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# *The Residential Gateway Report*
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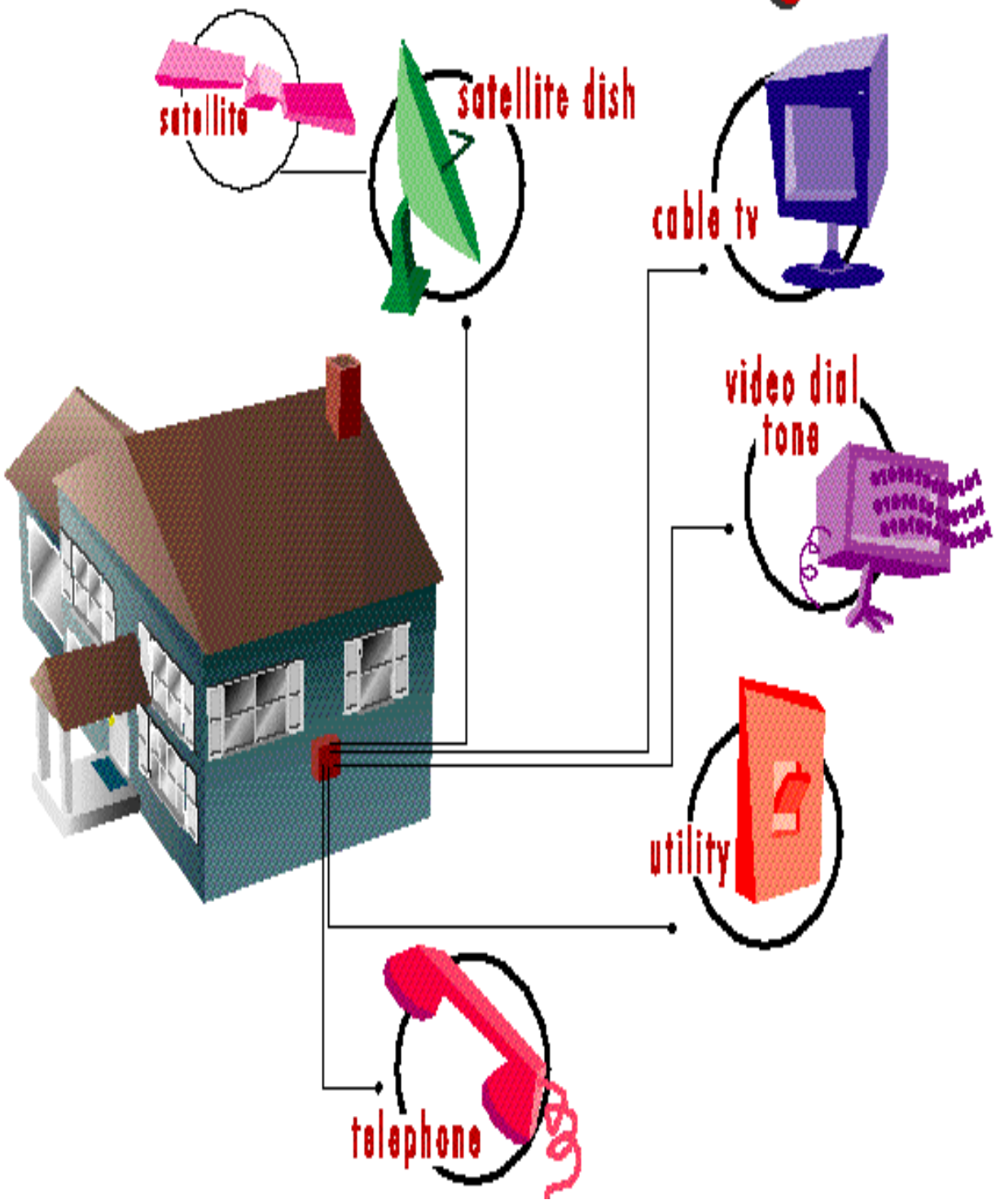
# the Residential Gateway



# The Residential Gateway Report

By:

- B&C Consulting Services;
- Bellcore;
- David Sarnoff Research Center
- GTE;
- Hewlett-Packard; and
- IBM.

Report Date: December 1995

Reprint Date: December 1998

# TIA/EIA
# Residential Gateway

By:

- ANSI/TIA/EIA TR41.5 Residential Gateway Task Group

Report Date: December 1998

Reprint Date: December 1998

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# Preface

An informal group of companies consisting of: David Sarnoff Research Center, GTE, Hewlett-Packard Co., IBM Corporation, Bellcore, Reltec, and B&C Consulting came together in early 1995 to develop the Residential Gateway (RG) concept with the goal of cost effectively meeting the needs of video service providers, cable companies, telcos, utilities, and consumers. The RG Group consists of interested companies who have a common vision for bringing information into the home. While some of the material in this document is now dated, CABA members may still benefit from this RG information.

The purpose and charter of the RG Group was to develop this report which focuses on the RG approach to deliver and manage information flexibly to and from the home. For this vision to be accepted, a standard architecture must be adopted. The RG Group will not identify a standard architecture, but rather develop a concept and identify a set of design principles that embody the RG approach. The RG represents a specific application of the work ongoing in DAVIC, ATM Forum, EIA, VESA, and IEEE802.14. The RG is not meant to compete with, but integrate into, these implementation groups.

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# Concept

**Needs of the Consumer**

Around the world deregulation of the telecommunications industry is resulting in competition among telephone carriers, cable TV services, utilities and other newcomers. One effect of this competition is the sudden emergence of not one but several broadband digital communications services into homes and small businesses. Another effect will be the emergence of new consumer digital devices such as set-top boxes and telephone base stations. The initial catalyst for these consumer choices was the promise of interactive video services. In the last year, however, consumers have shown additional interests:

- Consumers need the ability to access multiple competing networks.
- Consumers need for these networks to be accessible *transparently* and *seamlessly*.
- Consumers need to more fully utilize the existing networks and appliances in the home.
- Consumers want the ability to choose more services, conveniently and cost effectively.

**Needs of the Service**

Cable providers offer high bandwidth "to-the-home" networks, while the telephone companies are building their own high bandwidth networks, utility companies are building fiber optic

networks, and digital broadcast satellite passes 94 million US households with high bandwidth MPEG digital television. These companies need a common flexible platform in each household that will enable them to compete more effectively by offering more, differentiated services. Examples include high bandwidth access to the Internet and private networks, video telephony, and two-way interactivity.

- Service providers need the ability to offer more services to consumers.

- Service providers need a low-cost flexible package that allows upgradeability for new services into the future.

- Service providers need an agreed-upon standard so that manufacturers will be able to lower costs with economics of scale.

- Service providers need more cost-effective ways to service and manage the emerging digital consumer networks.

**Needs of the Equipment Designers and Manufacturers**

"In-home" networks are also growing, especially in new construction. Security, audio, appliance automation, HVAC, and data/LAN networks are getting more attention. Three "home-bus" standards compete for leadership: X-10, CEBus, and LonWorks. These need to be integrated with each other, to offer new and differentiated intelligent home management services. The integration of "to-the-home" networks with "in-home" networks is where opportunity is abundant for innovation and differentiation.

- Equipment designers and manufacturers need a standard interface specification, which has been agreed to by the service provider, customer premises equipment, and home automation industries.

- In-home networks need to be integrated with each other, and integrated with access networks, enabling new differentiated services.

- Homes need to be more cost-effectively managed. The lack of a standard has prevented widespread innovation of products and services.

**Approach**

A given residence will have a broadband service provided by a telephone carrier, a cable TV service provider, a utility company, and/or a wireless communications provider through copper wires, hybrid fiber coax, RF transmission, or fiber to the curb (including any combination of these sources and structures). The authors of this document believe that it is essential to develop a set of interface standards between the broadband residential access network(s) and the communication services (the "in-house" networks) required by the residence.

As previously stated, this document will not define a specification, but lay out the concept and design principles. We call this interface between the access network and the residential services the Residential Gateway (RG).

The RG will provide two key gateway/bridge/switch functions:

I. The physical interface to terminate all external access networks to the home, with multiple residential services being delivered over each type of access network.

II. The enabling platform for residential services to be delivered to the consumer, for example, telephone, television, and PC networking, or the termination point of internal home networks.

**Advantages**

A single, flexible, extensible intelligent interface is ideal to satisfy both short-term "analog" needs, and high bandwidth "digital" services, such as Internet access, HDTV, and services yet to come. The RG approach provides this intelligent interface and has many inherent advantages to three major classes: consumers, network operators/service providers, and home device/equipment designers. Consumers gain access to multiple digital communications services without installation headaches or increased costs. The operators of the access networks can offer a wider range of services and more efficiently manage a standardized infrastructure. Designers of home application devices gain the advantage of a standardized interface for their products.

**Advantages for Consumers**

The following provides further elaboration of the benefits to consumers:

- **Ease of Use:** The RG plug-and-play approach provides the consumer the ease of use they demand, as installation and upgrades offered by service providers would be seamless and transparent. The RG hides the complexity of multiple networks and keeps things simple for the consumer.

- **Lower Cost:** Most American households have between two and three TV's. The RG approach is more cost-effective than an expensive TV set-top box, and provides for the future requirements of interactivity. Prices for today's hybrid analog/digital set-top models and emerging digital models range between $300. and $700. per box. The trend among television manufacturers is to move the digital decompression (MPEG) technology into the TV set and PC motherboard. The RG represents an opportunity to centralize – and reduce the cost of the network interface.

