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Examination of Evaluation Method in High Load Use Case for IVI System

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AGENDA

1. Background in IVI System
2. Problem of IVI System
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4. Approach
   - Modeling of IVI System
   - Specification of Evaluation Software
   - Evaluation Results
   - Feasible specification on AGL-PF
5. Future Issues
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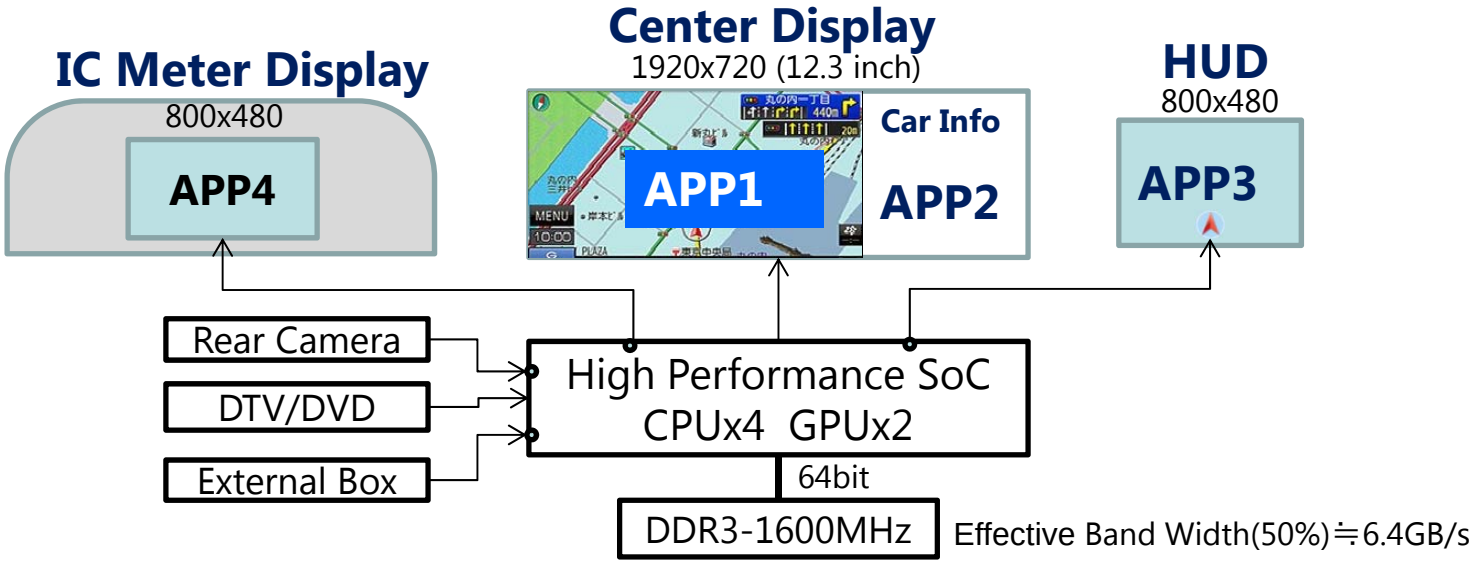
(Reference)

Location to Download the Evaluation Software

Background in IVI System

More and more data need to be processed along with multi screen and high resolution mainly for high-end car.

1. **Simultaneous operation of multiple Apps**
2. **High resolution display, and multi-display**
3. **Automotive SOC supports multi-display**
   (Need high GPU performance, and wide memory bandwidth)



ex) IVI system of Multi-Display High Resolution

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Problem of IVI System

End users expect high-quality UX like smart phone, but current performance of SOC for IVI is not good enough.
(Reason) 1) Many simultaneous apps.
2) In the automotive products, SOC one or two generations older than smartphone tends to be used.

1. Consume a lot of memory bandwidth to compose windows.

ex) Previous: 3 windows (1Display)
Latest : 8 windows (3Display) → 2.6times

2. Increase memory bandwidth because of high resolution

ex)Previous: 800x480@60fps → 88MB/s
Latest : 1920x720@60fps → 316MB/s → 3.6times

3. Difference of GPU performance between the vehicle and the Smart Phone

ex) Vehicle : Renesas R-CarH1 (SGX543MP2) ≒iPhone4s→ 517Mtexcels/s(*1)
Smart Phone: Apple iPhone5s → 2560Mtexcels/s(*1) → 5times

(*1) reffer to GFXBench3.0 1080p Fill offscreen

Objective

Objective

Define suitable specification for comfortable User Experience(UX) in multi screen using the current SOC.

