# Will 802.11n be a good neighbor?

**The protocol is designed to interoperate with legacy a/b/g access points, with a non-high-throughput duplicate mode aiding performance.**

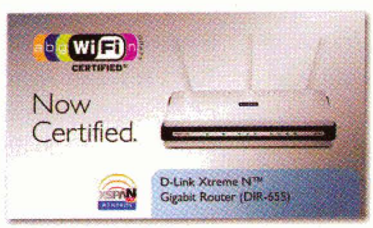
On June 25, the Wi-Fi Alliance (www.wi-fi.org) officially started its 802.11n draft 2.0 certification, and products from 14 vendors (and counting) are now certified.

But will these new products work well side-by-side with their legacy counterparts? Can they be phased into the existing network gradually, or will 802.11n systems require exclusively 802.11n equipment?

## 802.11n's technological advances

The new generation 802.11n technology is expected to gain significant market momentum in 2008, with the 802.11n chipsets dominating total chipset sales by 2012, according to ABI Research (www.abiresearch.com). In the home, 802.11n will offer sufficient bandwidth to run video, voice, and data applications. In the enterprise, 802.11n will support mission-critical applications with throughput comparable to Fast Ethernet.

Draft IEEE 802.11n specification is based on multiple-input multiple-output (MIMO) radio technology. MIMO is a major innovation in wireless data communications and a technology that is being adapted by other standards, including WiMAX and long-term evolution (LTE)—the emerging standard for 4G cellular.




The "certified" mark granted by the Wi-Fi Alliance can be seen on products that have been proven to meet the specifications of 802.11a/b/g, as well as the specs of the draft 802.11n.

MIMO uses spatial multiplexing to transport two or more data streams simultaneously in the same frequency channel. Spatial multiplexing can double the throughput of a wireless channel when two spatial streams are transmitted. Generating multiple spatial streams requires multiple transmitters, multiple receivers, and distinct, uncorrelated paths for each stream through the medium.

While the legacy networks operate in a 20-MHz channel, 802.11n permits the use of 20- and 40-MHz channels with up to four spatial streams per channel. With four spatial streams in a 40-MHz channel, the maximum transmission data rate is up to 600 Mbits/sec. Current products can transmit at up to 300 Mbits/sec using two spatial streams in a 40-MHz channel.

In addition to spatial multiplexing, physical layer (PHY) improvements include more efficient orthogonal frequency-division multiplexing (OFDM) and short guard interval (GI—a time period at the end of each OFDM symbol introduced to let multipath reflections settle prior to transmitting the next symbol).

With 52 data subcarriers, the highest data rate per stream of 802.11n is 65 Mbits/sec, versus 54 Mbits/sec for the 48 data subcarrier legacy technology. Legacy 802.11a/b/g devices use 800-ns GI, while 802.11n devices can optionally use GI of 400 ns, shortening the OFDM symbol by 400 ns. Short GI reduces the symbol time from 4 microseconds for legacy networks to 3.6 microseconds for 802.11n, thereby increasing the symbol rate by 10%.

The emerging 802.11n specification is more than just a new PHY. It is a whole new standard with efficiency improvements in the medium access control (MAC) and PHY layers. A significant contributor to 802.11 protocol overhead is the acknowledgement (ACK) protocol—an ACK packet sent by the receiving station to the ➤

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## 802.11n addresses interoperability and backward compatibility

Five concerns about the draft 802.11n's interoperability and backward-compatibility capabilities may trouble some potential users; however, the 802.11n draft standard addresses each of one.

