Phonelines-Based Home Networking

Xilinx Spartan-II FPGAs Enable HomePNA-Based Solutions

Agenda

- Home networking - the complete solution
- Introducing phoneline home networking
- Industry initiated consortiums - HomePNA
- Phoneline home networking technology
- HomePNA solutions available today
- Xilinx Solutions for phoneline home networking (HomePNA) based products
- Summary

Home Networking - The Complete Solution

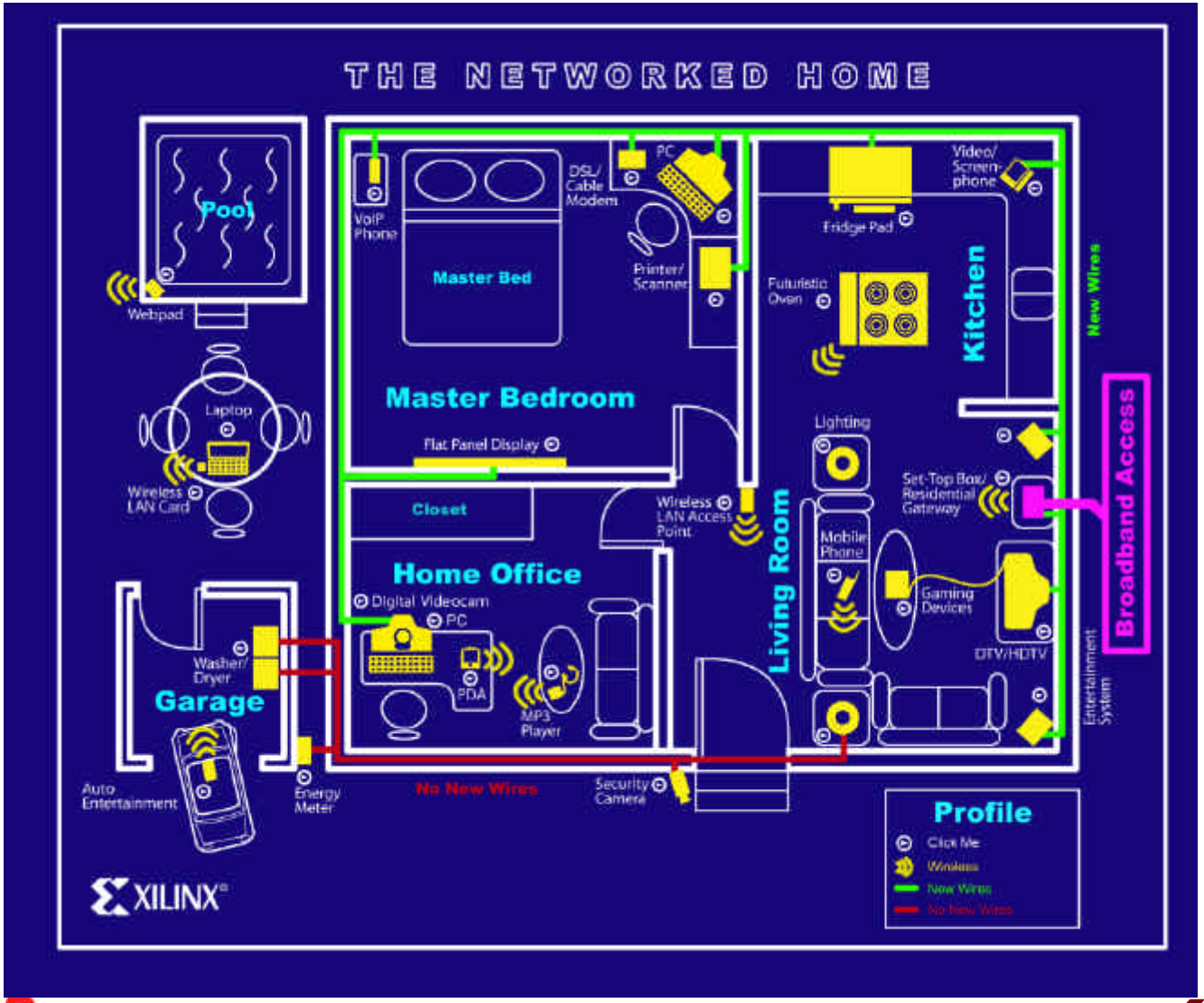
Vision

What is Home Networking?

- Distribution of audio, video and data between information appliances
  - Provide communication, information, multimedia & automation services anywhere and anytime around the home
    - Bring the Internet to the hands of the consumer
    - Interconnect people in data, voice and video
- The interconnection and interoperability of
  - Home appliances
  - Entertainment devices
  - PC hardware
  - Telecommunication devices
  - Security, lighting and environmental control systems

It's All About Convergence!

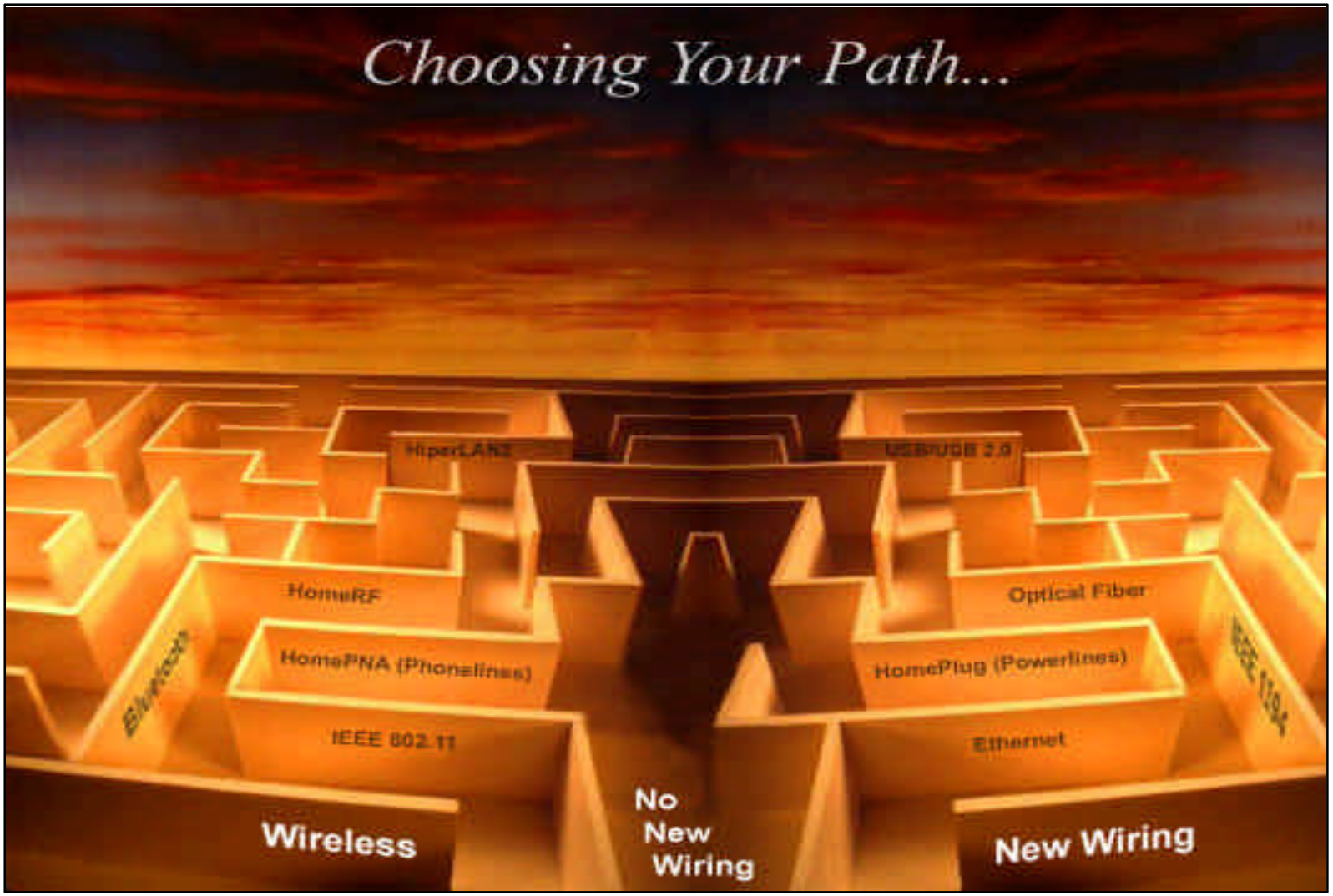
Problem: Islands of Technology



Market Requirements and Solutions Available

	Market Requirements	Solutions Available
Broadband Access	High Speed Access for Data, Voice and Video, Always on, Simultaneous Up-link &Down-link Communication, Support Simultaneous and Multi-User Access	xDSL, Cable, Powerline, Satellite, Mobile/Wireless
Residential Gateway	Provides Access into the Home, Remote Management Access Platform, Bridging between Different Networks, Firewall and Security, E-Services Capabilities	Open System Gateway initiative (OSGI), Jini, UPnP, HAVi, DVI
Home Networking Technologies	Low Cost, Speed, Mobility, Quality of Service, Security, Reliability, Ubiquity, Ease of Use	No new wires (Phonelines, Powerlines), New wires (Ethernet, 1394, USB2.0, Optic Fiber), Wireless (HomeRF, Bluetooth, Wireless LAN)
Information Application Networks	Digital electronics with advanced computational capabilities that add more value and convenience when networked	Digital TV, HDTV, set-top box, internet screen phones, digital VCR, gaming consoles, MP3 players, cordless phones, security systems, utility meters, PCs, web pads & terminals, PDAs, digital cameras, auto PCs etc.

Home Networking Technologies



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Introducing
Phonelines Home Networking

The Home Networking Challenge

- Creating a technology that can deliver high-speed networking in the home is a challenging task
  - Commercial networks are designed from the ground up to minimize noise & interference
    - High-speed, corporate networks typically use fiber optic, twisted pair, or coaxial cables that are dedicated for a single use
    - Manufacturers are free to design commercial network products for reliable, noise-free environments
  - Most homes do not have dedicated high-speed network wiring
    - Cost & labor required to install such wiring is high for homeowners & small business owners to fund

Home Networking Requirements

- Consumers prefer home networks that
  - Use the existing wiring infrastructure
  - Are easy to install
  - Leverage existing standards
  - Work together with common OS and software platforms
- Home networks must implement a QoS mechanism
  - Quality of service provides low latency for telephony, and streaming audio & video applications
- Home networks should be very robust and provide connectivity to essentially every home

Home Networking Requirements

- Home networks should support data rates in excess of 10Base-T Ethernet
  - Provide scalability to 100Mbps
  - Compatible with earlier generations and be future safe
    - Employ scalable & extensible designs to prevent “fork-lift” replacements when upgrading networks in the future
- They must provide reasonable privacy at the physical layer
- Home networks must be implementable at low cost with a wide variety of products

Phoneline Home Networking

- Networking information appliances in the homes using existing phone lines infrastructure
  - Using existing phone lines and regular phone jacks to connect consumer devices such as PCs, digital TVs, DVD/MP3/CD players to each other and to the Internet
  - Exchange of data, voice and video between appliances using phone lines

Are Phonelines A Natural Solution for Home Networking?

- Yes
  - Phonelines meet most of the HN requirements
    - Uses pre-existing home telephone wiring to transmit data
  - Phonelines HN is promoted aggressively by the home phoneline networking alliance (HomePNA)
    - 115+ members
    - Endorsed by top OEMs for different industries
      - PC manufacturers sell phoneline home networks as add-on with PCs
  - Technology can be easily integrated into silicon

Are Phonelines A Natural Solution for Home Networking?

- But
  - Home phonelines were not designed for high speed data transmission between multiple appliances
  - Phone jacks are not ubiquitous in every home worldwide
    - Technology could lose momentum when it attempts to move beyond the US
      - While US households tend to have multiple phone jacks, other countries are often limited to one or two phone jacks per home
  - Homes with multiple phone lines are limited to confining the network to one phoneline

Issues

- Random wiring topologies & signal attenuation
  - Telephone wiring structure within each home is different
  - Home phoneline wiring system is a random “tree” topology
    - It is not a hub structure similar to business networks
    - Simply plugging in the phone or disconnecting the fax changes the tree
    - This topology can cause signal attenuation
      - Open plugs & unterminated devices can cause impedance mismatches, signal echoes & lead to multi-path signals
- Signal noise
  - Appliances, heaters, air conditioners, consumer appliances & telephones can introduce signal noise onto the phone wires

Issues

- Changing transmission line characteristics
  - Network must be able to function reliably despite changes resulting from someone picking up the phone or receiving a fax, or an answering machine recording a message
- Coexistence with other phone line equipment & compliance with FCC regulation
  - Must use signals with low power levels
    - Further complicates the task of establishing adequate signal-to-noise ratio
  - Must work without interrupting existing phone services
- Performance
  - High reliability at speeds of at least 1Mbps

Phoneline Market Outlook

- Huge short-term and long-term growth outlook for phoneline home networking*
  - In 2000, phoneline-based home networks will account for 34% of the installed base
  - By 2004, proportion will grow to 72% of total HN market's installed base
    - Widespread PC OEM support & multiple aftermarket solutions
    - HomePNA is the de facto phoneline networking standard
    - Widespread educational marketing campaign will gain marketing acceptance for the technology

* Source: IDC

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Consortiums - HomePNA

Home Phoneline Networking Alliance

About HomePNA

- An association of 115+ industry-leading companies
  - Represented by PC, networking, semiconductor sectors
  - Founded by 3Com, AMD, AT&T, Compaq, Epigram (now Broadcom), HP, IBM, Intel, Lucent Technologies, Conexant & Tut Systems
  - Xilinx is a member & active participant
- Ensures adoption of a single, unified phoneline networking standard and rapidly bring to market a range of interoperable home networking solutions

Importance of the Alliance

- Leading companies have combined their efforts to foster the creation of standards for an entirely new market
  - Become the de facto & officially adopted std.
- Facilitates the rapid proliferation of affordable in-home networking products
- Alliance has adopted a technology from Tut Systems that will allow consumers to establish home networks that can run 1Mbps over existing telephone wires
- Member companies pool their resources
  - To develop future specs for higher speed home phoneline networking & interoperate

Primary Objectives

- Ensure mass deployment
  - Consumer friendly, low cost, no-new-wires solution for in-home, phoneline based networking solution
- Industry standardization
  - Through widespread deployment & acceptance by appropriate standards bodies such as ITU & IEEE

Primary Objectives (contd.)

- Develop certification standards to ensure interoperability
  - Between HPNA products from broadest range of technology & equipment vendors
  - Between complimentary home networking technologies such as HomeRF
  - Compatibility with high-speed Internet access technologies such as UADSL
- Define & articulate a roadmap for current & next-generation technologies
  - Ensuring investment protection through backward compatibility

Advantages of HomePNA

- Ensures a single, unified phoneline networking standard
  - Widely supported alliance
    - Rapidly brings to market a range of interoperable home networking solutions
    - A single, well-known standard helps alleviate confusion
      - Enables more sales
- Inexpensive
  - Several solutions at lower prices
- Easy installation & network management
  - “No new wires” concept kept in place
- Robust data throughput solution

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Phoneline Home Networking Technology

Technology - Leveraging Standards

- Only protocols that have been extensively tested for many years in real use are ready for large scale deployment
- HPNA has chosen IEEE-802.3 layer 2 networking
  - Uses 802.3 framing & Ethernet CSMA/CD MAC behavior
- Guarantees
  - Interoperability between equipment from multiple manufacturers
  - Support for networking standards, particularly IP suite

Technology - QoS Support

- HN applications such as transport of digital audio, video and voice (IP telephony) drive the need for QoS
  - Latency in voice connection must be controlled below 10 to 20 ms for voice quality to be maintained
- HPNA 2.0 has an aggregate throughput of 10Mbps
  - Adequate for many application scenerios
  - Burst loads presented by TCP transfers between PCs without QoS makes the network unable to meet the latency & guaranteed bandwidth service requirements
- HPNA 2.0 MAC layer introduces 8 priority levels & an improved collision resolution technique

Technology - Robustness

- Ad hoc home wiring topology results in
  - Reflections & frequency-dependent channel transfer functions
  - Uncharacterized & highly variable wire transmission parameters especially at higher frequencies
  - Telephone instruments on the same wiring that present a wide range of frequency-dependent impedance
  - POTS signaling & ringing which produces significant transients
  - Impulse noise coupled from AC power wiring that is seen on many phonelines
  - RF ingress & egress particularly in the amateur RF bands
- Phonelines are robust supporting up to 500 feet of phone wire between devices connected to RJ-11 jacks

Technology - Performance

- Rating of up to 10Mbps
- HPNA 2.0 with a self-describing frame format with PHY-level signals directly control equalizer training & demodulation

Technology - PHY Layer Privacy

- Powerline & wireless technologies allow users to share the same physical medium
  - Encryption at the link level helps attain a degree of privacy equivalent to the phone line
  - Requires some user user key configuration thus defeating the plug-and-play objective
- Privacy in phone wires is not a substitute for true cryptographic security

Technology - Future Safeness & Cost

- Future safeness
  - Once installed home networks remain in place for several years
  - Home networks interfaces become embedded in appliances and impossible to replace
  - Good HN technologies build future generation interoperability into current generations
- Cost
  - Home networks should be at consumer prices with few, additional requirements of external components

Phoneline HN Technology

- Based on HomePNA 2.0 - the de facto industry standard
- Easy to use
  - User must install the software, set up the network through both the software settings & physically connect to the phone jack
- Security is excellent
  - Each home has a unique phone circuit (phone number) from the phone company's CO

Critical Aspects of the Phoneline HN Technology

- Foundation is based on Ethernet technology
  - Packet based architecture
- Spectral compatibility
  - Allows the network to coexist with other telephone services and emerging broadband Internet access
- High performance encoding scheme

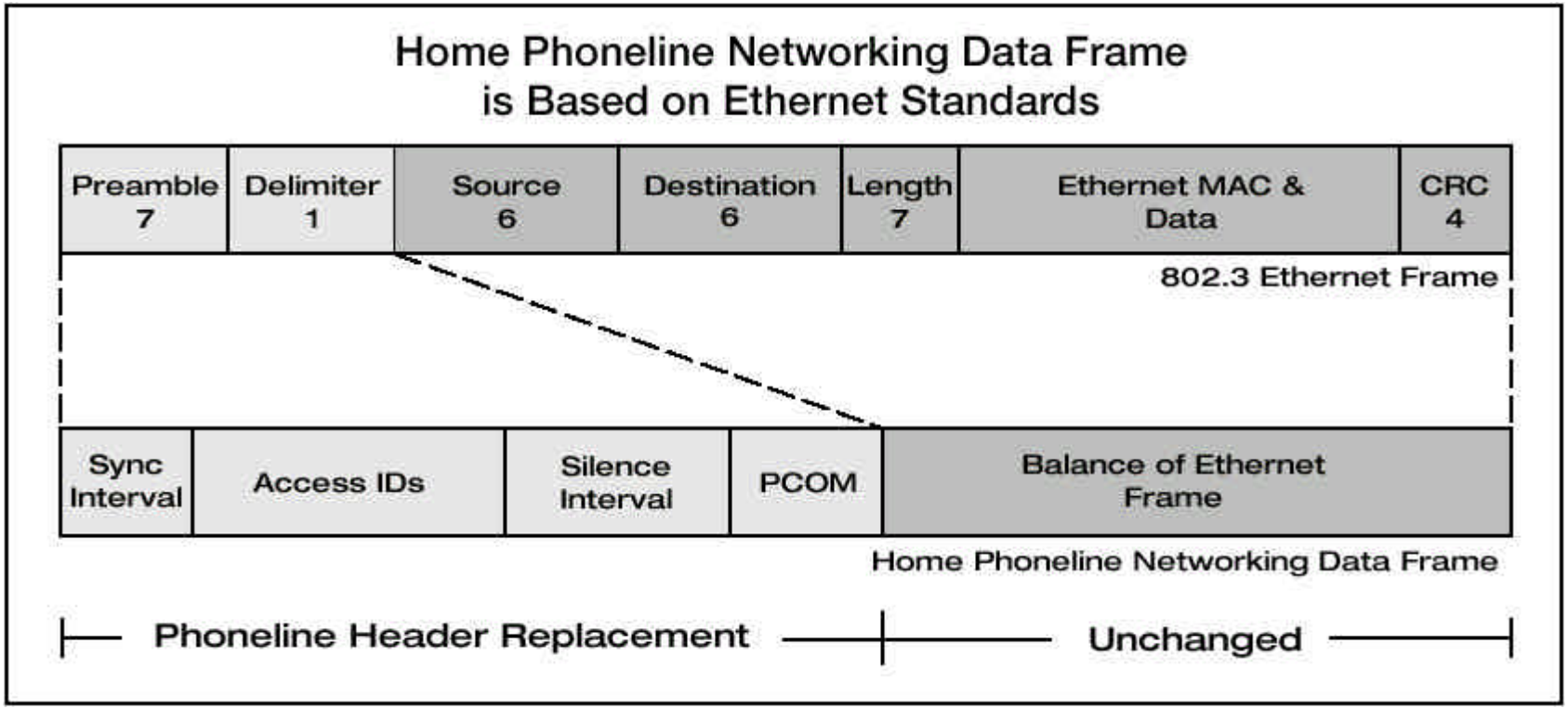
Leveraging Ethernet Technology

- Home phoneline networking technology uses standard Ethernet technology
  - It is adapted to overcome challenges of the home phoneline environment
  - Enables phoneline HN to leverage the tremendous amount of Ethernet-compatible software that exists today while meeting the needs of the home environment
- IEEE 802.3 compliant MAC
- CSMA/CD as access method for sharing the baseband signal on the home network bus
  - Carrier Sense Multiple Access with Collision Detect

CSMA/CD

- When a station has data to send, it first listens to the channel to see if any other station is transmitting
- If the channel is busy, the station waits until it becomes idle
- Collisions occur when 2 stations listen for traffic, hear none, and then transmit simultaneously
  - This causes both transmissions to be damaged
  - Stations must retransmit at some later time
- Back-off algorithm determines when the colliding stations should retransmit

Leveraging Ethernet Technology



Source: Intel Corporation

The home phoneline networking data frame is based on Ethernet standards with a specialized header

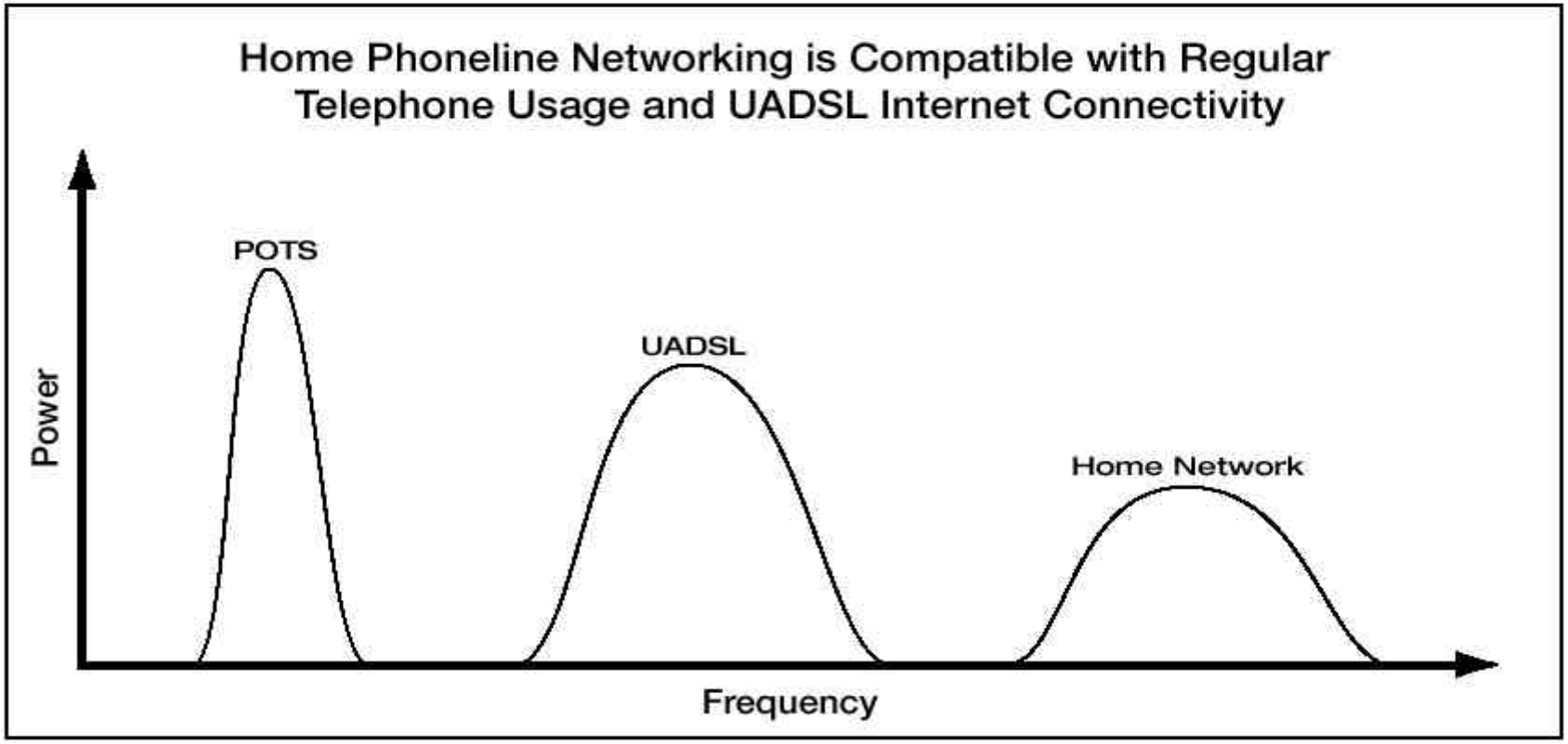
Leveraging Ethernet Technology

- Data originating from applications within the PC
  - Formed into standard 802.3 Ethernet data frames
  - Passed to the phoneline PHY
    - PHY circuitry strips off the first 8 octets of the Ethernet frame (preamble & delimiter fields) and replaces it with a PHY header designed specifically for phoneline networking
- Receiver - Reverse is executed
  - PHY is used to establish the validity of the frame
  - PHY header is stripped off & replaced by a IEEE 802.3 compatible preamble & delimiter field
  - At this point the PHY can pass the frame to a standard Ethernet controller for passage to upper layer applications

Peaceful Co-existence: Spectral Compatibility

- Ensure compatibility with other communication services within the home
  - Home phoneline networking must work with voice & emerging UADSL (universal asynchronous DSL) data services
- Home phoneline networking uses filtering technology - Frequency Division Multiplexing (FDM)
  - Allows simultaneous operation of multiple services over single pair of wires
  - In POTS bandwidth is segregated into channels for each type of traffic - power, analog voice, digital information (audio, data & video)

Peaceful Coexistence: Spectral Compatibility



Source: Intel Corporation

Spectral usage of three services (POTS, UADSL & home phoneline networking) share the same line by operating at different frequencies

Spectral Compatibility

- Frequency Division Multiplexing (FDM)
  - Each communications service is assigned a frequency spectrum different from all others
  - Using frequency-selective filters devices using one type of service can exchange information without interference from other services that communicate in another frequency band
- Frequency range
  - Home network operates between 5.5MHz - 9.5MHz
    - Passband filters attenuate frequencies below 5.5MHz very rapidly to eliminate interference very rapidly to eliminate interference with other potential services sharing wire
  - Standard voice communications operate in 20Hz - 3.4kHz
  - UADSL services occupy 25kHz - 1.1MHz

High Performance Encoding

- Home phoneline networking technology uses time modulation line coding method
  - Developed & patented by Tut Systems
  - Increases data throughput
  - Allows reliable transmission of data over the unknown cabling system of home phone wiring at 1Mbps
  - Incorporates an adaptive circuit
    - Can dynamically correct for varying environmental conditions characteristic of residential phonelines

High Performance Encoding

- Both transmit & receive circuits continually monitor line conditions & adjust settings accordingly
  - The receiver circuit of the PHY layer adapts to the varying noise levels on the wire
  - The transmitting circuit is adapting output signal strength to match requirements of other receivers
- 'Squelch' algorithm sets the minimum & maximum signal levels
  - The receiver can filter out extraneous noise that otherwise might compromise data transmission & reception

HomePNA 2.0 Specification

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HPNA 2.0 Spec Introduction

- HPNA 2.0 defines the PHY & MAC layers for a system
  - PHY-layer payload transmission rates of 4 - 32 Mbps with throughput rates equivalent to 10Base-T Ethernet
    - Provides ability to extend transmission rates to over 100 Mbps
  - Rate adaptive transceivers
    - Optimize data rates and packet error rates for dynamically varying channel conditions on a per-packet basis
  - Frequency Diverse QAM techniques provides robust communication over highly frequency selective channels

Spec Introduction (contd.)

