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Minds in Motion

The New and Enhanced DaVinci VPSS Drivers

Xiangdong Fu
Catalog/EEE DSP Applications
Texas Instruments

Goal

- Provide a high-level overview of the newly developed DaVinci VPSS drivers
- Discuss design requirement, architecture and supported features
- Targeted audience are DaVinci Linux application developers responsible for video capture/display, pre- and post-processing

Agenda

- Introduction
- Overview of DaVinci VPSS Drivers
- Driver Requirement & Architecture
- HW & Driver Feature Comparison
- Programming Considerations

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TI Video Expertise Enables Faster and Easier Product Innovation

TI has a long history covering the video market from end to end

R&D began on image processing in the early 80s

TI leverages video systems expertise and R&D across internal design teams to drive innovation and business development

Customers can leverage TI's expertise in end-to-end video to quickly launch into multiple video markets

Minds in Motion

TI Expertise Covers Full Digital Video Spectrum

Digital Still Camera

Automotive Entertainment & NAV

Automotive Vision

Machine Vision

Video Phones

Personal Media Players

Set-Top Box & Digital TV

Cell Phones

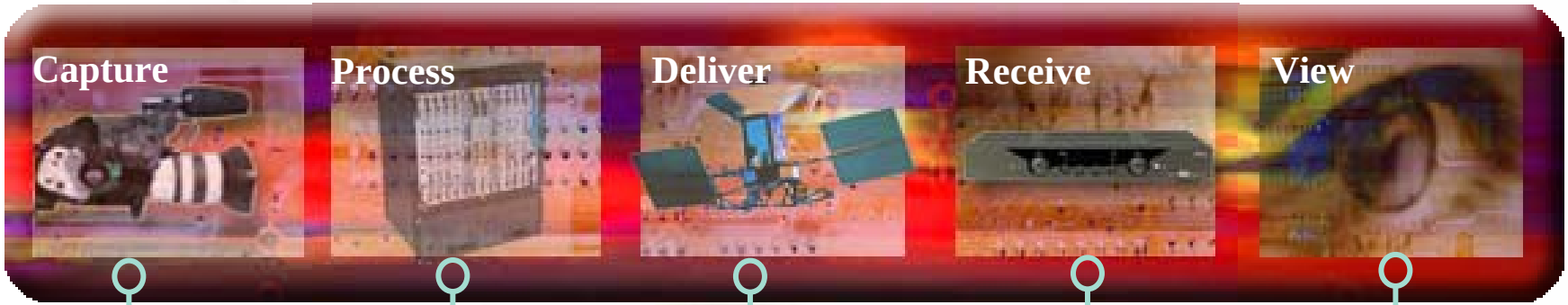
Video Security

Video Infrastructure

Medical Imaging

Video Conferencing

Defining the Video Chain – Working With Customers Throughout the Entire Video Chain



Acquisition of original video content including A/D and sampling

Kodak
POLYCOM
SONY
hp
HIKVISION
LifeSize

Content is encoded, transcoded, transrated and/or analyzed

POLYCOM
INLET HIGH-DEFINITION
HIKVISION
LifeSize
TANDBERG
NMS COMMUNICATIONS

Content is transported via private or public networks

ZyXEL
WESTELL
ARRIS
SIEMENS
TIME WARNER CABLE
Comcast
verizon
TELECOM ITALIA
Telefonica
at&t

