



Imagine a World Without Wires.

# Agenda

- ◆ Introduction to home networking
- ◆ Wireless home networking
- ◆ Consortium - HomeRF Working Group
- ◆ HomeRF technology - SWAP
- ◆ Xilinx Spartan-II FPGAs in HomeRF-Based Products
- ◆ Summary



# Home Networking - The Complete Solution

Introduction & Vision

# What is Home Networking?

- ◆ The distribution of information (Audio, Video, & Data) around the home and their interface with attached devices and external services
- ◆ The interconnection and interoperation of
  - Home appliances
  - Entertainment devices
  - PC hardware
  - Telecommunication devices
  - Security, lighting and environmental control systems

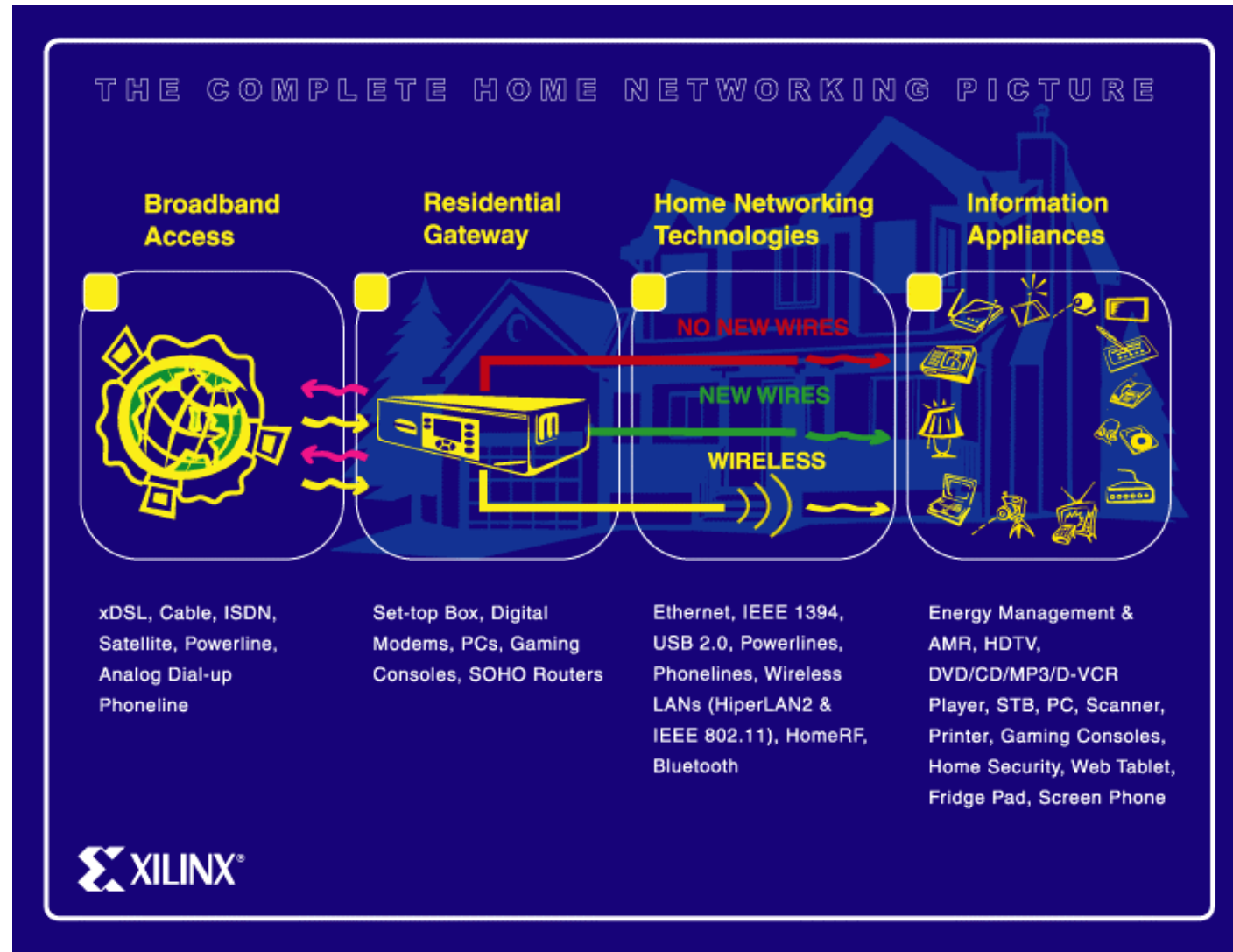
Its All About Convergence



# Goal of Home Networking

- ◆ Provide the ability to access information, entertainment and communicate anywhere, anytime
  - Bring the Internet to the hands of the consumer
  - Interconnect people in data, voice and video
    - Enables users to communicate & share data
  - Bring interconnectivity to intelligent devices
  - Always on, anytime, anywhere access to the home network

# Four Aspects to Home Networking



# Market Requirements and Solutions Available

	Market Requirements	Solutions Available
<b>Broadband Access</b>	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
<b>Residential Gateway</b>	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
<b>Home Networking Technologies</b>	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)
<b>Information Application Networks</b>	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.

# Residential Gateway

## *The Key Ingredient For Home Networking*

- ◆ RGs provide integration of different broadband access types & different home networking solutions
  - Broadband access: xDSL & cable modems
    - Each modem offers an Ethernet port for connecting one computer
    - Increasing number of households have multiple computers
      - Tech-savvy users may install Ethernet hub and pull Cat5 cabling to each computer
      - Most users will not find this a viable option due to installation obstacles or cost
  - Home networking solutions: HomePNA, HomePlug, HomeRF, Wireless LANs, IEEE 1394

# Key Information Appliances

- ◆ Digital TV
- ◆ Set-Top box
- ◆ Internet screen phones
- ◆ Interactive DVD players, Digital VCR
- ◆ Gaming devices
- ◆ MP3 players/audio Devices
- ◆ Cordless phones
- ◆ Security systems
- ◆ Utility meters
- ◆ PCs (desktop & notebook)
- ◆ Web (kitchen) pads
- ◆ Web/Email terminals
- ◆ PDAs (personal digital assistant)
- ◆ Digital Cameras
- ◆ Emerging technologies
  - Auto PCs



# Home Networking Technologies



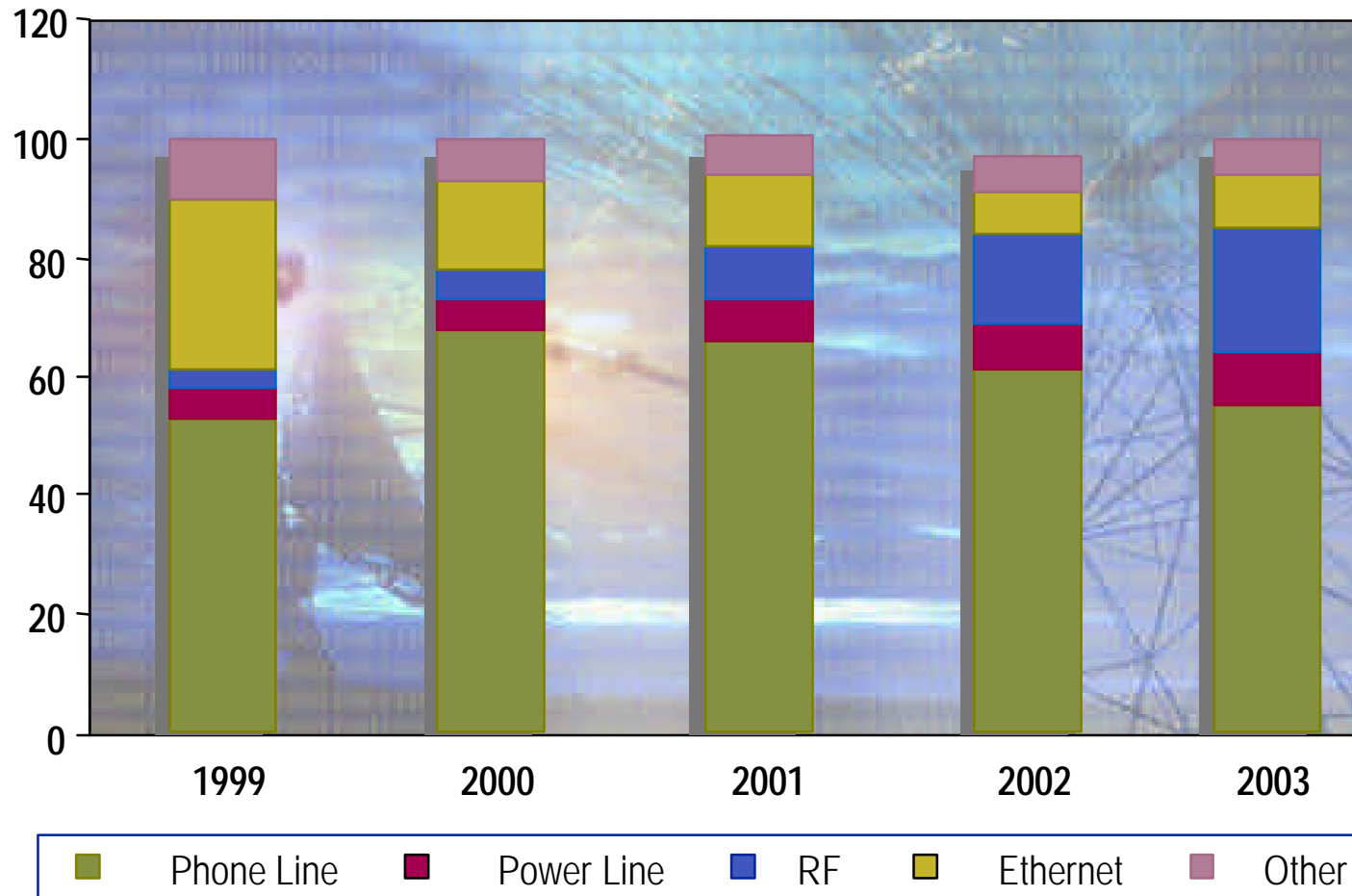
# Different Applications Require Different Data Rates

Service	Description	Rate (bps)	Rate (bps)	Rate (bps)	Rate (bps)
Telephony	1 to 6 lines at 64 kbps with guaranteed bandwidth	64k	128k	256k	384k
Video Conference	1 to 2 streams at 384 kbps	-	384k	768k	768k
Data	www, ftp, asynchronous traffic	1M	1M	3M	5M+
IP Streaming	Multiple video and audio streams (10 kbps to 3 Mbps)	128k	3M	6M	6M
DTV	MPEG2 SDTV or HDTV (2–19.4 Mbps)	-	-	6M	30M+
Internal Traffic	Printer/file sharing, gaming, intercom, video monitor, DVD, digital audio, etc.	250k	500k	2M	6M
TOTAL	Estimate of Home network capacity	2M	6M	20M	50M+

Source: CableLabs



# Market Acceptance



Courtesy: Dataquest



Courtesy: Dataquest



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# Wireless Home Networking Solutions

# The Coming of Wireless Home Networking

- ◆ Home networking solutions demand
  - No new additional wires or phone jacks
  - Interoperability
    - Compliment phoneline-based home network solutions
  - Convenience
    - Simple to install
    - Easy-to-use
  - Economical: Low cost
  - Performance
    - Bandwidth to support common home networking applications
  - Secure
  - Big industry & consortium support (Bluetooth, IEEE, H2GF)

# Why Go Wireless?

- ◆ Provide core home networking capabilities
  - Multiple PC users share Internet access, printers, files, drives & participate in multi-player games
  - Internet access - anywhere in & around the home
- ◆ Share wireless voice & data
- ◆ Review incoming messages
- ◆ Activate other home electronic systems by voice
- ◆ Needed in countries where phone lines cannot be used

**Key Drivers: Portability & “No new wires”**

# Wireless Home Networking Solutions - Pros & Cons

## ◆ Pros

- Flexibility & mobility
- Broad geography support at specific frequency
- Can compliment a wired network with bridging

## ◆ Cons

- Relatively expensive
- Distance limits & wall attenuation (150ft barrier)
- Security must be addressed
- Prone to narrowband interference

# What is a Good Wireless HN Solution?

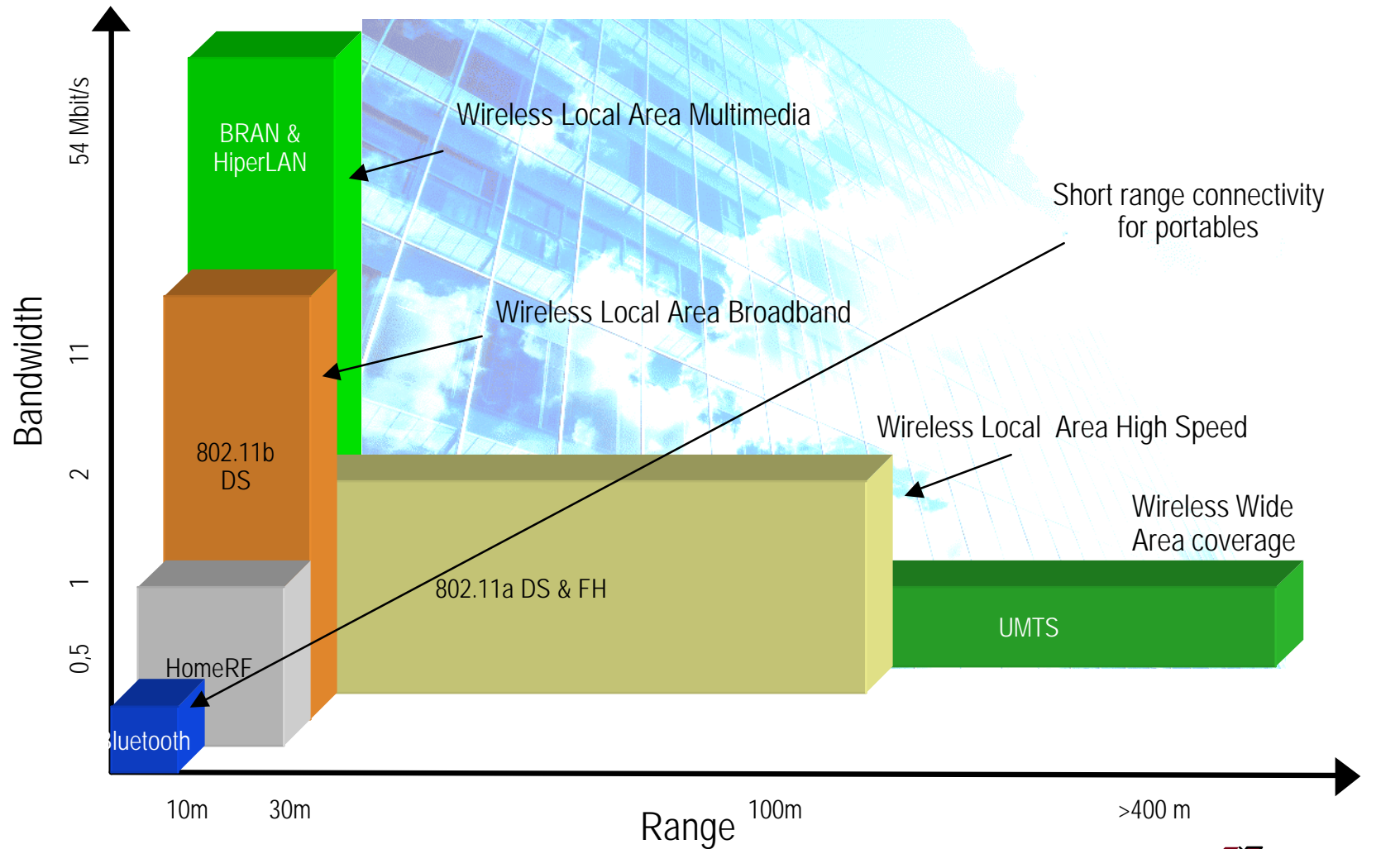
- ◆ Powerful
  - Similar capabilities of a typical office network
  - Simultaneous Internet access, file & drive sharing, printer sharing
- ◆ Simple
  - Simple Installation
  - Easy & intuitive use of network
- ◆ Economical



# Wireless In-Home Networking Technologies

- ◆ Bluetooth & IEEE 802.15
  - Personal area network for data & voice communications
- ◆ HomeRF
  - Home based data & voice transmissions
- ◆ Wireless LAN
  - High-speed wireless connectivity augmenting wired networks
  - IEEE 802.11 (a & b variations)
    - a - 5GHz standard based on OFDM
    - b - 2.4GHz standard based on Ethernet
  - HiperLAN & HiperLAN2
    - 5GHz standard based on OFDM

# Wireless Technologies in Home Networking



# Bluetooth

- ◆ Short-range wireless data transmission technology - Personal Area Networks
  - Provide a simple module that will allow a wide variety of electronic devices to exchange data electronically over short ranges
- ◆ Low-cost, low power consumption methods of transmitting data without using wires
- ◆ By 2003, Bluetooth market could be worth \$5 billion (SG Cowen)
- ◆ Major industry backing of Bluetooth SIG
  - Ericsson, Nokia, IBM, Intel, Toshiba, Motorola, Lucent, 3Com
  - 2000+ members today

# Key Characteristics & Capabilities of Bluetooth

- ◆ Transmits sound and data
- ◆ Used worldwide (standard technology)
- ◆ Ad hoc connection
- ◆ Open environment, but prevents external reception
- ◆ Compact, & able to be installed in a variety of devices
- ◆ Extremely low power consumption
- ◆ Open industry standard
- ◆ Low cost

# Wireless LANs

- ◆ Wireless Local Area Networks combines data connectivity with user mobility
  - Implemented as an extension to wired LAN
  - Minimizes the need for wired connections
- ◆ Radio or Infrared waves are used to transmit & receive data over the air
- ◆ Strong popularity in vertical markets for productivity gains
  - Health-care, retail, manufacturing, warehousing, academia
- ◆ Worldwide wireless LAN market
  - More than \$2 billion revenues by year 2000 (Business Research Group)



# Different Strokes for Different Folks

	Home Automation	Entertainment	Information	Personal Communications	Communication
Devices	<ul style="list-style-type: none"> <li>- Home appliances</li> <li>- Security/safety systems</li> <li>- Utility meters</li> </ul>	<ul style="list-style-type: none"> <li>- TV sets</li> <li>- Set-top boxes</li> <li>- DVD Players</li> <li>- Game consoles</li> <li>- VCRs</li> <li>- MP3 Players</li> </ul>	<ul style="list-style-type: none"> <li>- PCs</li> <li>- Screen phones</li> <li>- Printers</li> <li>- Modems</li> <li>- Routers</li> <li>- Hubs</li> <li>- Scanners</li> </ul>	<ul style="list-style-type: none"> <li>- Mobile phones</li> <li>- Smart phones</li> <li>- Handheld</li> <li>- Laptop</li> <li>- Pagers</li> </ul>	<ul style="list-style-type: none"> <li>- Corded/Cordless telephones</li> <li>- Fax machines</li> </ul>
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	<ul style="list-style-type: none"> <li>- Power line</li> <li>- POTS</li> </ul>	<ul style="list-style-type: none"> <li>- Cable</li> <li>- DBS</li> </ul>	<ul style="list-style-type: none"> <li>- Cable modem</li> <li>- ADSL</li> <li>- POTS, ISDN</li> </ul>	<ul style="list-style-type: none"> <li>- GSM</li> <li>- Infrared</li> </ul>	<ul style="list-style-type: none"> <li>- POTS</li> </ul>
Practical Networking Technology	<ul style="list-style-type: none"> <li>- CEBus</li> <li>- X-10</li> <li>- LONWorks</li> </ul>	<ul style="list-style-type: none"> <li>- IEEE 1394 (Fire Wire)</li> </ul>	<ul style="list-style-type: none"> <li>- HomeRF</li> <li>- HomePNA</li> <li>- Ethernet</li> </ul>	<ul style="list-style-type: none"> <li>- Infrared</li> <li>- Bluetooth</li> </ul>	<ul style="list-style-type: none"> <li>- POTS</li> <li>- DECT</li> <li>- 900MHz, 2.4GHz</li> </ul>

