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Multi-Service Delivery Framework for Home Networks

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Document History

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1 SCOPE AND PURPOSE

1.1 Introduction

The growth and expansion of high-speed Internet access is undeniable. As more and more consumers consider their high-speed Internet access options, network providers, equipment vendors, and other industry participants want to ensure that the benefits of broadband services are known to consumers, and that customers can easily consume their services where and when they want.

Two characteristics of broadband service technologies that make them an integral part of the home network are: (1) the ability to support multiple logical data connections on the same physical access technology; and (2) the ability to tailor those connections with different qualities of transmission characteristics (i.e., quality of service [QoS]).

Home networking is a phenomenon that has risen in popularity primarily for two reasons: (1) the increasing availability of high-speed Internet access, and (2) the growth in households with multiple PC's. These two drivers combine to create a desire by customers to get the most value from their high speed Internet subscription by connecting multiple devices (usually PC's) to it. Service providers that promote home networking options with their broadband access services will be sought after by customers for information and assistance with setting up and managing their own home networks.

This home networking architecture is proposed in order to facilitate a common understanding of the home environment into which broadband services developed to DSL Forum TR's will be delivered.

1.2 Purpose

The purpose of this working text is to define requirements and capabilities that a home network should provide to take advantage of the full capabilities of multi-service, broadband access services. It also presents a functional home networking architecture that permits multiple residents within the home to use multiple applications and devices with differing connectivity requirements (QoS) and at the same time minimizing poor application performance that could result from conflicting or competing application demands.

This document intends to:

1. Identify some of the applications that the home network will be expected to support in the coming few years.
2. List the functionality that a home network must deliver to meet the application requirements and,
3. Present a reference architecture for a home network that will deliver the above functionality.

The home networking architecture will be defined using functional terms rather than physical devices. By doing so, customers and CPE vendors should be able to create home networks and the related CPE in a way that meets the identified needs and also assures that the resulting home network and equipment will inter-work effectively with the services and applications delivered by the provider broadband (BB) networks.

1.3 Scope

This document presents a reference architecture focused on the home network as it might exist in the residential mass market. It strives to address most aspects of home information technology and applications, with specific attention focused on those aspects that could facilitate the delivery of network-based services and applications. Intra-home applications (i.e., those with no external connectivity needs) are acknowledged, but are generally not explored in-depth.

The potential needs of typical business tele-workers operating at home also are within the scope of the architecture discussion.

The following diagram illustrates the potential scope of this architecture:

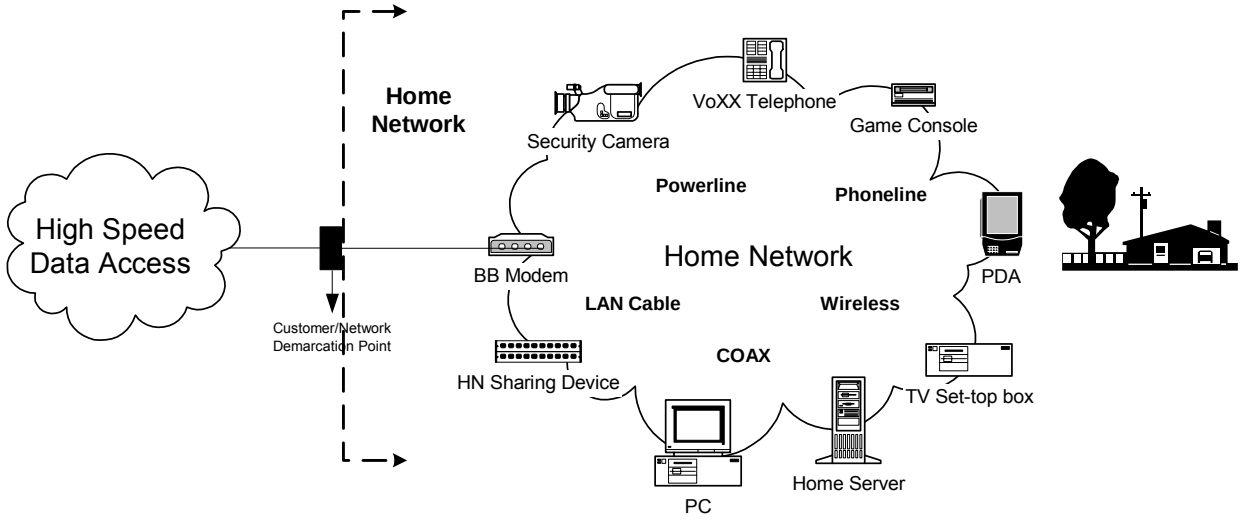

Figure 1 - Home Networking Architecture Scope

Note that while small business networks share many of the attributes of the home network, the architecture discussed in this document might not address all aspects of these small business networks.

1.4 Relation to Other Standards and Forums

Significant work has been done in various standards bodies and industry forums that relates to home networking. One issue with some of this work is that the home network has not been considered as a discrete subject, but rather as part of some other subject. This has led to a fractured view of the home network with some aspects of home networking addressed in one standard and other aspects addressed in another standard, sometimes with conflicting requirements or views.

This document is provided as a complement to other standards and industry efforts that include aspects of home networking. It is intended to provide a high level, integrated view of the home network and identify where the other standards (or portions of standards) apply specifically to the home network.

1.5 Requirements

In this document, several words are used to signify the requirements of the specification. These words are often capitalized and the requirement is preceded by an arrow "→".

MUST This word, or the adjective "REQUIRED", means that the definition is an absolute requirement of the architecture.

MUST NOT This phrase means that the definition is an absolute prohibition of the architecture.

SHOULD This word, or the adjective "RECOMMENDED", means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications must be understood and carefully weighted before choosing a different course.

SHOULD NOT This phrase, means that the item should generally be avoided unless valid reasons in particular circumstances warrant including it.

MAY This word, or the adjective "OPTIONAL", means that this item is one of an allowed set of alternatives. An implementation that does not include this option MUST be prepared to inter-operate with another implementation that does include the option.

1.6 Home Networking Architecture Goals

The following is a list of the goals to be achieved with this home networking architecture.

- Ensure that the home network and its functionality are agnostic to the access technology used to deliver the broadband services and QoS. This permits a wide array of access technologies (e.g., ADSL, ADSL2plus, VDSL., PON) to be used to deliver broadband services to the home and minimizes the impact of changes in the access technology on existing home networking applications.
- Assure interoperability and compatibility with network based services.
- Ensure that the home network and applications take advantage of the benefits delivered by the DSL access. In fact, the home network architecture should be an enabler to delivering multiple applications, both with and without QoS.
- Minimize CPE complexity without sacrificing QoS functionality or flexibility.
- Provide flexibility in the bundling of functions to enable equipment vendors and service providers to provide customers with enticing home network enabled applications tailored to their needs.
- Provide a home network Management capability that is flexible enough to provide a "Plug it in and it works" experience for those customers that choose to have a service provider manage their home network as well as a shared management role between the service provider and the technically savvy customers that wish to take an active role in their home network management.

1.7 Assumptions

- The WAN network services delivered to the home will predominantly be IP and Ethernet based.
- A single broadband data access technology will be used with a particular home network. i.e. one ADSL line, one VDSL line, etc. (This does not preclude the existence of other access technologies into the home [eg. CATV over COAX]).
- The home network will initially be PC centric until wide spread networking capability is built into Consumer Electronic (CE) devices.

2 APPLICATIONS AND SERVICES

This section provides a brief overview of some of the applications that the reference architecture discussed in this document should support.

The following list is not exhaustive, but covers the three primary service areas associated with "Triple Play" of voice, video, and data services.

- Best effort Internet access (Simple Web Surfing)
- Derived voice lines (VoIP based)
- Near Video on Demand - nVoD (store and forward)
- Video on Demand - VoD (streaming video)
- Audio, image and video distribution
- Bandwidth on Demand ("Turbo Button")
- Multiplayer gaming using either PC's or console devices
- Home automation (Telemetry and control)
- Remote Education

2.1 Voice

In addition to the underlying POTS voice services delivered by some DSL technologies, the home network will be required to support additional voice lines derived from the high speed data capabilities of the DSL technologies.

These derived voice services might be offered with few, if any, guarantees (Teen chat over Internet) or with service levels similar to the conventional POTS services. In the case of the latter, the home network will be expected to support some sort of QoS.

2.2 Video

2.2.1 Digital Broadcast Video

Broadcast TV has historically been delivered to a large number of consumers using analog based radio frequency (RF) transmission systems and cable television (CATV) technology. It normally involves re-transmission of video content produced by large television networks as well as independent stations.

Digital Broadcast Video (DBV) replaces the analog CATV technology with digital technology to enable the distribution of broadcast television. In simple terms, the video content is converted to digital format for transmission to the consumer and converted back to analog format in the home for reception on a standard television set. At a minimum, DBV must deliver a customer experience as good as or better than that offered by analog CATV.

There are a number of common ways to deliver the DBV to the consumer. They include modified CATV technology to support digital video, Direct to Home (DTH) satellite transmission and the more recent use of Very high speed DSL technology (e.g., VDSL). Other types of DSL show promise as well.

2.2.2 Non-traditional Video

2.2.2.1 Internet Video

Internet video content commonly found on today's Internet. It is usually delivered in a best effort fashion to a PC running a software player. This is accomplished by streaming the video and other content, whereby the end user can begin to view the content, while it is being downloaded into the computer or other device. The streaming can be delivered via unicast or multicast methods. With unicast, a point to point connection for each receiving device is created. With multicast, a single source stream is replicated by the network to be delivered for each receiving device, reducing the total bandwidth of all sessions.

Examples of typical Internet video content currently include movie trailers, specialty programming, and web cams.

2.2.2.2 Video on Demand (VoD)

VoD provides users with the ability to select video content (usually a movie from a library) and view it at their convenience. It is similar to a video tape being played in a VCR except that the content is delivered via a video distribution technology, instead of from a VCR.

VoD service can be delivered in two primary ways. One is to use IP streaming to deliver the video content in real time to the consuming terminal. Using this type of approach usually requires a better than best effort (BE) QoS from both the WAN and the home network to maintain an acceptable picture quality but it does not require an intermediate staging point.

