

# IVI Fast boot approach

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- Yuichi Kusakabe (Fujitsu TEN LIMITED)
- Software Engineer of IVI about 10 years  
(for 16-bit and 32-bit architecture)
- Linux Software Engineer(2011–2013)
- Linux Software Lead Engineer(2013–Now)
- BSP Porting/Customizing
- Supporting for in-house software developers



# Agenda

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- IVI Fast boot requirement
- Target Hardware and Software Spec
- Boot time optimization
- Demonstration & Results
- Conclusion

# IVI Fast boot requirement

## IVI Typical Requirements

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- Functional Requirements :
  - Navigation
  - DTV/DVD/USB-VIDEO
  - HD-RADIO/XM/DAB/RDS
  - Bluetooth/WiFi
  - MirrorLink/Miracast/Carplay
  - Voice Recognition
  - Full Browser
  - Download Apps
  - Back Camera/Image Recognition
  - CAN/MOST/Ether AVB
- Non-Functional Requirements :
  - Fast boot(Booting in 2 seconds)
  - Protecting system against power outage
  - BSP Update/Security Fix
  - Very Long-Term Support (7 years)



Point: These requirements are quite different from 'Smartphones'.

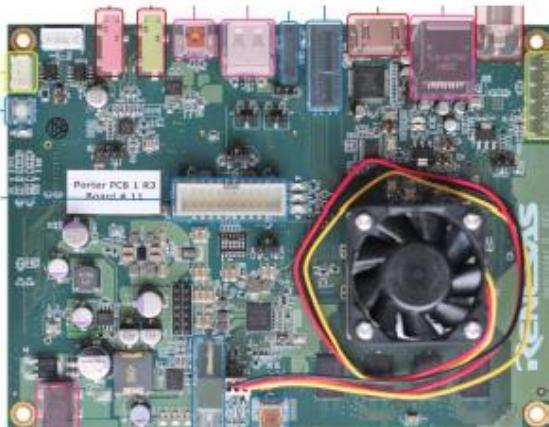
## IVI Typical Requirements v.s. Technical Issues (Fast boot)

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- Fast boot(Driver/kernel/Middleware/Application)
  - Starting CAN communication : **60ms**
  - Displaying Back Camera Image : **2sec**
  - Playing music : **2sec**
  - Displaying Last Screen Image : **3sec**

### Tech Issue

- Starting CAN communications before kernel booting
- Getting ready for user land in **1.5 sec** with Cold Start



R-CAR M2N: <http://elinux.org/R-Car>

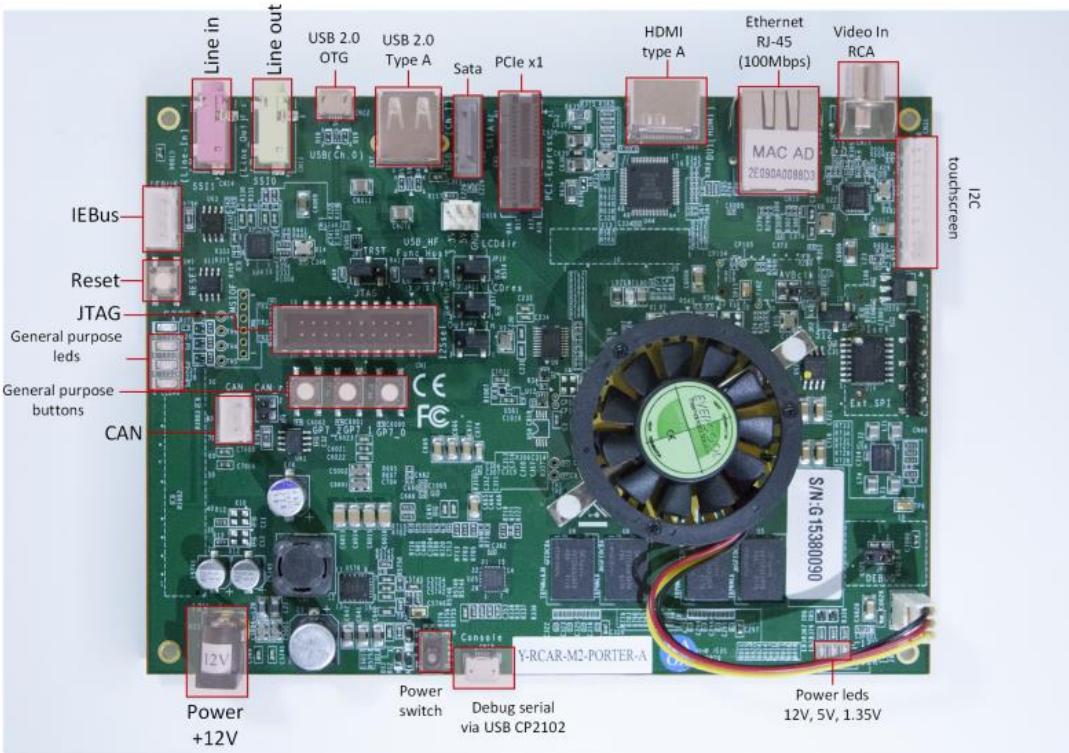
**Renesas R-CAR M2N**  
-CPU : ARM CA15 (1.5GHz)  
-MEMORY : DDR3 1GB  
-64MB QSPI  
-SD CARD (SDR50)

