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The 802.11g standard -- IEEE



Alphabet soup

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The bid continues to improve the 802.11 standard to something that fulfills our wireless transmitting fantasies. Victor Marks shows us how 802.11g has shaped up, and how it's fareing in the race.

Introduction

*Trivia: In the Hebrew alphabet, the letter order begins Aleph, Bet, Gimel... and has no connection to the 802.11a, b, and g standards for wireless technology.*

The 802.11b standard in wireless technology was the first wave to hit big in wireless development, due in large part to Lucent and Apple's adoption. In 1999, Lucent and Apple introduced 802.11b base stations, or access points, based on a reference design by AMD. Since that time, adoption has been wide. Wireless bases have been installed everywhere, from corporate environments to homes to coffee shops. Now, we all know that 802.11b operates in the 2.4GHz range, along with cordless phones, microwaves, and Bluetooth. Two years ago, when people began looking forward to "The Next Big Thing," we looked to 802.11a as the way forward.

802.11a -- The Big Kahuna

Wireless developers wanted speed, performance faster than the promised 11Mbps of 802.11b, and we wanted plenty of it. We were grasping at straws like a monster-clown in search of adrenochrome. Atheros and Radiata were working against each other on the chips required, getting power demands and cost down, and signal range up.

Standard	IEEE 802.11a, WLAN
Frequency wavelength	5GHz
Data bandwidth	54Mbps, 48Mbps, 36Mbps, 24Mbps, 12Mbps, 6Mbps
Security measures	WEP, OFDM
Optimum operating range	150 ft. indoors, 300 ft. outdoors
Best suited for a specific purpose or device type	Roaming laptops in home or business; computers when wiring is inconvenient

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Devices currently using the standard	Consumer products by Linksys, Intel, Lucent, Proxim, Cisco; chipsets made by Atheros and Radiata
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What happened? Proxim, Linksys, and a few others sold 802.11a equipment, but without any real support from computer manufacturers bundling the equipment as an option -- as Apple, Dell, and Compaq have with 802.11b. 802.11a hasn't taken off wildly on its own. No consumer was ready to give up his investment in 802.11b, even to satisfy the insatiable thirst for speed.

What is g? (Embrace me, you sweet embraceable you)

802.11g is an easy choice for corporate sites and home users to adopt because it doesn't require an upgrade to client equipment. 802.11g is backward-compatible with 802.11b, and it offers speeds similar to those of 802.11a.

Standard	IEEE 802.11g, Wi-Fi
Frequency wavelength	2.4GHz
Data bandwidth	54Mbps, 48Mbps, 36Mbps, 24Mbps, 12Mbps, 6Mbps
Security measures	WEP, OFDM, AES (in Broadcom 54g) and possibly WPA/Wi-Fi protected access
Optimum operating range	1000 ft. under ideal conditions; expect more like 150 ft. indoors, 300 ft. outdoors, under normal conditions
Best suited for a specific purpose or device type	Roaming laptops in home or business; computers when wiring is inconvenient
Devices currently using the standard	Consumer products by Apple, Linksys, Lucent, Cisco, Buffalo, Belkin; chipsets made by Broadcom, Atheros, Intersil

Alfie, what's it all about?

This immediately places it as a winner, preserving the investment in 802.11b client equipment while moving speeds forward. To compete, 802.11a would have to be combined in an 802.11a and 802.11b base station, and this still wouldn't be as good a solution, because an 802.11a client card cannot talk to older base stations the way 802.11g client cards can. The only solution for 802.11a to match the abilities of 802.11g is for manufacturers to produce client and access point equipment incorporating 802.11a and 802.11b. Unless such a plan can be competitive in price or offer greater usability range, it is difficult to see how it could succeed in the market. Take this speculation with the largest grain of salt you can chip off of a glacier-sized salt lick; after all, 802.11a was perceived to be a sure thing.

Why g is problematic, or "The wonderful thing about standards is there are so many to choose from." -- Prof. Andrew Tennenbaum

**Standards that haven't been ratified: Broadcom.**

802.11b users could get frozen out of the network because of contention with 802.11g clients. This is possible because the standard stacks the deck in favor of 802.11g. When a 'g' and a 'b' fight for air time, the 'g' will always win. Ideally, that wouldn't be a problem for 802.11b users, because there's a protection mechanism written into the 802.11g standard. But therein lies the problem: When devices are released before the standard is ratified, equipment vendors can conveniently ignore such protection measures.

That's the cause of some potential interoperability problems. One way you can boost your performance is to not send out the bulky protection mechanisms.

For high speeds, 802.11g uses orthogonal frequency-division multiplexing (OFDM), just as 802.11a does.

But the protection signal has to be receivable by 802.11b clients, meaning it must be sent using their complementary code keying (CCK) waveform. Because the CCK preamble (the initial string of data starting a transmission) is longer than OFDM's, the protection message can damage network performance noticeably. But Broadcom's Jeff Abramowitz, senior director of wireless LAN marketing for Broadcom (see [Resources](#)), says none of this is an issue, because it's actually not true that 802.11g takes priority over 802.11b.

