IEEE1394 / FireWire / iLink

Agenda

- Introduction
  - Market trend and application
    - 1394 Market Analysis Data
    - 1394 and industry
    - Applications
- Technology
  - What is 1394?
  - Why 1394?
  - Applications
  - 1394 Protocol
  - PHY
  - Link Layer
  - Transaction Layer
  - 1394 Operation
  - Bus Management
  - Cable and Connection
  - Architecture
  - Topology
- Other Technologies
  - USB
  - DVI
- 1394 In Home Networking
- Xilinx Value
- Alliances
- Summary

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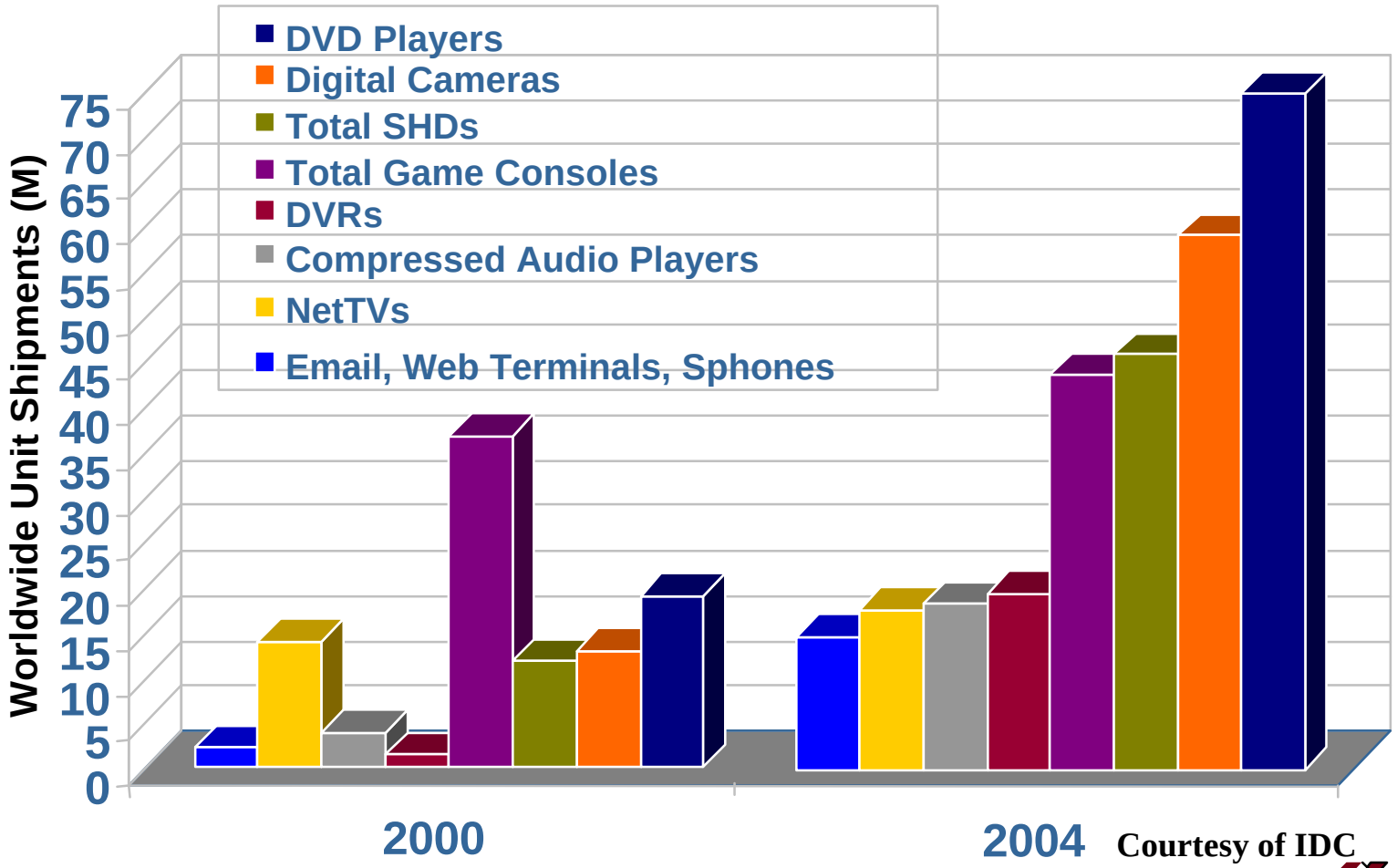
Introduction

- Consumers Share Video, Audio, Images, and Data
- Faster and easier ways of sharing data is the ultimate goal
- This phenomenon is driving the convergence of computers, consumer equipment, and communications
- Convergence will happen when seamless, high-speed communication becomes readily available
  - The IEEE 1394 protocol appears to be a strong contender for the communications channel that will make this happen.

Multimedia Bandwidth Requirements

- High Quality Video
  - Digital Data = (30 frames / second) (640 x 480 Pixels) (24-bit color / Pixel) = 221 Mbps
- Reduced Quality Video
  - Digital Data = (15 frames / second) (320 x 240 Pixels) (16-bit color / Pixel) = 18 Mbps
- High Quality Audio
  - Digital Data = (44,100 audio samples / sec) (16-bit audio samples) (2 audio channels for stereo) = 1.4 Mbps
- Reduced Quality Audio
  - Digital Data = (11,050 audio samples / sec) (8-bit audio samples) (1 audio channel for monaural) = 0.1 Mbps

Consumer Devices Growth

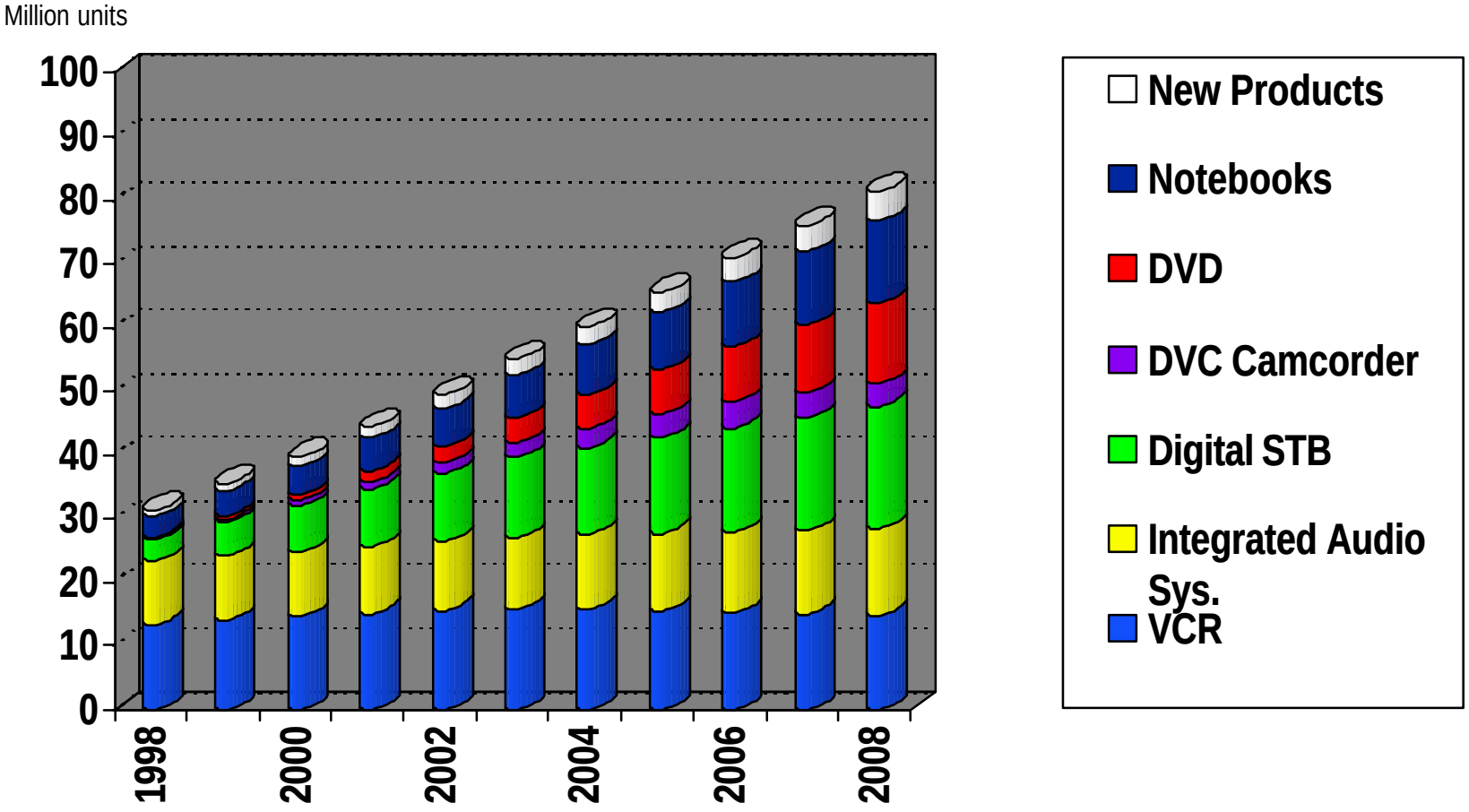


Courtesy of IDC

Driving Forces For IEEE 1394

- Digital Broadcasting
- The Internet
- Digitalization Of Modern Homes
- Entertainment & Video Appliances
- Digital Home Networking
- High Bandwidth Requirements For Transmission of Audio and Video Signals

IEEE 1394 Usage & Growth



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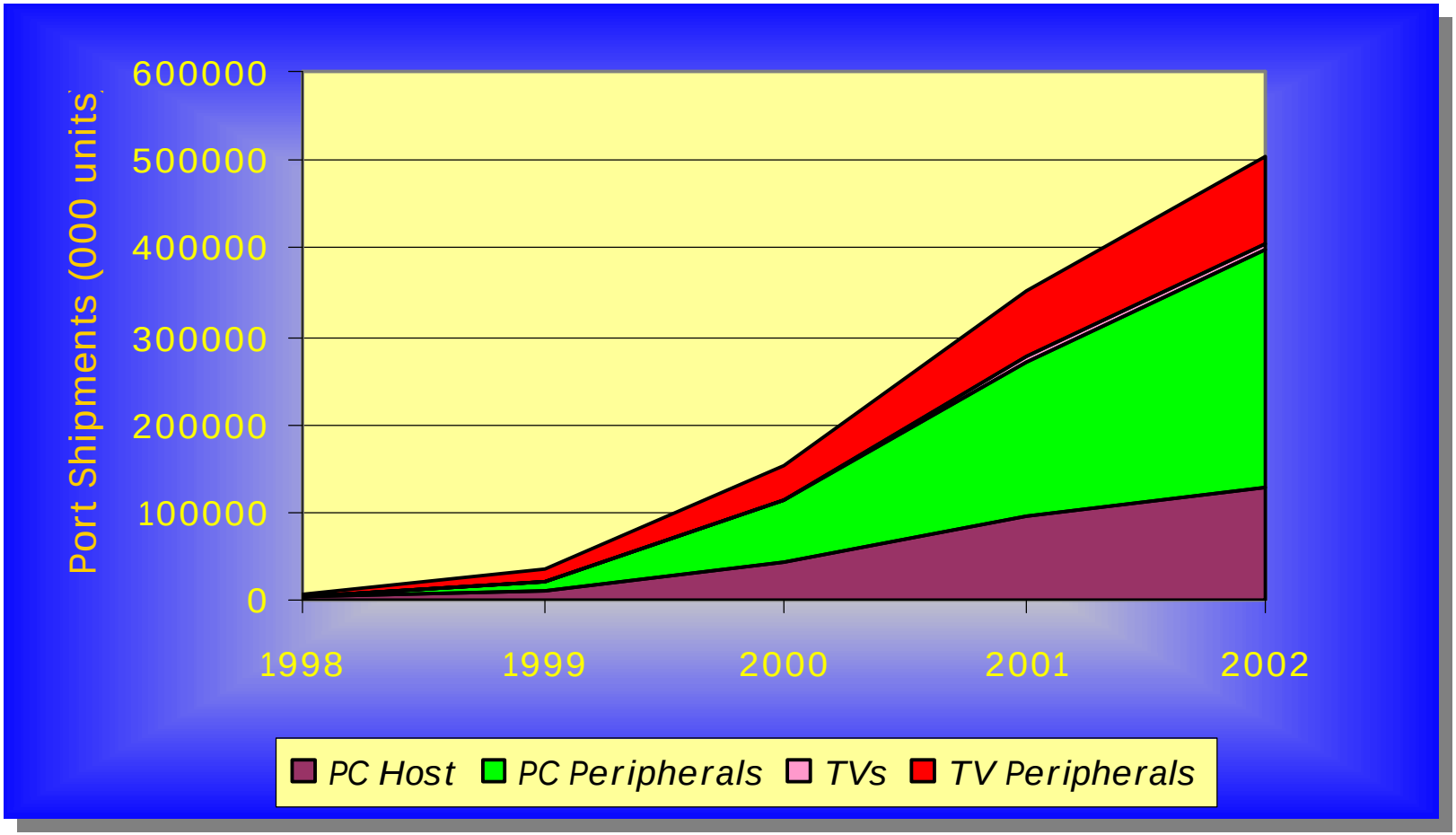
1394 Market Forecast



Source - In-Stat

IEEE 1394 & Industry

- 1394 is a low cost audio/video digital interface
- New audio/video applications are the first market for IEEE1394
  - Digital Television (DTV)
  - Multimedia CDROM (MMCD)
  - Home Networks
- IEEE 1394 has been accepted as the standard digital interface by the Digital VCR Consortium

IEEE 1394 & Industry

- The European Digital Video Broadcasters (DVB) have endorsed IEEE 1394 as their digital television interface as well
  - Several of these companies have proposed IEEE 1394 to the VESA (Video Experts Standards Association) for the digital home network media of choice
- The EIA 4.1 subcommittee has voted for IEEE 1394 as the point-to-point interface for digital TV as well as the multi-point interface for entertainment systems

IEEE 1394 & Industry

- SCSI products would be enhanced by migrating to IEEE 1394
  - Scanners
  - CDROMs
  - Disk Drives
  - Printers
- The American National Standards Institute (ANSI) has defined Serial Bus Protocol (SBP) to encapsulate SCSI-3 for IEEE 1394

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Why IEEE 1394?

- A digital interface
  - There is no need to convert digital data into analog and tolerate a loss of data integrity
  - Transferring data @ 100, 200, 400 Mbps (Cable)
  - Transferring data @ 12.5, 25 or 50 Mbps (Backplane)
- Physically small
  - The thin serial cable can replace larger and more expensive interfaces

Why IEEE 1394?

- Easy to use
- There is no need for terminators, device IDs, or elaborate setup
- Hot pluggable
  - Users can add or remove 1394 devices with the bus active
- Inexpensive
  - Priced for consumer products
- Scaleable architecture
  - May mix 100, 200, and 400 Mbps devices on a bus

Why IEEE 1394?

- Flexible topology
  - Support of daisy chaining and branching for true peer-to-peer communication
- Non-proprietary

IEEE 1394b

- 1394b is a significant enhancement to the basic 1394 specification that enables:
  - Speed increases to 3.2 Gbps
  - Supports distances of 100 meters on UTP-5, plastic optical fiber, and glass optical fiber
  - Significantly reduces latency times by using arbitration pipelining
- It is fully backwards compatible with the current 1394 and 1394a specifications

New Extensions (1394b)

- Gigabit speeds for cables
- 100Mb for backplane implementations
- Longer distance cables using copper wire and fiber
- A/V command and control protocols
- 1394 to 1394b bus bridges
- IEEE 1394 gateways to communication interfaces, such as ATM

IEEE 1394 Standards Update

- 1394-1995
  - Supports up to 400 Mbps Links and PHYs
  - 6 pin cables
- 1394a (1998)
  - Power management clean up
  - Cable power specification in flux
- Open Host Controller Interface (1998)
  - Ultimate goal is a single driver for OS support
- 1394b (1999)
  - Could be a legitimate storage I/O at 800 Mbps

1394 Based Applications

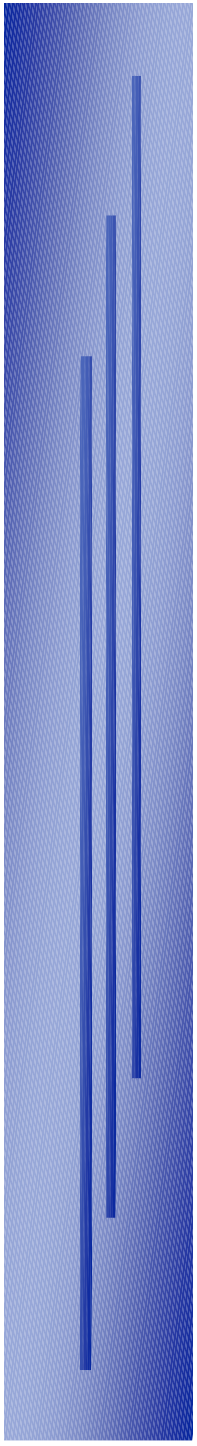
- Digital camcorders and VCRs
- Direct-to-Home (DTH) satellite audio/video
- Cable TV and MMDS (microwave) set-top boxes
- DVD Players
- Video Games
- Home Theater
- Home Networks

1394 Based Applications

- Musical synthesizers/samplers with MIDI and digital audio capabilities
- Digital audio tape (DAT) recorders, mixers, hard-disk recorders, video editors, etc.
- Professionals and affluent consumers Digital Video (DV) applications
- Professional video equipment
- Fixed and removable PC disk drives

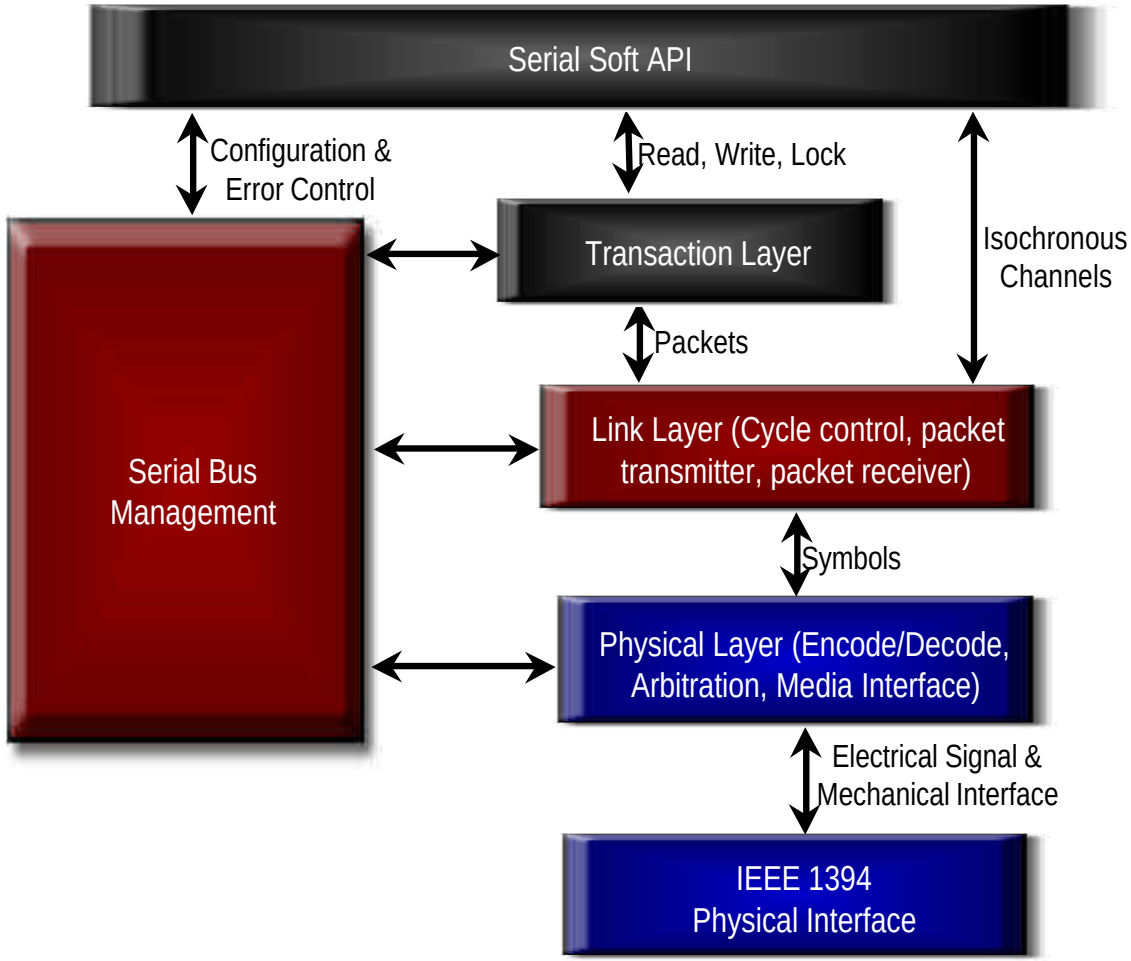
1394 Based Applications

- PC-to-PC networking and PC peripheral component sharing
- Printers for video and computer data
- Digital cameras and videoconferencing cameras
- Industrial



IEEE 1394 Protocol

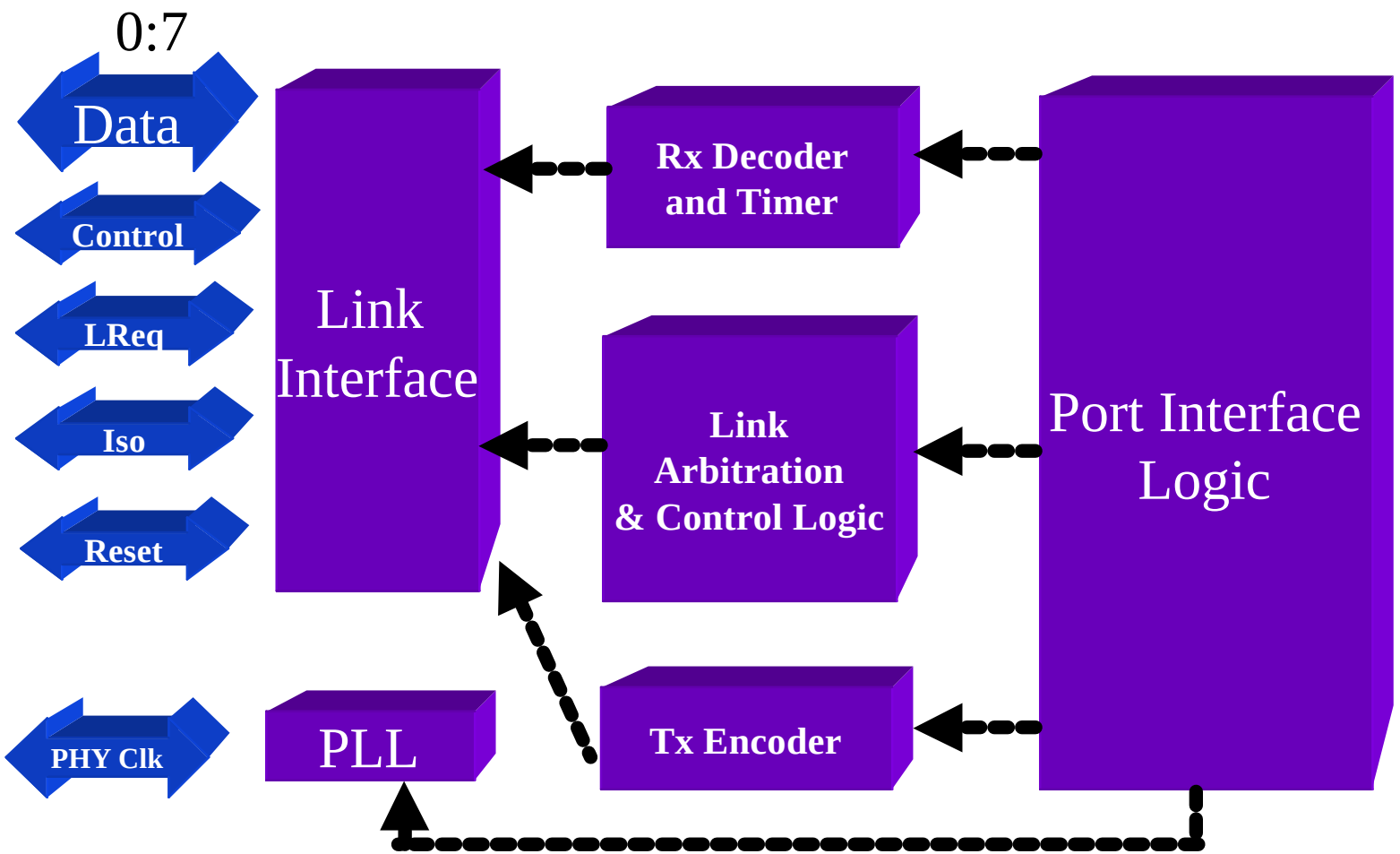
IEEE 1394 Protocol Stack



1394 PHY Layer

- The Physical layer provides the initialization and arbitration services
  - It assures that only one node at a time is sending data
- The physical layer of the 1394 protocol includes:
  - The electrical signaling
  - The mechanical connectors and cabling
  - The arbitration mechanisms
  - The serial coding and decoding of the data being transferred or received
  - Transfer Speed detection