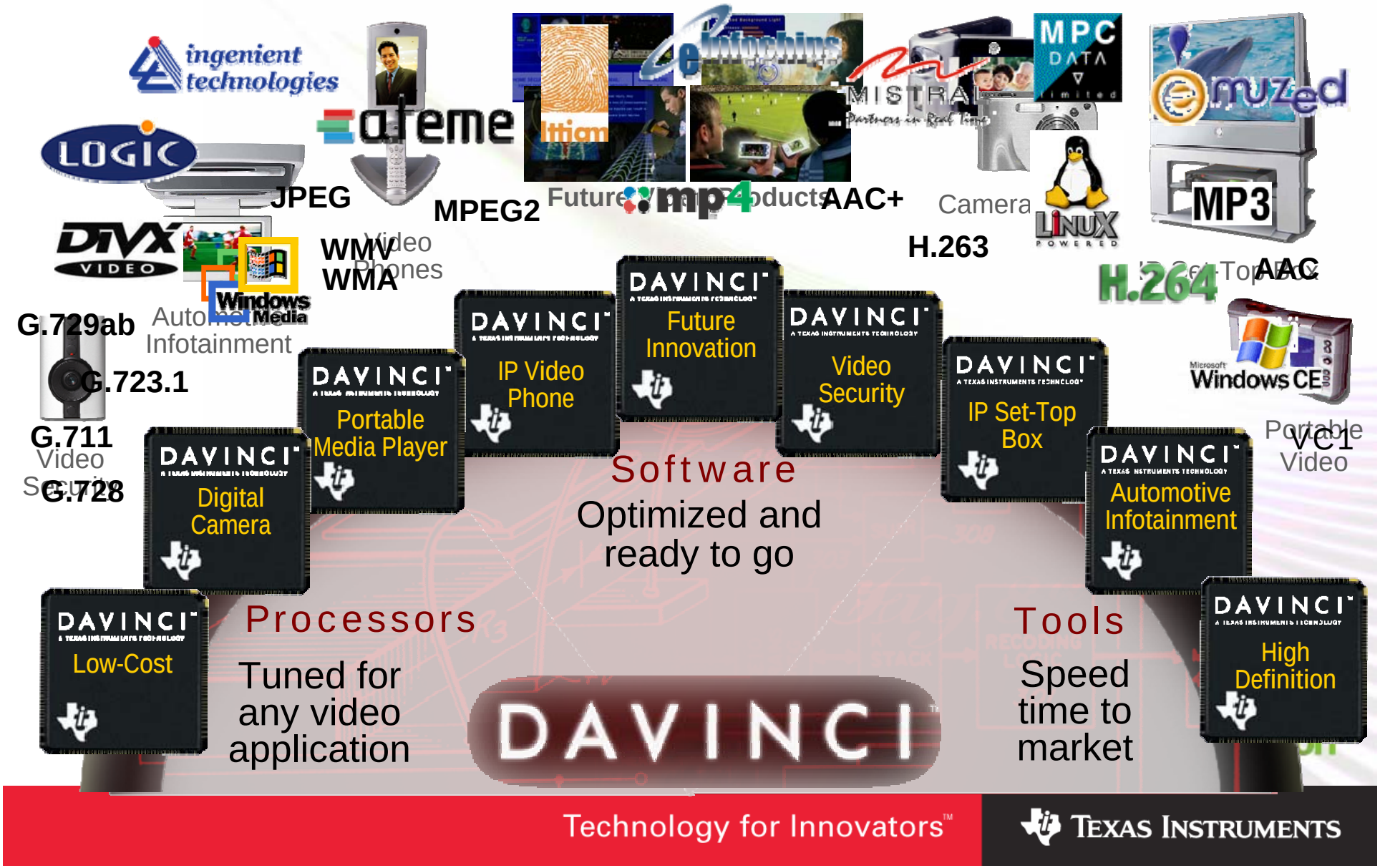
Received content is stored, decoded and/or transcoded

