



# Converging Technologies - Moving from HomePNA to G.hn

A Guide for Service Providers

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#### Note

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## 1 Introduction

This White Paper provides a vision of, and guidance on, migration approaches for Service Providers who currently use HomePNA technology. It is intended to aid those considering adding G.hn to their existing deployments and/or migrating to G.hn. This will enable Service Providers to extend the life of their HomePNA installations and thereby gain further benefits from existing investments, while at the same time facilitating the migration to G.hn.

While HomePNA technology meets the current needs of many Service Providers, G.hn will meet their evolving needs. G.hn is the only technology that operates over all types of home wiring, and provides optimum speed and robustness. It also has a number of other significant advantages over current and legacy technologies.

## 2 Executive Summary

This document is fairly long and contains some technical detail. This summary therefore answers the key business questions that Service Providers are likely to have following the announcement of the merger of HomeGrid Forum and the HomePNA Alliance, with the stated goal of long-term convergence of wired home networking on G.hn. One can read this section, in isolation or use it as an introduction to the later, more detailed Sections. The merger FAQ document covers broader technical and organizational implications of the merger.

### Question 1

**We are currently deploying HomePNA systems and they meet our current service needs. Will these devices continue to be available in light of the merger?**

Continued support of HomePNA technology is a key documented goal of the new organization. The current HomePNA certification and logo program will continue, now under the auspices of HomeGrid. Marketing activity will also carry on. Manufacturers will continue to produce HomePNA devices as long as there is sufficient market demand.

### Question 2

**We are currently deploying HomePNA systems, why should we change to G.hn?**

G.hn has two main advantages over HomePNA. It is a much newer technology and therefore takes advantage of developments in silicon and signal processing to provide significantly higher peak rates with more robust performance, particularly in difficult environments; this results in greater in-home coverage at a given rate. The second advantage is that G.hn supports operation over powerlines and Plastic Optical Fiber in addition to its phoneline and coax modes, which are similar to, yet higher performing than those modes already defined for HomePNA. This now complete set of home wiring types will significantly increase the coverage obtainable in a wide variety of homes – powerline wiring is near ubiquitous.

The need for higher aggregate rates and better coverage is largely driven by simultaneous use of video on an increasing number of personal devices - laptops, tablets and smartphones, which are now used throughout the home.

In short, G.hn provides higher speeds at a more robust performance level over an expanded range of home wiring types.

### Question 3

**We are currently only deploying wireless home networking, why do we need to go back to wired networks?**

Wireless attachment is very convenient, especially for non-fixed devices. However, wireless is partly a victim of its own success, with interference between systems increasing all the time. While wireless headline rates can be very impressive, the real-world throughput is often very much less; this is an issue with all home network types, but wireless suffers more than most. Finally, wireless performance can vary significantly over time, and as a function of location in the home. For these reasons, few Service Providers rely on wireless for video distribution, and the problem worsens with the move to multi-stream video and HD TV.

In contrast, G.hn offers higher speeds with a more robust, stable performance direct to fixed devices. It is also likely to play a major role as the wired home backbone, feeding a set of distributed wireless Access Points. This hybrid architecture addresses many of the wireless coverage and performance issues.

### Question 4

**We are currently deploying another PLC-based home networking solution, why should we switch to G.hn?**

There are indeed other powerline technologies, but G.hn has significant advantages over these. Firstly, it is fully and openly standardized, there is no danger of being locked into a proprietary solution or a technology dominated by single silicon supplier. Secondly, again because of its more modern technology, it significantly outperforms these other systems, especially in its robustness. Thirdly, it supports MIMO, which means that it can use different transmission paths in a 3-wire mains system, either combining both paths to increase aggregate throughput or choosing the best path at any one time to give a more robust performance in the presence of noise. Finally, the nature of home electrical wiring is such that there is significant potential for interference between systems in close proximity, the so-called "network neighbor interference" problem. This can both reduce performance and threaten privacy. G.hn has an unrivalled range of advanced techniques to mitigate this interference, and advanced security features to protect content and access to services.

### Question 5

**If we want to change to G.hn, when will we be able to do so?**

The first HomeGrid Forum Certified G.hn silicon is on the market, with more silicon certifications slated for announcement shortly, and prototype products have been produced. Full HGF product certification is imminent and mass-market production devices will start to appear in Q3 2013.

