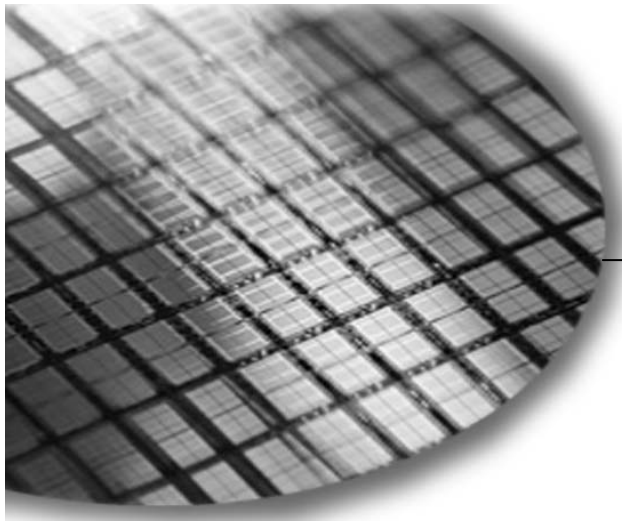
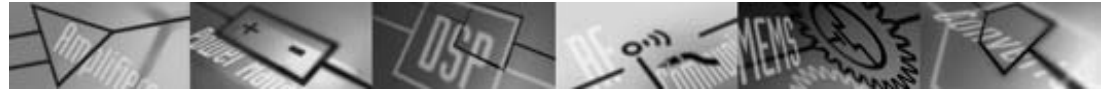




The World Leader in High-Performance Signal Processing Solutions



ADV202 Session 1

Overview, JPEG2000, Demo Tools



Brief Overview of JPEG2000

- ◆ **JPEG2000, the new still and moving image compression standard from the JPEG Committee, was designed to address the shortcoming of JPEG**
 - **Better image quality:**
 - ◆ Up to 50% better Pixel SNR performance than JPEG
 - ◆ Lossless compression possible
 - ◆ Compresses continuous tone and bi-level compression equally well
- ◆ **JPEG2000 uses wavelet-based transform to achieve better compression**
 - Possible to design systems with minimum latency [1field].
 - Exact bit-rate control [within less than 5%].
 - Better error-resilience compared to other compression standards.
 - Frame-accuracy.
 - Lossless and lossy compression in one codestream.
 - Scalability - dynamic bandwidth / quality control possible
 - Better error resilience compared to JPEG and MPEG
- ◆ **No user fees for JPEG2000 (unlike MPEG4)**



Brief Overview of JPEG2000

- ◆ **A new image compression standard from the JPEG Committee**
 - Committee members include Kodak, Sony, Canon, Matsushita, HP, Sharp, Ricoh, Adobe, Nokia, Ericsson, etc.
 - JPEG2000 [ISO/IEC-15444] standard can be downloaded at no charge from <http://www.jpeg.org/jpeg2000/>
 - The de facto or government mandated imaging standard for the following:
 - ◆ US National Imaging and Mapping Agency (satellite imagery)
 - ◆ NATO, US intelligence agencies, and the Department of Defense
 - ◆ Drivers License Photos in Japan
 - ◆ DICOM – Digital Imaging and Communication in Medicine – only accepted image compression standard
 - ◆ Various national libraries for archiving purpose
 - ◆ Digital Cinema.

More on this at:

<http://www.jpeg.org/jpeg2000/>



Image Comparison: JPEG2000 and JPEG Picture (50:1)