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

# Wireless Home Networking Technology Comparison

- Wireless LAN, HomeRF & Bluetooth technologies vary in data rate, range, frequency & marketplace aimed for

Technology		Standards Body /Proponent	PHY Layer	Data Rate	Range (meters)	Frequency (GHz)	Technology Aimed For
Wireless LAN	IEEE 802.11a	IEEE	OFDM	40	TBD	5	Office Environments
	IEEE 802.11b	IEEE	DSSS	11	100	2.4	
	HiperLAN2	HiperLAN2 Global Forum	OFDM	54	150	5	
HomeRF	SWAP 1.1	HomeRF Working Group	FHSS	1.6	50	2.4	Home Space
	HomeRF (next generation)	HomeRF Working Group	FHSS	10	50	2.4	
Bluetooth	IEEE 802.15 (Bluetooth)	Bluetooth SIG	FHSS	1	10	2.4	Consumer, short-range wireless personal area network communication
	IEEE 802.15 (high-rate)	Bluetooth SIG	FHSS	2+	TBD	2.4/5	

DSSS- Direct Sequence Spread Spectrum, FHSS - Frequency Hopping Spread Spectrum, OFDM - Orthogonal Frequency Division Multiplexing



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# HomeRF WG (Working Group)

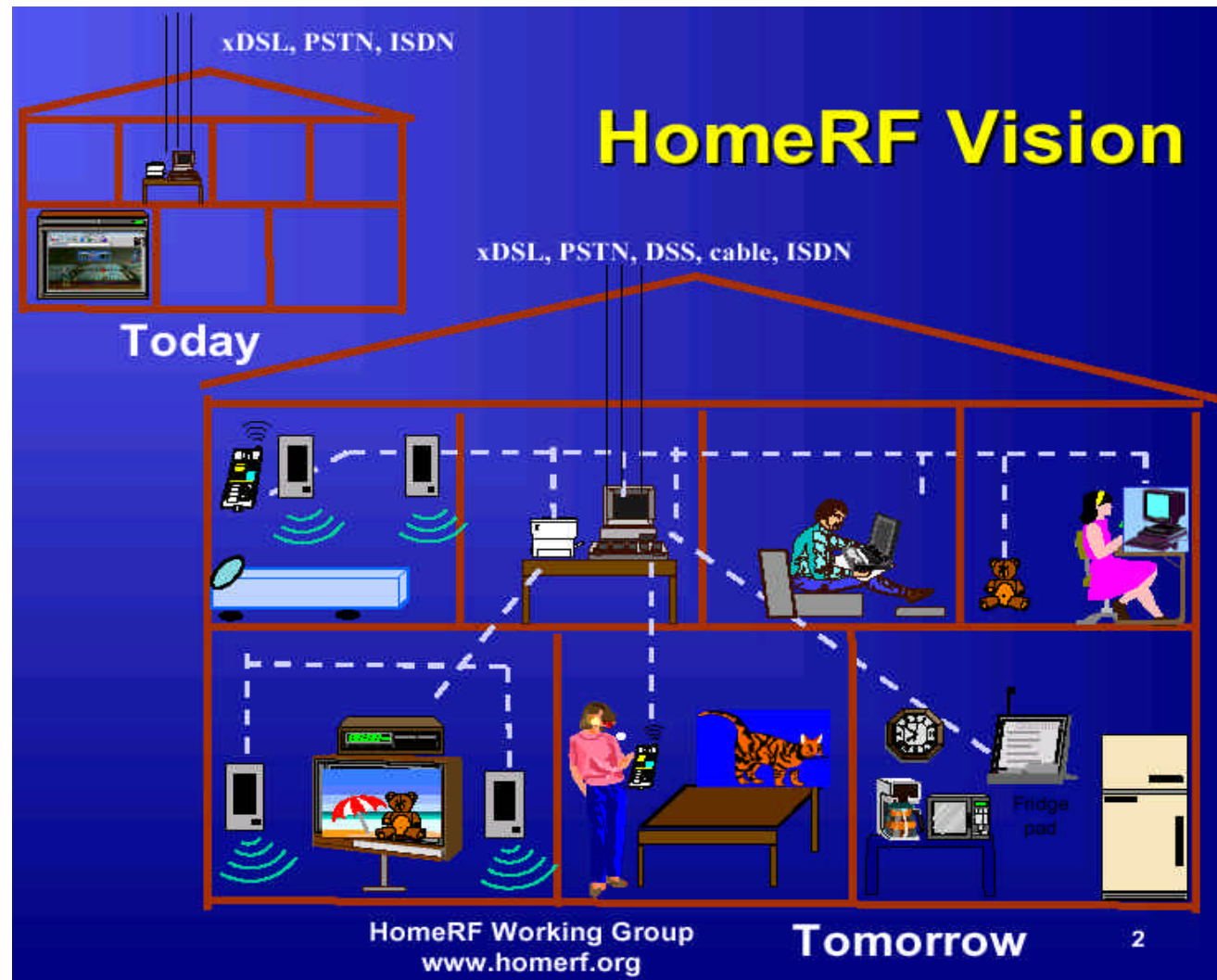
- ◆ Mission Statement

- Enable existence of a broad range of interoperable consumer devices bringing information services to each part of the home
- Establish an open industry specification for unlicensed RF digital communications for PCs and consumer devices anywhere in and around the house

- ◆ 85+ Members - Xilinx is an active member

- Initiating members: Compaq, Ericsson, HP, IBM, Intel, Microsoft, Motorola, Philips, Proxim, Symbionics
- Broad, cross industry support
  - Communications, Consumer Electronics, Home Control/Home Automation, Networking, Peripherals, PC, Semiconductors /Components, Software

# HomeRF Vision



# Home Environment for RF

- ◆ The home environment is harsh for RF and multiple factors effect RF performance in the home
  - Path Loss due to diverse home floor plans, different building materials and no control over antenna placements
  - In-band interferers such as microwaves, cordless phones
  - Multi-path
    - Traffic patterns
    - Ceiling fans
  - Co-location of Subnets
    - Multiple dwelling units
    - Higher density single family homes

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# HomeRF Technology - SWAP

Shared Wireless Access Protocol



# HomeRF Technical Goals

- ◆ Low cost and voice support of DECT
  - Adapted to 2.4GHz band
  - Client call services well defined
- ◆ TCP/IP support of IEEE 802.11
  - Relaxed specs to lower cost
  - Use existing 2.4GHz support (FH)
  - Eliminate complex parts of protocol (PCF & CTS/RTS) to lower cost

**Low Cost, Availability, and Technical  
Features are Keys to Success**

# HomeRF Origins

**802.11**  
Uses CSMA/CA  
Good for Data

**DECT**  
Uses TDMA  
Good for Voice

**SWAP**  
TDMA + CSMA/CA

Good for Voice & Data  
Optimized for small networks (in home)  
Simplified radio & protocol to reduce cost

Both Data & Voice are Important for HomeRF

# SWAP

- ◆ HomeRF SWAP spec
  - Designed for both data & voice wireless communication
  - Defines interoperation of PSTN & Internet
- ◆ Operates in the 2.4GHz band
  - Uses digital frequency hopping spread spectrum radio
- ◆ Derived from extensions of existing cordless telephone (DECT) & wireless LAN technology
  - Enables new class of home cordless services

**IP Data at up to 2Mbps & Supports Cordless Telephony**

# SWAP Supports

- ◆ TDMA
  - Time Division Multiple Access
  - Provides delivery of interactive voice & other time-critical service
- ◆ CSMA/CA
  - Carrier Sense Multiple Access/Collision Avoidance
  - Service for delivery of high speed packet data

# SWAP

- ◆ Developed & optimized
  - Meet unique consumer needs at home & SOHO
  - Powerful combination of data & voice capabilities
- ◆ Ensure interoperability among SWAP products
  - Backed by major industry companies
  - HomeRF group is working with Home PNA and other organizations to deliver interoperability with complimentary home networking solutions



# Capabilities of HomeRF

- ◆ Up to 150 foot range
- ◆ Networks up to 50 PCs
- ◆ Work with dial-up, DSL, and cable modems
- ◆ Work through walls & floors
- ◆ Data secured through unique network ID
- ◆ Robust & reliable & minimizes the impact of radio frequencies
- ◆ Includes support of near line quality voice & full telephony

# Performance

- ◆ Designed to meet the performance demands of available applications
- ◆ Product performance will easily enable a user to simultaneously
  - Browse the Internet
  - Print a web page
  - Listen to music

# Technical Summary

- ◆ Hybrid TDMA/CSMA frame
  - Beacon from Connection Point (CP) sets frame structure
- ◆ Frequency Hopping: 50 hops/sec
- ◆ Range up to 50 meters indoors
- ◆ Speed: dual speed
  - 2 or 4 FSK Yields 1 or 2 Mb/sec
  - Also supports TCP/IP voice
- ◆ Voice: High quality voice channels with retransmission
  - High quality cordless telephones
  - Voice recognition

# Technical Summary - Data

- ◆ Handles data like IEEE 802.11
- ◆ Relaxed PHY specs from IEEE 802.11
  - Lowers radio cost significantly
  - Same hop sequences
    - Localized for France, Spain, Japan, US, EC
    - Different bandwidth for Japan, France, Spain
- ◆ Manages isochronous traffic
- ◆ Simplified protocol
- ◆ Comparable backoff, packet structure, ad-hoc capabilities

# Technical Summary - Voice

- ◆ Handles voice like DECT with retransmission
- ◆ Uses DECT calling stack
- ◆ Uses DECT A/B fields
- ◆ 32kb/s ADPCM (Adaptive Differential Pulse Code Modulation)
- ◆ 20ms Frames - retransmit in beginning, outbound at end (better for data)
- ◆ Interleaved up and down link packets



# Data Service Types

- ◆ Isochronous (I Node)
  - Circuit switched & connection-oriented
  - Used mainly to carry interactive voice
    - Minimum latency
    - Requires the presence of a Connection Point
  - Example: cordless telephones
- ◆ Asynchronous (A Node)
  - Packet switched & connectionless
  - Used for data networking - TCP/IP traffic
  - Example: fridge pad
- ◆ I Nodes get priority on bandwidth

# Data Service Types

- ◆ CP - connection point
  - Can manage a network or act as an A node
  - Can be USB, PCI, PC-Card, Device Bay
  - CP can place calls even when PC is down



# Voice in HomeRF

# What is DECT?

- ◆ Digital Enhanced Cordless Telecommunications
- ◆ Target applications
  - SOHO voice and data
    - Residential cordless
  - Wireless enterprise systems
  - Fixed wireless systems with range up to 15km

# DECT Market

- ◆ It is one of the world's most successful cordless voice standard
  - Over 45 million DECT terminals in use\*
  - Installed base of 200 million units forecast by 2003\*
  - Growing supplier base: over 200 today\*
- ◆ DECT is a worldwide solution
  - Accepted over 110 countries worldwide
  - Long-term spectrum availability
  - More countries are accessible through the 2.45 GHz ISM frequency band

\* - Source: Siemens



# Elements of High Quality Cordless Voice

- ◆ Expectation of the audio path
  - Wire-line audio clarity
  - Void of pops, clicks, echoes or delays
  - Functions with other telephony appliances
- ◆ Expectation of mobility and range
  - Wander anywhere within the residence
  - And to the mailbox and the pool
  - And some expect to go to the neighbor's home!
- ◆ General expectations of mobile voice devices
  - Several days of standby and 10 or more hours of talk
  - Easy and intuitive to operate

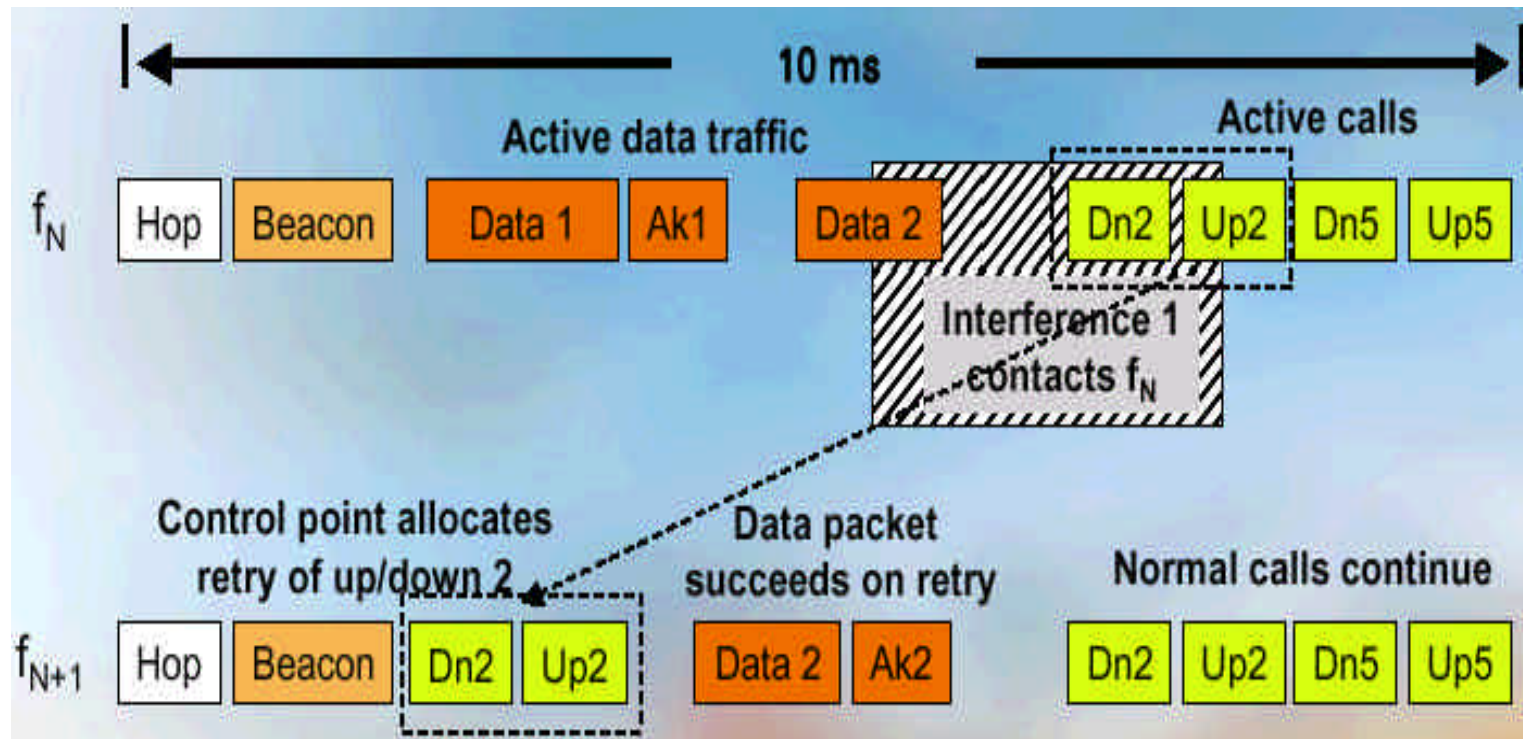
# Major Threats to Cordless Voice Quality

- ◆ Speech encoding & modulation technique
  - Efficient conversion of speech to digital format
  - Guaranteed maximum transmit and processing delay
- ◆ Bit errors and packet errors
  - Detect and repair, or retransmit
- ◆ Interference from other RF emitters
  - Avoid or recover

# Threats to Cordless Voice Quality Due to Latency

- ◆ Latency is caused by the round trip transmit times
  - Between base station/access points and handset/NIC
- ◆ Latency is a function of the size of the frames transmitted
  - Voice is best served by short frames
  - Data is best served by longer frames
- ◆ Latency is a function of the channel access method
  - Interference probability increases with frame size
  - Contention methods are undesirable for real time applications like voice
  - High priority, guaranteed periodicity is optimal for voice

# HomeRF Minimizes Latency to Voice Data Even in the Presence of Interference



Source: Siemens

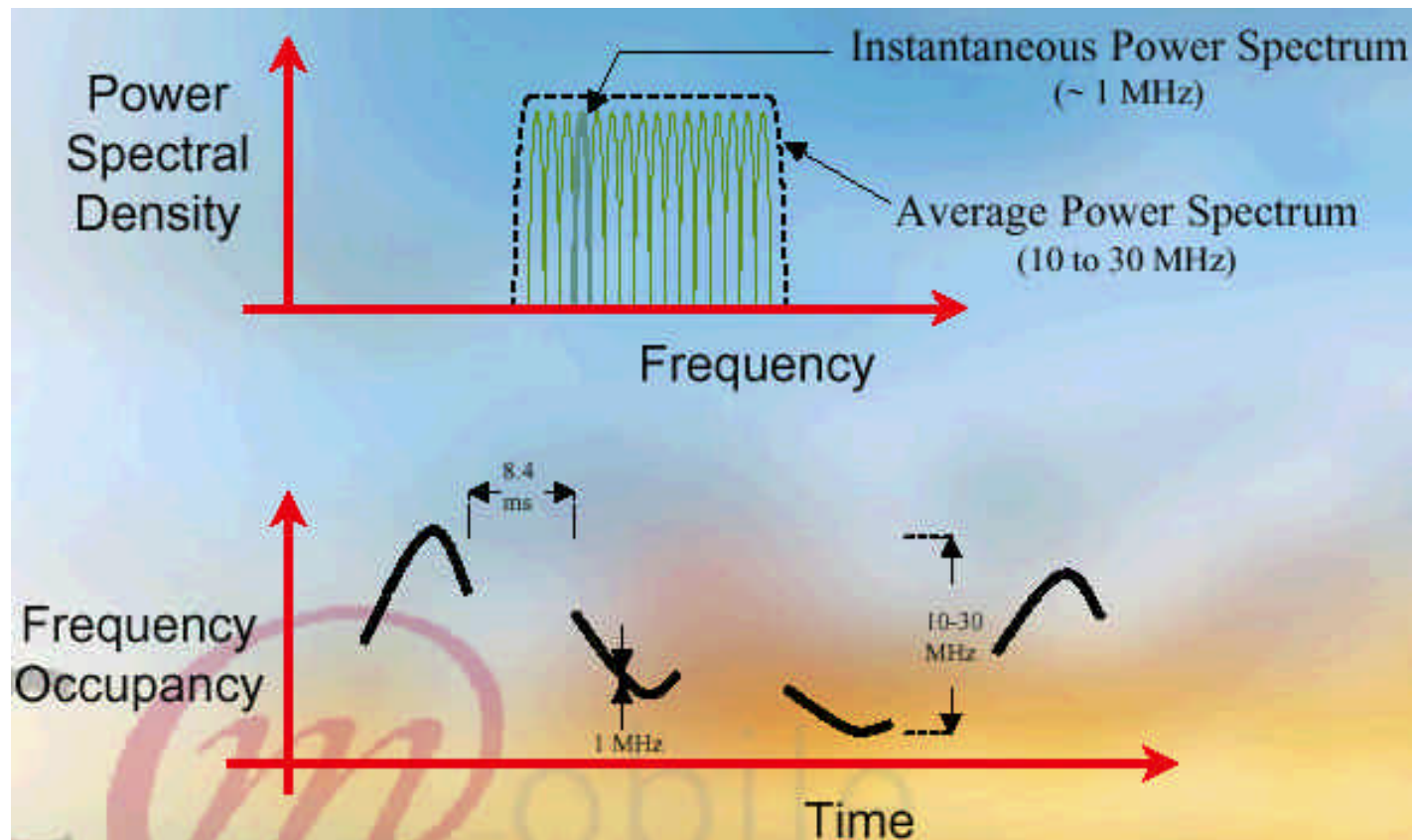


# Microwave Ovens Are a Common Source of Interference

- ◆ Nominal 2450- MHz center frequency
- ◆ Approximately 50% duty factor
  - 8.4- ms on- time in US
  - 10- ms on- time in Europe
- ◆ Instantaneous narrowband, but “wandering”
  - 1- MHz short- term spectral width
  - 1- to 3- MHz chirp, probably magnetron self- heating
  - 10-30 MHz average occupancy due to “mode stirring”
- ◆ Relatively intense
  - Avoidance yields most effective mitigation
  - Linear processing of marginal value



