FPGA-Enabled Home Networking Bridges Isolated Islands of Technology

Field programmable gate arrays show great promise to interconnect disparate home networking systems.

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Chaos reigns in the home networking marketplace. Too many conflicting technologies and standards are competing to gain preeminence in home networking. Moreover, these technologies and standards are constantly evolving to add more functionality, to fix bugs, and to interface with as many competing standards and technologies as possible. The fierce competition inevitably leads to a counterproductive development model. Although a product should be planned for the longest possible life cycle, this tenet is often overridden by pressure to get the product to market as fast as possible.

As a consequence, technology leaders must proactively participate in multiple consortia and standards committees to keep track of the market. Until the market stabilizes under a single standard, leading technology players must support several, if not all, possible standards.

Conflicting specifications and the lack of a clear direction for future technology have created a pressing demand for home network bridges that can interconnect the various information appliances found in the modern home. As we will show, Xilinx Spartan-II™ field programmable gate arrays are the logical choice to form the infrastructure of these bridges now and in the future.

An Introduction to Home Networking

Home networking involves the distribution of audio, video, and data around the home.

	Market Requirements	Solutions Available
Broadband Access	High speed access for data, voice, and video; always on; simultaneous uplink & downlink communication; support simultaneous and multi-user access	xDSL, cable, ISDN, powerline, satellite, mobile/wireless
Residential Gateway or Home Gateway or Services Gateway	Provides access into the home; remote management access platform; bridging between different networks; firewall and security; e-services capabilities	Open System Gateway initiative(OSGi) Jini™ UPnP (Universal Plug and Play) HAVi (Home Audio-Video interoperability) standard
Information Appliances	Digital electronics with advanced computational capabilities add more value and convenience when networked.	Digital TV/HDTV, set-top boxes, Internet screen phones, digital VCRs, gaming consoles, MP3 players, cordless phones, security systems, utility meters, PCs, Web pads, Web terminals, PDAs, digital cameras, auto PCs, etc.
Home Networking Technologies	Low cost; speed; mobility; quality of service (QoS); security; reliability; ubiquity; ease of use	No new wires: phonelines, powerlines New wires: Ethernet, IEEE 1394/FireWire, USB 2.0 Wireless: HomeRF, Bluetooth, wireless LANs (IEEE 802.11, HiperLAN2)

Table 1 - Aspects of home networking

In a perfect world, home networking ensures interoperability among various information appliances in your home. At present, however, home networking represents a collection of more than 20 end technologies.

As shown in Table 1, home networking has four aspects:

- Broadband access
- Residential gateways
- Information appliances
- Home networking technologies.

No one technology dominates the home networking arena. Therefore, different technologies must co-exist without being able to communicate with one another. For example:

- Bluetooth™ networks mobile devices such as cellular phones, PDAs, and notebook PCs.
- USB/USB 2.0 networks PC-centric devices such as desktop PCs, printers, and scanners.
- FireWire™ networks digital TVs, set-top boxes, gaming consoles, and other bandwidth-heavy entertainment appliances.

These co-existing, disparate technologies are like islands in need of bridges to connect them.

Islands of Home Networking Technologies

As illustrated in Figure 1, three technological islands, each with their own market niches, exist in the home networking environment:

No New Wires

The "no new wires" technology utilizes the existing infrastructure available in most homes across the world. The technology utilizes existing powerlines and phonelines. The advantage of using no new wires is that consumers do not need to rewire their homes. Furthermore, products based on this technology can be cost-effectively deployed immediately.

The two power players on the no new wires island are HomePNA (Phone Networking Alliance) and PowerPlug™ Power Alliance. The ability, however, to handle high-speed video and other high bandwidth applications under a noisy electromagnetic environment is a formidable obstacle to overcome.

