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BUILDING AND MAINTAINING THE EVER-MUTATING, MULTIMEDIA-CAPABLE HOME NETWORK.

A man, a LAN, a plan

By Brian Dipert, Technical Editor

I first set out almost a year ago to write an article describing my experiences setting up and maintaining a complex home network. But every time I plopped down at the keyboard with a few hours reserved for the task, something network-related manifested itself and sidetracked me.

Maybe a previously reliable network link would start flaking out. Or my wife or I would bring home some new piece of gear that begged for connectivity and needed placement in a location that necessitated an evolution of the network topology. Maybe we'd decide to expand our wireless connectivity to an area of our property that previously had insufficient coverage. Or the network links themselves would evolve, as they did when we upgraded from 802.11b to 802.11g wireless equipment.

Today, the emergence of 802.11g-derivative products that operate at more than 100 Mbps threatens to distract me from writing yet again. But I'm going to resist.

Consumers seem to intuitively grasp the benefits of networking PCs and media devices in homes. However, my experience illustrates that with multiple networking technologies to choose from, not to mention complicating factors, such as wireless interference, the implementation and upkeep of a home network can be taxing. Manufacturers take note: Installing and maintaining networking gear aren't even close to being intuitive, plug-and-play experiences (yet).

Life was much simpler in early 1999 when I first got DSL in my previous single-story, less-than-1000-sq-ft home. One Buffalo Technology WLA-L11 802.11b AP (access point), placed in my office in the southwest corner of the house, blanketed the entire place with wireless access. A CAT5 (Category 5) Ethernet cable, running under the house from the office to the living room in the northeast corner, provided network connectivity for various products, such as a Microsoft Xbox, a Voyetra Turtle Beach Audiotron, and a ReplayTV 4504 (see the online version of this article for a list of links to past articles describing these devices).

CHALLENGING ENVIRONMENT

My new home, which we've been in for about a year, is also a single-story dwelling, but its footprint is roughly twice the size of its predecessor. And, unlike my nearly square previous home, this one is mildly rectangular, with its longer sides running north to south (**Figure 1**).

DSL connectivity enters the home through my office in the southwest corner. When we moved in, I put the router and one AP there. I knew that a single AP probably wouldn't be adequate to cover the entire dwelling, but I was planning to crawl under the house and

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run CAT5 to the living room in the northeast corner. I figured that installation would be sufficient in conjunction with a second AP connected to a living-room-based switch.

My guesstimate proved largely correct with two major exceptions. The AP in the living room (the Buffalo WLA-L11), aided by an external omnidirectional Orinoco antenna, blanketed not only the living room, but also the dining room and most of the kitchen. Right at the point where the refrigerator and stove began to attenuate the WLA-L11's signal, the AP in my office, an Orinoco RG-1000, which had its routing functions disabled and also sported an omni Orinoco antenna, took over. That AP's signal also washed over the laundry room. However, the coverage proved lousy in both my wife's office—fewer than 20 feet from my office's AP—and in our bedroom at the north end of the hallway.

By the way, the freeware product, Netstumbler, running on my Windows XP notebook, along with the companion Mini-stumbler on my iPaq 3835 Pocket PC, proved invaluable in analyzing my network's coverage. Neither tool supports every 802.11 card out there, but they work fine with my Lucent (now Proxim) 802.11b cards, which, due to frequency-range compatibility, also detect 802.11g-signal strength.

Looking again at **Figure 1**, you'll see that the wireless signal coming from my office needs to exit and re-enter the home, passing through two sets of windows along the way, to cover the far west edge of my wife's office, where her desk resides. But that quirk only partly explained the lack of signal strength in her office.

After much experimentation, I think I've identified the other culprits. The closet in my office has mirrored doors. The shower in the bathroom has a glass door and is completely encased in glazed ceramic tile. The ceramic tile also covers the lower half of the bathroom's walls, and a large vanity mirror sits above the sink on the north side of the room. All of these act as effective attenuators.