1394 PHY


0:7
Data
Control
LReq
Iso
Reset
PHY Clk
Link Interface
PLL
Rx Decoder and Timer
Link Arbitration & Control Logic
Tx Encoder
Port Interface Logic

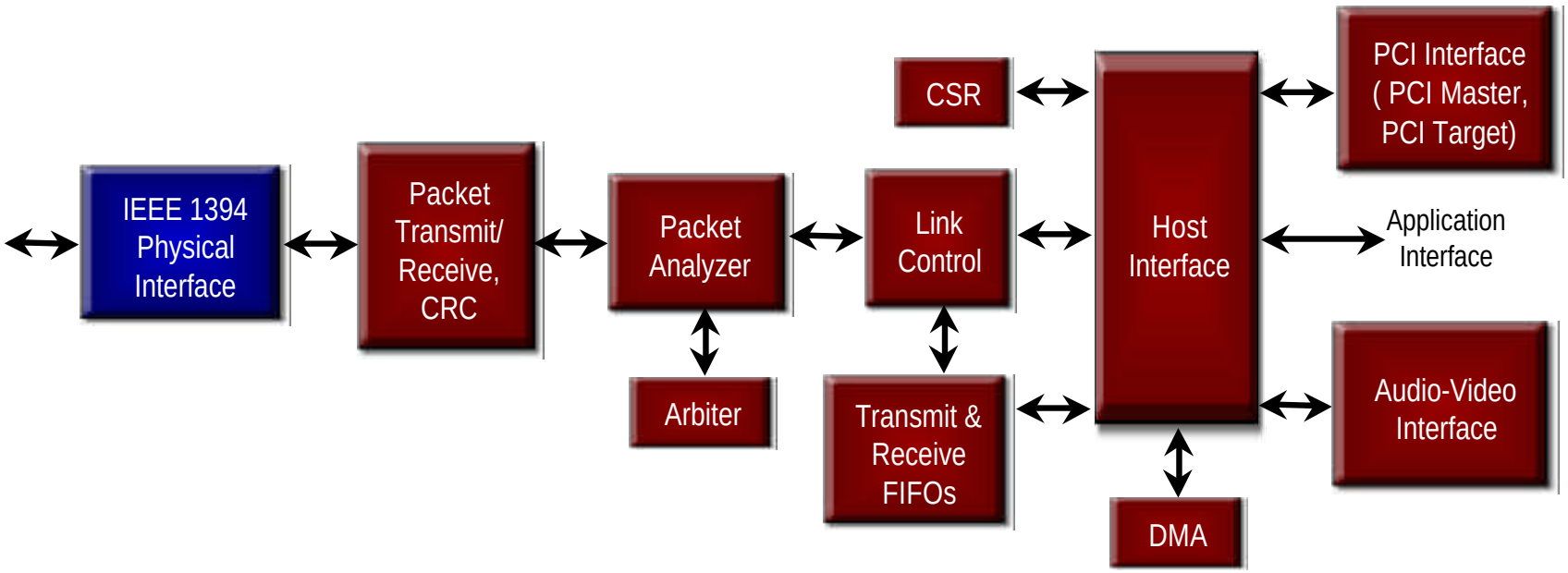
Physical layer Controller Products

Physical Layer Controllers Manufacturer	Part Number	Description
Fujitsu Microelectronics	MB8661x	Combined link/PHY core & ICs
IBM	IBM21S85xPFD IBM21S760PFD	400Mbps 1- and 3-port devices 200Mbps 1- and 3-port devices
Innovative Semiconductor	SL75x	Physical layer cores
Philips Semiconductor	PDI1394P11	Physical layer IC
Macro Designs		Physical layer cores
Phoenix Technologies	VirtualLink	100, 200, and 400Mbps 1394a-compatible cores
Sand	1394 CPHY	1394 cable physical layer core
Symbios (LSI)	SYM13FW403	1394 cable PHY interface IC
NEC	uPD72850	3-port PHY IC
Texas Instruments	TSB11C01 TSB11LV01 TSB14C01A TSB21LV03A TSB41IV0x	Up to 400Mbps PHY ICs
Sony	CXD1944R	3-Port 200Mbps PHY IC

Link Layer

- Gets data packets on and off the wire
- Does error detection and correction
- Does retransmission
- Handles provision of cycle control for Isochronous channels
- The Link layer supplies an acknowledged datagram to the Transaction layer
  - A datagram is a one-way data transfer with request confirmation

IEEE 1394 Link Controller



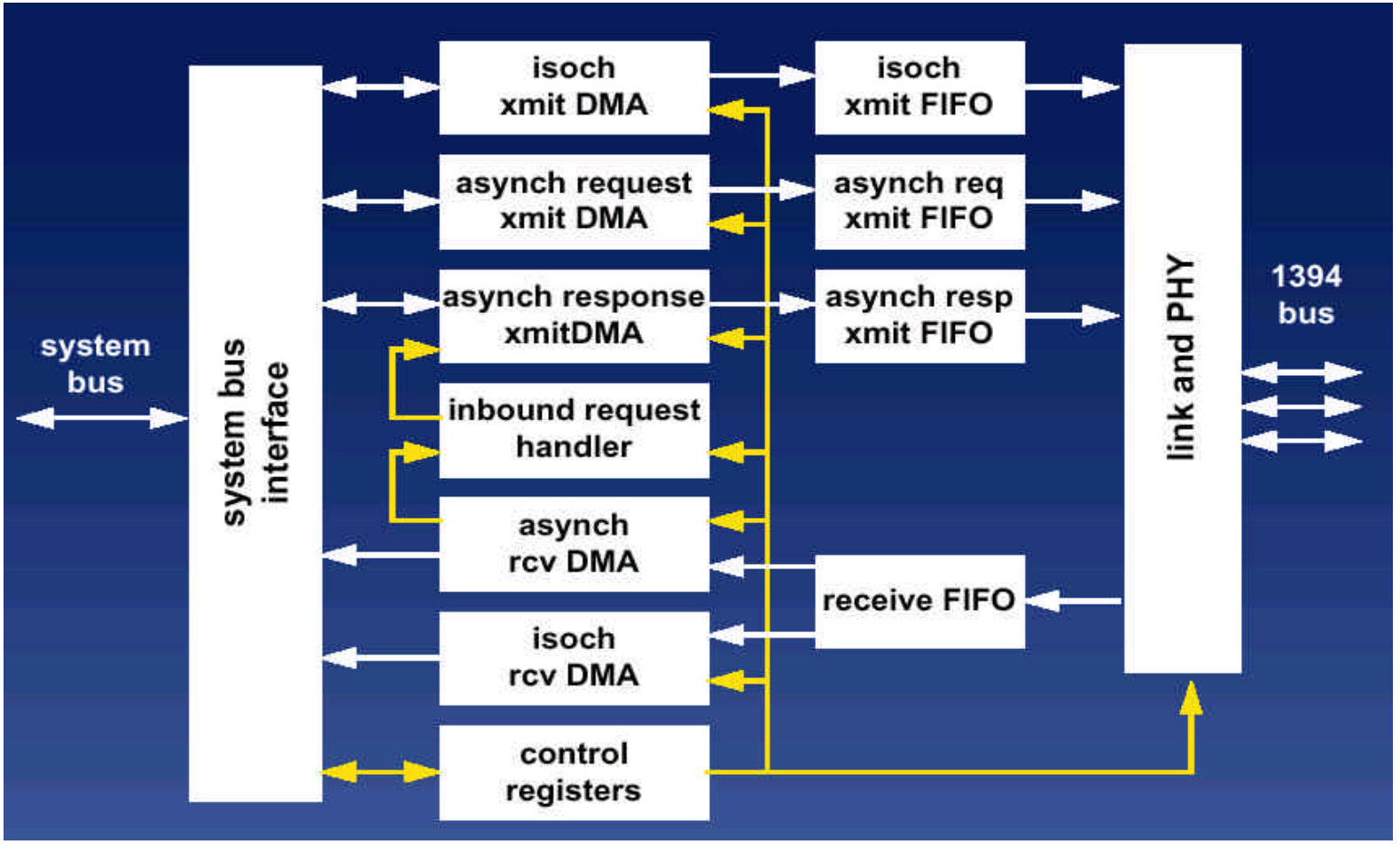
Link Layer Controller Products

Link Layer Controllers Manufacturer	Part Number	Description
Fujitsu Microelectronic	MB8661x	Combined link/PHY core & ICs
IBM	IBM21S650PF IBM21S550PFB	A PCI-based link layer controller Generic bus interface link layer controller
Innovative Semiconductor	SL75x	Link layer cores
Philips Semiconductor	PDI1394L11	A/V link layer controller
Phoenix Technologies	Virtual Link 1394a	Compatible link layer cores
Sand	1394 Device Controller	1394 link layer core
LSI	Sand Microelectronics	1394 Link Layer
NEC	uPD728xx	OHCI link layer IC (some integrate PHY)
Texas Instruments	TSB12LV21B TSB12LV22 TSB12LV31	Lynx HCI (PCI) IC OHCI (PCI) IC General-purpose bus interface IC
Sony	CXD1940R	AV protocol support

Transaction Layer

- Implements the request-response protocol
- This protocol is required to conform to:
  - ISO/IEC 13213 [ANSI/IEEE Std 1212, 1994 Edition] Standard Control
  - Status Register (CSR) Architecture for Microcomputer Buses
- Conformance to ISO/IEC 13213:1994
  - Minimizes the amount of circuitry required by1394 ICs to interconnect with 1212-standard parallel buses, such as the PCI bus

IEEE 1394 Host Controller



Courtesy of Apple

IEEE 1394 Operation

IEEE 1394 Operation

- Isochronous Transfers
  - Isochronous transfers are always broadcast in a one-to-one or one-to-many fashion
  - No error correction nor retransmission is available for Isochronous transfers
  - Up to 80% of the available bus bandwidth can be used for Isochronous transfers
  - The delegation of bandwidth is tracked by a node on the bus
  - Isochronous channel IDs are transmitted followed by the packet data
  - The receiver monitors the incoming data's channel ID and accepts only data with the specified ID

IEEE 1394 Operation

- Asynchronous Transfers
  - Asynchronous transfers are targeted to a specific node with an explicit address
  - They are not guaranteed a specific amount of bandwidth on the bus
  - They are guaranteed a fair shot at gaining access to the bus when asynchronous transfers are permitted
  - Asynchronous transfers are acknowledged and responded to
    - This allows error-checking and retransmission mechanisms to take place

IEEE 1394 Operation

- Isochronous transfers are the best choice for sending time-critical, and error-tolerant data
  - Video or Audio stream
- If the data isn't error-tolerant, such as a disk drive, then asynchronous transfers are preferable

Bus Management

- The Bus Manager must collect the self-id packets and create the topology and speed maps from them
- Bus management involves the following three services:
  - A Cycle Master that broadcasts cycle start packets (required for Isochronous operation)
  - An Isochronous Resource Manager, if any nodes support Isochronous communication
  - An optional Bus Master

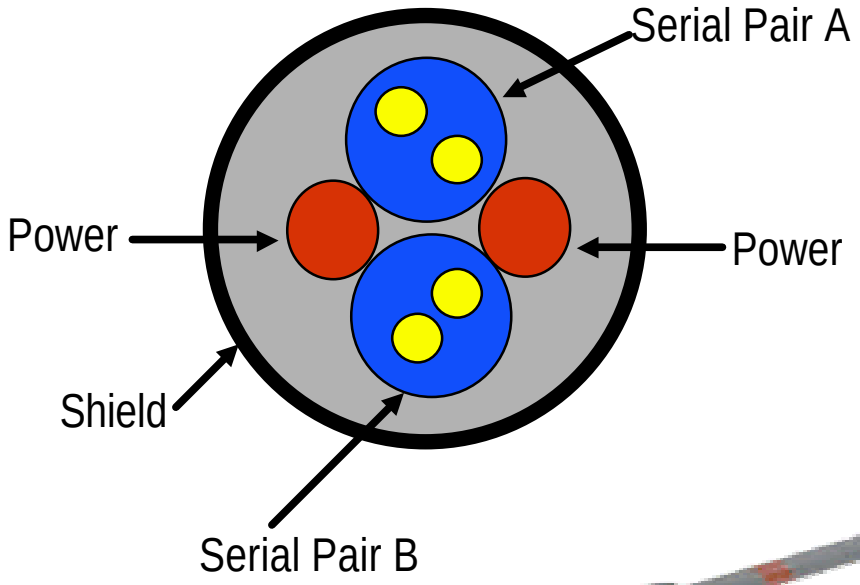
Bus Management

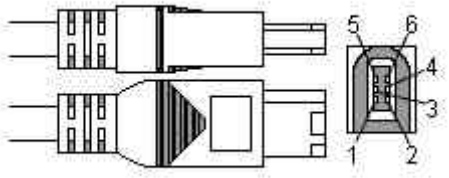
- The structure of the bus is determined on bus reset
  - Node IDs (physical addresses) are assigned to each node
  - Arbitration occurs for Cycle Master, Isochronous Resource Manager, and Bus Master nodes
- Serial bus management in portable consumer products is handled by a microprocessor designed to minimize battery power consumption
  - Most battery-operated 1394 gear is expected to run at S100 speed for power conservation

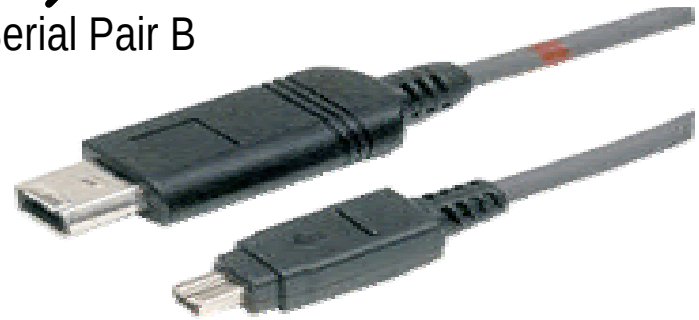
IEEE 1394 Cabling

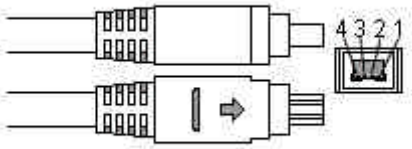
- It can connect up to 63 devices @ transfer rate of 400Mbps
- Is "hot-pluggable" and PnP
- A 1394 cable can be up to 15 feet in length
- The 6-pin connectors have two data wires and two power wires for devices which derive their power from the 1394 bus
- Data-only cables use one 6-pin and one 4-pin connector or two 4-pin connectors

Cable









IEEE 1394 Architecture (Bus Categories)

- Backplane bus
  - Supplements parallel bus structures by providing an alternate serial communication path between devices plugged into the backplane.
- Cable bus
  - Is a "non-cyclic network
    - Devices can not be plugged together to create loops
  - The networks has finite branches, consisting of bus bridges and nodes
  - 16-bit addressing provide for up to 64K nodes in a system
  - Up to 16 cable hops are allowed between nodes, thus the term finite branches

IEEE 1394 Architecture (Bus Categories)

- A bus bridge serves to connect busses of similar or different types
- A bus bridge also would be used to interconnect a 1394 cable and a 1394 backplane bus
- Six-bit Node_IDs allow up to 63 nodes to be connected to a single bus bridge
- 10 bit Bus_IDs accommodate up to 1,023 bridges in a system.

IEEE 1394 Architecture

- Each node usually has three connectors
- Up to 16 nodes can be daisy-chained through the connectors
  - Standard cables up to 4.5 m in length for a total standard cable length of 72 m.
- Additional devices can be connected in a leaf-node configuration
- Physical addresses are assigned on:
  - Bridge power up(bus reset)
  - Whenever a node is added or removed from the system, either by physical connection/disconnection or power up/down

Connection Steps

- Step 1: Physical connection between two nodes
  - Triggers serial bus configuration
- Step 2: Bus Reset
  - Forces all nodes to their initialized state
  - All bus topology information is cleared
- Step 3: Tree Id
  - Transforms a simple net topology into a tree topology
- Step 4: Self ID
  - Assigns physical node numbers or IDs
  - Exchanges speed capabilities with neighbors
- Step 5: Arbitration

Connection Steps (Reset)

- Reset is signaled by a node driving both TPA and TPB to logic 1.
  - A logic 1 will always be detected by a port, even if its bi-directional driver is in the transmit state.
- When a node detects a reset, it will propagate this signal to all of the other ports that this node supports.
- The node then enters the idle state for a given period of time to allow the reset indication to propagate to all other nodes on the bus.
- Reset clears any topology information within the node

Connection Steps (Tree identification)

- Defines the bus topology.
- After reset, all leaf nodes present a Parent_Notify signaling state on their data and strobe pairs.
- When a branch node receives the Parent_Notify signal on one of its ports, it marks that port as containing a child, and outputs a Child_Notify signaling state.
  - The ports marked with a “P” indicate that a device which is closer to the root node is attached to that port.
  - The port marked with a “C” indicates that a node farther away from the root node is attached.

Connection Steps (Self Identification)

- Self identification consists of:
  - Assigning physical IDs to each node on the bus
  - Having neighboring nodes exchange transmission speed capabilities
  - Making all of the nodes on the bus aware of the topology that exists
- The self identification phase begins with the root node sending an arbitration grant signal to its lowest numbered port.
- The root node will then continue to signal an Arbitration Grant signal to its lowest numbered port.

Connection Steps (Arbitration)

- Immediately following the cycle start packet, devices that wish to broadcast their Isochronous data may arbitrate for the bus.
  - Cycle is a time slice with a nominal 125µs period
- Arbitration consists of signaling a designated parent node a wish to gain access to the bus.
- The parent nodes in turn signal their parents and so on, until the request reaches the root node.
- The closest device to the root node wins the arbitration.

Topology

- The 1394 protocol is a peer-to-peer network with a point-to-point signaling environment
  - A specific host isn't required
    - Digital camera could easily stream data to both the digital VCR and the DVD-RAM without any assistance from other devices on the bus
- Nodes on the bus may have several ports on them
  - Each of these ports acts as a repeater, retransmitting any packets received by other ports within the node

Topology

- Configuration of the bus occurs automatically whenever a new device is plugged in
- During system initialization, each node in a 1394 bus carries out :
  - A process of bus initialization
  - Tree identification
  - Self-identification
- A 1394 bus appears as a large memory-mapped space with each node occupying a certain address range

Topology

- The memory space is based to the IEEE 1212 Control and Status Register (CSR) Architecture
  - With some extensions specific to the 1394 standard
- Device addressing is 64 bits wide partitioned as:
  - 10 bits for network Ids
  - 6 bits for node Ids
  - 48 bits for memory addresses
- Each node supports up to 48 bits of address space (256 Tera Bytes)

Topology

- Each bus can support up to 64 nodes
  - The 1394 serial bus specification supports up to 1,024 buses
- The topology of a 1394 system can be:
  - Daisy chain
  - Tree
  - Star
  - Or a combination of these
- 1394 can connect devices directly without the intervention of a computer

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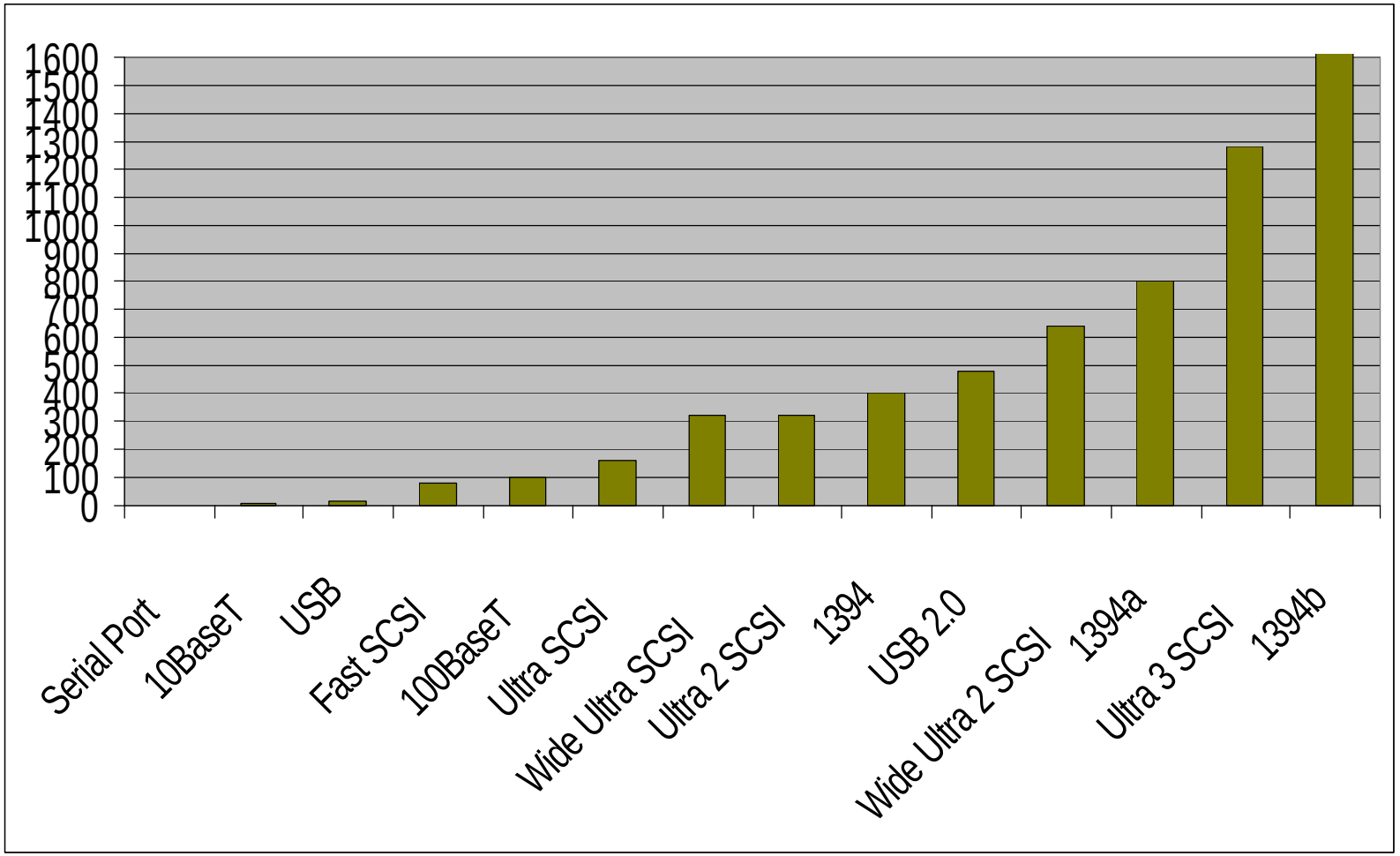
Data Rates Of Various Ports