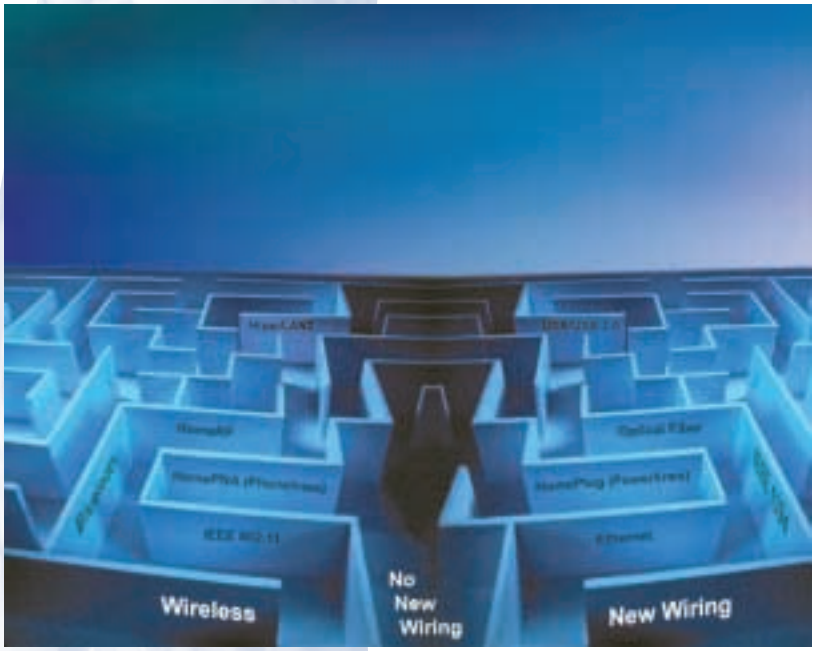

Figure 1 - Disparate islands of home networking technologies

New Wires

Consumer devices that require high-speed data and video packets use Ethernet (IEEE 802.3), FireWire (IEEE 1394), optical fiber, or USB 2.0 (Universal Serial Bus) technologies. The downside of all of these technologies, is that they require additional special wiring around the house. Although it is relatively inexpensive to include network wiring in new home construction, retrofitting existing homes with network wiring can be quite expensive.

Wireless

Wireless technologies such as Bluetooth, HomeRF™, IEEE-802.11a, IEEE-802.11b, and HiperLAN2 provide users with mobility, but bandwidth remains an issue. Whereas Bluetooth is a popular personal area network technology, IEEE 802.11 and HiperLAN2 are wireless LAN technologies that provide connectivity to telecommuters, SOHOs (small office/home office), and hospitals. HomeRF remains focused on cordless transmission of voice and data around the home.

FPGA-Based Home Networking Bridges the Islands

Home networking bridges exist at the periphery of each technology island. These bridges need a flexible, reprogrammable, and low-cost platform to accommodate time-to-market pressures, specification changes, and short product lifecycles.

Aggressive process technology adoption has enabled FPGAs to obtain more die per wafer, provide more logic, offer increased performance, and accommodate various ASIC-like features required for system integration. This fast-evolving process technology has been fundamentally instrumental in narrowing the wide gap between FPGAs and ASSPs (Application Specific Standard Products). FPGA vendors, by virtue of the benefits reaped through process technology, now have the capability to bring traditional FPGA benefits to the cost-sensitive home networking market.

As previously noted, conflicting specifications and the lack of a clear direction of

future technology have created the need for FPGA-based home networking bridges. Figures 2 and 3 show two examples of FPGA-enabled bridges: a wireless LAN-to-Ethernet bridge, and a USB-to-HomePNA-and-Ethernet bridge. Xilinx Spartan-II FPGAs – highlighted in red – are at the heart of both network bridges.

Home network bridges operate in the second layer of the classic, seven-layer OSI (Open System Interconnect) network reference model. The first layer PHY (physical) defines the electrical, mechanical, and procedural specifications that provide the transmission of bits over a communication medium or channel. The second layer - the data link layer – consists of an upper sub-layer, logical link control (LLC), and a lower sub-layer, media access control (MAC). The MAC ensures error control and synchronization between the two engaged network segments. It is also responsible for determining priority and allocation to access the channel to the third layer – the network layer.

