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The Use of Ethernet-Over-Coax in HFC Networks

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Abstract

The growing use of IP technology to deliver audio, video and data to subscribers often faces a simple problem. The physical connection to the IP network is often not available at the site where the equipment associated with these new services is located. For example, a DSL modem is typically located at a telephone outlet that is not close to the TV, and a cable modem is connected to an RF wall outlet that is usually not close to the home office or computer.

The installation of Ethernet cables to overcome this problem isn't a solution with wide appeal to subscribers, the industry has come up with several technical solutions for this problem. The various technologies available today, found under the umbrella of Home Networking Equipment, offer solutions that use existing in-building wiring or available wireless technologies. The wire-based solutions include systems known as Powerline, MoCA (Multimedia over Cable Alliance) and HPNA (Home Phone Networking Alliance).

While these technologies are originally designed for IP distribution in apartments or single-family houses, one of them has found applications within HFC networks. That solution, Ethernet-over-Coax, is described in this white paper.

Ethernet-over-Coax Technology, a quick overview

The term Ethernet-over-Coax (EoC) is a generic term for Ethernet transport systems that use coaxial cables to transport the Ethernet signal between two or more sites. The first differentiator between available EoC systems is the method they use to transport data over the coaxial cable: either baseband or modulated RF.

Baseband systems can be called passive systems while systems using modulated RF are active systems due to the fact that they require an active device on either side of the network. But while a baseband system is typically easy to setup and use, it does have the disadvantage of requiring a point-to-point connection between two sites in order to achieve suitable data rates >10Mbps needed for today's applications running over IP networks. Active systems in turn allow connecting multiple Customer Premise Devices (CPE) to the same coaxial cable. The variety of available active systems can be divided into the two groups: proprietary and standards-based systems. MoCA (Multimedia over Cable Alliance) and HPNA (Home Phone Networking Alliance) represent standards-based systems.

The major difference between MoCA and HPNA is the frequency range each uses. While MoCA has been designed for local in-building distribution using the frequency range above 862 MHz, which limits its use in HFC plants, HPNA in its latest revision 3.1 uses the frequency range of 4 to 52 MHz and can therefore, due to the low loss of coaxial cable in that frequency range, bridge greater distances.

HPNA system overview

An HPNA system is comprised of a master unit (sometimes called a bridge device) that serves as gateway between the coaxial network and the main IP connection, and multiple CPE devices as end-points. In an HPNA 3.1 based system, the master unit can support and control up to 32 CPE devices, which can all be connected to one coaxial cable in any mix of tree and branch, and/or star architecture. Figure 1 shows a typical network layout in an MDU environment.

The frequency spectrum allocation of HPNA 3.1 is shown in figure 2. The four different operational modes shown occupy different frequency spectrums and allow the system to be optimally adapted to the coaxial distribution network it is connected to.

