Wi-Fi's Best Kept Secret

White Paper

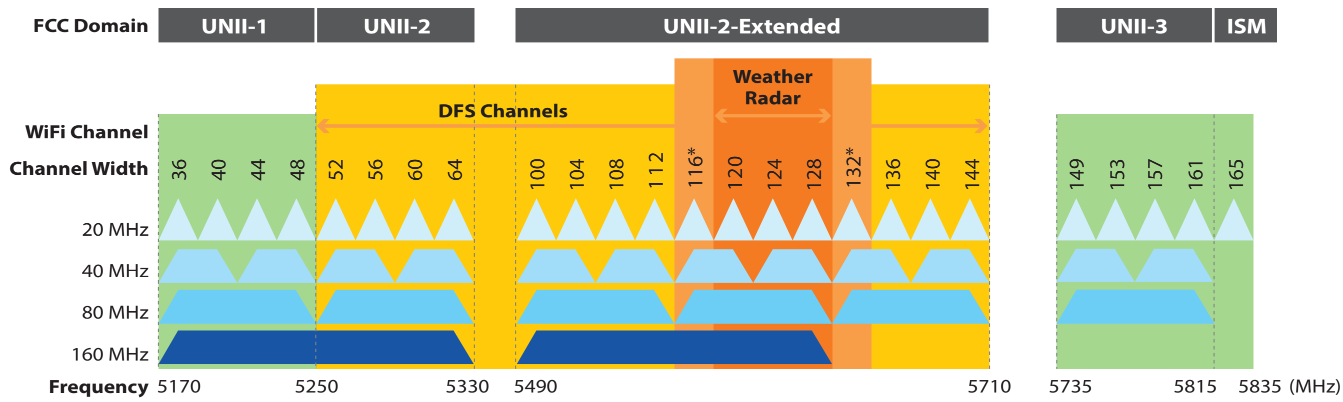
Co-channel Interference Test Report

Overcoming the Ultimate Wi-Fi Challenge

Co-channel interference is a problem common to any large-scale wireless deployment. However, no wireless vendor has tested what would happen when operating two access points set to identical channels. The reason for this is that, until recently, there existed no effective solution to manage or eliminate co-channel interference.

From the earliest stages in the development of smart-antenna technology, ZyXEL's primary goal was to resolve the issue of co-channel interference.

We all love high-quality video streaming and lag-free mobile learning made possible by today's 802.11ac APs, but the advantages of this new technology come at a price. With IEEE802.11 and all other wireless networking technology, accessing wider bandwidth offers an effective means of achieving higher transfer rates. For example, a single stream at the 802.11ac standard supports 433 Mbps at 80 MHz bandwidth and up to 866 Mbps at 160 MHz. Spectrum frequencies allocate just six and two non-overlapping channels for 80 and 160 MHz channel bandwidths, respectively. The situation is further complicated by the fact that not all six channels are available in every region. In addition, experienced IT staffers know to avoid using certain channels within the range of weather radar, which can negatively impact wireless signals operating on the same frequency.



How bad can the effects co-channel interference be?

Reducing transmission power may seem to be the obvious solution to alleviate the impact of co-channel interference, but this remedy comes with its side effects — reduced coverage and an increase in the number of dead zones. In addition, co-channel interference raises several complex questions: Can APs effectively send data in the presence of co-channel interference from other APs, and if so, can the client receive the data and send it back?

In accordance with the 802.11ac standard, an access point will cease transmitting when it receives a signal stronger than -82 dBM — what is known as the clear channel assessment. In practice, when the signal between two APs falls to -82 dBm — and the mean distance between the two APs is between 300 to 400 meters in an open space or blocked by 2-3 brick or concrete walls — co-channel interference can be expected. In addition, the impacted area is much larger than the -82 dBm line. A client is able to establish a connection with an AP when the AP signal is as low as -80 to -90 dBM, depending on the AP and the client's capability. As long as the client is within the coverage area of the other AP using the same channel, co-channel interference can occur. This can result not only in a client failing to receive a packet, but can also cause a massive delays as both APs continue to reattempt failed transmissions, significantly reducing data transmission rates.

