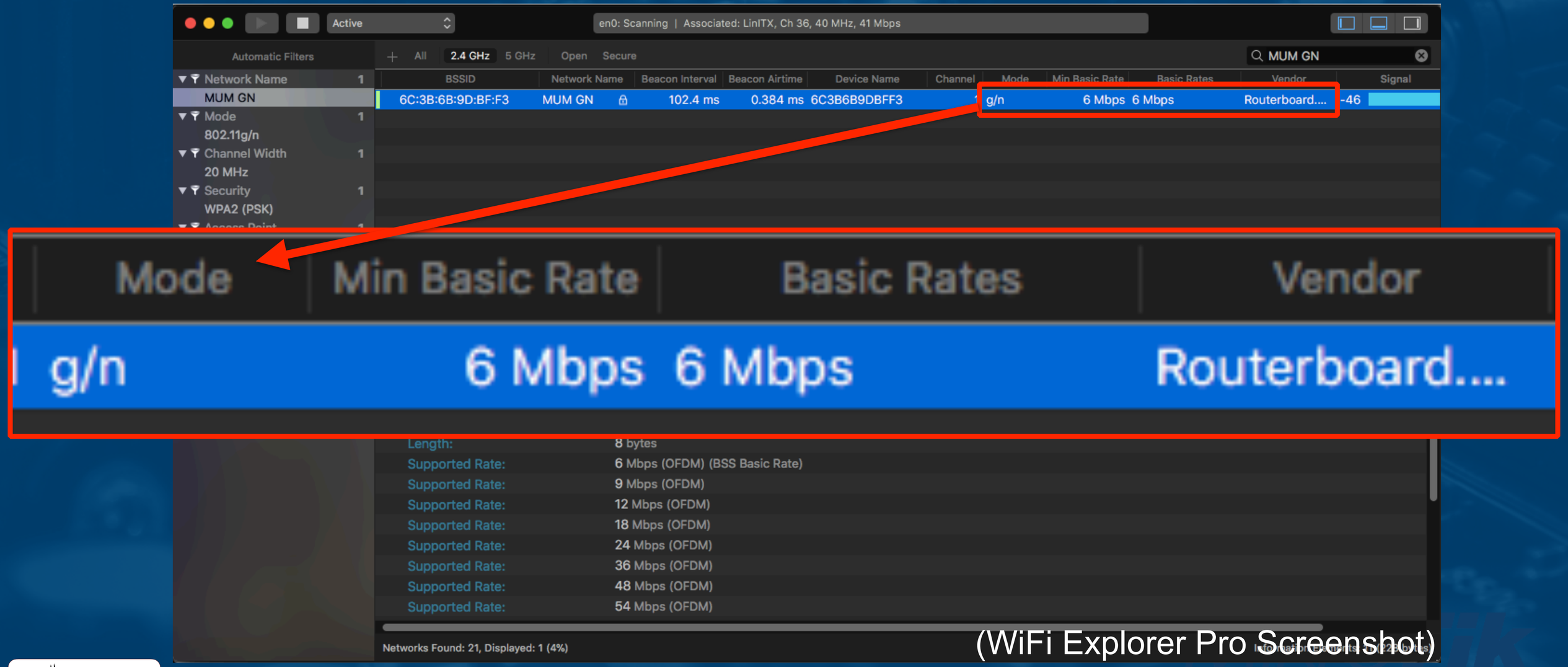


End result? g/n only

- Result is 802.11b disabled, (CCK:1-11 has gone)



End result? g/n only!

