



# Wi-Fi 7 – Lessons from the field

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# Agenda

- MLO Station Modes
- SSID deployment strategy
- Demo1 – iPhone 16 MLO behavior
- Demo2 – Google Pixel 8 – Spectrum view of EMLSR during interference.
- Demo 3 – MS Team call between MLO and Non-MLO—Induce interference on one channel and highlight how MLO dynamically switches between bands and maintains good voice quality compared to the Non-MLO client.
- Wi-Fi 7 Design Considerations

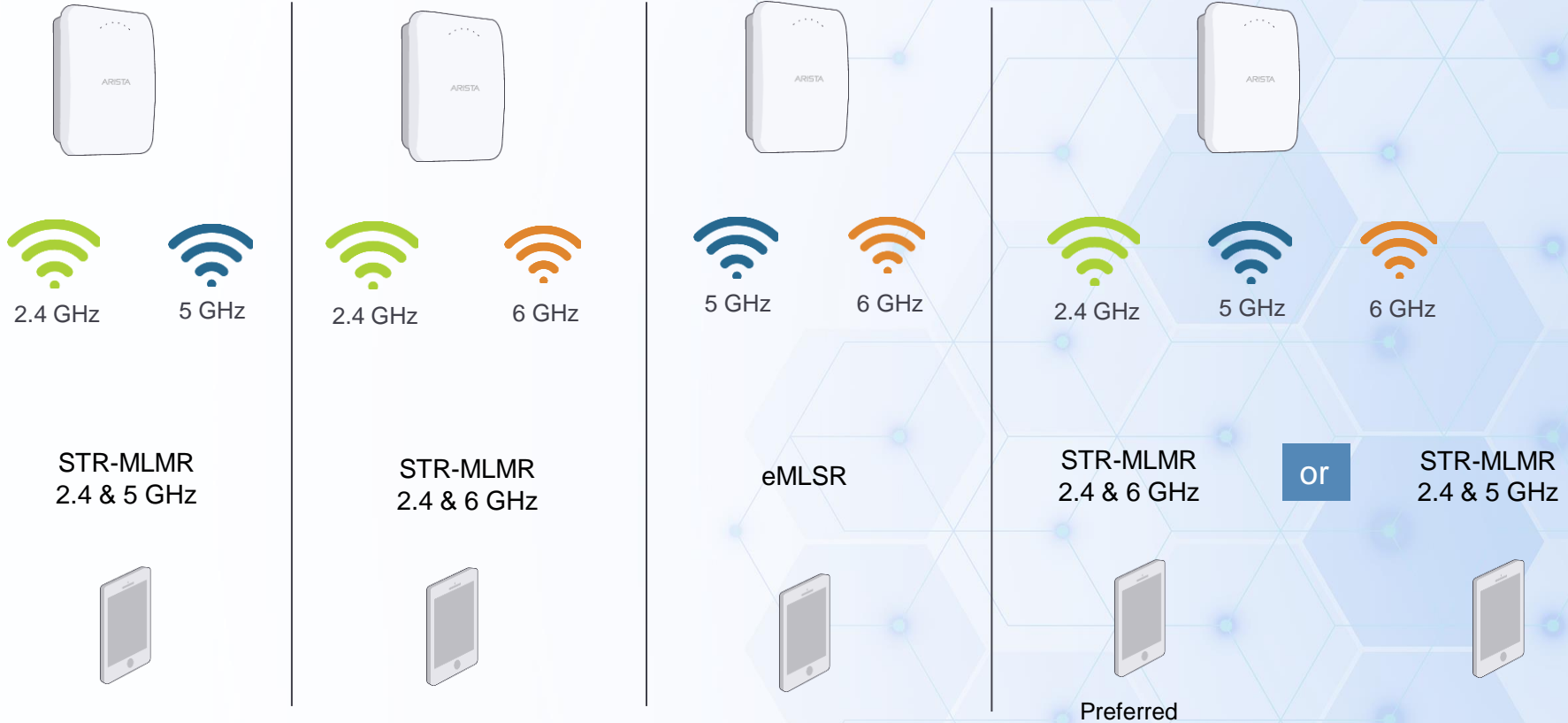
# MLO STA Modes

802.11be defines following different operational modes for MLDs

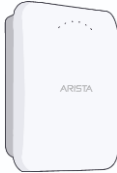





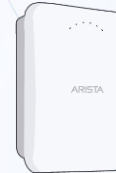


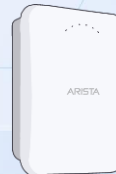







Single Radio	<b>Single link eMLSR</b> Single link enhanced multi link single radio	Able to Tx and Rx over only one radio at a time
	<b>Multi Link eMLSR</b> Enhanced Multiple Link Single Radio	Enhanced MLSR with additional capability to listen on two links simultaneously
Multi Radio	<b>STR-MLMR</b> Simultaneous Transmit & Receive Multiple Link Multiple Radio	Simultaneous Tx / Tx, Rx / Rx and Tx / Rx over multiple links
	<b>NSTR-MLMR</b> Non-Simultaneous Transmit & Receive Multiple Link Single Radio	Simultaneous Tx/Tx and Rx/Rx over multiple links
	<b>eMLMR</b> Enhanced Multi Link Multi Radio	Capabilities to dynamically reconfigure links