- IEEE Std 802.3 “Ethernet” MAC
- Compatibility with IEEE Std 802.3 MII
- Backward Compatible with HomePNA 1M8
  - Allows interleaved transmissions at 1 Mbit/s rates and 10M8 compatibility mode rates
- Compatibility with other phoneline services such as POTS, V.90, ISDN and G.lite
- Spectrum notching for compatibility with Amateur Radio services

HomePNA Protocol

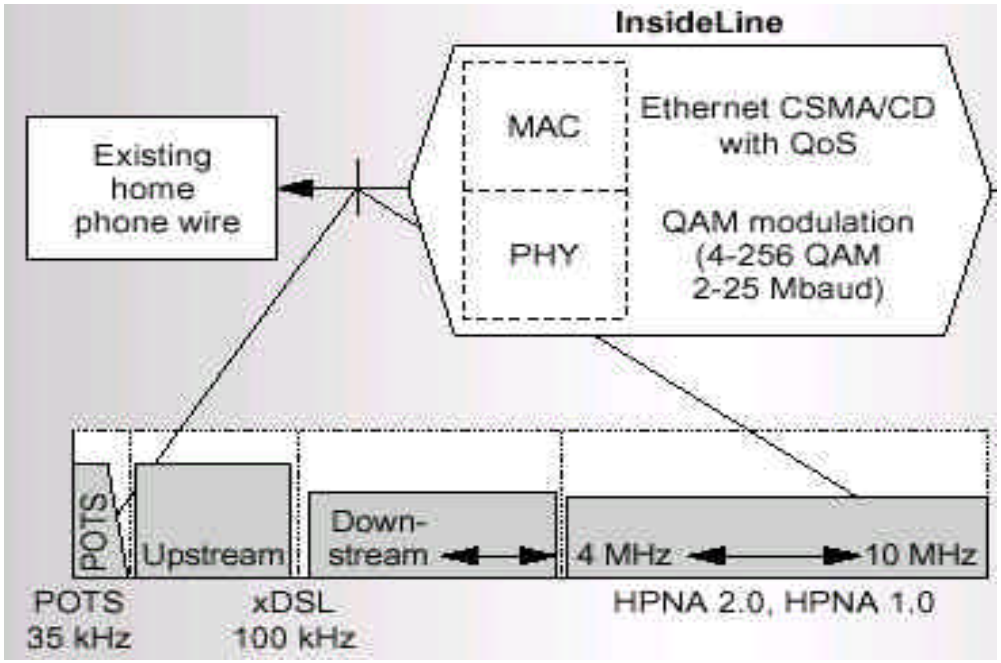
Network Stack and Responsibilities

- PHY layer
  - Framing, scrambling, symbol mapping, modulation
- MAC layer
  - CSMA/CD
  - Collision resolution
- MII (media independent interface)
  - MAC-PHY interface
- Link layer protocols
  - Rate negotiation, link integrity, link ARQ, capability announcement

HomePNA 2.0

- Current 2.0 spec was introduced in late 1999 by HPNA
  - This revised spec is backward compliance with the 1.0 spec
- Throughput rating of 10Mbps
  - Products show an active throughput in 7-8Mbps range
  - Sufficient for most home networking applications
    - Not sufficiently fast for users engaged in streaming video applications
- HPNA 2.0 spec can support up to 25 PCs, peripherals & other network devices

View of the HPNA 2.0 Stack & Spectrum



Source: 2000 IEEE, HPNA 2.0

HPNA 2.0 System from Point of View of the Network Stack and Frequency Spectrum

Physical Layer

- System is FDM on the same wire as used by the std. analog phone service & splitterless ADSL
  - Analog telephony uses low part of the spectrum - below 35kHz
  - ADSL uses spectrum up to 1.1 MHz
  - HPNA selected 4 to 10 MHz band
    - Lower limit of 4 MHz makes it feasible to implement the filters needed to reduce out-of-band interference between HPNA & ADSL
    - Modeling phone networks shows the spectrum above 10 MHz to be have wider & deeper nulls caused by reflections
    - Cross talk between phone lines increases with frequency
      - Analog front end is harder to implement at higher frequencies
    - Choice of 4-10 MHz only overlaps a single amateur radio band (40m) which simplifies ingress & egress filtering

Physical Layer

- HPNA 1.0 uses pulse position modulation (PPM)
  - This technique adapts to the modulation rate
- HPNA 2.0 uses quadrature amplitude modulation (QAM)
  - Get more throughput in the same bandwidth
  - Achieve greater robustness
- Both techniques are used
  - Because the channels may have very deep nulls & multiple nulls in band

Physical Layer

- The transmitter may vary the packet encoding from 2-8 bits/symbol on a packet-by-packet basis
  - This is instead of having a fixed number of bits/symbol
  - A packet header is always encoded at 2 bits/symbol so that every receiver can demodulate at least the packet's header
  - System uses a fixed 7MHz carrier freq. & can operate at either 2 or 4 Mbaud with modulation encoding of 2-8 bits/symbol
    - Base symbol rate is 2 Mbaud
      - At this rate, the system has a peak data rate ranging from 4 to 16 Mbps
      - Overhead reduces the actual throughput the system can achieve
    - In practice, to achieve performance equivalent to 10Base-T Ethernet, a packet must be sent at 6 bits/symbol

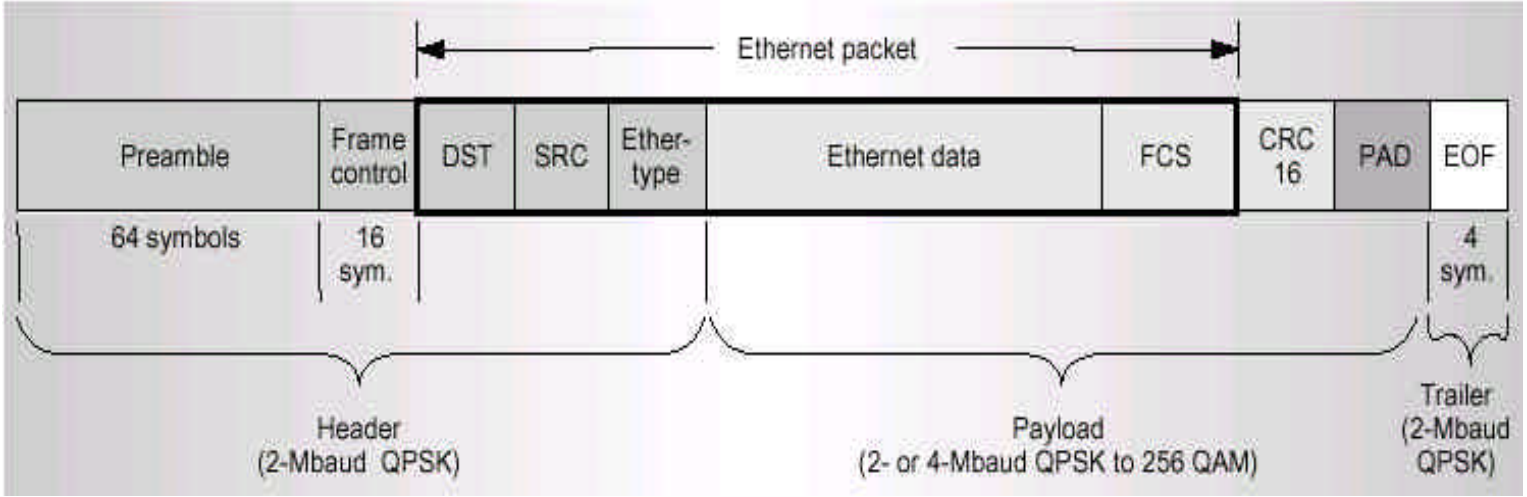
Frequency-Diverse QAM

- HPNA 2.0 implements a modified version of QAM at its 2-Mbaud rate called frequency-diverse QAM (FDQAM)
  - The nature of channel nulls can be such that even rate adaptation down to 2 bits per symbol is not sufficient to guarantee that the packet can be received
  - In a traditional QAM system, if there is an extreme null (i.e., one with which the equalizer can't cope) in the band, the system will fail to operate
- HPNA 2.0 allows for a higher performance 4-Mbaud mode, which achieves peak data rates up to 32 Mbps & through-put above 20 Mbps
  - In cases where the channel nulls are not particularly deep

Frequency-Diverse QAM

- Signal is frequency diverse, motivating the name FDQAM
  - The baud rate is less than half the filter's width
  - Output signal has 2 (redundant) copies of the baseband signal
    - In a traditional QAM system, a single copy of the baseband signal is sent & received
  - One copy of the signal will still make it through
    - On channels with a low SNR ratio, where a large part of the spectrum is severely attenuated, FDQAM works robustly in many cases where uncoded QAM would fail
    - Such channels are common on home phone lines
  - Simplified protocol enables robust performance over time-varying channels
  - Unlike other methods of handling severe channels, in FDQAM does not require the transmitter to have knowledge of the channel characteristics

Frame Format



Source: 2000 IEEE, HPNA 2.0

- Frame includes
  - Preamble, frame control, 802.3 Ethernet frame, CRC16, padding and EOF (end-of-frame) sequence

Frame Format Fields

- Preamble
  - 64-symbols at the beginning of the frame
  - It supports robust carrier sensing & collision detection, equalizer training, timing recovery & gain adjustment
- Frame control
  - 8-bit frame type which follows the preamble
  - Following the frame type is an 8-bit field that specifies the modulation format (bits per symbol, for example)
  - There are other miscellaneous control fields in frame control including an 8-bit CRC header

Frame Format Fields

- IEEE 802.3 Ethernet frame
- CRC-16
  - Cyclic Redundancy Check
  - It covers the header and payload, & reduces the undetected error rate for severely impaired networks
- Padding and EOF sequence

Frame Format - Key to Operation

- The first 120 bits of the frame are sent at the most robust 2-Mbaud, 2-bits/symbol rate
- Any station able to demodulate a packet can do it at this encoding
- Even if the payload is encoded at a rate (bits/symbol) that the receiver can't demodulate, it will be possible to demodulate the header
- In this situation, the receiver sends a rate request control frame (RRCF) to the sender, asking it to reduce the number of bits/symbol or the symbol rate

Frame Format - In Practice

- System starts out sending at 2 bits/symbol
  - Unless the receiver sends an RRCF, asking for future packets to be sent at higher data rates
  - Several algorithms can be used to determine when to send RRCFs and to estimate the channel capacity using an approximate SNR and bit error statistics
  - The rate adaptation algorithm can optimize the rate used when sending to multicast and broadcast groups

Medium Access Control (MAC)

- HPNA 2.0 is a CSMA/CD system
  - Like the standard IEEE 802.3 Ethernet
- HPNA 2.0 introduces 8 levels of priority and uses a new collision resolution algorithm called distributed fair priority queuing (DFPQ)
- Using the Ethernet MAC does not guarantee any real service
  - Voice telephony requires a low-latency network service, and streaming audio or video applications require a guaranteed bandwidth service

MAC - Access Priority for VoIP

- Different access priorities with the VoIP station having a higher priority than best-effort file transfer traffic
- HPNA 2.0 accomplishes access priority by organizing the time following the interframe gap into an ordered series of priority slots
  - Access priority lets software define different service classes
    - Such as low-latency, controlled-bandwidth, guaranteed-bandwidth, best effort, and penalty
    - Each uses a different priority level

MAC - Access Priority for VoIP

- Within a given priority level, HPNA 2.0 uses a new algorithm for collision resolution
  - Each station keeps track of a back-off level & after a collision, randomly chooses to increment the back-off level by 0, 1, or 2
  - During a collision resolution cycle, stations incrementally establish a partial ordering
  - Eventually, only one station remains at the lowest back-off level and gains access to the channel

MAC - Access Priority for VoIP

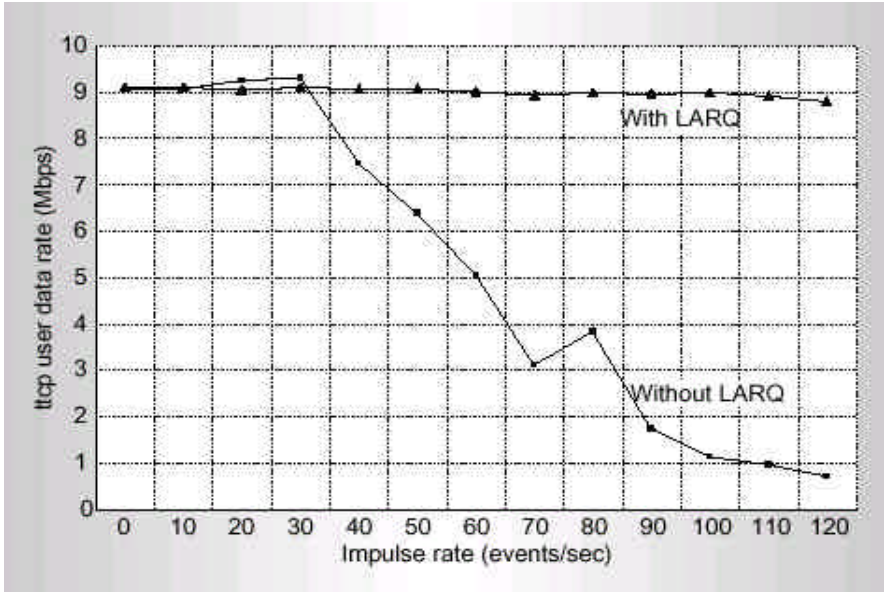
- In practice & even on saturated networks, HPNA 2.0 behaves very well
  - Unlike traditional Ethernet it does not exhibit the capture effect
  - As the offered load increases, Ethernet experiences delays of hundreds of frame times for several percent of transmission attempts
  - When compared with the Ethernet delay, the HPNA 2.0 access latency distribution reveals a negligible tail beyond twice the minimum time to service each active station, even at high offered loads

Link Layer Protocols

- Home networks using no-new-wires technology have another problem : impulse noise
  - On phone wires, impulse noise exists due to phone ringing, switch-hook transitions, & noise coupled from the AC power wiring
  - Fortunately, the impulses tend to be short and destroy only a single packet
  - There are coding techniques that might reduce the number of packets destroyed by impulses
  - HPNA 2.0 has however chosen to use a fast retransmission mechanism called limited automatic repeat request (LARQ)

Link Layer Protocols - LARQ

- LARQ is implemented (in software) at Layer 2
- Because it only operates on a single segment of the network, it is very effective in hiding packet erasure from TCP/IP



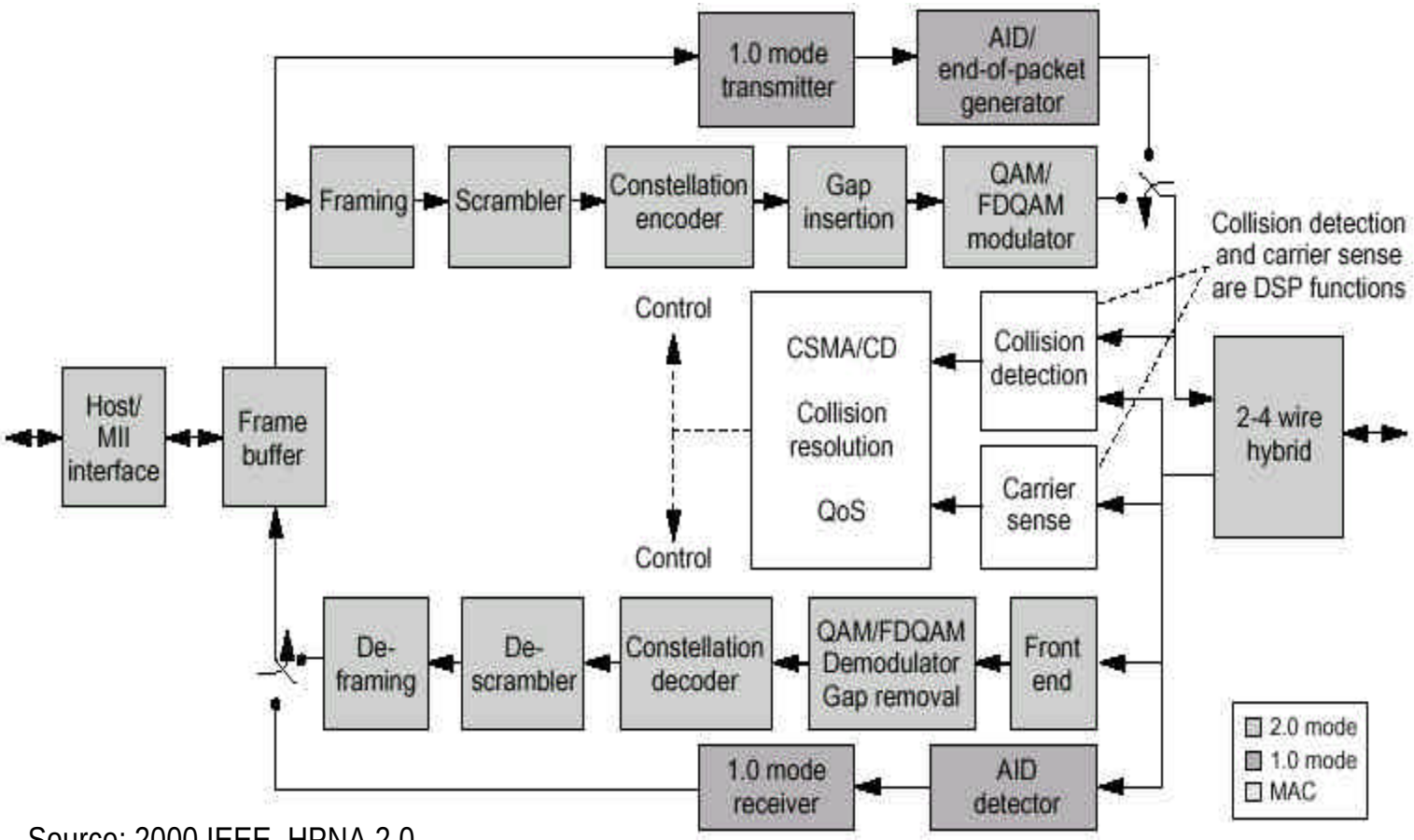
Source: 2000 IEEE, HPNA 2.0

User-level Throughput versus Impulse Noise Events/sec

Link Layer Protocols - Link Integrity

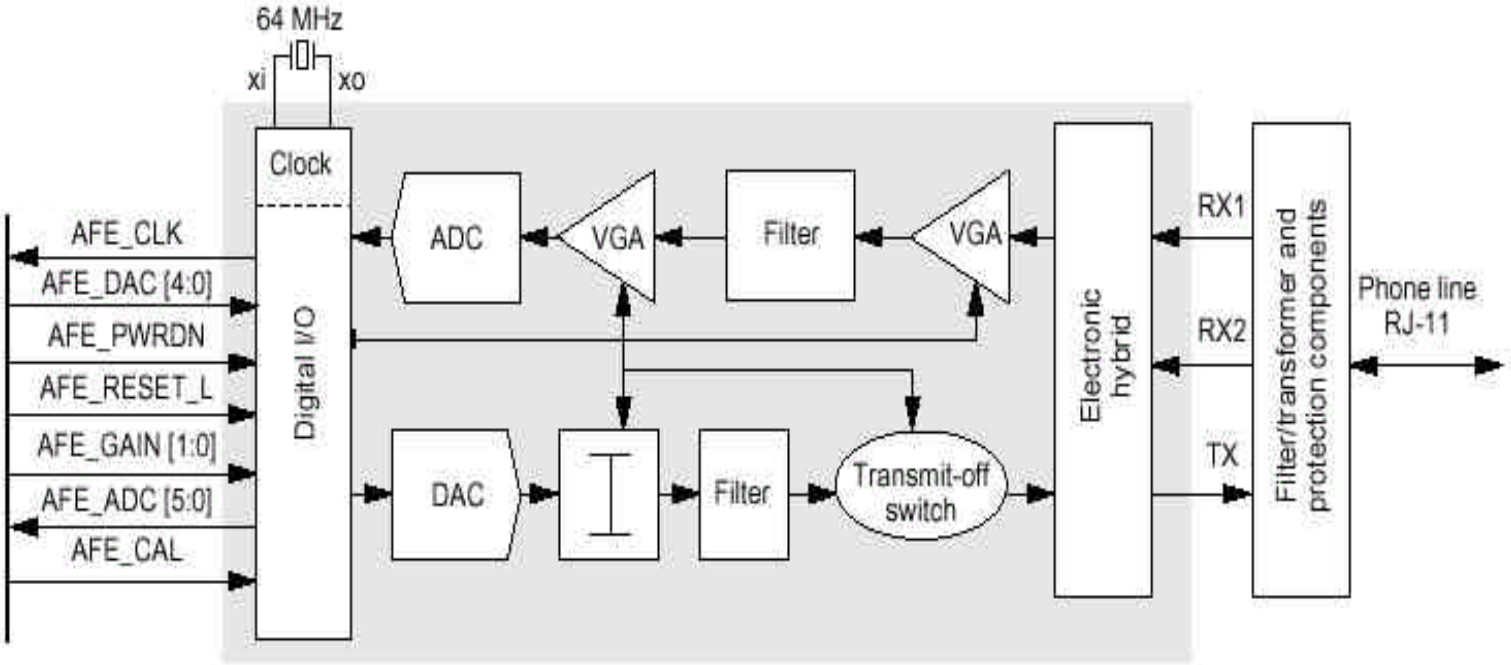
- HPNA 2.0 implements a link integrity mechanism
  - It can be implemented either in hardware or at low levels of a software driver
  - It provides a quick & easy way for the end user to determine if the network has basic connectivity
  - Link integrity frames are sent once per second, unless there is traffic on the wire, in which case a reduced number of frames may be sent

