

virtual GPU for consolidation of digital instrument cluster
and IVI on top of hypervisor
(virtual GPU)

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1. Last presentation about Digital cockpit

- Composite layers between Cluster and Infotainment(IVI) on single SoC.



Consolidate



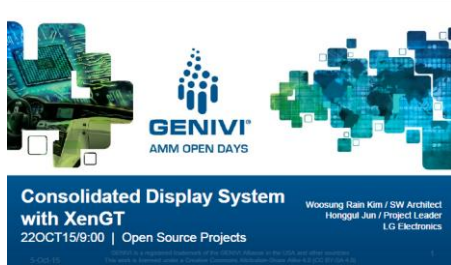
Consolidated Display System for Automotive using XenGT

Automotive Linux Summit
1-2 June, Tokyo

Bumhyeon Baek*, Honggul Jun, Woosung Kim
LG Electronics Inc.



2JUN2015, AGL



22OCT2015, GENIVI

- Consolidated display system is important for rich UI/UX and reconfiguration that is utilizing virtualization technology.
- Digital instrument cluster and Infotainment head unit (a.k.a IVI) system can directly access to GPU for graphical and multiple information integration.
- Merged both screen into one, it allows us to use digital cluster and IVI at the same time.
- Light weight compositor for reduce the resource of system.
- Feasibility of affordable consolidation system
: ARM SoC / vGPU / Wayland, Weston, IVI Extension



1. Last presentation about Digital cockpit

Why? Consolidate display on digital cockpit?

- Increase Computing Power at embedded system
 - : Resource Utilization
- Ultra High resolution , large size screen and increase number of displays
 - : Sharing bandwidth between them
 - e.g. High Speed Ethernet or Shared memory
- Memory is going Cost down and Capacity up

Why do we need to use virtualization?

- Allows the use of multiple operating systems running simultaneously on Single SoC
- Ensures that each OS instance or VM(Virtual Machine) is independent and cannot adversely affect another instance
- Allows each VM to share resources

2. Requirement for safety & functionality

Functional Requirement	Non-functional Requirement
Hypervisor Graphic Virtualization (vGPU) Composition (Overlay btw VM) Inter Domain Communication and so on.	Cost Safety Real-time Performance Power-consumption and so on

LGE defined Shared Graphics

: **vGPU** + Composition = Shared Graphics

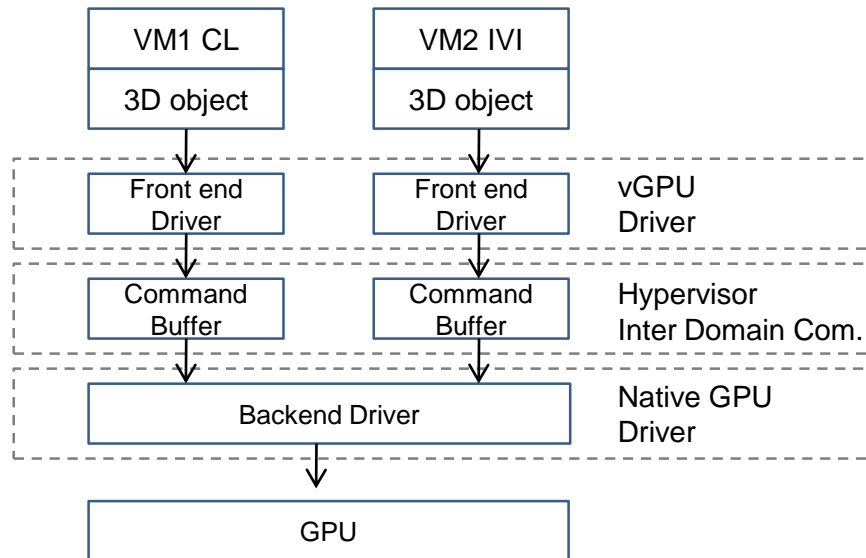
What is specify vGPU for Digital Cluster?