Interconnect Technologies

Technology	Throughput Data Rate	Applications
Apple Desktop Bus	0.01 Mbps	Input Devices like Mouse, Keyboards, Joysticks, etc
Serial Port	0.23 Mbps	Printers, Telephony Devices, Modems, etc
USB at low data rate	1.5 Mbps	Most Devices
10Base-T	10 Mbps	Laser Printers, Network Connections, etc
USB at high transfer rates	12 Mbps	Most Devices
SCSI	40 Mbps	Hard Drives, Removable Storage, Scanners, etc
Fast SCSI	80 Mbps	High Performance Drives
100Base-T	100 Mbps	Laser Printers, Network Connections, etc
Ultra SCSI	160 Mbps	High Performance Drives
Wide Ultra SCSI	320 Mbps	High Performance Drives
Ultra2 SCSI	320 Mbps	High Performance Drives
1394	400 Mbps	Hard drives, Scanners, Digital Video
USB 2.0 (Intel)	480 Mbps	Most Devices
Wide Ultra2 SCSI	640 Mbps	High Performance Drives
1394a	800 Mbps	Hard Drives, Scanners, Digital Video
Ultra3 SCSI	1280 Mbps	High Performance Drives
1394b	1600 Mbps	Hard Drives, Scanners, Digital Video

USB 2.0 & 1394

- USB and 1394 are complementary buses, differing in their application focus
- USB 2.0 is the preferred connection for most PC peripherals
- 1394's primary target is audio/visual consumer electronic devices such as digital camcorders, digital VCRs, DVD players, and digital televisions
- Both USB 2.0 and 1394 are expected to co-exist on many consumer systems in the future

USB 2.0 & 1394

- USB requires a CPU to perform the bus master functions while 1394 is peer-to-peer
  - A D-VCR must be able to talk directly to a D-TV without going through a PC first
- USB throughput is not nearly as fast as advertised
  - When shipping data directly from a peripheral to the host, throughput is OK
  - When shipping data from a peripheral to another peripheral, real bandwidth drops in half
  - All data must be be moved from the peripheral to the host and then from the host to the target peripheral

USB 2.0 & 1394

- The USB 2.0 hubs are more complicated
  - They require an entire USB 1.1 HOST controller and a new USB 2.0 hub controller
  - They require a high-speed signal repeater, routing logic, dual-function ports, etc
- 1394 is for devices where high performance is a priority and price is not
- USB is for devices where price is a priority and high performance is not

1394 & DVI

- IEEE 1394, is a two-way high-speed interface capable of sending command and control protocols
  - It enables devices to both broadcast and record data
- DVI is a point-to-point digital interface designed to send uncompressed streams
  - It is a one-way interface with a display
- IEEE 1394 is inherently suited for recording and networking applications within the home

1394 & DVI

- DVI is pitched as an interface between a graphics chip and various kinds of monitors
  - including plasma display panels, LCDs and even CRTs
- 1394 is suitable for distribution of compressed data (MPEG-2)
  - Most digital content received at home from DVD, satellite or cable is based on MPEG-2 streams
- DVI is suitable for distribution of uncompressed data
  - Designed to carry sustained HDTV data rate without interruption

1394 & DVI

- 1394 distribute video data at 100, 200, or 400 Mbps, Scalable
- 1394b is being designed to deliver data at 800 Mbps to 3.2 Gbps, Scalable
- DVI's single link can distribute video data at 4.9 Gbps
- DVI's double link can distribute video data at 9.9 Gbps
  - Does not support audio/video commands

1394 & DVI

	Stream	Bit Rate	Architecture	Command & Control	Applications
IEEE 1394	Compressed MPEG-2 Transport	1394: 100, 200, or 400 Mbps, Scalable 1394b: 800 Mbps to 3.2 Gbps, Scalable	Peer-to-peer	Support for AV command & control	Storage, networking
DVI	Uncompressed baseband	Single link DVI: 4.9 Gbps Double link DVI: 9.9 Gbps	Point-to-point	No support for AV command & control	Digital interface between a graphics chip and a monitor

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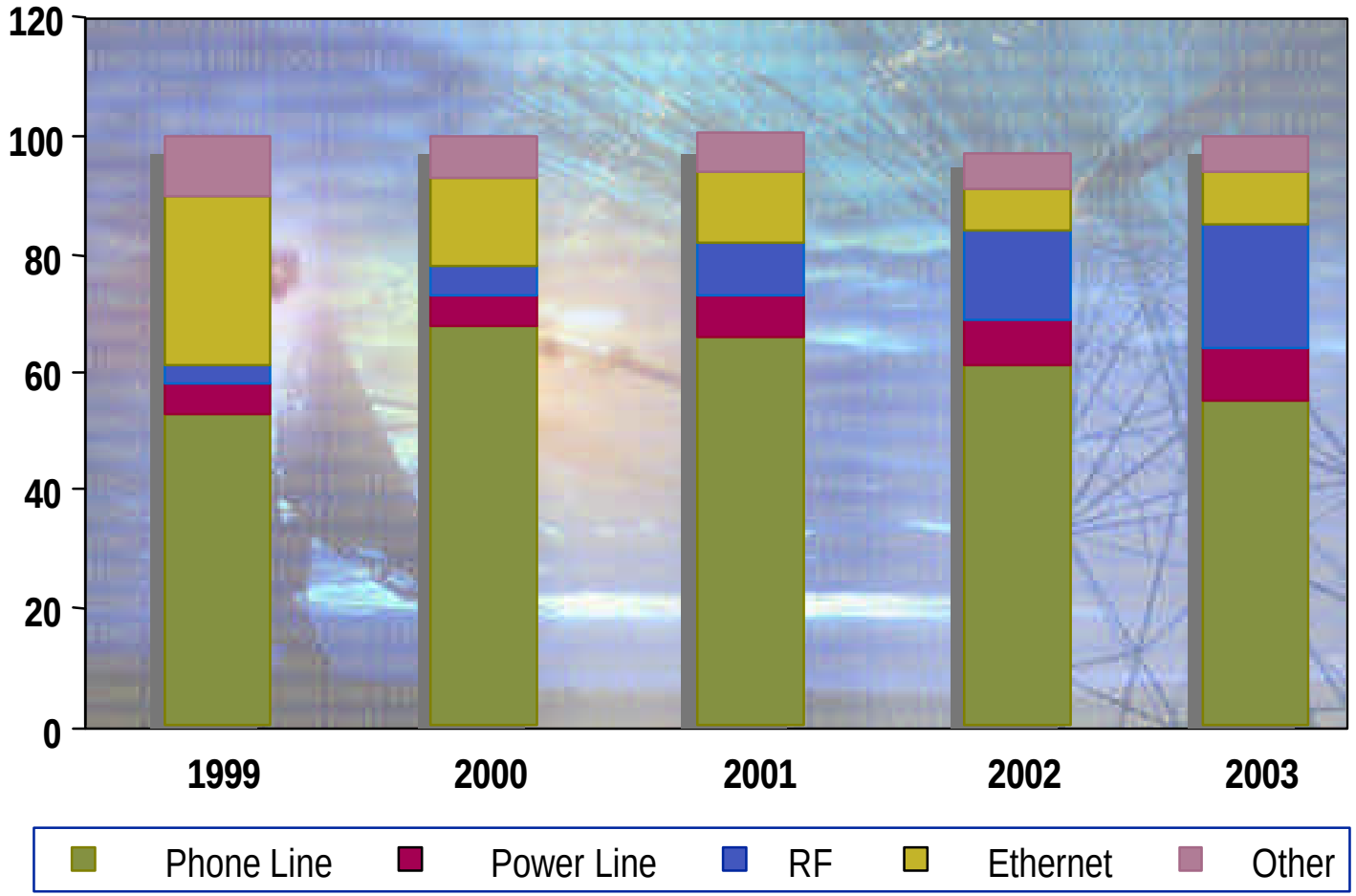
The Push for Home Networking

- Rapid growth in multiple-PC household penetration (Dataquest)
  - PC penetration exceeds 50% in US households
  - Multi-PC households growth: 15M (in 1998) to 26M (in 2003)
- Increasing Internet usage (Yankee Group)
  - Nearly 90% of PC households will be online by 2001
  - Online households growth: 20% (in 1997) to 47% (in 2001)
- Broadband Internet access (Forrester Research)
  - Broadband penetration growth: less than 1M (in 1998) to more than 15M (in 2002)
  - % Penetration of online households: increases from 2% (in 1998) to 26% (in 2002)

The Push for Home Networking

- More digital appliances are coming into the home
  - DSS, DVD, Digital TV
  - Web-Top boxes, set-top boxes
  - PDAs, mobile (cellular) phones
  - Digital cameras
  - Installed base of internet appliances will exceed 50M by 2001 (by IDC)
- More digital content entering the home
  - Published Content
    - CD-ROMs, DVDs, DVRs, digital photography
  - Networked Content
    - DTV, DBS, VoIP, MP3, movies-on-demand, streaming media

Applications Driving Home Networking



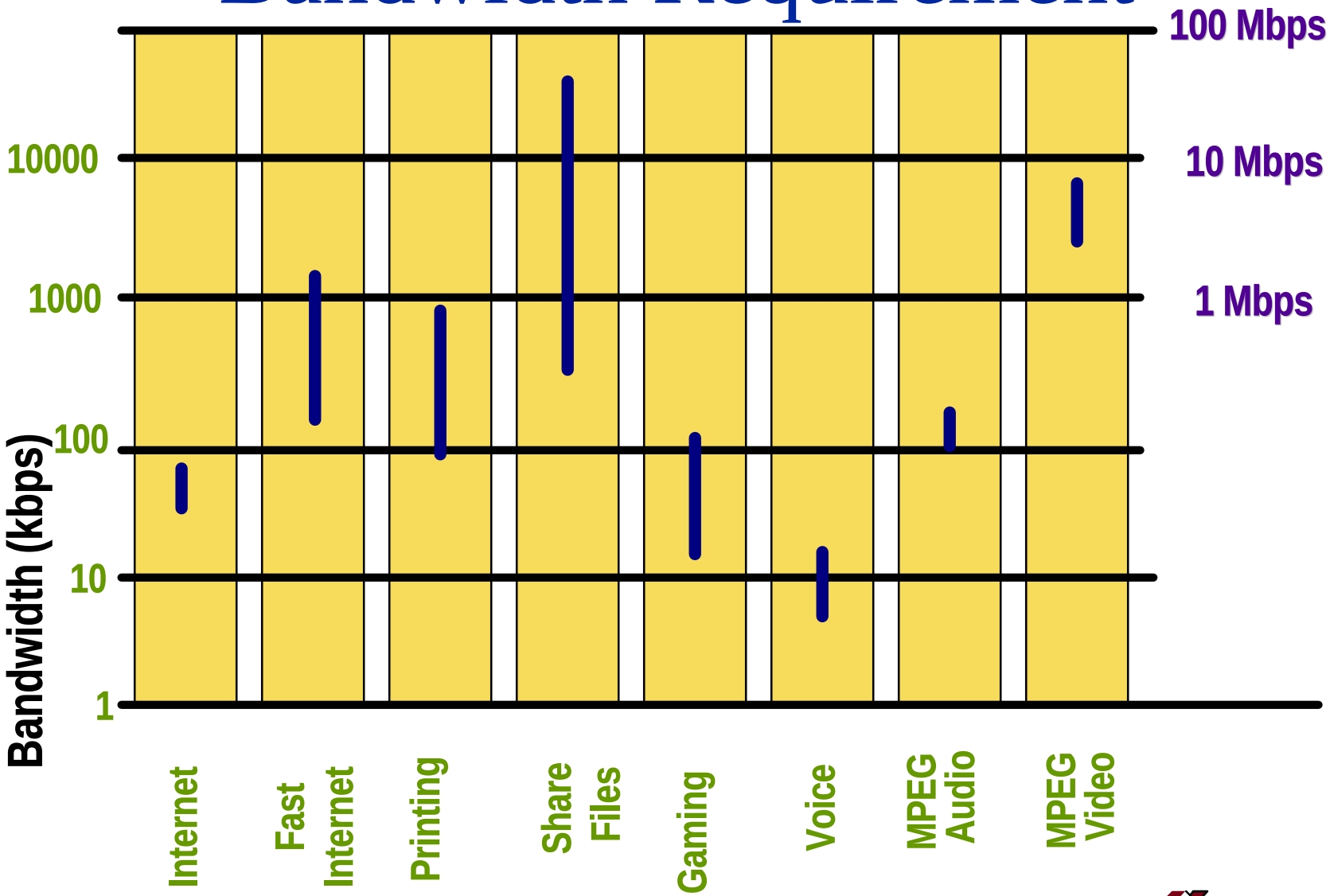
Courtesy: Dataquest

Different Strokes for Different Folks

	Home Automation	Entertainment	Information	Personal Communications	Communication
Devices	- Home appliances - Security/safety systems - Utility meters	- TV sets - Set-top boxes - DVD Players - Game consoles - VCRs - MP3 Players	- PCs - Screen phones - Printers - Modems - Routers - Hubs - Scanners	- Mobile phones - Smart phones - Handheld - Laptop - Pagers	- Corded/Cordless telephones - Fax machines
Content	Information on home processes, house environment, remote diagnostics and technical support	Rich multimedia content, electronic programming guides, impulse purchases	Discrete information on external world, shopping for household goods	Information used on the move or requiring instant action: travel, weather, local services, stock market	Information on how to reach people in time and space
Usage Pattern	Communal	Communal	Individual Shared	Individual Personal	Communal or Individual Shared
Connection to Outside World	- Power line - POTS	- Cable - DBS	- Cable modem - ADSL - POTS, ISDN	- GSM - Infrared	- POTS
Practical Networking Technology	- CEBus - X-10 - LONWorks	- IEEE 1394 (Fire Wire)	- HomeRF - HomePNA - Ethernet	- Infrared - Bluetooth	- POTS - DECT - 900MHz, 2.4GHz

Home appliances have different content, functionality, application, and use different interconnection technologies

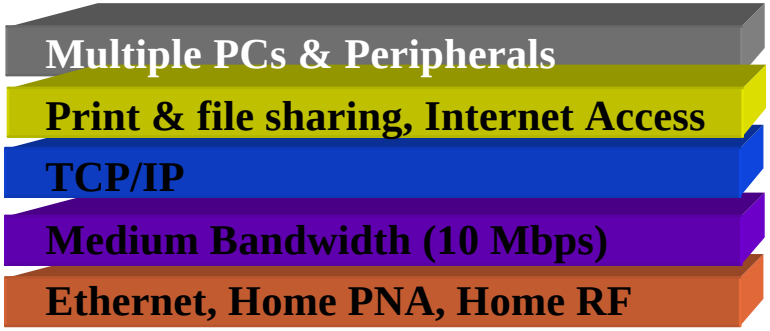
Bandwidth Requirement



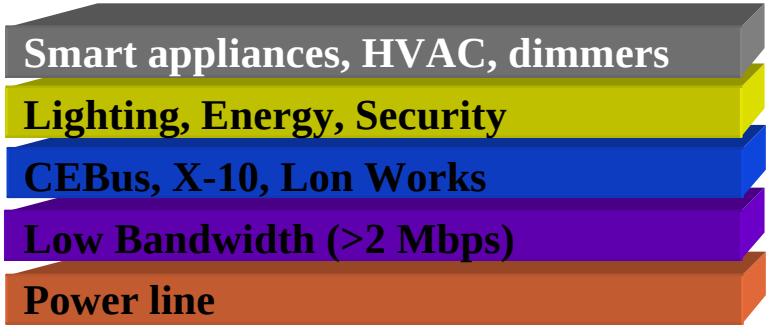
Different Home Networks

Digital Entertainment Network

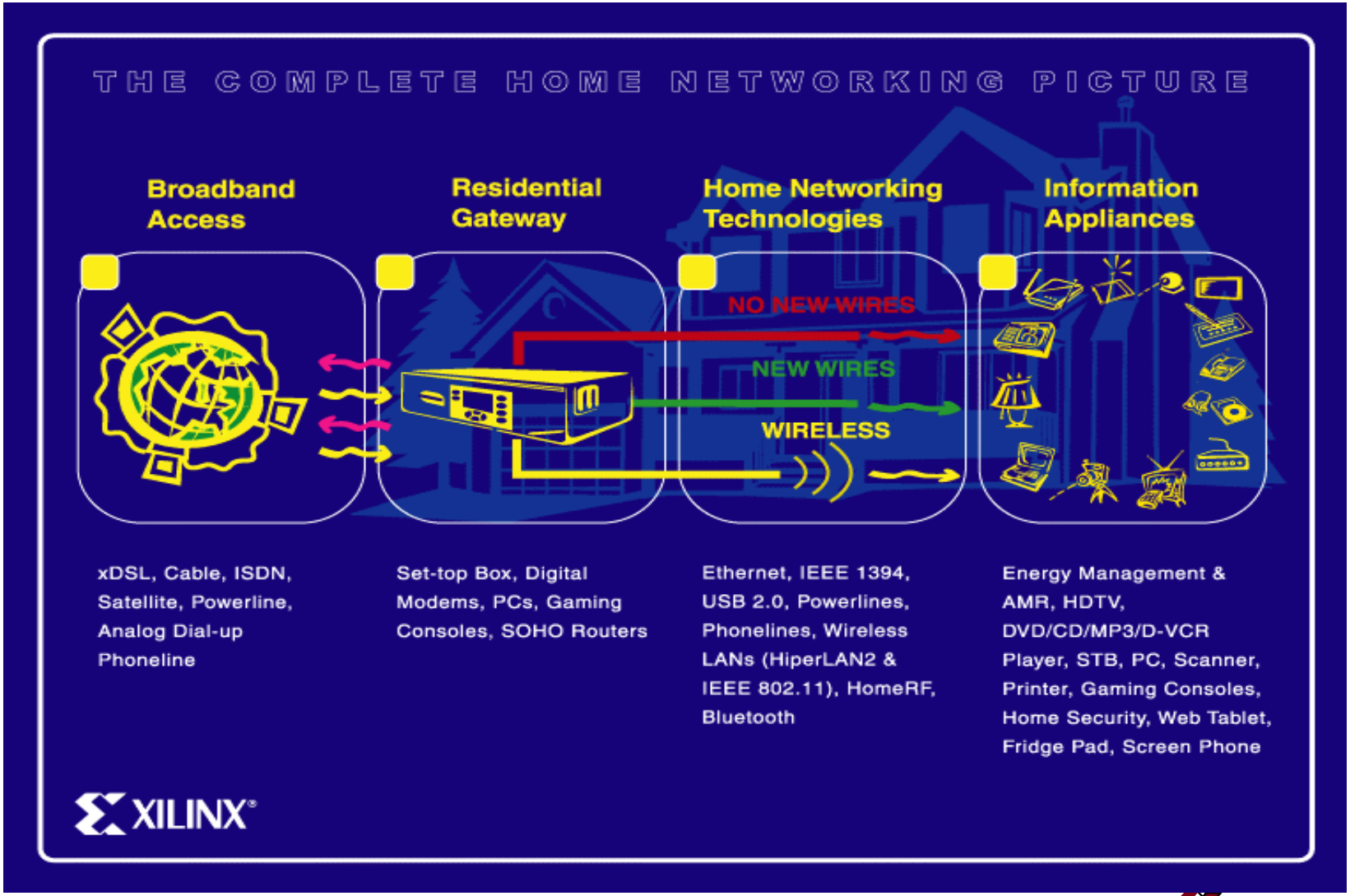
Computer System Network



Home Automation Network



Four Aspects to Home Networking



Bandwidth Requirements

Application		Technique	Data Rate	Compression
Video	Video Conference Quality	H.261	0.1 Mbps	Yes
	Streaming Video	MPEG-4	5 Kbps ~10 Mbps	Yes
	VCR Quality	MPEG-1	1.2 Mbps	Yes
	Broadcast Quality	MPEG-2	2 ~ 4 Mbps	Yes
	Studio Quality Digital TV	ITU-R 601	166 Mbps	No
	DVD/ Studio Quality DTV	MPEG –2	3 ~6 Mbps	Yes
	HDTV	CD-DA	2000 Mbps	No
	HDTV	MPEG-2	25 ~ 34 Mbps	Yes
Audio	Streaming Audio	MPEG L3(MP3)	32~ 320 Kbps	
	Consumer CD-Audio	CD-DA	1441 Kbps	No
	Consumer CD-Audio	MPEG with FFT	192 ~256 Kbps	Yes
	Sound Studio Quality	MPEG with FFT	384 Kbps	Yes
	Dolby AC-3	5.1 Channels	640 Kbps	Yes
Telephone	Standard	G.711 PCM	64 Kbps	No
	Standard	G.721 ADPCM	32 Kbps	Yes
	Lower	GSM	13 Kbps	Yes
	Lower	CELP	5 ~7 Kbps	Yes
Broadband Internet Access	DSL	ADSL	1.5 ~9 Mbps	N/A
	Cable Modem	DOCSIS	2 Mbps	N/A

IEEE 1394 & Home Networking

- Distribution of Video for the entertainment applications requires larger bandwidth
  - MPEG 2 (used in HDTV) requires between 24 to 35Mbps
    - 1394 delivers video data at 400 Mbps
  - CD-DA (used in high quality HDTV) requires 2Gbps
    - Bit rates required for uncompressed high definition TV (HDTV)
    - 1920 x 1080 = 2073600 pixels in each frame, frame rate = 60 , bit rate > 2 Gbps
    - 1394b will deliver video data at 3.2 Gbps
- 1394 is capable of delivering video data at high speed
  - 1394 has the advantage of being adopted by consumer electronics manufacturers

IEEE 1394 & Home Networking

- Using 1394 for home networking does not require using a PC
- 1394 is easy to use
- 1394 is hot Pluggable
- 1394 has scalable architecture
- 1394 is a digital interface
- 1394 has physically small serial cables

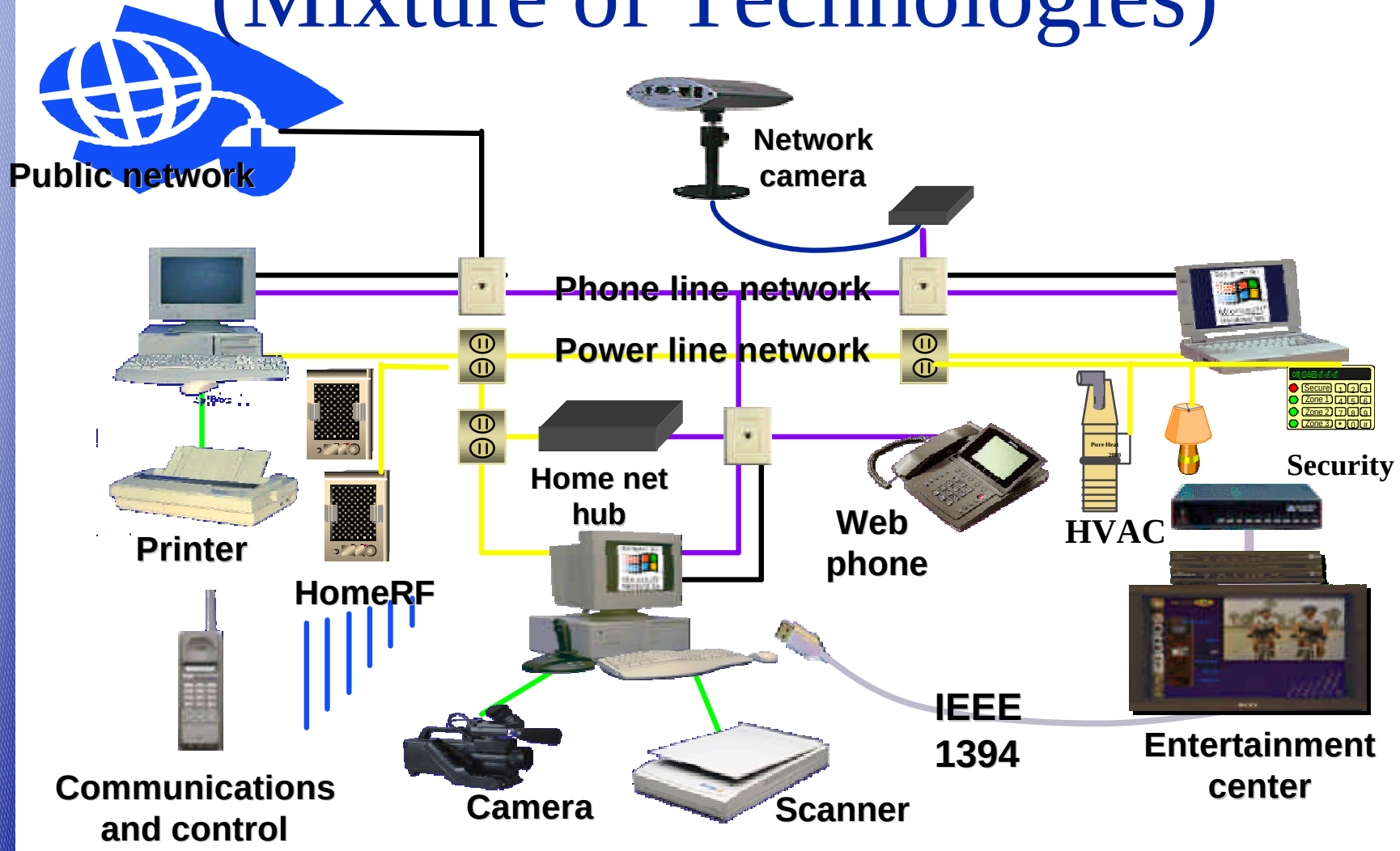
Home Networking Applications

- IEEE 1394 is an enabling technology for connecting devices such as:
  - Digital Camcorders and VCRs
  - Direct-to-Home (DTH) satellite audio/video
  - Cable TV and MMDS (microwave) set-top boxes
  - DVD Players
  - Video Games
  - Home Theater
  - Musical synthesizers/samplers with MIDI and digital audio capabilities
  - Digital audio tape (DAT) recorders, mixers, hard-disk recorders, video editors, etc.