*Unstrung* (see [Resources](#)) quoted him as saying "There is no priority for 'g' over 'b' -- not to my understanding. The spec is designed to be fair." Even without the protection mechanism, 802.11g and 802.11b feeds would simply share the bandwidth in his estimation. However, his conclusion only works if the protection mechanism is used, and even then, 802.11b gets a lower priority in the air.

The implementations so far have had to answer how 802.11b is treated on an 802.11g base station, which the standard exists to define. In order to achieve maximum speed, OEMs are recommending that all users must use the faster cards. The presence of a slower card accessing the base station causes the wireless network to decrease its maximum data rate to accommodate it. According to [Apple's overview](#) of their implementation, when many 802.11b users are active on the wireless network, the overall data rate begins to approximate 802.11b rates.

### Security

When 802.11b clients are granted access to an 802.11g base station, security inevitably must be set to allow 802.11b clients on, and thanks to WEP and its problems (see [Safe Travels](#), here on *developerWorks*), the whole network is reduced to a lowest common denominator. Security of 802.11g, when only 802.11g is permitted, is reputed to be much better. But then, thanks to standards that haven't been approved yet, Broadcom's chips don't even include WPA, the Wi-Fi Protected Access. Broadcom and others employing their chipset hint that a firmware update would add WPA when the standard is later ratified.

What happens to an 802.11b base when 802.11g is allowed on? What happens to an 802.11g base when 802.11b comes on? Does speed drop? Does security drop? Does one user get priority over another? These are the questions that get answered by the standards working group, and a ratified standard answers these situations. Certainly introducing a product using a non-ratified standard that is later in the ratification process is better than earlier, but 'better' isn't standards-compliant, and means interoperability may be problematic.

What does this mean for the adoption of 802.11a and 5UP?

802.11a probably will not attract new buyers or developers who integrate it into their products, unless there's some serious advantage: security for corporate adoption, or speed gains that are unprecedented (which 5UP made room for). What can really lead it to succeed is a product like the one Cisco's Bill Rossi, head of Cisco's Wireless Business Unit, mentioned in [NetworkFusion](#), when he said, "Eventually, with adapter cards that can support all three wireless LAN standards -- 802.11b, 802.11a, and 802.11g -- you'll have lots of capacity." Even he admits that security has been the main obstacle, and that large-scale enterprise LANs will happen "when security becomes a standard; when it's well-defined and well-tested."

### Cautionary tales and speed bumps

What we're left with is a trio of chipmakers and a larger number of OEMs using those chips to make products using a standard that isn't ratified, claiming Wi-Fi compatibility where no Wi-Fi Alliance tests exist and won't exist for an estimated four months to come. Not to mention that one of those chipmakers has created its own label and organization -- 54g -- and is biting its thumb at the Wi-Fi Alliance and IEEE standards body. The events so far described should be a warning to developers. Trying to be first with product offerings on a non-ratified standard and claiming compliance is a neat bit of alchemy, but like alchemy, it's a fool's folly. The potential advantage of making a de-facto standard device, which everyone else must then conform to, is alluring as a business proposition. But the potential detriment to the customer and to the business, if no other company adopts compatibility with an early implementation, is that it only fragments the market, and makes development decisions about what to support that much more difficult.

Now, because these products are available in the marketplace, some users are reporting success, and some are experiencing incompatibilities and problems. I fully expect to receive protests from users saying,

"Mine works! You must be imagining things!" Some users are blaming incompatibilities on 802.11b not having a full RTS/CTS implementation. Exactly where the fault lies in this breakdown is unimportant. The greater problem is that of companies putting out products before a standard is finalized, or falsely claiming compliance. Everyone loses in that situation, as the users face frustration with applying firmware updates and trying to get technical support in order to fix what should never have been broken.

The subverting of standards and claiming compliance is obviously wrong and evil. It is also sadly traditional. It is difficult to claim that these companies are ignoring interoperability and the importance of standards intentionally. Whether by intent or by over-enthusiasm for being first at all costs, anything that compromises standards compliance and interoperability decreases a product's value.

#### Resources

- Visit *Unstrung* to read how [Interop Woes Smite 802.11g](#).
- On the same day, NetworkWorldFusion reported [Cisco betting big on wireless LANs](#).
- See the [hot topics](#) at the IEEE P802.11, The Wireless LAN Working Group site.
- Read "[Big Day at Broadcom](#)."
- See Victor's previous article on [wireless security](#) (*developerWorks*, June 2002).
- IBM Research offers the [Wireless Security Auditor \(WSA\)](#) to aid in the security of 802.11 wireless networking transmissions.
- The book [802.11 Networks: The Definitive Guide](#) came out last fall and was reviewed on developerWorks by Danny Kalev (*developerWorks*, September 2002).

#### About the author



L. Victor Marks is a voracious follower of all things wireless and is a regular contributor to the developerWorks Wireless zone. He's also a musician, and fan of classic automobiles and products that meet their design goals without getting in the way of the user. You can contact Victor at [victor@victormarks.com](mailto:victor@victormarks.com).



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#### What do you think of this document?

Killer! (5)      Good stuff (4)      So-so; not bad (3)      Needs work (2)      Lame! (1)

#### Comments?

