

Automotive Linux Summit 2017

Power management for in-vehicle infotainment systems

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BIG IDEAS
FOR EVERY SPACE

Who am I ?

- Name : Takahiko Gomi
- Company : Renesas Electronics corp.
- Career : 10 years experiences in power management development
 - ✓ Estimation of power consumption for Mobile use-cases
 - ✓ Promotion activity and market analysis in Mobile platform
 - ✓ Development of thermal control with power management for in-vehicle infotainment systems



Today's GOAL

■ Introducing our power management solution for in-vehicle infotainment systems

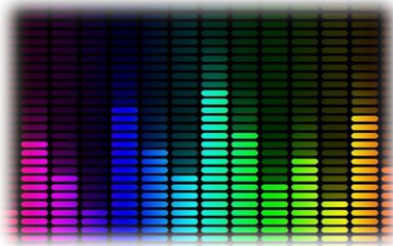
- ✓ Two solutions of those three our power management solutions introduce today, are already contributed to AGL DD.

Market trend of the IVI systems

Now : Increasing running application

In former : Independent systems

- Car navigation system, Audio/Video feature, Analog meter cluster, Rear-view monitor, etc.



- Connectivity for smart-phones, Enriched graphical monitor on meter cluster systems, Surround view camera features, Smart camera features, etc.



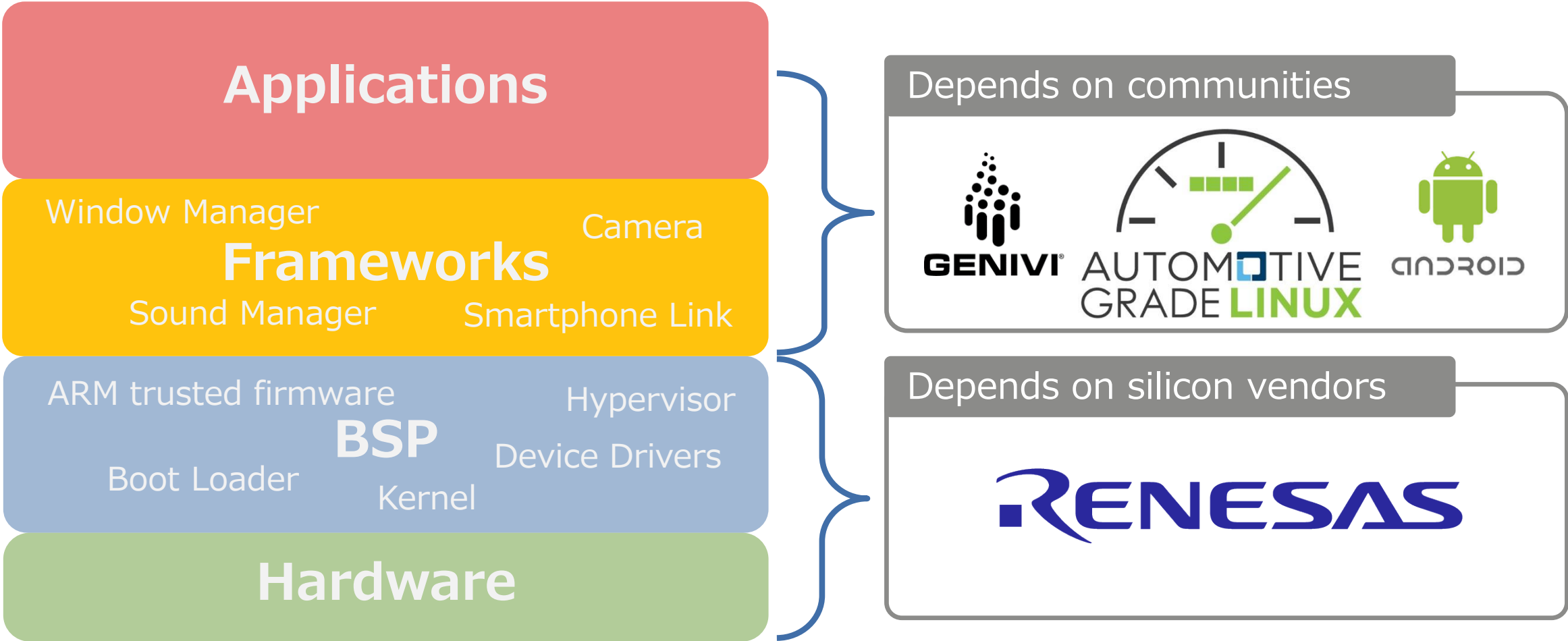
It changed its roles and quantities of the applications on the system to improve safety and user experiences.

In the future . . .

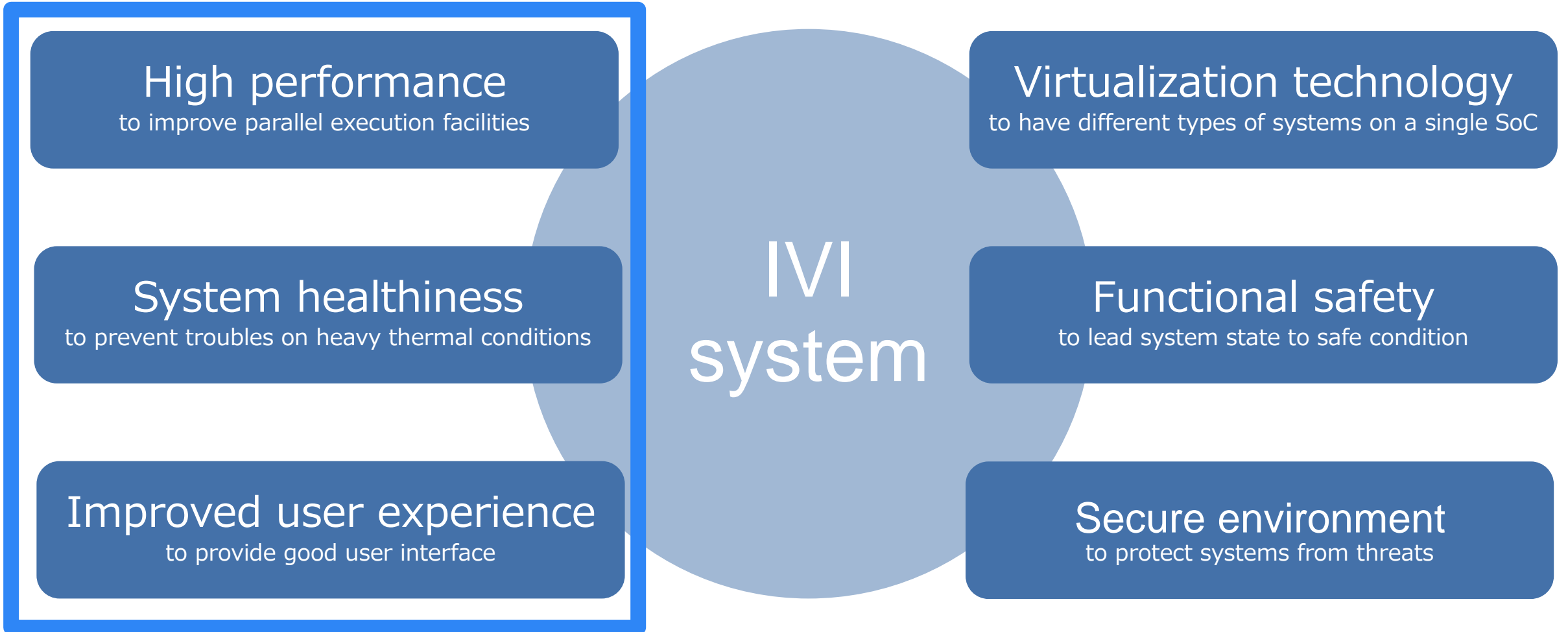


It would be integrated to “Connected car” in cooperation with the cloud system.

Corresponding scope of Renesas



Major key technology for IVI system



Scope of presentation

Efforts on power management in key technology for IVI system

High performance

to improve parallel execution facilities

- ✓ To process huge amount of running application



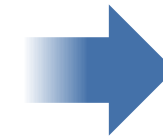
More multiple computation

- ✓ Multi-processing with big.LITTLE methodology

System healthiness

to prevent troubles on heavy thermal conditions

- ✓ To keep thermal condition within the specification



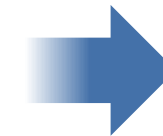
Reliable thermal control

- ✓ Controlling performance by power management features

Improved user experience

to provide good user interface

- ✓ To keep system requirement of boot time



Sophisticated user experience

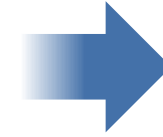
- ✓ "fast boot feature" using Suspend to RAM

Solution for more multiple computation

High performance

to improve parallel execution facilities

- ✓ To process huge amount of running application



More multiple computation

- ✓ Multi-processing with big.LITTLE methodology

System healthiness

to prevent troubles on heavy thermal conditions

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Reliable thermal control

- ✓ Controlling performance by power management features

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Sophisticated user experience

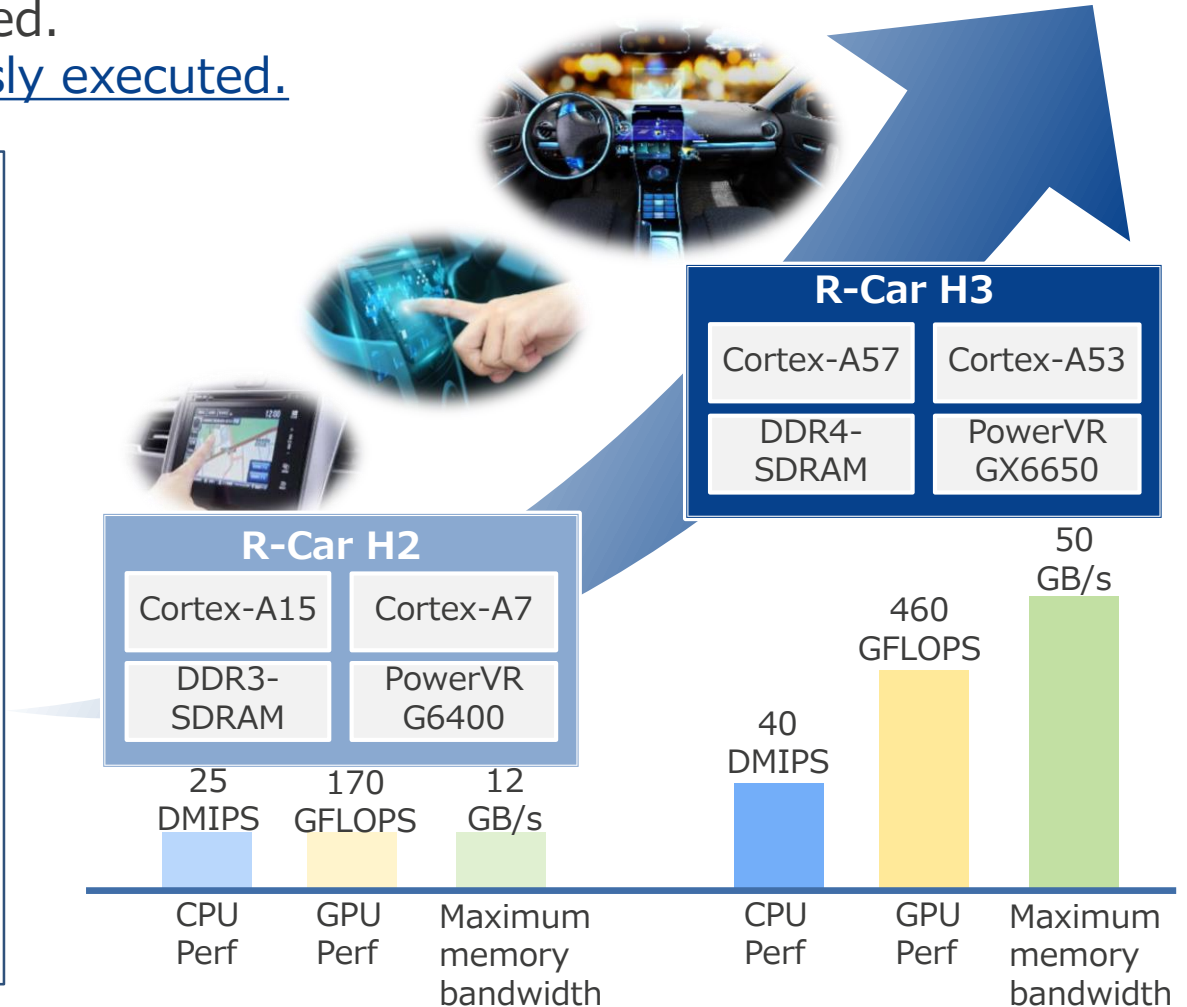
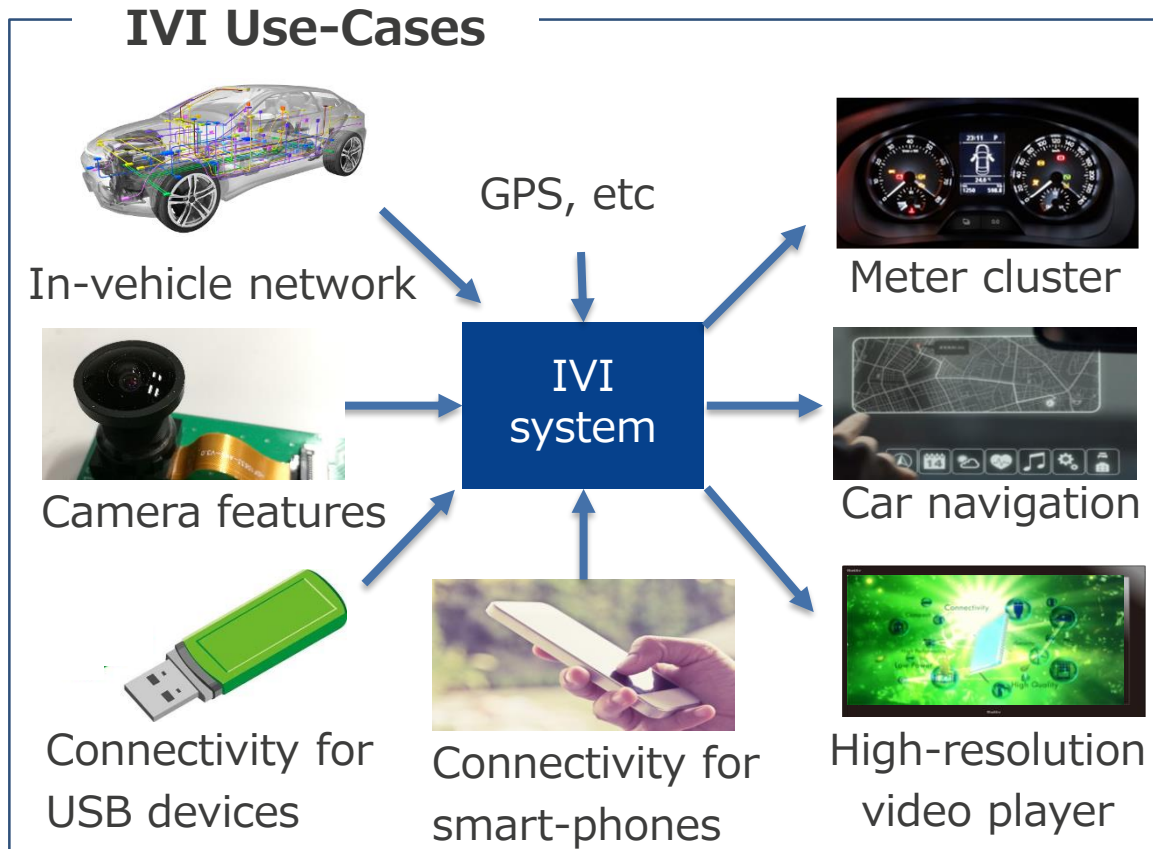
- ✓ "fast boot feature" using Suspend to RAM

