

What is BSS Coloring? and is it useful in practice?



Theory

How it works

Wi-Fi 6 (802.11ax) adds a 6-bit identifier (values 1–63) to the PHY header (HE-SIG-A), “color-coding” each network.

Where to check

The HE Operation element contains the BSS color value in Beacons, Probe Responses and (Re)Association Responses.

```
Ext Tag: HE Operation
Ext Tag length: 11 (Tag len: 12)
Ext Tag Number: HE Operation (36)
HE Operation Parameters: 0x023ff4
BSS Color Information: 0x12
..01 0010 = BSS Color: 0x12
..0... = Partial BSS Color: False
0... = BSS Color Disabled: False
Basic HE-MCS and NSS Set: 0xffff
```

Frame Type	SSID	BSS Color	Channel
Beacon	"xfinitywifi","Xfinity Mobile"	0x05	117
Beacon	<MISSING>	0x12	1
Beacon	"WPA3 Ent Test"	0x12	117
Beacon	"WPA3 Ent Test"	0x05	112
Beacon	<MISSING>	0x12	117
Beacon	<MISSING>	0x05	112
Beacon	"WPA3 Ent Test"	0x17	1
Beacon	<MISSING>	0x17	1

Frame format

BSS Color	Partial BSS Color	BSS Color Disable
6 bits	1 bit	1 bit

Figure 9-906—BSS Color Information field format, IEEE 802.11-2024

BSS Recognition

Devices can distinguish between

- Intra-BSS frames (same color)
- Inter-BSS frames (different color)

without demodulating the entire packet.

Spatial Reuse

If a neighboring signal has a different color and its strength is below a specific OBSS_PD threshold (typically -62 dBm), the device ignores it and transmits simultaneously.

“The PHY entity shall check the BSS color in the HE-SIG-A field. If the BSS color does not contain an intended value[...], the PHY entity shall issue a PHY-RXSTART.indication(RXVECTOR) and then issue a PHY-RXEND.indication”
- 27.3.23 HE transmit procedure, IEEE 802.11-2024

Promised Payoff

Simulations suggest BSS Coloring can deliver throughput increases of 43% in dense environments, lower latency, and better battery life via early packet dropping.

(Natkaniec, M.; Bieryt, N. An Analysis of the Mixed IEEE 802.11ax Wireless Networks in the 5 GHz Band. Sensors 2023, 23, 4964.)

Practice

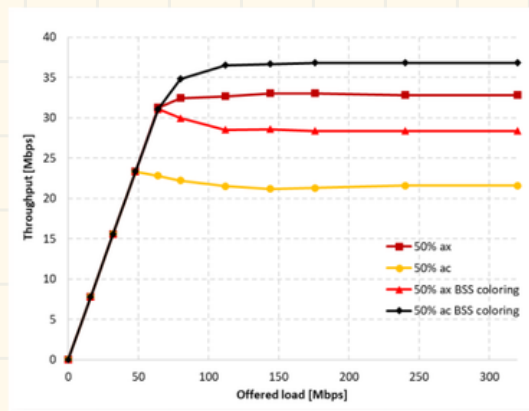
Legacy Pains

Older devices (802.11a/b/g/n/ac) are “colorblind”. They read a different PHY header format, neutralizing the airtime gains.



Mixed-Networks

In saturated mixed environments, legacy stations can gain an unfair advantage, while Wi-Fi 6 stations may experience lower throughput than if BSS Coloring was disabled.



“Figure 13. Throughput vs. offered load for mixed ax (50%) and ac (50%) networks without aggregation
- Natkaniec, M.; Bieryt, N. An Analysis of the Mixed IEEE 802.11ax Wireless Networks in the 5 GHz Band. Sensors 2023, 23, 4964.

Threshold Trade-off

Increasing the OBSS_PD threshold too much can minimize throughput gains. -64 dBm resulted in the smallest increase in this study. High thresholds and low distances actually decreased throughput when frame aggregation was disabled.

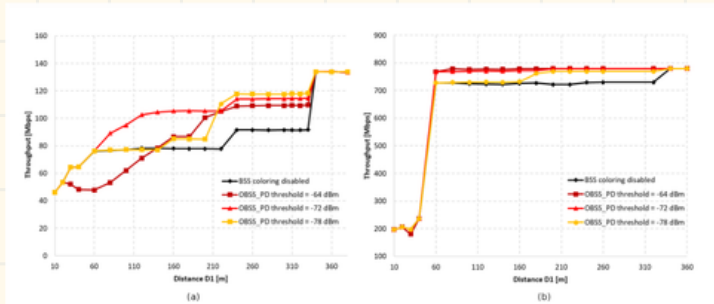


Figure 7. Throughput as a function of D1 distance for different OBSS_PD threshold values and four BSS: (a) aggregation disabled and (b) aggregation enabled.
- Natkaniec, M.; Bieryt, N. An Analysis of the Mixed IEEE 802.11ax Wireless Networks in the 5 GHz Band. Sensors 2023, 23, 4964.

Validation Gap

While BSS Coloring is elegant engineering, measurable production gains often require manual tuning and expert RF design. These are also simulated events without the variances of real-world PHY.