IPTV ecosystems and DSP-based set top box design

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The market for Internet Protocol delivery of digital television (IPTV) by telecommunications service providers promises to become sizable in the next few years. Today, however, this market is a welter of competing hardware and software solutions, complicated by a variety of compression technologies and the potential convergence with home network applications. These factors make decisions difficult when it comes to designing IP set-top boxes (STBs), so original equipment manufacturers (OEMs) need to select processing technology that lets them keep their implementation options open.

As the focal point of delivery, the STB must be able to adapt to the particular IPTV "ecosystem" in which it is deployed. Interoperability is therefore vital for these systems, as well as the performance needed to handle the high throughput of video. With the many new applications that IPTV networks may offer, scalability becomes important as well, and cost is always an issue with consumer appliances. STB designers are finding that these requirements are met by highly integrated digital signal processors (DSPs), which not only supply high real-time performance affordably, but can also be reprogrammed easily for new configurations, updates, upgrades and applications.

View full size
Figure 1: The IPTV ecosystem

The IPTV ecosystem
The STB has to interact with all the equipment and software in an IPTV ecosystem, the major items of which are shown in Figure 1. At the head end, the service provider encodes video for IPTV transmission from sources such as terrestrial broadcast, pre-recorded specialty content, and satellite TV channels. Content can also be provided directly from the VOD server. To insure proper access, all of this content delivery is tied closely to the Conditional Access Server (CAS), which provides transmission security through measures such as encryption, verification and authorization.
Coordinating these elements is the middleware server, which monitors client requests, communicates with the other servers, schedules transmissions, and interfaces to network administration for provisioning, billing, maintenance and other necessary services. This server also communicates with the middleware in the client Set Top Box (STB) to manage these requests and provide a friendly graphical user interface (GUI).

The client end of the figure shows a DSL modem and the STB --functions that in some cases may be combined in a single box. The STB receives and decodes the IPTV signal from the broadband connection, then outputs one or more streams for TV display. It should be noted that most schemes proposed today do not include wide-open access to the Internet through the STB, but this capability is likely to be supported in the future.

**Next: STB browsers and middleware**

**Figure 1: The IPTV ecosystem (repeated from first page)**

**STB browsers and middleware**

On top of the STB's WinCE, Linux or VxWorks operating system (OS) sits the browser, which acts as the graphical engine and permits easy access for interactive services through its interaction with the middleware. The middleware client software coordinates access to the network. Some browsers and middleware clients are based on HTML with JavaScript, while others are Java-based and run on a Java Virtual Machine (JVM) in the STB. An emerging option integrates the middleware with Macromedia Flash or Dynamic HTML for more complex graphic capabilities. Each of these options in turn is more complex and requires a greater degree of performance, so the STB processor needs to scale in order to support these different combinations. A processing architecture that allows processing-intensive graphics and video tasks to be partitioned from ordinary operational tasks can accelerate the overall performance of the system, providing overhead for scalability.

Service providers all have their own systems, and the STB must comply with these in order to be used in different IPTV environments. Each deployment has a unique network configuration and list of offerings, so the middleware, browsers and other software continue to evolve as new features and services are added. OEMs must consider whether the performance of a given processor permits the system to be scaled to support these changes and perform new tasks.

**Providing security**

Software-based conditional access (CA) systems, much like Digital Rights Management (DRM) software, employ open security standards such as AES or 3DES to enable the exchange of encryption
keys for conditional access. If a hacker manages to break the key, a programmable processor allows the STB to be quickly modified to enhance the security level.

Traditional hardware-based approaches to CA use smart cards and fixed hardware to guard the system from unsecured access. Like software-based systems, these hardware-based security systems must continually evolve in order to defeat hackers; therefore, the CA vendors build into their designs different levels of security that not only support legacy usage, but also anticipate new access conditions in the future. These security features require that intellectual property be built into the processor; and since each of the CA vendors has its own set-up, a STB manufacturer needs to insure that the proper support is built in for all major vendors.

More recently, watermarking has become of interest to content owners and thus to service providers and the manufacturers who provide IPTV equipment to them. In the event that content is accessed without the proper authorization, watermarking technologies allow the service provider to quickly find the point of this illegal access and where the CA must be upgraded. As with other IPTV technologies today, there are several vendors now offering watermarking technologies.

**Video encoding and VoD**
MPEG-2, the legacy video codec (coder/decoder) used today by the industry, has been available for standard-definition TVs for many years, and it is now used routinely for high-definition TVs as well. Initial roll-outs of IPTV relied on MPEG-2; however, to improve bandwidth utilization and increase the number of homes reached, many service providers are introducing more advanced codecs such as H.264/MPEG-4 part 10/AVC and WMV9/VC1. These newer codecs typically offer gains on the order of 2-3 in bandwidth utilization over MPEG-2. In addition to these popular advanced codecs, China is deploying its own new standard, AVS.

Along with the video codecs comes a variety of available audio compression standards that can be used in combination with the various video codecs. Also to be considered is that, within each codec specification there is some room for interpretation, allowing encoder vendors to continually enhance their products to achieve better quality and reduced bit rates. There are thus several possible combinations of video and audio codecs, which may differ slightly in implementation, from the various encoder vendors.