- **More Services:** A consumer business model can be developed where value-added modules for consumers are offered. Eventual widespread acceptance would enable more services and capabilities to be offered at a lower cost, in a plug-and-play fashion.

**Advantages for Service Providers**

Service providers will see specific benefits, outlined below. The primary advantage of the RG is that one service provider could provide all information services to and from the home.

- **Standard Interface:** The RG approach provides a common core set of protocols in a one-box design. Standardization will lower the costs of the box due to economies of scale.

- **Packaging Options:** Service providers can extend their current business model for the RG approach, and build the cost of the RG into the base rate.

- **New Markets:** The service providers will achieve new revenue streams, by offering new differentiated services, such as Internet access, video telephony, and wireless capabilities. Differential services give the service provider a competitive advantage.

- **Network Management:** One service provider can perform all security and network diagnostics from the external network interface. The RG will be much easier to service and maintain than currently proposed TV set-top box approaches. The enabling of remote software diagnostics and extensive network monitoring results in substantial labor savings in field service calls.

- **Protection Against Obsolescence:** The RG approach provides a flexible package for the service provider, that should not become obsolete as new services emerge. Upgrading should involve no more than swapping out a module.

**Advantages for Equipment Designers and Manufacturers**

Equipment designers and manufacturers will realize the following advantages:

**Standard Interface:** The RG will provide the consumer electronics designers with a standard interconnection that will define the network interface. The RG Group envisions that appliances such as VCRs, camcorders, and game machines will be connected to an integrated home network that will enable new multi-media services.

**Lower Costs:** Network interface designers have too many protocol options at the appliance or peripheral side of the network. Without a standardized design such as the RG, they must guess or design for multiple interfaces. Standardization in the home will lower costs and accelerate the use of in-home networks.

**Support Convergence:** Development of network technologies and home device technologies are driven by very different industries. The RG concept will join advances in either area, thus reducing obsolescence and facilitating innovation.

The business model for this approach is designed to be open. Either, the utility, municipality, cable TV, telco, consumer, or satellite service provider can own the RG. It is financially attractive for the utility, telco, or cable TV company to build the cost into the utility rate base. The maximum point of insertion rule allows the operator to place a box before the demarcation point, and it remains part of the access network. Analogous to utility poles, consumers benefit from lower rates through the scale and scope of the utilities. The RG could rapidly evolve into the

consumer marketplace, given widespread acceptance of value-added services and plug-in cards.

**Business Case**

The business case for a flexible network interface in the homes to integrate today's multiple independent networks is driven by quality, choice, and convenience. Below are some market research data points that help to build the primary business case for the RG that consumers will pay a premium for quality service, choice of offerings, and convenience.

**Consumer Trends:**

- The Internet and Worldwide Web is estimated to grow from 4.8 million Web site servers today to 100 million in 2000. Current market estimates for Internet users vary:

  - Interactive Age: 22 to 24 million; and
  - FCC Chairman Reed Hundt: 40 million (expects 200 million by 1999).

- Current number of on-line subscription users (Prodigy, America OnLine, Compuserve): 8 million, with 40% growth projections (Source: *Wall Street Journal*).

- Forrester Research predicts the Internet Access market to be:

  - Consumer: Growing to $250M in 1997, and $700M in 1999; and

- Consumer/Education: Growing to $250M in 1997, and $1.2B in 1999.

- The Electronic Industries Association reports that the "Home Information" products market (PCs, telephones, faxes) is gaining a larger share of consumer electronics sales. Figures show growth from 26% in 1993, to 33% of all CE sales in 1995.

- Parks Associates (Dallas, TX) found in a recent home automation study that savings was not the primary motivator for installing HVAC and appliance management systems. The top motivators were convenience, comfort, and ease of use.

- In a recent technology manager survey, 86% believe the new telecommunications deregulation bill will lead to innovation of products, new services and lower prices (Source: *Information Week*).

- Consumers have been willing to spend a significant amount ($1,000.) for quality video service and choice (180 stations), proven by the Hughes/RCA consumer business model.

**Service Provider Trends**

- There are 10 million telecommuters today, compared with three million five years ago. By 2000, the number is expected to reach 25 million (Source: *JALA International*). This trend is fueling the growth of home PCs and shifting PC usage patterns from games to "work," which service providers are

attempting to capitalize on with high-speed lines and multi-media products.

- Digital Equipment conducted a survey of 9,600 corporate managers, and asked about computer networking over their cable TV:

  > "If you could use your cable TV connection for computer networking, which of the following applications would be your #1 choice?"

  - Internet Access: 34%;
  - Data Sharing: 24%;
  - Distance Learning: 16%; and
  - Other: 26%.

  > 80% would be very/moderately interested if their cable TV provider offered a computer networking capability through their TV.

- Cable TV operators are facing a new era of competition with DBS and telco-backed Wireless Cable video services. Aggressive cable companies are using technology as a competitive weapon to develop movies-on-demand and video telephony. The RG can be a more cost-effective platform to offer these emerging services.

- Cable TV market penetration ranges from 58% to 62% of US households or, 55M to 61M households are cable subscribers. (Sources: S.G. Warburg, Nielsen, and Dataquest studies show varied figures). Cable TV growth has leveled, as recently

published by Nielsen. Studies are showing that about 60% of people with cable available will subscribe. The current figures show that 80 to 85 million homes are passed by cable. It is also important to note that the current DBS subscriber base (two million people) represents about 4% of cable share. Cable operators have enjoyed regional exclusive markets. The RG could provide a mechanism to rejuvenate the cable industry.

- The Digital Broadcast Satellite (DBS) market represents a major opportunity due to its success and continued growth projections. Two million customers have signed in the first year of operations, and DBS will "pass" two billion homes worldwide by 1997, (Source*: DBS Digest*). The RG offers innovation possibilities for digital receiver module designs.

- Telcos are planning to offer wireless cable video services in the short-term, as recently reported in the *Wall Street Journal*. Bell Atlantic and NYNEX are planning to pass seven million homes, and Pacific Telesis recently acquired Cross Country systems. The RG offers wireless cable receiver design opportunities.

**Equipment Designer**

- Dataquest reports the number of cable modems shipped in 1995, and manufacturer to be 14,000 units. Dataquest also estimates the number of high Trends speed (V.34) PC modems to be over one million units in 1995, and strong growth is projected.

- There are 233 million analog TVs in 94 million homes, and these analog TVs will be in use for a decade (Source: FCC Chairman Reed Hundt). Digital standards are being developed for set-tops, which will act as a bridge until the digital compression functionality can be integrated into the television itself. The RG can act as a bridge for the transition period from analog TV to digital.

- Hughes/RCA DirecTV has shipped 1.2M units in 12 months, and Primestar Partners (TCI and cable-backed consortium) have signed 770,000 subscribers in nine months (Source: *DBS Digest*). Forrester Research forecasts DBS subscribers to reach 10 to 12 million by the year 2000.

- US households are acquiring PCs in record numbers and will continue to do so in the short-term, spending more on PCs than on TVs and VCRs combined. Today, 30% of homes have a PC and 50% of households are expected to own a PC in two years (Source: *Wall Street Journal*).

The following sections of this report define the types of services that a Residential Gateway could provide or facilitate, identifies the known and expected interfaces, and provides the design principles that the RG group feels are required to make the RG concept a reality.

# Services

**Head-End Gateway Relationship**

The RG will enable multiple, digital communication services over various broadband access networks to enter the home and small businesses in the coming years. The RG Group recommends that each access network provide outbound (to the home) and inbound (return path) digital channels using the data communication protocc to support multiple virtual circuits between residential customer premises equipment (CPE) and remote services. Given the predominance of video data outbound to the home, it may be preferable to separate this traffic from all other services, by using separate frequency bands. This is an aspect to be established during the detailed standardization process of the RG.

At the head-end of the access network, means must be provided for multiplexing the various services onto the channels provided by the access networks. Much, if not all, of these means can be provided b data communication switches in conjunction with re-synchronizers for video streams. There must be provisions in the RG itself to multiplex various channels from different service providers.

The head-end is also the access point for the service provider's network management system, and may also act as a firewall for secure access to public data networks. The possibility does exist to move security functions into the RG.

**Examples of Value-Added Services**

The RG Group envisions the RG enabling a wealth of new applications through the availability of an "Information Gateway" being in the home. Electronics manufacturers, software developers, and service providers will factor new products into their business plans in support of the RG concept, once given widespread acceptance.

The summary below is examples of new applications the RG would enable. The business case for many of these examples is made by value-added, differentiated, easy-to-use services.

**Emerging Applications**

- Telecommuting (Secure High-Speed Access to Office);
- Internet Access (Non Secure);
- Distance Learning (Education at Home);
- Telemedicine (In-Home Monitoring, Remote Diagnostics);
- Video Telephony (TV or PC);
- Home Appliance Management and Integration (example: Smok alarm alerts firehouse, closes vents);
- Security Systems Management (Low bit Rate Video Monitoring video sensors);

- In-Home Power Regulation and Management;
- Automated Meter Reading;
- Neighborhood Cordless Roam Phones;
- Video Dial Tone (300+ Channels);
- Virtual VCR and Video-on-Demand;
- Video Intercom;
- CD Jukebox (Music, Music Videos, Movies, Family Photos/Video);
- On-line Advertising and Electronic Catalogs;
- Video Casino; and
- Cut and Paste Video Clips from Internet.

**Specific Examples**

The following series of examples illustrates the application of the R in the home. This series starts with a simple example and, in fairly common steps, builds to greater complexity. The RG protects the consumer from this complexity, while allowing for extensibility.

