WP132 (v1.0) March 21, 2001

Information (Internet) Appliances

Author: Amit Dhir

Summary

Market researchers predict that information appliances will out-ship consumer PCs by 2002 in the U.S. High-volume information appliances will be products such as digital TV, DVD players, digital cameras, and handheld devices. Semiconductors enable new devices and players, but technology is increasingly becoming invisible. In the future, more functionality will be available at lower price points. Information appliance products will evolve to deliver Web content. Brands will change from “device only” to service, solutions or customer relationship provider such as financial institutions. The digital consumer revolution and the Internet are forcing broadband into the home. Such an evolution will fuel the demand for a variety of different information appliances in the current years.

Xilinx programmable logic products (Spartan™-II FPGAs, CoolRunner™, and 9500 CPLDs) ported with intellectual property (IP) provide solutions like ASSPs, but with increased flexibility. FPGA logic not used from the IP can be programmed with other IP cores—such as embedded solutions. Other features within the Spartan-II FPGAs provide system integration, and the reprogrammability enables time-to-market and flexibility at low costs. Xilinx Online™ allows time-in-market as specifications in emerging technologies keep evolving.

Introduction

The push for home networking has really come from the consumer. With a drastic reduction in PC prices, multiple PCs are making their way into households. The rise in the number of PCs within the home brings the need for data sharing, file sharing, and sharing of PC peripheral resources (such as printers and scanners) and hence PC-to-PC networking.

Over the last couple of years, the Internet has grown ubiquitous to a large number of consumers. These consumers are demanding Internet access from their home. The need for fast access to the Internet is coming from not only PCs, but other appliances in the home such as Web pads, Web terminals, e-mail terminals, digital TV, and set-top boxes. Also, pushing the need for Internet access are applications such as e-mail, web shopping, remote monitoring, MP3 files, and streaming video. Many of these appliances such as gaming consoles, PCs and set-top boxes also provide broadband access and home networking to the home.

Over the past few years, these types of appliances have already formed networks with other appliances, creating various islands of technologies. For example, the PC network island has had a network of appliances, such as multiple PCs, printers, scanners, PDAs, and others. Another network island that has existed in the home is the multimedia island consisting of multiple TVs, VCR players, DVD players, receivers/amplifiers, speakers, etc. The home networking technologies connects the different information appliances and the network islands. In this white paper, we discuss and explain the different types of information appliances that are emerging to populate the consumer's homes.

Definition: Information (Internet) Appliances

Information appliances (IAs) are an emerging category of digital consumer electronics that provide the consumer with a low-cost, easy-to-use, instant-on device, lightweight, reliable, special-purpose access to the features and benefits of the Internet. These devices have advanced computational capabilities that add more value and convenience when networked.

IAs enable infotainment by providing services such as:

- Accessing e-mail on the move
- Checking driving directions when on the road
- Managing appointments and schedules when waiting at the doctor’s office

- Playing video games when relaxing on the sofa

Examples of IAs:

- PCs, notebook PCs
- PC peripherals: printers, scanners, digital cameras
- Digital displays (PDPs, LCDs, TFTs)
- Digital TV (SDTV, HDTV)
- Internet audio players (CD/MP3 players)
- DVD players
- Digital VCRs
- Set-top boxes
- Gaming consoles
- Internet screen phones or video phones
- Web pads/fridge pads/Web tablets
- Security units
- Energy management units, automated meter reading (AMR) and RF metering
- VoIP and IP phones
- PDA and other smart handheld devices
- Web terminals, e-mail terminals
- Mobile phones
- Auto PCs, telematics
- White goods (dish washers, dryers, washing machines)

Market Forecast

While market forecasters are predicting varying growth numbers, all data shows exploding growth. Market research firm, International Data Corporation (IDC) predicts that in 2001, 18.5 million Internet appliance units will ship compared with 15.7 million units of home personal computers. IDC also predicts that the total IA market will top $15.3 billion by 2002. By 2005, the total revenues from all IAs is expected to exceed $33.7 billion. Figure 1 shows the worldwide unit shipments of IAs between 2000 and 2004.

Dataquest-GartnerGroup predicts that worldwide production of IAs will explode from 1.8 million units in 1999 to 391 million units in 2003. Complimenting the unit shipment, the worldwide revenue forecast for IAs is predicted to grow from $497 million in 1999 to $91 billion in 2003.

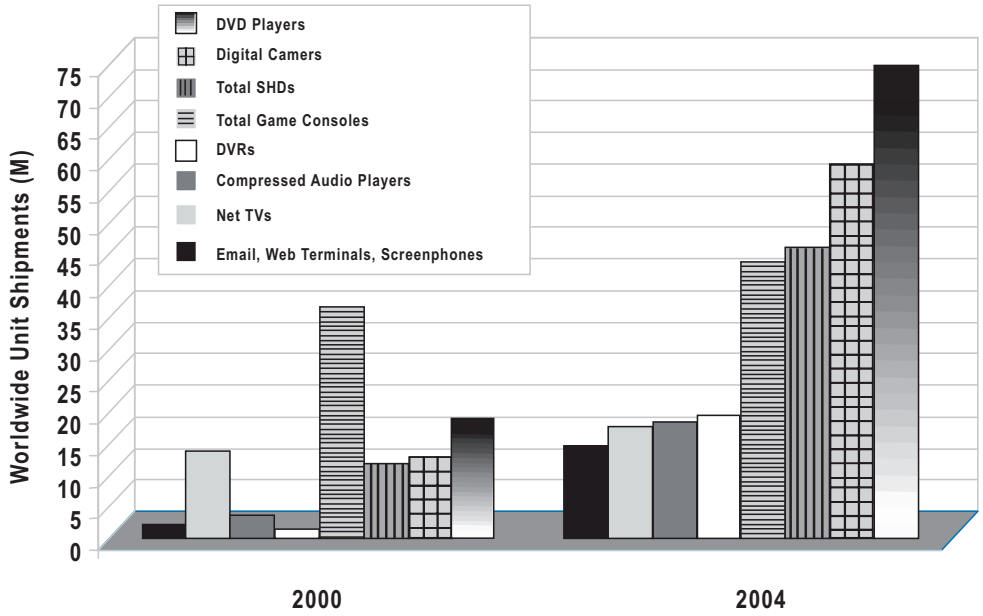

Figure 1: **Worldwide Shipments for Internet Appliances in 2000 and 2004 (Courtesy: Cahners In-Stat)**

The worldwide acceptance and shipments of IAs are rapidly growing. For many years, access to the Web and e-mail was the exclusive domain of the PC until the arrival of IAs. These are clearly an alternative to the PC and provide benefits of network services. IAs are rapidly outgrowing PCs because of the lack of PC portability, the heavy price tag associated with the PC, and the complicated software installation involved in the PC. The IAs are providing a low cost, consumer focussed, easy-to-use device that provides Internet access. The introduction and acceptance of these low cost appliances is causing a reduction in prices for PCs.

Phases of Market Acceptance

While huge growth is being predicted for information appliances, the acceptance of these products will be in phases. Some of the factors that will contribute to the success of IAs are the following:

- Offering services such as digitalized photography, ease in communications, etc., is key
- Elegant product design
- Branding and channels: Established names and established channels are key
- Critical, supporting technologies must hit their strides: Broadband, wireless, home networking
- Heightened industry investment must continue
- New product concepts must gain significant consumer awareness
- Business models: Low-cost solutions backed by partnerships and sustainable services

The networking of consumer devices and information appliances are divided into market acceptance phases. In the pre-market acceptance phase there is:

- Hype and debate
- Few actual products
- Limited business models
- Limited Web pervasiveness
- Less technology ammunition

The acceptance of these products will lead to:

- Rise of the digital home
- Broadening range of products
- Diversification of business models
- Heightened industry support
- Bandwidth, home networking, and wireless
- Maturation of the Internet base

Functional Requirements

Some of the key requirements for IAs to gain market acceptance include:

- **Ubiquity:** Prevalence of network access points
- **Reliability:** Operational consistency in face of environmental fluctuation such as noise interference and multipath
- **Cost:** Affordable for mass market
- **Speed:** Support high-speed distribution of media rich content (>10 Mbps)
- **Mobility:** Must support “untethered” devices
- **Quality of Service (QoS):** Must support scalable QoS levels for application requirements of individual devices
- **Security:** User authentication, encryption, and remote access protection
- **Remote management:** Ability for external network management (queries, configuration, upgrades)
- **Ease-of-use:** Operational complexity must be similar to existing technologies, such as TVs and telephones

Types of Internet Appliances

IAs provide specific functionality and services, other than e-mail and Web access. We address some of these appliances and their functionality.

Digital Television—DTV

So why do we want to change the TV system? Today’s TV systems have been around for three generations. Additional features and functions such as color, stereo sound, remote control, cable channels, closed captioning and others have been added. The shortcomings of the 50-year old analog technology used by broadcasters are increasingly apparent—due to limited resolution and color rendition. Also “ghosting” and interference from other radio sources are visible. DTV is the most significant development in TV technology since the advent of color TV in 1950s. The transition to digital is occurring in all media technologies. Even in satellite transmission, direct broadcast satellite (DBS) offers digital service.

DTV is a new “over-the-air” digital TV system providing new and higher quality services. Over 1600 broadcast TV stations in the U.S. will use DTV. The technology is based on the Advanced Television System Committee (ATSC) standard A/53.

For the consumers, the DTV system will provide:

- Clearer and sharper cinema-like pictures
- Multi-channel (up to five channels/program)
- CD-quality sound
- Broadcasters have the ability to simultaneously transmit multiple video programs using a single TV channel. TV stations will be able to transmit multiple SDTV or two HDTV programs depending on the type and source of programming
- Digital signals that provide 1080-line or “full-HDTV“ features such as switching between camera angles
- Multicasting: DTV signals are carried over a wider bandwidth and can be split into sub-

segments of an original channel but of lower resolution programming

- New services such as data communications, video conferencing, and high-speed modem access. Simultaneous delivery of digital data services with TV and audio programming such as publications (local electronic newspaper), program schedules, computer software, specific product information, e-mail, and Internet will also be possible

These unique features are made possible by:

- Transmitting TV images, sound, and data services digitally rather than as analog signals
- Using digital compression techniques: It allows more information to be transmitted in the same amount of spectrum used by an existing TV channel. Data rate of the DTV signal in the 6 MHz broadcast TV channel is 19.44 Mbps, compared with data rates of today's telephone modems of between 28-56 Kbps

IC Insights predicts that over one million digital TV units will be sold in the U.S. by 2002. They also predict that some form of DTV will be in every U.S. home by 2006.

- Some of the early difficulties of DTV:
- High costs of equipment associated with transitioning to digital broadcasting
- Cable industry adaptability: Ability of cable wires to carry digital signals
- Interference hinders the ability to see clear, perfect pictures. Interference disrupts the signal to DTV sets when coupled with an indoor antenna
- Newly introduced DTV sets cost several thousand dollars
- Live digital broadcasting is a problem. Signals must be transmitted from the event to a broadcast center and across the network and with limited digital equipment available, the process can be very complex
- Standards: Continuing conflicts over broadcasting standards may confuse consumers and cause problems with picture quality at the major U.S. networks
- Consumers will view decoded digital images on analog TV sets and have them look worse than standard broadcasts

There are two types of digital TV systems: standard definition television (SDTV) and high definition television (HDTV). Both HDTV and SDTV formats will have significantly better color performance than the existing analog TV system.

SDTV

It is a digital broadcast scheme that provides consumers with better pictures and richer colors than analog transmissions.

HDTV

HDTV is one of the many (18) subsets in the DTV standards to transmit TV programs in wide screen, high-resolution format. It represents the premier method of transmitting, receiving and viewing digital broadcasts. It is the highest-quality version of DTV providing a sharp, bright and crystal-clear picture on a wide-screen TV set. It began its commercial life in July 1997 when WRAL-HD in Raleigh, North Carolina, became the nation's first commercial, over-the-air, HDTV station. The market size for wide format and HDTV display systems is predicted by Stanford Resources to grow from eight million units in 1999 to over 14.2 million units in 2003.

HDTV provides resolution of about twice that of conventional TV in both horizontal (H) and vertical (V) dimensions. The full HDTV signal requires a much wider bandwidth than a regular digital signal. The HDTV signal is compressed before transmission. The picture aspect ratio (H x V) of HDTV is 16:9. HDTV approved formats are 1,080 horizontal lines of resolution interlaced and 720 horizontal lines of resolution progressive, and Dolby digital audio.

Both the receiver and transmitter blocks of a DTV have been populated by different analog, digital, and mixed-signal components (Figure 2). Xilinx products are focused on providing solutions in the digital blocks of the DTV products. Xilinx Spartan-II FPGAs provide solutions such as the memory controller, microcontroller, MPEG 2 decoder, YUB-to-RGB color space converter, I/O controller, descrambler, interfaces (such as PCI, RS-232, parallel, serial,

HomePNA, Ethernet), and MUX. Distribution of high-quality video data can be done by connecting a DTV to a home network via a phone or Ethernet jack or wireless interface.

