



Home Gateway

WHITE PAPER

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The ubiquity of broadband connectivity and the advancements in home networking technologies introduces into market a new breed of consumer premises equipment termed as home gateways or residential gateways. Home gateway device provides the consumer, benefits such as broadband Internet connection sharing, Firewall security, VPN connectivity, IP telephony, audio/video streaming, Wireless LAN connectivity etc.

At present, home gateway devices are available in market in various physical device personalities or form factors like the SOHO Router home gateway, cable Router/MTA home gateway, DSL Router/IAD home gateway, STB home gateway etc. Each of the home gateway device personality is targeted for a particular segment and for a particular usage scenario of the end consumer. This paper discusses the various personalities of the home gateway devices along with its usage scenario.

Although the home gateway device is a consumer communication equipment with a low price point, engineering wise it is a highly sophisticated device demanding a lot of design, integration, development and testing challenges both on the hardware and on the software front. This paper details the hardware, software technical architecture and specifications of the home gateway devices and lists out the engineering design challenges (along with the possible solutions) faced by a home gateway product designer or a home gateway silicon designer.

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1 Home Gateway

1.1 What is Home Gateway?

Home gateway, also called as residential gateway is defined as an intelligent network interface device located at the consumer premises. It provides the means for the residential user to access the Internet services delivered to home and also to access the different services offered by the various smart devices located within home. Essentially the home gateway device provides the necessary connectivity features to enable the consumer to exploit the advantages of a networked home.

In technical terms, a home gateway device does the bridging/routing, protocol and address translation between external broadband network and the internal home networks. It acts as a secure firewall, and also is the focal point for applications such as Voice/Video Over IP, home automation etc. Home gateway device allows the residential users to access their home networks and to control various devices from a remote location through Internet.

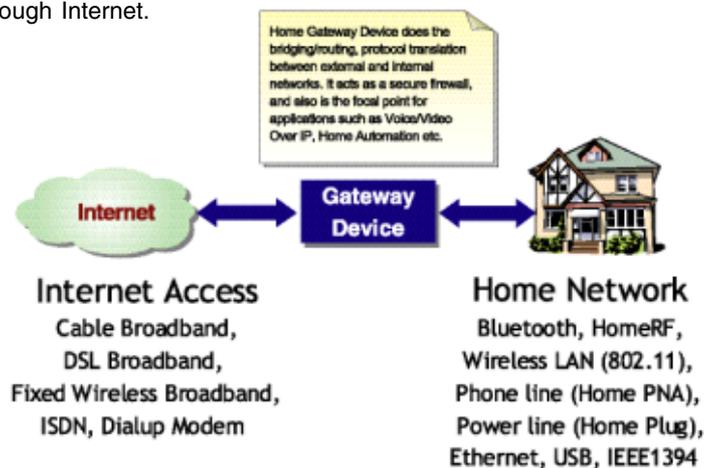


Figure 1: Home Gateway Usage Scenario

1.2 Benefits of Home Gateway

The consumer benefits provided by the Home Gateway device include:

- Internet connection sharing and simultaneous Internet access
- In-home file/print sharing
- In-home Wireless LAN connectivity
- VPN connectivity to work place
- Firewall security, parental protection
- Broadband telephony (Voice over IP)
- IP Video on Demand
- In-home audio & video streaming
- Remote health monitoring
- Security surveillance
- Home automation & home control
- Remote meter reading

For the Service Provider, the home gateway device provides the following benefits:

- New revenue streams due to new and differentiating services/applications
- Ability to deliver multiple services through a single consumer premises equipment
- Ability to reduce the expensive truck roll costs

1.3 Home Gateway Market Potential

With the increased penetration of broadband and with the technological advances in home networking, there is a considerable market demand for the home gateway devices.

Wireless SOHO Router home gateway devices from vendors like D-Link, Linksys, Netgear etc. are very popular in North America. And there is a renewed interest among the silicon vendors in the home gateway market and we see all the major silicon vendors viz. Intel, Conexant, Texas Instruments, Broadcom, Motorola etc. offering custom communication ASICs for the home gateway devices.

Allied Business Intelligence (ABI) predicts that the home gateway equipment annual revenues would scale to USD 7.1\$ billion by the year 2006.

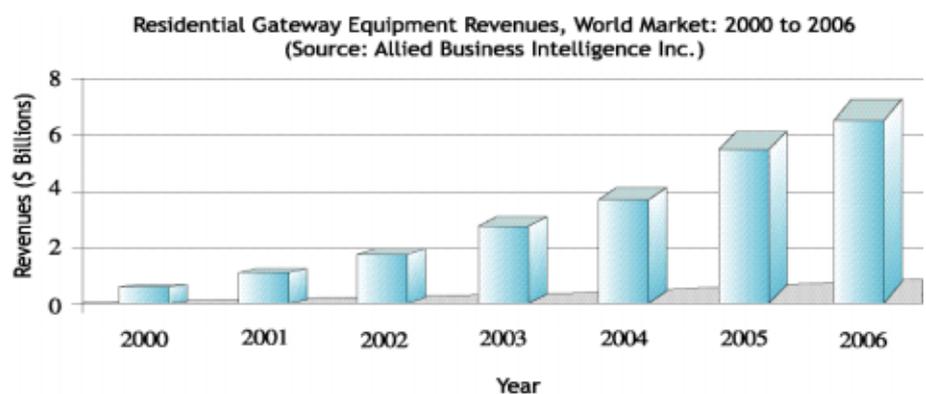


Figure 2: Home Gateway Market Potential

2 Home Gateway Device Personalities

At the technical functionality level the home gateway device performs the activities such as bridging, routing, security processing (Firewall, VPN), address management, quality of service etc. However the home gateway device may take various physical device personalities or form factors.

The various physical device personalities of a home gateway is described in Figure-3. Examples of the home gateway device personalities available in the market is provided in Table-1 . Subsequent sections of this paper explains in detail the usage scenario of each of the home gateway device personality along with the typical applications/benefits the home gateway device personality provides.

The traditional broadband modem devices (cable modem, DSL modem, fixed wireless modem) could be added with the home networking hardware and software functionality so as to perform the role of a home gateway. Most of the new broadband modems in the market have the home networking functionality and hence classify as home gateway devices. The popular home networking options include the Wireless LAN, Home PNA, 4 Port Ethernet Switch, Home Plug etc. and the desired software functionality include bridging, routing, Voice Over IP, VPN, and Firewall Remote Management capabilities.

The traditional Digital Settop Box (STB) is a consumer device providing services like HDTV, content decryption, Personal Video Recorder, electronic programming guide etc. Optionally it provides Web browsing and interactive television features. The Digital Settop Box is fast evolving in to a Settop Box home gateway, where in it caters to the data, voice

and entertainment connectivity needs of all the devices located in the household and does not limit the connectivity to the TV set alone. STB home gateway is essentially a functional combination of normal STB, broadband modem, home networking and IP streaming capability.

