

WLAN 802.11n MIMO Analysis

June 17, 2010

Rolf Leutert

Network Consultant & Trainer | Leutert NetServices | Switzerland

SHARKFEST '10

Stanford University

June 14-17, 2010



Trace files and coloring rules can be copied from circulating memory stick



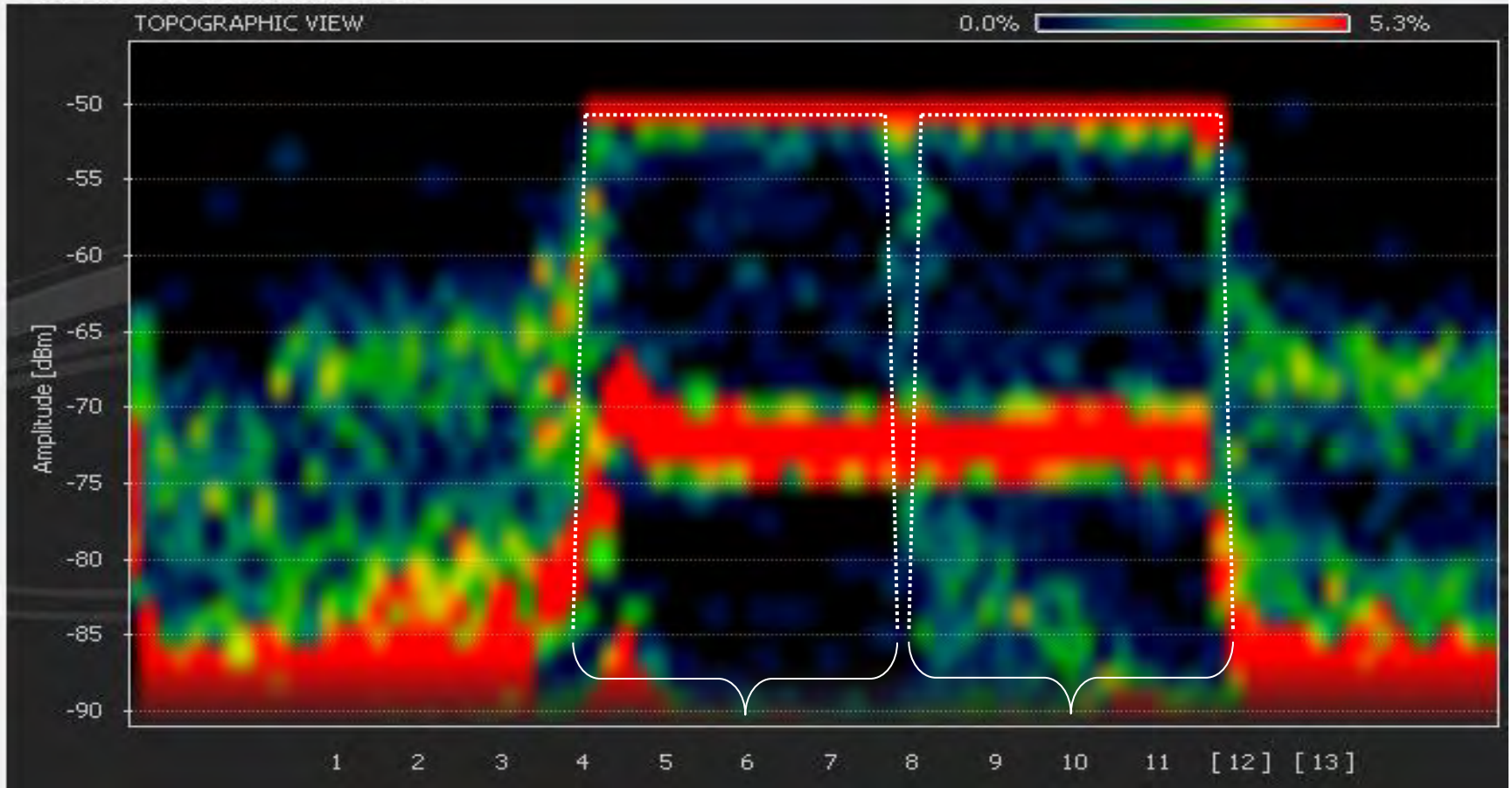




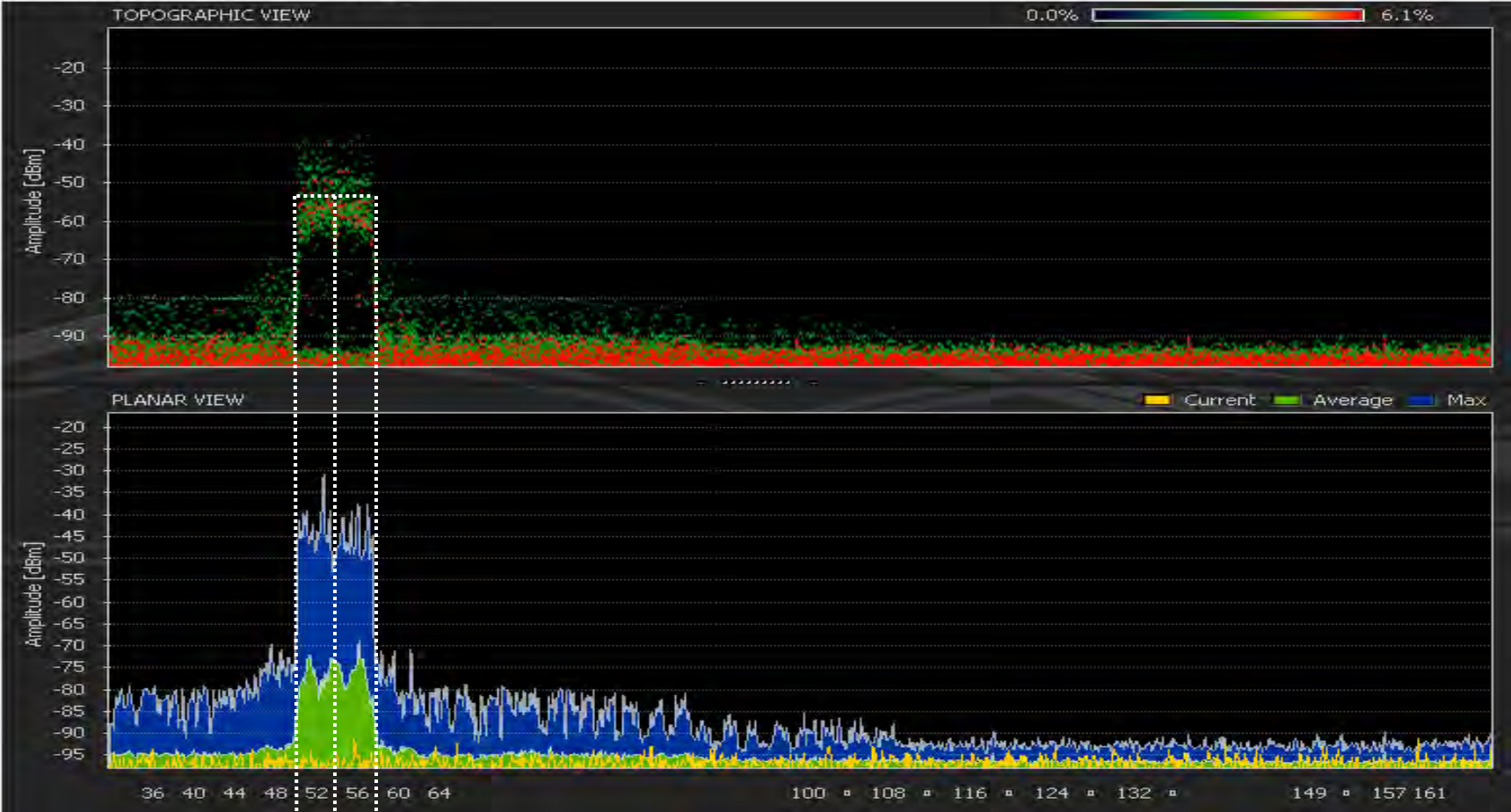




File: Channel Bonding 2_4.wsr



Channel Bonding 52 and 56.wsr





Dynamic Frequency Selection (DFS) Channel 44 5220 MHz

- Band 1 - 5.150 to 5.250 GHz
- Band 2 - 5.250 to 5.350 GHz
- Band 3 - 5.470 to 5.725 GHz

Above 40 MHz

- < NONE >
- 20 MHz
- Below 40 MHz
- Above 40 MHz

Interface

AirPcap N Wireless Capture Device

Basic Parameters

Channel: 5220 [A 44]

