Digital Set Top Box Architecture

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Outline

- Introduction to Digital Video Network
- Set Top Boxes Choices
- H/W Architecture
- S/W Architecture



Digital Video Network



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Digital Video Network





Set Top Box

- Functionality is moving beyond normal TV viewing
- Better User experience
 - Increased number of channels Pay per view
 - Online shopping
 - Interactive TV
 - Video on Demand
 - Digital Video Recording capability
- Accountability
 - Easy to manage subscriber
 - Viewer ratings can be better monitored
 - Easier control on payment and service



STB Choices

Analog

- Simple Encryption schemes
- Graceful degradation of Quality
- Low Cost
- Limited number of Channels

Simple Digital

Robust Encryption Schemes
Uses MPEG2 Compression for Video
Multiple Digital channels possible
Cost Competitive to Analog box
Simple Graphics
Typically Single Tuner



STB choices - cont'd

- Advanced Digital
 - Home Gateway
 - Gaming station
 - High End 2D/3D graphics
 - More powerful CPU
 - Interactivity with return channel
- Advanced Digital with PVR capabilities
 - Personal Video Recording Capabilities
 - Digital Video Recording Capability
 - High end Applications
 - Dual Video and Main + PIP
- Choice of SD/HD



Digital TV - SD vs. HD



- SD or standard Definition TV resolution is 720 x 576 @25 fps (PAL) and 720x480 @ 30fps (NTSC)
- HD or High Definition TV has several resolutions going up to 1920x1080 @ 30 fps.
- India may not be ready for HD yet, however, the choices made today should be easily scalable for High Definition TV

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Convergence

 Broadband driving more and more features on both platforms - PC and TV.



Distribution of services in the networked home ENTERTAINMENT COMMUNICATIONS **Telecom** PC IDD Games MP3 **SECURITY Broadband** information Superhighway Gateway **Expander** 0 **Home Gateway HOME AUTOMATION** G6666-0 BROADCO

Issues and Challenges

- Integrating different Features on the same platform
- Need to deal with different Standards
 - Digital Video MPEG2
 - Digital Audio Dolby Digital, MPEG 1/2
 - Broadband access
 - Home networking
 - Various output formats
 - Different Conditional Access
- Integration of various Intellectual Properties from different Vendors
- Cost



Hardware Architecture



Simple Digital Set-top Box



Advanced Set-top Box



Advanced Set-top Box



Advanced Set-top Box



Advanced 3D Interactive Set-top Box



Advanced 3D Digital PVR Set-top Box



Advanced 3D/analog PVR Set-top Box



Tuner and Demodulator

- Tuner for Digital and Analog networks
- QAM for Cable networks
- QPSK for Satellite networks
- COFDM/VSB for terrestrial Networks
- QAM modulator for Cable return channel
- Choice of silicon for Combinations of more than one Demodulators on the same chip
- Silicon CMOS tuners are in vogue now



MPEG Transport Decoder

- Extraction of the PSI information
 - Construct Program Association Table (PAT)
 - Program Map Table (PMT)
 - Network Information Table (NIT)
 - Conditional Access Table (CAT)
 - Other Tables
- Separation of the Video and Audio Data
- Descrambler for Conditional Access
- Interface to external interfaces for Key Management
- Extraction of other Private data



Conditional Access

• Two business models available :

- Customer is given a box by the MSO.
 - That box works with only that MSO's network.
 - Here the CAS system chosen can be Embedded into the box
 - Cost of the box can be lower
- Customer buys an "Open" box
 - Gets a Smart card access from the MSO of his choice or operating in his locality.
 - Adds cost of the Smart card and the interface



Conditional Access

- DVB has Common Scrambling Algorithm
- DVB defines the Common Header for CA messages
- DVB-SimulCrypt for Interoperability
 - Allows a single transport stream to contain several CA systems
 - Allows different Box population of different CA systems to receive the same program
- DVB-MultiCrypt for Interoperability
 - Different Content is potentially transmitted using different CAS systems
 - The box does not have Embedded CAS system
 - Uses the DVB-Common Interface to connect to a Smart Card



Conditional Access - DVB- SimulCrypt





Conditional Access - DVB- MultiCrypt





Conditional Access Vendors

















MPEG Video Decoder

- Should be a standard MPEG1 & MPEG2 decoder
- Should be capable of handling any sizes upto & including 720x576 @ 25 fps for SD boxes
- Should have been Qualified with Standard Test suites.
- Support for Still pictures
- Capability to handle HITS streams
- Capability to handle DirecTV streams
- Need a higher end decoder for systems with PVR capability to support trick modes



MPEG/Dolby Digital Audio Decoder

- Should be qualified with Standard Test Suites
- Inputs for Baseband Audio
- SPDIF input interface for external Dolby/MPEG/PCM sources
- Can have added attractive features like :
 - Support for VoIP algorithms.
 - Support for virtual surround algorithms.