HPNA 2.0 MAC/PHY Block Diagram



Source: 2000 IEEE, HPNA 2.0

HPNA 2.0 Analog Front End Block Diagram



Source: 2000 IEEE, HPNA 2.0

HPNA 2.0 Technology

- Tut Systems & Epigram (Broadcom Corp.) are the alliance's initial technology providers
- Comparison with IEEE1394/FireWire specification
  - Firewire is a high-speed technology requiring new optical fiber or high grade copper wiring throughout the home
  - Firewire technology is used for special applications requiring enormous amounts of bandwidth
  - HPNA will be widely popular for applications with multiple PCs & for those looking for existing wires solutions

HPNA 2.0 Technology

- Phoneline based home networking
  - Will ensure interoperable & coexistence with wireless, powerline, Universal ADSL/G.Lite & Ethernet networks
    - Co-exists with the new splitterless Universal ADSL standard
    - Fully compatible with the Ethernet MAC layer standard (IEEE 802.3 CSMA/CD)
    - Meets FCC requirements
  - Complement high speed Internet access technolgies such as cable modems, ISDN, xDSL, satellite
    - Ensures sharing Internet access with all other PCs or devices in the home simply by plugging into the telephone jack with an adapter or NIC

HPNA 2.0 Technology

- Does not require any hubs or new Cat 5 wiring
- Supports the complex, random-tree type of wiring typically found in the home
- Such an arrangement requires no special terminations, filters or splitters
- Provides QoS
  - Allows streaming audio, video & telephony over the same wires through which Internet access occurs

Key Consumer Applications Require HPNA 2.0

- High speed Internet access sharing
- High speed file sharing
- Peripheral sharing
  - Printer, scanner
- Voice over IP (VoIP)
- Multimedia
  - Streaming digital audio & video throughout the home
- Backward compatibility & support for applications supported by HomePNA specification 1.0

Examples of Products that are Expected to Use the Technology

- PCs
- Modems (including cable, xDSL, satellite, analog)
- Network hubs
- IP telephones
- Digital TVs and set-top boxes
- Home security & automation
- Network appliances
- ‘Bridges’ to Ethernet, wireless, powerline, 1394, USB

Performance Requirements

- HPNA Spec 2.0 shall be capable of achieving nominal data rates of 10 Mbps over typical phonelines
  - Based on 10 Mbps 10BaseT Ethernet network
- Coverage over phoneline networks for HPNA spec 2.0 is defined as follows:
  - Achieve full rate throughput operation over at least 80% of home networks
  - Provide ability to connect, at no specified rate, in 100% of home networks
- Maximum internode distances are required to be greater than or equal to the HPNA spec 1.0

Performance Requirements

- Number of nodes supported on one network greater than or equal to HomePNA spec 1.0
- It is desirable that specifications feature adaptive capability above and below the nominal 10 Mbps rate
  - This allows optimization of throughput over the widest range of phoneline network topologies
  - This extends the coverage of homes served by HPNA spec 2.0 relative to the HPNA Spec 1.0
- It is desirable that specifications show scalability to future higher data rates well over 10 Mbps

Compatibility Requirements

- HPNA spec 2.0 addresses the physical and logical interface point between the phoneline and HomePNA network devices
  - This ensures interoperability between Promoter's/Adopter's home phoneline network products
- HPNA spec 2.0 should be electrically compatible with other services
  - POTS, V.90, ISDN & G.lite should coexist on the same phoneline

Backwards Compatibility With Earlier Specs

- HPNA Spec 2.0 specifies a mode for backward compatibility with HPNA Spec 1.0
  - The minimum requirement specifies a ‘fall back’ mode which selects operation of HPNA Specification 1.0 for all nodes
  - In a mixed network of HPNA Specs 1.0 and 2.0 nodes, all HPNA Spec 2.0 stations should communicate at their full 10Mbps rate
    - Regardless of the presence of HomePNA Spec 1.0 nodes
    - Without interfering with the HomePNA Spec 1.0 nodes

Interoperability

- With HomeRF products
  - HomeRF products work with HPNA-based products
    - TCP/IP is used in HPNA based products & HomeRF products fully supports TCP/IP
    - Consumer requires a bridge to interface the phoneline network to wireless HomeRF network
      - HomeRF SWAP spec defines this bridging
      - Vendors are currently developing future bridging products
- With Ethernet products
  - HomePNA is an Ethernet based technology and are seamlessly interoperable

So, Can We Use Powerlines for Home Networking?

Powerlines are also an Omnipresent,
'No New Wires' Solution!

Powerline Home Networking

- Uses existing power & electric lines in the homes
  - Quite similar to phoneline networks
- Several AC/power sockets/outlets in a home
- Powerline capabilities
  - Data rates up to 10Mbps are possible
- Low cost solution

Powerline Home Networking Pros

- Multiple power outlets can be fund in each room
- AC outlets are ubiquitous in virtually every existing home
- Powerline networking takes advantage of the unused capacity of the power cable to transmit data over the existing home power cabling
- Is capable of distributing data as fast as 10+ Mbps

Powerline Home Networking Cons

- Widely varying transfer response- frequency & attenuation
- Different types of noise impairments at unpredictable times
- RF jammers (particularly at night)
- Time delay spread (multipath)
- Usable bandwidth is not contiguous due to impairments or regulations
- Channel Adaptation is required to achieve high data rates and reliability

Noise Sources

- Switching power supplies
  - Rich in harmonics with oscillator 20Kh to > 1MHz
  - Conduct oscillator noise onto power line
  - Frequency often varies with load
- Universal series wound motors
  - Vacuum cleaners, kitchen appliances, drills
  - High repetition rate impulses

Noise Sources

- Light dimmers
  - Produce large impulses at 100-120 Hz
  - Large 20V to 50V impulses
- Power line intercoms
  - 3Vpp to 7Vpp from 150KHz to 400KHz
  - Large harmonics of about 30KHz bandwidth

Powerline Technologies

- X10
  - X-10 controllers send signals over existing AC wiring to receiver modules
  - X-10 power line technology transmits binary data using an Amplitude Modulation (AM) technique
- Intellon CEBus
  - Open standard that provides separate PHY layer specification documents for communication on power lines & other media
  - Data packets are transmitted by the transceiver at about 10Kbps employing spread spectrum technology
  - Uses a Carrier Sense Multiple Access/Collision Detection and Resolution (CSMA/CDCR) protocol to avoid data collisions

Powerline Technologies

- Echelon LONWorks
  - Provides a peer-to-peer communication protocol, implementing Carrier Sense Multiple Access (CSMA) techniques
- Adaptive Networks
  - Utilizes a hybrid token passing media access scheme as opposed to the peer-to-peer CSMA/CDCR schemes

Powerline Applications

- Industrial
  - Utility telemetering, automated storage, factory and machine automation, shipboard refrigerated container monitoring
- Commercial
  - Point-of-sale networks, public transit vehicles, residential LAN, vending machines monitoring

Issues to Overcome in Powerline HN

- Immature technology
  - Interference Issues
  - Low Speed and Attenuation
- Lack of standards
- Lack of consumer adoption
- Regulatory issues
- There is an added cost for the extra safety isolation needed with power connections
  - This type of modem is likely to remain significantly more costly than phoneline models but below the cost of wireless systems

Agenda

- Home networking - the complete solution
- Introducing phoneline home networking
- Industry initiated consortiums - HomePNA
- Phoneline home networking technology
- HomePNA solutions available today
- Xilinx Solutions for phoneline home networking (HomePNA) based products
- Summary

HomePNA Solutions

Chipset manufacturers & OEM Vendors

Product Portfolios

XILINX®

Chipset Manufacturers

Intel Corp, Tut Systems, Broadcom Corp,
Conexant Systems, Lucent Microelectronics,
AvioDigital

Broadcom Corporation

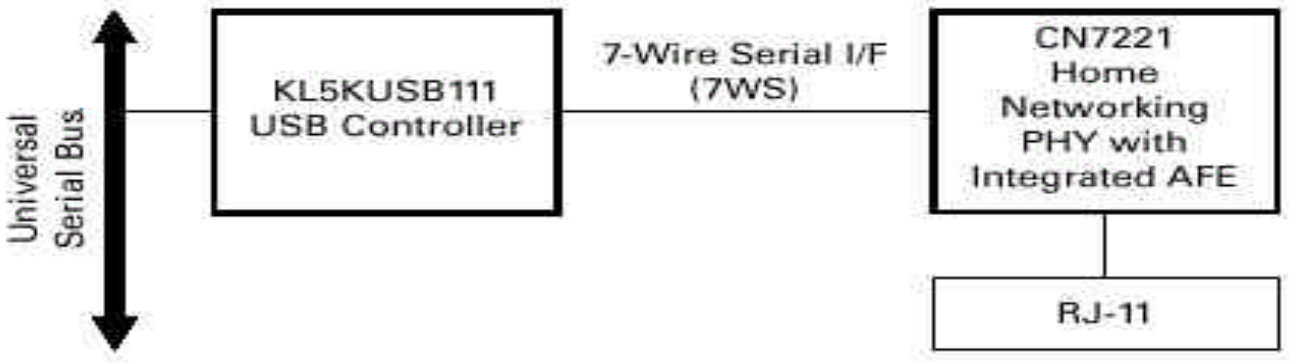
- Made its home networking entry through the Epigram acquisition in April 1999
  - Founding member of HomePNA
  - Creates silicon for consumer devices
  - Technology is being licensed by Lucent and other giants
- Supplies BCM4210/BCM4100 “iLine10” chipsets
  - Complete host bus to phone wire solution for home networking
  - Each code a packet of data so that the receiver can properly decode it

Broadcom Corporation

- BCM4210 MAC/PHY features
  - 10Mbps Ethernet controller for phoneline networks
  - Meets HPNA 2.0 proposed spec requirements
    - 16Mbps peak data rates
  - Integrated CSMA/CD Ethernet MAC with multi-level QoS
  - Integrated iLine10 digital PHY
- BCM4100 Integrated Analog Front End (IAFE) features
  - Custom IAFE for iLine10 controllers
  - Performs all required Analog Front End transmit & receive operations (PMD Function)
  - Transmit & receive filters
  - Analog to digital & digital to analog converters

Conexant Systems

- USB Home Networking Solution
  - KL5KUSB111 USB Controller
    - Interfaces the USB to the HPNA PHY layer
    - HPNA compliant MAC layer interface
    - IEEE 802.3-compliant 10Mbps Ethernet MAC layer interface
  - CN7221 HomePNA PHY layer device
    - Integrated Analog Front End circuitry
  - Interfaces to the USB port for easy system installation



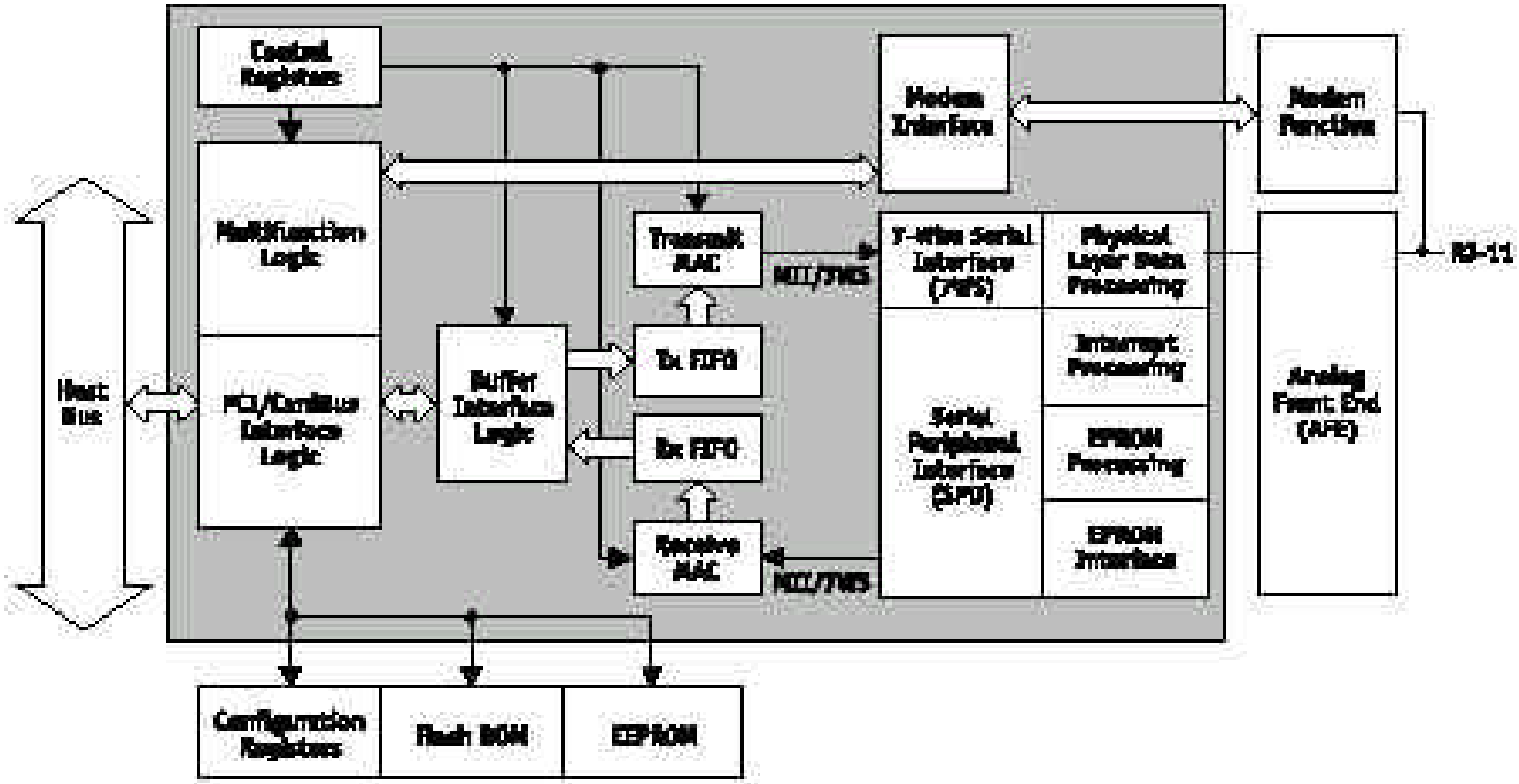
Conexant Systems

- Provides ADSL modem chipset & V.90/K56flex modem
- Home phone line networking
  - 1Mbps data rates, scalable to higher speeds
  - Ethernet: standard 802.3 MAC, CSMA/CD
  - Uses existing phonelines - no new wires required
  - Supports up to 25 nodes across 500 feet
  - Compatible with existing services such as Internet access, voice services, & home network coexists on the same wire
  - Robustness assures performance over poor wiring
  - True plug and play operation
  - Secure because home wiring is not shared

Conexant Systems

- LANfinity RS7112 - Multifunction Ethernet Controller with Integrated HomePNA 1.0 PHY layer
  - Multifunction 1/10/100 Mbps LAN/modem controller
    - 100 Mbps IEEE 802.3 100Base-T compliant
    - 10 Mbps IEEE 802.3 10Base-T compliant
  - Integrated HomePNA 1.0 1Mbps physical layer
  - Supports host controlled (HCF) or software (HCS) modems
  - Supports CardBus & PCI bus interface
  - Multifunction logic supports simultaneous modem/network operation
  - Media Independent Interface (MII)

Conexant Systems - Ethernet Controller



RS7112 functional block diagram

Lucent

- Home Wire products
  - Uses ordinary copper phone wires
  - Provide easy interface to communication products such as DSL modems & Ethernet
  - Data transmission rates from 1Mbps to 16Mbps
  - Compliant to HPNA 2.0 10 Mbps spec, backward compliant
  - Allows
    - Fast in-home Web surfing & high bandwidth file transfer
    - Download video & graphics
    - Connect more devices to home networks
    - Multimedia & real-time applications
      - In-home video distribution, voice compression & VoIP

Lucent (contd.) - Products

- HW3130 Home Wire PCI/Cardbus HPNA/LAN/Modem Controller
  - Integrated 1/10 Mbps device with a dual speed 10/100 Mbps LAN Controller
  - Interfaces to 10/100 Mbps Ethernet PHY
  - Ideal solution for triple-function PC add-in card
- HW3100 Home Wire PCI/Cardbus HPNA/Modem Controller
  - Integrated 1/10 Mbps device
  - Support for 56 Kbps modem
  - Ideal solution for dual-function PC add-in card

Lucent (contd.) - Products

- HW3000S Home Wire MSI Controller
  - Integrated 1/10 Mbps device
  - 16 bit microprocessor slave interface
  - Glueless interface to analog front end
  - Interfaces to ADSL modem chip set
  - Ideal solution for broadband residential gateways (DSL, cable modem) & other in-home networking appliances

Lucent (contd.) - Products

- HW3000M Home Wire MII PHY
  - Integrated 1/10 Mbps HPNA PHY device
  - Media Independent Interface to an external 10/100 Mbps Ethernet MAC
  - Ideal solution for PC and Embedded motherboard applications
- HW2000 Home Wire Analog Front End
  - Fully integrated analog front end transceiver for HPNA 2.0 10 Mbps home networking

Avio Digital

- Products are not based on HPNA 2.0 technology
- Products - MediaWire chipsets
  - Phoneline networking solutions
  - Provide up to 88Mbps bandwidth for home networking over Category 3 wiring & double over Category 5
  - Offer up to 33 meters between devices using standard Cat 3 telephone wiring, 100 meters with Cat 5 wiring or 400 meters with coaxial cable
  - Capable of supporting up to 100 different types of devices located through out the house

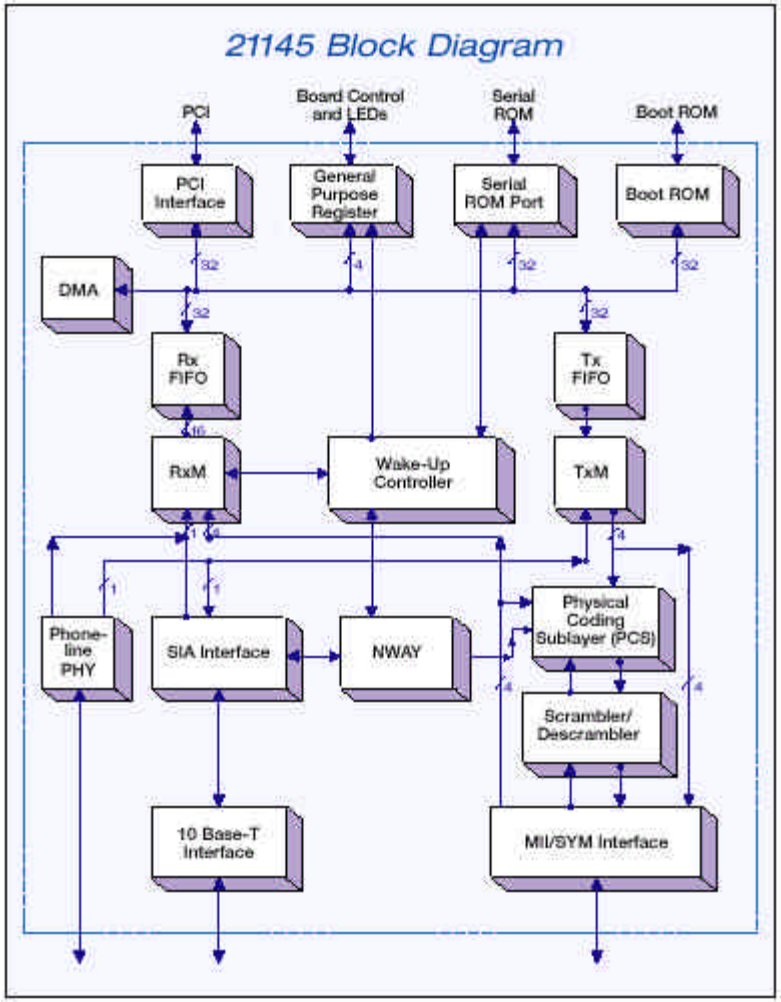
Intel Corporation

- Believes that the existing phoneline infrastructure in the home is an excellent basis for implementing home networks today
  - Founding member of HPNA
  - Working with industry leaders to establish open spec for phoneline-based home networking

Intel Corporation

- Intel 21145 Phoneline/Ethernet LAN Controller
  - Integrated single-chip silicon solution for 1Mbps phoneline & 10Mbps Ethernet connectivity
  - Provides foundation for implementing fully functional home phoneline network
  - Utilizes 21x4x MAC core for 10Base-T Ethernet network
  - Fully compatible with HPNA 1.0 spec
  - Fully compliant with the IEEE 802.3 & ANSI 802-3 Ethernet standards
  - PCI interface

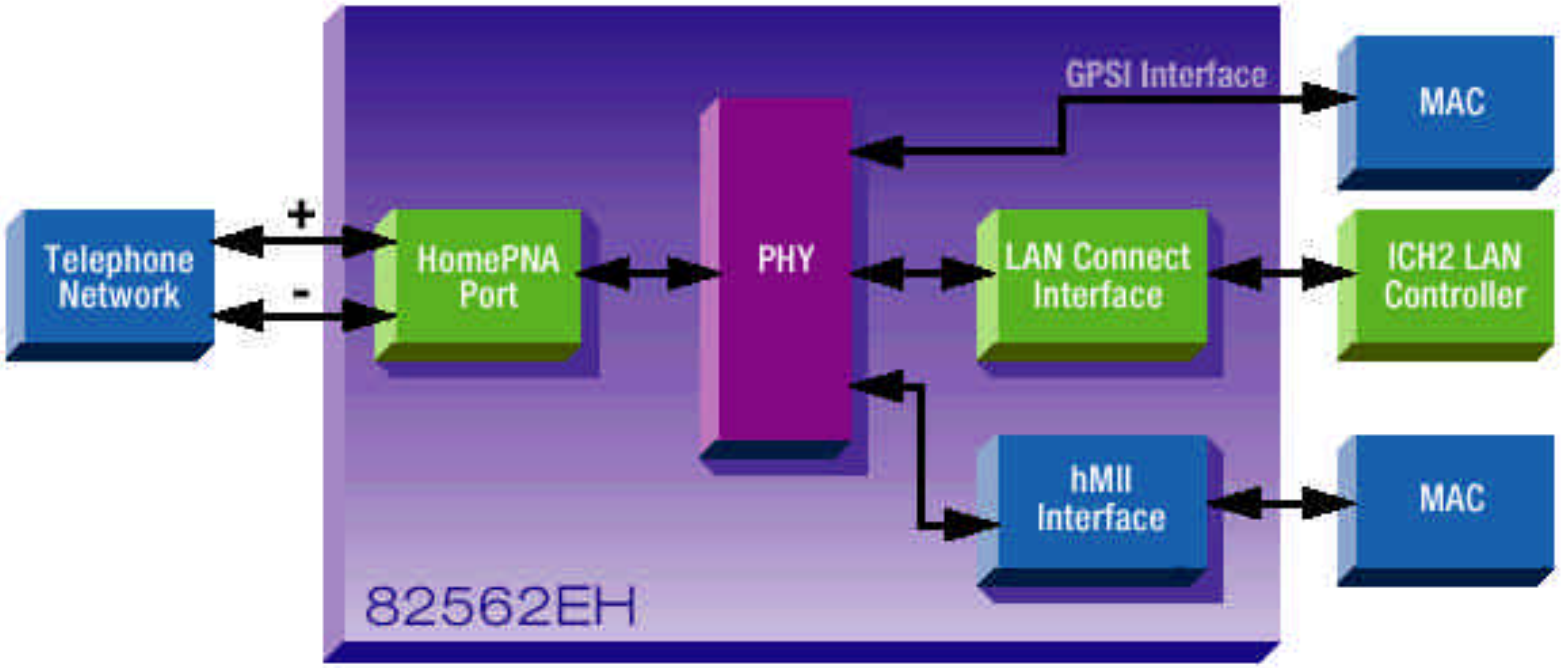
Intel - 21145 Phoneline/Ethernet LAN Controller



Intel

- Intel 82562EH - HomePNA LAN Connect Option
  - Highly-integrated, low cost, fully flexible network component ideal for use in a wide range of home networking designs
    - Fully compliant with HPNA 1.0 and includes a 1Mbps HomePNA port for connection to home telephone with three data interfaces
      - LAN Connect Interface for connecting Intel I/O Communications Hub2 (ICH2)
      - HomePNA Media Independent Interface (hMII)
      - General Purpose Serial Interface (GPSI)
  - Targeted for LAN-on-motherboard (LOM), Communication and Networking Riser Cards (CNR), set-top boxes, residential gateways or network information appliances
  - Supports Wake-On LAN
  - Low power consumption

Intel - 82562EH HomePNA LAN Connect



Key Vendors

Diamond Multimedia/S3

- Diamond Multimedia was acquired by S3
- Offers the HomeFree Phoneline 10Mbps Desktop Pack (PCI)
  - Includes 2 PCI Cards & associated software

D-Link Systems

- Offers DHN-910
  - 10Mbps Phoneline network
  - Kit includes 2 standard PCI adapters with phone-line cords, software, and RJ-11 jacks

Intel

- Branded its HPNA technology under AnyPoint Home Network
  - Offers parallel, PCI, external USB versions
    - PCI & USB versions are rated at 10Mbps
    - Parallel port & another USB version is rated at 1Mbps

Linksys

- Offers HomeLink Phone Network in a Box
  - Includes 2 PCI cards with RJ-45 jacks
- Dual capability of being used for HPNA network or 10BaseT Ethernet network

NETGEAR

- Former Nortel subsidiary
- Offers Home Phone Line PCI Adapter (PA 301) & USB versions
  - Rated at 10Mbps

3Com

- Offers HomeConnect 10Mbps PCI Phoneline Kit
  - Includes 2 PCI adapters & HomeClick networking software
  - Rated at 10 Mbps

Agenda

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- HomePNA solutions available today
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Xilinx Programmable Solutions Enable HomePNA Devices

Value Proposition

XILINX®

Chaos in the HN Marketplace

- Multiple broadband & multiple Home LAN technologies

	RF - Wireless	Phoneline	Powerline
Pros	Mobility - UNTETHERED Broad geography support at specific frequencies Can compliment a wired network with bridging	Low cost and fast (10Mbps+) Strong Industry Alliance (HPNA) Dedicated home bandwidth Voice and data share existing lines	Electrical outlets in every room easy connection for non-PC appliances Low cost - will drop with silicon integration High performance (up to 10Mbps)
Cons	Relatively expensive - getting cheaper Distance limits & wall attenuation (150 ft/10 barriers) Security must be addressed Prone to narrowband interference	Phone jacks not near every PC in home Different phone lines (numbers) isolated International deployment issues	Must be robust in hostile environment (noise, stubs, vnet) International deployment issues (Regulatory issues) Security must be addressed Standards need to be addressed
Snapshot Take Away	International Solution, Mobile in North America	Low-cost desktop solution for North America	Ideal for non-PC devices

Chaos in the HN Marketplace

- Three Major Wireless Consumer Home Networking Campaigns are Racing in Separate Directions
  - Wireless LAN/Ethernet, HomeRF & Bluetooth technologies vary in data rate, range, frequency & marketplace aimed for

Technology		Data Rate (Mbits/sec)	Range (meters)	Frequency (GHz)	Technology Aimed For
Wireless LAN/ Wireless Ethernet	802.11	2	100	2.4	Office Enviornments
	802.11b	11	100	2.4	
	802.11a	~40	TBD	5	
Bluetooth	802.15 (Bluetooth)	<1	10	2.4	Consumer, short-range, wireless personal-area technology
	802.15 (high-rate)	20+	TBD	2.4/5	
Home RF	HomeRF	1.6	50	2.4	Home Space
	HomeRF (next gen)	10	50	2.4	

Home Networking Today

- Growing chaos in this emerging technology
  - Solutions are just coming to market
  - Leading players are showing indecisiveness towards different varying technologies
    - Building independent solutions
    - Participation in multiple consortiums
    - Different wireless standards for same frequency band
- Interoperability is a key factor to market success
- Future revisions already in the works
  - HomePNA is already out with v2.0

Implications of this Chaos...