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# Target Hardware and Software Spec

# Target Hardware spec

## AGL reference Hardware to Renesas R-CAR M2 Porter board



<http://elinux.org/R-Car/Boards/Porter>

**32GB microSDHC**

<http://panasonic.jp/sd/p-db/RP-SMGB32GJK.html>



- R-Car M2 SoC

- ARM® Cortex-A15 Dual Core 1.5GHz
- Multimedia Engine SH4A 780 MHz
- GPU
  - PowerVR SGX544MP2 (3D)
  - Renesas graphics processor (2D)
- 2 GB DDR3 memory (dual channel)
- Two flash memory chips
  - 4 MB SPI
  - 64 MB SPI
- Debug Ethernet (100 Mbps)
- Storage connection
  - one SATA rev. 3.1 port
  - one SD card slot
  - one microSD card slot
- Analog Video In: ADV7180 Video Decoder
  - RCA jack
  - NTSC/PAL/SECAM autodetection
- Audio codec: AK4643EN
  - Line In 3.5 mm jack
  - LineOut 3.5 mm jack
- Two USB 2.0 ports
  - microUSB port supports host, device and OTG modes
- PCI Express x1 slot
- CAN transceiver

# Target Software Spec

## Base soft AGL 1<sup>st</sup> release software

The initial release of the AGL Unified Code Base, Agile Albacore was made on January 4, 2016.

## Supported Hardware

- Renesas R-CAR M2 PORTER – Refer to the [AGL Kickstart Guide for Porter Board](#) for instructions to download source code and build
- Renesas R-CAR E2 SILK – Refer to the [AGL Kickstart Guide for Porter Board](#) for instructions to download source code and build
- QEMU x86 – [Download a QEMU virtual machine with AGL prebuilt](#) and links to source code.

## Developer Resources

- [AGL Wiki Page](#)
- [AGL Source Code Repositories](#)

## Agile Albacore Features and Benefits

Based on the Yocto Project, a complete embedded Linux development environment with tools, metadata, and documentation, the new AGL distribution includes:

- Complete Linux-based distribution based on Yocto Project
- Common IVI layer that can be shared by multiple projects (AGL, GENIVI, others)
- Complete open source development infrastructure including Git code repositories, Gerrit code review and Jira bug and issues tracking, all hosted by the Linux Foundation
- Continuous integration via Jenkins
- Automated testing infrastructure
- Westin IVI shell with Wayland IVI extension (from GENIVI)
- Support for Qt multimedia and QML applications
- Demo applications for Home Screen, Media Browser, HVAC Control and Display, AM/FM Radio and Navigation
- First open source MOST device driver developed by Microchip Technology
- Option for both native and HTML5 applications