The other device personalities that can be classified as home gateways include the home automation and security gateways. These devices are not full-fledged home gateways. They only provide a subset of the home gateway functionality and serve the niche need of home security surveillance and automation.



Figure 3: Home Gateway Device Personalities

Table 1: Home Gateway Device Personalities in the Market

Home Gateway Personality	Intended Functionality	Example Products in Market
SOHO Router Home Gateway	Broadband Internet Connection Sharing, VPN, Firewall, Parental Filter, Wireless LAN Residential Access Point	D-link DI-713P, Netgear RP334, Linksys BEFW11S4, Panasonic KX-HGW200
Cable Router Home Gateway	Secure Cable Broadband to Multiple Clients, VPN, Firewall, Parental Filter, Wireless LAN Residential Access Point	Cisco uBR905, Linksys BEFCMUH4, Motorola (GI) SBG1000
Cable MTA Home Gateway (SMTA, EMTA)	Data and Voice Over Cable Broadband Through the PacketCable Standard	Toshiba PCX3000, Arris TouchStone, Tellabs CVM315A, ADC BTI, Thomson THG440
DSL IAD/Router Home Gateway	Secure DSL Broadband (voice and Data) to Multiple In-home Client Devices	Intel AnyPoint 4200, 2 Wire Home Portal 1000, PolyCom NetEngine 8000, CISCO IAD 2400
Digital STB Home Gateway	IP Based Video/Entertainment, Streaming, VOIP and Shared Internet Connectivity	Scientific Atlanta Explorer 4000, PACE DSL 4000, Motorola / GI DCT 5100, 5200
Other Types of Home Gateway	Security/ Home Automation Gateway, PC Based Gateway etc.	Coactive Connector-2010, Echelon I.LON1000, IBM Home Director, Ericsson Ebox

Parks Associates classifies the home gateway devices based on their functionality (personality). Parks Associates predicts that STB based home gateway device personality would be the dominant physical form for the home gateway by 2005. This is shown in Figure-4.

As per the Parks Associates classification, Virtual RG is the device, which is separate from the broadband and provides the home networking support through bridging and routing. This can be mapped to the SOHO Router home gateway device personality. Web centric RG is a broadband modem with built-in home networking functionality (routing/bridging). This can be mapped to the cable Router and DSL Router device personalities of home gateway. Multi-service RG is a device which provides data, voice/video and home networking functionality. This can be mapped to the cable MTA and DSL IAD device personalities of the home gateway. Thin server gateway is a niche home gateway performing the specific functionalities like home security/home automation etc.

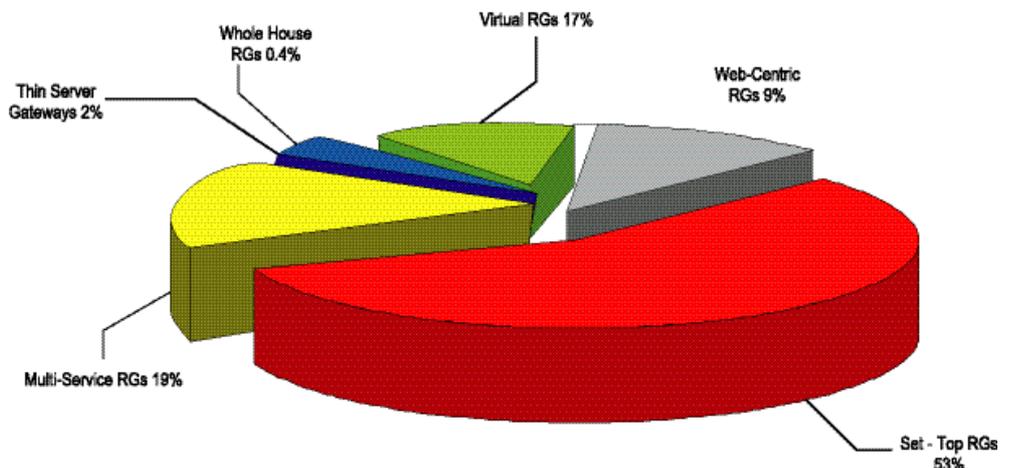
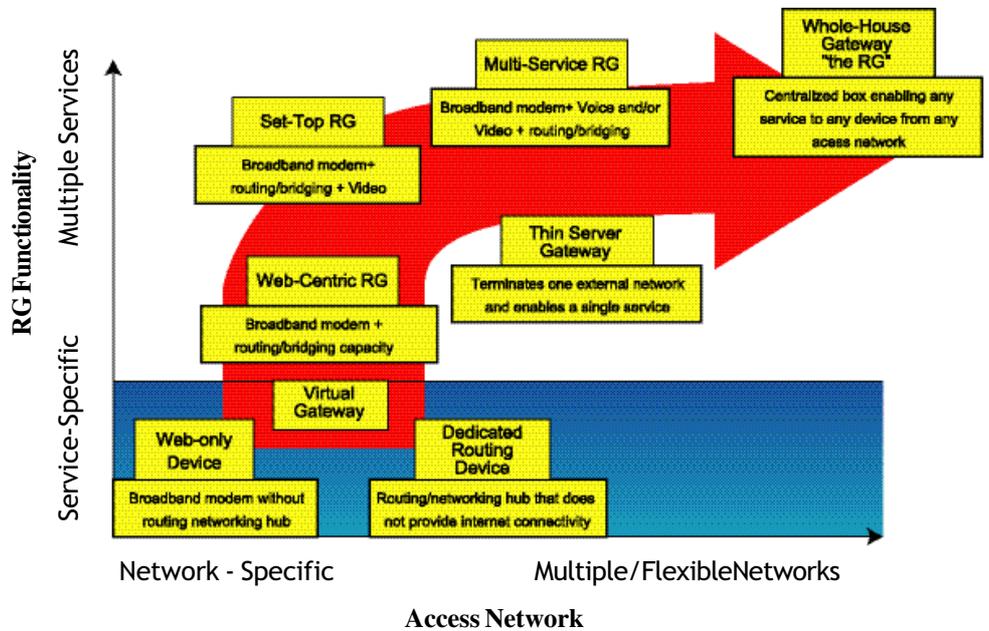


Figure 4: Home Gateway Classification (Parks Associates)

2.1 SOHO Router Home Gateway

SOHO Router is a consumer communication device that is connected to the external broadband modem (Cable or DSL modem) via Ethernet or USB and supports Internet connectivity sharing and several other consumer benefits. It is essentially a two box solution (SOHO Router works in conjunction with a Cable or DSL broadband modem) and it could optionally contain the Wireless LAN (IEEE802.11) Access Point functionality. The typical usage scenario of SOHO Router home gateway is shown in Figure-5.