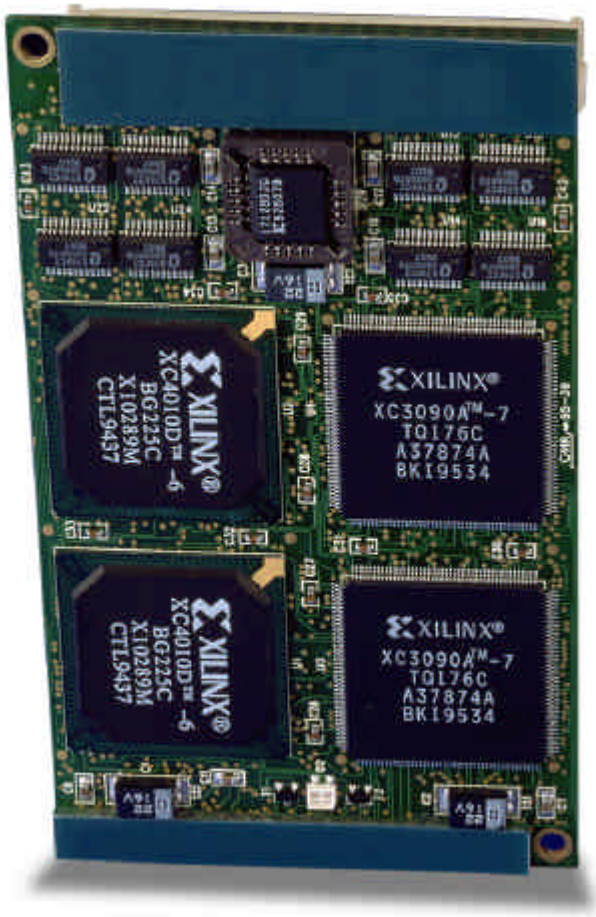
- Brings about an Environment That Guarantees Unanticipated Problems
  - Bugs
  - Incompatibilities
  - The Great Unknown about what is going to be the changes
- Translates to a Steep Learning Curve
  - Virtually mandates a “Ready, Fire, Aim” development model
    - Plan products for the longest life cycles
    - Get a product to market “now”
    - Rapidly integrate refinements and enhancements

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 Steering Consortiums

Home Phoneline Network CERTIFIED

WLANA The Wireless LAN Association

HiperLAN2 Global Forum

LONMARK INTEROPERABILITY ASSOCIATION

Xilinx Product Portfolio

Advanced Products Group

High Performance
High Density

General Products Division

High Volume
Low Cost

CPLD Division

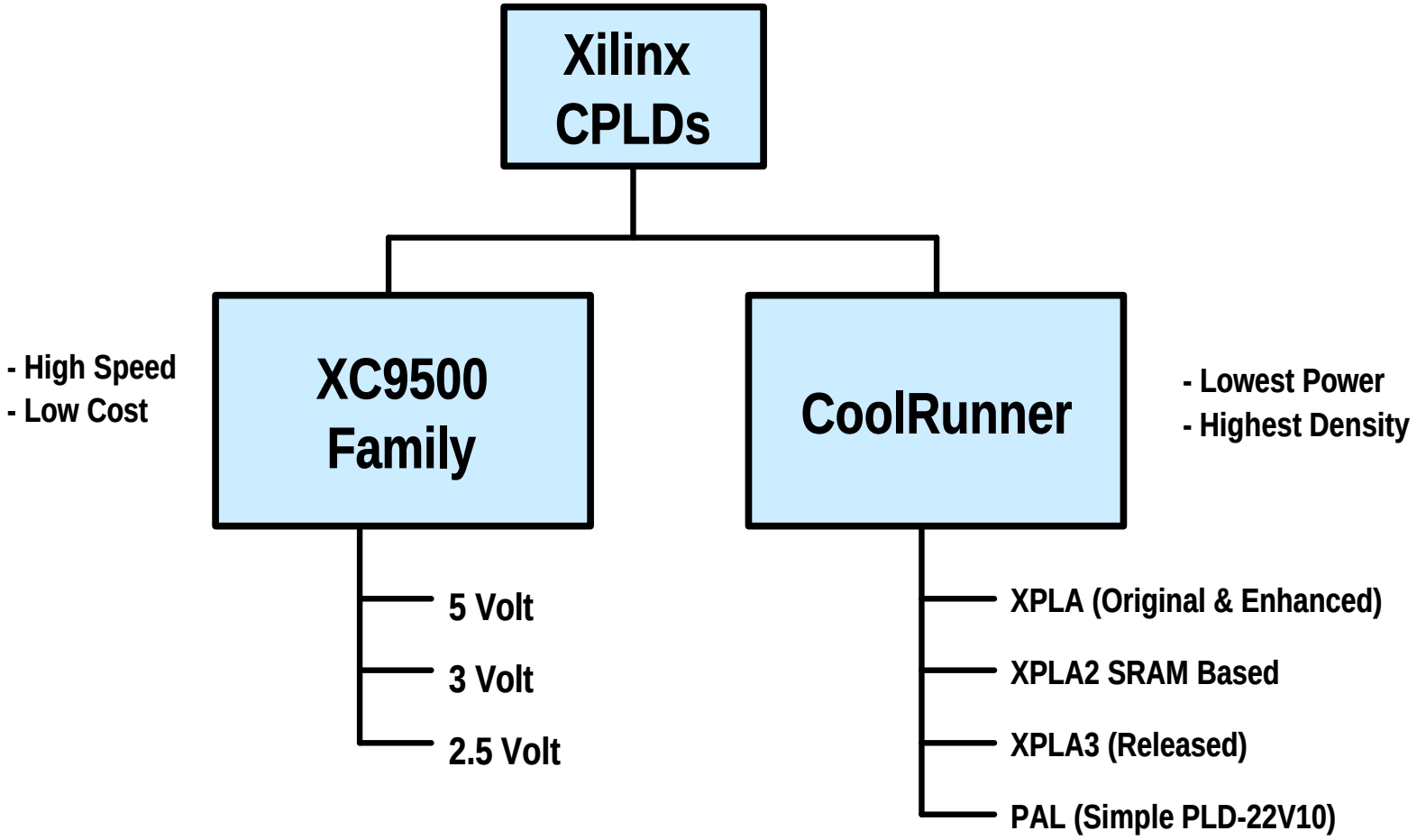
Low Power
Low Cost

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

Xilinx CPLD Families



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

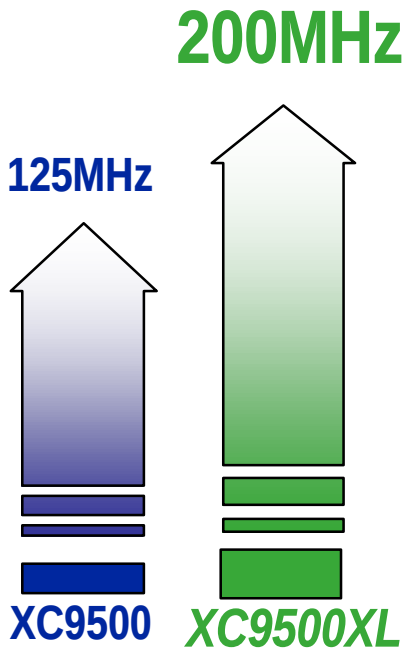
The CoolRunner Advantage

- 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.

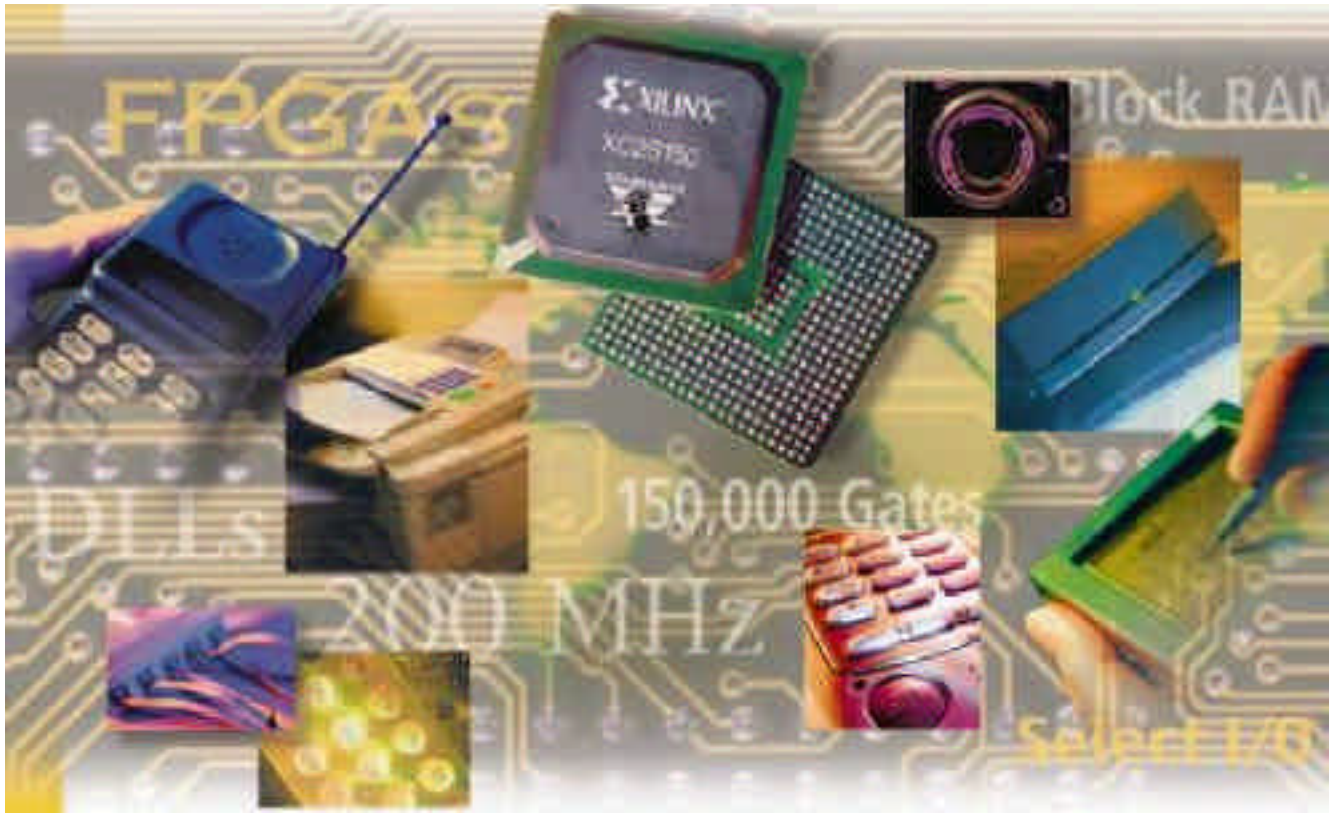


Lowest Price Per Macrocell

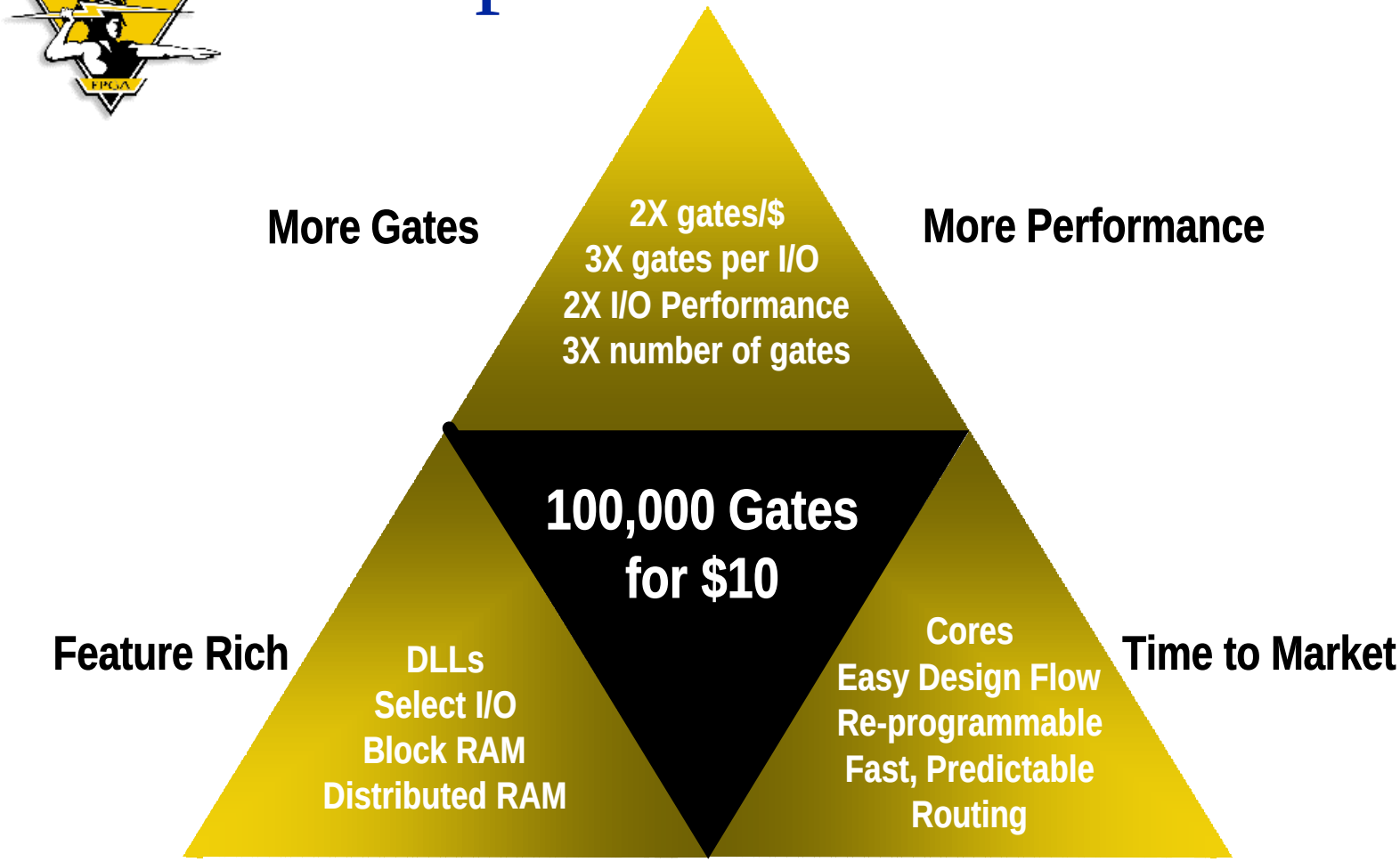
XC9500XL/XV System Features

- 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

Introducing the Spartan-II FPGA

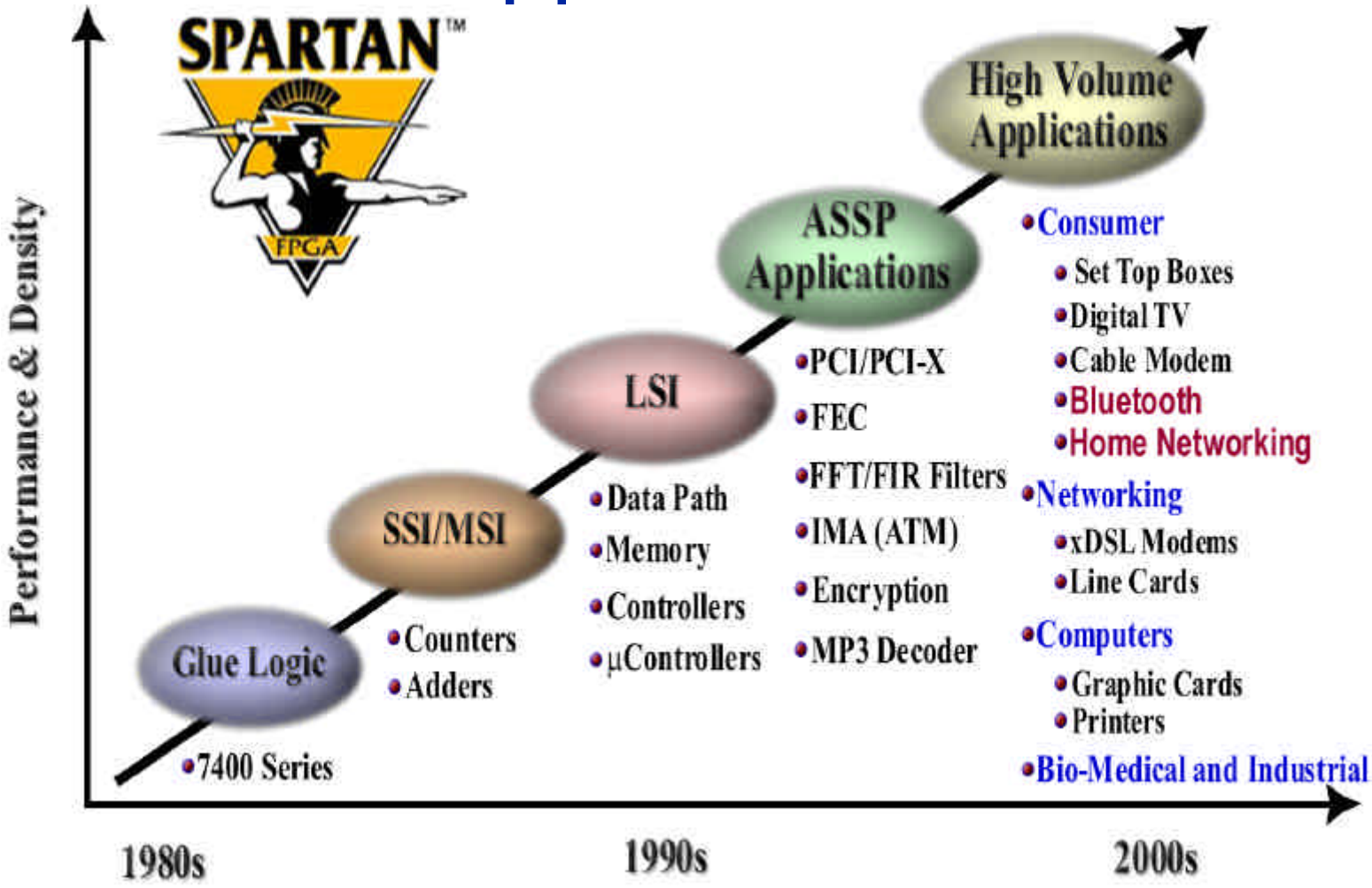


Spartan-II: Extending the Spartan Series



Programmable ASIC/ASSP Replacement!

FPGA Application Trends



Programmable ASIC/ASSP Replacement!

Spartan-II - Architecture Overview

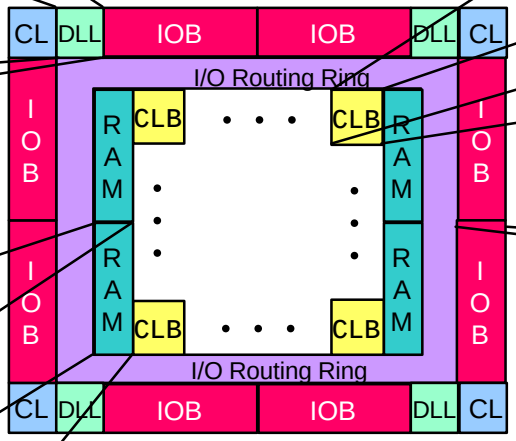
Delay Locked Loop (DLL)

