Integration Of Home Networking Technologies With The HFC Residential Gateway

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Abstract

This paper analyses the currently available and developing home networking technologies from a Hybrid Fiber-Coax (HFC) based services perspective. The following home networking technologies are assessed for suitability to support these services; Home Phoneline Networking Alliance (HPNA) 2.0, powerline networking, wireless networking and cluster networking. Each technology's basic characteristics, advantages and disadvantages are described. Finally, technology gaps for implementing a robust end-to-end service model are identified.

INTRODUCTION

Home Networking has become a hot topic over the past year and it is an issue that must be addressed by cable modem providers. One of the pressing issues is how to deploy Home Networks given the cost to provide the wiring infrastructure for traditional methods like running Ethernet over 10 base T. In this paper I will address some of the technologies that can be deployed to provide Home Networking capabilities without adding new wires in the home. I will discuss the popular technologies for wire line and wire less networking in the home both in terms of where they are and where they are headed. I will conclude with some brief comments about what capabilities these "no new wires" technologies need to provide to support the advanced applications that service providers may want to deploy. Applications like telephony and streaming media.

HOME NETWORKING DRIVERS

Before I dive into the technologies I will cover some background on what is driving the need for Home Networking. There are two near term and one general long-term driver. In the near term the need for Home Networking is being driven by the growth in the number of homes with multiple PCs and the number of homes with broadband access. Longer term the need for Home Networking will be driven by advanced services delivered over the broadband network.

Multiple PC Homes

The growth in the number of homes with multiple PCs is growing faster than the number of homes with any PC at all. The chart below from a Yankee group report supports this finding. In addition the data from the Yankee Group shows that 78% of the homes with multiple PCs have a printer. Once there are two PCs in a home with a printer there is a strong need for a home network unless all the devices are located in the same room.

Broadband Access

Broadband access is growing very rapidly and all the analysts' predictions are for continued rapid growth. Our data indicates that over half of the households with broadband access have multiple PCs. Once broadband hits the home there is a strong desire to share the bandwidth among all the PCs in the home.

Advanced Services

Over time, as broadband access becomes pervasive, new services that use the broadband access will appear. In addition more and more devices in the home will have Internet access capability and will want to share the broadband connection. The long-term outlook is for broad networking capability in the home with bandwidth and quality of service demands increasing.

No New Wires Technologies

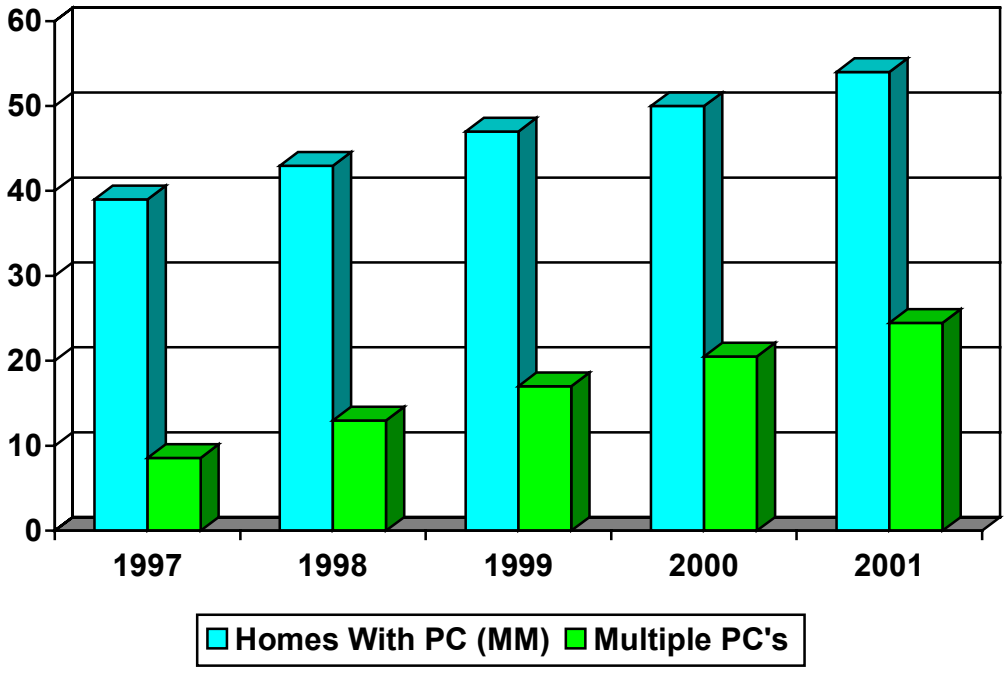
The rest of the paper will look at technologies that provide Home Networking capabilities without having to wire the home. This means either using the existing wiring infrastructure or use wireless techniques.