**Concern:** *40-MHz channels in 2.4-GHz band*
**Explanation:** Traditional 802.11a/b/g channels are 20-MHz wide. To increase the throughput, 802.11n service can operate in a 40-MHz channel made up of two legacy channels. With only 70 MHz available in the already overcrowded 2.4-GHz band, 40-MHz operation can potentially disrupt existing installations and fall victim to 11 possible overlapping channels. At 2.4 GHz, channels are specified on a 5-MHz boundary. The non-overlapping 20-MHz channels are channels 1, 6, and 11. If a legacy 802.11b/g service operates in any other channel, its spectrum may fall partially into the channel of a neighboring network and be the source of significant interference because the packets of an overlapping channel may be undecipherable, preventing the collision-avoidance protocol from working.
**How 802.11n addresses the concern:** This issue was addressed by introducing new coexistence protocols that include methodology for detecting wireless LAN activity in the band, and for switching channels when necessary to avoid interference. These are complex protocols requiring coordinated periodic scanning of all channels, and the 802.11 working group may still refine them. For now, the Wi-Fi Alliance certification does not allow 40-MHz operation in the 2.4-GHz band.

**Concern:** *More efficient orthogonal frequency-division multiplexing (OFDM)*
**Explanation:** Legacy receivers are unable to demodulate a 52-data subcarrier signal, and packets with such signaling will appear to legacy receivers as noise disrupting the collision-avoidance protocol and compromising airlink efficiency.

**Concern:** *Short guard interval (GI)*
**Explanation:** Legacy devices are unable to process packets with a short GI.

**Concern:** *Frame aggregation*
**Explanation:** Legacy devices are unable to process aggregate frames.

**Concern:** *Block acknowledgement (ACK)*
**Explanation:** Legacy devices use 128-byte block ACK frame and cannot understand the 802.11n 8-byte block ACK.
**How 802.11n addresses OFDM efficiency, short GI, frame aggregation, and block ACK:** These conditions require that the legacy stations not attempt to interpret the traffic they are unable to receive and decode. The non-high throughput (HT) mode is used to protect legacy networks from 802.11n traffic. Prior to transmitting 802.11n-specific protocols, two packets are sent on both halves of the 40-MHz channel, simultaneously announcing the network allocation vector (NAV) to let the legacy stations know how long to stay off the air. During this interval, the 802.11n protocol can be used without disturbing legacy networks.

transmitting station to acknowledge each received frame. If the transmitter does not receive an ACK, it retransmits the frame.

ACKs and inter-frame gaps take up a significant percentage of airlink capacity, and 802.11n has introduced protocols—frame aggregation and block ACK—to improve the efficiency of the airlink.

- *Frame aggregation* is the method of combining several frames into one, thereby reducing the number of inter-frame gaps and ACK frames. Aggregate frames on the airlink, called aggregate MAC protocol data unit (A-MPDU), can reach the length of 64-k bytes and are made up of multiple traditional frames that can range in size from 52 to 2,304 bytes.
- *Block ACK* is the method of sending a single acknowledgement packet to confirm receipt of multiple frames. Block ACK improves the efficiency by removing the need to transmit an ACK frame for every transmitted frame on the link. While the block ACK protocol exists in the current 802.11 standard, it is not widely deployed. 802.11n has shortened the block ACK frame from the legacy 128 bytes to 8 bytes, to improve airlink efficiency.

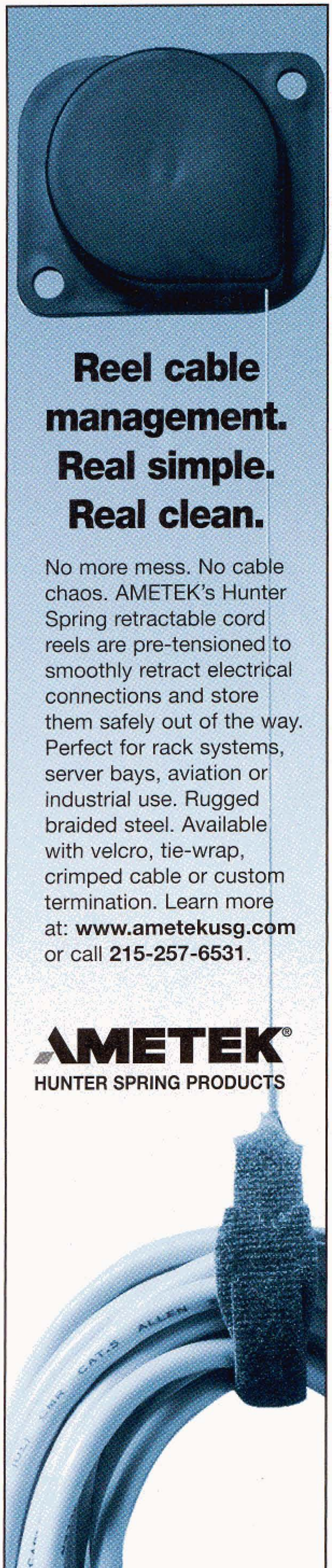
### Backward compatibility, protection mode