sentivision
KONKA
sling media
ADB
amino

Content is accessible through a viewing mechanism

ARCHOS
SAMSUNG
Panasonic
Kodak

DaVinci™…a Revolutionary Platform for Video Applications



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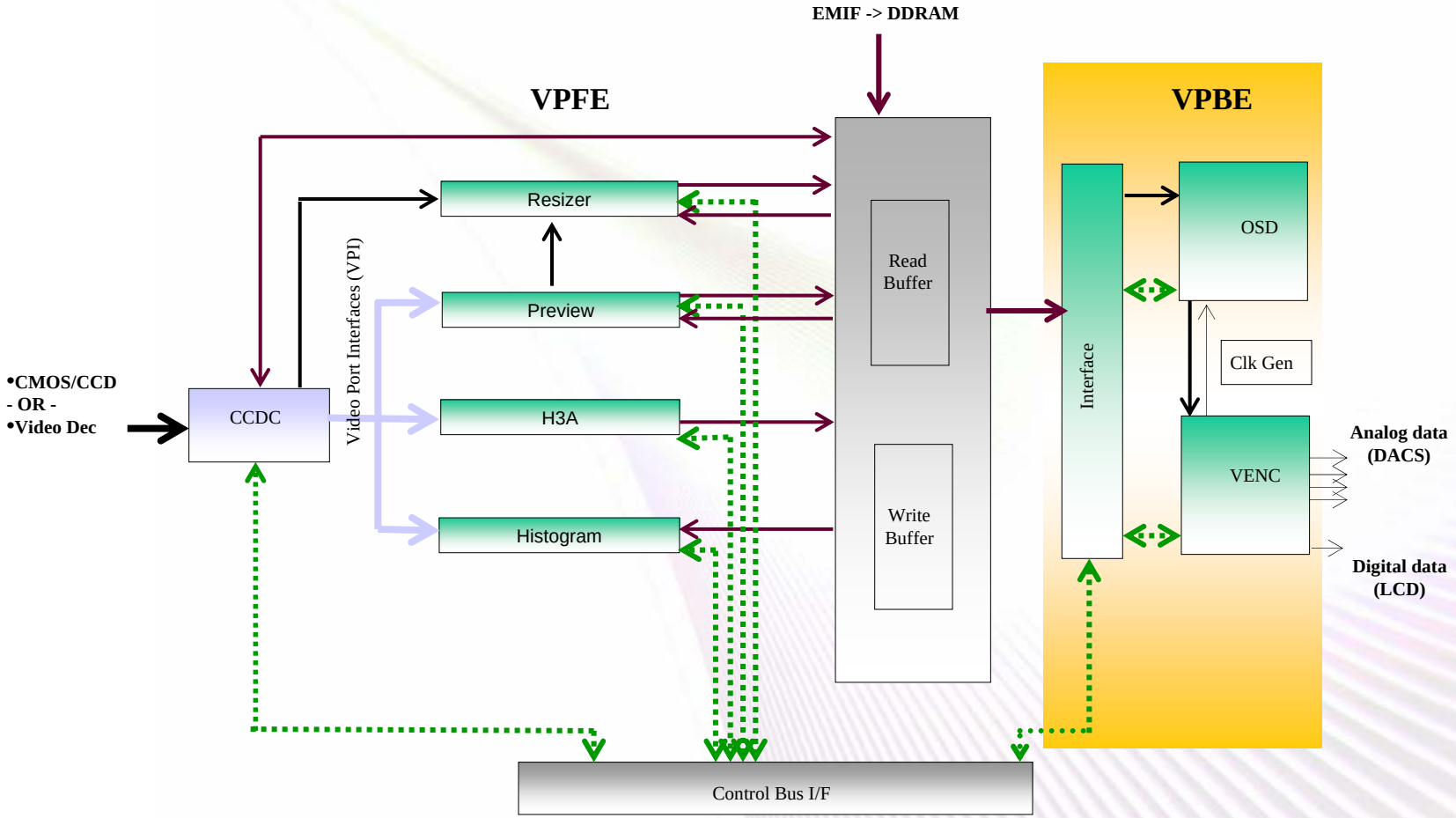
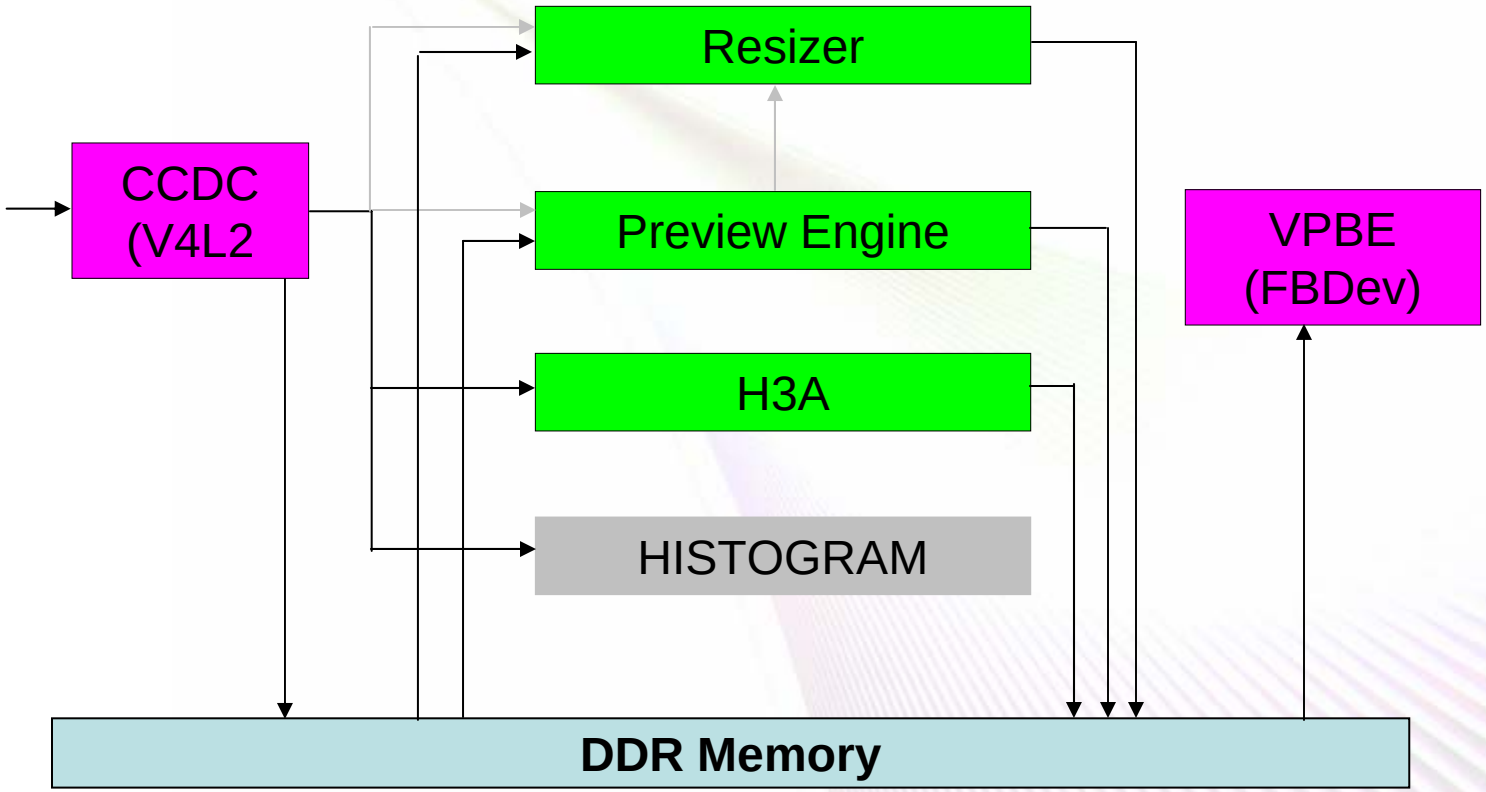
VPSS Block Diagram