Existing wire

The two existing wiring infrastructures in nearly every home that has a PC are phone lines and power lines. Both are viable alternatives for Home Networking.

Phone Lines

An industry group to standardize the use of phone lines for Home Networking called HomePNA was formed almost two years ago and the second generation of products are now available. HomePNA is currently the defined standard for phone line Home Networking.



Power Line

An industry group to standardize the use of power lines for Home Networking called Home Plug was formed in early March this year. The intent of Home Plug is to create a single standard from the range of power line technologies evolving for Home Networking.

Wireless

In the wireless area there are two main technologies gaining acceptance for Home Networking. They are the IEEE 802.11 standard called 802.11b and the standard developed by the HomeRF group call SWAP. Both of these standards use the 2.4 GHz band. I do not include Bluetooth in this discussion because Bluetooth is not a networking technology

For each of these technologies I will discuss the current status and future trends.

HomePNA Today

As I mentioned above HomePNA is an industry organizational that has released a specification for Home Networking on phone lines. This technology coexists with POTS and ADSL by occupying a different frequency spectrum.

Version 2.0 of the specification was released by HomePNA late last year and many products that support HomePNA2 are on the market. The significant advance in HomePNA 2.0 is an increase in the data rate from 1mbps to 10 mbps.

There are however two other interesting changes in the 2.0 spec. The PHY layer is capable of supporting 32 mbps. While there are no publicly announced products that take advantage of this to go beyond 10 mbps, the technology will support it.

The 2.0 spec also adds a feature called Differential Fair Priority Queuing, also called DFPQ. DFPQ allows for upper layers and applications to signal the MAC layer to provide priority access to the media. This means that HPNA2.0 could be extended to support telephony and streaming applications.

HPNA Future Trends

The demand for higher speed continues to grow and will likely result in higher data rate standards from HomePNA. Even thought the current PHY spec supports 32 mbps it is quite possible that there are PHY extensions that could allow phone line networking to be extended even further.

To support telephony there will need to be agreement on the signaling protocol to allow telephony terminals from multiple vendors to interoperate with each other in the home and to gain access to the voice network which might be provided by another vendor. The point is that for voice interoperability it is required that higher layer protocols, beyond the MAC and PHY layers, are agreed to.

It should also be noted that while DFPQ looks very promising there have not yet been any telephony or streaming products developed using DFPQ. We need to see products using DFPQ successfully to fully determine its viability.

Power Line Today

An industry group called Home Plug has been recently formed to develop and endorse standards for using the power line infrastructure in the home for Home Networking applications. There have been a number of companies developing technologies for power line home networking but to this point none have

proven to be effective either because data rate is low or because error rates are high or both.

This technology continues to evolve however and shows promise for being able to achieve the data rates and Quality of Service required for Home Networking applications.

Power Line Future Trends

The notion of using the power lines in the home for Home Networking is compelling because power outlets tend to be ubiquitous in the home. In addition society is used to the idea of a power plug on a device and if networking could be achieved without another cable it would be easy to promulgate.

The current baseline for home networking is the ability to support 10 mbps with error rates in the neighborhood of 5% or below. Power line technologies need to be at this level of technology and competitively priced today to become accepted.

Over time the expectations of the capabilities of the Home Networking will increase and all technologies will be required to keep pace or fall by the way side.

Because of the ubiquity of power outlets in the home, power line networking will always be welcomed in the door if the technology can compete.

Wireless

Wireless LAN products are becoming very popular since some proprietary products hit consumer price levels last year. Recently products based on HomeRF and 802.11 standards have reached the market. Both HomeRF and 802.11 operate at 2.4 GHz and each has its own advantages and disadvantages.

Wireless is generally regarded as the first choice by consumers because of the mobility that is offered by the technology.

HomeRF Today

HomeRF operates at 1.6 mbps and products based on HomeRF have just recently been released. The current spec also provides for 4 voice channels and at least one company has stated an intention to develop voice products.

The obvious problem with HomeRF is the data rate. An FCC ruling to allow HomeRF is operate at 10mbps is expected to be approved by mid year to allow vendors to address this issue.

HomeRF Future Trends

HomeRF will need to get to higher data rates. The immediate opportunity is to take advantage of the FCC ruling and extend the 2.4 GHz technology to 10 mbps.

It may also be possible that HomeRF will pursue 5.5 GHz technology to obtain even greater bandwidth capability.

Because HomeRF has a TDM channel and an a greed to signaling protocol it is quite possible that voice products based on HomeRF will have an impact on the market.

802.11b Today

802.11b is also a 2.4 GHz standard that provides 11 mbps data rate. There are multiple vendors providing NICs and access points based on this standard. The current prices are slightly higher than HomeRF but many consumers are willing to pay extra for the increased data rate.