# MLO Mode Selection by MLO Capable Clients



# iPhone 16 – Client behavior

  2.4 GHz  5 GHz	  2.4 GHz  6 GHz	  5 GHz  6 GHz	  2.4 GHz  5 GHz  6 GHz
STR-MLMR	STR-MLMR	NSTR MLMR	Supported link = 2 (5GHz + 6GHz) ; NSTR MLMR
			
Data Transfer only on one band	Data Transfer only on one band	Data Transfer only on one band.	Data Transfer only on one band

# iPhone 16 – SSID on 2.4 + 5.0 + 6.0 GHz band

```
(wlan.fc.type_subtype==0) && (wlan.ssn==32:b1:d9:d1:b7:56)
No. Time Delta Source Destination Length Channel fr Signal strength (dBm) Basic STA Profile Count Info
5224 15:11:10.242011 0.000007 32:b1:d9:d1:b7:56 MojoNetworks_a6:96:a0 652 6135 -54 dBm 2 Association Request, SSN=2394, FN=0, Flags=....., SSID="Iphone16"

> Frame 5224: 652 bytes on wire (5216 bits), 652 bytes captured (5216 bits)
> Radiotap Header v0, Length 48
> 802.11 radio information
> IEEE 802.11 Association Request, Flags: .....
> IEEE 802.11 Wireless Management
  > Fixed parameters (4 bytes)
  > Tagged parameters (576 bytes)
    > Tag: SSID parameter set: "Iphone16"
    > Tag: Supported Rates 6(B), 9, 12(B), 18, 24(B), 36, 48, 54, [Mbit/sec]
    > Tag: Power Capability Min: -14, Max: 19
    > Tag: Supported Channels
    > Tag: RSN Information
    > Tag: Extended Capabilities (9 octets)
    > Tag: RSN eXtension (1 octet)
    > Ext Tag: HE Capabilities
    > Ext Tag: HE 6 GHz Band Capabilities
    > Ext Tag: Multi-Link (802.11be D3.0)
      Ext Tag length: 386 (Tag len: 387)
      Ext Tag Number: Multi-Link (802.11be D3.0) (107)
      > Multi-Link Control: 0x0100 Basic
        > Common Info
          Common Info Length: 9
          MLD MAC Address: fe:94:d6:b2:37:d7 (fe:94:d6:b2:37:d7)
          > MLD Capabilities: 0x0fe1
            .... 0001 = Maximum Number of Simultaneous Links: 1
            .... 0 = SRS Support: False
            .... 11 = TID-To-Link Mapping Negotiation Support: 3
            .... 1111 = Frequency Separation For STR/AP MLD Type Indication: 31
            .... 0 = AAR Support: False
            .... 0 = Link Reconfiguration Operation Support: False
            .... 0 = Aligned TWT Support: False
            0... = Reserved: 0x0
          Subelement ID: Per-STA Profile (0x00)
          Subelement Length: 172
          > Per-STA Profile 1
            > Per-STA Profile, Link-ID = 0
            Subelement ID: Per-STA Profile (0x00)
            Subelement Length: 199
          > Per-STA Profile 2
            > Per-STA Profile, Link-ID = 1
            Basic STA Profile Count: 2
            STA Profiles LinkIDs: 0_1
            > Ext Tag: EHT Capabilities (802.11be D3.0)
            > Ext Tag: TID-To-Link Mapping (802.11be D3.0)
            > Ext Tag: Unknown (137): Undecoded
            > Tag: Vendor Specific: Apple, Inc.
            > Tag: Vendor Specific: Broadcom
            > Tag: Vendor Specific: Microsoft Corp.: WMM/WME: Information Element
```



# iPhone 16 – SSID on 2.4 + 5.0 + 6.0 GHz band

```

  Per-STA Profile 1
  Per-STA Profile, Link-ID = 0
    STA Control: 0x0030, Complete Profile, MAC Address Present
    .... 0000 = Link ID: 0x0
    .... 1. .... = Complete Profile: True
    .... 1. .... = MAC Address Present: True
    .... 0.. .... = Beacon Interval Present: False
    .... 0... .... = TSF Offset Present: False
    .... 0... .... = DTIM Info Present: False
    .... 0.. .... = NSTR Link Pair Present: False
    .... 0.. .... = NSTR Bitmap Size: 0
    .... 0... .... = BSS Parameters Change Count Present: False
    0000 .... .... = Reserved: 0x0
  STA Info
  Capabilities Information: 0x0431
  Tag: Supported Rates 6, 9, 12, 18, 24, 36, 48, 54, [Mbit/sec]
  Tag: Power Capability Min: -7, Max: 21
  Tag: Supported Channels
  Tag: Supported Operating Classes
  Tag: HT Capabilities (802.11n D1.10)
  Ext Tag: HE Capabilities
  Ext Tag: EHT Capabilities (802.11be D3.0)
  Ext Tag: Unknown (137): Undecoded
  Tag: Vendor Specific: Apple, Inc.
  Tag: Vendor Specific: Broadcom
  Tag: Vendor Specific: Microsoft Corp.: WMM/WME: Information Element
  Ext Tag: Non-Inheritance
Subelement ID: Per-STA Profile (0x00)
Subelement Length: 199