VPSS Drivers



VPSS Driver Support

Modules	Driver Support	Driver Model
CCDC	Y, E	V4L2
Resizer	Y	CHAR
Preview Engine	Y	CHAR
H3A	Y	CHAR
Histogram	X	
OSD	Y, E	FBDEV
VENC	Y, E	

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Requirement

- Completeness
  - 100% or nearly 100% coverage of available HW features
- Application centric
  - Multiple channel support for Resizer driver
  - Flexible buffer allocation and management scheme
- Efficiency
  - In general, not support features that are not available in HW

Driver Architecture

- Two layer architecture for easy customization
- Bottom layer: hardware abstraction layer
  - OS agonistic
  - HW configuration
- Top layer:
  - Driver registration, initialization
  - Buffer allocation and management
  - Logical channel => HW mapping
  - ISR handling

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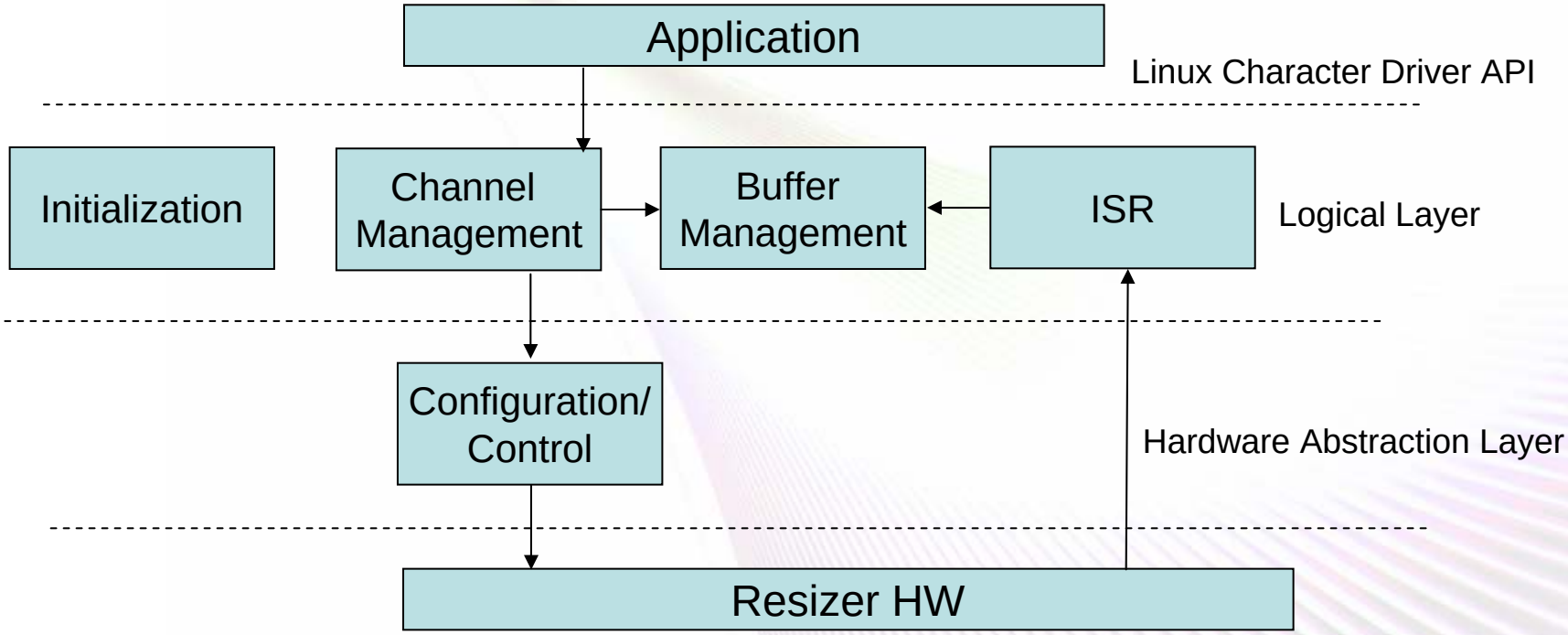
VPSS Driver architecture