**Telephone** At the simplest level, the interconnection needed is to the telephone network and the in-house telephone wiring with its connected devic for telephony, and computer data, etc. In this basic case the RG provides a pass-through function.

**TV** A next stage of complexity may be to add the ubiquitous TV. The RG must accommodate whatever type of external network that serv the NTSC TV signal. This stage may represent the typical level of home complexity with telephone service, along with two to three televisions served either from a CATV network or from an antenna. In some cases this may be as simple as providing the pass-through capability of the CATV (or of a 300 ohm, balanced antenna lead), a well as of the telephone signals. At this stage, the RG is providing very limited functionality, primarily being a point of interconnectio for pass-through.

**Second Source Television Network** If now we add a DBS TV network connection (or other potential future video sources), then the complexity increases. The complexi comes from the desire to be able to choose between video sources a each TV. This could be accommodated by providing:

- Separate physical paths (separate in-house networks) to each TV and allowing for a switching function (between the networks) at the TVs. This would require separate, but very simple, interfac cards for each in-house video network.

- A tuning capability at the RG for each video network and a separate modulated signal for each network (e.g., channel 3 for DBS, and channel 4 for CATV). This would require much mor complex (expensive) video modules, but it would add a great de

of enhanced functionality. It would also require a backward signaling path from each TV to the RG to allow channel changing, and a method of setting priorities and avoiding conflicting signaling in the backwards path (to prevent two user at two separate TV sets from trying to change the channel on a given network at one time).

**Set-top Boxes** The introduction of set-top boxes somewhat further complicates the issue. In some CATV networks the set-top box is used as an addressable device and in others it is used to merely augment the tuning capabilities of a non-cable ready TV. In the addressable situation, this function is a unique capability provided by the set-top box and it must be provided (possibly by a special interface card). Taking this approach will eliminate the set-top box and it will allow easy access of the selected output channel to the RG (as an input) so that the selected channel can be routed for availability to any sub-tending video device (TV, VCR, computer video capture card, etc.) As noted above this approach will require the development of a signaling capability from the end devices back to the RG, but the payoff in greatly added flexibility could easily be worth the price of overcoming that issue.

In other CATV networks, the set-top box only provides a tuning function for video receiving devices that are not cable ready. In this tuner function, the set-top box adds no complexity to the RG, but the set-top box merely becomes part of the TV or, the set-top box could be replaced by the tuning capability of interface modules with that function. The selection of the approach to be taken should be determined by the individual circumstances of a given end-user.

**VCR**

To increase the complexity we can make a very common addition – VCR. A VCR greatly increases the complexity because it is a sourc of video signals as well as a user of video signals. As a user of vide signals it appears the same as a TV, and the above mentioned solutions will also work for it. As a source of video signals, there a two ways to use the VCR with the RG:

- If separate wiring is available, or is to be installed, back to the RG, then the VCR output (source of video signals) could be connected to the RG as another external network. This would require a fairly simple interface card to allow the interconnectio of the VCR, and would provide the signals of the VCR to any video receiver device in the home.

- Another approach to allowing the VCR to provide signals back the RG by modulating them on to the coax bus back to the RG and filtering and bypassing the backwards signal to a network interface card for input as in the first option.

**Other Levels of Complexity**

Added telephones or telephone like devices (modems, faxes, etc.) operating in an analog mode generally do not substantially increase the level of complexity in a home environment because of the frequent existence of multiple pair home wiring. The existence of this wiring amounts to having multiple independent networks. Each such in-house network would require an RG interface card, but one of limited complexity.

If devices are added that require direct digital connectivity then this will require the provision of separate wiring (a separate in-

home network). In most circumstances (ISDN, T1, and other low- and medium-speed data services) this requirement could be met with the normal telephony prewire in many homes. This would again require a separate card, believed to be relatively simple.

A further expansion of this concept would be to add the capability of home stereo-type functions. This will require some very complex and expensive modules, and the currently available alternatives are very expensive and inflexible. It would be relatively easy to extend the concepts wherein to include pre-amp type functions in a card that would have direct access to all of the connected networks, and that could drive amps and speakers. This type of functionality would provide for advanced multi-media delivery services to a number of home devices.

The above description may at first reading, suggest that the RG is a complicating device rather than a simplifying one. But, in reality, the RG will hide the complexity for the consumer of the multiple sources to multiple (and incompatible) receivers. Herein lies the need for a common interface. The RG also greatly simplifies the design of network and CPE devices by the standardization of interfaces, while still leaving the opportunity for functional innovation for competitive differentiation. The development of new services will no longer require that network and CPE developments take place at the same pace. New and innovative consumer services will be achieved by the design of new CPE, and where necessary, by the design of new RG interface modules. The addition of MPEG, ADSL, ATM, and other technology standards will be accommodated by simply adding a network card of the appropriate type. With the approach outlined, the full capability of those technology standards will be available to a wide variety of

home devices with full flexibility of use. The fundamental principle is that all information in the home is converted to a common high-speed digital bus format.

# Interfaces and Adapters

The RG defined by this document is meant to provide a standardized approach to allow the interconnection of networks and devices. Specifically, it is intended to allow the interconnection of various existing (CATV, telephone, etc.) and future (FTTH, HFC, ATM, etc.) external networks to various in-home networks (telephone, coax, etc.) and consumer devices (telephones, TV, computers, etc.). This interconnection is achieved by providing Network Interface Unit (NIU) cards for each external network, which are bussed to Customer Premise Interface (CPI) cards for each in-house network. To be a successful device in the marketplace, the RG must add value to today's home configurations and to future configurations brought about by future proliferation of emerging broadband networks.

While the full list of interfaces (and the associated RG adapters) may be virtually endless, the following sections provide at least a starting point of minimal capability.

**Interfaces**

It is assumed that the RG will be able to provide universal support for these services, at a minimum:

1. External Network Physical Interfaces:
    a) Standard twisted pair phone wiring;
    b) Standard coaxial cable;
    c) Broadband fiber (HFC, "to-the-curb" and "to-the-home"); and
    d) Wireless (possible standards emerging).
2. Network Protocol Interfaces:
    a) ADSL/VHDSL;
    b) ISDN; and
    c) ATM.
3. Premise Physical Interfaces:
    a) RJ-11 (phone);
    b) F-coupler (coax);
    c) 9-pin serial connector; and
    d) RJ-45.
4. Premise Logical Interfaces:
    a) X-10;

b) CEBus;

c) LON; and

d) Tip and Ring.

5. Premise Devices:

a) Standard "POTS" telephone line card;

b) NTSC Television;

c) Digital MPEG Television; and

d) Personal Computer.

**Adapters**

As previously described one utility Network Interface Unit (NIU) adapter is required for each access network reaching the residence. In the 1997 timeframe, several access networks are expected to be capable (in principle) of providing multiple services (video, voice telephony, packet network access, etc.) over one network. As shown, the number of different NIUs required is quite extensive. The NIU is the sole termination for the access network to the Customer Premise Interface (CPI) adapters via the RG bus and vice versa. The NIU may be owned by the utility providing the access network service. Examples of NIU adapters include:

- **Standard POTS**: analog using twisted pair;

- **ISDN:** digital using twisted pair;

- **High-speed ADSL:** digital using twisted pair;
- **TV cable:** analog or digital using coaxial cable;
- **155/622 Mbps FTTH:** using optical fiber; and
- **Wireless transceiver:** (possibility of MMDS, LMDS).

Combining these functions offers the opportunity for innovation.

At least one CPI adapter is required for each type of cable or network that extends within the residence. In many cases, a single adapter may be able to service several in-residence cables, such as multiple telephone extensions.

Examples of CPI adapters include:

- NTSC TV adapter;
- MPEG2 TV adapter;
- POTS(s): one or more phone extensions w/optional services;
- High-speed digital networks: data network (e.g., Ethernet);
- Low-speed home automation networks: home control (X-10, CEBus, LonWorks, SmartHouse);
- Low-voltage systems (security, sprinklers and low-voltage contacts/relays); and

- Wireless: (RF or IR) capability may exist for each adapter function above.

While the RG is fundamentally a communications device, its function can be expanded by including on a CPI adapter, additional computing, and I/O capabilities, which may be accessible to the subscriber. For example:

A Processor/Memory adapter for user-controlled functions running under a separate PC operating systems

Storage Bays for SCSI hard disks, or universal CD jukebox
Parallel/Serial port(s) for printers and miscellaneous PC devices.

# Principles of Design and Operation

## Design Principles

The RG Group has recommended several basic design principles to guide the development of the RG. They are:

### Standards Principles

- The RG will be fully compliant with FCC Regulations;
- The RG supports the relevant industry standards to offer the proposed range of services; and
- The primary function of the RG is to provide a standard network interface unit for communication signals, as opposed to information processing.

### Reliability and Redundancy Principles

- There should be the option for redundancy in the adapters providing higher availability, if desired;
- The RG should follow and reinforce the telephone companies excellent reputation for availability (e.g., support uninterruptible power); and
- The basic function of the RG is to deliver information from the access network via the NIU adapters to the CPI adapters and vice versa. This must be a high availability function and must not require continual intervention by the RG controlling microprocessor. This function should also survive the failure of the control microprocessor or any individual CPI adapter.