<https://www.automotivelinux.org/software/download>

# Target Software Spec

## Kernel version is LTSI3.10.31 (Renesas BSP v1.9.2)

```
RENESAS_BACKPORTS_URL="git://git.kernel.org/pub/scm/linux/kernel/git/horms/renesas-backport.git"
SRCREV = "b0ca8c397343f4233f9f68fc3a5bf8e1c9b88251" ↓
SRC_URI = "${RENESAS_BACKPORTS_URL};protocol=git;branch=bsp/v3.10.31-ltsi/rcar-gen2-1.9.2 ↓
    file://0001-arm-lager-Add-vmalloc-384M-to-bootargs-of-DTS.patch ↓
    file://0001-arm-koelsch-Add-vmalloc-384M-to-bootargs-of-DTS.patch ↓
    file://0001-arm-alt-Add-vmalloc-384M-to-bootargs-of-DTS.patch ↓
    file://0001-arm-gose-Add-vmalloc-384M-to-bootargs-of-DTS.patch ↓
" ↓
↓
SRC_URI_append_porter = "" ↓
    file://0001-kernel-Silk-board-support.patch ↓
    file://0002-kernel-silk-fix-ethernet-phy-irq.patch ↓
    file://0003-kernel-silk-fix-sd-detect.patch ↓
    file://0004-kernel-Revert-i2c-rcar-Support-ACK-by-HW-auto-restart-after-NACK.patch ↓
    file://0006-Rcar-DU-add-RGB-connector.patch ↓
    file://0007-SILK-add-i2c0.patch ↓
    file://0008-Porter-board-support.patch ↓
    file://0009-shmobile-add-atag-dtb-compat.patch ↓
    file://0010-Silk-Add-missing-pins-handle-to-Eth.patch ↓
    file://0011-Silk-Add-missing-DU-pins.patch ↓
    file://0012-can-add-Renesas-R-Car-CAN-driver.patch ↓
    file://0013-sh-pfc-r8a7791-add-CAN-pin-groups.patch ↓
    file://0014-sh-pfc-r8a7791-fix-CAN-pin-groups.patch ↓
    file://0015-can-rcar_can-support-all-input-clocks.patch ↓
    file://0016-can-rcar_can-document-device-tree-bindings.patch ↓
    file://0017-can-rcar_can-add-device-tree-support.patch ↓
    file://0018-porter-can-support.patch ↓
    file://0019-i2c-busses-rcar-Workaround-arbitration-loss-error.patch ↓
    file://0020-Silk-Remove-I2C1-clock-from-clk_enables.patch ↓
    file://0001-ARM-shmobile-porter-board-Remove-Audio-platform-code.patch ↓
    file://0002-ARM-shmobile-porter-Sound-PIO-support-on-DTS.patch ↓
    file://0003-ARM-shmobile-porter-Sound-DMA-support-on-DTS.patch ↓
```

# Boot time optimization

# Fast boot approach

Target kernel and user land boot up time : **1.5 sec**

- Boot optimization
  - Cold boot tuning      <- But I can't for now
    - Many Hardware dependency
  - Linux standard Hibernation <- **Adopted**
    - Linux suspend type(disk, mem, \*\*\*)
    - Suspend to **disk**
      - <https://www.kernel.org/doc/Documentation/power/swsusp.txt>
- Application Hibernation(hooks) point
  - Process exec and pre-Initialization

- Hibernation image
  - Micro SD card(mmcblk0p2)
    - p1: rootfs area
    - p2: **Hibernation image area**
  - Image data compression: **LZO**
- Use command
  - mkswap /dev/mmcblk0p2
  - swapon /dev/mmcblk0p2
  - echo platform > /sys/power/disk
  - echo disk > /sys/power/state
  - resume=/dev/mmcblk0p2
  - U-boot: swsusP mmc 0:2