CCDC Features

- **Input format**
  - 8 or 10-bit BT.656
  - 8 or 16-bit Y/Cb/Cr with external syncs.
  - RGB Bayer pattern
- **Frame & field format**
  - Interlaced
  - Progressive
- **Timing mode**
  - Master
  - Slave
- **Output path**
  - DDR
  - Resizer
  - Preview Engine
- **Other**
  - Cropping
  - 10-bit to 8-bit A-law compression
  - Fault pixel correction
  - Optical & digital black clamping and black level compensation
  - LPF & Culling

Previous V4L2 Driver

- **Input format**
  - 8 or 10-bit BT.656
  - 8 or 16-bit Y/Cb/Cr with external syncs.
  - RGB Bayer pattern
- **Frame & field format**
  - Interlaced
  - Progressive
- **Timing mode**
  - Master
  - Slave
- **Output path**
  - DDR
  - Resizer
  - Preview Engine
- **Other**
  - Cropping
  - 10-bit to 8-bit A-law compression
  - Fault pixel correction
  - Optical & digital black clamping and black level compensation
  - LPF & Culling

Enhanced V4L2 Driver

- **Input format**
  - 8 or 10-bit BT.656
  - 8 or 16-bit Y/Cb/Cr with external syncs.
  - RGB Bayer pattern
- **Frame & field format**
  - Interlaced
  - Progressive
- **Timing mode**
  - Master
  - Slave
- **Output path**
  - DDR
  - Resizer
  - Preview Engine
- **Other**
  - Cropping
  - 10-bit to 8-bit A-law compression
  - Fault pixel correction
  - Optical & digital black clamping and black level compensation
  - LPF & Culling

Resizer Features

- **Data format**
  - 8-bit Y/Cb/Cr 4:2:2
  - 8-bit color separated
- **Input path**
  - DDR
  - Preview Engine
  - CCDC
- **Scaling range and ratios**
  - ¼X–4X
  - 256/N with N=64-1024
- **Operations**
  - Horizontal
  - Vertical (with separate scaling factors)
- **Luminance processing**
  - 4-tap 8-phase for ½X–4X
  - 7-tap 4-phase for ¼X–½X
- **Chrominance processing**
  - Bi-linear interpolation
  - Filtered with luminance
- **Edge enhancement**
  - Luminance sharpening

Resizer Driver

- **Data format**
  - 8-bit Y/Cb/Cr 4:2:2
  - 8-bit color separated
- **Input path**
  - DDR
  - Preview Engine
  - CCDC
- **Scaling range and ratios**
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  - Bi-linear interpolation
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  - Luminance sharpening

Preview Engine Features

- **Input**
  - 8-10 bit RGB Bayer pattern
- **Output**
  - 8-bit Y/Cb/Cr 4:2:2 interleaved
- **Input path**
  - CCDC
  - DDR
- **Output path**
  - Resizer
  - DDR
- **Input down-sampling**
  - 1x, 2x, 4x & 8x
- **Core processing**
  - CFA interpolation
  - RGB to Y/Cb/Cr color space conversion
- **Other pre-processing features**
  - Invert A-law transform
  - Dark frame capture & subtraction
  - Noise filter
  - Digital gain and white balancing
  - Gamma correction
  - RGB-RGB blending
  - Luminance enhancement
  - Chrominance suppression

Preview Engine Drivers

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- **Other features**
  - Invert A-law transform
  - Dark frame capture & subtraction
  - Length Shading Compensation
  - Noise Filter
  - Digital gain and white balancing
  - Gamma correction
  - RGB-RGB blending
  - Luminance enhancement
  - Chrominance suppression

