Future-Proof Your Broadband Gateway Designs

Through a little due diligence, a designer can do much to ensure gateway longevity in the face of rapidly evolving networking options.

By Ian Ferguson

The broadband gateway increasingly must support rapidly evolving technologies on both the local- and wide-area-network fronts. Future-proofing a system so that it can economically and efficiently support all requirements, without compromising performance, demands careful attention to architectural partitioning, processor selection, software design and reuse, quality-of-service support and system management.

Three broad categories of gateway systems are being deployed in residences: the broadband modem, the Ethernet gateway and the broadband router. A broadband modem includes the chip set to support the WAN port as well as one or two LAN ports. These systems act as a bridge between the WAN and the LAN media, converting the data received on one port into a form that the other port understands. In the case of asymmetric DSL (ADSL) technology, the Internet service provider (ISP) provides the system.

An Ethernet gateway does not include the WAN port inside the system. Instead, an Ethernet connection is provided to a separate modem. These gateways include multiple LAN ports, both wired and (increasingly) wireless, and are responsible for making routing decisions on incoming traffic. More systems are adding such services as firewall and security to prevent unauthorized access to the home network from the outside. Additionally, such services can control the type of content that each user inside the network can access externally, and they allow the professional user to access the high-speed broadband pipe to tunnel into his corporate network.

A broadband router is the integration of the modem and gateway functions into a single box. In the cable market such integration has already occurred, but for the ADSL market the two functions remain separate. While ISPs, system suppliers and end users clearly prefer to use a single box, several technical and business barriers, beyond the scope of this article, prevent the proliferation of such integrated boxes.

The diversity of technologies competing inside the home demonstrates the need for some degree of modularity and flexibility within the systems. The designer needs to architect a platform that not only can support a variety of existing WAN and LAN technologies, but also can expand upon those technologies to interface with any new connectivity standards.

Another dimension of future-proofing gateway designs is to provide the required headroom to support new, more valued services, including superior security, simplified system management, and...
additional ports and capabilities.

System cost is of paramount concern, especially for such consumer applications as broadband gateways. The pressure is on hardware suppliers to minimize the overall system cost and the initial outlay. Over time, this metric may become the total cost of ownership, rather than just the cost of the individual box.

As always, system performance is critical. As additional services are offered, the focus will shift from transmit, receive and data processing at line rates to tracking how efficiently the system can handle voice, video and control information.

**Building in flexibility**

While it may be relatively simple to design multiple hardware platforms for every WAN and LAN configuration, the need to develop and maintain a broad number of relatively complex software packages for each quickly renders an integrated solution prohibitive. Therefore, suppliers are moving toward a modular approach to gateway design.

For example, a gateway design can be partitioned into three blocks: a WAN module, a LAN module for wireless or wired Ethernet and phone connections, and a section for overarching system administration (see Fig. 1). Such partitioning allows the manufacturer to provide customizations without redesigning the whole system. It also enables the service provider to upgrade a customer without replacing the entire gateway.

Partitioning also streamlines the software task, enabling gateway manufacturers to reuse the majority of common code across all gateway platforms and to take advantage of third-party software. System design houses can then focus their software engineering resources on those areas that make the most sense for them.

**LAN options support**

There are a variety of connectivity standards, especially on the LAN side of the gateway, that a gateway might need to support. Only time will tell which of the standards will eventually dominate. Until then, gateways must offer support for most, if not all, of the connectivity standards and their respective interfaces. While the diversity of interfaces creates some interesting design challenges (see Fig. 2), most of the interfaces can be connected with the inclusion of a few industry-standard buses inside the system.

from a board layout point of view, building a platform for multiple I/O configurations is a relatively easy task. The most straightforward approach is to design in all of the interfaces but only populate those interfaces that are required for the gateway deployment in question.

- A modular approach allows customization without the need for a complete system redesign.

The challenge is more difficult from the system design and software perspective. For example, Universal Serial Bus (USB) 2.0 operates up to 480 Mbits/sec- ond, whereas 802.11b operates up to 11 Mbits/s. If the platform adds a USB 2.0 peripheral, it needs to be flexible enough to adjust to a bandwidth increase of more than 40 times the previous rate.

It is also important that the processor easily adapt to different system configurations. One way to facilitate that is to select a processor that already includes the interfaces needed to run concurrently. A big plus is extra central processing unit (CPU) performance that enables the processor to prioritize on-chip resources, such as the direct memory access (DMA), CPU compute time, interrupt handlers and certain I/O interfaces.

Beyond supporting the LAN/WAN interfaces, the integrated processor is responsible for the conversion of data between interfaces. When selecting a processor, the designer should look for performance numbers that convert data quickly and meet the required interface rates. For example, a 50-MHz CPU core provides ample horsepower to handle packet conversion tasks, but implementing such tasks as routing, firewalling and security will probably push the required CPU performance up to (and potentially above) 150 MHz.

Of course, system design significantly affects the efficiency of the processor throughput. Analysis of system performance usually shows that despite the seemingly high-performance potential of the underlying hardware, the overall system does not operate at peak performance. For example, performance is often lost in operating system (OS) overhead during the handling of interrupts and other such tasks. Since this performance differential is most likely due to software, a system builder can optimize performance by customizing the software. The trade-off with more customization is less portability. But recent developments are helping to reduce the computational overhead. That means that generic Ethernet drivers will perform multiple memory-to-memory transfers to convert data into a form that higher-layer software stacks understand.