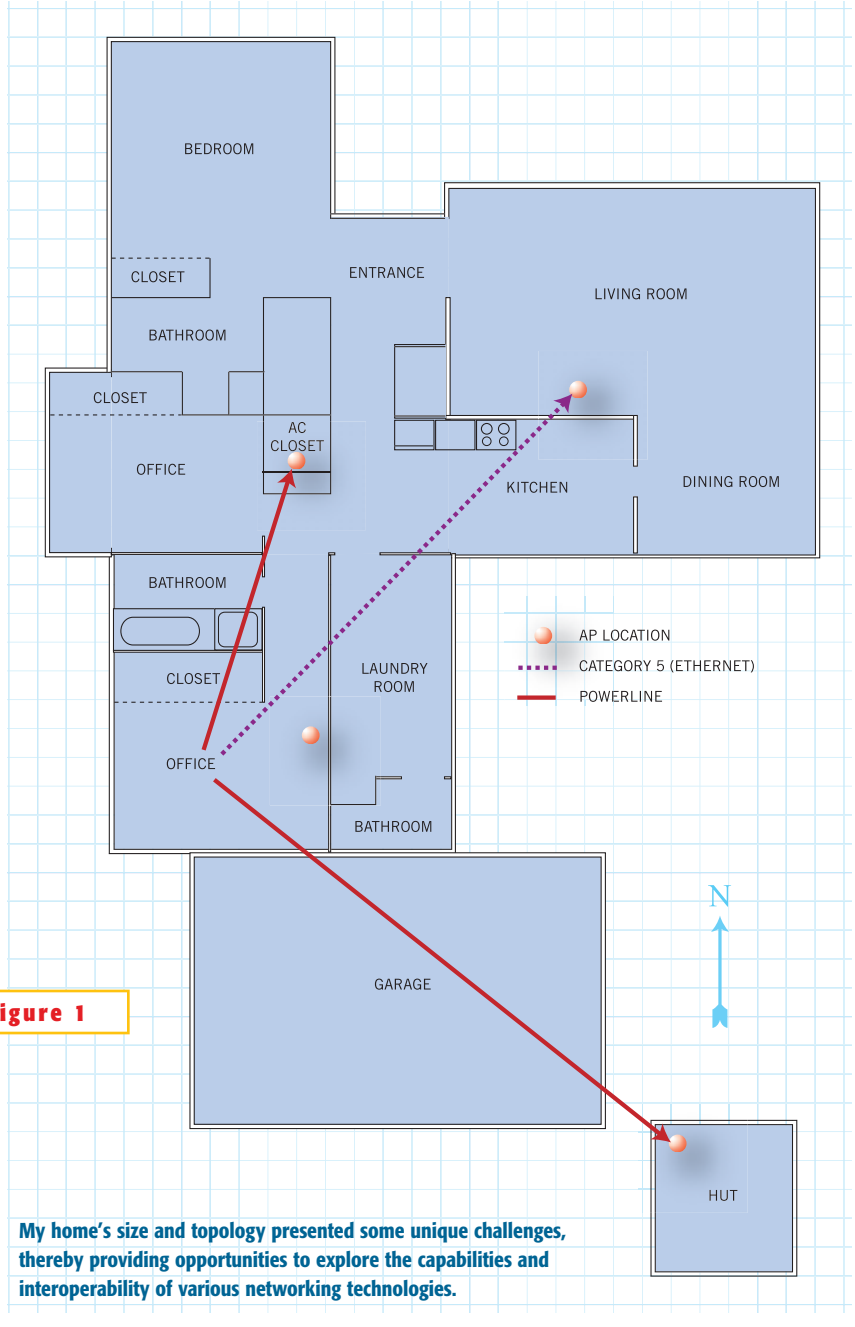

Figure 1

My home's size and topology presented some unique challenges, thereby providing opportunities to explore the capabilities and interoperability of various networking technologies.

WHY NOT POWER LINE?

Obviously, I needed to get the AP in my office closer to my wife's office. But wherever I put it, it would need a wired-Ethernet connection. I didn't look forward to crawling under the house again, and the extensive amount of piping and duct work under the bathroom would make running additional CAT5 cabling a tedious chore.

What better excuse could I find for trying out power-line networking? Had I known then about the frustration and tedium to come, I might not have proceeded down this path, but I learned a lot in the process, so the time wasn't completely wasted.

Before diving into specifics, I'll share a general observation: Power-line networking is frighteningly finicky. I've pulled my hair out (figuratively) when an Ethernet-to-power-line adapter that worked fine one day failed to work the next morning. I've struggled with adapters that work in only one plug of a two-plug outlet. I've seen adapters that don't work with the power plug oriented in one direction but behave nicely with the plug polarity flipped 180°. I've had adapters refuse to work when plugged directly into an outlet but function happily when connected to the same outlet through a several-foot extension cord and vice versa. (Explain that one!)

If you've explored power-line networking, you probably know that you

can't plug a power-line adapter into a surge protector, a surge-protected outlet, or a UPS (uninterruptible power supply); the circuitry filters out the high-frequency data superimposed on the ac-carrier sine wave. But did you know that you sometimes can't even get a power-line-networking adapter to work if you plug it into a two-plug outlet when you have a surge protector or UPS connected to the other plug? In a multiadapter setup like mine, you face a maddening array of dozens of combinations of variables to test each time something's not working or you need to move an adapter to a different outlet.