Approach

1. Define IVI systems model and estimate memory bandwidth
   3Displays system (Center + IC Meter + HUD)
2. Develop a evaluation software
3. Evaluate on AGL reference board
4. Redesign the specification (reduce drawing)

Modeling of IVI System

Approach

1. Define IVI systems model and estimate memory bandwidth
   3Displays system (Center + IC Meter + HUD)
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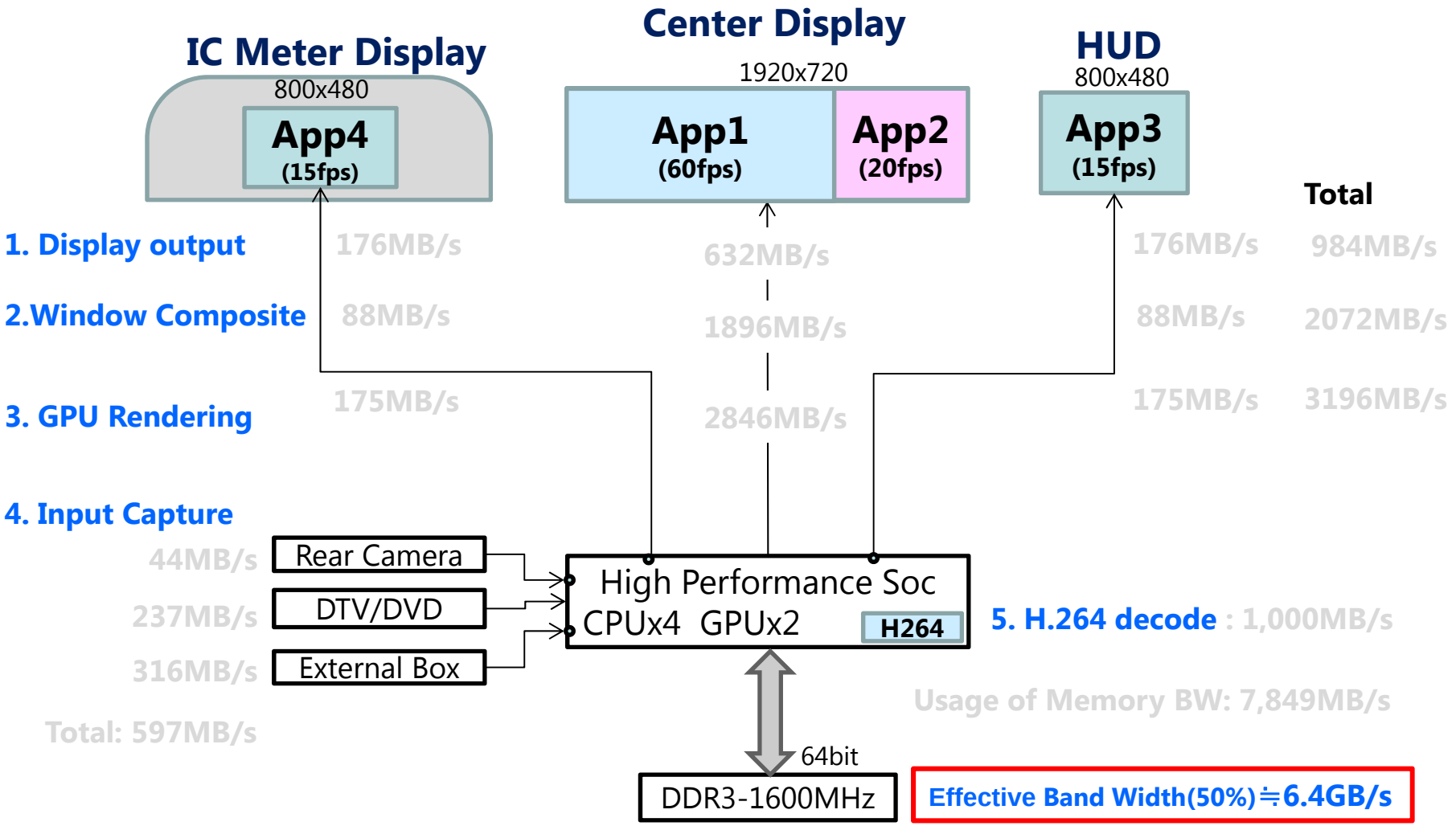
Modeling: 3Displays & 4Apps

Estimate memory usage focusing on graphics which consume a lot of memory.