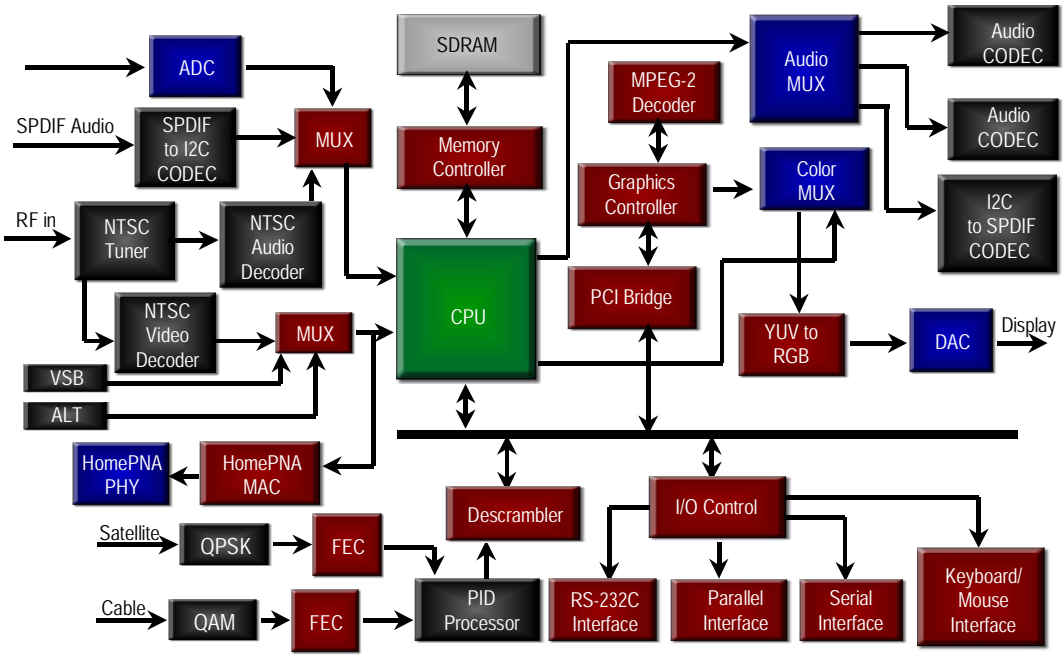

Figure 2: **Digital TV**

Digital Displays

Digital displays or flat panel displays (FPDs) are digital technology-based displays that are used for notebook PCs, handheld devices, and other IAs. Some of the digital TV technologies are plasma display panels (PDPs), liquid crystal displays (LCDs), and digital light processors (DLPs).

PDP

PDPs are the largest variations of FPDs available. They consist of front and back substrates with phosphors deposited on the inside of the front plates. These displays have cells that operate similarly to a plasma or fluorescent lamp, where the discharging of an inert gas between the glass plates of each cell generates light. Depending upon the type of gas used, various colors can be generated. In a monochrome display, the light from the gas discharge is that which is seen on the display. To obtain a multicolor display, phosphor is required. The plasma panel uses a gas discharge at each pixel to generate ultraviolet radiation that excites the particular phosphor, which is located at each pixel.

Advantages of PDPs over cathode ray tube (CRT) TVs are:

- PDPs have accurate cell structures producing a geometrically perfect picture
- CRT TVs have a geometric distortion due to inability of the beam of electrons to focus on all points
- PDPs are evenly illuminated without the typical dark/hot spots observed from CRTs
- PDPs can achieve perfect focus whereas the CRT has regions that are less focused than others
- PDPs are not susceptible to magnetic fields (while CRT's electron beam is influenced by the earth's magnetic fields)
- A plasma monitor/TV is never more than four inches thick and is lightweight. This allows PDPs to be hung on the wall making it an excellent solution when dealing with space restrictions

Disadvantages of PDPs:

- Costly manufacturing leading to higher consumer prices. Plasma technology is complex and the plasma manufacturing process is time consuming. Hence, the yield when producing a line of plasma panels in a factory is very low. Currently PDPs are incapable of taking significant volumes of sales away from CRT TV due to the $10,000 cost.
- Older generations of color plasma TV/monitors have experienced gas pixels burning out on the panel creating a visible black spot on the screen. This leads to frustrated customers who need to pay for the display's repair.

Electronic Trend and Business Communications Company, two independent market research firms, predict that FPD shipments will grow from ten million units in 1997 to 17 million units in 2001.

DLP

DLPs enable TV to be completely digital and provide superior video performance required by home entertainment enthusiasts. Texas Instruments (TI) has developed and patented this new technology (the semiconductor chip and the engine). It can be designed into both front and rear projection TVs. The TI DLP includes the Digital Micro-mirror Device (DMD). The optical semiconductor chip has an array of 480,000 (SVGA), 786,000 (XGA), or 1,310,000 (SXGA) hinged, microscopic mirrors mounted on a standard logic device. Tiny mirrors operate as optical switches to create a high-resolution, full color image.

LCD

LCDs consist of two glass plates with liquid crystal material (transparent organic polymers) between them. The LCD has an array of tiny segments (called pixels) that can be manipulated to present information. There is no bulky picture tube and a lot less power is consumed than its CRT counterparts. Many LCDs are reflective, meaning that they use only ambient light to illuminate the display.

LCDs contain transparent organic polymers that respond to an applied voltage. To form the display, manufacturers deposit a polarizing film on the outer surfaces of the two ultra-flat glass (or quartz) substrates with a matrix of transparent indium tin oxide (ITO) electrodes on the inner surfaces of these substrates. With micron-sized spacers holding the two substrates apart, the sandwich is joined together. The substrates are cut into one or more displays, depending on the original size of the substrates (from 12 inches to 22 inches square); the outer edges of each display are sealed with a gasket; the interior air is evacuated; and the void is injected with liquid crystals.

The polarizers on the front and back of the display are oriented 90 degrees from one another. With this orientation, no light can pass through unless the polarization of the light is altered. Liquid crystals are a means for changing the polarization. When no voltage is applied liquid crystals can be aligned in twisted (90 degrees) or super-twisted (270 degrees) configurations. With these configurations the polarity of light is rotated allowing the light to pass through the front polarizer, thus illuminating the viewing surface. When a voltage is applied, the liquid crystals align to the electric field created, the polarity of the incoming light does not change, and the viewing surface appears dark.

All LCDs must have a source of reflected or back lighting. This source is usually a metal halide, cold cathode, fluorescent, or halogen bulb placed behind the back plate. Since the light must pass through polarizers, glass, liquid crystals, filters, and electrodes, the light source must be of sufficient wattage to allow for the desired brightness of the display. Typically, the internal complexity of the display blocks over 95 percent of the original light from ever exiting on the viewer's side. As a result, the generation of unseen light causes a major drain on a battery-operated LCDs power source.

Some LCD systems perform much better than others. The greater twist angle of super-twisted nematic (STN) liquid crystals allows a much higher contrast ratio (light to dark) and faster response than conventional twisted nematic (TN) crystals. For color displays each visible pixel must consist of three adjoining cells, one with a red filter, one with a blue filter, and one with a

green filter, to achieve the red-green-blue (RGB) color standard. While color decreases the resolution of the display, color adds information to the display, particularly for desktop publishing and scientific applications.

DisplaySearch and IDC predict that worldwide in the year 2001, 1.25 million units will be shipped, and that portable PCs account for about 80 percent of the consumption of LCDs. LCD ASPs (average selling price) decreased from $1,124 in the third quarter of 1999 to $1,027 in the fourth quarter of 2000.

LCDs are practical for applications where size and weight are important. However, LCDs do have many problems with the viewing angle, contrast ratio and response times. These issues need to be solved before LCDs can completely replace CRTs.

Digital Set-Top Boxes (STB)

The digital STB is an IA that acts as a receiver/tuner for TV signals or service access. It provides control and access to premium channels and provides other features such as pay per view. There are separate STBs for cable and satellite systems. A STB is as an appliance designed to receive and decode digital broadcast channels and then subsequently display the program/material on a standard television set.

There are a number of positive reasons for the growth in digital services, which require an STB to receive them. Primarily, digital technology offers the consumer more choice in the number of channels offered. It also provides a better quality of picture, being immune to the various forms of interference, which can blight analog transmissions today. The other main advantage is in the new services, which will be offered, making the television much more interactive than before, and also providing much more information to the consumer.

Some of the STB market trends include:

- More channels
- Increased choices
- More specialist channels
- Immediate feedback to broadcasters
- New services
- Improved pay-as-you view
- Online shopping
- Interactive TV
- Hard-drive storage
- Instant replay
- Video-on-demand (VoD)
- Maximum use of available bandwidth
- Improved quality
- Support for HDTV
- No “ghosting“ or other interference effects
- Allows broadcasters flexibility in terms of bandwidth vs. quality

There is a considerable amount of uncertainty as to how the STB market will develop. As described in White Paper "WP131: Media (Residential) Gateways", Xilinx predicts that STBs will evolve into home multimedia centers, possibly forming the hub of the home network system and the primary access for consumers to connect to the Internet, i.e., the residential or media gateway. The STB market is very dynamic and will change dramatically over the next few years. We are already seeing a convergence of technology with equipment connected to the television, such as adding hard drives for television program storage and instant replay.

In the past, ASICs have been used to support this functionality. Today, given the price points of programmable logic devices, Xilinx has a solution that can address this fundamental disconnect between these ASSPs (Figure 3). Xilinx provides the following solutions for STBs today:

- System logic (UART)
- Clock distribution
- Memory (Flash, SDRAM, SRAM) controller
- Conditional access (encryption) unit
- Forward error correction
- HDLC controller
- FIR filter
- DCT/IDCT imaging solutions
- Fast Ethernet MAC (10/100 Mbps)
- I/O control: interface to multiple broadband technologies (xDSL, cable, satellite, wireless) and multiple back-end interfaces (FireWire, wireless LANs, HomeRF, HomePNA, Ethernet, Bluetooth, USB/USB 2.0)
- System interface (PCI controller, USB controller, IrDA interface)

The STB market is growing at a dramatic rate, with an unpredictable future. However, time-to market and the ability to upgrade very quickly is imperative for a successful product. The Spartan-II family of FPGAs provides the cutting edge to bring products first to market, while having the ability to remotely add features to the STB already deployed in the home. Hence, whatever happens in the years ahead, Xilinx FPGAs play an increasingly important role in the consumer systems of tomorrow.

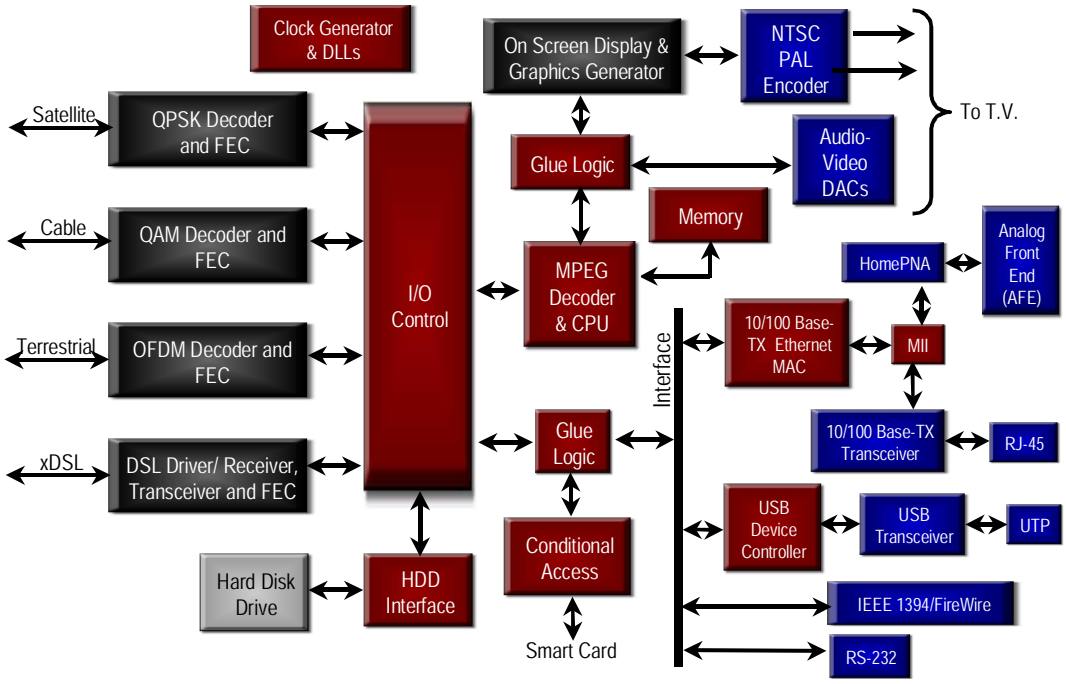

Figure 3: **Set-Top Box**

Internet Screenphones (or Video Phones)

The Internet screenphone is a high-end desktop telephone with an LCD screen. These include a base module, voice communications module (corded and cordless handset and speakerphone), keypad, and screen display. It provides Internet access for e-mail, messaging, informational services, and Web browsing. IDC predicts that by the year 2002, worldwide revenues and shipments for Internet screenphones will exceed $400 million and two million units.

