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Measurement Analysis
Testing Powerline Products

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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.

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During the last few months, we have seen powerline products being tested in several different scenarios including lab trials, house trials and field deployments. In principle this provides the powerline community with a huge amount of data to facilitate an educated choice when selecting a product. However, the measurements provided are raw data that need to be interpreted, which is particularly difficult for powerline systems. This White Paper provides guidance as to how this can be done.

The first step is to decide the role of the powerline nodes in the overall home network.

Powerline technology is used for three main purposes:

- **Single room distribution**: Connection of powerline-capable equipment within the same room. For instance, a router to a nearby Set Top Box (STB) or to a desktop PC.
- **Multi-room distribution**: Connection of multiple STBs (one in each room) to a central GW that provides the access to the external world.
- **Backbone for Wi-Fi extender**: Provide a robust backbone for the extension of the Wi-Fi signals through a home.

There are three considerations related to assessing powerline performance for the above:

- **Distance/attenuation**: In powerline systems there is no simple “cable length” concept since the cabling of an apartment normally has a rather complex, unknown topology. So the behavior of the system cannot be predicted from the physical (or cable) distance between the transmitter and receiver. Instead, we use the concept of “logical distance”, which is equivalent to the attenuation between the transmitter and the receiver. This takes into account the complex topology. This logical distance is calculated by the nodes and used as a reference in the performance tests.
- **Required throughput**: This is the minimum throughput required for a given service or mix of services.
- **Worst-case principle**: In order to be able to provide the required service wherever the end-user decides to locate the powerline equipment, the analysis of the data always has to be done for the worst-case scenario.

The difficulty of testing powerline systems is that these three aspects are tightly linked and need to be taken into account collectively. For example, if the requirement was to distribute a 4 HD channel service around an apartment, then a product that could support 8 HD streams but with low coverage would not be suitable, nor one that provided high coverage for just 2 HD streams.

Analyzing performance in the context of three deployment models above, and allowing for the worst-case scenario, leads to the following:

In a single-room application we typically see low logical distances between nodes, and the aggregate throughput is not that high since the number of nodes within a room (STBs, for instance) is limited. Therefore, in this scenario the key metric is maximum throughput, rather than coverage.

In a multi-room application we observe medium/high logical distances. The main consideration is therefore the maximum "logical distance" a node can reach while providing traffic above a given threshold.

In a backbone application, by definition, the attenuation between nodes is also medium/high, The objective of this application is to increase the coverage of the network and so the powerline nodes will be well separated, but they do not need to provide the distribution within a room. As in the previous case, the main aspect we need to consider is the maximum "logical distance" a node can reach while supporting the aggregate backbone traffic.

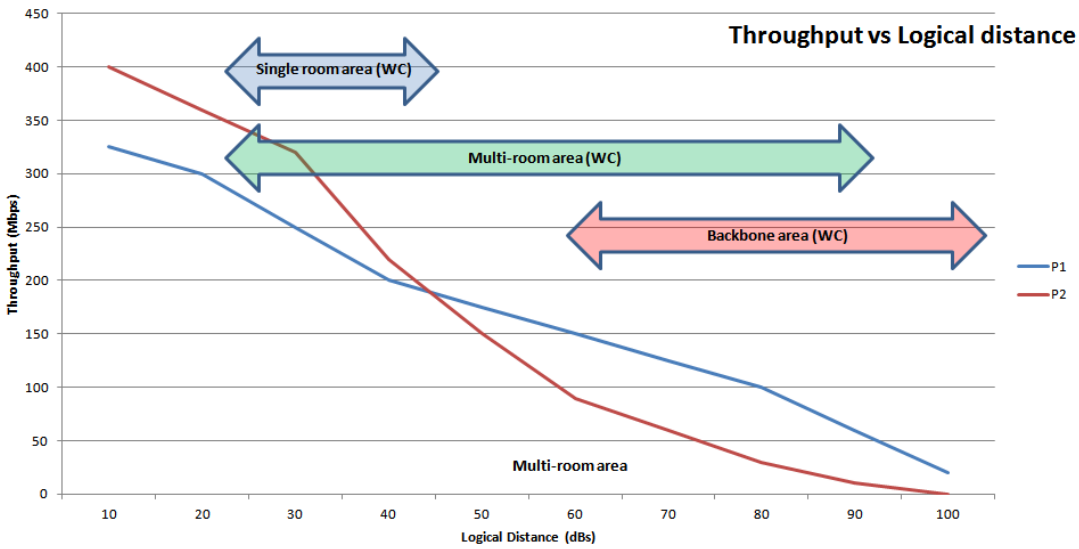
Summarizing these rules of thumb in a table:

Table 1: Selection criteria

Application	Selection criteria	Logical distance
Single-room	Maximum throughput	Low
Multi-room	Maximum logical distance achieved for a given threshold of traffic required by the service provider	Medium/High
Backbone	Maximum logical distance achieved for a given threshold of traffic and logical distance set by service provider	Medium/High

As an example, let's apply these three rules to compare two imaginary G.hn products (P1 and P2) in order to select a product for the different services:

Figure 1: Throughput vs. Logical distance (worst-case scenario)



We've shown the zones to consider for the different applications, also taking into account the worst-case scenario.

The following table suggests the product that should be selected, for each of the applications.

Table 2: Example of product selection

Service	Requirements	Selected product	Comments
Single-room	4 HD channels 4x25=100 Mbps	P2	In a single room, fewer channels are necessary. In the single room area, P2 is superior but both P1 and P2 fulfill the requirements.
Multi-room	8 HD channels 8x25=200 Mbps	P1	P2 achieves a logical distance of 70 dB for the required throughput in the required area while P1 achieves 80 dB.
Backbone	4 HD channels 4x25=100 Mbps. Minimum logical distance 60 dBs	P1	It is expected that some channels will not be conveyed through the extender. P1 achieves a logical distance of 80 dB while P2 does not provide the required throughput at the minimum logical distance.

In summary, when analyzing test results for a powerline technology, the appropriate selection rule for the intended deployment scenario should be used, and the worst-case situation should be considered.