S0341 - See the Big Picture
Scalable Visualization Solutions for System Integrators
Doug Traill - dtraill@nvidia.com /QuadroSVS@nvidia.com
SVS Solutions

MOSAIC

4K Desktop
Conference Room
4K Cinema
Visualization Room

GSync

Operations Center
Visual Simulation
Immersive VR Room
Planetarium
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<tr>
<td>10:30am</td>
<td>Room A2</td>
<td>S0341, See the Big Picture Scalable Visualization Solutions for System Integrators</td>
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<tr>
<td>1:00pm</td>
<td>Room A2</td>
<td>S0530, Multi-Display Roundtable</td>
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<td>S0601, GPU-Based Video Processing Round Table</td>
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<td>9:00am</td>
<td>Room A1</td>
<td>S0353, Programming Multi-GPUs for Scalable Rendering</td>
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<td>S0322, Warping &amp; Blending for Multi-Display Systems</td>
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<td>S0355, Seamless Scalable Displays - Using NVIDIA Warp + Intensity API</td>
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Three (3) things that I want you learn

- **MOSAIC** - Application Scalability

- **Synchronization** - Focus to on the image and not the artifacts

- **Visual Acuity** - ultra high resolution “retina” displays.
Quadro Features for System Integrators

- Custom Resolutions
  - GTF, DMT, CVT, CVT-RB + Custom Timings

- MOSAIC
  - Seamless Desktop across multiple GPUs

- Stereo
  - Active Stereo support
  - OpenGL/DirectX
  - Passive or Dual Pipe Stereo

- 10bit Color
  - Support for High Dynamic range displays

- ManageEDID
  - Capture + Read EDID from file

- Premium MOSAIC
  - Overlap Support to match projector edge-blending
  - Stereo support
  - Warp + Blend

- Ultra High resolution Desktop
  - 16K by 16K

- HDMI 1.4a
  - 4K resolution support
  - Stereo support

- 3D Vision Pro
  - Active stereo glasses

- GPU Direct for Video
  - Picture in Picture

- External or Internal Sync
  - GsyncII supports:
    - Genlock
    - TTL sync
    - Internal sync

- Warp + Intensity API
  - NV-WARP
  - Auto-calibration

- Vertical Sync
  - Synchronizes swap-buffer to Projector refresh

- NVAPI + NV-WMI
  - Programmatic Interface to NVIDIA driver
MOSAIC Technologies

- Without Mosaic:
- With Mosaic:
Mosaic Features
Scale with Quadro and NVS Solutions

Key Features

• Unified Desktop (up to 8 display devices*)
• Application Spanning
• Taskbar Spanning
• Bezel Correction
• Windows 7 + Linux Support

* All displays require matching timings and resolution
Premium Mosaic Features

Additional Premium Features

• Seamless Display
• Projector Overlap
• Stereo Support
• Quadro G-Sync Support
• Linux and Windows Vista, XP and 7 Support
• NEW API Support for Warp + Intensity Correction

Single or Dual Quadro Plex

Single or SLI: Quadro 5000, 6000
NV-WARP - Warp + Intensity API

Wednesday Room A1 - 10.00am Warping + Blending for Seamless Displays

SDK - Available to Registered Developers

- Sample SDK
- Three function calls
- NVAPI
- Win7 only

3rd party applications

- Full Auto-calibration system
- Premium MOSAIC support
- Win 7 only

Image courtesy of Joachim Tesch - Max Planck Institute for Biological Cybernetics
Certified Platforms for Dual QUADRO 5000/6000
Premium MOSAIC

HP Z800/Z820
Dual Quadro5000/6000

Dell T7500
Dual Quadro5000/6000

Lenovo D20/C20
Dual Quadro5000/6000

Fujitsu R670/R570
Dual Quadro5000/6000

http://www.nvidia.com/object/quadro_sli_compatible_systems.html
Certified Quadro Plex Platforms

- Most workstation/server class platforms support single Quadro Plex
- Most can support Dual Quadro Plex
- Test suite for system builders to certify Quadro Plex.

http://www.nvidia.com/page/quadroplex_certified_platforms.html
Differences between Premium Mosaic + Mosaic

- **Frame Synchronization**
  - **Vertical Sync** - to a common timing - without a physical connection between cards there is no method for having a common sync
    - Effect is tearing
  - **Stereo**
    - **Without** frame sync don’t have method for sync left/right eye between GPUs
  - **Overlap**
    - **Without** frame sync tearing would be most noticeable in a blend region.
    - We disable this feature so tearing is not shown.
**No Frame Sync**

