

**White Paper**

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# **Atheros eXtended Range XR<sup>™</sup> Technology**

**Going the Distance**



# Atheros eXtended Range XR™ Technology

## Executive Summary

Wireless networking applications and services require an infrastructure that enables high bandwidth performance, ubiquitous coverage and robust delivery capability for WLAN products. While each market segment may have different application drivers and needs, all require these underlying infrastructure performance characteristics.

As outlined in the Atheros white paper, Super G - Maximizing Wireless Performance, WLAN infrastructure performance requirements fall into two key areas that determine the quality of a wireless solution:

- Throughput- needed for bandwidth intensive applications and growing volume of users; must meet or exceed “wired” speeds
- Coverage-required for connectivity at long range and in all corners of the home, office, enterprise, or hot spot

Adequate coverage is especially critical in the home/SOHO arena. Consumer “product return” decisions are frequently tied to the connection success or failure at the moment of installation. This means that ample range is crucial along with solving the wireless “dead spot” challenge. Of course, these requirements must also be addressed in a way that is easy for the user and/or network administrator to utilize and support. Atheros' eXtended Range (XR™) technology was designed to provide unprecedented wireless LAN coverage including:

- Line-of-sight range that is 2x to 3x that of traditional solutions: a connection where otherwise it is not possible
- Elimination of indoor dead spots
- Transparent operation with no user intervention required
- Enabled devices that still remain standards-interoperable with 3rd party devices

eXtended Range technology consists of a signal processing architecture that stretches the performance of a WLAN by embedding separate optimized designs for both high performance/high signal-to-noise ratio environments and long range/low signal-to-noise ratio environments. XR is able to maintain standards compliance while providing these unique benefits individually to those stations and APs on a given network that can support this technology. [Table 1-1](#) summarizes XR's components and benefits, which are described in detail later in this white paper.

*Table 1-1. eXtended Range Component Summary*

Component	Benefit
Enhanced Receive Sensitivity	<ul style="list-style-type: none"> <li>■ Up to -105dBm: over 20 dB better than the 802.11 specification</li> <li>■ Process extremely weak signals</li> <li>■ Supports additional transmission rates equivalent to 3, 2, 1, 0.5, 0.25 Mbps</li> <li>■ Extends support for signal beyond traditional 802.11 boundaries</li> </ul>
Seamless Standard and XR Mode Support	<ul style="list-style-type: none"> <li>■ Transparent to users</li> <li>■ Standards-interoperable</li> </ul>

**NOTE:** Actual operational rates subject to specific regulatory requirements.

## Coverage Needs of Wireless Networking Applications

Coverage is an issue for all segments as shown in figure 1-1. Traditional 802.11 solutions were not designed to support many of the current coverage needs as follows:

### Home

Typically, a single AP/router provides access to valuable broadband services and coordinates network activity throughout the home and yard. For a solid home network foundation, the following must be considered:

- A single AP must cover the entire property
  - Pulling Ethernet cable for additional APs is not viable
  - Placement of the AP may not be centrally located because it is dictated by the location of the broadband modem
- The WLAN must support transmission through all types of home layouts
  - Many homes include basements with cement walls or converted garages
  - Large variety of construction materials: stucco, brick, plaster, wood
- Emerging multimedia applications such as wireless audio players which are much less forgiving of “dead spots” must be supported

## Office

Office environments are also susceptible to “dead spots”. The current solution is to deploy additional APs which is a costly installation and configuration exercise. Initial AP deployment with broader coverage is preferred in these scenarios due to configuration management simplicity and reduced cost.

## Public Areas

Simply put, “best possible” range for public areas or hot spots translates to more users/customers capable of accessing the network and greater utility derived from the network. In summary, all market segments are experiencing coverage issues.