The PHY and MAC improvements introduced by 802.11n bring impressive range and throughput performance to new-generation Wi-Fi networks. But these new protocols have the potential of interfering with or hampering the performance of legacy networks.

To achieve backward compatibility and coexistence with legacy networks, 802.11n had to take special precautions against the potential disruption of the collision-avoidance mechanism. Collision avoidance is central to all 802.11 networks and lets multiple stations share the airlink efficiently. For collision avoidance to work, all stations must be able to interpret each other's packets and exchange information on how long each station intends to occupy the medium.

Network allocation vector (NAV) is the main mechanism of collision avoidance—the indicator of time kept by each station when transmission onto the wireless medium cannot be initiated. NAV information is derived by each station from the announcements by other stations of how long they intend to occupy the medium.

The new 802.11n protocols, such as more-efficient OFDM, short GI, aggregate frames, and block ACK, cannot be ➤




interpreted by the legacy devices and may appear as strong noise that occupies a significant percentage of the airlink capacity. The 802.11n traffic can pose a serious disruption to the legacy networks that wouldn't know how to predict the duration of such traffic on the airlink, and thus wouldn't be able to avoid colliding with it.

To address this issue, the 802.11n draft incorporates a protocol specifically designed to protect legacy networks from the potential disruption by 802.11n traffic that they are unable to understand. This protection protocol is called *non-high throughput (non-HT) duplicate mode.* In this mode, prior

802.11n has been architected for backward compatibility and interoperability with legacy equipment.

to the use of 802.11n-specific protocols, two packets are sent on both halves of the 40-MHz channel simultaneously, announcing the NAV to let the legacy stations know how long to stay off the air. Following the non-HT duplicate mode NAV message, the 802.11n protocol can be used for the announced duration of time without disturbing legacy networks.

The sidebar, "802.11n addresses interoperability and backward compatibility" (page 42), looks at specific concerns.

### Deploying within a legacy network

Draft 802.11n equipment compliant with the Wi-Fi alliance 802.11n certification (certified products are listed on the organization's Web site, www.wi-fi.org), is expected to be aware of and interoperate with the legacy equipment. The 802.11n protocol has been architected for backward compatibility and interoperability with the legacy equipment, either mixed in the same network or operating in separate networks side-by-side with the legacy devices.

When 802.11 stations or access points detect the presence of legacy devices or nearby networks, they are required to use protection protocols, such as non-HT duplicate mode. Thus, the Wi-Fi Alliance expects that 802.11n draft 2.0-certified devices can be gradually deployed within legacy networks or side-by-side with legacy networks without the need to upgrade the entire network to 802.11n.

The issue of 40-MHz channels in the 2.4-MHz band is still a potential concern, but sites that can tolerate 40-MHz 802.11n channels can use draft 802.11n to double the bandwidth for video and other multimedia services.

### Mixed vs. Greenfield performance

The highest performance is achievable in Greenfield mode, with only 802.11n stations in the network and no legacy devices within reception reach. If legacy devices or networks are present, 802.11n devices communicate using protection mode, which reduces network efficiency. Nevertheless, gains in performance even in a mixed network should be apparent.

Spatial multiplexing and 40-MHz channels alone can quadruple the throughput of 802.11n devices. A Wi-Fi Alliance white paper, *Wi-Fi Certified 802.11n draft 2.0: Longer-range, faster-throughput, multimedia-grade Wi-Fi networks,* downloadable from the alliance's website, provides a complete overview of performance improvements offered by 802.11n.

An independent test by octoScope of draft 802.11n products demonstrates the level of improvement achieved by the 802.11n devices over the legacy equipment.