Tips, Techniques, and Tools for Troubleshooting Wireless LANs

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Troubleshooting Process Steps

Identify

Determine problem exists
Ask Questions & Collect Info
Correctly Identify Issue

Locate

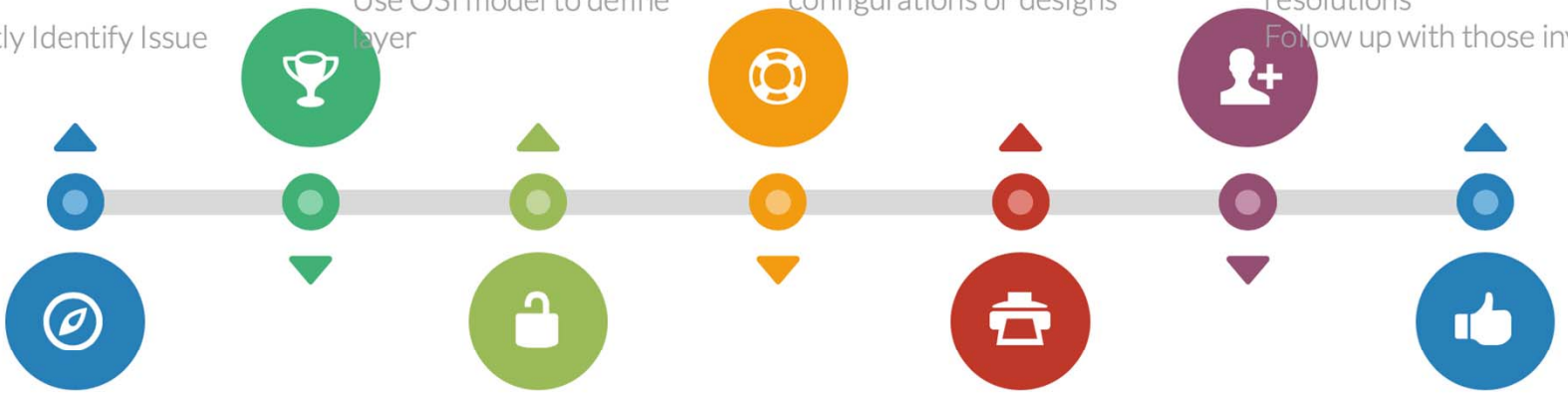
Tied to physical space
Tied to specific devices
Use OSI model to define layer

Solve

Formulate & Implement plans
May include changes to drivers, configurations or designs

Document

Document initial issues, processes, diagnostics & resolutions
Follow up with those involved



Re-Create

If you can't recreate the issue, return to step one and ask more questions

Isolate

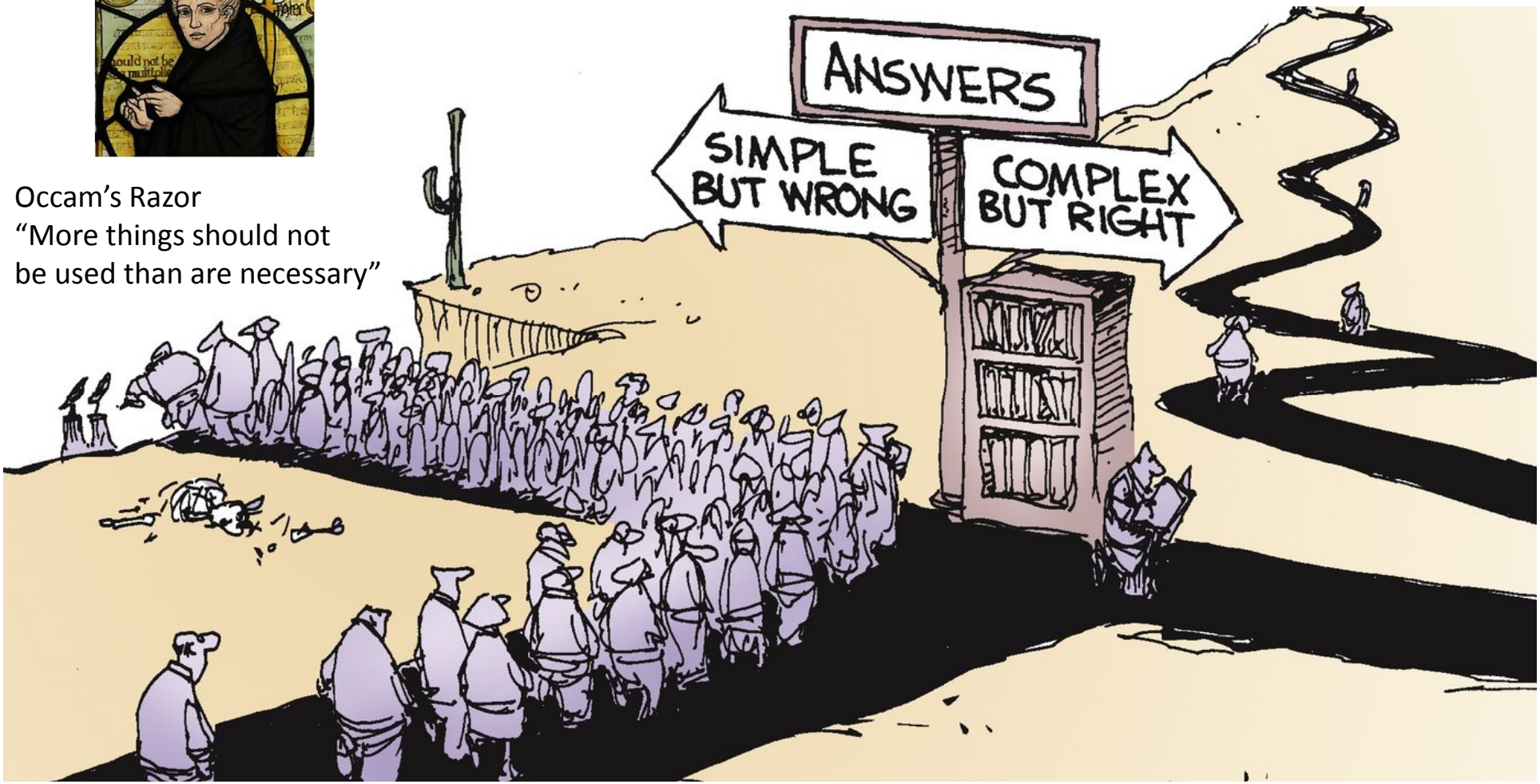
Identify OSI Layer, Specific devices, Specific locations, Driver versions

Verify

Extensive testing to confirm and verify the solution did indeed solve the issue at hand

Simple or Complex?

Occam's Razor
"More things should not be used than are necessary"



“Too Much Plane for One Man to Fly!”

“Surgeries are becoming too complex…”

Surgical Safety Checklist

World Health Organization | Patient Safety
A World Alliance for Safer Health Care

Before induction of anaesthesia
(with at least nurse and anaesthetist)

Has the patient confirmed his/her identity, site, procedure, and consent?
- ☐ Yes

Is the site marked?
- ☐ Yes
- ☐ Not applicable

Is the anaesthesia machine and medication check complete?
- ☐ Yes

Is the pulse oximeter on the patient and functioning?
- ☐ Yes

Does the patient have a:
Known allergy?
- ☐ No
- ☐ Yes

Difficult airway or aspiration risk?
- ☐ No
- ☐ Yes, and equipment/assistance available

Risk of > 500 ml blood loss (7 ml/kg in children?)
- ☐ No
- ☐ Yes, and two IVs/central access and fluids planned

Before skin incision
(with nurse, anaesthetist and surgeon)

- ☐ **Confirm all team members have introduced themselves by name and role.**
- ☐ **Confirm the patient's name, procedure, and where the incision will be made.**

Has antibiotic prophylaxis been given within the last 60 minutes?
- ☐ Yes
- ☐ Not applicable

Anticipated Critical Events
To Surgeon:
- ☐ What are the critical or non-routine steps?
- ☐ How long will the case take?
- ☐ What is the anticipated blood loss?

To Anaesthetist:
- ☐ Are there any patient-specific concerns?

To Nursing Team:
- ☐ Has sterility (including indicator results) been confirmed?
- ☐ Are there equipment issues or any concerns?

Is essential imaging displayed?
- ☐ Yes
- ☐ Not applicable

Before patient leaves operating room
(with nurse, anaesthetist and surgeon)

Nurse Verbally Confirms:
- ☐ The name of the procedure
- ☐ Completion of instrument, sponge and needle counts
- ☐ Specimen labelling (read specimen labels aloud, including patient name)
- ☐ Whether there are any equipment problems to be addressed

To Surgeon, Anaesthetist and Nurse:
- ☐ What are the key concerns for recovery and management of this patient?

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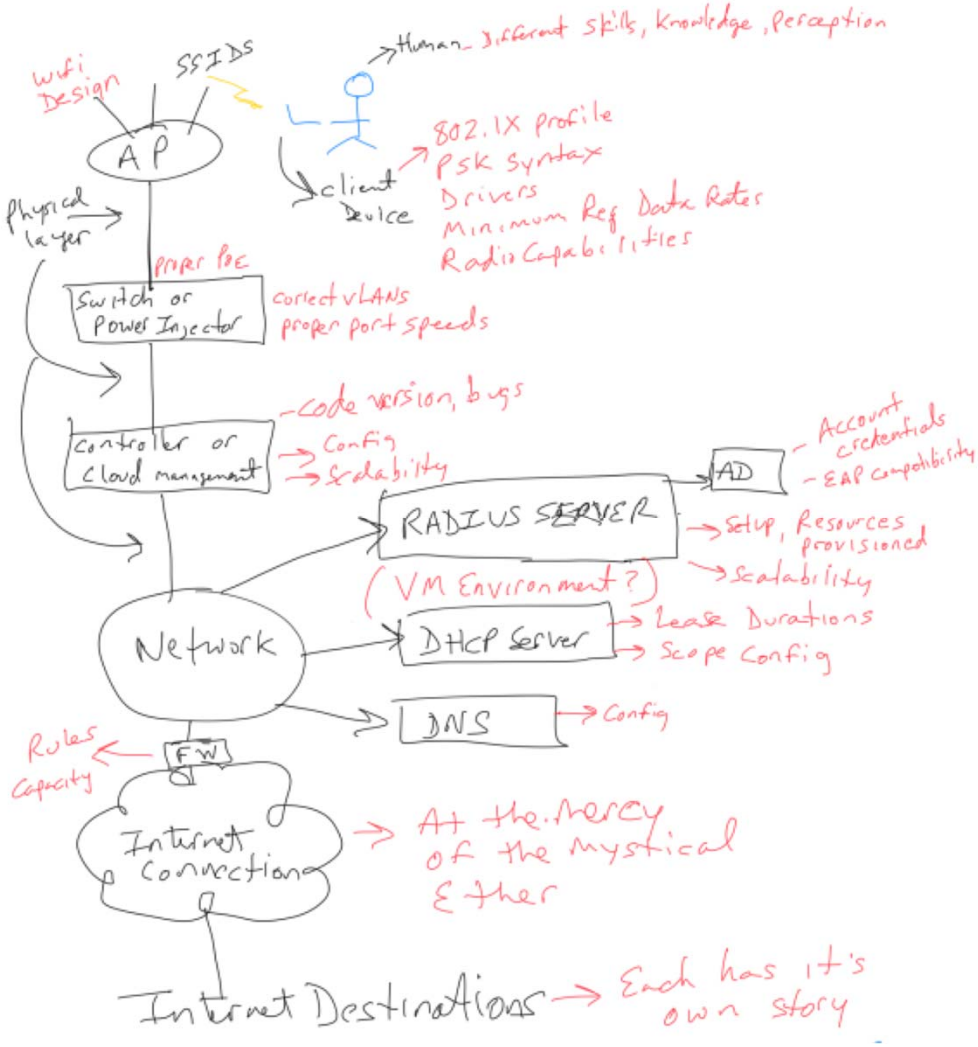
Lee Badman

