How HomePlug Technologies Enhance the Consumer Experience

A discussion on the requirements of the connected home, and how HomePlug technologies meet the tough demands of consumers

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This paper discusses the merits of the development process used for all HomePlug specifications. The HomePlug Powerline Alliance created a series of processes and a system of checks and balances in order to ensure that our specifications benefit the whole of the industry and are easily licensed between the industry's various stakeholders. As a result, a great mind share of expert industry-wide talent worked to create best-in-class technologies. This paper also shares a compendium of independent test results and figures that support our claims.

For those in the consumer electronics industry, every New Year brings a similar feeling: In the same moment that we countdown the waning seconds of the old year, we begin to count the seconds remaining until the opening of the International Consumer Electronics Show, which in 2007 celebrated its 40th anniversary.

Although both the New Year celebrations around the globe, and the CES show in Las Vegas, are now a distant memory, the products introduced at CES 2007 are likely to stay with us–and enhance our life with new entertainment options–for decades to come. Those who follow these trends will begin to notice that a dramatic shift is beginning to affect both the industry and consumers alike.

But exactly what is this dramatic and revolutionary step that will change everything? Is it hype? Or is it reality?

Two recent CNET reviews provide examples of products that are standouts, and mark the next step for all of us who love movies and television:

- *Network AQUOS promises HD over power lines*
- *Motorola's place-shifting set-top: Follow Me TV*

Both of these products are revolutionary. But not simply because of the incredible picture or revolutionary concepts that they present, but because of *how* these items connect. These applications would not have been possible without a networking technology that enables easy connectivity among all these devices.

Understanding the Requirements

What are the requirements for these connectivity technologies? What makes this futuristic vision into a reality of today?

Before embarking on any long and detailed development process, the HomePlug Alliance asks itself the questions above.

REQUIREMENT #1
A high-bandwidth network has to be available everywhere in the home; no corner of any room should be "dark".

REQUIREMENT #2
Audio and video content has to be delivered perfectly. In other words, pixilation and frame loss are not acceptable, and the user experience with the content must remain unchanged from one that uses dedicated wiring.

REQUIREMENT #3
The connectivity technology must provide a high level of Quality of Service (QoS) to ensure reliable delivery of entertainment content, even in cases when the network becomes congested. As networks become more and more overloaded with gaming, VoIP, Internet Browsing, and other traffic, QoS sets the priorities of these various applications.

The alliance also addressed these topics:

- The number of supported streams per application
- Interoperability with HomePlug 1.0 technology
- Security
- Geographical & Regulatory Requirements
- Cost
- Diagnostic capabilities

Most digital applications for the home are easily supported with a network speed of about 1.5 to 2Mbps. HomePlug 1.0 technology can easily tackle these kinds of applications, like audio distribution, Internet sharing, wireless extension, gaming, and others. The outliers are high-quality video applications such as HDTV. Building a technology that can support a wide variety of simultaneous applications including HDTV is the challenge.

To illustrate, the following scenarios show a typical home and typical user experience and demands.

Application App. Rate (Mbps)	Scenario 1: Two-person family		Scenario 2: Six-person family with small children		Scenario 3: Six-person family with small children and teenagers	
	Qty	App Rate (Mbps)	Qty	App Rate (Mbps)	Qty	App Rate (Mbps)
HDTV Home Theater 22—27.8 Mbps	1	22—27.8	1	22-27.8	1	22-27.8
SDTV 3—7 Mbps	1	3—7	3	9—21	2	6—14
Home Theater Audio 5.4 Mbps	1	5.4	1	5.4	1	5.4
CD Audio 0.8 x 2 Mbps					3	4.8
Phone—VoIP (.064 + .016) x 2 = .160 Mbps	2	0.16	2	0.16	3	0.24
IP Data 2 Mbps	2	4	2	4	5	10
Total	7	34.5—44.4	9	40.6-58.4	15	48.4-62.2

Table 1: The Application Bandwidth Table from the HomePlug AV Marketing Requirements Document, v1.1, April 18, 2003.