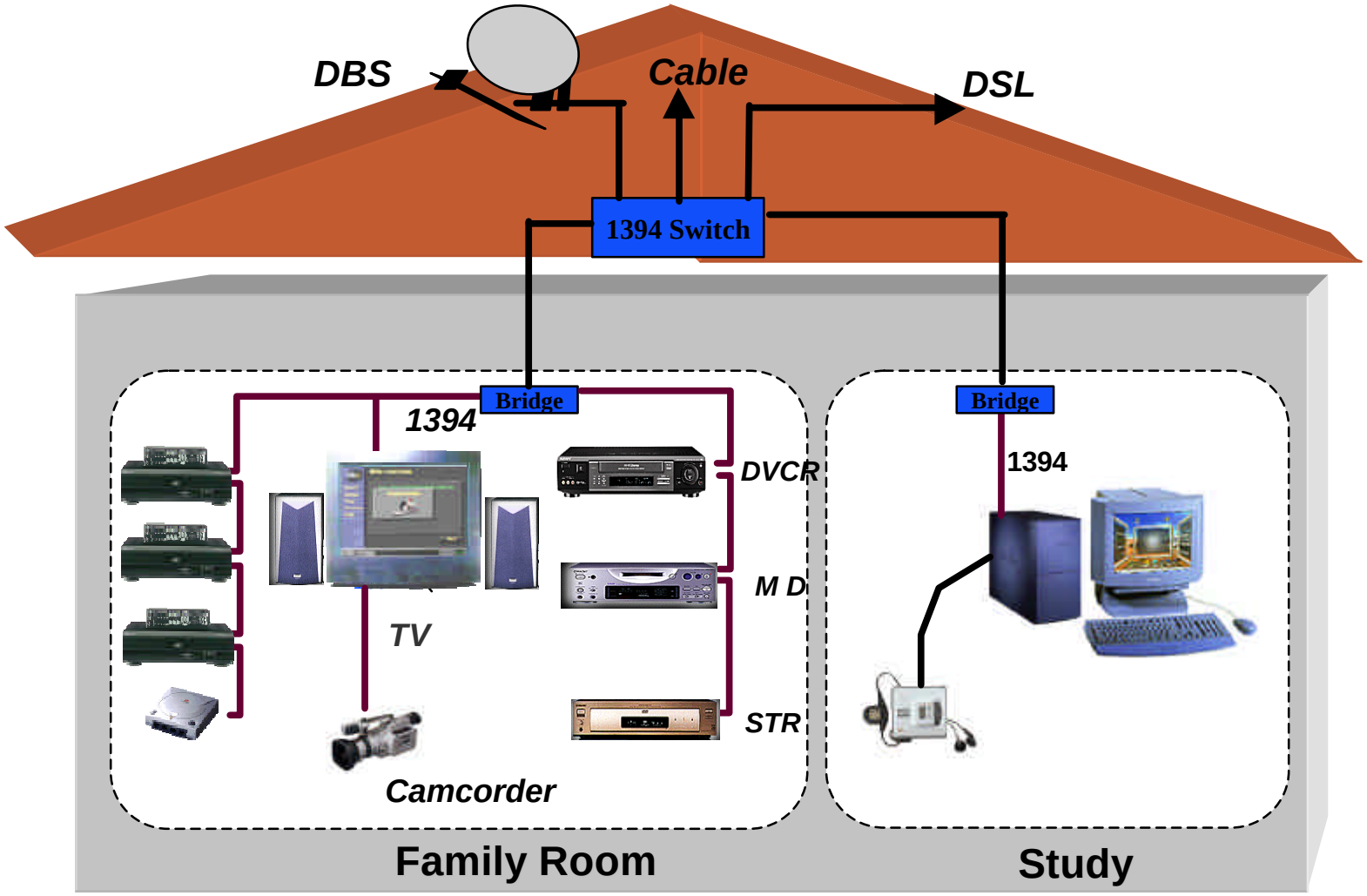
Home Networking Applications

- Digital Video (DV) applications (including security cameras)
- Fixed and removable PC disk drives
- PC-to-PC networking and PC peripheral component sharing
- Printers for video and computer data

A Networked home (Mixture of Technologies)



A 1394 Networked Home



Agenda

- Introduction
  - Market trend and application
    - 1394 Market Analysis Data
    - 1394 and industry
    - Applications
- Technology
  - What is 1394?
  - Why 1394?
  - Applications
  - 1394 Protocol
  - PHY
  - Link Layer
  - Transaction Layer
  - 1394 Operation
  - Bus Management
  - Cable and Connection
  - Architecture
  - Topology
- Other Technologies
  - USB
  - DVI
- 1394 In Home Networking
- Xilinx Value
- Alliances
- Summary

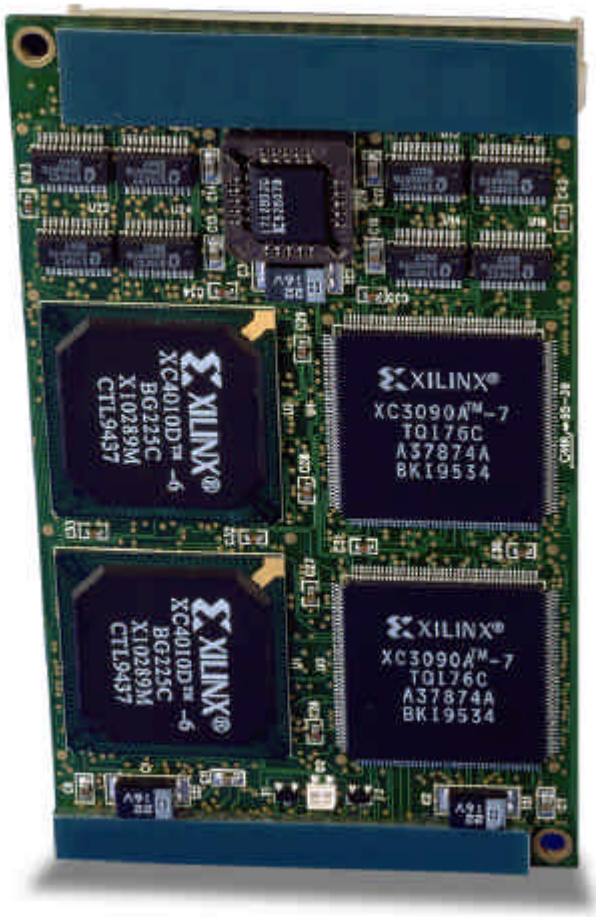
Introduction to Xilinx

Where Does Xilinx Fit In the Electronics Industry

Key components of an electronics system:

- Processor
- Memory
- *Logic*

Xilinx is the Leading Innovator of Complete Programmable Logic Solutions



Strategic Business Model Ensures Focus

- "Fabless" strategy
  - Leading edge IC process technology
  - Wafer capacity at competitive prices
  - Fastest, lowest cost, densest parts
- Independent sales organization (Reps & Distributors)
  - Sales is a variable cost
  - Permits greater reach—over 20,000 Customers
  - Over 10,000 "Feet On The Street"
- Focus on key strengths
  - Product design
  - Marketing
  - Applications & Technical Support

Xilinx Product Portfolio

Advanced Products Group

High Performance
High Density

General Products Division

High Volume
Low Cost

CPLD Division

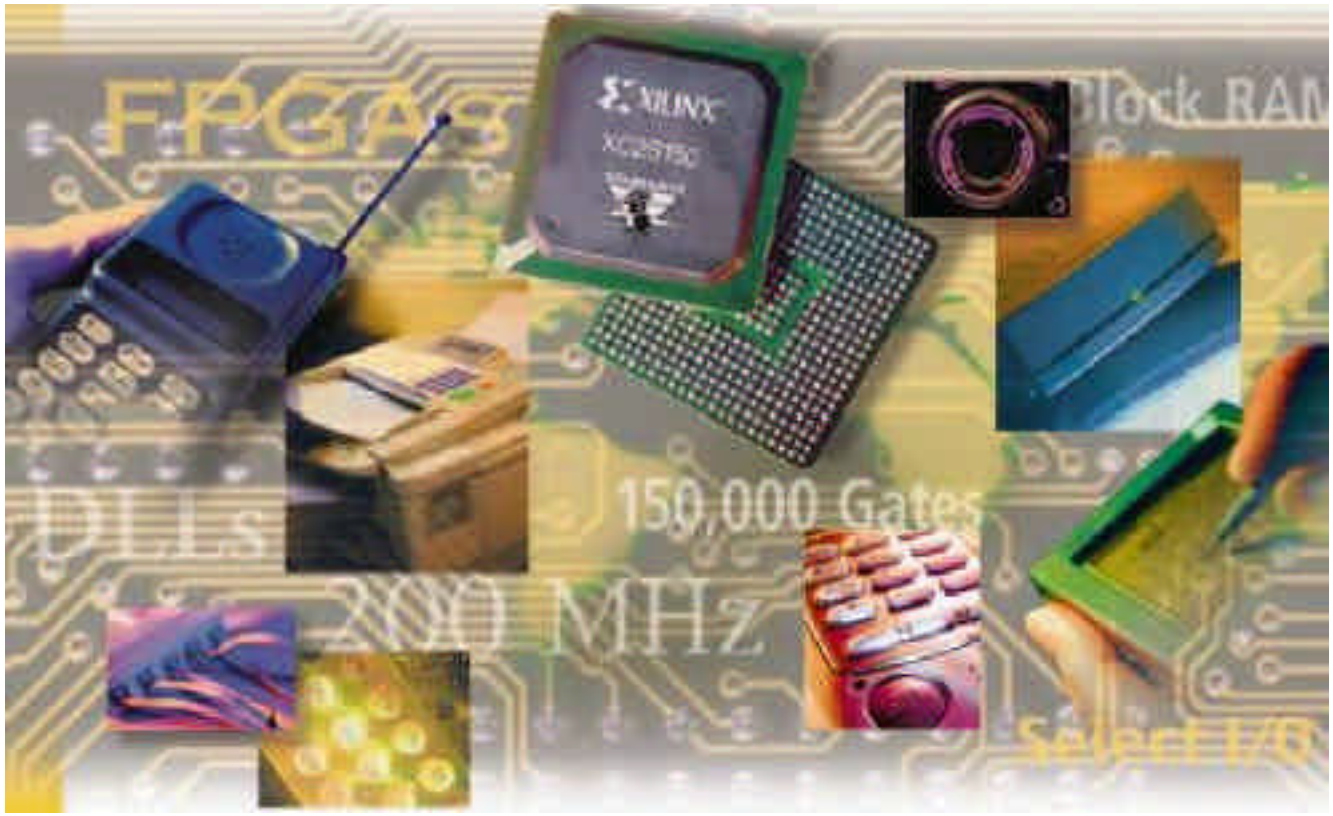
Low Power
Low Cost

Software Solutions

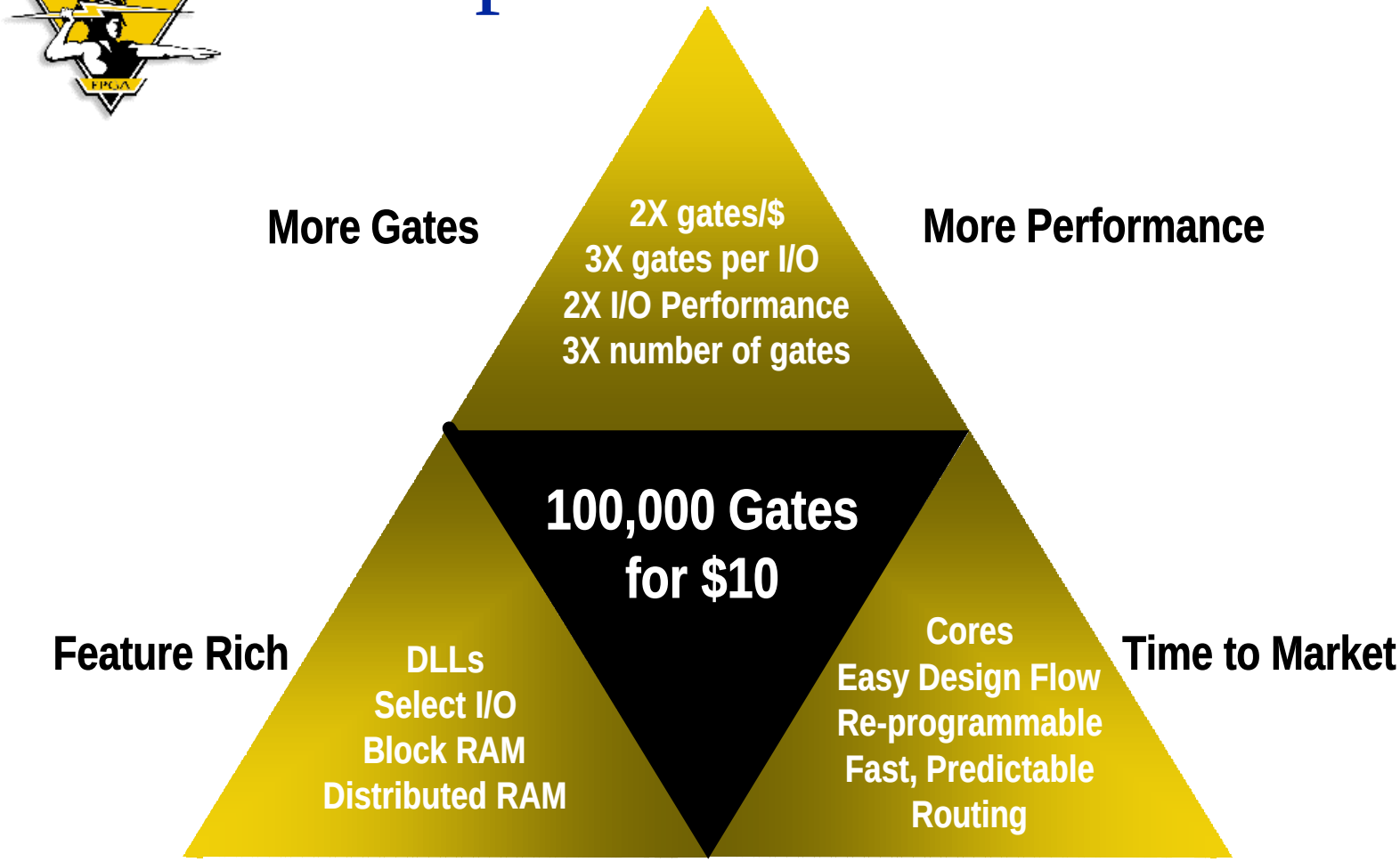
Xilinx - Leader in Core Solutions

	1998	1999	2000	2002	2004
Base Level Functions	- 82xx, UARTs, DMA - 66MHz DRAM, SDRAM I/F - Memory blocks - 29xx - Proprietary RISC Processors	- 8051 - IEEE 1284 - 200MHz SDRAM I/F - SGRAM, ZBTRAM I/F - Multi-channel DMA	- JAVA - Adv 32-bit RISC Processors - 64-bit RISC - DDR/QDR RAM - 622 Mbps LVDS		- 128-bit processors - Reconfigurable processors
Communication & Networking	- Cell assem/delin - CRC - T1 Framer - HDLC - Reed-Solomon - Viterbi - UTOPIA	- 10/100 Ethernet - ATM/IP Over SONET - Cell scram/descram - SONET OC3/12 - ADPCM - IMA	- Network processors - 1Gb Ethernet - SONET OC48/192 - CELP - VoIP - ADSL, HDSL, xDSL - UMTS, wCDMA		- Software Radio - Modems - Neural networking - Emerging Telecom and Networking Standards
DSP Functions	- Basic Math - Correlators - Filters: FIR, Comb - Multipliers - FFT, DFT - Sin/Cos	- DCT - Adaptive filters - Cordic - DES - DES - Divider - NCO - Satellite decoders	- MP3 - QAM - JPEG - Speech Recognition - DSP Processor I/Fs - Wavelet		- MPEG - DSP Functions > 200 MSPS - Programmable DSP Engines
Standard Bus Interfaces	- CAN - ISA PnP - I2C - PCI 32-bit - PCMCIA	- CardBus - FireWire - PCI 64-bit/66MHz - Compact PCI Hot-Swap - PC104 - VME	- AGP - PCI-X 133MHz		- InfiniBand - Emerging High-Speed Standard Interfaces

Introducing the Spartan-II FPGA

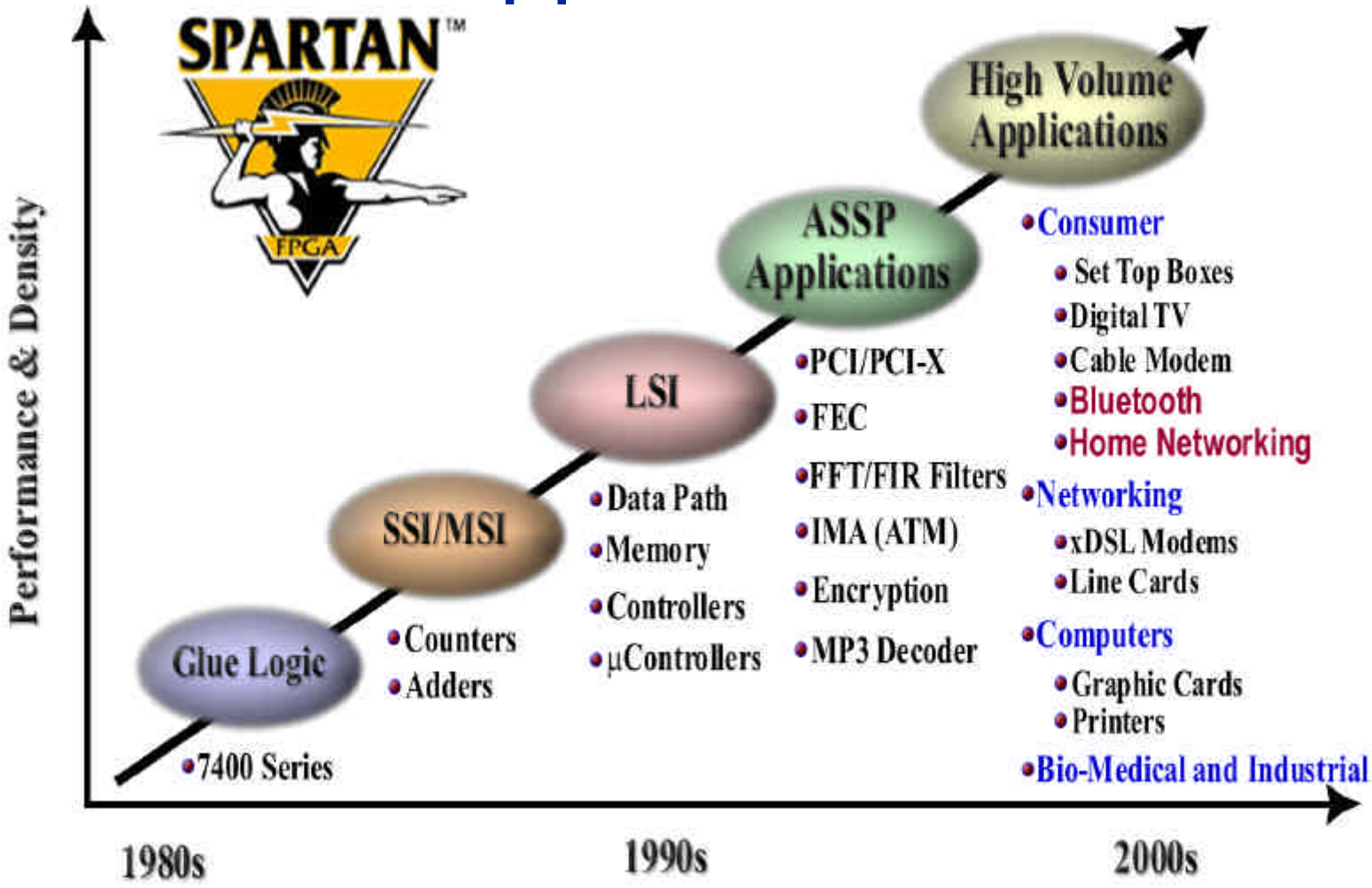


Spartan-II: Extending the Spartan Series



Programmable ASIC/ASSP Replacement!

FPGA Application Trends



Programmable ASIC/ASSP Replacement!