```

```

  Per-STA Profile 2
  Per-STA Profile, Link-ID = 1
    STA Control: 0x0231, Complete Profile, MAC Address Present, NSTR Link P
    .... 0001 = Link ID: 0x1
    .... 1. .... = Complete Profile: True
    .... 1. .... = MAC Address Present: True
    .... 0.. .... = Beacon Interval Present: False
    .... 0... .... = TSF Offset Present: False
    .... 0... .... = DTIM Info Present: False
    .... 1. .... = NSTR Link Pair Present: True
    .... 0.. .... = NSTR Bitmap Size: 0
    .... 0... .... = BSS Parameters Change Count Present: False
    0000 .... .... = Reserved: 0x0
  STA Info
  Capabilities Information: 0x0111
  Tag: Power Capability Min: -14, Max: 20
  Tag: Supported Channels
  Tag: Supported Operating Classes
  Tag: HT Capabilities (802.11n D1.10)
  Tag: VHT Capabilities
  Ext Tag: HE Capabilities
  Ext Tag: EHT Capabilities (802.11be D3.0)
  Ext Tag: Unknown (137): Undecoded
  Tag: Vendor Specific: Apple, Inc.
  Tag: Vendor Specific: Epigram, Inc.
  Tag: Vendor Specific: Broadcom
  Tag: Vendor Specific: Microsoft Corp.: WMM/WME: Information Element
  Ext Tag: Non-Inheritance
Basic STA Profile Count: 2
STA Profiles LinkIds: 0_1

```

# iPhone 16 – SSID on 5.0 + 6.0 GHz band

```
.type_subtype eq 0 && wlan.addr[4-5]==07:30
Time Delta Source Destination Length Channel Signal strength PWR MGT Part Info
2024/190 20:57:18.216318 ce:e5:e3:89:07:30 MojoNetworks_a0:79:f0 476 6135 -56 dBm STA will stay up Assoc
2024/190 20:57:18.262068 ce:e5:e3:89:07:30 MojoNetworks_a0:79:f0 476 6135 -55 dBm STA will stay up Assoc

802.11 Association Request, Flags: .....
802.11 Wireless Management
ed parameters (4 bytes)
ged parameters (400 bytes)
Tag: SSID parameter set: "Iphone16"
Tag: Supported Rates 6(B), 9, 12(B), 18, 24(B), 36, 48, 54, [Mbit/sec]
Tag: Power Capability Min: -14, Max: 19
Tag: Supported Channels
Tag: RSN Information
Tag: Extended Capabilities (9 octets)
Tag: RSN eXtension (1 octet)
Ext Tag: HE Capabilities
Ext Tag: HE 6 GHz Band Capabilities
Ext Tag: Multi-Link (802.11be D3.0)
Ext Tag length: 212 (Tag len: 213)
Ext Tag Number: Multi-Link (802.11be D3.0) (107)
Multi-Link Control: 0x0100 Basic
... .. 0000 = Type: Basic (0)
... .. 0... = Reserved: 0x0
... .. 0... = Link ID Info Present: False
... .. 0... = BSS Parameters Change Count Present: False
... .. 0... = Medium Synchronization Delay Info Present: False
... .. 0... = EML Capabilities Present: False
... .. 1... = MLD Capabilities Present: True
... .. 0... = AP MLD ID Present: False
... .. 0... = Extended MLD Capabilities and Operations Present: False
0000 0... = Reserved: 0x00
Common Info
Common Info Length: 9
MLD MAC Address: e2:b4:da:7c:de:0d (e2:b4:da:7c:de:0d)
MLD Capabilities: 0x0fe1
... .. 0001 = Maximum Number of Simultaneous Links: 1
... .. 0... = SRS Support: False
... .. 11... = TID-To-Link Mapping Negotiation Support: 3
... 1111 1... = Frequency Separation For STR/AP MLD Type Indication: 31
... .. 0... = AAR Support: False
... .. 0... = Link Reconfiguration Operation Support: False
... .. 0... = Aligned TWT Support: False
... .. 0... = Reserved: 0x0
Subelement ID: Per-STA Profile (0x00)
Subelement Length: 199
Per-STA Profile 1
Basic STA Profile Count: 1
STA Profiles LinkIds: 1
Ext Tag: EHT Capabilities (802.11be D3.0)
```

```
Per-STA Profile 1
Per-STA Profile Link-ID = 1
STA Control: 0x0231, Complete Profile, MAC Address Present, NSTR Link Pair Present
... .. 0001 = Link ID: 0x1
... .. 1... = Complete Profile: True
... .. 1... = MAC Address Present: True
... .. 0... = Beacon Interval Present: False
... .. 0... = TSF Offset Present: False
... .. 0... = DTTM Info Present: False
... .. 1... = NSTR Link Pair Present: True
... .. 0... = NSTR Bitmap Size: 0
... .. 0... = BSS Parameters Change Count Present: False
0000 ... = Reserved: 0x0
STA Info
STA Info Length: 8
STA MAC Address: a2:04:75:d0:03:82 (a2:04:75:d0:03:82)
NSTR Indication Bitmap: 04
Capabilities Information: 0x0111
Tag: Power Capability Min: -14, Max: 20
Tag: Supported Channels
Tag: Supported Operating Classes
Tag: HT Capabilities (802.11n D1.10)
Tag: VHT Capabilities
Ext Tag: HE Capabilities
Ext Tag: EHT Capabilities (802.11be D3.0)
Ext Tag: Unknown (137): Undecoded
Tag: Vendor Specific: Apple, Inc.
Tag: Vendor Specific: Epigram, Inc.
Tag: Vendor Specific: Broadcom
Tag: Vendor Specific: Microsoft Corp.: WMM/WME: Information Element
Ext Tag: Non-Inheritance
Basic STA Profile Count: 1
STA Profiles LinkIds: 1
Ext Tag: EHT Capabilities (802.11be D3.0)
Ext Tag: TID-To-Link Mapping (802.11be D3.0)
Ext Tag: Unknown (137): Undecoded
Tag: Vendor Specific: Apple, Inc.
Tag: Vendor Specific: Broadcom
```