### Needs in All Segments

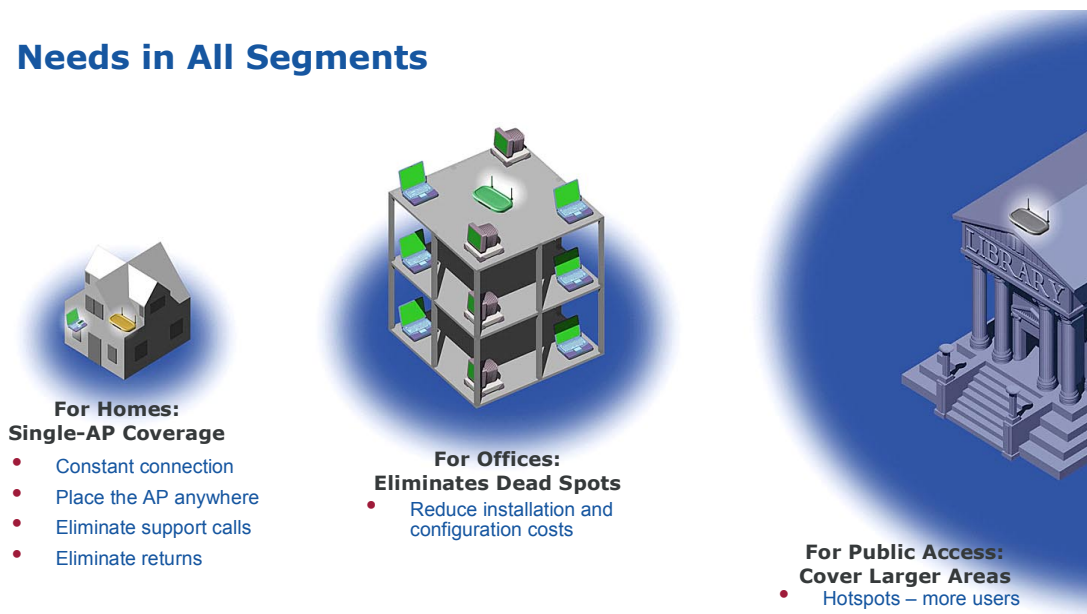


Figure 1-1. Coverage Requirements per Segment

### Resulting Coverage Requirements Common to Segments

- **Extended Range**—Whether it's access from the yard, corporate conference room, or hot spot park bench, connectivity is critical. So, the WLAN architecture must be tuned for long range, low signal-to-noise environments as well as be able to support maximum throughputs in typical environments
- **Reliable Coverage**—No “dead spots”- Given the desire for ubiquitous wireless networking, it must be deployed virtually everywhere without regard to specific construction materials. The attenuation characteristics of these construction materials varies greatly and wireless solutions must be robust enough to address these variabilities
- **Ease of Use**—Like throughput enhancements, coverage enhancements must allow standard devices to maintain communication while enhanced stations and APs take advantage of the additional capabilities

# eXtended Range: Addresses Coverage Requirements

## XR Overview

Atheros' eXtended Range (XR) technology is a method of processing 802.11 signals that enables wireless networks to have fewer "dead spots" and greater range than typical 802.11 products; in effect, a "low gear" for wireless networks. The basic methods of processing wireless signals, as defined by the IEEE 802.11a and 802.11g standards are optimized for the delivery of signals in environments where signal strength is strong. As range increases or walls intervene, signal strength drops, but the same basic signal processing methods are used. This is why "dead spots" occur in wireless networks and why the connection drops abruptly at longer ranges.

eXtended Range products dynamically adapt to sub-optimal environments and process weaker signals more effectively. The products shift from the more limited signal recovery techniques described by the IEEE standard to more advanced techniques used in cellular and other wireless industries. As a result, eXtended Range (XR) greatly increases the coverage of an 802.11a/b/g network.

