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Reinventing the STB

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Technologies such as multi-standard video decoders, advanced video processing, RF and near-field communications will enable STBs to power the revolution in the TV viewing experience. In addition, the rise of IP networks will partly replace or complement existing networks for receiving television signals.

Video is being revolutionized by the ability of semiconductors to process staggering amounts of data in real time. For consumers, long-term benefits will be threefold:

1. More content is available with the ongoing transition from analog to digital.
2. Consumers will enjoy a substantially better viewing experience with the switch from SD to HD.
3. Access to this cornucopia of vibrant content will be possible anywhere and anytime.

Delivering these benefits will require nothing less than the reinvention of the STB itself and its ability to function in a peer-to-peer entertainment network where it cooperates with PCs and audio-hubs and incorporates functionality to act as a DMA or PVR. This will require the introduction of new technologies and products that make the reinvention possible.

While processing power on sophisticated silicon architectures is a sine qua non for the video revolution, other technologies are also playing important roles in revolutionizing the video viewing experience.

The Internet is driving the widespread distribution -- the virtual ubiquity -- of digital content to a degree that DVDs and other digital media could not. But the Internet's impact is more extensive than that: it is also evolving from a simple delivery pipe into a means of providing customized, content-related services that allows consumers to use video content in entirely new and different ways, such as Google's You Tube.

From analog to digital

A parallel but intimately related development is the migration from analog to digital. By 2011, 90% of homes in Europe and North America will consume digital content. The migration will be much faster for Japan and Korea. China will soon catch up after developing its own digital standard.

For the design engineer, the transitions from analog to digital and from SD to HD together add up to one big challenge: Format conversion.

On the analog side, the variants are NTSC, SECAM, and the various PAL standards. The digital menu, on the other hand, is more diverse, particularly when legacy content is included. MPEG1, MPEG2, MPEG4, H.264 and WMV are familiar enough. But digital broadcast standards such as the DVB variants in Europe, ATSC in North America, ISDB in Japan and China's AVS must also be included if the list is to be complete.

Table 1 provides a summary of the options, including audio, that are essential to achieving a vibrant digital video experience in the IP-STB era.

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<td>H.263</td>
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<td>AVS for China</td>
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Table 1. Multiple format and connectivity options add up to a big engineering challenge

From SD to HD
The SD to HD trend has implications for the Internet because by 2011 more than 50 million households worldwide will have IPTV subscriptions. The vast majority of these households will tap into their IPTV service with an IP-STB.

The panels in LCD televisions have reached the limits in picture quality capabilities. Improvements have to come from advanced video processing to:

- Increase the frame-rate
  - 120Hz with full up-conversion
  - Motion compensation in all directions, not just horizontal
  - Seamless operation of enhancements
- Create smart algorithms
  - MPEG artifacts reduction
  - Moving artifact reduction
  - Out of focus background sharpening
- Advance in digital without neglecting SD material
  - Large amounts of SD material for the foreseeable future
  - Sharpening / up-conversion algorithms to reduce consumer awareness of SD
- Process in HD at 10 bits throughout
  - Must be throughout the entire video processing chain
  - No down scaling to 8-bit components for intermediate calculations!

These semiconductor processor developments will make sure that displays will match the characteristics of the human eye and therewith give a better sensory experience.

Standards for anywhere/anytime access in the home
There is still an additional set of technologies that must be included if the reinvention of the STB is to be properly realized.

The third consumer benefit cited above—anytime/anywhere media—can only be achieved through robust wireless RF such as Wi-Fi (more specifically IEEE 802.11n), WiMAX, advanced 3G cellular and 4G cellular networks, and undoubtedly other technologies as well such as powerline, HomePNA, Moca, ethernet, etc.

An option that is receiving a great deal of technical interest is the introduction of peer-to-peer networks in the home because it reduces Internet bandwidth requirements—a worthy goal in a telecommunications infrastructure stressed by sharply rising video content. Today's paradigm calls for material that is requested from any part of the home to be routed through the home network.

The IP-STB is likely to play a key role in this, as it is already connected to a (home) IP network. Therefore access to content in other places in the home over the same IP network is enabled. Current WiFi technology (based on IEEE 802.11g) lacks bandwidth for HDTV video streaming. The new 802.11n standard operating on 5Ghz will be essential for IP-STB enabling fast and reliable streaming of video content through the home. New silicon available for 802.11n is all in the draft certification phase and currently used on a small scale for gateways. As this WiFi standard is the ideal fit with an IP-STB, a strong market penetration is expected starting in 2008.

By adding a PVR (personal video recorder) to the STB, content can be stored—and accessed—locally, giving consumer the ability to time-shift the viewing and not worry about the time of broadcast.

The new service and financial transaction options that will be available in the Internet will also make it necessary for the IP-STB to offer a very high level of security and accommodate digital rights management (DRM) concerns.

Now that the engineering challenges have been defined, let's look at the most promising solutions.

Multi Standard Video Decoder
Performance and cost are the primary drivers when developing video products for mass-market adoption. In the case of format conversion for next-generation of STB video, the two become almost complementary. Single-chip solutions are always cost effective and since the performance for this application has been set so high, on-chip processing is also a must-have.

The need for a multi-standard video decoder (MSVD) is evident. Implementing it is easier said than done. But it is possible through the clever use of hardware and software partitioning coupled with efficient media processing DSPs.

The key to a cost-effective, high performance MSVD is to recognize that decoding a video stream can be seen as a two-step process. The first is a control-intensive parsing procedure in which the stream is interpreted to recover basic information such as macroblock type, macroblock partition, prediction type, motion vectors, residues etc. In the second step, this information is used to drive the signal-processing intensive pixel processing units that produce a decoded frame.