Pixellphone56.pcap



# iPhone 16 vs Pixel 9 – SSID on 5.0 + 6.0 GHz band

No.	Time	Delta	Source	Destination	Length	Channel	Signal strength	B	Info
933	20:56:59.702366	0.000009	2a:38:ab:e0:04:0f	MojoNetworks_a0:79:f0	337	5180	-43 dBm	0	Association Request, S
> Frame 5842: 475 bytes on wire (3800 bits), 475 bytes captured (3800 bits)									
> Radiotap Header v0, Length 48									
> 802.11 radio information									
> IEEE 802.11 Association Request, Flags: .....									
IEEE 802.11 Wireless Management									
> Fixed parameters (4 bytes)									
Tagged parameters (399 bytes)									
> Tag: SSID parameter set: "iPhone16"									
> Tag: Supported Rates 6(B), 9, 12(B), 18, 24(B), 36, 48, 54, [Mbit/sec]									
> Tag: Power Capability Min: -7, Max: 18									
> Tag: Supported Channels									
> Tag: RSN Information									
> Tag: Supported Operating Classes									
> Tag: Extended Capabilities (9 octets)									
> Tag: RSN extension (1 octet)									
> Ext Tag: HE Capabilities									
> Ext Tag: HE 6 GHz Band Capabilities									
Ext Tag: Multi-Link (802.11be D3.0)									
Ext Tag length: 201 (Tag len: 202)									
Ext Tag Number: Multi-Link (802.11be D3.0) (107)									
Multi-Link Control: 0x0100 Basic									
.....0000 = Type: Basic (0)									
.....0000 = Reserved: 0x0									
.....0000 = Link ID Info Present: False									
.....0000 = BSS Parameters Change Count Present: False									
.....0000 = Medium Synchronization Delay Info Present: False									
.....0001 = EML Capabilities Present: True									
.....0001 = MLD Capabilities Present: True									
.....0000 = AP MLD ID Present: False									
.....0000 = Extended MLD Capabilities and Operations Present: False									
0000 0000 = Reserved: 0x00									
Common Info									
Common Info Length: 11									
MLD MAC Address: 2a:38:ab:e0:04:0e (2a:38:ab:e0:04:0e)									
EML Capabilities: 0x0025, EMLSR Support									
.....0001 = EMLSR Support: True									
.....0010 = EMLSR Padding Delay: 2									
.....0010 = EMLSR Transition Delay: 2									
.....0000 = EMLMR Support: False									
.....0000 = EMLMR Delay: 0									
.....0000 = Transition Timeout: 0									
.....0000 = Reserved: 0x0									
MLD Capabilities: 0x0fe1									
.....0001 = Maximum Number of Simultaneous Links: 1									
.....0000 = SRS Support: False									
.....0011 = TID-To-Link Mapping Negotiation Support: 3									
.....1111 1... = Frequency Separation For STR/AP MLD Type Indication: 31									