# Normal kernel boot up time

**Kernel boot up time : 33.3 sec, user land boot up time : 37.3 sec**

```
[ 0.000000] Booting Linux on physical CPU 0x0
[ 0.000000] Initializing cgroup subsys cpuset
[ 0.000000] Initializing cgroup subsys cpu
[ 0.000000] Initializing cgroup subsys cpufreq
[ 0.000000] Linux version 3.10.31-ltsi+ (kusakabe@localhost.localdomain) (gcc version 4.8.3 20140401 (prerelease)
(Linaro GCC 4.8-2014.04) ) #5 SMP PREEMPT Sun Jul 10 10:20:12 JST 2016
[ 0.000000] CPU: ARMv7 Processor [413fc0f2] revision 2 (ARMv7), cr=30c73c7d
<snip>
[ 15.558789] drivers/rtc/hctosys.c: unable to open rtc device (rtc0)
[ 27.686622] ALSA device list:
[ 27.691604] #0: rsnd-dai.0-ak4642-hifi
[ 33.083764] kjournald starting. Commit interval 5 seconds
[ 33.083764] kjournald starting. Commit interval 5 seconds
[ 33.287096] EXT3-fs (mmcblk0p1): using internal journal
[ 33.301991] EXT3-fs (mmcblk0p1): recovery complete
[ 33.312460] EXT3-fs (mmcblk0p1): mounted filesystem with ordered data mode
[ 33.329228] VFS: Mounted root (ext3 filesystem) on device 179:1.
[ 33.345216] devtmpfs: mounted
[ 33.350333] Freeing unused kernel memory: 220K (c06a1000 - c06d8000)
<snip>
[ 35.176802] systemd[1]: Started Journal Service.
[ 36.931048] systemd-udevd[157]: starting version 216
[ 37.213706] adv7180 2-0020: Not detect any video input signal
[ 37.382886] systemd-journald[146]: Received request to flush runtime journal from PID 1
```

# Hibernation(suspend to disk) boot up time

## Add kernel cmdline ‘resume=/dev/mmcblk0p2’

```
[Sun Jul 10 19:06:56.146 2016] Booting Linux on physical CPU 0x0
[Sun Jul 10 19:06:56.146 2016] Initializing cgroup subsys cpuset
[Sun Jul 10 19:06:56.146 2016] Initializing cgroup subsys cpu
[Sun Jul 10 19:06:56.146 2016] Initializing cgroup subsys cpacct
[Sun Jul 10 19:06:56.146 2016] Linux version 3.10.31-ltsi+ (kusakabe@localhost.localdomain) (gcc version 4.8.3
20140401 (prerelease) (Linaro GCC 4.8-2014.04) ) #5 SMP PREEMPT Sun Jul 10 10:20:12 JST 2016
<snip>
[Sun Jul 10 19:07:00.158 2016] drivers/rtc/hctosys.c: unable to open rtc device (rtc0)
[Sun Jul 10 19:07:12.988 2016] Freezing user space processes ... (elapsed 0.000 seconds) done.
[Sun Jul 10 19:07:13.028 2016] PM: Using 1 thread(s) for decompression.
[Sun Jul 10 19:07:13.028 2016] PM: Loading and decompressing image data (25914 pages)...
[Sun Jul 10 19:07:14.375 2016] PM: Image loading progress:  0%
<snip>
[Sun Jul 10 19:07:15.355 2016] PM: Image loading progress: 100%
[Sun Jul 10 19:07:15.375 2016] PM: Image loading done.
[Sun Jul 10 19:07:15.375 2016] PM: Read 103656 kbytes in Compressed image size: 25,171,600 byte
[Sun Jul 10 19:07:15.395 2016] renesas_spi e6b10000.spi: freeze
[Sun Jul 10 19:07:15.405 2016] PM: quiesce of devices complete after 12.235 msecs
[Sun Jul 10 19:07:15.425 2016] PM: late quiesce of devices complete after 0.685 msecs
[Sun Jul 10 19:07:15.455 2016] freeze: (null)
[Sun Jul 10 19:07:15.455 2016] PM: noirq quiesce of devices complete after 5.690 msecs
[Sun Jul 10 19:07:15.455 2016] Disabling non-boot CPUs ...
[Sun Jul 10 19:07:15.455 2016] CPU1: shutdown
[Sun Jul 10 19:07:15.565 2016] Enabling non-boot CPUs ...
```