Screenphones can be divided into three broad product categories:

- Low-end products (range $100-$150) use a very small LCD display and provide the most basic access to limited Internet content such as text e-mail or news.

- Midrange products (range $199-$399) have a larger screen with a miniature keyboard. These products provide interactive e-mail or news feeds from the Internet with limited Web-browsing capabilities.
- The high-end products (range $400+) have a color screen of 7-8 inches with graphics and touch-screen capabilities that allow e-mail, and web browser functionality.

Some of the growth accelerators include:

- More vendors with more products, leading to competition
- Big vendors with large marketing departments help validate the screenphone concept and help in promotion
- Increasing demand for Internet at multiple points in the home
- Service provider distribution and promotion of devices

Some of the growth inhibitors include:

- Uncertain business model
- Shift to IP resulting in higher bill of materials
- Minimal consumer awareness
- Lack of a killer application
- Competing IAs
- Issues with form factors: Small screens, smaller keyboards, large physical sizes

Trends in the screenphone market:

- Touch-screen control
- Biometric security features
- Speech recognition
- Evolving standards in security and data processing
- Advanced LCD technology

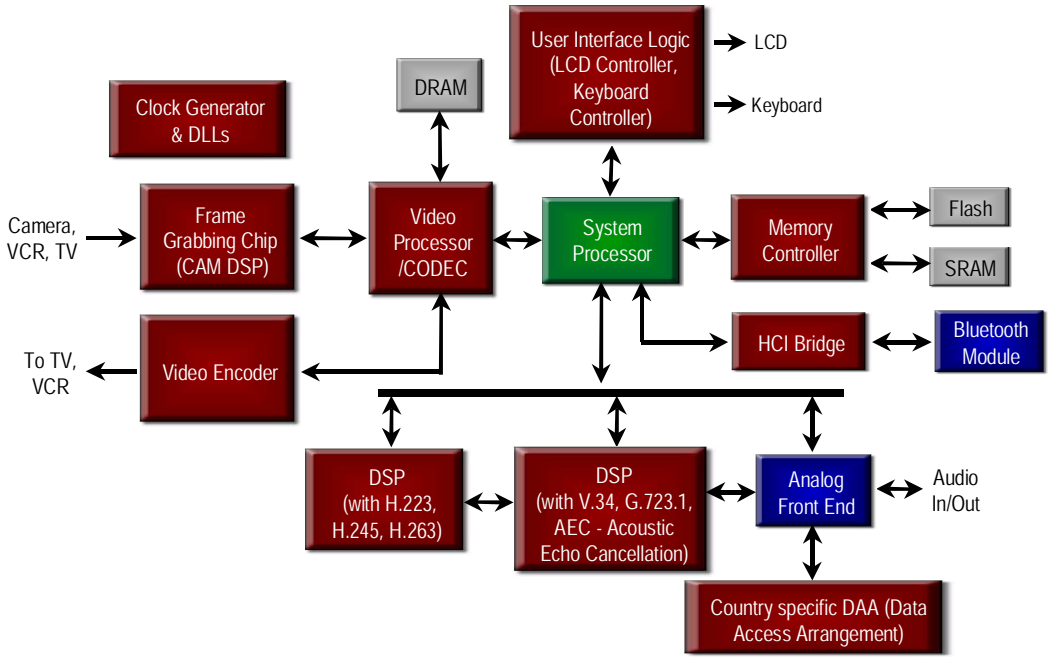

Figure 4: **Digital Video Phone, Internet Screen**

Spartan-II FPGAs enable Internet screenphones to provide solutions as memory controllers, user interface logic (LCD controller, keyboard controller), DSP, clock distribution chips, and system interfaces (such as USB, PCI, HomePNA, Ethernet, wireless LANs).

Web Terminals

Web terminals are standalone devices used primarily for web browsing and e-mail that can exist in tethered forms. These appliances are typically based on embedded operating systems and are in an all-in-one form factor including a monitor.

Market accelerators include:

- Web terminals and e-mail stations
- Low cost and refined utility
- Varied deployment

Market inhibitors include:

- Questions about support from service providers
- Lower PC prices and new subsidized distribution models
- Xilinx Spartan-II FPGAs provide system interface and glue logic functionality in Web terminals.

Web Pad/Fridge Pad/Web Tablet

The Web pad is a wireless, portable, low-cost, easy-to-use, tablet-shaped consumer-focussed IA usually with a touch-screen user interface. It has a browser-based interface to simplify and enhance the Internet experience. It is a subcategory of web terminals that consists of two separate components:

1. A portable LCD built in a tablet shaped device.
2. A base station that is plugged into the Internet via an analog or broadband connection and sends/receives wireless (RF) transmissions from the tablet.

The Web pad is used for Internet browsing, e-mail, inventory control, order entry systems, and as Internet enabled appliances. The Web pad uses an RF interface (such as Bluetooth, HomeRF, wireless LAN) which allows users the capability of operation within range of a base station transceiver. IDC predicts that the worldwide market for Web terminals and Web pads will exceed ten million units by 2003.

Some of the issues facing web tablets from becoming a mass market product are:

- **High bill of materials (BOM)**: The high cost of wireless technologies and LCD display causes significant consumer price-point issues. A $500 BOM results in a discouraging end user pricing of over $799.
- **Value proposition:** With a unique value proposition, the Web tablet only provides the mobile connection to the Web. This is not enough to drive mass-market success of the device.
- **PC competition:** PCs and notebook PCs destroy the single, unique value proposition presented by the Web tablet.
- **Lack of vendor support:** Top consumer electronics and PC manufacturers have not embraced this technology.

A perfect application of the CoolRunner's low power and high-speed capability is demonstrated by the Web tablet application. These devices typically use an RF interface to allow users the capability of operating within range of a base station transceiver. The main user interface is accomplished via a touch screen LCD, which provides a simple to operate consumer friendly solution. Web tablets are primarily tools for Web surfing, e-mails, multimedia, and e-books, however some Web tablets also have hard disk drives and may be used in more sophisticated applications such as in health care and education.

The Web tablet can be divided up into three main sections: user interface, processing and core logic, and RF communications. The CoolRunner CPLD provides glue logic and interface control

for several of the elements of a Web tablet; the flexibility and pin locking advantages of a PLA architecture allows concurrent design of the Web tablet.

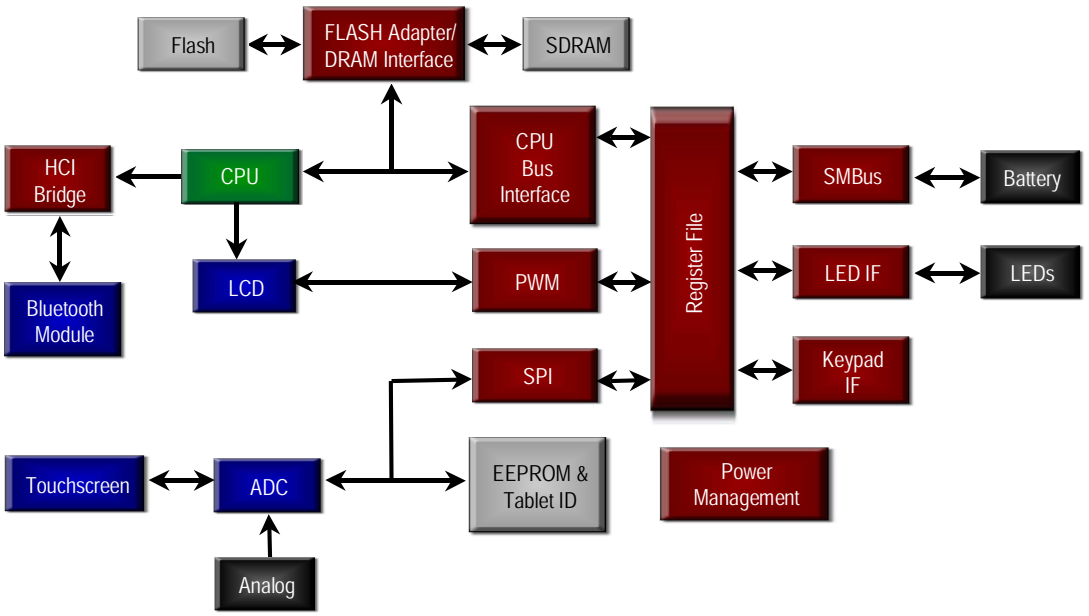

Figure 5: **Web Pad, Web Tablet**

The CoolRunner CPLD functions primarily as an interface to multiple portions of the Web tablet, translating bus protocols, and passing system information to the processor. The CPLD provides an SMBus interface to communicate with the battery, an SPI interface to communicate with an EEPROM and to get data from an A/D converter, a PWM output to control the contrast of the LCD panel, and a Host Interface Bus (HIB) to communicate system status and command information to the main processor. Other tasks include a button and LED interface, as well as reset and wakeup functions.

The solution provided by the CPLD could be handled by a low power microcontroller, but due to the multitasking requirements of the application, the single thread nature of the microcontroller would require very high clocking rates which would increase the power consumption of the system. Using a CoolRunner in this application provides the required bandwidth for signal handling and keeps power consumption to a minimum.

E-mail Terminals

E-mail terminals are standalone; non-portable, consumer-oriented devices that are dedicated for accessing e-mail, without Web browsing capabilities. They do not include Web browsers or additional applications. They include a keyboard, a small LCD screen, and some soft function keys.

Xilinx FPGAs interface to the system interface and provide glue logic functionality in e-mail terminals.

Game Consoles

Game consoles can be divided into two broad categories, namely video-game consoles and handheld appliances.

Videogame consoles are consumer devices that deliver electronic games-based entertainment for household consumption. They feature proprietary hardware designs and software OS, and rely primarily on AC power as primary energy source and must be plugged into an external video display such as a TV. They can also provide Internet and e-mail access. Handheld gaming devices are primarily for mobile and household use. They rely on DC (battery) power as the primary energy source. They include an embedded video display, such as an LCD.

IDC predicts that in the year 2002, the shipments and revenue of game consoles in the U.S. will exceed 20 million units and $2.5 billion, respectively. The worldwide shipment of game consoles is forecast to exceed 40 million units for the same year.

Some of the market trends for gaming consoles are:

- Generation “Y” is entering the teenage years with a keen interest in games and interactive entertainment
- Growing pervasiveness of the Internet will help online gaming
- Home networking and broadband access: Online gaming with a high-speed access and in-home gaming between consoles and PCs
- Digital TV, high definition TV (HDTV), and set-top box: High-quality video and gaming enhances the viewer experience and interactive capabilities through cable, satellite, and xDSL

Market accelerators include:

- Next generation product cycle
- Installed base
- Internet/Web access feature

Market inhibitors include:

- Limited success of on-line, console-based gaming
- PCs: low-cost and performance improvements
- Higher prices

Online gaming is the interactive electronic game play capability involving offsite, independent variables such as another human opponent or an offsite PC. Online gaming capabilities are promoting the gaming consoles into potential home gateways. Playing between different players across the Internet has been gaining prominence with the coming of broadband access and ubiquity of the Internet. Most existent gaming consoles have a 56K (analog) modem embedded to allow this. The addition of home networking capabilities within the gaming console will make the evolution into a residential gateway a realistic possibility in the near future.

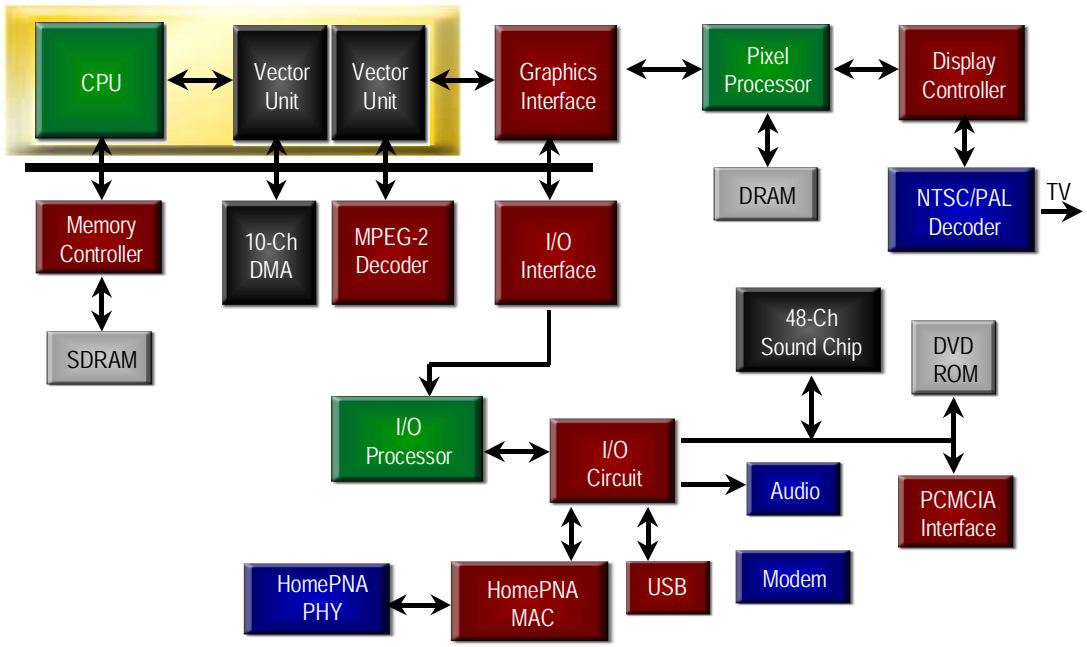

Figure 6: **Gaming Consoles**

A game console has three major blocks. These blocks are the main MPEG processor, the graphics manager, and the I/O processing unit. The MPEG processor contains a super scalar CPU core (128-bit), two vector units (vector operators for floating point data), a graphics interface, I/O interface, a variable-length MPEG decoder, a memory controller, DRAM, and a 10-channel DMA Controller.