### Question 6

**Will G.hn-based systems have any commercial advantages over current systems with regard to choice of vendor, product variety and price?**

There are already five G.hn silicon vendors, and a significant number of system vendors are known to be working on products, so there should be no problem with variety and security of supply.

HomeGrid Forum is a certification and marketing organization; it cannot get involved in any pricing issues. However, the basic facts that G.hn is a convergence technology from several sources and has a wide range of applicable network types, based on a single world-wide standard, should result in very significant volumes which in turn leads to many commercial benefits.

### 3 The Current State of Home Networking

All homes have some existing wiring, which in addition to the ubiquitous powerlines, may include phonelines and/or coaxial cables. These wires offer a convenient means of distributing data throughout the home as they eliminate the need for new cables. Over the past decade, wired home networking has evolved to use these existing wires extensively, with silicon advances enabling higher performing networks with each new technology generation.

In 2007, HomePNA technology for home networking over coax was introduced to the market. HomePNA over coax (based on the standard: Recommendation ITU-T1 G.9954) joined HomePNA over phone wiring<sup>2</sup>, which was standardized in 2001, in Recommendation ITU-T G.9951. Service Providers of all sizes, including some of the world's largest, have deployed HomePNA technology. HomePNA is used to distribute high bitrate services, such as IPTV, throughout homes in four continents. HomePNA certified products include set-top boxes, residential gateways, Ethernet bridges, and fiber to coax ONTs. There is an installed base of over 40 million HomePNA nodes and more than 85 products are HomePNA certified.

Other wired home networking technologies introduced during the last decade work over just one of the types of existing in-home wires - coax, phoneline, or powerline. Each of these legacy technologies has its own limitations. Further, when multiple, legacy wired networking technologies are used in a home, they are essentially network "islands," which may or may not be bridged, but are certainly not jointly managed, or able to route traffic based on overall network demands and traffic. In addition, there is a growing mix of wired and wireless networks, with wired-wireless hybrids becoming the norm.

#### 3.1 Enter G.hn

In 2006, the home networking industry recognized that Service Providers and consumers no longer wanted non-interoperable home networking technologies. Further, the sheer variety of technologies meant that mass-market economies of scale were not being realized. To address these issues, a standardization effort was started in the ITU-T to develop a single technology that would work over any wire type in the home. This effort brought all the interested parties together to develop a state-of-the-art home-network technology that could work over any wire type and so, by definition, provide a homogenous network for traffic management purposes regardless of the wires used. The ITU-T work group that developed the G.hn standards built on the experiences and advances made with multi-wire HomePNA technology.

The goals of the G.hn standardization activity were for it to achieve the best possible performance over any wire type, overcome the limitations of legacy technologies, and thereby enable a true mass market. G.hn is the only home networking technology that enables such economies of scale as every G.hn transceiver is capable of operating over any wired medium.

The ITU-T completed the core family of G.hn standards in 2010, with each standard focused on specific functionalities. Since 2010, work has continued in ITU-T to extend and enhance the technology, with advances such as the addition of a PLC MIMO standard for G.hn in 2012. The following table provides an overview of this family of standards.

<sup>1</sup> ITU-T: The ITU is the Telecom and networking arm of the UN. The ITU-T focuses specifically on developing Telecom network standards, including for in-home networks. Standards developed by the ITU-T are "Recommendations," as individual UN member countries can mandate them or not.

<sup>2</sup> Phone cabling is also known as phonelines, phone wiring, phone wire, and twisted pair. Both HomePNA technology and G.hn operate over any copper pairs, twisted or untwisted, with the term "phonelines" used generically.

» **Table 1:** G.hn Family of Standards (Recommendations ITU-T)

| Standard | Title                                                                                                                 | Technology Defined               |
|----------|-----------------------------------------------------------------------------------------------------------------------|----------------------------------|
| G.9960   | Unified high-speed wireline-based home networking transceivers - System architecture and physical layer specification | Network Architecture & PHY       |
| G.9961   | Unified high-speed wire line based home networking transceivers – Data link layer specification                       | DLL                              |
| G.9962   | Unified high-speed wire-line based home networking transceivers - management specification                            | Management & Control Planes      |
| G.9963   | Unified high-speed wireline-based home networking transceivers – Multiple input/multiple output specification         | PLC MIMO                         |
| G.9964   | Unified high-speed wireline-based home networking transceivers – Power spectral density specification                 | PSD Tools                        |
| G..9972  | Coexistence mechanism for wireline home networking transceivers                                                       | G.hn Coexistence with Legacy PLC |