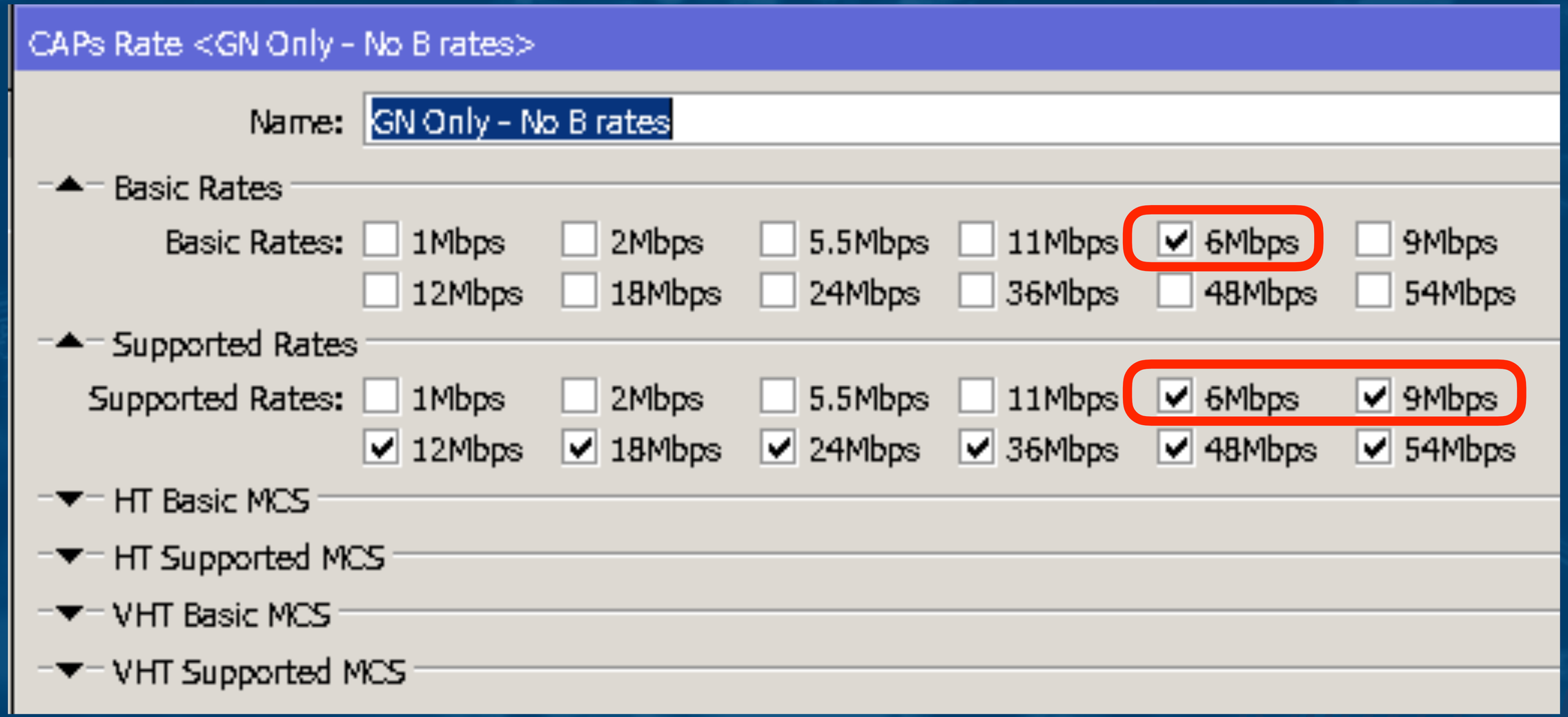


(WiFi Explorer Pro Screenshot)