**Design Factors Principles**

- There must be no degradation in any standard analog service (POTS and NTSC), and there must also be backward compatibility with analog services;

- All active components are on adapter cards;

- Extensibility and scalability are designed into the RG (for example, it is a matter of adding adapter cards to go from supporting one phone and one TV to three phones and two TV's); and

- Cable attachment interfaces (such as RJ-l1 ports, F-couplers, and 9-pin serial connections) either can be built into the RG itself, or placed on an adapter card for greater flexibility.

**Cost Effectiveness Principles**

- The consumer should not pay more than today's cost for an equivalent level of service;

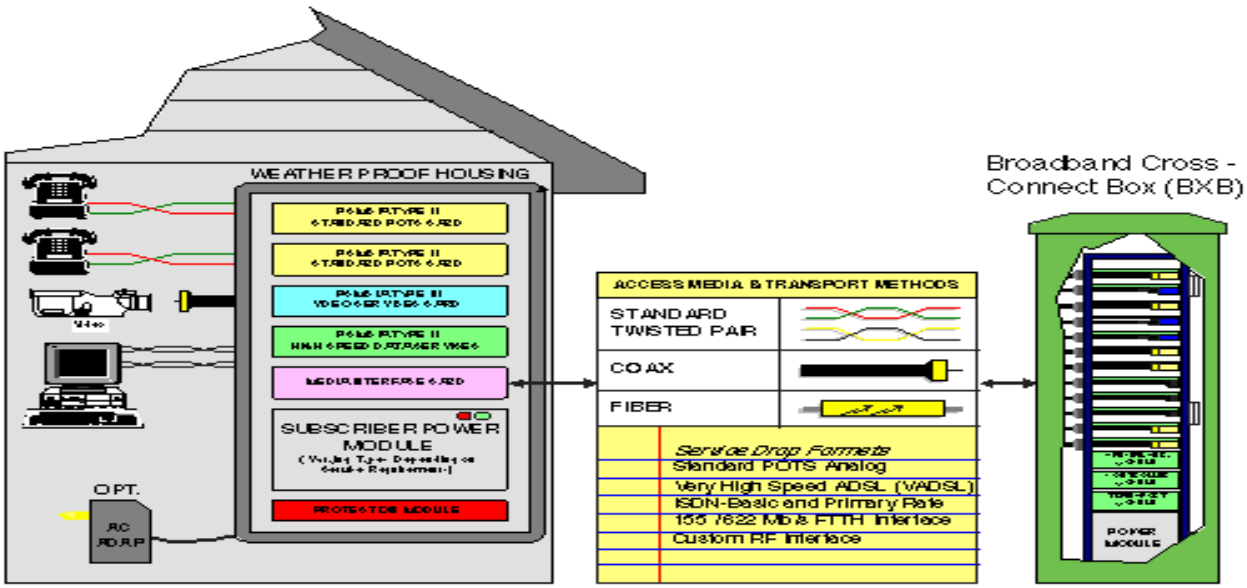
- Consumers will have an alternative to the traditional TV set-top box; and

- Broadband ATM networks will proliferate as a communications delivery standard to residences. Any digital data from a network is assumed to be ATM.

**Packaging Principles**

In the RG business model, the RG system unit would initially be owned and managed by an access network provider. To permit owner access to the unit it is packaged in a weatherproof enclosure designed to be mounted at the point of entry to the residence, either outside or inside the building. The package consists of a rugged enclosure with lockable hatches permitting the owner, the subscriber, and potentially another service provider access to different sections of the unit. Internally, there are slots or receptacles for NIU adapters and CPI adapters. The unit also includes a high-performance, low-cost bus for communication among the adapters, a controlling microprocessor, and memory.

When mounted externally, the RG will be exposed to a very wide range of environmental factors. Some of this can be avoided (at a cost) by splitting the unit into two units (external and internal), with the internal unit accommodating the CPI adapters.



**Security Principles**

To keep consumers from tampering with important controller functions, a "secure" section is required that allows for local or remote software/firmware updates by utility company "owners" of the RG hardware. The RG Group envisions security to consist of physical logical box and the security software.

**Concept of Operation**

This section reviews the principles behind the basic operation of the RG and points to the core functions that need to be standardized. In its simplest form, the RG may be viewed as a set of ports, which are connected via the internal bus of the RG. The ports are created by the installation of CPI and NIU adapters into the RG. In more advanced adapters there may be substantial computing capability on the adapter itself that may implement some high-level service, such as a security system, or a small PBX. A core part of the RG standard will be a mechanism for delivery of ATM cells from the access network via the NIU adapters to the CPI adapters and vice versa.

The purpose of the RG is to provide inter-communication among the adapters at bit rates up to some defined rate. One such rate could be the 25.6 Mbps standard defined as the lowest rate for an ATM port. For example, the access network could provide a raw outbound data rate of 25.6 Mbps (to the RG) and an in-bound rate of, say, 1.5 Mbps (to the local PSTN exchange or to the level 1 gateway of a cable TV network). The purpose of the RG is then to allocate the capacities of the outbound and inbound channels to the various end-user services attached to the RG. Note that the access network need not provide a single bearer channel; it could, for example, provide an outbound broadband channel for video services and a set of narrow-band (ISDN)

channels for data and telephony services. The RG may also provide a bridging function among the adapters on the residence side, connecting, for example, a home automation network to a PC LAN.

**Processor Sub-System and Software**

The RG system contains a microprocessor and memory that supports the software services required to operate the basic function of the device. The system processor and its resources should not be employed for end-user applications, since there is no way to guarantee that these applications will be well behaved, and will not reduce the available computational resources below the level required for reliable operation of the gateway. End-user applications can be supported by imbedding processors and memory on the adapters. It may be possible to boot such adapters with software stored permanently on the system disk.

**Software**

Software functions to be supported by the control microprocessor include:

- Registration of adapters (hot-plugging);
- Connection allocation among adapters, including Quality of Service reservation;
- System management of the gateway, including communication with the access network service provider's management system. Network management agent and MIB;

- Remote restart and diagnostics capability;

- Service metering; and

- Security services, and subscriber authentication.

These functions demand a real-time multi-tasking operating system, in order that multiple service requests are not serialized. Candidate operating systems include: OS/2, OS/9, Unix, Windows NT, and (possibly) Windows '95. In general, this implies a 32-bit microprocessor and a minimum of 2 MB of system memory. Note that the RG does not require user interface devices, although these could be provided. Configuration services should be provided by remote access via the CPI adapter to the control microprocessor.

**Hardware**

A fundamental design principle is that processing should be a function of a plug-in card, while the RG processor is optimized for communications.

Computer intelligence will be used for functions such as: ridging (from one media/protocol to another), switching (acting as traffic cop to determine which TV gets what signal, for example), and gateway (to tie in-home networks to external ones), along with a whole host of services such as PBX, fax, e-mail, electronic yellow pages, directory services, energy management, and security. The RG Group views bridging to one common protocol on the bus to be a primary function of the CPI

adapters. Functions and services provided by utility companies need to be protected from intentional or accidental damage by consumers, using "firewall" techniques and specialized, operating systems. On the other hand, consumers will want flexibility in selecting services and where/how they are provided.

Intelligence can be placed in different locations, largely depending on how much control is given to (or demanded by) consumers through packaging, such as:

- Weatherproof utility box on exterior wall. In this location, processor electronics must be hardened for extremes in temperature, humidity, dust, and other environmental hazards. It is possible using today's PC technology to package all components (including plug-in adapters) in this manner and to exclude access to consumers.

- Interior utility box. The possibility exists to "split" the RG into an "inside/outside" combination system. The maximum point of insertion rule would allow the demarcation point to be moved inside. An inside box protects sensitive electronics, and allows for easier consumer access to the CPIs.

- For expansion adapters, it is important to note that the need for the physical layer protocol translation does not preclude the need for a TV set-top adapter. MPEG video compression circuits and software, for example, could be placed on the adapter that is used to distribute TV signals throughout the residence, as opposed to building this intelligence into the utility box. Although more expensive initially, this allows

for maximum flexibility by adding or replacing adapters. With on-board processors and memory, the MPEG adapter might be controlled by an operating system designed for TV set-top boxes or game boxes, while other utility box functions might be controlled by a different operating system.

- In the PC evolution, for example, as certain technologies became pervasive standards, they moved from multiple adapters to single, multi-function adapters, and then from adapters to built-in functions. These included serial/parallel/ mouse ports, graphics controllers, and memory. Other components, such as math coprocessors and cache even moved into microprocessor chips. A similar trend is likely to happen with microprocessor-based utility boxes, suggesting a need for flexibility in the placement of (and use of) intelligence.

- Consumers will want direct, individual access to information delivered to the home, and will want to use a variety of devices to process that information, including game boxes, TV set-top boxes and PCs. Their PC personal agents will be able to collect relevant information, provide universal mailbox functions (voice, fax, e-mail), and produce customized news (paper & video), video programming, and references for shopping, financial and health management, along with other applications. Consumer-controlled devices will also offer interface improvements such as voice navigation and dictation using natural language terms and translating into national languages in real-time.

**Buses**

A core part of the RG standard will be the mechanism for the basic function of the RG, the delivery of ATM cells from the access network via the NIU adapters to the CPI adapters and vice versa. The RG Group did not reach consensus on whether the standard implementation should specify a specific bus protocol architecture, or specify only functionality and performance specifications of interface modules allowing the RG to have varying bus protocols.

Bus/adapter interfaces depend on the expansion bus selected. Below is a summary of the industry standard interface buses used for PCs, both currently and emerging.