The Soon To Be Famous

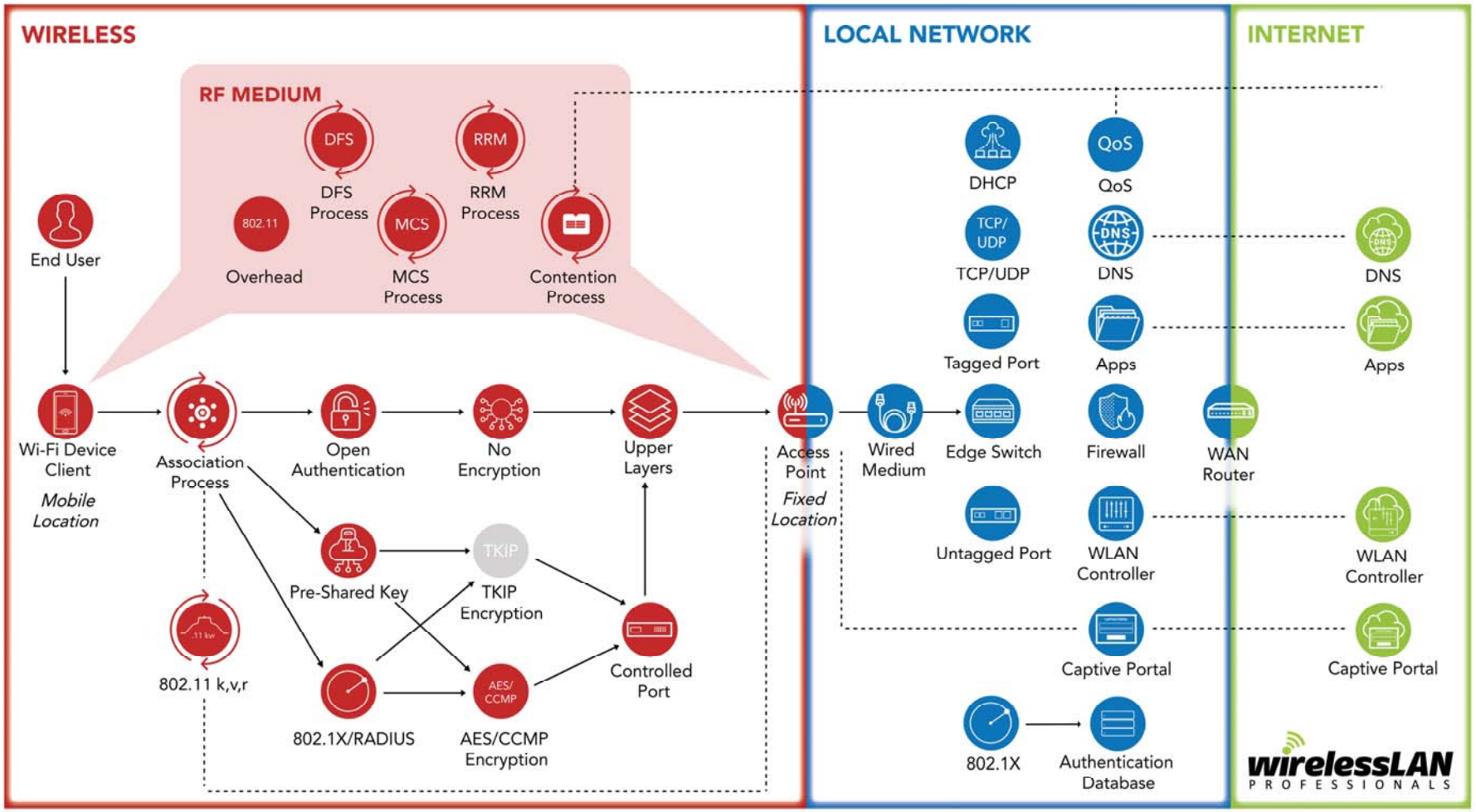
Cocktail Napkin

Wi-Fi Big Picture

March 19, 2016



WIRELESS LAN TROUBLESHOOTING - POTENTIAL CAUSES



Potential Wireless LAN Troubleshooting Causes

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	Wired/Wireless	Location	Potential Issues
1	**Wireless**	End User	Skills, Knowledge Perceptions, Device on/off, Understanding of Concepts & Device capabilities, Wi-Fi vs Cellular
2	*Mobile*	Wi-Fi Client Device	Drivers, Radio Capabilities, Profiles, Supported PHY, QoS, Power Save, Applications, Location, Vendor IE Support, Chipset Behavior, Roaming Algorithms, Auto-Negotiated MCS, MDM, Protection
3		RF Media	RSSI, SNR, SNiR, Primary & Secondary Coverage, CCI/ACI, Retry Rates, Average MCS, Jitter, Latency, Consistency, Regulatory Domains, Non-Wi-Fi Interference, Spectrum Analysis
4	Per Frame Tx	Contention Process	Preamble Detect, Energy Detect, Triggers, NAV Timers, TxOP, AIFS, Random Slots, QoS, WMM, Duration ID, Ch Capacity, Non-Wi-Fi Inteference
5	Per Frame Tx	MCS Process	Per Frame Decisions - Modulation Technique, Coding Technique, Ch Width, Guard Interval, Spatial Streams, Tx Power, ACK vs No ACK, TX decides
6	Per Time	Radio Resource Mgmt	Per Period Decisions - Channel, Tx Power, CCI, ACI, Noise, Duty Cycle, Retry Rates, CRC's, Load, Ch Width, DFS, User Traffic, Reg Domain, KPI's, Thresholds, Neighbor Discovery, Interference, Timing
7	Per Time	DFS Process	802.11 is NOT primary User - AP Scans for 60-Seconds, AP Enabled, Continuos Scanning, If RADAR detected, send CSA, Change to new CH, After 30-min can return, after 60-second scan
8	Per Frame Tx	Single Frame on RF	Overhead to delivery IP Payload - AIFS, CW, BPSK Preamble, RTS, SIFS, Preamble BPSK, CTS, SIFS, Preamble, Preamble VHT, Header MBR, Payload PHY rate, CRC, SIFS, Preamble, ACK
9	Per Timers	Association Process	Beacon, Probe Request, Probe Reponse, Authentication Request, Authentication Response, Association Request, Association Response, Decide on which AP by: RSSI, SNR, Auth Method, Encrypt Method, Channel Switch Announcement, Error Ratios, MCS/Data Rates Supported, Heuristics, Internal Lists, De-Authentication, Dis-Associate, 802.11 k, v, r, MBR, Proprietary Methods!
10		802.11 k, v, r	AP's try to influence the roaming decisions via 'standard' modes
11	Per Changes	Authentication Process	Open, Pre-Shared Key, 802.1X RADIUS, PSK includes Exchange of 4-Way Handshake to trigger Encryption Keys, 802.1X EAP Exchange, ending in 4-Way Handshake
12		Encrytion Process	None, TKIP, AES/CCMP, Punishment for using TKIP, Confusion with Wi-Fi Alliance naming - WPA2 PSK… is PSK-WPA2
13	From LAN	Upper Layers	DHCP, IP , DNS, VLAN, Subnet Mask, Default Gateway, Captive Portal
14		Controlled Port	AP Controls which 802.11 Frames can cross Wireless to Wired Boundary
15	*Fixed*	Access Point	Configurations, SSIDs, Minimum Basic Rates, Supported PHY Rates, Band Steering, Client Control, Radio Capabilities, Tx Rates, Client Isolation, Roaming, QOS PoE, Antenna Pattern, Mounting, 1GB backhaul limit, AP Locations, Physcial Layer Issues, Firmware Revisions, Custom Configurations, RRM/ARM, Proprietary
16	**Local Network**	Wired Medium	EIA/TIA 568A/B, Category Mismatch, Validation Tests, Grounding, other issues
17		Edge Switch	VLANs, Port Speeds, PoE, Configurations, QoS, End-to-End?, COS vs DSCP
18		Local Network	Distributed vs Centralized Forwarding, ACLs, VLANs, QoS, Tunnels, Layers, NAT
19		TCP/UDP	Following all TCP issues as well as UDP reasons for using each
20		Quality of Service	Tagged Port vs Untagged Port, DSCP, WMM Categories, End-to-End QoS
21		Applicatons	MTU, TCP Window, Round Trip Time, Processing Time, TCP Retransmission times
22		DHCP Server	Lease Durations, Configurations, Broadcast Storms, Latency, Performance, Address Pool Scopes, Scalability, DHCP Options, Auto Renew
23		DNS	Configuration, Scalability, Security, Accuracy, Customization, Control, Blacklists
24		802.1X/RADIUS	Configuration, Ports, Ranges, Licensing Issues, EAP types, Custom VSA, Scalability, Resouces, Certificate Issues, Fast/Secure Roaming types
25		Active Directory	Accounts, Credentials, EAP Compatibility, Custom RADIUS Attributes
26		Controller Functions	Code Versions, Bugs, Configurations, Local vs Cloud, Licensing Issues, Distributed vs Centralized Forwarding, VLAN choices
27		Firewall	Firewall Rules, Capacity, Compatibility, Rate Limiting, Bandwidth Shaping
28		WAN Router	Size of Internet Pipe, Inernet Destination Issues, Costs, Availability, Consistency
29	**Internet**	Internet Connection	Bandwidth Throttling, Jitter, Latency
30		Captive Portal	Security, Client Issues, Privacy, Friction, Triggers, Certificates, DNS, Captive Portal Location, Control, Monetization, Legal, MiFi

Wireless LAN Troubleshooting

ekahau UNIVERSITY

ecse TROUBLESHOOTING

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ekahau WIRELESS DESIGN

Tools Used in ECSE-Troubleshooting Course

Free
Wireshark, Kismet, Bettercap, HORST, Client Profiler, iPerf, HTML Tests

Low Cost
Wi-Fi Analyzer Pro, WLAN Pi, Netool.IO, Apps

Professional
Ekahau Pro v.10, Ekahau Sidekick,

Wireless LAN Troubleshooting Process

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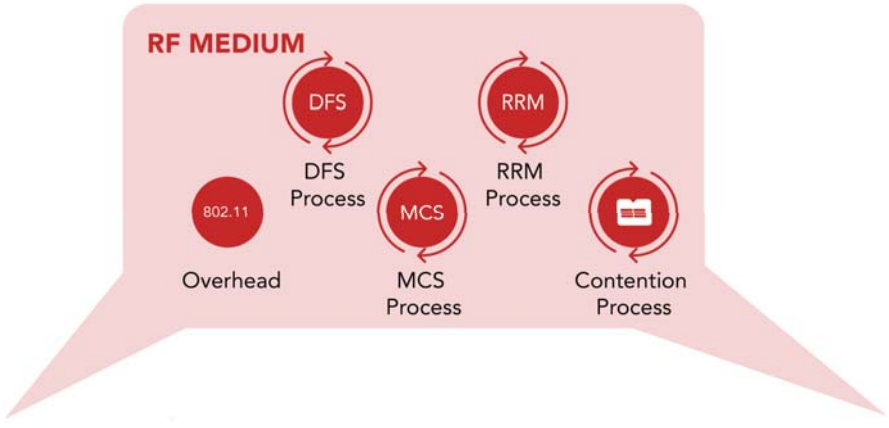
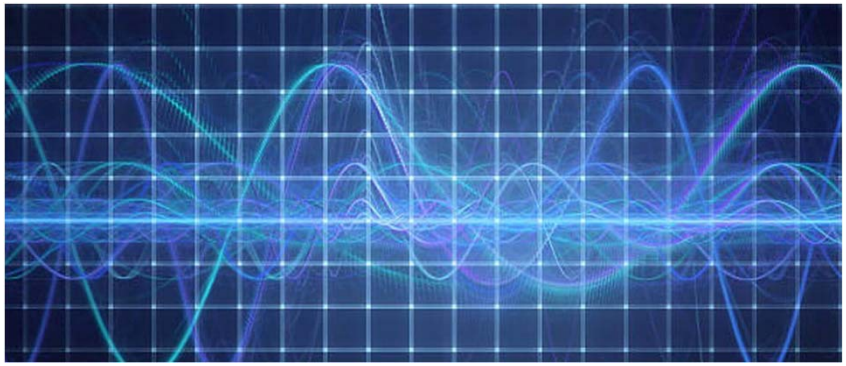
Radio Frequency Medium