Background for higher performance requirement

Trend of IVI systems

- ✓ Many type of application would be implemented.
- ✓ Several type of service would be simultaneously executed.

Improvement along trend of IVI systems



“Multi Core Solution” is required on latest multiple application environment.

Multi Core Solution

Only high performance big CPUs



- High performance
- High power consumption
- Large HW footprint

Only high efficiency LITTLE CPUs



- Low performance
- Low power consumption
- Smaller HW footprint

big.LITTLE architecture



- High performance
- Low power consumption
- Smaller HW footprint

ARM

Renesas

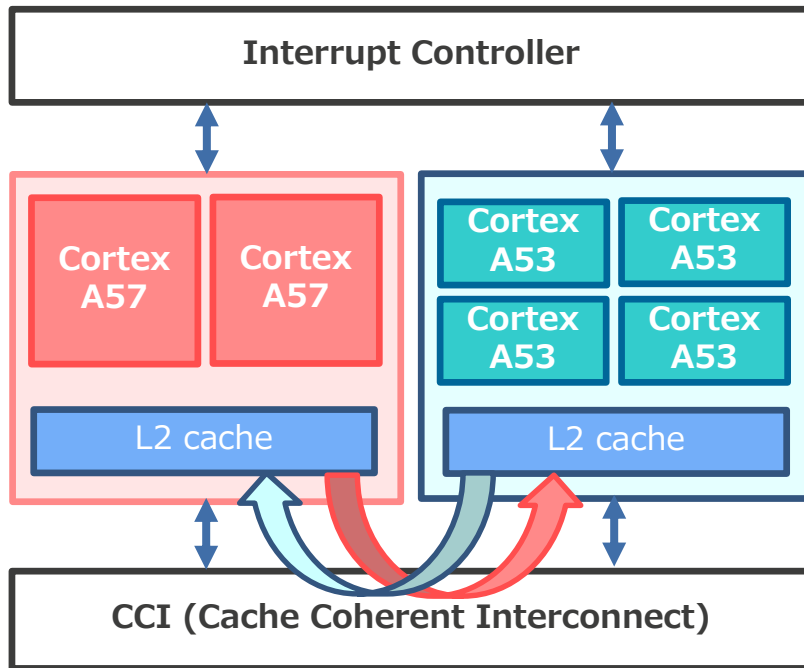


R-Car Starter Kit Gen3

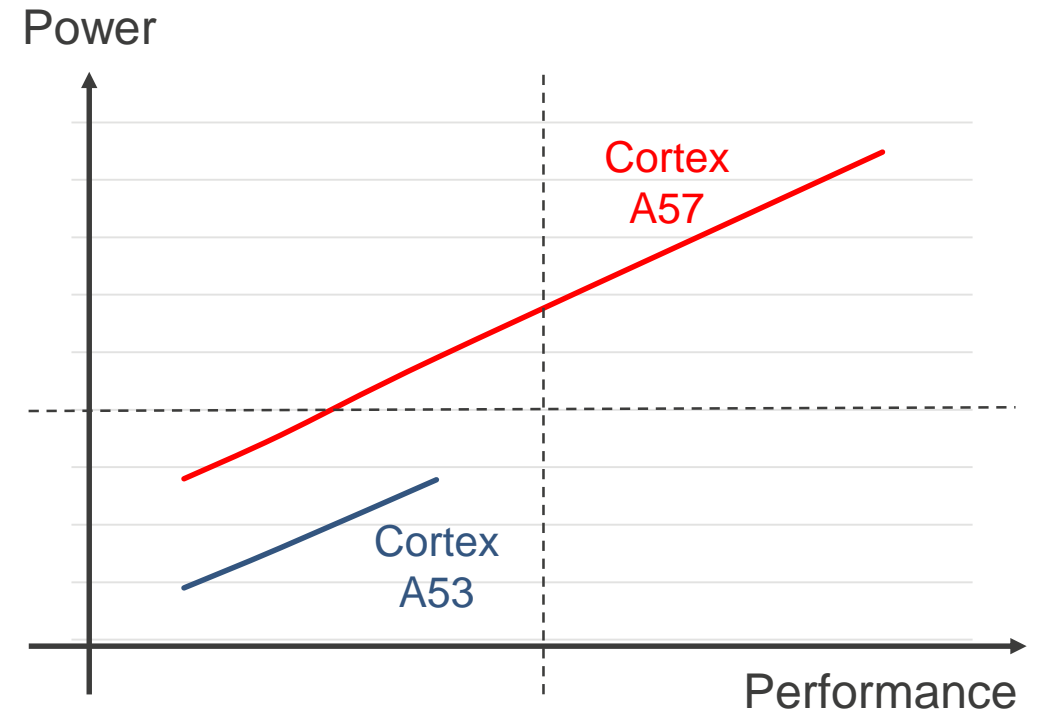
big.LITTLE realizes appropriate combination balance of the performance, hardware footprint and power consumptions.

big.LITTLE Overview

■ Hardware Structure



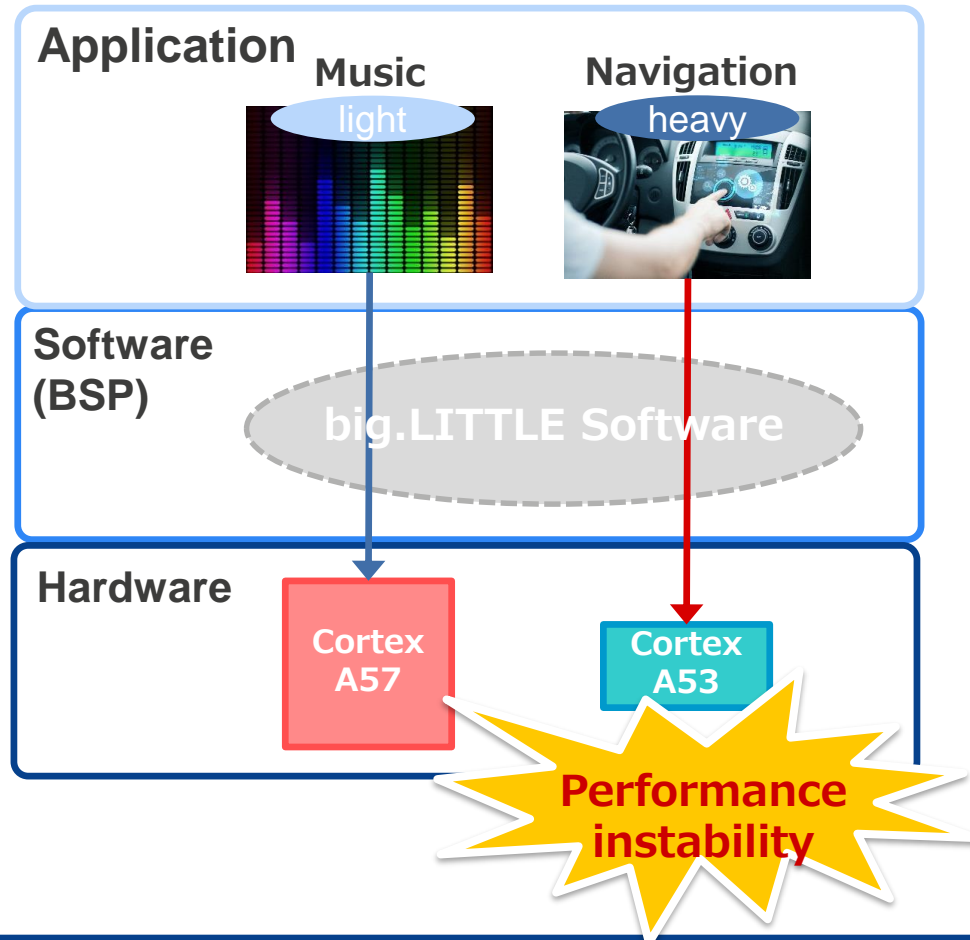
■ Power performance curve



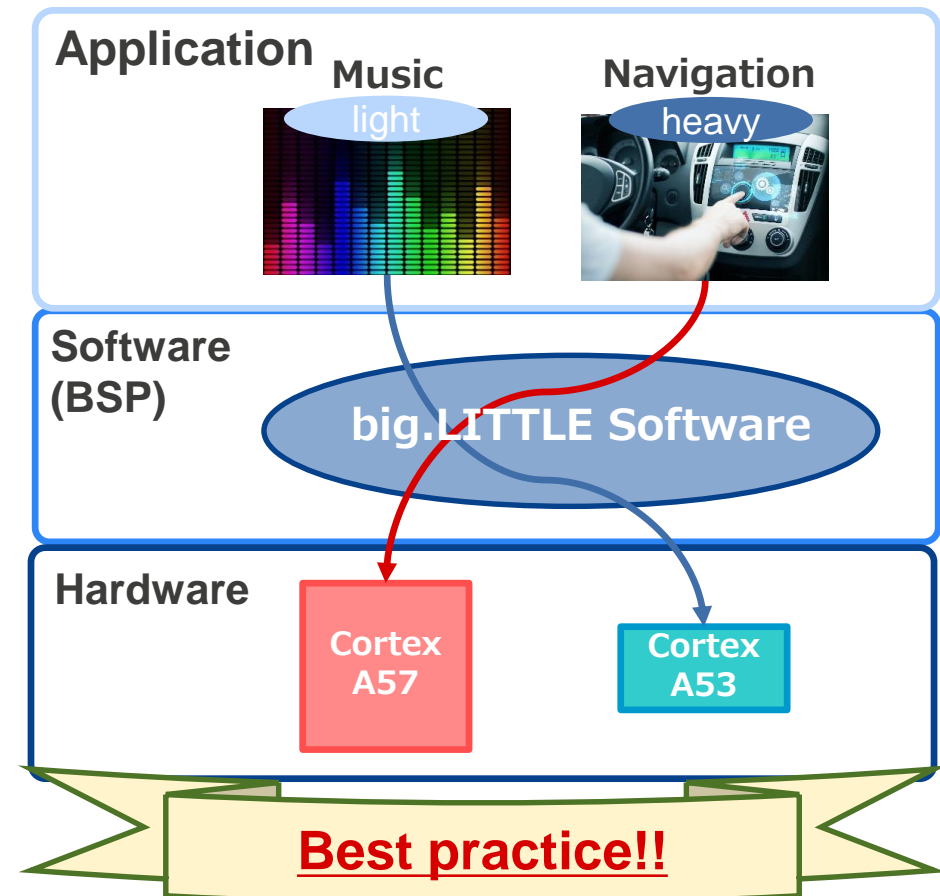
- ✓ The big CPU such as Cortex-A57 has higher single thread performance.
- ✓ The LITTLE CPU such as Cortex-A53 has better power consumptions statistics.