Channel Offset: +1

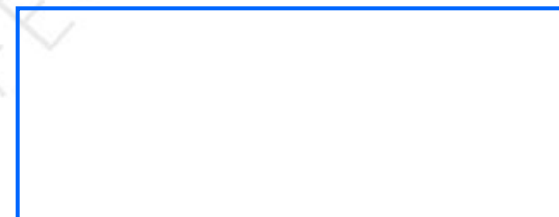
Capture Type: -1, 0, +1

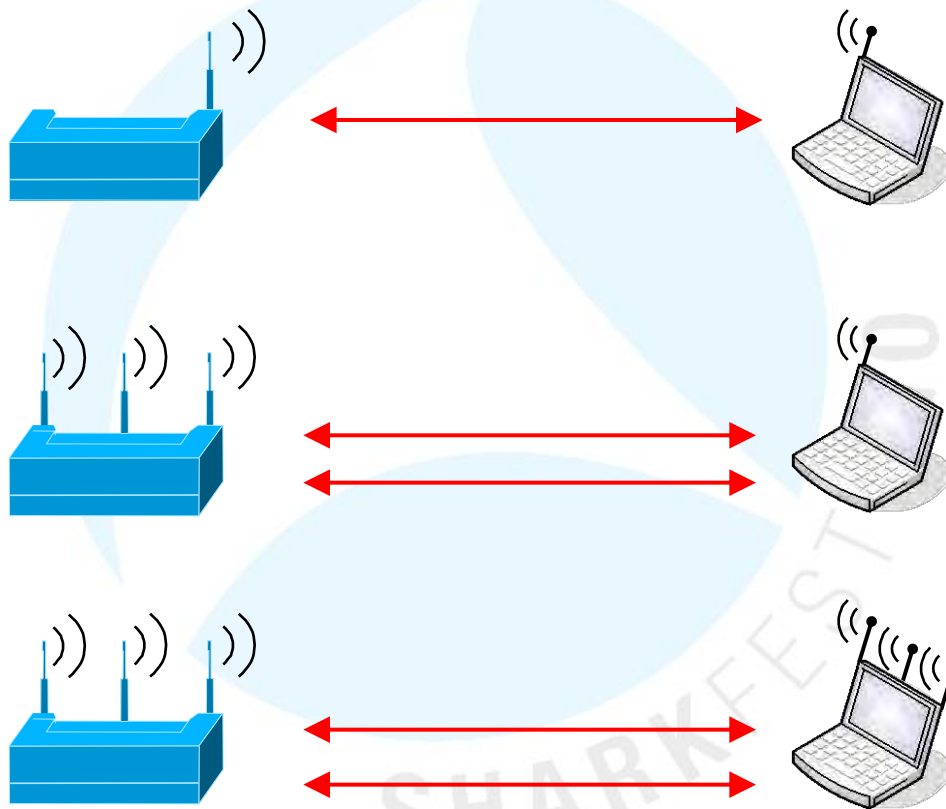
| Frequency Band | Channel ID | FCC (GHz) | ETSI (GHz) | MKK (GHz) |
|---------------------------------|------------|-----------|------------|-----------|
| Lower Band UNII-1 | 34 | -- | -- | 5.170 |
| | 36 | 5.180 | 5.180 | -- |
| | 38 | -- | -- | 5.190 |
| | 40 | 5.200 | 5.200 | -- |
| | 42 | -- | -- | 5.210 |
| | 44 | 5.220 | 5.220 | -- |
| | 46 | -- | -- | 5.230 |
| | 48 | 5.240 | 5.240 | -- |
| Middle Band UNII-2 | 52 | 5.260* | 5.260 | 5.260 |
| | 56 | 5.280* | 5.280 | 5.280 |
| | 60 | 5.300* | 5.300 | 5.300 |
| | 64 | 5.320* | 5.320 | 5.320 |
| High Band UNII-2 extended | 100 | 5.500* | 5.500 | 5.500 |
| | 104 | 5.520* | 5.520 | 5.520 |
| | 108 | 5.540* | 5.540 | 5.540 |
| | 112 | 5.560* | 5.560 | 5.560 |
| | 116 | 5.580* | 5.580 | 5.580 |
| | 120 | 5.600* | 5.600 | 5.600 |
| | 124 | 5.620* | 5.620 | 5.620 |
| | 128 | 5.640* | 5.640 | 5.640 |
| | 132 | 5.660* | 5.660 | 5.660 |
| | 136 | 5.680* | 5.680 | 5.680 |
| | 140 | 5.700* | 5.700 | 5.700 |
| Upper Band UNII-3/ISM | 149 | 5.745 | -- | -- |
| | 153 | 5.765 | -- | -- |
| | 157 | 5.785 | -- | -- |
| | 161 | 5.805 | -- | -- |
| ISM | 165 | 5.825 | -- | -- |

| Available non-overlapping channels | |
|------------------------------------|----|
| FCC (USA and Canada) | 24 |
| ETSI (Europe) | 19 |
| MKK (Japan) | 19 |

| Transmit Power Control (TPC) required for | |
|---|-------------|
| FCC (USA and Canada) | Band 2,2e |
| ETSI (Europe) | Band 1,2,2e |
| MKK (Japan) | Band 1,2,2e |

| Dynamic Frequency Selection (DFS) required for | |
|--|-------------|
| FCC* (USA and Canada) | Band 2,2e |
| ETSI (Europe) | Band 1,2,2e |
| MKK (Japan) | Band 1,2,2e |







Data Rates:

Best Range

Best Throughput

Default

| | | | |
|------------|--|------------------------------|-------------------------------|
| 6.0Mb/sec | <input checked="" type="radio"/> Require | <input type="radio"/> Enable | <input type="radio"/> Disable |
| 9.0Mb/sec | <input checked="" type="radio"/> Require | <input type="radio"/> Enable | <input type="radio"/> Disable |
| 12.0Mb/sec | <input checked="" type="radio"/> Require | <input type="radio"/> Enable | <input type="radio"/> Disable |
| 18.0Mb/sec | <input checked="" type="radio"/> Require | <input type="radio"/> Enable | <input type="radio"/> Disable |
| 24.0Mb/sec | <input checked="" type="radio"/> Require | <input type="radio"/> Enable | <input type="radio"/> Disable |
| 36.0Mb/sec | <input checked="" type="radio"/> Require | <input type="radio"/> Enable | <input type="radio"/> Disable |
| 48.0Mb/sec | <input checked="" type="radio"/> Require | <input type="radio"/> Enable | <input type="radio"/> Disable |
| 54.0Mb/sec | <input checked="" type="radio"/> Require | <input type="radio"/> Enable | <input type="radio"/> Disable |

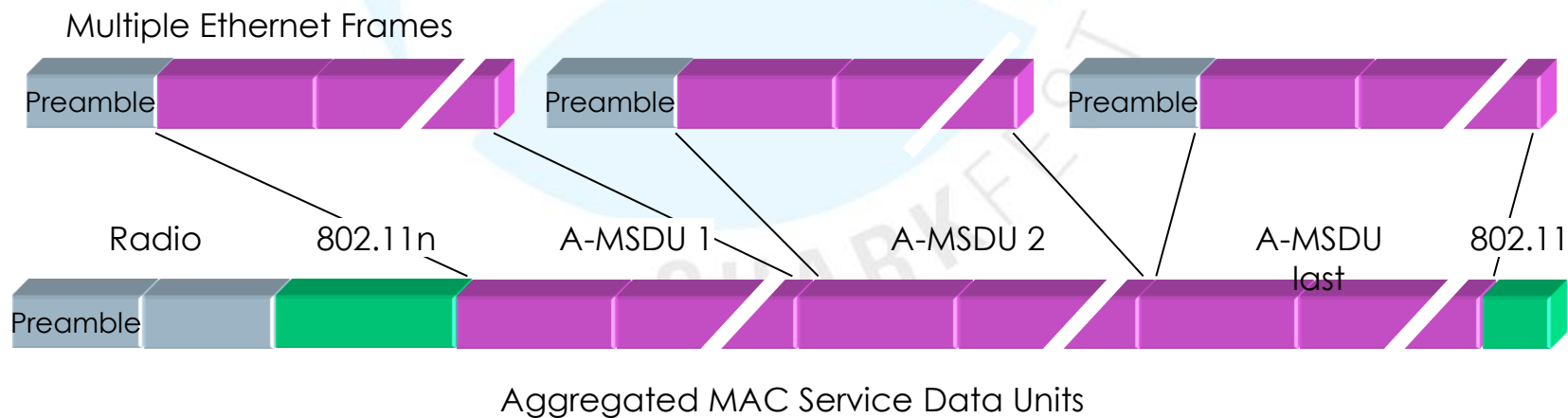
MCS Rates:

| | | | | | | | | | | | | | | | | |
|---------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| Enable | <input checked="" type="radio"/> | <input checked="" type="radio"/> | <input checked="" type="radio"/> | <input checked="" type="radio"/> | <input checked="" type="radio"/> | <input checked="" type="radio"/> | <input checked="" type="radio"/> | <input checked="" type="radio"/> | <input checked="" type="radio"/> | <input checked="" type="radio"/> | <input checked="" type="radio"/> | <input checked="" type="radio"/> | <input checked="" type="radio"/> | <input checked="" type="radio"/> | <input checked="" type="radio"/> | <input checked="" type="radio"/> |
| Disable | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |