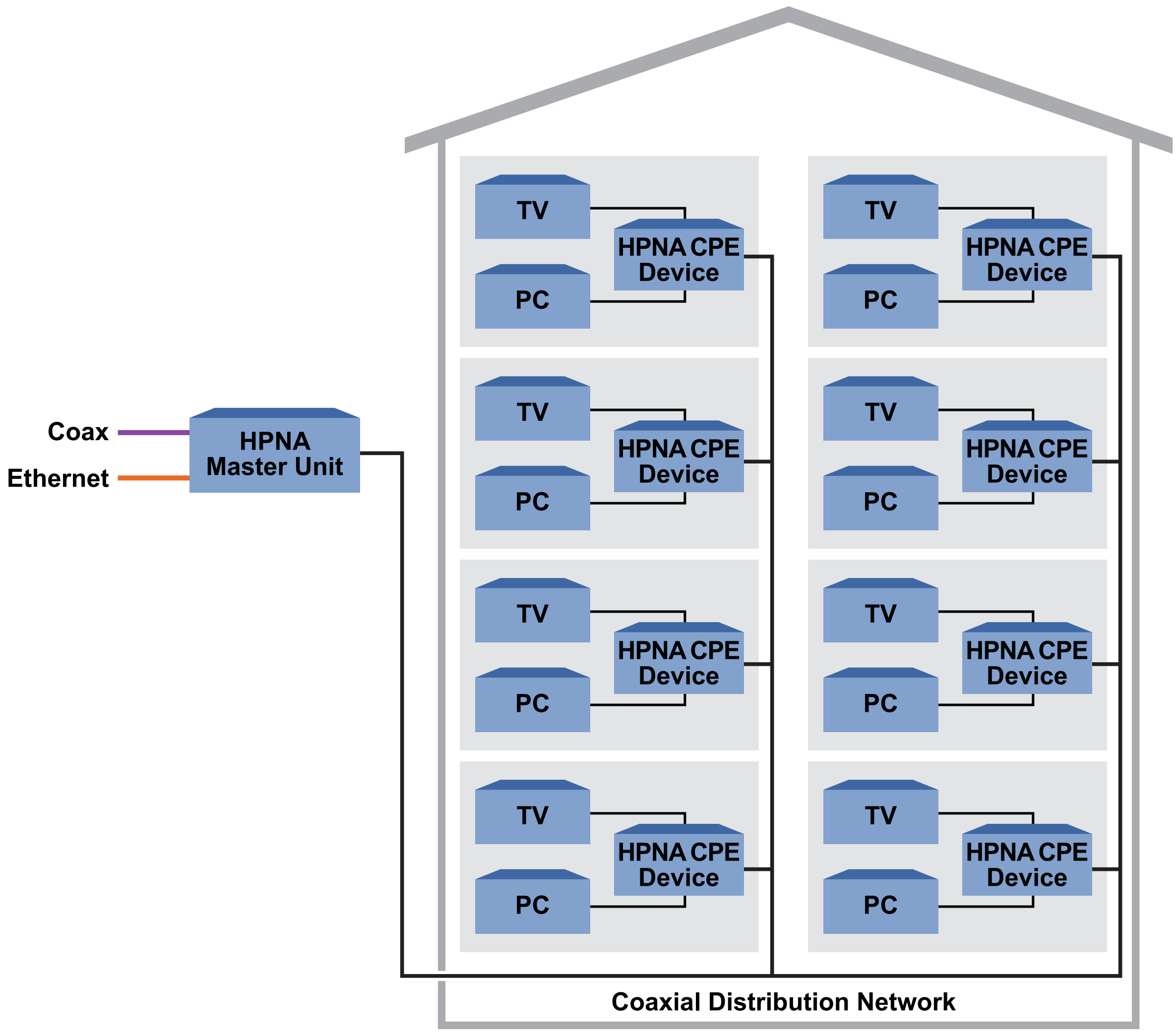

Figure 1: Typical HPNA distribution system

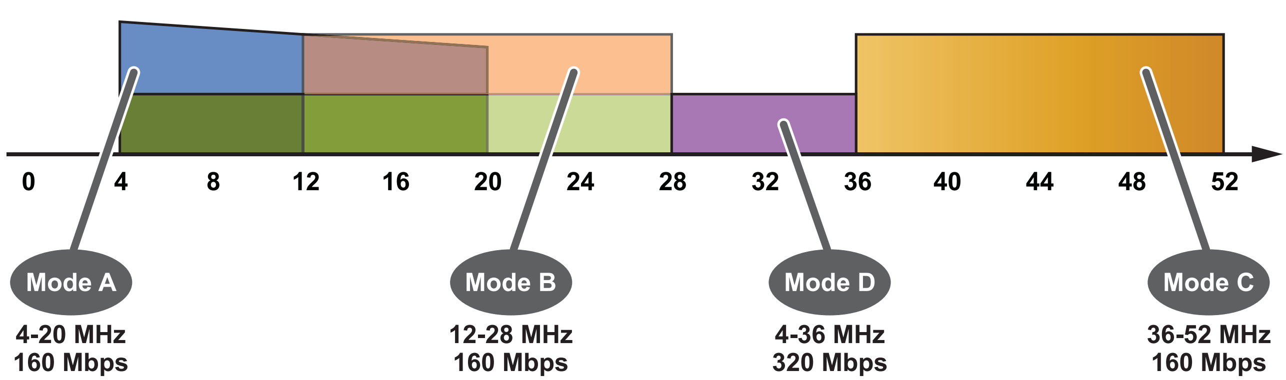

Figure 2: HPNA V3.1 frequency allocation

This frequency allocation allows raw data-rates of up to a maximum 320 Mbps, which is then dynamically shared between up to 62 CPE devices in half-duplex mode (i.e. the HPNA system uses the same frequency spectrum range to transmit to the CPE devices and to receive from the CPE devices, thus making it half-duplex). The modulation scheme used is Quadrature Amplitude Modulation (QAM) and FDQAM (Frequency Diverse QAM) with the master unit dynamically selecting the optimum modulation scheme depending on the current noise and ingress situation. In a clean environment, the system uses a single QAM channel of maximum 32 MHz operated at 32 Mbaud. If noise or ingress causes the bit error rate (BER) to go up, the system can change the symbol rate and modulation rate, going from a single 32 MHz carrier to a maximum of 16 times 2 MHz carriers, that can then operate at a 12dB lower signal-to-noise ratio (SNR).

The maximum data throughput of the system is guaranteed for a cable loss of up to 40dB between the HPNA master unit and any CPE device. As the HPNA system operates at low frequencies, up to max 52MHz, the 40 dB maximum loss translates into either substantial cable length (up to 600m for RG 59) or enables the use in a coax distribution system built of lower quality, high loss cable.

The control of up to 32 CPE devices connected to the same coaxial cable requires a well-defined MAC layer protocol to optimally manage the CPE devices while guaranteeing maximum bandwidth per CPE. In addition to CPE device management, the HPNA MAC layer supports all necessary features needed to successfully manage guaranteed and prioritized Quality of Service (QoS), thus enabling the use of HPNA in Voice over IP (VoIP) or equivalent multimedia applications that do require guaranteed transmission bandwidth. The flexibility in RF transmission together with the focus on QoS in the MAC layer makes HPNA a very robust system that can easily adapt itself to changes in the environment it's working in, thus helping to achieve the QoS for multimedia applications.

Using HPNA based EoC in HFC networks