Necessity of big.LITTLE Software

■ Non big.LITTLE Software



■ big.LITTLE Software



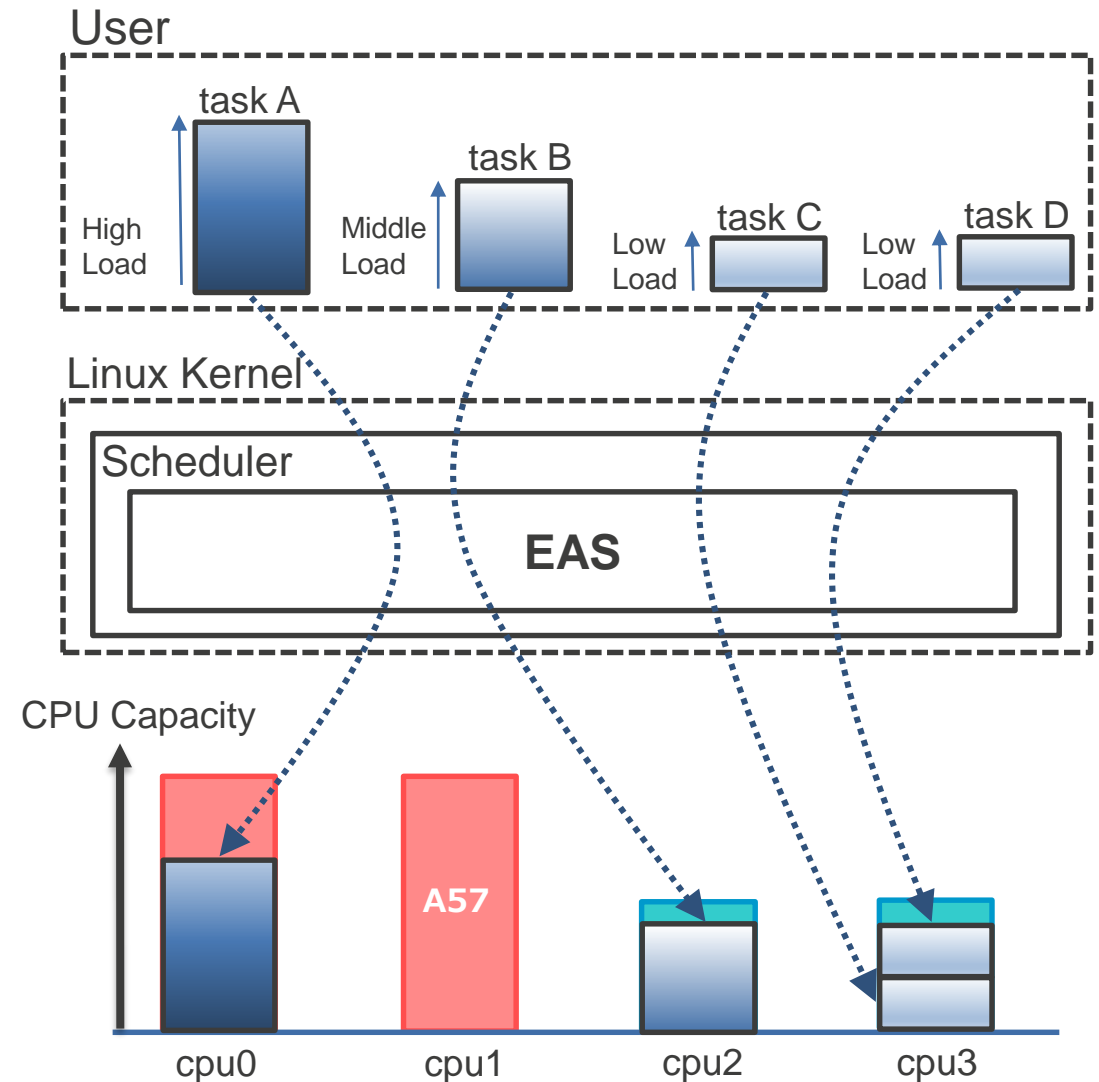
In big.LITTLE SW, heavy weight process would be assigned big CPU core.
And any other light process would be assigned LITTLE CPU core.

big.LITTLE Software Overview

Energy Aware Scheduling(EAS)

EAS have two characteristics :

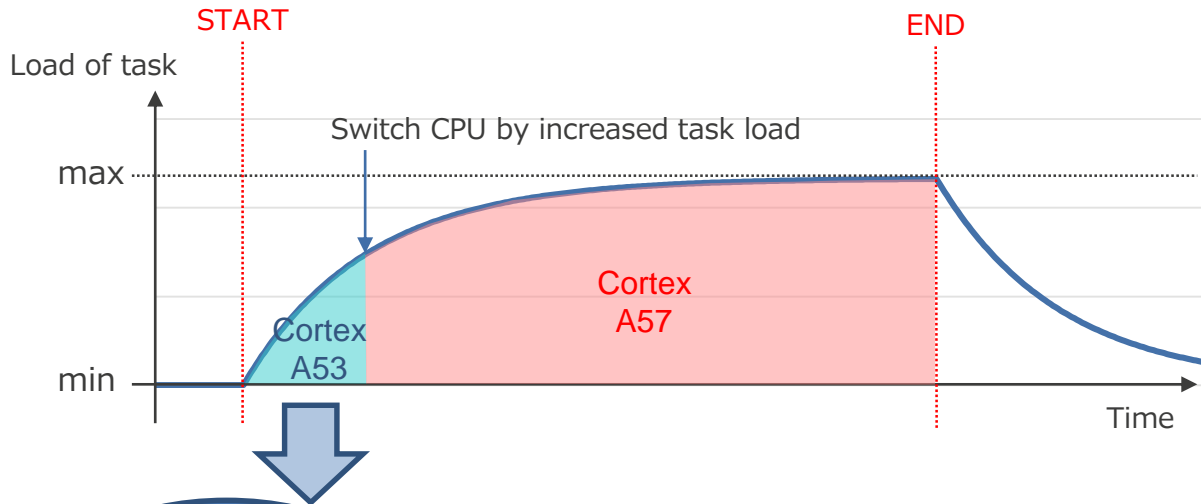
- ✓ It assigns applications using process load statistics.
- ✓ It reduces power consumptions by utilizing light weight LITTLE core as possible.



big.LITTLE - EAS Issue

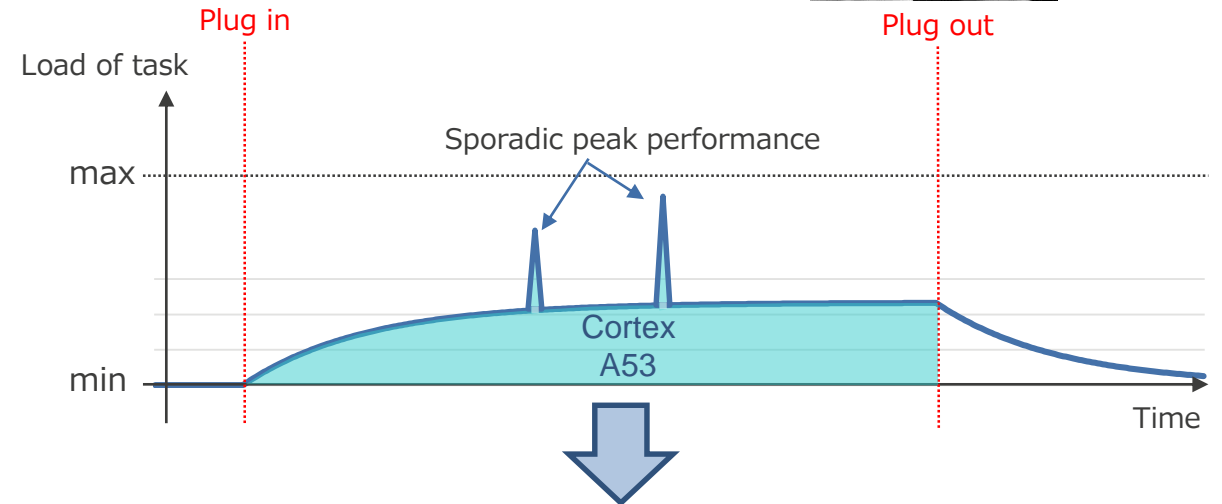
Lower performance at starting application

Video playback



Lower response of application manipulation

Connectivity for smart-phones



Solution

It can use taskset or cgroup features to assign such heavy weight applications into big CPU as designer's will.

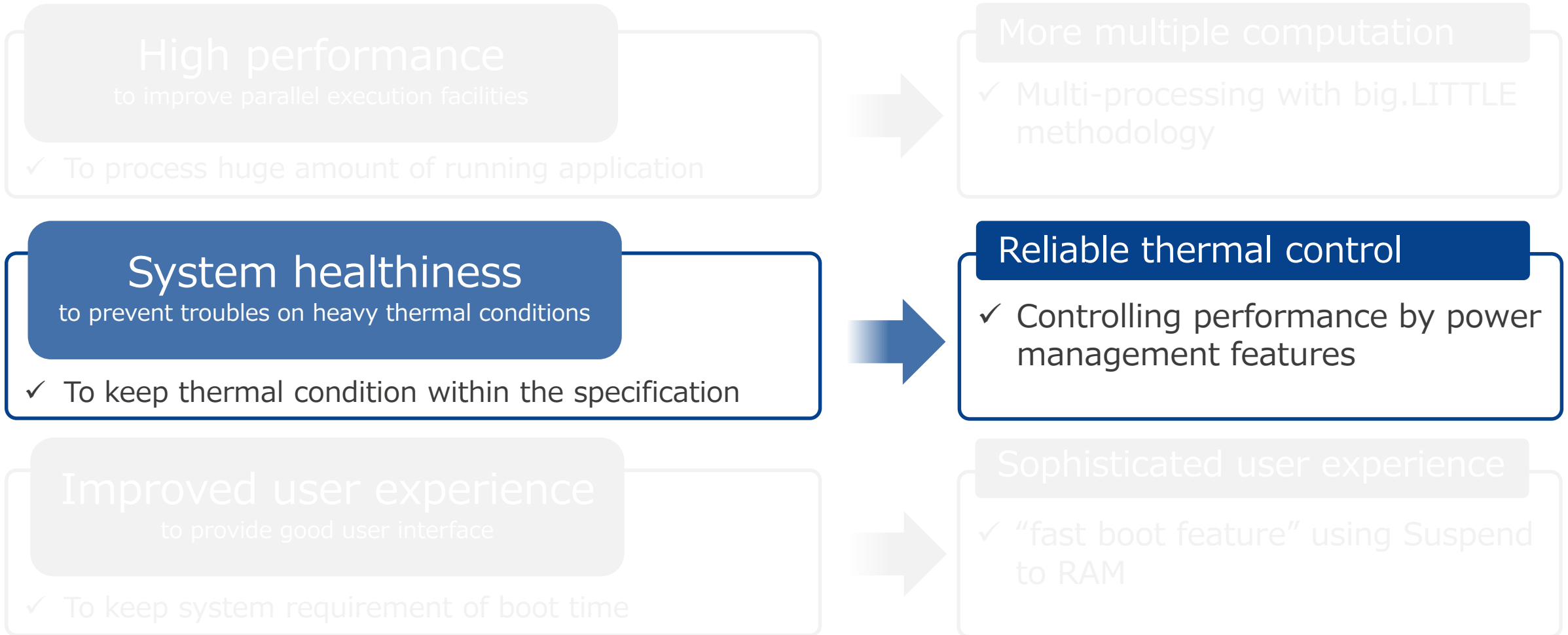
When we use original EAS on IVI systems, it have to solve such issues on it.

Renesas's future activity for big.LITTLE

- ✓ Renesas is developing additional tools which makes easy to assign applications with some hint or static enforcement.
- ✓ Renesas is continuing evaluation of EAS under AGL UCB DD.
- ✓ Renesas will promote such additional feature and tools to our BSP and contribute to AGL community in near future.