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

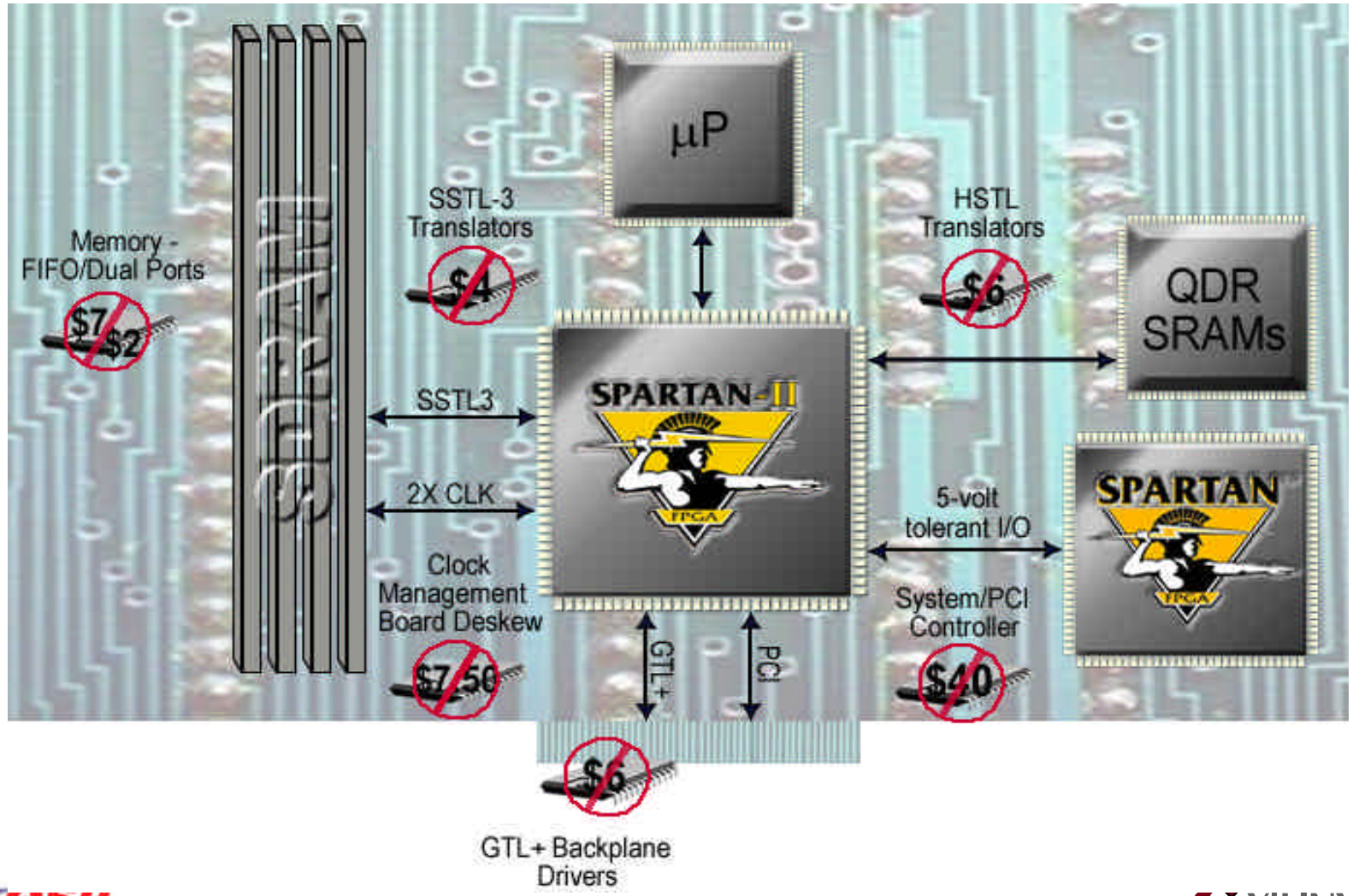
Block Memory

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

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

System Block Diagrams for HomePNA Solutions

Block Diagram Template / Index

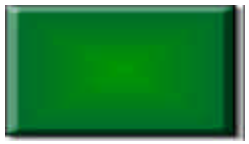
Xilinx Solution

Or

Non-Xilinx Components

Memory

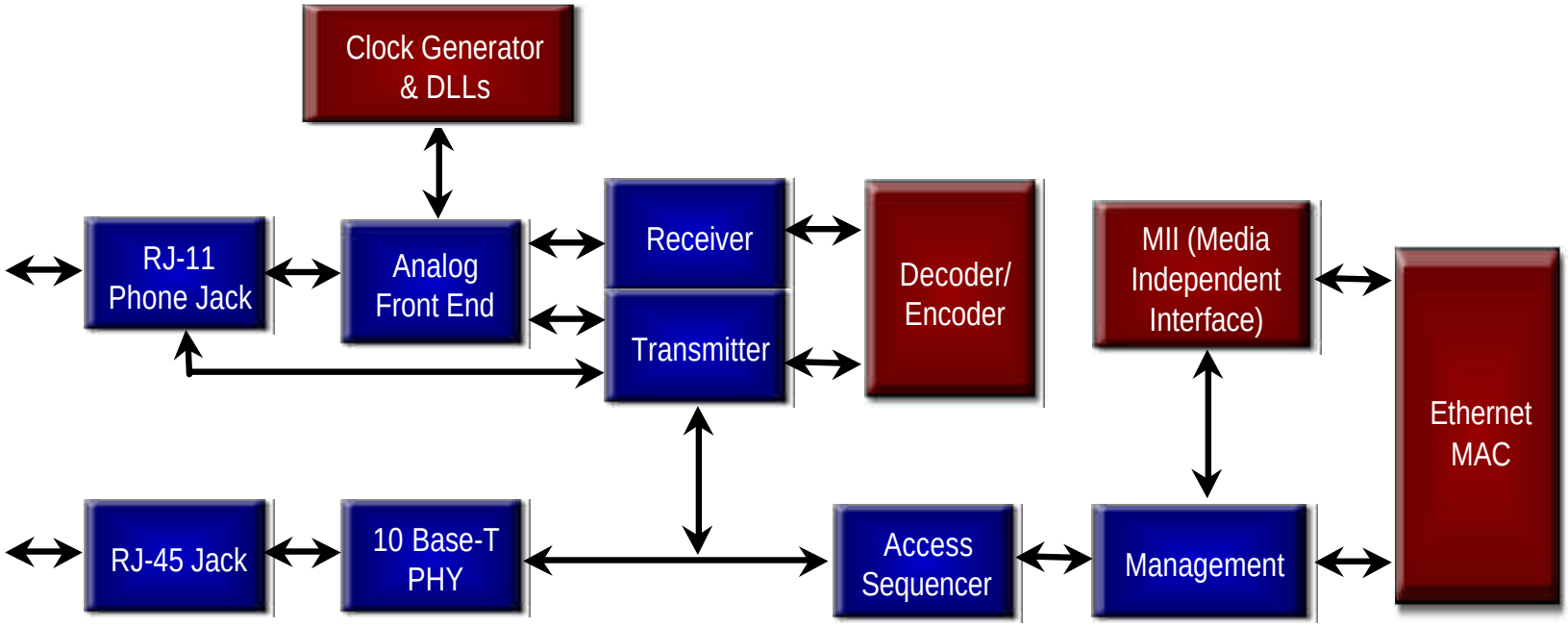
Mixed Signal / RF



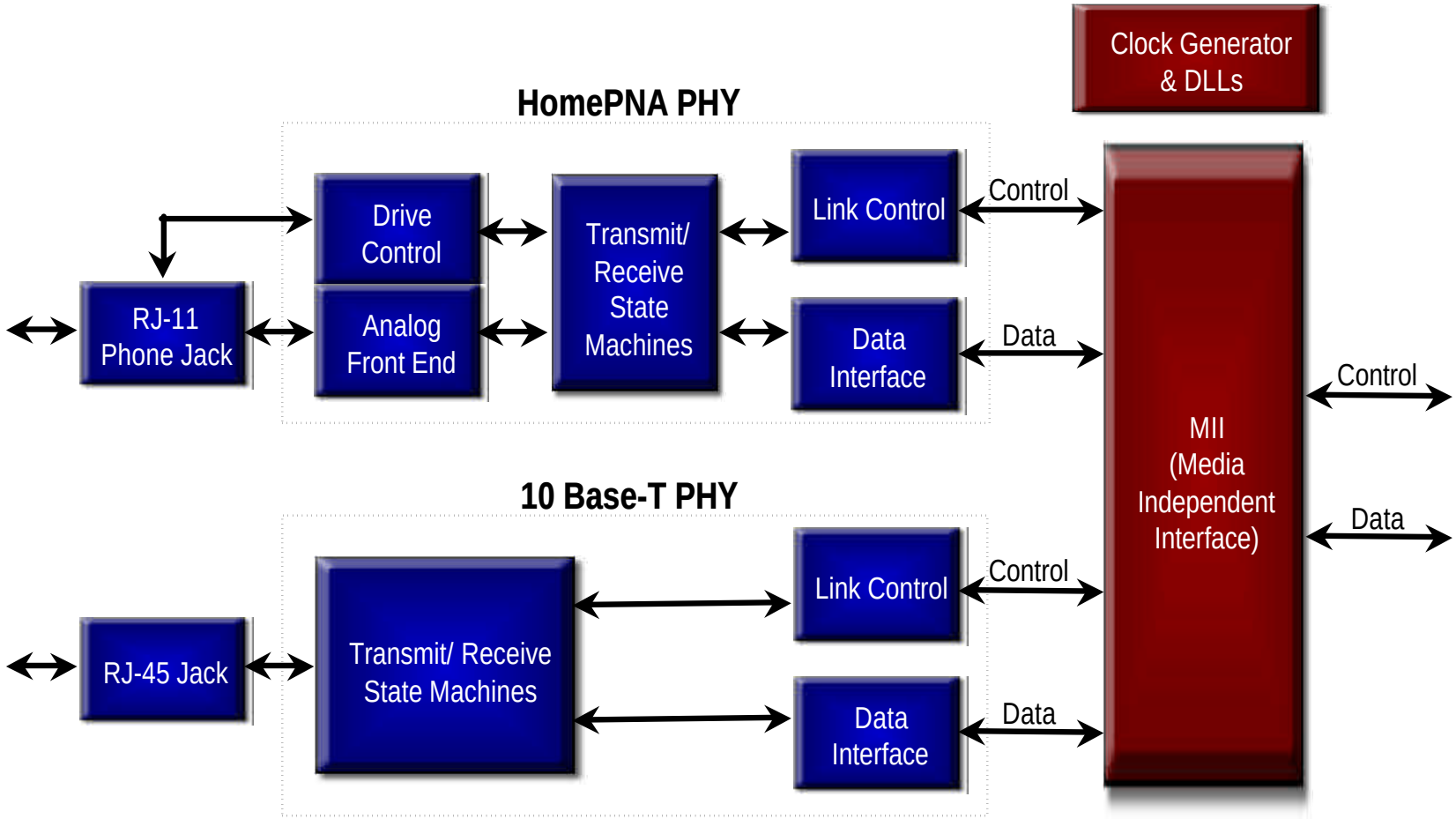
CPU

Embedded Chip

HomePNA PHY-MAC

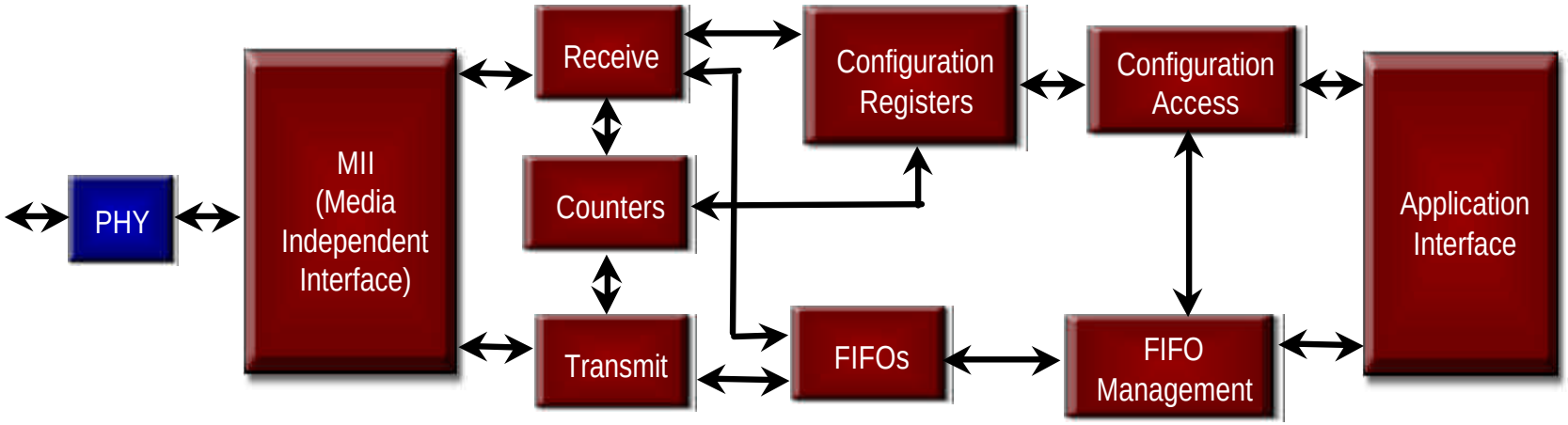


HomePNA PHY

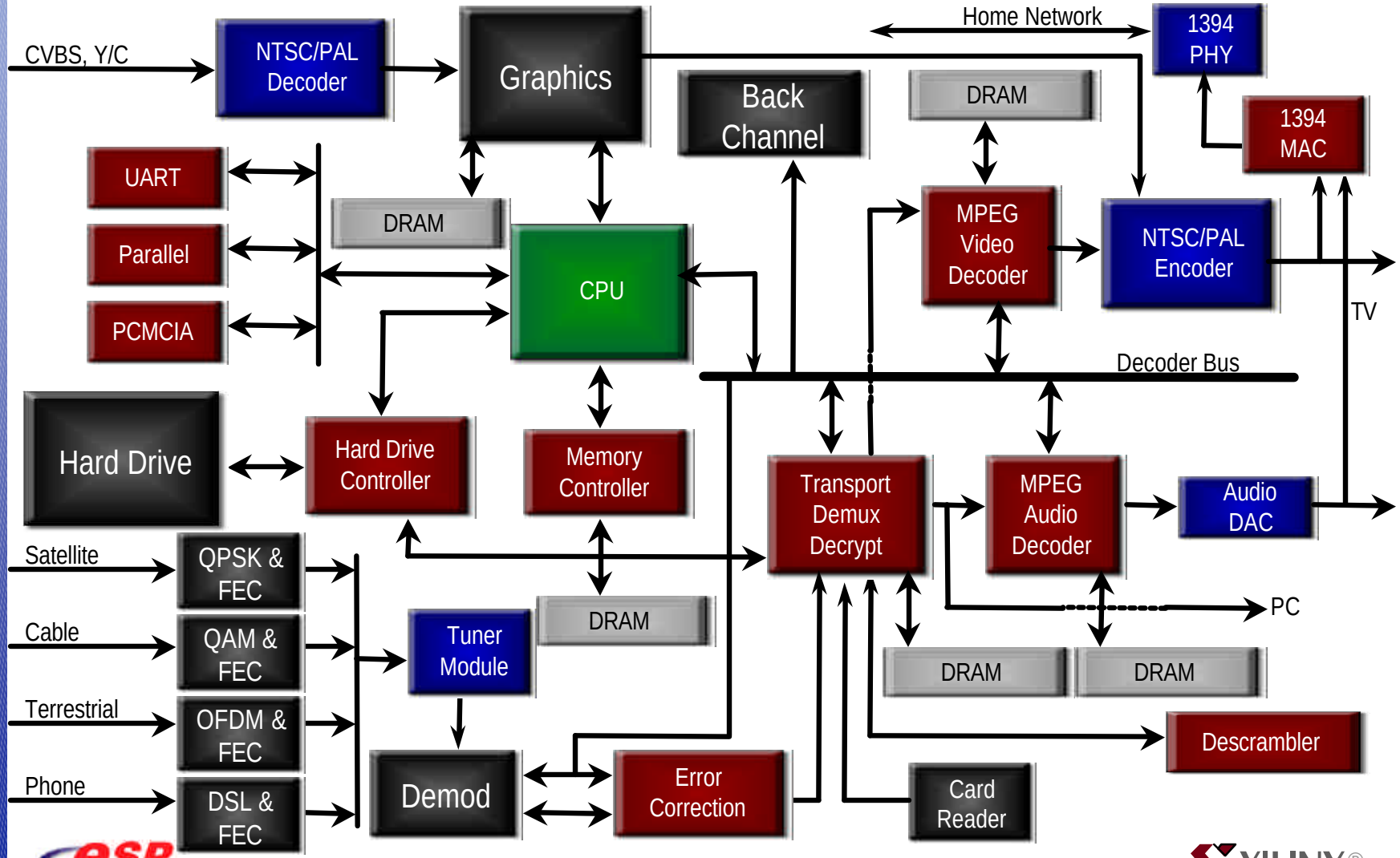

Clock Generator & DLLs
HomePNA PHY
Drive Control
Analog Front End
Transmit/ Receive State Machines
Link Control
Data Interface
Control
Data
RJ-11 Phone Jack
MII (Media Independent Interface)
Control
Data
10 Base-T PHY
Transmit/ Receive State Machines
Link Control
Data Interface
Control
Data
RJ-45 Jack

HomePNA MAC

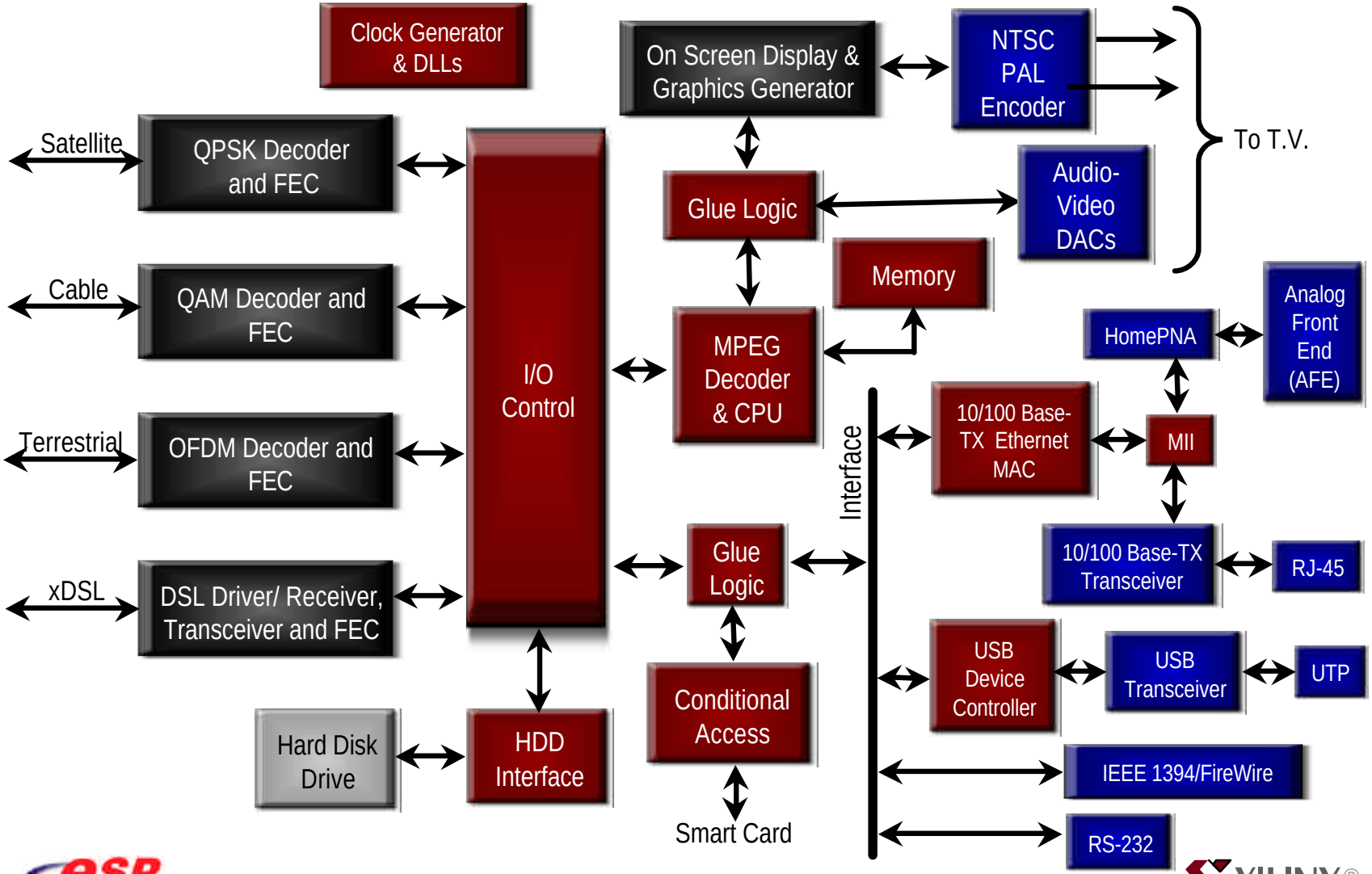
(and 10/100 Base-T Ethernet MAC)