Like HomePNA, G.hn technology can operate in baseband mode over coax and phonelines (see following table), and operate concurrently over these same wires (with HomePNA network coexistence) as an overlay network. This is one of the G.hn value propositions for Service Providers with deployed HomePNA networks. With a dual mode silicon approach to building G.hn and HomePNA systems, the same equipment can be used to extend existing HomePNA coax or phoneline networks, or create a new, G.hn-only one. Moreover, G.hn networks over powerlines or plastic fiber in the home can be adjunct networks to existing HomePNA ones over coax and/or phonelines, i.e. they run over a completely different physical infrastructure which of course provides completely interference-free coexistence.

» **Table 2:** Mediums and Bandplans for HomePNA and G.hn Technologies

| Medium            | Technology               | Baseband or RF | Start Frequency (MHz) | End Frequency (MHz) | Bandwidth(MHz)  |
|-------------------|--------------------------|----------------|-----------------------|---------------------|-----------------|
| Coax              | HomePNA                  | Baseband       | 12                    | 44                  | 32              |
| Coax              | G.hn Baseband            | Baseband       | 5                     | 50 or 100           | 48 or 98        |
| Coax              | G.hn RF mode             | RF             | 300                   | 3000                | 50, 100, or 200 |
| Phoneline         | HomePNA                  | Baseband       | 12                    | 28                  |                 |
| Phoneline         | G.hn                     | Baseband       | 2                     | 50 or 100           | 48 or 98        |
| Powerline         | G.hn                     | Baseband       | 2                     | 25, 50 or 100       | 23, 48 or 98*   |
| Fiber             | G.hn                     | Baseband       | 2                     | 100 or 200          | 98 or 198       |
| Coax or Phoneline | G.hn coexistence mode ** | Baseband       | 50                    | 100                 | 50              |

\* PLC mode for G.hn is notched at 80 MHz to avoid interfering with the FM band. This results in 78 MHz of usable frequency (not counting other notches)

\*\* G.hn in baseband mode over coax or phoneline can be notched to operate above HomePNA over the same coax or phoneline. G.hn RF mode for coax operates in a frequency range above the range of HomePNA over coax, achieving HomePNA coexistence as well.

### 3.2 G.hn Today (Mid 2013)

G.hn is a completely new technology, and so it has had to go through the normal silicon and system gestation processes to get to full market-readiness.

Since first prototype availability in 2010, G.hn silicon has matured quickly, while products have gone through their own development stages and are now entering the market. To foster this rapid

development, from concept designs to final, certified products, the HomeGrid Forum (HGF), an industry special interest group composed of major Service Providers, retailers, system companies, silicon companies, and research groups, was formed to promote advanced, interoperable home networking and smart grid applications based on G.hn..

Before the merger of HomePNA and HomeGrid Forum, G.hn technology was the sole focus of HGF. HGF has fostered strict compliance to G.hn standards through an initial interoperability development phase consisting of 2 years of plugfests and test events, while developing its formal G.hn Compliance and Interoperability (C&I) certification program. This program ensures that all HGF Certified G.hn products are compliant to G.hn standards and HGF mandatory specifications, and that certified products interoperate with any other G.hn products networked over the same wire type, regardless of vendor.

### 3.2.1 G.hn Silicon

To date, five silicon companies have announced G.hn silicon: Marvell, Metanoia, Sigma Designs, TangoTec, and Xingtera. TangoTec will deliver silicon during the coming months while the other four have silicon available now. Already, HGF has certified one vendor's silicon and will certify more during Spring 2013.

With multiple G.hn silicon sources, there is the need to ensure compliance to all key requirements as the foundation for interoperability. HomeGrid's C&I program requires full interoperation and silicon compliance to all mandatory specifications, including those developed by HGF.

### 3.2.2 Systems with G.hn

To speed the delivery of systems with high performance and complete interoperability, HGF has launched lab certification testing for systems with G.hn transceivers. Full product certification testing at the HGF accredited test lab is imminent. Some G.hn silicon companies have already announced several G.hn system design wins.