Pixel 9

No.	Time	Delta	Source	Destination	Length	Channel	Signal strength	B	Info
1664	20:57:04.332726	0.000004	ce:e5:e3:89:07:30	MojoNetworks_a0:79:f0	476	6135	-55 dBm	1	Association
> Frame 1664: 476 bytes on wire (3800 bits), 476 bytes captured (3800 bits)									
> Radiotap Header v0, Length 48									
> 802.11 radio information									
> IEEE 802.11 Association Request, Flags: .....									
IEEE 802.11 Wireless Management									
> Fixed parameters (4 bytes)									
Tagged parameters (400 bytes)									
> Tag: SSID parameter set: "iPhone16"									
> Tag: Supported Rates 6(B), 9, 12(B), 18, 24(B), 36, 48, 54, [Mbit/sec]									
> Tag: Power Capability Min: -14, Max: 19									
> Tag: Supported Channels									
> Tag: RSN Information									
> Tag: Extended Capabilities (9 octets)									
> Tag: RSN extension (1 octet)									
> Ext Tag: HE Capabilities									
> Ext Tag: HE 6 GHz Band Capabilities									
Ext Tag: Multi-Link (802.11be D3.0)									
Ext Tag length: 212 (Tag len: 213)									
Ext Tag Number: Multi-Link (802.11be D3.0) (107)									
Multi-Link Control: 0x0100 Basic									
.....0000 = Type: Basic (0)									
.....0000 = Reserved: 0x0									
.....0000 = Link ID Info Present: False									
.....0000 = BSS Parameters Change Count Present: False									
.....0000 = Medium Synchronization Delay Info Present: False									
.....0000 = EML Capabilities Present: False									
.....0001 = MLD Capabilities Present: True									
.....0000 = AP MLD ID Present: False									
.....0000 = Extended MLD Capabilities and Operations Present: False									
0000 0000 = Reserved: 0x00									
Common Info									