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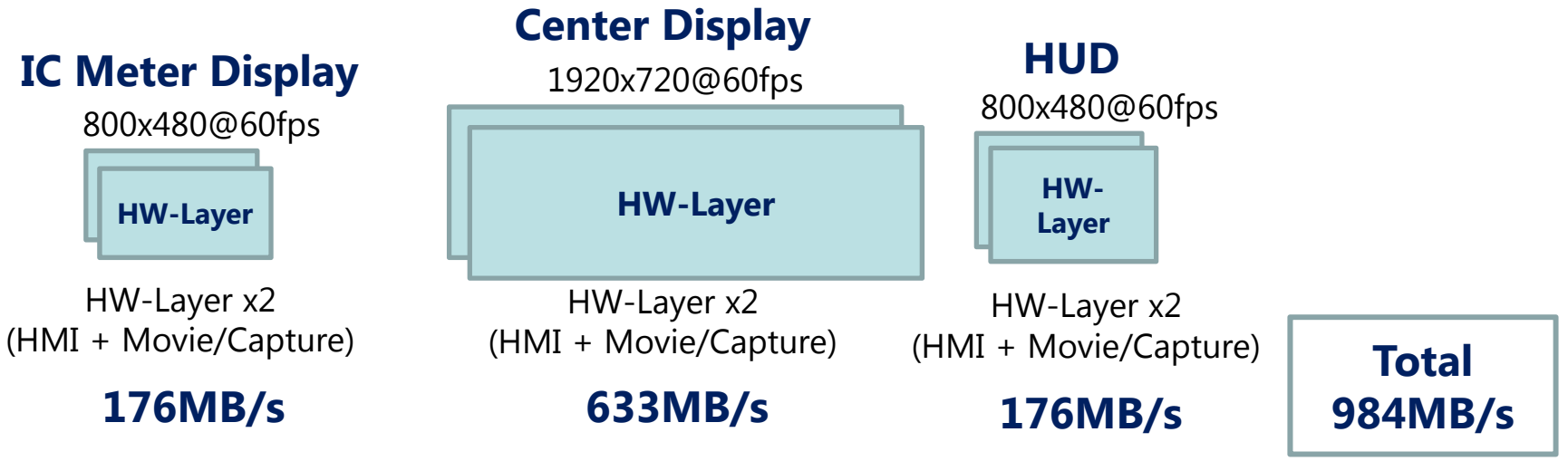
Modeling:1. Memory Bandwidth of Display Output

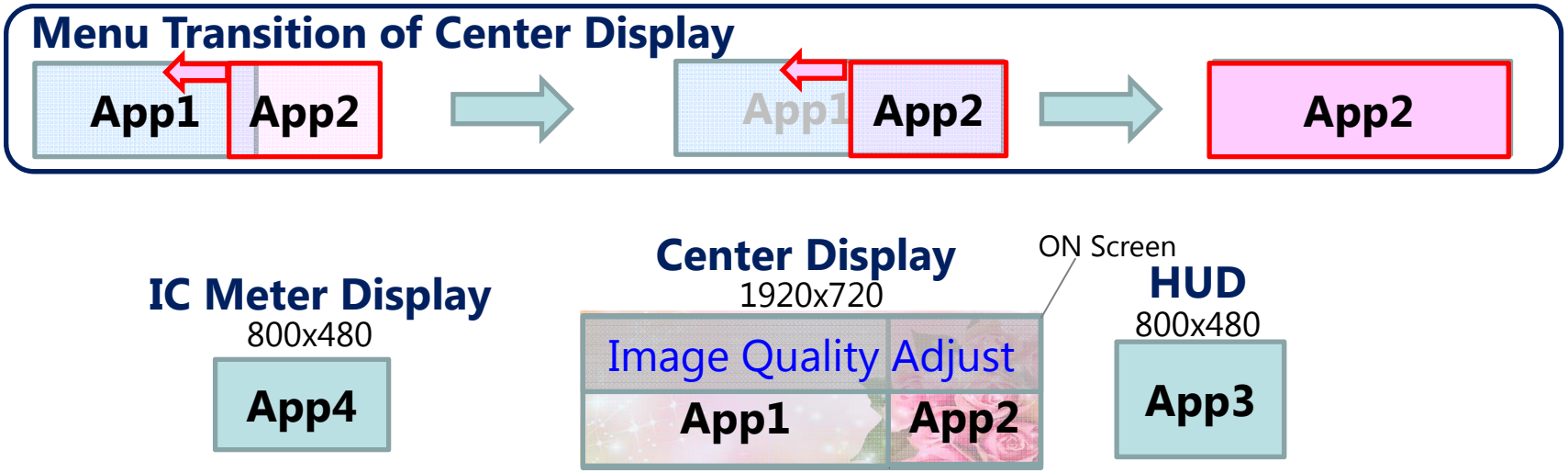


- **Memory BW: Resolution x Num of color x Num of HW layer x frame rate**

1. **Memory BW of Center Display**
   1920 x 720 x 32bit x 2layer x 60fps=633MB/s

2. **Memory BM of IC Meter&HUD**
   800 x 480 x 32bit x 2layter x 60fps=176MB/s

Modeling:2. Memory Bandwidth of Window Composition



Window Name	Resolution(max)	Memory BW.
1. On Screen(ONS:ex Image quality adjust)	1920x720x60fps(*1)	316MB/s
2. App1 GFX(ex Navigation MAP)	1920x720x60fps(max)	316MB/s
3. App1 HMI	1920x720x60fps(max)	316MB/s
4. App2 GFX	1920x720x60fps(max)	316MB/s
5. App2 HMI	1920x720x60fps(max)	316MB/s
6. Background picture	1920x720x60fps	316MB/s
7. App3 GFX/HMI (ex crossing enlarged view)	800x480x60fps	88MB/s
8. App4 GFX/HMI (ex camera&guideline)	800x480x60fps	88MB/s