Spartan-II - Architecture Overview

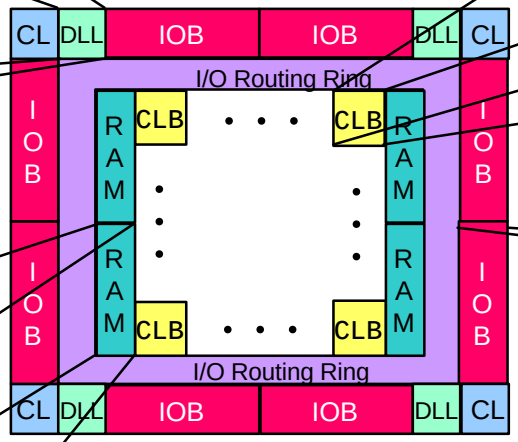
Delay Locked Loop (DLL)

Clock Management:

Multiply clock
Divide clock
De-skew clock

Configurable Logic Blocks (CLB)

Configurable Logic Block Array and Distributed RAM



Select I/O™ Technology

Chip to Backplane
PCI 33MHz 3.3V
PCI 33MHz 5.0V
PCI 66MHz 3.3V
GTL, GTL+, AGP
Chip to Memory
HSTL-I, HSTL-III
HSTL-IV
SSTL3-I, SSTL3-II
SSTL2-I, SSTL2-II
CTT
Chip to Chip
LVTTL, LVCMOS

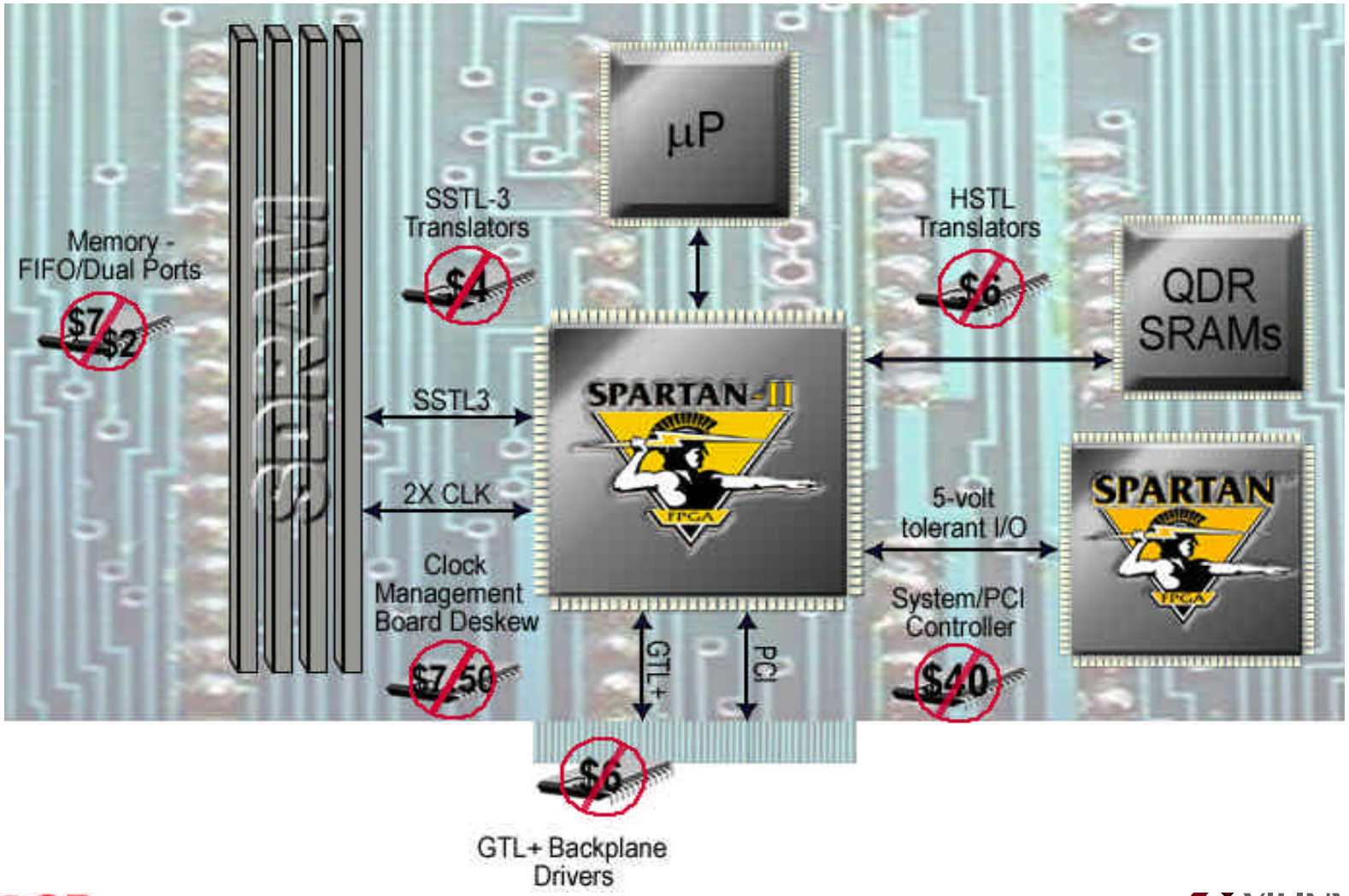
Block Memory

True Dual-Port™ 4K bit RAM

4Kx1
2Kx2
1Kx4
512x8
256x16

"The Spartan-II family, in our opinion, may be the closest that any FPGA has come to being at a low-enough price to compete against an ASIC"
--Dan Niles, Industry Analyst

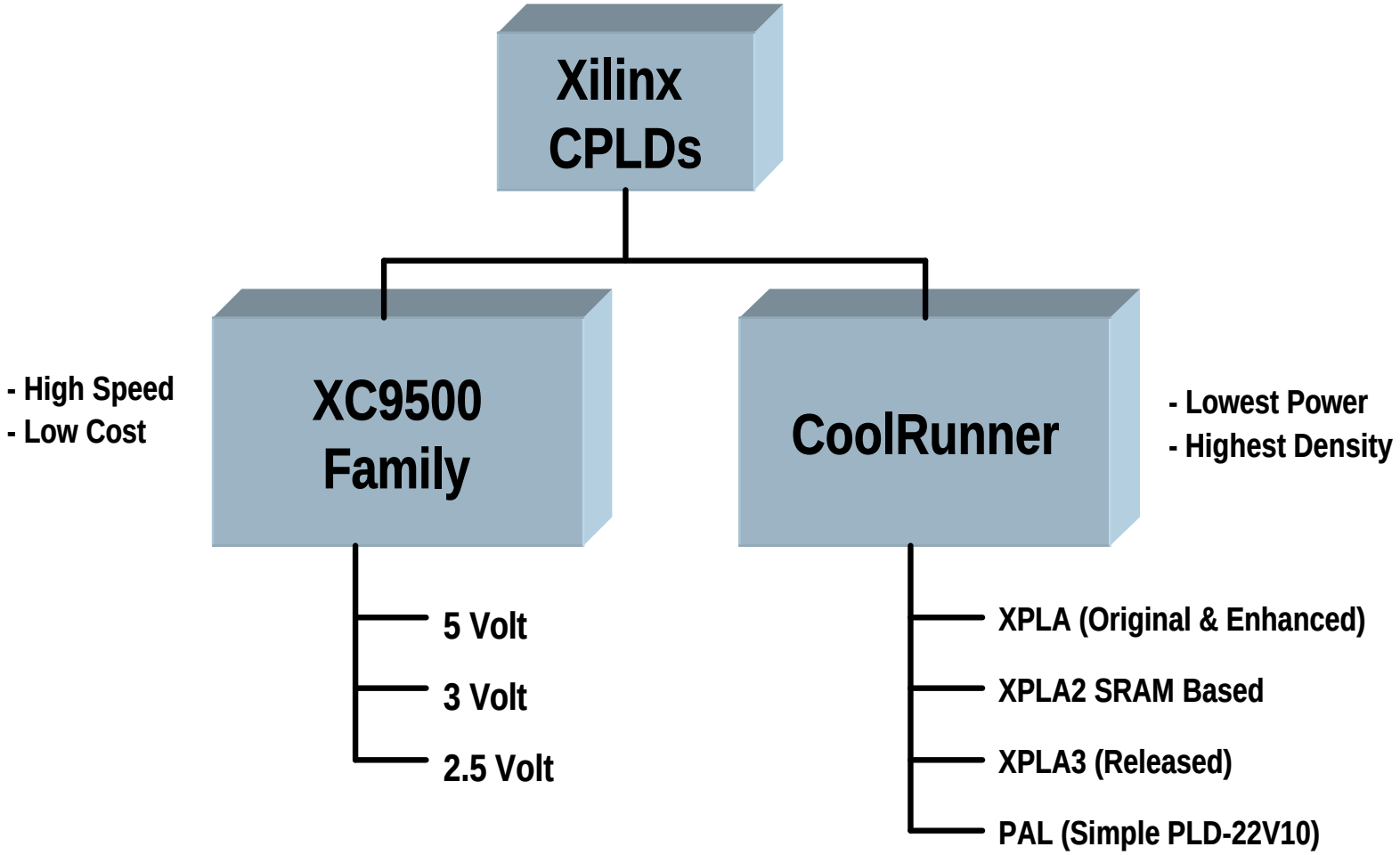
Spartan-II - System Integration



Spartan-II Core Support

- On-chip memory & storage
  - Distributed, BlockRAM, FIFOs
- Bus products
  - PCI (64- & 32-bit, 33/66MHz), Arbiter, CAN bus interface
- DSP Functions (FIR filter)
- Error correction
  - Reed-Solomon, Viterbi
- Encryption (DES & triple DES)
- Microprocessor
  - ARC 32-bit configurable RISC, 8-bit 8051 microcontroller
- Memory controllers (10+)
  - SDRAM, QDR SRAM
- Communications
  - ATM (IMA, UTOPIA), Fast Ethernet (MAC)
- Telecom
  - CDMA matched filter, HDLC, DVB satellite, ADPCM speech codec
- Video & image processing
  - JPEG codec, DCT/IDCT, color space converter
- UARTs

Xilinx CPLD Families



Spartan-II End Applications

- Consumer
  - Set Top Boxes/Digital VCRs
  - DTV/HDTV
  - Digital Modems
    - xDSL, Cable, Satellite
  - Home Networking products
  - Bluetooth appliances
  - LCD/Flat-Panel Displays
- Networking
  - Telecom linecards
  - DSLAMs
  - LAN Hubs/Switches
  - SOHO Routers
  - Cellular base stations
- Computer/Storage
  - Printer/Scanner
  - Multi-function office equipment
  - Storage devices
  - Home servers
  - Audio/Video add-in cards
- Industrial/Medical
  - Medical Imaging
  - Industrial automation/control
  - Data acquisition
  - Video capture/editing
  - Automated test equipment
  - Automotive Info-tainment systems

CoolRunner Technology

- Full density range 32 to 960 macrocells
- World's only TotalCMOS CPLD
  - Bipolar style sense amps eliminated
  - Virtually no static power dissipation
- Advanced PLA Architecture
  - Product term sharing (no redundant logic)
  - No wasted product terms
- 3.3v and 5.0v devices
- ISP/JTAG compatible & full software support

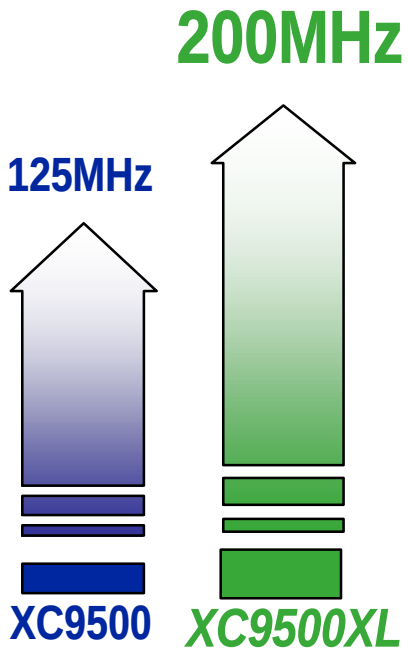
The CoolRunner Advantage

- Industry's lowest power CPLDs
  - Standby current < 100uA
  - High speed TPD = 6 ns
  - Revolutionary XPLA architecture
    - Exceptional routability & pin-locking
    - Fast, predictable timing
  - Small form factor packaging
    - New 0.5mm 56-pin MicroBGA

- No Speed / Power tradeoffs in scaling
  - Can build very large / very fast devices
  - 960 macrocell device @ 7.5 nsec t_{PD}

XC9500XL Key Features

- High performance
  - t_{PD} = 5ns, f_{SYS} = 178MHz
- 36 to 288 macrocell densities
- Lowest price, best value CPLD
- Highest programming reliability
- Most complete IEEE 1149.1 JTAG
- Space-efficient packaging, including chip scale pkg.



Lowest Price Per Macrocell

XC9500XL/XV System Features

- I/O Flexibility
  - XL:5V tolerant; direct interface to 3.3V & 2.5V
  - XV:5V tolerant; direct interface to 3.3V, 2.5V & 1.8V
- Input hysteresis on all pins
- User programmable grounds
- Bus hold circuitry for simple bus interface
- Easy ATE integration for ISP & JTAG
  - Fast, concurrent programming times

System Block Diagrams for 1394 Solutions

Block Diagram Template / Index

Xilinx Solution Or

Peripheral Components

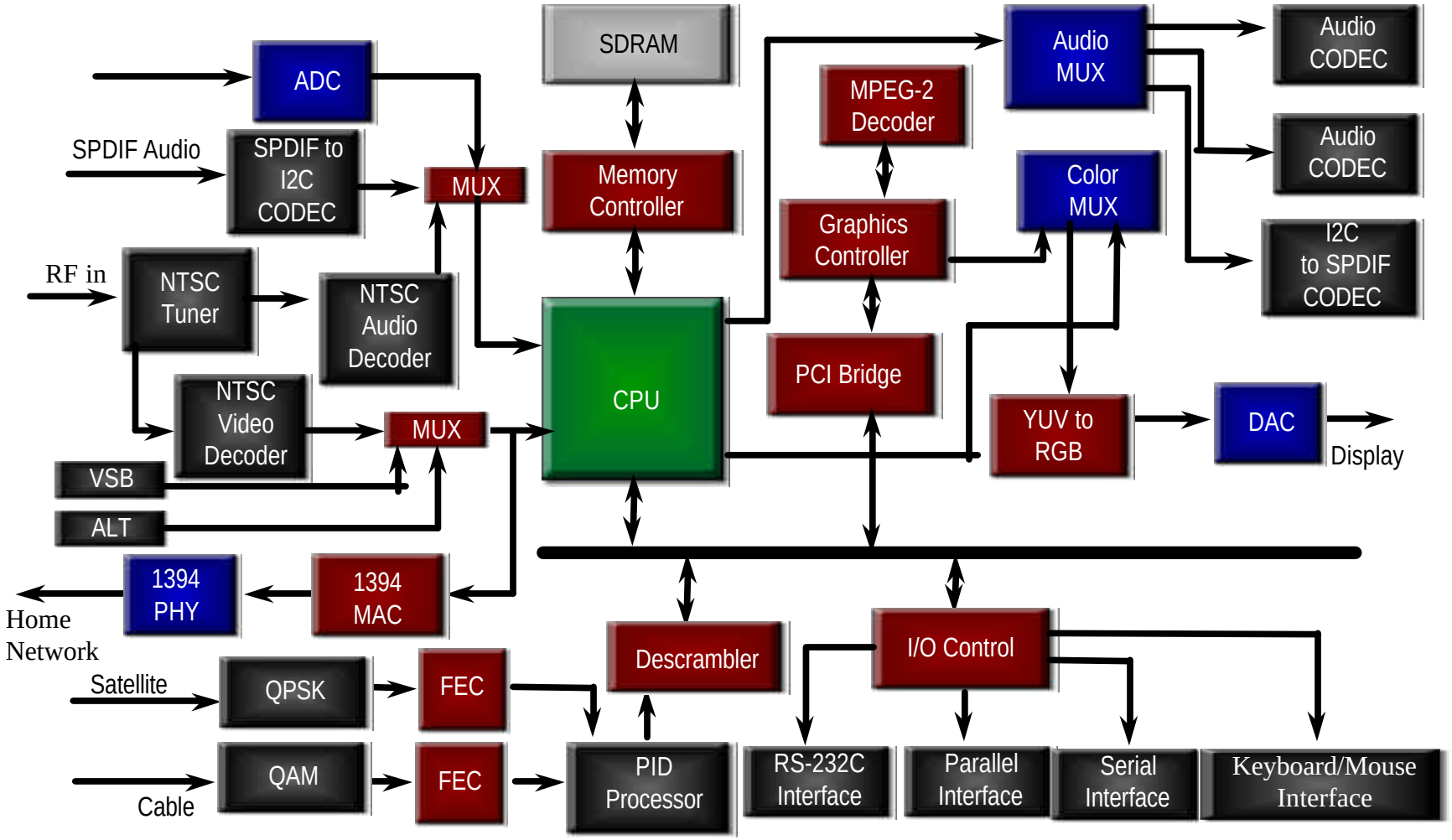
Memory

Mixed Signal / RF / Analog Component

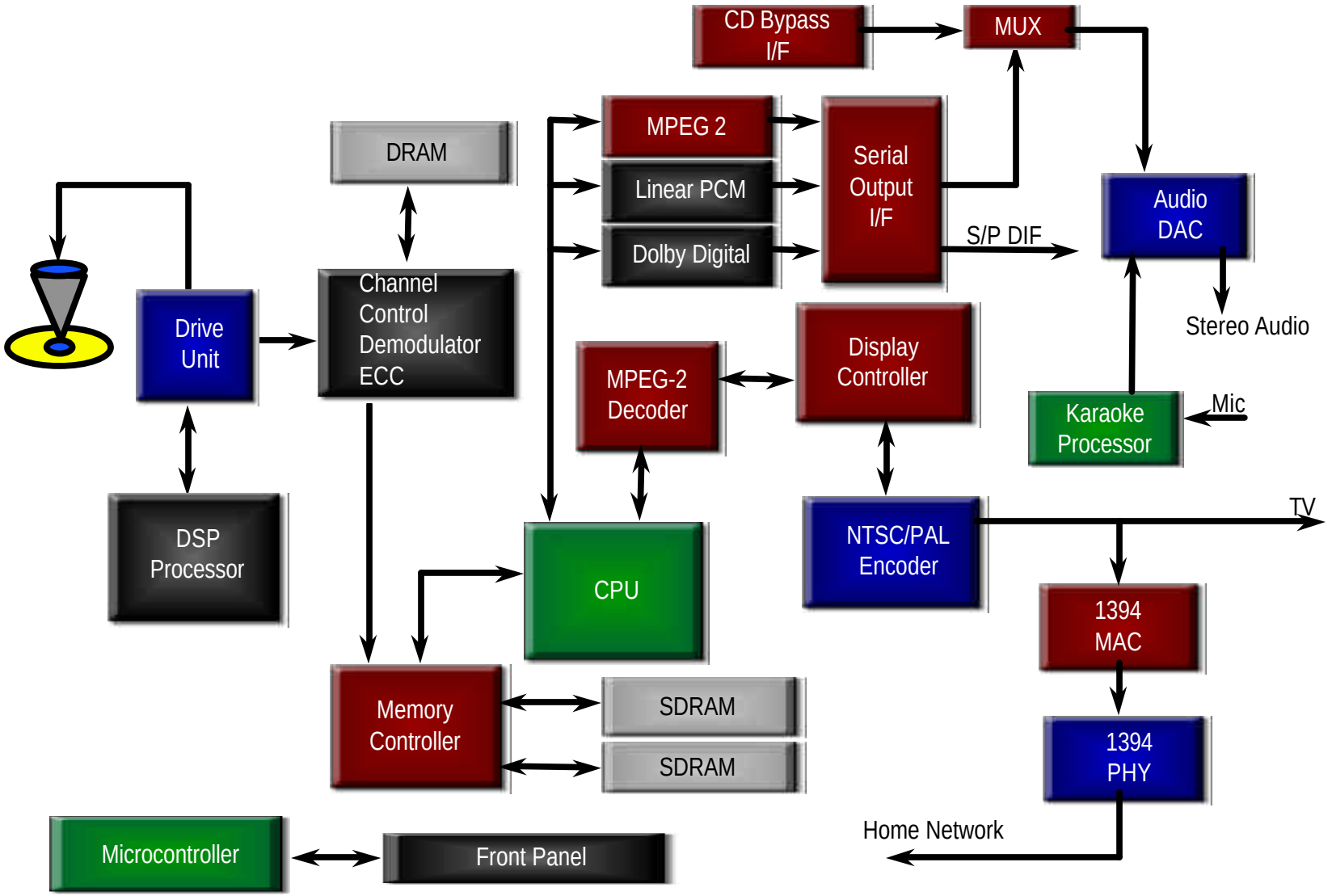
mP/ mC

Embedded Chip/ ASSP

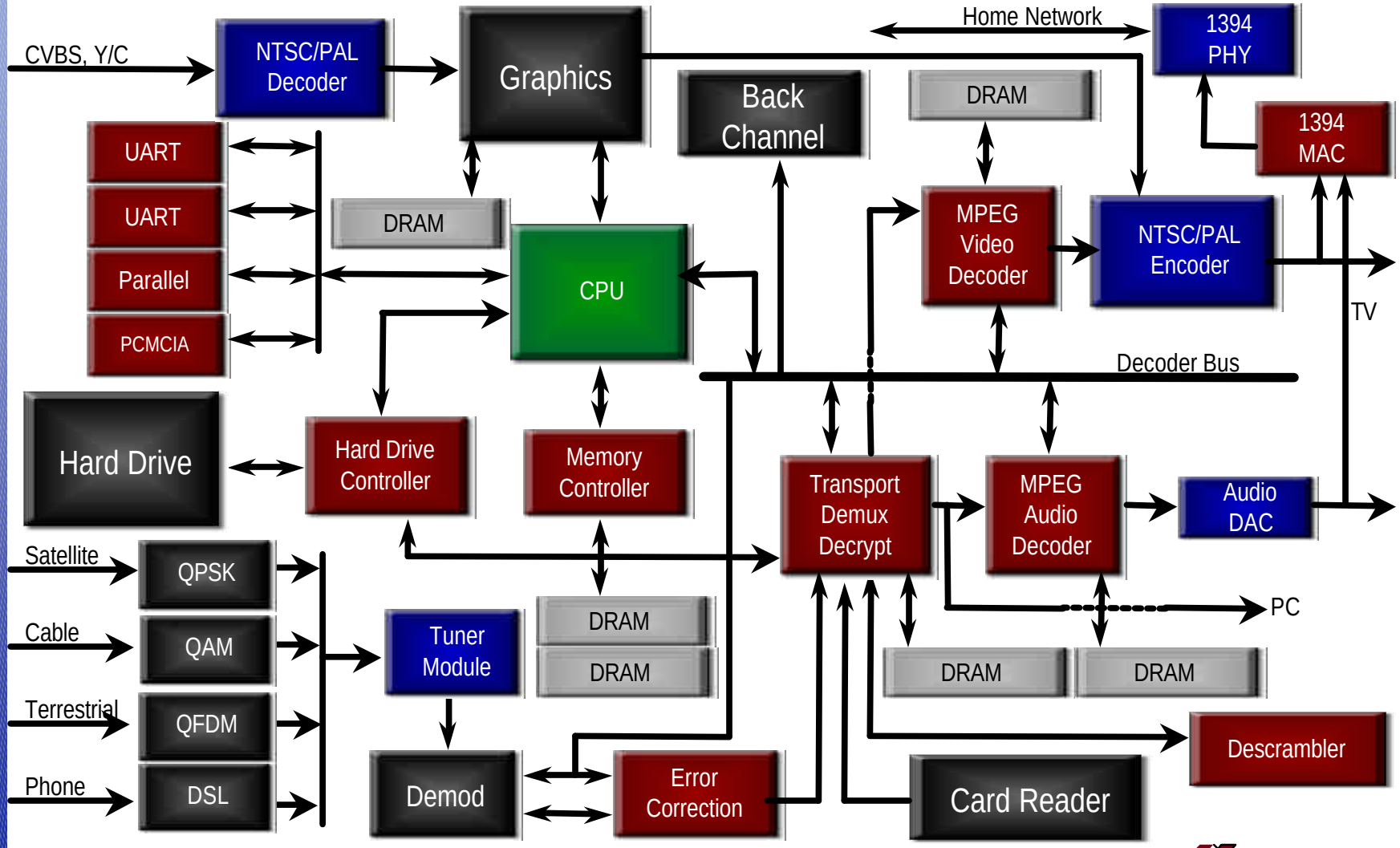
Digital TV


SDRAM
ADC
Audio MUX
Audio CODEC
MPEG-2 Decoder
SPDIF Audio
SPDIF to I2C CODEC
MUX
Memory Controller
Audio CODEC
Color MUX
Graphics Controller
RF in
NTSC Tuner
NTSC Audio Decoder
I2C to SPDIF CODEC
PCI Bridge
NTSC Video Decoder
CPU
YUV to RGB
DAC
Display
MUX
VSB
ALT
1394 PHY
1394 MAC
Home Network
Descrambler
I/O Control
Satellite
QPSK
FEC
QAM
FEC
Cable
PID Processor
RS-232C Interface
Parallel Interface
Serial Interface
Keyboard/Mouse Interface