- **Vertical Sync** is the pulse that indicates the start of the display refresh.
- To avoid *tearing* on a single screen the application swap buffers are synced to *vertical sync*.
- Although all four displays may have the same refresh rate - *vertical sync* start between 2 GPUs will be different.
- This can result in *tearing* between displays.
**Frame Sync - on SLI Mosaic**

- **Framelock** provides a common sync signal between graphics cards to ensure the vertical sync pulse starts at a common start.
- This is commonly referred to as **Frame Synchronization**
- On **SLI Mosaic** in a workstation - Framelock signal is provided across the SLI Bridge.
- Between **Dual Quadro Plex’s** framelock signal is provided between the CAT5 cable
Let the OS manage multiple displays

(1) Rendering occurs on one GPU

(2) Pixels are copied across PCIe bus to the other GPU for display
Let the Application manage multiple displays

(1) Rendering occurs on one GPU

(2) Pixels are copied across PCIe
Application with GPU Affinity

Wednesday 9.00am Programming Multi-GPUs for Scalable Rendering

- Application needs to be multi-threaded (4 Draw threads)
- Needs be programmed using GPU Affinity (nvidia extensions) for Max performance
- Application should use NV swap groups to sync swap buffer between GPUs
- GSyncII Card needed for framelock
MOSAIC - hides the complexity from the application

In MOSAIC mode driver works in Broadcast mode to GPUs
NVIDIA Control Panel

Order in which commands are applied can matter

1. Manage 3D Settings
   - Profile
   - Stereo
   - Vsync etc
2. Set Resolution
3. Set MOSAIC and/or Synchronization
Understanding Topologies

- MOSAIC uses Grids to Topology
- Grid is numbered by TOP ROW - left to right
Port numbers - QuadroPlex 7000

Amber LED indicates the primary GPU (0)
Right hand port = is the primary port (0)
We can describe each port by (GPU,Port) number
Relating Ports to Grid

configureMosaic.exe set rows=2 cols=2
configureMosaic.exe set rows=2 cols=2 out=0,0 out=0,1 out=1,0 out=1,1
configureMosaic.exe set rows=1 cols=4

configureMosaic.exe set rows=2 cols=2

configureMosaic.exe set rows=1 cols=2

configureMosaic.exe set rows=2 cols=1

configureMosaic.exe set rows=1 cols=3
Passive Stereo

configureMosaic.exe set rows=1 cols=2 passivestereo

configureMosaic.exe set rows=2 cols=1 passivestereo
Port layout for SLI workstation

Master - PCI Slot 2
Blank
PCI Slot 4

Only two connections per GPU!
Port layout for SLI workstation

Verifying outputs

- only 0,0 on configuremosaic set rows=1, cols=1 out=0,0
- only 0,1 on configuremosaic set rows=1, cols=1 out=0,1
- only 1,0 on configuremosaic set rows=1, cols=1 out=1,0
- only 1,1 on configuremosaic set rows=1, cols=1 out=1,1

Only two connections per GPU!

Layout for HP Z800 – other workstations may vary
Port layout for SLI workstation

DVI port is always primary on card – if used!
Dual Quadro Plex

- DHIC required for SLI Mosaic > 4 displays
- Amber LED - indicates master
- Framelock
  - RJ45 between Gsyncll cards
2x4 Grid

configureMosaic set rows=2 cols=4 out=0,0 out=0,1 out=2,0 out=2,1 out=1,0 out=1,1 out=3,0 out=3,1

2x4 Grid

configureMosaic set rows=2 cols=4
2 Channel Overlap

configureMosaic.exe set rows=1 cols=2 overlap=180,0
Blending 4K Projectors

configureMosaic.exe set rows=2 cols=4  overlapcol=0,180,0
Portrait Mode - Win 7 only

configureMosaic set rows=1 cols=4 rotate=90

Rotate values
90
180
270
MOSAIC + 1 - setting up multiple GRIDS

configureMosaic set rows=2 cols=2 nextgrid rows=1 cols=1

Note: only 1 grid can be across multiple GPUs
configureMosaic set rows=2 cols=2 nextgrid rows=1 cols=1

The first grid set is the primary
configureMosaic set rows=2 cols=2 rotate=90 nextgrid rows=1 cols=1
Win 7 - Driver Profiles

- Set **Default** 3D settings for profile
- Sets **Driver Optimization**
- **Generic + ISV Types**
  - 3D App - Visual Simulation
  - 3D App - Video Editing
  - Autodesk Motion Builder
  - Dassault System CATIA
  - etc.
Common Profiles