- Adjacent Channel Interference
- Automated Channel Planning
- Average Data Rates
- Average MCS
- Channel Occupancy
- Co-Channel Contention/CCI
- Consistency
- Jitter
- Latency
- Multipath
- Non-Wi-Fi Interference
- Regulatory Domains
- Retry Rates
- Spatial Streams
- Spectrum Analysis

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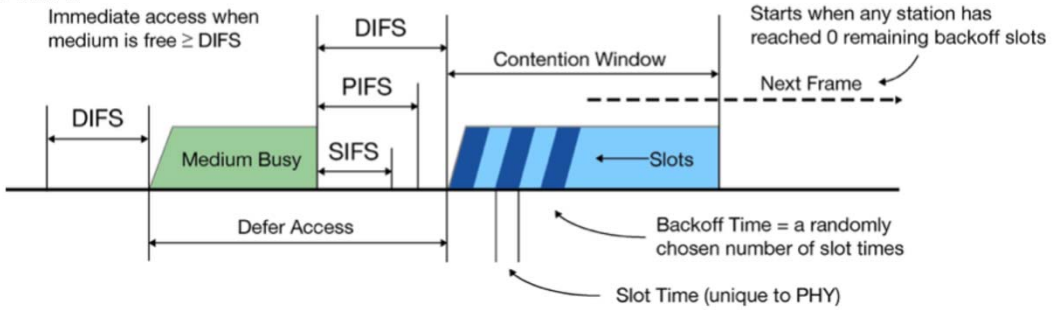
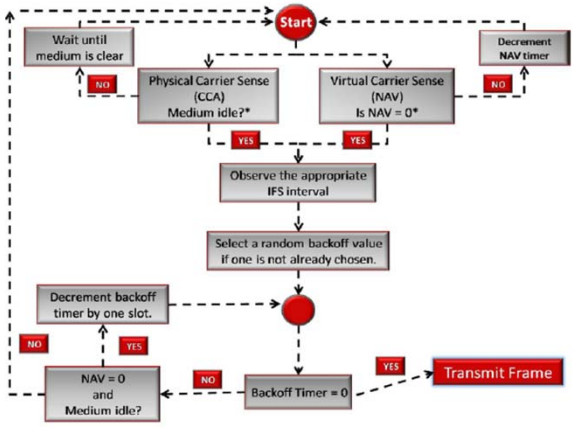
Contention Process

- How to Access RF Medium
- AKA - "The Game"
- Preamble Detect
- Energy Detect
- Transmit Opportunity TxOp
- Wait Time
- Random Slots (CW)
- QoS
- Duration ID





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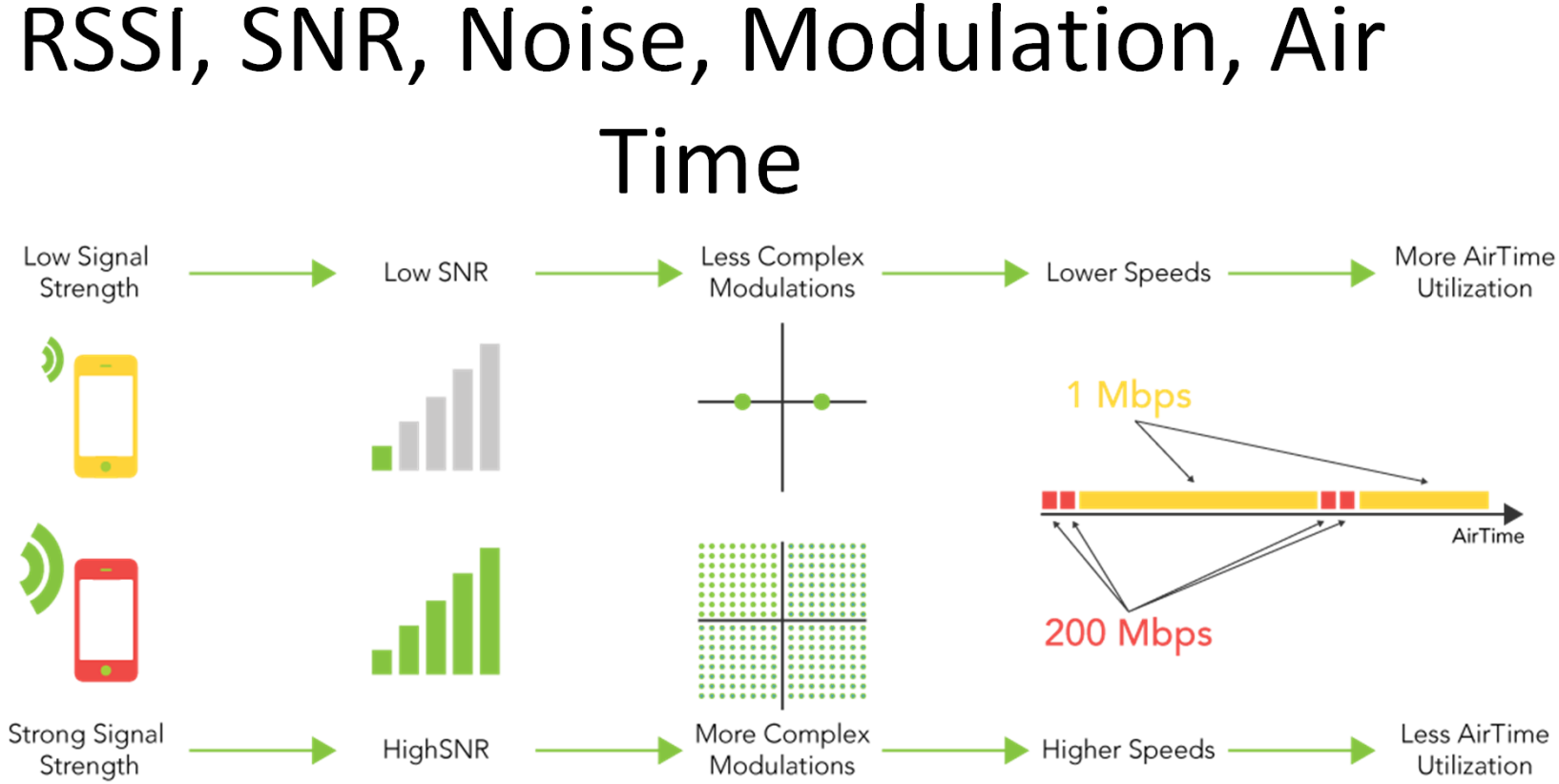
RSSI, SNR, Noise, Modulation, Air Time



802.11n and 802.11ac MCS, SNR and RSSI

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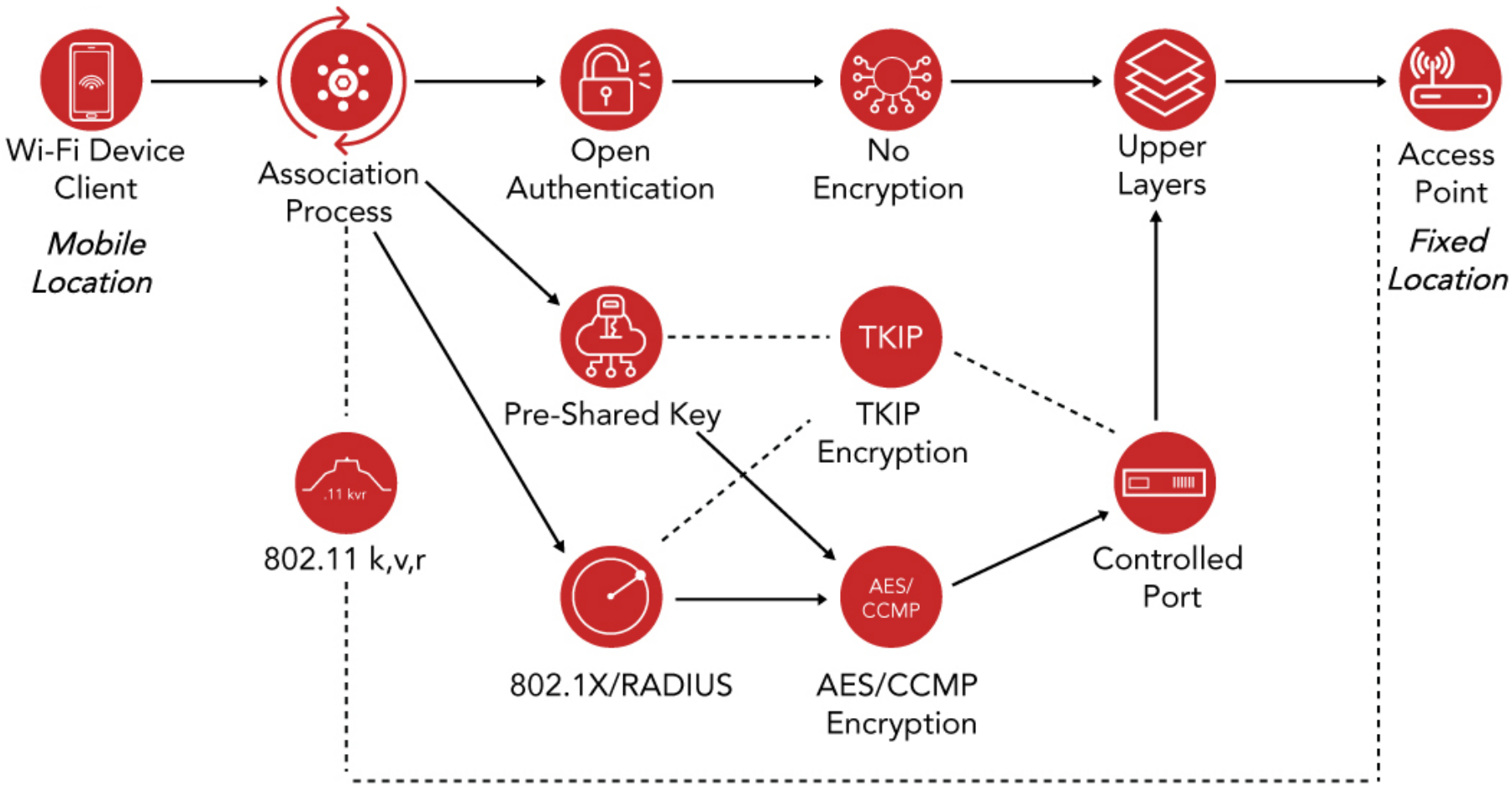
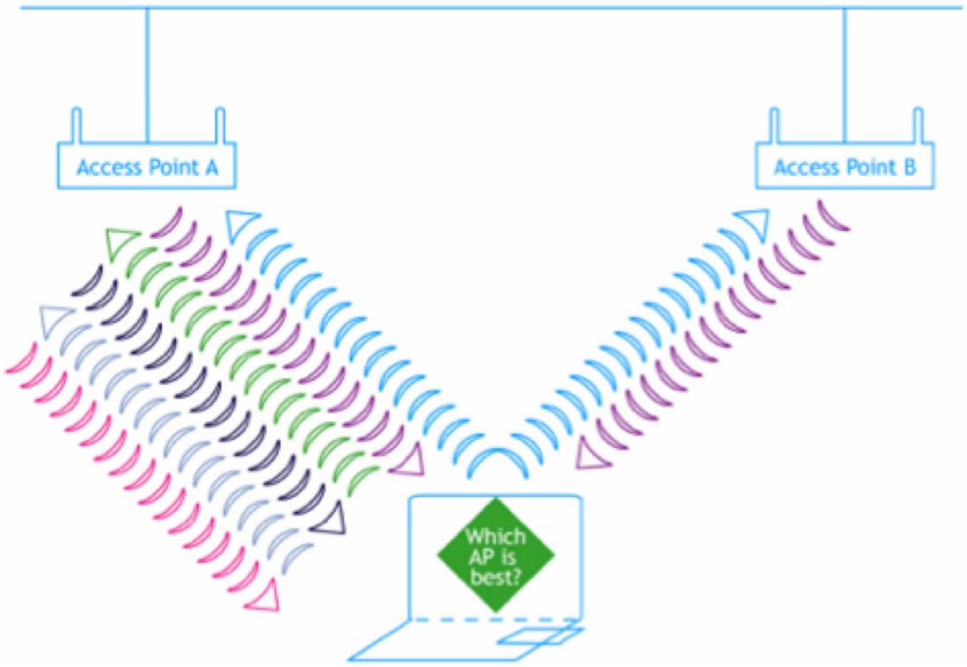
HT MCS	VHT MCS	Modulation	Coding	20MHz				40MHz				80MHz				160MHz			
				Data Rate		Min. SNR	RSSI	Data Rate		Min. SNR	RSSI	Data Rate		Min. SNR	RSSI	Data Rate		Min. SNR	RSSI
				800ns	400ns			800ns	400ns			800ns	400ns			800ns	400ns		
1 Spatial Stream																			
0	0	BPSK	1/2	6.5	7.2	2	-82	13.5	15	5	-79	29.3	32.5	8	-76	58.5	65	11	-73
1	1	QPSK	1/2	13	14.4	5	-79	27	30	8	-76	58.5	65	11	-73	117	130	14	-70
2	2	QPSK	3/4	19.5	21.7	9	-77	40.5	45	12	-74	87.8	97.5	15	-71	175.5	195	18	-68
3	3	16-QAM	1/2	26	28.9	11	-74	54	60	14	-71	117	130	17	-68	234	260	20	-65
4	4	16-QAM	3/4	39	43.3	15	-70	81	90	18	-67	175.5	195	21	-64	351	390	24	-61
5	5	64-QAM	2/3	52	57.8	18	-66	108	120	21	-63	234	260	24	-60	468	520	27	-57
6	6	64-QAM	3/4	58.5	65	20	-65	121.5	135	23	-62	263.3	292.5	26	-59	526.5	585	29	-56
7	7	64-QAM	5/6	65	72.2	25	-64	135	150	28	-61	292.5	325	31	-58	585	650	34	-55
	8	256-QAM	3/4	78	86.7	29	-59	162	180	32	-56	351	390	35	-53	702	780	38	-50
	9	256-QAM	5/6			31	-57	180	200	34	-54	390	433.3	37	-51	780	866.7	40	-48
2 Spatial Streams																			
8	0	BPSK	1/2	13	14.4	2	-82	27	30	5	-79	58.5	65	8	-76	117	130	11	-73
9	1	QPSK	1/2	26	28.9	5	-79	54	60	8	-76	117	130	11	-73	234	260	14	-70
10	2	QPSK	3/4	39	43.3	9	-77	81	90	12	-74	175.5	195	15	-71	351	390	18	-68
11	3	16-QAM	1/2	52	57.8	11	-74	108	120	14	-71	234	260	17	-68	468	520	20	-65
12	4	16-QAM	3/4	78	86.7	15	-70	162	180	18	-67	351	390	21	-64	702	780	24	-61
13	5	64-QAM	2/3	104	115.6	18	-66	216	240	21	-63	468	520	24	-60	936	1040	27	-57
14	6	64-QAM	3/4	117	130.3	20	-65	243	270	23	-62	526.5	585	26	-59	1053	1170	29	-56
15	7	64-QAM	5/6	130	144.4	25	-64	270	300	28	-61	585	650	31	-58	1170	1300	34	-55
	8	256-QAM	3/4	156	173.3	29	-59	324	360	32	-56	702	780	35	-53	1404	1560	38	-50
	9	256-QAM	5/6			31	-57	360	400	34	-54	780	866.7	37	-51	1560	1733	40	-48
3 Spatial Streams																			
16	0	BPSK	1/2	19.5	21.7	2	-82	40.5	45	5	-79	87.8	97.5	8	-76	175.5	195	11	-73
17	1	QPSK	1/2	39	43.3	5	-79	81	90	8	-76	175.5	195	11	-73	351	390	14	-70
18	2	QPSK	3/4	58.5	65	9	-77	121.5	135	12	-74	263.3	292.5	15	-71	526.5	585	18	-68
19	3	16-QAM	1/2	78	86.7	11	-74	162	180	14	-71	351	390	17	-68	702	780	20	-65
20	4	16-QAM	3/4	117	130	15	-70	243	270	18	-67	526.5	585	21	-64	1053	1170	24	-61
21	5	64-QAM	2/3	156	173.3	18	-66	324	360	21	-63	702	780	24	-60	1404	1560	27	-57
22	6	64-QAM	3/4	175.5	195	20	-65	364.5	405	23	-62			26	-59	1580	1755	29	-56
23	7	64-QAM	5/6	195	216.7	25	-64	405	450	28	-61	877.5	975	31	-58	1755	1950	34	-55
	8	256-QAM	3/4	234	260	29	-59	486	540	32	-56	1053	1170	35	-53	2106	2340	38	-50
	9	256-QAM	5/6	260	288.9	31	-57	540	600	34	-54	1170	1300	37	-51			40	-48