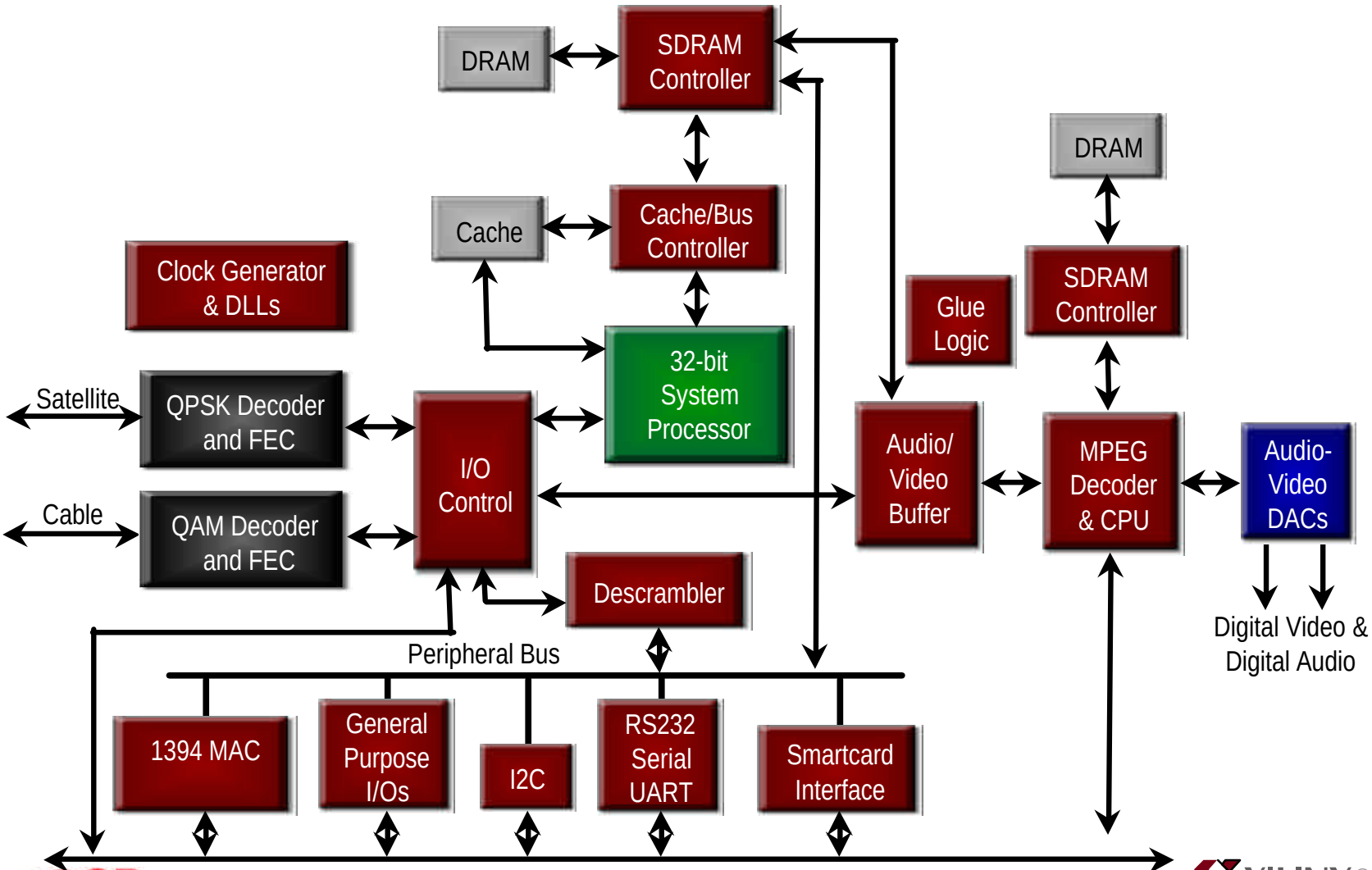
Interactive DVD Player



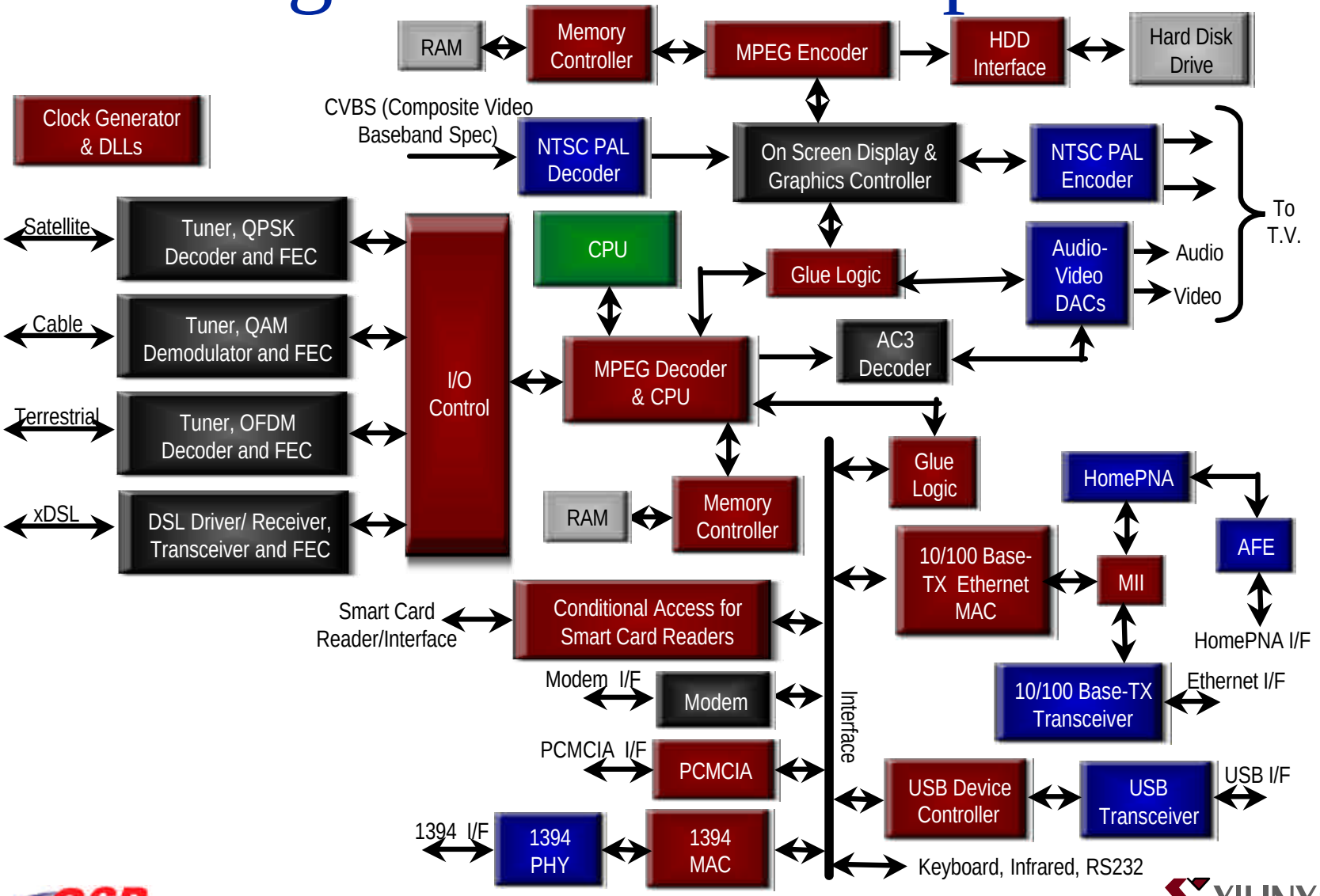
Set Top Box


CVBS, Y/C
NTSC/PAL Decoder
Graphics
Home Network
1394 PHY
Back Channel
DRAM
1394 MAC
UART
UART
Parallel
PCMCIA
DRAM
CPU
MPEG Video Decoder
NTSC/PAL Encoder
TV
Decoder Bus
Hard Drive
Hard Drive Controller
Memory Controller
Transport Demux Decrypt
MPEG Audio Decoder
Audio DAC
Satellite
QPSK
Cable
QAM
Terrestrial
QFDM
Phone
DSL
Tuner Module
DRAM
DRAM
PC
DRAM
DRAM
Descrambler
Demod
Error Correction
Card Reader

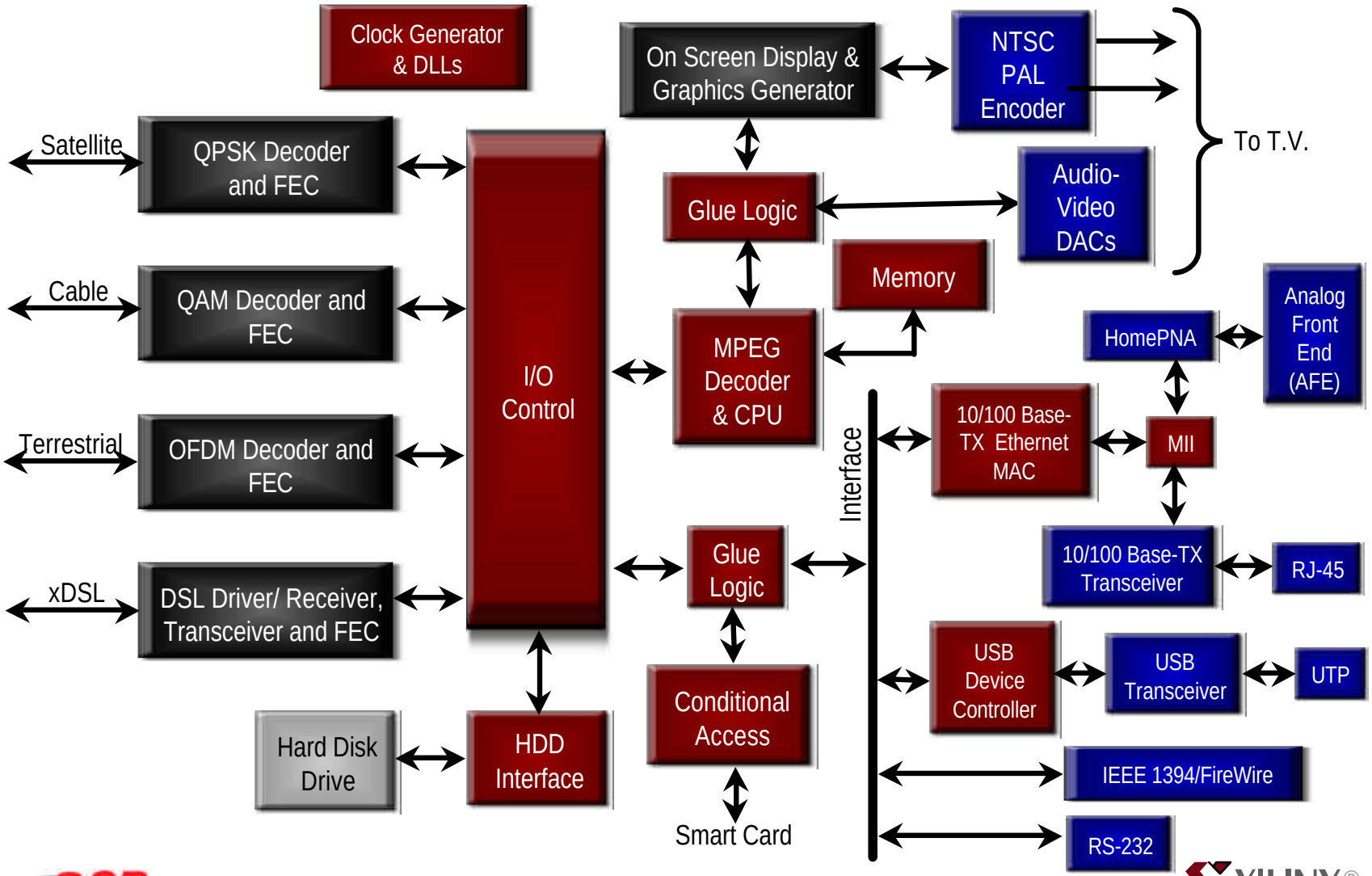
Set-Top Decoder Box



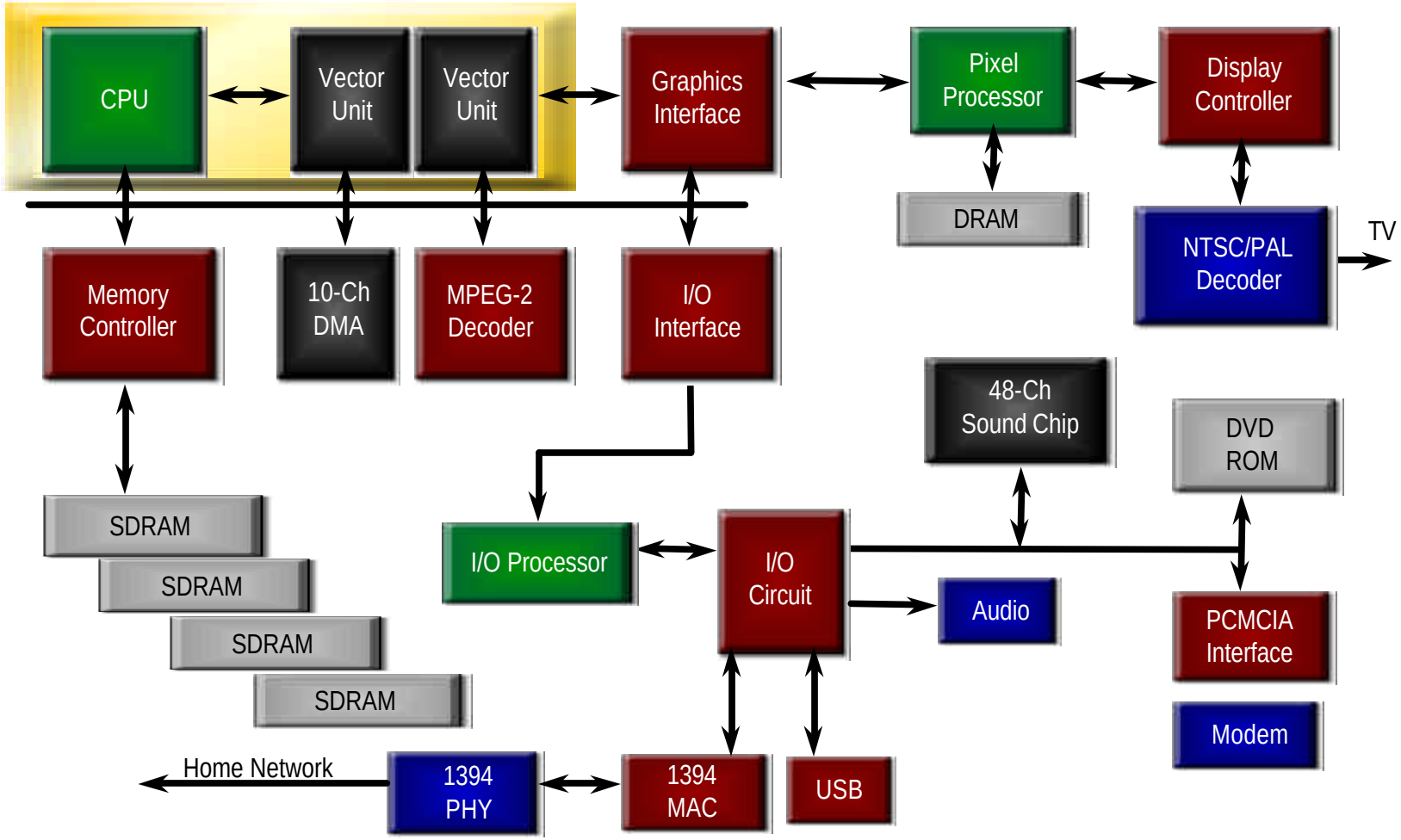
Digital VCR Set-Top Box



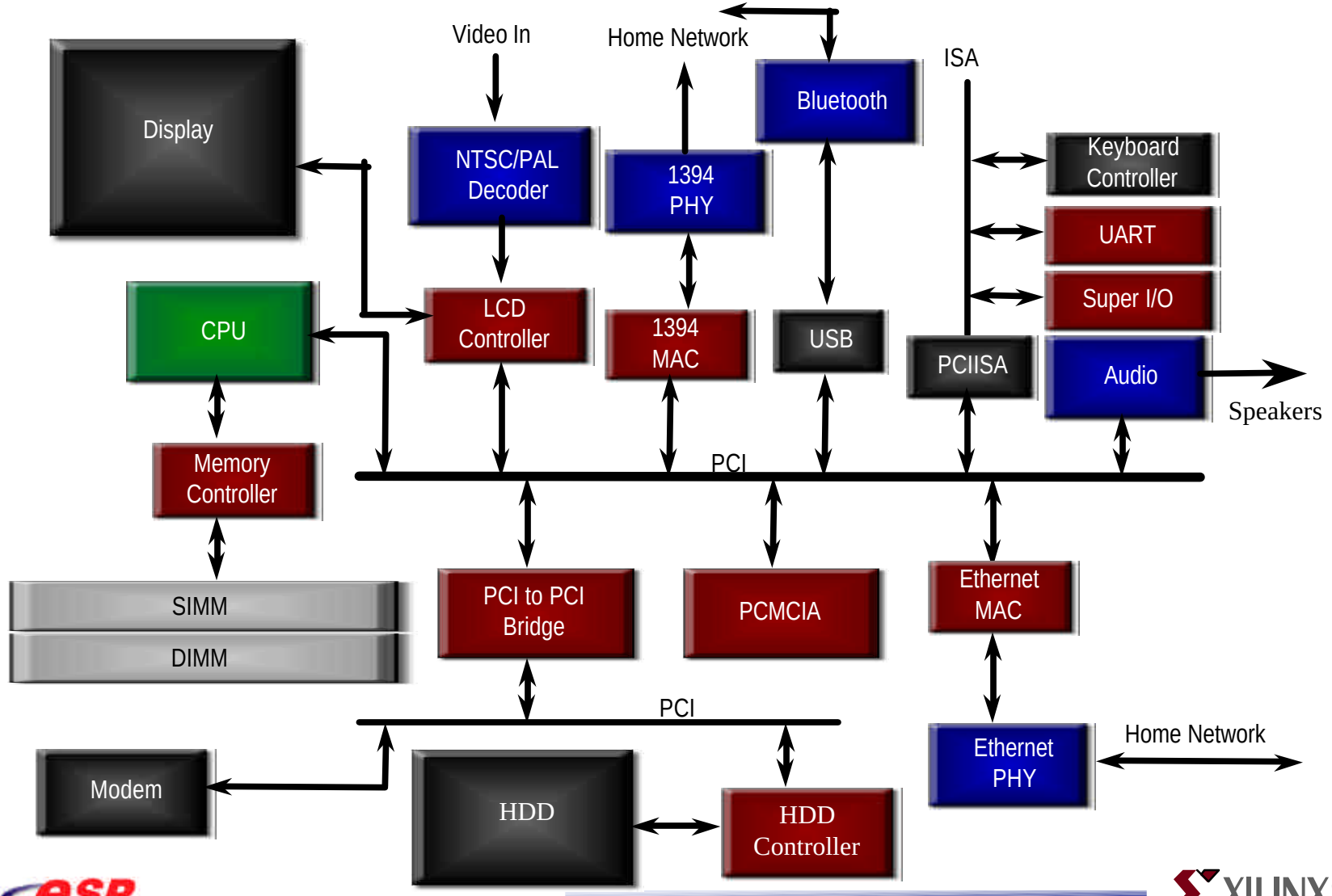
Residential Gateway (STB)