- Mobile CE (Handheld device, Smart Phone) was not big issue of GPU sharing.
There were HW constrains. i.e. single small touch screen, small battery and so on.
- But, Vehicle is important factor. i.e. Cluster : 60 fps , IVI : 30 fps
- Full programmable digital cluster for flexibility and rich UI/UX
- Composition among many contents and objects

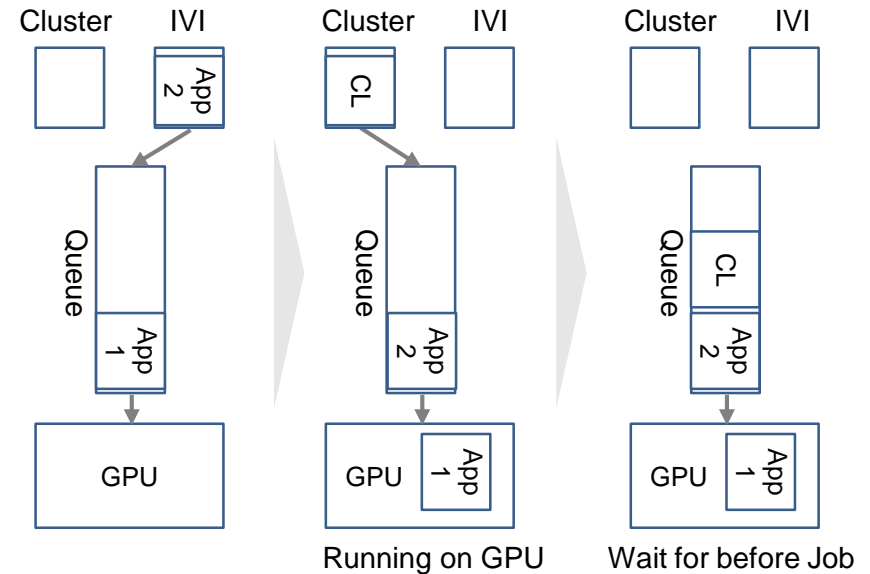
3. Current limitation of legacy a GPU

Simple vGPU Architecture

- Multiple OSs can make use of a GPU by making hyper-calls to a hypervisor to schedule jobs and resources using a command buffer queue.
- Frontend and Backend drivers require modifications to reduce the overhead of context switching by a hyper-call and inter domain communication.



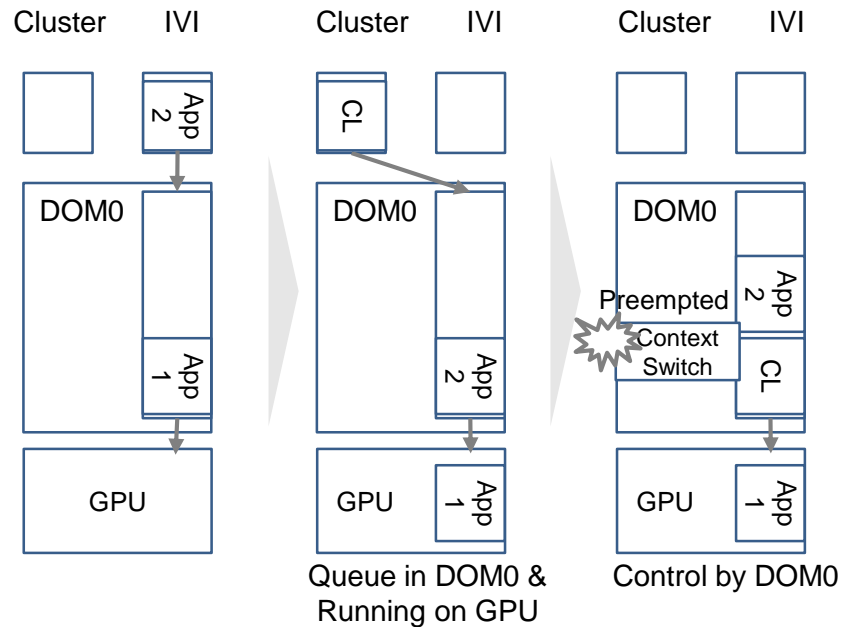
Simple Structure of GPU para virtualization