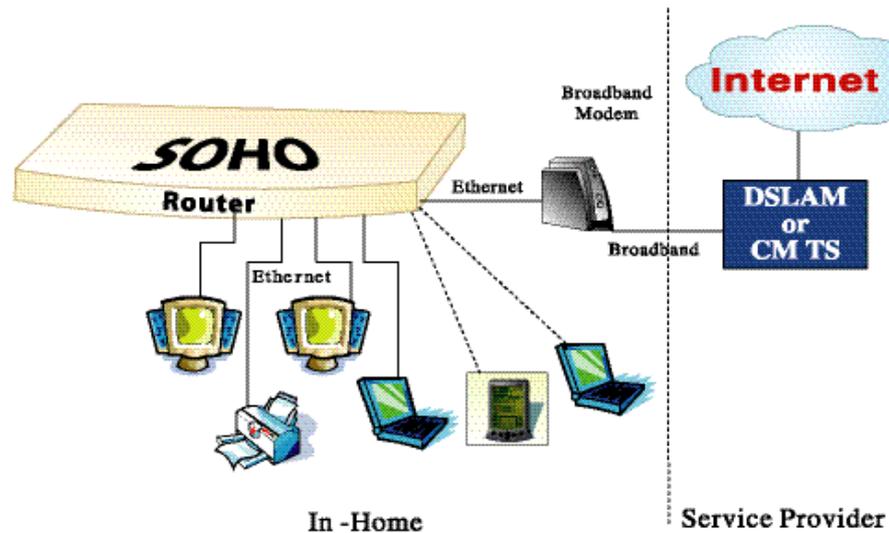


Figure 5: SOHO Router Home Gateway Usage Scenario

2.2 Cable Router Home Gateway

Cable Router (also called as cable home gateway) device is a one box solution integrating the DOCSIS cable modem device and the SOHO Router device. Cable Router facilitates the cable broadband Internet connection sharing, VPN and other applications all in one box. Application scenario of cable Router home gateway is shown in Figure-6.

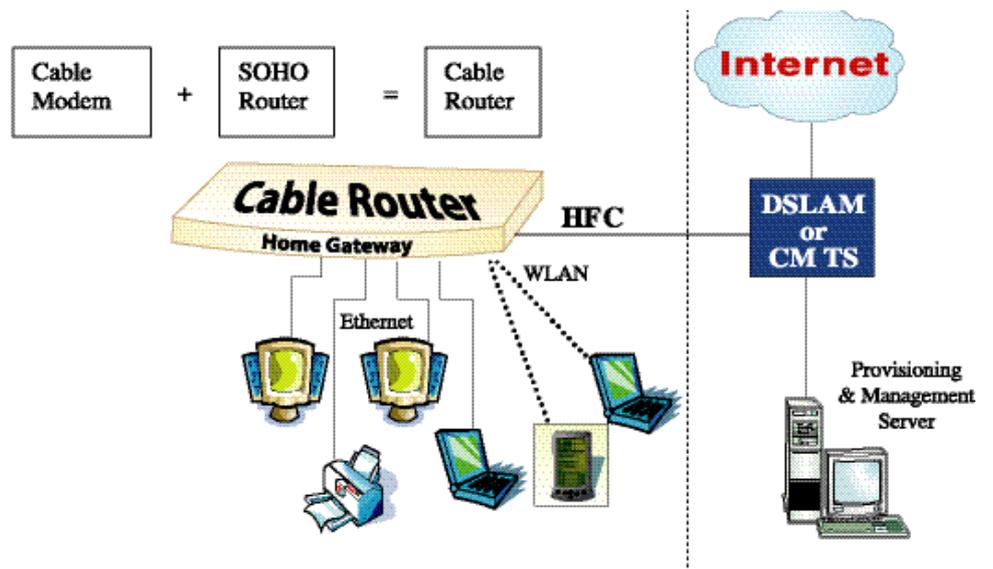


Figure 6: Cable Router Home Gateway Usage Scenario

2.3 Cable MTA Home Gateway

Cable MTA (Multimedia Terminal Adaptor) home gateway device provides the Voice and IP Video functionality over cable broadband and is based on the PacketCable Standards from Cablelabs. There are two flavors of cable MTA:

- EMTA (Embedded Multimedia Terminal Adapter) is a one-box solution providing both Voice Over Cable and High Speed Data Over Cable Broadband. A DOCSIS 1.1 Cable modem providing the Voice Over Cable functionality is an EMTA.
- SMTA (Standalone Multimedia Terminal Adapter) is a two-box solution. SMTA device providing the Voice Over Cable functionality is externally connected to a DOCSIS 1.1 cable modem through the USB or Ethernet port.

The application/usage scenario of Cable MTA home gateway is shown in Figure-7.

Voice Over Cable (through PacketCable) is deployed in several regions of USA by major operators like Time Warner, Cox etc. and is in field trials by other operators. Euro PacketCable is under development for Euro DOCSIS systems. The main difference between Voice Over Cable (Packet Cable) and normal Voice Over IP (IP Telephony) is that the Cablelabs PacketCable defines complete specifications for addressing the end-to-end quality of service guarantee, security and provisioning aspects of the voice calls over cable broadband. Normal IP telephony standards like H.323 or SIP defines only the telephony signaling and does not address the important QoS, security and provisioning aspects of the voice calls. Conformance to PacketCable Standard, for the MTA device ensures the interoperability/compatibility with the cable head end systems deployed in North America.

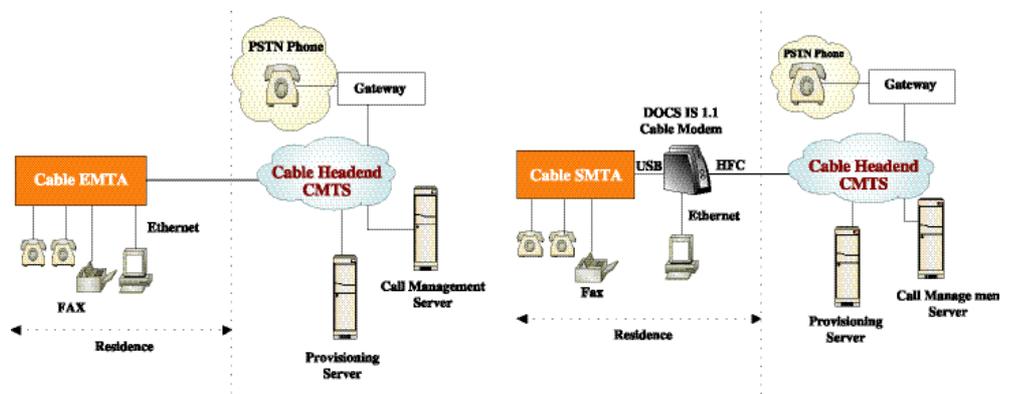
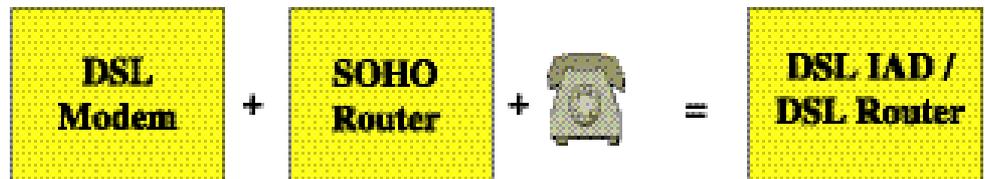


Figure 7: Cable MTA Home Gateway Usage Scenario

2.4 DSL IAD / Router Home Gateway

DSL IAD (Integrated Access Device) is a single box consumer premises equipment solution, providing for the simultaneous high speed Internet data access and toll quality voice calls over DSL broadband connection. DSL IAD could additionally incorporate the SOHO Router functionality (hence called a DSL Router or DSL residential gateway) and provides for the Internet connection sharing, VPN and Wireless LAN access point benefits to the consumer.