# Spectral/Temporal Characteristics of Microwave Ovens



Source: Siemens

# HomeRF Mitigates the Effects of Microwave Ovens

- ◆ Probability of a hit by microwave oven interference
  - 20% of the band for 50% of the time
- ◆ HomeRF uses time/frequency diversity to reduce probability
- ◆ HomeRF uses hopset adaptation for persistent interferers

# Consumer Benefits of HomeRF for Residential Cordless Voice Networks

- ◆ Provides mobility throughout the home or small office
- ◆ Extremely high quality voice suitable for home or business
- ◆ Security against eavesdropping
- ◆ Multi-user capabilities capitalizes on household trends
- ◆ Extensive core feature set beneficial to residence & SOHO
- ◆ Meets price point expectations

# Technical Advantages of HomeRF for Residential Cordless Voice Networks

- ◆ Audio Clarity is achieved by
  - Use of Adaptive Differential Pulse Code Modulation
- ◆ Latency is minimized by
  - Utilizing 10ms frame length when voice is active
  - Providing high priority isochronous channels for voice

# Technical Advantages of HomeRF for Residential Cordless Voice Networks

- ◆ Bit and frame errors are reduced by
  - Active interference avoidance
  - Time/Frequency diversity by re-transmitting the frame
- ◆ Interference is mitigated in HomeRF by
  - Re-transmitting lost data in the very next frame
  - Hopping to a new frequency each frame
  - Modifying the hopset to hop around the interferer



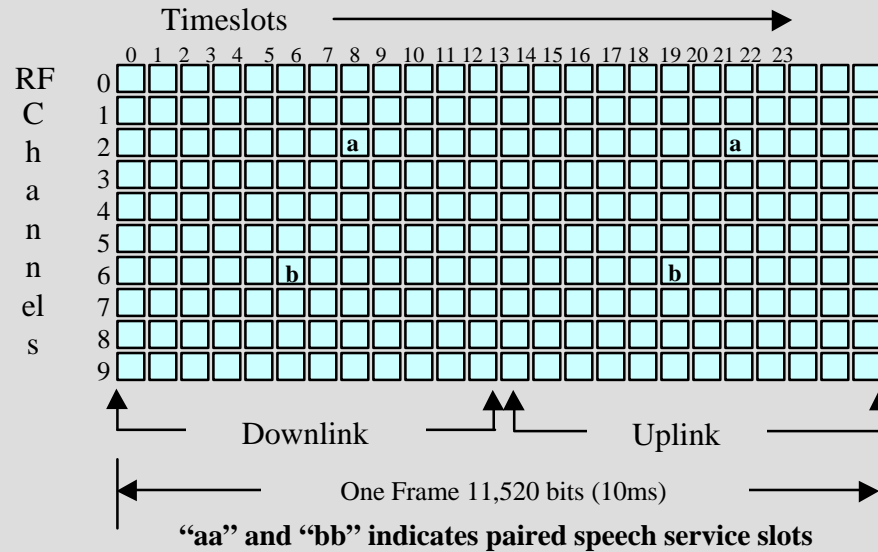
# ADPCM

## *Adaptive Differential Pulse Code Modulation*

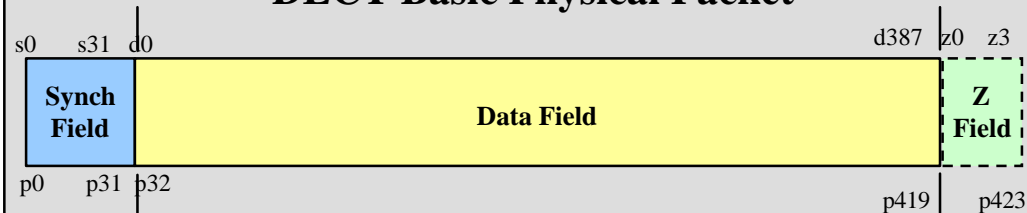
- ◆ Coding technique optimized for human voice spectrum
  - Carefully designed around 'what we hear'
- ◆ Optimal tradeoff between BW and Quality
  - Bit rate scheme is optimized for clarity
  - 32 Kbps is efficient use of radio spectrum
- ◆ ADPCM rates high on subjective listening tests
  - Mean opinion scores are on a scale of 1- 5 (5 is highest)
  - Land-line at 64Kbps produces an MOS of 4.3
  - ADPCM at 32Kbps produces an MOS of 4.1
  - Digital cellular at 8Kbps produces an MOS of 3.4
- ◆ Near land-line quality

# DECT

## DECT Frequency/Time Spectrum



## DECT Basic Physical Packet



The Z field repeats the last 4 bits of the Data Field to allow detection of unsynchronized interference affecting the end of the physical packet.

# DECT Features

- ◆ Features
  - Supports data, voice, and video
  - 1.152 Mbps data rate
  - High network capacity
  - 1.88-1.90 GHz frequency band
  - Available now
- ◆ Access/Modulation
  - TDMA/GFSK

# DECT

## Advantages & Disadvantages

- ◆ Advantages
  - ETSI sanction
  - Coexistence with 2.4 GHz LANs
- ◆ Disadvantages
  - Lower speed



# Data in HomeRF



# PHY Features

- ◆ Nominal 100 mW transmit power
- ◆ Minimum receiver sensitivity of -76 dBm (2FSK)
  - Range >50 m in typical homes
  - -85 dBm typical sensitivity
- ◆ Cost effective filter requirements
  - Use MAC to reduce PHY cost
  - Makes single-chip integration simpler

# FH - Frequency Hopping

- ◆ It works very much like its name implies
  - Frequency hopping
    - Data signal is modulated with a narrowband carrier signal that hops from frequency to frequency as a function of time over a wide band of frequencies
    - Relies on frequency diversity to combat interference
      - This is accomplished by multiple frequencies, code selection & FSK
  - E.g., A FH radio will hop the carrier frequency over the 2.4GHz frequency band between 2.4GHz & 2.483GHz
    - If the radio encounters interference on one frequency, the radio will retransmit the signal on a subsequent hop on another frequency

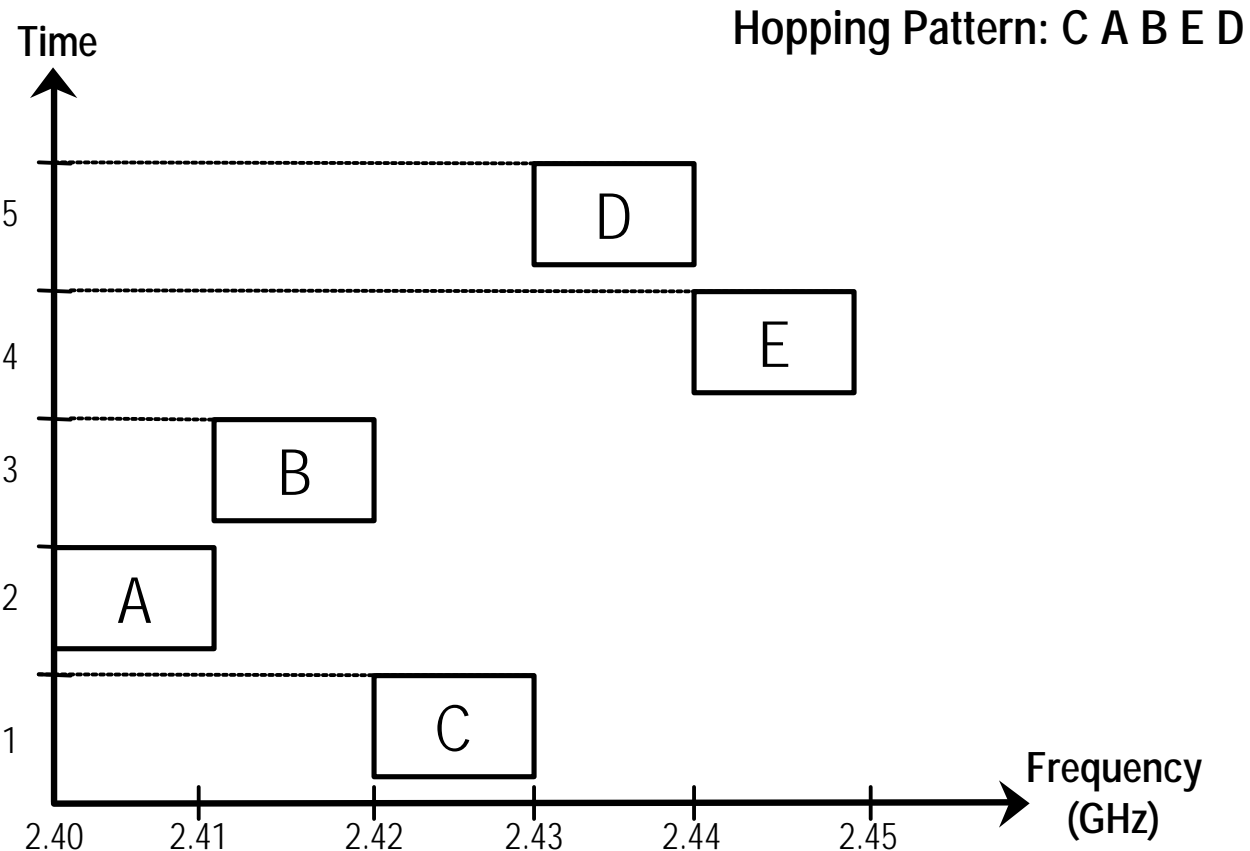
# FH Technology

- ◆ Hopping code determines the frequencies the radio will transmit and in which order
  - Hopping pattern is known to both transmitter & receiver
    - To properly receive the signal the receiver must be set to the same hopping code & listen to the incoming signal at the right time & correct frequency
  - If properly synchronized the net effect is to maintain a single logical channel
- ◆ Unintended receiver see FH to be short-duration impulse noise

# FH Technology

- ◆ FH system must hop its whole information signal over a band of frequencies of the ISM band in use
  - Does not interfere with primary user
- ◆ Because of the nature of its modulation technique frequency hopping can achieve up to 2Mbps data rates
  - Faster data rates are susceptible to huge number of errors
- ◆ Frequency hopping technique reduces interference
  - An interfering signal from a narrowband system will affect the spread spectrum signal only if both are transmitting at the same frequency at the same time
  - Aggregate interference will be very low, resulting in little or no bit errors

# FH Example

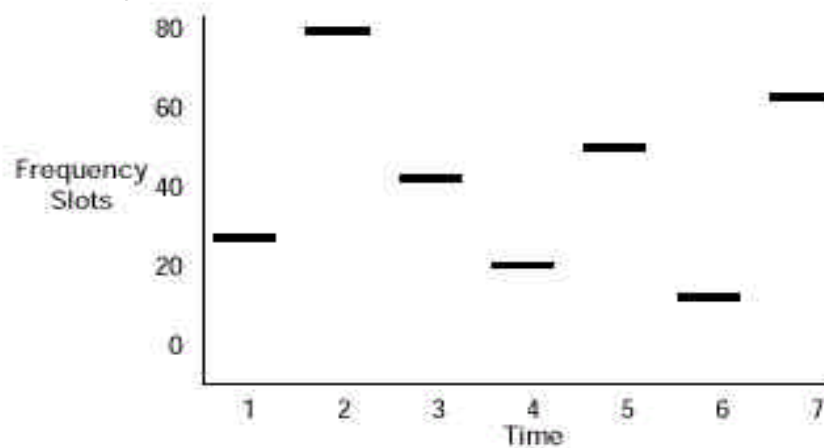


With FH, the Carrier Frequency Changes Periodically - The incoming digital stream is shifted in frequency by an amount determined by a code that spreads the signal power over a wide bandwidth



# FH Example for One Channel

- ◆ 7 frequency slots exist in the band
  - System send the information signal in frequency slot 24 for the first time slot, then frequency slot 78 for the second time slot, then frequency slot 42 for the third time slot, and so on
- ◆ Users wishing to receive signals must tune receiver to particular frequency slot
  - To receiver channel number 1 must tune its receiver to frequency slot 24 for first time slot, frequency slot 78 for the second time slot, then frequency slot 42 for the third time slot, and so on



# Different FH Pattern

- ◆ Each channel is a different frequency hopping pattern
  - Channels are distinguished between channel 1 & channel 2 by having a different frequency hopping pattern
  - Receiver of channel 2 must hop his receiver according to the channel 2 FH pattern
  - This is not a different frequency as in Frequency Division Multiplexing - it is a different Frequency Hopping Pattern
    - In FDM each channel simply stays on one frequency slot for the duration of the transmission

# Different FH Pattern

- ◆ It is possible to have operating radios use spread spectrum within the same frequency band & not interfere
  - Such that they use a different hopping pattern
  - While one radio is transmitting at one particular frequency the other radio is using a different frequency
    - A set of hopping codes that never use the same frequencies at the same time are considered orthogonal

# FH PHY Layer

- ◆ Has 22 hop patterns to choose from
- ◆ Frequency hop physical layer is required to hop across the 2.4 GHz ISM band covering 79 channels
- ◆ Each channel occupies 1MHz of bandwidth
  - Must hop at the minimum rate specified by the regulatory bodies of the intended country
    - Minimum hop rate of 2.5 hops per second is specified for the US

# PHY Layer Header

- ◆ Each physical layer uses their unique header
  - To synchronize the receiver & determine signal modulation format & data packet length
- ◆ PHY layer headers are always transmitted at 1Mbps
- ◆ Predefined fields in headers provide the option to increase the data rate to 2Mbps for the actual data packet



# MAC Features

- ◆ MAC provides good support for voice & data
- ◆ Leverages existing DECT technology for voice
- ◆ Excellent integration with TCP/IP networking protocols
  - Easy integration with Ethernet
  - Support broadcast, multicast & fragmenting
- ◆ Data security - basic/enhanced levels of encryption
  - Basic: 24-bit Network ID & Frequency Hopping
  - Enhanced: Basic + LFSR algorithm
- ◆ Extensive power management for ultra-portable devices

Optimizes Existing Technology for Home Use

# What Does the MAC Do?

- ◆ Provide access control functions for shared medium PHYs in support of the LLC layer
- ◆ MAC layer provides these primary functions
  - Addressing - Accessing the wireless medium
  - Access coordination - Joining the network
  - Frame check sequence generation and checking - Providing authentication and privacy
- ◆ MAC layer performs the addressing and recognition of frames in support of the LLC

# What Does the MAC Do?

- ◆ Accessing the wireless medium
  - CSMA/CA
    - Contention based protocol similar to IEEE 802.3 Ethernet
    - 802.11 specification refers to this mode as distributed coordination function (DCF)
  - Priority based access
    - Contention free access protocol
    - Usable on infrastructure network configurations containing a controller called a point coordinator with the access points
    - 802.11 specification refers to this mode as point coordination function (PCF)

# Multiple Access

- ◆ Basic access method for IEEE 802.11 is the DCF which uses CSMA/CA
  - Station listens for users
  - If the channel is idle, the station may transmit
  - However if it is busy, each station waits until transmission stops, and then enters into a random back off procedure
    - Prevents multiple stations from seizing the medium immediately after completion of the preceding transmission

# The MAC Sub-layer

- ◆ MAC specification for 802.11 has similarities to 802.3 Ethernet wired line standard
  - CSMA/CA protocol used for 802.11
    - Uses carrier-sense, multiple access, collision avoidance
    - Avoids collisions instead of detecting a collision like the algorithm in 802.3
    - Collision avoidance is used because it is difficult to detect collisions in an RF transmission network



# MAC & PHY Layer Operation

- ◆ MAC layer operates together with the PHY layer by sampling the energy over the medium transmitting data
- ◆ PHY layer uses a clear channel assessment (CCA) algorithm to determine if the channel is clear
  - This is accomplished by measuring the RF energy at the antenna and determining the strength of the received signal
    - This measured signal is commonly known as RSSI
  - If the received signal strength is below a specified threshold the channel is declared clear and the MAC layer is given the clear channel status for data transmission
  - If the RF energy is above the threshold, data transmissions are deferred in accordance with the protocol rules
  - The standard provides another option for CCA that can be alone or with the RSSI measurement

# MAC & PHY Layer Operation

- ◆ Carrier sense can also be used to determine if the channel is available
  - This technique is more selective sense since it verifies that the signal is the same carrier type as 802.11 transmitters
- ◆ The best method to use depends upon the levels of interference in the operating environment
- ◆ CSMA/CA protocol allows options to minimize collisions
  - Using request to send (RTS), clear-to-send (CTS), data & acknowledge (ACK) transmission frames in a sequential fashion

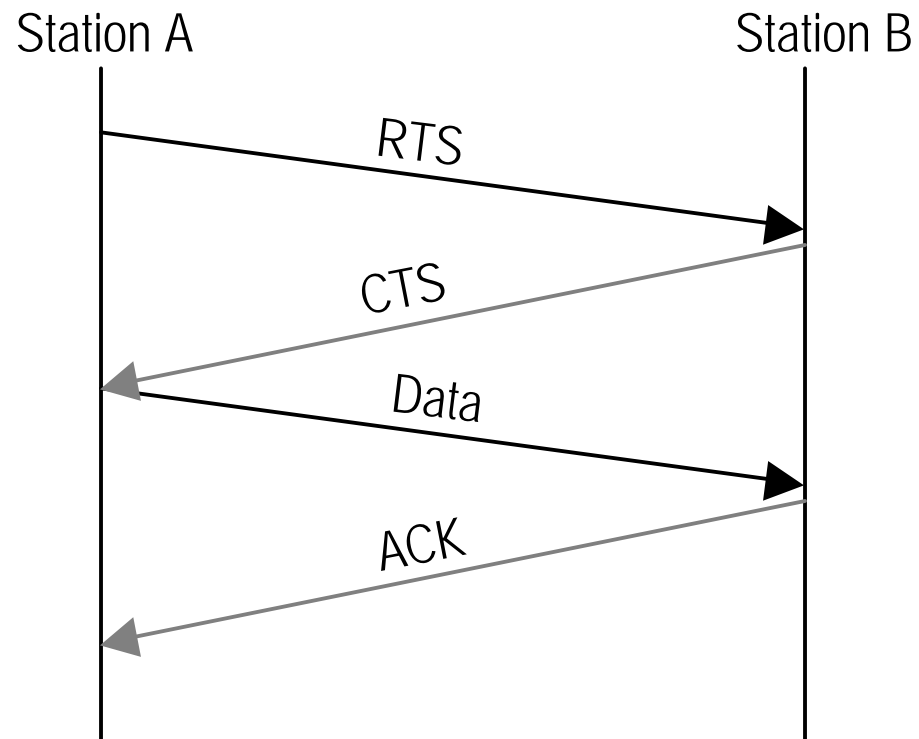
# CSMA/CA Protocol Minimizes Collisions

- ◆ Communication is established when one of the wireless nodes sends a short message RTS frame
- ◆ The RTS frame includes the destination and the length of message
- ◆ The message duration is known as the network allocation vector (NAV)
- ◆ The NAV alerts all others in the medium, to back off for the duration of the transmission