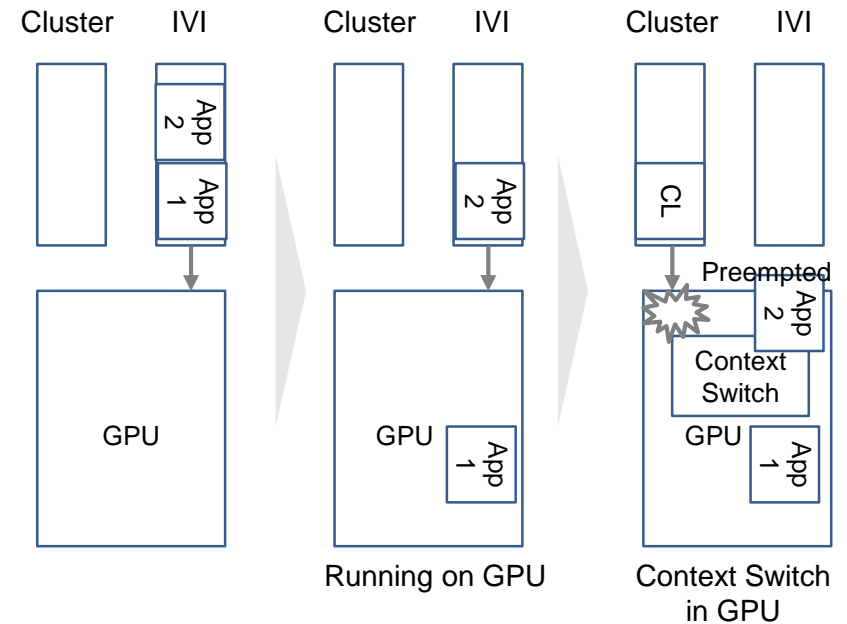
Without preemption case.

4. Necessary preemption of GPU and technical approach.

- GPU resource share by DOM 0 (Privileged Domain)
 - : Incorporates both time-driven and preemptive priority based scheduling
- HW assisted GPU resource management
 - : GPU HW equips the multiple command input ports directly connected to each OS



GPU resource share by DOM0 (Privileged Domain)