DSL broadband is based on the ATM technology. Data over DSL is transported as AAL5 cells and IP packets are encapsulated in the AAL5 cells. Voice calls (called as derived voice lines) can be made over DSL broadband in two ways :

- Voice Over DSL: Voice is transported as AAL2 cells. BLES (Broadband Loop Emulation Service) spec TR-036 of DSL forum defines the guidelines.
- Voice Over IP Over DSL: Voice is transported as IP packets (RTP Packets) which are encapsulated in AAL5 cells. MGCP is commonly used for signaling. However H.323 and SIP signaling are also used based on the investment decisions of TELCO.

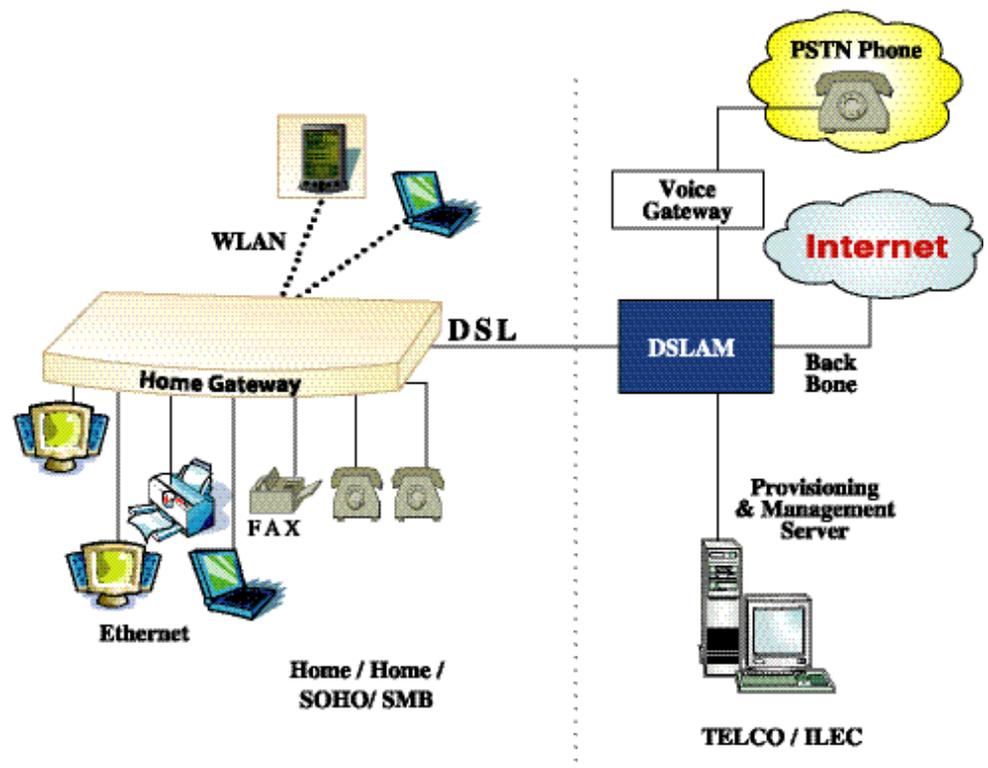


Figure 8: DSL IAD / Router Home Gateway Usage Scenario

2.5 Digital Settop Box Home Gateway

Digital Settop Box (STB) is a consumer device connected to a TV set to provide the services like Digital High Definition Television, Content Decryption (based on consumer subscription of pay channels), Personal Video Recorder, Electronic Programming Guide etc. Optionally it provides Web browsing and interactive television features. STB gets the content feed (channel programming) from digital cable, terrestrial or satellite broadcast and the return path for the interactive TV up-clicks could be either through a dialup or broadband modem which could be built-in or connected externally.

The Digital Settop Box device is fast evolving in to a Settop Box home gateway, where in it caters to the data, voice and entertainment connectivity needs of the entire household and does not limit the connectivity to the TV set alone. This is attributed to the factors described below.

- Consumers demand to see the media content /programming and streaming audio/video on multiple TV sets/display devices
- Advances in home networking technologies (especially Wireless LAN)
- The availability of multiple PCs, information appliances (like PDAs, Web Pads etc.), intelligent/smart home devices and increase of telecommuters
- The penetration levels and reach of broadband connectivity



In addition to the traditional functionality of digital/HDTV, Content Decryption, Pay Per View, PVR, EPG, and Interactive TV, the STB home gateway device provides the below mentioned additional consumer benefits. The application/usage scenario of an STB home gateway device is shown in Figure-9

- High broadband connectivity to the multiple PCs, and the information appliances in the house hold. high speed Wireless LAN access to anywhere in the house
- In-home file/print/device sharing
- Firewall security, parental protection and VPN connectivity
- Show the content programming (directly received through satellite, cable, terrestrial or stored in the STB PVR hard disk) on to multiple TVs and display devices located in various rooms of the house
- Streaming content and IP Video on Demand (received through broadband Internet connectivity or stored in the STB PVR hard disk) on to multiple TVs and display devices located in various rooms of the house
- Enables remote health monitoring and security surveillance applications

In the case of a voice enabled home gateway, DSP and SLIC are needed for the voice

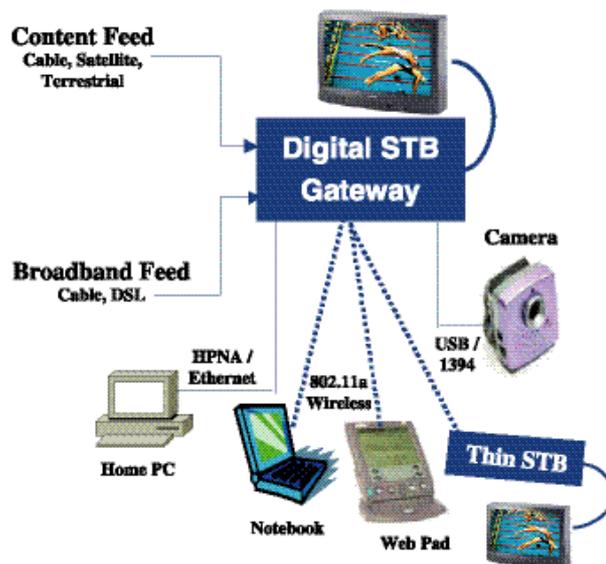


Figure 9 : Digital Settop Box Home Gateway Usage Scenario

The Consumer benefits offered by Home Gateway Device Personalities are summarized in Table-2.