The graphic manager contains a pixel processor, a 64-bit external interface, a video memory interface, and a display controller. The graphic synthesizer connects to NTSC, PAL, DTV, or VESA via a NTSC/PAL decoder. The I/O processing unit contains a CPU with Bus Controller and geometry processing engine (high speed matrix calculator), an I/O Circuit which gets connected to a 48-channel Sound Chip, DVD ROM, PCMCIA, and modem (via local bus). The I/O circuit provides interface for HomePNA, USB, and IEEE 1394. The USB and 1394 connections make it possible to use the existing PC peripherals and create a networked home. Xilinx Spartan-II FPGAs provide solutions for the graphics interface, memory controller, I/O controller, MPEG decoder, HomePNA MAC, USB, DMA controller, PCMCIA interface, and graphic interface.

Internet Audio Players

An Internet audio player is any device or program that supports the playback of music compressed using any one of several audio compression algorithms, the best known of which is MP3. Internet audio players are available as application programs for Windows and Macintosh PCs and dedicated hardware players in a variety of forms including in-dash automotive players.

The players that people are most familiar with are the portable MP3 players which resemble a Walkman or a pager. Portable MP3 players store the music files in flash memory. Players typically come equipped with 32 MB of flash, which can be expanded to 64 MB and beyond through the addition of a compact flash card. Music is transferred to the player from a PC using a cable connected to the parallel port or USB port of the PC.

All analysts predict tremendous growth in the market for portable Internet audio players. This growth is driven by the acceptance of the Internet as a medium for online commerce and music delivery. Currently, the Internet generates a mere $88 million in annual domestic sales of retail music, or less than one percent of the total. By 2002, analysts expect online music sales to rise to $1.4 billion, or nearly eight percent of the total market. Today, the CD (compact disc) dominates the industry and in 1998, over one billion prerecorded CDs were sold in the U.S., thus accounting for 81 percent of prerecorded music sales. It took ten years for the CD format to overtake the cassette in terms of unit shipments. Some of the emerging audio technologies are MP3, DVD-Audio (DVD-A), and Super Audio CD (SACD).

The Internet audio market is seeing growing support from consumer electronics vendors. Some of the drivers also include the high consumer awareness and growing popularity for digital downloads. In spite of dramatic growth forecasts for the overall MP3 player market, the following three key issues will limit the rate of market growth and impact the definition of products:

- **Music file format:** While MP3 is the dominant format for music download, other formats are emerging.
- **Copyright protection:** New formats were designed to provide the copyright protection features that are being demanded by the music industry.

There are three different types of physical music media formats: MD, DVD-A, and SACD.

MiniDisc (MD): The MD was a technology pioneered by Sony in 1993. While MD has been much slower to take off in the U.S., it continues to enjoy a strong presence in Japan, because

- Most mini-component systems sold in Japan include a MD drive
- Portable MD players are offered by a number of manufacturers in a variety of designs, and
- Sony has advertised and promoted this technology through heavy advertisements and low prices for players and media

The MD technology is a small-format optical storage medium with read/write capabilities. It is positioned as a new consumer-recording format with smaller size and better fidelity than audio.

DVD-Audio (DVD-A): DVD-A is a new DVD format providing multi-channel audio in a loss-less format. The industry confirmed the standard in mid-1999 and it is positioned as a replacement for the CD and brings new capabilities to audio, providing the opportunity for additional content such as video and lyrics. It supports 5.1 channels with quadrupled capacity.

Super Audio Compact Disc (SACD): SACD technology was jointly developed by Sony and Philips to compete with DVD-A. The format is the same size as both the CD and DVD media but offers potential for higher sampling rates. SACD is fully compatible with CD format and can play SACDs in today's CD players. SACD is considered an audiophile format, while DVD-A is positioned as the mass-market option.

There are multiple Internet audio formats: MP3, Secure MP3, MPEG2 AAC, Liquid Audio, Windows Media Player, a2b, EPAC, TwinVQ, MPEG-4, Qdesign Music Codec, SDMI.

MP3 (MPEG Layer III Audio Coding): The MPEG Layer III audio compression scheme that was defined as part of the International Standards Organization (ISO) Moving Picture Experts Group (MPEG) audio/video coding standard. MPEG-I defined three encoding schemes, referred to as Layer I, Layer II, and Layer III. Each of these schemes uses increasingly sophisticated encoding techniques and gives correspondingly better audio quality at a given bit rate. The three layers are hierarchical, in that a Layer III decoder can decode Layer I, II, and III bit-streams; a Layer II decoder Layer II and I bitstreams; and a Layer I decoder only Layer I bitstreams. Each of the layers support decoding audio sampled at 48, 44.1, or 32 KHz. MPEG 2 uses the same family of codecs but extends it by adding support for 24, 22.05, or 16 KHz sampling rates as well as more audio channels for surround sound and multilingual applications.

Of the Internet audio download formats, MP3 is the most popular. MP3 supports audio sampling rates ranging from 16-48 KHz and with extensions that were incorporated as part of MPEG-2, up to five main audio channels. MP3 is a variable-bit codec and users can determine the sampling rate for encoded audio. Higher sampling rates mean that the audio maintains better fidelity to the original but results in less compression. The better the quality, the larger are the resulting files, and vice versa. For most consumers, MP3 files encoded at reasonable rates (96 Kbps or 120 Kbps) are indistinguishable from CDs. MP3 features include:

- Sample rates from 16-48 KHz
- Up to five main channels (MPEG-2 only)
- Has no built-in security, no safeguards, or usage policies to govern its use
- Algorithm uses 50 percent performance of a 74 MHz ARM7 CPU
- **Secure MP3**: Secure MP3 is a version of MP3 that is working to add security in the format. Some of the approaches to security are:
- Packing the MP3 files in a secure container that can be opened with a key. The key can be associated with a particular system or sent to the user separately. However, issues include tracking the keys and lack of consumer flexibility.
- Using encryption technology combined with the encoded file. The key could be the drive ID to user information. Information held in the encryption code ensures copyright protection, establishment of new business models, and the specific uses of songs.

MPEG-2 AAC: Advanced Audio Coding (AAC) is one of the audio compression formats defined by the MPEG-2 standard. AAC used to be called Non-Backward-Compatible (NBC), because it is not compatible with the MPEG-1 audio formats. MPEG-2 also defined another audio format called MPEG-2 multi-channel or MPEG-2 BC (Backward Compatible), which is compatible with MPEG-1. AAC is more efficient than MP3 (MPEG-1 Layer III) and is the state of the art in audio compression technology.

Formal listening tests have demonstrated its ability to provide slightly better audio quality. The essential benefits of AAC are a wider range of sampling rates, from 8-96 KHz; enhanced multi-channel support, up to 48 channels; and better quality. AAC can deliver equivalent quality to

MP3 at 70 percent of the bit rate or can deliver significantly better audio at the same bit rate. Like MPEG-1 audio encoding standards, AAC supports three levels of encoding complexity. Perhaps the biggest indication of the significance AAC is by its use as the core audio encoding technology for AT&T's a2b, Microsoft's WMA, and Liquid Audio.

Liquid Audio: The Liquid Audio Company was formed in 1996, and it developed an end-to-end solution to provide high-quality, secure music. It enables music to be encoded in a secure format, compressed to a reasonable file size, purchased online, downloaded and played. It included creating back-end solutions to manage and track payments—acted as a clearinghouse for downloaded music. The Liquid Music Network includes over 200 powerful partners and affiliates. The network has been hindered by its PC-only playback capabilities, but has recently gained support from silicon vendors and consumer electronics companies.

Microsoft Windows Media Player: Microsoft has been involved with audio for many years and has incorporated multimedia in its operating systems since Windows 95. It provides basic support for CDs and WAV files and the recently introduced MS Audio format. The Windows Media Player is a multimedia platform that comes with Windows. It has a default front end for playing audio and video files. Microsoft is aggressively working to develop new technologies for the secure download of music. Their primary goal is to make its technology as pervasive as possible.

Windows Media Audio (WMA) recently developed a codec that is twice as effective as MP3. It is a variable-rate technology with new compression technology providing good quality in very small files. It has licensed its codec to other software providers and has incorporated WMA on server-side technology in Windows NT Server OS (royalty-free). Microsoft is also working on support for other Microsoft products such as Windows CE OS for hand-held devices and set-top boxes.

a2b: a2b format is a compression and security technology supported by AT&T. The web site promotes the a2b codec with free players and available content. It has a limited installed base of players and little momentum in the market, prevents a2b in becoming a widely supported format.

Enhanced Perceptual Audio Codec (EPAC): EPAC is a codec developed by Lucent Technologies (Bell Labs). The technology compresses audio at a rate of 1:11. It is supported by Real Networks in its popular G2 player, but very few content owners and distributors support it.

TwinVQ (Transform-domain Weighted Interleave Vector Quantization): This compression technology, targeted at download applications, was originally developed by Yamaha and has been incorporated, along with AAC, into the MPEG-4 specification. The underlying algorithms are significantly different from the algorithm used in MP3. It has attracted high industry interest due to its quality and compression capabilities. The codec can compress audio at rates of 1:18 to 1:96, which implies a near CD-quality file size of about 0.55 MB per minute.

MPEG-4: It is a format developed by same group supporting MPEG-1 and MPEG-2. It is a new audio/video codec with better compression capabilities than previous standards and additional interactive support.

Qdesign Music Codec: Based in British Columbia, Qdesign developed a high-quality, streaming audio codec. It is distributed by Apple Computer as part of their QuickTime media architecture and gives excellent quality at dial-up data rates.

SDMI: The Secure Digital Music Initiative (SDMI) is a forum that brings together more than 180 companies and organizations representing information technology, consumer electronics, security technology, the worldwide recording industry, and Internet service providers. SDMI's charter is to develop open technology specifications that protect the playing, storing, and distributing of digital music such that a new market for digital music may emerge. The open technology specifications released by SDMI will ultimately:

- Provide consumers with convenient access to music both online and in new emerging digital distribution systems
- Enable copyright protection for artists' works, and
- Promote the development of new music-related business and technologies

- Some market trends in the Internet audio player industry are:
- There is a tremendous consolidation at every level, thus increasing the market power for the remaining players. The number of top-tier music labels has reduced, and this consolidation is due to corporations seeking economies of scale and profitability in the mature industry. This leads to artists and independent labels to search for new ways to promote and distribute music. Efficient systems provide lower costs and higher profits for the labels. The new medium provides an opportunity for promotion and exposure to artists.
- The trends are shifting towards digital formats. Communication, entertainment, and information are all transitioning from analog to digital. The shift has been occurring in the music industry for decades through CD formats as consumers expect greater fidelity, depth, and range in the music. It is also easier to copy without losing quality. PCs aid in making digital files easy to store and replicate.
- Internet becoming a mass-market phenomenon has been helpful. It is a superb distribution channel for anything that can be digitized. It is serving as a new medium for music promotion and distribution.
- Digital compression: Reducing music files to a fraction of their size, makes them easier to manage and distribute, without sacrificing quality
- New (non-traditional/experimentation) business models: Knowledge of consumer information removes distance between the consumer (fans) and artists. Focussed marketing allows closer relationship while increasing profits for everyone. Electronic distribution allows per-play fees, limited-play samples, and subscription models.
- Broadband (high-speed) access to the home will promote electronic music distribution over the Internet.
- Indications are that the Internet audio market will not converge on a single standard any time soon, in fact, it will probably get more fragmented as it grows. Each of these standards will be optimized for different applications (streaming versus download), bit rates (users with DSL versus modem connections), and the business agendas of the media providers.
- As this takes shape users will want players that support multiple standards. An essential component of a player is of course the range of music that it makes available to its owner. This trend has already started the recently announced Creative Labs Nomad II and will be able to support multiple standards. It will have the ability to download support for new standards in the future.
- Another trend that is emerging is support for “metadata“ in the music standards. Metadata is non-music data that is included in the music files, and includes things such as track information and cover art. Another potential use for metadata is advertisements.
- Copyright protection is the biggest issue hindering the growth of Internet music distribution market. MP3 files can be easily distributed across the Internet using web page downloads or e-mail. Since MP3 has no inherent copy protection, once it is made available on the web everyone has access to it at no charge. The recording industry headed by the Recording Industry Association of America (RIAA) sees the combination of MP3 and the Internet as a Pandora’s box that will result in the widespread piracy of copyrighted material. The RIAA perceives the threat to be significant enough that they took legal action in a failed attempt to block the sale of the Diamond Rio in late 1998. The fear of piracy by mainstream artists and the recording industry has limited the availability of legitimate MP3 material to emerging/fading artists and sample tracks from mainstream artists.