# CSMA/CA Protocol Minimizes Collisions

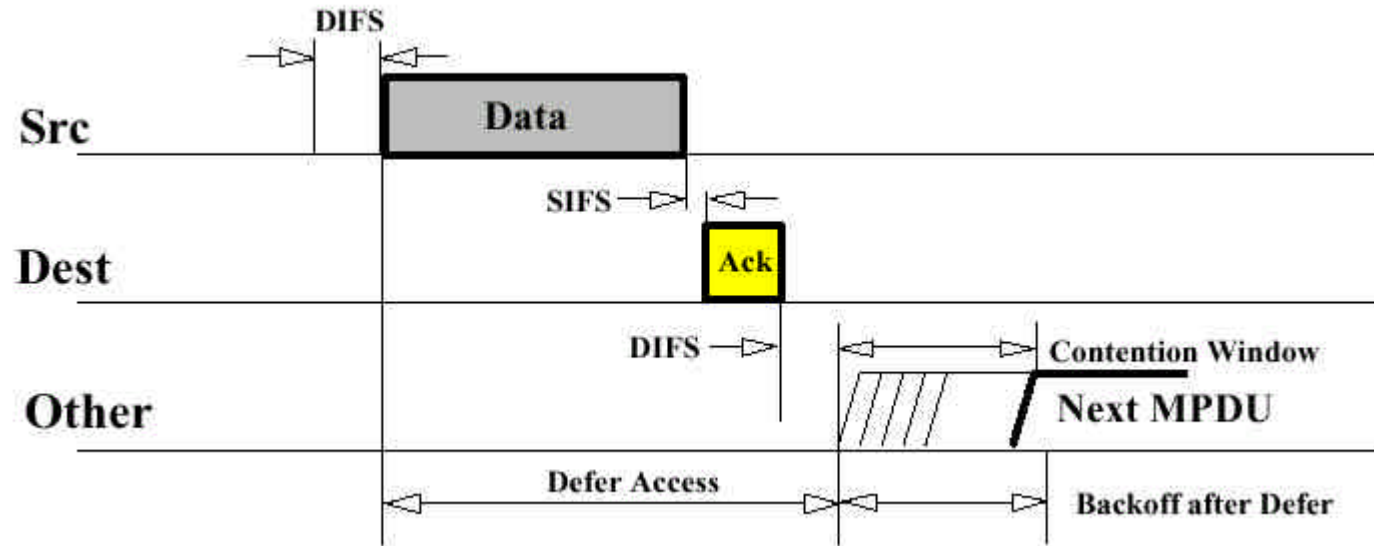
- ◆ The receiving station issues a CTS frame which echoes the senders address and the NAV
- ◆ If the CTS frame is not received, it is assumed that a collision occurred and the RTS process starts over
- ◆ After the data frame is received, an ACK frame is sent back verifying a successful data transmission

# RTS/CTS/ACK Protocol





# CSMA/CA Back-off Algorithm



- ◆ Packet reception in DCF requires acknowledgment
- ◆ The period between completion of packet transmission and start of the ACK frame is one Short Inter Frame Space (SIFS)
- ◆ ACK frames have a higher priority than other traffic
  - Fast acknowledgement is one of the salient features of the 802.11 standard, because it requires ACKs to be handled at the MAC sublayer

# PC Interface

- ◆ SWAP's PC connection is designed for use under Windows 98, Windows2000, and beyond
  - Wake on Ring
  - Connection oriented NDIS
  - A nodes appear as Ethernet devices
  - I nodes become Connection Oriented clients

# Network Topology

## *SWAP System Support*

- ◆ Ad-Hoc Network
  - Only data communication is supported
  - All stations are equal
  - Control of the network is distributed between the stations
- ◆ Managed network under the control of a CP
  - Ideal for isochronous data and power savings
    - Such as time critical communications such as Interactive voice
  - Provides gateway to PSTN
  - Can be connected to PC via standard interface such as USB that will enable voice & data services
  - Support power management for prolonged battery life by scheduling device wakeup & polling

# Network Topology

- ◆ HomeRF networks accommodate - **127** Nodes (max.)
- ◆ Nodes can be a mixture of 4 basic types:
  - Connection point that supports both voice & data services
  - Voice terminal that only uses TDMA service to communicate with a Base Station
  - Data node that uses CSMA/CA service to communicate with a base station and other data nodes
  - Voice & data nodes which can use both types of service



# Main SWAP System Parameters

Main System Paramters	HomeRF - SWAP
PHY Layer - Frequency Hopping/Direct Sequence Range	2.4GHz Frequency Hopping ISM band
Frequency Hopping Network (hops per second) Radio	50, less reliable than Bluetooth
Optimized for	Voice & Data
Real data rate	1Mbps using 2FSK modulation, 2 Mbps using 4FSK modulation; Standard 800kbps rate for Isochronous & Asynchronous data, Optional 1.6Mbps rate for Asynchronous data
Near-line quality voice links/channels	4
Device links per base	Unlimited
Encryption Routine	Blowfish
Bridge Range	100 meters
Transmission Power	100mW
Power Management	Both A-nodes & I-nodes can achieve power savings using power management services of a CP
Range	Covers typical home & yard
Supported stations	Up to 127 devices per network
Voice connections	Up to 6 full duplex conversations
Data Security	Blowfish encryption algorithm (over 1 trillion codes)
Data Compression	LZRW3-A algorithm
48-bit Network ID	Enables concurrent operation of multiple co-loacted networks



# Interoperability with HomePNA

- ◆ HomeRF Products Work With HPNA-based Products
  - TCP/IP is used in HPNA based products
    - HomeRF products fully support TCP/IP
  - Consumer requires a bridge
    - Interface to connect phone line network to wireless HomeRF network
    - SWAP spec defines this bridging
    - Vendors are developing future bridging products

# Interoperability with Bluetooth

- ◆ Bluetooth
  - Technology to connect devices without wires
  - Provide short-range connections between mobile devices & to Internet via bridging devices to different networks
  - Provide Internet capability
- ◆ HomeRF SWAP
  - Wireless technology optimized for home
  - Data networking & dial tones between devices like PCs, cordless phones, web tablets, broadband cable & DSL modem

# Interoperability with Bluetooth

- ◆ Full Bluetooth & HomeRF functionality can be implemented Within one device
- ◆ Frequency spectrum is shared without interference when operating in the same space
- ◆ Both technologies might coexist
  - E.g.; Bluetooth enabled handheld PDA may be need to synchronize addresses between the PDA and home PC based mail lists

# Examples of SWAP Products

- ◆ Set up a wireless home network
  - Share voice & data between PC's, peripherals, PC-enhanced cordless phones & new devices such as portable, remote display pads
- ◆ Access the Internet from anywhere in and around the home from portable display devices
- ◆ Share an ISP connection between PC's and other new devices
- ◆ Share files/modems/printers in multi-PC homes

# Examples of SWAP Products

- ◆ Intelligently forward incoming telephone calls to multiple cordless handsets, FAX machines & voice mailboxes
- ◆ Review incoming voice, FAX & e-mail messages from a small PC-enhanced cordless telephone handset
- ◆ Activate other home electronic systems by simply speaking a command into a PC-enhanced cordless handset
- ◆ Multi-player games and/or toys based on PC or Internet resources



# Companies Developing SWAP Products

- ◆ Butterfly Communications
- ◆ Cayman Systems
- ◆ Compaq Computer Corp.
- ◆ Hewlett Packard
- ◆ IBM
- ◆ Intel
- ◆ iReady
- ◆ Microsoft
- ◆ Motorola
- ◆ Proxim
- ◆ OTC telecom
- ◆ RF Monolithics
- ◆ Samsung
- ◆ Symbionics

# Agenda

- ◆ Introduction to home networking
- ◆ Wireless home networking
- ◆ Consortium - HomeRF Working Group
- ◆ HomeRF technology - SWAP
- ◆ Xilinx Spartan-II FPGAs in HomeRF-Based Products
- ◆ Summary



# Xilinx Spartan-II FPGAs in HomeRF Products

# Chaos in the HN Marketplace

- ◆ Multiple broadband & multiple Home LAN technologies
- ◆ Too Many Standards & Too Many Specs

	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...

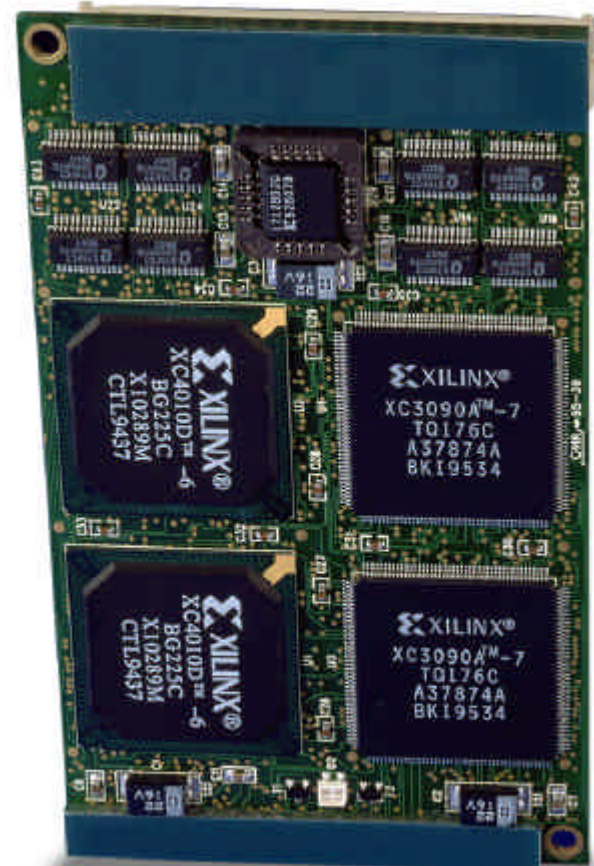
- ◆ Brings about an Environment That Guarantees Unanticipated Problems
  - Bugs
  - Incompatibilities
  - The Great Unknown about what is going to be the changes
- ◆ Translates to a Steep Learning Curve
  - Virtually mandates a “Ready, Fire, Aim” development model
    - Plan products for the longest 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 Consortia



Home  
Phoneline  
Network  
CERTIFIED™

**WLANA**  
The Wireless LAN 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



IP Center



Alliance  
CORE



# Xilinx - Leader in Core Solutions

Base Level Functions	<ul style="list-style-type: none"> <li>- 82xx, UARTs, DMA</li> <li>- 66MHz DRAM, SDRAM I/F</li> <li>- Memory blocks</li> <li>- 29xx</li> <li>- Proprietary RISC Processors</li> </ul>	<ul style="list-style-type: none"> <li>- 8051</li> <li>- IEEE 1284</li> <li>- 200MHz SDRAM I/F</li> <li>- SGRAM, ZBTRAM I/F</li> <li>- Multi-channel DMA</li> </ul>	<ul style="list-style-type: none"> <li>- JAVA</li> <li>- Adv 32-bit RISC Processors</li> <li>- 64-bit RISC</li> <li>- DDR/QDR RAM</li> <li>- 622 Mbps LVDS</li> </ul>	<ul style="list-style-type: none"> <li>- 128-bit processors</li> <li>- Reconfigurable processors</li> </ul>
Communication & Networking	<ul style="list-style-type: none"> <li>- Cell assem/delin</li> <li>- CRC</li> <li>- T1 Framer</li> <li>- HDLC</li> <li>- Reed-Solomon</li> <li>- Viterbi</li> <li>- UTOPIA</li> </ul>	<ul style="list-style-type: none"> <li>- 10/100 Ethernet</li> <li>- ATM/IP Over SONET</li> <li>- Cell scram/descram</li> <li>- SONET OC3/12</li> <li>- ADPCM</li> <li>- IMA</li> </ul>	<ul style="list-style-type: none"> <li>- Network processors</li> <li>- 1Gb Ethernet</li> <li>- SONET OC48/192</li> <li>- CELP</li> <li>- VoIP</li> <li>- ADSL, HDSL, xDSL</li> <li>- UMTS, wCDMA</li> </ul>	<ul style="list-style-type: none"> <li>- Software Radio</li> <li>- Modems</li> <li>- Neural networking</li> <li>- Emerging Telecom and Networking Standards</li> </ul>
DSP Functions	<ul style="list-style-type: none"> <li>- Basic Math</li> <li>- Correlators</li> <li>- Filters: FIR, Comb</li> <li>- Multipliers</li> <li>- FFT, DFT</li> <li>- Sin/Cos</li> </ul>	<ul style="list-style-type: none"> <li>- DCT</li> <li>- Adaptive filters</li> <li>- Cordic</li> <li>- DES</li> <li>- DES</li> <li>- Divider</li> <li>- NCO</li> <li>- Satellite decoders</li> </ul>	<ul style="list-style-type: none"> <li>- MP3</li> <li>- QAM</li> <li>- JPEG</li> <li>- Speech Recognition</li> <li>- DSP Processor I/Fs</li> <li>- Wavelet</li> </ul>	<ul style="list-style-type: none"> <li>- MPEG</li> <li>- DSP Functions &gt; 200 MSPS</li> <li>- Programmable DSP Engines</li> </ul>
Standard Bus Interfaces	<ul style="list-style-type: none"> <li>- CAN</li> <li>- ISA PnP</li> <li>- I2C</li> <li>- PCI 32-bit</li> <li>- PCMCIA</li> </ul>	<ul style="list-style-type: none"> <li>- CardBus</li> <li>- FireWire</li> <li>- PCI 64-bit/66MHz</li> <li>- Compact PCI Hot-Swap</li> <li>- PC104</li> <li>- VME</li> </ul>	<ul style="list-style-type: none"> <li>- AGP</li> <li>- PCI-X 133MHz</li> </ul>	<ul style="list-style-type: none"> <li>- InfiniBand</li> <li>- Emerging High-Speed Standard Interfaces</li> </ul>

1998

1999

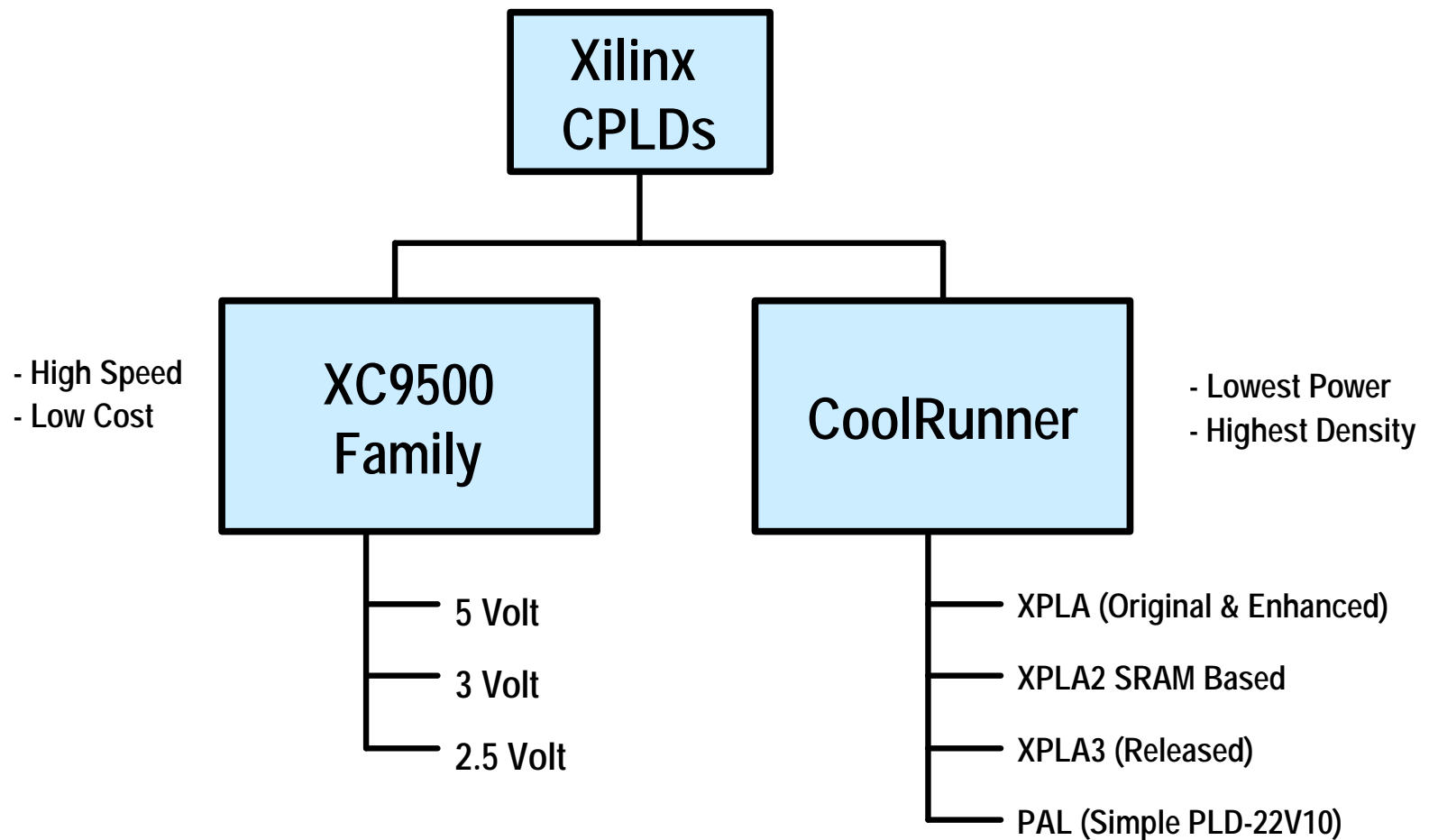
2000

2002

2004



# 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



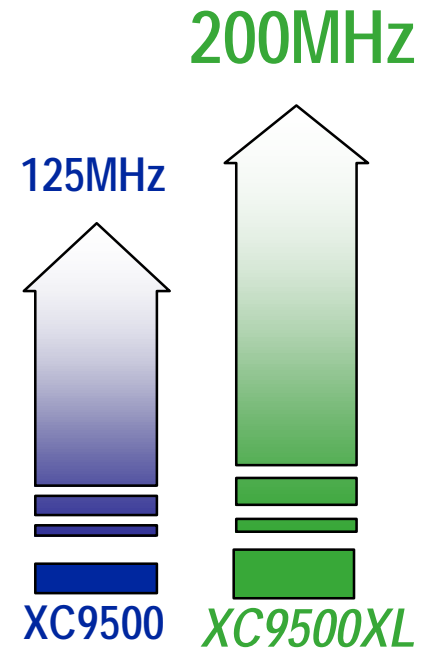
- ◆ Industry's lowest power CPLDs
  - Standby current  $< 100\mu\text{A}$
  - High speed TPD = 6 ns
  - Revolutionary XPLA architecture
    - Exceptional routability & pin-locking
    - Fast, predictable timing
  - Small form factor packaging
    - New 0.5mm 56-pin MicroBGA
- ◆ No Speed / Power tradeoffs 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