Table 2: Summary of Consumer Benefits offered by Home Gateway Devices

Consumer Benefit	SOHO Router	Cable Router	Cable MTA	DSL Router	DSL IAD	STB Gateway
Broadband Connection Sharing	Yes	Yes	Yes	Yes	Yes	Yes
File / Print / Device Sharing	Yes	Yes	Yes	Yes	Yes	Yes
VPN Connectivity to Work Place from Home	Yes	Yes	Yes	Yes	Yes	Yes
VPN Connectivity to Home/Office from external world	Yes	Yes	Yes	Yes	Yes	Yes
Print Server	Yes	Yes	Yes	Yes	Yes	Optional
Web Based Configuration and Administration	Yes	Yes	Yes	Yes	Yes	Displays on TV
Voice Over Broadband Support	No	No	Yes	No	Yes	Optional
Firewall Protection	Yes	Yes	Yes	Yes	Yes	Yes
URL Filter (Parental Filter)	Yes	Yes	Yes	Yes	Yes	Yes
Wireless LAN Connectivity	Yes	Yes	Yes	Yes	Yes	Yes
Service Provider Manageability (CableHome)	Yes	Yes	Yes	No	No	Optional
One Box Solution (Home Networking + Broadband)	No	Yes	Yes	Yes	Yes	Yes
Video Conferencing / Video Phone Over Broadband	No	No	Yes	No	Yes	Yes
In-Home Audio / Video Distribution & Streaming (VoD)	No	No	No	No	No	Yes
Home Automation and Control	No	No	No	No	No	Yes

3 Technical Architecture of Home Gateway

3.1 Hardware Architecture

The home gateway device hardware could be implemented as a single chip solution or a single board solution or a multi board solution depending on the perceived device volume and BOM cost trade offs. The hardware architecture for a home gateway device (implemented as a custom communication ASIC) is illustrated in Figure-10.

At the functional level the home gateway device SOC contains a RISC processor core, memory, DMA controllers and peripheral I/O interfaces. The I/O interfaces could be embedded with in the home gateway ASIC or they can be located as an external chip on the home gateway hardware board. The popular home networking interfaces include Ethernet (as a 4 port Ethernet switch) , Home PNA (phone line), Home Plug (power line), USB Device, USB Host, IEEE 1394, Wireless LAN, and Bluetooth. The popular broadband Interfaces include cable and DSL. In general all the MAC's could be implemented in the ASIC itself and the PHYs can be connected externally to the home gateway ASIC.

compression and for analog phone connectivity. Some home gateway designs use an external DSP, whereas some implement the DSP instruction set in the custom ASIC through either the usage of a RISC/DSP combo processor core or through the usage of a DSP processor core. There are also implementations, where the Real Time Protocol (RTP) packetization of the voice samples could be done within the hardware itself.

To improve the performance of the VPN functionality, the security (Crypto) algorithm functionality could be implemented in the hardware itself though a dedicated security coprocessor.

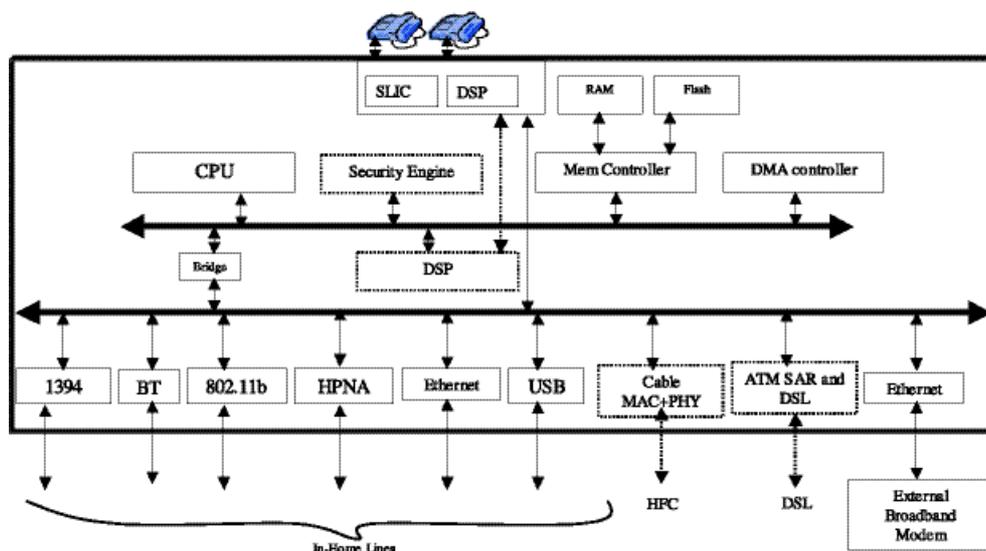


Figure 10: Home Gateway Hardware Block Diagram

3.2 Software Architecture

The software building blocks of a home gateway device is shown in Figure-11. The software for home gateway devices can be classified into three levels: firmware, OS and application software stacks. The firmware level software includes the diagnostics, boot loader, debug interface drivers and operating system board support package. The home gateway device needs an embedded operating system, with the device drivers for all the on-board and on-chip physical interfaces like the cable, DSL, Wireless LAN, Ethernet, USB, 1394, Bluetooth, Home PNA, Home Plug etc. The Popular embedded operating systems include Embedded Linux, VxWorks, Nucleous etc.

The home gateway application software stacks, shown in Figure-12 and explained in Table-3, provide the core functionality of the home gateway. The home gateway application stacks are comprised of the following software components:

- Communication protocol stacks for Routing, Bridging, Address Management (DNS, DHCP, NAT), quality of service (class based queuing, RSVP), security (VPN, IPSEC, Firewall), Remote and System Management (SNMP, Software Upgrades, HTML UI, UPnP IGD)
- Voice Over Cable (Cablelabs PacketCable) and Voice Over DSL (DSL Forum BLES Specification) and Voice Over IP (H.323, SIP, MGCP) infrastructure software stacks

- Audio/video streaming (RTP, RTCP, SDP, RTSP) and application service delivery (UPnP, OSGi) software stacks.

All the software components for home gateway devices are based on the open standards like IEEE specifications, IETF RFCs, ITU specifications and industry specific forums like Cablelabs, DSL/ATM Forum, UPnP Forum, OSGi Consortium etc. The home gateway software should have well defined interfaces to integrate with the underlying hardware and should hold finely defined and documented APIs for the application development.