Scalers and Filters

- Broadcasters may not always transmit 720x576. Need capability to resize
- Video quality is the one key differentiating factor
- Graphics poses problems with display on TV (interlaced). Need to employ anti-flutter filter
- Graphics may need Pixel aspect ratio correction
- Video and Graphics should have independent scaling
- Most MPEG decoders have this built into it.



Graphics

- Simple boxes require Graphics to put out Simple User Interface
- Middle end graphics should have 2D graphics capabilities close to that on a PC to be able to run applications such as Browser/EPG
- 3D graphics for STBs with interactivity for Gaming applications
- Graphics engines have to be extremely efficient in the use of memory, bandwidth and mips utilisation



PAL/NTSC Video Decoder & Encoder

• Encoder

- Converts the Digital pixels to Analog Composite NTSC/PAL output
- Need to support teletext/Closed caption in the VBI zone
- Composite and S-Video outputs.
- Decoder
 - Converts PAL/NTSC analog to Digital formats
 - VBI decoding of CC, Teletext
 - S-Video and Composite inputs



Main CPU choice

- Availability of RTOS environments.
- Software Development and Debugging tools is one of the key deciding factor
- Memory footprint is another key criteria
- Power consumption
- Area of silicon
- Cost
- With all these criteria, RISC seems the best choice for STB type of applications

MIPS, ARM, Power PC, SH3, SH4, NEC



Memory Subsystem

- Based on Bandwidth requirements
- FLASH/EPROM for configuration of the Board
- Choice between SDRAM and DDR for the main memory depending on the features
- Memory Bandwidth is premium. The controller has to be designed to get the best performance.
- Data organization is the other key factor to get the best performance
- Key element to decide the cost of the box



Interfaces

- Smart card
- 10/100 base-T Ethernet port
- 1394 interface
- HPNA interface
- Keyboard, mouse, serial and parallel I/O ports

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- IDE
- PCMCIA
- USB

Interface Blocks





MPEG Video and Audio Encoder

- Key component for Analog PVR to be featured on a Digital STB
- Should have capability to generate good quality video even at very high compression ratios
- Controllability of the characteristics of the output compressed stream.
- Automatic 3-2 pulldown detection
- VBI and closed caption insertion

Software Architecture



Generic STB Software Architecture





Hardware Interface

- Isolates the functional levels from device and board configuration.
- Provides register access for all Endian orientations
- Handles lowest level system initialization
- intermediate software layer between API implementation and STB environment



Porting Interface

- Application Program Interface to basic chip features at a functional level
- Provides consistent Programming Interface to Syslib/Middleware
- Isolates chip level changes from end-user application development
- Provides a standard programming interface across the product line

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- Facilitates Operating System migration across product lines
- OS and Endian Independent code

Porting Interface Modules

- Transport
- MpegVideo (SD/HD)
- AC3 / MpegAudio
- Olosed Caption/ Teletext
- Graphics Library (2D & 3D)
- PCM audio
- PVR
- Front Panel Keypad & LED Control
- IR Control
- 🔸 Tuner & Qam
- VideoDisplay
- Others..



System Library

- Designed to address complex functionality that crosses multiple Porting Interface modules
- Library of functions used to create applications

e.g. Personal Digital Video Application

- Fast Forward, Rewind, Start Record, Stop Record...
- Customers can also use functions within Syslib for enduser applications
- Customers can create extensions to the basic Syslib for increased or added functionality



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- What Makes a Good RTOS?
 - Size of footprint
 - Language, Tools and Microprocessor Support
 - Field Upgradability
 - Processor Independence
 - Technical Considerations levels of interrupts/priorities/multitasking/etc
 - Financial Considerations Cost structure
 - Strategic Considerations Source code availability, support etc.
- Choices:
 - VxWorks, Linux, WinCE, Nucleus etc

Kernel Interface

 Isolates Middleware Libraries from OS implementation

 Abstract definitions for Threads, Synchronization Services and Memory Management



Middleware

- No standards available. But they are evolving.
- What features are you looking for?
- How many different applications are available?
- Is the Middleware and its applications integrated with conditional access you want?
- Is it ready when you need it?
- Make sure it allows you to download a newer version later.



Popular Middleware



OpenCable™



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Middleware - MHP

- Multimedia Home Platform (MHP) The MHP supports many kinds of applications including the following typical examples:
 - Electronic program guides (EPG),
 - Information services ("super teletext", news tickers, stock tickers),
 - Applications synchronised to TV content - scorecards, local play-along games,
 - e-commerce and secure transactions.



Middleware – MHP architecture



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Middleware - MHP

• Profiles

- Enhanced Broadcasting: (Profile 1)
 - Requiring limited interactivity (telephone return channel), but a more sophisticated STB than existed in 2000 and early 2001.
- Interactive TV: (Profile 2)
 - This Profile uses a similar return channel path to the above scenario, but with greater activity along this path. Thus requiring greater support in the software platform for interactive applications.
- Internet Profile: (Profile 3)
 - The most complex Profile targets a wide band interactive and return channel consistent with say, cable modems or other larger bandwidth return channel technologies. In addition, these platforms will have to support Internet type content downloaded directly from the Internet.



Thank You !