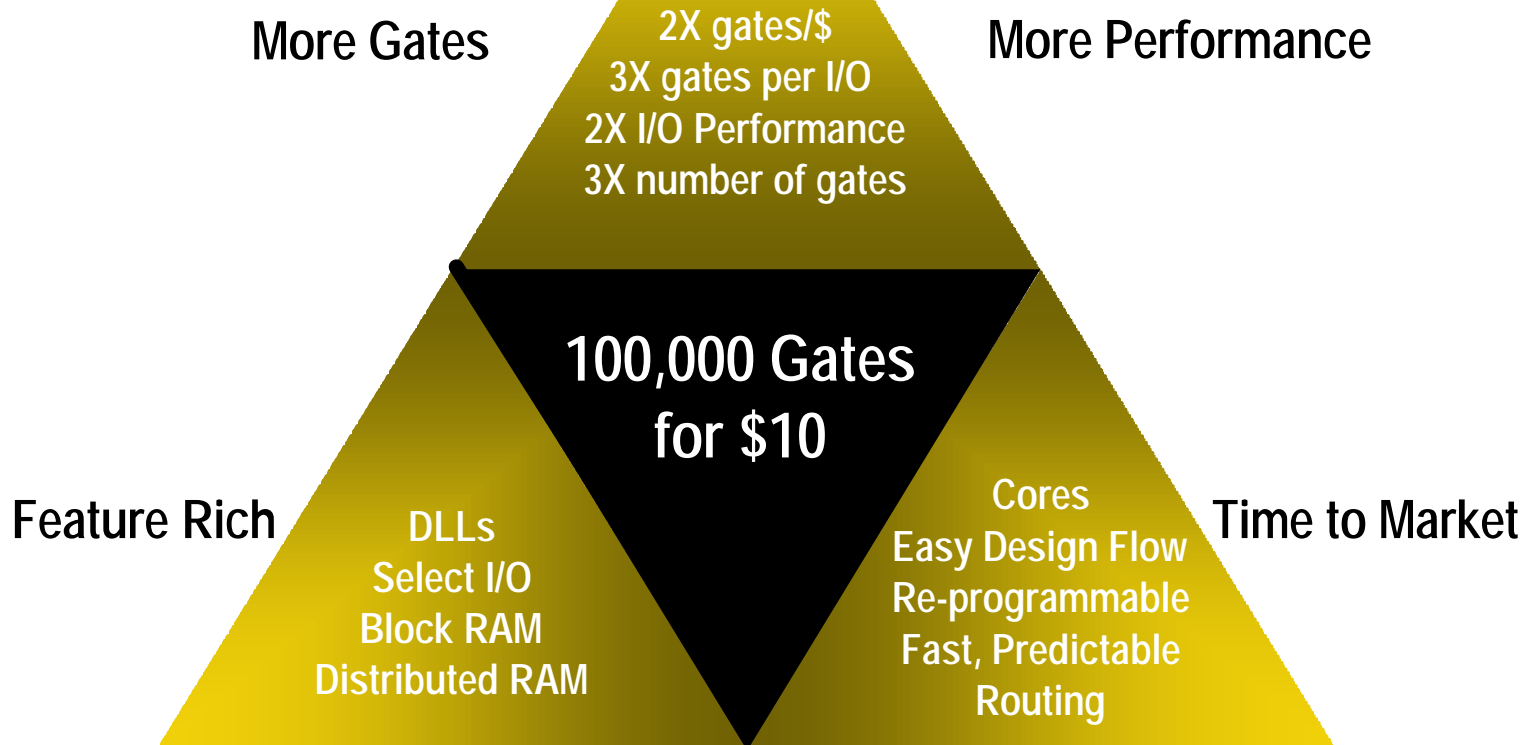
# XC9500XL/XV System Features

- ◆ 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



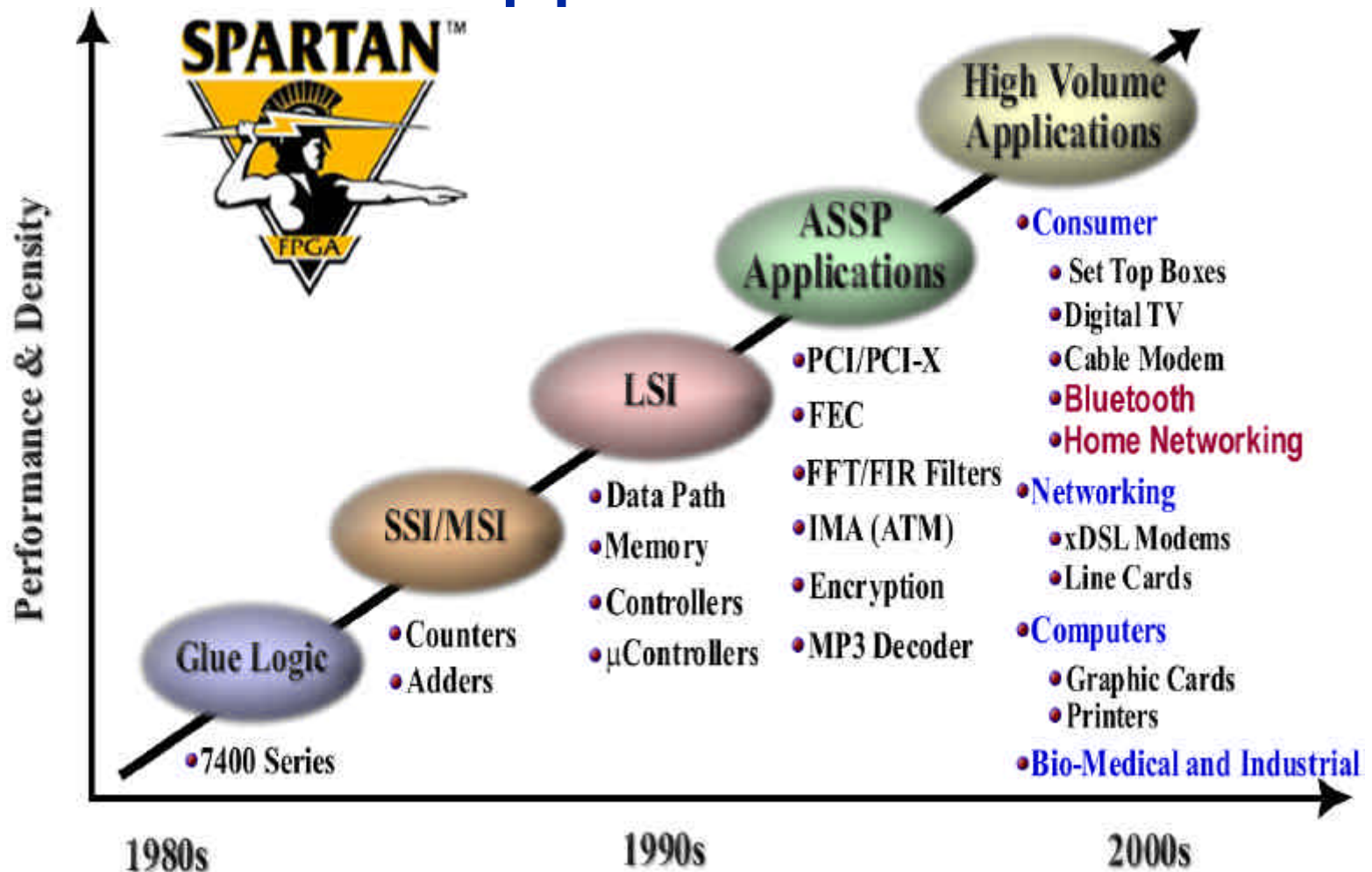
# Spartan-II: Extending the Spartan Series



***Programmable ASIC/ASSP Replacement!***



# FPGA Application Trends



*Programmable ASIC/ASSP Replacement!*



# Spartan-II - Architecture Overview

## Delay Locked Loop (DLL)

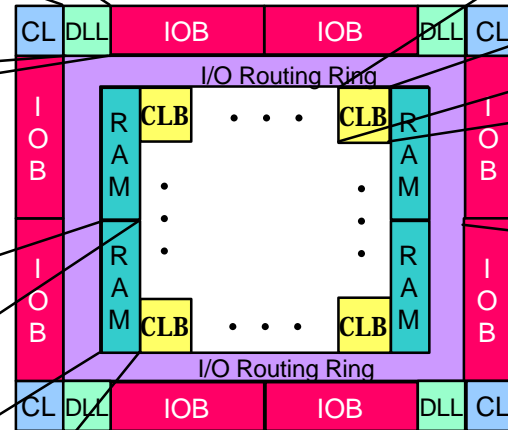
**Clock Management:**  
Multiply clock  
Divide clock  
De-skew clock