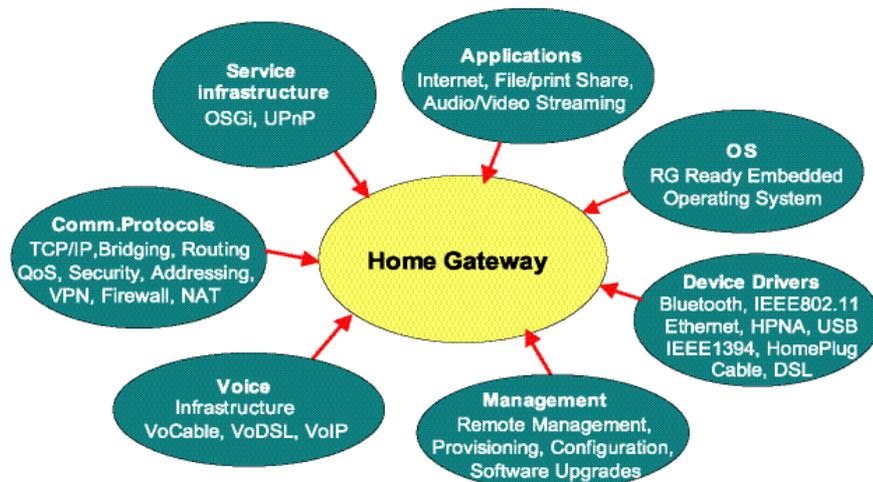


Figure 11: Home Gateway Software Building Blocks

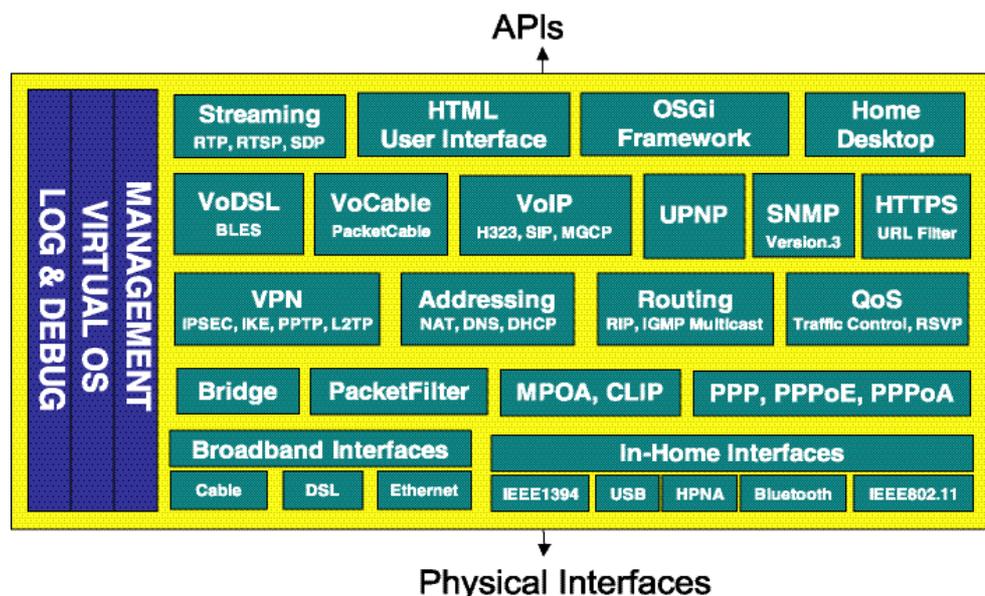


Figure 12: Home Gateway Software Stack

Table 3: Home Gateway Software Specifications

Interfaces	Broadband: Cable, ADSL, Fixed Wireless In-home: IEEE802.11b, Bluetooth, IEEE1394, USB, HomePNA, Ethernet
Protocol Bridging	Spanning tree (IEEE802.1d) & Transparent Bridging, Media Translation
Routing	RIP (RFC1058), Multicast Routing (through IGMP Proxy)
Addressing	NAT/NAPT (RFC1631, 2993), DHCP client, server (RFC2131,2132), Dynamic DNS (RFC 1034-35, 2136, 2535)
QoS	RSVP (RFC2205, 2210) and Traffic Control Module implementing the Class Based Queuing
Security	Layer 2 Stateful and dynamic IP Packet Filtering, URL Filter, HTTPS
VPN	IPSec (RFC 2401, 06), IKE, PPTP (RFC2637), L2TP (RFC2661), PPPoE (RFC2516). Easy integration with 3rd party h/w & s/w crypto libraries - SHA-1, MD5, 3DES, AES
Data Over DSL	ILMI, Classical IP & ARP Over ATM, MPOA (RFC1483), PPPoATM (RFC2364), OAM
Voice Over DSL	BLES (DSL Forum TR-036)
Voice Over Cable	PacketCable NCS (MGCP), PacketCable MTA
VOIP	H323, SIP and MGCP protocols
Streaming Stack	RTP, RTCP, SDP, RTSP, MEP Over RTP
Remote Management	SNMPv3 (RFC1157, 2271-227) with MIBS, Remote Software Upgrades, Logging and System Trace Features
Service Discovery	UPnP Application Framework, OSGi Application Framework, Application Bridging
Home Desktop	Application framework for easy and quicker deployment of Web Based Portal Applications to Discover, Operate, Control, Monitor and Administer the home devices and services

3.3 Home Gateway Engineering Design Challenges

Since the home gateway device is a consumer premises equipment, with low price point, it poses a number of engineering design challenges and constraints for the product manufacturers and silicon vendors. Explained below are a few of the software challenges and the proposed solutions for these challenges.

Low BOM cost : It would be a design challenge to manage the BOM cost within the prescribed limits, without compromising on the feature set and functionality. The home gateway software should occupy minimal FLASH and RAM. To accommodate this, the code should be optimized, pruned and should include only those features that are required. The software components should be well integrated to reduce redundancy of code. Home gateway usually runs on a low powered processor. To accommodate this, the software is separated into control and data path. The data path is frequently traversed, hence the source code for it has to be highly profiled and finely tuned, and code segments have to be optimized for performance. Data path can also utilize the services of hardware accelerators (e.g. DES, SHA-1, Bridging/NAT etc.).

Interoperability : Home gateway device has to be interoperable with other devices and network elements. Interoperability gives confidence to the end user, that he can communicate to any body in the world over his broadband network. This is a very time consuming and capital-intensive process and can be achieved through the participation in the interop and dry-run events organized by the standards forums. On the data side, VPNC, UPnP, ICSA CableHome certifications help home gateway to be interoperable. A Cable MTA home gateway device has to be interop tested with other MTA devices and with multiple Call Management, Gateway and Provisioning Servers deployed at the cable head end.