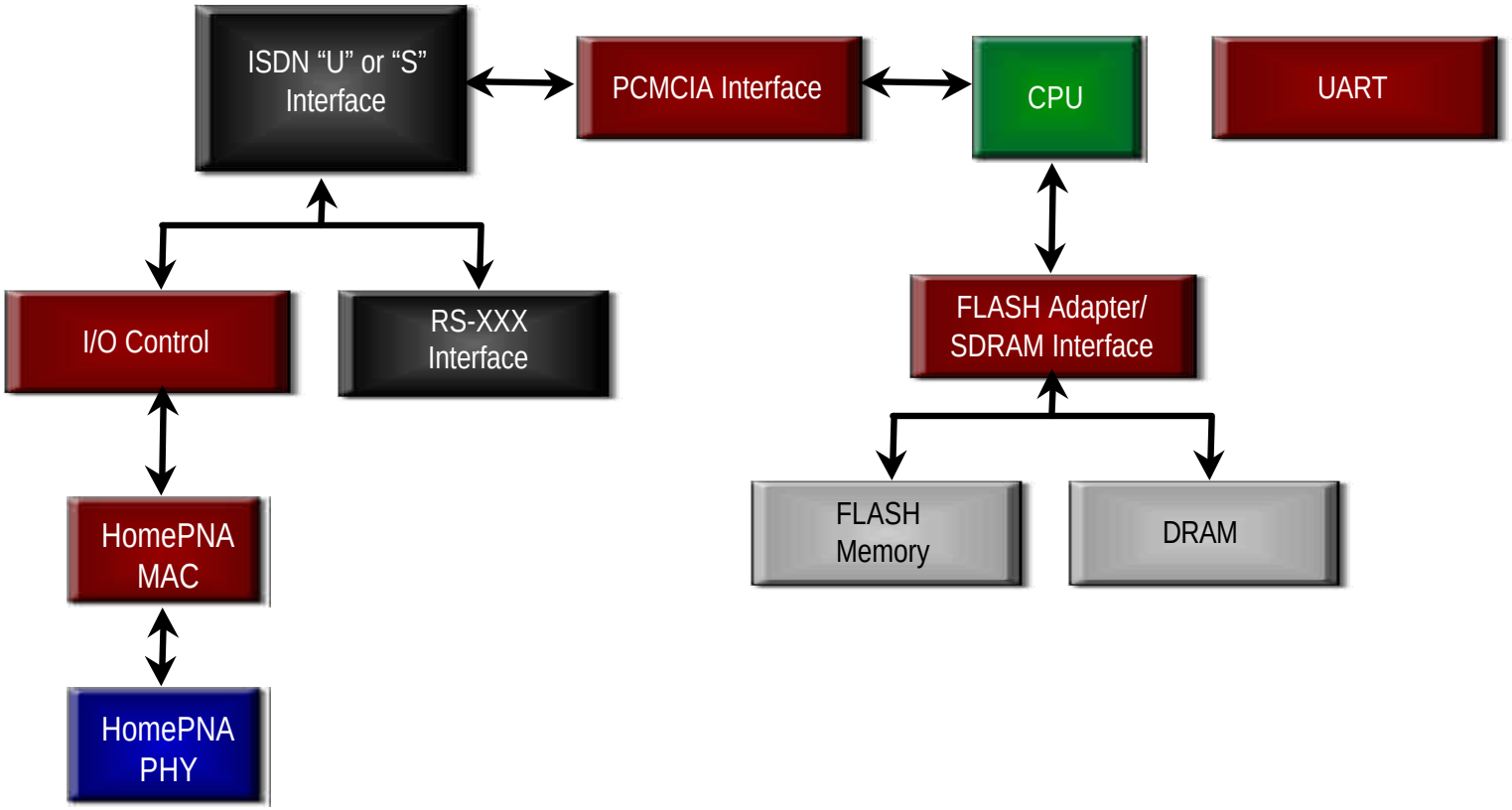
“Super” Set Top Box



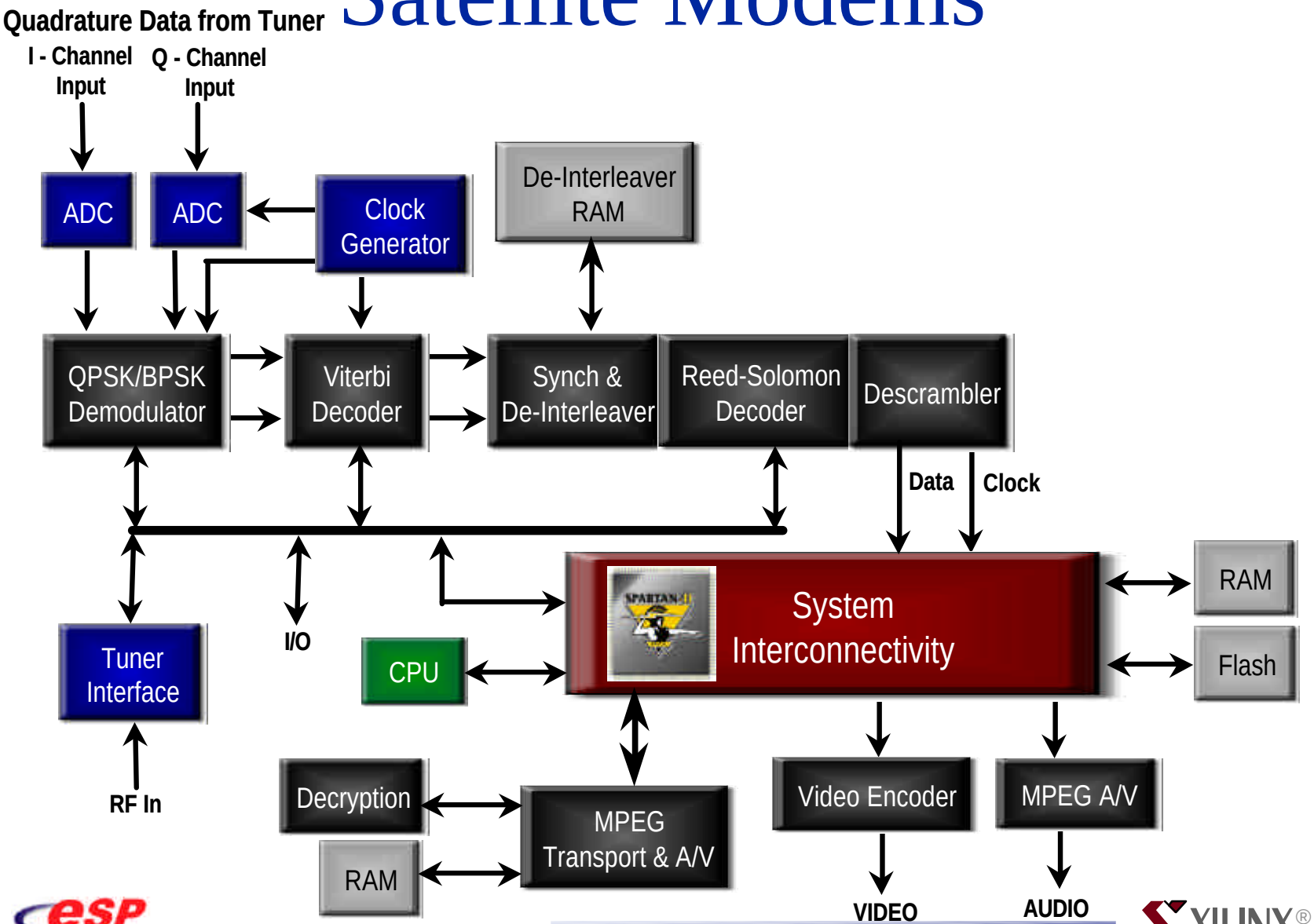
Super Set-Top Box: Residential Gateway



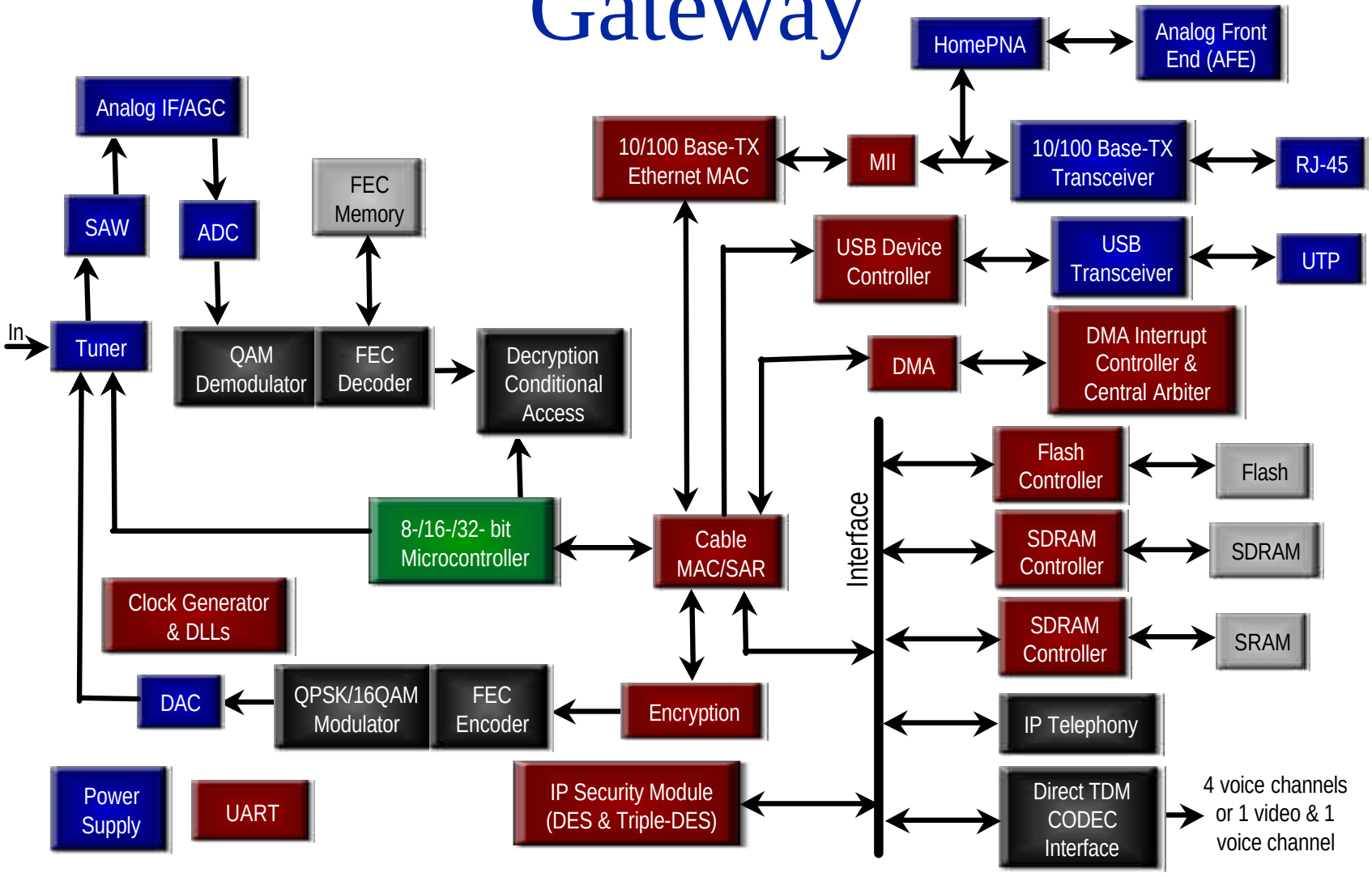
ISDN Modems


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

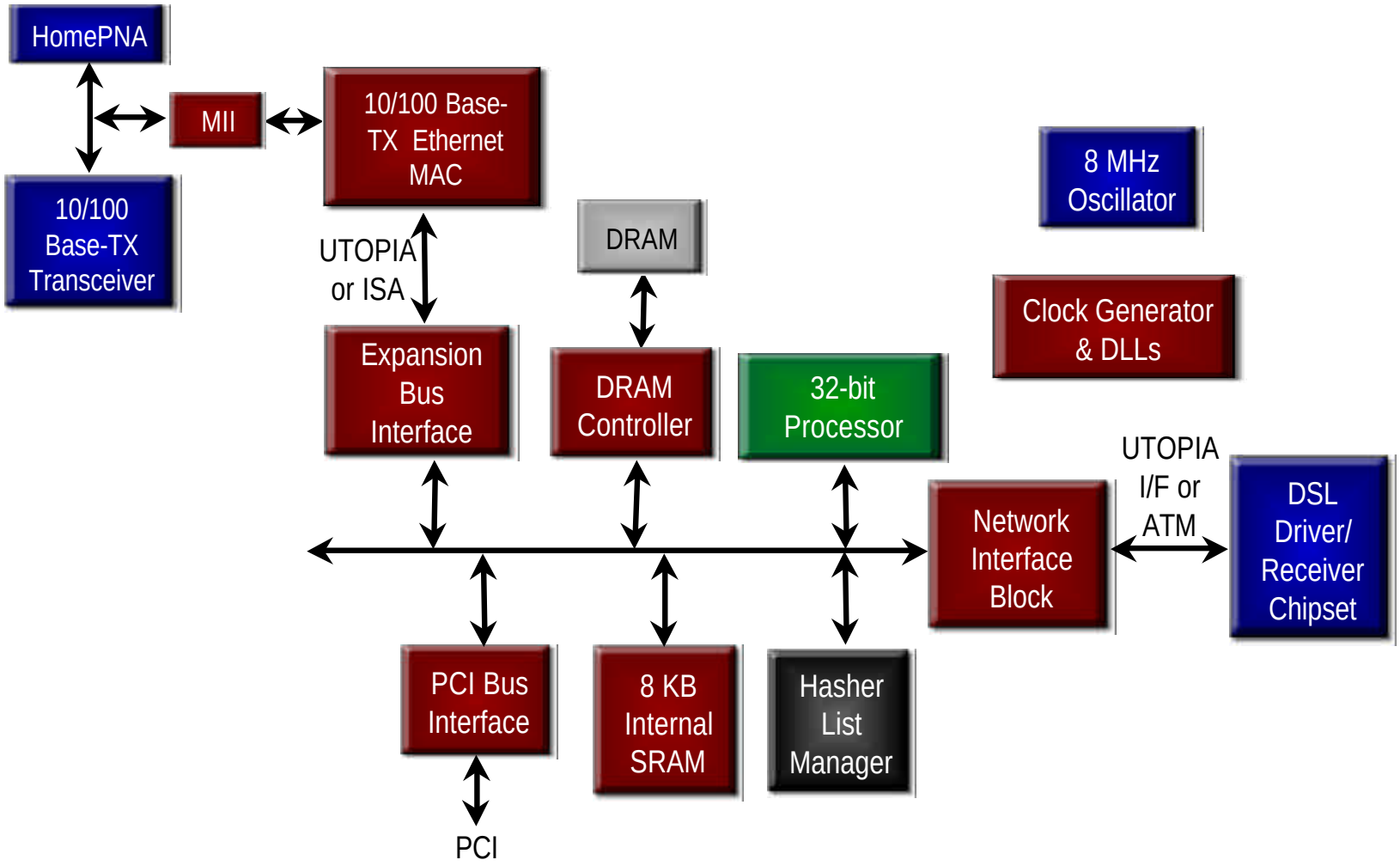
Satellite Modems



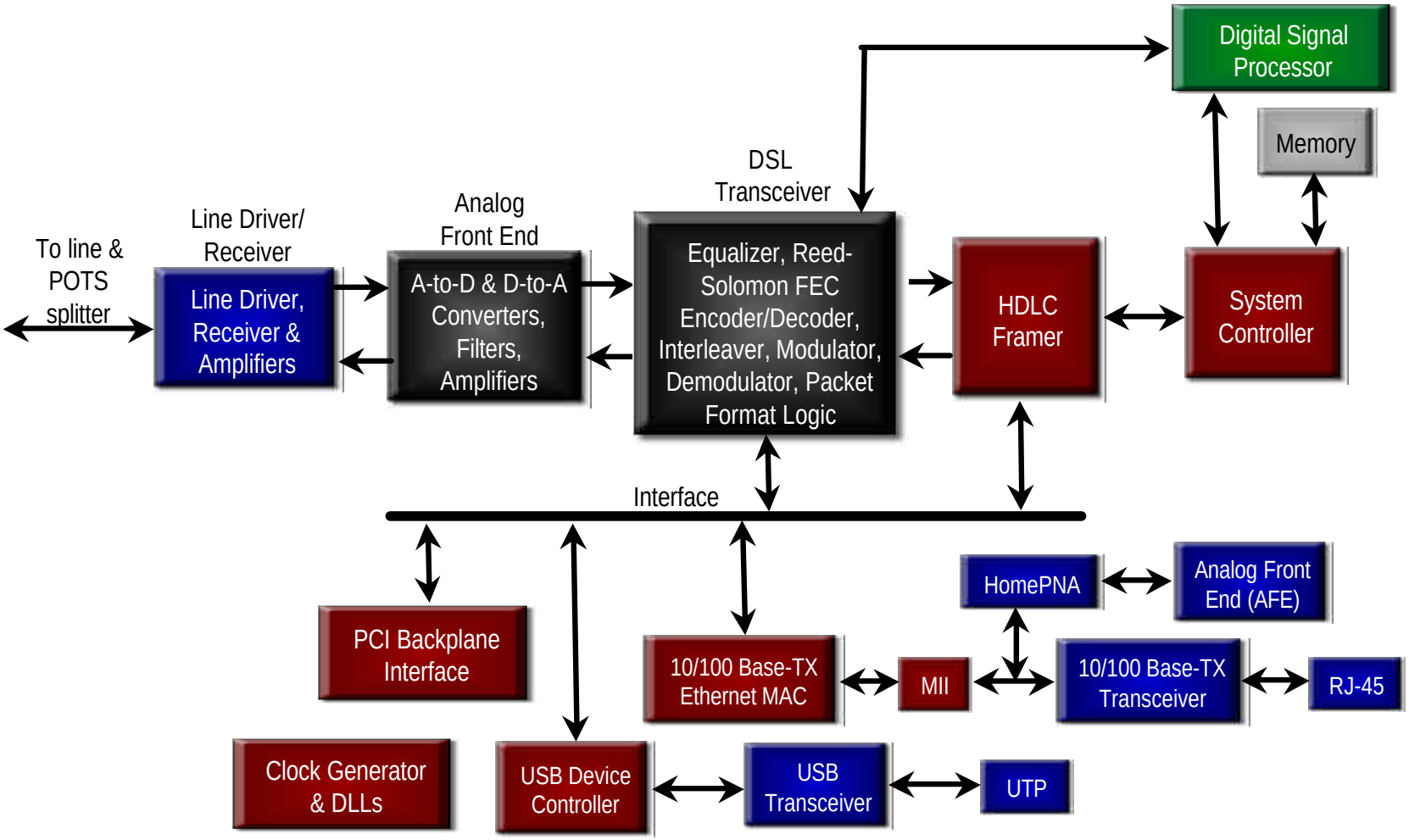
Cable Modem Residential Gateway



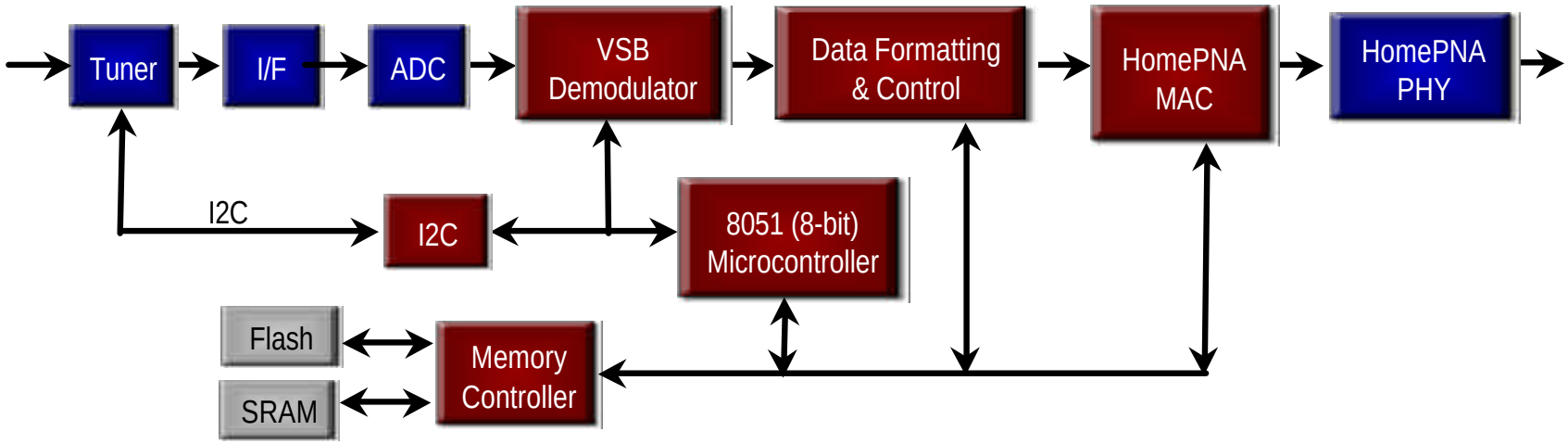
DSL Modem Home Gateway



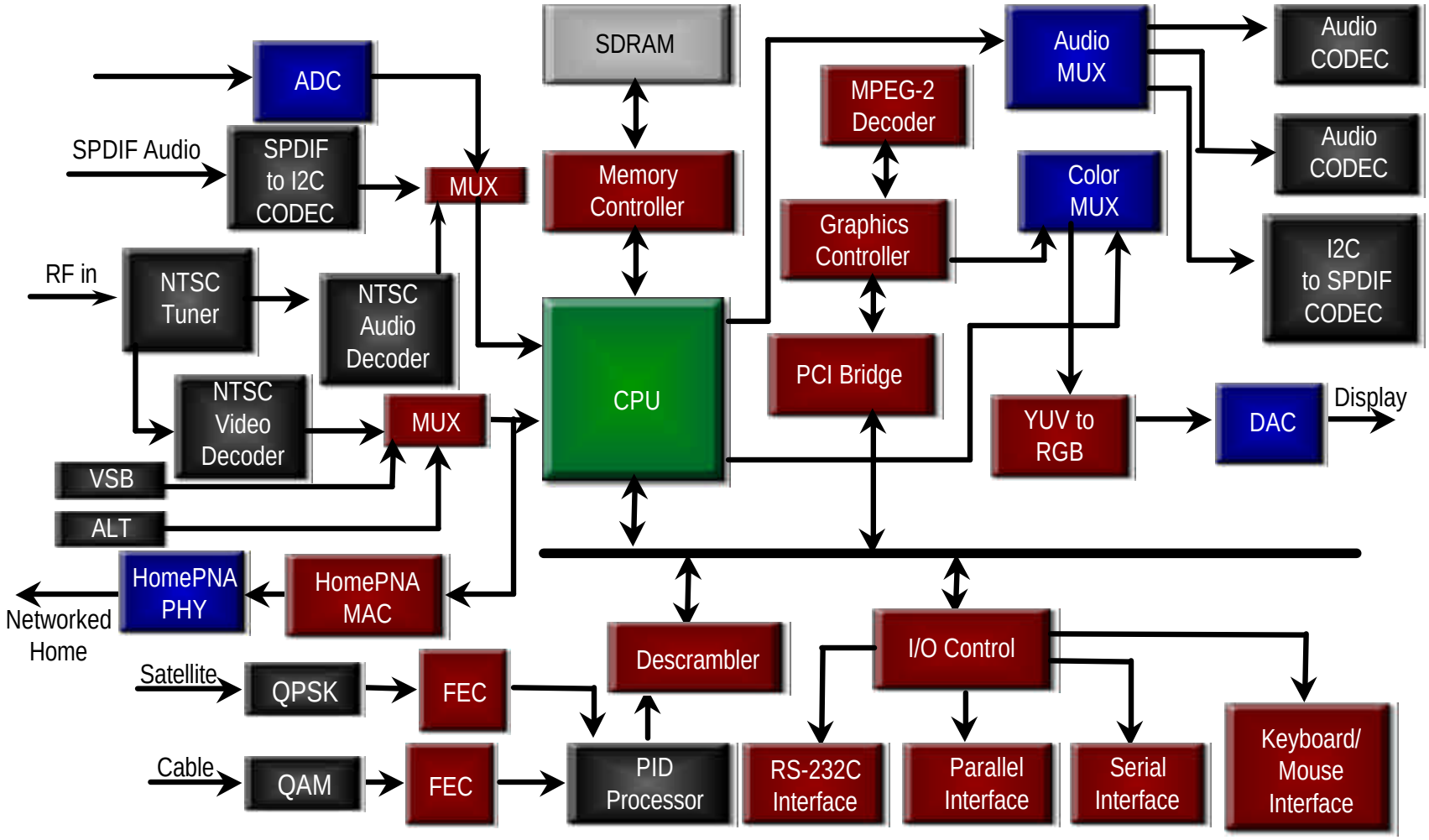
DSL CPE (Customer Premise Equipment)



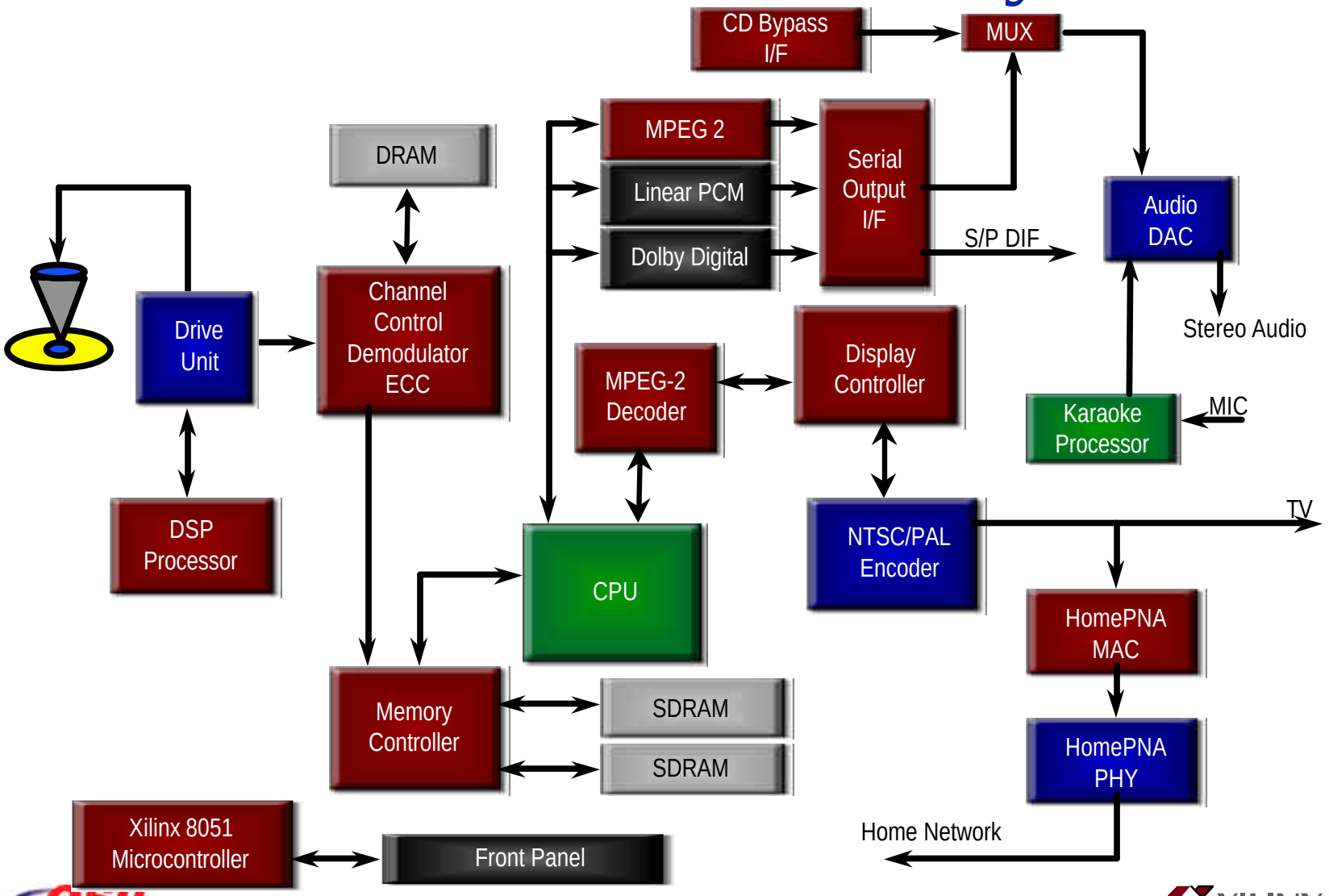
Digital TV


Tuner
I/F
ADC
VSB Demodulator
Data Formatting & Control
HomePNA MAC
HomePNA PHY
I2C
I2C
8051 (8-bit) Microcontroller
Flash
SRAM
Memory Controller