The second way to deliver video on demand is to use a "download, store, present" model. This involves the best effort download of the video content to a storage device connected within the home network. Once downloaded, the content can be delivered to the consuming terminal. Having the content stored locally significantly reduces the need for the WAN network to support QoS. The need for the home network to support a better relative QoS for the video content depends on whether the content is stored on the same device as is used to deliver it (i.e., a simple video set top box [STB] or a STB equipped with Personal Video Recorder [PVR] capabilities.).

VoD can also be scheduled in the form of live broadcast. Although not a focus of this document, multicast can be accomplished at the ATM layer as well.

2.2.2.3 Video Conferencing

Video conferencing or video telephony permits users to establish point to point connections between their PC's and allow them to see and hear each other as well as share PC data/applications.

R# 1 Home networks **SHOULD** support video conferencing applications.

It is recognized that video conferencing applications normally require symmetrical bandwidth so the home network should provide support for video conferencing applications to the extent permitted by the upstream speed of the access service. This includes supporting any QoS needs of the video conferencing application.

2.2.2.4 Remote Education

Remote education combines both video conferencing and the 2-way interactive data capabilities of the broadband network to create a virtual classroom where students participate remotely with an instructor in a way that mimics a regular class.

Remote education also encompasses the remote access of computer based, multi-media training material.

R# 2 Home networks **SHOULD** support these types of remote education.

2.2.3 Digital Video & the DSL Based Home Network

2.2.3.1 The Analog Split-off

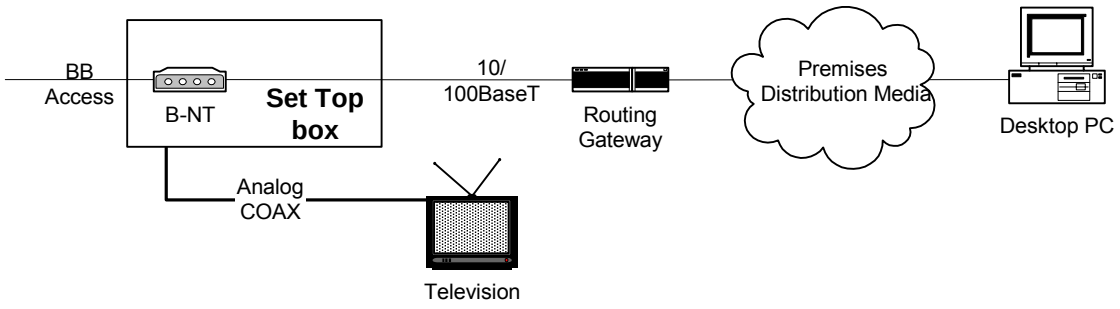

Figure 2 - The Analog Split-off

In this mode of operation, the DBV signals are split and delivered to the television ahead without using the home network to support it. As such, the home network is not required to provide any specific support for the video and hence no special QoS must be supported in the home network to provide an acceptable customer experience.

The analog split-off mode is equivalent to the "Centralized" CPE model described by [5] where the DBV content is converted back to an analog form by a primary set top box and any further distribution of the content (e.g., to other STB's, PC's) is done using analog techniques.

In this configuration, the STB acts as the broadband network termination device for the home network.

The PC could receive some niche video via the Internet connection, but this is normally done today using "best effort" techniques. Evolution towards the QoS enabled home network might hasten the use of the PC as a video presentation device for the DBV stream in addition to the STB.

2.2.3.2 End to end Digital Video

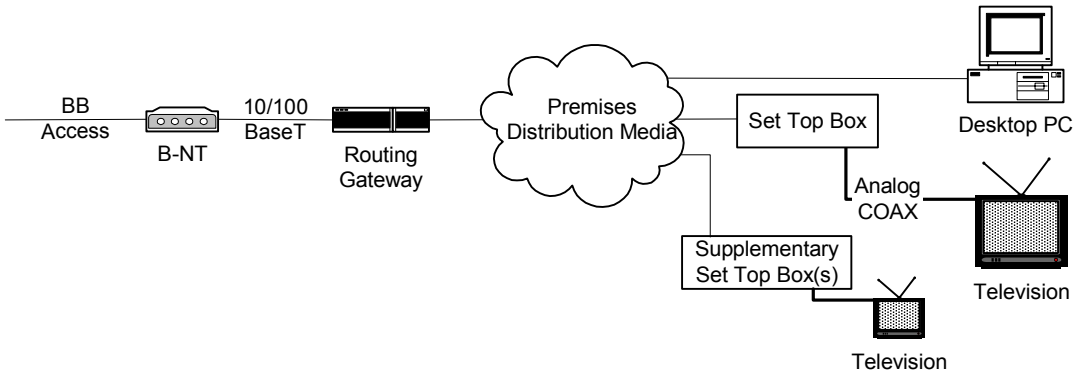

Figure 3 - End to end Digital Video

The end to end digital video configuration sees the home network playing a key role in the delivery of the DBV. In this case, the home network must be able to treat the DBV sessions with a better QoS in order to deliver an acceptable customer experience. The PC will generally continue to receive some niche video via the Internet connection; however the opportunity for the PC to participate in the delivery of the DBV is also possible with this configuration. For example, the PC could use the internal connectivity of the home network to work with the DBV STB to present the DBV content to the PC.

The end to end digital video mode described above is equivalent to the "Distributed" CPE model defined by [5]. The combination of the B-NT and RG replaces the role of the VDSL Termination Processing (VTP) unit in [5] where the DBV content stream is taken from the access and delivered to one or more STB's using a normalized format (commonly Ethernet) via the premises distribution network.

2.2.3.3 Hybrid (Combo-box)

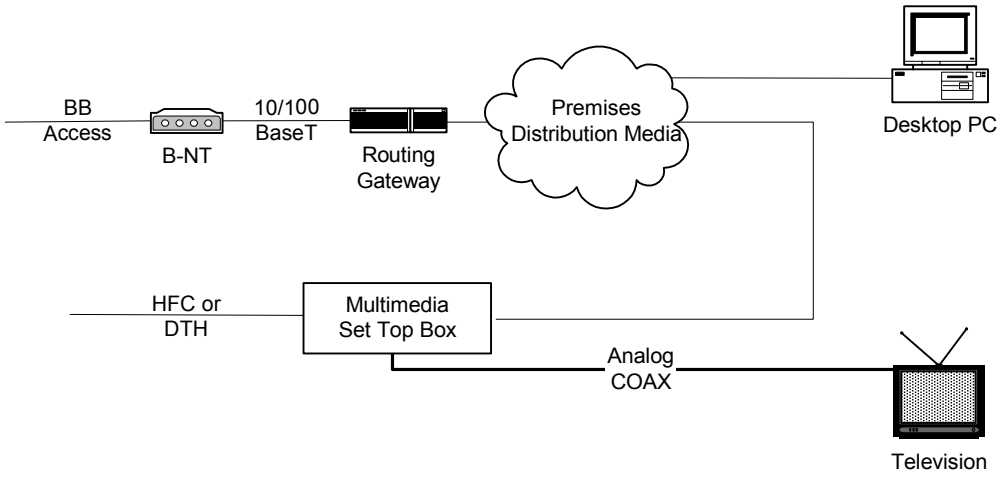

Figure 4 - Hybrid (Combo-box)

The hybrid model sees the DBV (or the analog CATV service) delivered to the home using non DSL access technologies. In this model, the home network supplements the DBV by providing Internet access to a multimedia set top box designed to connect to both the DBV access technology and the home network. This makes it possible for niche video services to be presented on the standard television.

R# 3 The home network **MAY** support different QoS for the niche video if required.

2.2.3.4 Digital Media Server/Receiver

Digital Media Servers/Receivers are becoming more popular as more content becomes available in digital form. Some of the more common digital content includes:

- Images (JPEG's) from digital cameras.
- Audio (MP3's) created from CD's and downloaded from the Internet.
- Video (MOV, WMV, MPEG's) from consumer electronics devices and downloaded from the Internet.

The Digital Media Server/Receiver concept sees a new set of devices connected to the home network that permits digital content to be used throughout the home. The Digital Media Server is a special purpose PC or other device that implements a central repository of digital content. It is connected to the home network and uses the home network connectivity to collect and store the digital content from both local and remote sources.

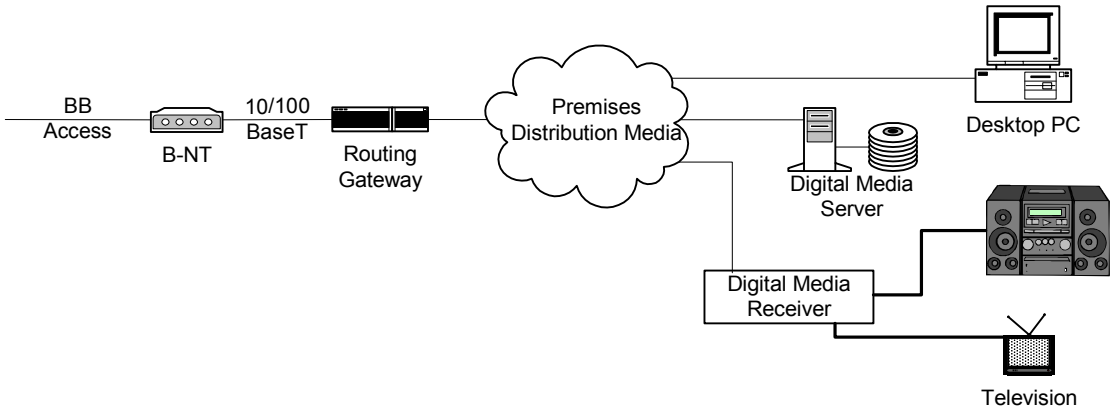

Figure 5 - Digital Media Server/Receiver

Once stored on the Digital Media Server, the content can be accessed by any PC connected to the home network. In addition to using the content with PC's, Digital Media Receivers are now appearing that permit delivering the digital content to more conventional entertainment appliances like stereos and televisions. The Digital Media Receivers are connected to the home network and act as the "bridge" between the home network and the existing home entertainment device.

R# 4 The home network **MUST** support Digital Media devices with the collection, storage and delivery of digital content from the WAN.

2.3 Data

2.3.1 Web Browsing/Internet Sharing

Web browsing and the desire to share a broadband access among multiple PC's for this purpose have been the driving force behind the creation of home networks. This will continue to be the case.

R# 5 The home network **MUST** support simple web browsing and sharing this capability among multiple PC's in the home.