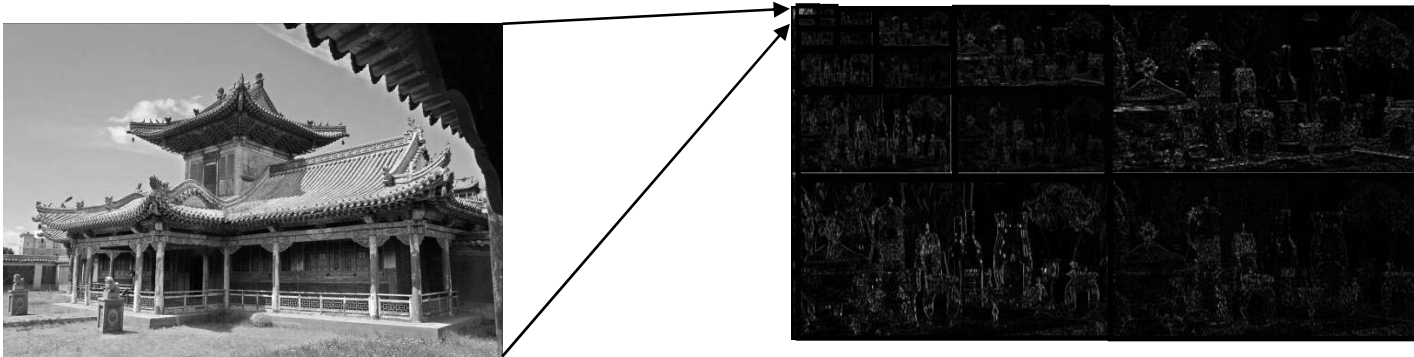
JPEG2000



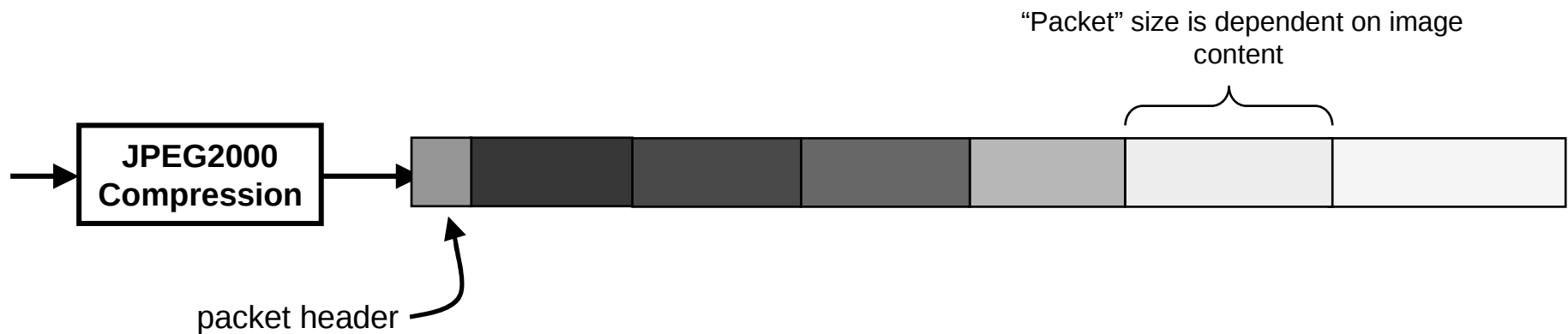
JPEG

JPEG2000 Compression

First stage: Wavelet Transform



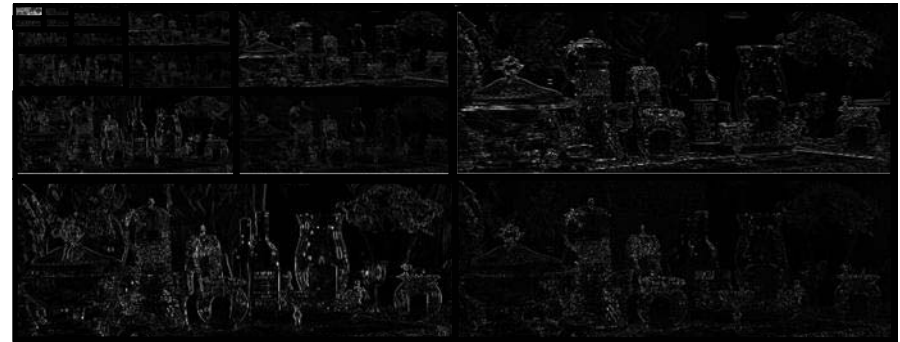
- ◆ High pass and low pass filters are applied to rows and columns, producing four sub-bands.
- ◆ Process is repeated on the “low low”, or LL sub-band.
- ◆ Very light quantization of all the frequency components in each transform level and each sub-band
- ◆ Compressed to $\frac{1}{2}$ to $\frac{1}{3}$ of original size



JPEG2000 Compression

Second stage: Entropy Encoding

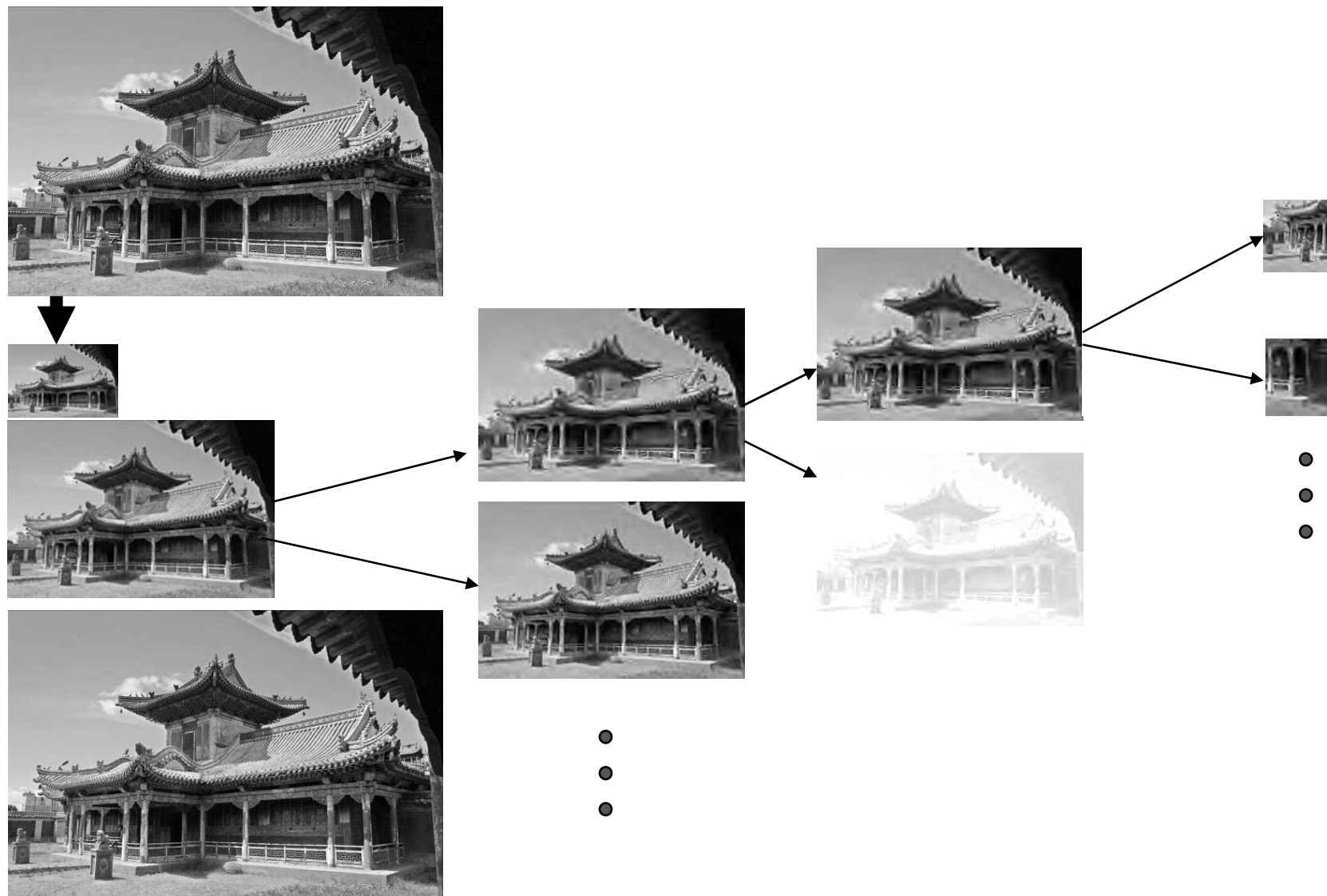
- ◆ Four parameters (Resolution / Quality Layer / Component / Precinct) can be hierarchically selected during the encoding process
- ◆ Possible because sub-bands are divisible into “layers”



In the case of *Resolution* Scaling (RLCP)



Resolution Scaling (RLCP)