The portable players are small players that leverage a PC for content storage, encoding, download, and cost between $100-300. Home systems must support multiple output formats and have robust storage capabilities. They also have higher cost designs. Automotive products require broad operating environment support, specific industrial design specifications and multiple format support including radio and CD. Product differentiation trends include adding Bluetooth capability, user interface, video, games, day-timer features, etc.

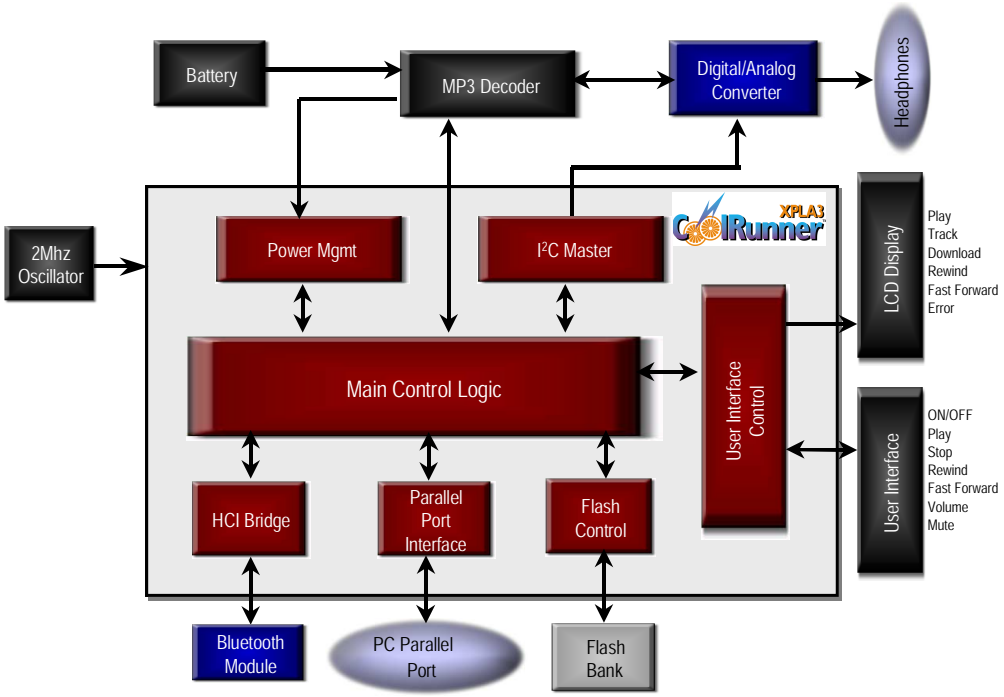

Figure 7: **MP3 Players**

The CoolRunner CPLD provides the main control of the MP3 player (Figure 7). The MP3 songs are downloaded into the flash memory via the PC parallel port. The user interface controls are interpreted by the main control logic and the song data in the flash is manipulated to play a song, rewind to the previous song, skip ahead to the next song, or simply stop. The main control logic interfaces directly to the MP3 decoder to provide the MP3 data from the flash to the MP3 decoder. The volume is adjusted in the DAC over an I^2C interface by the CoolRunner CPLD I^2C master.

Internet Smart Handheld Devices (SHDs)

Internet SHDs are vertical application devices that provide direct Internet access capabilities using an add-on or integrated modem. Several vendors such as Palm Computing, Compaq, Nokia, Handspring, and Hewlett-Packard have announced Internet SHDs. SHD subcategories include: Handheld companions, smart handheld phones, vertical application devices (VADs). Some of the market accelerators for SHDs include corporate acceptance and the presence of content (Internet and e-mail such as stocks, news, weather). The slow acceptance for the Windows CE operating system is a key market inhibitor. IDC predicts that by the year 2002, annual SHD shipments will exceed 23 million units.

Handheld companions include PDAs (personal digital/data assistant), personal companions and PC companions. Applications for handheld companions include:

- Personal information management (PIM)
- Data collection
- Light data creation capabilities such as word processing for memos

Smart handheld phones include emerging enhanced, super-portable cellular phones that enable both voice and data communications. Some applications for smart handheld phones include cellular voice communications, Internet access, calendar, and Rolodex data such as names, addresses, and phone numbers.

VADs are pen or keypad based used in specific vertical applications in a variety of industries. Key applications for VADs include:

- Routing, collecting and delivering data for a vendor in the transportation industry

- Physician accessing patient's records in a hospital

PDA: Personal digital (data) assistants come in many shapes and sizes, and are synonymous with names like handheld computer, PC companion, connected organizer, IA, smart phone, etc. A PDA or handheld computer is primarily a productivity and communications tool that is lightweight, compact, durable, reliable, easy-to-use, and integrates into existing operations. Typically, it can be held in one hand leaving the other to enter data with a pen type stylus or a reduced size keyboard.

PDAs fall into one of four general categories—handheld PCs (HPCs), palm-size PCs (PPCs), smart phones, or handheld instruments. Ease-of-use and affordability are two essential factors driving consumer demand.

PDA shipments are expected to display impressive growth through the year 2003. From four million units in 1998, annual shipments are forecasted to increase to more than 19 million units by the year 2003. While the PDA ASP is expected to continue to decline, the PDA market is still forecast to expand at a solid rate. Consequently, demand for ICs in PDA applications will also grow significantly. The average IC content in a PDA, in terms of dollars, is about 40 percent, corresponding to a PDA IC market of $456 million in 1998 and is expected to exceed $1.9 billion by 2003.

PDA market trends include:

- Addition of wireless connectivity such as faster Internet access, Bluetooth
- Auto-synchronization
- Multimedia emerging: color, audio, voice recorder
- High-capacity storage: flash, micro hard disk drive

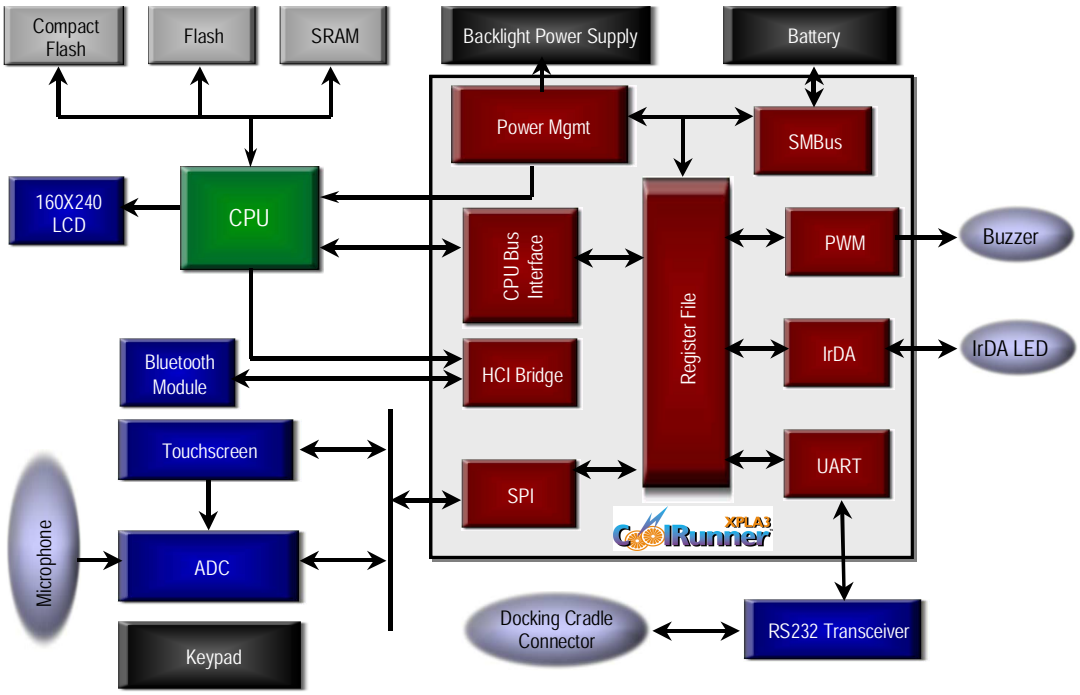

Figure 8: **PDA**

CoolRunner CPLDs are the lowest power CPLDs in the market today and thus, are an obvious choice for use in PDAs (Figure 8). Used in conjunction with a CPU, the CoolRunner CPLD provides a very low power solution for PDAs. The CoolRunner CPLD provides a memory mapped interface to the CPU allowing the CPU to control many aspects of the PDA by simply reading and writing registers. These registers provide control and status information for the various interfaces in the PDA system. The CoolRunner CPLD provides the SMBus interface for smart battery control, an SPI interface for communication with two ADCs and the keypad, a

UART for interfacing with the docking cradle, and an IrDA interface. A PWM is also included for control of a buzzer. Since the CoolRunner CPLD is in-system programmable, the interfaces can be modified to support the necessary peripherals as needed.

The CoolRunner CPLD also contains the power management function for the entire PDA. Since the static power of the CoolRunner CPLD is <100 µA, the CoolRunner CPLD can remained powered during periods of PDA inactivity and monitor interfaces for activity. This allows the CPU to be placed in its lowest power standby mode, saving power for the entire system and extending the battery life of the PDA. When activity is required, the CoolRunner CPLD can “wake up“ the CPU if necessary, making the PDA as power efficient as possible.

Digital Video Recorders (DVR), Personal Video Recorders (PVR)

The digital television industry has been abuzz over the past year about a new category of products called personal video recorders and digital video recorders. They are also known as digital VCRs and exist as DVR-enabled set-top boxes.

DVRs are products used for local storage to enable consumers to control storage and playback of live digital video streams on a real-time basis. DVRs are similar to traditional VCRs in many ways, and they simultaneously record, pause, instant replay, and playback live TV shows and movies. Instead of using traditional videotapes, DVRs use a large HDD along with sophisticated video compression and decompression hardware to record television streams. Using an HDD instead of a tape gives the DVR the following capabilities:

- Real-time recording
- Storing in digital video (high) quality
- Instant access
- Proactive and quick TV management
- Simultaneous use of multiple data streams

The analysts predict fast growth for DVR-enabled products, with 13 million shipments in the U.S. and 19 million units worldwide in 2004. Market drivers for DVRs include its single functionality, multiple vendor support, and component cost declines. However, challenges such as consumer awareness and price persist. This is a hot category with growing vendor support. Additionally, several set-top box manufacturers are entering this market. The DVR functionality can also be incorporated directly inside the TV set or included in set-top boxes. DVR products have a built-in modem to dial a service provider and download the programming guide and software updates. Many of the DVR manufacturers are adding home networking interfaces to their designs to promote the evolution of this access device into a high-end residential (media) gateway product.

In a digital VCR, Xilinx products provide system interface, I/O control, glue logic, memory controller, HDD interface, MPEG decoder, and ASSP functionalities.

In a digital VCR, Xilinx products provide system interface, I/O control, glue logic, memory controller, HDD interface, MPEG decoder, and ASSP functionalities (Figure 9).