## 3.3 After the Merger

In the near term, the market for HomePNA will continue to grow and the expanded HomeGrid Forum will support this. South America is a market with an immediate need for a substantial amount of HomePNA technology.

Meanwhile, Service Providers worldwide are running G.hn products through rigorous testing and trials, with plans to deploy in late 2013 or early 2014.

Those Service Providers with an installed base of HomePNA networks benefit in several ways from the merger. The expanded HGF will continue to support and maintain a C&I program for HomePNA products, HGF will include HomePNA technology in work related to IEEE 1905.1 and other advances, and HGF will provide a clear migration plan for moving the installed base to G.hn as explained in this document.

## 4 Internetworking, Coexistence and Convergence

Although the technologies do not interoperate directly, Ethernet packets cross between G.hn and HomePNA networks using simple Ethernet Layer 2 bridges. Having such bridges to link these networks is a low-cost, easy to deploy networking solution for the home. When combined with the ability of G.hn and HomePNA technology to coexist on the same wire, the resulting Service Provider benefits are substantial. Therefore, a Service Provider technology convergence strategy is possible when combining G.hn with HomePNA.

### 4.1 Coexistence of G.hn and HomePNA networks

There are two different ways in which G.hn and HomePNA networks can coexist in a given home. Since G.hn is an “any wire” technology, if there is a need to extend a network, this can simply be done by installing G.hn nodes, which operate over a different medium; this would typically be powerline, although phoneline is also a possibility. If installing new cabling is acceptable, then the plastic optical fiber option comes into play.

A G.hn network operating as an adjunct network, over a different medium than the existing network, increases the overall distribution capacity, and extent of coverage, within the home. For example, all fixed devices that require high throughput and quality of service will have an adjacent electric socket and so G.hn over powerline can form a particularly useful adjunct network for such devices. Just as with the original HomePNA network, this will of course be completely “self-install.” The new network will also benefit from the advanced transmission techniques that G.hn brings.

The second approach to coexistence is to use the same wires already used for HomePNA. This applies to both coax and phoneline networks, and is possible because G.hn can be configured to operate at different frequencies to the HomePNA system.

G.hn’s baseband coax mode operates in a frequency band between 2 MHz and 100 MHz. HomePNA over coax operates between 12 MHz and 44 MHz; the higher start frequency avoids interfering with other services that might be operating over the coax such as VDSL2. In order to coexist with HomePNA over coax, G.hn can be set to operate in the 50 to 100 MHz range by simply “notching out” the frequencies below 50 MHz.

If the case of G.hn RF mode, there is no coexistence issue. HomePNA does not have an RF mode and G.hn RF has a lower frequency bound of 300 MHz.

If a Service Provider wants higher G.hn throughput over the same, shared coax, the HomePNA frequency band can be reduced to the 12 to 28 MHz range. While this would cut the HomePNA throughput in half, G.hn’s greater spectral efficiency means that the total aggregate capacity of the two networks would actually increase.

G.hn over phonelines can also coexist with HomePNA using the same notching technique as with baseband coax. However, note regional government regulation may restrict operational frequencies over phonelines.

### 4.2 Dual mode network nodes

An approach pioneered by a HomeGrid member is the addition of HomePNA functionality into their G.hn chipsets. Dual mode silicon, and resulting systems, is one way of providing Service Providers with

an easy migration from HomePNA to G.hn. New devices added to existing HomePNA networks could be dual-mode devices, and initially operate in HomePNA mode, but reconfigure to G.hn mode when all HomePNA-only devices in the network had been replaced. The same dual mode devices could be used for new installs, creating all-G.hn networks, operating in G.hn mode from Day 1. This would reduce a Service Provider's (and Retailer's) stock holding requirement and remove the logistical challenge of knowing which type of device to supply or sell to a given customer.

Two basic product types are part of a dual mode concept. The first type consists of multi-port products, such as gateways, which are capable of operating in G.hn and HomePNA modes simultaneously. The second product type is capable of operating in either G.hn or HomePNA modes, but not both simultaneously, for example Set Top Boxes (STBs). In the latter case, an automatic mode selection/detection capability would ease installation.