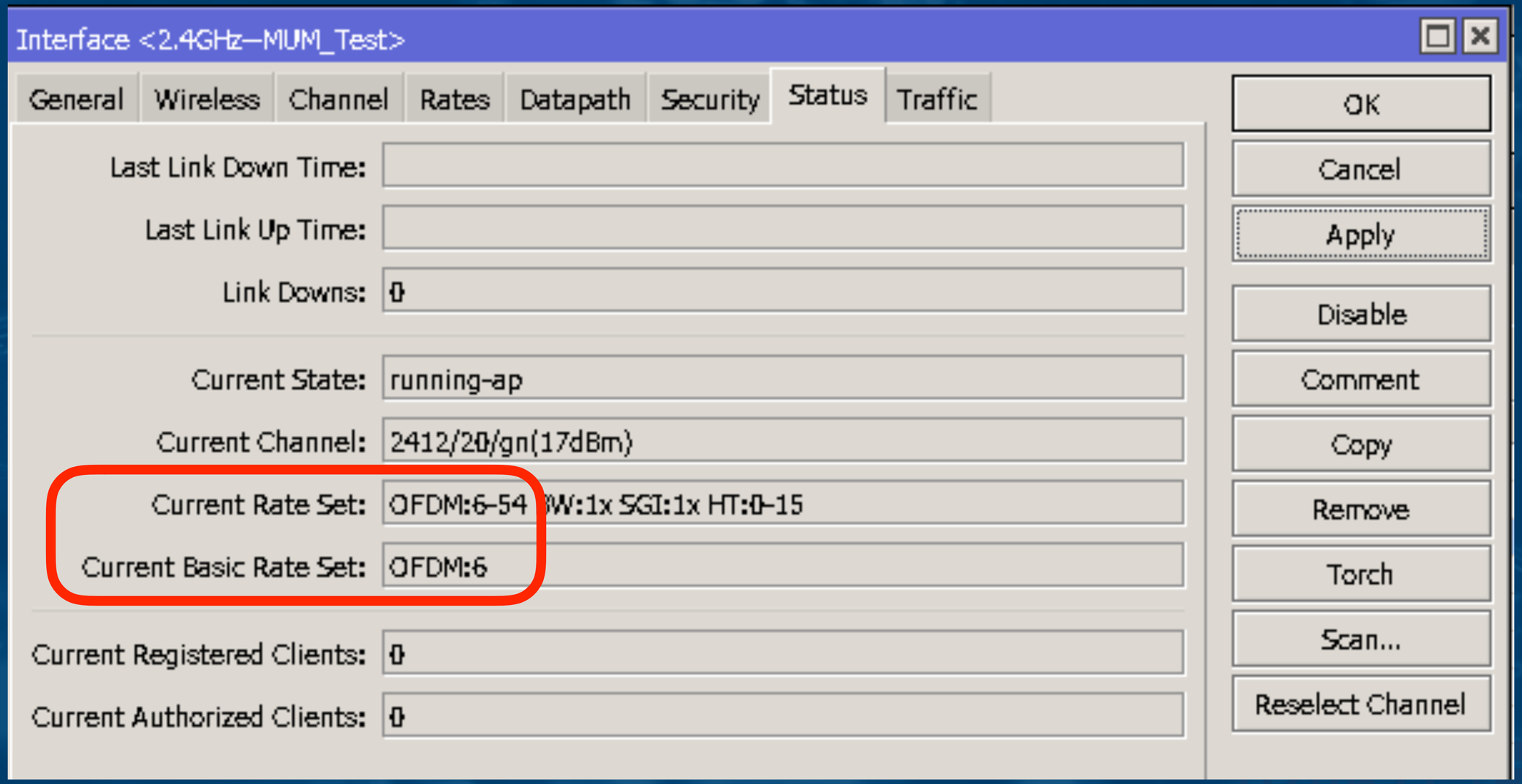
Further improvements

- Now with 802.11b banished to where it belongs, what about the slower data rates?
- First we need to create a ‘Rates’ config that contains all the same rates as the default

Default starting position - 802.11g/n only (no 802.11b)