Auto Focus Engine Features

- Paxel Mode
  - Peak mode
  - Accumulation/sum mode
- # of Paxels
  - Up to 36 Paxels in the horizontal direction
  - Up to 128 Paxels in the vertical direction.
- Paxel programmability
  - Width & Height
  - Horizontal start
  - Horizontal & vertical line increments

All features supported by driver

Auto Exposure/Auto White Balancing Engine Features

- # of Windows
  - Up to 36 horizontal windows
  - Up to 128 vertical windows
  - Additional row of window for black pixel data
- Windows Programmability
  - Programmable width and height
  - Separate vertical start and height for a black row of window
  - Horizontal Sampling Points
  - Vertical Sampling Points

All features supported by driver

Previous VPBE Driver Features

- **Windows**
  - Video window 0
  - Video window 1
  - OSD window 0
  - Attribute window
- **DAC outputs**
  - NTSC
  - PAL
- **Input**
  - Y/Cb/Cr 4:2:2 for video window
  - RGB565 for OSD window

Enhanced VPBE Driver Features

- **Windows**
  - Video window 0
  - Video window 1
  - OSD window 0
  - Attribute window
- **DAC outputs**
  - NTSC
  - PAL
- **Input**
  - Y/Cb/Cr 4:2:2 for video window
  - RGB565 for OSD window
- **Other**
  - RAM LUT
  - Hardware Ping-pong buffer
  - Component/Composite/S-Video

Run-time configurable

- **Windows**
  - OSD window1 vs. Attribute window
  - Cursor window
  - Enable vs. disable
  - Progressive vs. Interlaced
  - Global vs. pixel level blending
  - Size/position/pitch configuration
- **DAC output**
  - 480p
  - 576p
  - Non standard
- **Digital output**
  - 8/16-bit Y/Cb/Cr
  - RGB 888 or 666
  - PRGB/SRGB
  - Digital LCD output
- **Input**
  - RGB888 input for video windows
  - Bit-map input (1/2/4/8 bit) for OSD windows.

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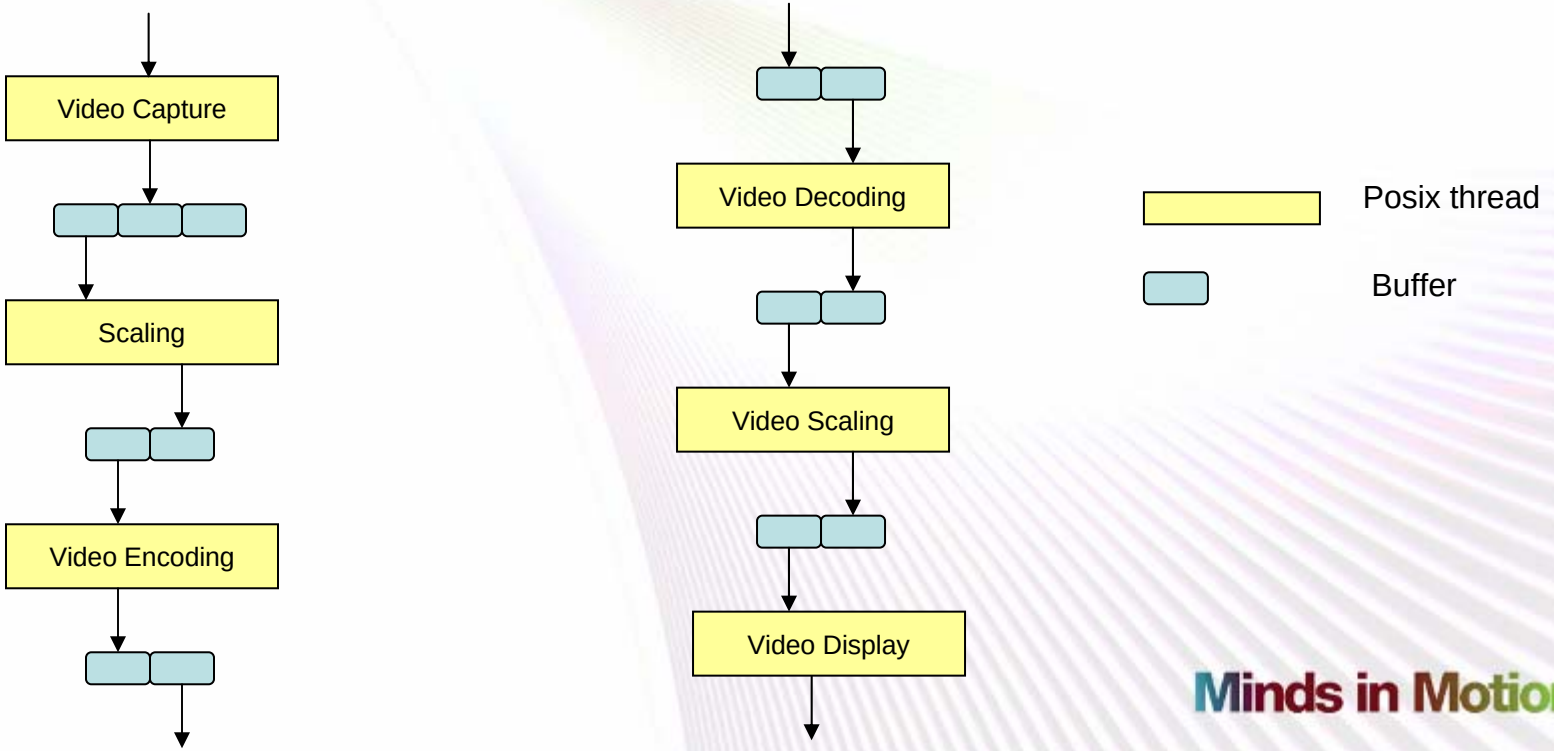
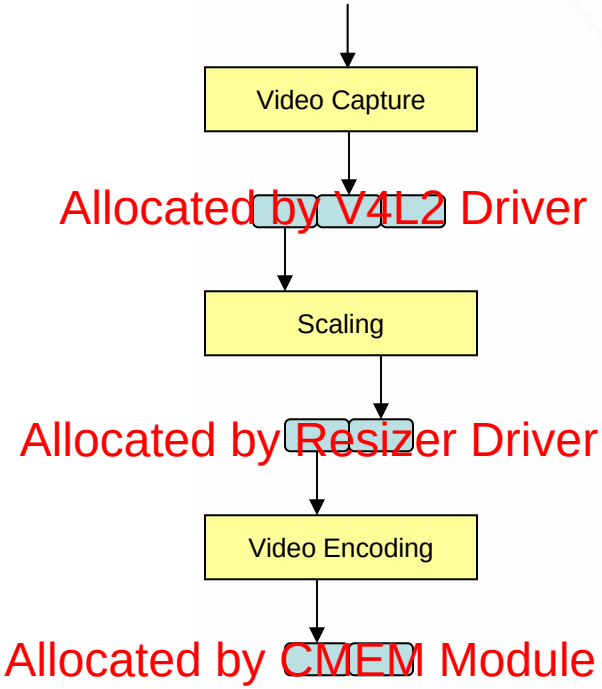
Parallel Processing