## Configurable Logic Blocks (CLB)

**Configurable Logic Block Array and Distributed RAM**

## Block Memory

**True Dual-Port™**  
**4K bit RAM**  
4Kx1  
2Kx2  
1Kx4  
512x8  
256x16

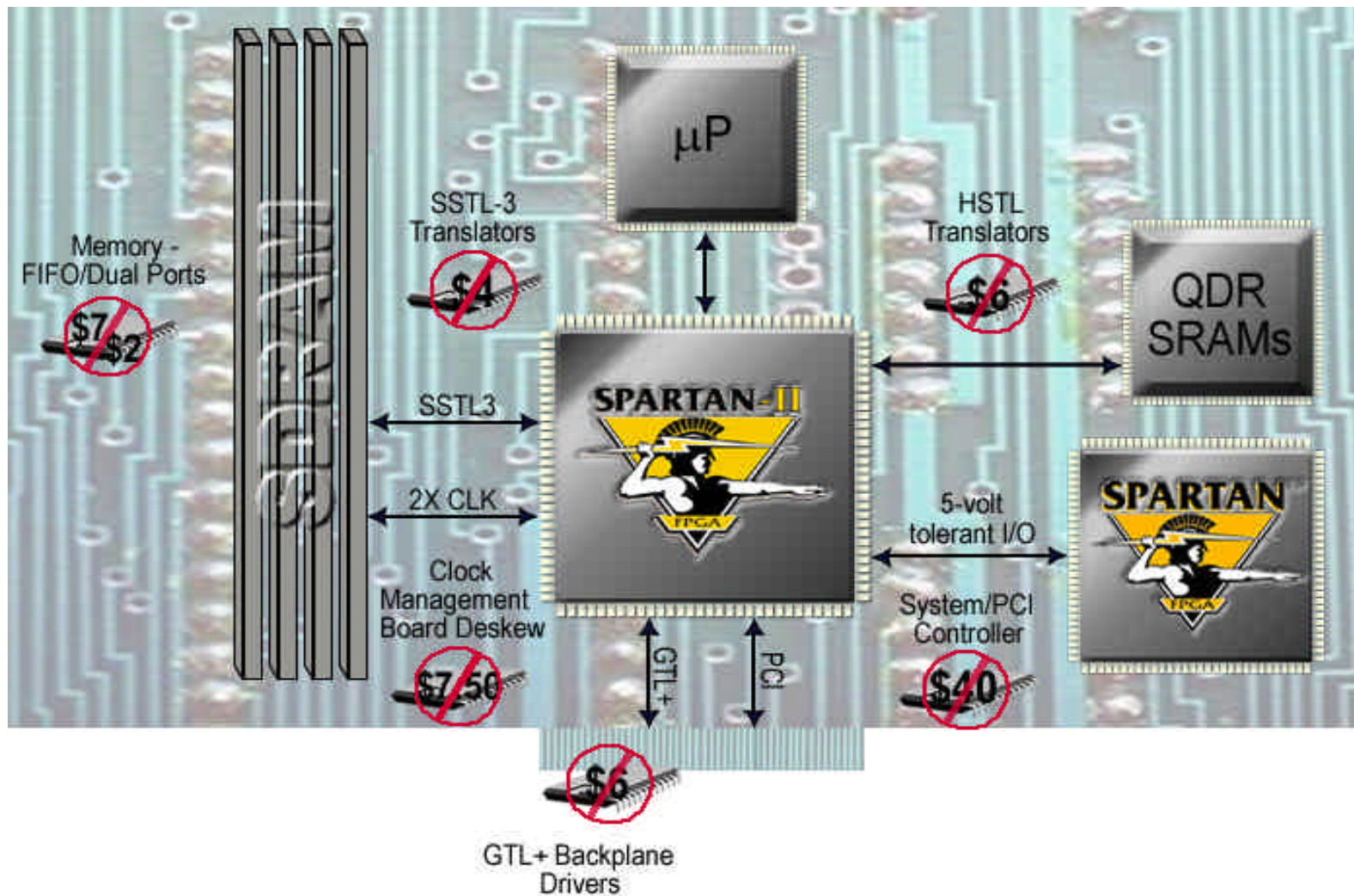


## Select I/O™ Technology

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

**"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 HomeRF Solutions



# Block Diagram Template / Index



Xilinx Solution



Or



Non-Xilinx Components



Memory



Mixed Signal / RF

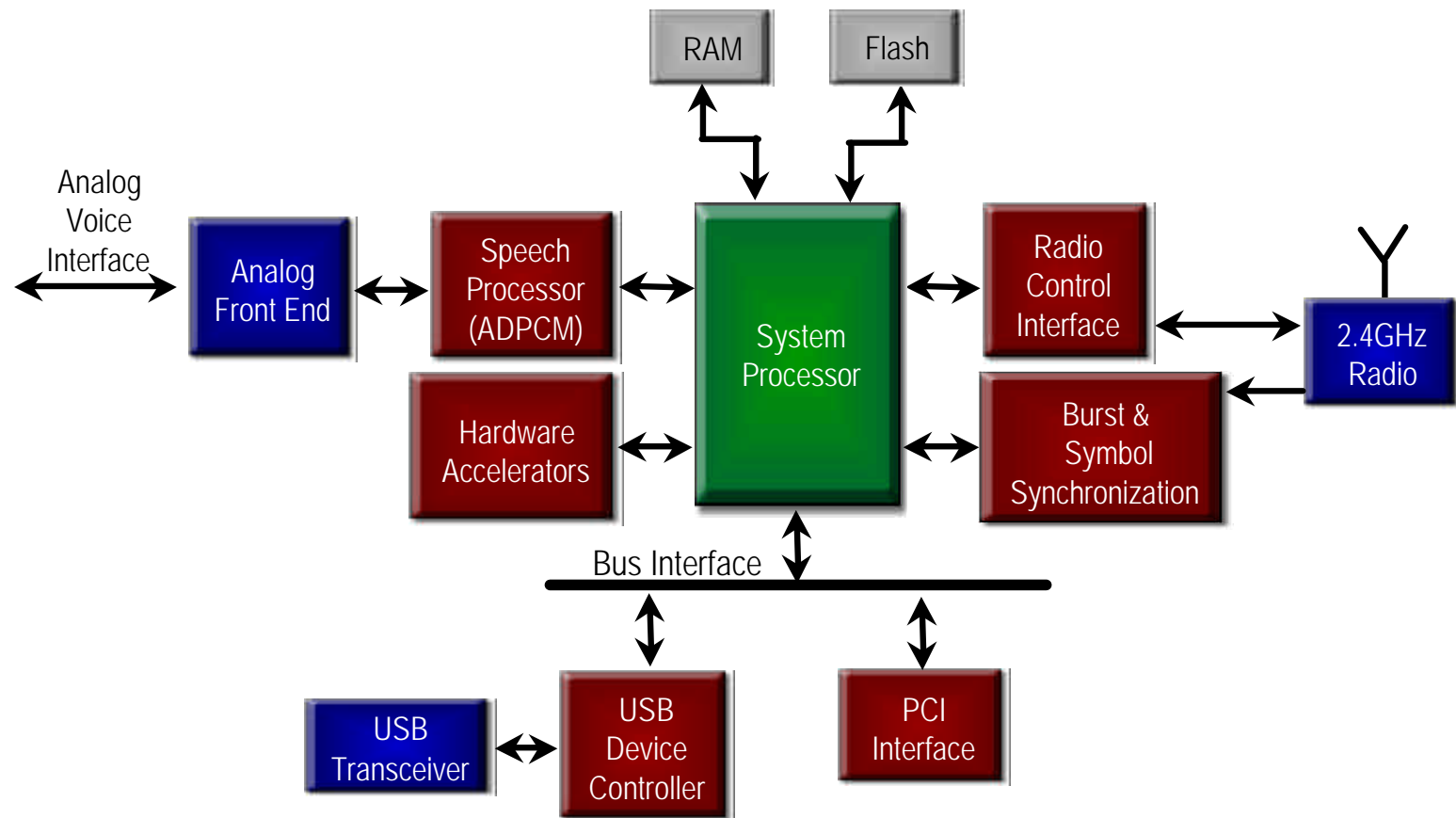


CPU

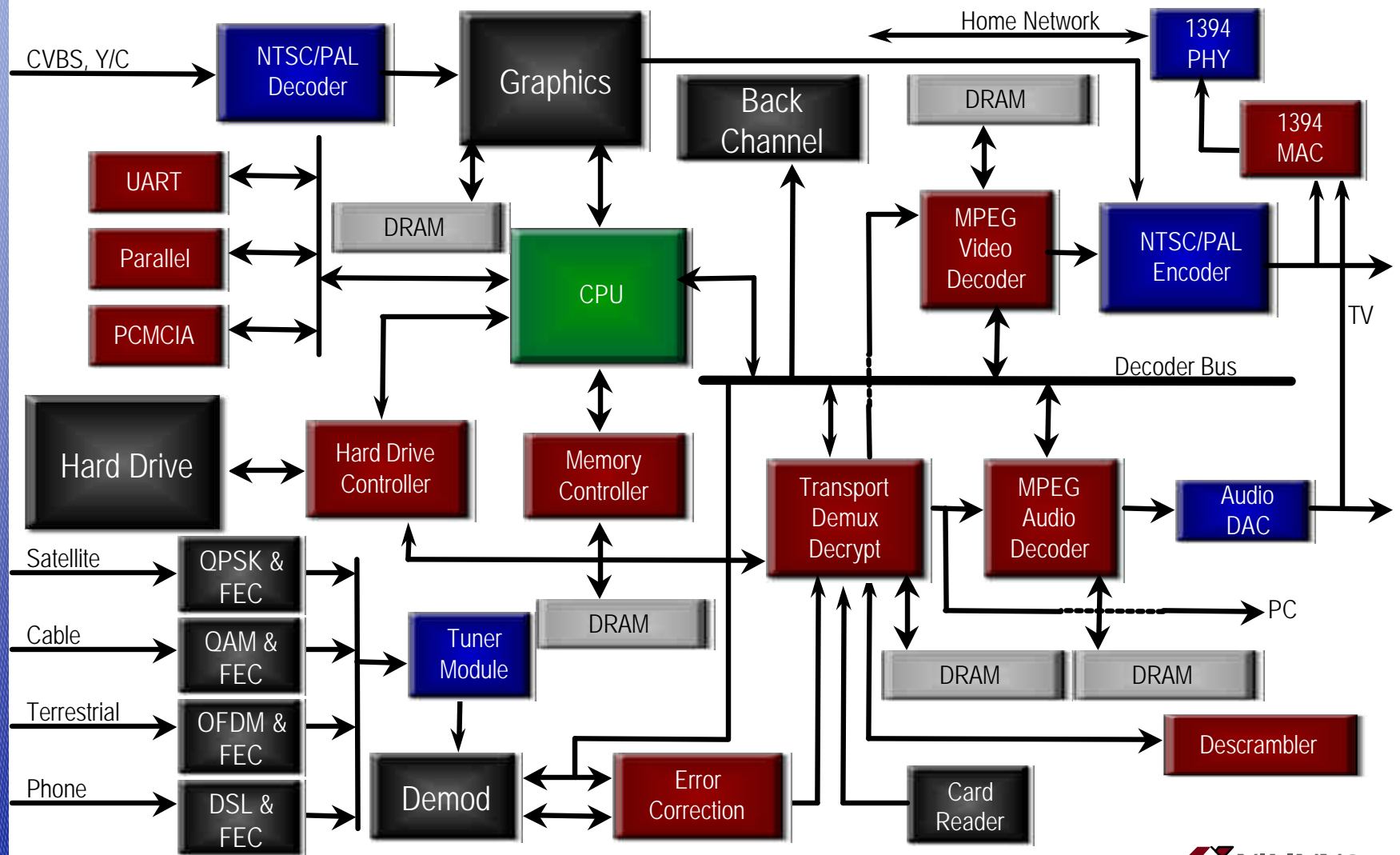


Embedded Chip

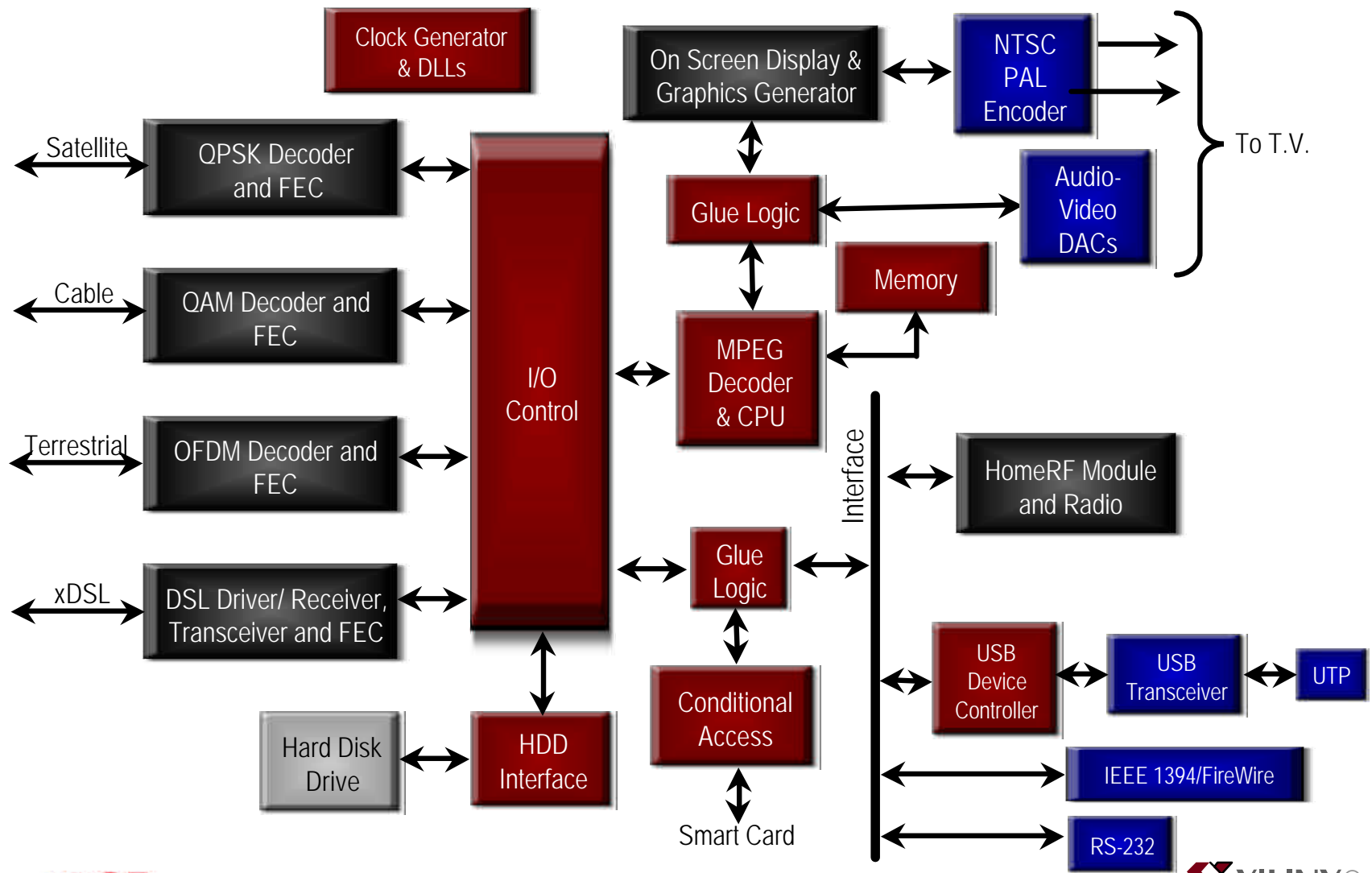
# HomeRF Module



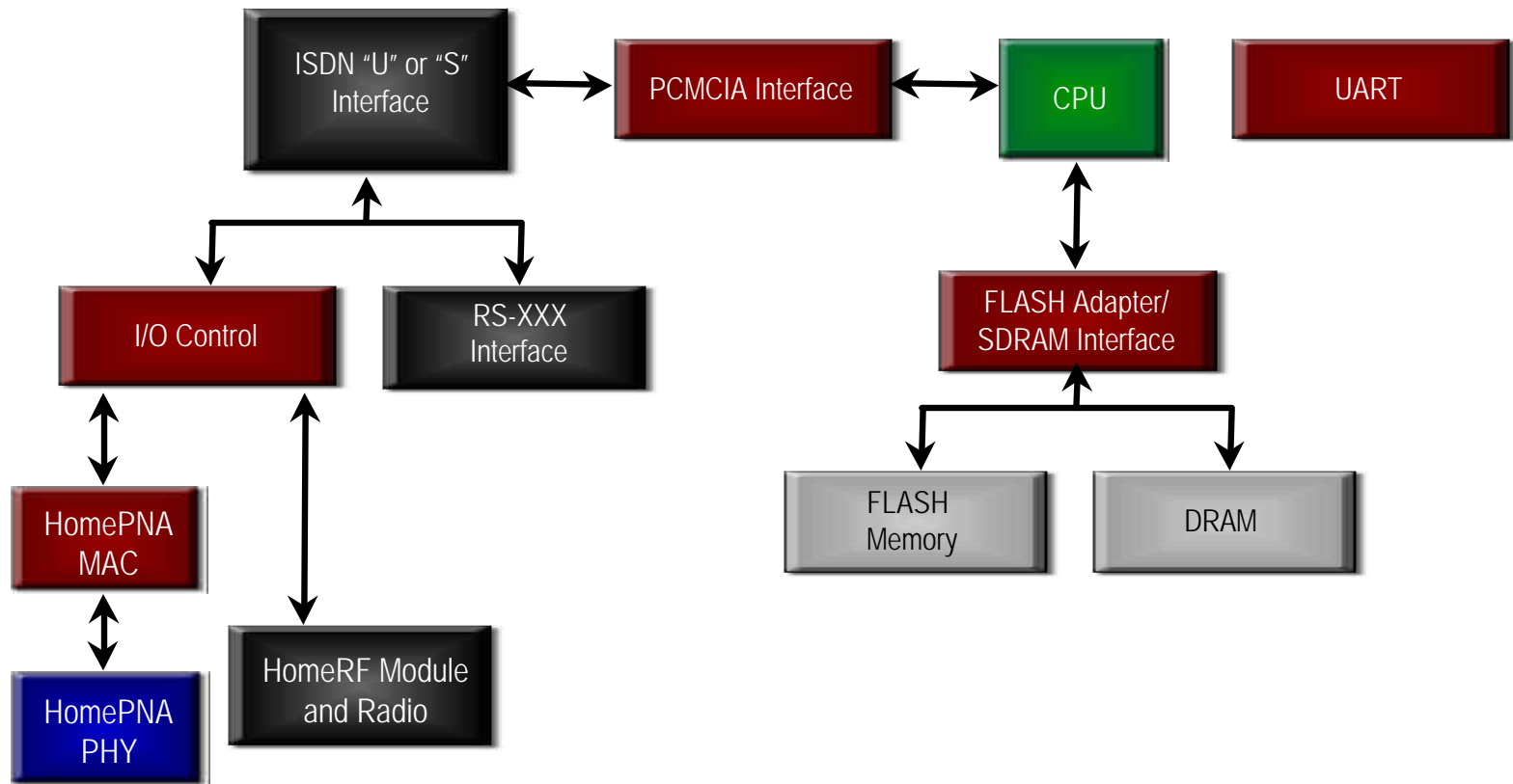
# “Super” Set Top Box



# HomeRF- Based Residential Gateway



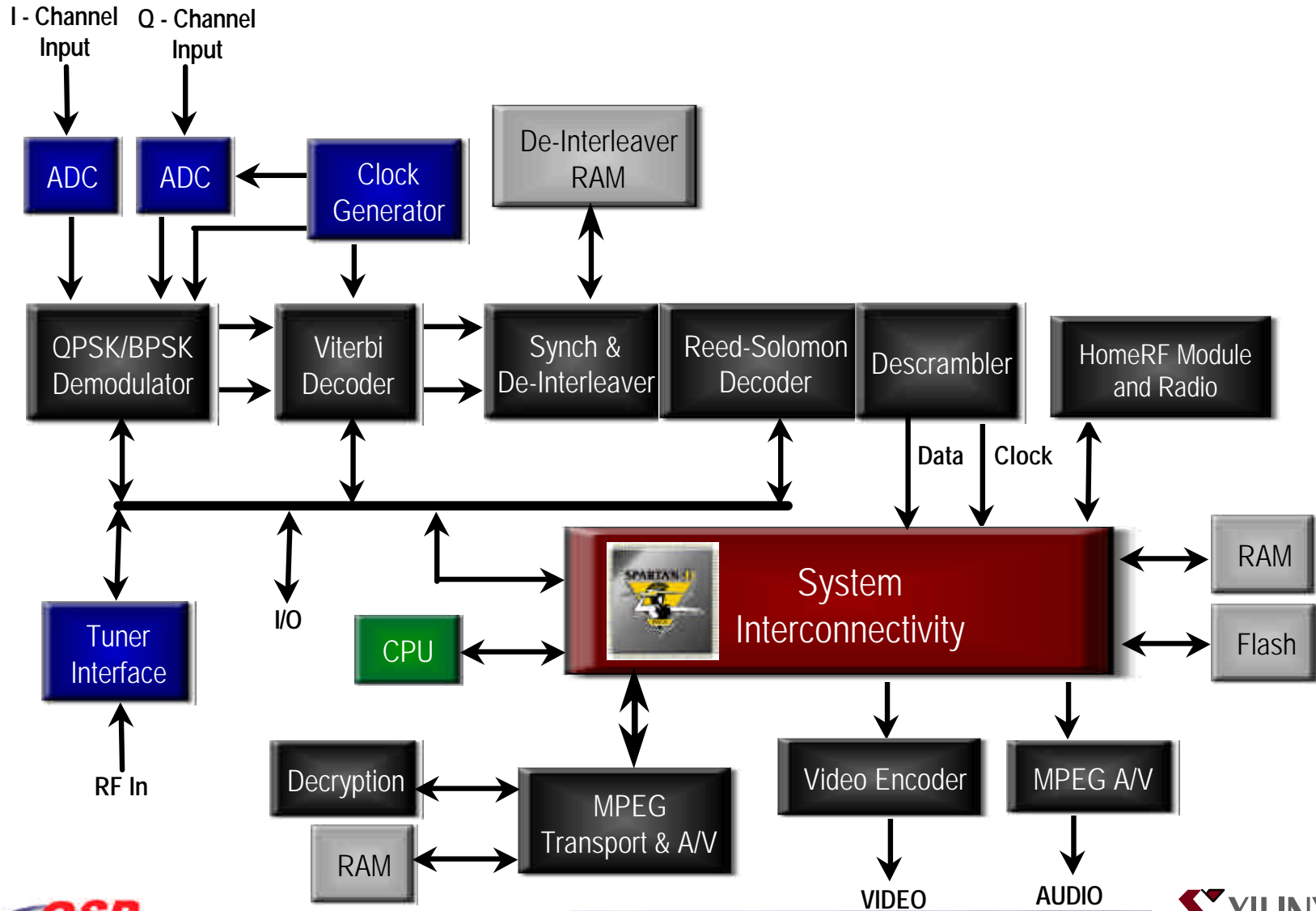
# ISDN Modems - HomeRF Residential Gateway