In this benchmark test, two APs are set up in line with a received signal below -82 dBM. This ensures that both APs are able to transmit continuously while interfering with each other's signal as multiple clients link to them.

The following test results show that ZyXEL Smart Antenna technology offers a breakthrough by providing wider coverage and delivering the best throughput while exposed to co-channel interference. ZyXEL placed number-one in the coverage test by delivering the best throughput to the most locations at both 2.4 GHz and 5 GHz, as well as 66% higher throughput in those locations that were difficult to reach. In the co-channel interference test, the Smart Antenna advantage of the ZyXEL APs improves overall Wi-Fi performance as much as +100% when compared to products from other industry-leading competitors.

What follows are the findings of our Co-channel Interference Challenge.

Devices Under Test

Vendor	Aruba	Cisco	Ruckus	ZyXEL
Model name	**AP-225**	**2702i**	**R700**	**WAC6503D-S**
PHY	802.11ac	802.11ac	802.11ac	802.11ac
Spatial streams	3x3:3	3x4:3	3x3:3	3x3:3
Radio	Dual radio	Dual radio	Dual radio	Dual radio
Smart antenna	-	-	Yes	Yes

Key Finding

- **ZyXEL APs featuring Smart Antenna achieved the best coverage.**
  In the coverage test, the Smart Antenna-equipped AP from ZyXEL achieve the best results at both 2.4 GHz and 5 GHz, and delivered 66% better throughput in difficult-to-reach locations.

- **Reconfigurable antenna technologies are the key for improving throughput and for reducing co-channel interference in Wi-Fi networks.**
  In the co-channel interference test, the ZyXEL smart-antenna-equipped AP performed 75% better on average over the Aruba device. In fact, the single ZyXEL AP outperformed two Aruba APs.

Study Confirms that ZyXEL Smart Antenna AP is the Best Solution

Increased use of mobile applications and demand for wireless service has been matched by steady growth in the number of mobile devices. To keep pace with this demand, WLAN infrastructures must offer more throughput and higher data speeds. Currently, the 802.11ac wireless standard with its superior bandwidth, MIMO, and denser modulation offers the best wireless solution for modern venues. In addition to standard features offered, every vendor pays close attention to optimized antenna design. ZyXEL and Ruckus concurrently introduced AP products that adopt smart-antenna technology.

The coverage performance test results demonstrate that the smart-antenna APs from Ruckus and ZyXEL see gains of 60% and 35% respectively when compared to products from Cisco and Aruba in deployments with significant physical obstacles — like concrete or brick walls — between the AP and client. The performance of the Ruckus AP, however, falls off sharply at 2.4 GHz, and is barely able to connect with the client in some locations.

The second test, conducted at the University of Brescia, simulates overt co-channel interference in large-venue deployments. To be objective, four pairs of APs were configured to transmit at 17 dBm, and each AP was individually deployed in a separate room on the same floor, surrounded by four clients. The total aggregate throughput for the four clients is calculated in four separate deployments. On average, the ZyXEL devices demonstrated a 70% performance advantage. To determine whether smart-antenna technology addresses the co-channel interference issue even at higher transmission power levels, the university executed a similar test in which transmission power was increased 4 times to 23 dBm for the access points equipped with smart antennas. The other devices were maintained at 17 dBm, which should with advantage with less co-channel interference. Even under such conditions, ZyXEL outperformed the other APs in all four deployments. This confirmed that ZyXEL smart-antenna technology stood out in the most demanding Wi-Fi environments.

Conduct and Procedure of The Experiment

This experiment was conducted with the assistance of the Wireless Networking Group of the University of Brescia, a professional outreach unit that focuses on wireless networking. The group specializes in analysis, design, and experimental characteristics related to wireless network performance at the physical and media-access control layers. Research activities include the opportunistic exploitation of 802.11 networks for localization, jamming, and pseudo-deterministic channel algorithms.

Coverage Test

This test was designed to determine if access points adopting smart-antenna technology achieve higher throughput in multi-reflective environments, and whether performance in these situations directly impacts user experience.