| MCS Rate Chart | | 20 MHz Channel | | | | | | | | 40 MHz Channel | | | | | | | |
|---------------------------------|----------|---------------------|------|------|------|------------------|-------|------|-------|---------------------|------|-------|-----|------------------|-----|-----|-----|
| | | 1 Stream (non MIMO) | | | | 2 Streams (MIMO) | | | | 1 Stream (non MIMO) | | | | 2 Streams (MIMO) | | | |
| 802.11n 2.4GHz GI = 800ns | MCS Rate | 0 | 1 | 2 | 3 | 8 | 9 | 10 | 11 | n.a. | n.a. | | | | | | |
| | Mbps | 6.5 | 13 | 19.5 | 26 | 13 | 26 | 39 | 52 | | | | | | | | |
| | | 39 | 52 | 58.5 | 65 | 78 | 104 | 117 | 130 | | | | | | | | |
| MCS Rate | 4 | 5 | 6 | 7 | 12 | 13 | 14 | 15 | | | | | | | | | |
| 802.11n 5GHz GI = 800ns | MCS Rate | 0 | 1 | 2 | 3 | 8 | 9 | 10 | 11 | 0 | 1 | 2 | 3 | 8 | 9 | 10 | 11 |
| | Mbps | 6.5 | 13 | 19.5 | 26 | 13 | 26 | 39 | 52 | 13.5 | 27 | 40.5 | 54 | 27 | 54 | 81 | 108 |
| | | 39 | 52 | 58.5 | 65 | 78 | 104 | 117 | 130 | 81 | 108 | 121.5 | 135 | 162 | 216 | 243 | 270 |
| MCS Rate | 4 | 5 | 6 | 7 | 12 | 13 | 14 | 15 | 4 | 5 | 6 | 7 | 12 | 13 | 14 | 15 | |
| 802.11n 5GHz GI = 400ns | MCS Rate | 0 | 1 | 2 | 3 | 8 | 9 | 10 | 11 | 0 | 1 | 2 | 3 | 8 | 9 | 10 | 11 |
| | Mbps | 7.2 | 14.4 | 21.7 | 28.9 | 14.4 | 28.9 | 43.3 | 57.8 | 15 | 30 | 45 | 60 | 30 | 60 | 90 | 120 |
| | | 43.3 | 57.8 | 65 | 72.2 | 86.7 | 115.6 | 130 | 144.4 | 90 | 120 | 135 | 150 | 180 | 240 | 270 | 300 |
| MCS Rate | 4 | 5 | 6 | 7 | 12 | 13 | 14 | 15 | 4 | 5 | 6 | 7 | 12 | 13 | 14 | 15 | |





D05-1_AMSDU.pcap - Wireshark

File Edit View Go Capture Analyze Statistics Help

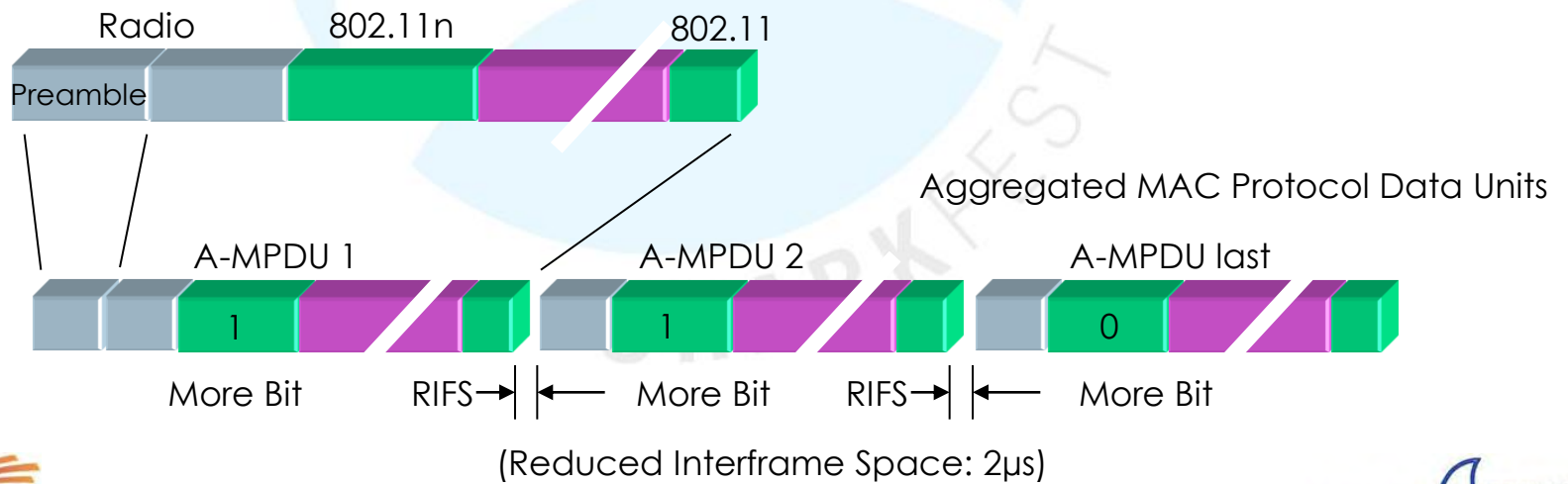
Filter: Expression... Clear Apply

802.11 Channel: Channel Offset: PCAP Filter: Decryption Mode: None Wireless Settings... Decryption Keys...

| No. | Delta Time | TX Rate | RSSI | Source | Destination | Protocol | Info |
|-----|------------|------------|------|---------------|---------------------|----------|--|
| 867 | 0.000129 | 300.0 Mbps | -40 | 192.168.0.181 | 192.168.0.187 | UDP | Source port: 4071 Destination port: 4071 |
| 868 | 0.000022 | 54.0 Mbps | -45 | | Cisco_a0:8d:c0 (RA) | IEEE 802 | Acknowledgement, Flags=..... |
| 869 | 0.000224 | 270.0 Mbps | -40 | 192.168.0.181 | 192.168.0.187 | UDP | Source port: 4071 Destination port: 4071 |
| 870 | 0.000021 | 54.0 Mbps | -45 | | Cisco_a0:8d:c0 (RA) | IEEE 802 | Acknowledgement, Flags=..... |
| 871 | 0.000206 | 270.0 Mbps | -41 | 192.168.0.181 | 192.168.0.187 | UDP | Source port: 4071 Destination port: 4071 |
| 872 | 0.000021 | 54.0 Mbps | -45 | | Cisco_a0:8d:c0 (RA) | IEEE 802 | Acknowledgement, Flags=..... |

Frame 867 (2628 bytes on wire, 2628 bytes captured)

- PPI version 0, 84 bytes
- IEEE 802.11 QoS Data, Flags:F.
- IEEE 802.11 Aggregate MSDU
 - A-MSDU Subframe #1
 - A-MSDU Subframe #2
 - A-MSDU Subframe #3
 - A-MSDU Subframe #4
 - A-MSDU Subframe #5
 - A-MSDU Subframe #6
 - A-MSDU Subframe #7
 - A-MSDU Subframe #8
 - A-MSDU Subframe #9
 - A-MSDU Subframe #10