- **ISA (PC/AT):** Inexpensive and pervasive 16-bit expansion bus, but with limited functionality and performance. Satisfactory for low bandwidth, asynchronous services (computer network access, home automation...), but its lack of multiple peer bus mastering and its low bandwidth (maximum of 6 Mbps) means that it is unsuitable for multi-media services. EISA is a 32 bit extension providing higher performance, but still does not provide multiple peer bus mastering.

- **PCMCIA:** Inexpensive and small expansion adapter (treated as an expansion bus) with low power requirements, but with limited real estate for electronics and cable connections, and with limited performance. An alternative to ISA adapters, this technology is expected to reach mass consumer acceptance in 1997, or 1998, for peripheral devices.

- **MCA (MicroChannel Architecture):** Offers high bandwidth at 20-160 Mbps. Offers many unique intelligence features, such as peer-to-peer communication, bus mastering, automatic configuration, reliability/data integrity, and remote communications/diagnostics. Compared to other buses in use, MCA is relatively expensive and not widely supported.

- **PCI:** Offers high bandwidth at 132 to 264 Mbps. Offers similar features to Microchannel, but limited in the extensibility and expansion slots. PCI appears to be the emerging *de facto* standard for high-performance PC expansion buses.

- **USB (Universal Serial Bus):** A group of computer vendors including IBM, Intel, and Microsoft introduced the Universal Serial Bus peripheral connection architecture in June 1995, which is targeted at peripheral connections. The universal bus will combine serial, parallel, mouse, telephony, and keyboard ports into a single standard. This will enable hot, active plug-and-play of peripherals, and any port can be used for any peripheral. The universal serial bus will feature bandwidths of up to 12 Mbps, a data rate could benefit the current 1 Mbps for parallel ports and 2 Mbps for serial ports. This higher data rate could benefit telephony because serial and parallel ports don't have enough bandwidth for digital audio and digital telephony.

- **IEEE 1394 (Firewire):** Co-developed by IBM and Apple, Firewire employs a modified GameBoyreg. connector to carry consumer-grade I/O traffic and support a wide range of

consumer devices (digital VCRs, cameras, and TVs). IEEE 1394 offers high bandwidth in the range of 100 to 400 Mbps.

- **SSA (Serial Storage Architecture):** Championed by IBM initially for servers and workstations, SSA offers good performance (20-80 Mbps) over short wires, with more intelligence at each end. Eventually, this protocol could find its way down the chain from corporate client-server to consumers.

- **FC (Fiber Channel):** Aimed primarily at mainframe computers, FC offers high bandwidth (100 Mbps) over medium distances (25 meters with copper pair and 100 meters with coaxial cable). This type of technology could eventually deliver bandwidth from the Residential Gateway box to PCs or other devices using the existing copper pair or coaxial cable that's in the walls. Today, however, the connection logic, at each end of the wire, is too expensive and power hungry for consumer applications.

With all of the buses, there are no active components on the bus backplane. All active components required for the basic RG functions are either on the adapters, or on the RG control section. The priority for utility companies should be NIU flexibility and local intelligence for utility functions and custom services.

With the possible (arguable) exception of ISA, these bus architectures are all well documented and open industry standards. And, with the exception of ISA, these architectures are fairly recent introductions (less than eight years old), meaning that further evolution in technology is extremely likely

and should be planned for. This suggests that the selection of bus architecture (and its adapter interface) should not be part of a proposed standard but left up to the manufacturer(s). An alternate viewpoint is that the RG may not become a standard without an agreed upon bus protocol, with designers having to support multiple protocols. The standards implementation groups should decide this issue.

**Operating Example**

Here is an example of the possible operation of the adapters in the RG. The details of how the RG actually operates will be defined during the standardization process.

Typically, each adapter will be servicing multiple data streams; for example, multiple telephone calls, multiple Internet accesses, or multiple video streams. When the RG is configured initially, and thereafter whenever an adapter is added or removed, each adapter registers with the system manager the services that are connected. For example, it might register that two telephones with distinct telephone numbers are attached; or it might register that it offers one or more access network services. When an adapter on the residence side initiates a new session, for example, Internet access or video-on-demand access, the adapter associates a stream identifier with the new session and requests the system manager to allocate an appropriate inbound (and outbound) transport to it. This is done by setting registers on the adapters and then interrupting the system processor; the RG control microprocessor collects the data from the adapter and passes it to the system manager program. If there is available capacity, the system manager returns the bus address of a register on the appropriate adapter (typically the access network

adapter) to the requesting adapter. The requesting adapter can now independently pass small bursts or cells of information to the allocated adapter. The requesting adapter may, for example, have received from the residence PC LAN a request to initiate an Internet Protocol session. The packet representing this request is fragmented by the LAN adapter into multiple cells, which are then transferred via the bus to the access network adapter. The register address allocated by the system manager will correspond on the access network adapter to a data transport service. Obviously, there may be multiple requests for this kind of service, and their requests are managed separately, using the stream identifier allocated by the requesting adapters. The access network adapter assembles the cells into the format required for transmission over the access network and transmits them inbound.

As can be seen from this example, for the RG to operate reliably, the protocol for exchange of data among the various adapters must be very tightly defined, and each adapter should be tested for compliance.

**The RG and the Telecommunications Management Network**

It is proposed that the RG NIUs be compliant with the Telecommunications Management Network (TMN) interface specifications. Use of internationally agreed upon object definitions allows immediate introduction of new devices from multiple vendors into the network without impact to existing service provider operational support systems. It is anticipated that a single network will ultimately support millions of RGs, precluding the exclusive use of polled management schemes such as the Simple Network Management Protocol (SNMP). It

is left to the manufacturer to architect the partitioning of the TMN functionality between the RG and the head-end. For example, a head-end element manager may interface to the TMN network while using SNMP to manage a small number of RGs within the Element Manager's domain.

# Summary

In summary, the RG Group strongly believes that several key trends will prove that this approach to residential information management is the most effective, both short-term and long-term. The rapid pace of change can be seen in these developments:

- Telephone companies withdrawing their Section 214 video dial tone applications and changing their proposed network architectures underscore the rapid pace of change and suggest that ATM-to-the-home will be delivered sooner than expected;

- The government would like to accelerate the deployment of digital television, in order to gain back the NTSC spectrum, for re-allocation to new services;

- Rapid technology "form-factor" integration is proving that performance is doubling every 12-18 months, while the "form" is shrinking by a factor of two in the same time period;

- Power technology advances are progressing, such that voltage requirements are decreasing by a factor of two every 12 months; and

- Growth of consumer acceptance of on-line information services and home PCs.

Deregulation and the telecommunications bill, being re-written in 1995, will have a dramatic impact on the US. On one hand, consumers will see the benefits of technology developments quickly integrated into consumer products. On the other hand, consumers will have to pay for previously subsidized services, and bear the fully loaded costs of bringing information into the home.

We believe that the RG will lessen this cost burden on consumers, enhance services provided, and accelerate the deployment of new services.

The service providers should embrace the RG approach as a means to generate new revenues and be poised to offer emerging services. The ability to build the cost of the RG into the base rate provides a concept, which is financially feasible. The RG can enable a service provider to access to all information to and from the home, and offer a new level of targeted customized service offerings to the individual household and even the consumer.

Consumers will benefit by having reduced complexities from emerging digital services. People should not have to manage integration challenges of multiple services, and ensure backward compatibility of analog services. The consumer should not pay extra for this, and will not have to, if a standard is embraced and discussions are initiated that could bring this vision to the US.

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as next generation OSP designs and the like. Jason Jacobs and Arianne Lewis from GTE both contributed greatly to writing this paper.

The original document and supporting functional specification can be found on-line at the AIM Web site at the following URL:

http://www.interactivehq.org/councils/html2/feigel/title.htm

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PN-4407 TR41.5/98-11-028

(to be published as TIA/EIA TSB-110)

# TIA/EIA

# Residential Gateway

**Reflects Palm Springs, CA Meeting of November 16-17, 1998**

**Prepared by: ANSI/TIA/EIA**

**TR41.5 Residential Gateway Task Group**

**NOTICE:**

This contribution has been prepared to assist the TR41 Standards Committee. It is offered to the Committee as a basis of discussion and is not a binding proposal on the members of the TR41.5 Residential Gateway Task Group. The proposed recommendations presented in this document are subject to change in form and technical content after more study. Members of the RG Task Group specifically reserve the right to add to, or revise, the statements contained herein.

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# PN-4407

## To be published as

# TIA/EIA TSB-110

RESIDENTIAL GATEWAY –
Recommended minimum application, feature and operational requirements for product development and procurement purposes

PN-4407
(to be published as TIA/EIA TSB-110)

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Published by

TELECOMMUNICATIONS INDUSTRIES ASSOCIATION

Engineering Department

2500 Wilson Blvd., Suite 300

Arlington, VA 22201



Printed in North America

# Residential Gateway

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## Foreword

(This foreword is not a part of this Technical Systems Bulletin)

This Technical Systems Bulletin (TSB) was developed by TIA/EIA Subcommittee TR-41.5, Residential Gateway Task Group.

### Approval of TSB

This TSB was approved by TIA/EIA Subcommittee TR-41.5, and TIA/EIA Technical Committee TR-41.

The life of a TSB is normally 3 years. By that time it is anticipated that the information contained therein will form the basis of a standard or will be no longer needed by industry.

### Contributing Organizations

More than 25 organizations within the telecommunications industry including manufacturers, consultants, end users, and other organizations contributed their expertise to the development of this TSB.