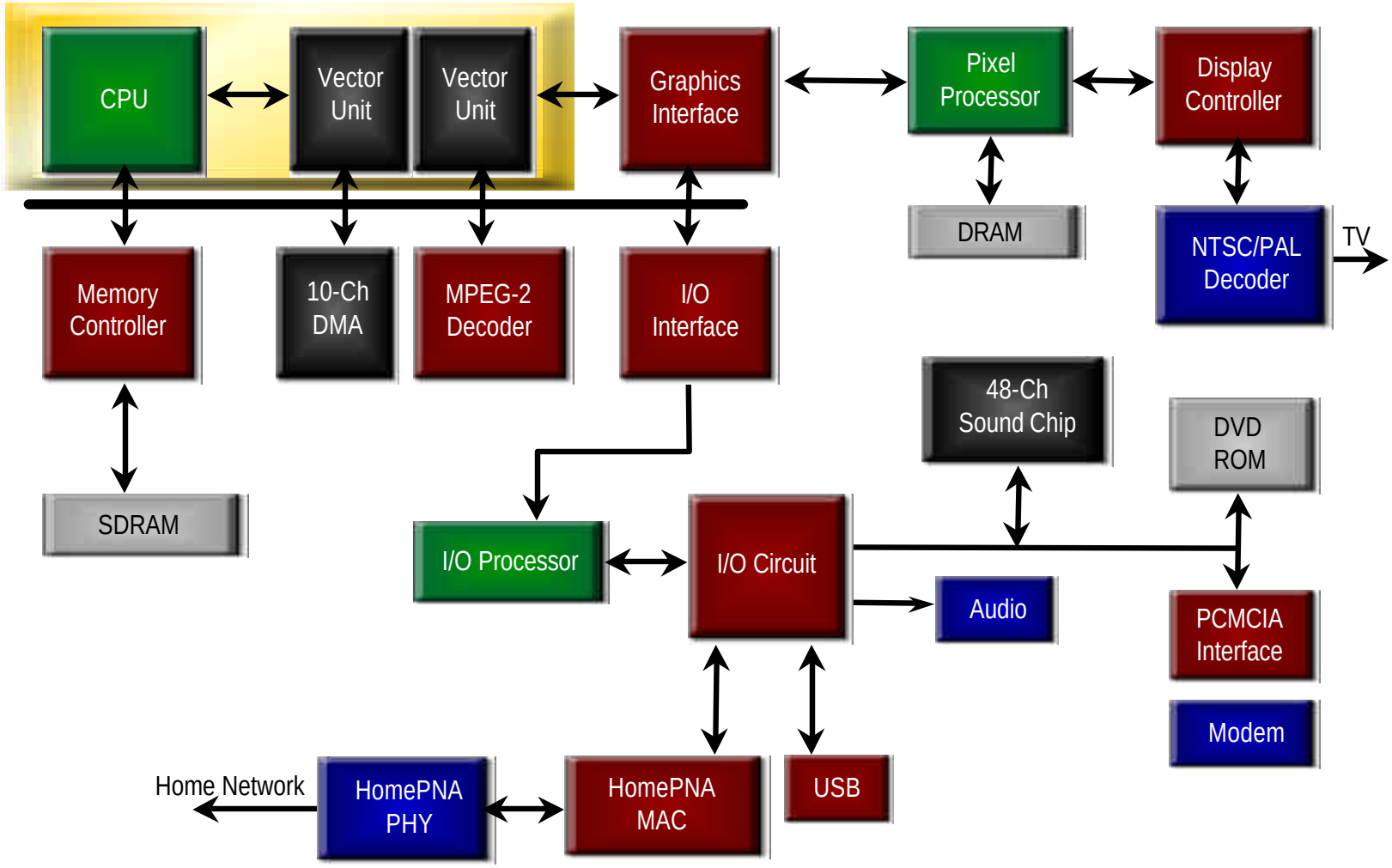
Digital TV


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

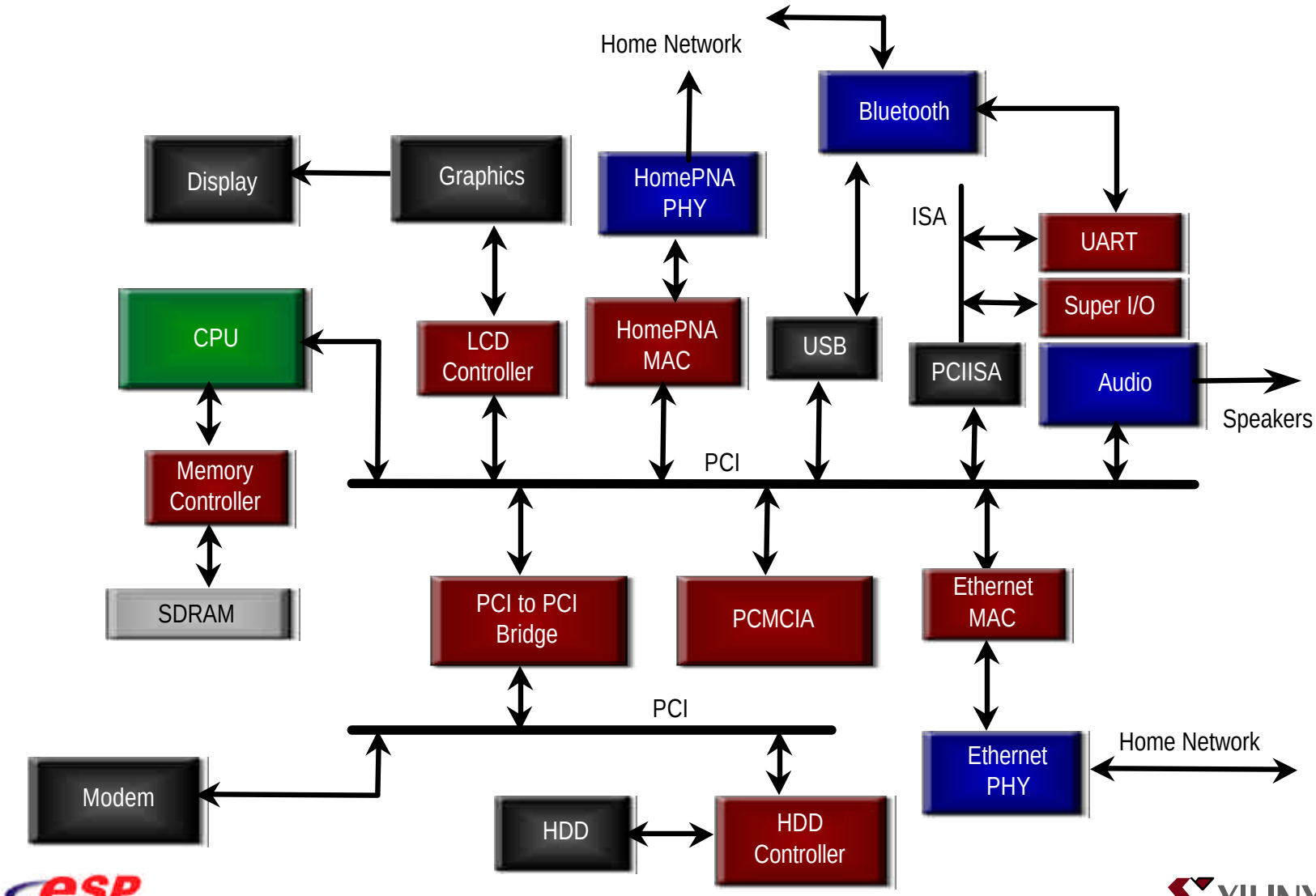
Interactive DVD Player



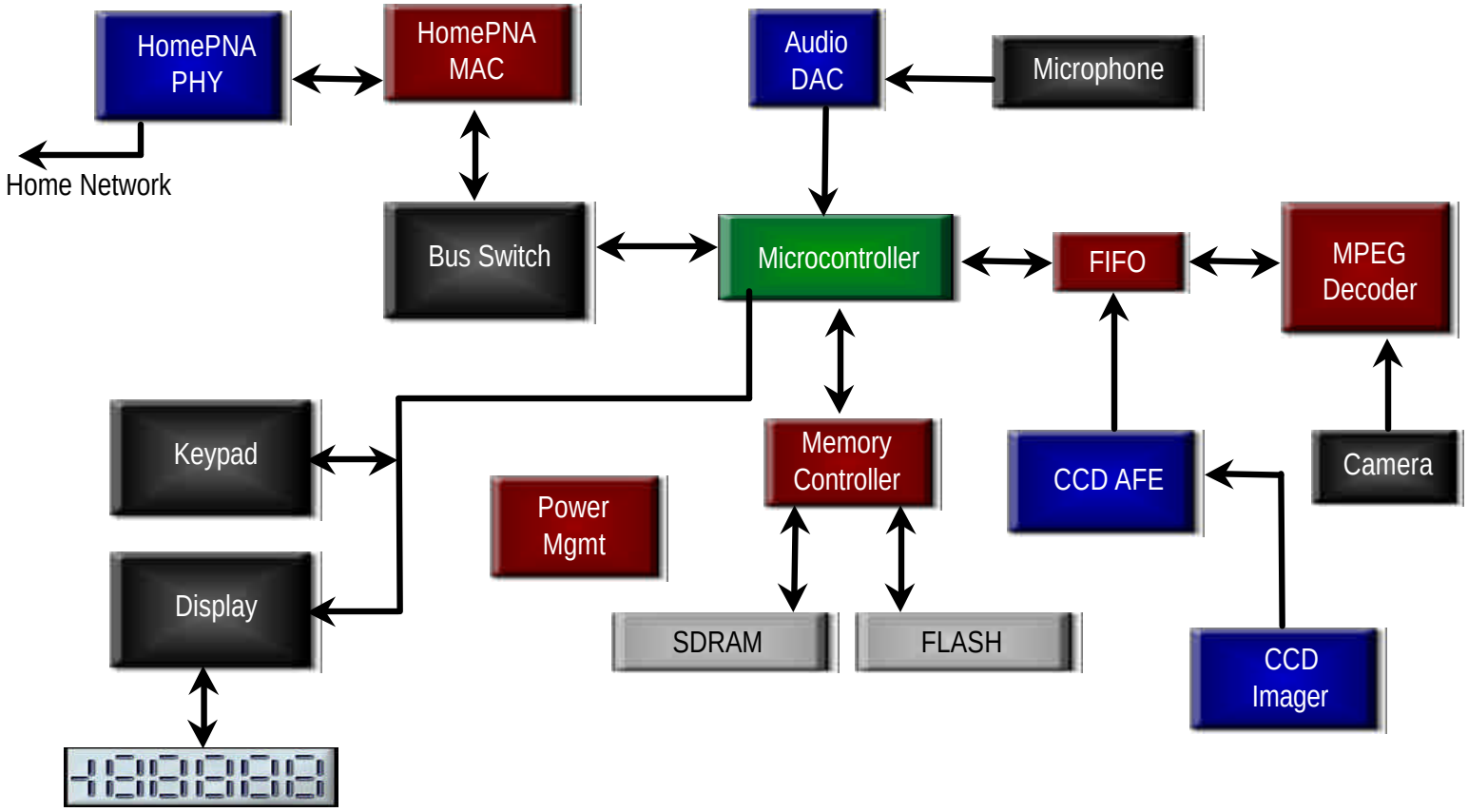
Gaming Console



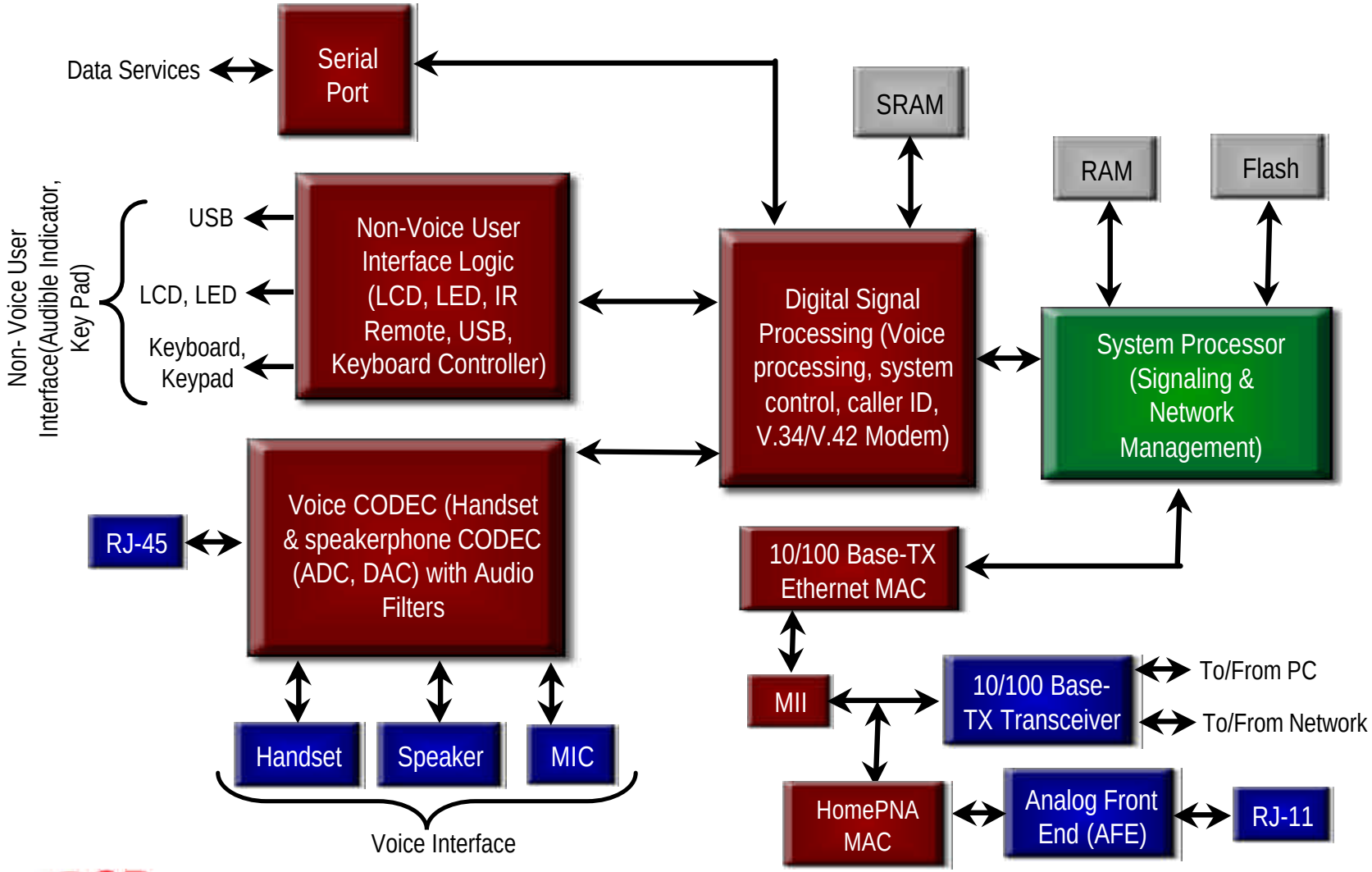
PC


Home Network
Bluetooth
Display
Graphics
HomePNA PHY
ISA
UART
Super I/O
CPU
LCD Controller
HomePNA MAC
USB
PCIISA
Audio
Speakers
PCI
Memory Controller
SDRAM
PCI to PCI Bridge
PCMCIA
Ethernet MAC
PCI
Modem
HDD
HDD Controller
Ethernet PHY
Home Network

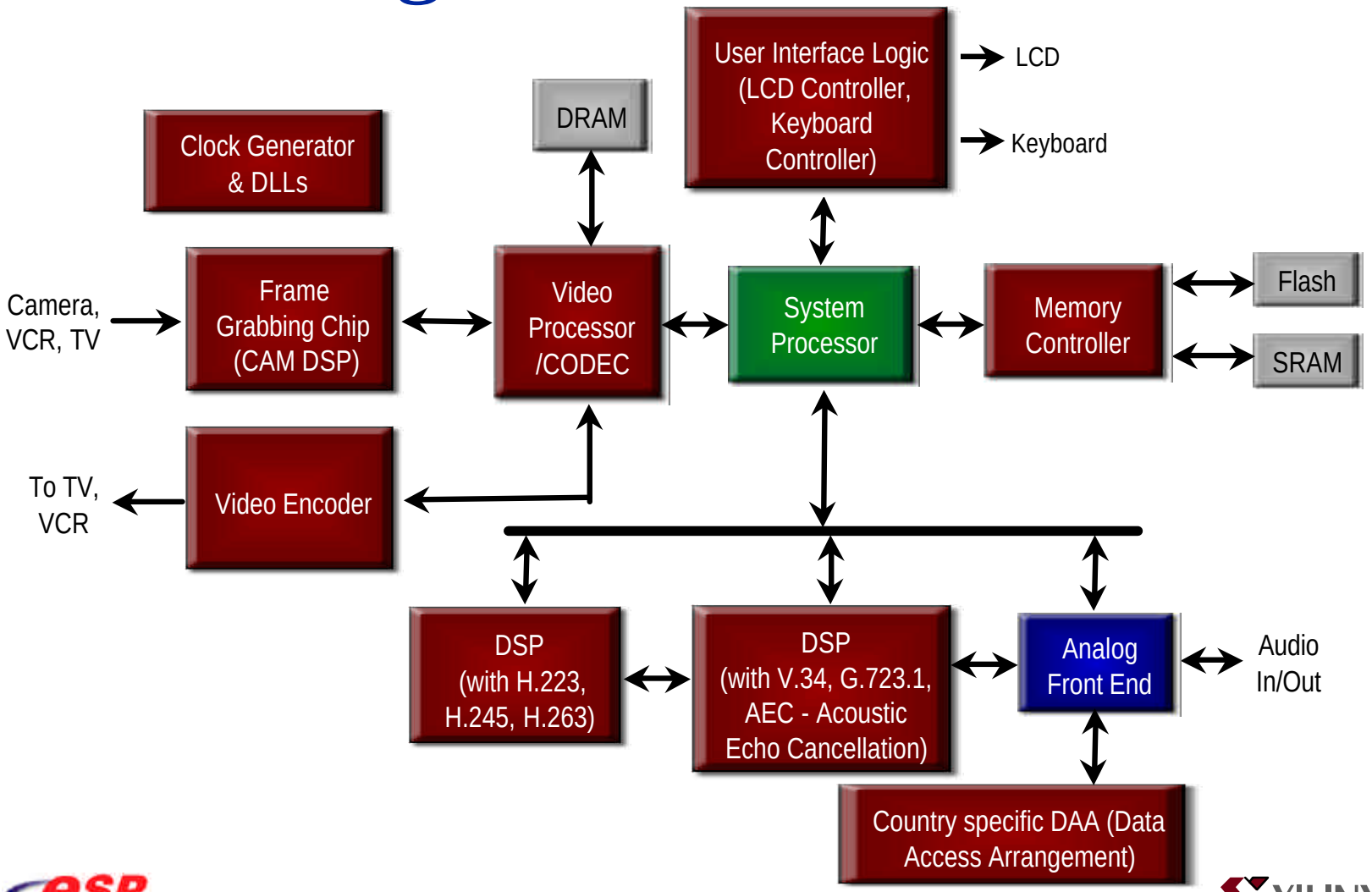
Home Security



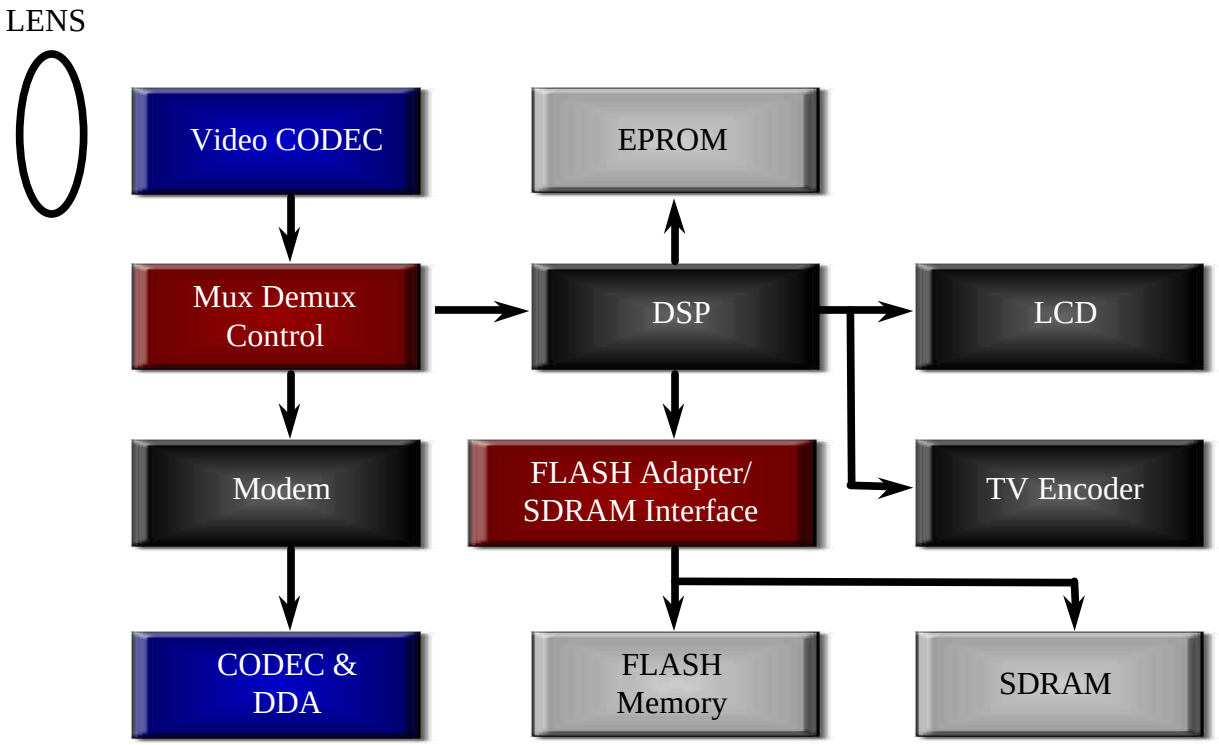
VoIP Phone


Data Services
Serial Port
SRAM
RAM
Flash
Non-Voice User Interface(Audible Indicator, Key Pad)
USB
LCD, LED
Keyboard, Keypad
Non-Voice User Interface Logic (LCD, LED, IR Remote, USB, Keyboard Controller)
Digital Signal Processing (Voice processing, system control, caller ID, V.34/V.42 Modem)
System Processor (Signaling & Network Management)
RJ-45
Voice CODEC (Handset & speakerphone CODEC (ADC, DAC) with Audio Filters
10/100 Base-TX Ethernet MAC
MII
10/100 Base-TX Transceiver
To/From PC
To/From Network
Handset
Speaker
MIC
Voice Interface
HomePNA MAC
Analog Front End (AFE)
RJ-11

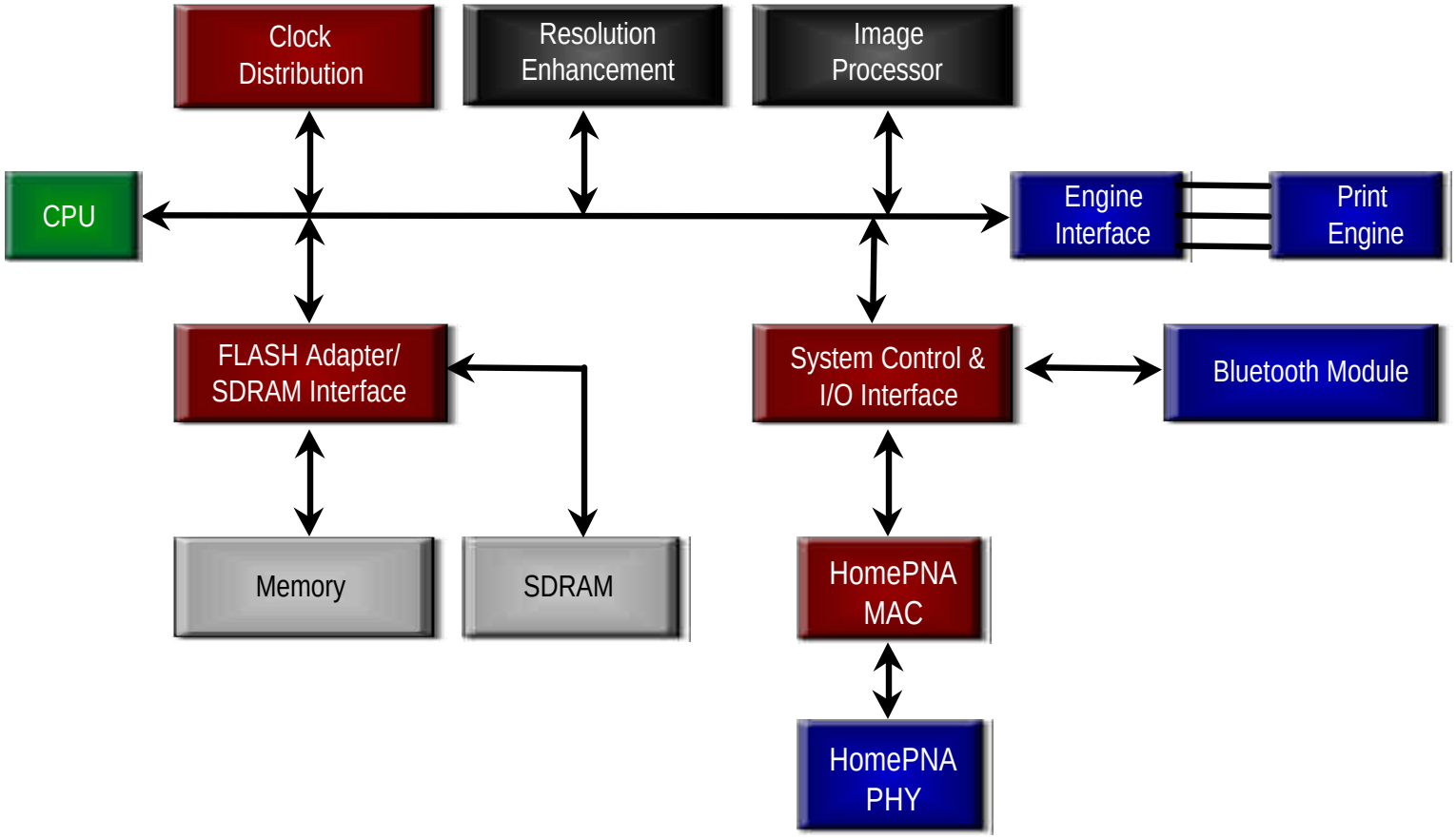
Internet Screen Phone/ Digital Video Phone



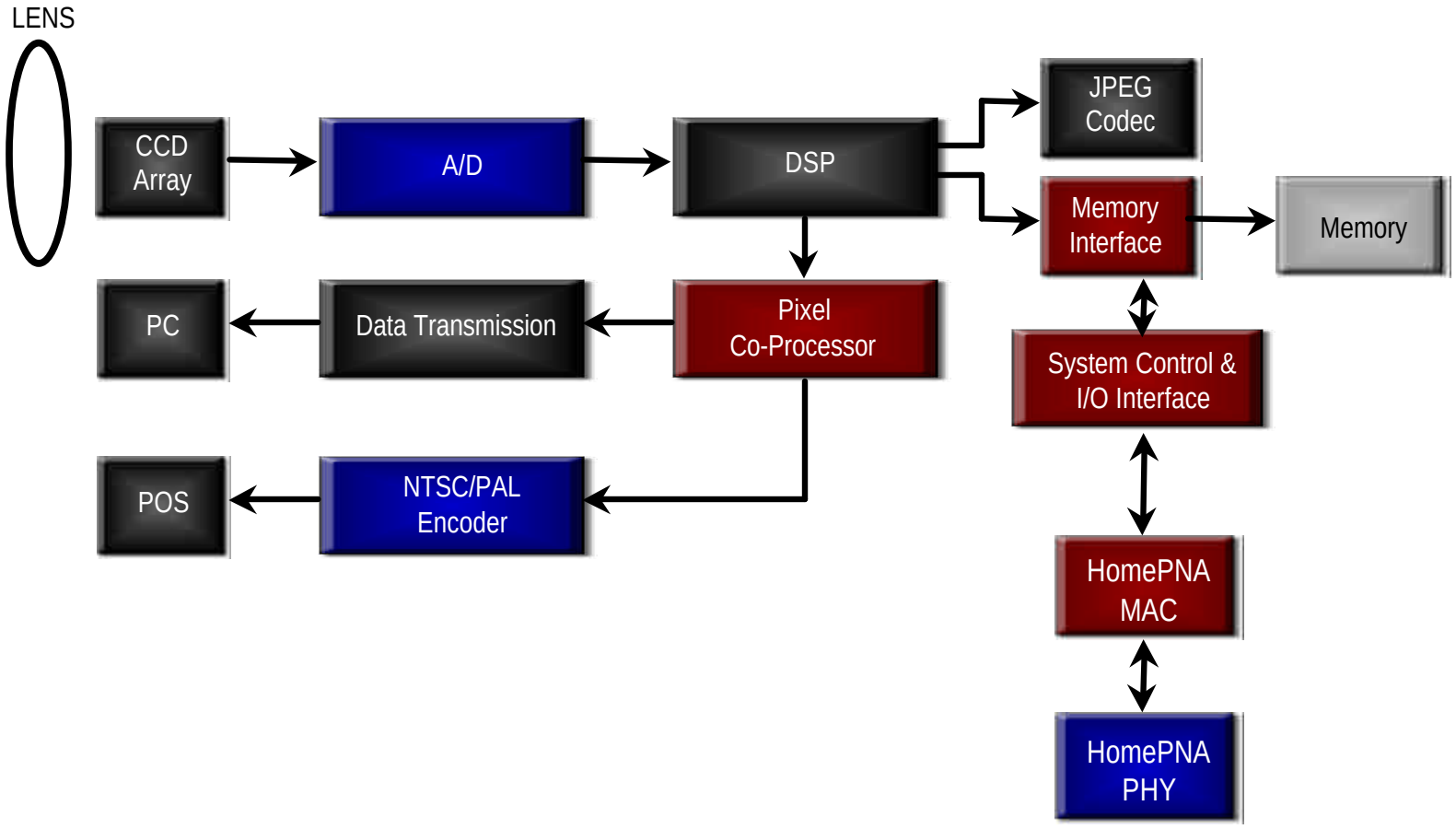
Internet Screen Phone/ Digital Video Phone