Modern HFC networks that use DOCSIS to offer High Speed Data (HSD) services MSOs may cause someone to question the need for EoC systems, as each customer can have its own cable modem. But the coaxial in-building installations in large MDU buildings, which can be found in most big cities all across Europe, are often the source for severe ingress. If multiple large Multiple Dwelling Unit (MDU) buildings are connected to one optical node, which is often the case in suburbs with MDU structure, the ingress coming from these in-building networks accumulate and can force a DOCSIS system to switch back to low upstream bandwidth or even fail to operate.

In these critical environments EoC offers the ability to terminate the DOCSIS system at the access point to the in-building coax system and then use the ruggedness of HPNA in the existing RF distribution to overcome the many issues with existing old coaxial in-building distribution systems while keeping the data throughput at maximum level. The basic network layout will be to use a cable modem in the basement and then use an HPNA-based EoC to distribute IP connectivity throughout the building via the coaxial distribution system, which is at the same time used for distribution of TV signals. As the throughput of the cable modem is shared among the number of subscribers connected to the HPNA EoC system, most preferably the cable modem should be a wideband or DOCSIS 3.0 type to maximize the available bandwidth in downstream and upstream by the use of channel bonding technology. A typical network layout of such a system is shown in figure 3.

Another scenario for the use of EoC is for network demarcation. Residential construction unions are often known for wanting to own the CATV and IP data distribution service as they want to offer these services as part of the rental contract. Here the cable modem installation in the basement of the MDU building can act as a demarcation point between CATV MSO and the owner of the MDU building. At this point, the MSO hands over the CATV and Ethernet signal to the building owner. The residential construction unions can then use an HPNA-EoC system to distribute the CATV and IP service via the existing coaxial distribution system while having full control over the connected subscribers.