MCS Process


Wi-Fi Device Client
Mobile Location
Association Process
Open Authentication
No Encryption
Upper Layers
Access Point
Fixed Location
Pre-Shared Key
TKIP
TKIP Encryption
.11 kvr
802.11 k,v,r
802.1X/RADIUS
AES/ CCMP
AES/CCMP Encryption
Controlled Port

“Green Diamond” Association/Roaming Algorithms



- SSID
- RSSI
- SNR
- Authentication Method
- Channel Switch Announcements
- De-Authentication Frame
- Dis-Association Frame
- Encryption Methods
- Error Ratios
- Heuristics
- Internal Lists - White/Grey/Black
- MCS/Data Rate
- Minimum Basic Rate
- Supported Data Rates
- 802.11k, 802.11r, 802.11v

Association Process

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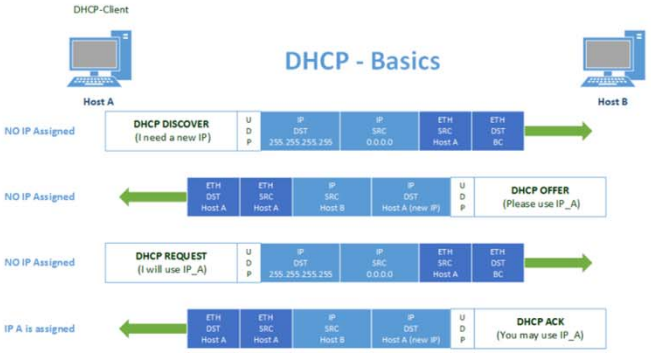
Upper Layers

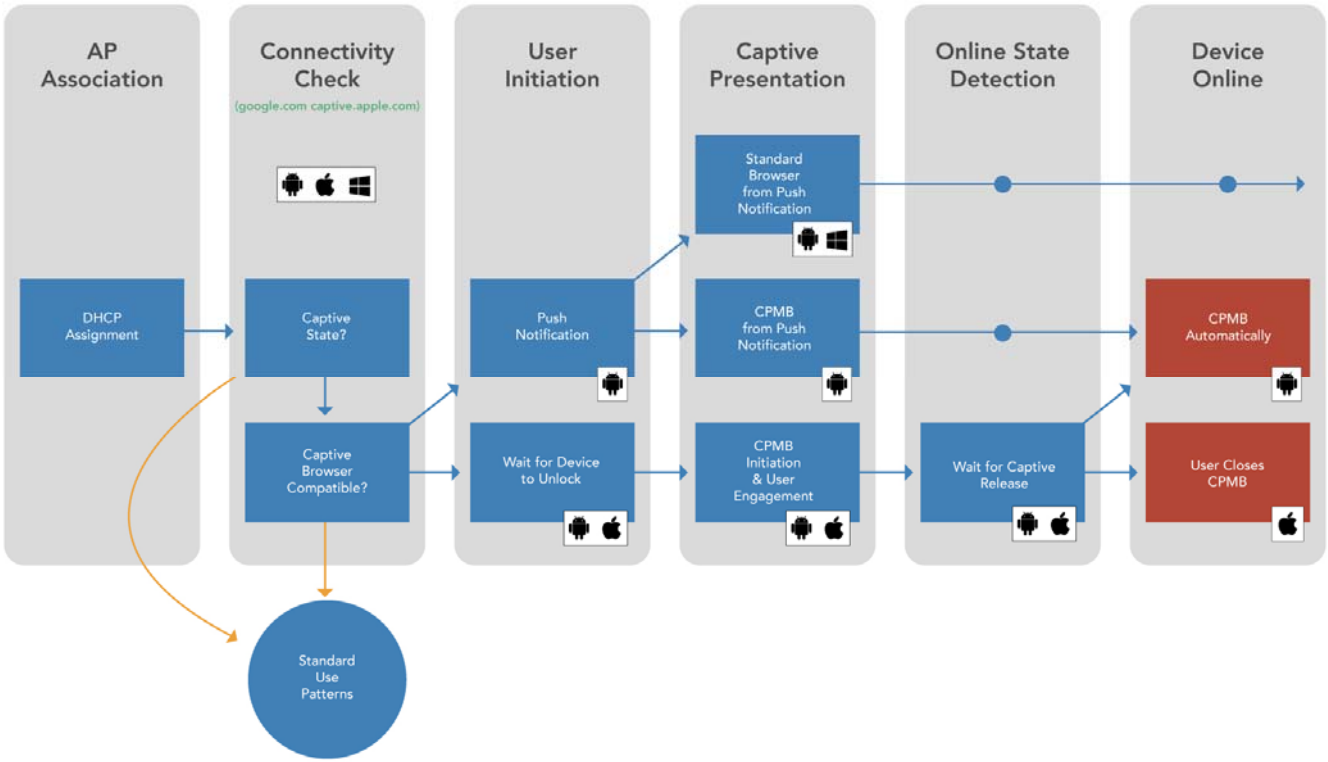
- VLAN Assignment
- DHCP (Request/Response)
- Subnet Mask
- Default Gateway
- DNS
- Captive Portal ?



Captive Portal

Captive Portal

- Captive Portal Location
- Certificate Issue
- Client Issues
- Control
- Encrypted DNS
- Friction
- Legal Issues
- Mi-Fi Issues
- Monetization
- Privacy Issues
- Triggers