2.3.2 File and Peripheral Sharing

One of the original purposes for establishing a local area network (LAN) was to provide the ability to share files and other peripherals among the connected PC's. A primary advantage of a home network, in addition to sharing a broadband Internet access, is that the PC's sharing the Internet access can also share files as well as other devices (e.g., printers) attached to the PC.

Once the base connectivity is established for sharing the Internet access, the use of network services within the home network enables the sharing of files and printers. These services have been provided by Network Operating Systems (NOS) in the past and have been absorbed into many of today's operating systems. Examples in use today in home networks include Microsoft Networking and AppleTalk.

R# 6 The home network **MUST** support file and printer network services which allow for sharing and printing among multiple PC's in the home.

2.3.3 Game Consoles

Until recently, PC's have been the primary type of device driving the need for shared Internet access. With broadband access and the ability to share this access in place, other types of devices are appearing that take advantage of the basic data capabilities of the broadband access.

One example is the availability of broadband enabled versions of popular game consoles. Broadband connectivity permits the gaming experience to be enhanced in a number of ways, including (but not limited to):

- Head to head competition with others users outside the home, anywhere in the world.
- New features that are enabled by the broadband capabilities (e.g., voice taunts of your opponent.)
- New games and feature add-ons that can be delivered via the network connection.
- Simplified maintenance of the game console itself though downloadable firmware upgrades.

R# 7 The home network **MUST** support the evolving broadband enabled game consoles and **SHOULD** evolve to provide QoS capabilities that improve the gaming experience.

2.3.4 Remote Telemetry & Control

Home automation involves both remote sensing as well as remote control of various devices within the home. The always connected nature of the broadband access together with a home network makes this possible.

The Open Services Gateway Initiative [OSGi] defines an architecture [7] that enables secure access to remote sensing and control applications within the home. Part of the OSGi architecture includes software functionality at the customer premises that implements the Service Gateway. This Service Gateway uses the external connectivity provided by the broadband access and the home network to provide a secure access to/from the home network.

Note: For the purposes of this home network architecture, the Service Gateway functionality is considered as an application using the connectivity of the home network rather than being a component of the home network itself.

3 HOME NETWORK OPERATIONAL FUNCTIONALITY

The following functional requirements are addressed by this home network architecture.

3.1 External Connectivity

The home network **SHOULD** be able to:

R# 8 Enable sharing of the BB access within the home by many devices, users and applications.

R# 9 Provide physical connectivity to the access network for any device connected to the home network. The home network **MUST** provide these components with seamless access to the BB access capabilities (multiple channels, QoS).

R# 10 Support connectivity to multiple Application Service Providers (ASP's) and Internet Service Providers (ISP's).

R# 11 Support incoming as well as outgoing access to the Home Network for both customer and service providers.

R# 12 Provide appropriate QoS delivery from the WAN to and from the home network.

R# 13 Support IP multicast to the extent needed to permit reception of 1 or more multicast streams by devices within the home network simultaneously.

R# 14 Be transparent to the applications connected to the home network (e.g., support of SIP sessions for IP telephony, IP VPN transparency).

3.2 Intra-home Connectivity

Intra-home connectivity provides for the interconnection of communicating devices within the customer premises itself. This connectivity supports the more common existing PC based applications (file and printer sharing) and will also begin to play a bigger role as new digital media applications (e.g., those enabled by new IP appliances such as Digital Media Receivers) become popular.

R# 15 The home network **MUST** support intra-home connectivity.

Most of today's home networking solutions that support intra-home connectivity provide best effort connections only and do not support any QoS or traffic differentiation features. This is due in part to the general availability of economical and relatively high speed LAN (>=100 Mbps) switching technologies that make QoS awareness unnecessary for today's applications. As applications evolve and the network demands increase, there will be a need for differentiation of traffic within the home to avoid congestion. With this in mind,

3.3 QoS and the Home Network Architecture

Today's home networks are commonly built using off the shelf technology that consumers purchase from major electronic retailers. The current generation of consumer DSL/Cable routers used in today's home networks are built to be economical for the consumer; however, functionality is sacrificed. Part of the lost functionality is the ability for a home gateway and network to deal with different qualities of service resulting in a home network that supports best effort service only. This hampers the delivery of certain value added applications to subscribers using home networks.

Service Providers and equipment vendors should begin defining and delivering home networking equipment and services that allow their customers to continue realizing the best effort applications they use today but also begin to lay the foundation for new and different applications. One way to do this is to take advantage of the QoS mechanisms of the ATM, Ethernet and IP technologies used to deliver broadband services to deliver extra value to applications running on the home network.

QoS is a nebulous term with many meanings and connotations. This home network Architecture strives to be consistent with the QoS terms defined in section 4.2 of TR-058. The QoS definitions are repeated here for convenience; however the actual TR-058 document should be referenced for current info.

TR-058 QoS Definitions

- **Quality of Service (QoS)** Quality of Service or QoS refers to the nature of the differentiated traffic delivery service provided, as described by parameters such as achieved bandwidth, packet delay, and packet loss rates. Traditionally, the Internet has offered a Best Effort delivery service, with available bandwidth and delay characteristics dependent on instantaneous load.

  There are different types of QoS:

- **Relative QoS**: This term is used to refer to a traffic delivery service without absolute bounds on the achieved bandwidth, packet delay or packet loss rates. It is used to handle certain classes of traffic differently from other classes;

- **Guaranteed QoS**: This term is used to refer to a traffic delivery service with certain bounds on some or all of the QoS parameters. These bounds may be hard ones, such as those encountered through such mechanisms as an ATM Call Admission Control (CAC) function or RSVP reservation. Other sets of bounds may be contractual, such as those defined in service level agreements (SLAs) that often typically define a monetary penalty should a certain threshold be crossed or missed.

NOTE: Within this document (and hopefully all derivative documents), the generic terms "QoS" and "QoS on Demand" will be used to describe the general concept of differentiated traffic delivery implemented by means of traffic parameters, without regard to any specific parameter or bound / guarantee. Wherever possible, the qualifying adjectives "Relative" and "Guaranteed" should, at a minimum, be used when describing the needs of a particular service. Ideally, the full definition of the QoS requirements of an application or service should define the various parameters (priority, delay, jitter, etc), any boundaries and the type of boundaries (engineered or contractual) involved.

Figure 6 below illustrates how the above terms relate to the home network. The terms GQoS and RQoS refer to Guaranteed QoS and Relative QoS respectively.

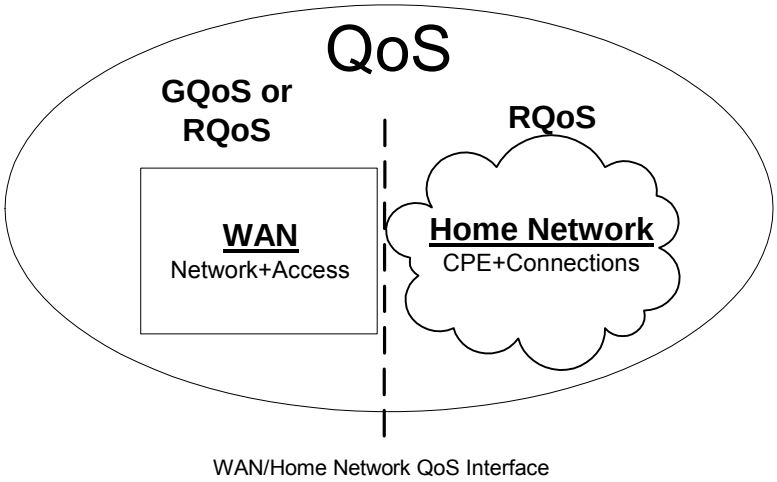

Figure 6 - QoS Model for the Home Network

At the interface between the WAN and the Home Network there will be a function to map between the QoS of the WAN and the relative QoS of the home network. This isolation of the home network QoS from the WAN guaranteed QoS mechanisms will help facilitate migration to full IP QoS in the WAN by insulating the home network applications from the changes in the WAN.

3.3.1 WAN QoS

It is acknowledged that IP will ultimately become a predominant QoS delivery mechanism on the WAN. It is also recognized that significant DSL deployments of ATM based DSL with limited ATM QoS mechanisms are already in place. To address this, the home network architecture defined in this working text will support QoS features independent of the WAN QoS mechanisms (ATM, Ethernet or IP) employed to deliver them.

R# 16 The home network architecture **MUST** support ATM, IP and Ethernet QoS mechanisms used with traffic arriving at and leaving the customer premises.

3.3.2 Home Network QoS

Within the home. the home network's use of relative QoS avoids the need for complex mechanisms and techniques (e.g., subnet bandwidth management, CAC, etc.). The following list summarizes the relative QoS requirements for the home network:

R# 17 The relative QoS within the home network **MUST** be based on the IEEE 802.1q (VLAN) and IEEE 802.1D Annex H.2 (User Priorities and Traffic Classes) standards. Any L3 and above QoS mechanisms will be carried transparently between devices in the home and the routing gateway. Applications operating within the home network may mark IP traffic with different DiffServ code points; however they must encapsulate those IP packets in a tagged Ethernet frame constructed with an appropriate traffic class in the priority field of the IEEE 802.1q VLAN tag.

R# 18 A mapping function between the WAN and LAN QoS's **SHOULD** be employed.

R# 19 Two or more traffic classes **SHOULD** exist in the home network. A "Best Effort" traffic class will always exist and provide the default mode of QoS operation. This ensures backward compatibility with the ad hoc home networks being created by customers today.

R# 20 One or more higher quality traffic classes **SHOULD** exist within the home network.

R# 21 All devices and applications using these additional traffic classes **MUST** be aware of and behave responsibly within the QoS home network so as to ensure acceptable application performance.

R# 22 The IEEE 802.1D Annex H.2 priority field **SHOULD** be mapped as defined in CEA-2007. This standard creates four types of QoS that can operate simultaneously in the same network. The four types are:

1. Best Effort effectively implies that no QoS treatment is applied to traffic marked with this priority.
2. Prioritized QoS represents traffic with relative QoS. Any prioritized QoS traffic gets better treatment than Best Effort.
3. Parameterized QoS represents traffic that requires a guarantee of one or more QoS parameters e.g. latency, jitter or packet loss. Parameterized QoS traffic gets better treatment than Prioritized QoS traffic.
4. Critical QoS is normally reserved for network control messages (channel changes, device mgmt., etc) and not used for content.