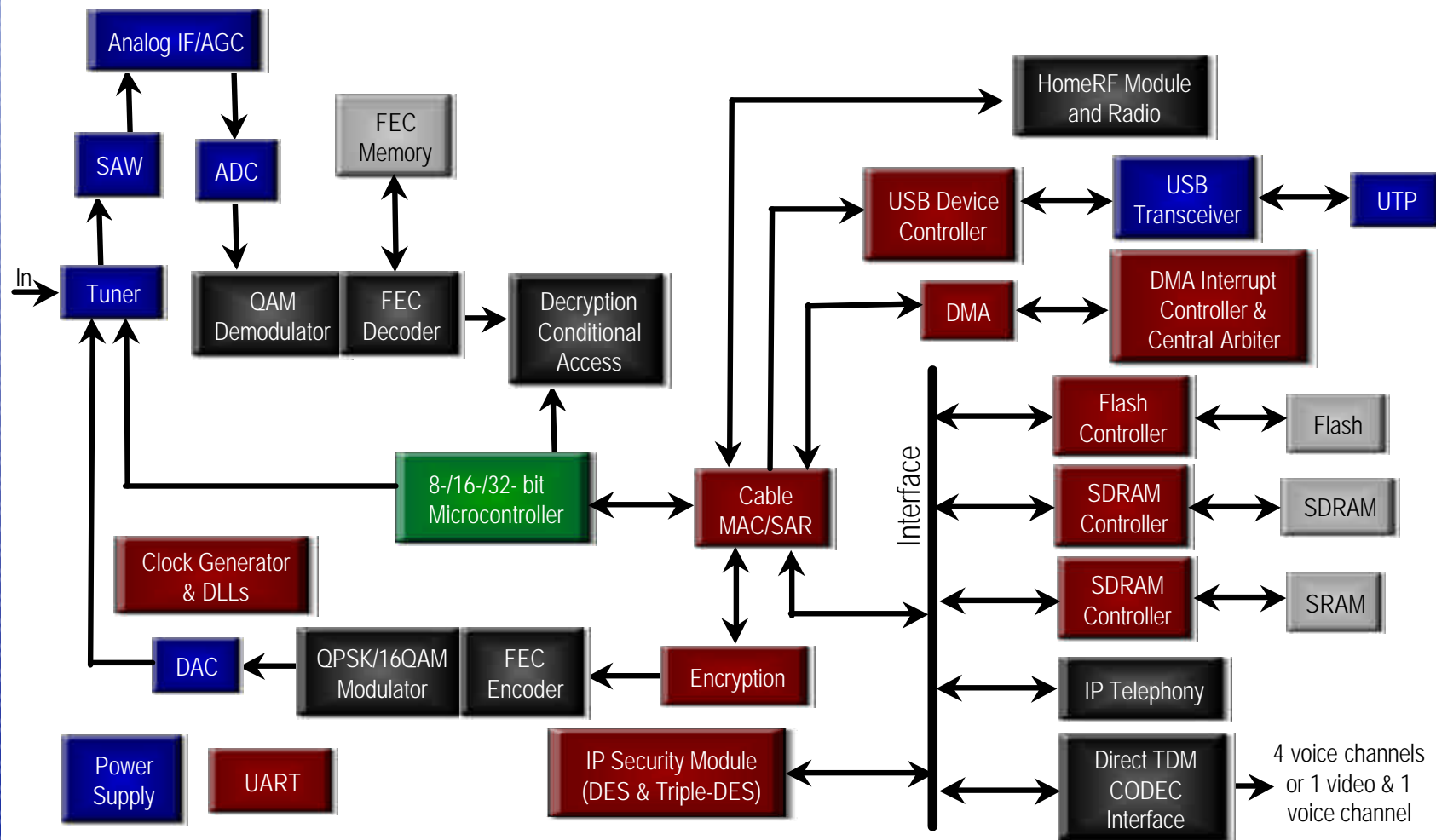


# Satellite Modems

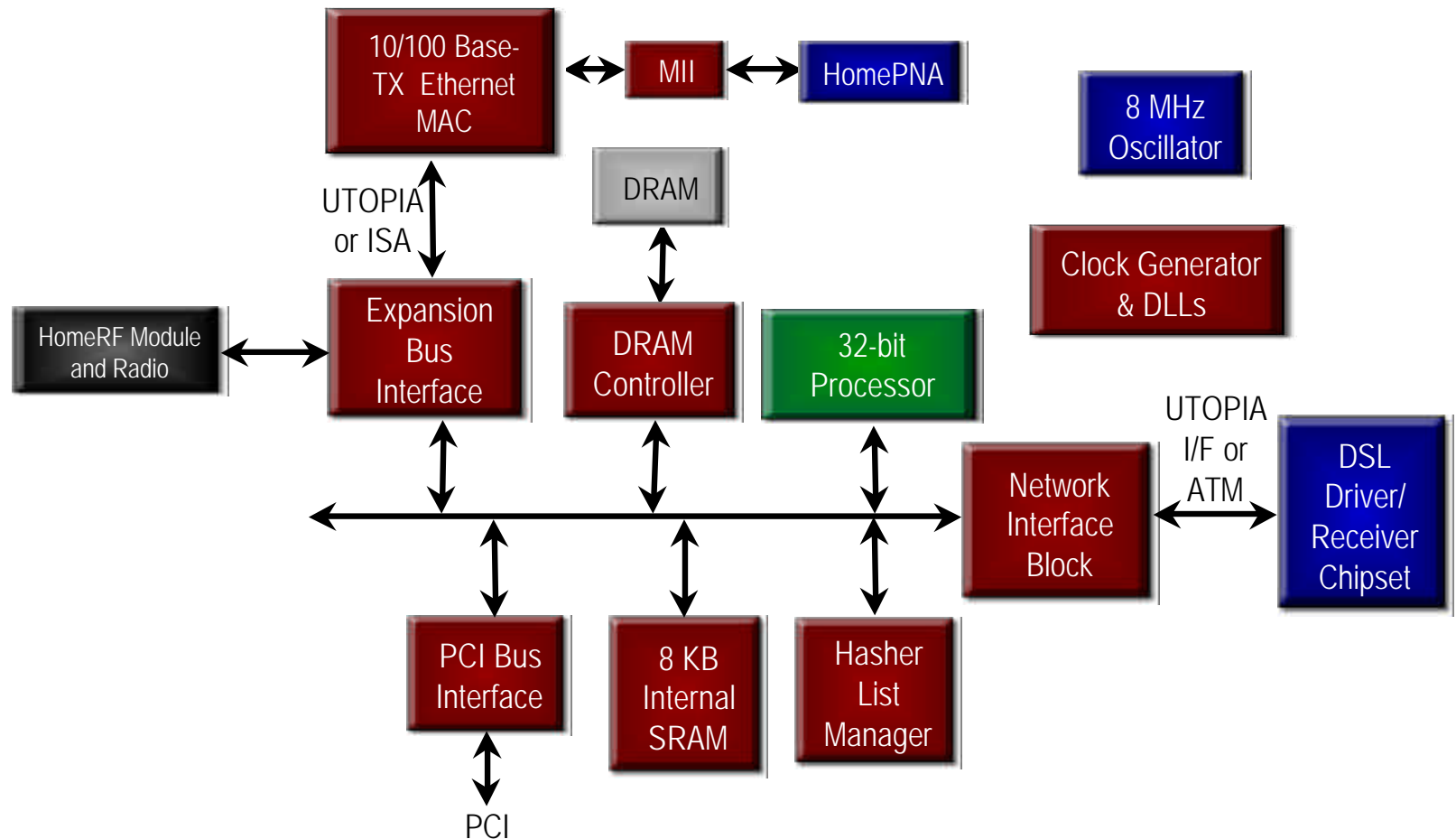
Quadrature Data from Tuner



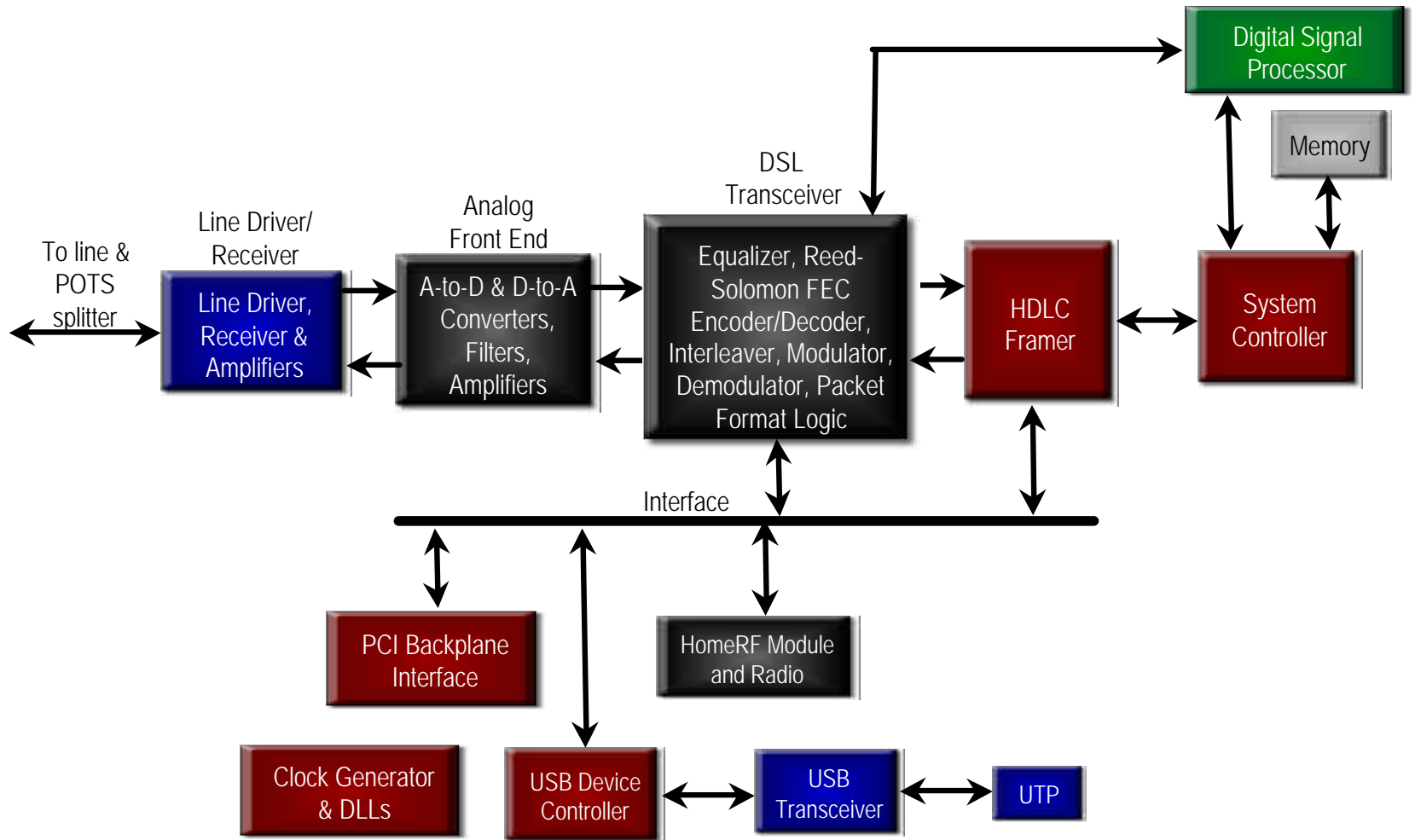
# HomeRF - Cable Modem Residential Gateway