# Hibernation(suspend to disk) boot up time

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Kernel boot up time : 16.8 sec, user land boot up time : 20.6 sec (-16.7 sec)

```
[Sun Jul 10 19:07:15.575 2016] CPU1: Booted secondary processor
[Sun Jul 10 19:07:15.575 2016] CPU1 is up
[Sun Jul 10 19:07:15.605 2016] pci-rkar-gen2 pci-rkar-gen2.0: PCI: bus0 revision 11
[Sun Jul 10 19:07:15.605 2016] pci-rkar-gen2 pci-rkar-gen2.1: PCI: bus1 revision 11
[Sun Jul 10 19:07:15.625 2016] PM: noirq restore of devices complete after 29.034 msecs
[Sun Jul 10 19:07:15.635 2016] PM: early restore of devices complete after 0.500 msecs
[Sun Jul 10 19:07:15.795 2016] renesas_spi e6b10000.spi: restore
[Sun Jul 10 19:07:15.795 2016] sh_mobile_sdhi sdhi2: timeout waiting for SD bus idle
[Sun Jul 10 19:07:15.795 2016] sh_mobile_sdhi sdhi2: timeout waiting for SD bus idle
[Sun Jul 10 19:07:15.805 2016] restore: e7a84100
[Sun Jul 10 19:07:16.235 2016] ata1: link resume succeeded after 1 retries
[Sun Jul 10 19:07:16.365 2016] ata1: SATA link down (SStatus 0 SControl 300)
[Sun Jul 10 19:07:16.395 2016] usb usb2: root hub lost power or was reset
<snip>
[Sun Jul 10 19:07:16.705 2016] PM: restore of devices complete after 935.860 msecs
[Sun Jul 10 19:07:16.715 2016] Restarting tasks ... done.
[Sun Jul 10 19:07:16.775 2016] !!!! end snap.sh to SD !!!!
[Sun Jul 10 19:07:16.785 2016] root@porter:~# dmesg
```

kernel boot up: 16.842 sec

Hibernation image load: 2.32 sec (Compressed image size: 25,171,600 byte)

driver resume: 0.935 sec (PM: restore of devices complete after 935.860 msecs)

user land boot up time: 20.639 sec

# Hibernation image load from U-boot

## Porting “swsus” command to U-boot, Boot time 8.3 sec (-29 sec)

```
[Sun Jul 10 20:19:04.126 2016] => swsus p mmc 0:2
[Sun Jul 10 20:19:40.996 2016] Allocating 106496 bytes (nr_pfn_pages 26)
[Sun Jul 10 20:19:41.039 2016] Loading image data pages (25898 pages)
[Sun Jul 10 20:19:41.039 2016] Image loading progress: 0%
<snip>
[Sun Jul 10 20:19:48.060 2016] Image loading progress: 100%
[Sun Jul 10 20:19:48.067 2016] Image loading done.
[Sun Jul 10 20:19:48.080 2016] Enabling non-boot CPUs ...
[Sun Jul 10 20:19:48.093 2016] CPU1: Booted secondary processor
[Sun Jul 10 20:19:48.093 2016] CPU1 is up
[Sun Jul 10 20:19:48.122 2016] pci-rcar-gen2 pci-rcar-gen2.0: PCI: bus0 revision 11
[Sun Jul 10 20:19:48.137 2016] PM: noirq restore of devices complete after 28.497 msecs
[Sun Jul 10 20:19:48.153 2016] PM: early restore of devices complete after 0.500 msecs
[Sun Jul 10 20:19:48.314 2016] renesas_spi e6b10000.spi: restore
<snip>
[Sun Jul 10 20:19:49.220 2016] PM: restore of devices complete after 931.115 msecs
[Sun Jul 10 20:19:49.225 2016] Restarting tasks ... done.
[Sun Jul 10 20:19:49.307 2016] !!!! end snap.sh to SD !!!!
[Sun Jul 10 20:19:49.321 2016] root@porter:~#
```

U-boot SD read spec  
=> ext4load mmc 0:1 0x40007fc0 boot/zImage  
3601624 bytes read in 326 ms (10.5 MiB/s)

Hibernation image load: 7.07 sec (Compressed output size: 25253220)  
driver resume: 0.931 sec (PM: restore of devices complete after 931.115 msecs)

user land boot up time: 8.325 sec

# Hibernation image size optimization

## Hibernation resume speed is dependent on the Hibernation image size

use parameter '`/proc/sys/vm/drop_caches`' (0, 1, 2, 3)

Default `/proc/sys/vm/drop_caches = 0`

	total	used	free	shared	buffers	cached
Mem:	1974432	105848	1868584	0	4824	52188

PM: Hibernation image created (32437 pages copied)

PM: Compressed output size: 38431016 [41119744] (imgsize=41115648/swaped size=41119744)

Hibernation image load from SD: 10.61 sec

`echo 1 > /proc/sys/vm/drop_caches`

	total	used	free	shared	buffers	cached
Mem:	1974432	80572	1893860	0	84	31604

PM: Hibernation image created (26078 pages copied)