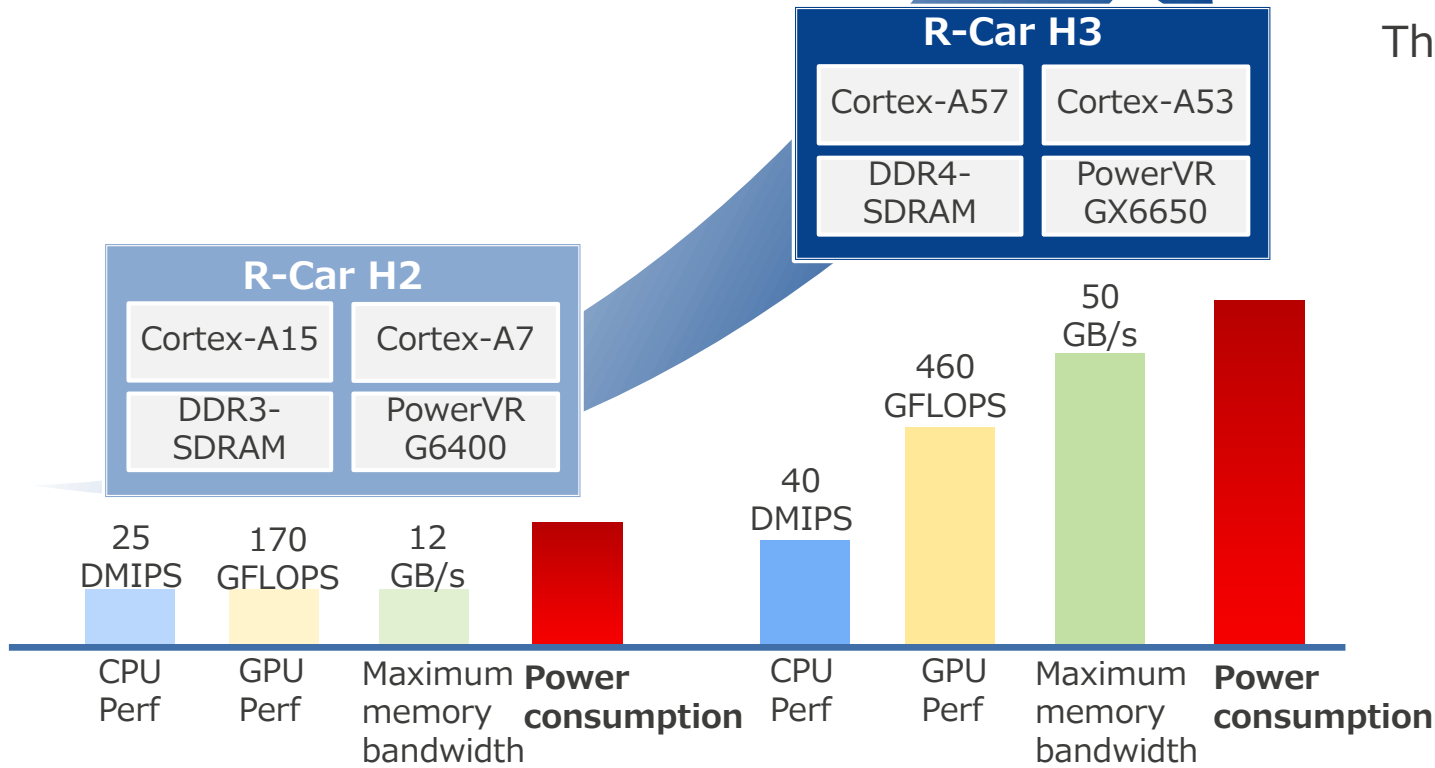
Renesas will provide solution which able to used by everyone on AGL community utilize full performance result of big.LITTLE hardware architecture.

Solution for reliable thermal control



Impact by increased power consumption

It's consuming more electricity accordance as its computing performance improvement

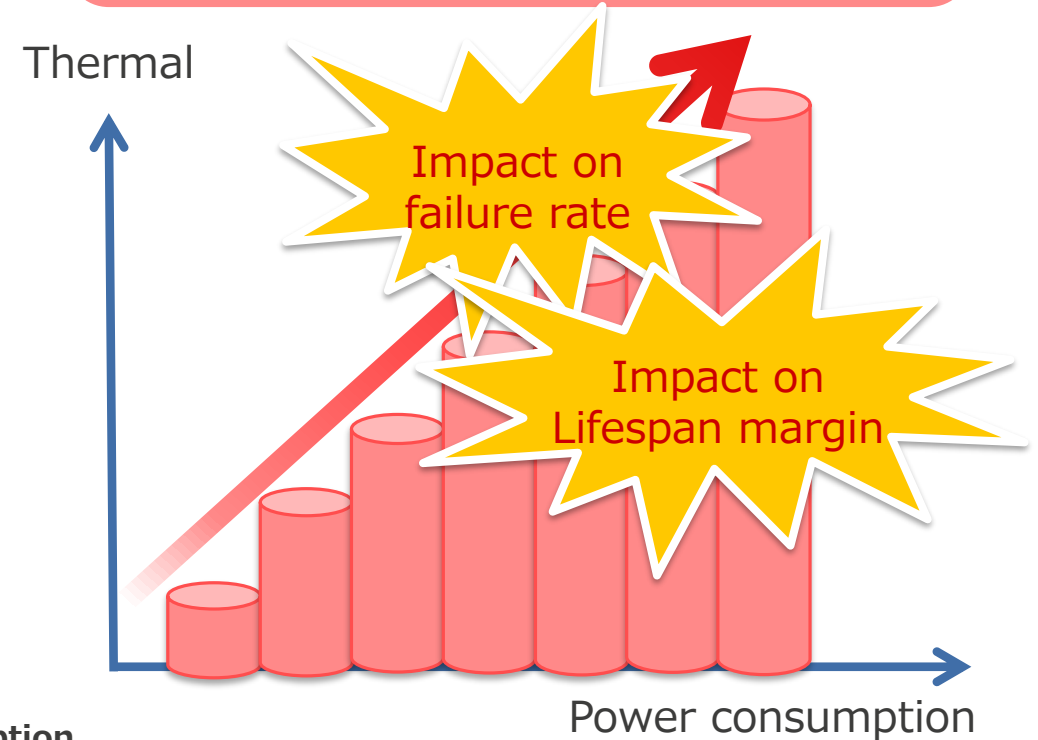


R-Car H3	
Cortex-A57	Cortex-A53
DDR4-SDRAM	PowerVR GX6650

R-Car H2	
Cortex-A15	Cortex-A7
DDR3-SDRAM	PowerVR G6400

When huge heat is generated by increased power consumption,

- ✓ Impact on lifespan margin
- ✓ Impact on failure rate



“thermal control feature” is needed to prevent to keeping lifespan margin and protecting failure rate.

How to approach to reduce thermal

To prevent thermal runaway ...?

HW approach

No heat radiation

With heat radiation

- Heat radiation devices
- Air-flow aware case design etc.