I SHOULD HAVE LEFT WELL ENOUGH ALONE. BUT THEN I WANTED CONNECTIVITY IN THE HUT.

My first stab at the power-line-networking problem employed Phonex NeverWire 14 Ethernet-to-power-line bridges. Unfortunately, I couldn't convince them to reliably pass network communications to LAN clients that had static IP (Internet Protocol) addresses. The Phonex bridges would route traffic to and from DHCP (Dynamic Host Control Protocol)-assigned clients until the DHCP expiration delays my router defined timed out, but DHCP assignments and renewals would sporadically fail.

Phonex provides a downloadable Java-based diagnostic utility that assisted to a degree in my debugging. It would tell me, for example, if the two bridges could "see" each other and the bandwidth flowing between them. But it seemed that the Phonex units were failing to pass some incoming packets onward through the power-line link—or at least transforming those packets in a fashion that rendered them unusable at the other end.

I had much better, although still not perfect, luck with Maverick Power System's Powerline 4-Port Bridge, which, as the name implies, integrates both an Ethernet-to-power-line adapter and a four-port, 10-Mbps Ethernet hub. The included Connection Manager software was less informative than Phonex's utility, but it provided enough data to help me diagnose and overcome the various connectivity problems I encountered. It also allowed me to calculate network bandwidth at various bridge locations and change the default encryption password. Happily, once I established reliable communications between two Powerline 4-Port Bridges—one in my office connected to the router and the other paired with the AP formerly in my office—all packets seemed to pass through the powerline link intact.

However, recall that the point of the power-line-networking exercise was to find a spot for my wireless AP that would serve both my office and my wife's. Unfortunately, I found that if I put the AP in my office, she'd have lousy connectivity. If I moved it to her office, it would improve her situation but leave me disconnected. Putting the AP in the bathroom between us would not only give both of us less-than-optimal connectivity, but also raise questions from guests about that "thing with the blinking lights and antenna" on the toilet (not to mention the safety issue of an electrified appliance near the tub and sink).

Clearly, I needed to break down and put an AP in each office. But an AP in my wife's office still didn't solve my setup's wireless-access shortcomings in the bedroom at the other end of the hall. Eventually, I figured out that I should hang an AP—a Belkin F5D6130 802.11b model—from the ceiling of the air-conditioner closet next door to and just north of my wife's office. I then discovered, through the SeattleWireless.net enthusiast site, an Atmel utility that enabled me to boost the unit's power output. These actions finally gave me robust wireless connectivity in my wife's office, the bedroom, and, more generally, throughout the house.

REMOTE ACCESS

I should have left well enough alone. But then I got the idea that it would be nice to have both wireless and wired connectivity—the wired connection for a second Voyetra Turtle Beach Audiotron—in a small back-yard-retreat building, "the hut."

So, I replaced the Maverick 4-Port power-line bridge in the air-conditioning closet with a Belkin F5D4070 power-line

Ethernet adapter. (After all, I didn't need a four-port hub in the closet.) The bridge went to the hut, along with a second Belkin F5D6130 AP, which also nicely envelops the back yard and patio with WiFi waves. I was happily surprised to discover that the Maverick and Belkin units both seem to be based on silicon from Cogency (now Intellon), because I could monitor and configure them all from the same Connection Manager utility.

NOT DONE YET

Was I done yet? No. Belkin rolled out 54G (later standardized as 802.11g) products based on Broadcom chips, and I took the bait, installing an F5D7010 PC Card on my notebook PC and swapping out the Buffalo and Orinoco APs in my office and the living room for Belkin F5D7130 APs. It made no sense to put 802.11g APs in the closet or the hut, because the power-line links between them and the router would limit their available bandwidth to around 5 or 6 Mbps. The AP in my office has worked like a charm. The one in the living room failed after a few weeks, but its replacement is still going strong after several months.

The Belkin 802.11g APs offer browser-based and, therefore, operating system-independent configuration, which I generally prefer to the alternative of installing separate management utilities, as Belkin's 802.11b APs and other networking products require. However, in this case, the browser interfaces led to minor complications.

Had Belkin shipped the 802.11g APs from the factory with DHCP enabled, I could have viewed my router logs to see what IP addresses they were assigned and then navigated to those addresses with my Web browser. However the APs came with pre-assigned static-IP addresses in the 192.168.2.xxx subnet. Unfortunately, my LAN employs the 192.168.0.xxx subnet. So, I had to temporarily redefine one of my computers to use a 192.168.2.xxx static address, connect to and switch the APs to DHCP mode, and then return the computer to DHCP to restore LAN connectivity and complete the AP configuration.

