# Creating the Connected Home:
# The Debate over Home Networking Standards

October 2006

## Home Networking at a Crossroads

The rise of triple play services in general, and IP-based video in particular, has rekindled the debate over the best way to create the connected digital home. While broadband service providers eager to offer IPTV programming continue to grapple with the challenge of providing a sufficiently large data pipe to deliver multiple high-definition video streams from the head end to subscribers' homes, they face a parallel challenge in distributing the content from room to room once it gets there. Today only 1% of U.S. households have Cat5 Ethernet networks, and pulling Ethernet cable in a house can take an installer four to six hours. The search for a less costly, time-consuming and disruptive in-home distribution strategy is prompting fresh consideration of alternative networking strategies such as MoCA, HomePlug AV and HPNA as well as the emerging 802.11n/e standards.

What follows is a brief overview of the current market factors that are fueling the debate, the options available, the pros and cons of each, and where the market stands today.

## Beyond WiFi

Most of today's non-wired home networking technologies were available five years ago when the debate over Ethernet alternatives first heated up. At that point, however, the discussion was largely focused on supporting the relatively small bandwidth requirements of Web surfing, email, file transfers and other data exchange to and from PCs.

Wireless 802.11b/g networking won that round, in part because of the room-to-room mobility advantages for notebook PCs but also because notebook vendors began shipping their products with built-in WiFi clients. Users therefore needed to supply only one end of the connection instead of two. The other major contenders at the time — HomePlug (over powerlines) and HPNA (over telephone lines) — required the purchase and installation of two adapters with the associated extra cost.

Today, nearly every notebook PC has WiFi connectivity, but 802.11b/g in its current form remains an imperfect solution. First, it leaves dead spots in parts of the house where the wireless signal does not reach or is not reliable, limiting its usefulness even for data delivery. Second, it lacks the bandwidth, consistent quality and low latency required to support high-quality video, particularly multiple high-definition streams. It also suffers from interference from devices from portable phones to microwave ovens, uses data-based error correction methods that deliver poor results in video streams, and has no means of prioritizing multimedia packets to ensure quality of service.

Even without the latency and interference issues, the now-prevalent 802.11g WiFi standard clearly is not a feasible solution for porting video from room to room because of its bandwidth limitations. At its best, 802.11g has a maximum actual throughput of 20 to 25 Mbps and often can carry only a fraction of that traffic. With the advent of IPTV, service providers today need speeds that are closer to 100 Mbps: 60 Mbps for three HDTV streams (at 20 Mbps each), 10 Mbps for two standard TV streams (at 5 Mbps each), and the balance for services such as data, voice over IP, audio, computer-based video ranging from YouTube to movie downloads, and placeshifting solutions like Sling Media's Slingbox that feed digital video files from home to remote sites across a broadband connection.

The re-examination of non-Ethernet home networking methods is also being stimulated by two other factors. One is that home Internet connections are becoming faster than data speeds inside the home because of developments such as fiber networks and 100 Mbps broadband home routers, bringing more services than previously possible and thus creating the need to deliver those services to the right room. The other is the evolution of TV services like TiVo, Dish Network and DirecTV that require multi-room distribution, triggering talk of creating a media center solution that would converge TV and broadband networks.

With these developments and the fact that there are 3.5 televisions in the average U.S. household, there is no question of the need to look beyond WiFi for the home networking infrastructure. The only question is which of the available technologies to choose.

| | **PHY Rate** | **MAC Rate** | **Latency *** |
|---|---|---|---|
| Ethernet | 100 Mbps | 96 Mbps | <1 ms |
| 802.11g | 54 Mbps | 20-25 Mbps | 20-30 ms |
| MoCA | 270 Mbps | 135 Mbps | 5 ms |
| HomePlug AV | 200 Mbps | 100 Mbps over coax<br>50-55 Mbps over powerline | 20-30 ms |
| HPNA | 240 Mbps | 80-100 Mbps | 20-30 ms |
| 802.11n/e | 200+ Mbps | 100 Mbps | ?? |

*All numbers are based on industry data*
** Real-world usage in milliseconds*

As shown in the chart above, the current candidates include MoCA, HomePlug AV, HPNA and 802.11n/e. All four offer the essential benefit of simple installation with no need to retrofit the house with new wiring, enabling rapid deployment while also keeping costs low. In general, all four also provide the necessary quality of service (QoS) capabilities enabling service providers to assign bandwidth priorities for data, video and voice streams in triple play environments.