3D App - Game Development
- Turns card into GeForce card
- Good for DirectX Games

3D App - Modeling AFR
- CAD/3D modeling type applications
- Support for SLI Alternate frame rendering

3D App - Video Editing
- Optimization for video playback & editing
- Eliminates video tearing

3D App - Visual Simulation
- Optimizes OpenGL pipeline for Viz Sim Applications
- Good for applications wanting fixed fps - i.e. 60fps
- No Quad-buffered stereo support

Workstation Dynamic Streaming
- Applications using GSync
- Applications wanting fixed fps.
- Quad-buffered stereo support.
Performance Hit for Multiple Displays

Viewperf 10.0

The chart shows the performance hit for multiple displays using various software tools:
- 3dsmax-04
- catia-02
- ensight-03
- maya-02
- proe-04
- sw-01
- tcvis-01
- ugnx-01

Performance metrics are indicated on the X-axis, and the Y-axis represents the performance hit. The bars represent different display configurations: 1 screen, 4 screens, and 8 screens.
SLI Mosaic Performance Advantage

Viewperf 10.0

- 3dsmax-04
- catia-02
- ensight-03
- maya-02
- proe-04
- sw-01
- tcvis-01
- ugnx-01

- 1 screen
- 4 screens, Mosaic
- 8 screens, Mosaic
MOSAIC Performance Enhancements

- Multi-GPUs (does not work on single GPU)
- Pixel Fill limited apps
- MOSAIC uses a lot of fill

Pixel Fill = Screen size – larger screen more fill

If you shrink the window and performance improves the app is fill limited
MOSAIC Performance Enhancements

- Scissor clip function
- Best for full screen apps
- If you drag windows around you will see distortion.

To enable
- enable_Mosaic_Clip_To_Subdev.exe

To disable
- disable_Mosaic_Clip_To_Subdev.exe

Improves fill performance on MOSAIC – Performance Gain will vary by Application

email: QuadroSVS@nvidia.com
Video Display Controllers

Features

• Dual link DVI or DP input
• 2 or more DVI outputs

Examples

• CYVIZ XPO.3
• DataPath X4
• Pixell VP-4xx
• Planar Quad Controller
• Black Diamond Video - DVI splitter
• Matrox Triple head to Go
• Etc

330 MHz video bandwidth

Each output up to 165 MHz

1:1 pixel mapping of input to output
16 BARCO Projection cubes

- 4x4 BARCO Projection cubes
- Dual Quadro Plex 7000
- Linux running Premium MOASIC
- Each output runs two cubes - 1920x2160@60Hz
- CUBE splits signal across two displays at 1920x1080
- For Stereo 3D input is frame doubled to 120Hz
4x4 1920x1080@60Hz

configureMosaic set rows=2 cols=4 res=1920,2160,60
Using Linux

#Configure MOSAIC layout
nvidia-xconfig --sli=Mosaic --metamodes="
"GPU-0.DFP-0: 1920x2160+0+0, GPU-0.DFP-1: 1920x2160+1920+0,
GPU-1.DFP-0: 1920x2160+3840+0, GPU-1.DFP-1: 1920x2160+5760+0,
GPU-2.DFP-0: 1920x2160+0+2160, GPU-2.DFP-1: 1920x2160+1920+2160,
GPU-3.DFP-0: 1920x2160+3840+2160, GPU-3.DFP-1: 1920x2160+5760+2160"

#Turn off composite Desktop - this affects stereo + gsync.
nvidia-xconfig --no-composite

#Set stereo mode.  On board DIN =3;
nvidia-xconfig --stereo=3

#Turn off twinview xinerama info - this creates a large desktop.
nvidia-xconfig --no-twinview-xinerama-info
USF - Tampa

- 16 thin bezel - LCD panels
  - 720p resolution
  - Passive stereo - horizontal line interlace.
  - 4 x4 array
- Dual Quadro Plex 7000
  - One output per card
  - Video processor splits across 4 cubes
  - 1:1 pixel mapping

Image courtesy of University of South Florida - Tampa
configureMosaic set rows=1 cols=8 res=1366,3072,60

NOTE: follow the display ordering diagrams from earlier, this image is wired for visual clarity

Total Resolution – 10,944 x 3072
Create the Custom Resolution

- If the controller does not provide the resolution, create one.
- Make sure to select a timing other than Automatic for the Standard.
- Make sure the Pixel clock on the lower right is $\leq 330\text{MHz}$.
- Set the same resolution on all attached controllers.
NVIDIA Scalable Visualization Solutions

Quadro Plex
Scalable Visualization Solutions
(Single Host)

Quadro SLI Workstation
(Dual Quadro 5000/6000)

Single Workstation
(with Add-in Card)

> 8 DVI

2-4 DVI

4-8 DVI

or

2-4 DP

2-4 DP

Beyond 8 DVI Dual Link Requires Clustered PCs with Quadro G-Sync to synchronize displays and Multi GPU aware software.