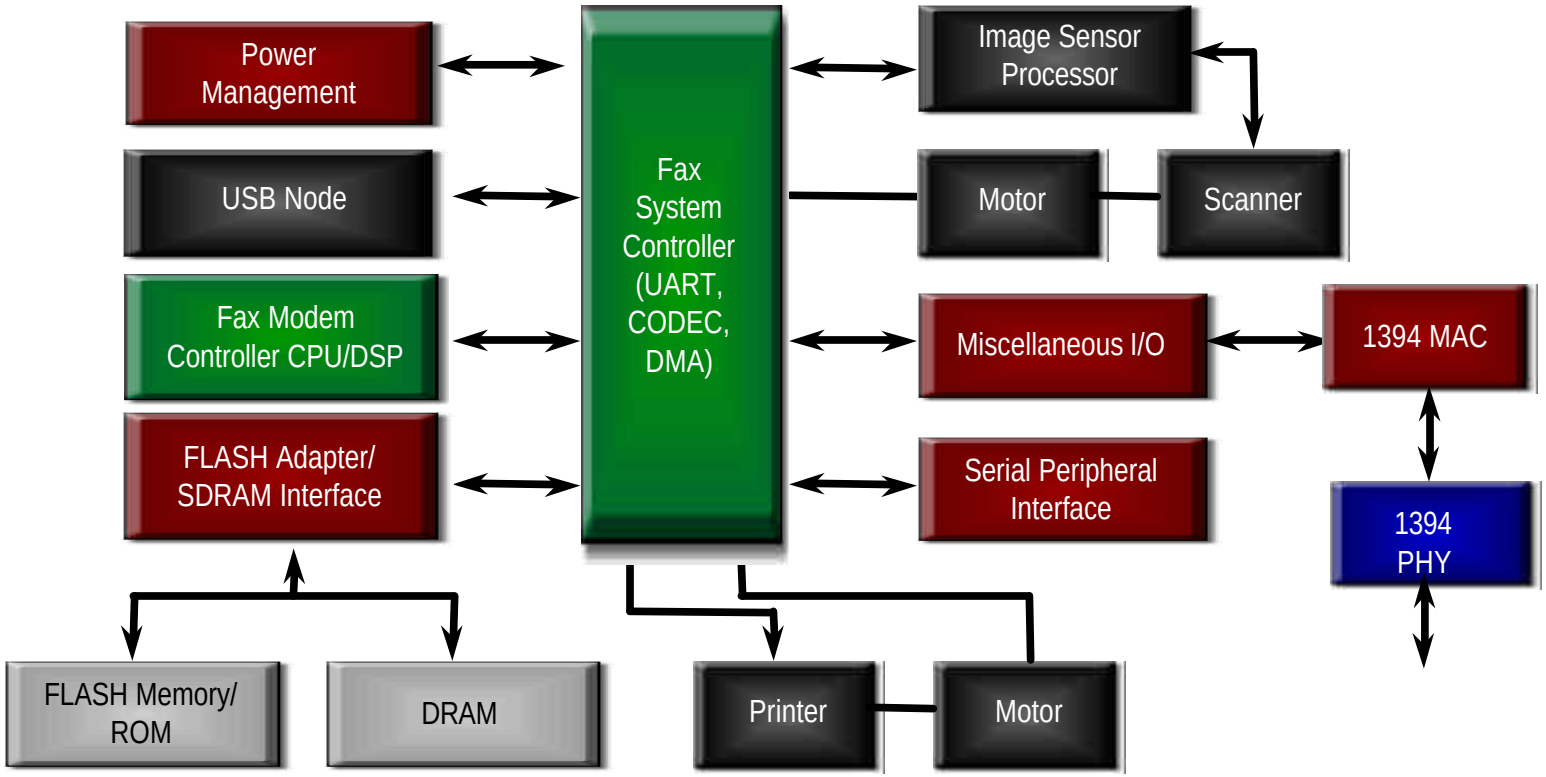
Gaming Station



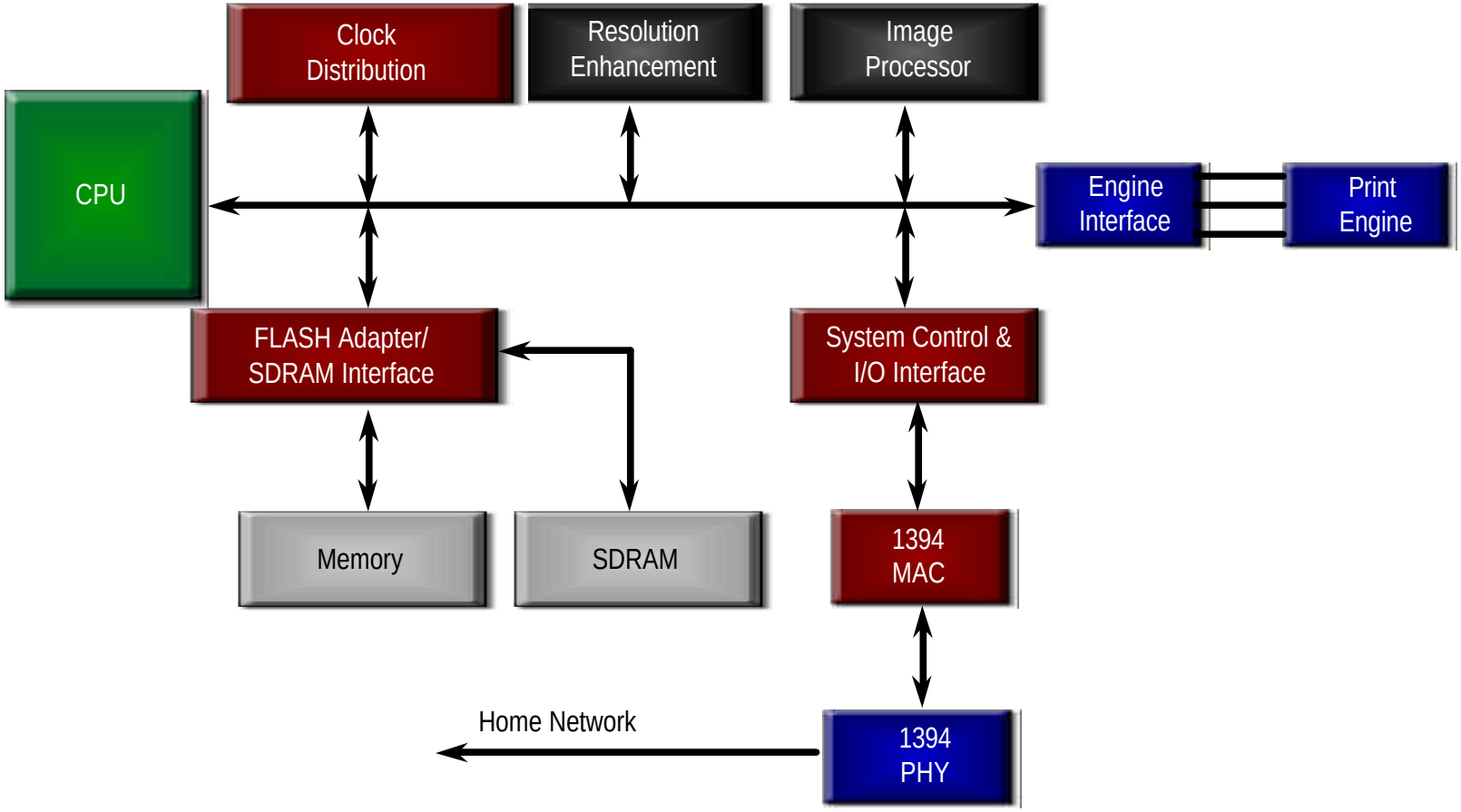
Desktop PC


Video In
Home Network
ISA
Display
Bluetooth
NTSC/PAL Decoder
1394 PHY
Keyboard Controller
UART
Super I/O
CPU
LCD Controller
1394 MAC
USB
PCIISA
Audio
Speakers
Memory Controller
PCI
SIMM
DIMM
PCI to PCI Bridge
PCMCIA
Ethernet MAC
PCI
Modem
HDD
HDD Controller
Ethernet PHY
Home Network

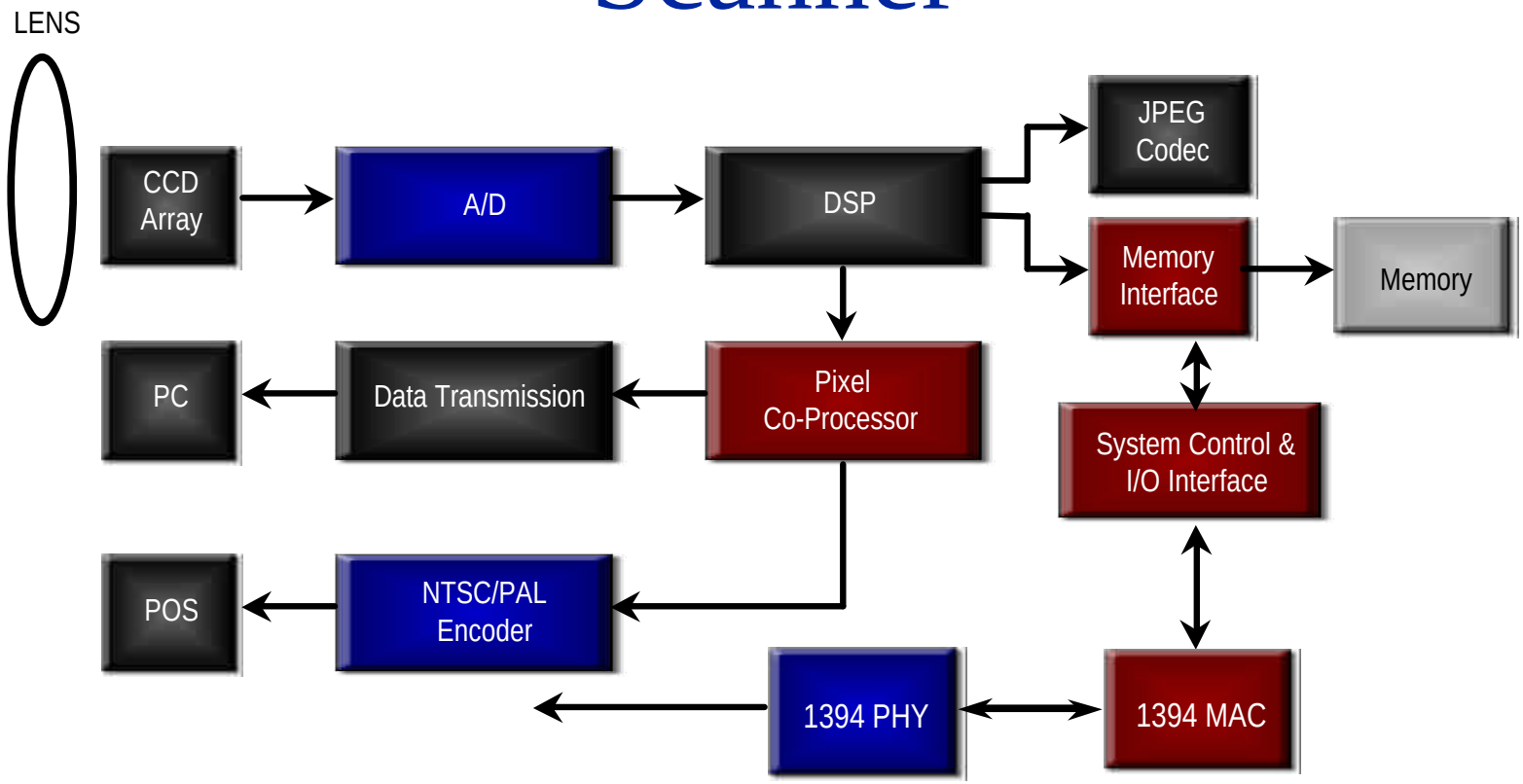
Multi-Function Peripheral



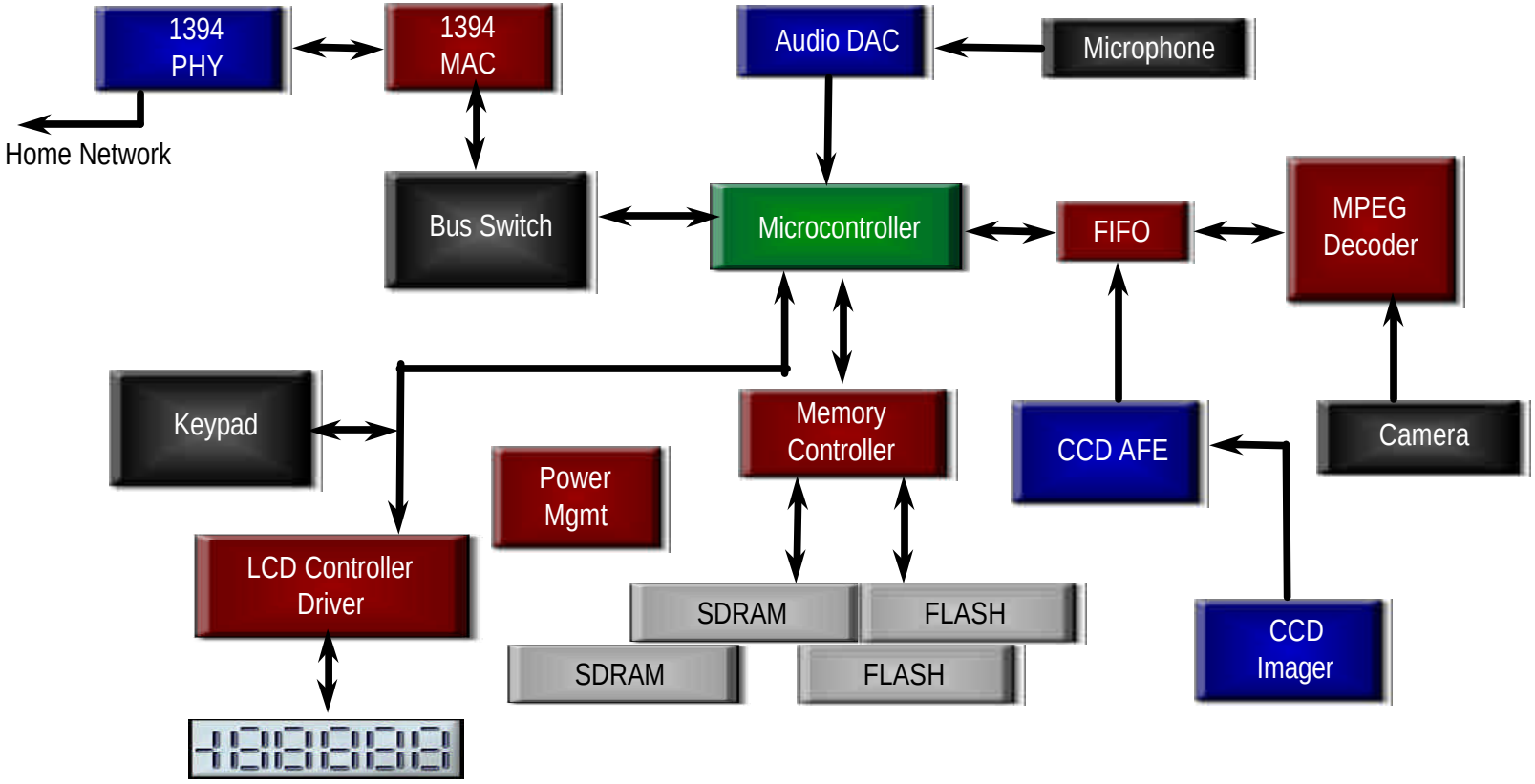
Printer


Clock Distribution
Resolution Enhancement
Image Processor
CPU
Engine Interface
Print Engine
FLASH Adapter/ SDRAM Interface
System Control & I/O Interface
Memory
SDRAM
1394 MAC
Home Network
1394 PHY

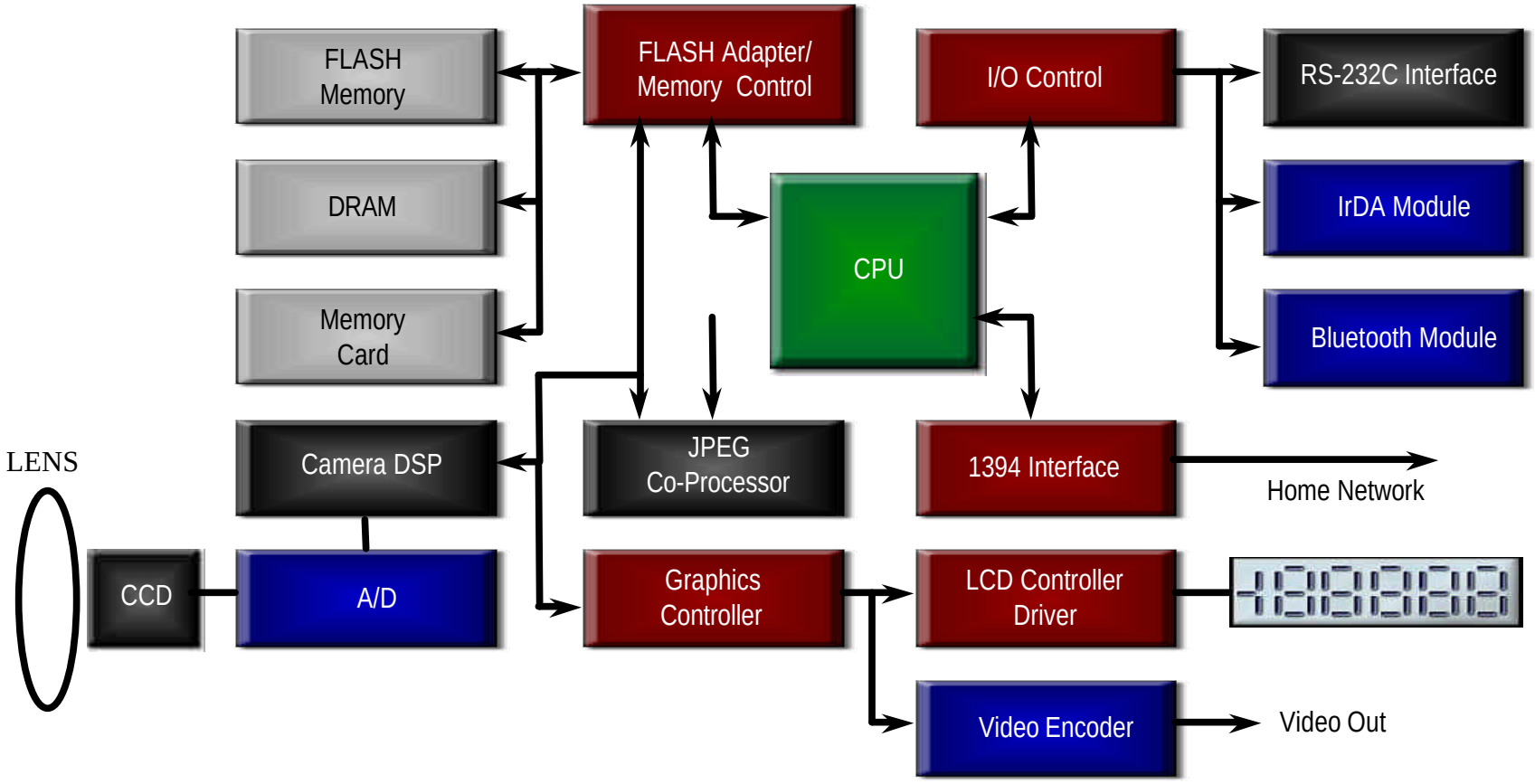
Scanner


LENS
CCD Array
A/D
DSP
JPEG Codec
Memory Interface
Memory
PC
Data Transmission
Pixel Co-Processor
System Control & I/O Interface
POS
NTSC/PAL Encoder
1394 PHY
1394 MAC