A given network could have both types of products; for example a gateway with multiple, simultaneous-use G.hn and HPNA ports, connected to network endpoints, (e.g. STBs) that had the either/or capability. Assume that the G.hn network is over powerline and HomePNA is over coax. A dual mode STB automatically detects which medium and mode is available (G.hn powerline or HomePNA coax) and operates accordingly. Since STBs are always connected to a power socket, G.hn powerline mode will be the "always available" option. If coax is also connected to the STB and a HomePNA network detected, then it may be the selected route for data.

This approach simplifies relocating an STB or adding a new one, as it does not require a technician or a new cable. If no coax outlet exists at the new location, then the G.hn PLC link is used, there is no need to run a new coax cable and selection of the media type can be automatic. The user selects the location most convenient for them, and is no longer limited by the availability of coax cable connection points.

The Service Provider can ship a dual-mode STB to a customer who wants to add a TV, without needing to know what network technology is being used. The same STB can auto-configure itself to the network technology. Service Providers can therefore reduce inventory and the number of truck rolls.

However, the real value of dual mode is in easing migration. Service Providers can start their HomePNA to G.hn migration by procuring and supplying dual-mode devices for all new installs, additions and replacements. Once dual-mode devices are deployed, the Service Provider could implement a program of replacing the existing HomePNA gateways with dual mode gateways configured to operate as HomePNA and G.hn (either as overlay or adjunct network) or use external G.hn to Ethernet adapters connected to existing gateways. This can be done for newly supplied gateways, and an SP would take a commercial view as to when and whether to replace the installed base. Gateways can be shipped to customers with simple swap-out instructions. There is no need for installers as the infrastructure exists and the service is already provisioned. In the same manner, gradual replacement of STBs can occur with new dual mode STBs. When appropriate for the SP, or when a customer wants to upgrade their service, a given home network can be remotely configured (e.g., via TR-069) to operate in G.hn-only mode. STBs could automatically reconfigure to the relevant mode of operation.

Section 5 uses an example network modification to show how G.hn can be used to extend a HomePNA deployment adding value, performance and longevity to the embedded base. Using dual-mode devices, either for simultaneous or non-concurrent mode operation, smooths the transition from HomePNA to G.hn.

### 4.3 Eliminating Network Islands with 1905.1

As discussed earlier, G.hn is able to manage traffic across G.hn domains over different wire types in the home. This eliminates the network islands issue for wired networks. However, wireless is also present in today's homes and that should not be another island network. The industry recognized this issue and IEEE 1905.1, a standard for managing traffic over disparate networks in an intelligent fashion, was developed. The HomePNA Alliance and HomeGrid Forum played leading roles in the development of the standard. With an in-depth understanding of the IEEE 1905.1 standard, HGF formed a task force in late 2012 to create a 1905.1 Annex for G.hn. With the merger of HomePNA and HGF in place, this HGF work is being extended to include HomePNA technology.

What this means to those that deploy HomePNA and G.hn in mixed environments is that the two networks can coordinate traffic flows, as well as over any other network technology, provided the network transceivers have a 1905.1 Abstraction Layer.

With 1905.1, the ability of future HomePNA networks to closely link to G.hn ones, providing a seamless network of networks for any traffic, offers an advantage for Service Providers as they look to ensure the best quality of experience for their end users while minimizing capital expenditures and service calls.

## 5 Example Deployment and Migration Scenarios

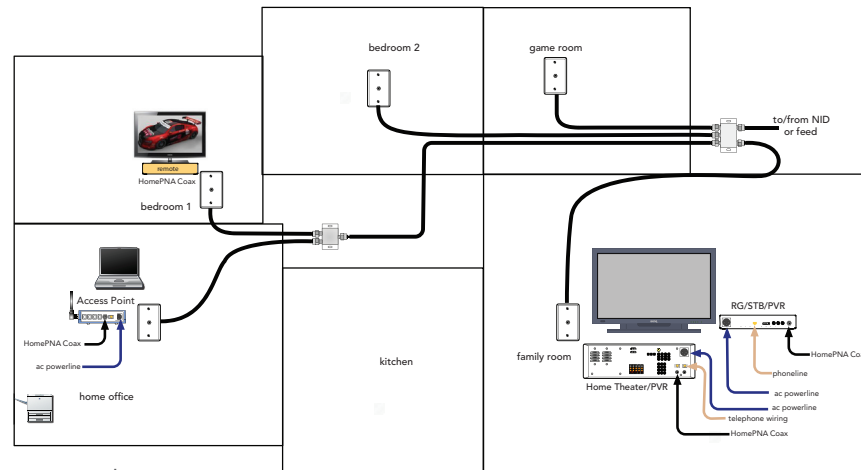
Many Service Providers have HomePNA deployed; successfully delivering IPTV streams around the home. This section discusses various ways of adding G.hn to an existing HomePNA deployment to boost overall performance.