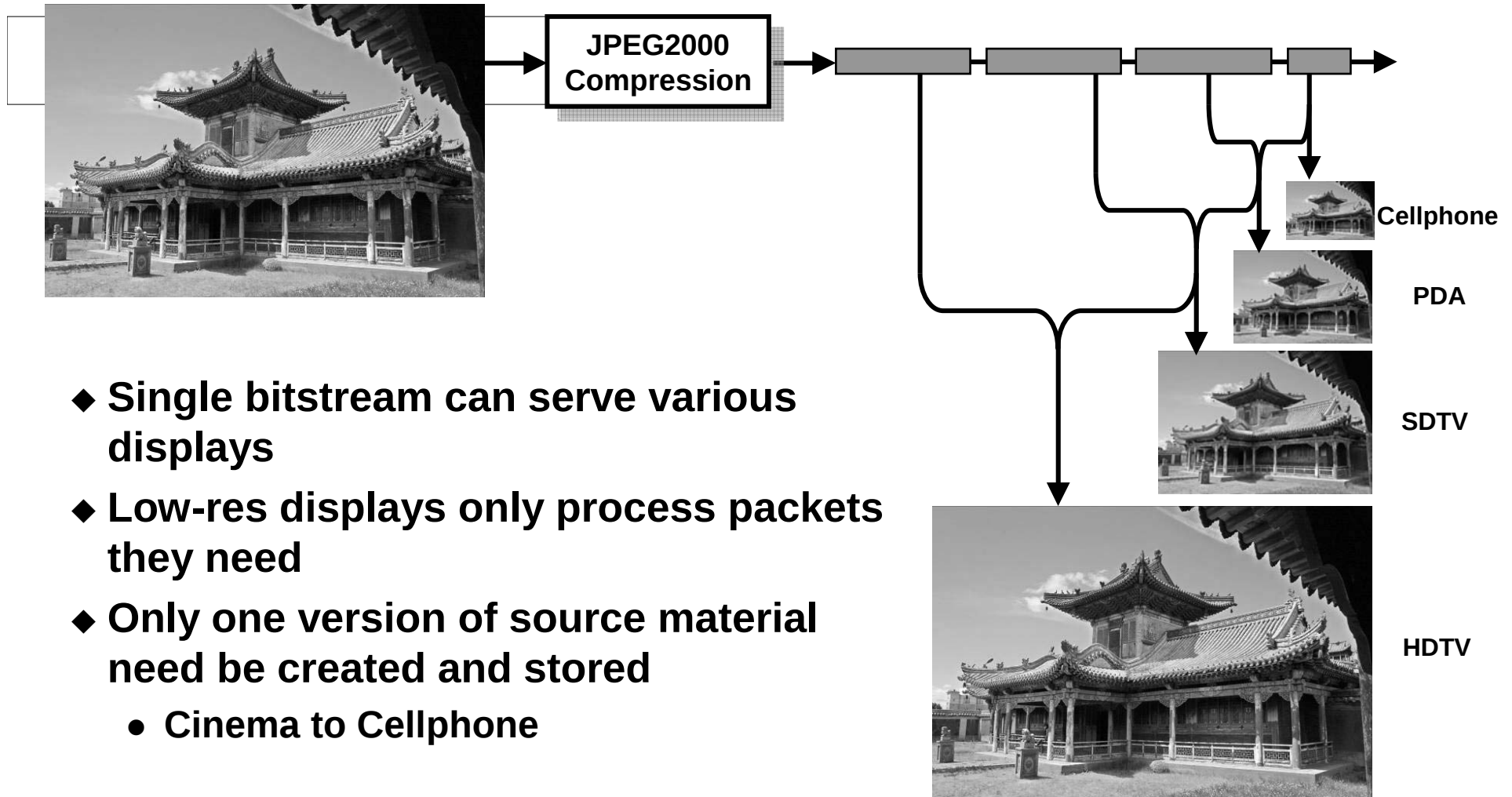
Resolution

Quality Layer

Component

Precinct

How RLCP Scalability Can be Used

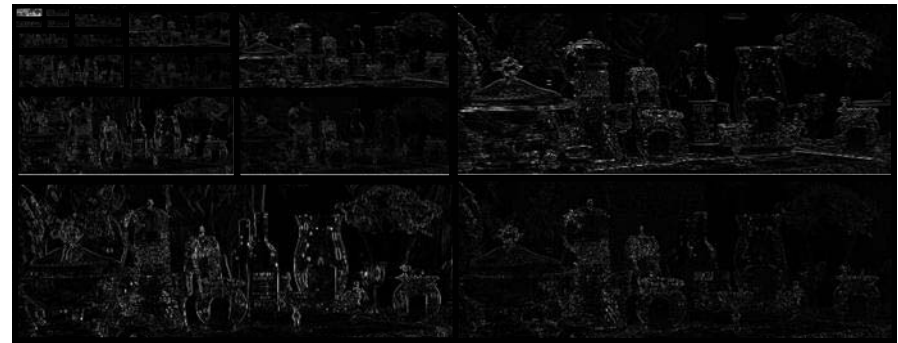


- ◆ Single bitstream can serve various displays
- ◆ Low-res displays only process packets they need
- ◆ Only one version of source material need be created and stored
 - Cinema to Cellphone