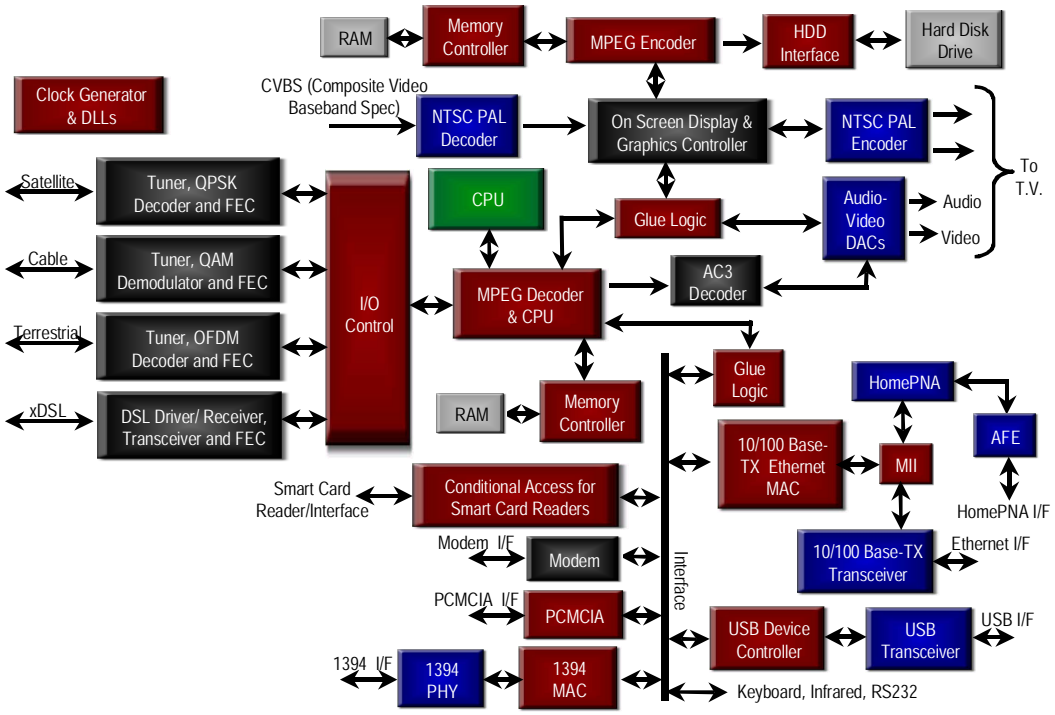

Figure 9: **Digital VCR**

NetTV

NetTVs are TV-centric Internet appliances that provide Internet access using the TV as their primary display. These standalone products are set on top of the TV ("set-top"). They could also be TVs with Internet connectivity, built in at the time of being manufactured. Examples of these products include set-top boxes, integrated TVs, enhanced traditional cable boxes, and direct satellite devices. The components include communications module (modem), core processor, operating system, display driver, and usage specific applications such as Web browser and e-mail client. NetTV offerings provided include

- Basic service, with limited interactive electronic programming guides or customized information tickers
- Advanced services, with full graphical Web browsing, e-mail, and streaming video.

Analysts predict that worldwide shipments for NetTVs will exceed 19 million in 2002. Key market accelerators include:

- Infrastructure upgrade: back end to clients
- Consumer interest in the Internet and new services
- Intense competition and drive for new revenue

Some market inhibitors are:

- The consumer's interest in interactive services
- High costs
- Regulatory issues

Digital Video/Versatile Disk (DVD)

DVD technology provides storage capacity that is about 6-7 times greater than that of CD technology with the same aerial space. It provides multiple languages on movies, with multiple language subtitles. The beam of laser light touches the data portion of a DVD disc, and it is never touched by a mechanical part when played eliminating wear characteristics on the disc.

The DVD disc can be used for data storage in a PC through using a DVD- ROM drive. Using the similar format each DVD can store up to 17 GB of data compared to CD-ROM disc stores

650 MB of data. While a single layer of DVD disc can hold 4.7 GB of data, a greatly increased storage capacity is accomplished by using both sides of the disc and storing two layers of data on each side. A new technology, using blue laser technology, to provide superior quality video is being developed by several vendors. This technology will be capable of achieving higher data densities with 12-30 GB capacity. Some key DVD features include:

- MPEG-2 video compression
- Digital Theatre Systems (DTS), Dolby Digital Sound
- Up to eight audio tracks
- 133 minutes/side video running time (at minimum)
- Disk changers
- Backward compatibility with CD and/or CD-ROM
- Still motion, slow motion, freeze frame, jump-to-scene finding
- Interactive/programming capable: story lines and subtitles

Major components of a DVD player include:

- **Disc reader mechanism:** It includes the motor that spins the disc and the laser that reads the information from it.
- **Digital signal processor (DSP) IC:** It translates the laser pulses back to electrical form that other parts of the decoder can use.
- D**igital audio/video decoder IC:** It decodes and formats the compressed data on the disc and converts data into superior-quality audio and video for output to TVs and stereo systems.
- **Microcontroller:** It controls operation of the player and translates user inputs from the remote control or front panel into commands for audio/video decoder and disc reader mechanism.

Adoption of DVD players is quickly growing and analysts predict that unit shipments of DVD players will exceed the total shipments of VCR shipments by 2003. Analysts predict that by 2003, in the U.S., shipments for DVD players will exceed 20 million units, compared to 18 million VCR players. The installed base for DVD players will grow to 63.5 million units by the end of 2004, representing the rise of the installed base from 5.5 percent of the estimated 100 million total U.S. households in 1999 to 63.5 percent in 2004. Analysts predict that worldwide shipments for DVD players will exceed 75 million units in 2004.

The market is currently experiencing high volume, declining prices, broadening vendor support, and more interactive features (gaming, Internet). Market drivers include low-cost, consumer awareness, and content availability. However, challenges such as DeCSS, consumer confusion, and increasing DVD capabilities on other devices exist.

Emerging DVD player technology:

- DVD players are combining DVD-A capabilities, thus enabling DVD players to achieve higher-quality audio. DVD-A is a new music format that provides a major advance in audio performance. It enables the listener to have advanced resolution stereo (two channels), multi-channel surround sound (six channels) music or both.
- DVD-Video players are combining the capability to write on the disk.
- Interactive and access to the Internet feature is gaining prominence in DVD players and DVD gaming consoles.
- PCs are adopting DVD read and write drives.
- A networked DVD player allows the user to play DVD movies across the home network in multiple rooms.

Spartan-II FPGAs are used to perform DSP functions, channel controller, MPEG-2 decoder, memory controller, display controller, I/O controller, CD interface, and interface to other home networking and system technologies (Figure 10).

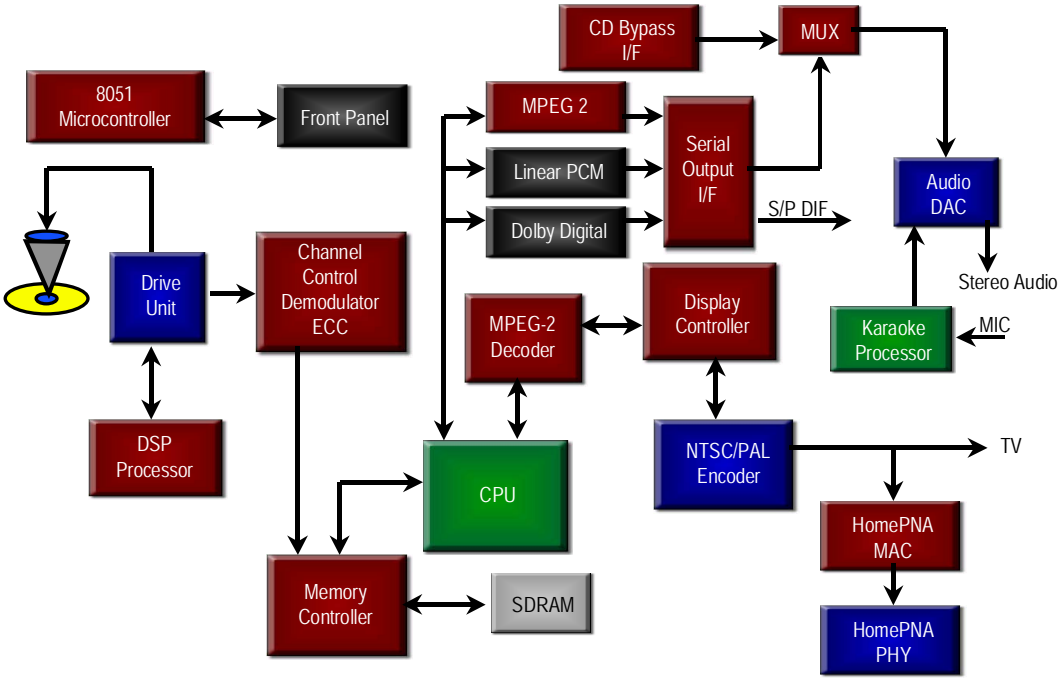

Figure 10: **DVD Players**

Personal Computers (PCs)—Notebook and Desktop

Over the last ten years, the PC has become prominent and is found in almost every home, with a sizeable percentage of the homes even having multiple PCs. Dataquest-GartnerGroup predicts that the PC penetration exceeds 50 percent of U.S. households (of the 102 million U.S. households, 52 million own a PC). The research also forecasts that multi-PC households will grow from 15 million in 1998 to over 26 million in 2003.

The rapid growth in multi-PC households brings the need for sharing broadband, files/data, and peripherals (such as printers and scanners) between the multiple PCs in different rooms of a house. This is causing the networking of PCs, PC peripherals, and other appliances. In the home, the PC is the most important and widely used device for computing, Internet access, on-line gaming, data storage, and is hence, also seeing a place as a residential gateway to network the home.

With the worldwide PC shipments totaling 134.7 million units in 2000 and predicted to exceed 200 million in year 2004, the PC is seeing a healthy demand. This is due to the ongoing price per performance improvement and the position of the PC as a productivity tool. However, there are several weaknesses with the PC such as being complex, buggy, and confusing.

Market opportunities include:

- Growth in multiple PC households
- Evolution of new business models
- Introduction of new and innovative PC designs
- The growing ubiquity of the Internet

Market threats include:

- IAs
- Web-based services and applications
- Saturation in key markets
- Low margins

The unit shipments and revenues for PCs exceeded 11.6 million and $21 billion in the U.S. in 1998, respectively. Market analysts projected an increase in shipments to 22.3 million units in

2000 and 25.2 million units in the year 2001 for the U.S. Interestingly, desktop PCs own 95.7 percent of the overall PC market. The top 23 vendors account for only 80 percent of the market, showing the large number of vendors in this space. For the past decade, PCs have been the world's largest IC consuming product. According to an analysis by IC Insights, in 1993 PC-related chips accounted for one-third of the IC market and by 2003 are expected to claim 47 percent of the IC market.

PCs vs. IAs

Over the last few years, PCs are seeing a slower growth in revenues. Part of this slower growth is because of the increase in the number of IAs.

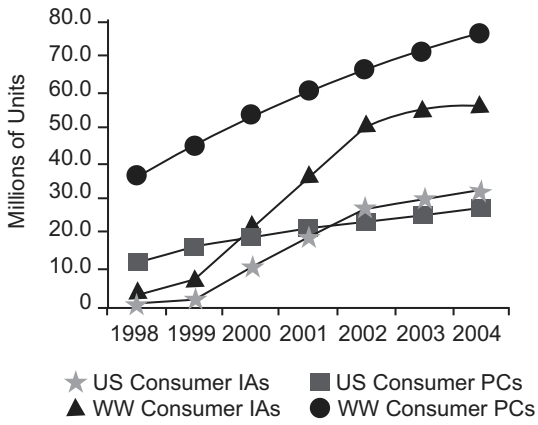

Figure 11: **U.S. and Worldwide Shipments of PCs and IAs (Courtesy: IDC)**

Figure 11, shows the U.S. and worldwide shipments of PCs and IAs. In the year 2001, U.S. shipments for IAs will exceed unit shipments for PCs. Non-PC vendors, who are seeking an opportunity to capture the $21 billion market (in U.S. alone), are promoting IAs. Industry research firm, Parks Associates predicts that IAs will out-ship the number of PCs in the U.S. The total PC revenues will fall below the revenues of IAs. Parks Associates, a leading market research firm, predicts that in 2001, in the U.S., 22 million home IAs (excluding Internet-enabled mobile phones and telematics systems) will be shipped compared with 18 million home PCs shipments.

IAs are targeting three specific areas in:

- Replacing PCs and providing robust Web browsing, e-mail, and interactivity (examples: e-mail terminals, Web terminals, Web pads)
- Supplementing PCs and coexisting (examples: PDAs, printers, scanners)
- Side-stepping PCs—This is not a significant threat to PCs (examples: set-top boxes, cellular phones)

A lot of factors are driving IAs, such as:

- Aggressive vendor pursuit
- Consumer market demands
- Advancing bandwidth capacity
- Lower product costs
- Consumer needs
- Device distribution subsidized by service contracts rather than retail or direct-sales like in PCs. These include examples such as: Microsoft WebTV

The PC is however not going away soon, because of its:

- **Compatibility:** Interoperability between documents for business, education, and

government. Also, IAs support open standards, or proprietary, non-PC supportive media standards.

- **Flexibility in the PC platform:** Video editing, music authoring, Web hosting, gaming, etc. can all be done in one PC. Comparatively, IAs are dedicated for one function.
- **Momentum:** PCs have a huge installed base, high revenue, and annual shipments.
- **Awareness:** More than 50 percent of consumer homes have PCs.
- **Investment** protection and reluctance to discard.
- P**ace of improvement:** Faster processors, bigger hard drives, better communication.
- **Established industry:** Corporate momentum will continue due to PC vendors, software developers, stores, support networks.