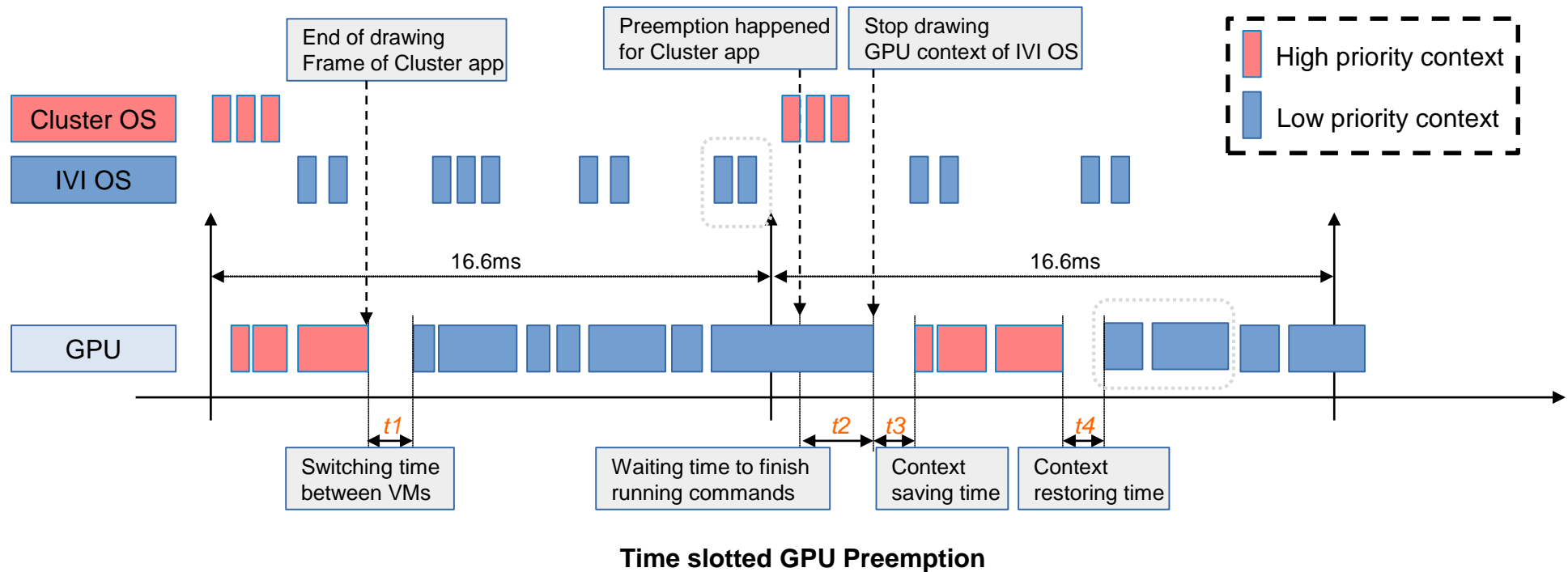
HW assisted GPU resource management

4. Necessary preemption of GPU and technical approach. (Cont.)

Real-time factors for vGPU

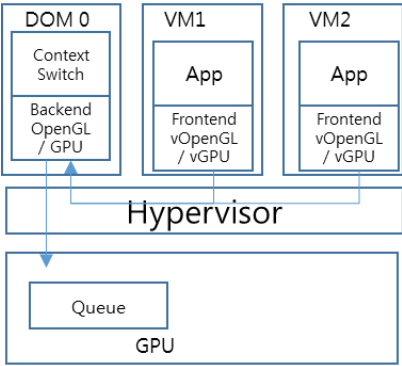
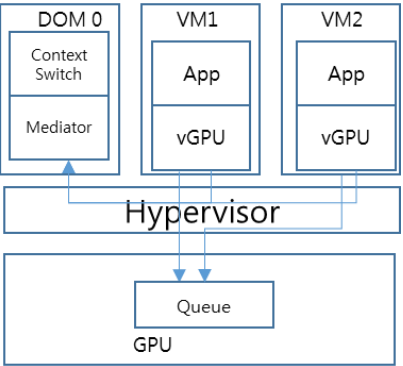
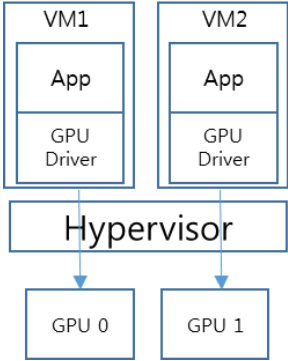
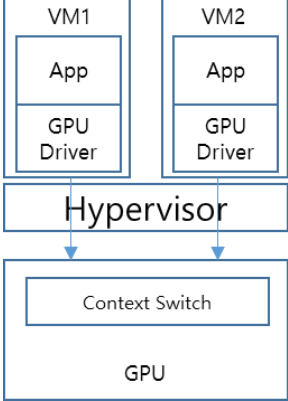
- Support priority based GPU scheduling
- Support context switching between VMs with low overhead
- Support high-speed preemption with fine granularity

Cluster should steadily run at 60fps (16.6ms) with minimum time granularity.



4. Necessary preemption of GPU and technical approach. (Cont.)

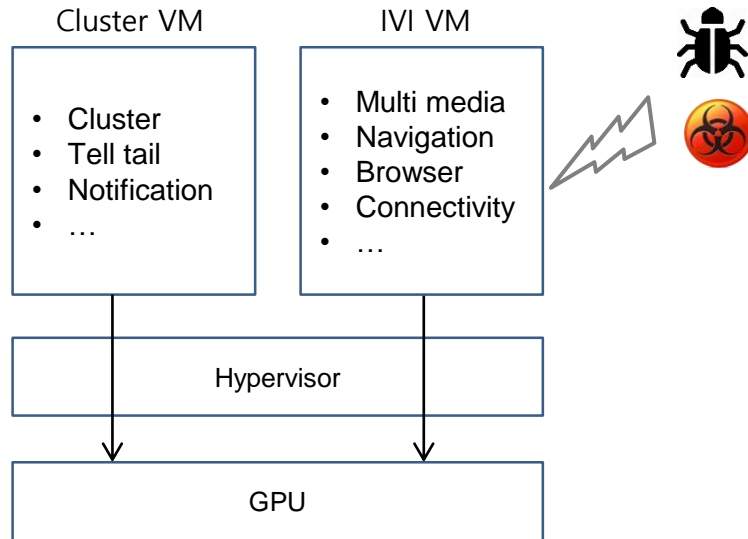
Comparison

	Backend-Frontend vOpenGL / vGPU Driver	Mediator vGPU Driver XenGT	Dual GPU	Specific GPU IP
GPU Virtualization	Backend-Frontend type SW virtualization,	GPU Driver SW & HW virtualization, Mediated Pass-Though	Separate GPU No GPU virtualization	GPU HW virtualization
Technical Approach	Server-Client SW Orchestra by DOM 0 Modify B-F driver also scheduler.	Mediator SW & HW Orchestra by DOM 0 Modify round-robin scheduler for Automotive grade.	GPU dedication (each VM)	Server-Client HW assist and SW Reduce SW overhead
Simple Diagram				

5. Security and Safety , GPU Perspective

DMA Controller, Controller HW mapping and so on...