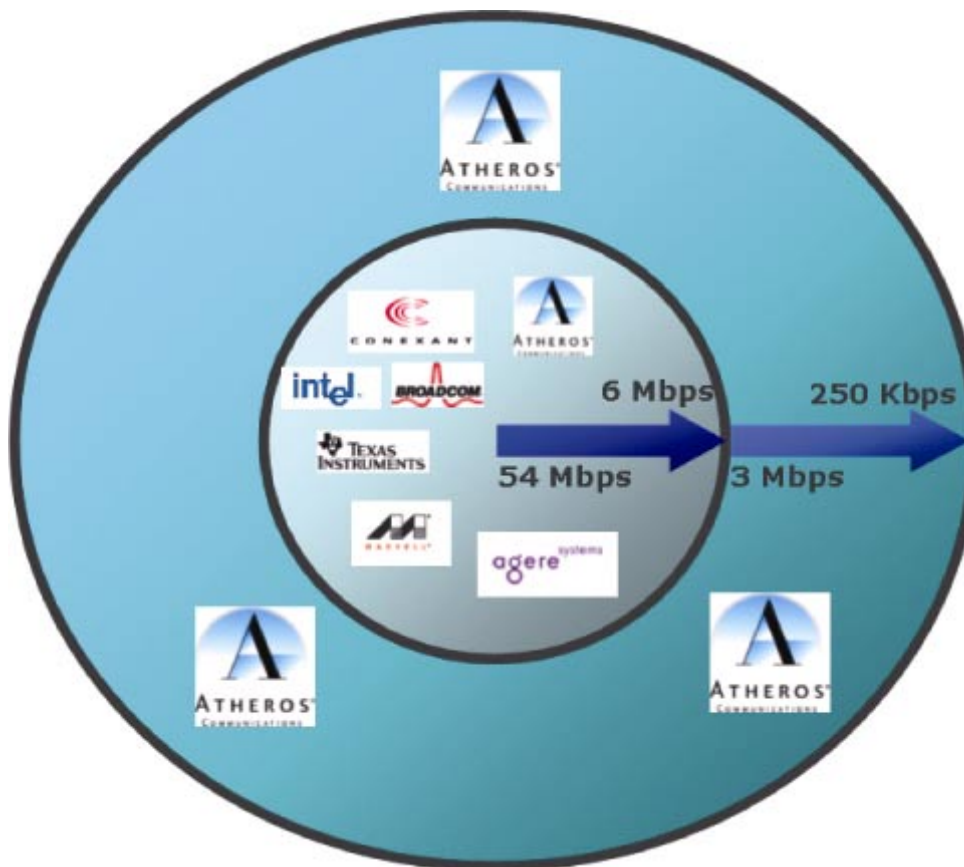


Figure 1-2. eXtended Range Mode vs. Standard Mode

In standard 802.11a/b/g mode (inner circle of Figure 1-2), Atheros' RF transmit power and high receive sensitivity capabilities translate to industry best range and throughput performance. However, there are situations where users require coverage beyond traditional 802.11 capabilities and in areas where the AP signal may be weak due to propagation issues (outer circle of Figure 1-2). Key components of the "XR" solution include (1) Enhanced Receive Sensitivity and (2) Seamless Standard and XR Mode Support.

## XR Key Components

### 1. Enhanced Receive Sensitivity

Received signal power falls rapidly with distance and obstructions which is a phenomenon called path loss. The capability to enable low signal to noise (SNR) operation is critical to address this RF signal path loss in all operating environments. Different environments experience varying effects of path loss. Further, indoor path loss is much worse than outdoor path loss due to greater attenuation of dense walls and objects. A common model for calculating 2.4 GHz RF path loss is as follows:

$$\text{Path loss(dB)} = P(1) + 10 \cdot \log[D^n]$$

where D = distance in meters (1 meter = 3.28 feet)

P(1) = path loss at 1 meter = 41 dB

n = path loss exponent: open space = 2, open office = 3.3, home = 4.5

(Note that the path loss exponent varies based on attenuation characteristics of the specific environment)

#### Home Case Study - Receive Sensitivity

Using this model, we can estimate path loss for between 10 meters and 70 meters in a home environment at 10 meter increments. Of course, these figures can vary significantly depending on the environmental factors listed above. This exercise simply illustrates the importance of receive sensitivity differences.

Table 1-2. Home path loss at 10 m increments

	10 m	20 m	30 m	40 m	50 m	60 m	70 m
Overall Loss	86 dB	100 dB	107 dB	113 dB	117 dB	121 dB	124 dB
Incremental Loss for Prior 10 meters	N/A	14 dB	7 dB	6 dB	4 dB	4 dB	3 dB

Two facts stand out:

1. As a station moves further away from the AP, each single dB loss is more critical with respect to supported range. Further, this is magnified for an outdoor line-of-sight environment because a small difference in receive sensitivity can alter coverage by hundreds of meters.
2. As additional obstacles are introduced, the importance of each dB is even more significant when coverage of a particular area is desired. For example, a ¾" piece of plywood can attenuate a signal by ~4dB, while a concrete wall can attenuate a signal on the order of ~8–15 dB depending on thickness.

So, when covering a structure at distances of ~30 meters or more through multiple walls or open air at much longer distances, it is essential to have very robust receive sensitivity capability to make practical use of weaker signals. Atheros has enhanced its MAC and PHY technology to support very low signal to noise (SNR) operation. This leads to significantly improved receive sensitivity measurements that provide superior signal processing capability.

eXtended Range builds upon 802.11a/g by adding transmission rates equivalent to 3, 2, 1, 0.5 and 0.25 Mbps. As with typical operation, these new rates are added to the list of rates used by Atheros' rate adaptation algorithm to maximize throughput while maintaining reliable data transmission. This rate adaptation automatically engages as required to mitigate the effects of distance, obstacles and interference.