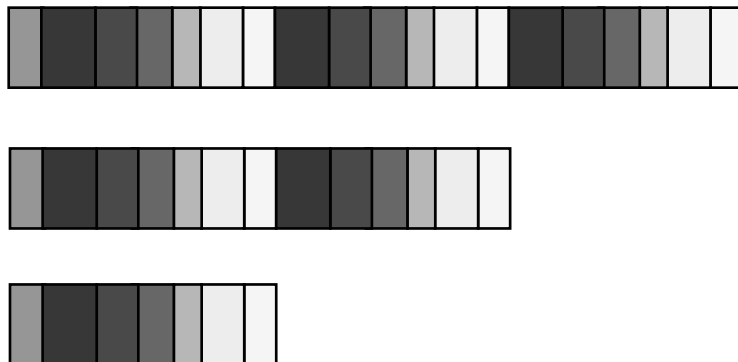
JPEG2000 Compression

Second stage: Entropy Encoding

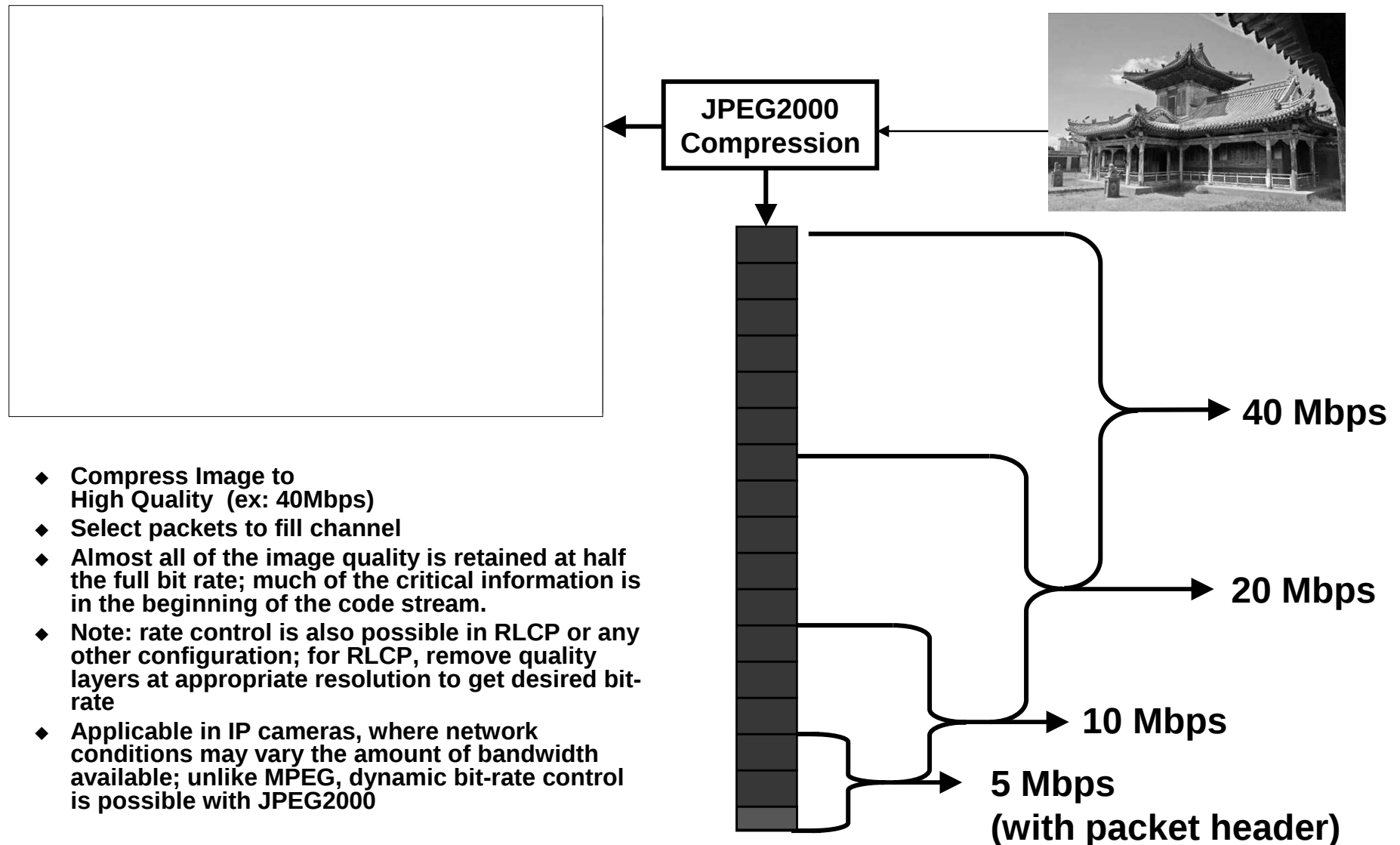
- ◆ Four parameters (Resolution / Quality Layer / Component / Precinct) can be hierarchically selected during the encoding process
- ◆ Possible because sub-bands are divisible into “layers”



In the case of *Quality Layer* Scaling (LRCP)



How LRCP Can be Used – Precise Rate Control



- ◆ Compress Image to High Quality (ex: 40Mbps)
- ◆ Select packets to fill channel
- ◆ Almost all of the image quality is retained at half the full bit rate; much of the critical information is in the beginning of the code stream.
- ◆ Note: rate control is also possible in RLCP or any other configuration; for RLCP, remove quality layers at appropriate resolution to get desired bit-rate
- ◆ Applicable in IP cameras, where network conditions may vary the amount of bandwidth available; unlike MPEG, dynamic bit-rate control is possible with JPEG2000



JPEG 2000 Handles High Bit Error Rates*

(Compression ratio of 80:1, BER of 10^{-4})



Motion-JPEG2000



Motion-JPEG



MPEG-2



MPEG-4

*-"Motion JPEG2000 in Video Processing," Master's Thesis, Wei Yu, Washington University July 2002



What is the ADV202 ?

- ◆ **Dedicated JPEG2000 hardware solution.**
- ◆ **Encodes and decodes to JPEG2000 standard.**
- ◆ **Specific functional blocks that allow JPEG2000 compression on a single chip solution as opposed to a multiple DSP solution or a software only solution.**
- ◆ **Simultaneous input of uncompressed video/pixel and output of compressed data using a dedicated Video in/out port and a 16-bit/32-bit host data bus.**
- ◆ **No external DRAM requirement**
- ◆ **No external DSP requirement**
- ◆ **Max. data input rate 65Msamples/sec [=approx. 2x CCIR656 data rate]**
- ◆ **High Definition Video : In sync mode, several ADV202s can be sync-ed together for higher data input rates.**
- ◆ **Video compression :**
 - **direct interface to YCbCr 4:2:2 video [ITU.R.BT656 or SMPTE274M [1080i, 720p]**
- ◆ **Still image compression**



ADV202 Features

◆ Functional Features/Software

- JPEG2000 part 1 standard for still and motion pictures.
- SURF (Spatial Ultra-efficient Recursive Filtering) technology
 - ◆ No external memory needed – competitive solutions need frame buffer memory
 - ◆ Low Latency - <1.5 frames for encode or decode; MPEG solutions have up to 10 frames worth of latency
- Internal rate control is accurate to +/-5% [MPEG or JPEG solutions are content dependent]

◆ Programmable JPEG2000 parameters:

- Rate Control: program for fixed output rate.
- Rate Control: program for fixed output quality with variable output rate.
- Number of wavelet transforms
- File format: .j2c or .jp2
- Code block size
- Progression order
- Compression Mode [9/7 or 5/3].

◆ Downloadable firmware.

◆ Hardware

- **Host Interface: 32-bit/16-bit.**
 - ◆ Used to configure Direct Registers
 - ◆ Used to configure Indirect Registers
 - ◆ Data transfer of compressed data
 - ◆ Data transfer of uncompressed data
- **Video Interface:**
 - ◆ direct interface to YCbCr video in 4:2:2 format.
 - ◆ Video can be either EAV/SAV or HVF, or Raw.
 - ◆ Up to 14-bit wide, ie supports 8, 10, 12, 14-bit wide video.
 - ◆ 16-bit wide video supported in monochrome mode.
- **Package:**
 - ◆ 144-pin, 13 x 13 BGA package at different speed and price grades.
 - ◆ 121-pin, 12 x 12 BGA package.
- **Power supply:**
 - ◆ VDD_IO = 3.3V/2.5V
 - ◆ VDD_core = 1.5 V
- **Clock requirements:**
 - ◆ Up to 74.25MHz for Host Interface
 - ◆ Up to 74.25MHz on Video Interface



ADV202 Host Interface modes

◆ Normal Host mode

- least efficient but lowest pin count, ie does not require DREQ/DACK pins.
- max. data throughput = 120 Mbytes/sec

◆ JDATA mode

- synchronous interface
- max. data throughput = 37 Mbytes/sec

◆ DREQ/DACK DMA mode

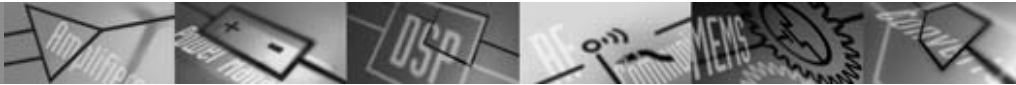
- DREQ/ asserted by the ADV202 whenever data is ready
- No FIFO threshold programming required

◆ DCS DMA mode

- hardwired directly from the FIFOs
- FIFO thresholds must be programmed by the user

◆ Fly-By DMA mode

- functionally the same as DREQ/DACK except that RD/ and WR/ pin functionalities are swapped.
- Designed for compatibility with previous JPEG2000 chip.