D05-2_AMPDU.pcap - Wireshark

File Edit View Go Capture Analyze Statistics Help

Filter: Expression... Clear Apply

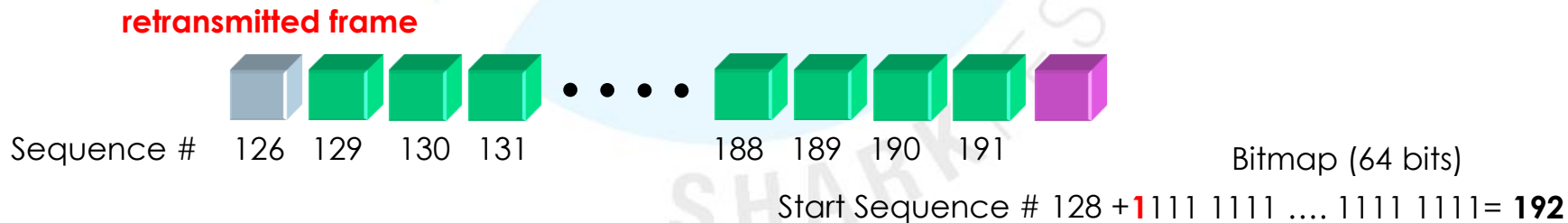
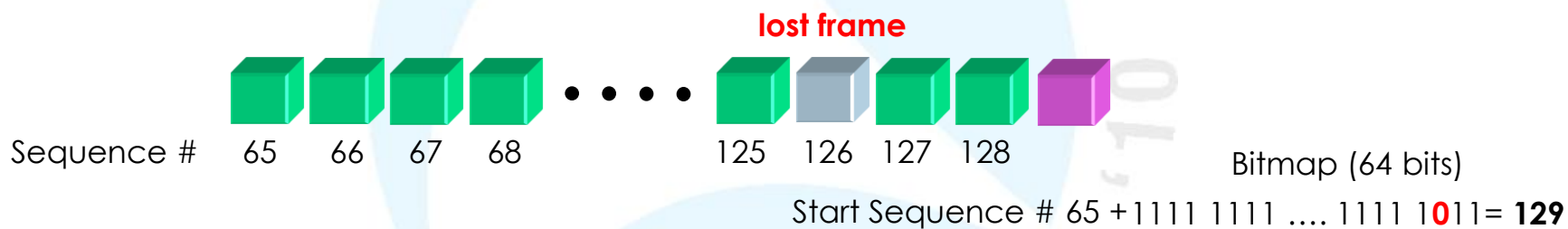
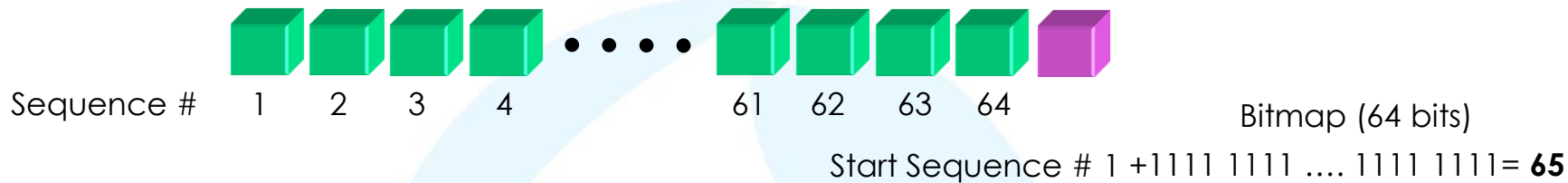
802.11 Channel: Channel Offset: FCS Filter: Decryption Mode: None Wireless Settings... Decryption Keys...

| No. | Delta Time | TX Rate | RSSI | Source | Destination | Protocol | Info |
|-----|------------|------------|------|-----------------------|---------------------|----------|----------------------------------|
| 66 | 0.000022 | 300.0 Mbps | -33 | 192.168.0.180 | 192.168.0.185 | UDP | Source port: 2658 Destination... |
| 67 | 0.000022 | 54.0 Mbps | -44 | Buffalo_73:05:af (TA) | Cisco_a0:8d:c0 (RA) | IEEE 802 | 802.11 Block Ack, Flags=... |
| 68 | 0.000418 | 300.0 Mbps | -39 | | | IEEE 802 | Unreassembled A-MPDU data |
| 69 | 0.000026 | 300.0 Mbps | -39 | | | IEEE 802 | Unreassembled A-MPDU data |
| 70 | 0.000027 | 300.0 Mbps | -47 | | | IEEE 802 | Unreassembled A-MPDU data |
| 71 | 0.000026 | 300.0 Mbps | -47 | | | IEEE 802 | Unreassembled A-MPDU data |
| 72 | 0.000025 | 300.0 Mbps | -47 | | | IEEE 802 | Unreassembled A-MPDU data |
| 73 | 0.000027 | 300.0 Mbps | -47 | | | IEEE 802 | Unreassembled A-MPDU data |
| 74 | 0.000034 | 300.0 Mbps | -47 | | | IEEE 802 | Unreassembled A-MPDU data |
| 75 | 0.000132 | 300.0 Mbps | -33 | 192.168.0.180 | 192.168.0.185 | UDP | Source port: 2658 Destination... |
| 76 | 0.000023 | 54.0 Mbps | -45 | Buffalo_73:05:af (TA) | Cisco_a0:8d:c0 (RA) | IEEE 802 | 802.11 Block Ack, Flags=... |

Frame 75 (1620 bytes on wire, 1620 bytes captured)

- PPI version 0, 84 bytes
- IEEE 802.11 Aggregate MPDU
 - MPDU #1
 - MPDU #2
 - MPDU #3
 - MPDU #4
 - MPDU #5
 - MPDU #6
 - MPDU #7
 - MPDU #8





D05-2_AMPDU.pcap - Wireshark

File Edit View Go Capture Analyze Statistics Help

Filter: Expression... Clear Apply

802.11 Channel: Channel Offset: FCS Filter: Decryption Mode: None Wireless Settings... Decryption Keys...

| No. | Delta Time | TX Rate | RSSI | Source | Destination | Protocol | Info |
|------|------------|------------|------|-----------------------|---------------------|----------|----------------------------------|
| 4579 | 0.000021 | 54.0 Mbps | -47 | Buffalo_73:05:af (TA) | Cisco_a0:8d:c0 (RA) | IEEE 802 | 802.11 Block Ack, Flags=... |
| 4580 | 0.000369 | 300.0 Mbps | -39 | | | IEEE 802 | Unreassembled A-MPDU data |
| 4581 | 0.000027 | 300.0 Mbps | -39 | | | IEEE 802 | Unreassembled A-MPDU data |
| 4582 | 0.000028 | 300.0 Mbps | -47 | | | IEEE 802 | Unreassembled A-MPDU data |
| 4583 | 0.000024 | 300.0 Mbps | -47 | | | IEEE 802 | Unreassembled A-MPDU data |
| 4584 | 0.000031 | 300.0 Mbps | -47 | | | IEEE 802 | Unreassembled A-MPDU data |
| 4585 | 0.000137 | 300.0 Mbps | -47 | | | IEEE 802 | Unreassembled A-MPDU data |
| 4586 | 0.000021 | 300.0 Mbps | -47 | | | IEEE 802 | Unreassembled A-MPDU data |
| 4587 | 0.000021 | 300.0 Mbps | -36 | 192.168.0.180 | 192.168.0.185 | UDP | Source port: 2658 Destination... |
| 4588 | 0.000021 | 54.0 Mbps | -47 | Buffalo_73:05:af (TA) | Cisco_a0:8d:c0 (RA) | IEEE 802 | 802.11 Block Ack, Flags=... |

