Xilinx FPGAs and IRL Keep ReplayTV on Target

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Field programmable gate arrays and Internet Reconfigurable Logic™ from Xilinx are critical elements of ReplayTV's strategy to be first to market and best in class.

The best way to hit a moving target is to move with it. As a business strategy, ReplayTV™ is leading the edge of the fast-moving personal video recording market. Based in Mountain View, Calif., ReplayTV Inc is a digital PVR (Personal Video Recorder) manufacturer and online service company that finds and records television shows - broadcast, cable, satellite – on a hard disk so you can watch them whenever and however you want. Besides offering all the functionality of high-end videotape recorders, ReplayTV features pause, rewind, slow motion, and instant replay of live television. Furthermore, it automates program selection and records up to 60 hours of television using the MPEG-2 audio/video protocol for DVD-quality viewing and listening.

The two enabling technologies are the Xilinx Spartan-II™ XC2S40 FPGA and the Xilinx IRL (Internet Reconfigurable Logic) system. Using the XC2S40 device, ReplayTV estimates it saved as much as four months in bringing their product to market. Moreover, combining the reprogrammability of an FPGA with IRL technology allows ReplayTV to perform transparent bug fixes, upgrades, and feature additions to PVRs in the field long after the sale. This makes it possible for ReplayTV to adapt to and adopt emerging standards and protocols, thus extending product life – and value. (For more on emerging standards and protocols, see "eSP Solutions at Your Fingertips" and "Xilinx eSP Initiative Will Accelerate Time-to-Market for Consumer Products" in this issue of Xcell Journal. Also, visit the new Xilinx eSP website www.xilinx.com/esp.)

PVRs (or DVRs – Digital Video Recorders) are among the newest consumer products. Both the market they serve and the feature sets they offer are continually changing. ReplayTV's forward-thinking business strategy, therefore, is to carry on the design and deployment cycle long after the original sale.

What It Is and What It Does

Bigger than a black bread box, the ReplayTV PVR unit looks somewhat like a common VCR, but compared to a VCR, it's definitely next-generation technology. It does much more than a VCR – and it's much easier to use. With the free ReplayTV Service, the ReplayTV PVR can find, catalog, and record all the television you have access to – broadcast (antenna), satellite dish, and/or cable TV. Using an onboard 56K modem hooked into your telephone system, the PVR updates its program guide nightly from the ReplayTV Service Internet server. In addition to tracking program schedules, ReplayTV also offers other value-added services such as:

- ReplayZones™ – programming organized by categories such as situation comedies, sports, news, movies, and so on
- Closed-caption support – for secondary text for the hearing impaired

- MyReplayTV – a website that allows you to remotely program your PVR over the Internet
- Personal Theme Channels – consumer customizable Replay Zones that will record programming based on personal preferences, such as favorite actors
- ReplayTV Presents – original programming from ReplayTV
- QuickSkip™ – 30-second jump-forward (not fast forward) to skip commercials or undesirable scenes in recorded programming
- Instant Replay – jump 7 seconds back during live or recorded shows
- Universal remote control – full-featured ReplayTV remote controller for TV, VCR, DVD player, satellite receiver, and cable box.

The combination of reprogrammable hardware combined with reconfigurable software permits ReplayTV to stay on target with the moving market. Along with the nightly update of the program schedule, ReplayTV can transparently deliver to all its customers anything from a debug to an upgrade to an entirely new feature as soon as it is available. With no user intervention or attention required, the ReplayTV PVR continues to gain value-added service and functionality – after the sale.

For instance, ReplayTV was recently forced to deal with an edge condition that caused video noise in a few systems already in homes. One of the chips in the system had an undocumented clock threshold-switching problem. Because the control signals for this device were generated in the FPGA inside the PVR, it was possible to eliminate the problem by changing the timing of the FPGA-generated signal. As soon as the problem was debugged and certified, the company uploaded the fix to all ReplayTV systems in the field. Most customers never realized the change had been made, although some probably noticed improved video quality.