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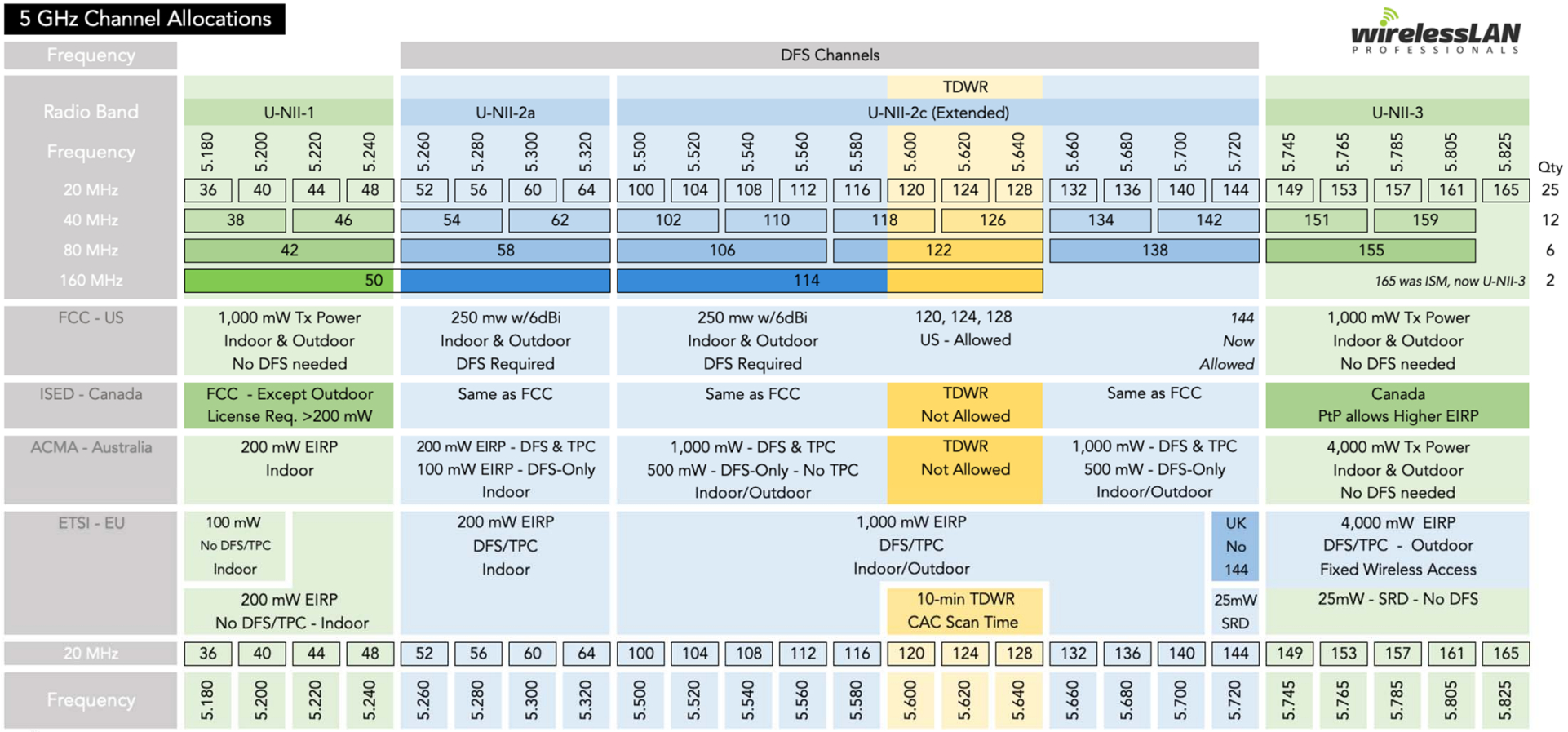
5GHz Channels



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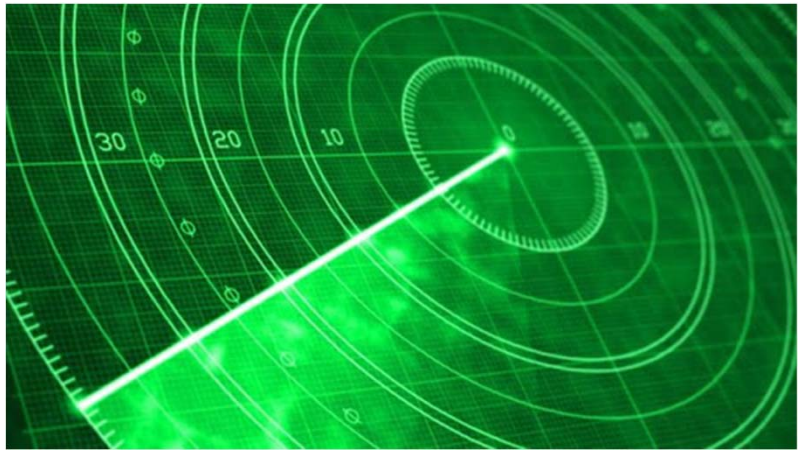
DFS Channels

DFS Process

802.11 is NOT Primary User

- AP Scans for 60-Seconds
- AP Enabled on Channel
- Continuous Scanning
- If Radar Detected
- Send Channel Switch Announcement
- Change to New Channel
- After 30-Min Can Return
- After 60-Second Scan
- Repeat

- Check your regulatory domain for details!



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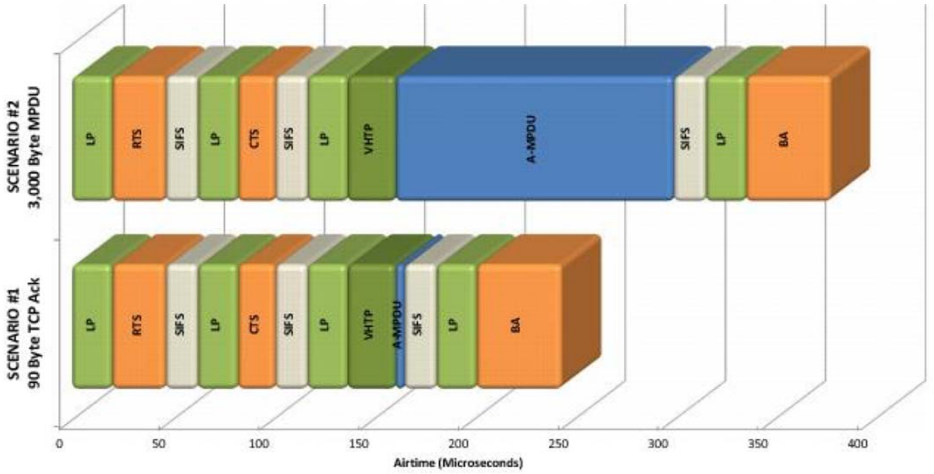
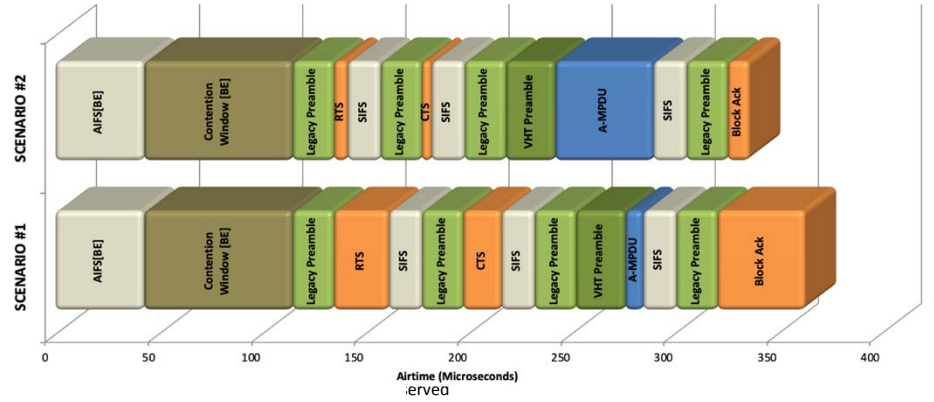
Sample Single Frame Transmission

802.11

Overhead

- AIFS - Arbitration Inter-frame Space
- Contention Window (CW)
- Preamble - BPSK
- RTS - Lowest Basic
- SIFS - Fixed Tme
- Preamble - BPSK
- CTS - Lowest Basic
- SIFS - Fixed Tme
- Preamble - BPSK
- Preamble - VHT
- Header - MBR
- Payload - PHY Rate
- CRC
- SIFS - Fixed Tme
- Preamble - BPSK
- ACK - MBR