ADV202 Video Interface modes

◆ EAV/SAV Mode

- CCIR656 for SD
- Embedded syncs for luma/chroma in HD

◆ HVF Mode

- Separated Horizontal, Vertical syncs, field
- Master or Slave mode

◆ RAW Pixel mode

- Simple, handshaking mode
- No blanking



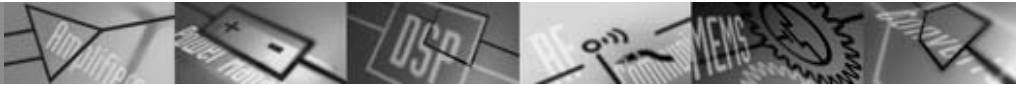
JPEG2000 Features not in the ADV202

◆ Region of Interest (ROI)

- Would allow different rate control parameters (more bits) to a subset of the image

◆ Precincts

- Codes for a particular location of the image
- Is implemented for Digital Cinema decode



ADV202 Firmware

- ◆ Loaded as part of the start up procedure
- ◆ Handles Rate Control
- ◆ Handles Packetization
- ◆ Four different types
 - Encode
 - Decode
 - Decode 2K DCI
 - Decode 4k DCI
- ◆ Regularly updated with fixes
- ◆ Customization possible for the right opportunity
 - Not possible by customer



When to use JPEG2000

◆ Low latency is required

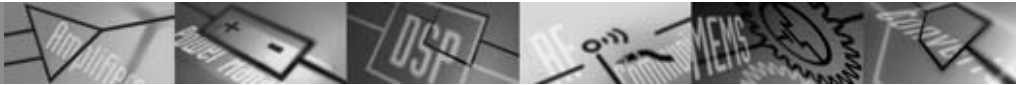
- Real-time compression (Gaming, User interfaces)
- JPEG2000 has no temporal compression, latency < 1 Frame

◆ Scalability is required

- Encode once, decode many times
- Multiple different receivers with different capabilities
- Communication channel with variable bandwidth

◆ High bit rates (quality) are required

- From very high compression to lossless
- MPEG solutions “top-out” in terms of quality– no lossless



When not to use JPEG2000

◆ Distribution

- No time limits on encode
- Asymmetric codec (decode can be much simpler)

◆ Very high compression required

- Extremely limited storage or bandwidth

◆ Non-realtime compression

- No latency requirements

◆ Single, known, playback system

- No scalability requirements



JPEG2000 in Surveillance

◆ ***Why consider JPEG2000 when there is MPEG2/4 or H.264?***

- More flexibility - encode at the highest quality (for detailed viewing) but only send portions that fit lower transmission bandwidth, resolution, frame rate, etc.
 - ◆ To address HDD space concerns, the customer can reduce bit rate during scenes with no motion and increase quality when motion is detected
 - ◆ Any forward error correction implemented in MPEG2/4 may eliminate any bit rate advantage that it may have to JPEG2000
- Low latency - useful in remotely operating a camera
- Multiplexing multiple cameras - not possible with MPEG
- Regions of motion can be enhanced - not possible with MPEG
- Higher image quality
 - ◆ MPEG is not conducive toward high image quality since it is 8-bits only and has no still image capability – key in legal cases
 - ◆ Most MPEG encoders first scale D1 images to CIF, then perform the encode
- Legal Issues – Some countries (Australia) may not consider MPEG still images as legal evidence

◆ **Gaining acceptance in surveillance applications –**

- Designed into three of the top DVR makers in the United States
- Designed into Asian DVR manufacturers

JPEG2000 in Surveillance (cont.)

◆ *Who can provide my customer with more complete JPEG2000 software?*

- As previously noted, the FTP site provides basic JPEG2000 software for evaluation purposes only
- An example of software available for commercial licensing would include the following from CA Technologies (contact: sales@catechnology.com)



- ◆ Network Video Recorder (NVR)
 - Capable of recording and managing video from a variety of sources – network codecs, IP cameras, and DVRs from different manufacturers.
 - Industrial strength storage management subsystem can handle thousands of sources and clients simultaneously- easily scaled to large enterprise installations.
 - Video routing system actively manages multi-resolutional streams – like JP2K – for individual client bandwidth control, regardless of source.



JPEG2000 for Broadcast professionals

◆ *Why consider JPEG2000 when there is MPEG2/4 or H.264?*

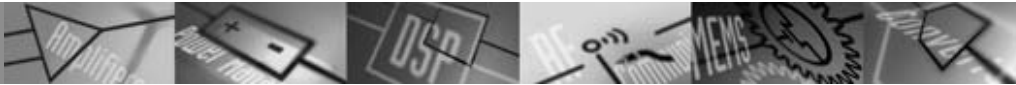
- Price – No realtime solution for MPEG2/4 or H.264 HD encoding
 - ◆ 10K+ Rack-mount devices needed to encode
- Size - Camera men don't want to carry a server farm on their backs
- Higher image quality
 - ◆ MPEG is not conducive toward high image quality since it is 8-bits only, no lossless, and “tops out” below bitrates needed for broadcast quality HD
- Workflow – Because there is no temporal compression, back end video editing can be done far more easily on a frame by frame basis

JPEG2000 for Broadcast professionals (cont.)

- ◆ Thomson Grass Valley design-ins the ADV202 in their Infinity™ Digital Media Camcorder and Recorder for the professional broadcast market



- ◆ JPEG2000 Standard for HD
- ◆ Extensive evaluation process led to this decision
- ◆ 1080p Support yet to come...