DSL IAD home gateway device has to be interop tested with other DSL IAD devices and with multiple voice gateway and Provisioning Servers deployed in the field, which is achieved through the participation in the interop and dry-run events organized by the organizations like OpenVoB CallFests, CIRPACK, NH-IOL.

Standards Compliance : Open Standards Compliance is a must for the home gateway device, which incorporates advanced technologies. Open Standards Compliance and non-proprietary technologies guarantee an assured migration path for the next generation of features and helps in the maintainability of the Intellectual Property. The Open Standards to be followed include the IEEE Standards, IETF RFCs, Cablelabs Specifications and DSL Forum Recommendations. Cable MTA Home Gateway is based on the PacketCable spec, which is big and covers diverse areas as Signaling, CODECs, Security, QoS, Provisioning and Event Messaging. PacketCable is still evolving, and certain portions of the spec (for SMTA) is under development. DSL IAD home gateway is closely coupled with DSL forum and ATM forum specs. These standards keep evolving from time to time. Working with evolving standards is not easy, since the development engineers have to be on top of every ECR/ECN that are submitted for the spec. This is where a licensed solution from a reliable vendor would be of value compared to the home grown solution; since the licensed stack takes care of the complete standards compliance and would provide assured migration path.

Well Defined Programmer Interfaces / APIs : Home gateway device software should have well defined interfaces for integration with the various types of Voice CODECs, various DSP/SLICs, and should have well defined interfaces for the QoS Module (RSVP or DQoS), Security Module (hardware or software crypto, RSA, SHA etc.), various ATM SAR in case of DSL (AAL2 And AAL5). Well-defined interfaces protect the investment of the home gateway device manufacture and also saves valuable engineering time, in the event of change of the hardware components or certain software components. In the case of an STB gateway, the infrastructure communications software stacks pertaining to the gateway, has to integrate well with the traditional STB software like the Conditional Access, Middleware, TV APIs etc. The stacks have to be easily portable to the STB OS (popular ones being VxWorks, Embedded Linux, Nucleous, PowerOS etc.).

Integrated Address Repository : For reasons of processing efficiency, many of home gateway software modules (such as packet filter) formulate/use rules based on IP address. Each time an in-home device is rebooted it may acquire a different IP address (from the DHCP Server), resulting in malfunctioning of certain software modules. Hence there is a need for an Integrated Address Management System, which informs all relevant modules about the IP address changes; giving details of host name, old IP address and new IP address.

Reliable Software/Firmware Upgrades : Possibility of power failure during firmware upgrade may lead to non-usable home gateway box. This possibility should be minimized. The firmware is divided into two parts (A - basic needed for obtaining new image and upgrading the firmware, B - full functionality). Part A needs to be rarely/never upgraded. After, the power comes, Part A checks for the sanity of part B firmware, and in case it identifies corruption, it automatically obtains the new firmware from the vendor's web-site and upgrades the home gateway.

Configuration Changes by End User : When configuration rules are modified by end user (without proper knowledge), the system might not function as expected. For supporting this, the user configuration is to be minimized and the user should also be provided with sufficient documentation (both on-line and off-line). User should be provided with an option to restore previous settings (saved somewhere else in the network).

NAT ALGs : To support Internet sharing, the private IP addresses of all outgoing packets are translated by NAT, to use Router's public IP address. However, some applications embed IP address within the packets exchanged with peer devices. Such applications would not work because NAT cannot decipher the application payload. Additional processing, specific to each application needs to be done along with NAT to enable support for such applications. This is called ALGs (Application Level Gateways). Since there are many such applications, supporting all ALGs in one-go is not easy, so a well-documented framework is needed to develop ALGs for new applications. This framework reduces the effort required for adding new ALGs.

Internet Gateway Device (IGD) Profile of UPnP : facilitates the Windows client based applications to find the gateway's translated addresses, after communicating with the home gateway's NAT. Applications can then use this information inside the payload of their packet exchanges. This is called NAT traversal using UPnP. This avoids the need for modifying the router's firmware for supporting new applications.

CableHome Management : CableHome facilitates the MSO, to provision and manage the home gateway device and the home network for the managed service deployment capabilities. It includes remote diagnostics for each of the network interfaces, configuration of Firewall/NAT rules, and NAT ALGs for frequently used applications, and providing pass through support for in-home devices having external IP address etc. CableHome support needs extensive SNMPv3 MIB instrumentation, CableHome Portal Services and provisioning related feature additions to the cable Router and involves extensive amount of certification and interop testing.

Quality of Voice : One of the objectives of voice enabled home gateway device is to provide a toll quality voice. While there are a number of parameters that come into play for the quality of voice; the important ones would be the selection and usage of correct DSP CODECs, real time performance of the RTP media stack, implementation of Jitter Buffer, latency of the packets etc. To maintain the toll quality voice, the packet processing has to be very accurate in VoDSL IAD's. This is accomplished by implementing the ATM AAL2 components I.366.2 and AAL2 CPS with a real time performance, which also takes care of silence suppression, Jitter Buffer and latency.

Ability to Support Multiple In-home Display Clients : Since the STB home gateway can stream the media content and IP content to a number of in-home client devices with displays (like TVs connected to Thin STBs, Web Pads, IAs etc.) the streaming software has to be based on open standards like the IETF RFC Based RTP/RTCP and RTSP and has to support multiple content streams like MPEG4, MPEG2 etc. The streaming Software has to be interoperable tested with many streaming clients and servers.

4 Wipro Home Gateway Solution

Wipro Home Gateway Software Solution (Figure-13) is a complete infrastructure software providing rich functionalities. It is based on open standards like IETF RFCs, IEEE, ITU Standards, CableHome, PacketCable, DSL Forum, OSGi, and UPnP etc. and is easily customizable to any home gateway device personality/form factor. Reference port of software is available on embedded Linux and VxWorks operating system and hardware platforms based on x86, MIPS and ARM processors. It provides comprehensive set of APIs to the equipment vendor for building various gateway applications and has well defined interfaces for ease of porting on to the hardware platforms.