The access point in this test is deployed in a room with an open floor plan, while 10 clients are located in several nearby rooms. Each is configured to experience different levels of reflection from single and multiple sources. To avoid the bias of reciprocal orientation of the APs, the test is run twice for each of the four rotations — 0, 90, 180, 270 degrees. The final result is obtained by picking the best result from two outcomes and calculating the average over the four rotations.

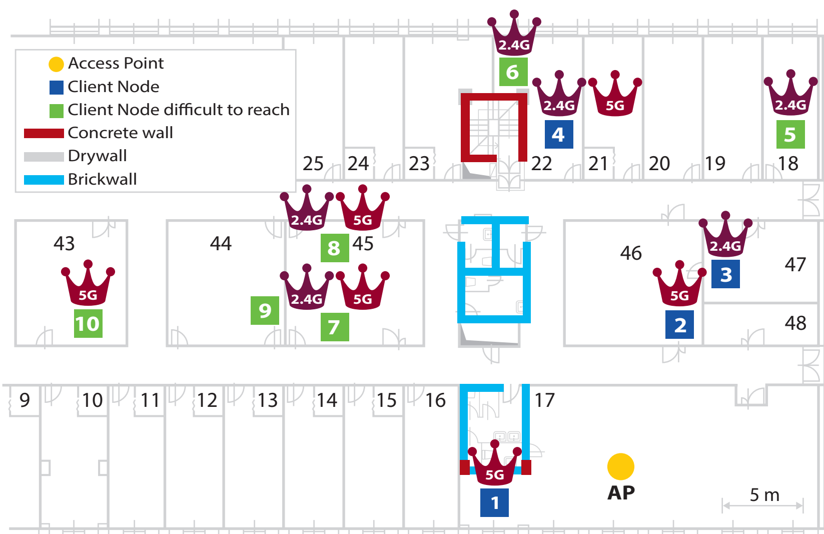


Figure 1 The deployment of coverage test; ZyXEL ranks no.1 in the most positions

As shown in the following figures, the first- and second-best performance was achieved by Ruckus and ZyXEL devices in almost every category. This reflects the benefits of the smart antenna, with ZyXEL's smart antenna boosting performance by 60% at both 5 GHz and 2.4 GHz.

Position	Aruba	Cisco	Ruckus	ZyXEL
P1	431.82	367.35	371.99	497.61
P2	373.06	453.71	377.58	493.11
P3	288.62	247.34	299.09	291.38
P4	248.83	258.82	284.10	333.04
P5	**77.13**	**72.46**	**125.03**	**99.76**
P6	**125.73**	**108.78**	**162.15**	**149.11**
P7	**103.56**	**76.88**	**122.34**	**141.35**
P8	**105.32**	**95.87**	**128.92**	**144.24**
P9	**37.97**	**28.33**	**76.83**	**55.59**
P10	**7.94**	**10.26**	**21.61**	**21.96**
sum	457.65	392.58	636.88	612.01
gain	17%	0%	62%	56%

Table1 The result at 5 GHz

Position	Aruba	Cisco	Ruckus	ZyXEL
P1	110.59	111.55	115.32	111.90
P2	120.77	116.42	117.92	119.44
P3	112.56	102.56	111.24	116.97
P4	109.12	99.88	106.20	117.14
P5	**41.00**	**72.05**	**0.16**	**85.03**
P6	**47.74**	**49.06**	**65.37**	**80.84**
P7	**60.28**	**64.96**	**35.22**	**80.67**
P8	**50.70**	**46.16**	**36.61**	**63.94**
P9	**46.95**	**37.75**	**64.88**	**61.25**
P10	**26.62**	**25.31**	**45.62**	**40.92**
sum	273.29	295.29	247.86	412.65
gain	10%	19%	0%	66%

Table2 The result at 2.4 GHz

Co-channel Interference Test

The mainstream popularity of the 802.11ac standard brings with it the potential issue of a lack of available channels in the 80/160 MHz range. Therefore, co-channel interference is an unavoidable consequence of 802.11ac when planning deployments in large venues or high-density Wi-Fi environments. The co-channel test reveals the potential benefits of smart-antenna technology in such scenarios.