Impact on Lifespan margin

Impact on failure rate

SW approach

No thermal control

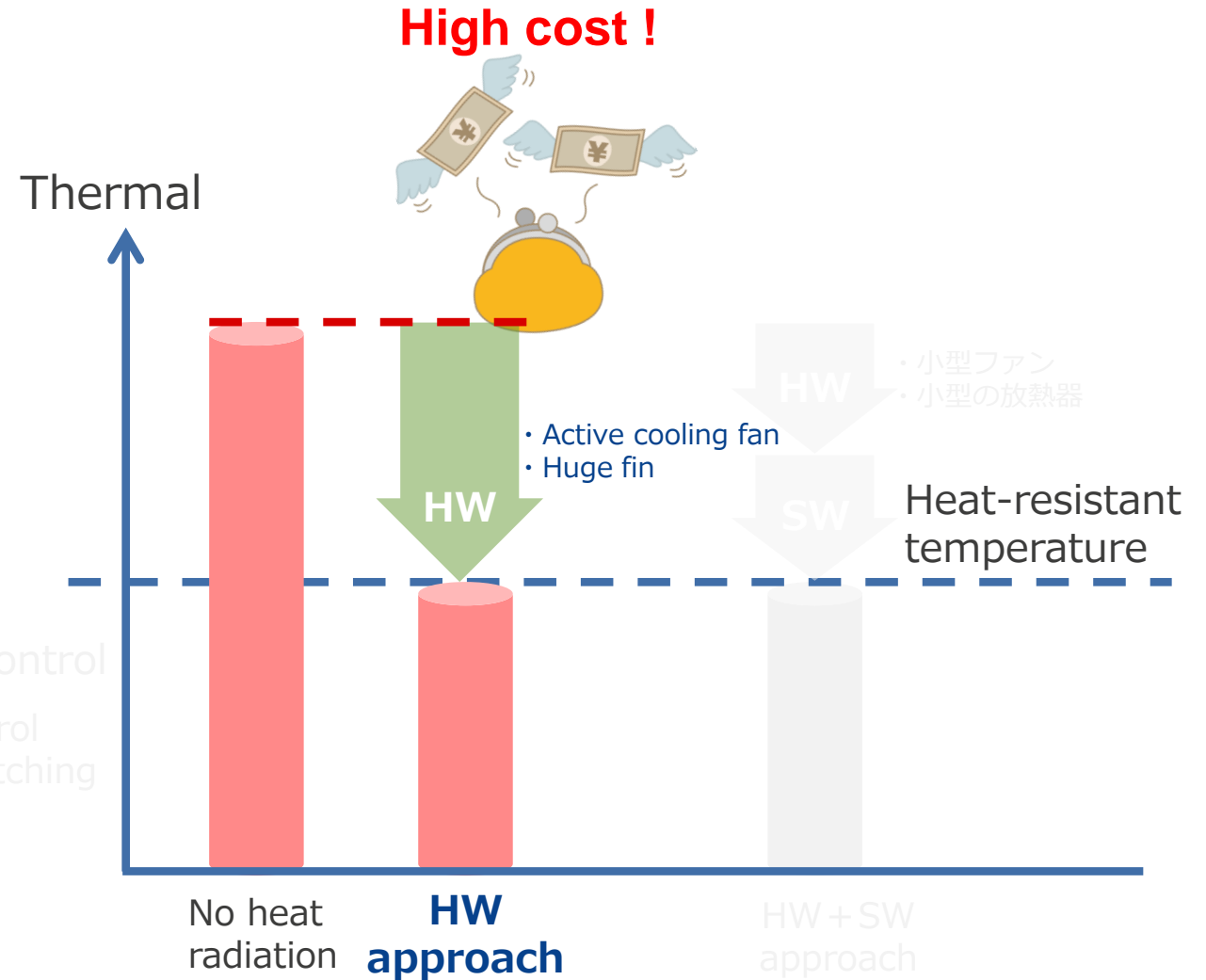
With thermal control

- Clock control
- Power switching

Lack of safety

High cost

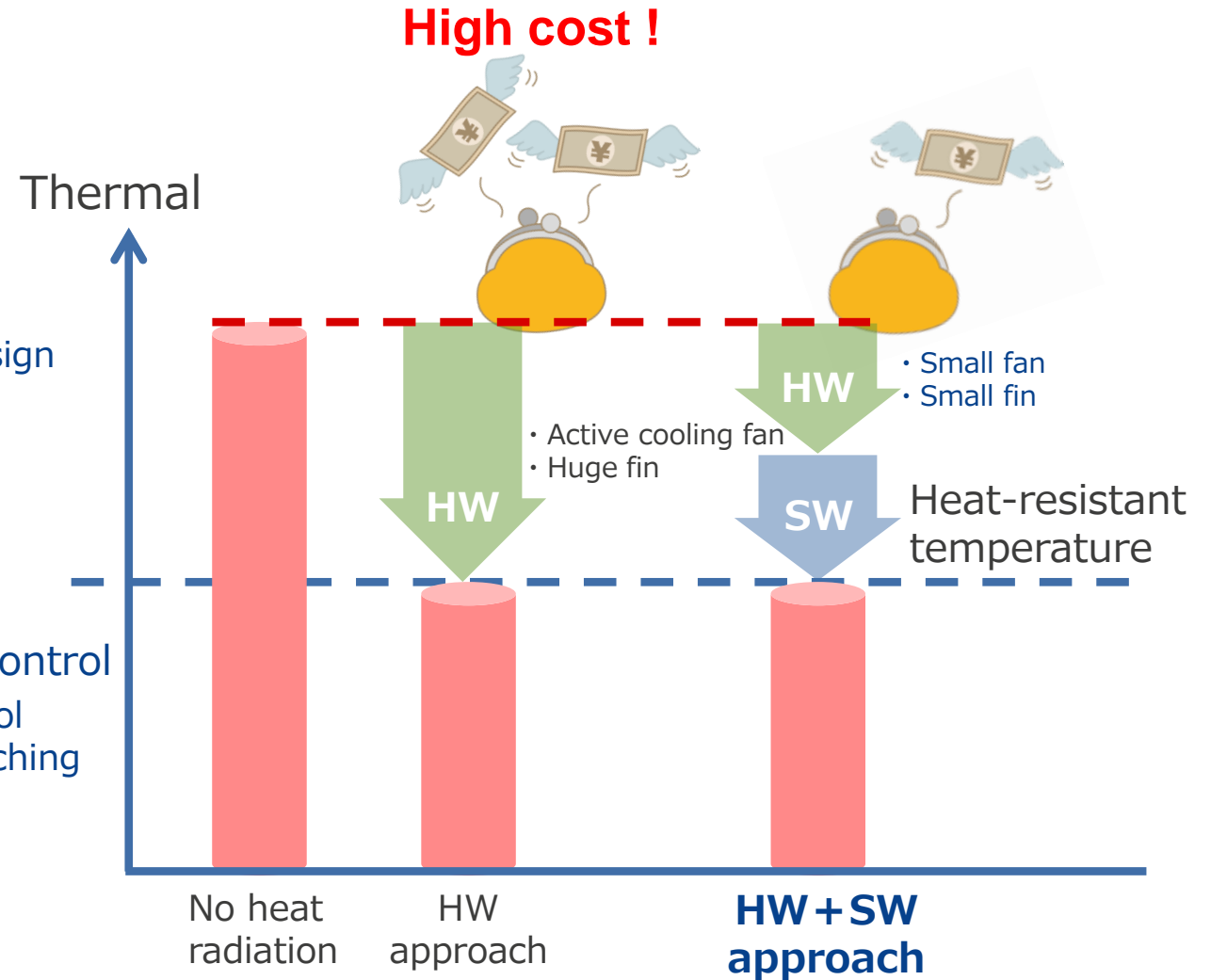
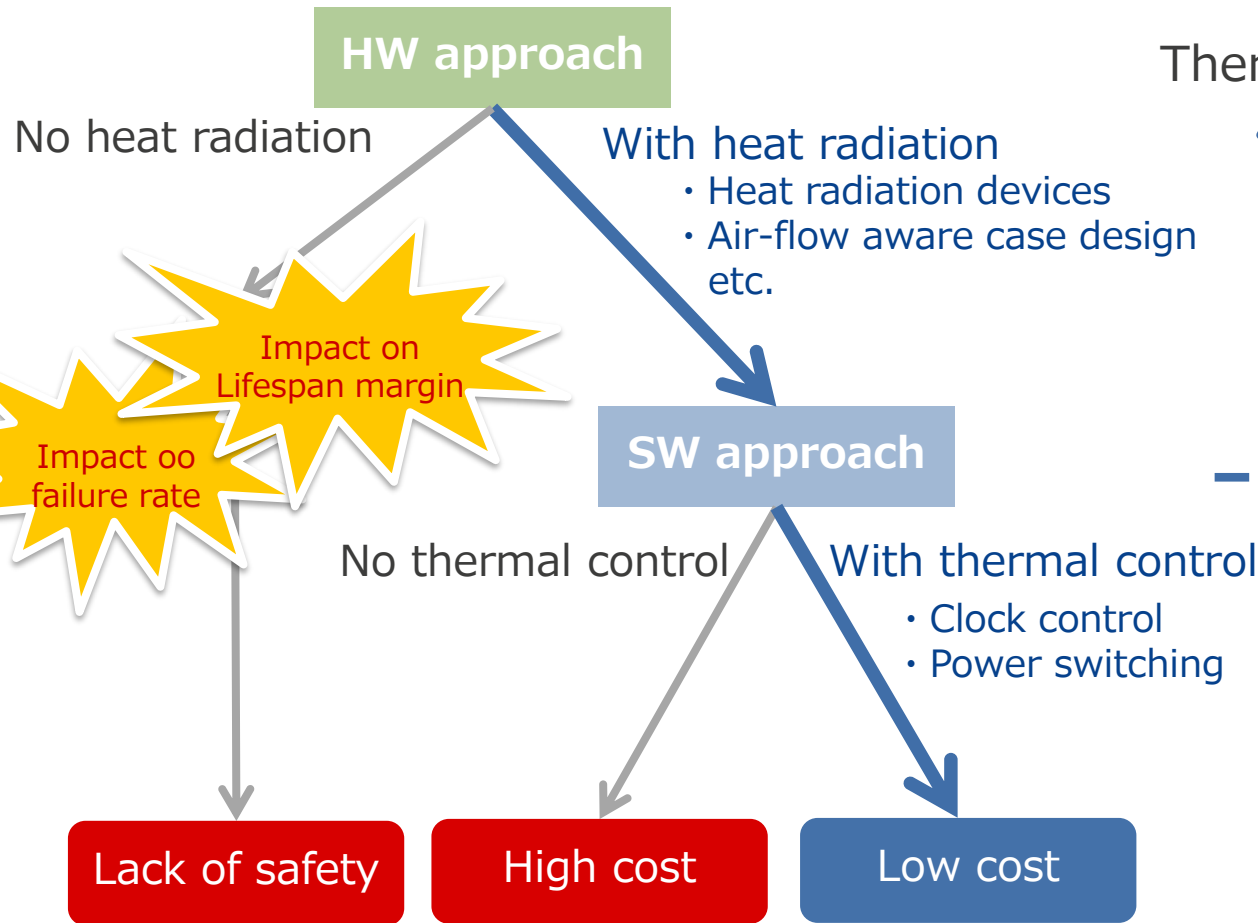
Low cost



Software approach is needed as it reduce heat generation just when it exceeded capability of hardware cooling devices.

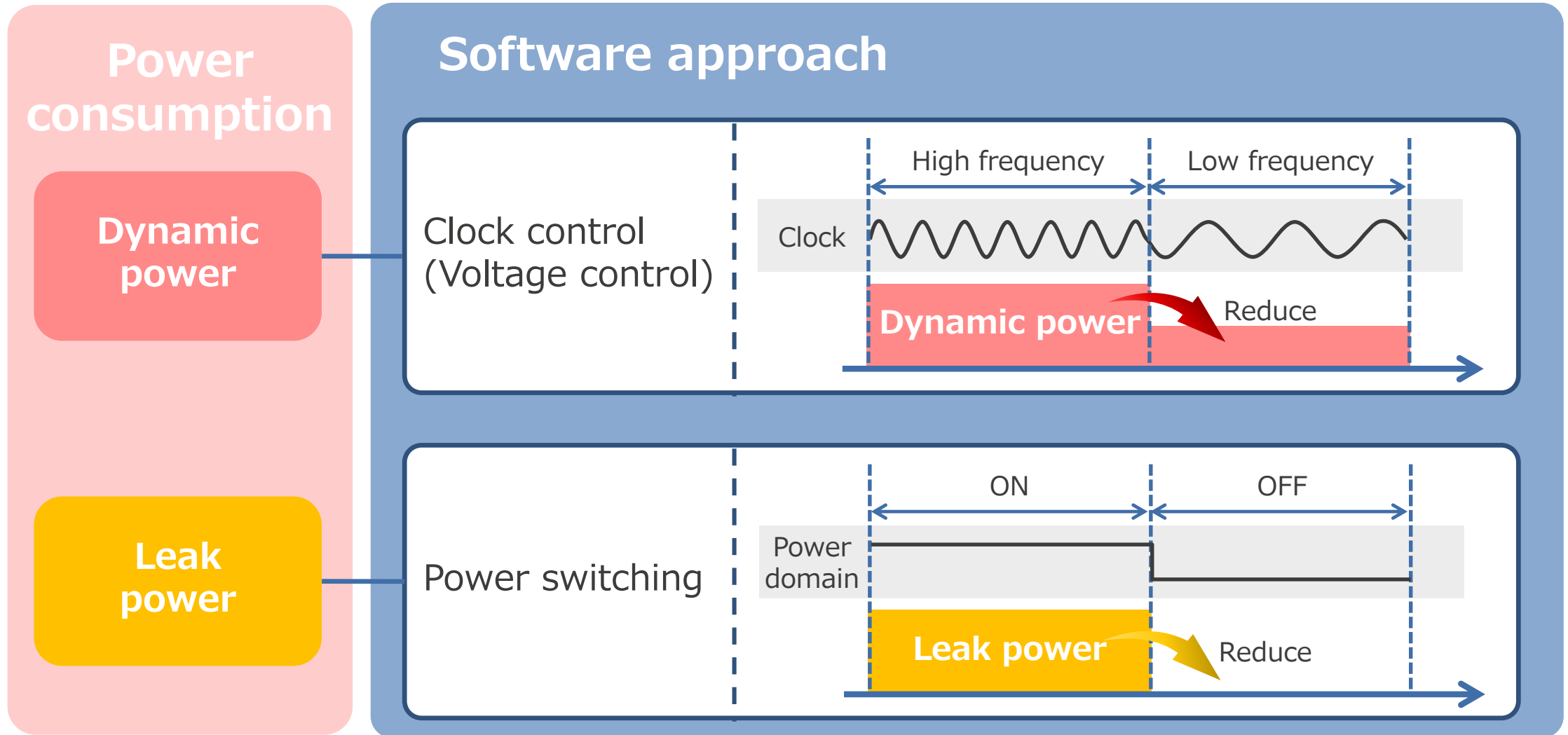
How to approach to reduce thermal

To prevent thermal runaway ...?



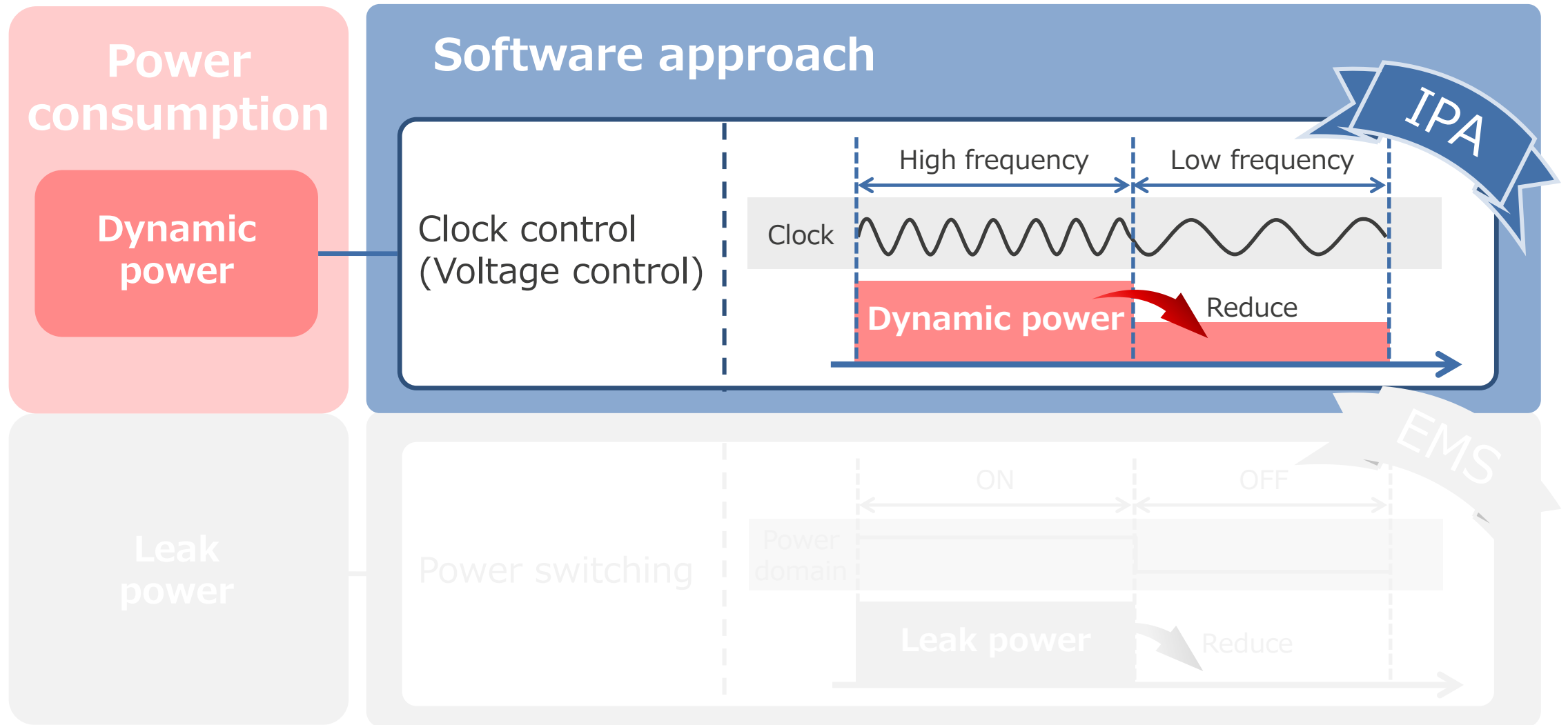
Software approach is needed as it reduce heat generation just when it exceeded capability of hardware cooling devices.

The methodology of the “thermal control feature” software design

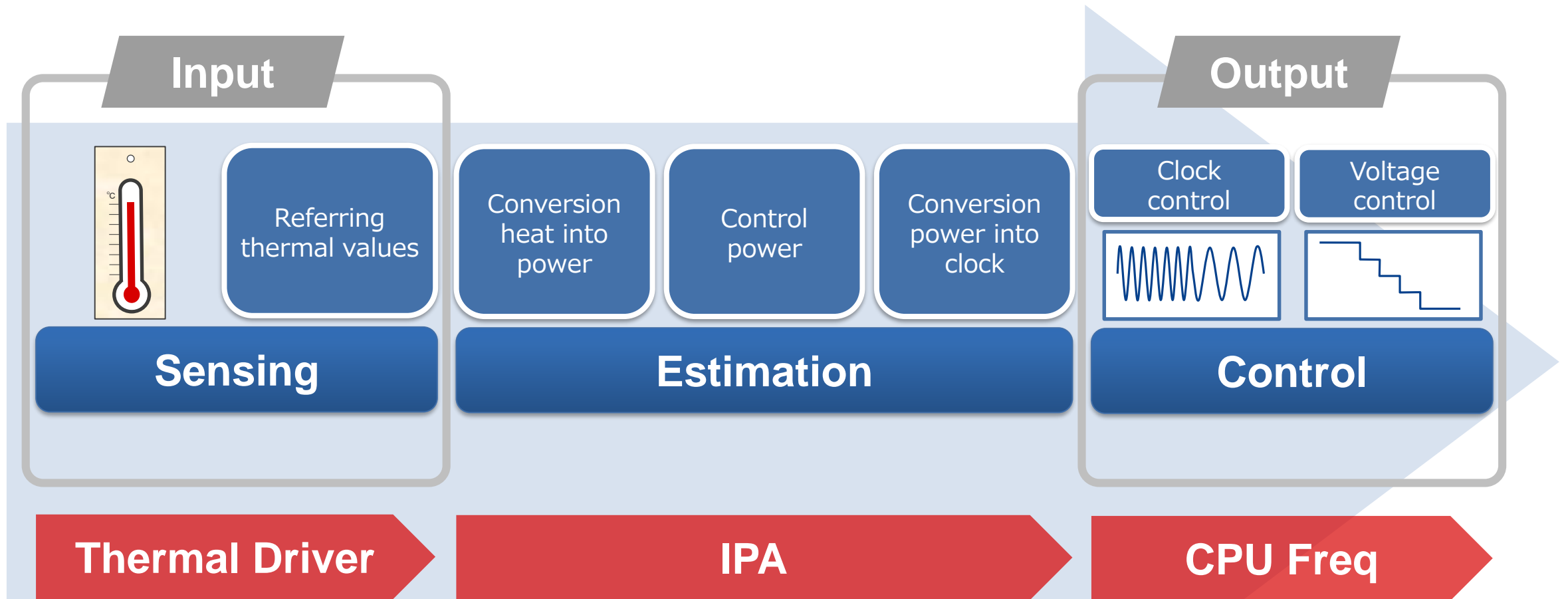


Software approach is able to reduce heat generation by declining power consumption with clock control and or power switching.