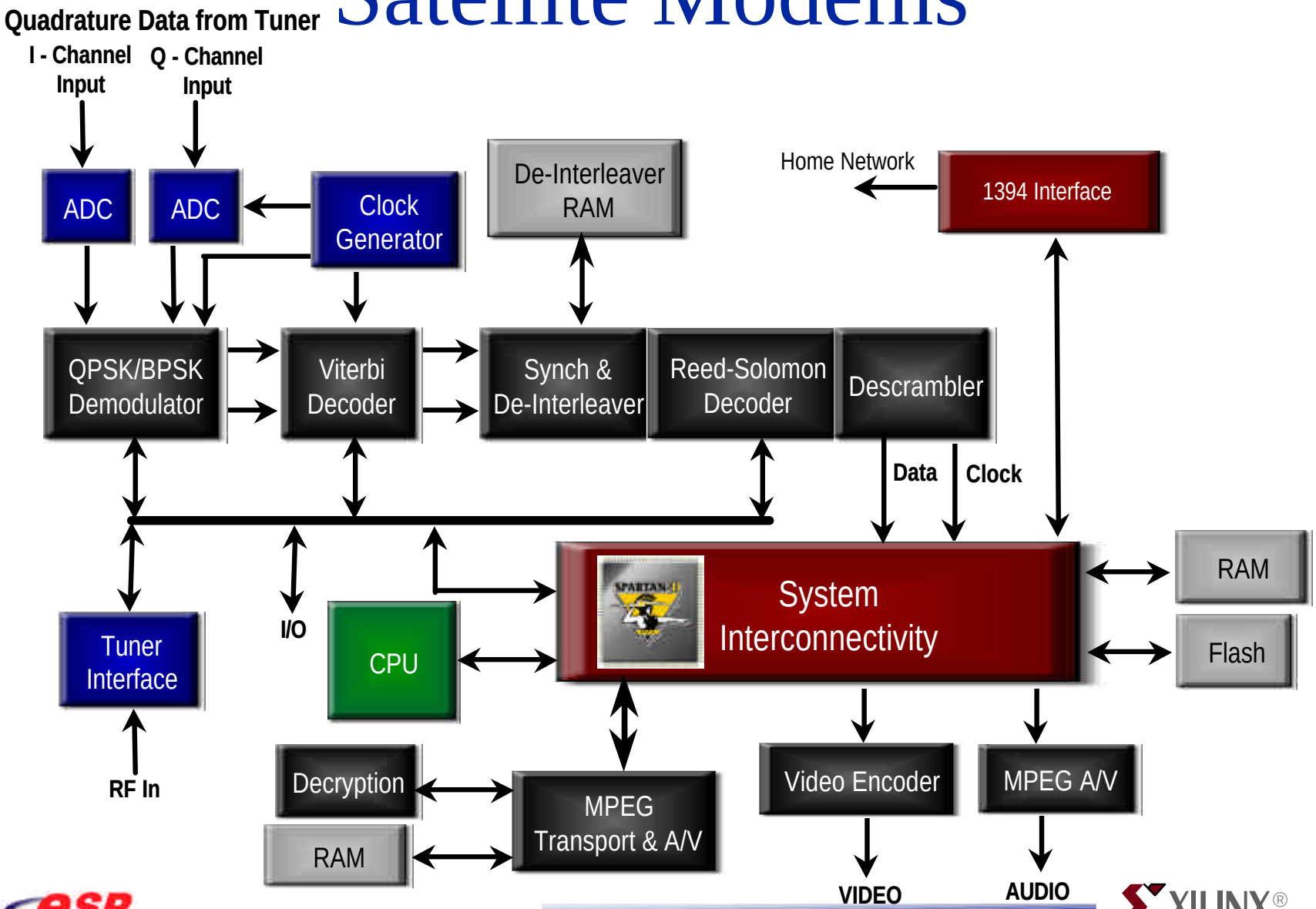
Home Security



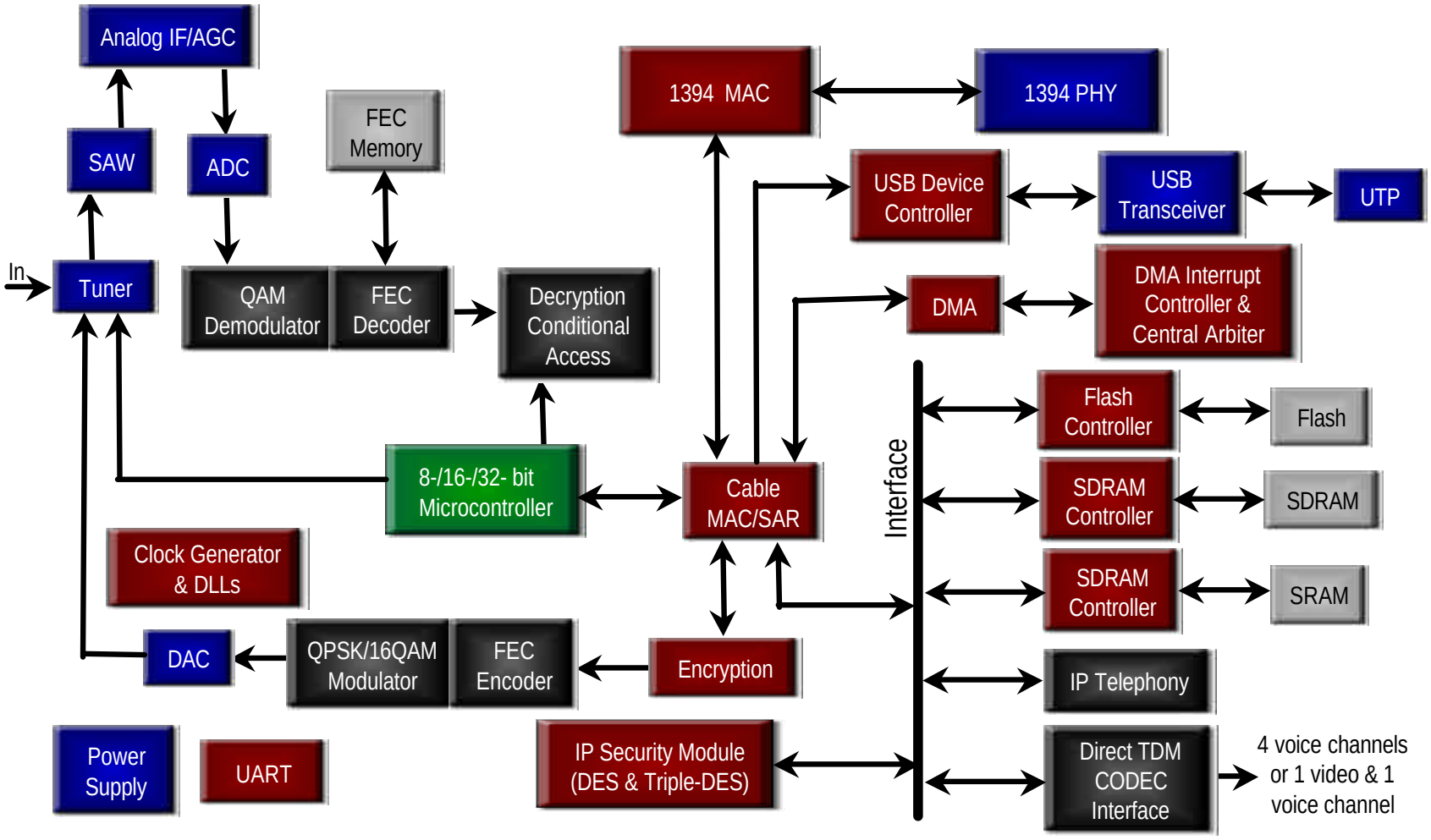
Digital Camera



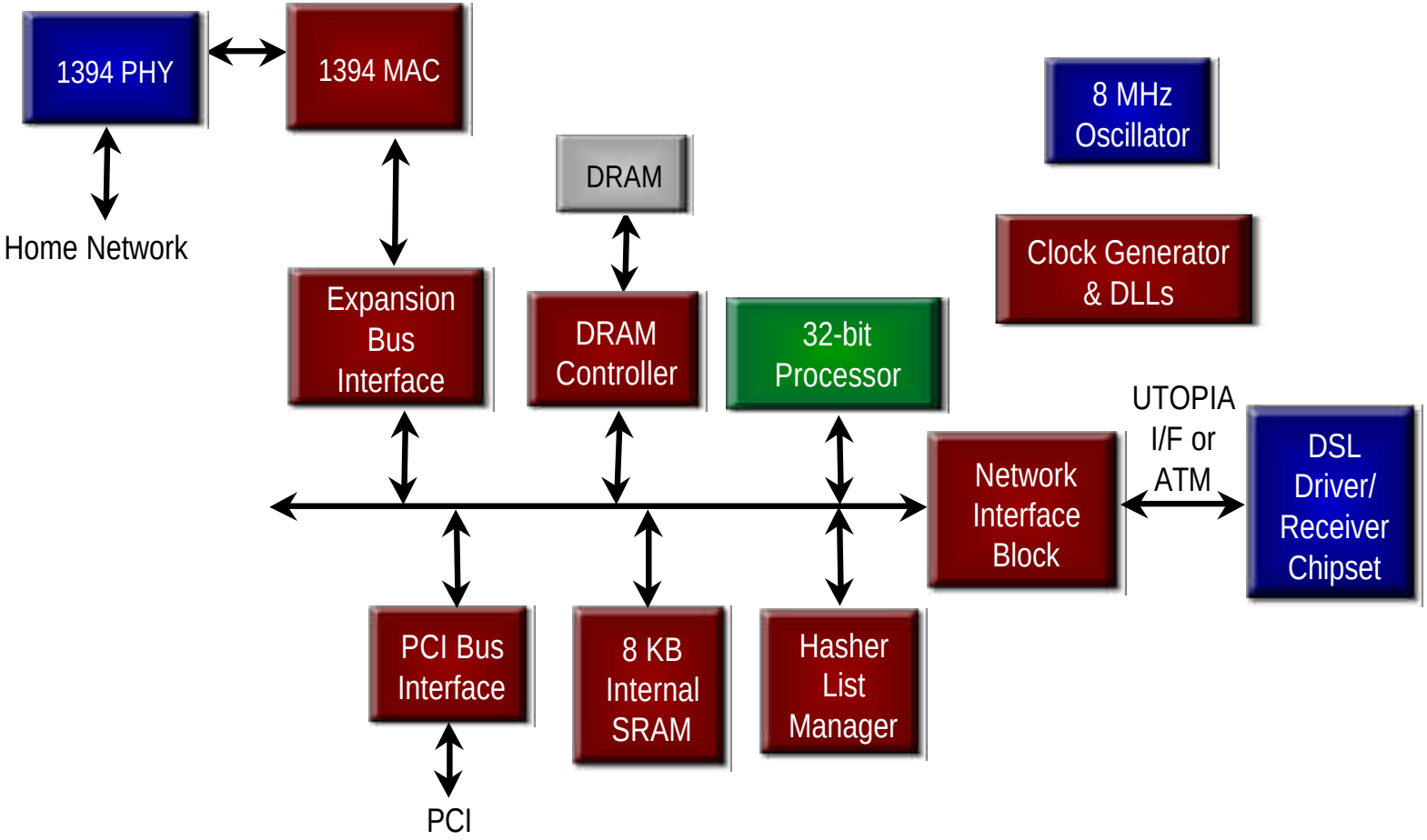
Satellite Modems



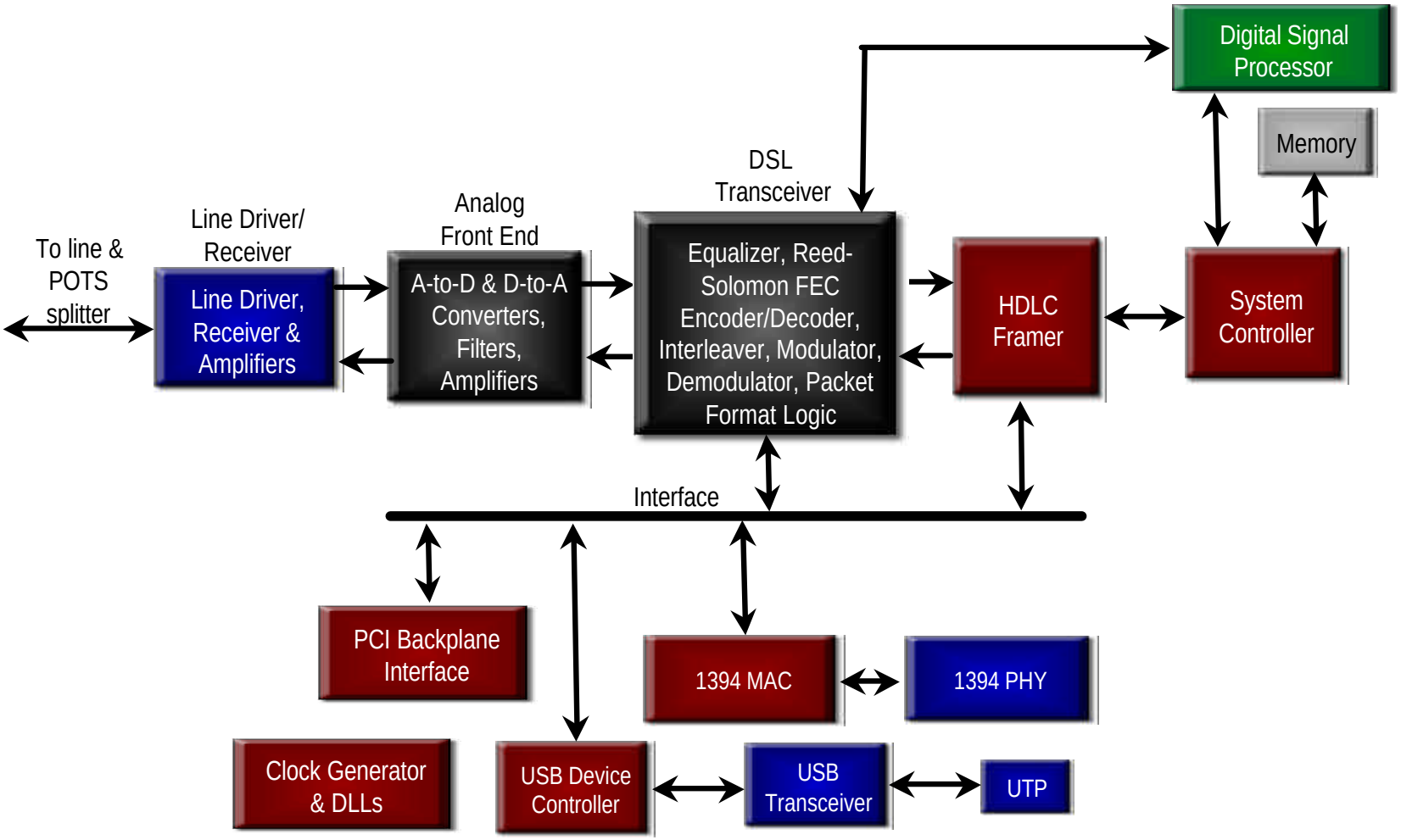
Cable Modem Residential Gateway



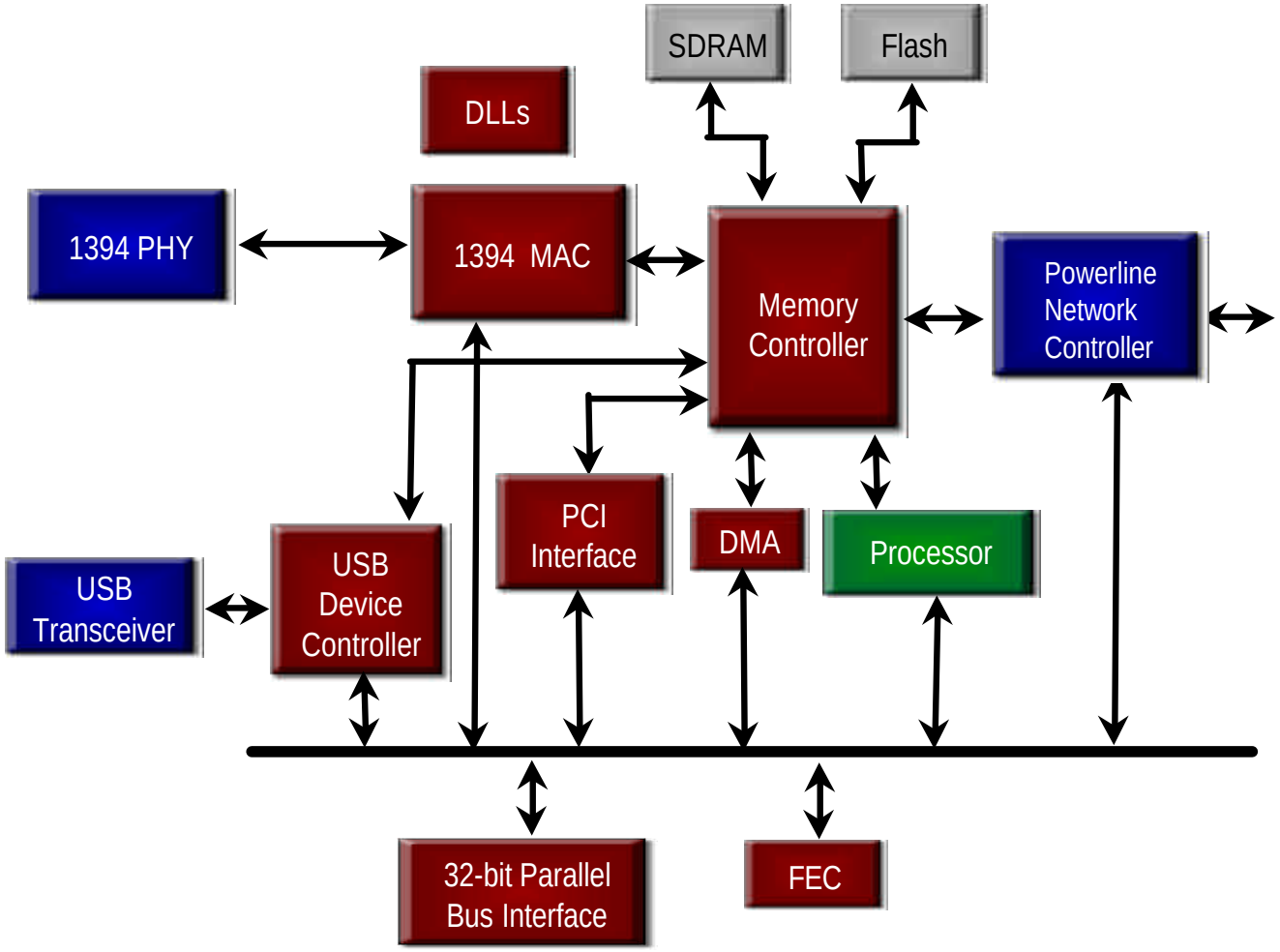
DSL Modem Home Gateway



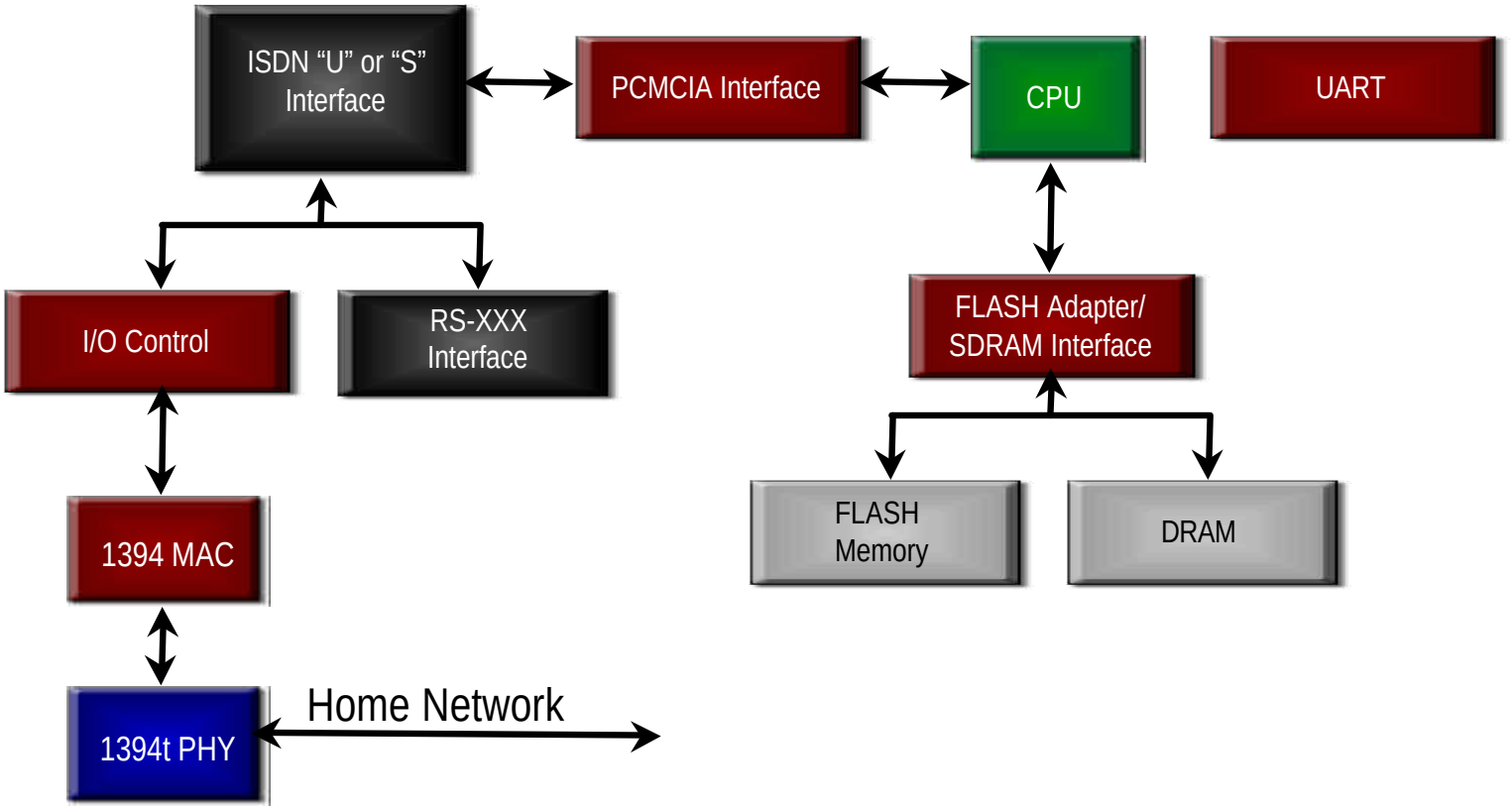
DSL CPE (Customer Premise Equipment)



HomePlug to 1394 Bridge



ISDN Modems


ISDN "U" or "S" Interface
PCMCIA Interface
CPU
UART
I/O Control
RS-XXX Interface
FLASH Adapter/ SDRAM Interface
1394 MAC
FLASH Memory
DRAM
1394t PHY
Home Network

Spartan-II IP Solutions for 1394 Enabled Devices

- I/O Control
  - Multiple front end interfaces
  - Multiple back end interfaces
- Hard disk drive interface
- Clock distribution
  - DLLs
- MPEG decoder
- Ethernet MAC
- Error Correction
  - Reed-Solomon, Viterbi
- Memory solutions
  - Distributed memory, BlockRAM
  - Memory controllers
- CPU
- HDLC controller
- PCI
- Glue Logic
  - LCD controllers
  - UARTs
  - DMA controllers

Programmable Solutions Advantages

Xilinx Programmable Solutions Provide Several Benefits

- Time to market
  - Consumer devices require fast time-to-market
  - ASICs & ASSPs take 12-18 months to spin out
- Flexibility
  - Product customization to meet customer needs
  - Accommodate multiple standards & spec updates/changes
  - Feature upgrades
- Testing and verification
  - Re-programmable allows risk aversion
  - Your solutions are built on a proven FPGA technology with pre-verified silicon and IP that guarantees performance

Xilinx Programmable Solutions Provide Several Advantages

- Xilinx On-line - field upgradability
  - Remote update of software and hardware
  - Results in increased lifetime for a product (time-in-market) and allows new, interesting applications
  - Enable product features per end-user needs
- Issues in creating a stand-alone ASIC/ASSP
  - Choosing the right solution
  - Product customization
  - Development cost and amortization
- Low Cost

Lifecycle Component Logistics

- Xilinx is an assured source of supply
  - Spartan FPGAs are high volume standard parts
  - Xilinx is a Strategic customer to our fab partners
  - If a device is retired, designs are quickly portable
- Xilinx's solutions reduce exposure to component supply issues
  - Designs can be quickly adapted to efficiently address component supply problems
    - NAND to NOR type Flash support for example
  - Gives latitude in maintaining a cost effective BOM in dealing with the allocation, end of life & generational migration realities of today's component market

Specification Changes

- Emerging markets are exposed to multiple standards and specification changes
  - DSL Modem market
    - 6 different variations
  - DTV market
    - 18 different formats

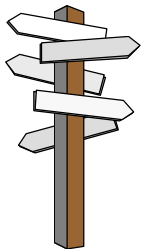
U.S. Networks Select Digital Broadcasting Format

ABC	720-Progressive. For non-HDTV broadcasts, ABC will use 480-line progressive format.
CBS	1,080-Interlaced. Wants to be compatible with HDTV sets as well as normal quality formats on regular analog television sets. Digital broadcasting will begin at select CBS-owned stations in the fall of 1998. By November 1999, CBS plans to be broadcasting digitally into 43% of U.S. households. For other broadcasts, CBS will use the 480-line Interlaced format.
NBC	1,080-Interlaced. NBC is leaning toward 480-line progressive for non-HDTV broadcasts.
FOX	720-Progressive. For non-HDTV broadcasts, Fox will use the 480-line progressive format.
PBS	For HDTV, PBS is undecided. For non-HDTV broadcasts, PBS will use the 480-line interlaced format.
Local Stations	Will have to conform to their network's format for national programming but can select any format for local programming.

Source: IC Insights

OEM/ Vendor

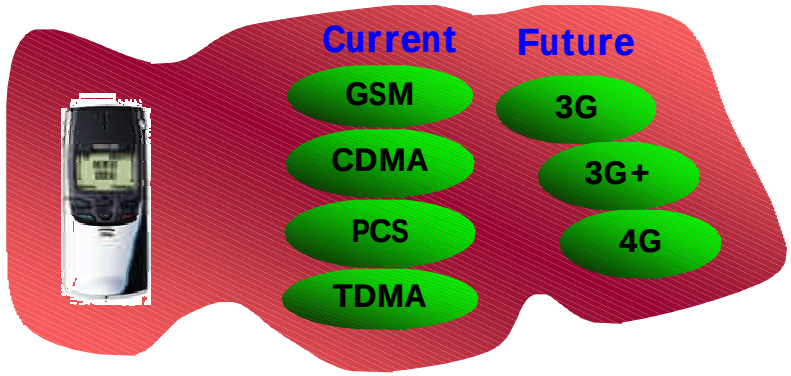
Market



A Programmable Solution Future Proof's Success

New Flexibility from FPGAs

Driving down the cost of consumer products with low cost reprogrammable products



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Enabling a whole new breed of consumer products

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Reprogrammable nature allows
- Field upgrades
- Field fixes
  - Mars probe repair from earth
- Support for numerous standards

Xilinx & Replay TV
- Revolutionizing consumer TV

FPGAs, the Unsung Hero

Driving the Consumer Digital Logic Revolution

- The digital consumer world is here
  - Imperatives driving market success
    - Time to market and time-in-market
    - Flexibility
    - Custom digital logic

- Xilinx - The answer for consumer digital applications
  - Introducing the low cost Spartan-II programmable family
    - Cost reduced for the consumer market
    - Fully programmable at the desktop, in the field or in the application
    - Future proofed for changing standards

Xilinx Digital Consumer Logic

A Natural Fit for Home Networking

- Xilinx solutions enable you to thrive in chaos
  - Fastest time-to-market
    - First to market, gains market share and revenue advantage
  - Xilinx Online provides reconfigurability in the field
    - Allows shipped product to support revisions to the spec
    - Enables unique opportunities to add Value
    - Increases life-cycle revenue yield & hence time-in-market
  - Enables rapid product proliferation
    - New designs can be quickly turned into derivatives
  - Feature superior lifecycle component logistics
  - Testing and Verification
    - Proven FPGA technology, software, test benches
- Cost Effective!!!

Agenda

- Introduction
  - Market trend and application
    - 1394 Market Analysis Data
    - 1394 and industry
    - Applications
- Technology
  - What is 1394?
  - Why 1394?
  - Applications
  - 1394 Protocol
  - PHY
  - Link Layer
  - Transaction Layer
  - 1394 Operation
  - Bus Management
  - Cable and Connection
  - Architecture
  - Topology
- Other Technologies
  - USB
  - DVI
- 1394 In Home Networking
- Xilinx Value
- Alliances
- Summary

IEEE 1394 Trade Association

- Was founded in 1994
- Supports the development of electronics systems which can be connected with each other via a single serial multimedia link
- Comprised of more than 170 member companies
  - Sony, Intel, Microsoft, JVC, IBM, Matsushita, Compaq, NEC, Philips, Samsung, and …..
- Is incorporated as a nonprofit trade organization

HAVi
(Home Audio Video interface)

- Is a none profit association of leading consumer electronics, software, semiconductor, and computer manufacturers
- The goal is to promote a network architecture for Home Audio/Video Interoperability
- Was founded by
  - Grundig AG, Hitachi, Matsushita (Panasonic), Philips, Sharp Sony, Thomson, Toshiba
- Xilinx is a participant member of HAVi

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1394 In Your Home

- Digital broadcasting, the Internet, digitalization of modern homes, entertainment & video appliances are driving demand for 1394-based products
- Supports data transfer rates @ 100, 200, 400 Mbps
- 1394 benefits
  - No need for terminators, device IDs, or elaborate setup
  - 1394 is Hot pluggable
  - 1394 has scaleable architecture
    - May mix 100, 200, and 400 Mbps devices on a bus
  - 1394 has flexible topology
    - Support of daisy chaining and branching without CPU

Summary

- Various 1394-based products are being developed
  - Residential gateways: DSL, cable, satellite modem
  - Technology bridges: Ethernet-to-1394, 1394-to-HomePNA, 1394-to-wireless LANs
  - 1394 enabled information appliances: digital TV, DVD player, Internet screen phones, PCs, printers, etc.
- Spartan-II FPGAs, CoolRunner & 9500 CPLDs provide system interconnectivity in 1394/Firewire based products