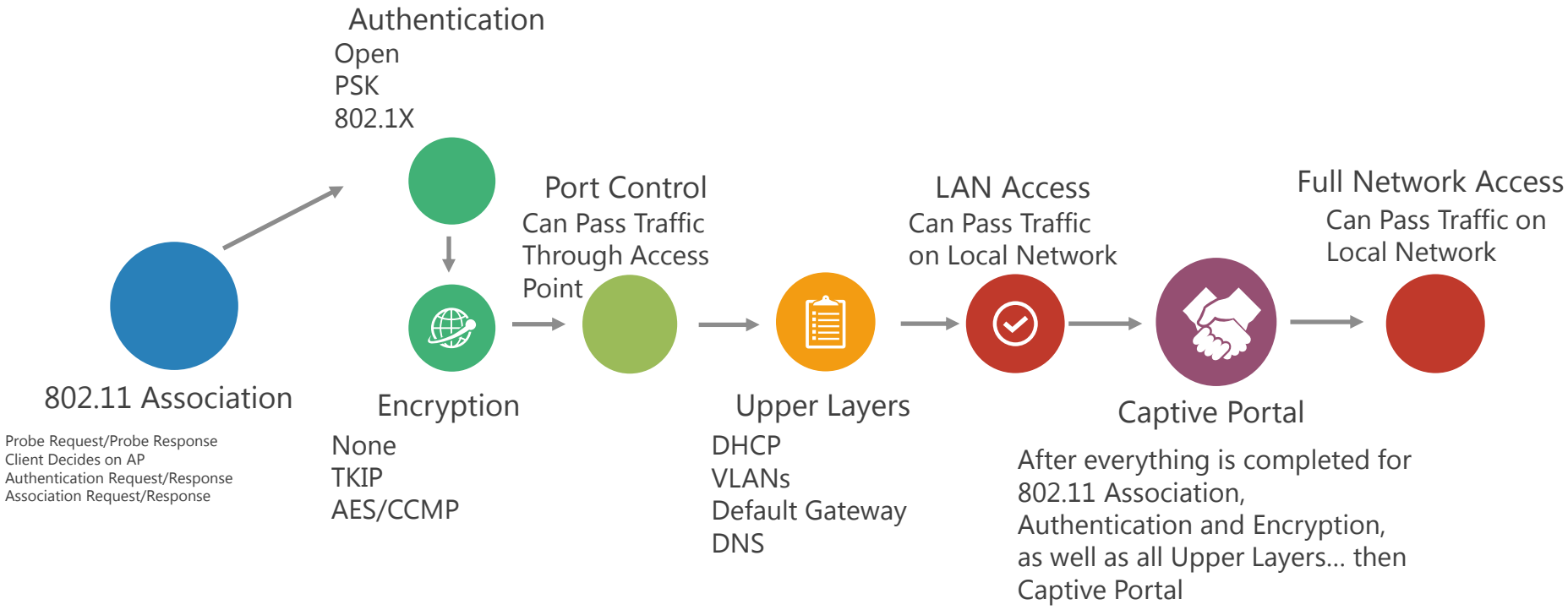


Association is to Wireless

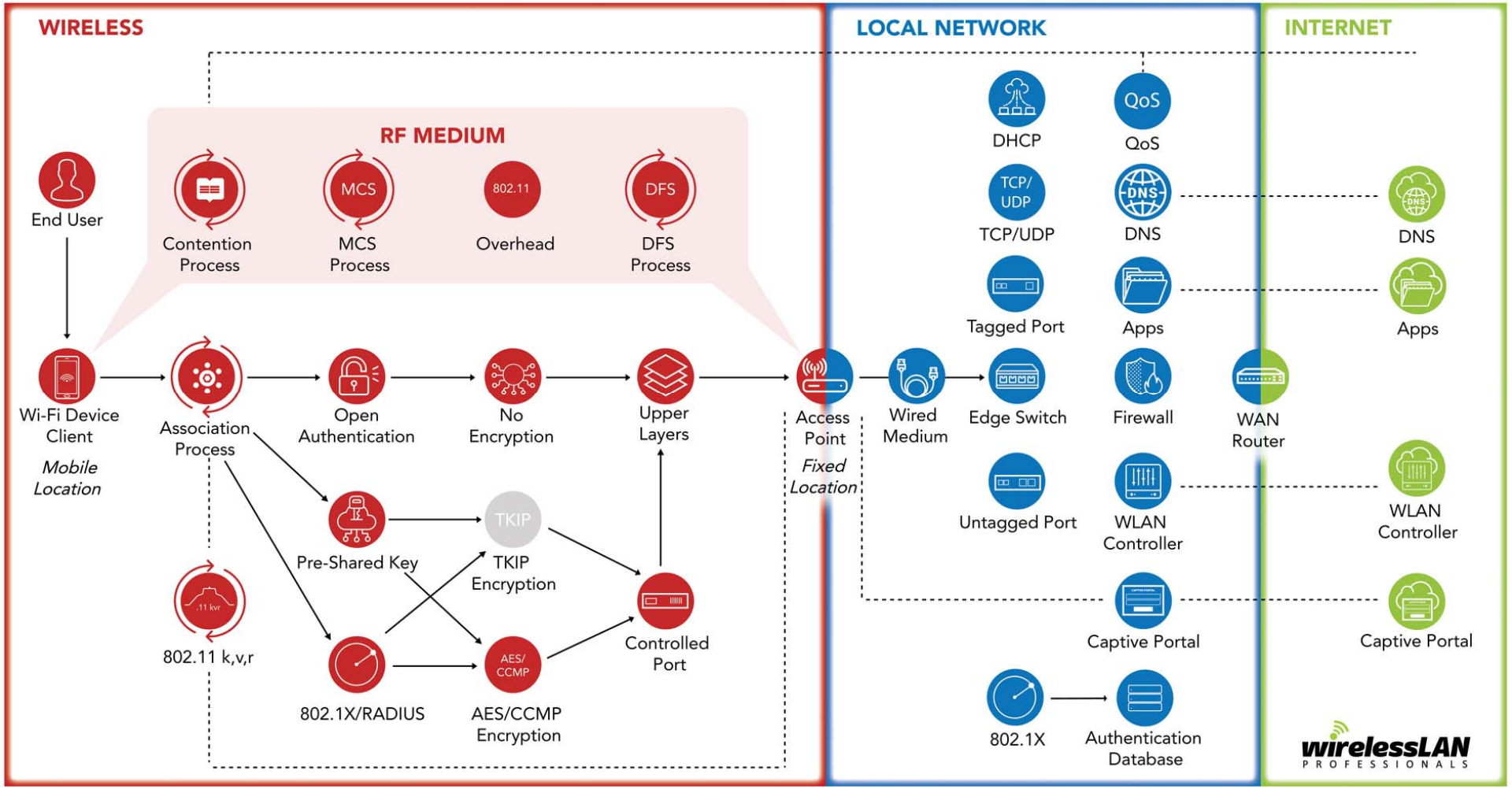
what a

Link Light is to Wired

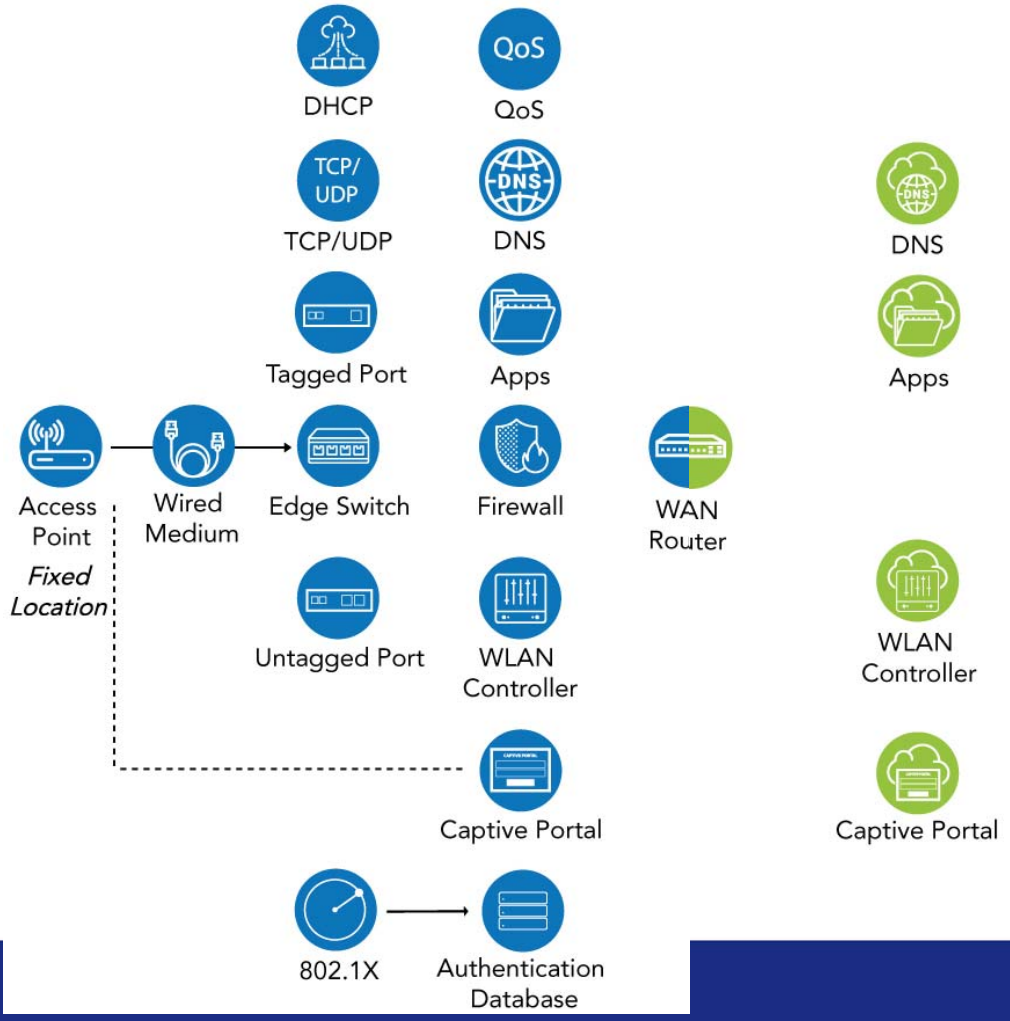
Wi-Fi Client Joining WLAN



Potential Wireless LAN Troubleshooting Causes

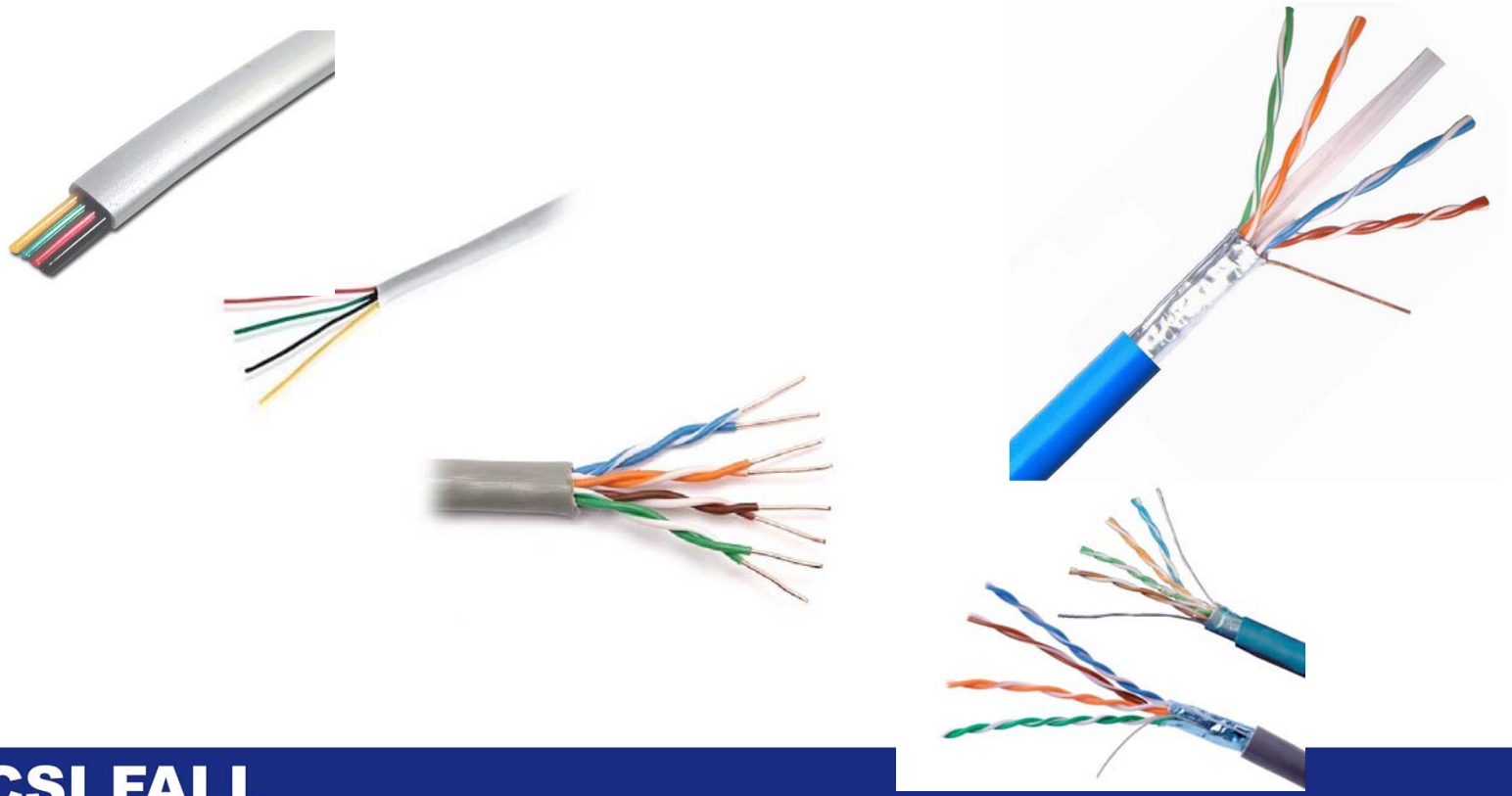


Local Network and Internet

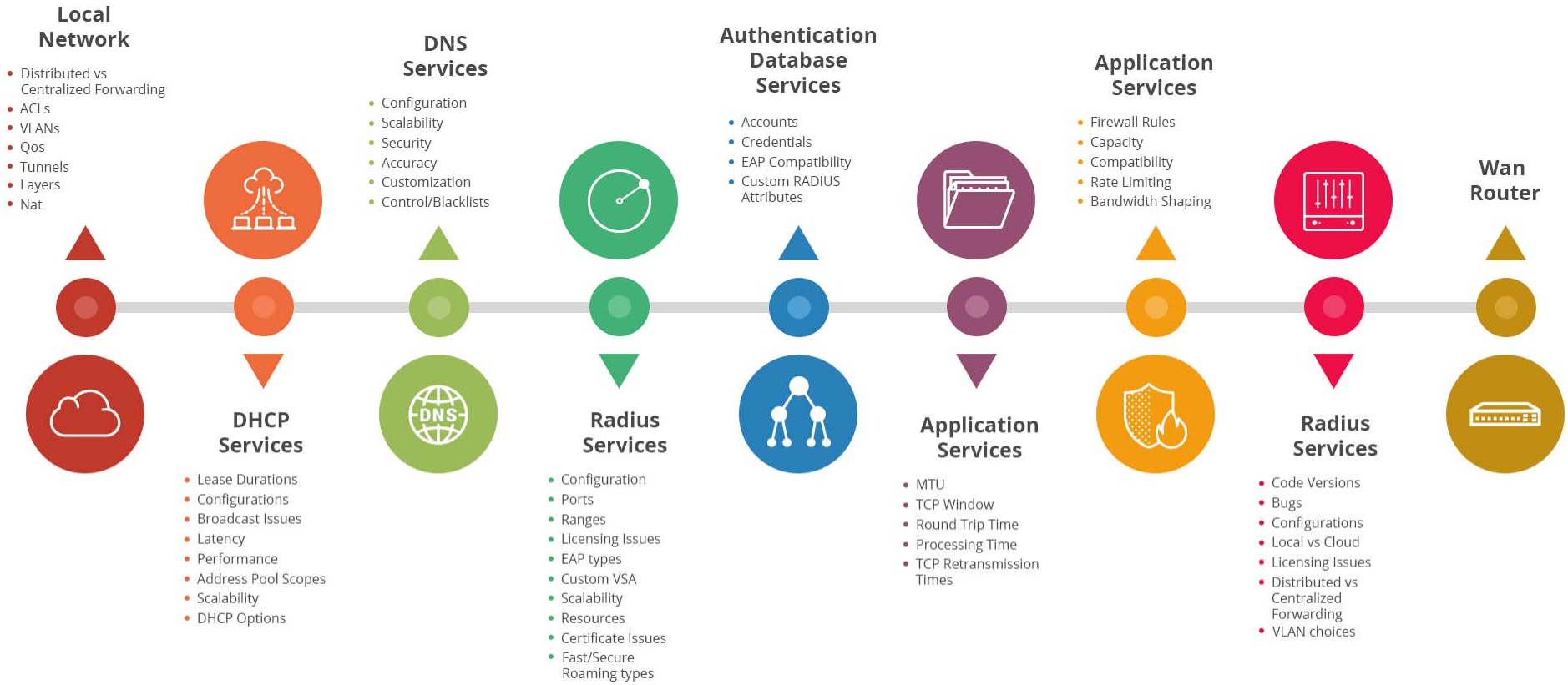


Evolution in Cabling

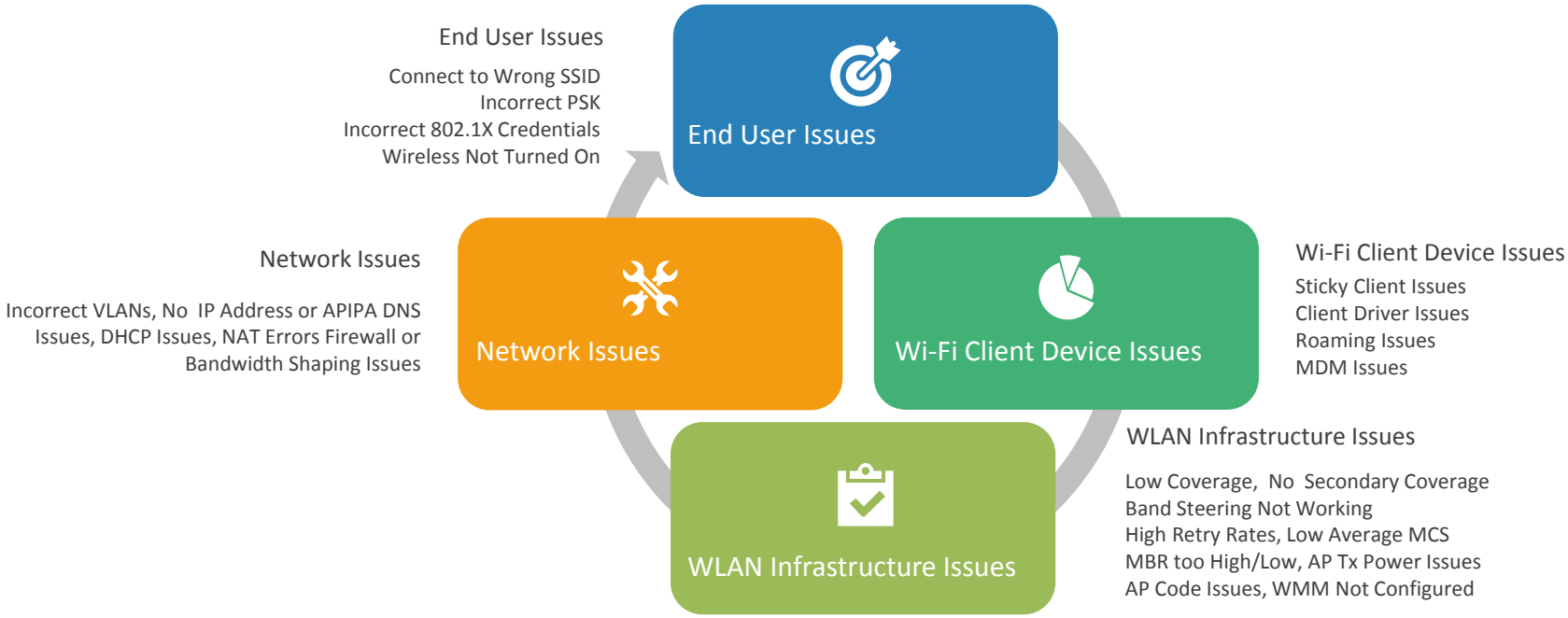
Wired Medium



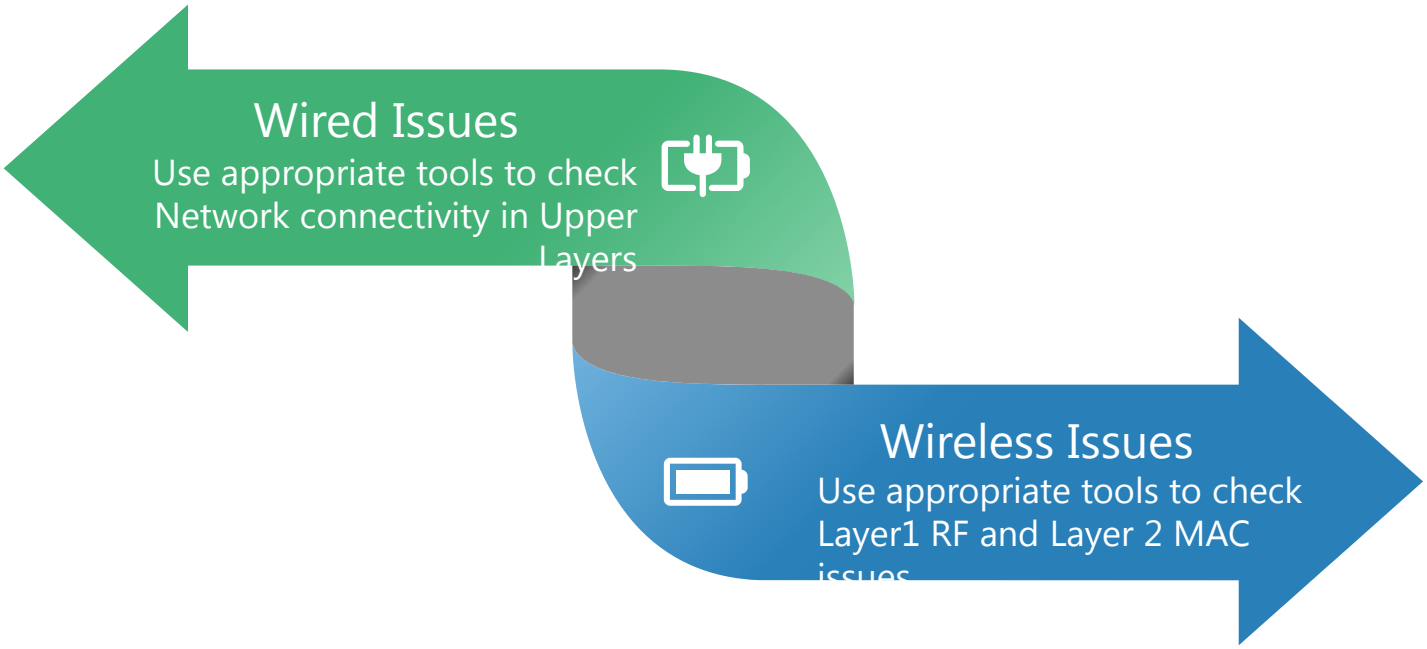
LOCAL NETWORK SERVICES



Survey Says: Top Wireless Issues



Wired vs Wireless

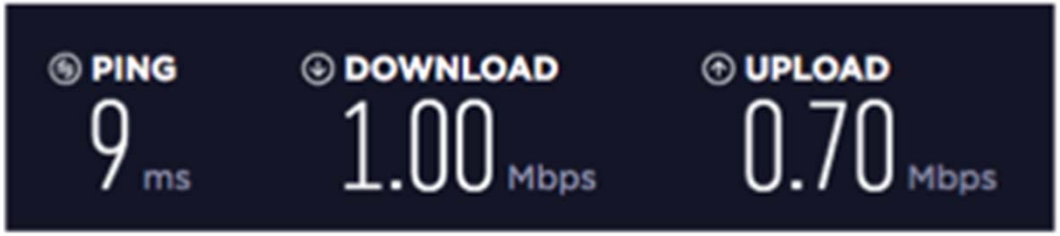


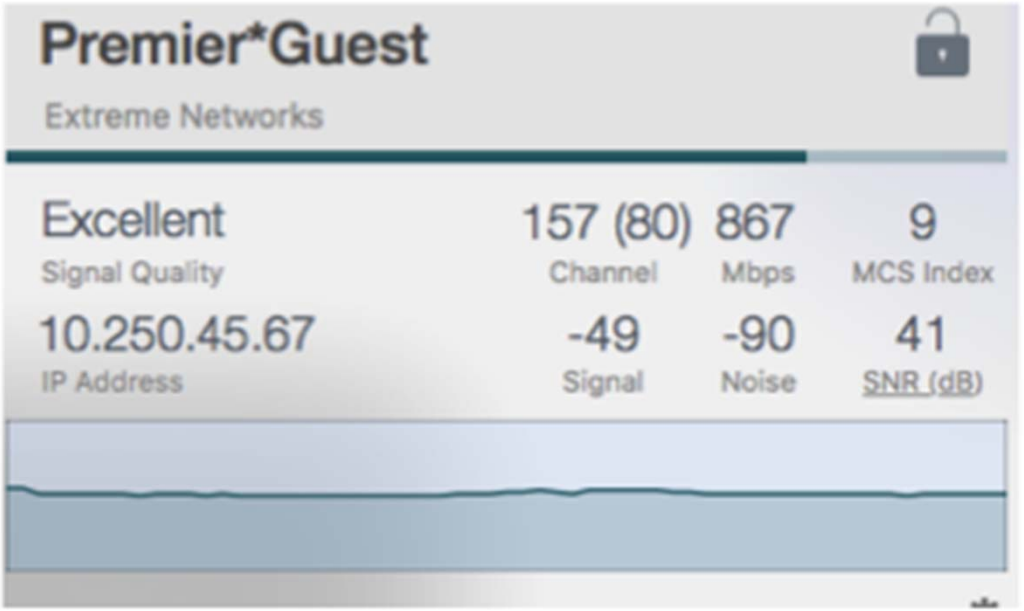
Wired or Wireless Problem?