IPA(Intelligent power allocation) for software approach

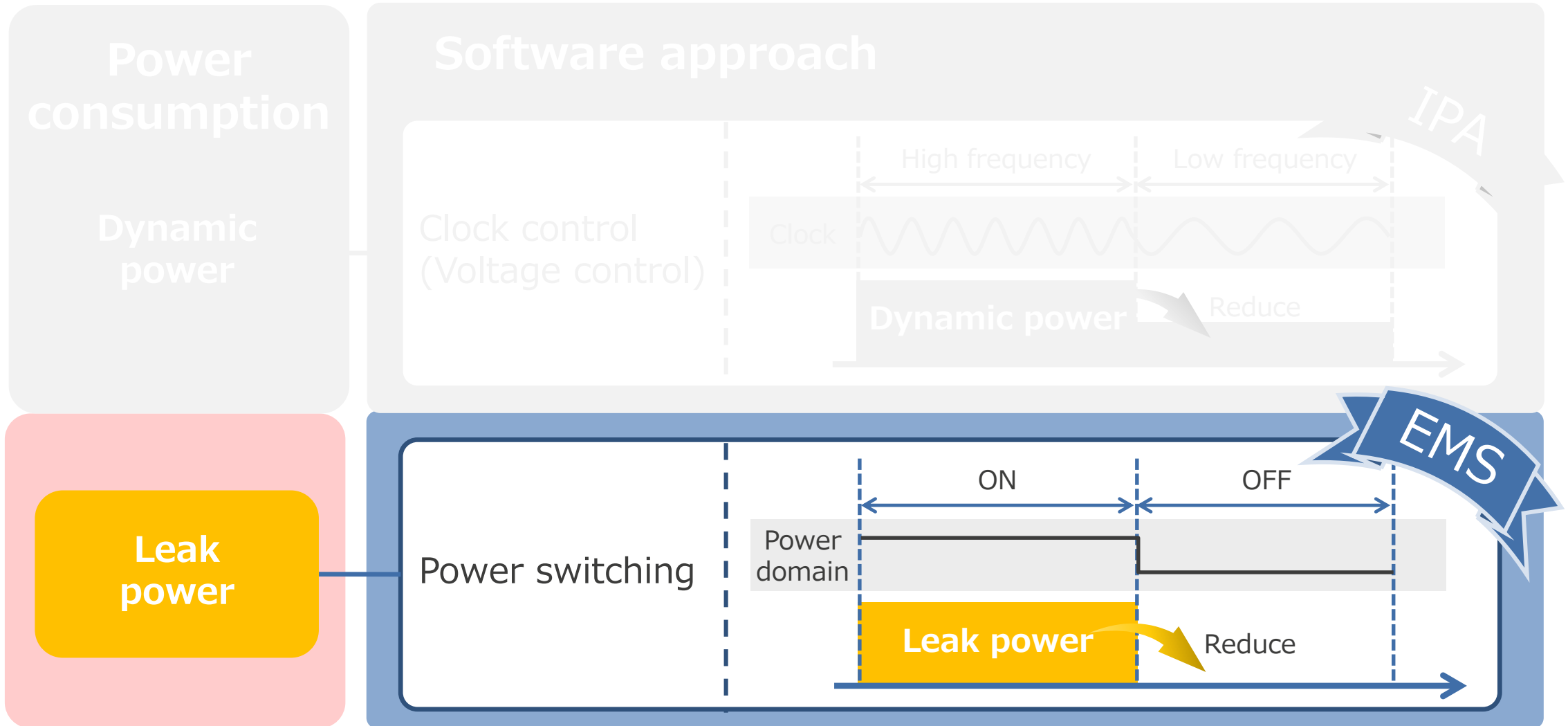


What is IPA ?

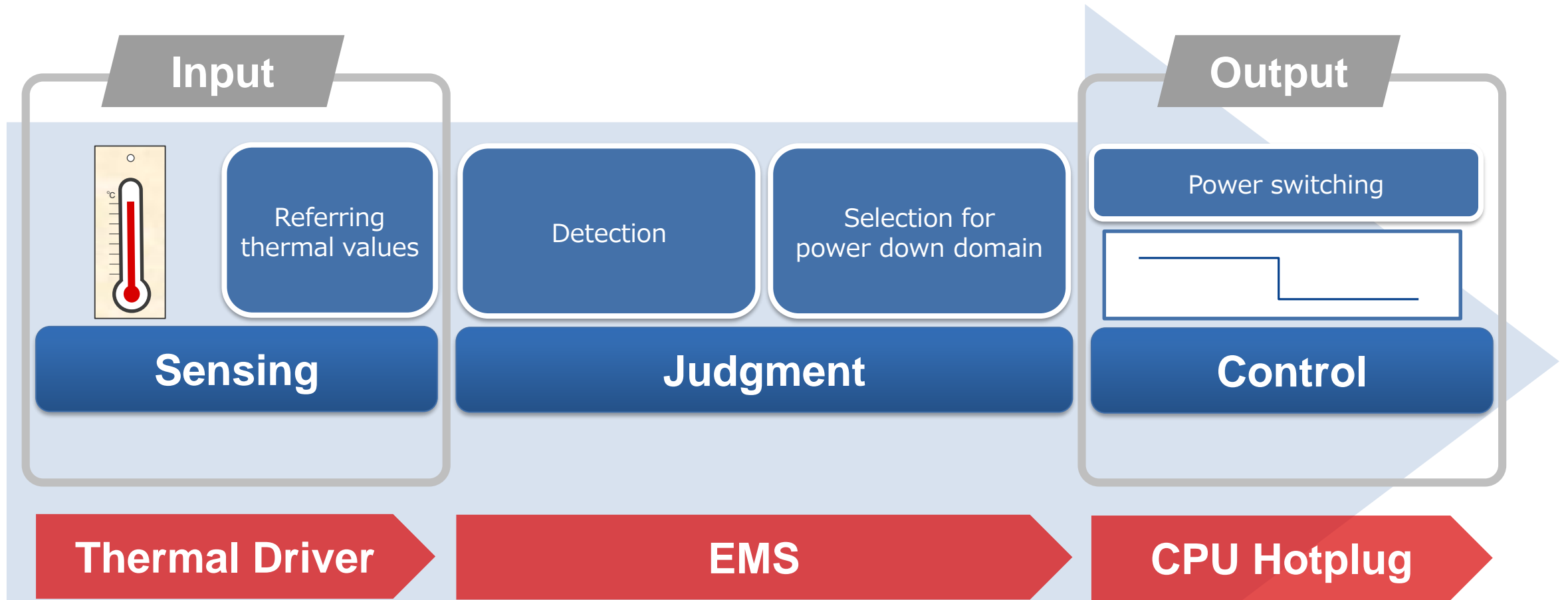


IPA reduces dynamic power and keep performance as maximum as possible under the thermal condition.

EMS(Emergency shutdown) for software approach

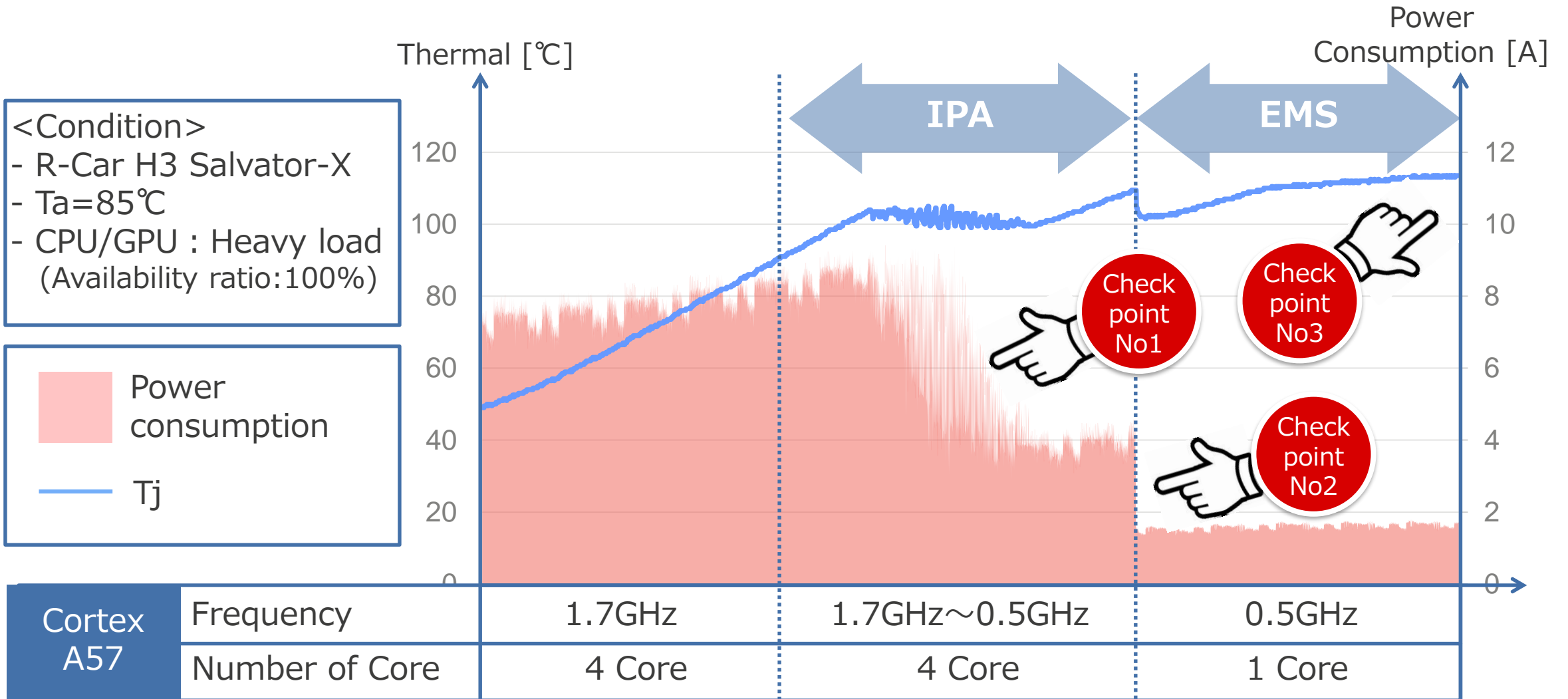


What is EMS ?



EMS reduces leak power as the "second safety net" for heavy thermal condition.