JPEG2000 for Streaming Media

◆ *Why consider JPEG2000 when there is MPEG2/4 or H.264?*

- Latency – <1 Frame each for encode or decode
 - ◆ User interface can be encoded with the data and still be used
- Scalability - Resolution and bitrate can be adjusted on the fly
- Symmetry – Encode is no more complicated than decode



JPEG2000 for Digital Cinema

◆ *Why consider JPEG2000 when there is MPEG2/4 or H.264?*

- High Quality
 - ◆ Digital Cinema calls for 250Mbps/s. Temporal compression schemes “top out” long below this point
- Hardware solution available now - The ADV202!
- Scalability
 - ◆ DCI calls for 2 resolutions, 2K & 4K. With JPEG2000, a single encode provides both

**Recommended by Digital
Cinema Initiatives (DCI)
as the cinema distribution
medium for Hollywood
motion pictures**



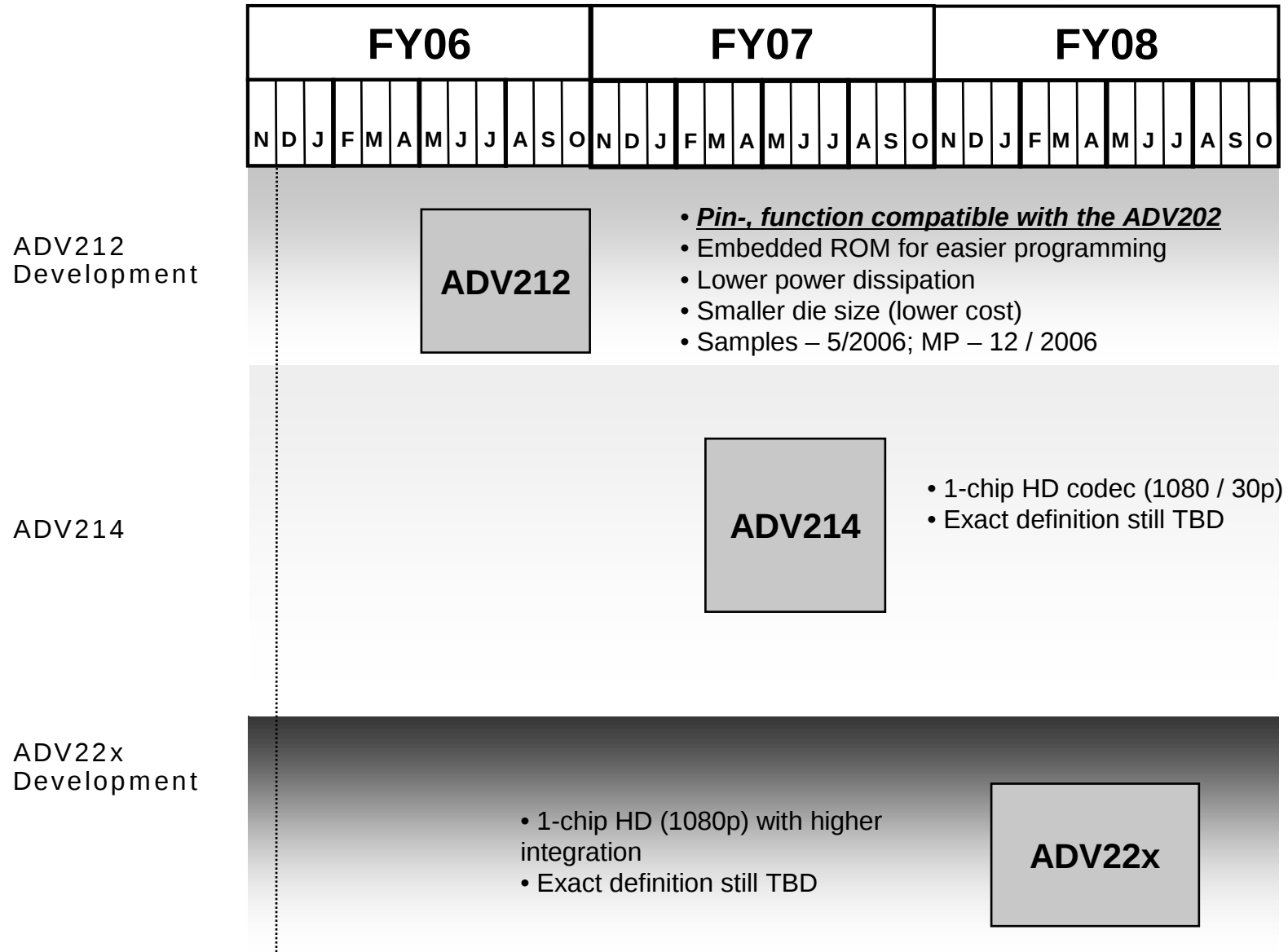


JPEG2000 for Wireless HD Video

◆ *Why consider JPEG2000 when there is MPEG2/4 or H.264?*

- Latency – <1 Frame each for encode or decode
 - ◆ User interface can be encoded with the data and still be used
 - ◆ Latency low enough for even gaming applications
- Error resiliency
 - ◆ Errors don't propagate over multiple frames as with MPEG
 - ◆ Only a small portion of the codestream needs to be protected since errors in most of it won't be seen
- Symmetry – Encode is no more complicated than decode
- Price – HD realtime solution not feasible right now with MPEG

JPEG2000 Product Roadmap

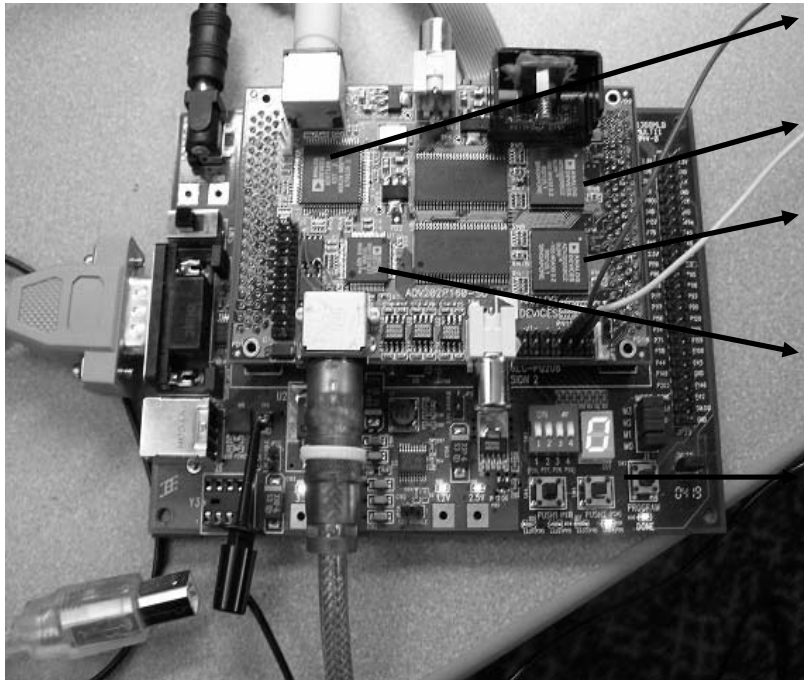




ADV202

Demo Tools / Evaluation Systems

ADV202 Evaluation systems – p160 SD



- ADV7189 S-Video or CVBS analog video
- ADV202 encode
- ADV202 decode
- ADV7321 S-Video or CVBS analog output
- Memec Design – Xilinx Spartan 3SxLC mother board