A Brief History of HomePlug Technology Development

As with HomePlug 1.0 development, HomePlug AV technology went through an open and scientific process in order to develop the best known powerline communication technology.

A team of technology and marketing experts from the communications and consumer electronics industries judged the various powerline technologies through lab tests, field tests, and unbiased scoring for powerline technologies.

The process has always followed these strict steps as established by the alliance in the year 2000:

1. Determine market requirements
2. Make a call to the industry to submit new powerline technologies for study
3. Conduct an unbiased analysis of each submitted technology
4. Choose a baseline technology
5. Develop the technology with open participation from HomePlug member companies
6. License the technology and intellectual property through Reasonable and Non-Discriminatory terms (RAND)
7. Promote the technology worldwide for use in all its applications.
8. Offer services to perform product certification and a certification mark

This process worked very well for the development of HomePlug 1.0 technology, and with HomePlug AV, the process was kept intact.

Developing HomePlug AV Technology

Beginning in early 2003, the market requirements were decided by industry leaders from many levels of the value chain and many soon-to-be complementary industries: consumer electronics, networking, service providers, retailers, silicon vendors, equipment manufacturers, and others.

After the market requirements were complete, and shown to all technology vendors known to the alliance, the members of HomePlug began testing and studying proponent technologies from all over the world. HomePlug BoD and committee members thoroughly examined the best technologies available and determined that while all of them had similar performance, none of them met the previously stated market requirements that the alliance had established.

Due to the fact that the alliance had access to the world's best technical minds that the powerline industry had to offer, we felt we would best serve the industry if we embarked on a mission to improve the technology, so that it truly met the requirements that the market demanded.

The majority of the proponent companies began working together to create a new specification that combined the best of what was originally proposed with new features that enhanced the technology and brought it to a higher performance level.

But all this work would make little sense if consumers were unable to recognize the products that embedded our robust and speedy HomePlug technology.

To this end, the alliance created a certification process and a certification mark. When a product carries the HomePlug-certified mark, consumers know that each product will work with other HomePlug products, and that they can expect the same level of performance from all the products sporting the mark.

Testing the Technology

Since the processes put in place by the alliance became the rules by which the technology was developed, it became very important to prioritize and score the performance aspects of the system in a logical manner. Now that HomePlug AV units are coming to market, proving the technology's dominance is important to potential customers–especially in the face of competing proprietary technologies.

Before the HomePlug AV technology was released, several reports were published by interest groups that support certain proprietary technologies which compared older versions of HomePlug technologies with new 200Mbps-class proprietary technologies. It was important to the HomePlug alliance–and to the industry–to seek the help of an autonomous testing facility to perform our evaluations. The alliance found a solution in an Independent Test Laboratory (ITL) and commissioned it to conduct rigorous and unbiased testing.

The test lab chosen was *Laboratoire des Applications Numériques* (LAN). The facility is located in France and is used for testing all kinds of digital home technologies. LAN offers a real-life 170 m² home connected to an 800m² laboratory that includes infrastructures for testing xDSL, TV, PLC, and RF technologies.