Common Info Length: 9									
MLD MAC Address: e2:b4:da:7c:de:0d (e2:b4:da:7c:de:0d)									
MLD Capabilities: 0x0fe1									
.....0001 = Maximum Number of Simultaneous Links: 1									
.....0000 = SRS Support: False									
.....0011 = TID-To-Link Mapping Negotiation Support: 3									
.....1111 1... = Frequency Separation For STR/AP MLD Type Indication: 31									
.....0000 = AAR Support: False									
.....0000 = Link Reconfiguration Operation Support: False									
.....0000 = Aligned TWT Support: False									
.....0000 = Reserved: 0x0									
Subelement ID: Per-STA Profile (0x00)									

iPhone 16

# Device MLO Mode Selection

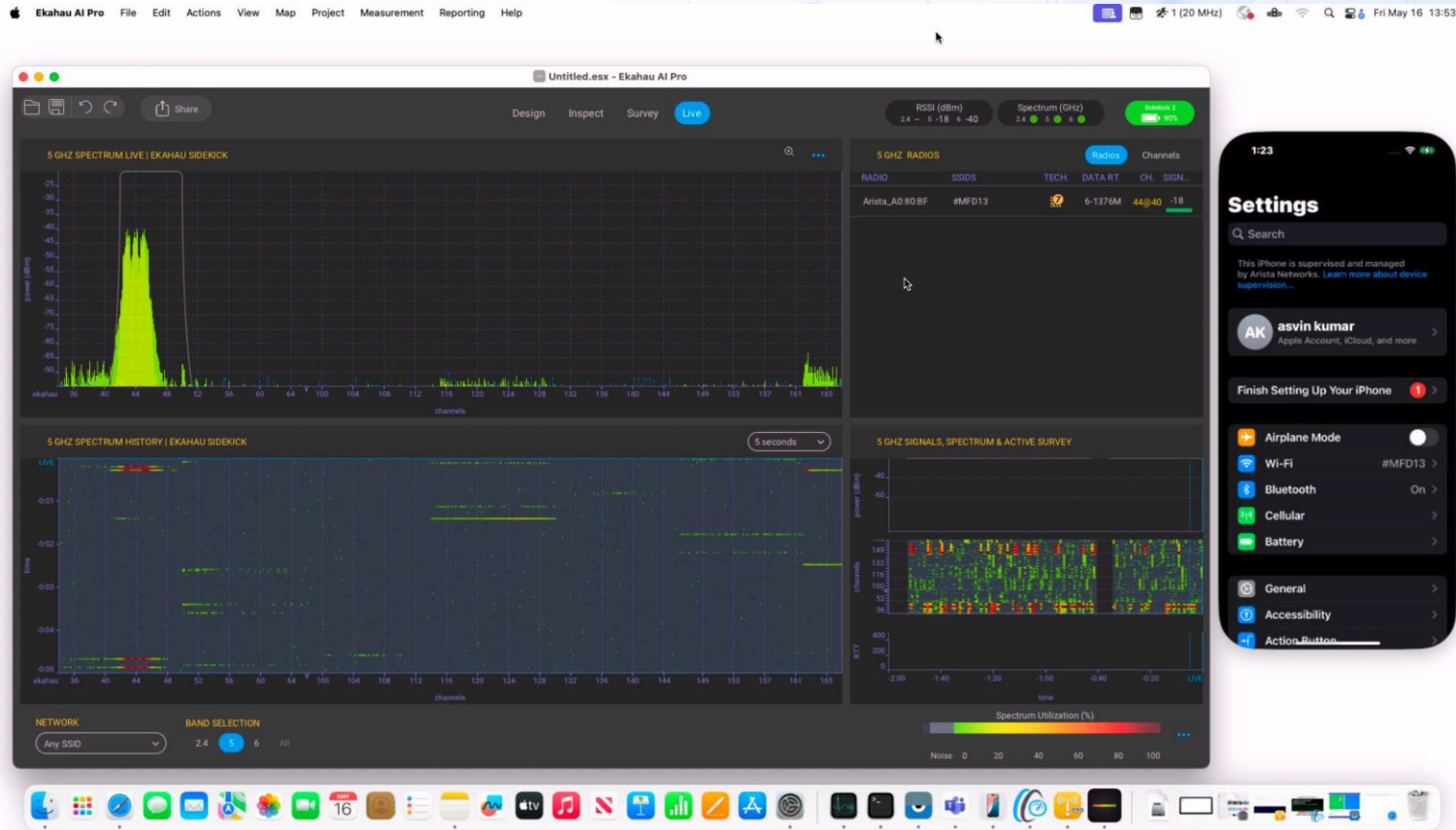
Client	Chipset	EMLSR	STR-MLMR	NSTR-MLMR
Google Pixel 8	Broadcom	5 + 6	2.4 + 5, 2.4 + 6	Not supported
Google Pixel 8 Pro	Broadcom	5 + 6	2.4 + 5, 2.4 + 6	Not supported
Google Pixel 9	Broadcom	5 + 6	2.4 + 5, 2.4 + 6	5 + 6 Advertised, not supported
iPhone 16	Broadcom	Data transfer only on one link either 5 or 6 GHz based on association	2.4 + 5 Advertised, Data transfer only on one link. 2.5 + 6 Advertised, Data transfer only on one link	5 + 6 Advertised, not supported
iPhone 16 Pro	Broadcom	Data transfer only on one link either 5 or 6 GHz based on association	2.4 + 5 Advertised, Data transfer only on one link. 2.5 + 6 Advertised, Data transfer only on one link	5 + 6 Advertised, not supported
OnePlus 11	Qualcomm	Not supported	2.4 + 5, 2.4 + 6	Not supported
Samsung S24	Qualcomm	Not supported	2.4 + 5, 2.4 + 6	Not supported
Intel BE200	Intel	2.4 + 5, 2.4 + 6, 5+ 6	Not supported	Not supported
QC Fast Connect 7800	Qualcomm	5 + 6 GHz STR-MLMR	2.4 + 5, 2.4 + 6, 5 + 6	Not supported