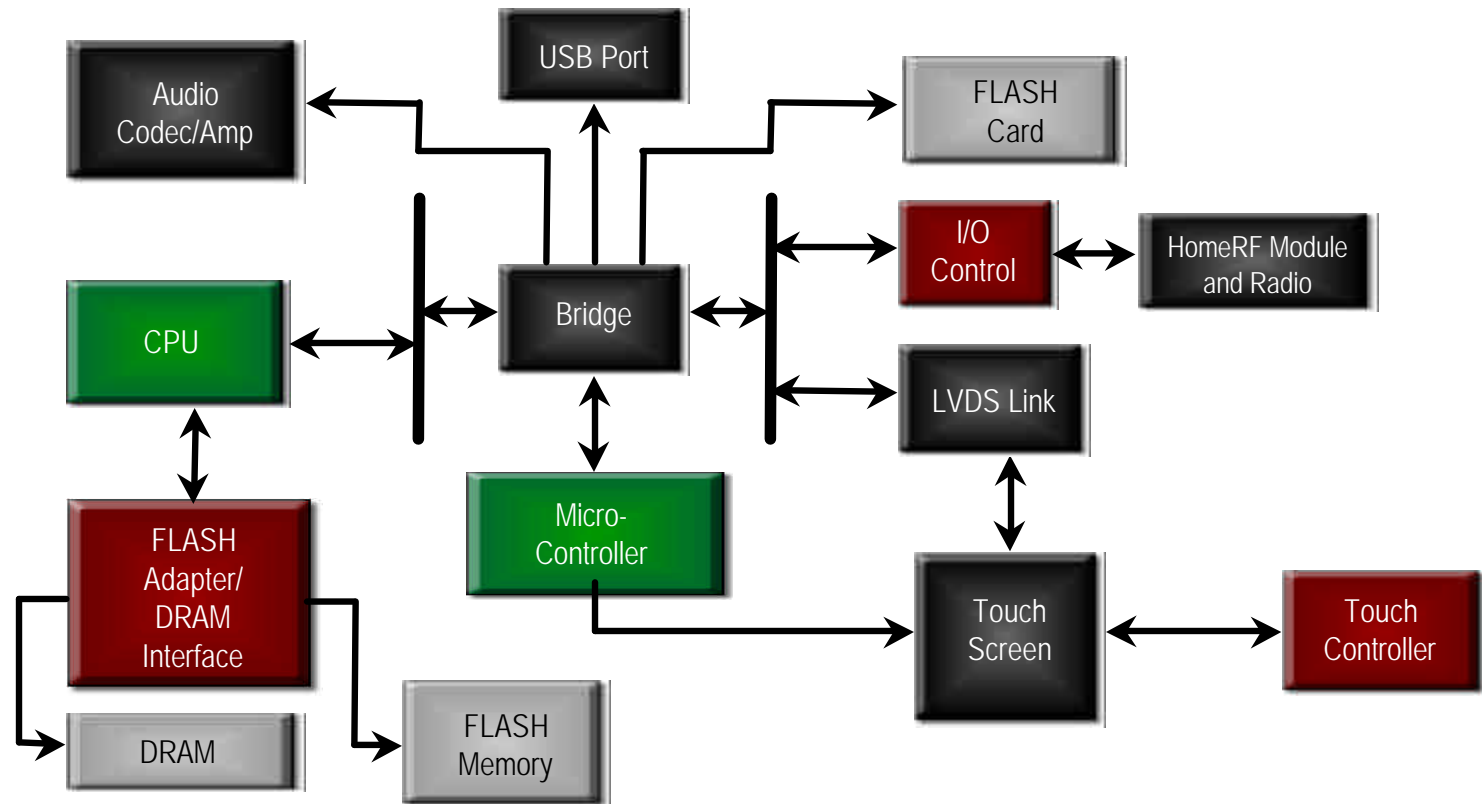
# DSL Modem - HomeRF Home Gateway



# DSL CPE (Customer Premise Equipment)

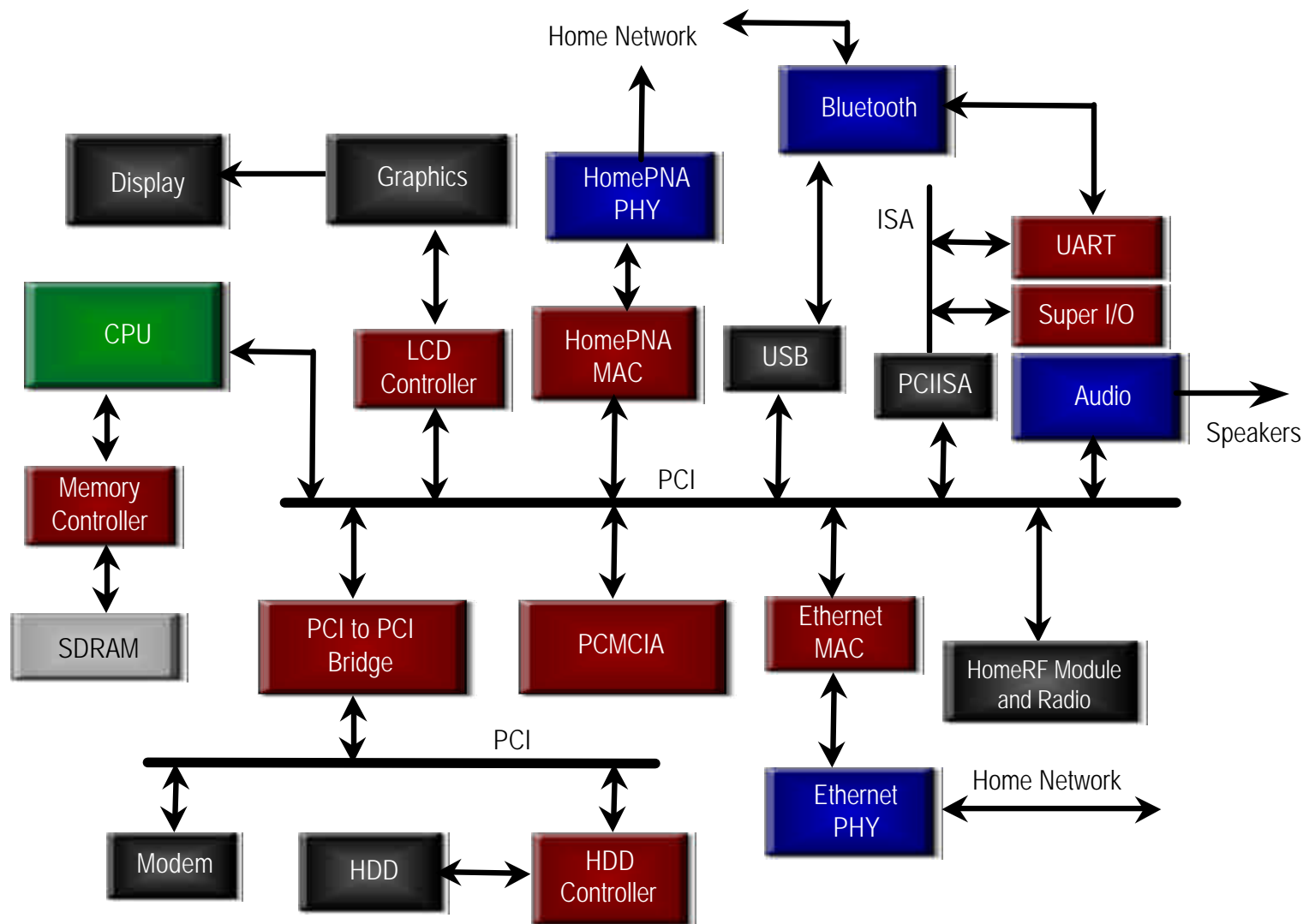


# Web Pad / Fridge Pad

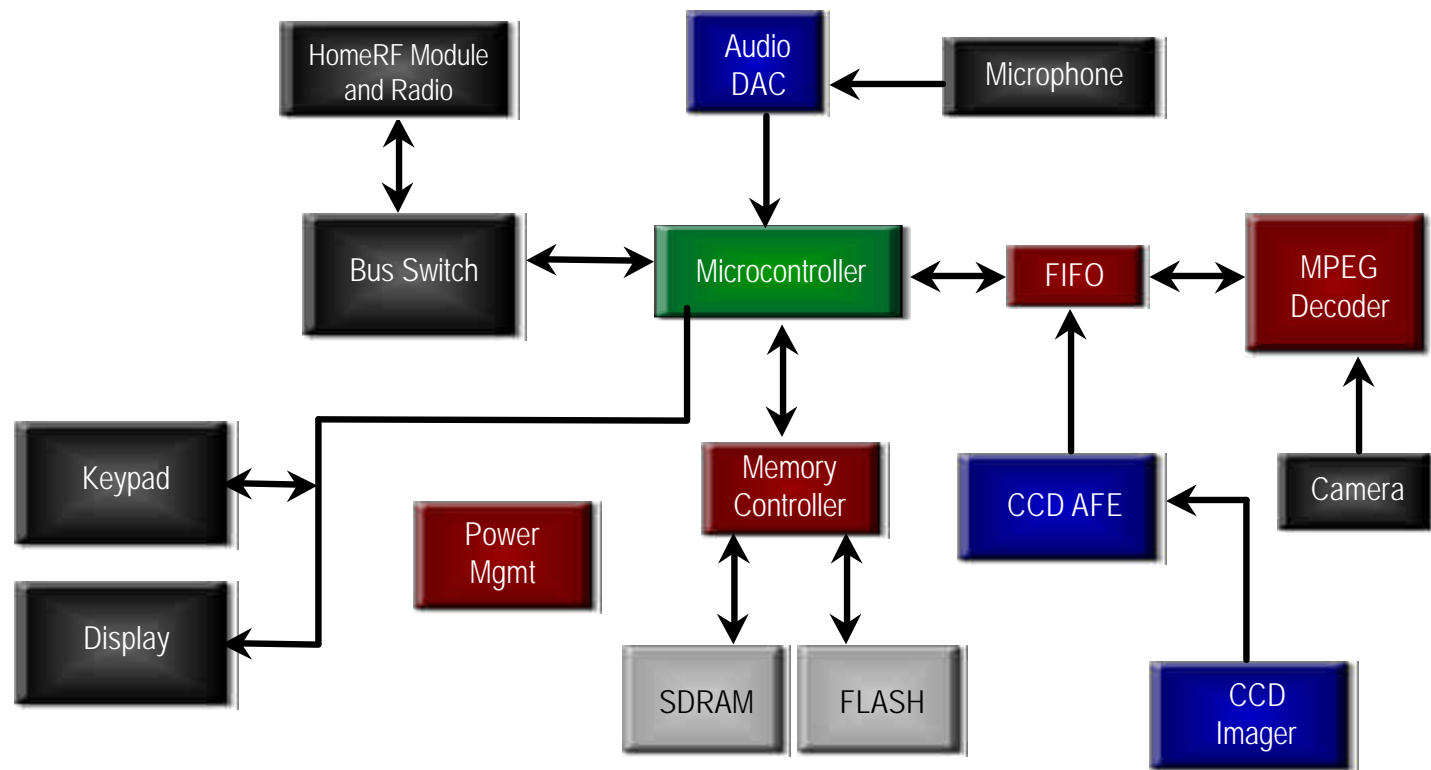




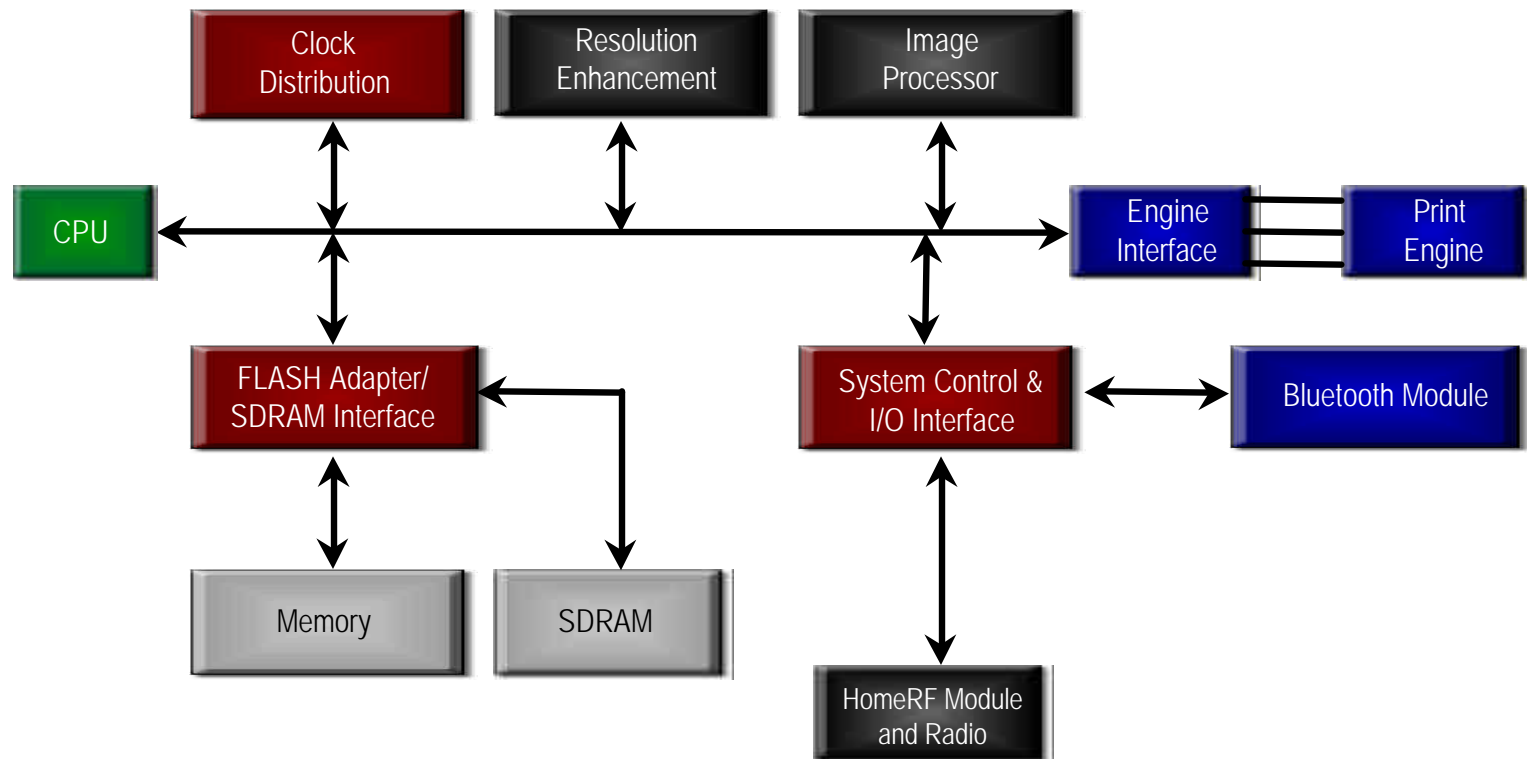
# PC



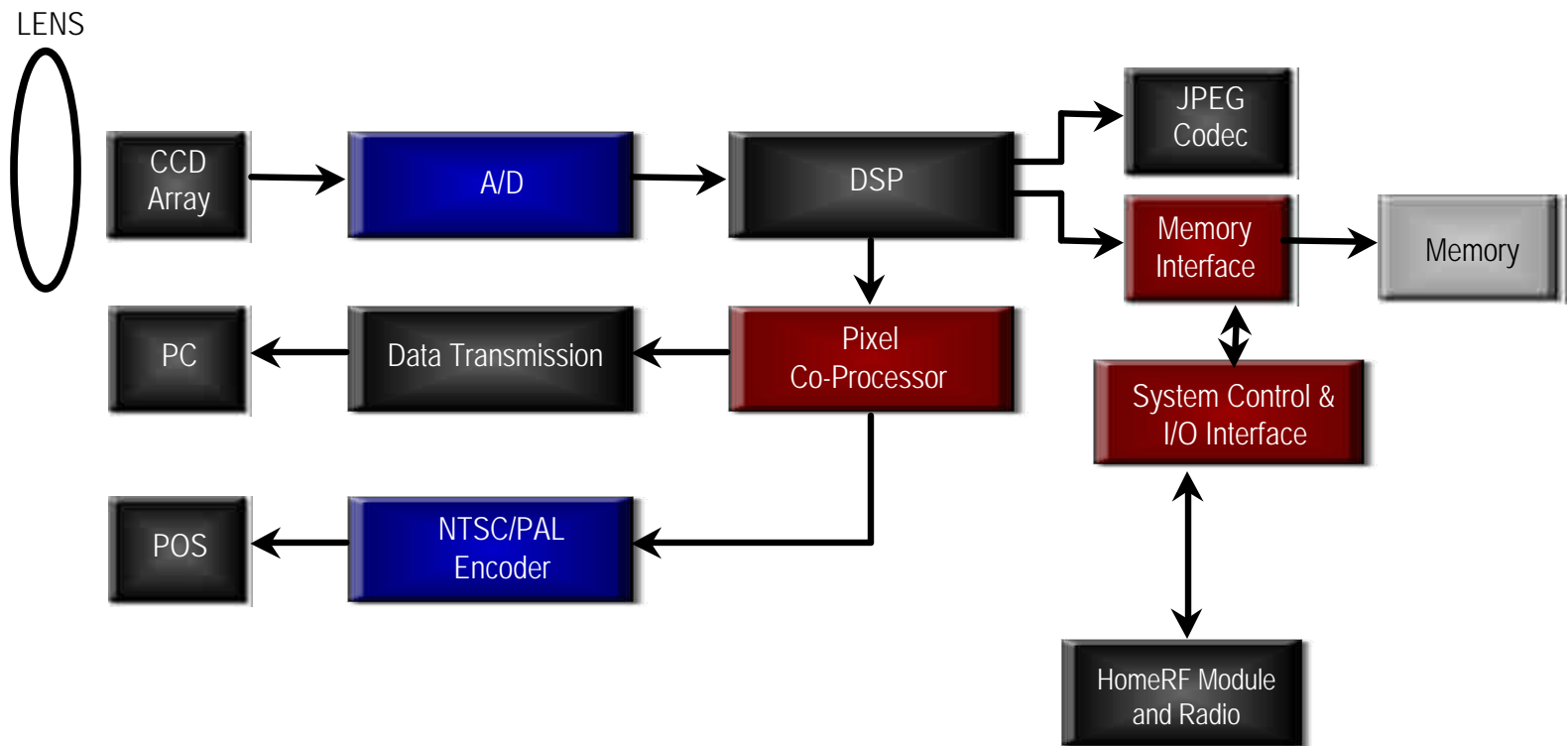
# Home Security System



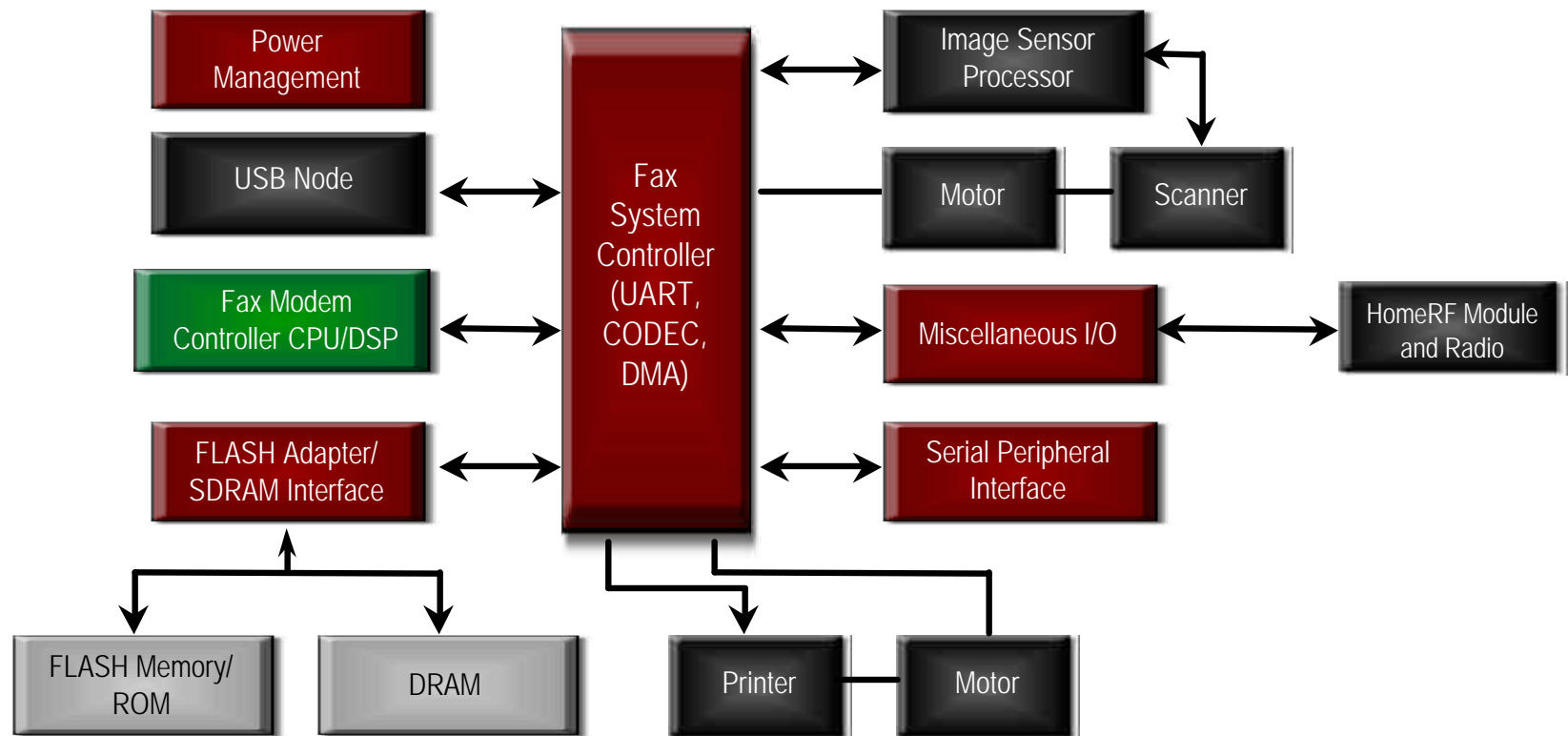
# Printer



# Scanner

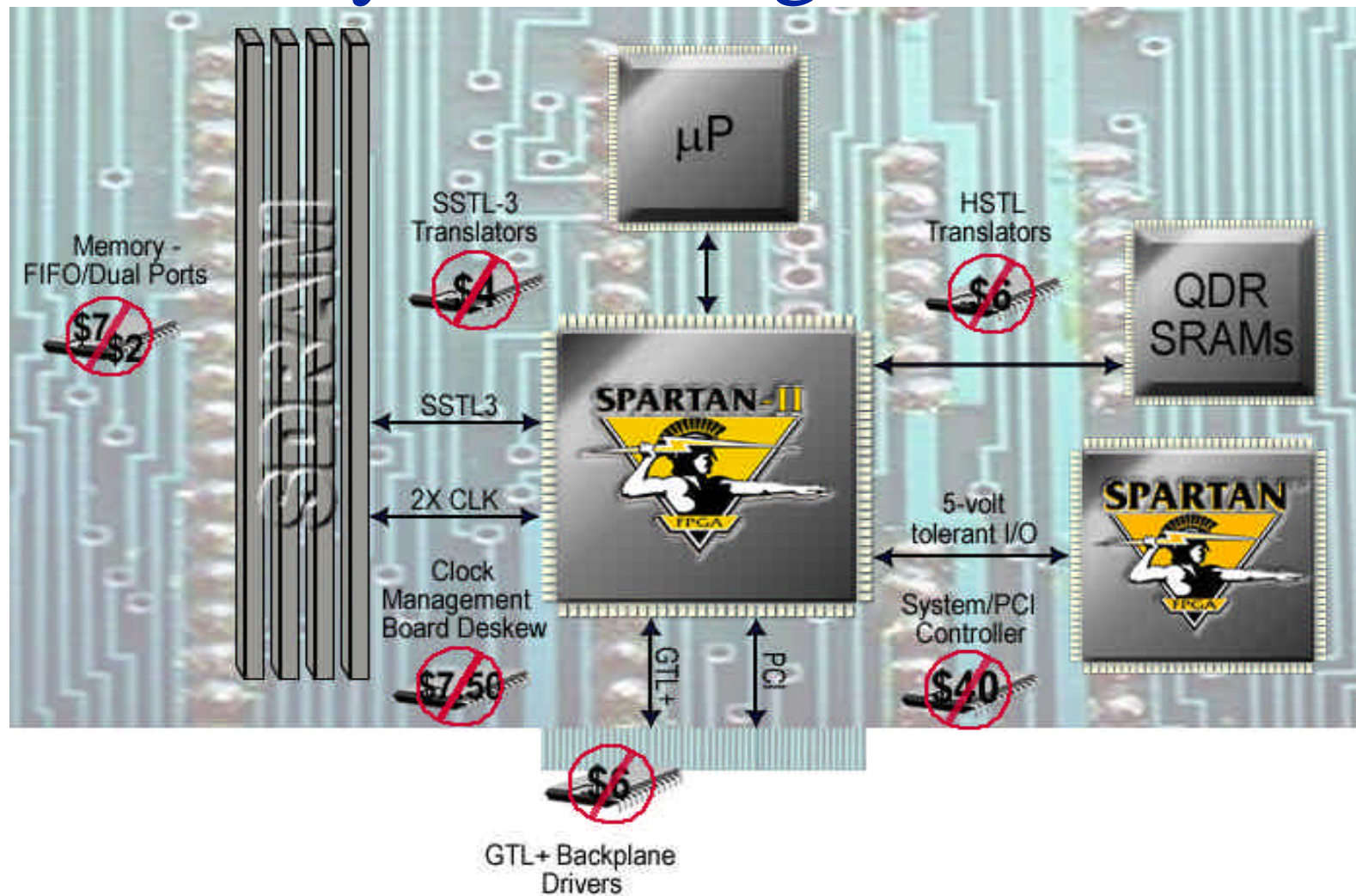


# Multi-Function Peripheral





# Spartan-II Features Provide System Integration



# Where does Xilinx fit in HomeRF?

- ◆ Everything!!
  - Enabling broadband local loop in digital modems
    - xDSL, cable, satellite
  - Residential gateways
  - Bridges
    - Enabling different technologies to co-exist
  - Enabling the information appliance network within information appliances
    - Web tablets, screen phones, PCs, printers, scanners

# Spartan-II Solutions for HomeRF-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

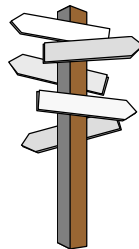
# Specification Changes

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

OEM/ Vendor



Market



## U.S. Networks Select Digital Broadcasting Format

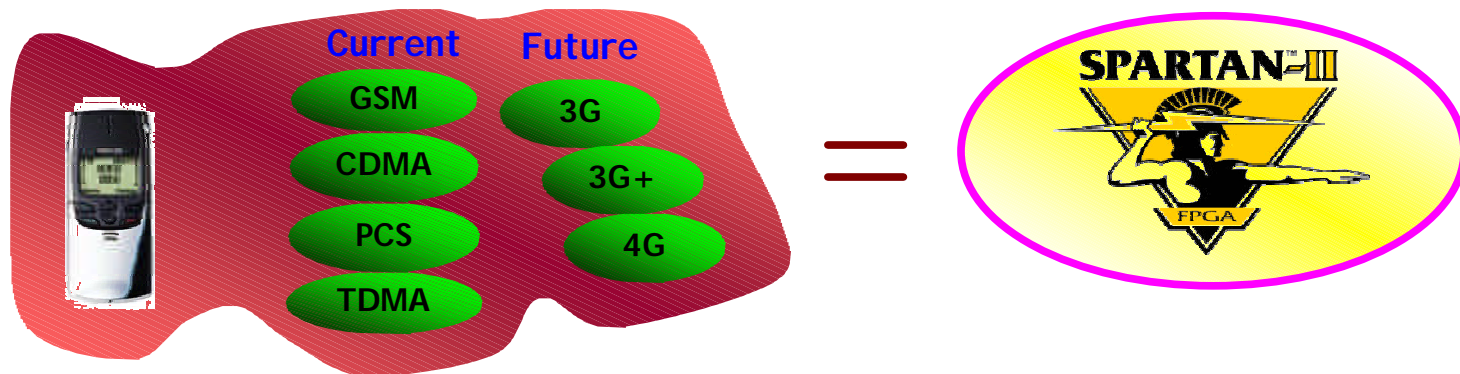
<b>ABC</b>	720-Progressive. For non-HDTV broadcasts, ABC will use 480-line progressive format.
<b>CBS</b>	1,080-Interlaced. Wants to be compatible with HDTV sets as well as normal quality formats on regular analog television sets. Digital broadcasting will begin at select CBS-owned stations in the fall 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.
<b>NBC</b>	1,080-Interlaced. NBC is leaning toward 480-line progressive for non-HDTV broadcasts.
<b>FOX</b>	720-Progressive. For non-HDTV broadcasts, Fox will use the 480-line progressive format.
<b>PBS</b>	For HDTV, PBS is undecided. For non-HDTV broadcasts, PBS will use the 480-line interlaced format.
<b>Local Stations</b>	Will have to conform to their network's format for national programming but can select any format for local programming.

Source: IC Insights

## A Programmable Solution Future Proof's Success

# New Flexibility from FPGAs

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



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

- ◆ Introduction to home networking
- ◆ Wireless home networking
- ◆ Consortium - HomeRF Working Group
- ◆ HomeRF technology - SWAP
- ◆ Xilinx Spartan-II FPGAs in HomeRF-Based Products
- ◆ Summary

# Summary

- ◆ The digital consumer revolution & the Internet are forcing broadband to the home
  - HomeRF provides a viable home networking technology
    - Mobility with voice and data connectivity at low prices
    - Sharing of broadband access and wireless communications between multiple consumer devices
- ◆ Technical summary
  - Use DECT for low cost, voice communications
  - Uses TCP/IP and IEEE 802.11 for data communications

# Summary

- ◆ Various HomeRF products are being developed
  - Residential gateways using HomeRF for home networking
    - Broadband access choices - DSL, cable, satellite, ISDN
  - Technology bridges (several choices)
    - HomeRF-to-HomePNA, IEEE802.11-to- HomeRF, HiperLAN2-to- HomeRF, HomeRF-to-Ethernet, etc.
  - HomeRF enabled information appliances
    - Internet screen phones, PCs, printers, scanners, web pads, etc.

# Summary

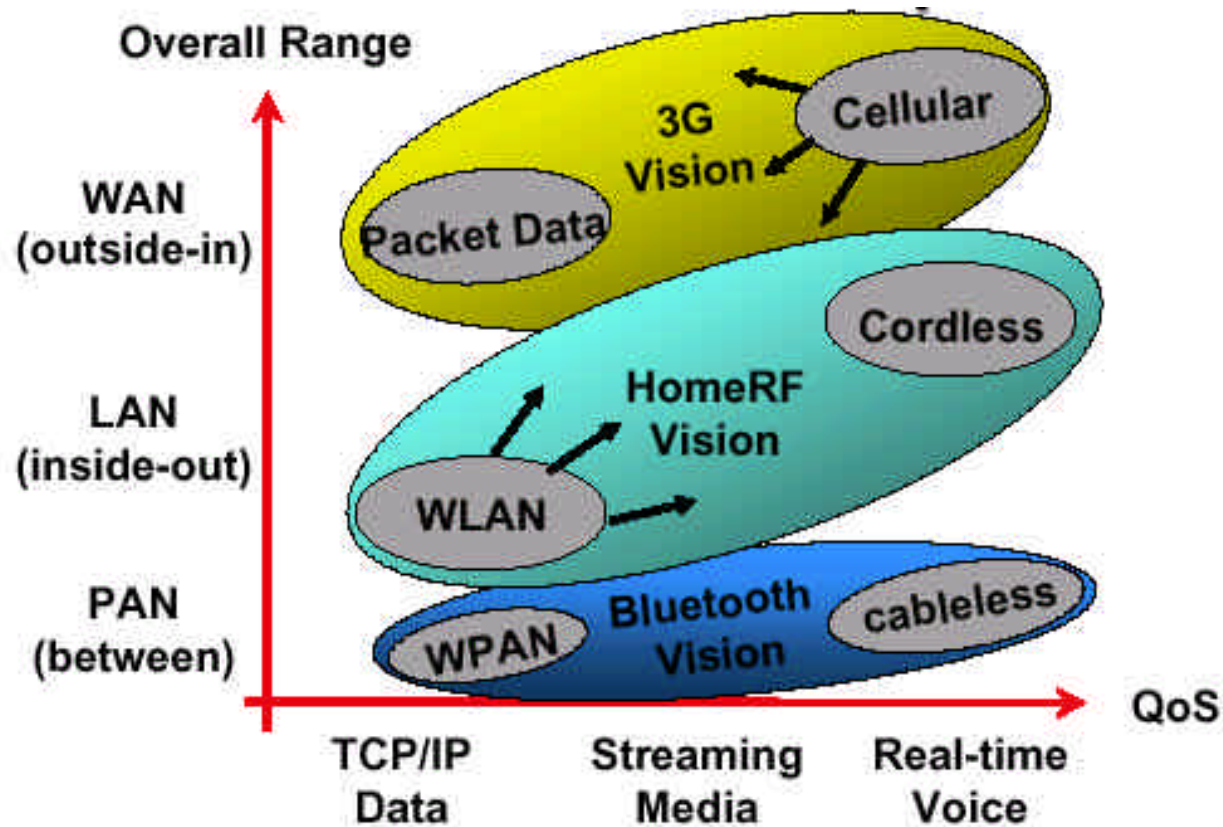
- ◆ Xilinx solutions enable HomeRF-based products
  - Spartan-II + IP provides a better solution than competing ASSPs
    - Higher performance & cost effective
    - Greater flexibility is provided through reprogrammability
      - The market is rapidly growing & competition from Bluetooth & wireless LANs is causing the need for products to be rolled out: time-to-market
      - IRL provides time-in-market as specs for emerging technologies evolve
    - 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
    - Proprietary encryption algorithms can be programmed in the FPGA depending on the application and geography
  - Spartan-II FPGAs, CoolRunner & 9500 CPLDs provide system interconnectivity in HomeRF based products





# Extra

# Wireless Networking Landscape



# HomeRF Origins

802.11  
Uses CSMA/CA  
Good for Data

DECT  
Uses TDMA  
Good for Voice



SWAP  
TDMA + CSMA/CA  
Good for Voice & Data  
Optimized for small networks (in home)  
Simplified radio & protocol to reduce cost

**Both Data & Voice are Important for HomeRF**