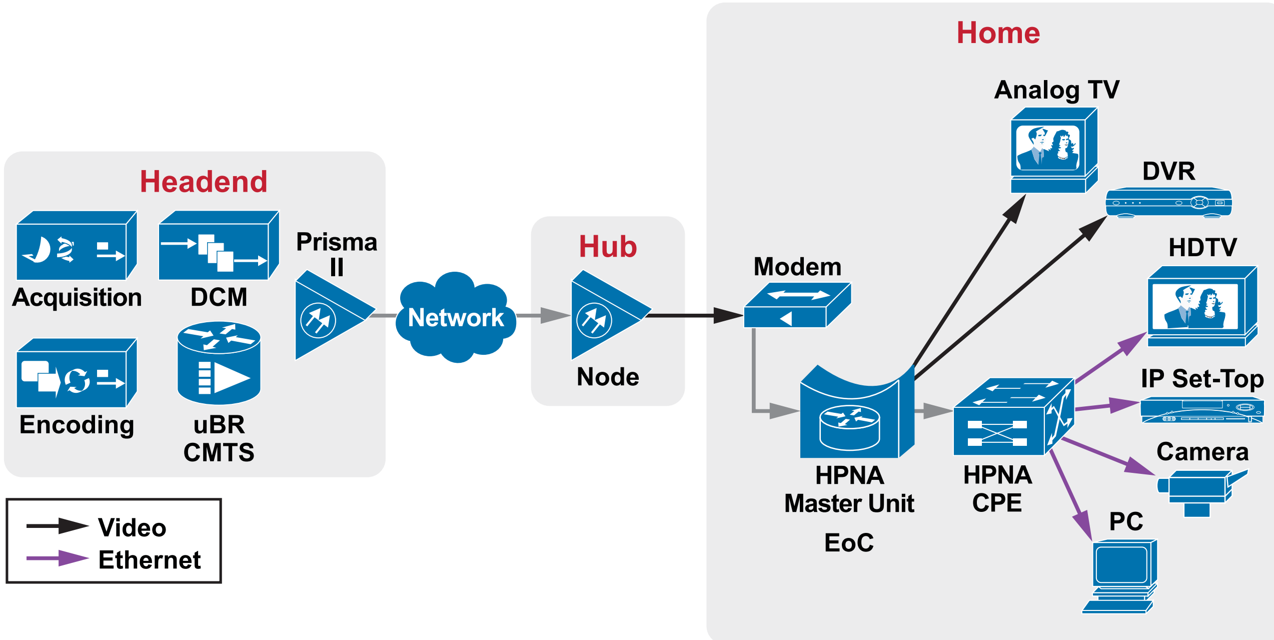

Figure 3: The use of EoC in an HFC network to clean up the return path

Both applications require sharing the available bandwidth successfully among multiple subscribers. With the introduction of HPNA V3.0, intensive QoS management has been introduced to the system to enable its use for multimedia applications. The QoS measures, based on ITU recommendations G989.1/.2, allow the operator to set guaranteed and prioritized bandwidth on a per subscriber level to avoid one customer monopolizing use of the system's full bandwidth, which would not leave enough bandwidth for other subscribers to conduct even IP based phone calls.

Summary

An HPNA-based Ethernet-over-Coax system can help MSOs improve the return path signal quality in troublesome areas, such as large MDU buildings, by simply separating the CATV and the coaxial in-building distribution network in the return path frequency range, thus blocking the noise and ingress from the coaxial in-building network to enter the CATV plant. The HPNA EoC system offers all the QoS measures needed by MSOs to offer their subscribers the same interactive service quality they would have with a direct connection to a cable modem.

Scientific Atlanta's HPNA-based EoC system is delivered by the Master Unit E200, which acts as the bridge to combine the CATV and Ethernet signal for delivery over the standard coaxial in-building distribution system. The Master Unit also offers all the functions expected from a modern router/switch for data networks. The E300-DHP548 is the CPE device that separates the Ethernet signal from the CATV signal at the subscriber's premises. It offers two Ethernet ports connected to a built in layer-2 switch and has one RF output port to connect to the TV set.

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