Animation Windows use maxim resolution

Total 2,072MB/s

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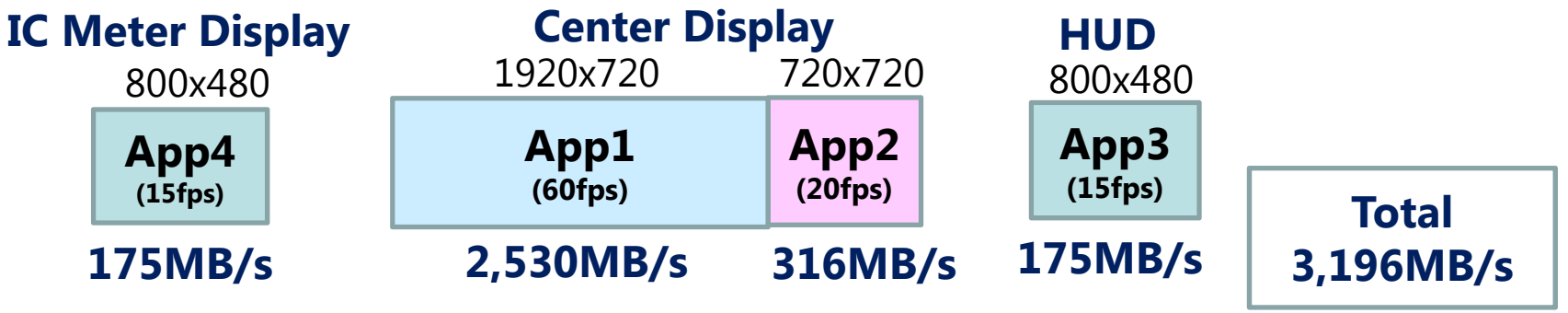
Modeling: 3. Memory Bandwidth of GPU Rendering

The consumption of the memory BW is about 8 times as large as the size of 1fps screen based on GPU bandwidth measurement result of 2D benchmark(*1).

- **GPU performance factor: 8 times of screen size/1fps**



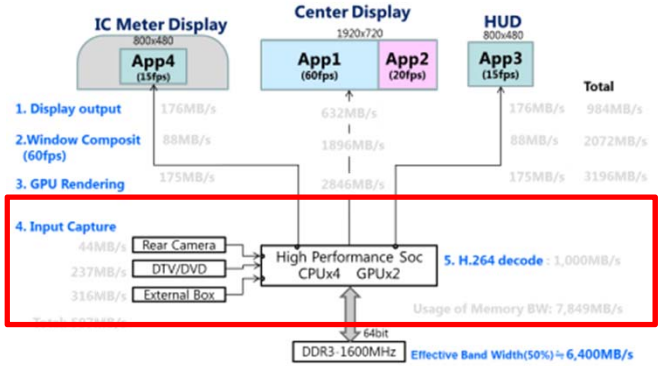
- **Memory BW:**
  Resolution x Num of color x GPU performance factor x frame rate

ex） IC Meter Display memory BW
800x480x32bpp x 8times x 15fps → 175MB/s

(*1): GLmark2 "Effect 2D": 800x480, Memory BW= 1420MB/s, 119fps → 8.2 times of display size/ 1fps (SGX544MP2 results)

(*2): Select similar benchmarks of vehicle and calculate the average value.

Modeling:4. Memory Bandwidth of Input Devices



4. Input Capture

800x480/YUV **44MB/s** — Rear Camera

1920x1080/YUV **237MB/s** — DTV/DVD

1920x720/RGB **316MB/s** — External Box

Total: 597MB/s

→ High Performance Soc CPUx4 GPUx2

- **Memory BW:**
  Resolution x Num of color x frame rate

ex) Memory BW of Rear Camera Capture
800 x 480 x 16bit(YUV) x 60fps=44MB/s

Modeling: Total of Memory Bandwidth

- **Effective memory BW 6.4GB/s(100%) < Total memory BW 7.8GB/s(122%)**
- **82% of the memory BW: GPU consumption and window composition**

1. **Effective memory bandwidth** (Estimate the effective efficiency 50%)
   DDR3-1600 (64bit):1600MB/s x 8 x 50%=12.8GB/s x 50%=6.4GB/s(100%)