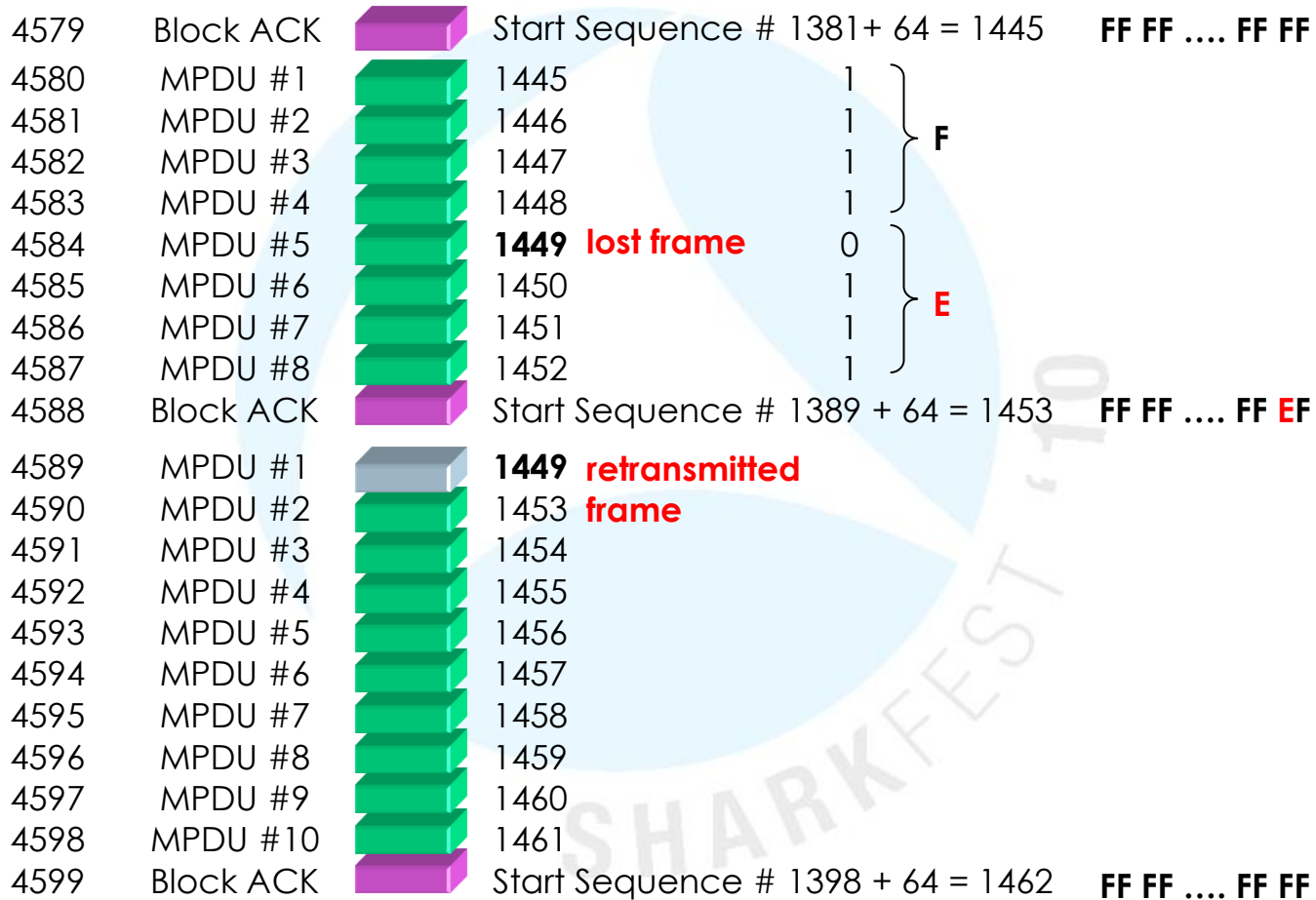
IEEE 802.11 802.11 Block Ack, Flags:C

- Type/Subtype: 802.11 Block Ack (0x19)
- Frame Control: 0x0094 (Normal)
- Duration: 0
- Receiver address: Cisco_a0:8d:c0 (00:17:df:a0:8d:c0)
- Transmitter address: Buffalo_73:05:af (00:16:01:73:05:af)
- Block Ack Request Type: Compressed Block (0x02)
- Block Ack (BA) Control: 0x0004
- Block Ack Starting Sequence Control (SSC): 0x56d0
- Block Ack Bitmap
- Frame check sequence: 0xf47ea4d2 [correct]

```

0000 00 00 20 00 69 00 00 02 00 14 00 56 f0 08 c6  ...i...V...
0010 01 00 00 00 01 00 6c 00 50 14 40 01 00 00 d1 a0  ....l.P@....
0020 94 00 00 00 00 17 df a0 8d c0 00 16 01 73 05 af  ....s...
0030 04 00 d0 56 ff ff ff ff ff ff ff ef f4 7e a4 d2  ...V.....~..

```





D05-3_BAR&BA.pcap - Wireshark

File Edit View Go Capture Analyze Statistics Help

Filter: Expression... Clear Apply

802.11 Channel: Channel Offset: FCS Filter: Decryption Mode: None Wireless Settings... Decryption Keys...

| No. | Delta Time | TX Rate | RSSI | Source | Destination | Protocol | Info |
|-----|------------|---------|------|-----------------------|-----------------------|----------|--|
| 140 | 0.000022 | 54.0 Mb | -35 | | Cisco_a0:8d:c0 (RA) | IEEE 802 | Acknowledgement, Flags=.....C |
| 141 | 0.000024 | 300.0 M | -37 | Cisco_a0:8d:c0 | Buffalo_73:05:af | IEEE 802 | Action, SN=3837, FN=0, Flags=.....C |
| 142 | 0.000021 | 54.0 Mb | -35 | | Cisco_a0:8d:c0 (RA) | IEEE 802 | Acknowledgement, Flags=.....C |
| 143 | 0.001046 | 6.0 Mbp | -33 | Buffalo_73:05:af | Cisco_a0:8d:c0 | IEEE 802 | Action, SN=79, FN=0, Flags=.....C |
| 144 | 0.000021 | 6.0 Mbp | -41 | | Buffalo_73:05:af (RA) | IEEE 802 | Acknowledgement, Flags=.....C |
| 145 | 0.000145 | 54.0 Mb | -37 | Cisco_a0:8d:c0 (TA) | Buffalo_73:05:af (RA) | IEEE 802 | 802.11 Block Ack Req, Flags=.....C |
| 146 | 0.000019 | 54.0 Mb | -33 | Buffalo_73:05:af (TA) | Cisco_a0:8d:c0 (RA) | IEEE 802 | 802.11 Block Ack, Flags=.....C |
| 147 | 0.097038 | 6.0 Mbp | -41 | Cisco_a0:8d:c0 | Broadcast | IEEE 802 | Beacon frame, SN=3838, FN=0, Flags=..... |
| 148 | 0.104498 | 6.0 Mbp | -38 | Cisco_a0:8d:c0 | Broadcast | IEEE 802 | Beacon frame, SN=3839, FN=0, Flags=..... |

Frame 141 (121 bytes on wire, 121 bytes captured)

- PPI version 0, 84 bytes
- IEEE 802.11 Action, Flags:C
- IEEE 802.11 wireless LAN management frame
 - Fixed parameters
 - Action: 0x03
 - Category code: Block Ack (3)
 - Action code: Add Block Ack Request (0x00)
 - Dialog token: 0x01
 - Block Ack Parameters: 0x1002
 - = A-MSDUs: Not Permitted
 - = Block Ack Policy: Immediate Block Ack
 - ..00 00.. = Traffic Identifier: 0x00
 - 0001 0000 00.. = Number of Buffers (1 Buffer = 2304 Bytes): 64
 - Block Ack Timeout: 0x0000
 - Block Ack Starting Sequence Control (SSC): 0x0010

D05-3_BAR&BA.pcap - Wireshark

File Edit View Go Capture Analyze Statistics Help

Filter: Expression... Clear Apply

802.11 Channel: Channel Offset: FCS Filter: Decryption Mode: None Wireshark Settings... Decryption Keys...

| No. | Delta Time | Tx Rate | RSSI | Source | Destination | Protocol | Info |
|-----|------------|----------|------|----------------|-------------|----------|------------------------------|
| 1 | 0.000000 | 6.0 Mbps | -40 | Cisco_a0:8d:c0 | Broadcast | IEEE 802 | Beacon frame, SN=3727, FN=0, |
| 2 | 0.104453 | 6.0 Mbps | -38 | Cisco_a0:8d:c0 | Broadcast | IEEE 802 | Beacon frame, SN=3728, FN=0, |

- [-] HT Capabilities (802.11n D1.10)
 - Tag Number: 45 (HT Capabilities (802.11n D1.10))
 - Tag length: 26
 - [-] HT Capabilities Info: 0x186e
 - [-] A-MPDU Parameters: 0x001b
 - [-] Rx Supported Modulation and Coding Scheme Set: MCS Set
 - [-] HT Extended Capabilities: 0x0000
 - [-] Transmit Beam Forming (TxBF) Capabilities: 0x0000
 - [-] Antenna Selection (ASEL) Capabilities: 0x00
 - [-] HT Information (802.11n D1.10)**
 - Tag Number: 61 (HT Information (802.11n D1.10))
 - Tag length: 22
 - Primary Channel: 48**
 - [-] HT Information Subset (1 of 3): 0x0F
 -11 = Secondary channel offset: Secondary channel is below the primary channel (0x03)
 -1.. = Supported channel width: Channel of any width supported
 -1.. = Reduced Interframe Spacing (RIFS): Permitted
 - ...0 = Power Save Multi-Poll (PSMP) stations only: Association requests are accepted regardless c
 - 000. = Shortest service interval: 5 ms (0x00)



Advanced Wireless Settings

Interface

AirPcap N Wireless Capture Device Blink Led

Basic Parameters

Channel: 5220 [A 44] Include 802.11 FCS in Frames

Channel Offset: +1

Capture Type: 802.11 + PPI FCS Filter: Valid Frames

- 802.11 Only
- 802.11 + Radio
- 802.11 + PPI

Apply Cancel

SHARKFEST

D05-2_AMPDU.pcap - Wireshark

File Edit View Go Capture Analyze Statistics Help

Filter: Expression... Clear Apply

802.11 Channel: Channel Offset: FC Filter: Decryption Mode: None Wireless Settings... Decryption Keys...

| No. | Delta Time | Tx Rate | RSSI | Source | Destination | Protocol | Info |
|-----|------------|------------|------|-----------------------|---------------------|-------------|----------------------------------|
| 54 | 0.000021 | 54.0 Mbps | -44 | Buffalo_73:05:af (TA) | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack, Flags=... |
| 55 | 0.000187 | 300.0 Mbps | -39 | | | IEEE 802.11 | Unreassembled A-MPDU data |
| 56 | 0.000025 | 300.0 Mbps | -39 | | | IEEE 802.11 | Unreassembled A-MPDU data |
| 57 | 0.000026 | 300.0 Mbps | -47 | | | IEEE 802.11 | Unreassembled A-MPDU data |
| 58 | 0.000026 | 300.0 Mbps | -47 | | | IEEE 802.11 | Unreassembled A-MPDU data |
| 59 | 0.000026 | 300.0 Mbps | -47 | | | IEEE 802.11 | Unreassembled A-MPDU data |
| 60 | 0.000028 | 300.0 Mbps | -34 | 192.168.0.180 | 192.168.0.185 | UDP | Source port: 2658 Destination... |
| 61 | 0.000024 | 54.0 Mbps | -44 | Buffalo_73:05:af (TA) | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack, Flags=... |

Frame 60 (1620 bytes on wire (1296 bytes captured) on interface 0)