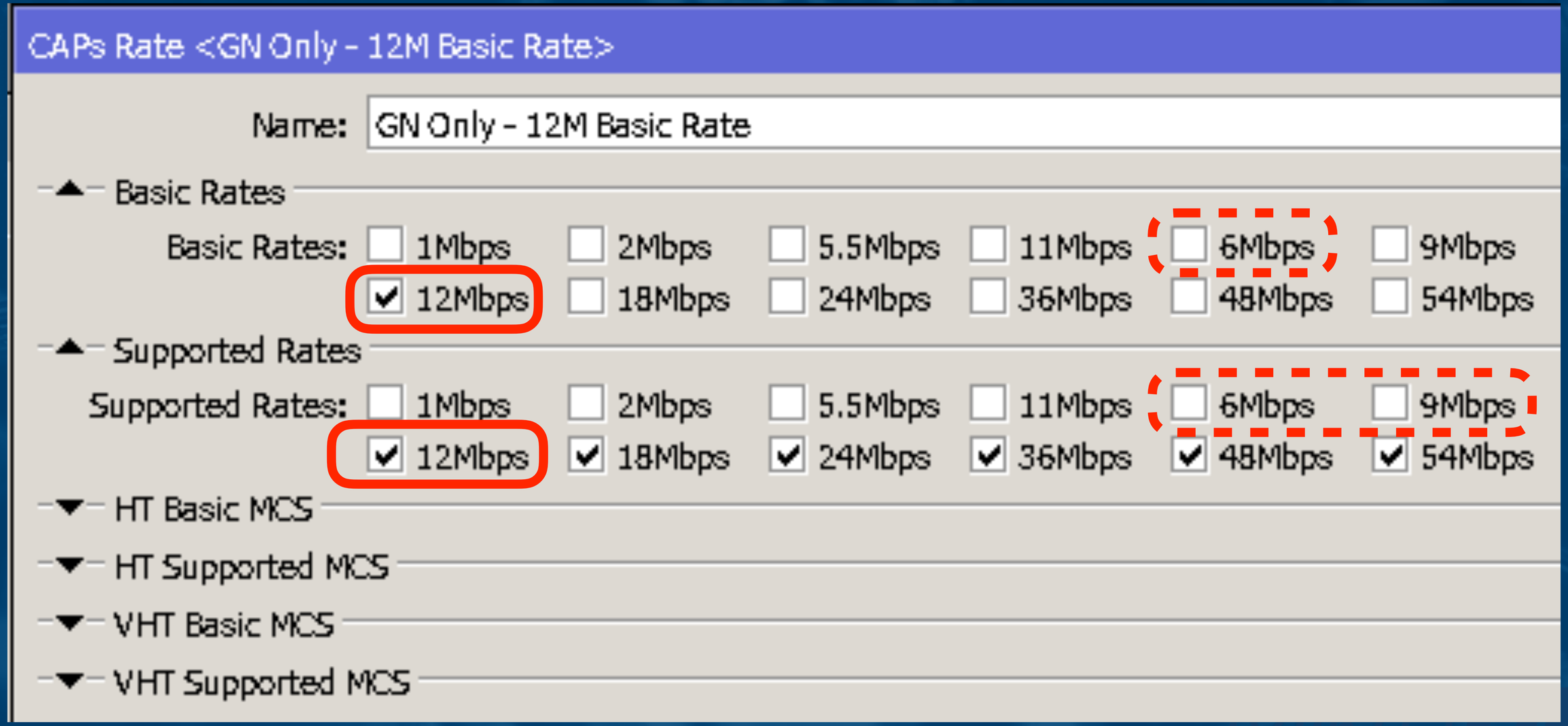
Hopefully - nothing has changed



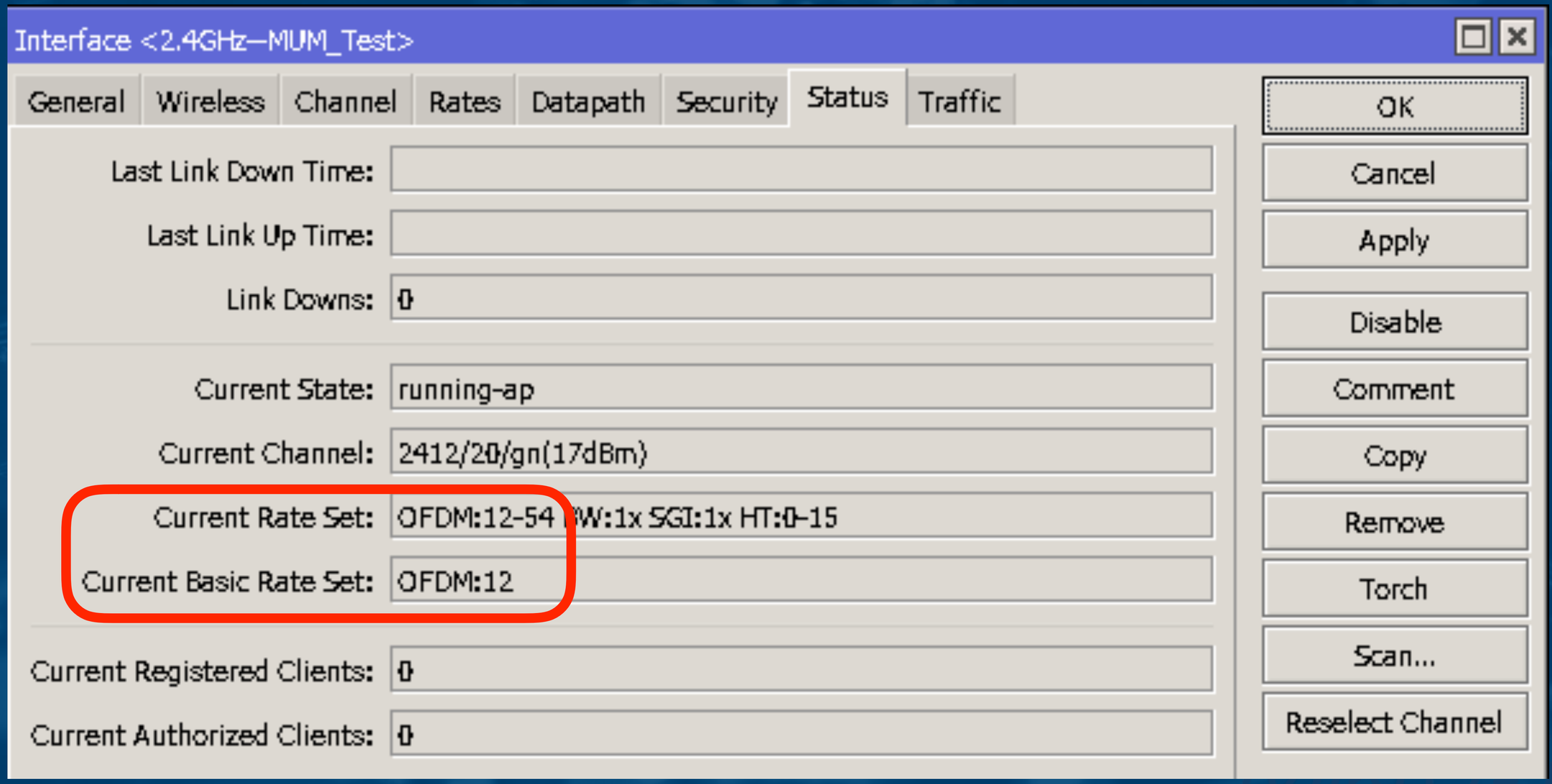
Further improvements

- Recommend lowest basic rate is raised to at least 12Mbps or possibly even as high as 24Mbps
- Remove the slower rates of 6Mbps and 9Mbps and enable 12Mbps (preferred option)
- Or, remove the slower rates of 6Mbps, 9Mbps, 12Mbps and 18Mbps and enable 24Mbps

