

[Engineering Essentials]

## **Can Home Networking Find A Happy Medium?**

A host of standards and methods continues to jostle for the top spots within the home-entertainment and home-control connectivity world.

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Do you need a home network? Many consumers seem to be wondering just that, with the prospect of a total home-networking solution hovering for more than a decade now. Many homes, in fact, already have some form of networking in place today. And there have been lots of advances in data speeds as well as new methods, products, and standards. So what's the holdup?

Right now, there are three basic networking functions: computer connections to the Internet, home entertainment, and home control. Separate networks with multiple alternatives are used for each function. Is convergence possible? Yes, but it doesn't appear to be in sight yet. While the rich variety of choices seems great, multiple standards and methods only create confusion, conflict, and complexity.

Current networks primarily use Wi-Fi to share high-speed Internet connections among several PCs and laptops. Home entertainment networks aren't common yet, as most of these devices are standalone units with cable defining their connections. Nonetheless, as more homes adopt two or more HDTVs, DVRs, and multiple set-top boxes (STBs), the trend toward networked home entertainment will seemingly intensify despite the expense and complexity.

Networking home lighting, air conditioning and heating controls, appliances, security systems, and other home electrical devices is slowly catching on. Remote monitoring and control is attractive, especially in large luxury homes, as it can provide convenience and manageability of many functions at a central point. Future energy-management methods will need a network, too.

Identifying all of the possibilities is an overwhelming task, not to mention deciding which technology best suits each application. Many consumers would say that they only want to watch TV, access their e-mail, and adjust their thermostat, so make it easy.

As the networking effort moves forward, experts hope the number of standards will whittle down to a few robust, simple, and affordable specifications. Right now, the whole home-networking effort continues to trudge along as a multifaceted work in progress (Fig. 1).

## **WIRED TECHNOLOGIES**

Wired networking approaches are the oldest and best known. For example, some newer and more upscale homes are wired for Ethernet with CAT5/6 going to RJ-45 jacks in most rooms. The approach in new homes is structured wiring, where all of the cabling is bundled together and terminated at a central cable box.

The bundles always contain twisted pair for telephone and Ethernet, coax for cable TV or satellite, fiber, and power line. Such setups are nice if you're able to afford them or can rewire an older home. Most rooms will have connectors for each, which really simplifies making any kind of connection.

JDSU offers the TestifierPRO Cable Tester to test and troubleshoot structured wiring (Fig. 2). Also, JDSU's Net Complete Home Performance Management software ensures quality of service (QoS) and quality of experience (QoE) for video, voice, and data over xDSL and FFTx networks. That's because it will continuously monitor the performance of home-networking equipment and services.

A key factor in home wiring is the limited bandwidth. Coax is less of a problem, but twisted pair is particularly troublesome in transporting video. Gennum's Active-Connect ICs can transmit full-rate uncompressed HDMI over CAT5e or CAT6 twisted pair. The GV8500 and GV8501 transmit and receive chip sets support 1080p and 1080p 12-bit Deep Color formats. They're ideal for use in professional AV or custom home-theater installations.

**Valens Semiconductor offers a similar solution. With its HDBaseT VS100SK and VS100SR receiver and transmitter chips, you can transmit full-rate HDMI over 100 m of CAT5e/6 twisted-pair cable.** Monster Cable also has several products that can support these technologies (Fig. 3). Other wired systems use the home coax cable, phone lines, or ac power lines for connections.

The International Telecommunications Union – Telecom (ITU-T) G.hn standard is an effort to create a common protocol for wired home technologies. Also known by its ITU designation G.9960, it defines methods and protocols that can take advantage of coax, phone lines, or the ac power-line physical-layer (PHY) connections. Developed under the working group that created ADSL and VDSL, it uses orthogonal frequency-division multiplexing (OFDM) as its modulation/access method.

The standard will certainly give Internet Protocol TV (IPTV) providers a cost effective and usable medium over a wide geographical area. Available for home entertainment, it also can be applied to home automation and security. It has passed its consent phase and will move on to final ratification later this year.

The maximum data rate defined for the standard is 1 Gbit/s. However, estimates reveal that maximum throughput will be 400 Mbits/s for coax and phone line and 250 Mbits/s for power lines in real-world situations.

The standard's coexistence mechanism is aligned with the IEEE P1901 powerline standard, which factors in three different PHYs and architectures competing for the power-line space. Few details on G.hn are available now, but look for specifications later in the year. G.hn lets chip companies start their designs, though products aren't expected until 2010 and beyond.

The whole effort seems to be a bit late in the game, as other technologies settle in now. Still, there's a strong need for any consolidating standard effort. In fact, a new industry alliance was created to promote and certify interoperability for G.hn. Known as the HomeGrid Forum, its members include Infineon, Intel, Panasonic, Texas Instruments, Aware, giggle, DS2, and Pulse~Link.