Runs Any Standard Application

Runs Any Standard Application
Largest CAVE in the World

C6 at Iowa State
- 4 x 4K projectors per wall
- 6 sides
- 96 NVIDIA GPUs in a cluster driving the display

Kaust University
- Similar in Design to C6
- Uses Quadro Plex’s to reduce node count.
GSync II - Hardware + Software Sync

- **Hardware**
  - RJ45 - Framelock for synchronization of multiple displays to a common internal sync
  - BNC/Genlock - Framelock for synchronization of multiple displays to a common external house sync

- **Software**
  - Requires application to be written with extensions
  - Swap Group and Swap Barrier are OpenGL / DirectX Extensions that provide enhanced synchronization of the graphics swap buffer.
Vertical Sync

- **Vertical Sync** is the pulse that indicates the start of the display refresh.
- To avoid *tearing* on a single screen the application swap buffers are synced to *vertical sync*.
- Although all three displays may have the same refresh rate - *vertical sync* start may be different.
- This can result in *tearing* between displays.
Framelock/Genlock

- **Framelock/Genlock** provides a common sync signal between graphics cards to insure the vertical sync pulse starts at a common start.
- This is commonly referred to as **Frame Synchronization**
- **Framelock** - Synchronization is generated from a master node. All other nodes would be sync to this.
- **Genlock** - Synchronization is from an external sync generator (house sync). Each node attached to the genlock signal is synced from that signal.
- **Framelock & Genlock** can be mixed in the cluster. With the master node being synchronized from the genlock pulse
Swapbuffers

- Mono OpenGL applications have two buffers

The application will render into one buffer while the pixels are read to the screen from the other buffer. Once the render process is complete the \textit{buffers swap}. i.e
- Front - render
- Back - read to screen
- swap
- Back - render
- Front - read to screen.
Swapbuffers

- **Swap** between the two buffers will occur:
  - On the first *vertical sync* after the Render process completes
- For example at 60Hz refresh rate we have 16.67 ms to complete the render of a frame
  - If render time = 10ms frame rate will be 60 fps (we swap on vertical sync)
  - If render time = 17 ms frame rate will be 30 fps (we swap on the next vertical sync).
Swapbuffers in a cluster

Each node is now rendering a scene with different complexity i.e from least to highest we get:
1. node 3  \( \sim 16 \text{ms} = 60 \text{fps} \)
2. node 4  \( \sim 36 \text{ms} = 30 \text{fps} \)
3. node 2  \( \sim 53 \text{ms} = 15 \text{fps} \)
4. node 1  \( \sim 99 \text{ms} = 10 \text{fps} \)

• With each node running at a different rate the user would perceive tearing on the screen.
• We need a mechanism to ensure that each node will *swap* at the same time.
Swap Group and Swap Barrier

• Nvidia Extensions to OpenGL /DirectX (via NVAPI)
  • Swap Group - provides synchronization multiple GPUs in a single host
  • Swap Barrier - provides synchronization of GPUs across multiple nodes.
  • Use RJ45 (framelock) connection on Gsync - so faster than sync over a network

With *Swap Barrier* each node will wait until all nodes have completed their render
1. node 3 ~ 16ms = 10fps
2. node 4 ~ 36ms = 10fps
3. node 2 ~ 53ms = 10fps
4. node 1 ~ 99ms = 10fps
32 Node cluster

- Framelock (RJ45) between nodes
- BNC – genlock cable

Application running
Swap Barrier

House Sync

Sync generator
GSyncII Signaling

- CAT 5 - not ethernet
  - Framelock (sync pulse - will be same as House Sync)
  - Swap Ready
    - Physical connection to GPU for swap group.
    - High when blocked, low when ready to swap.