The differences come in throughput, latency, the availability of outlets or jacks in the right locations in the home, and a variety of other issues.

## MoCA

The MoCA (Multimedia over Cable Alliance) protocol distributes digital entertainment over the unused bandwidth on the coaxial cable that is already installed in over 90% of the 110 million TV households in the U.S. for cable or satellite TV service. The initial MoCA specification was approved in February 2006, and the first routers with built-in MoCA capabilities, MoCA set-top boxes and MoCA adapters hit the market a few months later.

**Pros:**

- The highest throughput of any of the alternatives, with a PHY (theoretical maximum throughput) rate of 270 Mbps and a MAC (actual) rate of 135 Mbps. In a large-scale field trial, MoCA consistently delivered at least 100 Mbps of usable throughput under real-world conditions. According to proponents, this is fast enough to handle multiple simultaneous HD and DVD-quality streams and high-speed data without glitches or freezes.
- A latency rate of just 5 milliseconds under actual usage conditions, compared to 20 to 30 milliseconds for HomePlug AV and HPNA. (All three clock in at latency rates of 20 to 30 milliseconds in the lab.). This eliminates screen freezes, pixelation and related disruptions.
- Minimal interference from other TV signals and no interference from household appliances or devices, with operation on a protected signal above the 850 MHz spectrum that ensures no interference with cable TV, digital broadcast satellite or other media.
- Coexistence with cable TV, satellite, and over-the-air signals and services.
- Availability of coax outlets near TVs in the home, minimizing the need for new wiring for the IPTV portion of triple play services.
- Plug-and-play connectivity at most coax outlets with no need to access or change splitters.
- Proven standard since it is shipping in large volume now.

**Cons:**

- Lack of availability of a cable outlet in rooms without televisions. If a MoCA connection is required for hookup to a PC or other non-TV device in a location where there is no installed coax wire, new cables must be installed.

**Supporters:**

- The main advocate is the Multimedia over Coax Alliance (www.mocalliance.org), a group primarily composed of industry vendors, telcos, and cable and satellite vendors.
- Major phone, cable and satellite supporters include Verizon, Cox, Comcast and EchoStar. Verizon has MoCA networking integrated into the Motorola set-top boxes that it is buying for its FiOS TV service and has also begun shipping a 100 Mbps Actiontec router incorporating MoCA technology to new FiOS customers.

## HomePlug AV

HomePlug AV uses a home's electrical wiring as the home networking backbone, sending data over the same wiring that feeds a home's electrical needs. The protocol can also work over coax. The HomePlug AV standard adopted in 2005 offers a maximum theoretical data rate of up to 200 Mbps — up from 14 Mbps for the first-generation HomePlug 1.0 standard ratified in 2001and 85 Mbps for HomePlug Turbo ratified in 2004. The first adapters supporting the HomePlug AV protocol delivered in 2006.

**Pros:**

- Uses the most pervasive wiring in the home. According to one estimate, a typical home has 48 powerline outlets compared to just three or four coax outlets.
- Easy solution for combating the WiFi dead spot problem to deliver whole-house audio and data, particularly for locations such as the garage or backyard that will have electrical outlets but no coax or telephone lines.
- Potential solution for distributing digital video entertainment when used over coax, based on test data from the HomePlug Powerline Alliance indicating a net throughput of over 100 Mbps in the coax scenario.

**Cons:**

- Insufficient capacity to support video streams over powerlines, with a net throughput of only 50 to 55 Mbps in over 80% of powerline outlets in test scenarios reported by the HomePlug Powerline Alliance.
- Interference from household appliances such as washing machines and hair dryers, affecting the stability and quality of the connection.
- Inconsistent performance with excessive latency rates for video delivery as well as signal degradation with increasing loads, often accompanied by increased "noise" on the line.
- A spectrum that is limited to the 2 to 28 MHz range, creating a higher probability of crosstalk and associated interference.