One of the most widespread wired home-networking technologies, the MoCA (Multimedia over Coax Alliance) standard, defines a method of transmitting video and high-speed data over a home's installed cable TV coax. This wiring typically goes to most of the rooms where TVs will likely be situated (Fig. 4).

While such coax wiring can move content from a cable STB to multiple TV sets via a splitter, MoCA uses a backward path through the splitter for two-way communications. This method has proven itself in the cable TV market, with Verizon and the other top carriers using it. The only holdout is AT&T, which employs a version of the HomePNA wired standard in its U-verse IPTV system.

Entropic Communications has been making MoCA-compatible chips for several years, and it is the primary supplier. The latest version of its c.Link technology, the third-generation EN2510, puts the RF transceiver and the baseband circuits on the same chip. Modulation/access is OFDM in 50-MHz bands in the 800- to 1500-MHz range on the cable. Built with 65-nm CMOS, the chip comes in a 15- by 15-mm package.

The EN2510 offers MII, GMII, RGMII, and PCI Express (PCIe) x1 interfaces. Maximum data rate is 250 Mbits/s with a throughput of 175 Mbits/s via the media access layer (MAC). It's fully compatible with the MoCA 1.1 standard. MoCA, Ethernet, and Wi-Fi are the only local-area-network (LAN) technologies approved for inclusion in the Digital Living Network Alliance Interoperability Guidelines. In addition, Netgear's MCAB1001 Ethernet to-coax bridge allows consumers to network their SD/HD video devices, game consoles, network-attached storage

devices, and PCs to support multiple HD video streams simultaneously with high-speed file transfers.

Broadcom's BCM7420 and BCM7410 video decoder systems-on-a-chip (SoCs) integrate MoCA technology for STB applications. The BCM7420 has dual HD decoders and a 1.1 MoCA modem, while the BCM7410 is a single- HD-channel device. Both handle 1080p 60-Hz HD video and have an integrated IEEE 1394a MAC and PHY interface. Also, both support DLNA technology and include dynamic power management.

Also new in the wired space is the forthcoming IEEE P1901 power-line communications standard. Nothing is more ubiquitous than ac power plugs, which make home ac power wiring a real target for networking. Over the years, several companies have developed modulation standards that allow the ac line to carry high-speed data. Currently, three standards compete for support in this arena.

The oldest and most widely supported specification is HomePlug, which is backed primarily by chip maker and power-line communications pioneer Intellon and 73 other member companies. This standard uses OFDM to transmit data at up to 14 Mbits/s in the lower-speed version and up to 200 Mbits/s in the latest HomePlug A/V standard.

HD-PLC, supported by Panasonic, uses a different wavelet OFDM approach that's incompatible with the HomePlug OFDM/FFT technology. DS2, a Spanish chip maker associated with the Universal Powerline Association, supports yet another standard.

Each of these standards uses the same spectrum on the power line. However, incompatible protocols and modulation make them non-interoperable on the same power line.

The IEEE's P1901 group is attempting to make three MACs and PHYs coexist. An initial agreement permits any of the three to use the same line with backwards compatibility. The coexistence mechanism of P1901 is also part of the G.hn standard.

Wires and cables are generally a nuisance for consumers. But the existence of power-line and cable TV coax in most homes means consumers can use what they have. The cable TV and IPTV suppliers really prefer the reliability of integral wiring and the fact that fewer truck rolls are needed in support. Yet consumers love the flexibility of wireless—when it works.

## **WIRELESS TECHNOLOGIES**

Wireless is ideal for home networks, since no cabling is required. It's simple, very flexible, and the preferred choice of most consumers, as long as it has the speed and link reliability demanded by the application. By far, the most popular wireless networking technology is 802.11 Wi-Fi. It's very mature and reliable, as well as fast.

Improvements for the technology have maintained a steady pace over the years. The latest 11n version is super-fast and offers greater range thanks to multiple input/ multiple-output (MIMO)

antenna technology. Wi-Fi remains the technology of choice if your main networking objective is to connect one or more PCs to your DSL or cable TV line.

However, Wi-Fi probably isn't a clear choice if you need to wirelessly connect video devices. Even so, In-Stat reports a 51% increase in sales in 2008 for Wi-Fi enabled consumer products like digital TV sets, game consoles, STBs, and printers. There are also some interesting Wi-Fi options to consider.

Celero and Cavium Networks collaborated on a solution that transmits 1080p 60-Hz HDMI over Wi-Fi. Celero's CL3100 802.11n chip uses 4x4 MIMO to maximize speed and range. It works with the Cavium CNW3602 PureVu video processor, an H.264 compression chip, to deliver 480p/720p/1080p at 60 Hz over long distances, achieving sub-frame latency and perceptual lossless video quality.