Phase 1

A pair of access points from the same vendor were deployed in two nearby rooms, as shown in figure 4, and both are configured at 80 MHz on channel 157 at 17 dBm transmission power. In this setup, the interference impact of the two APs should be identical, as they share the same channel. Each AP services four associated clients, which are deployed in four different configurations to avoid test bias. This test is designed to recreate a realistic usage scenario and monitor the TCP transport traffic of eight clients at once.

Table 5 shows the total aggregate throughput recorded in the four deployments for each vendor. In the first three deployments, ZyXEL stands out with an advantage ranging from 25.5% to 46.7% over the second-best performer, Cisco. Only in the fourth deployment does Cisco perform better, with a 14.6% advantage over ZyXEL. However, unlike the first test, fellow smart-antenna adopter Ruckus did not show significant advantage in a co-channel environment.

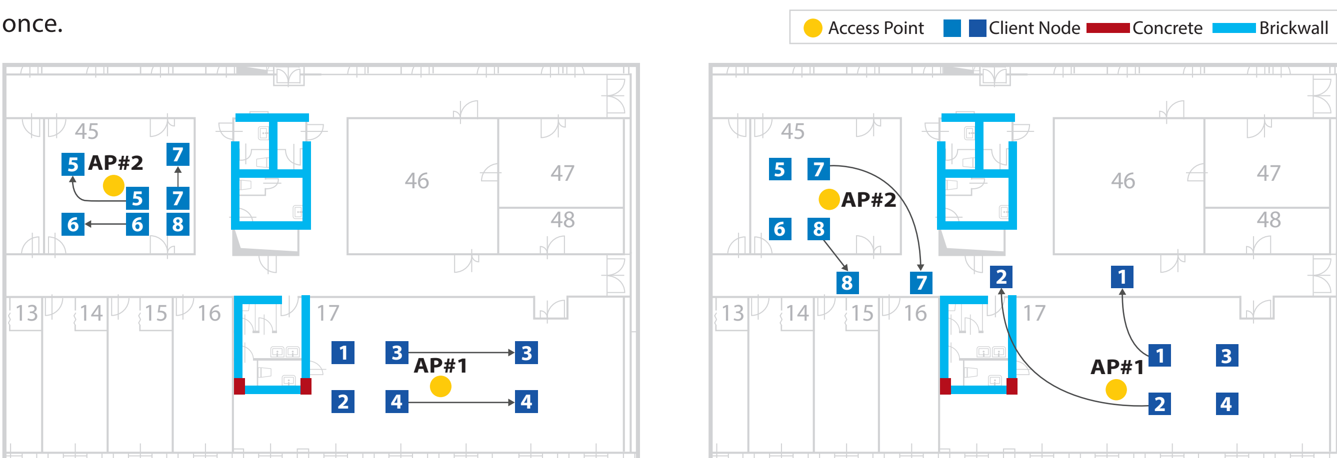
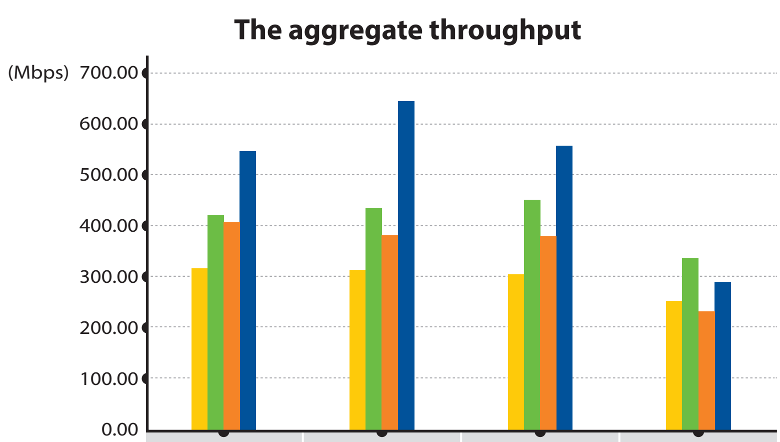