Figure 1. The LAN Testing Facility at Cesson Sévigné, France

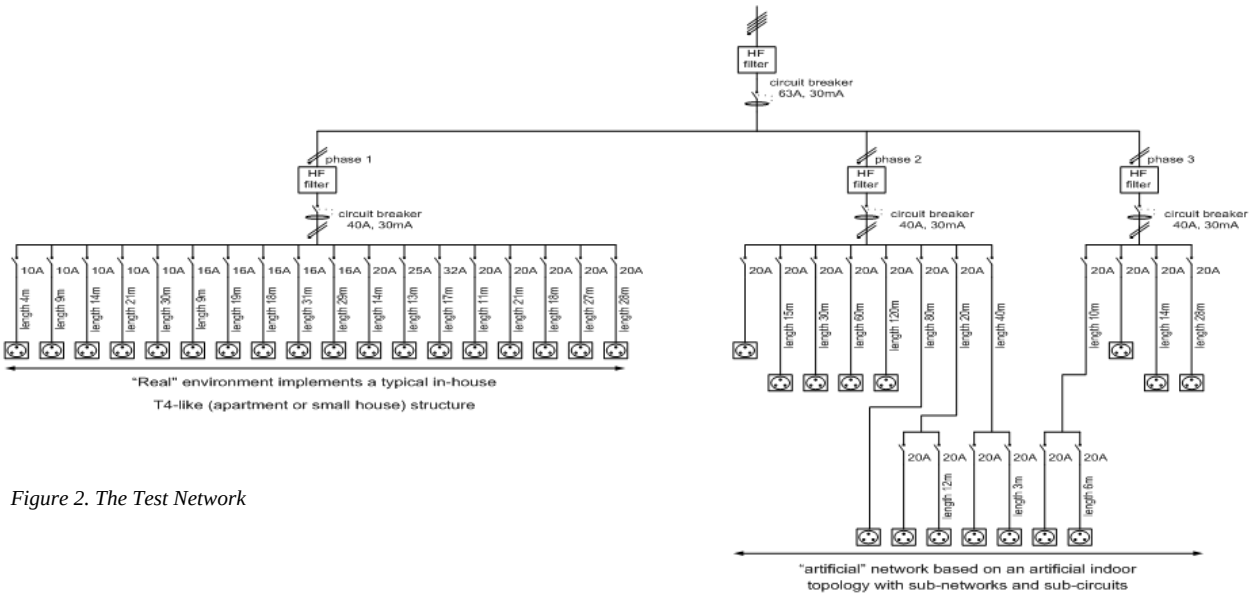
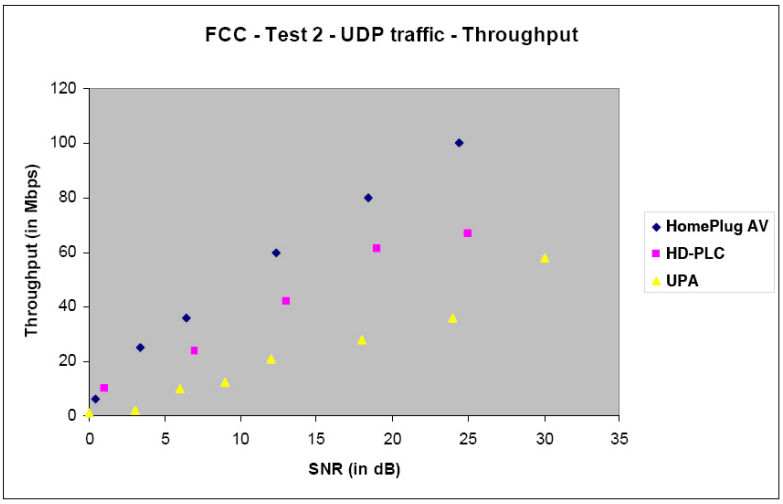


Figure 2. The Test Network

THE RESULTS:
HomePlug AV is the fastest and most robust powerline communication technology available!