- PPI version 0, 84 bytes
 - Version: 0
 - Flags: 0x00
 - Header length: 84
 - DLT: 105
 - 802.11-Common
 - 802.11n MAC+PHY
 - [A-MPDU (9244 bytes w/hdrs): #55(1536), #56(1536), #57(1536), #58(1536), #59(1536), #60(1536)]
 - IEEE 802.11 Aggregate MPDU

802.11n MAC+PHY

Field type: 802.11n MAC+PHY Extensions (4)

Field length: 48

MAC flags: 0x00000016

.....0 = Greenfield flag: False
.....1. = HT20/HT40 flag: HT40
.....1.. = RX Short Guard Interval (SGI) flag: True
.....0... = Duplicate RX flag: False
.....1.... = Aggregate flag: True
.....0..... = More aggregates flag: False
.....0.. = A-MPDU Delimiter CRC error after this frame flag: False
0..... = Debug Flag (more desc): False

AMPDU-ID: 0x000131cd

Num-Delimiters: 0

MCS: 15

Number of spatial streams: 2

RSSI combined: 62

Antenna 0 control RSSI: 53

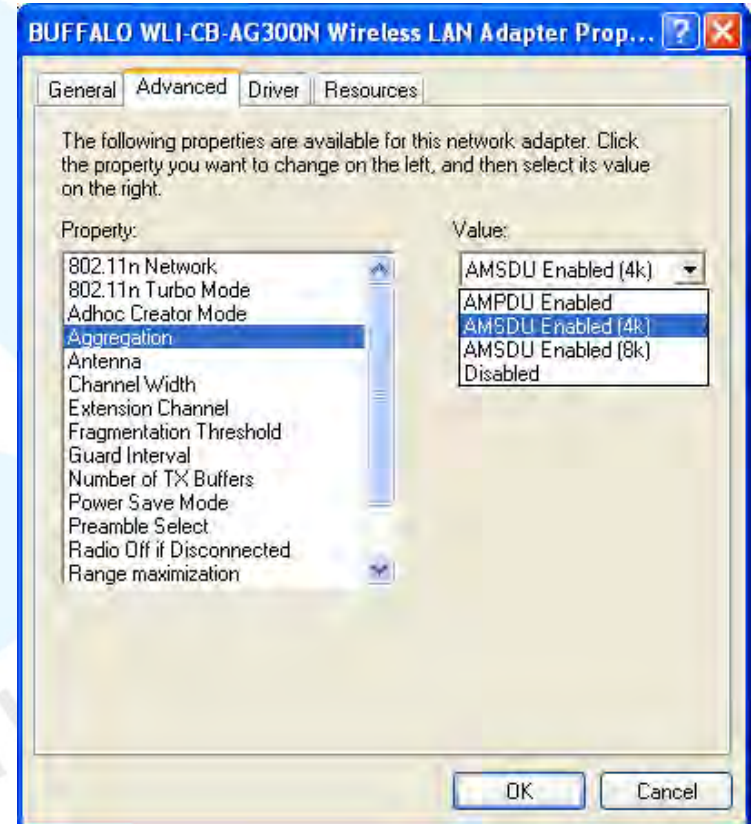
Antenna 1 control RSSI: 58

Antenna 2 control RSSI: 58

Antenna 3 control RSSI: 255 [invalid]

Antenna 0 extension RSSI: 55





D05-4_Bad_BAR.pcap - Wireshark

File Edit View Go Capture Analyze Statistics Help



Filter: Expression... Clear Apply

802.11 Channel: Channel Offset: FCS Filter: Decryption Mode: None Wireless Settings... Decryption Keys...

| No. | Delta Time | TX Rate | RSSI | Source | Destination | Protocol | Info |
|-----|------------|------------|------|--------------------------------------|---------------------|-------------|--|
| 583 | 0.000022 | 54.0 Mbps | -45 | Buffalo_73:05:af | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack, Flags=.....C |
| 584 | 0.000260 | 300.0 Mbps | 20 | 192.168.0.187 | 195.186.6.80 | TCP | 2823 > 80 [ACK] Seq=302 Ack=10881 win=65 |
| 585 | 0.000141 | 54.0 Mbps | -44 | 18:f0:9f:e5:18:f0 | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack Reg, Flags=.....C |
| 586 | 0.000020 | 54.0 Mbps | -38 | Cisco_a0:8d:c0 (T 18:f0:9f:e5:18:f0) | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack, Flags=.....C |
| 587 | 0.000174 | 54.0 Mbps | -44 | 18:f0:9f:e5:18:f0 | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack Reg, Flags=...R...C |
| 588 | 0.000021 | 54.0 Mbps | -38 | Cisco_a0:8d:c0 (T 18:f0:9f:e5:18:f0) | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack, Flags=.....C |
| 589 | 0.000126 | 243.0 Mbps | 19 | 195.186.6.80 | 192.168.0.187 | TCP | 80 > 2824 [SYN, ACK] Seq=0 Ack=1 win=584 |
| 590 | 0.000256 | 6.0 Mbps | -43 | 18:f0:9f:e5:18:f0 | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack Reg, Flags=...R...C |
| 591 | 0.000020 | 6.0 Mbps | -37 | Cisco_a0:8d:c0 (T 18:f0:9f:e5:18:f0) | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack, Flags=.....C |
| 592 | 0.000021 | 54.0 Mbps | -39 | Cisco_a0:8d:c0 | 18:f0:9f:e5:18:f0 | IEEE 802.11 | Deauthentication, SN=1287, FN=0, Flags=. |
| 593 | 0.000257 | 54.0 Mbps | -39 | Cisco_a0:8d:c0 | 18:f0:9f:e5:18:f0 | IEEE 802.11 | Deauthentication, SN=1287, FN=0, Flags=. |
| 594 | 0.000196 | 54.0 Mbps | -38 | Cisco_a0:8d:c0 | 18:f0:9f:e5:18:f0 | IEEE 802.11 | Deauthentication, SN=1287, FN=0, Flags=. |
| 595 | 0.000268 | 243.0 Mbps | -71 | 195.186.6.80 | 192.168.0.187 | TCP | 80 > 2824 [SYN, ACK] Seq=0 Ack=1 win=584 |
| 596 | 0.000020 | 54.0 Mbps | -44 | Buffalo_73:05:af | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack, Flags=.....C |
| 597 | 0.000218 | 6.0 Mbps | -43 | 18:f0:9f:e5:18:f0 | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack Reg, Flags=...R...C |
| 598 | 0.000020 | 6.0 Mbps | -36 | Cisco_a0:8d:c0 (T 18:f0:9f:e5:18:f0) | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack, Flags=.....C |
| 599 | 0.000212 | 6.0 Mbps | -43 | 18:f0:9f:e5:18:f0 | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack Reg, Flags=...R...C |
| 600 | 0.000019 | 6.0 Mbps | -36 | Cisco_a0:8d:c0 (T 18:f0:9f:e5:18:f0) | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack, Flags=.....C |
| 601 | 0.000523 | 6.0 Mbps | -43 | 18:f0:9f:e5:18:f0 | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack Reg, Flags=...R...C |
| 602 | 0.000020 | 6.0 Mbps | -36 | Cisco_a0:8d:c0 (T 18:f0:9f:e5:18:f0) | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack, Flags=.....C |
| 603 | 0.000307 | 6.0 Mbps | -42 | 18:f0:9f:e5:18:f0 | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack Reg, Flags=...R...C |
| 604 | 0.000021 | 6.0 Mbps | -35 | Cisco_a0:8d:c0 (T 18:f0:9f:e5:18:f0) | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack, Flags=.....C |
| 605 | 0.000707 | 6.0 Mbps | -41 | 18:f0:9f:e5:18:f0 | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack Reg, Flags=...R...C |
| 606 | 0.000021 | 6.0 Mbps | -35 | Cisco_a0:8d:c0 (T 18:f0:9f:e5:18:f0) | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack, Flags=.....C |
| 607 | 0.000166 | 6.0 Mbps | -41 | 18:f0:9f:e5:18:f0 | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack Reg, Flags=...R...C |
| 608 | 0.000020 | 6.0 Mbps | -35 | Cisco_a0:8d:c0 (T 18:f0:9f:e5:18:f0) | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack, Flags=.....C |
| 609 | 0.000224 | 6.0 Mbps | -41 | 18:f0:9f:e5:18:f0 | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack Reg, Flags=...R...C |
| 610 | 0.000020 | 6.0 Mbps | -36 | Cisco_a0:8d:c0 (T 18:f0:9f:e5:18:f0) | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack, Flags=.....C |
| 611 | 0.000119 | 6.0 Mbps | -42 | 18:f0:9f:e5:18:f0 | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack Reg, Flags=...R...C |



BUFFALO WLI-CB-AG300N Wireless LAN Adapter Prop...