2. **Total memory bandwidth**

Item	Explanation	Memory BW	(%)
1. Display Output	1920x720x2layer+800x480x2layer x2 (632MB/s) (176MBx2)	984MB/s	15%
2. Window Composite	8 Window composit	2,072MB/s	32%
3. GPU Consumption	4App use GPU memory BW	3,196MB/s	50%
4. Capture input	Rear Camera + DTV + Ex-box (44MB/s) (237MB/s) (316MB/s)	597MB/s	9%
5. Video Decode	H.264 decode(MiraCast/FullHD)	1,000MB/s	16%
	Total:	7,849MB/s	122%

82%

Specification of Evaluation Software

Approach

1. Define IVI systems model and estimate memory bandwidth
   3Displays system (Center + IC Meter + HUD)
2. Develop a evaluation software
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4. Redesign the specification (reduce drawing)

Specification of Evaluation Software

Evaluation software developed using the AGL reference board.
- **Intel board (ATOM based)**
- **Renesas board (ARM based)**

1. Support multi-display

Simulate system load of multi-display.

2. Easy to customize the number of windows and window size

3. Easy to change CPU and GPU load

- CPU load
- GPU load (Number of FPS and polygon can be changed)

UseCase 1: 3 Video Outputs & 4Apps

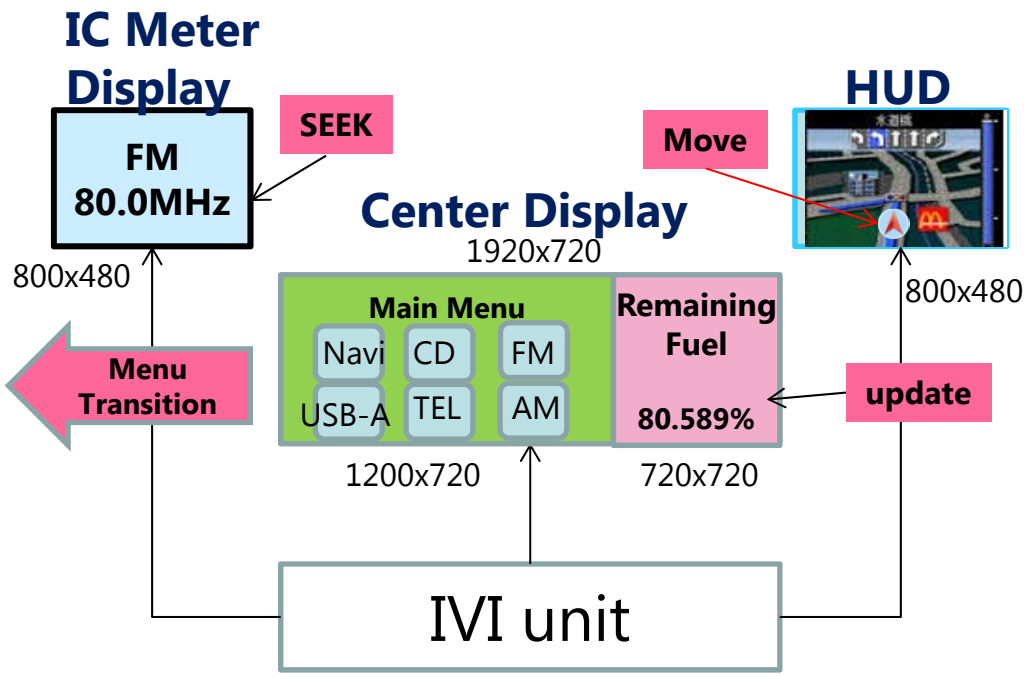
The following parameters are tentative for this evaluation.
For actual estimation it depends on the product specifications.

1)App1: Main Menu Transition
Navigation → USB-Audio → Radio
60fps Animation

2)App2: Fuel consumption meter
- xxx.xxx %
- 10fps, 4polygons

3)App3: HUD
- Intersection enlarged view
- 20fps, 100 polygons

4)App4: IC Meter Display
- FM radio frequency seek(xx.x MHz)
- 10fps, 3polygons



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UseCase1: 3 Video Outputs & 4Apps

Instead of using 3 displays, one Full HD display is used for the evaluation because the AGL reference board only use one video output.