Four APs in close proximity can lead to nasty destructive interference if they're all using the same center frequency or even have overlapping frequency bands. The AP in my office employs Channel 1, and the one in the living room uses Channel 11. The AP in the air-conditioning closet and the one in the hut—the APs farthest from each other—both use Channel 6. All the devices employ 64-bit WEP (Wired Equivalent Privacy) encryption. I've also fine-tuned the 802.11g AP settings for my home's mixed b/g environment and disabled the broadcast of their SSIDs (service-set identifications). The 802.11b APs unfortunately don't support SSID-broadcast disable, although I've set them to reject the "any" SSID.

It's sometimes difficult, after my 802.11g PC Card has locked onto the strong signal coming from the 802.11b AP in the air-conditioning closet, to coax it over to the faster 802.11g wireless link after I move to the living room, dining room, kitchen, or office. In the worst-case scenario, I need to disable and then re-enable the 802.11 PC Card profile in Windows XP's Networking Properties.

Unlike in my former home, I notice no wireless-network degradation in the presence of an operating microwave oven. I chalk this up to second- and third-generation 802.11 technology that better coexists with other 2.4-GHz broadcast sources, a more robust multi-AP wireless topology, and a newer microwave oven with better shielding. I'm also careful to use only 900-MHz cordless phones in the house to avoid another 2.4-GHz interference source that has plagued me in the past.

The power-line link between my office and the hut occasionally flakes out. For that reason, the Audiotron in the hut has a static-IP assignment; I can cycle power on the hut's four-port power-line bridge to restore connectivity.

All in all, now that I've got everything debugged (knock on wood), I'm pleased with my network's reliability and robustness. It even rebounds from the occasional Sacramento-area brownout or blackout with little to no manual intervention.

The one technology I haven't tried is phone-line networking. However, that approach is, for all intents and purposes, dead. I consider it a case of too little, too late—no matter how much the HomePNA (Home Phoneline Networking Association) tries to convince us otherwise.

I'd still like to have 802.11g coverage throughout the house. So, I may someday muster up the enthusiasm to crawl under the house or into the attic, do battle with the black-widow spiders, and figure out how to run CAT5 to the air-conditioning closet. Although 802.11g doesn't noticeably boost my Internet-access speeds over those of 802.11b, it significantly accelerates LAN functions, such as file transfers and print jobs. (The 1.2-Mbps DSL rate is the bottleneck).

Finally, now that I've retired the Buffalo and Orinoco APs, I believe but haven't yet confirmed that all of the 802.11 gear in my LAN supports 128-bit WEP, so I plan to move to that standard for additional security. Unfortunately, most of my gear doesn't support the follow-on WPA (WiFi Protected Access) standard. Maybe I should consider upgrading all of my APs.□

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Author's biography

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ETHERNET EVERYWHERE

Here's a complete census of the network gear currently in my abode:

My office

- Alcatel DSL modem
- Netopia R9100 router with a static IP (Internet Protocol) address
- Netgear eight-port 10/100-Mbps switch
- Belkin 802.11g access point (static IP address)
- Maverick Power Systems Powerline four-port bridge
- Toshiba Magnia SG10 server appliance with integrated print server and seven-port, 10/100-Mbps switch (static IP address)
- Ximeta 160-Gbyte NetDrive NDAS
- D-Link 40 Gbyte MediaLounge NAS (static IP address)
- Microsoft Xbox with a static IP address when running Linux
- Two desktop PCs
- Troy PocketPro USB print server

My wife's office

- Linksys 802.11b print server with a static IP address

Air-conditioning closet

- Belkin Ethernet-to-powerline bridge
- Belkin 802.11b access point (static IP address)

Living room

- Belkin 802.11g access point (static IP address)
- GigaFast 5-port 10/100-Mbps switch
- Microsoft Xbox
- ReplayTV 4504
- Voyetra Turtle Beach Audiotron

Hut

- Maverick Power Systems Power-line four-port bridge
- Belkin 802.11b access point with a static IP address
- Voyetra Turtle Beach Audiotron (static IP address)

Everywhere

- Two Fujitsu Lifebook P-2xxx notebook PCs, one with a Belkin 802.11g PC Card, and one with built-in 802.11b connectivity
- Two Pocket PCs, employing an Orinoco PC Card and a Dell CompactFlash 802.11b adapter, respectively
- Apple 12-in. PowerBook with AirPort Extreme module

Planned additions

- Sony PlayStation 2 with Linux developer's kit
- VoIP equipment

Past citizens, no longer online

- Apple iBook and PowerBook notebook PCs
- Small-form-factor PCs built for recent hands-on project (see "And then there was one," *EDN*, March 4, 2004, pg 44 and "And then there was one: one more time," *EDN*, April 29, 2004, pg 29)