

## IEEE 802.11g New Draft Standard Clarifies Future of Wireless LAN

*Users to benefit from higher data rates, extended reach and backward compatibility with 802.11b, plus forward compatibility to 802.11a*

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### Introduction

Prior to the recent selection of the IEEE 802.11g draft standard for wireless local area networks (WLANs) operating up to 54 megabits per second (Mbps) in the 2.4 gigahertz (GHz) band, the market was served by two non-compatible specifications, 802.11b and 802.11a. Faced with market availability of both products in late 2001, some end users were potentially confused about which technology would evolve to meet their future needs, and some networking manufacturers were unsure about which specification would be best to direct their developmental efforts.

There is much to be understood about the new 802.11g draft standard, including its history, specifications and implications in the WLAN market, but this much is certain: it combines the best of the existing 802.11b and 802.11a standards, and promises a harmonized future that will encourage continued and rapid market development in 802.11 WLANs. In addition, users will benefit from higher data rates, extended range and compatibility with already installed Wi-Fi™ devices.

### Where did 802.11g come from?

The first wireless Ethernet standard, IEEE 802.11, was adopted in 1997. This standard provided for three physical layer (PHY) specifications including infrared, 1-2 Mbps frequency hopping spread spectrum (FHSS) and 1-2 Mbps direct sequence spread spectrum (DSSS) in the 2.4 GHz ISM band. Because wired Ethernet LANs at the time were capable of speeds up to 10 Mbps and early products were quite pricey, the original 802.11 standard had limited success in the market.

Two years later, the original 802.11 standard evolved along two paths. The 802.11b specification increased data rates well beyond the critical 10 Mbps mark, maintained compatibility with the original 802.11 DSSS standard and incorporated a more efficient coding scheme known as complimentary code keying (CCK) to attain a top-end data rate of 11 Mbps. A second coding scheme, Packet Binary Convolutional Code (PBCC™), was included as an option for higher performance in the form of range at the 5.5 and 11 Mbps rates, as it provided for a 3 decibel (dB)

coding gain. The second offshoot of 802.11 was designated as 802.11a. It ventured into a different frequency band, the 5.2 GHz U-NII band, and was specified to achieve data rates up to 54 Mbps. Unlike 802.11b, which is a single carrier system, 802.11a utilized a multi-carrier modulation technique known as orthogonal frequency division multiplexing (OFDM). By utilizing the 5.2 GHz radio spectrum, 802.11a is not interoperable with either 802.11b, or the initial 802.11 WLAN standard. In March 2000, the IEEE 802.11 Working Group formed a study group to explore the feasibility of establishing an extension to the 802.11b standard for higher data rates greater than 20 Mbps. In July 2000, this study group became a full task group, Task Group G (TGg), with a mission to define the next standard for higher rates in the 2.4 GHz band.

For the past year and a half, TGg reviewed potential technical solutions for the new 802.11g standard, with the field of candidates being narrowed to two final proposals in the May 2001 meeting. At this meeting, TI's proposal called PBCC-22, offering 22 Mbps operation in the 2.4 GHz band and seamless compatibility with existing Wi-Fi devices, was eliminated from consideration under the selection criteria being used by the group. However, the remaining proposal from Intersil Corporation, CCK-OFDM, proposed to make use of 802.11a-like OFDM modulation to attain higher rates, failed to achieve the necessary 75 percent approval in order to become the selected technology for the new standard. TI continued to support the standards process, contributing compromise

proposals to the TGg through the November 2001 meeting.

As of the third day of the November 2001 802.11 IEEE meeting, Intersil's CCK-OFDM proposal appeared to be headed for uncertainty, having received only 55 percent acceptance of the required 75 percent to become the draft standard at the first-round vote. At this point, members considered the very real possibility of discontinuing the entire 802.11g effort, versus finding a common ground and consensus-oriented solution that would be agreeable to the majority of the task group. On November 15, a compromise proposal that combined elements of both TI and Intersil's original proposals, became the 802.11g draft standard with 76.3 percent of members voting in favor of it.

### **What's in 802.11g?**

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The 802.11g draft standard utilizes existing elements from the original CCK-OFDM and PBCC-22 proposals. Each of these proposals called for true 802.11a OFDM operation in the 2.4 GHz band as an optional mode to the primary proposed modulation, either CCK-OFDM or PBCC-22. The 802.11g draft standard makes OFDM the mandatory technology, offering 802.11a data rates in the 2.4 GHz band, requires mandatory implementation of 802.11b modes and offers optional modes of CCK-OFDM and PBCC-22. This balanced compromise offers a much clearer bridge between 802.11a and 802.11b, plus is a straightforward means to develop true multi-mode WLAN products.

802.11g achieves the high 54 Mbps data rates (Table 1, Appendix, page 5) of 802.11a in the 2.4 GHz band, thereby

maintaining compatibility with installed 802.11b equipment. Figure 1 (page 5) demonstrates that the performance of 802.11g, in terms of both data transfer speeds and range, is better than any of the alternatives that had been considered earlier in the selection process.