Hypervisor security checking of controller accesses no longer needed ?



Automotive grade system has to use features of GPU (a.k.a GPU HW virtualization)

- GPU Preemption implementation
 - : HW supported virtual GPU channel for allows fine-grain control
- Malicious SW prevention
 - : Channel Reset, Block per App.

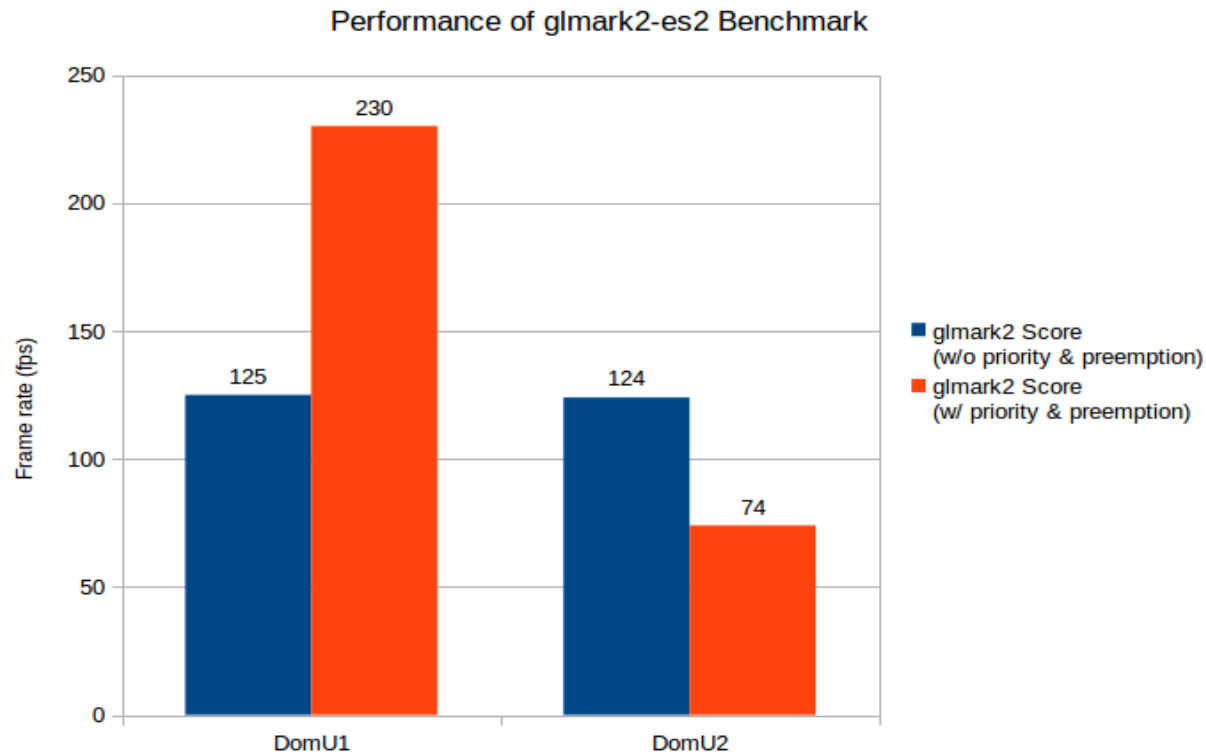
It have to prepare that GPU driver residing within privileged domain such as DOM 0.

- Secure access to buffer.
 - : Page table updates and control can only happen from DOM 0.
- Privileged domain to control priority of OpenGL/GPU driver clients.
- Validation of command buffers before submitting to buffer
 - : Can be reordered by priority and weight.
- Central control of logging for performance and errors.