ADV202 Evaluation systems – p160 SD

Stand-Alone mode:

Control over push-button and DIP switch :

- o Demo Interlaced or De-Interlaced mode
- o Demo Rate Control [=Compression Ratio]

PC control mode:

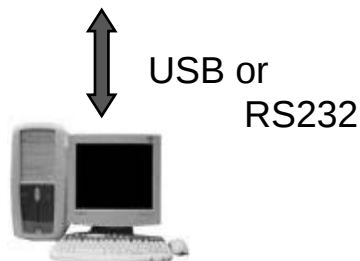
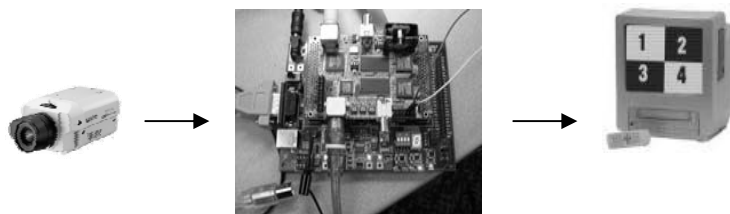
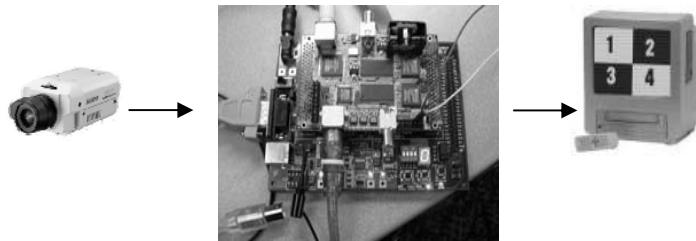
Control over HyperTerminal using provided Main Menu options:

1. Read compression rate used
2. Change compression rate
3. Change register settings
4. Change encode or decode parameters
5. Upload different firmware
6. Read registers from all ADV devices on board

Developer mode:

Control over entire system using source code:

1. Change to Custom Specific mode configuration
2. Change to DMA DREQ/DACK access
3. Change push-button and/or DIP switch assignment





ADV202 Evaluation systems – p160 SD

The p160-SD evaluation kit comes with :

1. ADV202 daughter card
2. Memec Design Xilinx S3 mother board
3. Power supply for board
4. Jtag interface cable [only required for Developer mode control to program the FPGA]
5. SDK Eval version of Xilinx software tools [only required for Developer mode control]

Additionally required by the User:

1. **Stand-Alone Mode:** 2x S-Video or CVBS video cable, S-Video [CVBS] video source, video monitor
2. **PC Control Mode:** USB cable, 2x S-Video or CVBS video cable, S-Video [CVBS] video source, video monitor, PC
3. **Developer Mode:** USB cable, 2x S-Video or CVBS video cable, S-Video [CVBS] video source, video monitor, PC

Schematics, User Guide, Source code can be downloaded from :

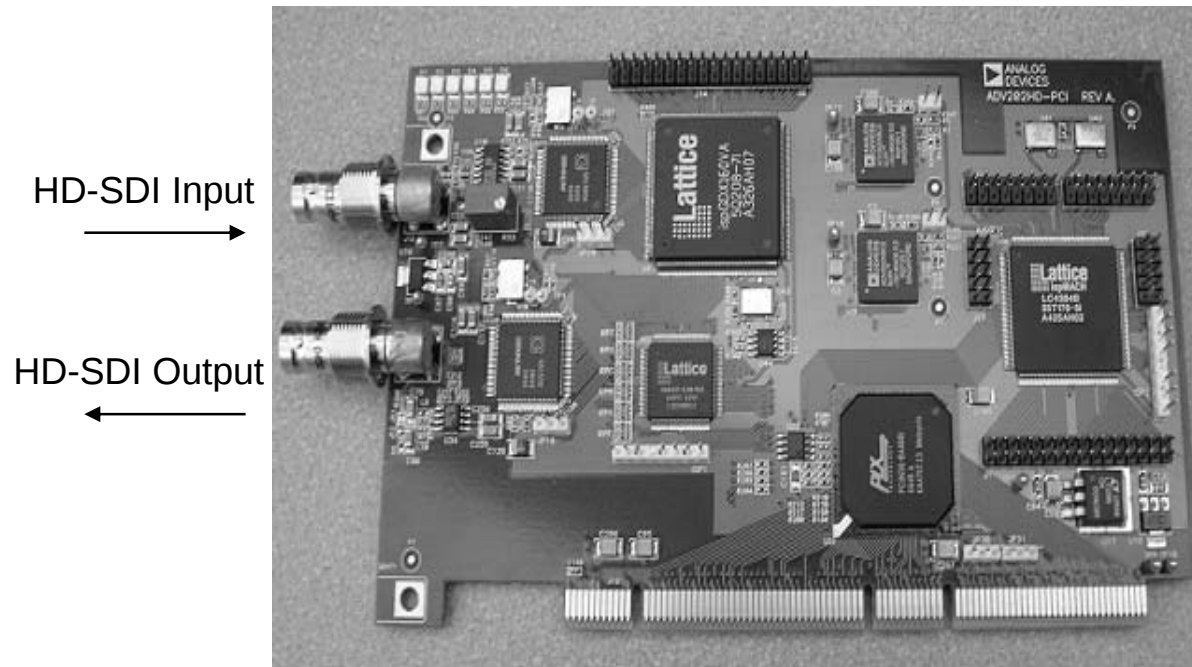
ftp://ftp.analog.com/pub/Digital_Imaging/ADV202_Eval_P160SD_FPGA_SYSTEM/P160SD_system/

or from

<http://www.analog.com> – search for ADV202 – use the *Technical Documentation* link



ADV202 evaluation systems – ADV202 HD PCI



- 1080i and 720p compatible
- 32/64-bit, 33/66 MHz PCI card
- WinXP Application Software [Alberio]
- Encode JPEG2000 to file
- Decode JPEG2000 from file
- Use 2 cards in HD pass-through mode