Quantenna's Wi-Fi chip also features 4x4 MIMO with transmit beamforming. When used with the Cavium PureVu video processor chip, it too makes it easy to deliver real-time error-free HDTV wirelessly. MIMO and the Cavium video codec really make Wi-Fi a viable option to stream video in the home.

Ultra-Wideband (UWB) once was touted as the way to transmit video. But its speed and range generally aren't sufficient, except for perhaps some short-distance compressed video. The WiMedia Alliance's UWB standard provides a video-transfer profile, and a few UWB chip companies make ICs to facilitate that application.

T-Zero's ZeroWire 2.0 solution incorporates the TZC7200 chipset, which complies with the WiMedia Alliance standard and can deliver a peak link rate of 480 Mbits/s at 20 m or so. The T-Zero solution also includes an H.264 video codec with support for sub-frame latency, which is required for HDTV and gaming. It works with HDMI 1.3a and supports Consumer Electronics Control functionality in addition to legacy IR control.

Furthermore, Radian's unique UWB Roomcaster wireless system lets consumers set up 5.1 and 7.1 surround sound.

Another wireless standard making headway is the Wireless Home Digital Interface (WHDI). Its special interest group (SIG) comprises Amimon, Hitachi, LG Electronics, Motorola, Samsung, Sharp, and Sony. Amimon developed the technology. If you must have uncompressed video, it's a good way to go (see "Standards Groups Showcase Developments In Consumer Electronics").

WHDI products can transmit data at up to 3 Gbits/s in a 40-MHz channel in the unlicensed 5-GHz spectrum. Maximum range is about 100 ft, but it can pass easily through most walls. Latency is only 1 ms. The WHDI standard, which uses high-bandwidth digital content protection (HDCP) ver. 2.0, incorporates a 1024 RSA key exchange and a 128-bit AES encryption facility.

Perhaps the most exotic wireless networking technology is incorporated in the WirelessHD standard, which is another way to transmit uncompressed HD. Pioneered by SiBEAM, this

technology uses the unlicensed 60-GHz millimeter wave band, which is the spectrum from 57 to 64 GHz in the U.S. and 59 to 66 GHz in Japan. At these frequencies, data rates to about 25 Gbits/s are possible.

The WirelessHD standard accommodates rates to 4 Gbits/s, though, which is more than enough for uncompressed video and surroundsound audio. In this frequency range, multipath reflections are a real issue. The ability to penetrate walls isn't as strong at lower frequencies, and range is naturally limited by physics. Objects passing between transmit and receive antennas can block reception as well.

The standard overcomes these problems by incorporating phased-array antennas that use beamforming and beamsteering to maintain a solid link under varying conditions. The high transmitter power and antenna gain provides an equivalent isotropic radiated power (EIRP) of 10 W. Antenna adjustments take place in less than 1 ms.

The WirelessHD Consortium recently announced that the WirelessHD Compliance Test Specification version 1.0 is available to those wishing to adopt and evaluate the technology. Initial WirelessHD compliance testing will begin during the first quarter of this year.

SiBEAM's OmniLink60 chipset consists of the SB9120 Transmit Network Processor and the SB9121 Receive Network Processor. These chips are being widely considered for HDTV sets, Blu-ray DVD players, and other home media products. The SiBEAM/WirelessHD technology could also become a contender for the new wireless 1-Gbit/s Ethernet standard now in development.

## **HOME MONITORING/CONTROL**

Most home-networking solutions address the interconnection of consumer electronics equipment like TV sets, DVRs, and STBs. They also extend the reach of high-speed Internet connections to multiple PCs. Yet we're seeing greater use of home networks in home monitoring and control as well as home automation. Examples include security systems, and the control of heating and air conditioning and other energy-consuming items like water heaters, pool heaters, and other appliances.

Furthermore, many states are pushing energy monitoring and control methods through local utility companies—systems that require some kind of network connection. But will these networks be separate from or part of the home entertainment network? Apparently, it can go either way. The most likely approach right now, though, seems to be a separate network for monitor and control functions.

ZigBee already addresses this home-networking niche. The low-speed, 2.4-GHz unlicensed wireless technology is ideal for setting up point-to-point, point-to-multipoint, and mesh networks to control lighting, appliances, and other electrical devices. Such systems are already on the market using ZigBee, Z-Wave, and other wireless standards.

One interesting development is that the HomePlug Powerline Alliance and the ZigBee Alliance are joining forces to create a way for the ZigBee stack to run over the HomePlug ac power-line PHY. Along with major utility companies, these groups hope to build the Home Area Network (HAN) Green Ecosystem for controlling load devices at peak demand. Covering everything from thermostats, pool pumps, and white goods to electric vehicles, it would ultimately provide real-time information to the consumer. In fact, larger states like California and Texas have public utilities commissions (PUCs) that mandate the implementation of an automatic metering infrastructure (AMI).