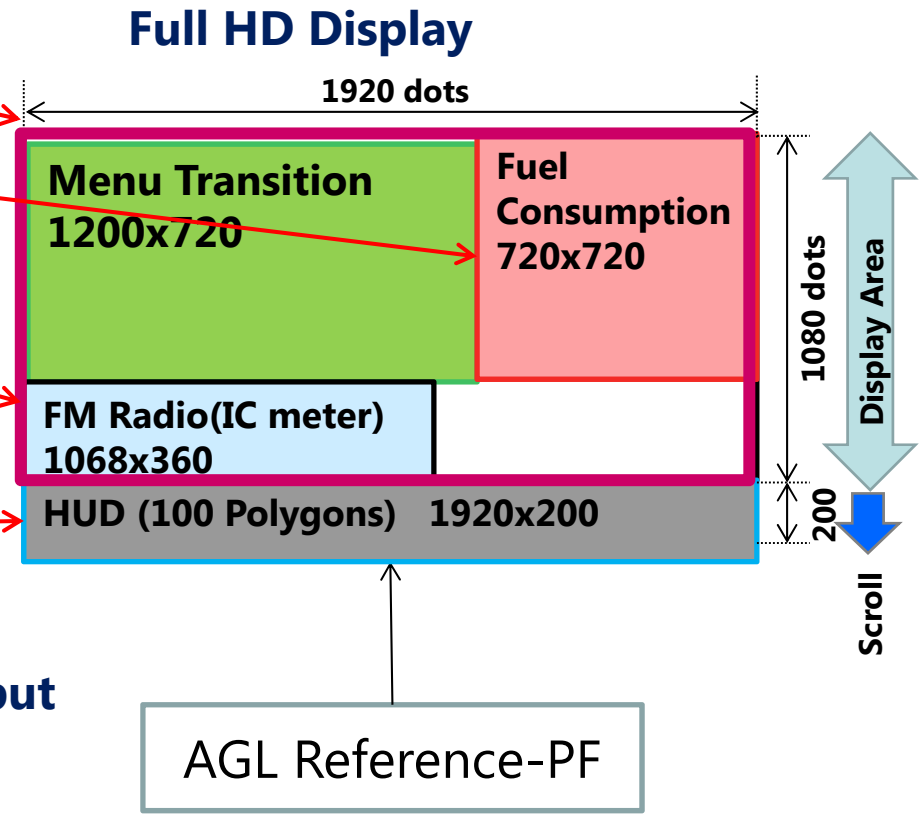
800x480(IC meter) + 1920x720(Center) + 800x 480(HUD)

1)Menu Transition
1200x720@60fps

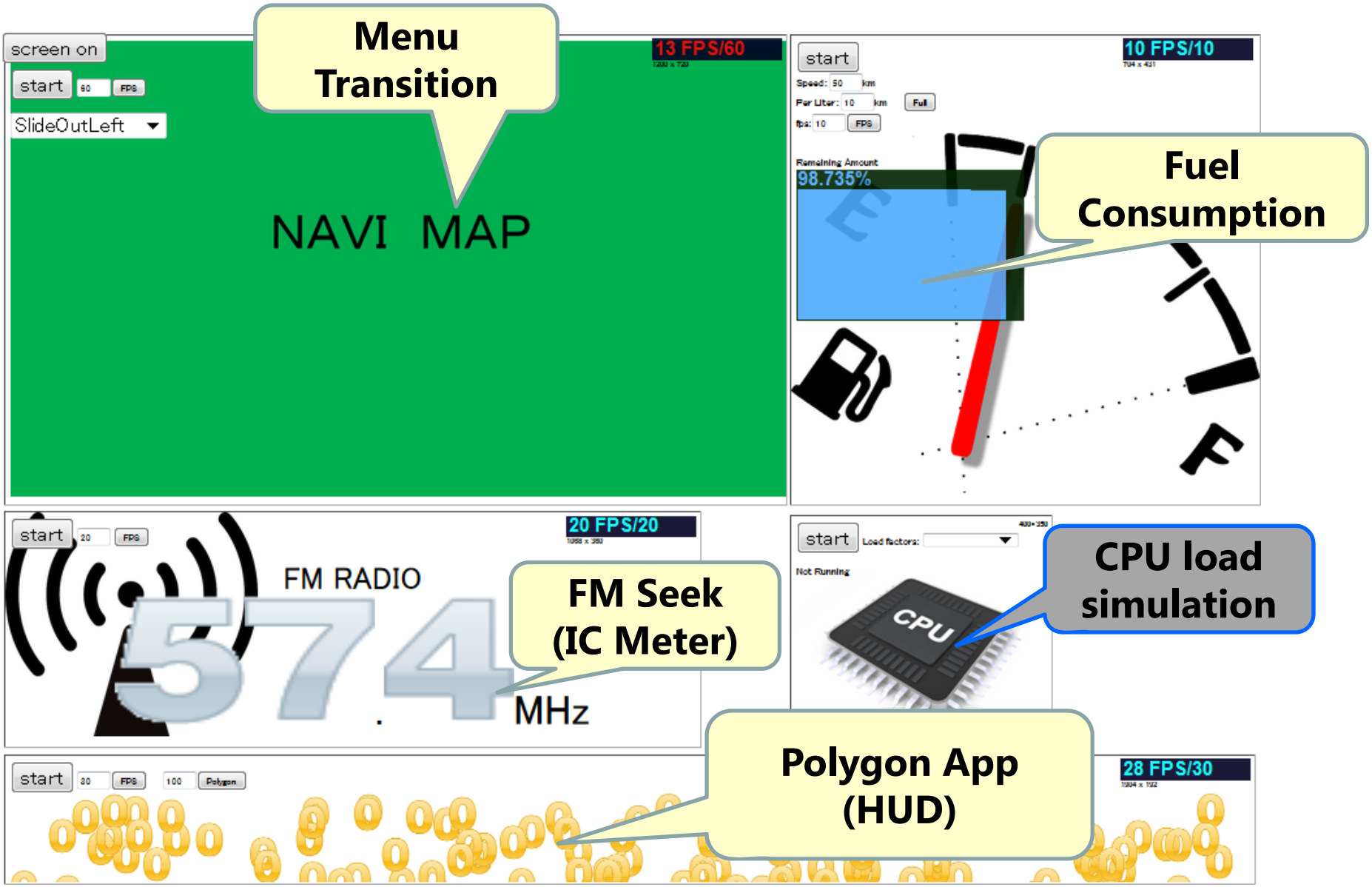
2)Fuel Consumption
720x720@10fps (5polygon)