General | **Advanced** | Driver | Resources

The following properties are available for this network adapter. Click the property you want to change on the left, and then select its value on the right.

| Property: | Value: |
|---------------------------|--------------------|
| 802.11n Network | AMPDU Enabled |
| 802.11n Turbo Mode | AMPDU Enabled |
| Adhoc Creator Mode | AMPDU Enabled (4k) |
| Aggregation | AMPDU Enabled (8k) |
| Antenna | Disabled |
| Channel Width | |
| Extension Channel | |
| Fragmentation Threshold | |
| Guard Interval | |
| Number of TX Buffers | |
| Power Save Mode | |
| Preamble Select | |
| Radio Off if Disconnected | |
| Range maximization | |

OK Cancel

D05-5_DeadLock.pcap - Wireshark

File Edit View Go Capture Analyze Statistics Help

Filter: Expression... Clear Apply

802.11 Channel: Channel Offset: FCS Filter: Decryption Mode: None Wireless Settings... Decryption Keys...

| No. | Delta Time | TX Rate | RSSI | Source | Destination | Protocol | Info |
|-------|------------|------------|------|-----------------------|-----------------------|-------------|---------------------------------------|
| 22105 | 0.000022 | 6.0 Mbps | -39 | Buffalo_73:05:af (TA) | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack, Flags=.....C |
| 22106 | 0.001719 | 216.0 Mbps | 78 | 195.186.8.35 | 192.168.0.187 | TCP | 1935 > 2604 [ACK] Seq=3788779 Ack=380 |
| 22107 | 0.000022 | 6.0 Mbps | -40 | Buffalo_73:05:af (TA) | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack, Flags=.....C |
| 22108 | 0.000243 | 6.0 Mbps | -45 | Buffalo_73:05:af (RA) | Buffalo_73:05:af (RA) | IEEE 802.11 | Acknowledgement, Flags=.....C |
| 22109 | 0.001525 | 216.0 Mbps | -97 | 195.186.8.35 | 192.168.0.187 | TCP | 1935 > 2604 [ACK] Seq=3789303 Ack=380 |
| 22110 | 0.000252 | 216.0 Mbps | -50 | 195.186.8.35 | 192.168.0.187 | TCP | [TCP out-of-order] 1935 > 2604 [ACK] |
| 22111 | 0.000020 | 6.0 Mbps | -40 | Buffalo_73:05:af (TA) | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack, Flags=.....C |
| 22112 | 0.000276 | 216.0 Mbps | -44 | 195.186.8.35 | 192.168.0.187 | RTMP | Audio Data[Malformed Packet] |
| 22113 | 0.000021 | 6.0 Mbps | -40 | Buffalo_73:05:af (TA) | Cisco_a0:8d:c0 (RA) | IEEE 802.11 | 802.11 Block Ack, Flags=.....C |
| 22114 | 0.000122 | 300.0 Mbps | -39 | 192.168.0.187 | 195.186.8.35 | TCP | 2604 > 1935 [ACK] Seq=3803 Ack=378989 |
| 22115 | 0.000115 | 6.0 Mbps | -45 | Buffalo_73:05:af (RA) | Buffalo_73:05:af (RA) | IEEE 802.11 | Acknowledgement, Flags=.....C |
| 22116 | 0.001367 | 216.0 Mbps | -96 | 195.186.8.35 | 192.168.0.187 | RTMP | Audio Data[Malformed Packet] |
| 22117 | 0.000942 | 216.0 Mbps | 107 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP out-of-order] Audio Data[Malform |
| 22118 | 0.000213 | 216.0 Mbps | -35 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP out-of-order] Audio Data[Malform |
| 22119 | 0.000223 | 216.0 Mbps | -60 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP out-of-order] Audio Data[Malform |
| 22120 | 0.000346 | 162.0 Mbps | -60 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP out-of-order] Audio Data[Malform |
| 22121 | 0.000223 | 162.0 Mbps | -96 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP out-of-order] Audio Data[Malform |
| 22122 | 0.000307 | 108.0 Mbps | -96 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP out-of-order] Audio Data[Malform |
| 22123 | 0.000233 | 108.0 Mbps | -125 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP out-of-order] Audio Data[Malform |
| 22124 | 0.000363 | 54.0 Mbps | -125 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP out-of-order] Audio Data[Malform |

SHARK

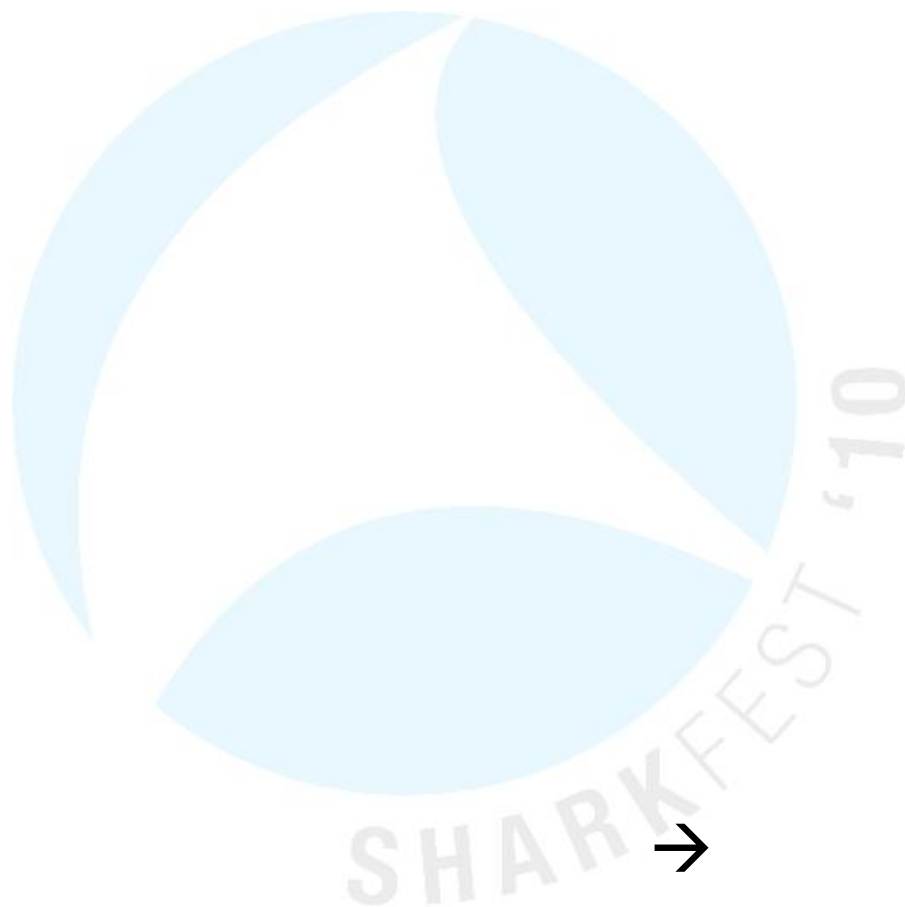
D05_5_DeadLock.pcap - Wireshark

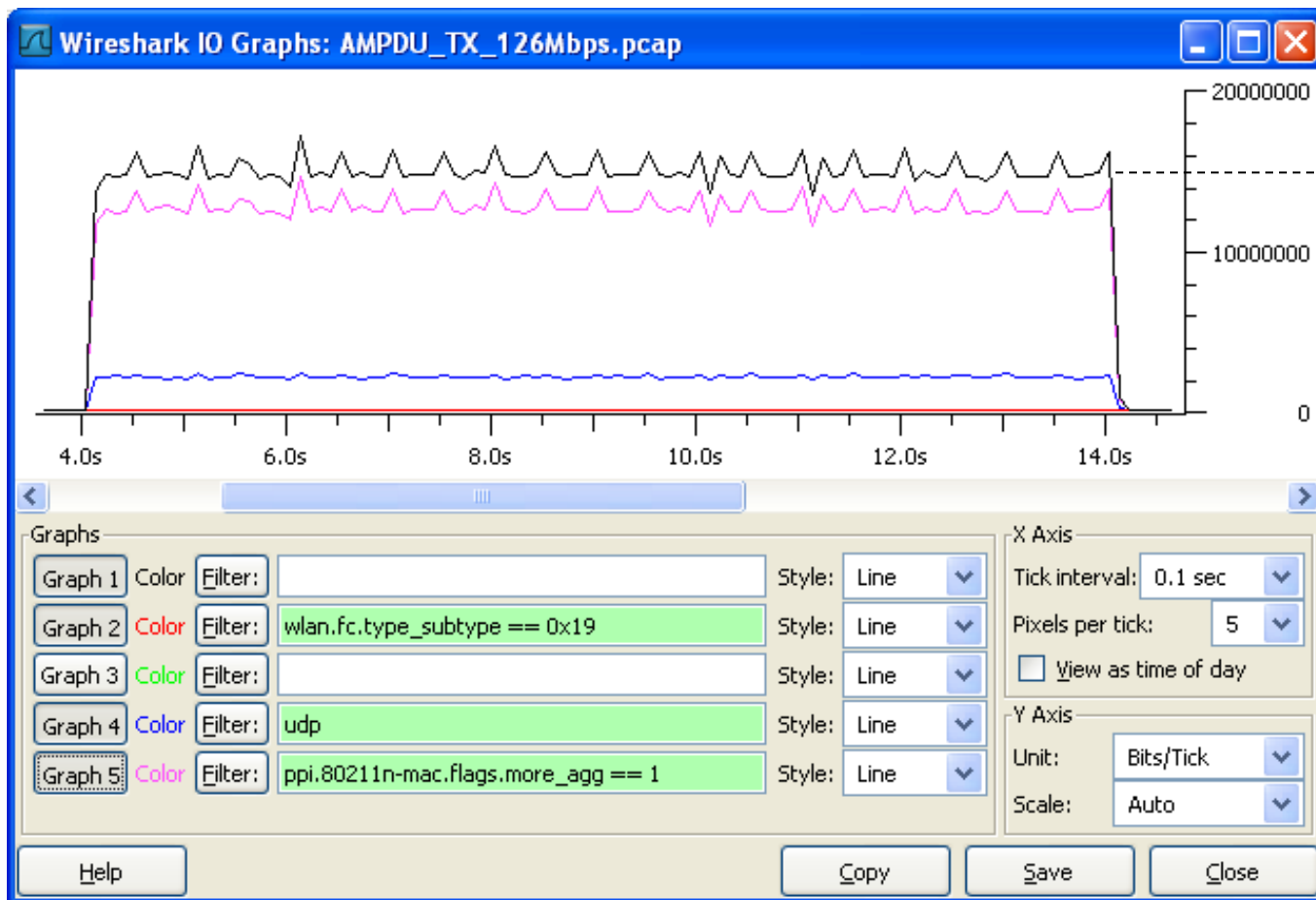
File Edit View Go Capture Analyze Statistics Help