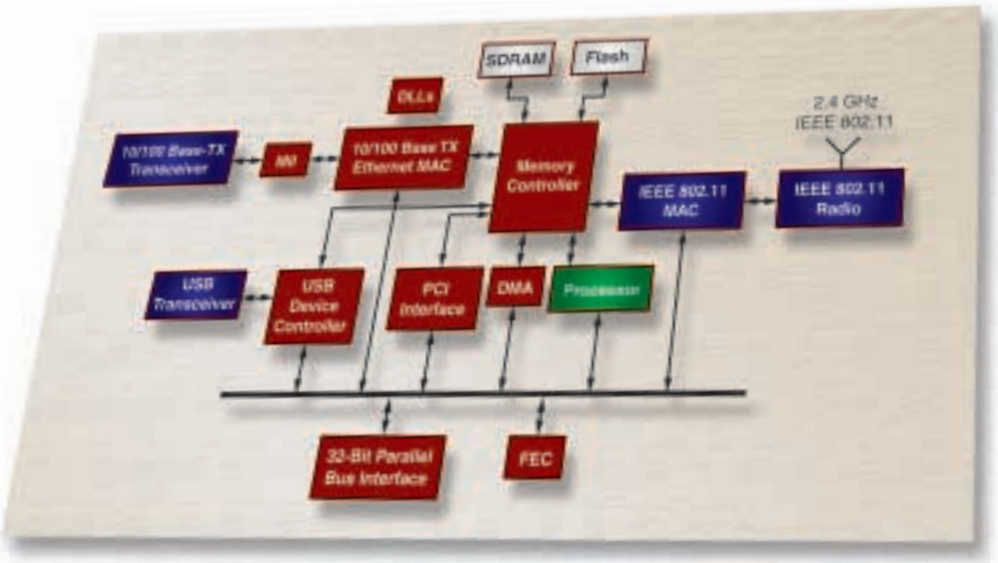

Figure 2 - Wireless LAN-to-Ethernet home networking bridge

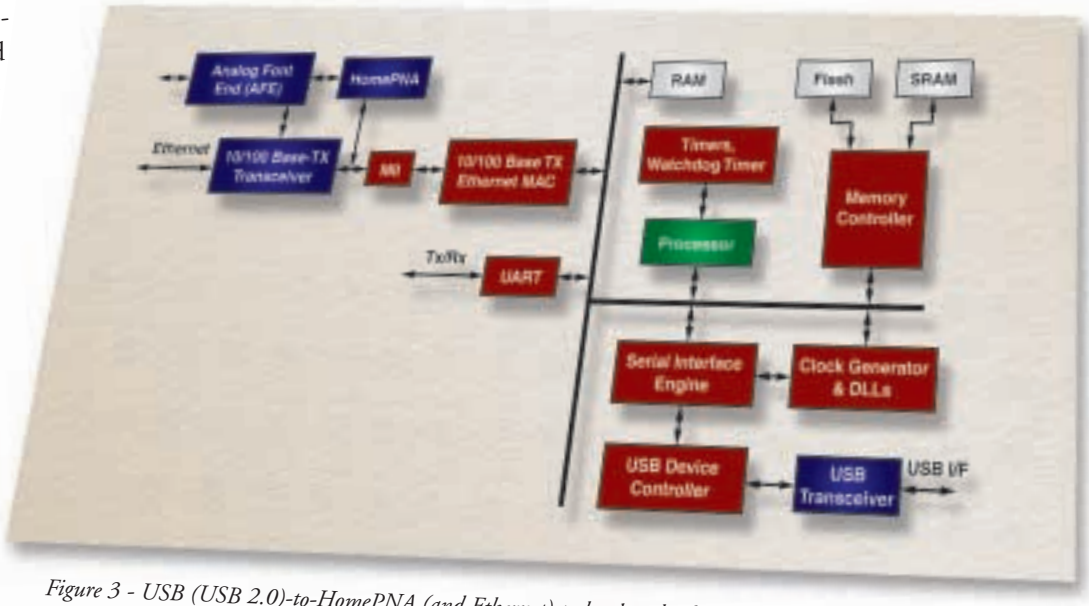

Figure 3 - USB (USB 2.0)-to-HomePNA (and Ethernet) technology bridge

While the Ethernet MAC has been around for a long time, the HomePNA specification that defines the MAC and PHY layers is quickly evolving. With the HomePNA 2.0 specification already defined (and a faster, higher bandwidth phoneline specification is on the way) it seems ideal for the MAC and media independent interface to be programmed in an FPGA. Similarly, the IEEE 802.11, HomeRF, FireWire, USB, HiperLAN2, and Bluetooth are all technologies with evolving specifications ripe for FPGA-enabled system integration and upgrades.

Spartan-II FPGAs Bridge the Gap

Spartan-II FPGAs not only provide critical parts of the technology bridges at low costs, they also offer system-level features such as DLLs (delay-locked loops), BlockRAM, and SelectI/O™ technology to provide additional savings. FPGA gates left over from programming the MAC may be used to customize the end product. They may also be used for additional functionality, such as memory controllers, (SRAM, DRAM, and flash) PCI controllers UARTs, and forward error correction.

Xilinx FPGAs are based on SRAM technology and can be reprogrammed an unlimited number of times. Field upgradability gives you the ability to upgrade functionality of the FPGA through a simple update to the FPGA configuration bitstream. FPGAs allow you to gain market share by bringing products to market sooner than with stand-alone ASSPs. Moreover, FPGAs enable you to upgrade your hardware in the field and stay in the marketplace longer. This ability to adapt to specification changes maximizes profitability.

Interoperability is the key to market success in home networking. Technology bridges based on Xilinx FPGAs address some of the most fundamental challenges facing home networking today: they can connect different information appliance home networks and ensure seamless interoperability. As the world leader in field programmable gate arrays, Xilinx is uniquely positioned to be the matchmaker between incompatible technologies.