### Documents Superseded

None

### Relationship to other TIA standards and documents

This document is the second in a series that should lead ultimately to a Residential Gateway standard. The first document was TIA/EIA/TSB109, Multimedia Reference Architecture, which provided the high level fundamental architecture for the gateway. In addition, the residential gateway work depends upon SP-3490 (intended to be published as ANSI/EIA/TIA 570A, Residential Telecommunications Cabling Standard), which describes the physical media that will support current and future home networks and services.

# 1. INTRODUCTION

## 1.1 Purpose

The purpose of this document is to promote industry comments on the minimum application, features, and operational parameters of a Residential Gateway (RG). The recommendations included herein are based on the interface and mediation requirements at the customer premises necessary to effectively utilize existing and emerging telecommunication service access and delivery systems. The document describes the basic functions of the RG, and recommends the associated hardware and software interfaces. When sufficient industry comments are received by the formulating committee, implementation specifications for the RG will be develped and published in a subsequent standard.

## 1.2 Application

The Residential Gateway is intended to provide a common intelligent interface between the service access distribution networks and the consumer's in-home networks and devices. The interface and mediation capabilities of the RG should enable independent evolution of the technologies and physical media used in the destribution network and in the home. This attribute of the RG should make evolution and innovation in both the service delivery and consumer arenas feasible. It should enable service providers and application vendors to offer a variety of multimedia services while masking the complexity of the service access from the consumer.

## 1.3 Mandatory Advisory Terms

In accordance with TIA Engineering Style Manual [TIA_Style] two categories of performance standards are specified: mandatory and advisory. The mandatory performance criteria are designated by the word "shall" while advisory criteria are designated by the words "should," "may," or "desireable" (which are used interchangeably in this docment).

The mandatory criteria generally apply to performance and compatibility issues. They specify the absolute minimum acceptable performance requirements in areas such as transmission, equipment parameters, and durability.

Advisory or desirable criteria represent "above minimum" product goals. In some instances, these criteria are included in an effort to assure universal product compatibility on a national or global basis even with equipment and facilities operational in statistically small quantities. In other cases, advisory critera are presented when their attainment will enhanse the general performance of the service or product in complicated applications.

Where both mandatory and advisory levels are specified for the same criterion, the advisory level represents a goal currently identifiable as having distinct compatibility or performance advantages, or both, toward which future designs should strive.

Although mandatory performance criteria has been designated in this document, these requirements are all subject to change during the follow-on work that should result in the published standard.

## 1.4 Metric Equivalents of US Customary Units

The majority of the metric dimensions in this Standard are soft conversions of US customary units; e.g. 100 mm is the soft conversion of 4 inches.

### 1.5 Life of the TSB

This document is intended to provide interim guidance on emerging technology. The criteria contained in the document are subject to revisions and updating as warranted by advances in telecommunications techniques and technology as they apply to the service delivery and consumer environments.

## 2. SCOPE

### 2.1 Applicability

This document applies to residential gateway systems for single-tenant residences and to the associated telecommunications service delivery and in-home environments. Residential gateway functions may reside in a single physical entity or be distributed among several entities. The intent of TR41.5 is to develop a residential gateway standard that specifies a system that may be made up of a single element or multiple elements that act in concert as a single system. Some residences may elect to have multiple independent gateways for discrete applications such as satellite TV or CATV. While comparable gateway systems may be feasible for multi-tenant residences, they are beyond the scope of this document.

This Document is intended to be in conformance with FCC Rules and regulations, National Electric Code, and National Electrical Safety Code. However, applicable local codes and regulations take precedence over these national regulations and codes.

Figure 1 provides an overview of a typical Residential Gateway environment. The figure indicates some of the services and delivery schemes for a single tenant residence that utilizes an RG as the interface to in-house networks and consumer devices. This figure is intended to provide an overview of the environment in logical terms only, and does not attempt to identify all of the possible service access media or technologies, or in-house facilities.

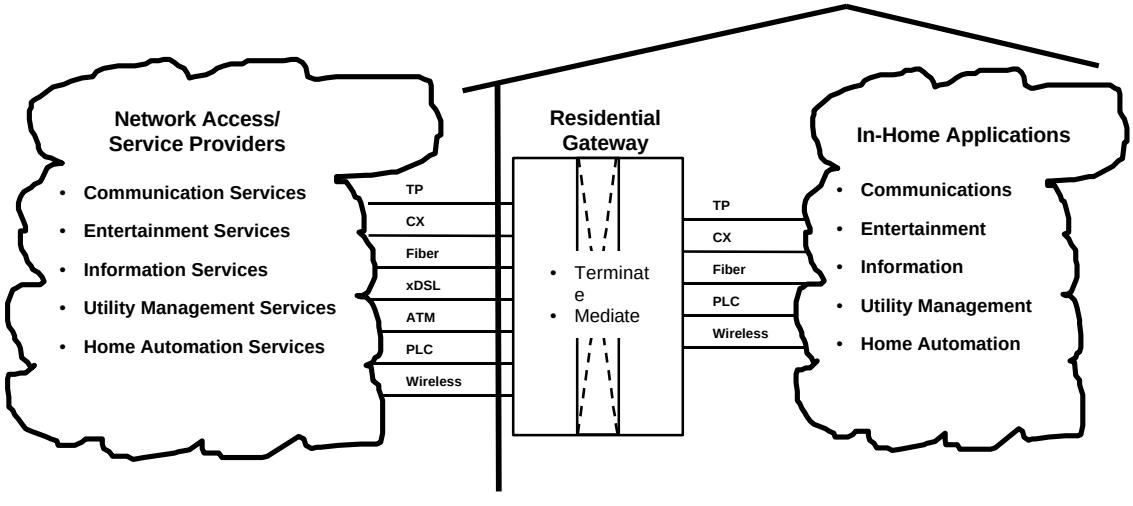


**Figure 1. Overview of Residential Gateway environment**

### 2.2 Normative References

This following standards and codes contain provisions that by reference constitute provisions of this document. At the time of publication, the editions were valid. All standards are subject to

revision; parties to agreements based on this document are encouraged to investigate the possibility of applying the most recent editions of standards indicated. ANSI and TIA maintain registers of currently valid national standards published by them.

- Residential Telecommunications Cabling Standard (SP-3490, to be published as ANSI/TIA/EIA-570-A);
- National Electrical Code (ANSI/NFPA-70);
- National Electrical Safety Code (ANSI/IEEE C2);
- Peripheral Component Interconnect (PCI) Local Bus Standard;
- Personal Computer Memory Card International Association (PCMCIA) PC Card Standard;

# 3. DEFINITIONS, ACRONYMS AND ABBREVIATIONS

## 3.1 Definitions

The generic definitions in this section have been formulated for use by the entire family of telecommunications infrastructure standards. As such, the definitions do not contain mandatory requirements.

**Access line:** a telecommunications circuit provided by the local service provider at the demarcation point.

**Auxiliary disconnect outlet, telecommunications:** a device usually located within the tenant or living unit used to terminate the ADO cable.

**Backbone:** A facility (e.g. pathway, cable or conductors) between telecommunications closets, or floor distribution terminals, the entrance facilities, and the equipment rooms within or between buildings.

**Cable:** An assembly of one or more conductors or optical fibers, within an enveloping sheath, constructed so as to permit use of the conductors singly, or in groups.

**Cable run:** A length of installed media which may include other components along its path.

**Connecting hardware:** A device providing mechanical cable terminations.

**Cross-connect:** A facility enabling the termination of cable elements and their interconnection, and/or cross-connection, primarily by means of a patch cord or jumper.

**Customer premises equipment (CPE):** Telecommunications equipment located on the customer's premises.

**Customer Premises Interface Unit:** Element of the residential gateway system that provides for interconnection and interoperability with the technology of the in-house network.

**Demarcation point:** The point in the access line where ownership changes or responsibility and operational control for service access ends, and the customer's responsibility begins.

**Distribution device:** A device located within the dwelling unit for interconnection or cross connection of cables, e.g. outlet cable, equipment cable, distribution device cable/cord.

**Enclosure:** Assembly that houses the residential gateway system.

**End user:** The owner or user of the telecommunications system.

**Entrance bridge:** A terminal strip that is an optional component in a network interface device and is provided for the connection of distribution wire.

**Ground:** A conducting connection, whether intentional or accidental, between an electrical circuit (e.g. telecommunications) or equipment and the earth, or to some conducting body that serves in place of earth.

**Media, telecommunications:** Wire, cable, or conductors used for telecommunications.

**Minimum point of entry:** The closest practical point where the service provider's access cabling enters the premises, or the closest practical point to where the cabling enters a multi-unit building or buildings.

**Network Interface Unit:** Element of the residential gateway system that provides for interconnection and interoperability with the technology of the service access line.

**Outlet box, telecommunications:** Metallic or non-metallic box mounted within a wall, floor, or ceiling and used to hold telecommunications outlets/connectors or transition devices.

**Outlet cable:** A cable placed in a residential unit extending between the telecommunications outlet/connector and the distribution device.

**Outlet/connector, telecommunications:** A connecting device in the work area, on which horizontal cable terminates.

**Premises:** All portions of the same building or buildings occupied by the same customer, provided that the buildings are not separated by a public thoroughfare.

**Resident:** Individual responsible and accountable for the premises and the services and applications provided there to, may be an individual actually residing on the premises or in the case of a rental or similar category dwelling, the owner or property manager.

**Residential Gateway:** A system that provides an intelligent interface and mediation facility between the service access line(s) and the consumer's in-home networks and devices.

**Star topology:** A topology in which each telecommunications outlet/connector is cabled directly to the distribution device.