# ARISTA

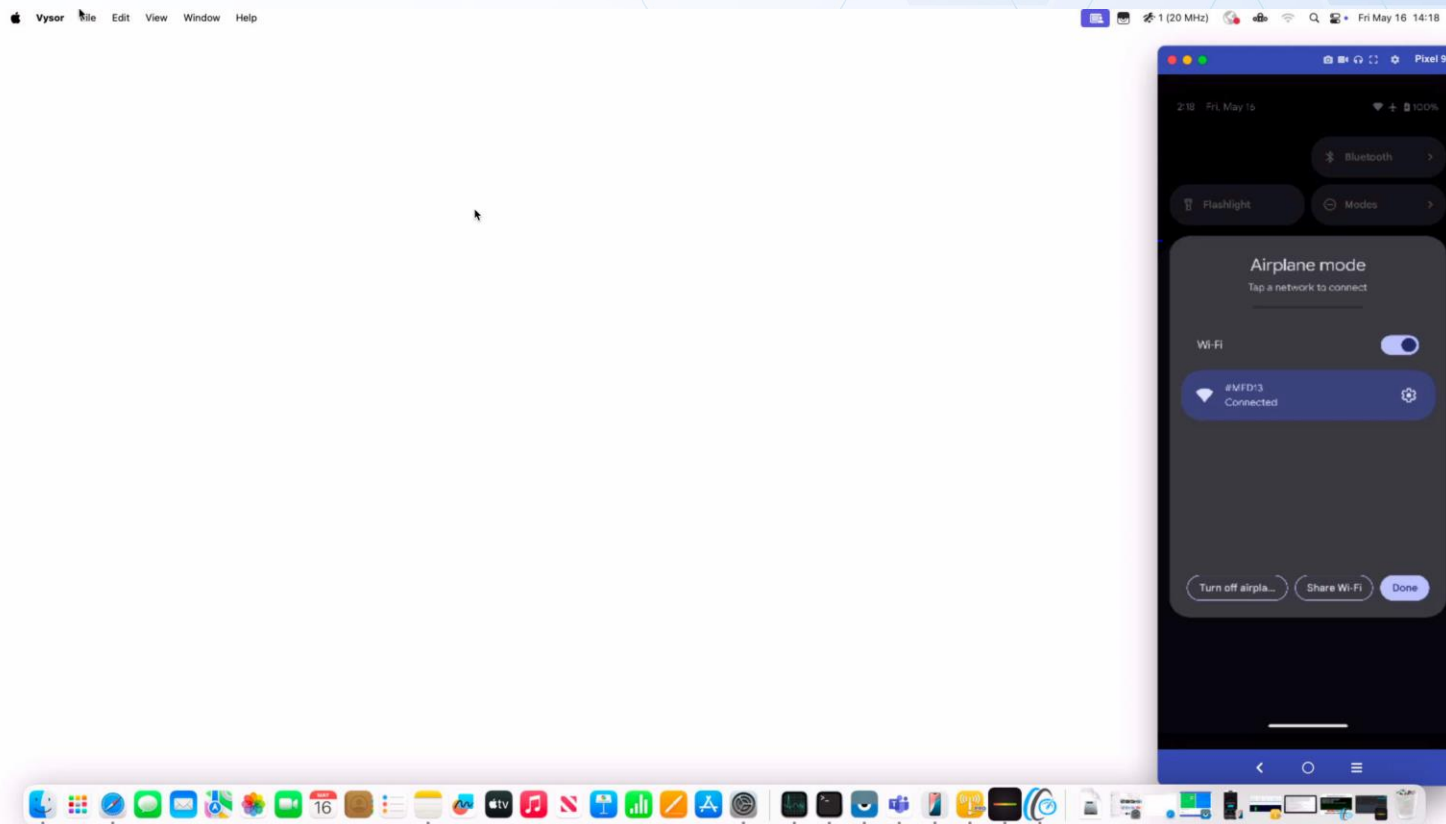
## Demos



# Demo 1 – Spectrum view of iPhone 16

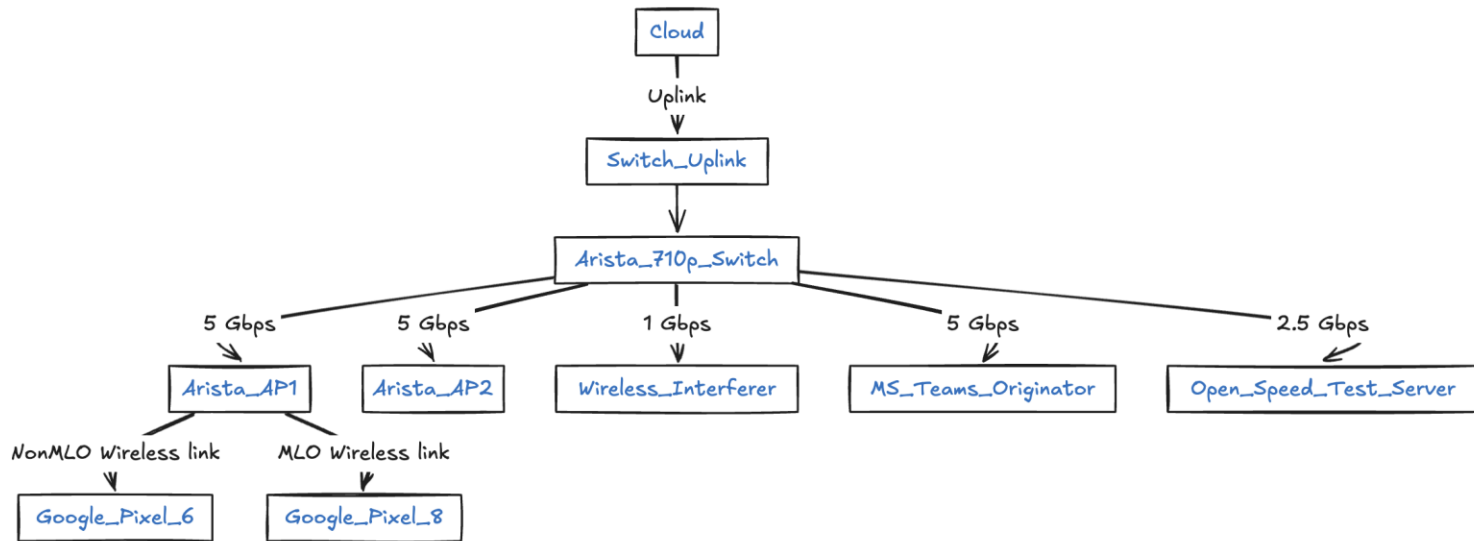


# Demo 2 – Spectrum view of Google Pixel 9 during Interference



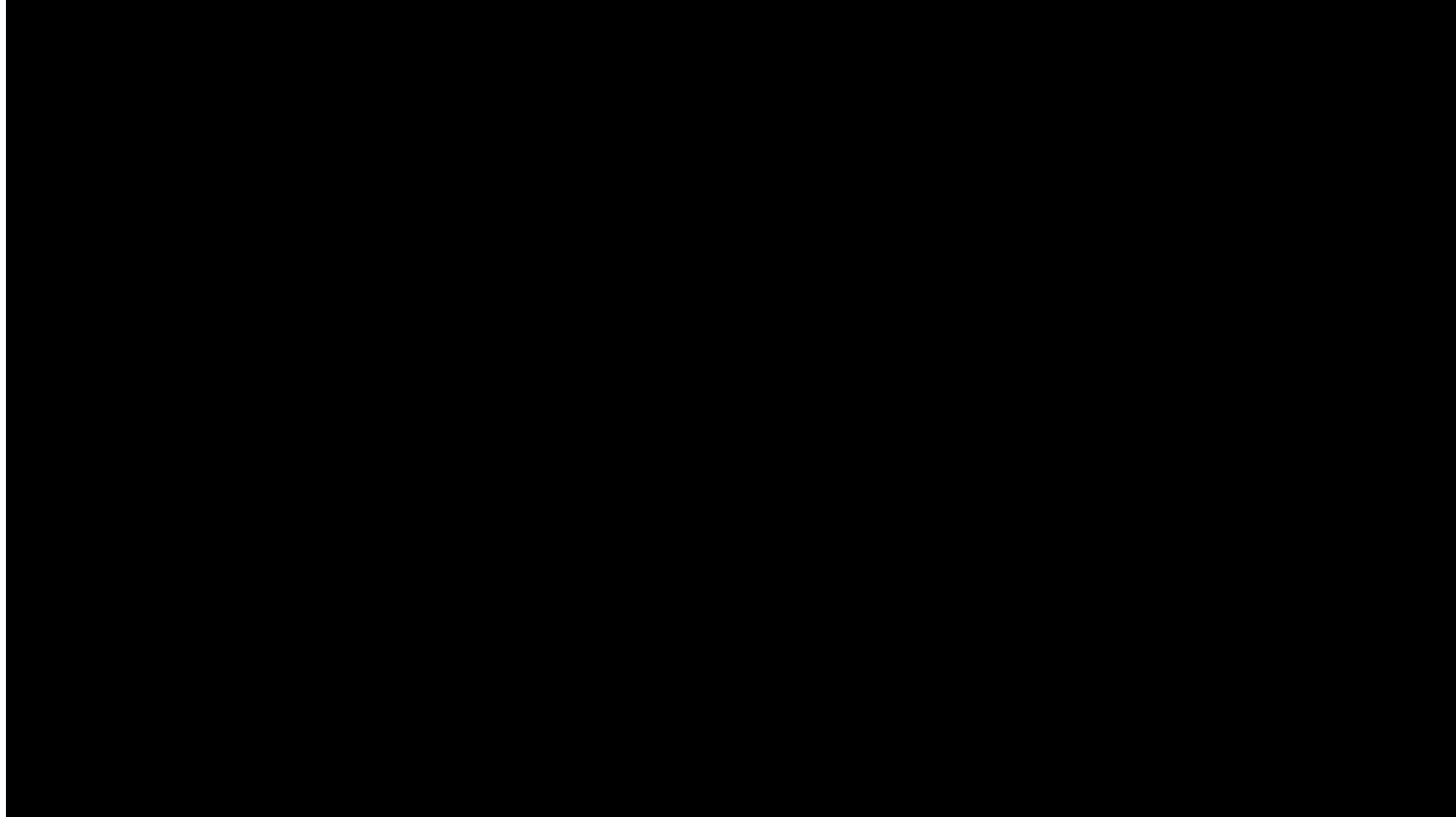
# Demo 3 – MLO Vs Non-MLO during active MS-Teams voice calls in congested environment.

## Topology





# Demo 3 – MLO Vs Non-MLO during active voice calls in congested environment.



## Demo 3 - Key Takeaway

- Voice call quality is good for MLO clients compared to Non-MLO clients. MLO clients took advantage of dynamic steering and doesn't break the connection
- For the bad calls – Admin get a live feed via slack or google meet thru webhooks indicating the location of the client
- MLO + QOS Telemetry come together to support Day2 operation helping admin to understand and act on the issues in real time.

# Wi-Fi 7 Deployment Guidelines/Design Considerations



## SSID Configuration

For Enterprise (dot1x) SSIDs, use WPA3 Transition mode with PMF optional

- MLO clients will connect with WPA3 in MLO mode.
- Non-MLO clients will connect with WPA3/WPA2 in Non-MLO mode based on their capabilities

For Personal (PSK/SAE) SSIDs, use WPA3 Transition mode with PMF optional

- MLO clients will connect with WPA3 in MLO mode.
- Non-MLO clients will connect with WPA3/WPA2 in Non-MLO mode based on their capabilities

For IoT SSIDs, MLO may not be applicable and better to turn off MLO



## AP Deployment

Replace Wi-Fi 6E APs with Wi-Fi 7 APs directly if the RF design and planning are already optimized.



## Network

High-end Wi-Fi 7 APs require BT power (802.3bt) to operate at full performance.

Mid-range and entry-level Wi-Fi 7 APs may function with AT power (802.3at), but with limited capabilities.

For optimal throughput, connect APs to multi-Gigabit switch ports (2.5G / 5G / 10G) or use link aggregation where supported.

Use Cat6a or higher cabling for 10G uplinks, especially for runs up to 100 meters.

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Thank You

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