### **Issues Raised**

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Since the selection of the 802.11g draft standard technology, some observers have questioned the merits of continuing development activity in the 2.4 GHz band. The reasoning has predominantly cited the increased crowding of this spectrum, versus that of the relatively clearer 5.2 GHz spectrum utilized by 802.11a. Certainly the past performance of already-installed 802.11b networks provides evidence that the 2.4 GHz band is well suited to wireless networking and the 802.11b devices have continued to provide excellent performance in the presence of increasing interference.

In addition, the 2.4 GHz ISM band is available throughout the world with relatively few, if any, regulatory restrictions. In contrast, the 5.2 GHz band is used by military applications such as high-energy radar and, as a result, several major global markets, including Western Europe and Japan, have to date placed regulatory restrictions on the commercial use of this band. Even in the United States there are questions concerning security risks for military operations with 802.11a operating in the 5.2 GHz band. Utilizing the 2.4 GHz band ensures that 802.11g WLANs will avoid the regulatory restrictions that are likely to be encountered, while offering backwards compatibility with 802.11b systems.

Cost is another issue that concerns some in the industry; however, a careful cost analysis shows that devices conforming to the 802.11g draft standard will be very close to the current cost of 802.11b devices. In addition, deployments of dual-band wireless networks compatible with the 802.11b, 802.11g and 802.11a specifications should be comparable in costs with 802.11a-only networks. That is to say, users will be able to deploy multimode WLANs for about the same cost of an “a” only network today. WLANs with “a”, “b” and “g” capabilities will require a dual-band radio or two radio transmitters, one each for the 2.4 GHz and 5.2 GHz bands, but this will not drive up the cost beyond that of an 802.11a-only implementation. TI believes that the cost advantages of the 802.11g specification certainly will encourage the continued development of the WLAN marketplace as it represents a strong technical unification between what had been until now two dissimilar and incompatible technical directions.

### **Implications**

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With the final selection of the 802.11g technology in 2001, the WLAN market at long last has one comprehensive specification around which next-generation products and multimode systems can be developed. The 802.11g draft standard involved certain compromises, but the specification itself does not compromise superior data throughput and range achievable by operating in the 2.4 GHz band. 802.11g clarifies the previous market situation where two incompatible specifications were vying for users. 802.11g includes the best of both 802.11a and 802.11b in a standard that can carry the industry into the future.

Since 802.11g combines fundamental features from both 802.11a and 802.11b, it lends itself to the development of devices that can interoperate with technology based on both of the previous versions of the specification. This solves many migration path questions of users who already installed 802.11b LANs and wanted to have higher data rates, but were unsure since 802.11a was not compatible with their existing network. This is similar to the evolution of wired Ethernet technology when Ethernet devices began supporting the 10- and 100-Mbps Ethernet specifications in dual-mode 10/100 devices to allow seamless operation in either mode without user intervention.

### **What is next for 802.11g?**

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Before 802.11g can be formally adopted as a standard, TGg must complete the technical comment resolution process of the 802.11g draft standard through letter ballot. This is where members' technical questions are answered and implementation details are clarified. Ultimately, the standard will likely be ratified by early 2003, if not sooner.

### **What does 802.11g mean for TI and its customers?**

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TI has a longstanding belief in the advantages of multimode wireless networking enabling mobile connectivity in any 802.11 environment, and the new 802.11g draft standard certainly supports this. Since PBCC-22 has been voted in by the 802.11g task group, manufacturers using TI's existing ACX100 Baseband/MAC are well positioned to quickly begin developing and deploying forward-compatible 802.11g products.

“The IEEE has defined a clear path for 802.11g that bridges 11, 22 and 54 Mbps, making multi-mode products based on one standard a reality,” said Allen Noguee, senior analyst Cahners In-Stat/MRD. “By already offering 22 Mbps capabilities with the ACX100, TI and its customers are well positioned to enable the first step in the deployment of 802.11g compliant products in the 2.4 GHz band.”

TI plans to develop 802.11g-compliant devices by using elements from its 802.11b devices and its existing 802.11a product development. In mid-2002, TI expects to sample devices based on the current state of the 802.11g draft standard.

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## Appendix

**Table 1. 802.11 Data Rates**

Rate, Mbps	Single/Multi Carrier	802.11b @2.4 GHz		802.11g @2.4 GHz		802.11a @5.2 GHz	
		Mandatory	Optional	Mandatory	Optional	Mandatory	Optional
1	Single	Barker		Barker			
2	Single	Barker		Barker			
5.5	Single	CCK	PBCC	CCK	PBCC		
6	Multi			OFDM	CCK-OFDM	OFDM	
9	Multi				OFDM, CCK-OFDM		OFDM
11	Single	CCK	PBCC	CCK	PBCC		
12	Multi			OFDM	CCK-OFDM	OFDM	
18	Multi				OFDM, CCK-OFDM		OFDM
22	Single				PBCC		
24	Multi			OFDM	CCK-OFDM	OFDM	
33	Single				PBCC		
36	Multi				OFDM, CCK-OFDM		OFDM
48	Multi				OFDM, CCK-OFDM		OFDM
54	Multi				OFDM, CCK-OFDM		OFDM

**Figure 1. 802.11 Reach-Rate Graph**