PM: Compressed output size: 25456529 [27697152] (imgsize=27693056/swaped size=27697152)

Hibernation image load from SD: 7.13 sec

`echo 2 > /proc/sys/vm/drop_caches`

	total	used	free	shared	buffers	cached
Mem:	1974432	104448	1869984	0	4160	51196

PM: Hibernation image created (31797 pages copied)

PM: Compressed output size: 37486193 [40132608] (imgsize=40128512/swaped size=40132608)

Hibernation image load from SD: 10.35 sec

`echo 3 > /proc/sys/vm/drop_caches`

	total	used	free	shared	buffers	cached
Mem:	1974432	80460	1893972	0	104	31592

PM: Hibernation image created (25853 pages copied)

PM: Compressed output size: 25220234 [27447296] (imgsize=27443200/swaped size=27447296)

Hibernation image load from SD: 7.06 sec

Best score

- Hibernation image
  - DDR Hibernation store area
    - Kernel :0x40000000 <-> 0x7A000000
    - Hibernation:0x7A000000 <-> 0x80000000
      - Need to DDR back up
- Use command
  - mkswap /dev/**mtdblock3**
  - swapon /dev/**mtdblock3**
  - echo platform > /sys/power/disk
  - echo disk > /sys/power/state
  - U-boot: **suspmem**

# Demonstration & Results

# **Demonstration**

# **Image to SD / DDR**

# Hibernation(image to DDR) boot up time

Kernel and user land boot up time : **1.74 sec (-35.5 sec)**

[Sun Jul 10 21:48:18.834 2016] PM: Compressed output size: **25148369** [27385856] (imgsize=27381760/swaped size=27385856)

<snip>

[Sun Jul 10 21:49:37.024 2016] => swsuspmem

[Sun Jul 10 21:49:**40.474** 2016] **Allocating 106496 bytes (nr\_pfn\_pages 26)**

[Sun Jul 10 21:49:**40.484** 2016] **Loading image data pages (25859 pages)**

[Sun Jul 10 21:49:**40.984** 2016] **Image loading done.**

[Sun Jul 10 21:49:40.994 2016] Enabling non-boot CPUs ...

[Sun Jul 10 21:49:41.004 2016] CPU1: Booted secondary processor

[Sun Jul 10 21:49:41.004 2016] CPU1 is up

[Sun Jul 10 21:49:41.034 2016] pci-rcar-gen2 pci-rcar-gen2.0: PCI: bus0 revision 11

[Sun Jul 10 21:49:41.034 2016] pci-rcar-gen2 pci-rcar-gen2.1: PCI: bus1 revision 11

[Sun Jul 10 21:49:41.054 2016] PM: noirq restore of devices complete after 28.529 msecs

[Sun Jul 10 21:49:41.064 2016] PM: early restore of devices complete after 0.500 msecs

<snip>

[Sun Jul 10 21:49:42.134 2016] PM: restore of devices complete after 928.881 msecs

[Sun Jul 10 21:49:42.134 2016] Restarting tasks ... done.

[Sun Jul 10 21:49:42.214 2016] !!!!! end snap.sh to DDR !!!!!

[Sun Jul 10 21:49:**42.214** 2016] **root@porter:~#**

**Hibernation image load: 0.5 sec (Compressed output size: 25148369 )**

driver resume: 0.928 sec(PM: restore of devices complete after 928.881 msecs)

**user land boot up time: 1.74 sec**

- kernel and user land boot time
  - Normal: 33.3sec(kernel)/37.3sec(user land)
  - Image to SD: **8.3sec**(-29 sec)
  - Image to DDR: **1.7sec**(-35.5 sec)
- details
  - Image load(SD): **7sec**(size:**24MB**)
  - Image load(DDR): **0.5sec**(size:**24MB**)
  - Driver resume: **0.9sec**