ADV202 HD PCI Card - Sources

- ◆ Inputs – HD-SDI
 - Can be converted from Component with 3rd party device (AJA)
- ◆ Outputs – HD-SDI
 - Also can be converted to Component with an AJA device
- ◆ Formats Supported on HD-SDI
 - 1080i/60Hz/59.94Hz
 - 720p/60Hz
- ◆ Other formats can be done but only in Host Mode
 - Custom specific formats can be used
 - NTSC, PAL, De-interlaced NTSC or PAL
 - Played back on PC Monitor



ADV202 HD PCI Card – Applications

◆ Evaluation

- Capture HD with various parameters, view results

◆ Hardware Acceleration

- Eval software is DirectShow compatible and can be (has been) integrated with other DirectX workflows

◆ Demo

- Streaming Media with 2 cards
- Real-time rate control

◆ Reference

- All software and schematics are available on FTP site



ADV202 HD PCI Card – What it's not good for

- ◆ Non standard video resolutions
 - Architecture is optimized for streaming video, not custom formats
- ◆ Prototyping Embedded Work
 - No CPLD space available for custom work
 - Chip is controlled from Windows XP, too complicated to learn much from
 - Windows Driver is a streaming filter driver so implementation is very obscure compared to an embedded system
- ◆ Incorporating into existing system
 - DirectShow is not easy to pick up
 - Hard to interface to standard windows drivers



ADV202 HD PCI card : Alberio Software - Overview

◆ Alberio is a toolkit, not an application

- DirectShow Kernel Streaming Filter Driver
- A set of DirectShow filters for moving data around
- Applications which simply tie these filters together

◆ DirectShow Filters

- A filter is simply a piece of code that either sources a frame of data (Capture) , sinks a frame of data (Render), or transforms a frame of data
- Filters are put together to make a “filter graph” that represents some dataflow. For example, an “Encode to File” graph might contain a ADV202 Capture filter and a Binary File Render filter



ADV202 HD PCI card : Alberio Software - Applications

- ◆ Applications are just UIs for the filters
- ◆ ADV202HDDemo
 - Main Application
 - Encode, Decode, Encode to Network, Passthrough
 - Provides realtime metrics for throughput and compression
- ◆ ADV202Player
 - Decode only application
 - Decode from file or network, play out SDI or to PC screen (maybe)
- ◆ HipiSourceCreator
 - Encodes custom formats from BMPs
 - Can take 720p BMPs and generate a playable file



ADV202 HD PCI card : Alberio Software - Applications

◆ StillsDemo

- Software only, any size image
- Compares to JPEG at same compression ratio

◆ DumpFileChecker

- Allows BIN files (Alberio's format) to be parsed and viewed as individual frames



ADV202 HD PCI card : Alberio Software - Filters

◆ Driver

- Render, Capture, Codec Filters
- Contains the code that sets up and programs the ADV202
- Manage the DMA of data in and out of the part

◆ File Filters

- Source, Render
- Reads BIN and MXF files
- Writes BIN files
- MJ2 coming

◆ Network Filters

- Source, Render
- UDP based, very simple packetization



ADV202 HD PCI card : Alberio Software – Filters [cont]

◆ TypeConverter

- Converts data from ADV202 into a format that the Windows renderer can display
 - ◆ IYUV for HD
 - ◆ YUY2 for SD

◆ Transcoder

- Shows scalability
- Allows user to strip off some number of quality or resolution layers if they encode with PLT



ADV202 HD PCI card : Alberio Software – Modifications

◆ Relatively Easy

- Changing UI for any application (buttons, logos, etc.)
- Making a new app with existing filters

◆ Moderate

- Modifying existing filters slightly (different file format, different network packets, etc.)
- Integrate existing filters with other custom filters
- Modifying interfaces

◆ Hard

- New video formats
- New custom filters
- Integrating with non-DirectShow windows (or other) code
- Linux



ADV202 HD PCI card : Alberio Software – What is needed to work with it

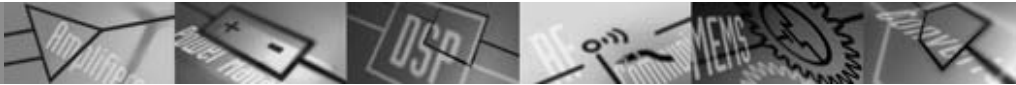
◆ Tools

- MS Visual Studio .NET 2003
- DirectX SDK
- For the driver: Compuware DriverStudio(\$\$\$), MS DDK (Nearly Free)

◆ Knowledge

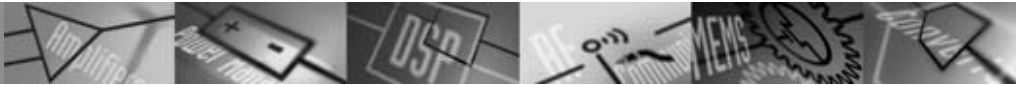
- Filters, Filter Graphs, DirectShow
- COM
- Any Windows programming knowledge helps, but learning curve is steep

◆ Many things you can do, IF you can take the time.



ADV202 HD PCI card : Alberio Software – Other Requirements

- ◆ Windows XP
 - Won't work on any earlier windows versions
- ◆ DirectX 9.0+
- ◆ Windows Media 9.0+
- ◆ To play HD to screen: IYUV conversion filter
 - Doesn't come with Alberio
 - Might come with Video card driver or Windows Media
- ◆ For StillImageDemo & DumpFileChecker
 - Kakadu software – www.kakadusoftware.com FREE software decoder



JPEG2000 Software Decoding

- ◆ Morgan Multimedia
 - Windows Media plugin (MJ2)
- ◆ Kakadu Software - www.kakadusoftware.com
 - Inexpensive license for full source code for customer to modify
 - Free to download binaries, utilities
- ◆ Aware -
www.aware.com/products/compression/compression.html
- ◆ Software decoding an option for very small image sizes or non-realtime needs



Eval / Development Tools Summary - Current

◆ P160 SD Board

- Good for demos– standalone and easy to use
- Simple embedded development
- Xilinx FPGA & Tools
- Single board Pass-through

◆ HD PCI Board

- Good for demos, but needs PC and Converters
- Complex Windows development environment
- Not great for prototyping
- Takes 2 boards for pass-through



Eval / Development Tools Summary - Planned

- ◆ P160 SD Board (Current)
- ◆ P160 HD Board (Q2 – Q3 2006)
 - Same idea as SD board but with 4 chips for HD
 - Will use faster FPGA and embedded CPU
- ◆ PCI Express Development Board (Q3 – Q4 2006)
 - 3 ADV202s
 - HDMI
 - 2 Virtex 4 FPGAs
 - PCI Express in PC, or standalone use with USB 2.0 / Ethernet
 - Not so good for reference design or demos
 - Designed for hardware / software / algorithm development
 - 2k DCI possible