Table 1-3. eXtended Range Receive Sensitivity vs. Standard

Data Rate	Receive Sensitivity	Incremental Range Benefit for Home and Office
IEEE 802.11 Spec	-85 dBm	N/A
Atheros 6 Mbps 802.11a/g std.	-93 dBm	N/A
Atheros 1 Mbps 802.11b std.	-96 dBm	N/A
Atheros eXtended Range at 1 Mbps	-101 dBm	30-42% more range vs. 1 Mbps 802.11b
Atheros eXtended Range at 250 Mbps	-105 dBm	58-86% more range vs. 1 Mbps 802.11b 85-130% more range vs. 6 Mbps 802.11ag

**NOTE:** Improvements are even greater over 54 Mbps 802.11ag data rate.

The obvious result of these receive sensitivity enhancements is the radically increased range as described in Table 1-3. Range benefits of a 9 dB receive sensitivity (or SNR gain) advantage over a 1Mbps 802.11b solution can be derived as follows:

$$9\text{dB}/3.3 = 2.7 \rightarrow 10^n = 1.86 \text{ (where } n = 2.7/10) \rightarrow 1.86 = 86\% \text{ more range for office}$$

$$9\text{dB}/4.5 = 2.0 \rightarrow 10^n = 1.58 \text{ (where } n = 2.0/10) \rightarrow 1.58 = 58\% \text{ more range for home}$$

(Note that 3.3 and 4.5 are the path loss exponents for open office and home, respectively.)

#### Outdoor: Open Air

The benefit is even more dramatic for the higher 802.11ag link rates and open air environments where XR range benefits are 2x to 3x. As shown in Figure 1-3, when compared to traditional 802.11g solutions in a simple line-of-sight test, XR clearly is superior with more than double the range.

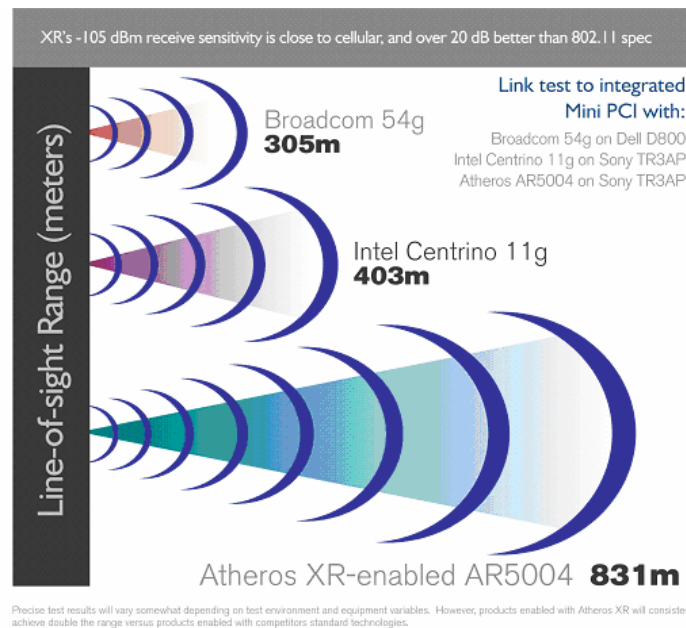


Figure 1-3. XR Superior Range



## 2. Seamless Standard and XR Mode Support

XR capable access points can communicate simultaneously with both legacy (non-XR) and XR-enabled stations, allowing XR stations to seamlessly “roam” between the standard and eXtended Range operations. This action is triggered by signal strength and link rate when both AP and stations are eXtended Range-enabled.

As part of normal roaming operation, a station typically looks for other APs whenever its link rate with the current AP falls below an acceptable minimum. At that point, the station scans for other APs. This is done to enhance performance, increase channel capacity, support mobility via “roaming” to another AP, or simply maintain connectivity. XR fits seamlessly into this same roaming architecture. The XR capable stations will associate with XR capable APs as necessary to maintain a reliable connection.

## Practical Benefits for Home and Office

eXtended Range technology is fully interoperable with other 802.11a, 802.11b, and 802.11g products. This feature operates transparently to the user, the network, and the operating system. An XR capable AP or station can communicate on a link-by-link basis with both products that support XR as well as with Wi-Fi compliant solutions. The XR benefits are enjoyed when communication is between an XR capable AP and an XR capable station.