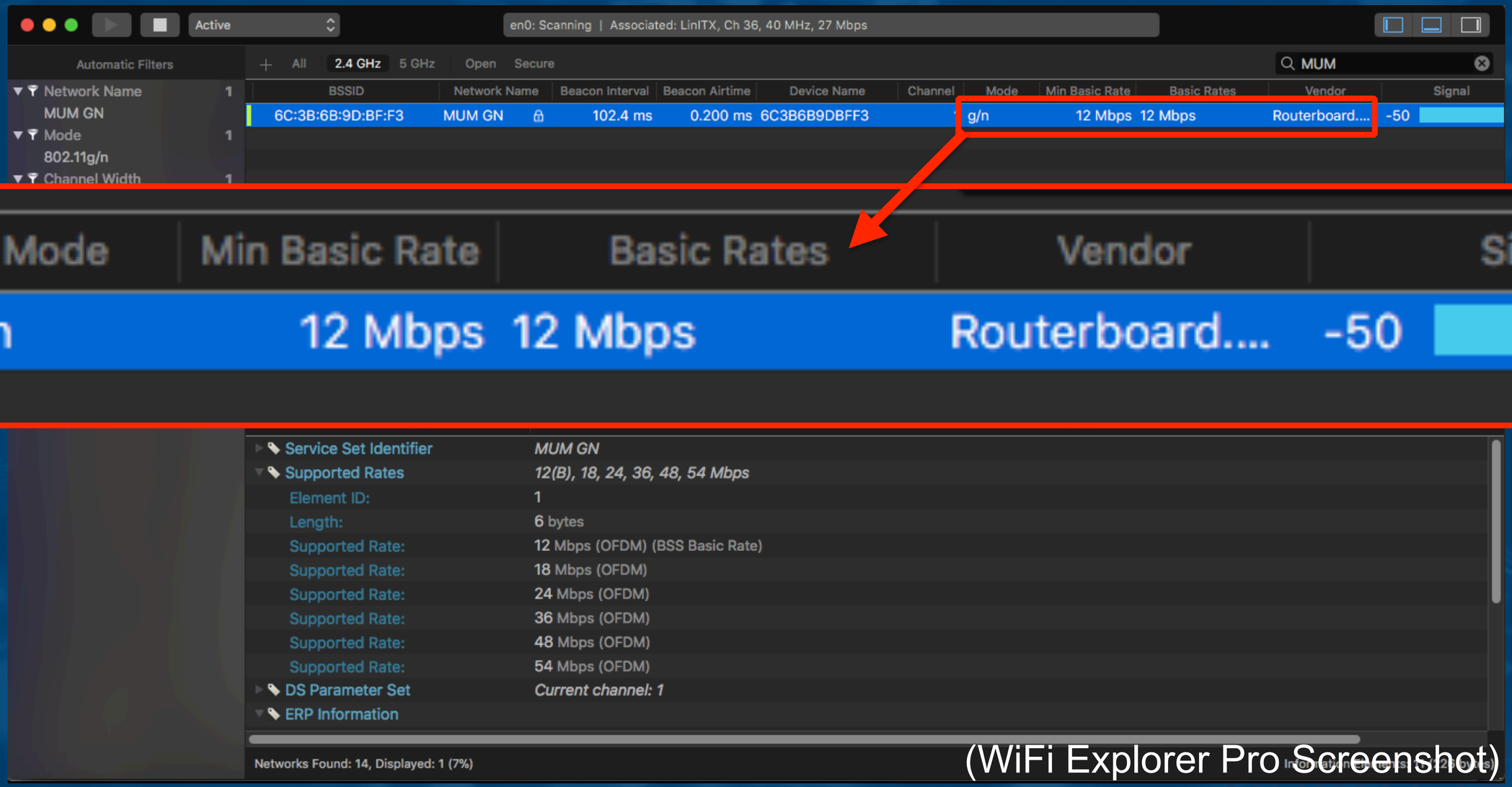
Removal of all slow rates below 12Mbps



End result? g/n only, no slow rates (the theory?)



End result? Better performance achieved



(WiFi Explorer Pro Screenshot)

Testing Coverage and interference

- Low cost Solutions (Mac OSX)
  - WiFi Signal (~€6) - perfect for testing when laptop connects, disconnects and roams between APs
  - WiFi Explorer (~€16) - In depth analysis of AP Beacons
  - WiFi Explorer Pro (~€81) - Adds Analog Spectrum Analyser (with suitable hardware) and much more

Testing Coverage and interference

- Low cost Solutions (Windows)
  - Ekahau HeatMapper (Free)
  - NetSpot (€0 to €405) (also available for Mac)

Testing Speed

- Possible Solution
  - BTest.exe on laptop with at least same capability as the AP under test
    - However Bandwidth Test tool can use up too much CPU on slower CPU APs - test to another more powerful RouterBoard ‘behind’ the AP (CCR?)
    - Ensure you are connected to the AP being tested

CAPsMAN DataPath

- Try to use ‘local forwarding’ of data rather than tunnelling back to CAPsMAN controller
  - ‘local forwarding’ is faster than ‘manager forwarding’ mode
  - At the moment FastPath on the CAP is not possible

End Result?

- End result should now be increased throughput
  - More clients on 5GHz than on 2.4GHz
  - Higher data rates, smaller cells, higher throughput
  - Co-Channel Interference reduced
  - non-802.11 Interference removed/reduced
- Happier customers? We can hope! :)

Want a couple of CAPsMAN Easter Eggs?

- Since v6.42rc39 (7 March 2018) …
- In Winbox, Access List can **only** directly specify a specific named interface or the default of ‘any’
- However, in CLI, it can **also** specify an Interface List
- `/caps-man access-list set {AccessListName} interface={all|any|discover|dynamic|none|` **`{InterfaceListName}`**`|{SpecificInterfaceName}`

Want a couple of CAPsMAN Easter Eggs?

- When a CAP is provisioned and the interface is added in CAPsMAN, the CAP interface can be also dynamically added to an interface list named in the DataPath config (now also in Winbox)
- `/caps-man datapath set {DataPathName}` **`interface-list`**`={all|discover|dynamic|none|{InterfaceListName}`

Thank You!

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