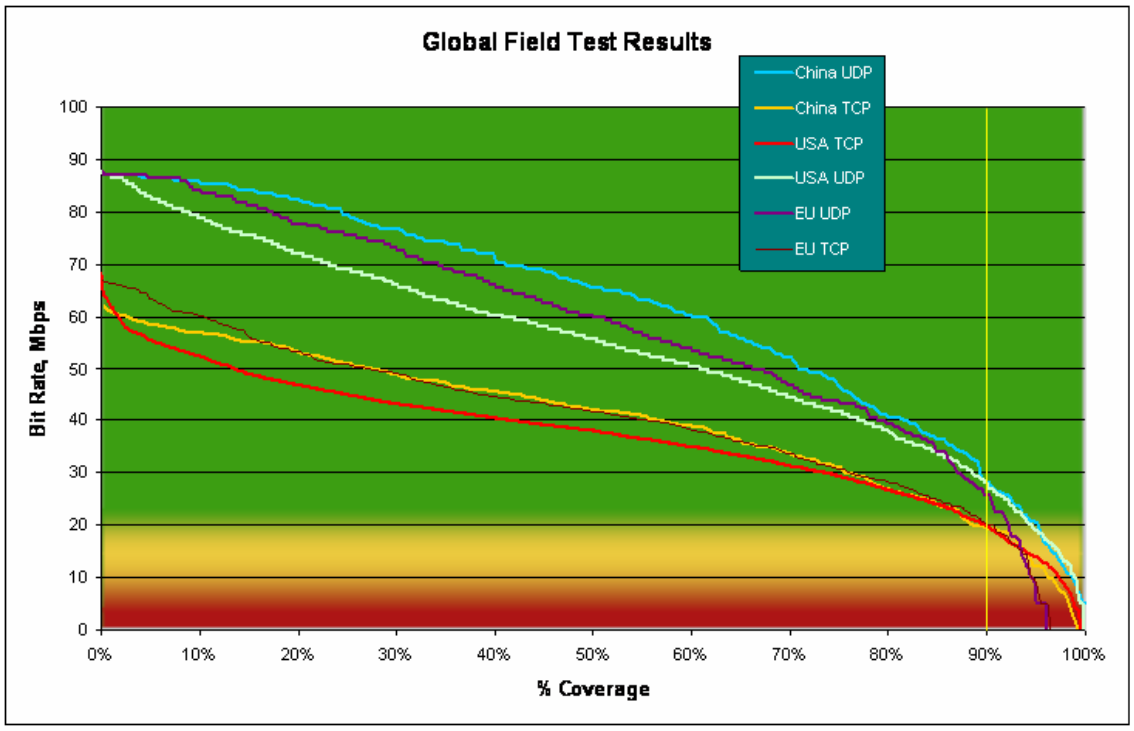
The following chart (*Figure 3*) shows how HomePlug AV powerline technology retains the excellent performance needed to support high-bandwidth applications even in the face of severe conditions on the power line. HomePlug AV outperforms the other powerline technologies especially when encountering a high Signal-to-noise Ratio (SNR).

Figure 3. The powerline network is a power cable 15m long. The noise is injected on the receiver side.
Note: The 100BASE-T Ethernet ports of the computers used in the test limited the maximum UDP throughput to approximately 95Mbps.



In addition to tests at LAN, Intel conducted field tests of HomePlug technology, and released the results at the 2007 Intel Developer Forum in Beijing (*Figure 4*). These tests, conducted in real homes around the world, showed the capabilities of HomePlug technologies to deliver robust communications around the world – even for challenging digital applications like HDTV.

Figure 4. Intel's results from their international field tests.



Closely following the test results that confirmed the outstanding performance of HomePlug AV technology, the alliance demonstrated the interoperability of 14 products that were designed for HomePlug AV. These included products from well-known technology companies such as

- Actiontec
- Asoka USA
- Aztech
- D-LINK
- Devolo AG
- Gigafast
- NETGEAR
- LINKSYS
- Intellon Corporation
- Solwise
- ZyXEL

Figure 5. The HomePlug Certification Mark

All of this translates into one reassuring item: *Consumers will benefit from the use of HomePlug technology.*

HomePlug technologies are breaking new ground for connected home applications, and remain the only industry standard for powerline communication that insures strict interoperability and multi-vendor support.

Only HomePlug technologies offer the highest levels of performance in the industry.

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The testing comparing HomePlug AV technology vs. HD-PLC and UPA technology was conducted at LAN. All testing was carefully segregated to insure that all reporting was independent. The tests were based upon the technological offerings available at the time of testing; HD-PLC and UPA may have modified their products and/or introduced other technological features and functions which could cause comparison results to be different if the testing were conducted at present. Additionally, the methodologies used in the testing do not reflect all possible operating conditions and any conclusions should be limited to those presented in the report. All trademarks and/or service marks in the report are used for reference purposes only, are the property of their respective owners, and no rights are claimed therein.