Design by Layer

It all started with the decision to use an FPGA instead of an ASIC (Application Specific Integrated Circuit) semiconductor. The difference between an FPGA and an ASIC is the difference between a process and an event. Not only is the FPGA design cycle faster, it's open-ended. If you want to change an ASIC, you have to build a new one. All you have to do to change an FPGA is feed it a new bitstream – over the Internet.

By choosing the reprogrammable Spartan-II™ XC2S40 FPGA as the core of their design, ReplayTV engineers found themselves with a new, more convenient design cycle. Instead of designing and debugging the system as a whole, they found it easier and faster to "layer" capabilities one at a

time, debug them individually, and then add the next function or feature. This made debugging easier and faster because only the latest layer's code could contain major bugs or interact negatively with the already bug-free code stored in the lower layers.

Of course, the basic hardware and control logic were implemented in the first layer. The embedded operating system and drivers were designed into the second layer. The applications software were programmed into the third layer. The upper layers consisted of "feature algorithms" such as vendor-specific copy protection, V-Chip detection of "adult" programming, and software peculiar to a specific vendor's front panel design. (In addition to selling its own brand, ReplayTV also licenses its technology to original equipment manufacturers.)

With an FPGA, the designers could iterate their way toward design goals, correcting bugs as they were uncovered. Using the layered approach, the engineers were able to implement their design in the most straightforward fashion first, taking as many gates as needed, getting the function debugged, and only then optimizing the bitstream to make the best use of the FPGA.

As the design progressed, ReplayTV's engineers found themselves adding more and more functions to the FPGA – many more than originally envisioned. Engineers began with what they thought was excess capacity in the FPGAs, but they "filled" the FPGA several times. Then they used iterative place-and-route software to place more logic onto the chip. If performance was an issue, they made the place-and-route operation timing-driven and let it run until it came up with the solution needed for a function to perform at a given rate. The designs were implemented using Xilinx Alliance™ and Foundation ISE ™ series software.

Marketing by Design

ReplayTV not only sells its system directly, but it also negotiates license agreements with companies such as Panasonic. In February, Panasonic introduced its 27-inch PV-SS2710 PanaBlack™ TV/ShowStopper® Hard Disk Recorder Combination with ReplayTV Service. Panasonic is the first OEM to integrate a television with a PVR. (ReplayTV just sells the PVR. You have to provide the television.)

For product differentiation, ReplayTV and its OEM partners each need slightly different feature sets, front-panel indicators, copy-protection algorithms, and other unique identifiers. Obviously, ReplayTV couldn't design different hardware for each market niche or OEM partner. The cost would have been prohibitive.

This is where the layered design approach enabled ReplayTV to service its respective partners' needs without compromising the underlying technology. For example, the basic PVR system must accommodate various copy-protection schemes. Not only are there several different copy-protection alliances throughout the world, but even for a given protection standard, each OEM must execute its own unique copy-protection agreement. (This is where lawyers effectively dictate standards and protocols to engineers.) Top-layer reprogrammability accommodates the nuances of each copy-protection agreement, worldwide, without changing the baseline system.

Moving with the Target Market

It's one thing for ReplayTV to proclaim itself best in class. It's quite another when the worldwide consumer electronics industry validates that claim. At the Consumer Electronics Shows in 2000 and 2001, ReplayTV was named the CES Innovations winner for both Video Software and Video Hardware. In 1999, ReplayTV won Best of Show in the entire video category. Popular Science magazine gave ReplayTV its Best of What's New Award, and Popular Mechanics magazine gave ReplayTV its 1999 Editor's Choice Award.

ReplayTV is not without competition, however, and the target market is still moving. By choosing a Xilinx-based FPGA/IRL solution, ReplayTV has intelligently positioned itself to dynamically move with the market, selling a product and service specifically designed to accommodate the emerging standards and protocols of consumer electronics.