- **High-end interfaces**

In addition to the diversity of WAN and LAN interfaces, several are migrating to higher performance. Designers who want their gateways to stay current with evolving interfaces should keep these emerging standards in mind. The 802.11a and 802.11g wireless standards support data rates that are five times faster than the 802.11b technology currently being deployed. ADSL 2 Plus and very high-data-rate DSL (VDSL) WAN technologies promise data rates far faster than today’s cable or ADSL technologies. Also, as discussed above, interfacing to USB 2.0-compatible peripherals adds a port operating about 40 times faster than most of today’s LAN technologies.

The impact on the system designer wishing to use one platform to support a broad range of standards is twofold:

1. Ensuring the selected device can support the worst-case system configurations that need to be supported.
2. Ensuring the core hardware is flexible enough to adapt to these changes and the throughput expectations on the various interfaces. That includes the capability to prioritize the servicing of certain I/O interfaces ahead of others with such resources as DMA, interrupt handling and available CPU bandwidth.

- **Quality-of-service**

It is imperative that a broadband design be able to sustain certain throughput performance levels. Several ISPs have developed their own benchmarks in this area, setting performance requirements based on various cable lengths and based on the need to simulate customer prem-
uses equipment (CPE) at different distances from the central office.

As these boxes start to support more than just data, new aspects of performance and associated considerations will appear. How well is voice traffic handled in the presence of data services? Can a user watch a video that is being streamed down from the central office while another user surfs the Internet? For time-critical media such as voice and video, the gateway will need to be able to prioritize the processing of such information ahead of simple data services. That includes specific quality-of-service (QoS) aspects, with WAN bandwidth allocated to the priority services.

Depending on the services being used at a particular point in time, bandwidth for the WAN port can be allocated dynamically. For example, video, when required, can be allocated a significant proportion of the bandwidth, relegating data services to a smaller proportion of the available bandwidth. If an intelligent appliance on the LAN is connected via a slow-speed connection—such as a Bluetooth-based connection to an intelligent phone—this port can be configured to a relatively small proportion of the overall bandwidth. Other ISP services—such as remote management, which allows a customer or service provider to check closed-circuit television (CCTV) in the home and control climate or other appliances—can be allocated a minimum level of WAN bandwidth.

Clearly, most of what is described here constitutes niche services today. But trials of ADSL-based video-on-demand services continue, and rollouts are approaching in certain territories around the world. Additionally, several security firms are eying gateways for remote management of properties as a significant new business opportunity. Companies are starting to figure out which functions—beyond the basic ability to check e-mail and Internet information—these deployed systems can provide.

In the past, system suppliers relied on the silicon supplier to provide software that handled the basic WAN and LAN protocols required in a gateway. That requirement has now been extended to include the provision of higher-layer software stacks, much of which can come off the shelf (see Fig. 3).

There is increasing momentum behind the inclusion of more advanced security functions in boxes. Today, there are two approaches for implementing advanced security functions: implementation in the software on the CPU core or the use of a dedicated chip that accelerates Internet Protocol security (IPsec) algorithms. To be more specific, the latter chips will convert (encrypt) the plain

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**Figure 3:** The diversity of possible interfaces creates some interesting design challenges, though most of these interfaces can be connected by including a few industry-standard buses inside the system.
text prepared to be sent across the WAN and will perform decryption in the reverse direction.

At the relatively low line rates of an ADSL or cable connection, these algorithms can be implemented in software. However, there are three considerations a system designer must review before taking this approach:

- Will the platform need to support data rates greater than 1 Mbit/s to 2 Mbits/s in the future?
- How many users concurrently connected to the box will need this service? Since the software implementation takes a significant amount of an integrated processor’s bandwidth, the need to support multiple secure links from a single box may result in the reduction of sustainable throughput across the WAN.

- Is support for future services being considered? Implementation of the IPsec function in software will leave very little CPU bandwidth available to support additional services that an ISP may wish to deploy via software updates over the network to systems deployed in the field.

**Implementing voice**

There are two approaches to implementing a voice integrated access device (IAD) in a broadband gateway, with the choice riding on the number of voice ports that need to be supported and the amount of processing that the gateway will need to do on each voice stream. For processing, the key consideration is the level of compression required.

One option for implementing a voice IAD is to include a dedicated digital signal processor (DSP). This device performs the compression, echo cancellation and dual-tone multifrequency (DTMF) signaling functions. The DSP will then issue the voice traffic as formatted IP packets to the control processor for subsequent transmission to the WAN.

An alternative solution is to implement the DSP function in other parts of the system.

Some companies are increasing the intelligence of the coder/decoder to include the voice-processing function. A more standard approach, however, is the use of the control processor to handle the voice processing (see Fig. 4). Some implementations include a small DSP on the control processor itself; others use the RISC CPU core included in the control processor to perform the voice-processing functions. For example, companies such as Hellosoft have demonstrated that G.729 compression for a single voice channel can take approximately 20 percent of a 150-MHz 32-bit CPU core.

For low-port-count (under four ports) solutions, the trend is clearly toward the removal of the external DSP. These systems are less capable of scaling upward but do reduce overall system cost. A system with more voice ports, typically eight and above, will include the external DSP.

As the broadband gateway market emerges, it will undoubtedly move in various directions before eventually settling down and maturing. Creating flexible, modular solutions with sufficient performance for advanced requirements will solidly position customer-premises equipment manufacturers to successfully negotiate any new requirements, while giving service providers sufficient room to innovate and adapt.

For related discussions, see:


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