Evaluation for thermal control

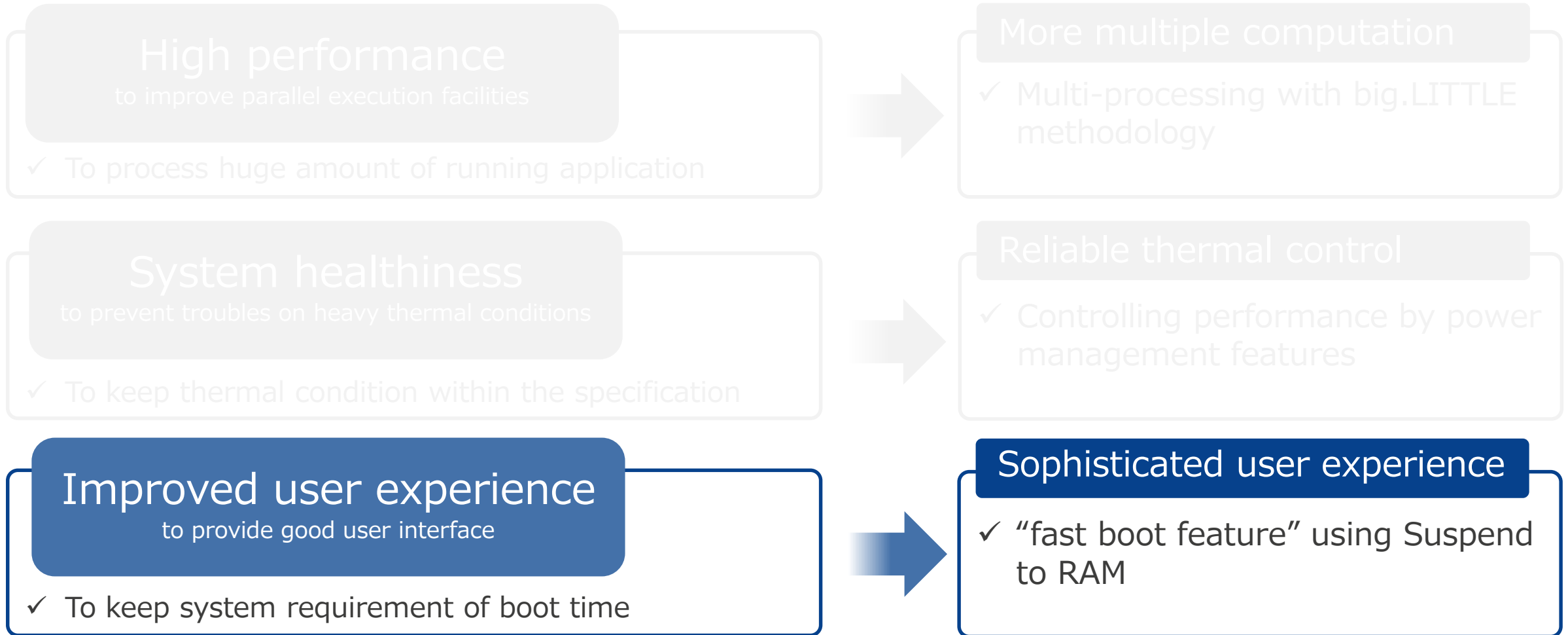


IPA and EMS are able to prevent thermal runaway in heavy thermal condition.

Conclusion of the “thermal control feature”

- ✓ Confirmed effectivity of the IPA and the EMS even the system operated in a quite extreme thermal condition.
- ✓ IPA and the EMS are able to use as the “safety net with the software thermal control solution”.

Solution for sophisticated user experience



Requirement of sophisticated user experience



Cooperation with
"cloud-solution"



Fast boot from engine starting

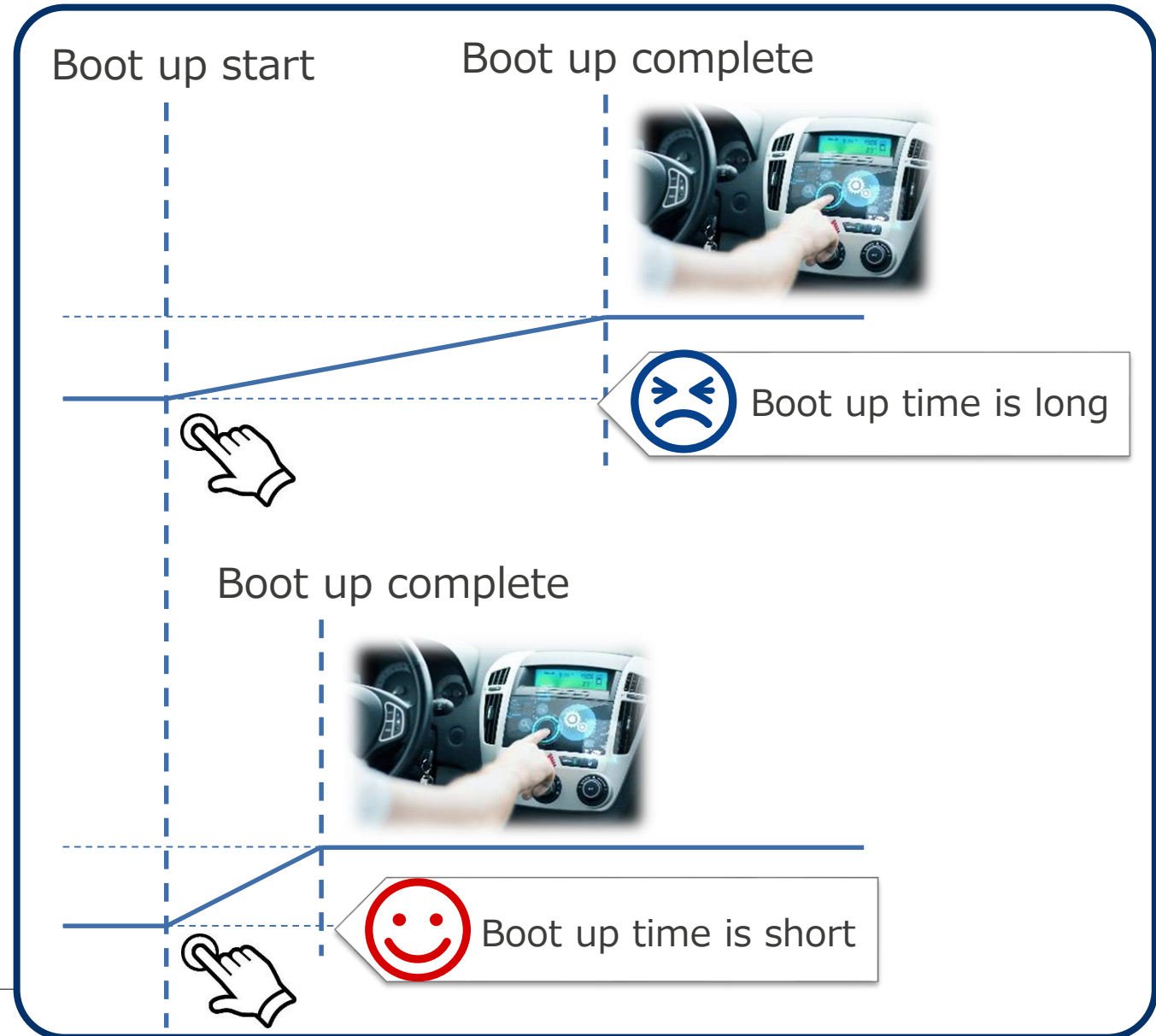


Voice / Image recognition



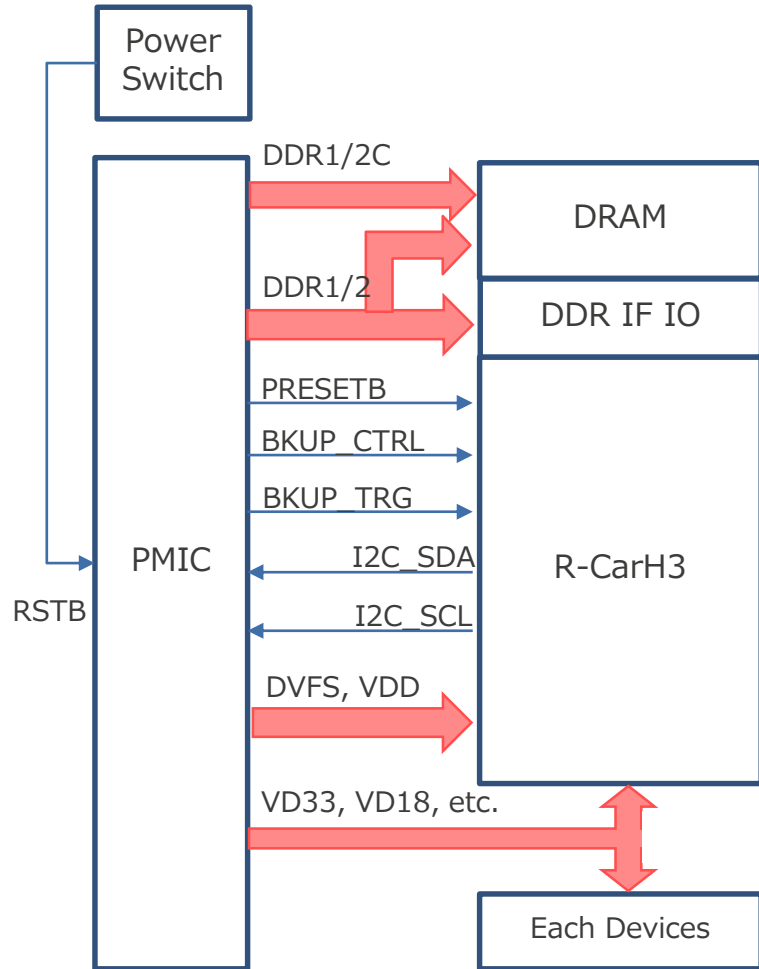
Augmented Reality

Background for requirements of fast boot facility on IVI system

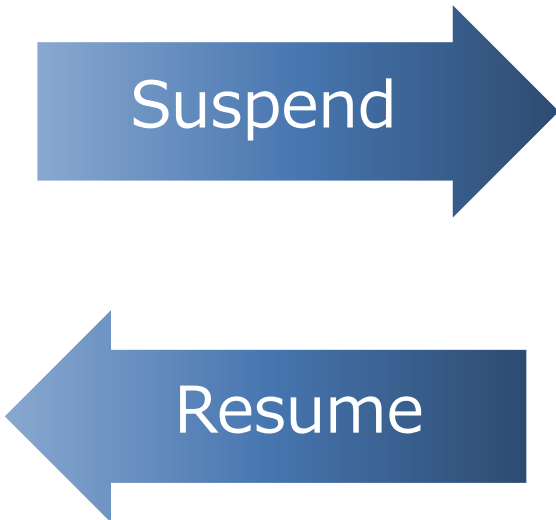
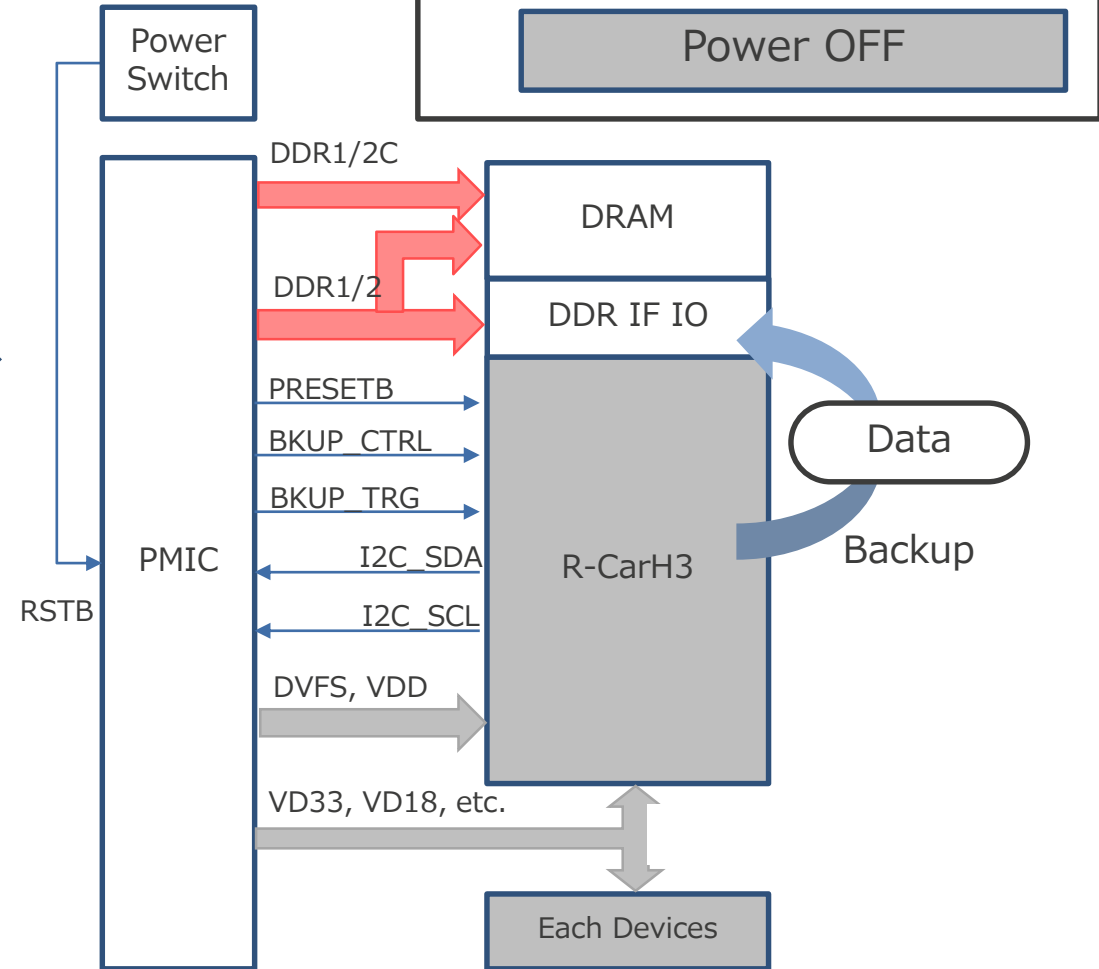