Figure 1-4 illustrates the XR benefits in a typical enterprise environment. While isolated rooms and corners are not served by traditional AP coverage, XR can provide coverage where an additional AP would otherwise need to be installed. XR reduces costly installations and minimizes overall configuration burden.

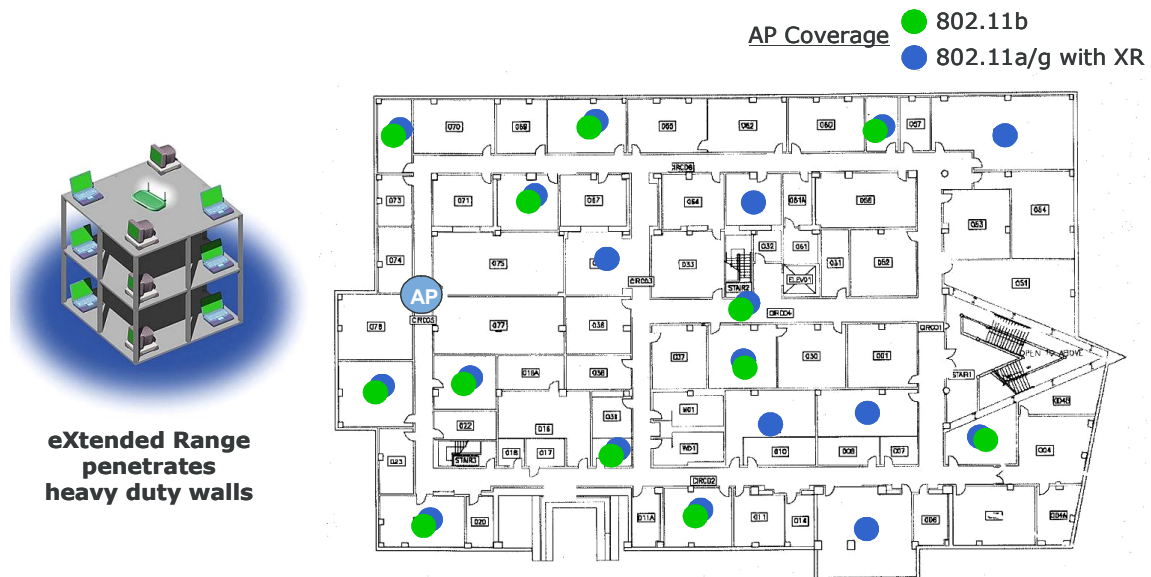


Figure 1-4. Enterprise Environment Benefits

Further, [Figure 1-5](#) and [Figure 1-6](#) illustrate the powerful impact of XR in a home environment. XR enables a single access point to cover a multi-story brick or masonry home and eliminate dead spots. This directly addresses key problems currently faced by WLAN solutions providers such as product support calls, product returns, and operational complexity.