Video-on-demand communication is based on RTP, the streaming protocol for downstream transmission, and RTSP, the control protocol for data -- both of which allow for a great deal of flexibility in implementation. To complicate interoperability even more, different VoD vendors use different off-line encoders that all have their own encoding characteristics. To compound the problem, VoD servers from different vendors may be installed by a single IPTV service provider.

Multiple codecs, a variety of codec combinations and implementations, and different protocol interpretations: all of these factors require that an STB be designed with flexibility and scalability in order to support widely varied, continually changing interoperability requirements.

**Home networking**
Since the STB shares much of the same technology that is used in digital media adapters (DMAs), it can be expected that the STB might also be connected via an Ethernet, HomePlug, WLAN or Moca
connection to a home network. The STB could then receive and play content from PCs, such as photo slide shows, music, or even video downloads from the Internet. It should be considered that the STB might also have its own hard disk for recording IPTV-delivered content, which could then be shared over the network. The possibilities for convergence become even more interesting if the STB is connected to entertainment systems such as networked DVD players, sound systems and game consoles. Eventually, applications such as videophones and on-line gambling are also likely to converge with STBs, bringing their own set of interoperability issues.

To be able to handle these new converged applications, it is important that the STB be able to support the standards used by a wide range of household systems and, because of the varying needs within a home network, that it also offer a variety of services to the user. For example, transcoding and transrating a 4-Mbps MPEG2 stream to, say, a 1.5-Mbps WMV9 can conserve bandwidth and increase the amount of media that can be stored in a given capacity drive. As another example, transcripting from CA to DRM security can insure the protection of video content within the home network. Developing interoperability standards for home networks is the concern of the industry consortium Digital Living Network Alliance (http://www.dlna.org), and most media products available today for use on the home network adhere to the DLNA standard.

Next: Processor requirements for IPTV

Processor requirements of STBs
Interoperability within different systems and configurations is important not only in the short term, while different IPTV ecosystems are being deployed, but also in the longer term as things continue to evolve. STBs will have to adapt as the many possible combinations of operating systems, compression technologies, middleware, browsers, CA/DRM, live encoder vendors and VoD server vendors are being deployed by different service providers and as the providers begin to add new services to their offerings. Successful STB designs will depend on processing solutions that offer high performance, programming flexibility, scalability and high system-level integration.

Audio-video codecs, graphics acceleration, communications and the many potential convergent household applications will require a high level of performance, most of it for signal processing in real time. Performance may be augmented by use of accelerators and through software partitioning—the separation of signal processing tasks such as video decoding that are performed best by a DSP from control tasks and the user interface that are better handled by a RISC microprocessor. By running tasks on the processor most suitable, the designer insures the highest performance and most efficient product design.

An example DSP media processor
TMS320DM644x digital media processors from Texas Instruments illustrate how DSPs meet the requirements of IP STBs. The advanced C64x+ DSP core is combined with video co-processors to provide the high-speed computation required for video encoding and decoding, plus an ARM926 RISC processor for user interfaces, system control and application programming ease. System-on-a-chip (SoC) integration also provides networking peripherals, audio-video interfaces, a high-speed memory subsystem, external memory interfaces, and enhanced direct memory access (EDMA), thus reducing hardware bills of materials by as much as 50 percent.

Figure 2 shows the features of the DM6443 processor, which is designed for decoding systems like STBs. Another device, the code- and pin-compatible DM6446, provides an easy upgrade for adding
DM644x processors can be programmed to support any number of audio and video standards, and could be updated easily via downloads as network configurations and service needs change. Software partitioning into mathematically intensive signal processing on the DSP and video accelerators, and control operations on the ARM, provides a great deal of performance overhead for use by other applications. As a key element of TI's DaVinci video technology, DM644x processors are supported by foundation software and APIs that make video system development straightforward and simplify the task of client-host interoperability.

**Next: IPTV Client Software System and DSP Architecture**

**DSP-based STB software architecture**

*Figure 3* shows the basic software architecture for a DM644x-based IP STB, including applications such as the host OS, browser and middleware in the software stack. At the base is the DSP/BIOS real-time OS and Link, the framework for communications between the RISC and DSP. On top of this layer lie the essential video rendering and playback software portions of the audio-video (AV) media engine. The browser with its graphics engine, and the client middleware and conditional access, are all tied to the media engine via the AV player, which is the key link between the applications and the codec engine. The applications tie into the host OS, along with the drivers, TCP/IP stack, and other network protocols necessary to provide communications and external interfaces.
Interoperability in a changing market
With the IPTV market set to take off, the number of competing ecosystems means that STB developers have to keep their implementation options open. Interoperability is key in today’s market environment. High-performance DSPs provide the programming flexibility that can insur interoperability and versatility in changing IPTV ecosystems. SoC integration brings these advantages at an affordable price, and software makes development fast and simple. In the evolving IPTV market, DSP-based STBs will be able to adapt to changes quickly and cost-effectively.

About the author
Charlie Gonsalves serves as the Business Development Manager for Texas Instruments’ Streaming Media group responsible for generating new business as well as driving the strategic direction and managing relationships with customers and partners. In his previous roles at TI, Gonsalves worked in strategic marketing for ADSL CPE chipsets in the Broadband group and the Modem Business Manager within the DSP organization. Prior joining TI 13 years ago, Gonsalves served as a program manager at Hayes Microcomputer Products Inc. Gonsalves holds a bachelor’s in electrical engineering from the University of Florida and an MBA from Georgia State University. He can be reached at c-gonsalves@ti.com.