Some of the market trends for PCs include:

- Lower price points: Rapidly moving below $500 and hence, causing blurred lines between PCs and IAs
- New downstream revenue opportunities: Internet services, financing/leasing and e-commerce options
- Super-efficient distribution via the Internet
- Offsetting profit products such as servers, services, and workstations enable aggressive prices on consumers

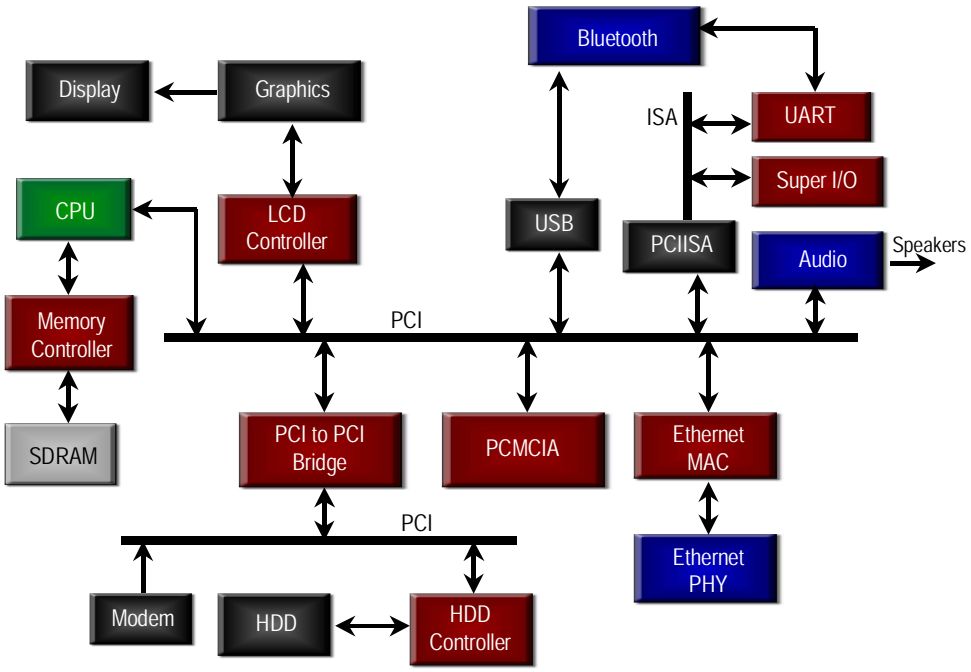

Figure 12: **PC**

Spartan-II FPGAs provide the functionality (Figure 12) of a memory controller, LCD controller (notebook PCs), PCMCIA, HDDD controller, I/O controller, UART, system interface, and ASSP functionality (PCI, USB, Ethernet, and HomePNA).

PC Peripherals

A peripheral device is defined as an external IA that is attached to the PC to provide a specific functionality. Examples of these peripheral include printers, scanners, and digital cameras.

Printers

Printers have always been a mainstream output technology for the computing industry. Earlier times found the impact and thermal printers as the cornerstone technologies most frequently

embraced. Within the last decade, this has dramatically shifted to both inkjet and laser technologies, which are extremely price sensitive. Also, note that most of the printer business is held by a relatively few large players. Dataquest has estimated that the 1998 world laser printer market to be near ten million units and the inkjet market to be over 45 million units.

Due to the widespread use of small office/home office (SOHO) operations and the corresponding need for consolidation of desktop area, an even newer extension—multifunction peripherals (MFP)—has arrived. These devices combine the fax machine, copier, scanner, and printer all into a single unit. At the heart of the MFP output device is fundamentally an inkjet or laser printer.

Xilinx programmable logic solutions are ideal system interface modules within printers (Figure 13), gluing the embedded processors, EPROMs, DRAMs, and ASSPs into a unified printer controller. Xilinx programmable logic performs these functions and retains the fundamentally low cost and low power required of this market.

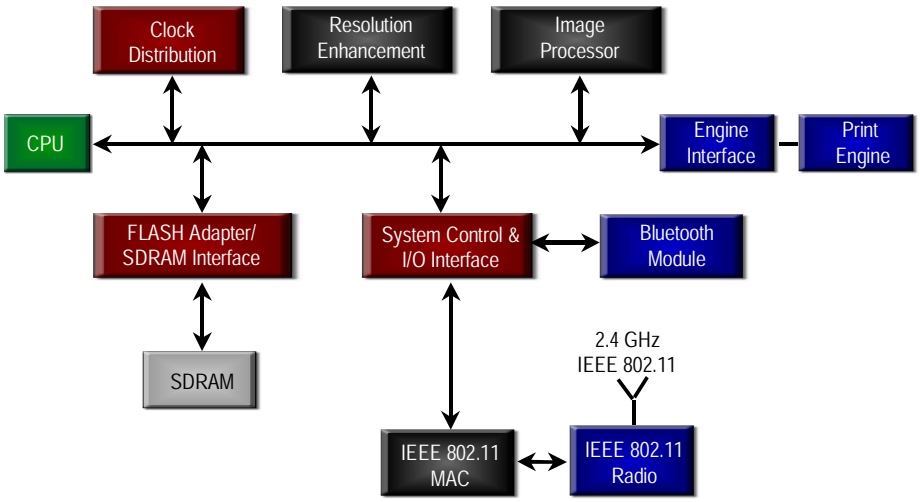

Figure 13: **Printers**

Digital Camera

By design, digital cameras require a considerable amount of image processing power. Microprocessor vendors, ASIC vendors, and DSP vendors all view this requirement as a potential gold mine—a huge market poised to buy their wares. In 1998, each of the nearly four million digital cameras shipped was equipped with a microprocessor, an A/D converter, some DRAM, and 4-16 MB of flash memory. IC Insights forecasts digital camera shipments of 59 million units and a $6.1 billion market in 2003.

In the current market, entry-level and toy category digital cameras are just beginning to emerge. Market drivers include declining prices, PC penetration, and an improving digital infrastructure. Some challenges for this technology include consumer awareness and the pervasiveness of digital infrastructure. The formula for success in the digital camera market is multifaceted. It is important to produce a picture with high-quality resolution and to view it as soon as the photo is taken. Decreasing prices of imaging sensors and inexpensive, removable picture storage (flash memory cards) will help expand the market. In addition, camera, PC, and IC vendors are working together to come up with different combinations that lower prices and that make their systems attractive in terms of providing seamless functionality with other equipment and being affordable.

Digital cameras can be classified into five different categories:

- Soft-display mobile cameras
- Basic point and shoot
- Photo quality point and shoot

- Professional mobile cameras
- Prepress, portrait, and studio cameras

Fundamentally, all digital cameras function in about the same manner. An image is focused through a lens and onto either a CMOS sensor or a charge-coupled device (CCD), which is an array of light-sensitive diodes. The sensor chip is typically housed on a daughter card along with numerous A/D converters. The CCD and its circuitry create a digital reproduction of the image. It does this through a series of photodiodes—each containing red, green, and blue filters—which respond to different ranges of the optical spectrum. Once a picture is snapped, an embedded processor reads the light level of each pixel and processes it to produce a 24-bit-per-pixel color image. Soon after the picture is taken, the JPEG (joint photographic experts group) image is projected onto a LCD display on the back of the camera or is compressed in non-volatile flash memory storage via software. Using a digital camera, the consumer is provided with the speed and convenience of instant development.

The Xilinx CoolRunner family can be used to implement the I/O control logic and LCD interface. In addition, it can implement the graphics controller logic that interfaces between the camera DSP, JPEG co-processor, and the memory control logic (Figure 14). The reprogrammable nature of these devices offers flexibility to add features and support several interface standards.

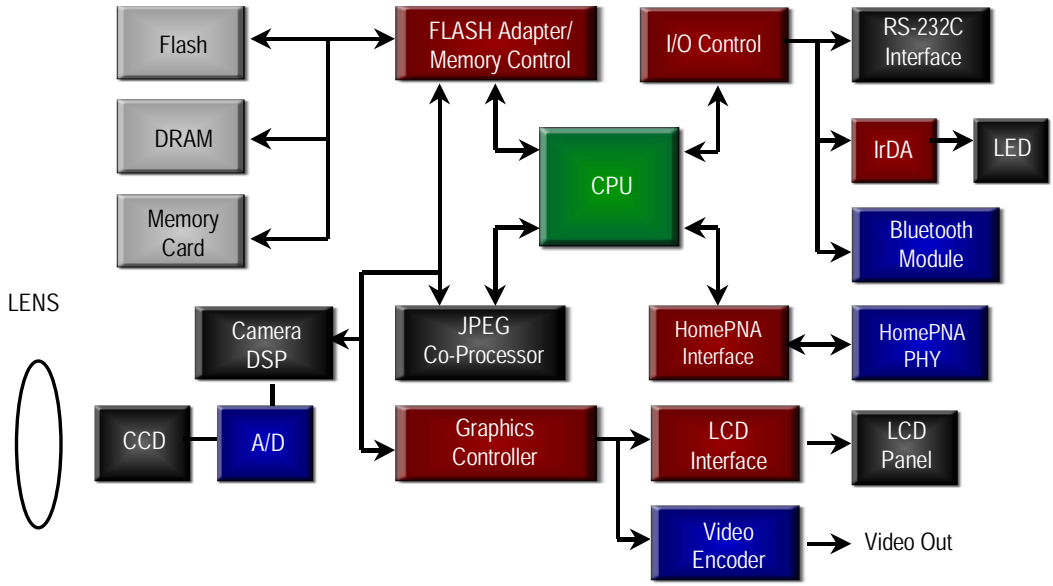

Figure 14: **Digital Camera**

Scanners

Any PC should be able to access the scanner in the home. It allows the ability to transfer scanned images and other files across the home network. Fundamentally, a scanner works like a digital camera. An image is scanned through a lens and onto either a CMOS sensor or a charge-coupled device (CCD), which is an array of light-sensitive diodes. The sensor chip is typically housed on a daughter card along with numerous A/D converters. The CCD and its circuitry create a digital reproduction of the image. It does this through a series of photodiodes—each containing red, green, and blue filters—which respond to different ranges of the optical spectrum. Once the picture is scanned the DSP and pixel co-processor produces a JPEG image that can be displayed on a screen. Scanners are differentiated by their scanning quality, and most of this work is done by the DSP processing power.

A Xilinx Spartan-II device is used to implement various signal-processing tasks such as the pixel co-processor, which can add processing power for improved scanning quality (Figure 15). Xilinx FPGAs perform these and other DSP tasks such as a DCT/IDCT, at frequencies beyond those of traditional DSPs. In addition, the same Xilinx devices are used for system control logic, clock distribution, or as a memory controller (for DRAM, SRAM, and flash).

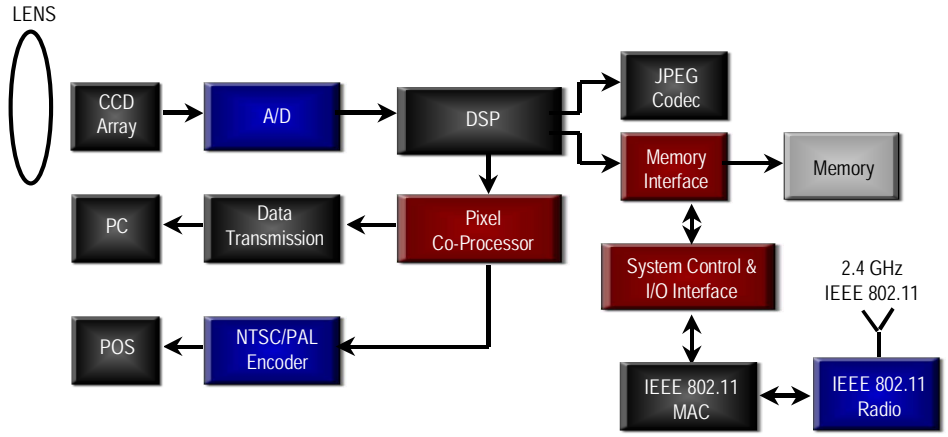

Figure 15: **Scanners**

Smart Card Readers

Imagine a time when the morning paper could simply be purchased using a card charged with small denominations of money, instead of fumbling for small coins. On public transportation, the same card could be used to pay for the ride. After arriving at work that card could be used to unlock the security door, enter the office, and used to boot up your PC with your personal configuration. In fact, everything you purchase, whether direct or through the Internet is made possible by the technology in this card. It may seem far-fetched but with the rapid advancements of semiconductor technologies, this type of card is a reality. In some parts of the world, the “smart card” has already started to obsolete cash, coins, and multiple cards. An essential part of the smart card system is the card reader which is used to exchange or transfer information.