In the home depicted in the following Figures, there is a family room with a TV, another TV in the master bedroom, and the need to provide an office with both wired and wireless connectivity.

The Service Provider here has deployed HomePNA over coax in the home gateway, there is an access point with embedded HomePNA, and the PVR/STB is also equipped with HomePNA. The following figure shows a coax-based HomePNA deployment, but is also broadly applicable to the phoneline case.

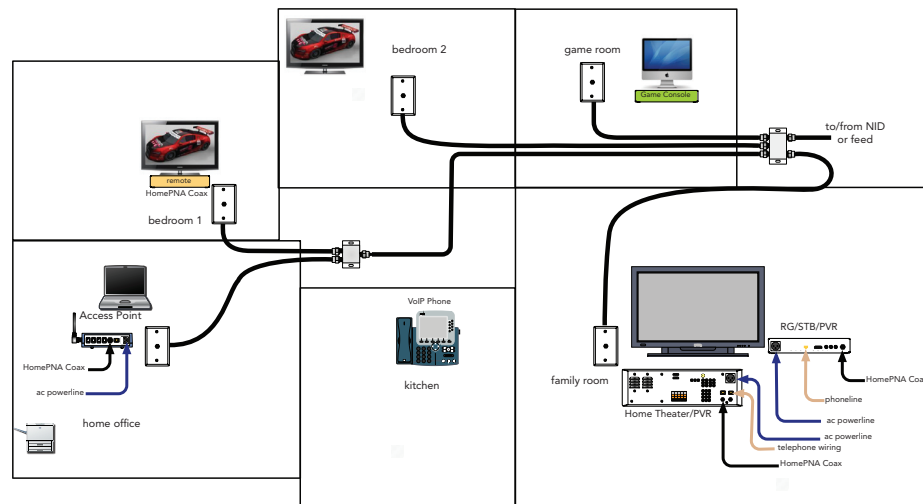
As the customer takes ever-higher rate access services, and adds more and more networked devices such as a printer, a TV in the second bedroom, and a game console, the aggregate bitrate may get to the point where there is a case for starting to migrate to G.hn. There may or may not be coax sockets near the new devices.

The Service Provider, or customer, could simply add new HomePNA nodes at all these new locations; however, this may soon run into throughput limitations, and cause services quality deterioration. Further, when new nodes are added, it makes sense to include some "future-proofing" to avoid having to upgrade the network yet again in the near future. This is where the use of G.hn for the upgrade can add substantial value. Several upgrade choices are possible.



» Figure 1: HomePNA Deployment

For example if the main problem is lack of bandwidth, a Service Provider can add a G.hn overlay to the coax network, either by baseband sharing, or operating at G.hn in the RF frequencies. This will increase the aggregate throughput on the coax without needing to replace any of the existing HomePNA network nodes. Alternatively, if lack of coverage is the issue, i.e. there are no coax outlets at some of the new locations; the Service Provider could add a G.hn PLC network. This will also increase the aggregate capacity, of course.