- **IP Address**
  - Does target Wi-Fi Client Devices have an IP Address?
- **Ping Wi-Fi Client**
  - Can you Ping your Wi-Fi Client Device from the Wired Network?
- **MCS of Wi-Fi Client**
  - Is the MCS of Wi-Fi client showing stress
  - MCS 5-9 means 64-QAM or Better
  - MCS of <5 means difficulty over RF

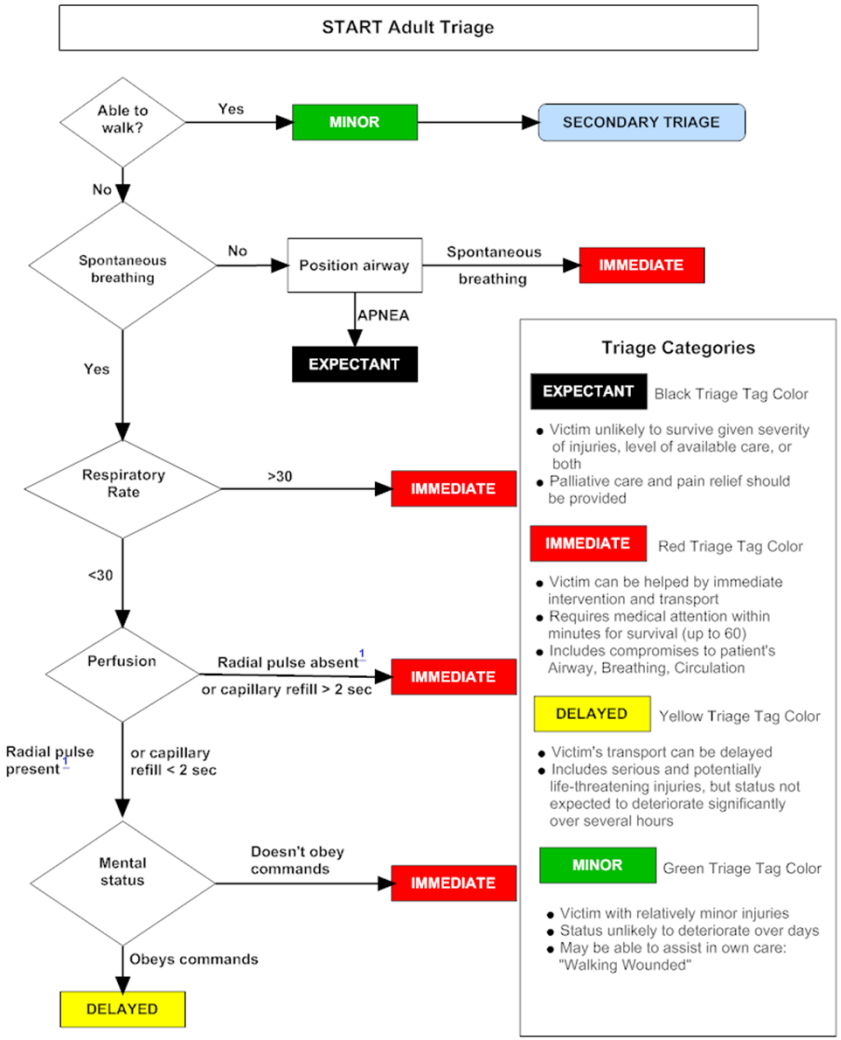
- **Compare Throughputs**
  - Compare Wi-Fi connection data rate to Internet Speed Test
- **Check RSSI & SNR**
  - Both from the Client's point of view as well as from the Access Points'
- **Isolated?**
  - Is the issues isolated to only Wi-Fi devices or across network
  - Especially check network services