Table 1 below illustrates the above grouping and the possible uses for the eight possible priority values. Note: QoS increases moving down the table.

LAN Service Type	LAN Service Level Attributes	Priority Value	Mandatory / Optional	Typical Application	Example Use
Best Effort	No QoS specified. (Default)	**000**	**MUST**	No QoS.	Web surfing, FTP, Telnet, Email, device discovery.
Prioritized QoS	Low latency	**001**	**SHOULD**	Uni-directional streams.	One way streams for VoD, movies, web cameras.
	Very low latency and low jitter.	**010**	**SHOULD**	Real time, bi-directional streams.	VoIP, Video conferencing, gaming.
	Connection control.	**011**	**SHOULD**	Stream, session control.	SIP messages, channel changes.
Parameterized QoS	Low latency with target latency specified	**100**	**MAY**	Uni-directional streams.	One way streams for broadcast TV, PPV.
	Very low latency and low jitter with latency and jitter parameters specified	**101**	**MAY**	Real time, bi-directional streams.	Toll quality VoIP and Video conferencing.
	Connection control.	**110**	**MAY**	Stream, session control.	SIP messages, channel changes.
Network Control	Guaranteed delivery	**111**	**MAY**	Critical network control and messages to stop network traffic.	Stream/session STOP messages.

Table 1 - Home Network Traffic Classes

Notes:

1. Traffic priority increases from top to bottom with the highest priority class at the bottom.

3.4 Provide a "Plug it in and it works" User Experience

Ideally, all a user sees is a physical jack that the home network device is plugged into and all configuration and set up takes place automatically or with very minimal customer configuration.

3.5 Storage

Storage will become increasingly important as more digital media is created by and for users. The architecture should support the concept of a generic storage function within the home network for storing and accessing various types of digital media. Content could be stored both outside the home network (i.e., in the WAN) and within the home network.

Storage within the home network will have multiple uses. It might act as a content cache to improve performance of a particular application and it could also be applied to longer term storage of user created content such as digital photos, MP3's, documents etc. This content should be accessible to all devices connected to the home network at any time.

R# 23 The home network **SHOULD** support some form of network attached storage for caching and/or long term storage.

3.6 Device Powering

Home network devices and equipment have historically used their own 120/230 VAC power supplies to meet their power requirements. These power supplies could be integrated into the device itself or consist of the power adapters that are commonly supplied with home network devices that plug directly into an AC outlet. The common mode of operation is that these devices usually do not incorporate backup power, leaving the home network and its attached devices susceptible to commercial power outages.

As VoIP services begin to be deployed into the residential consumer environment, there will be increasing demand for the home network and the VoIP terminal devices themselves to operate in a manner similar to today's analog voice services (i.e., continued operation through commercial power outages could be expected).

R# 24 To meet this expectation, the home network **MAY** be required to have a backup power source for both the home network infrastructure itself (i.e., the broadband modem and the LAN switches) as well as provide power to the VoIP terminal devices.

This functionality could be provided by using technology designs that incorporate centralized backup power combined with Power over LAN technologies such as that defined by the IEEE 802.3af standard. The IEEE 802.3af standard describes how to deliver -48VDC power from the central LAN switch over the same Category 5 (Cat 5) cable used for the data connection. This power can then be used by the terminal device, eliminating the time, cost and inconvenience of using separate power cabling, AC outlets and power adapters. Powering of the IEEE 802.3af equipped LAN switch itself using an un-interruptible power source could provide the backup power needs of the LAN infrastructure and the connected VoIP terminal devices.

In cases where the VoIP phone or an adapter does not use a cable that power can be delivered over, other solutions could include batteries within the phone or adapter itself, fallback to an analog mode of operation (as could be possible in the case of HPNA connected devices that are already connected to the phone line) or the use of uninterruptible power supplies to power devices providing VoIP functions such as a VoIP enabled RG.

4 HOME NETWORK ARCHITECTURE

4.1 The Reference Model

The following diagram illustrates the functional components of the DSL enabled home network. The interfaces and components from the DSL Access Network up to and including the SM are in line with the "Customer Premises Specific Reference Model" described in [5]. This home network architecture extends the concepts of TR-61 further into the home network and decouples it from the specific access technology used.

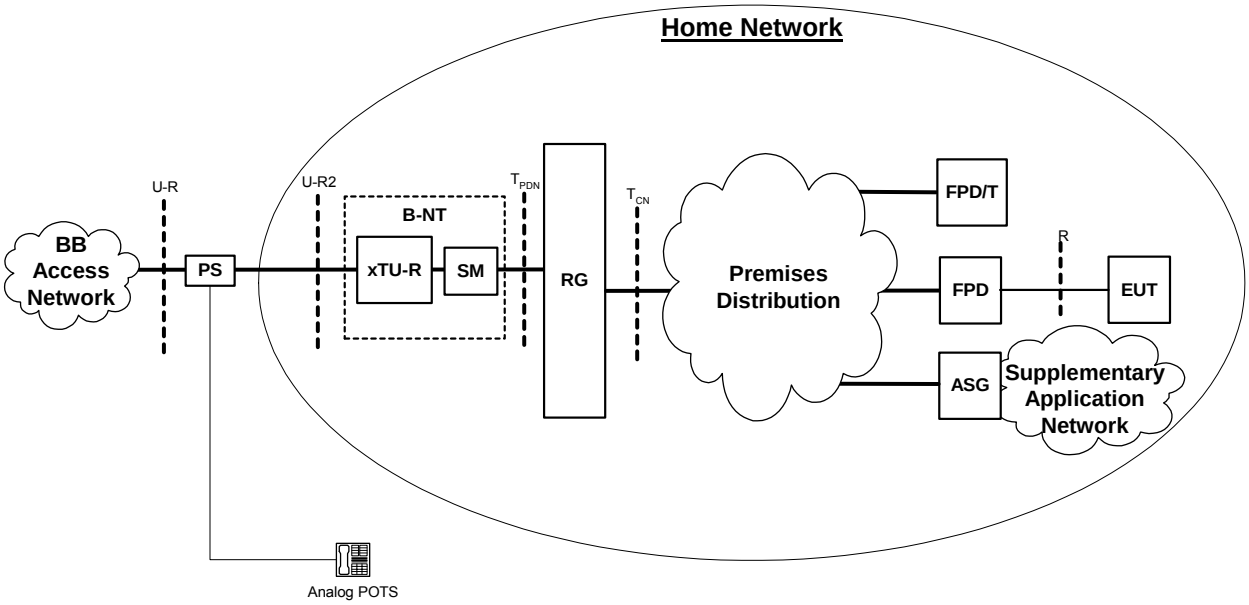

Figure 7 - The Home Network Functional Architecture

4.2 Functional Components

The following section describes in general terms the functions provided by each component of the Home Network Functional Architecture. This is a logical breakdown of these functions. Actual CPE devices could include one or more of these functions. For example, a device might include the B-NT and RG functions while another device might include both RG and ASG functionality.

4.2.1 PS – POTS Splitter

The POTS splitter functionality is used to separate POTS (or N-ISDN) access services from BB access services. The need for splitter functionality is dictated by the specific access technology used. The function could be centralized in one place (centralized POTS splitter) or distributed in the case of distributed filters.

4.2.2 B-NT – Broadband Network Termination

The B-NT is a combination of the xTU-R function and the Service Module (SM) functions described in TR-061. The B-NT physically terminates the specific BB access technology in the home and converts the received digital signals into a single common format for a particular PDN. Today's bridge DSL modems are a good example of the B-NT functionality where the ATU-R and IEEE 802.1D bridge are implemented in a single physical device.

R# 25 The B-NT function **MAY** be integrated with the RG in many products to simplify the implementation and control of QoS between the home network and the DSL access.

When the B-NT is not combined with the RG,

R# 26 The B-NT **MUST** support 10/100BaseT Ethernet toward the home network.

R# 27 The B-NT **SHOULD** implement the WAN side QoS mechanisms and make them accessible via the "T_{PDN}" interface.

4.2.2.1 xTU-R

R# 28 The xTU-R function terminates the BB access line in the customer premises. The specific type of xTU-R function will be determined by the particular access technology used to deliver BB service to the home network.

4.2.2.2 SM - Service Module

The Service Module converts received digital signals into signals suitable for a specific PDN. For the DSL Home Network Architecture the SM processes the digital signals from the xTU-R and presents a single, "normalized" physical and logical interface to the home network via the "TPDN" interface."

4.2.3 RG – Routing Gateway

The RG performs a number of functions described below. Detailed definition of the RG is beyond the scope of this architectural document and will depend on service provider requirements. As such, the definition of specific RG functionality is left for further study and the remainder of this section provides some general RG requirements.

4.2.3.1 PPPoE

R# 29 The RG **SHOULD** support a minimum of one PPPoE termination with the ability to connect directly with a BRAS.

R# 30 The RG **SHOULD** support a capability of initiating multiple PPPoE sessions.

R# 31 The RG **SHOULD** support a PPPoE pass-through capability to permit appropriately featured Functional Processing Devices (FPD) with the ability to connect directly with a BRAS.

4.2.3.2 IP Gateway

The RG is the "traffic cop" between the home network and the broadband access capabilities presented by the B-NT.

R# 32 There **SHOULD** be only one RG function for each home network.
This ensures that the RG is aware of ALL IP traffic into and out of the home network via the DSL access and makes it possible for the RG to perform the next function.

4.2.3.3 QoS Mapping

The RG provides mapping and pass through of all QoS between the WAN and the home network.