Some advantages of the smart card over the traditional magnetic strip card are that the smart cards:

- Are proven to be more reliable than the magnetic strip card
- Can store up to 100 times more information than the magnetic strip card
- Reduce tampering and counterfeiting through high security mechanisms
- Can be reusable
- Have a wide range of applications (banking, transportation, health care)
- Are compatible with portable electronics (PCs, telephones, PDAs)
- Can store many types of information (finger print data, credit, debit and loyalty card details, self-authorization data, access control information)

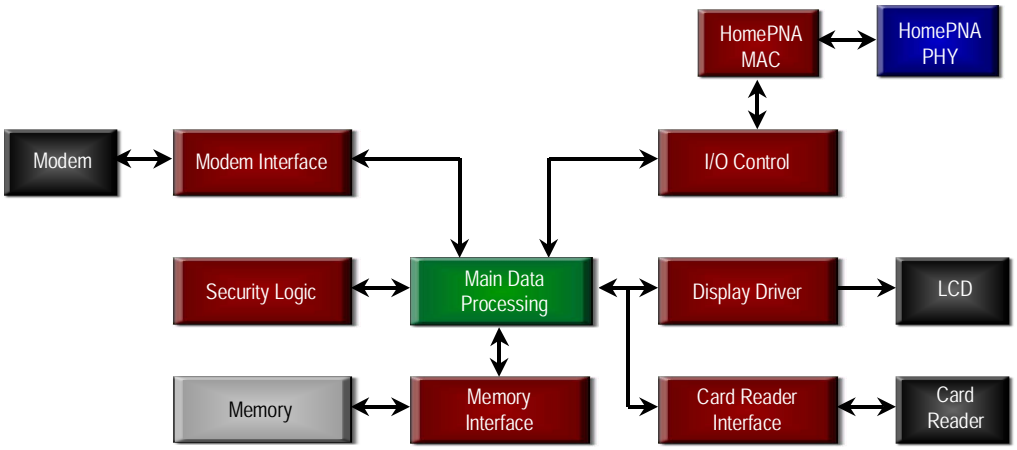

Figure 16: **Smart Card Readers**

Xilinx CoolRunner CPLDs provide smart card reader designers with cost effective solutions that retain the traditional PLD time to market advantage but with the added benefit of ultra low power operation and very small form factor packages (Figure 16).

Automotive Entertainment Devices (Auto PCs, Telematics, Web on Wheels, Automotive Net Devices, Intelligent Transmission Systems)

The motivation for invading the car with infotainment electronics is because every year in the U.S. alone over 100 million vehicles are registered. In addition, the average American daily commute is over 82 minutes. This provides huge opportunities for improving productivity while driving. Some of the potential applications for these products include communication, music-on-demand, real-time traffic information, and remote vehicle maintenance. Several opportunities for automotive manufacturers exist, including:

- Product differentiation
- Recurring revenues from monthly services
- Mobile commerce enabled by GPS: Advertisements/promotions based on location
- Multimedia specialized content transmission: Stocks, news, weather, sports

Several companies are building automotive entertainment products. Some of these companies are: Clarion, General Motors/OnStar, Delphi Automotive Systems, Ford Motors, Visteon, InfoMove, Intel, IBM, BMW, Motorola, Ericsson, Nokia, LoJack, and DamlerChrysler's Mercedes-Benz. Microsoft, with its Windows CE based Auto PC software, has made an aggressive move in this market. Some of the features provided by the software include: speech recognition, synthesis for hands-free operation, access to information such as address book and e-mail, and GPS. It is also interoperable with portable PCs and handheld devices. Alpine, Daewoo, Delphi Automotive Systems, Harmon Kardon, Hyundai, Infinity, JBL, Nissan, Peugeot, Citroen, Samsung, and Volkswagen support Microsoft's Auto PC.

These products provide navigation, entertainment, security/emergency, PIM, e-mail/messaging, web access, news/information, and e-Commerce capabilities.

However, the following issues exist before these products are mainstream:

- First-generation products need improvements
- High cost of ownership: Up front costs and service fees
- Safety issues with the vehicle in motion
- Underdeveloped wireless infrastructure: Slow data transmission speeds and spotty cellular coverage
- Several substitute products exist, which include:
- Cellular phones: Increase in cellular subscribers and increase in cellular services offered
- Handheld PDAs and pagers with wireless access (Palm VII)

Currently several after-market products exist. Also, companies are forming partnerships to develop standards and are working out the feature mix for Auto PC products. Market researchers believe that the automotive entertainment market will be a low-volume, high-end niche for next several years.

Xilinx CoolRunner CPLDs and Spartan-II FPGAs provide system interface and I/O control functionality (Bluetooth, CAN bus) in Auto PC products.

Xilinx CoolRunner CPLDs and Spartan-II FPGAs provide system interface and I/O control functionality (Bluetooth, CAN bus) in Auto PC products (Figure 17).

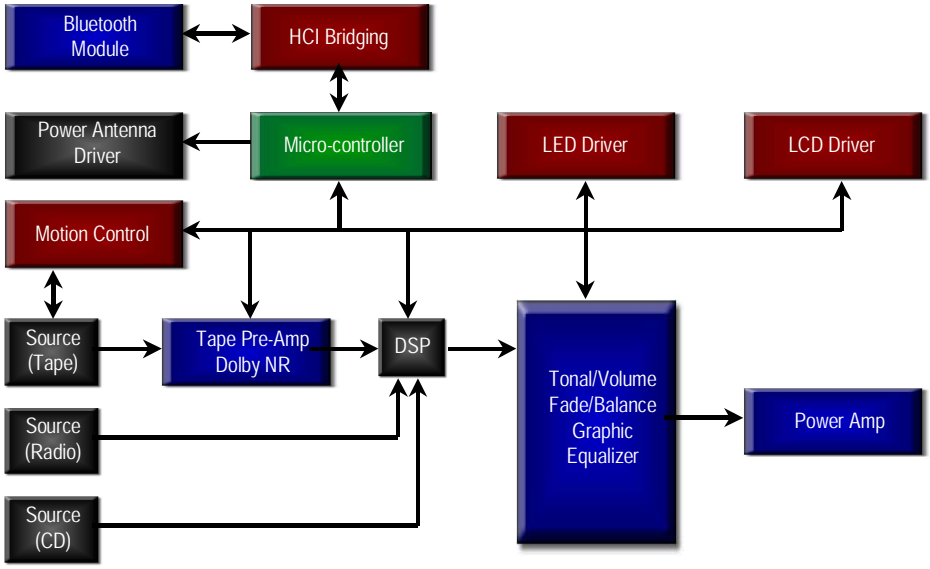

Figure 17: **Car Audio Systems**

Energy Management Systems (Automated Meter Reading, RF Metering)

In a home network, RF metering devices can perform energy management and automated meter reading (AMR). This allows remote readings of many commonly metered devices around the house, which include gas meters, electric meters, and water meters. It can be used for controlling appliances, fire detection/temperature surveillance and room temperature control. Some commercial applications include cable theft detectors, usage meters for billing information and security systems. An important role for these products is in helping the consumer to know and control the monthly utility bill.

The CoolRunner functions as a low power controller by transmitting and/or receiving information from the metered device, storage of information, LCD driver, and keyboard interface. When the CoolRunner CPLD receives the information, it can be displayed on the LCD screen, stored in EEPROM, or acted upon by the keypad-input mechanism. The information is received over the FSK (Frequency Shift Keying) RF transmitter/receiver. The serial link, consisting of transmit, receive, data clock, strobe, and mode select is used to transfer the RF data to the CoolRunner CPLD. The EEPROM and keypad are accessed via an SPI port. The EEPROM can hold previous values as a data logger or values to be compared against. If multiple devices are being metered it can be used as a means of tracking different device IDs. The keypad can serve as a means to input numerical values (e.g., house numbers) to separate individual readings. An auxiliary port (RS-232) is used as an external docking station connection if information is to be moved to a permanent location. The docking station is a means of transferring stored information from the portable RF metering device to a backup or data analysis system. Spartan-II FPGAs provide system interconnectivity feature in these products. (Figure 18).

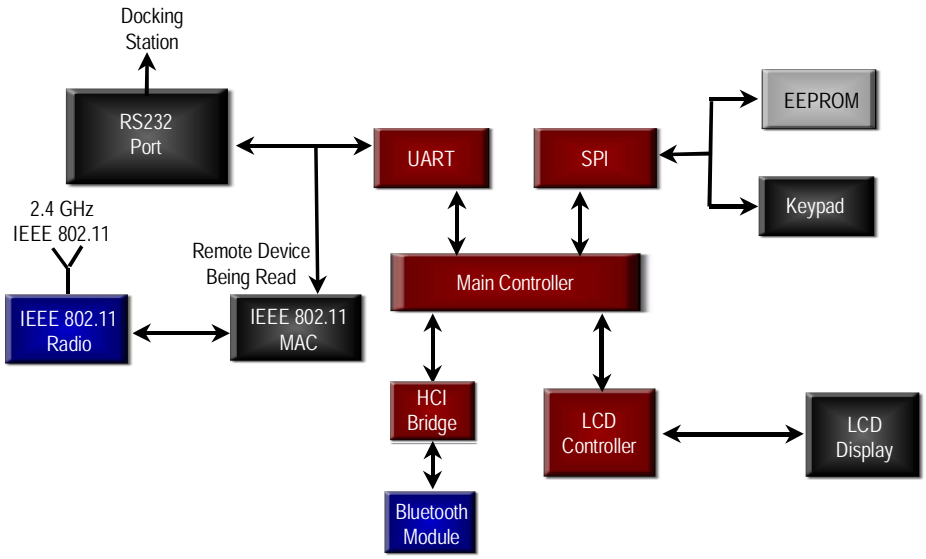

Figure 18: **RF Metering/AMR**

Home Security

The security market is broad, diverse, and growing with the rhythm of technology changes. The product variety ranges from simple articles as door locks, to high-tech network systems controlling sensors, locks, and surveillance cameras. In addition, prices for residential security systems fluctuate from the tens to the thousands of dollars. A complete and practical home security system contains video cameras, alarm systems, network access, and intelligent circuitry. Depending on the complexity of a home security system, it can be connected to home networks using powerlines, Ethernet, USB, phonelines, or wireless technologies.

Home security usually includes a camera and microphone to preserve security from intruders. Security cameras at the door or in your backyard and front yards protect the home from strangers, and allow the consumer the ability to monitor visitors at your doorstep. Home security systems will also be networked to the other information appliances in the home. This allows one to watch ones' home over the Internet while one is at work or away vacationing.

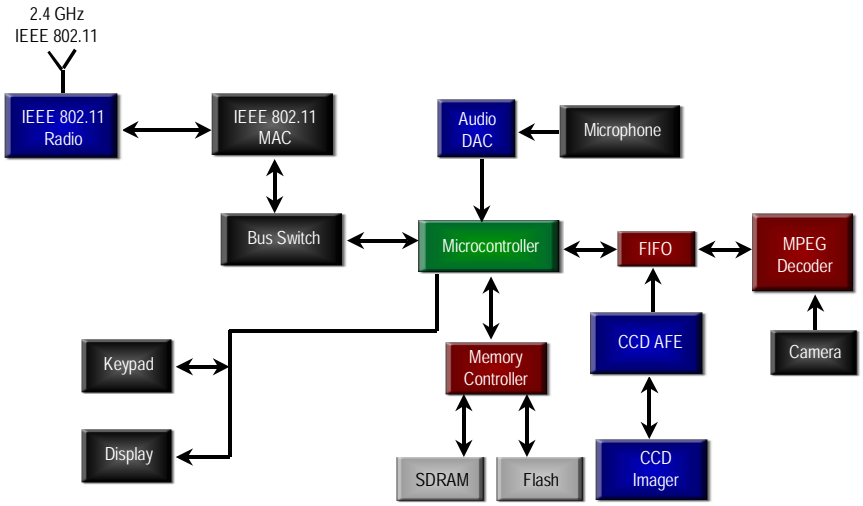

Figure 19: **Home Security Systems**

Xilinx FPGA and CPLD products provide solutions for memory controllers, power management, glue logic (FIFO), MPEG decoding and system interfacing to technologies such as HomePNA, Ethernet, and wireless (Figure 19).

White Goods

White goods are products such as washing machines, dryers, dishwashers, microwaves, ovens, and toasters. The future of white goods include the networking of these products to provide operation, service, support, and information between customers and manufacturers. The state of the market includes partnerships, announcements, and rapid product development by companies such as Sunbeam, General Electric, Whirlpool, Sharp, Electrolux, Maytag, and Merloni Eletrodomestici. These capabilities will exist in niche and high-end white goods, and for the success of these products, a large support infrastructure is required.

Summary

Market researchers predict that information appliances will out-ship consumer PCs by 2002 in the U.S. High-volume information appliances will be products such as digital TV, DVD players, digital cameras, and handheld devices. Semiconductors enable new devices and players, but technology is increasingly becoming invisible. In the future, more functionality will be available at lower price points. Information appliance products will evolve to deliver Web content. Brands will change from “device only” to service, solutions or customer relationship provider such as financial institutions. The digital consumer revolution and the Internet are forcing broadband into the home. Such an evolution will fuel the demand for a variety of different information appliances in the current years.

Xilinx programmable logic products (Spartan-II FPGAs, CoolRunner, and 9500 CPLDs) ported with intellectual property (IP) provide solutions like ASSPs, but with increased flexibility. FPGA logic not used from the IP can be programmed with other IP cores—such as embedded solutions. Other features within the Spartan-II FPGAs provide system integration, and the reprogrammability enables time-to-market and flexibility at low costs. Xilinx Online allows time-in-market as specifications in emerging technologies keep evolving.

Revision History

The following table shows the revision history for this document.

Date	Version	Revision
03/21/01	1.0	Initial Xilinx release.