Wi-Fi Signal Demo Lab



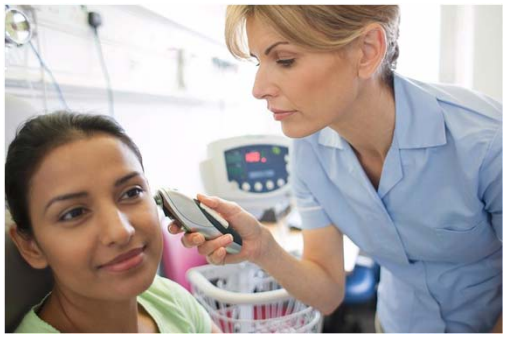


Doctor’s Visit / Triage



Blood Pressure - **Channel Utilization**

Pulse - **Retry Rates**



Temperature - **MCS Rates**

802.11n and 802.11ac MCS, SNR and RSSI

wirelessLAN PROFESSIONALS

HT MCS	VHT MCS	Modulation	Coding	20MHz				40MHz				80MHz				160MHz			
				Data Rate		Min. SNR	RSSI	Data Rate		Min. SNR	RSSI	Data Rate		Min. SNR	RSSI	Data Rate		Min. SNR	RSSI
				800ns	400ns			800ns	400ns			800ns	400ns			800ns	400ns		
1 Spatial Stream																			
0	0	BPSK	1/2	6.5	7.2	2	-82	13.5	15	5	-79	29.3	32.5	8	-76	58.5	65	11	-73
1	1	QPSK	1/2	13	14.4	5	-79	27	30	8	-76	58.5	65	11	-73	117	130	14	-70
2	2	QPSK	3/4	19.5	21.7	9	-77	40.5	45	12	-74	87.8	97.5	15	-71	175.5	195	18	-68
3	3	16-QAM	1/2	26	28.9	11	-74	54	60	14	-71	117	130	17	-68	234	260	20	-65
4	4	16-QAM	3/4	39	43.3	15	-70	81	90	18	-67	175.5	195	21	-64	351	390	24	-61
5	5	64-QAM	2/3	52	57.8	18	-66	108	120	21	-63	234	260	24	-60	468	520	27	-57
6	6	64-QAM	3/4	58.5	65	20	-65	121.5	135	23	-62	263.3	292.5	26	-59	526.5	585	29	-56
7	7	64-QAM	5/6	65	72.2	25	-64	135	150	28	-61	292.5	325	31	-58	585	650	34	-55
	8	256-QAM	3/4	78	86.7	29	-59	162	180	32	-56	351	390	35	-53	702	780	38	-50
	9	256-QAM	5/6			31	-57	180	200	34	-54	390	433.3	37	-51	780	866.7	40	-48
2 Spatial Streams																			
8	0	BPSK	1/2	13	14.4	2	-82	27	30	5	-79	58.5	65	8	-76	117	130	11	-73
9	1	QPSK	1/2	26	28.9	5	-79	54	60	8	-76	117	130	11	-73	234	260	14	-70
10	2	QPSK	3/4	39	43.3	9	-77	81	90	12	-74	175.5	195	15	-71	351	390	18	-68
11	3	16-QAM	1/2	52	57.8	11	-74	108	120	14	-71	234	260	17	-68	468	520	20	-65
12	4	16-QAM	3/4	78	86.7	15	-70	162	180	18	-67	351	390	21	-64	702	780	24	-61
13	5	64-QAM	2/3	104	115.6	18	-66	216	240	21	-63	468	520	24	-60	936	1040	27	-57
14	6	64-QAM	3/4	117	130.3	20	-65	243	270	23	-62	526.5	585	26	-59	1053	1170	29	-56
15	7	64-QAM	5/6	130	144.4	25	-64	270	300	28	-61	585	650	31	-58	1170	1300	34	-55
	8	256-QAM	3/4	156	173.3	29	-59	324	360	32	-56	702	780	35	-53	1404	1560	38	-50
	9	256-QAM	5/6			31	-57	360	400	34	-54	780	866.7	37	-51	1560	1733	40	-48
3 Spatial Streams																			
16	0	BPSK	1/2	19.5	21.7	2	-82	40.5	45	5	-79	87.8	97.5	8	-76	175.5	195	11	-73
17	1	QPSK	1/2	39	43.3	5	-79	81	90	8	-76	175.5	195	11	-73	351	390	14	-70
18	2	QPSK	3/4	58.5	65	9	-77	121.5	135	12	-74	263.3	292.5	15	-71	526.5	585	18	-68
19	3	16-QAM	1/2	78	86.7	11	-74	162	180	14	-71	351	390	17	-68	702	780	20	-65
20	4	16-QAM	3/4	117	130	15	-70	243	270	18	-67	526.5	585	21	-64	1053	1170	24	-61
21	5	64-QAM	2/3	156	173.3	18	-66	324	360	21	-63	702	780	24	-60	1404	1560	27	-57
22	6	64-QAM	3/4	175.5	195	20	-65	364.5	405	23	-62			26	-59	1580	1755	29	-56
23	7	64-QAM	5/6	195	216.7	25	-64	405	450	28	-61	877.5	975	31	-58	1755	1950	34	-55
	8	256-QAM	3/4	234	260	29	-59	486	540	32	-56	1053	1170	35	-53	2106	2340	38	-50
	9	256-QAM	5/6	260	288.9	31	-57	540	600	34	-54	1170	1300	37	-51			40	-48

MCS Process

Wireless LAN Troubleshooting Process

MANAGE
Vendor WMNS or 3rd-Party overlay systems to evaluate and supply pertinent data for WLAN Troubleshooting

INTERROGATE
Frame Captures for Wired and/or Wireless to understand details of Communication Flows

ANALYZE
Layer 1 Spectrum Analysis to evaluate both Modulated and Unmodulated Radio Frequency Interference

INVESTIGATE
Wi-Fi Scanners, Built-in Tools, CLI Commands, GUI Tools to evaluate Wi-Fi networks

MEASURE
Using performance/throughput testing on Wireless and Wired to document issues and where they exist

VALIDATE
Survey software to map RF Coverage, visualize RSSI, SNR, CCI, Capacity, and if WLAN meets ALL Requirements

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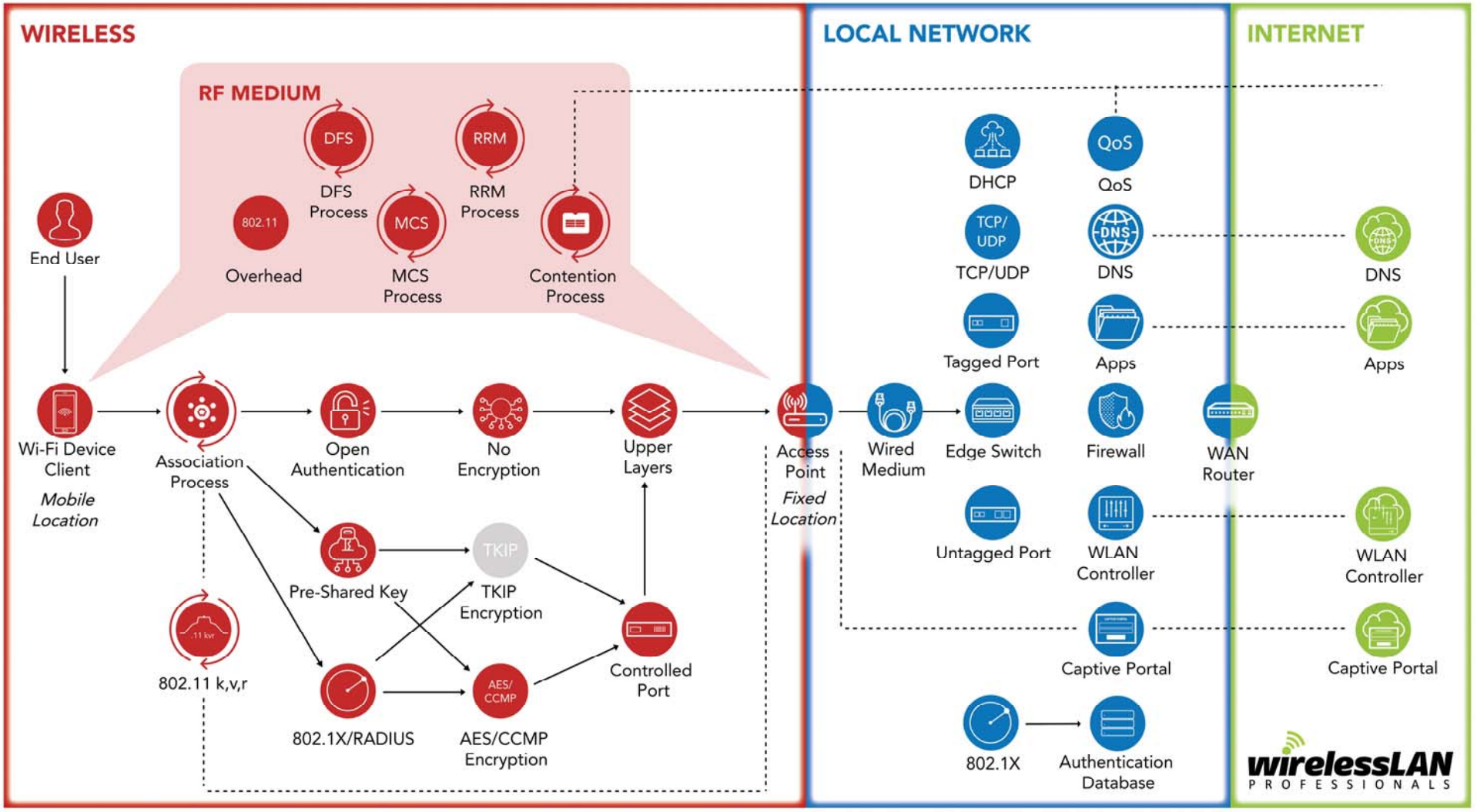
WIRELESS
RF MEDIUM
DFS
DFS Process
RRM
RRM Process
802.11
Overhead
MCS
MCS Process
Contention Process
End User
Wi-Fi Device Client
Mobile Location
Association Process
Open Authentication
No Encryption
Upper Layers
Pre-Shared Key
TKIP
TKIP Encryption
802.11 k,v,r
AES/ CCMP
Controlled Port
802.1X/RADIUS
AES/CCMP Encryption
Access Point
Fixed Location
LOCAL NETWORK
Wired Medium
Edge Switch
Firewall
WAN Router
DHCP
QoS
QoS
TCP/ UDP
TCP/UDP
DNS
DNS
Tagged Port
Apps
Apps
Untagged Port
WLAN Controller
WLAN Controller
Captive Portal
Captive Portal
802.1X
Authentication Database
INTERNET
wirelessLAN PROFESSIONALS

That's All Folks!

Resources from this presentation:
http://WLANPros.com/troubleshooting

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