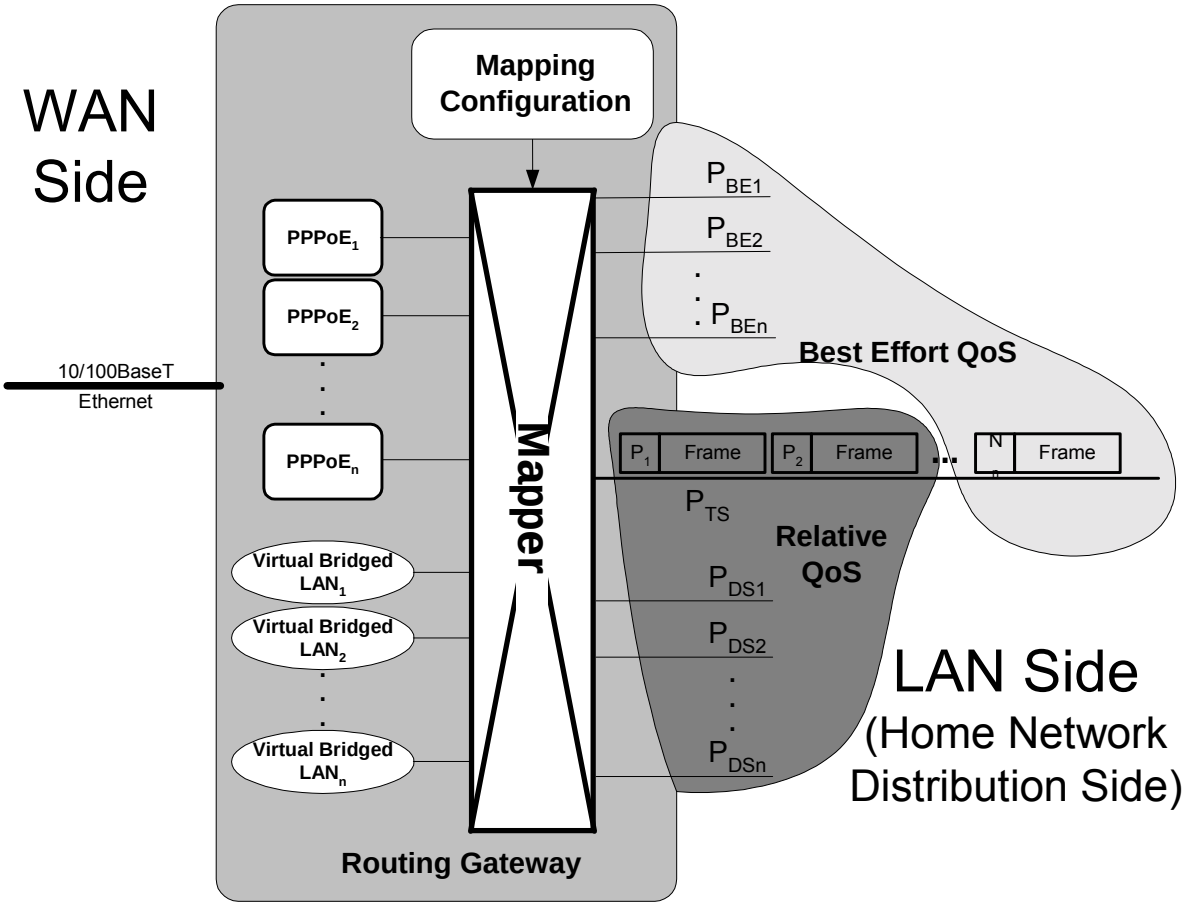

Figure 8 - RG Mapping Function

Figure 8 above shows the generic mapping functionality that the RG provides to support QoS enabled applications.

R# 33 The RG **MUST** implement Relative QoS awareness at layer 2 (IEEE 802.1Q and IEEE 802.1D Annex H) on the LAN side.

R# 34 The RG **SHOULD** implement IP based QoS mechanisms (DiffServ) on the WAN side of the RG.

Implementation of DiffServ in the RG permits it to support IP applications using differentiated services in conjunction with a QoS enabled BRAS.

R# 35 On the LAN side, an RG **MAY** distinguish the different traffic classes using either physical means (i.e., physical ports are mapped to one traffic class) and/or using frame by frame techniques (i.e., using the user priority field of the IEEE 802.1Q VLAN tag).

R# 36 The RG **SHOULD** map between the various Relative QoS services used in the home network and the appropriate QoS enabled virtual channel(s) available from the network. The mapping will be based on one or more characteristics of the data, one being the Relative QoS from the LAN side. The specific policies for doing so will be managed by the access service provider. (See section 5 below entitled "Home Network Management Functionality".)

4.2.3.4 Home Network Security

R# 37 The RG **SHOULD** provide firewall and network address with port translation (NAPT) capabilities for the home network. When the RG provides these functions, it **MUST** also provide the functions required for applications to work through or across the firewall and the NAPT.

4.2.3.5 Management Border Point

R# 38 The RG should play a major role in the management of the home network. At a minimum, the RG **SHOULD** be involved with:

- LAN+WAN connection mapping
- QoS mapping and policy
- Local IP address management (e.g., DHCP)
- Security configuration

4.2.4 Premises Distribution

The premises distribution function provides the connectivity between the RG and the FPD's. There are numerous technology choices for the premises distribution media, many of which are complex technologies in their own right. The following sections describe various aspects of the premises distribution function.

4.2.4.1 Distribution Media

Examples of premises distribution media that can be utilized for home networking include:

- Category 5 (or better) unshielded twisted pair (UTP) cable.
- Radio Frequency
- AC power electrical wires
- Phone wire
- Coaxial cable
- Multimode Fibre Optic cable

This home networking architecture assumes that multiple premises distribution media can be used to implement the home network connectivity.

4.2.4.2 Local Ethernet Switching

Regardless of the physical media used to make the connection between the RG and the FPD/T, this home networking architecture assumes that all premises distribution technologies are capable of supporting IP packets encapsulated by IEEE 802.3 Ethernet frames. The switching of Ethernet traffic between the various premises distribution media is also a role of the premises distribution function.

R# 39 The home network **MUST** be capable of supporting IP packets encapsulated by IEEE 802.3 Ethernet frames.

R# 40 Any intra-home connectivity **SHOULD** be implemented using LAN switch technology in order to provide the best possible application performance. Shared media hub devices **SHOULD NOT** be used.

R# 41 LAN switches used for home networks **SHOULD** provide multiple physical connections for connected devices within the home network allowing the DSL access to be shared by multiple end users and applications within the home.

R# 42 LAN switches used for home networks **SHOULD** support 10/100BaseT connections and include automatic speed as well as duplex (half or full) negotiation.

R# 43 Cascading of multiple LAN switches **SHOULD** be avoided to prevent congestion and poor application performance that could result from overloaded "uplink" network segments.

R# 44 LAN switches for home use **SHOULD** support QoS features.

R# 45 Any premises distribution technology used to support a L2 QoS aware device **MUST** be capable of providing the necessary support to maintain the distinction between traffic with varying types of QoS.

4.2.4.3 New Network Wiring

The application of network cabling solutions commonly found in business LAN installations can also be applied within the home. These cabling solutions involve "structured" wiring techniques that create a physical hub and spoke design. Figure 9 below illustrates the structured wiring concept.

Structured wiring dictates that a centralized point (hub) be selected on the premises where communication services (i.e., DSL) terminate. Media connectors (typically RJ-45 jacks) are installed throughout the home where required. A cable is then run from each installed connector back to the central wiring point. An Ethernet switch is located at the central wiring point to provide the interconnection of the devices throughout the home.

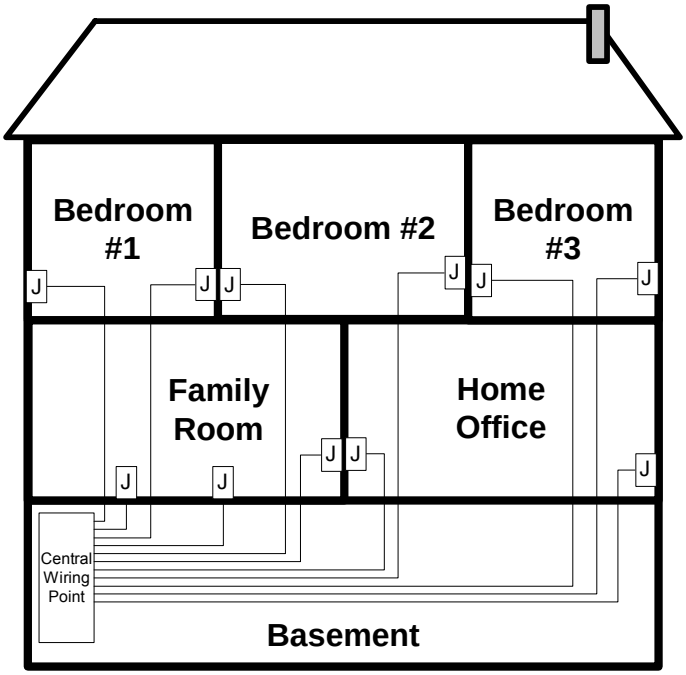

Figure 9 - Structured Wiring for Home Networks

Category 5 (Cat 5) cable is typically used for new structured wiring in a home network. The latest version of Cat 5 is the Cat 5e, although other variations are equally as useful. Cat 5 cabling represents the best option for new home network connections from a QoS perspective. This is due to the relatively high data speeds possible (100 Mbps) and the fact that each connected device has its own dedicated path (not shared with other devices) to the Ethernet switch. These advantages of a structured wiring solution cannot be over-emphasized.

R# 46 Structured wiring **SHOULD** be used for the home network whenever possible.

4.2.4.4 No New Network Wiring

In many situations, practical limitations, both physical and fiscal, exist in the home that preclude the use of standard LAN cabling for connecting devices. In these situations, a number of technology solutions exist to support in-home connectivity for devices without the need to install new wires. The choice of which one to use will depend on the factors that include application needs (especially in the area of QoS), the home environment and the consumer wishes.

Some of the technologies available to avoid the installation of new wiring for the home network include:

- IEEE 802.11x Wireless
- HomePlug™
- HomePNA™

- Data over CATV or Satellite COAX.
  (The actual Data over Coax implementation can take one of a number of different forms. These include HomePlug, HPNA & IEEE 802.11 running over the coax in parallel with the analog or digital cable TV signals.]

These technologies can be combined with "local" Ethernet wired connections for total flexibility and best performance. Refer to Appendix C – Premises Network Technologies for example applications and associated physical networking technologies.

4.2.5 FPD – Functional Processing Device

The FPD is a component within the home network that processes voice, video or data for its intended use/application. There can be multiple FPD's within a single home network.

R# 47 All FPD's **MUST** be IP aware and will function as an application specific IP host on the home network. This does not preclude the implementation of multiple FPD entities within a single physical device.

In many cases, the FPD will provide functionality to permit home devices not designed for IP connection to take advantage of network based content and services.