6. Performance benchmarking

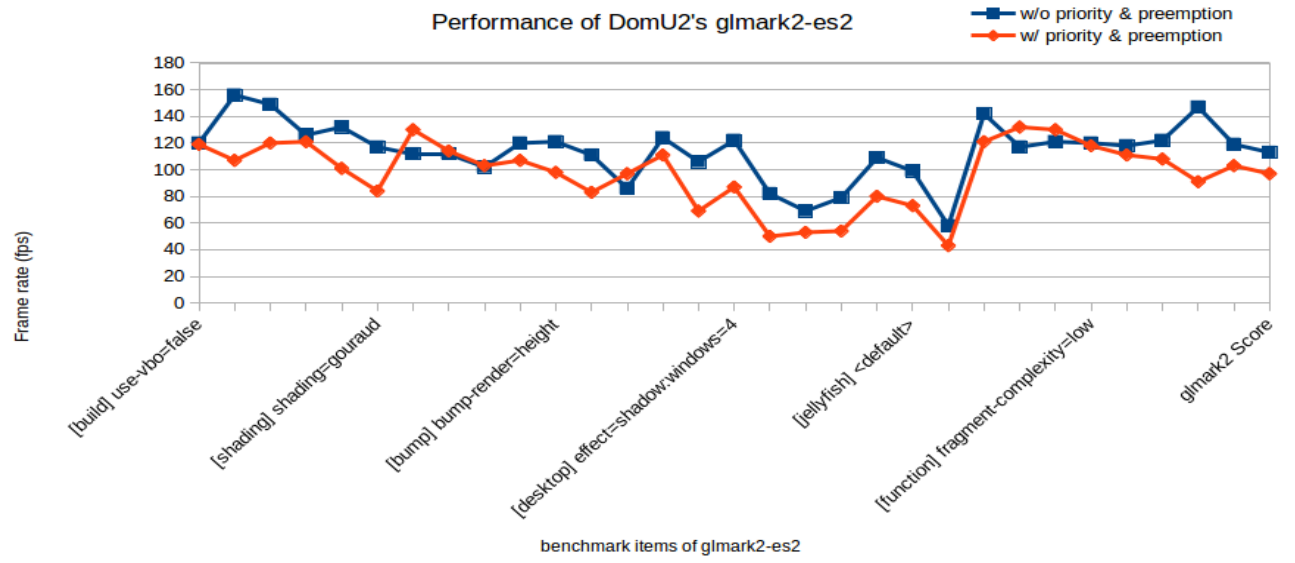
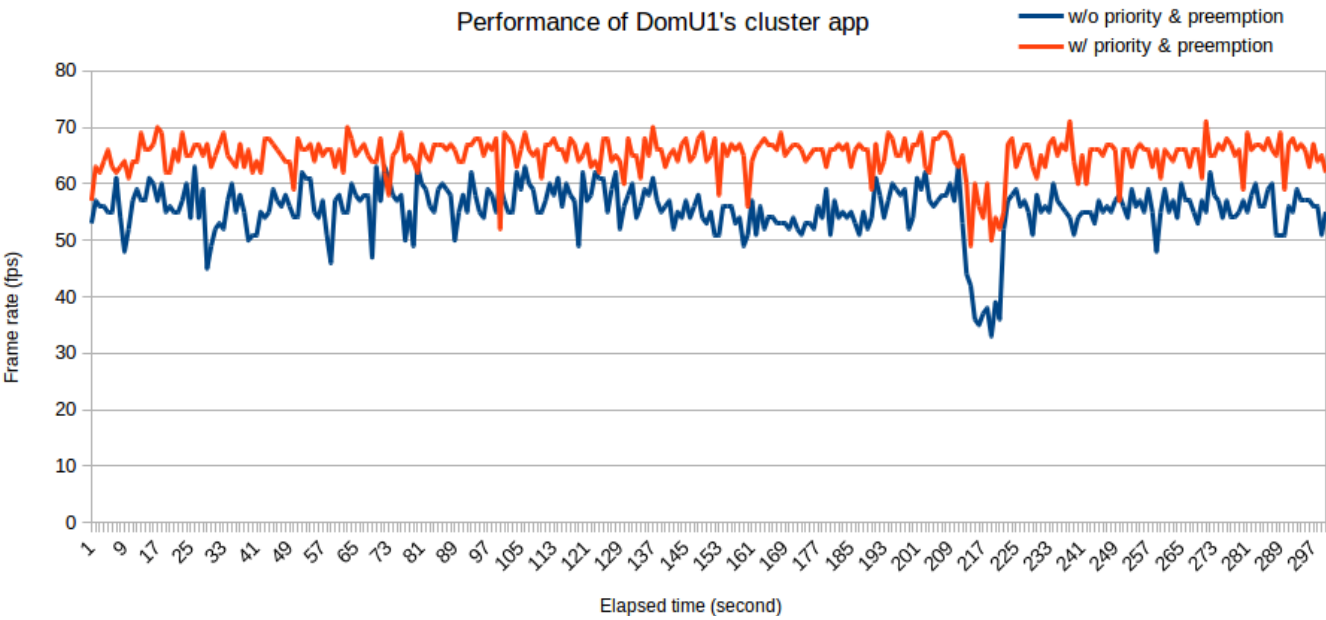
Environments