3)IC Meter(FM Freq. Seek)
800x480→1068x360
20fps(3polygon)

4)HUD (Intersection enlarged view): 20fps
- **100 polygons update at 20fps.**
- **800x480→ 1920x200@20fps**
- **Simulate memory BW of display output using memcpy(88MB/s).**



Screen Shot of Evaluation Software



Specification of AGL Reference PF

Cross walk (HTML5) of Tizen IVI Apps environment is used to configure the screen specification easily.

	Intel PF (ATOM)	Renesas PF(R-Car M2)
CPU	Intel® E3827 (1M Cache, 1.75GHz, 2core)	ARM®Cortex-A15 (1M Cache, 1.5GHz, 2core)
Memory (Ideal memory BW)	1333MHz x 32bit x 2ch =10.4GB/s	1600MHz x 32bit x 2ch = 12.8GB/s
Software PF Tizen IVI version	Tizen IVI 3.0.m14.3	Tizen IVI 3.0.m14.3
WebPF(HTML5) Crosswalk version	10.38.222.0-22.1.i686	10.38.222.0-22.1.armv7l

Evaluation Results

Approach

1. Define IVI systems model and estimate memory bandwidth
   3Displays system (Center + IC Meter + HUD)

↓

2. Develop a evaluation software

↓

3. Evaluate on AGL reference board

↓

4. Redesign the specification (reduce drawing)

Evaluation results: Only 1App (Menu Transition)

Single App with high GPU load achieved nearly 100% of the performance.

	High load App		
	1.Menu Transition		
	Target FPS	Measured FPS	(%)
IntelPF 3Display	60	59	98%
RenesasPF 3Display	60	59	98%

Evaluation results: 3Apps (Menu+Fuel+FM)

The performance in the case of simultaneous operation of App with high GPU load and two Apps with low GPU load:
- **High load App: 83% of target 60fps (ARM)**
- **Low load App: 95% of target 20fps (ARM)**

	High load App			Low load App(3-5polygon)					
	1.Menu Transition			2.FuelConsamption			3.FM Seek		
	Target FPS	Measured FPS	(%)	Target FPS	Measured FPS	(%)	Target FPS	Measured FPS	(%)
IntelPF 3Display	60	52	87%	10	10	100%	20	19	95%
RenesasPF 3Display	60	50	83%	10	10	100%	20	19	95%

Evaluation results: 4Apps (Menu+Fuel+FM+HUD)

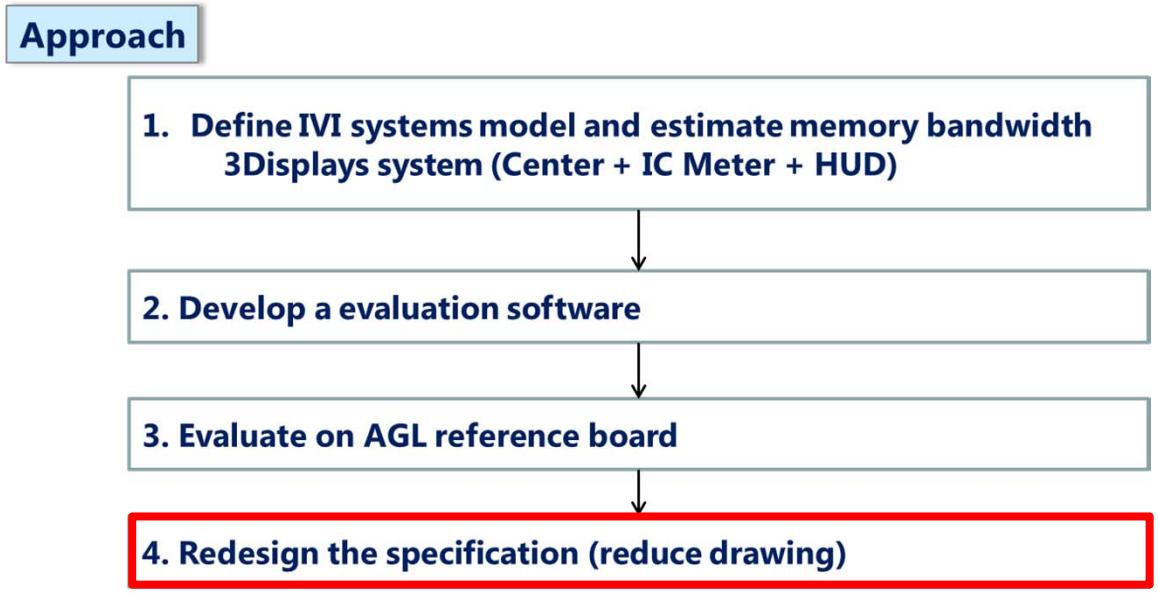
The performance in the case of simultaneous operation of 4Apps with high , mid , and two Apps with low GPU load:

- **High load App: only 57% of target 60fps (ARM)**
- **Mid load App : only 77% of target 30fps (ARM)**
- **Low load App : 80% of target 20fps (ARM)**

	High load App			Low load App(3-5polygon)						Middle load App			
	1.Menu Transition			2.FuelConsamption			3.FM Seek			4.HUD (Polygon App)			
	Target FPS	Measured FPS	(%)	Target FPS	Measured FPS	(%)	Target FPS	Measured FPS	(%)	Num of Polygon	Target FPS	Measured FPS	(%)
IntelPF 3Display	60	42	70%	10	9	90%	20	18	90%	100	30	27	90%
RenesasPF 3Display	60	34	57%	10	9	90%	20	16	80%	100	30	23	77%

But the results is not real performance of AGL reference board, because it is simple evaluation using HTML5 engine.
The performance is highly depend on implementation of the HTML5 engine.

Feasible specification on AGL-PF



Feasible specification on AGL-PF

Redesign the specification.

1. High load App:

- Decrease FPS by 10%: 60 → 55fps

2. Mid load App:

- Decrease polygon by 50%: 100→ 50polygon

- Decrease FPS by 30% : 30 → 10fps

It is possible to achieve the specification by the reduction.

	High loadApp	Low load App(3-5polygon)		Middle load App	
	1. Menu Transition	2.Fuel Consamption	3.FM Seek	4.HUD (Polygon App)	
Window Size	**1280x720**	**720x720**	**800x480**	**800x480**	
UseCase1 (Evaluation)	**60fps**	**10fps**	**10fps**	**100 polygon**	**30fps**
Available Spec.	**55fps**	**10fps**	**10fps**	**50 polygon**	**10fps**

Future Issues

1. Need evaluation environment close to actual products using native app.
   - In HTML5 environment window compositor occupies GPU.
   (Actual products use window system which is optimized for SOC hardware)

2. Need more memory bandwidth for next generation SOC.
   - Current Generation(4Apps): DDR3-1600/64bit
   - Next Generation : LPDDR4-3200/64bit or 128bit

   → FullHD(1920x1080) x 2Display(8Apps): need more than 15GB/s

   → 4K(3840x2160: 16Apps) : need more than 30GB/s

Kind of memory	Bandwidth	Effective BW (50%)	Usecase1 (7.8GB/s)	FullHD x 2 (15GB/s)	4K display (30GB/s)
DDR3-1600/64bit	1.6GHz x 64bit	6.4GB/s	122%	234%	
LPDDR4-3200/64bit	3.2GHz x 64bit	12.3GB/s	63%	122%	243%
LPDDR4-3200/128bit	3.2GHz x 128bit	25.6GB/s		59%	117%

Summary

1. IVI system with multi screen and high resolution needs more memory bandwidth.

2. High-performance SoC can output 3 videos simultaneously, but the limitation of memory bandwidth is the bottle neck to achieve comfortable user experience(UX).

3. It is possible to achieve the feasible specification by the design and the evaluation software.
   In this case, we achieved the feasible specification by adjusting the specification of high load and medium load App.

4. 70% of memory bandwidth is used by GPU that is used by the drawing and the window composition.
   → It is important to reduce these memory BW.
   (Reduce number of window and fps and simultaneous Apps)

Location to Download the Evaluation Software

1. **Location to download: AGL Server (This document is also available.)**

2. **License: MIT License (Free of use and update, No guarantee)**

3. **Programming language: HTML5, CSS, JavaScript**
   - Tested on Crosswalk, Chrome and Firefox.

4. **Evaluation Software: "Evaluation_Software_in_HighLoadUC.zip"**
   - **UseCase1: 3 Video Outputs and 4Apps**

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Thank you!