As an example in the figure below, an MP3 player has been designed to permit MP3 source material to be played on the existing stereo system. The material might originate from the Internet or be part of a personal MP3 library that is stored on a PC. The existing stereo receiver has not been designed to connect to the home network but it is the device that the end user normally uses to enjoy music. The MP3 player is the Functional Processing Device in that it is IP aware and processes the MP3 audio material to a form (analog right and left stereo channels) that the stereo receiver can use.

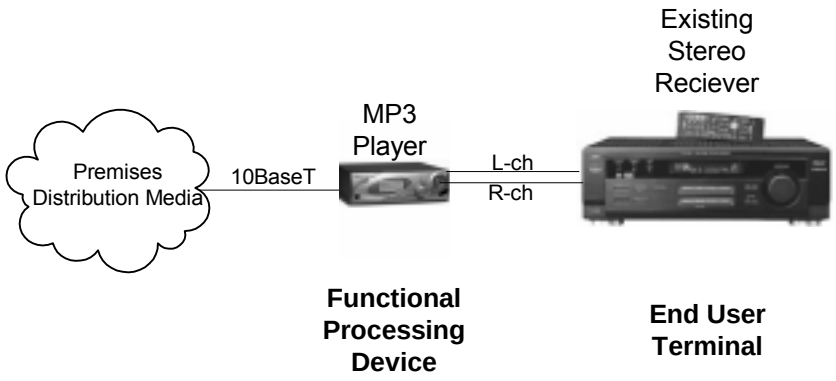

Figure 10 - A Functional Processing Device Example

Other examples of physical devices with FPD functionality include Video Set Top Boxes, streaming audio adapters and VoIP phone adapters for analog phones.

Management of the FPD will be application specific and is outside the scope of the home network architecture.

R# 48 The connectivity services provided by the home network and broadband access **MAY** be used by the application to manage the FPD.

4.2.6 EUT – End User Terminal

The EUT is a common home appliance that can indirectly take advantage of the home network connectivity but has not been specifically designed to do so. Referring to the previous example of a FPD in Figure 10, the stereo receiver is the End User Terminal. In this example, the stereo can play the analog music

generated by the MP3 player but it cannot be connected directly to the home network. Other examples of EUT's include standard television sets, analog telephones and printers with serial or parallel interfaces.

An EUT will connect to the home network using a FPD as described above.

4.2.7 FPD/T – Functional Processing Device and Terminal

The FPD/T is a FPD used directly by the end user. There is no EUT associated with an FPD/T. Examples include PC's, PDA's, IP Phones, printers with direct network attachment capability.

4.2.8 ASG – Application Service Gateway

It is recognized that there are and will continue to be non-IP based networks within a home. Examples include home automation networks based on technologies like Lonworks, CEBus, X.10 networks, IEEE 1394 Firewire and even analog based key telephone systems. Home entertainment system components can also be connected together with proprietary links for control purposes.

An ASG is a special instance of a FPD that acts as a gateway between the IP/QoS enabled home network defined by this architecture and these non-IP aware networks. As identified in Section 4.2, the ASG may be implemented in the same physical device as the RG or as a separate physical device.

The OSGi Service Gateway [7] is an example of an ASG device implemented on the home network with the external (WAN) connectivity and associated QoS provided by the home network.

4.2.9 Supplementary Application Network

Supplementary networks, specific to certain applications will exist within the home. The goal of this architecture is to recognize the existence of these networks and to provide these networks and their applications with access to the functionality provided by the home network as described in section 3 - Home Network Operational Functionality. Examples of some supplementary application networks include today's home security, climate control and telemetry systems. Home networking support of these supplementary networks will be via an ASG.

R# 49 The ASG **MAY** support a Home Distribution function running in addition to the Premises Distribution function already supported by the Home Network. In addition, the Supplementary Application Network **MAY** utilize the Premises Distribution network if the latter supports transport of non-IP traffic."

4.3 Interfaces

This section describes the interfaces between the functional components of the home networking architecture as illustrated in Figure 7 - The Home Network Functional Architecture.

Some of the sub-interfaces of the U, T and R interfaces, might not be physically discernable, as they could be integrated within home network devices. Examples of sub-interfaces are U-R, U-R2, T_{PDN}, and T_{CN}. In cases where the sub-interfaces are not discernable, the interface is comprised of the union of the individual sub-interface definitions.

4.3.1 U-R Interface

This is the interface presented by the specific access technology towards the customer premise. In most instances, it will be from the customer side of the customer/network demarcation device. The interface will take different forms depending on the access technology used to deliver the service. Some examples are:

- Single copper pair running ADSL
- Single copper pair running VDSL
- Single fibre running PON

R# 50 The B-NT **MUST** terminate at a single broadband U-interface.

4.3.2 U-R2 Interface

The U-R2 interface will be present in situations when the access technology delivers broadband and POTS access services on the same physical media. In cases where the access technology is dedicated to broadband access only (i.e., no POTS service is supported), the U-R and U-R2 interfaces are one and the same. No splitter is required in these circumstances.

4.3.3 T_{PDN} Interface

The T_{PDN} interface is physically discernable when the B-NT and RG are implemented in separate devices.

R# 51 In these situations, the TPDN interface **MUST** be limited to being a point to point layer 1+2 connection between the RG and the B-NT.

Use of shared media hubs in conjunction with this interface is discouraged. This will ensure that the RG has knowledge of the total traffic between the home network and the B-NT and permit the RG to maintain the integrity of the QoS for the external connections.

When present, the T_{PDN} interface has the following characteristics:

Data Link Layer

R# 52 The data link layer **MUST** support Ethernet in accordance with IEEE 802.2/ IEEE 802.3 (Ethernet)

R# 53 The data link layer **MUST** support the bidirectional delivery of PPP over Ethernet frames in accordance with IETF RFC 2516.

R# 54 The data link layer **MUST** support the operation of DHCP.

R# 55 The data link layer **SHOULD** support Ethernet virtual LANs (IEEE 802.1Q).

R# 56 The data link layer **SHOULD** support Ethernet precedence of LAN traffic (IEEE 802.1D Annex H).

R# 57 The data link layer **SHOULD** support the bidirectional delivery of IP packets.

Logical Link Controller (LLC) Sublayer

R# 58 The logical link controller sublayer subinterface **MUST** support Ethernet in accordance with IEEE 802.2.

Medium Access Control (MAC) Sublayer

R# 59 The medium access control sublayer subinterface **MUST** support Ethernet in accordance with IEEE 802.3.

Physical Layer

R# 60 The physical layer for the TPDN interface **MUST** be a 10/100BaseT interface, using an RJ45 connector.

R# 61 The TPDN interface **MUST** support the automatic negotiation of the speed without customer intervention.

R# 62 The TPDN interface **MUST** support full duplex operation to ensure that traffic in the downstream or upstream direction does not affect traffic in the opposite direction.

4.3.4 T_{CN} Interface

The T_{CN} Interface defines the interface between the RG and the various premises distribution technologies.

R# 63 There **MUST** be a minimum of one TCN interface presented by an RG for connection to the premises distribution network.

The above does not preclude an RG device from integrating premises distribution functions as described in section 4.2.4 Premises Distribution; however, at least one such interface must be available.

The T_{CN} Interface will have the following characteristics:

Network Layer

R# 64 The network layer **MUST** support IP version 4 in accordance with IETF RFC 1042.

R# 65 The network layer **SHOULD** support IP version 6 in accordance with IETF RFC 2460.

R# 66 The network layer interface **SHOULD** support IP precedence based on differentiated service (Diffserv) code points in accordance with IETF RFC 3140.

R# 67 The DiffServ requirements defined in TR-059 **SHOULD** be supported.

R# 68 The home network **MUST** support DHCP functions.

R# 69 The home network **MUST** support DNS functions.

R# 70 The home network **MUST** support NAPT functions.

R# 71 The home network **MUST** support UDP and TCP.

Data Link Layer

R# 72 The data link layer **MUST** support Ethernet in accordance with IEEE 802.2/ IEEE 802.3 (Ethernet).

R# 73 The data link layer **MUST** support the transport of PPP over Ethernet frames in accordance with IETF RFC 2516.

R# 74 The data link layer **SHOULD** support Ethernet precedence of LAN traffic (IEEE 802.1Q and IEEE 802.1d Annex H).

Logical Link Controller (LLC) Sublayer

R# 75 The logical link controller sublayer subinterface **MUST** support Ethernet in accordance with IEEE 802.2.

Medium Access Control (MAC) Sublayer

R# 76 The medium access control sublayer subinterface **MUST** support Ethernet in accordance with IEEE 802.3.

Physical Layer

R# 77 The TCN interface **MUST** support 10/100BaseT.

R# 78 The TCN interface **MUST** support both full and half duplex operation.

R# 79 The TCN interface **MUST** support the automatic negotiation of both the speed and duplex without customer intervention.

4.3.5 R Interface

The following table illustrates some of the interfaces that EUT's will present and that an FPD might support to provide connectivity for a particular EUT.

Tip/Ring Telephone line
Ethernet
USB
Coaxial Cable (RF modulated composite video)
S-Video
Composite Video
Component Video
SCART
Dolby Digital/AC-3
L/R Stereo
IEEE 1394
5-channel analogue audio
SCSI
LPDT parallel
RS-232 serial
Bluetooth
IR Emitter (for control of IR controlled devices)

Table 2 - End User Terminal Interfaces

5 HOME NETWORK MANAGEMENT FUNCTIONALITY

5.1 Home Network Management Reference Model

Figure 11 illustrates the management model for the home network. For the purposes of the following discussion, the term "Service Provider" (SP) will be used to refer to either or both an Internet Service Provider (ISP) and an Application Service Provider (ASP).