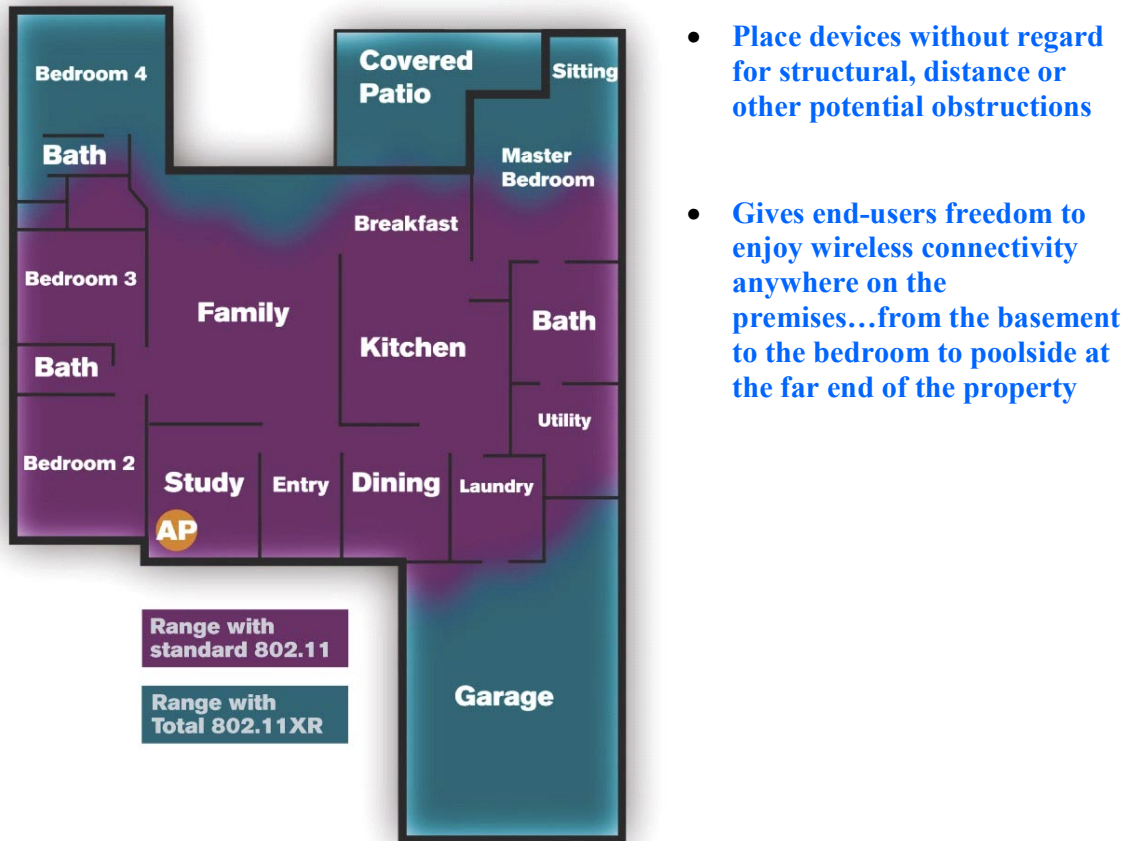


Figure 1-5. Total-home-coverage

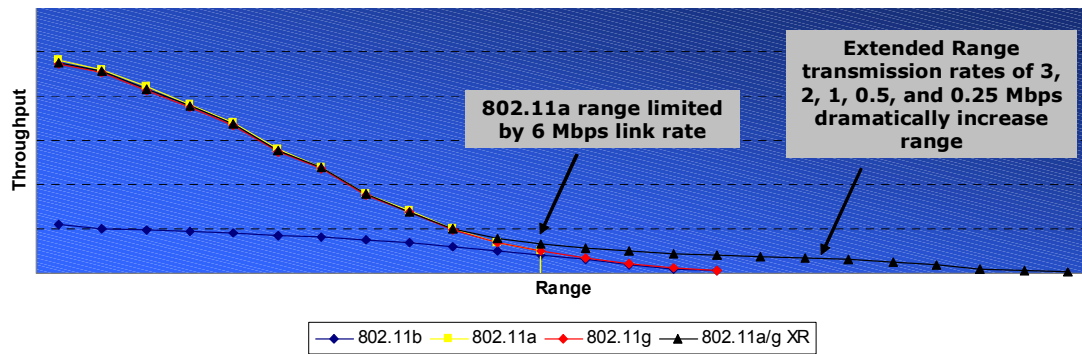


Figure 1-6. XR: Superior Range vs. Traditional 802.11

## Conclusion

Atheros' eXtended Range technology significantly benefits home users by allowing them to cover large, multi-story homes with a single access point (AP) or gateway. Moreover, home users can easily set up a wireless AP where the broadband connection enters the home, not just where it's optimal for radio signals to propagate. The number one reason for returned wireless products is lack of coverage or range, and for most customers XR is the solution to this problem. Its design allows individual stations and AP's to take advantage of XR technology on a link-by-link basis, even in mixed networks with third party devices.

In an enterprise environment, XR improves wireless coverage by eliminating "dead spots" while at the same time allowing IT managers to invest in fewer access points.

In outdoor environments, XR enables more economical point-to-point fixed wireless systems and provides for greater utility of public hot spot infrastructure with increased numbers of users able to connect to each access point.

eXtended Range is the premiere 802.11 extended coverage solution:

- 3x range of standard WLAN technologies in outdoor wireless networks
  - Extends the reach of public hot spots
- 2x range of standard WLAN technologies in indoor wireless networks:
  - Processes weak signals through walls
  - Eliminates dead spots
  - Allows placement of AP anywhere in home or office
  - Provides reliable connection from the moment of initial deployment
  - Reduces AP deployment costs in office environments
- Fully interoperable with 802.11a, b, g, and third party products
- No added configuration required by end-users

Atheros eXtended Range technology is fully compatible with IEEE and Wi-Fi Alliance standards and will evolve as part of the Atheros technology suite.

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