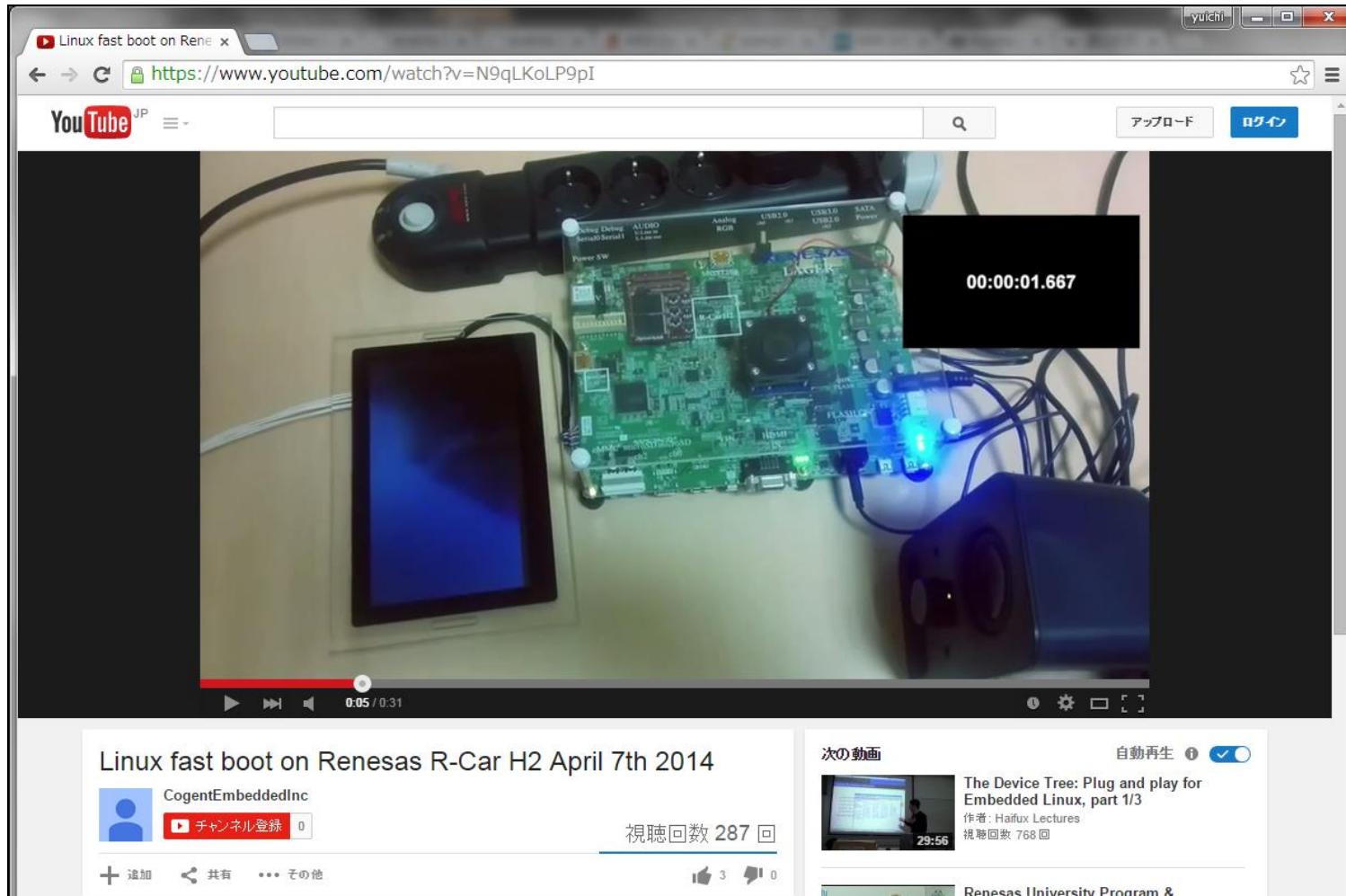
- Hibernation is good approach for fast boot
- Hibernation resume speed depends on the image size
- Next step
  - Optimization of U-Boot SD driver(ex. DMA)
  - Merging
    - Hibernation patch to AGL gerrit
    - Integration AGL software(Goal 2017 CES)

But  
I wanna do this !

# Other boot time optimize approach

## Cold boot : Customizing BSP by SoC Vendor

Starting video playback in **1.6 sec** (user space)



<https://www.youtube.com/watch?v=N9qLKoLP9pI>

R-CAR H2: <http://elinux.org/R-Car>

# Thank you!!!

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