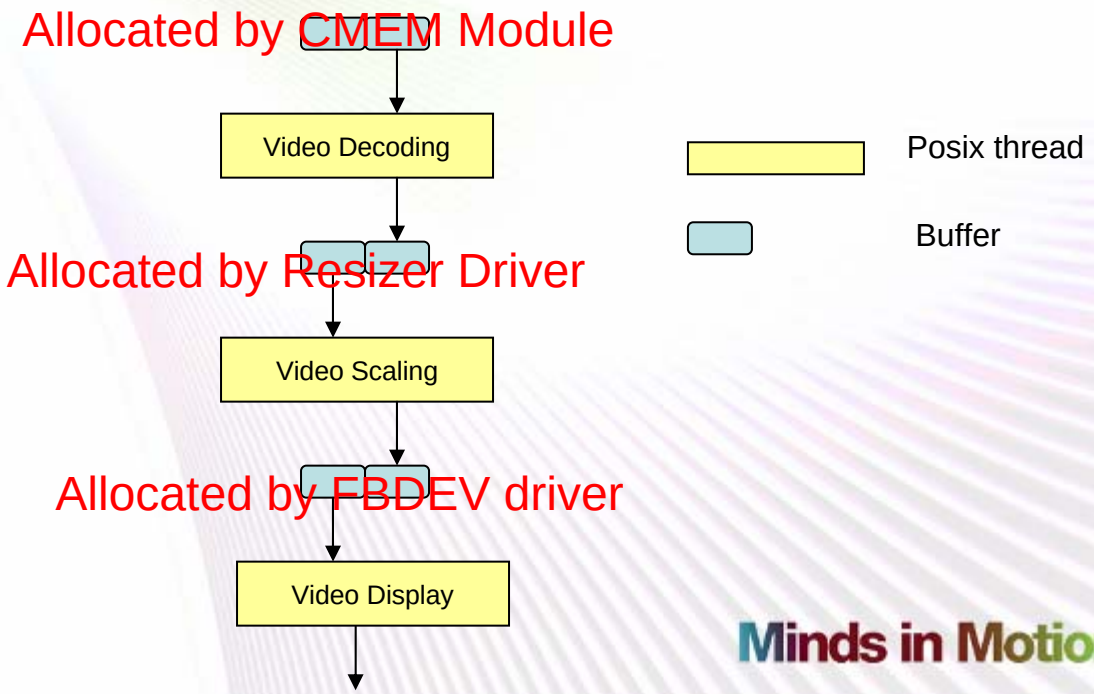
- VPSS modules can work in parallel.
- Different VPSS drivers should reside in different application threads.
- These threads must be set to be FIFO real-time scheduled.
- Example: An application uses CCDC, Resizer & VPBE drivers.