Overview of Suspend to RAM

Running system



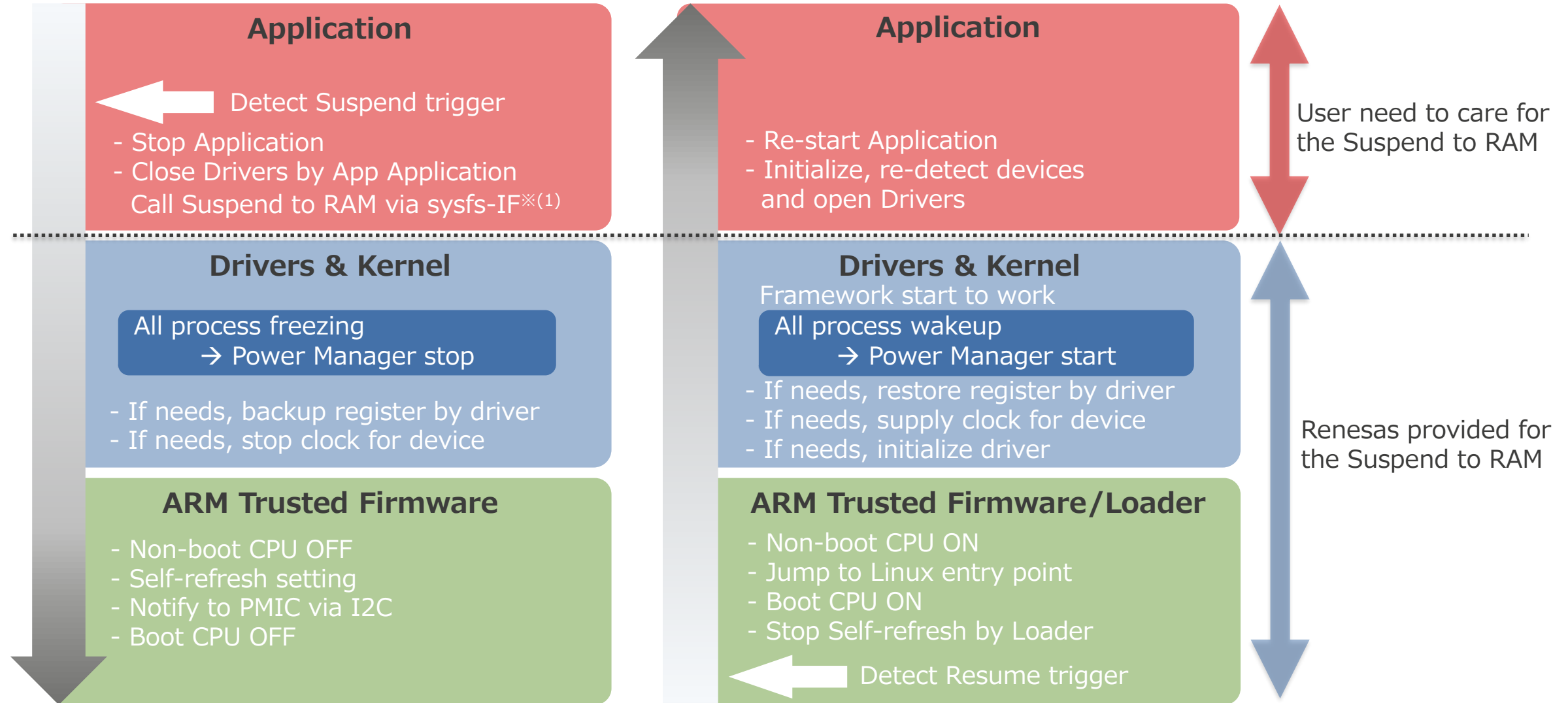
Suspend to RAM



Process flow of Suspend to RAM

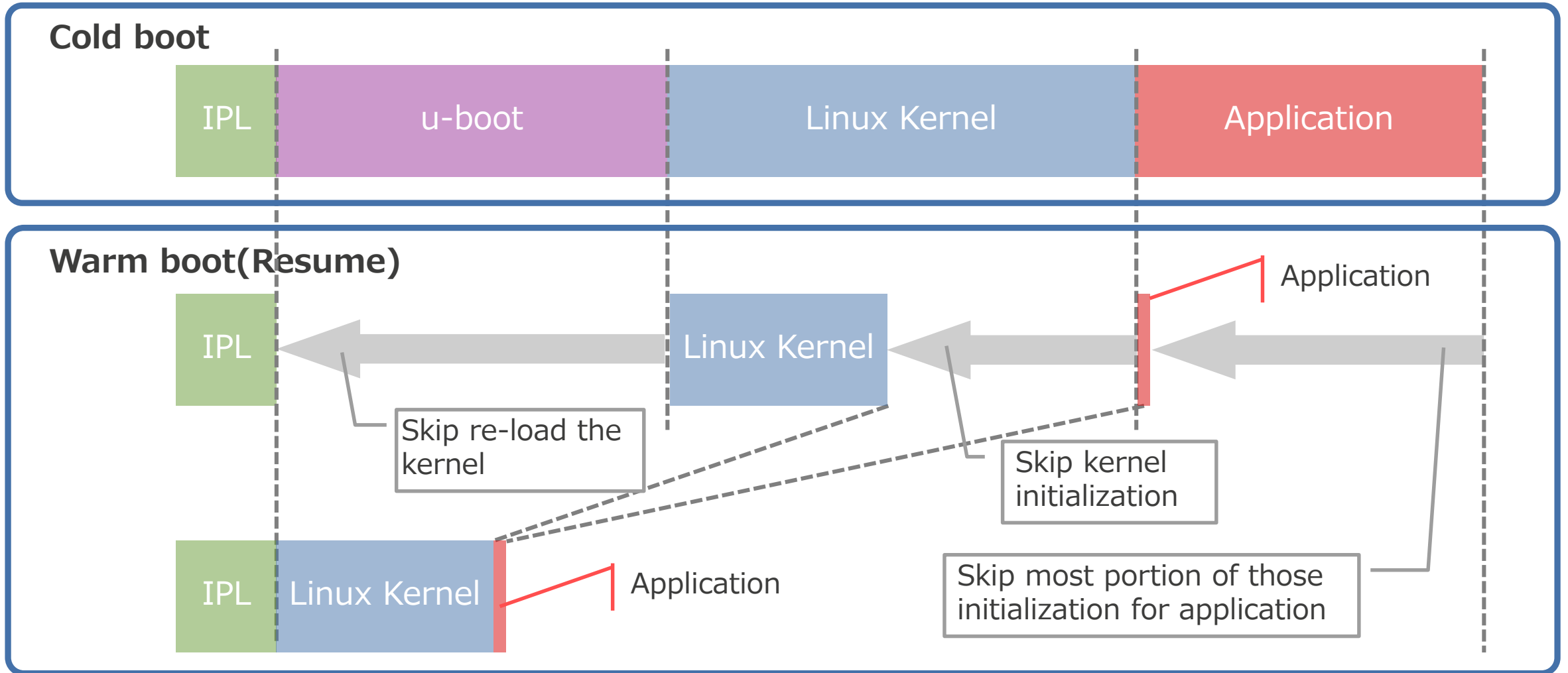
Suspend

Resume



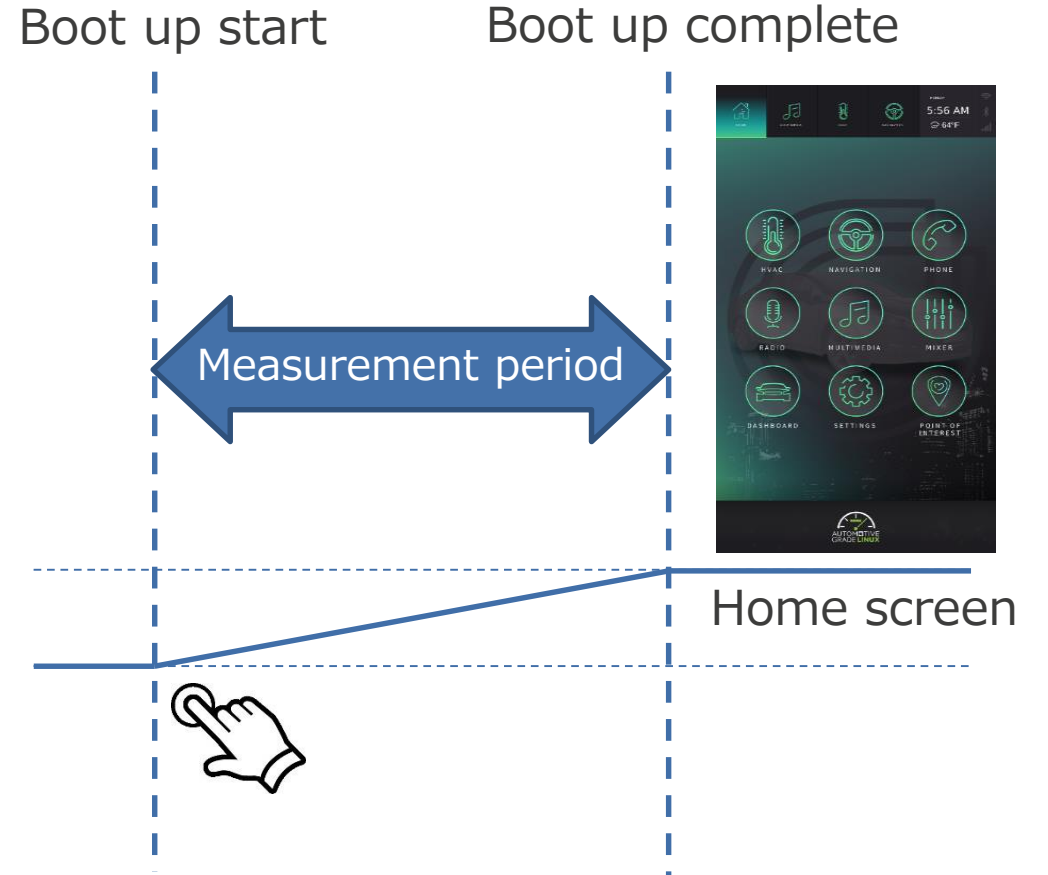
※1: # echo mem > /sys/power/state
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Mechanism for reduction of boot-up period



It's able to expect precise reduction of boot-up period with this Suspend to RAM facility.

Suspend to RAM on AGL environment



Board	R-Car Starter Kit Pro
Linux Kernel	v4.9
AGL	Daring Dab(As of May 9)

	Cold boot	Warm boot
Boot up time	12.8 [s]	3.9 [s]

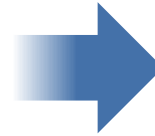
Conclusion of “Suspend to RAM facility”

- ✓ Confirmed the effort of the Suspend to RAM to get shorter boot-up period.
- ✓ Suspend to RAM is able to use as a effective candidate for provide fast boot facility in IVI systems.

Current status of three solution on AGL environment

High performance
to improve parallel execution facilities

- ✓ To process huge amount of running application



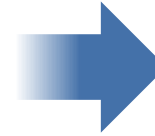
More multiple computation

- ✓ Multi-process methodology

Evaluation and performance tuning on AGLUCB DD

System healthiness
to prevent troubles on heavy thermal conditions

- ✓ To keep thermal condition within the specification



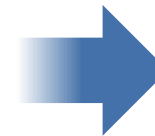
Reliable thermal control

- ✓ Controlling power management

Already contributed into AGL UCB DD

Improved user experience
to provide good user interface

- ✓ To keep system requirement of boot time



Sophisticated user experience

- ✓ "fast boot feature" to RAM

Already contributed into AGL UCB DD

In final conclusion

Renesas is providing many sort of solutions for customers and communities as a solution provider company.

Renesas will be contributing solutions to AGL and supporting it strongly.

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Appendix: Status of EAS

EAS has not been officially contributed to upstream community yet. Currently, ARM and Linaro are promoting this work, and it will take more time. If upstream community accepts EAS, it will be available in all Linux environments including AGL.

On the other hand, Renesas thinks as follows. BSP provided by Renesas is based on upstream first. So, EAS would be supported in BSP after acceptance by upstream community. However, Renesas has a plan to provide EAS to AGL in advance in order for AGL members to avail EAS as soon as possible. Renesas will announce this in near the future.

Appendix: Operation of Thermal control

Even you have to care about cause of HW failure, you are able to see effectiveness of IPA or EMS via sysfs under extreme thermal condition.

[IPA]

```
/* Checking current frequency of CPU */  
$ cat /sys/devices/system/cpu/cpu0/cpufreq/cpuinfo_cur_freq
```

[EMS]

```
/* Checking output log information */  
thermal emergency notifier: state=1 / Execute EMS  
thermal emergency notifier: state=0 / Release EMS
```


Appendix: Operation of Suspend to RAM on M3 SK

[Suspend]

1. Set to PMIC to backup mode via i2c-tools command:

```
$ i2cset -f -y 7 0x30 0x20 0x0F
```

2. Suspend to RAM can be operated via sysfs:

```
$ echo mem > /sys/power/state
```

[Resume]

1. Push SW8 (Power switch)

Appendix: Reference

IPA

<https://developer.arm.com/open-source/intelligent-power-allocation>

EAS

<https://developer.arm.com/open-source/energy-aware-scheduling>

CPU Hotplug

<Linux Kernel>/Documentation/cputopology.txt

<Linux Kernel>/Documentation/cpu-hotplug.txt

CPU Freq

<Linux Kernel>/Documentation/cpu-freq/user-guide.txt

Suspend to RAM

<Linux Kernel>/Documentation/power/states.txt