Making a clear separation between the control-intensive parsing process and computation intensive, highly parallel pixel processing provides the efficiencies required for a high-performance MSVD.

A block diagram of an MSVD that exhibits all of these architectural characteristics, NXP's PNX8335, is illustrated in
The CPU is complemented with hardware accelerators and custom instructions for stream parsing. This architectural choice provides flexibility necessary to deal with the different standards and the complex decision tree executed during parsing operations.

**Figure 1.** Multiple digital video formats can be handled by a single MSVD.

The CPU (TMConfig Figure 1) is a derivative of the TriMedia 32-bit CPU family that delivers raw performance of 1650 MOPS. It has a VLIW architecture with 5 issue slots and several functional units running at 330 MHz. A low latency load/store interface is added for optimal communication with hardware accelerators.

The load/store interface also allows operations to be scheduled optimally by the compiler tool chain. This approach eliminates most of the stalls usually induced by the interaction with an external accelerator.

The hardware accelerator attached to this interface carries out repetitive tasks (e.g. inverse transform coefficient decoding) but also CABAC (context-adaptive binary arithmetic coding) decoding. The CPU is not used because it is difficult to map this highly sequential operation on a CPU efficiently.

The core provides support for an additional custom unit for multi-cycle and pipelined operations, which makes it a powerful extension. This feature is used to extend the normal instruction set with dedicated operations mainly for motion vector computations.

For pixel processing, the challenge comes from the high throughput that has to be delivered when decoding HD material. Although it is possible to build a media processor that can execute some of the decoding tools with a very high efficiency, this often comes at the cost of other trade-offs. The result is an overall performance figure for the complete pixel processing stage that is inadequate for HD decoding, or, it may simply be too expensive.

The key to an efficient pipelining architecture is realizing that all mainstream video decoding standards use exactly the same three core processes: residual decoding, motion compensation and deblocking filtering.

Therefore, the MSVD has a 5-stage macroblock processing pipeline composed of 10 dedicated processing units running simultaneously to provide HD decoding performance in a small footprint. The logic runs at 165 MHz and is able to process up to 250 kMacroblock/s. Each dedicated unit can process a macroblock (16x16 luma pels + 16x8 chroma pels) in less than 640 cycles.

**Secure IP-STBs**

As previously mentioned, Internet services, including financial transactions, will become normal operating procedure in a few years. As an Internet portal, it's necessary for the IP-STB to provide a high level of security.

There is a second security aspect that is just as important. As new video devices enter a home, the IP-STB's role as a media server will also require a security layer. In particular, device configurations must be moved between devices easily and seamlessly.

NFC is designed with security in mind. It operates only over very short distances—typically less than 4 cm—and its communications are encrypted. NFC was originally designed for "no-touch" data transfers across very short distances using the 13.56 MHz RFID band. It is an open standard, defined by ISO 18092 and ECMA 340 and is backward-compatible with the global standard for RFID per ISO 14443.

Early applications of NFC technology in mobile phones more or less mirrored RFID applications such a swiping (or, more appropriately, tapping) an NFC-enabled phone near a reader to gain quick access to a technical conference.

Its application to the IP-STB become apparent when one considers that the IP-STB will become a means of making financial transactions such as paying for third-party services that are not provided by the initial service provider. Similarly, when a new device such as a second set-top box or a mobile media player is introduced to the IP-STB system it must be configured to work in the new on-the-go environment. On top of that, NFC can easily be combined with securing the 802.11n network without using complicated WPA codes. In the set up of the STB this could make life for the customer easier, therefore reducing the need for helpdeks and installation services.

A smart card with detailed configuration information—and identification information unique to the equipment's owner—is an ideal way to accomplish this task. NFC brings just the right mix of capabilities to the party.

**Conclusions**

Over the next few years, video will enter a new and exciting stage driven by the transition from analog to digital, SD to HD, the emergence of video services on the Internet, and the desire of consumers to take their personal media with them anywhere they go.
As a result, the IP-STB will be reengineered to deliver a richer, more vibrant user experience using a variety of technologies that include NFC, peer-to-peer networking over connectivity links, and silicon technologies such as NXP's MSVD.

The video revolution will not proceed at the same pace in every geographical region and consumers within regions will have to, as always, match equipment purchases to their household budgets. No single solution will suffice.

Evidence that the challenges can be addressed can be seen in the recent announcement of three STB development platforms developed for specific applications and markets by NXP Semiconductors.

The entry-level STB100 delivers and electronic BOM of $20 and is targeted at single-channel STBs. The STB220 includes a digital media adapter (DMA) and digital video recorder (DVR). It delivers a BOM, including hard drive, of less than $100. Finally, the STB225 HD IP-STB platform targets IPTV services and delivers a sub$70 BOM. Next to that a STB can be equipped with a Mini PCI 802.11n module. NXP has several module’s available with interfaces meeting most of the STB reference designs. These developments show that the STB has turned into a mature product, capable of dealing with complex structures and allowing many consumers all over the world to enjoy the ongoing flow of vibrant digital media, easily and affordably.

About the author
Roger Gregory is the marketing director of the Telco and Operator group in the Home business unit at NXP Semiconductors. Roger is responsible for leading the global marketing and business development activities for IP-set-top box (STB), satellite pay system STB solutions and wireless audio products. The global marketing team he leads is focused on bringing advanced solutions to customers that meet the requirements of these new, emerging markets. Roger began his career at NXP in 1994, as an engineer, and then a systems architect for the Philips optical drive solutions based in the United Kingdom. In 2000, he became the international marketing manager of DVD Recording systems. Following a year in corporate strategy, Roger moved to the U.S. in 2005 to lead the marketing activities for IP-STB solutions. Roger holds a degree in Electronic Engineering from University of Salford, England. He may be reached at roger.gregory@nxp.com.