**Telecommunications:** Any transmission, emission, and reception of signs, signals, writings, images, and sounds, that is information of any nature by cable, radio, optical, or other electromagnetic systems.

**Wire:** An individually insulated solid copper conductor, such as the wire used to make twisted wire pairs.

## 3.2 Acronyms and Abbreviations

The following acronyms and abbreviations are used in this document:

| | |
|---|---|
| AGM | Access Gateway Module |
| ANSI | American National Standards Institute |
| CATV | Community Antennae Television |
| CLASS | Custom Local Area Signaling Services |
| CPE | Customer Premises Equipment |
| EIA | Electronic Industries Association |
| FCC | Federal Communications Commission |
| GUI | Graphical User Interface |
| ID | Identification |
| IDI | Internal Digital Interface |
| IP | Internet Protocol |
| ISDN | Integrated Services Digital Network |
| LAN | Local Area Network |
| MMDS | Multichannel Multipoint Distribution Service |

| | |
|---|---|
| MTBF | Mean Time Between Failures |
| NID | Network Interface Device |
| NRTL | National Testing Laboratory |
| OS | Operating System |
| PC | Personal Computer |
| PCI | Peripheral Component Interface |
| PCMCIA | Personal Computer Memory Card International Association |
| PCS | Personal Communication Services |
| PLC | Powerline Carrier |
| PNM | Premises Network Module |
| POTS | Plain Old Telephone Service |
| RG | Residential Gateway |
| SM | Service Module |
| STB | Set Top Box |
| TDD | Telecommunications for the Deaf Device |
| TIA | Telecommunications Industry Association |
| xDSL | "x" variety of Digital Subscriber Lines |

# 4. SYSTEM OVERVIEW

## 4.1 General

As shown in figure 1, the Residential Gateway is an internetworking device that provides a common termination interface, mediation facility, and enabling mechanism between the service access distribution networks and those of the consumer's in-home networks and devices. The intelligent termination interface of the RG uncouples the technologies and physical media of the access networks from those used in the premises and vice versa, so that evolution and innovation are feasible in both the service delivery and consumer arenas. Further, through an open-ended architecture that is processor controlled and uses plug-in devices for services and features, the RG provides a platform upon which service providers and application vendors can offer a variety of new and creative services while masking the complexity of the service from the consumer. In addition, the RG provides an opportunity for remote management and maintenance.

Residential Gateways create a home network that can manage its own bandwidth and establish internal or external connections on demand. They make the system scaleable to large numbers of signal sources. They isolate home networks from the details of access systems' physical layer through network layer details.

The Residential Gateway should support the following classes of applications:

- Communications services -- which includes but is not limited to voice telephony (wired and wireless), video telephony and conferencing, distance learning, and remote access to corporate networks.
- Entertainment services -- which includes but is not limited to broadcast, sattelite and cable television.
- Information services -- which includes but is not limited to access to online or internet services.
- Utility management -- which includes but is not limited to demand side energy management and remote meter reading.
- Home automation services -- which includes but is not limited to premises security, lighting, and applicance control.

The Residential Gateway should incorporate means to address POTS service survivability in the event of commercial power outages, RG system failures, or RG unavailability. These means should accommodate fail-safe modes for analog POTS that is delivered through the Residential Gateway (no active elements, no mediation, metallic from power source to sink), and for the higher level communications, entertainment, information, utility, and home automation services that are terminated, mediated, enabled and distributed to home networks via the RG.

Although the residential gateway shall operate in physical environments that have been cabled in a star wired topology as specified in TIA/EIA 570A, the RG shall support operation in other topologies.

## 4.2 Components

As shown in Figure 2, the Residential Gateway shall be comprised of an enclosure, plug-in modules, and an Internal Digital Interface (IDI, bus-matrix fabric) arranged to accommodate the plug-in modules. The plug-in modules shall, at a minimum, comprise:

- Access Gateway Modules (AGMs) designed to terminate and mediate the associated external access. The AGMs implement the functions of the network interface units as described in TIA/EIA TSB109, Multimedia Reference Architecture.
- Premises Network Modules (PNMs) designed to terminate the in-home networks technologies and services The PNMs implement the functions of the customer premises interface units as described in TIA/EIA TSB109, Multimedia Reference Architecture.

Additional plug-in modules called Service Modules (SMs) may be supported to provide specialized services or to supplement the features and capabilities of the RG.

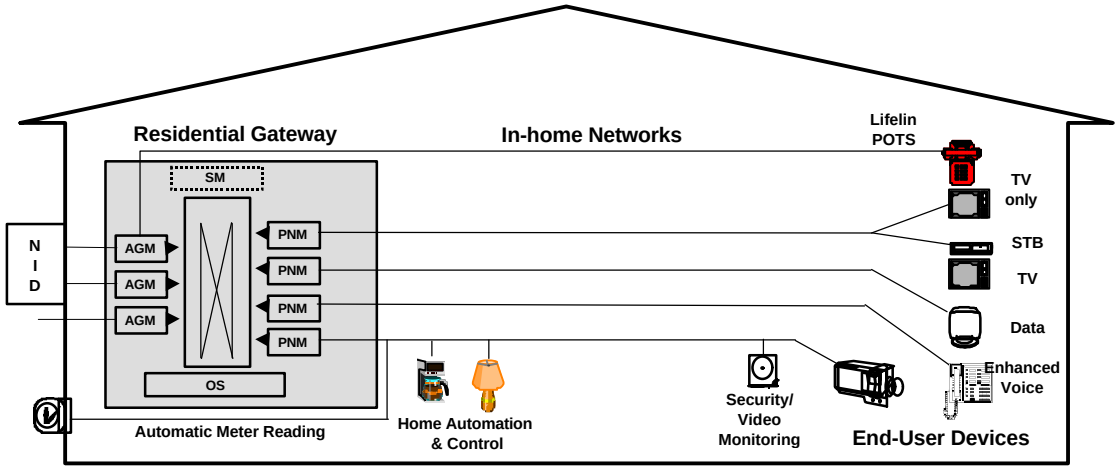


**Figure 2. A Typical Residential Gateway Application**

The functionality and inter-operability of the plug-in units and the core processes and integrity of the RG shall be controlled by a single operating system and one or more central processing units.

## 4.3 Operating System

The Operating System (OS) of the Residential Gateway should enable the smooth inter-operation of devices, services, and networks within the residence so that the complexity, distribution, and technical disparity of the system elements is hidden from users.

The operating system shall enable the RG to:

- Manage and allocate network resources
- Unify the operation of multiple element gateways into a single system
- Broker protocols
- Integrate control over appliances, servers, clients, actuators, etc.
- Provide directory/naming services used for addressing communications to endpoints
- Provide security functions and non-repudiation log files
- Provide easy-to-use interfaces for consumers

### 4.4 Security

The strategic role of the Residential Gateway makes it imperative that access to the RG is protected against hacker attacks and environmental hazards that may affect communications to and in the residential environment. Security functions shall:

- Protect the privacy of service usage,
- Prevent physical destruction of platform components,
- Make it virtually impossible for database items to be inadvertently or intentionally corrupted.

The recommended security functions shall include but are not limited to:

- Authentication: A mechanism by which a resident and the service provider or its authorized agent are authenticated by the RG. This mechanism shall provide a means to prevent the RG from reacting to potentially disruptive commands from unauthorized users.
- Access Control: A mechanism by which a user shall have read only, write only, or a read/write privilege. For example, a user with read-only privilege is only allowed to read data base information.
- Non-repudiation: A mechanism that records user actions to track responsibilities for system changes or actions.
- Physical Security: A means by which the RG and its system components shall be protected from unauthorized physical access.

## 5. FUNCTIONAL REQUIREMENTS

### 5.1 General

From the customers viewpoint, the services availability criteria is independent of the network and equipment architectures. Service availability contrasts with equipment downtime criteria, which depend on network technology and architecture. For consumer-oriented services, a customer services approach is necessary in addition to the more traditional approach based on technology considerations.

Customers expect different services to have different levels of availability. For example POTS should be highly reliable, while video and data services may be less critical thus it is reasonable to specify different classes of service availability and reliability. Services may be put into different classes such as POTS, security systems, video, data, etc. Requirements are only explicitly stated here for POTS and emergency services.

In the aggregate, the Residential Gateway IDI shall provide adequate bandwidth for the following simultaneous service activities:

- Four Set Top Boxes (STB), or the equivalent functionality, simultaneously channel surfing, with each STB/TV viewer surfing through a different set of video channels (i.e., different tiers of video broadcast, near video on demand, and/or pay-per-view services).
- One user connected to an enterprise LAN from a PC with guaranteed bandwidth for typical work-at-home applications such as file transfer, conferencing, etc. This work-at-home functionality should include support for IP-based tunneling protocols.
- One user browsing the Web from a PC utilizing a best-effort IP data capability.
- One fully capable derived voiceband circuit, supporting enhanced narrowband capabilities, including all CLASS features and ISDN-BRI.
- One lifeline POTS circuit, powered from the local Central Office.

### 5.1.1 Lifeline POTS

For analog lifeline POTS service, a power failure pass-through function shall be incorporated into the RG.

### 5.1.2 System Reliability

For any service the unavailability caused by failures in the RG should not exceed 26 minutes per year on average. The MTBF of any service-specific, or network specific devices in the RG should be a minimum of 5 years.