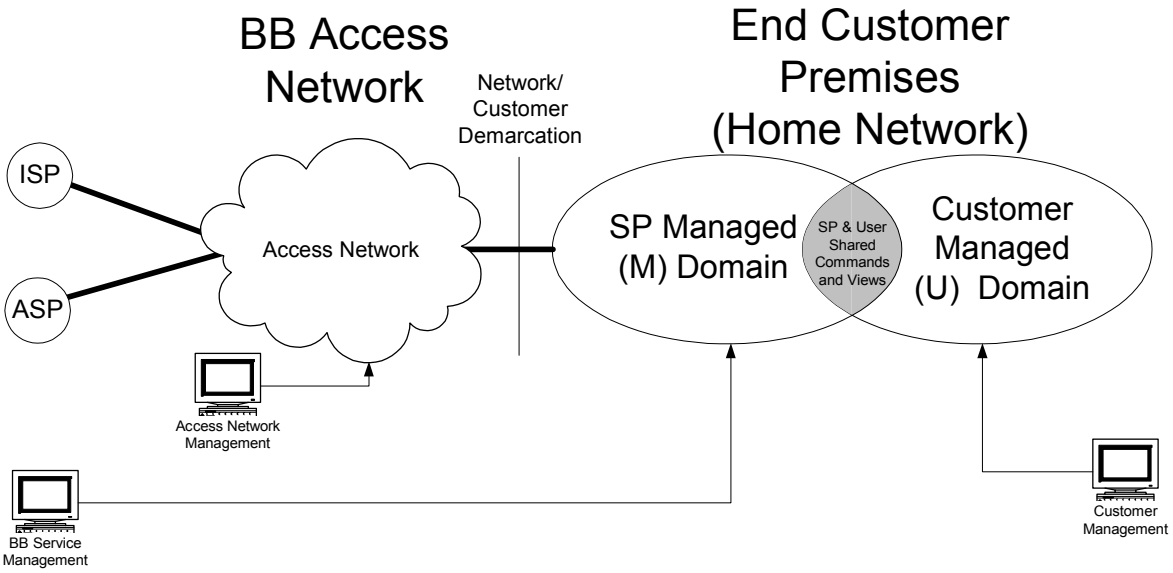

Figure 11 - The Home Network Management Model

5.2 DSL Access Network Management

The BB access network is managed by the provider/operator of the BB access to the home. The focus of this management is on the physical connectivity and switching network between the end customer premises and multiple SP's using the access.

As such, this management is done independent of both the customer and the SP; however, the effects of the management could be monitored by either the customer or the SP. (e.g., a change in the MAX sync speed of the line might be reported by a management entity within the SP or customer managed domains.

The BB management normally stops at the point where the BB access is terminated (the xTU-R) and does not extend into the home network.

5.3 Home Network Management

Management of the home network is a shared activity between the broadband SP and the customer. Figure 11 illustrates this overlap of the home network management responsibilities. The degree of responsibility for management of the home network will be based on an agreement between the customer and the service provider. For example, in cases of a customer purchased device, the customer can enable, disable and control the extent of service provider management of the device, if any. For those cases where a service provider supplies a device as part of the service, the service provider might restrict a customer's ability to manage that device.

5.3.1 Service Provider Managed [M] Domain

The M domain of the home network is part of the more general auto-configuration architecture described in DSL Forum TR-046. With the service provider managed domain of the home network as part of this architecture, the home network can be monitored and controlled by the broadband SP. This allows the broadband SP to configure and support the customer's consumption of their service.

In order to realize this management, devices associated with particular services and connected to the home network, will be accessed by the SP using remote connectivity to some form of back end infrastructure (management servers).

R# 80 Prime aspects of the home network that **MAY** be managed within the M domain include:

- B-NT configuration
- RG configuration including:
  - Connection mapping
  - NAPT configuration
  - QoS policy configuration
- Content security and digital rights management (DRM)
- Home network access security

R# 81 It is anticipated that the RG will be a prime component of the home network involved in the SP management domain. The interaction of the RG with the network **SHOULD** be in line with the recommendations described in DSL Forum TR-69.

5.3.2 Customer Managed (U) Domain

Management within the U domain of the home network is performed either directly by the customer themselves, (e.g., using a management GUI provided by a device) or indirectly by a software "agent" (e.g., a management application running on a PC, driving a LAN management interface like that described in TR-64 or another device discovery and configuration technology such as UPnP™, or Rendezvous™).

In cases where customer management is provided, the home networking devices might present either a management GUI (preferably web based) for direct access by the human client, a software interface (XML based as suggested in [3]) for use by a machine client or both.

Some customer management will be local to the home network only and will not be visible or controllable by the SP. In the case where the service permits some form of customer control/monitoring, user control will be limited to bounds set by the SP. This could be as simple as providing read only access to service configuration/status resident within the M domain or as complex as full user configuration/modification of service attributes within the M domain.

Given the preference for XML based technologies for remote management access within the M domain, it is also preferable to use XML based technologies within the U domain in order to facilitate inter-working between customer and SP management.

R# 82 XML based technologies **SHOULD** be employed within the U domain in order to facilitate inter-working between customer and SP management.

R# 83 Prime aspects of the home network that **MAY** be managed within the U domain include:

- RG configuration including
  - Mapping configuration
  - NAPT configuration
  - IP Addressing
- Home network access security
- Static and dynamic application configuration

5.4 IP Address Management

R# 84 The home network **MUST** support IPv4 addressing.

R# 85 The home network **SHOULD** be ready to support IPv6.

R# 86 When the RG supports bridged connections, IP address assignment for FPD's associated with these connections **MUST** be performed by mechanisms (DHCP, static) from within the ISP or ASP's network.

R# 87 Any use of private IP addressing **MUST** be done in accordance with [6].

5.4.1 RG WAN Side

On the WAN side of the RG, the following IP address management requirements apply:

R# 88 The RG **SHOULD** support the following IP address assignment techniques on WAN interfaces:

- o IPCP within PPPoE
- o DHCP
- o Static IP configuration

R# 89 The RG **MUST** accept any and all IP address assignments from the network.

R# 90 The RG **MAY** be capable of accepting a subnet range of IP addresses from the WAN side for re-assignment to the LAN side of the home network.

R# 91 When IPv6 support is available, the RG **SHOULD** be capable of accepting a subnet range of IP addresses from the WAN side for re-assignment to the LAN side of the home network.

5.4.2 RG LAN Side

When using routed IP connections, the following requirements apply:

R# 92 DHCP **MUST** be available for end users to assign addresses for those devices using the routing functions of the RG.

R# 93 Static IP addresses **SHOULD NOT** be used.

R# 94 Persistent IP address assignment (i.e., the same IP address is always assigned to a particular device) **SHOULD** be supported because it will be required by some applications.

R# 95 IP addresses on the TCN side of the RG **SHOULD** be assigned within a default IP address subnet.

R# 96 A home network **MAY** support multiple IP subnets within itself and the routing between them.

R# 97 In multiple PVC situations where bridged connections could be utilized, FPDs on the home network associated with those bridged connections will be assigned IP addresses from the network. This will normally be done using DHCP.

5.4.3 PPPoE FPD

Some devices will be capable of initiating and supporting their own IP connections using built-in PPPoE functionality. Examples include customer purchased DSL routers and game consoles. IP address assignment will have the following characteristics for these devices:

R# 98 IP addresses **SHOULD** be assigned using IPCP within the device specific PPPoE session by the responding BRAS based on service description (dynamic or persistent).

R# 99 1 IP address **SHOULD** be assigned per PPPoE session initiated.

R# 100 The IP address assigned to the PPPoE FPD **MUST NOT** conflict with any IP addresses on the WAN or LAN side of the RG.

5.5 Domain Name Services

DNS addresses will be communicated as part of the IP address assignment mechanism used for PPPoE enabled devices (RG & PPPoE FPDs). In the case of the RG, it is recommended that the RG act as the DNS server for the default IP subnet.

R# 101 Dynamic DNS update capabilities **MAY** be implemented by RG's and PPPoE enabled FPD's to communicate IP address assignments to Dynamic DNS services.

Any local host naming (i.e., naming of hosts within a private IP subnets) will be left to the customer.

5.6 Quality of Service (QoS)

Quality of service policy configuration will be done on the RG within the SP domain, with or without customer modification from the U domain. This will determine how the RG maps the relative QoS of the home network with the WAN QoS. The actual criteria and policies used to do the mapping are outside the scope of this architecture document. More information on how an RG may implement QoS can be found in [12] and [13].

6 HOME NETWORK SECURITY

The following aspects of security are addressed by devices and applications running on the home network. Together with these devices and applications:

R# 102 The home network **MUST** provide protection from unwanted connection to the home network from outside. The two main aspects of this include:

1. Undesired connection from the WAN access into the home network as well as restricting specific LAN devices from accessing the WAN. This protection is usually provided by a device providing firewall functions between the home network and the WAN.
2. Unwanted access to the home network infrastructure itself when that infrastructure includes premises distribution media that are susceptible to unwanted access from outside the home. Examples of these types of media include 802.11 wireless and HomePlug. Protection from this type of unwanted access is achieved by the use of technologies such as the Wired Equivalency Protocol (WEP), Wi-Fi Protected Access (WPA), WPA v2, 802.11i and DES.

R# 103 The home network **SHOULD** protect against and aid other security functions to protect against the following threats:

1. Trojan horse programs
2. Back door and remote administration programs
3. Denial of service
4. Being an intermediary for another attack
5. Unprotected Windows shares

R# 104 The home network **SHOULD** provide protection from unauthorized device configuration from within the home network; either by unauthorized users or rogue software (e.g., Trojan horse applications).

R# 105 The home network **MAY** provide filtering and parental control of content; however, SP based filtering/control can also be applied.

R# 106 The home network **SHOULD** support conditional access (CA) and digital rights management (DRM) mechanisms to prevent unauthorized use of content.

R# 107 The home network **MUST** support remote access VPN clients. This support **MUST** be available to multiple FPD's operating simultaneously on the home network.

R# 108 The home network **MUST** support the use of encryption both within the home network and toward the broadband network.