Filter: Expression... Clear Apply

802.11 Channel: Channel Offset: FCS Filter: Decryption Mode: None Wireless Settings... Decryption Keys...

| No. | Delta Time | TX Rate | RSSI | Source | Destination | Protocol | Info |
|-------|------------|----------|------|----------------|------------------|-------------|--|
| 22227 | 0.001221 | 6.5 Mbps | -125 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP Retransmission] Audio Data [Malformed Packe |
| 22228 | 0.001110 | 6.5 Mbps | -125 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP Retransmission] Audio Data [Malformed Packe |
| 22229 | 0.001212 | 6.5 Mbps | -125 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP Retransmission] Audio Data [Malformed Packe |
| 22230 | 0.001186 | 6.5 Mbps | -125 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP Retransmission] Audio Data [Malformed Packe |
| 22231 | 0.001169 | 6.5 Mbps | -125 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP Retransmission] Audio Data [Malformed Packe |
| 22232 | 0.001131 | 6.5 Mbps | -125 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP Retransmission] Audio Data [Malformed Packe |
| 22233 | 0.001169 | 6.5 Mbps | -125 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP Retransmission] Audio Data [Malformed Packe |
| 22234 | 0.001111 | 6.5 Mbps | -125 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP Retransmission] Audio Data [Malformed Packe |
| 22235 | 0.001168 | 6.5 Mbps | -125 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP Retransmission] Audio Data [Malformed Packe |
| 22236 | 0.001111 | 6.5 Mbps | -125 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP Retransmission] Audio Data [Malformed Packe |
| 22237 | 0.001194 | 6.5 Mbps | -125 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP Retransmission] Audio Data [Malformed Packe |
| 22238 | 0.001250 | 6.5 Mbps | -125 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP Retransmission] Audio Data [Malformed Packe |
| 22239 | 0.001219 | 6.5 Mbps | -125 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP Retransmission] Audio Data [Malformed Packe |
| 22240 | 0.001111 | 6.5 Mbps | -125 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP Retransmission] Audio Data [Malformed Packe |
| 22241 | 0.001169 | 6.5 Mbps | -125 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP Retransmission] Audio Data [Malformed Packe |
| 22242 | 0.001265 | 6.5 Mbps | -125 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP Retransmission] Audio Data [Malformed Packe |
| 22243 | 0.001241 | 6.5 Mbps | -125 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP Retransmission] Audio Data [Malformed Packe |
| 22244 | 0.001108 | 6.5 Mbps | -125 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP Retransmission] Audio Data [Malformed Packe |
| 22245 | 0.001170 | 6.5 Mbps | -125 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP Retransmission] Audio Data [Malformed Packe |
| 22246 | 0.001158 | 6.5 Mbps | -125 | 195.186.8.35 | 192.168.0.187 | RTMP | [TCP Retransmission] Audio Data [Malformed Packe |
| 22247 | 0.000970 | 6.0 Mbps | -41 | Cisco_a0:8d:c0 | Buffalo_73:05:af | IEEE 802.11 | Deauthentication, SN=1530, FN=0, Flags=..... |
| 22248 | 0.000225 | 6.0 Mbps | -41 | Cisco_a0:8d:c0 | Buffalo_73:05:af | IEEE 802.11 | Deauthentication, SN=1530, FN=0, Flags=...R... |
| 22249 | 0.000235 | 6.0 Mbps | -41 | Cisco_a0:8d:c0 | Buffalo_73:05:af | IEEE 802.11 | Deauthentication, SN=1530, FN=0, Flags=...R... |
| 22250 | 0.000232 | 6.0 Mbps | -41 | Cisco_a0:8d:c0 | Buffalo_73:05:af | IEEE 802.11 | Deauthentication, SN=1530, FN=0, Flags=...R... |
| 22251 | 0.009058 | 6.0 Mbps | -41 | Cisco_a0:8d:c0 | Broadcast | IEEE 802.11 | Beacon frame, SN=1531, FN=0, Flags=.....C, E |
| 22252 | 0.104451 | 6.0 Mbps | -42 | Cisco_a0:8d:c0 | Broadcast | IEEE 802.11 | Beacon frame, SN=1532, FN=0, Flags=.....C, E |
| 22253 | 0.104450 | 6.0 Mbps | -39 | Cisco_a0:8d:c0 | Broadcast | IEEE 802.11 | Beacon frame, SN=1533, FN=0, Flags=.....C, E |
| 22254 | 0.104446 | 6.0 Mbps | -42 | Cisco_a0:8d:c0 | Broadcast | IEEE 802.11 | Beacon frame, SN=1534, FN=0, Flags=.....C, E |



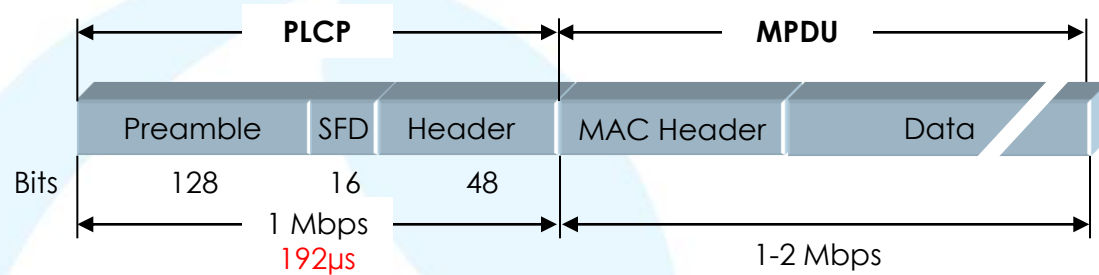




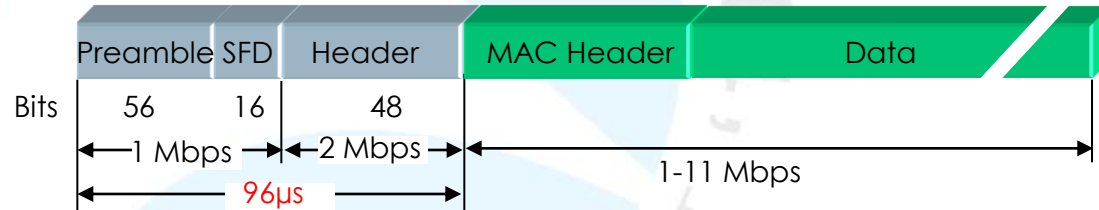
| | | | | |
|-----|-------------|--|--|----------------|
| 1 | Barker Code | 802.11 DSSS (Clause 15) with ,Long Preamble' | | |
| 2 | Barker Code | | | |
| 5.5 | CCK | 802.11b HR/DSSS (Clause 18) with ,Short Preamble' | | |
| 11 | CCK | | | |
| 6 | OFDM | 802.11g Extended Rate PHY (ERP) new Frame Format | | |
| 9 | OFDM | | | |
| 12 | OFDM | | | |
| 18 | OFDM | | | |
| 24 | OFDM | | | |
| 36 | OFDM | | | |
| 48 | OFDM | | | |
| 54 | OFDM | | | |
| | | | | 802.11a |



802.11 DSSS with
,Long Preamble'
Barker Code



802.11b HR/DSSS with
,Short Preamble'
Barker / CCK



802.11g (ERP)
Extended Rate PHY
new Frame Format
OFDM