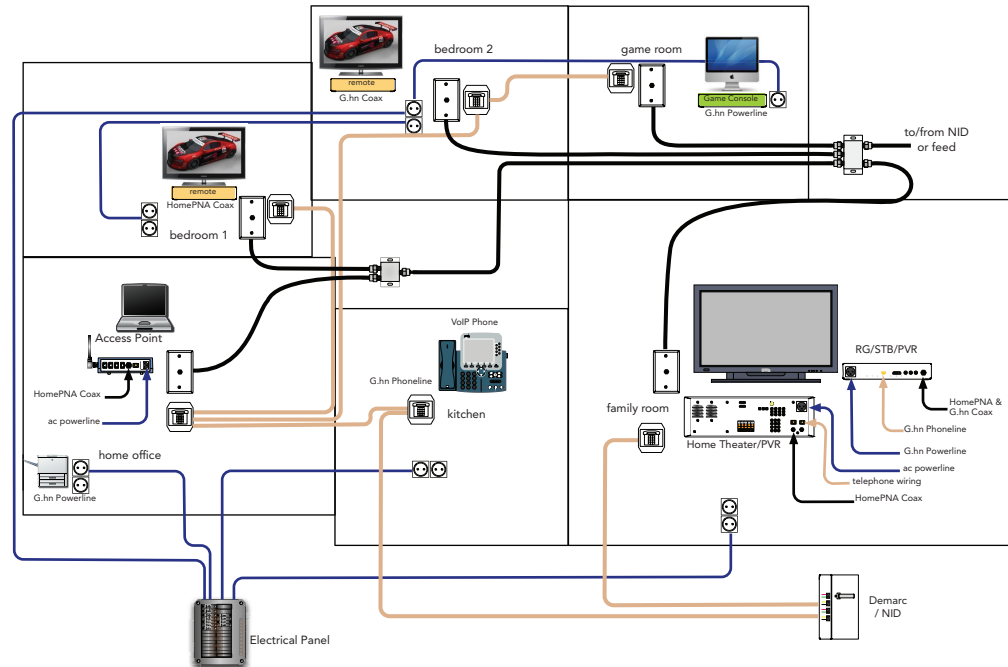


» Figure 2: New devices added in the home

If there is no immediate concern over bandwidth, the Service Provider could change to dual-mode devices deployed in HomePNA mode to work with the existing network, thus setting the stage for the transition to G.hn.

In more detail, suppose the games room console is not close to a coax outlet, but it does require AC power, and so must be close to an electrical socket; it is therefore amenable to G.hn over powerline. Bedroom 2 has a new HD IPTV and there is a coax socket. However, the children want picture-in-picture, and trick modes, which places significant additional bandwidth demands on the network. The aggregate capacity over coax will increase by either using G.hn in RF mode or 100 MHz baseband mode. The new VoIP phone in the kitchen could be connected via G.hn over either powerline, or phoneline. The networked printer in the office is a natural candidate for G.hn over powerline.

Typically, adding these new devices to the network will be done using external adapters connected to the new systems by means of an Ethernet 'patch' cable. The gateway may need to be upgraded, depending on the network architecture and devices used; however, in many cases an external adapter could again be used to connect the gateway to the G.hn networks. The addition of these simple adapter bridges is by straightforward customer self-install. Even when a new gateway, with embedded G.hn ports and HomePNA coax or phoneline ports is needed, it is an easy user install.



» **Figure 3:** A G.hn overlay coax network, as well as powerline and phoneline networks

As this example has shown, Service Providers can gain substantially from adding G.hn to their existing HomePNA installations, as either an overlay or adjunct network. There are various options, which can be combined to meet the needs of individual Service Providers and their customers. This makes for a cost-optimized and flexible migration and lays the foundation for a smooth transition to G.hn.

## 6 Conclusion

The merger has taken two organizations, with complementary views of the market, the same core values, and technologies that have much in common, and created a single, more focused and powerful organization.

This new organization is committed to developing a robust support and transition plan for existing HomePNA users, while at the same time providing a longer-term home network vision. This will lead the global market towards a high-performance, wired-wireless hybrid network architecture, with G.hn as the wireline backbone technology, which should last for many years.



## about **HomeGrid Forum**

HomeGrid Forum (HGF) merged with the HomePNA Alliance in May 2013, forming an industry alliance of over 70 members including some of the world's largest Service Providers, system manufacturers, and silicon companies. HGF promotes development and deployment of a single, unified, multi-sourced home networking technology, G.hn, over coax, phone wires, powerline, and plastic optic fiber while continuing to support the existing base of HomePNA deployments. HGF provides silicon and system certification through its compliance and interoperability testing programs to ensure that retail customers and service providers can have confidence in all G.hn and HomePNA products.

HGF members collectively provide an eco-system covering all aspects of the technology from Retailers to Service Providers, utilities to Smart Grid think tanks, system developers to test houses and silicon companies. Our goals include promoting the benefits of G.hn; enhancing G.hn technology to meet evolving industry requirements; ensuring interoperability, performance based on our certification program; and supporting the needs of Service Providers deploying G.hn and HomePNA technologies.

For more information on HomeGrid Forum, please visit our website at

<http://www.homegridforum.org>



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