Specifications

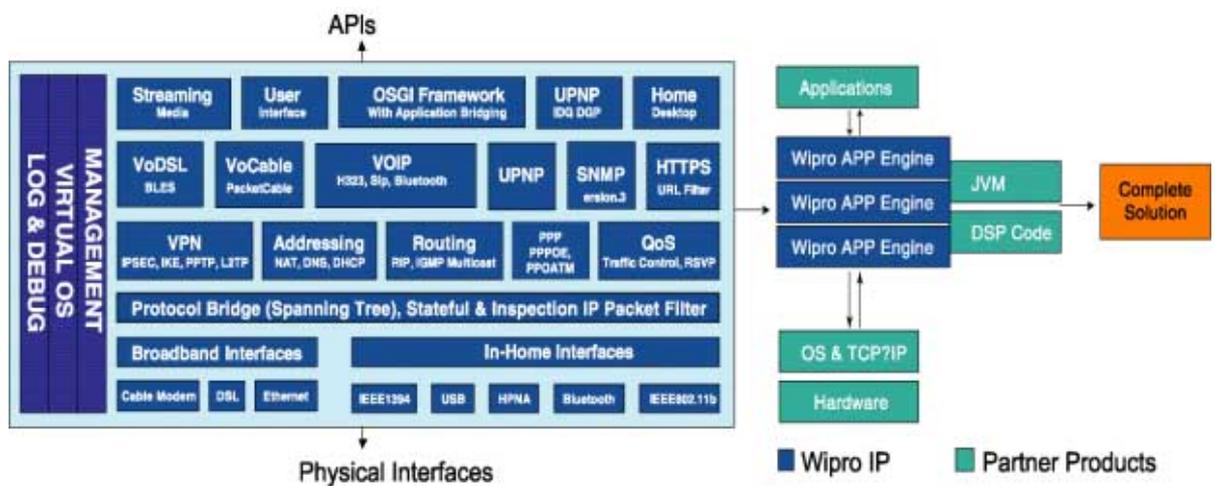


Figure 13: Wipro Home Gateway Solution

Wipro home gateway provides the complete solution to the customer, meeting most of his current and future requirements by taking care of various integration issues involved. Since 75% of the solution is pre-built and integration tested, this translates to cost savings of 30% - 70% and substantial time to market advantage to the product OEMs. Wipro can help the customers to roll out their product in around six months time, using this software solution. Home gateway software is backed by Wipro's strong design services that will help porting this solution to any relevant hardware platform and in customization.

4.1 Significant Time to Market Advantage

- Wipro Home Gateway Solution is Open Standards based and is well tested for device/technology Interoperability
- Wipro Home Gateway Solution addresses all the present and future software needs of residential gateway and other CPE devices
- Wipro Home Gateway Solution suite, provides software stacks for Advanced Communication Protocols, Voice Over Broadband, Voice Over IP, IP Video Streaming, UPnP and OSGi
- Software integration is the largest time consumer in CPE device space, which is taken care by the pre-built and tested Wipro Home Gateway Solution
- Well defined Interfaces and APIs for ease of porting/integration and facilitates easy application development

4.2 Reduced Total Cost of Ownership

- The code size of Wipro Home Gateway Solution is optimized to use minimum FLASH and RAM memory there by reducing the over all product BOM cost
- The BASIC Communication Engine package of Wipro can fit into a 2MB FLASH and needs no more than 4MB RAM
- Cost of in-house software development and integration would be greater than the Wipro Home Gateway Solution licensing cost
- Wipro is one stop shop for all outsourcing / IP needs. OEM customers do not have to deal with many parties and no need to pay multiple royalties
- In addition to the Home Gateway Solution, Wipro offers extensive product design/ engineering and services like customization, porting, certification, maintenance, continuous engineering etc.

5 References

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- [6.] DSL Forum (www.dslforum.org) Specifications

6 Glossary

API	Application Programming Interface
ASIC	Application Specific Integrated Circuit
ATM	Asynchronous Transfer Mode, a prominent Packet based transport technology
Bluetooth	Bluetooth is a short range wireless interconnection technology specification for hand held devices like Palms, Pagers, Mobiles, PDA etc.
BOM	Bill Of Material Cost
Broadband	Broadband refers to telecommunication that provides multiple channels of data over a single communications medium, typically using some form of multiplexing
CODEC	Coder / Decoder used for Packetization of Voice into Samples and further compression
CableHome	Home Networking Specification from Cablelabs extending the QoS, Manageability and Security aspects to the end devices on the home network
CPE	Consumer Premises Equipment
DOCSIS	Data Over Cable Specifications from CableLabs
DSL	Digital Subscriber Line. It is a digital technology for transporting faster bit streams over the ordinary copper telephone lines.
DSP	Digital Signal Processor
H323	Signaling Standard for Voice Over IP
HDTV	High Definition Television
HFC	Hybrid fiber coaxial (HFC) network is a technology in which optical fiber cable and coaxial cable are used in different portions of a network to carry broadband content (such as video, data, and voice).

HPNA	Home Phoneline Networking Association is a consortium of companies working on technologies to transport high speed data over the in-home phone line networking
Home Plug	Home Powerline Networking Association is a consortium of companies working on technologies to transport high speed data over the in-home electric wiring
IAD	Integrated Access Device. It is a device through which both Data and Voice can be accessed over a DSL network.
IEEE 1394	High Speed Serial Bus Standard for transferring Audio/Video Content
IEEE 802.11	High speed Wireless LAN standard
IP	Internet Protocol (also Intellectual Property)
MAC	Medium Access Controller
MGCP	Media Gateway Control Protocol (for Voice over IP Signaling)
MIPS	Name of a micro processor from MIPS Inc (also Million Instructions Per Second)
MTA	Multimedia Terminal Adapter. It is a device using which Video and Voice (multimedia) can be transmitted over Cable Data networks
NAT	Network Address Translation
NCS	Network Call Signaling (a variant of MGCP employed by PacketCable)
OS	Operating System
OSGi	Open Services Gateway Initiative
OEM	Original Equipment Manufacturer PacketCable Standards for transmitting voice and video services over Cable Data networks
PBX	Private Branch Exchange
PC	Personal Computer
PDA	Personal Digital Assistant. It is a small mobile hand-held device that provides computing and information storage
PSTN	Public Switched Telephone Network
QoS	Quality of Service
RG	Residential Gateway or Home Gateway Device
RTCP	Real Time Control Protocol
RTP	Real Time Protocol
SDP	Session Description Protocol
Settop Box (STB)	This is the black box sitting over TV. It's main function is decrypt DTV signals and signals for Pay Per View TV Channels received over cable. Advanced Settop Boxes have more features like Interactive TV, Personal Video Recording etc.
SOC	System On Chip
SOHO	Small Office Home Office
SIP	Session Initiation Protocol (for Voice Over IP Signaling)
SLIC	Serial Line Interface Card. Set of R11 ports for Phone/Fax Connectivity
SNMP	Simple Network Management Protocol
TCP	Transmission Control Protocol
UPNP	Universal Plug And Play. This is a device discovery and coordination protocol being pioneered by Microsoft.
USB	Universal Serial Bus
VLAN	Virtual LAN
VOIP	Voice Over IP Network
VPN	Virtual private Network
Web Pad	A touch screen based thin slate like device, which provides Internet Access and Browsing.



About the Author

Satish Gupta is a Technical Product Manager at Wipro Technologies, Bangalore. He takes care of the product management for Wipro's Home Gateway Solution. Satish is a member of CABA's (www.caba.org) Information Council and has authored several white papers in the home networking and residential broadband domain.

Satish received his Masters in Telecommunication Engineering from Indian Institute of Technology, Kharagpur and MBA from Indian Institute of Management Bangalore.

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