- Intel NUC board(NUC5i5RYH) Information
H/W : i5-5250U CPU(x86_64, 4 cores, 1.6GHz), HD Graphics 6000
- XenGT Information
Xen : 4.6.0
Linux kernel : 4.3.0-rc6-vgt+ (Dom0, DomU1, DomU2)
Guest OS : 2VMs (2 cores, 2GB memory, Ubuntu 14.04 LTS)



DomU1(Cluster OS) has higher priority than DomU2(IVI OS)

6. Performance benchmarking (Cont.)



DomU1(Cluster OS) has higher priority than DomU2(IVI OS)

7. Conclusion

- **Consolidate digital cluster and infotainment(IVI) on single SoC : Hypervisor needed**
 - Allows the use of multiple operating systems running simultaneously
 - VM is independent and cannot adversely affect another instance
 - Allows each VM to share resources

- **Design decision at early stage**
 - HW platform (SoC) Selection
 - Appropriate Hypervisor with suitable Real-time when consolidation
 - Consider OS for each VM.
 - Resource allocation for each Application

- **GPU virtualization, Preemption**
 - HW assisted GPU virtualization support
 - Virtual Channel (queue) for each VMs
 - GPU instance based preemption
 - Mediated Pass-Through with preemption
 - Interim architecture before HW assisted GPU virtualization designed
 - Dual GPU, (It is not GPU virtualization)

- **Performance & Quality factor**
 - GPU resource share between RTOS and GPOS (General Purpose OS)
 - Robustness (Privilege domain)



Appendix. Automotive Cockpit Trend

Stand-alone

- Separated Functionality
- No Information Sharing
- Straightforward HMI*



Connected

- Cross-function Multiple Display
- Information Sharing
- Complicated HMI



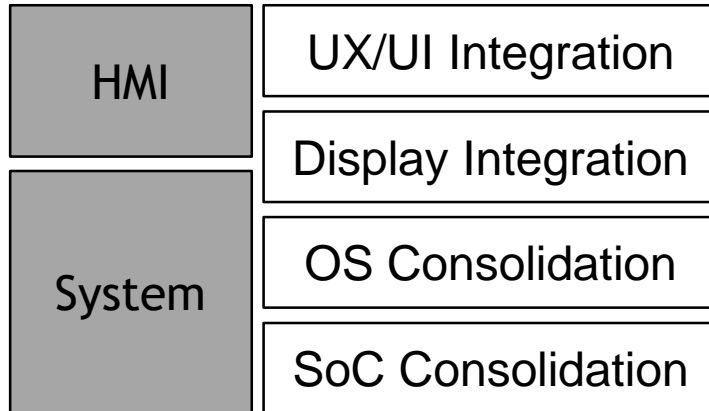
Integrated

- Free form Large Display
- Multiple information Integrated
- Intuitive HMI



* HMI: Human Machine Interface

▪ Advantages



▪ Benefits

- ❑ OEM Collaboration for UX Differentiation
- ❑ Full Re-configurable value creation
- ❑ Safety & Convenience with Reliability
- ❑ Efficient Resource Management (CPU & GPU)

▪ Requirements

- Cluster and IVI can be concurrently displayed on one display.
- Cluster and IVI system can share GPU to show graphical and multiple infotainment.
- They can communicate with each other for display consistency.
- IVI can exploit HMI such as touch.