**Supporters:**

- The main proponent is the HomePlug Powerline Alliance (www.homeplug.org). Other groups promoting and developing separate (and possibly incompatible) standards for powerline networking include the Universal Powerline Alliance, the Consumer Electronics Powerline Communications Alliance and the Open PLC European Research Alliance.
- Intel and Motorola are among the most prominent members of the HomePlug Powerline Alliance, and Intel has invested in broadband-over-powerline chipmaker Intellon.

## HPNA

HomePNA began as a strategy for using existing copper phone lines for in-home networking but recently added the ability to network over coax as well. The latest specification from the International Telecommunications Union, HomePNA 3.0 (G.9954), was developed specifically to support triple-play initiatives including the deployment of standard and high definition TV. The standard provides for data rates of up to 240 Mbps, and field tests have demonstrated an average data rate of 107 Mbps.

**Pros:**

- Connections near most computing and consumer electronic devices, with the ability to work through splitters.
- No interference with fax or answering machines, dialup modems or DSL service because these services occupy different frequency bands than HPNA on the telephone wire.
- Potential (but unproven) solution for video distribution based on throughput capabilities.
- For telcos, a choice of phone or coax networking that can be important in apartment buildings and townhouses where shared coaxial cables may be difficult to access.

**Cons:**

- Lack of telephone jacks near entertainment devices such as TVs, DVDs, set-top boxes and DVRs in most homes.
- Relatively high latency rates, which may affect the quality of the video signal.
- Rumored cases of interference with local cable operators when using HPNA over coax, which may bring down the local neighborhood cable network.
- Not shipping in large volume to date and therefore unproven.

**Supporters:**

- HPNA is being promoted by the Home Phoneline Networking Alliance (www.hpna.org).
- AT&T recently adopted HPNA 3.0 for its fiber-based U-verse data and television services as well as its copper-based AT&T Yahoo DSL high-speed Internet service, switching from its initial commitment to MoCA.

## Wireless 802.11n/e

The emerging 802.11n WiFi standard is expected to deliver user data rates that are four to eight times faster than today's 802.11g protocol through the use of Multiple-Input-Multiple-Output (MIMO) technology that employs multiple receivers and multiple transmitters in both the client and access point. The 802.11n effort began in 2004 but has been delayed, and the new standard may not be ratified until 2008.

When combined with the quality of service extensions in the recently adopted 802.11e standard, 802.11n is expected to offer an alternative wireless networking strategy capable of supporting video streaming and delivery of other multimedia services.

**Pros:**

- Reported actual throughput of up to 180 Mbps or higher, depending on the final standard.
- Extension of familiar WiFi technology that is already broadly accepted by consumers.
- No dependence on home's existing wire infrastructure.

**Cons:**
- No final standard expected until 2008, hindering accurate evaluation of the usefulness of the new standards for IPTV and other triple play delivery.
- Need to upgrade existing 802.11b/g equipment, including wireless clients, to take advantage of higher bandwidth.
- Potential incompatibility of "Pre-N" products already on the market with products that support the final standard.
- Wireless signal expected to degrade dramatically as the distance between the client and the access point grows.

**Supporters:**
- The Wi-Fi Alliance (www.wi-fi.org).

## Conclusion

With the disparate choices available to solve the problem of room-to-room delivery of video services and other digital entertainment, the debate over the best alternative to costly Ethernet networking is destined to continue into the foreseeable future. The jury is out on the preferred methodology, and it is possible that different service providers will turn to different solutions with n.o standardization on a single technology. Even service providers like Verizon that have stated a preference for a given technology are refusing to commit to a single method over the long term, and some like AT&T have switched allegiances as their business strategies and the technologies have evolved.

Still, if the promise of IPTV and the connected home is to be realized, service providers need to resolve the issue of which transmission wire they want to use for disseminating data and video inside the home. Instead of the original focus on the last mile, the discussion has now turned to the inside mile. Getting content to the home is one thing; getting it to the right room is another. By taking responsibility for the home networking strategy, service providers can help ensure the success of their triple play initiatives.

For more information,
contact Actiontec Sales at 408-752-7700.