Figure 2 & 3 The four deployments of co-channel interference (1)



	depl.1-1	depl.1-2	depl.2-1	depl.2-2
Aruba	317.81	314.20	303.57	268.44
Cisco	425.82	439.87	452.95	333.30
Ruckus	402.09	385.11	385.74	237.88
ZyXEL	544.98	645.36	568.57	290.68

Figure 4 The result of co-channel interference (1)

Phase 2

Drawing upon the findings of phase 1, phase 2 creates a similar test. Transmission power is adjusted up to 23 dBm on both the Ruckus and ZyXEL devices — the two access points with smart antennas — while the others are maintained at 17 dBm. In this phase — a much more demanding environment — the two smart-antenna APs are tested to see whether they demonstrate a significant performance advantage.

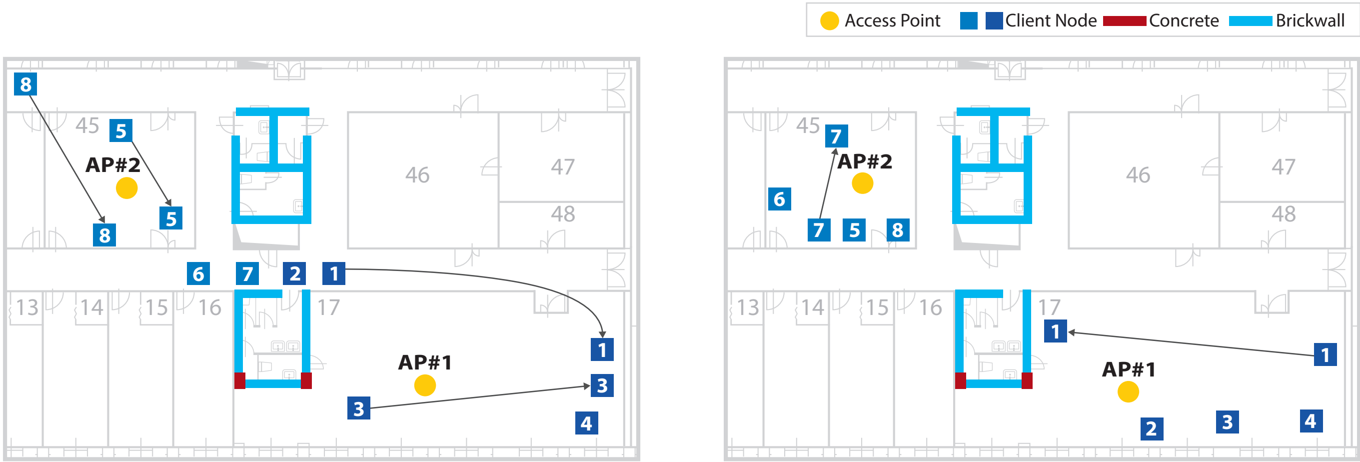
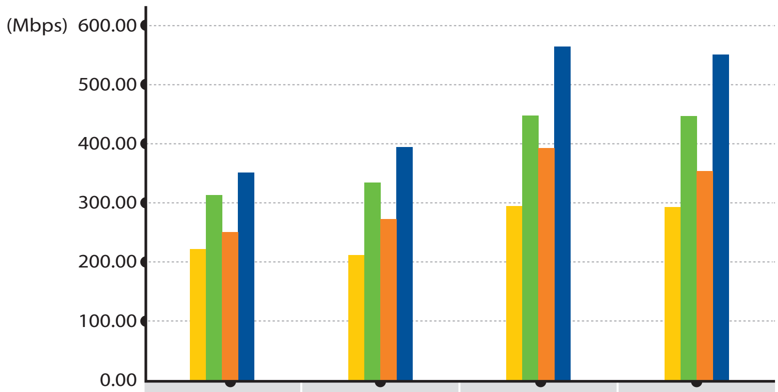


Figure 5 & 6 The four deployments of co-channel interference (2)



	depl.3-1	depl.3-2	depl.4-1	depl.4-2
Aruba	220.85	215.42	297.93	295.94
Cisco	315.28	336.18	448.62	444.03
Ruckus	261.92	280.10	391.25	366.35
ZyXEL	353.93	396.35	574.11	546.64

Figure 7 The result of co-channel interference (2)

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