### 5.1.3 Fault Monitoring

One of the primary potential advantages of an RG is its ability to serve as a single maintenance point for services. The RG can monitor its own functions for faults, and can isolate faults between those caused by the outside network and those caused by in-home networks and devices. By providing automatic fault monitoring, the availability and reliability of services provided through an RG can be significantly enhanced.

- Where practical the Access Gateway Modules should provide a loopback functionality that can be remotely activated to enable the location of faults.
- The RG should provide a "health check" function that reports any failures (including low battery charge) periodically. The reporting period may be as often as once or more a day. The system should be capable of remotely activating this capability.
- The RG should provide a power source alarm which is activated in the event of a power outage.
- The RG design should provide a means to notify of unauthorized access by activating remote alarms.

## 5.2 Components

### 5.2.1 Enclosure

The enclosure shall house the internal digital interface and a minimum of 4 plug-in modules. The enclosure shall be listed by a Nationally Recognized Testing Laboratory (NRTL) and shall also

provide an adequate environment for the operation of the RG, including power supplies, ventilation and mechanical protection from the elements.

### 5.2.2 Internal Digital Interface

The internal digital interface shall comply with all requirements of the PCI Local Bus standard

### 5.2.3 Plug-in Modules

The plug-in modules (AGMs, PNMs and SMs) provide the necessary flexibility to address the ongoing technology evolution in the service delivery and consumer products arena. Because the plug-in modules may be installed by a low-level technician or by the resident, the form factor for the devices should be rugged, consumer friendly, and plug-n-play capable. The plug-in modules shall be based on open industry standards to insure interoperability of modules provided by a number of suppliers. These modules shall employ technology and form factors as specified in the PCMCIA "PC Card" standard.

Such plug-in modules may require the use of a cable or dongle to interface with external associated media or ancillary apparatus.

#### 5.2.3.1 Access Gateway Modules

The Access Gateway Modules (AGM) shall be specific to each service delivery technology and shall terminate the access at standard physical and electrical interfaces. Some AGMs may incorporate special equipment (e.g., antennas, transceivers) needed on customer premises; and some may be physically divided between internal and outdoor chassis elements for environmental or service delivery reasons.

The types of service delivery technologies foreseen at this time include but are not limited to:

- Twisted pair, carrying POTS, ISDN BRI, or xDSL modulations.
- One or two-way analog or digital coaxial cable, frequency divided into channels. Currently this medium is primarily used for video broadcast and may also be used for high-speed data, voice, and digital video.
- Fixed wireless loop, narrowband media using analog or digital technology related to cellular, PCS, MMDS and others.
- Direct broadcast satellite, including a satellite dish and other special video reception equipment including satellite or terrestrial uplinks.
- Broadband microwave systems such as multi-Gigahertz, terrestrial or satellite cellular technologies.
- Optic fiber networks, carrying high-bandwidth, multi-wavelength analog and digital applications.
- Powerline networks, including energy management and information services.

#### 5.2.3.2 Premises Network Modules

The Premises Network Modules (PNMs) shall be specific to each in-home network and shall terminate the associated network at standard physical and electrical interfaces. Some PNMs may incorporate special equipment (e.g., antennas, transceivers) needed on customer premises.

The kinds of customer premises systems/networks foreseen at this time include but are not limited to:

- Twisted pair, carrying voice and information services, as well as LAN and home automation applications.
- Coaxial cable, carrying one- or two-way, analog or digital services, frequency-divided into channels. Currently this medium is primarily used for video broadcast and may also be used for high-speed data, voice, and digital video.
- In-home fixed wireless network, narrowband media using analog or digital technology related to micro-cell and 900 MHz.
- Infrared networks, carrying services such as home security, remote control and gaming.
- Optical fiber networks, carrying high-bandwidth analog and digital applications.
- Powerline networks, including control, energy management, and information services.

#### 5.2.3.3 Service Modules

The Service Modules (SMs) are application specific to expand Residential Gateway services. As such they are developed to meed the requirements of these applications. Applications envisioned at this time include:

- Enhanced RG management
- In-home network management
- Directory services
- Data storage
- Specialized services such as TDD and calling number ID display.
- Residential “PBX”
- Master set-top box  adjunct
- Net TV adjunct
- Security system adjunct

## 5.3 Operating System

The Residential Gateway Operating System shall arbitrate and select among access media and service providers, and shall coordinate network services that need access to home CPE. It shall exercise command and decision-making functions, process data related to service costs and preferences, and operate the network and premises interface devices.

The Residential Gateway Operating System shall:

- Supervise and perform plug-n-play functions such as driver support, address and interrupt assignment, hot plugging and recognition of plug-in modules,
- Perform bus arbitration and bus mastering functions to manage access and premises traffic on the PCI bus within the RG.
- Facilitate format conversions to or from in-home or access communication protocols and signal formats.

- Accommodate service provider applications such as customer care, service administration and billing, and other maintenance functions.

The RG OS may facilitate applications such as:

- Controlling telecommunications calls and data exchanges in progress.
- Initiating signaling exchanges with access networks to support call forwarding and related functions.
- Sending and receiving directory and related information requests.
- Coordinating cross-media services. For example, a packet radio control uplink to a network server that delivers IP format data via a unidirectional cable (data) channel.
- Relaying tuning choices, interactive TV responses, and other commands received from user input devices.
- Service provider GUIs and electronic program guides.

## 5.4 RG Access Security

A method of identification and authentication, using valid user identifier and password shall be applied for all accesses to the RG and its subsystems. Access control and non-repudiation security management functions shall be provided to control access for reading or changing data base information, and shall be used by the RG to perform real time functions for services being provided by the RG. Apart from these data base security management functions, physical security management functions shall be provided to protect against physical as well as environmental threats.

### 5.4.1 Authentication

The resident shall have the ability to enable or disable the authentication functions that are under the resident's control.

#### 5.4.1.1 User Identifier

User identification shall be required of all persons attempting to communicate with the RG. The relevant security requirements shall include the following:

- A valid user identifier should support an alphanumeric character string.
- The RG shall support at least 10 unique user identifiers for maintenance and administrative access.
- At the resident's option, repeated unsuccessful RG access attempts shall result in disconnecting the session after a resident-specified number of consecutive attempts.
- Alarms shall be automatically generated after a resident-specified number of consecutive unsuccessful RG access attempts.
- All access attempts by user identifiers shall be logged in appropriate log files.
- The RG access log file shall include the date, the time, and the user identifier.
- The deleted and/or deactivated user identifiers shall be noted in a User Identifier log file.

#### 5.4.1.2 Password

A password shall be used as a means of authenticating RG access. The following requirements may apply:

- A valid password should be an alphanumeric character string of 5-10 characters.
- Passwords should be stored in encrypted forms using standard encryption algorithms.
- Password management should enable password aging and stipulate the time period of password validity.

### 5.4.2 Access Control

A means shall be provided to prevent unauthorized access to RG functions. The RG's owner shall have the ability to enable or disable security functions under owner's control. Service providers shall have the ability to enable or disable security functions pertaining to their services.

#### 5.4.2.1 Inactivity Time-out Function

While performing security-protected functions, a means shall be provided to log off any user identifier after a predetermined period of inactivity. The ability to establish the time-out period and enable or disable its function shall be provided. This time interval may vary depending on the type of function being performed (e.g., monitoring).

### 5.4.3 Non-Repudiation

#### 5.4.3.1 Responsibility Boundaries

The interfaces between the service provider's Network Interface Devices (see Nat'l Electrical Code) and the RG equipment should be governed by an appropriate interface agreement. While no security risks are involved in the absence of such an agreement, inadequate or incomplete agreement may affect the overall service reliability. For example, administrative responsibilities may be left ambiguous, or hand-offs between the RG administrator and the NID administrator may be ill-defined, leading to the possibility of service failures. In such a situation the interface agreement becomes necessary, and its existence should be ensured at whatever cost. Along these lines a responsibility boundary should be defined between all users of the RG and the service providers. These are subjects for future study by TR41.5

#### 5.4.3.2 User System Access Security

The OS shall provide a means of accurate record keeping and non-repudiation (e.g., "I did not do it"). At a minimum these records shall include:

- A record of all successful attempts by user identifiers and all disabled user identifiers. This record includes the date, the time, the user identifier and the activity.
- A record of deleted and/or deactivated user identifiers. This record includes the date, the time, the user identifier.
- A record of user identifiers that have been inactive for 30 days.

#### 5.4.4 Physical Security

The RG should be resistant to vandalism and it should be difficult to surreptitiously disable any alarm services that the RG provides. If the RG is located outdoors, then it should be equipped with a locking mechanism. Other physical security requirements are addressed in Section 6.

## 6. PHYSICAL SPECIFICATIONS

This section is a subject for future study by TR41.5.1. The goal of this work (PN-4408) is specifications to be published as TSB-111 for the individual sections outlined below.

### 6.1 Enclosure

### 6.2 Plug-in Devices

### 6.3 Power Requirements

#### 6.3.1 Primary Power

#### 6.3.2 Back-up Power

#### 6.3.3 Electrical Protection

### 6.4 Operating Environments

## 7. RG OS SOFTWARE SPECIFICATIONS

This section is a subject for future study by TR41.5.2. The goal of this work (PN-4409) is specifications to be published as TSB-112 for a fast, small, multitasking, realtime OS that is non-proprietary.

## 8. RG SOFTWARE SERVICES SPECIFICATIONS

This section is a subject for future study by TR41.5.2. The goal of this work (PN-4409) is specifications to be published as TSB-112 for a non-proprietary set of messaging service primatives, protocols, and protocol translators internal to the gateway system for controlling the various service elements.