7 GLOSSARY

AAA	Authentication, Authorization, and Accounting
AAL5	ATM Adaptation Layer 5
ADSL	Asymmetric Digital Subscriber Line
ADSL2Plus	
AF	Assured Forwarding
API	Application Program Interface
APON	ATM Passive Optical Network
ARP	Address Resolution Protocol
ASG	Application Service Gateway
ASP	Application Service Provider
ATM	Asynchronous Transfer Mode
ATU-C	ADSL Termination Unit - Central Office (at Access Network end)
ATU-R	ADSL Termination Unit - Remote (at customer end)
BB	Broadband
BE	Best Effort
B-NT	Broadband Network Termination
BoD	Bandwidth on Demand
BRAS	Broadband Remote Access Server
CA	Conditional Access
CAC	Call Admission Control
Cat5	Category 5
CATV	Cable TV
CBR	Constant Bit Rate
CE	Consumer Electronic
CO	Central Office
COAX	Co-axial cable
CoS	Class of Service
CPE	Customer Premises Equipment
CPN	Customer Premises Network
DBV	Digital Broadcast Video
DES	Digital Encryption Standard
DHCP	Dynamic Host Configuration Protocol
Diffserv	Differentiated Services
DLC	Digital Loop Carrier
DNS	Domain Name Service
DRM	Digital Rights Management
DSL	Digital Subscriber Line
DSLAM	Digital Subscriber Line Access Multiplexer
DTH	Direct to Home
EF	Expedited Forwarding
EPON	Ethernet Passive Optical Network
EUT	End User Terminal
FPD	Functional Processing Device
FPD/T	Functional Processing Device and Terminal
GPON	Gigabit Passive Optical Network
GQoS	Guaranteed QoS
GUI	Graphical User Interface
HFC	Hybrid Fiber Coax
HN	Home Network
HPNA	Home Phoneline Networking Alliance
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IGMP	Internet Group Management Protocol
IKE	Internet Key Exchange

IP	Internet Protocol
IPCP	IP Control Protocol
IPsec	Secure Internet Protocol
IPv4	IP Version 4
IR	Infrared
ISP	Internet Service Provider
JPEG	Joint Photographic Experts Group
L/R	Left/Right
L2	Layer 2
L3	Layer 3
LAN	Local Area Network
LD	Long Distance
LLC	Logical Link Control
LPDT	Line Printing Data Terminal
MAC	Medium Access Control
MOV	Movie
MP3	MPEG Audio Layer 3
MPEG	Motion Pictures Expert Group
MPLS	Multi-Protocol Label Switching
MTU	Message Transfer Unit
NAPT	Network Address and Port Translation
NAT	Network Address Translation
NG-DLC	Next Generation Digital Loop Carrier
NOS	Network Operating System
NSP	Network Service Provider
nVod	Near Video on Demand
nVoD	Near Video on Demand
OSGi	Open Services Gateway Initiative
PC	Personal Computer
PDN	Premises Distribution Network
PON	Passive Optical Network
POTS	Plain Old Telephone Service
PPP	Point-to-Point Protocol
PPPoE	Point-to-Point Protocol over Ethernet
PS	POTS Splitter
PVC	Permanent Virtual Circuit
PVR	Personal Video Recorder
QoS	Quality of Service
RADIUS	Remote Access Dial-In User Service
RAM	Remote Access Multiplexer
RF	Radio Frequency
RFC	Request For Comments
RG	Routing Gateway
RQoS	Relative QoS
RSVP	ReSource reserVation Protocol
RT-DSLAM	Remote Digital Subscriber Line Access Multiplexer
SCART	Syndicat des Constructeurs d'Appareils Radiorécepteurs et Téléviseurs
SCSI	Small Computer Systems Interface
SIP	Session Initiation Protocol
SLA	Service Level Agreement
SLO	Service Level Objective
SM	Service Module
SONET	Synchronous Optical Network
SP	Service Provider
STB	Set Top Box
SVC	Switched Virtual Circuit
TCP	Transmission Control Protocol

TV	Television
UBR	Unspecified Bit Rate
UDP	User Datagram Protocol
UPnP	Universal Plug and Play
USB	Universal Serial Bus
UTP	Untwisted Pair
VAC	Volts Alternating Current
VBR-nrt	Variable Bit Rate - non-Real Time
VBR-rt	Variable Bit Rate - Real Time
VC	Virtual Circuit
VDC	Volts Direct Current
VDSL	Very high speed DSL
VLAN	Virtual Local Area Network
VoD	Video on Demand
VoIP	Voice over Internet Protocol
VTP	VDSL Termination Processing
WAN	Wide Area Network
WEP	Wireless Encryption Protocol
WMV	Windows Media Video
WPA	Wi-Fi Protective Access
XML	Extensible Markup Language

8 APPENDIX A – REFERENCES

[1] DSL Forum TR-046, “Auto-Configuration: Architecture & Framework”

[2] DSL Forum TR-058, “Multi-Service Architecture & Framework Requirements”

[3] DSL Forum TR-059, “DSL Evolution - Architecture Requirements for the Support of QoS-Enabled IP Services”

[4] DSL Forum TR-064, “LAN-Side DSL CPE Configuration Specification”

[5] DSL Forum TR-061, “Interfaces and System Configurations for ADSL: Customer Premises”

[6] DSL Forum TR-069, “CPE WAN Management Protocol”

[7] FS-VDSL Specification, Part 3, “Customer Premises Equipment Specification”

[8] IETF RFC 1918, “Best Current Practice - Address Allocation for Private Internets”

[9] The Open Services Gateway Initiative, “OSGi Service-Platform Release 3” (http://www.osgi.org/)

[10] Consumer Electronics Association, “CEA 2007 QoS Priority Groupings for 802.1Q”

[11] Consumer Electronics Association, “CEA 2008 Digital Entertainment Network”

[12] DSL Forum TR-068, “Dual Port ADSL Router Requirements Specification”

[13] DSL Forum WT-098v2, “Parameter Model Extensions for Service Differentiation”

9 APPENDIX C – PREMISES NETWORK TECHNOLOGIES

The following tables list example applications identified in TR-058 and a rough estimate of the downstream bandwidth required to them. This information can then be used with Table 4 to gauge the appropriate technologies to deploy in a particular environment.

TV Focused Services	Typical bandwidth (downstream)	Service Type[1]
Broadcast TV – (e.g., MPEG2)	2 to 6 Mb/s	Parameterized QoS
High definition TV – HDTV	12 to 19 Mb/s	Parameterized QoS
Pay Per View and NVOD (e.g., MPEG2)	2 to 6 Mb/s	Prioritized QoS
VOD – (e.g., MPEG2)	2 to 6 Mb/s	Prioritized QoS
Navigator and EPG (can be locally launched and updated in non real time)	Less than 0.5 Mb/s	Best Effort
Picture in Picture – two MPEG2 channels	Up to 12 Mb/s	Parameterized QoS
Picture in Browser – one MPEG2	Up to 9 Mb/s	Prioritized QoS
Personal Video Records PVR – replay MPEG2 file off hard disk	2 to 6 Mb/s local	Prioritized QoS
ITV - TV telephony features	Less than 64 Kb/s	Best Effort
- TV browser	Up to 3 Mb/s	Best Effort
- TV e-mail	Up to 3 Mb/s	Best Effort
- TV Instant Messaging	Up to 3 Mb/s	Best Effort
- TV Chat	Up to 3 Mb/s	Best Effort
- TV on-screen notification	Less than 64 Kb/s	Best Effort
- TV interactive games	Up to 3 Mb/s	Best Effort
- TV Audio Juke Box	Less than 128 Kb/s	Prioritized QoS

Table 3 : TV Delivered Applications and Their Traffic Characteristics

PC Focused Services	Typical bandwidth (downstream)	Service Type[1]
High Speed Internet Access (browsing, IM, Chat, FTP, VPN, access, etc)	Up to 3 Mb/s	Best Effort
Server based E-Mail	As above	Best Effort
Live TV on PC	300 to 750 kb/s	Prioritized QoS
Video on Demand	300 to 750 kb/s	Prioritized QoS
Video Conferencing	300 to 750 kb/s	Prioritized QoS
Voice/Video telephony	64 to 750 kb/s	Prioritized QoS
Interactive Games	10 to 750 kb/s	Prioritized QoS
Remote Education	300 to 750 kb/s	Prioritized QoS

Table 4 : PC Delivered Applications and Their Traffic Characteristics

Notes:

1. Service types are those listed in Table 1 - Home Network Traffic Classes.

The following table shows rough rules of thumb, intended to provide an estimation of how well the different technologies might work in homes. Actual speeds and ranges will vary considerably based on many factors including (but not limited to) vendor selection, installation as well as the caveats included in the "Notes" section.

The last column in the table notes whether a standard to support QoS exists for the networking technology. Even in cases where a technology exists, equipment that supports the QoS standard does not tend to be widely available at this time. It should never be assumed that equipment supports QoS, unless it is explicitly stated.

Technology	Notes	750kbps +	3Mbps+	6Mbps+	9Mbps+	12Mbps +	19Mbps +	50Mbps+	90Mbps +	QoS Standard
100bT Ethernet over CAT5 cable		✓	✓	✓	✓	✓	✓	✓	✓	802.1d Annex H.2
10bT Ethernet over CAT5 cable		✓	✓	✓	✓	No	No	No	No	802.1d Annex H.2
802.11b	1, 4, 7	✓ 40-60m or 3 walls	✓ 30-35m or 1 wall	#, 1 room no walls	No	No	No	No	No	802.11e
802.11g	1, 2, 4, 7	✓ 40-50m or 2 walls	✓ 40-50m or 2 walls	✓ 40-50m or 2 walls	✓ 30-35m or 1 wall	✓ 1 room, no walls	# 1 room, no walls	No	No	802.11e
802.11a	1, 3, 4, 7	✓ 30-35m or 1.5 wall	✓ 30-35m or 1.5 wall	✓ 30-35m or 1.5 wall	✓ 20-25m or 1 wall	✓ 1 room, no walls	# 1 room, no walls	No	No	802.11e
HomePlug 1.0	1, 5, 8	✓	✓	%	No	No	No	No	No	HomePlug QoS mapped to 802.1d Annex H.2
HPNA 2.0	1, 6, 8	✓	✓	%	No	No	No	No	No	for VoHPNA only
HPNA 3.0	1, 6	√	√	√	√	√	√	√	√	HPNA3 RQoS+GQoS

Table 5 : Rate/Reach Distances for Home Networking Premises Distribution Technologies

Notes:
+ = speeds shown represent approximate application throughput achievable after physical, link and IP overheads are taken into consideration.
# = this rate can be achieved in a few homes
% = this rate can be achieved in a majority of homes
✓ = can generally cover an entire average house at this rate
1 = claims higher bit rate possible, but that is generally not achievable
2 = without 802.11b present
3 = 802.11a is not currently allowed outside North America and Japan
4 = in chart, wall = regular inside wall; floor = 2 inside walls; outside wall = 4 inside walls
5 = assumes not plugged in through surge protector or UPS, circuit not overloaded
6 = assumes minimum of CAT3 wiring
7 = wireless performance is heavily influenced by materials used in home construction, the position of walls, mirrors, fireplace, closets, furniture, presence of Bluetooth, 2.4GHz phones, microwave ovens, etc.
8 = HomePlug and HomePNA have traffic classification features but they are not accessible by applications.