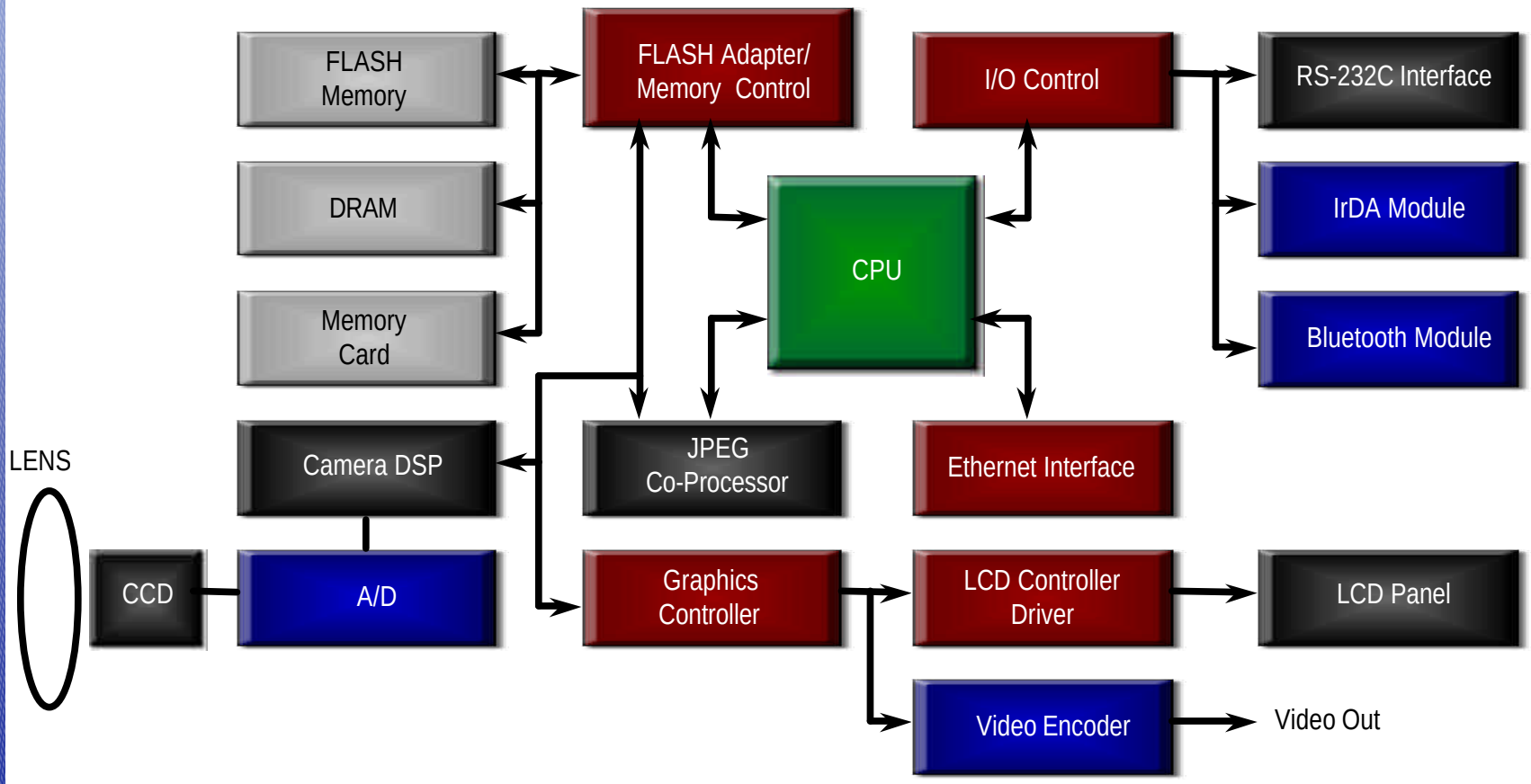
Printer


Clock Distribution
Resolution Enhancement
Image Processor
CPU
Engine Interface
Print Engine
FLASH Adapter/ SDRAM Interface
System Control & I/O Interface
Bluetooth Module
Memory
SDRAM
HomePNA MAC
HomePNA PHY

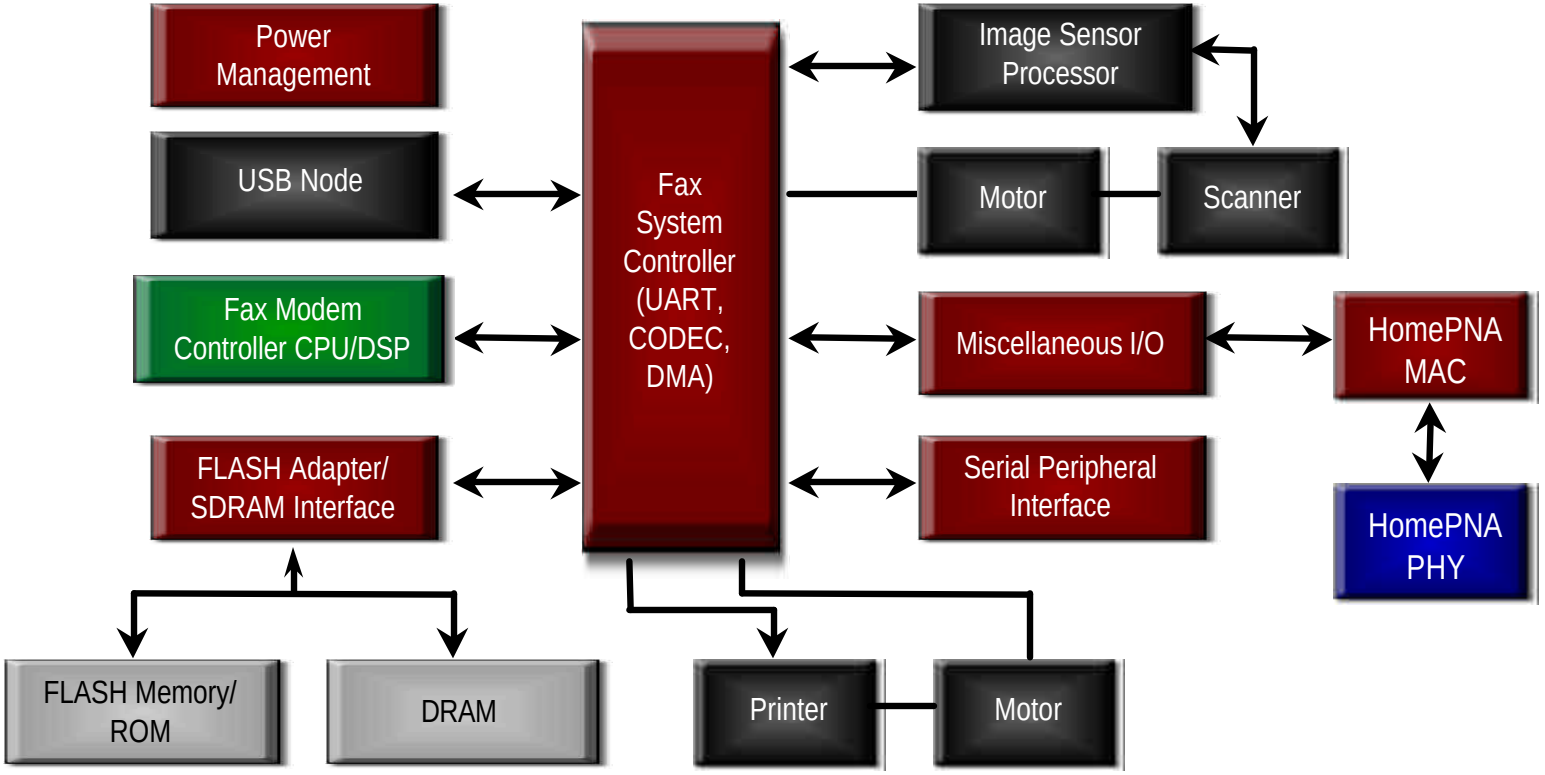
Scanner


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
HomePNA MAC
HomePNA PHY

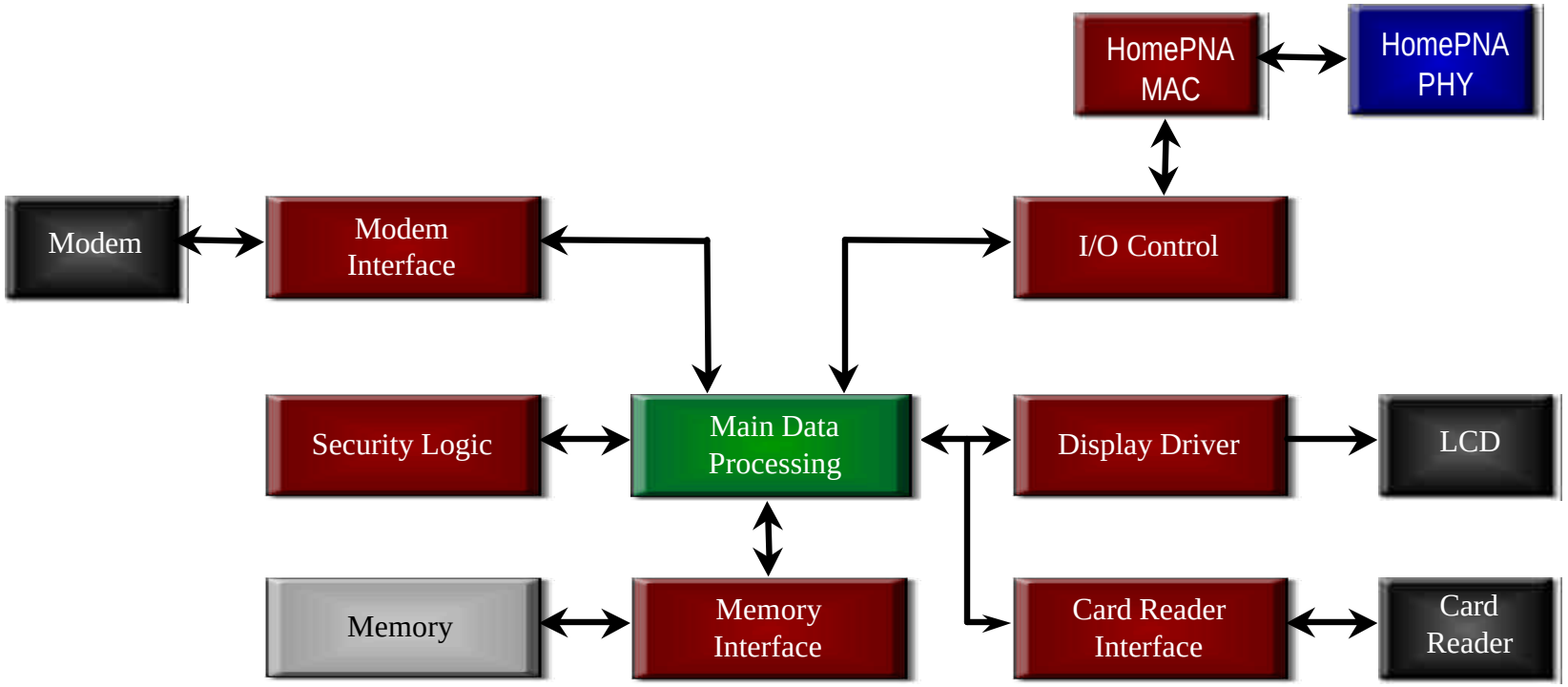
Digital Camera



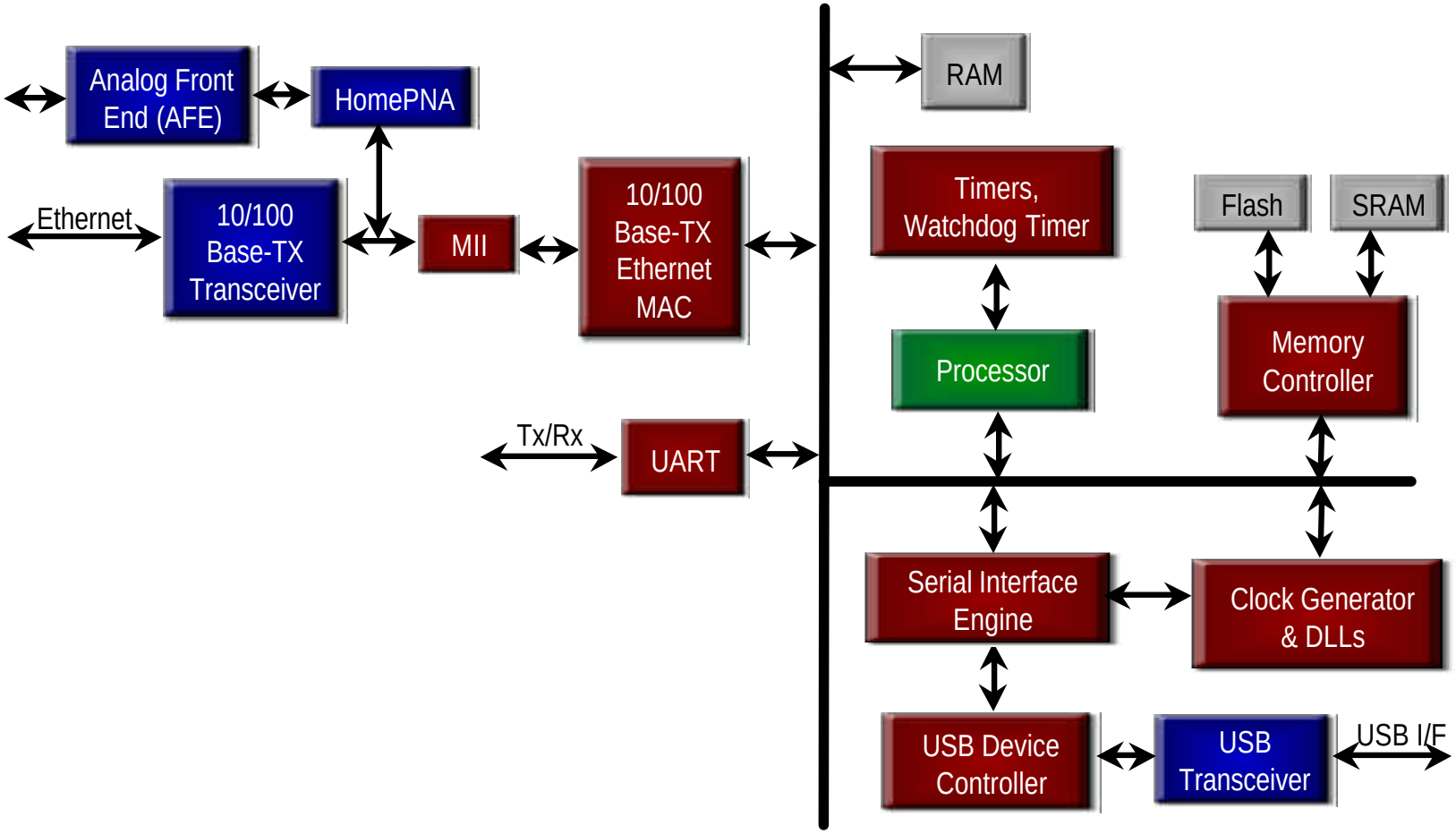
Multi-Function Peripheral



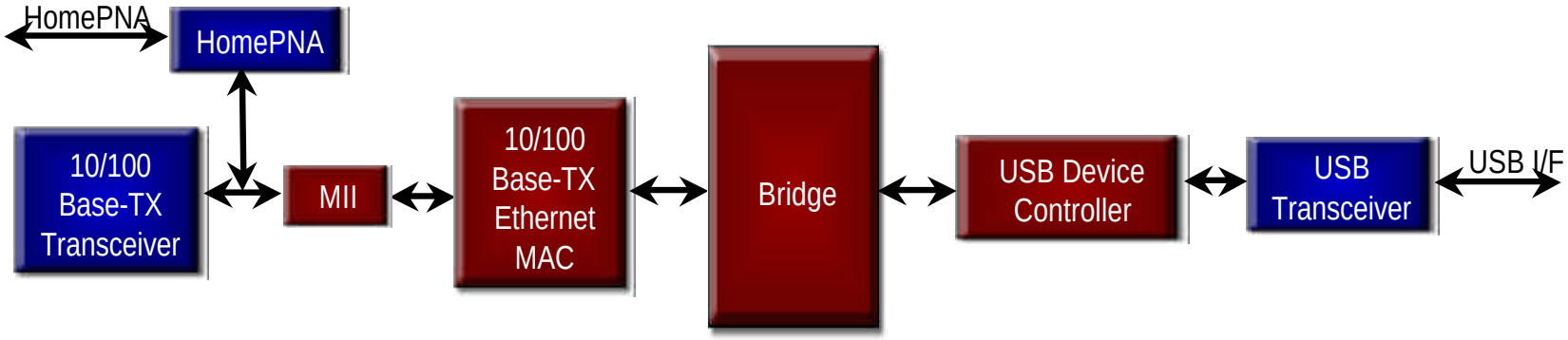
Smart Card Reader



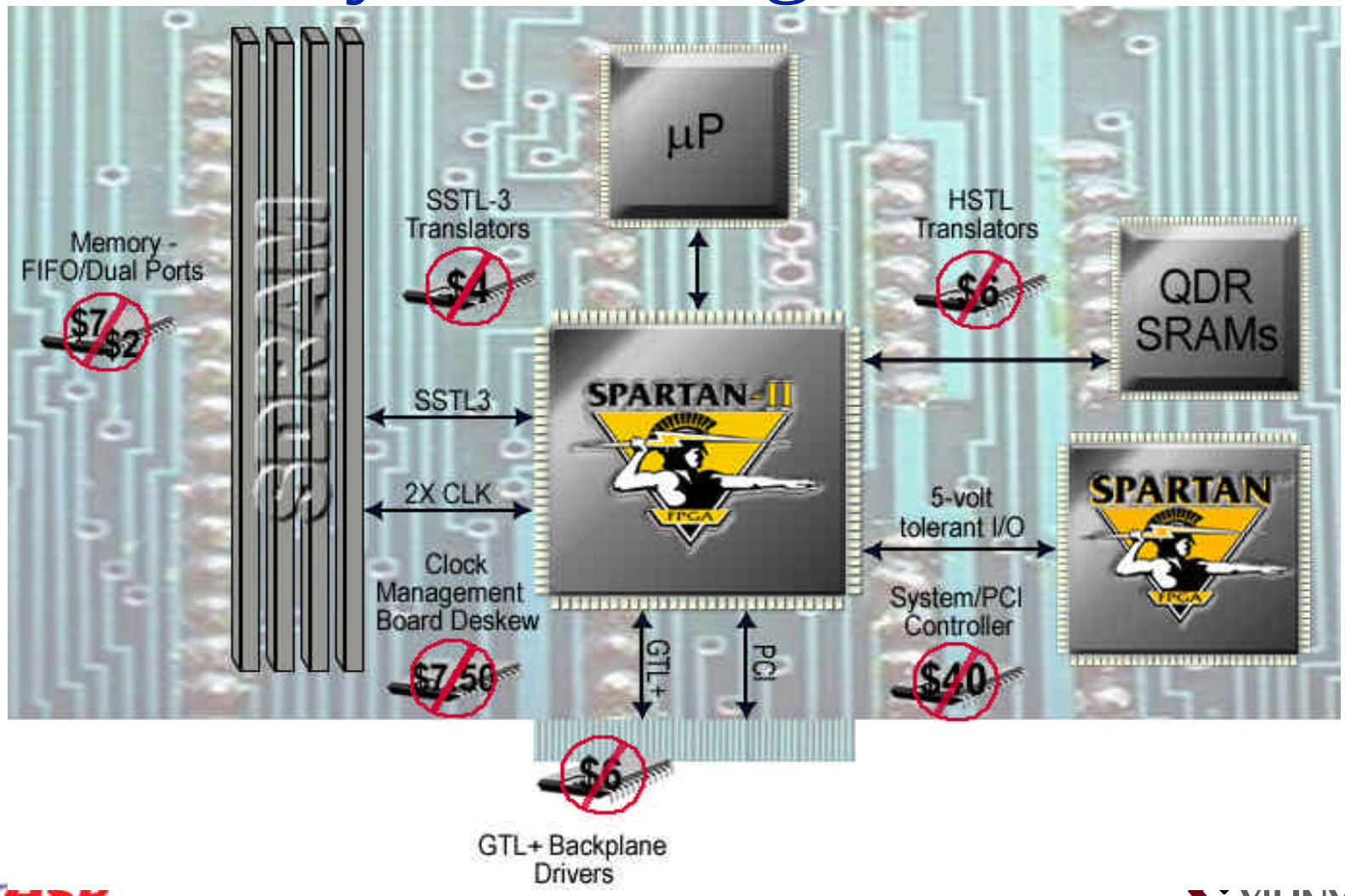
USB to HomePNA Bridge



USB to HomePNA Bridge



Spartan-II Features Provide System Integration



Spartan-II Solutions for HomePNA Based Products

- 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
- PCI
- Memory solutions
  - On-chip Distributed memory, BlockRAM
  - Memory controllers
- CPU / microcontroller
- HDLC controller
- ADPCM
- Color Space Converters
- Glue logic & system integration
  - 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

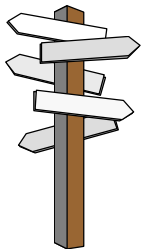
U.S. Networks Select Digital Broadcasting Format

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

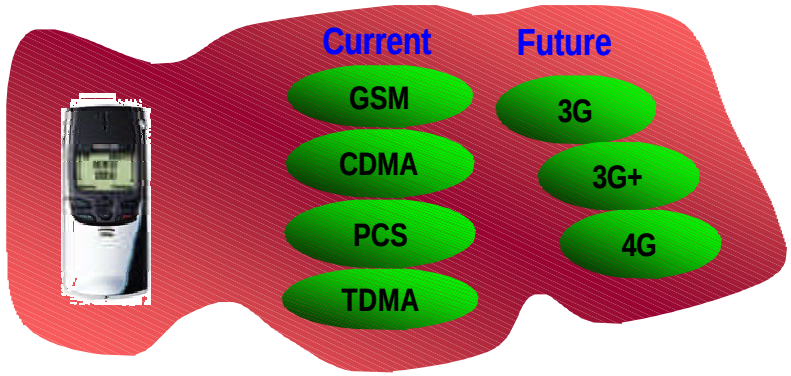
Market



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

=

Xilinx & Replay TV
-Revolutionizing consumer TV

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

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

- Home networking - the complete solution
- Introducing phoneline home networking
- Industry initiated consortiums - HomePNA
- Phoneline home networking technology
- HomePNA solutions available today
- Xilinx Solutions for phoneline home networking (HomePNA) based products
- Summary

Summary

- The digital consumer revolution & the Internet are forcing broadband to the home
  - Phonelines provide a viable home networking technology
    - No new wires
    - Ubiquitous presence of phone jacks & phonelines in US homes
    - Next generation HomePNA devices are looking at performance of up to 100Mbps
- Various HomePNA products are being developed
  - Residential gateways: DSL, cable, satellite modem based
  - Technology bridges: HomePNA-to-1394, HomePNA-to-Ethernet, HomePNA-to-wireless LANs
  - HomePNA enabled information appliances: digital TV, DVD player, Internet screen phones, PCs, printers, etc.

Summary

- Xilinx solutions enable HomePNA-based products
  - Spartan-II + IP provides better solutions than competing ASSPs
    - Higher performance & cost effective
    - More flexibility
      - Reprogrammability enables time-to-market & flexibility
        - Phoneline HN market is rapidly growing & products need to be rolled out
      - IRL provides time-in-market as specs in emerging technologies keep evolving
        - HPNA 2.0 spec is released with future revisions already underway
    - Features within the Spartan-II provide system integration
      - DLLs, SelectIO, BlockRAM
    - Embedded solutions
      - FPGA logic not used from IP can be programmed with other IP cores
  - Spartan-II FPGAs, CoolRunner & 9500 CPLDs provide system interconnectivity in HomePNA based products