Buffer Management

- CCDC and VPBE drivers allocated its buffers internally and memory mapped them to user space using mmap() system call.
- Resizer, Preview Engine drivers can also allocate buffers internally. Alternatively, they can use buffers allocated elsewhere, e.g., by CCDC or VPBE drivers.





Multi-Channel Operations

- The Resizer driver supports multi-channel operations such that the front-end and back-end processing can share the same Resizer HW
  - E.g., D1->CIF for capture & CIF->D1 for display
  - Each LOGICAL channel maintains its own file descriptor, parameters and buffers
  - Jobs submitted by each LOGICAL channel are prioritized and queued up by the driver
- Other VPSS drivers do not have multi-channel support

The Resizer Driver Utility

- This utility is used in conjunction with the driver to generate the filter coefficients and other parameters specific for the driver
- Three methods for coefficients calculation
  - Windowed sinc function (Hann, Blackman etc)
  - Bi-cubic
  - Bi-linear
- Calculation can be based on output size and either of the following:
  - Input size
  - rsz value
- Can generate only the filter coefficients or the complete driver parameter settings
  - The output of the utility is typically saved to a header file to be included in the application source code
- The function is separated from the driver because it involves mainly floating point arithmetic

The Utility Usage

```
Usage: ./calccoef [options]

Options:
-h | --help             print  this message
-i | --insize           input  image size(eg. 720x240, -1 for ignore)
-o | --outsize          output image size(eg. 352x288)
-r | --rsz              resizing factor: hrsz x vrsz(eg. 512x512, -1 for ignore)
-j | --sph              horizonal starting phase (0:7)[4]
-k | --spv              vertizonal starting phase (0:7)[4]
-w | --window           window type (HANN|[BLACKMAN]|TRANGULAR|RECTANGULAR)
-z | --horz_filter      horizontal filter type (BICUBIC|BILINEAR|[LOWPASS])
-f | --vert_filter      vertical filter type (BICUBIC|BILINEAR|[LOWPASS])
-n | --filename         file name for custom window coefficients
-p | --print_param      print out the complete resizer driver parameter settings
-s | --in_pitch         input image line pitch in bytes
-y | --out_pitch        output image line pitch in bytes
-t | --hstart           horizontal starting pixel #[0]
-v | --vstart           vertical starting line #[0]
-c | --cbilin           enable bi-linear interpolation for horizontal chroma processing
-g | --grayscale        input image is 8-bit grayscale
-x | --pixel_format     input pixel format([UYVY]|YUYV)
-a | --no_array         output data without array headers, can be used to generate multiple sets of coefficients.
```

The Utility Usage Examples

- Example 1, ½D1->CIF
  - `./calccoef –i720x240 –o352x288 > coefs_720x240_to_352x288.h`
- Example 2, CIF->D1
  - `./calccoef –i352x288 –o720x480 > coefs_352x288_to_720x480.h`
- Example 3, VGA->QVGA with exact 2:1 down-scaling:
  - `./calccoef –r 512x512 –o352x240 –s1312 > coefs_VGA_to_QVGA.h`

Output of Example 3

```
/* input image pixels/line  = 646 */
/* output image pixels/line  = 320 */
/* horizontal starting phase  = 4 */
/* horizontal filter type  = LOWPASS */
/* window type  = BLACKMAN */
/* hrsz = 512            */
/*horizontal resizing filter coefficients: */
const short horz_coefs[] =
{
     39,
     178,
     39,
     0,
     25,
     174,
     57,
     0,
     . . .
}
```

```
/* input image # lines  = 483 */
/* output image # lines  = 240 */
/* vertical starting phase  = 4 */
/* vertical filter type  = LOWPASS */
/* window type  = BLACKMAN */
/* vrsz = 512 */
/*vertical resizing filter coefficients: */
const short vert_coefs[] =
{
     39,
     178,
     39,
     0,
     25,
     174,
     57,
     0,
     . . .
};
```

For More Information

- Peripheral Reference Guide for DM644x VPFE & VPBE
- TI DVEVM customer web site
- Montavista Zone

Q& A