One problem frequently mentioned with 802.11b is that lack of QoS capability in such products appear on the market.

On the cost front the conventional wisdom is that volume will drive down cost to nearly the same levels as HomeRF. Only time will tell.

5 GHz

One observation is that there are two overlapping wireless alternatives and it is not clear that one is going to win out over the other.

Another observation is that the demand for greater bandwidth will continue to rise and that HomeRF and 802.11b will not be able to fulfill that demand.

A growing likelihood is that the 5 GHz band will become attractive for technology suppliers that want to provide greater throughput for applications like streaming video. This creates an opportunity for the industry to the MAC layer to add support for telephony applications. Some also feel that the security provided by 802.11b is not very strong.

802.11 Future Trends

Extensions to the MAC layer to provide QoS support and to improved security have been proposed. A Task Group called 802.11e has been assigned to evaluate these proposals against a set of requirements that were developed last year. The goal is to have a draft proposal for the 802.11 committee by November this year.

The QoS extensions will provide support for applications that require bounded latency, however to support telephony applications a signaling protocol will also have to be standardized. Currently there is no project within 802.11 to create such a standard. It is however possible that a defacto standard could be created by one of more companies that are able to develop and deploy telephony products based on 802.11. Either way it is very likely to be well into 2001 before adopt a single standard.

There are currently three standards that I know of in this range, HyperLan1, HyperLan2 and 802.11a. HyperLan2 and 802.11a have very similar PHY layer specifications and HyperLan1 is perceived to be a lower cost solution. This unfortunately sounds familiar. Currently there are no 5 GHz products widely deployed for Home Networking applications so there is still a chance for a unified standard for Home Networking in this band.

Summary

While the wireless technologies are attractive and are frequently the consumers' first choice the additional cost will very likely mean that a wire line alternative will always exist. Also working against wireless is that it doesn't work sometimes because of RF dead spots in the home or because of interference.

The current technology of choice for wire line is HomePNA that as mentioned earlier is a technology that operates using the telephone wiring in the home. At the same time consumers would prefer a power line solution because of the ubiquity of power connections in the home. It is also perceived to be easier to use because there would not be the need for an additional network cable.

The power line technologies still have a long way to go however and as long as HomePNA has an advantage in data rate and QoS it is likely to remain the technology of choice for wire line Home Networking.

At the same time wireless technologies will evolve and will always be more attractive to consumers because of the mobility provided. This mobility however brings with it a greater need for security. The wireless standards groups will need to develop standards that provide effective encryption and authentication.

The encryption available today is considered weak and authentication for 802.11b as a standard does not exist yet. Authentication currently requires a single vendor solution but the whole point of standards is to proliferate solutions from multiple vendors. As I mentioned there are plans to deal with these issues.

The two applications that require more capability from the MAC and PHY layers are telephony and streaming.

HomePNA has developed DFPQ and HomeRF has developed voice support using TDMA channels with DECT for signaling. At this point only HomeRF is prepared to support telephony and it looks like some products will be available late this year. For HomePNA to support voice the vendor community will need to agree to a common signaling protocol. Power Line and 802.11a are further in developing QoS standards.

To support streaming media the MAC layer needs to be able to provide a bounded latency and either maintain a very low error rate << 5% or employ a mechanism for retransmission or error correction (without contributing materially to latency).

HomePNA has an advantage here with DFPQ and because the error rate over phone lines in a vast majority of cases will be low enough so that lost frames will not be noticeable.

HomeRF and 802.11b need to develop extensions to the MAC layer to support streaming.

The other summary point is that demand for greater bandwidth will continue. HomePNA might have some capabilities to substantially increase the data rate on phone lines but for wireless it will mean moving to the 5 GHz spectrum.

End to End Management: The Next Frontier

Once Home Networking technologies are develop to support advanced applications like telephony and streaming media that require QoS from the MAC layer the need for the service provider to manage this QoS will appear. Service providers will have a need to manage the network that is delivering services to end users to maintain and ensure customer satisfaction with the service. Home Networking technologies will need to provide the following to be effectively managed:

1. An open and well-defined interface for configuration and status monitoring.
2. Protocols and open interfaces to request QoS and to resolve conflicts when over subscribed
3. Protocols and open interfaces to support event reporting and fault isolation.

These capabilities along with a Management System solution will allow delivery and management of advanced services to the home over a packet based network without deploying new wires in the home.

Glossary

ADSL – Asymmetric Digital Subscriber Loop

MAC Layer – Media Access Control Layer.

PHY Layer – Physical Layer

POTS – Plain Old telephone Service

QoS – Quality of Service.