- Stereo Sync
  - VESA stereo port
  - Not used for passive stereo
  - Make sure stereo is enabled in Manage 3D settings on timing server + client prior to enabling synchronization.
Driver Profiles for GSync

- Most Common (can be exceptions)
  - Workstation Dynamic streaming
    - Stereo
    - Swap Groups
    - Constant frame rate
  - 3D App Visual Simulation
    - Constant frame rate
3D Vision Pro with Projection systems
NVIDIA 3D Vision Pro

- 3D Vision Pro Glasses
  - 120 Hz Active Shutter
  - 2.4Ghz RF control
  - 24 hours battery life
  - Support for 3D Vision Ready LCDs, Projectors, CRT’s and DLP TVs

- 3D Vision Pro Hub
  - Up to 100 ft (30m) range
  - Provides UI and NVAPI information
  - Supports Quadro boards with stereo DIN and those without including mobile workstation
  - Supports same GeForce boards and features as 3D Vision
  - Wide Pro application support on Quadro
Installation - Windows

- Drivers and Guide are at www.nvidia.com/3dvpro
- Drivers need to be installed before the hub is connected
- Need
  - 266.35 or newer display driver
  - 266.21 or newer USB driver
  - Support display with refresh rate set correctly
More Complex 3D Vision Pro installs

- Projectors that require active stereo sync

- Double or Triple flash Projectors
  - 60Hz input to 120Hz
  - 48Hz input to 144Hz
3D Vision Pro Glasses Syncing to different timings

- **3DV Pro Glasses** adjust to the display or projector they are working with
  - Dark interval and timings
- When using the glasses you’ll see the lens “darkness” change with different devices
- Timings selected from display EDID
  - If EDID is known uses programmed values
  - If not recognized, uses CRT (or DLP if connected to a DLP TV)
Projectors that require active stereo sync

- Most Pro projectors require VESA stereo sync e.g.
  - BARCO Galaxy
  - Christie Mirage
  - DPi Titan
  - Projection Design F35
- Sync is used by the projector to identify left or right eye.
- Sync is looped through the projector to the hub (emitter).
  - Projector has a one frame buffer.
  - Projectors will delay the sync signal by one frame - reversing left/right eye.
Projectors that require active stereo sync

- **Problem**
  - Sync from the projector is typically BNC
  - Current Hub require 5V DC on VESA input.

- **Solution**
  - System integrators need to make special cable to provide 5V
Standard Pin outs for 3D Vision Pro Hub

Pin 1: Ground
Pin 2: +5V
Pin 3: Stereo Sync signal (High = Left Eye image being displayed, Low = Right Eye)
Custom Cable BNC to min-jack pinout

<table>
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<tr>
<th>Signal Name</th>
<th>Cable</th>
<th>BNC</th>
<th>3D Vision Pro - mini Jack</th>
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<tr>
<td>5Volts</td>
<td>ext source</td>
<td>N/A</td>
<td>2</td>
</tr>
<tr>
<td>GROUND</td>
<td>COAX Braid</td>
<td>Shell</td>
<td>1</td>
</tr>
<tr>
<td>Stereo L/R</td>
<td>COAX Center</td>
<td>Center</td>
<td>3</td>
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Double or triple flash projectors

- Take 60Hz input and double to 120Hz
- Take 48Hz input and triple to 144Hz
- Reduces overall infrastructure cost - single-link DLP.

Problem
- Stereo sync is generated by the projector at 120 Hz
- Hub is set to 60 Hz - this is what the workstation generates

Solution
- Command line tool that set hub to 120 Hz - runs on a proxy PC.
Proxy System

- Management of Glasses
  - Management is separate of on-screen rendering

- Multiple Stereo Sources
  - Single PC manages pairing for all devices

- Double or triple flash projectors
  - Command line tool
  - Sets hub to correct refresh rate
Command line for setting 3D Vision Pro

- `nv3dvp.exe`

`nv3dvp.exe activateproxy display-refresh-rate`  
`display-refresh-rate` is the refresh of the stereo display

Examples:

- `nv3dvp.exe activateproxy 120`  
  (120Hz stereo display)
- `nv3dvp.exe activateproxy 96`  
  (96Hz stereo display)
- `nv3dvp.exe activateproxy 144`  
  (144Hz stereo display)

Email: QuadroSVS@nvidia.com
Summary

- **Synchronization**
  - Focus on the image and not the artifacts

- **Reliability**
  - 24/7 Operation
  - Fortune 500 companies put their trust in Quadro

- **Visual Acuity**
  - Ultra high resolution ‘retina’ displays
  - Reality based Design

- **Application Scalability**
  - The applications I use on my desktop just work
Questions & a Reminder

To learn more or if have more questions - contact us at QuadroSVS@nvidia.com

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