With an AMI, electric and gas utilities can have two-way access to the home heating and air-conditioning systems as well as other heavy-energy home systems like hot-water heaters and pool heaters. The nation's energy policy demands such systems be in place by 2013. The utility company would control your energy usage based on your volunteer approach to set temperatures or to minimize cycling. This will cut your utility bill and save enormous amounts of energy overall.

According to Ed Drew, director of utilities solutions for machine-to-machine (M2M) company KORE Telematics, such an energy monitoring and control system might be a ZigBee network within the home linked to thermostats and other devices. The ZigBee node would then form a neighborhood-area network (NAN) with homes nearby to provide the communications link back to the utility company.

Several hundred homes in the mesh would transmit their data and any control information to a central collection point linked to the utility via M2M cellular backhaul. Texas and California already have such systems in place and seek to expand them over the years. Most other big states are also looking at this approach as we become a greener nation.

fig 1

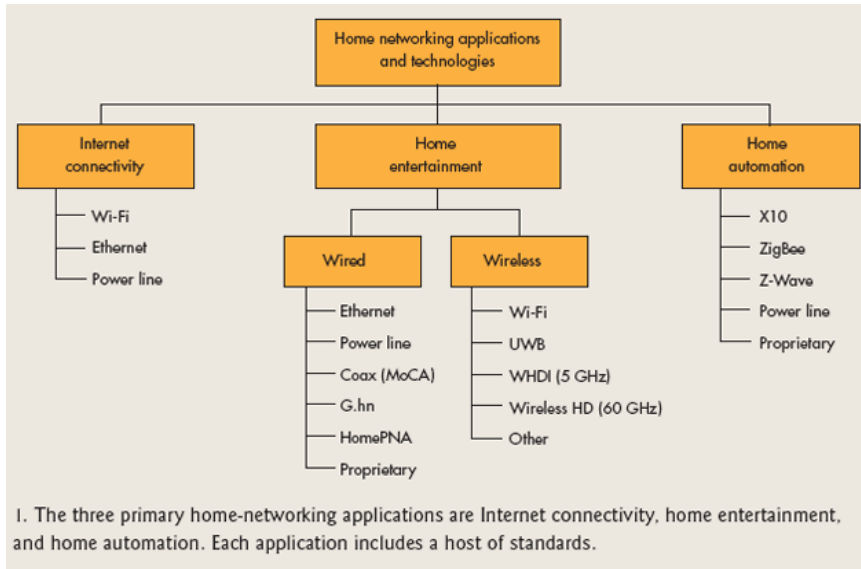


fig 2



fig 3

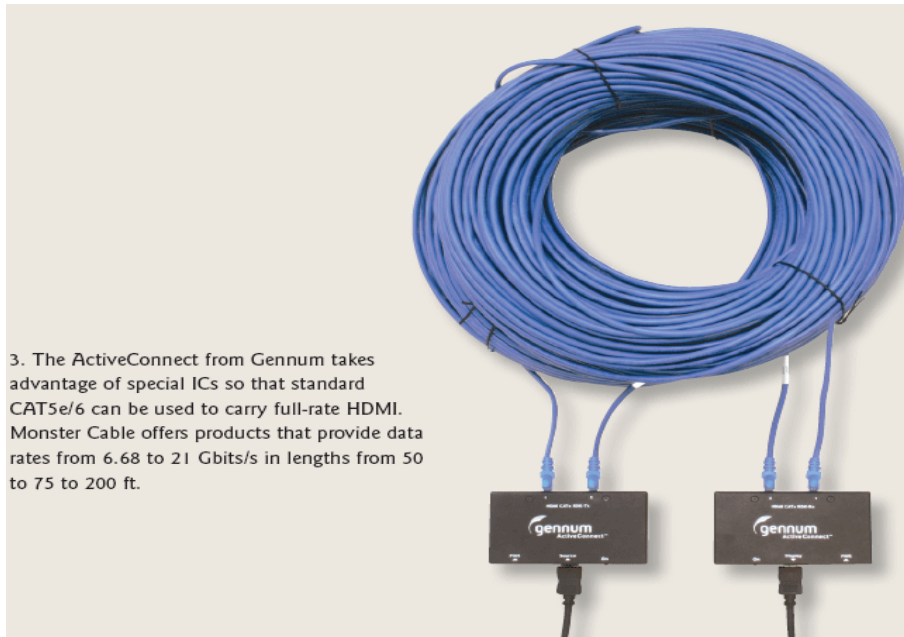


fig 4

