Thermal management using 'Generic Thermal FW'

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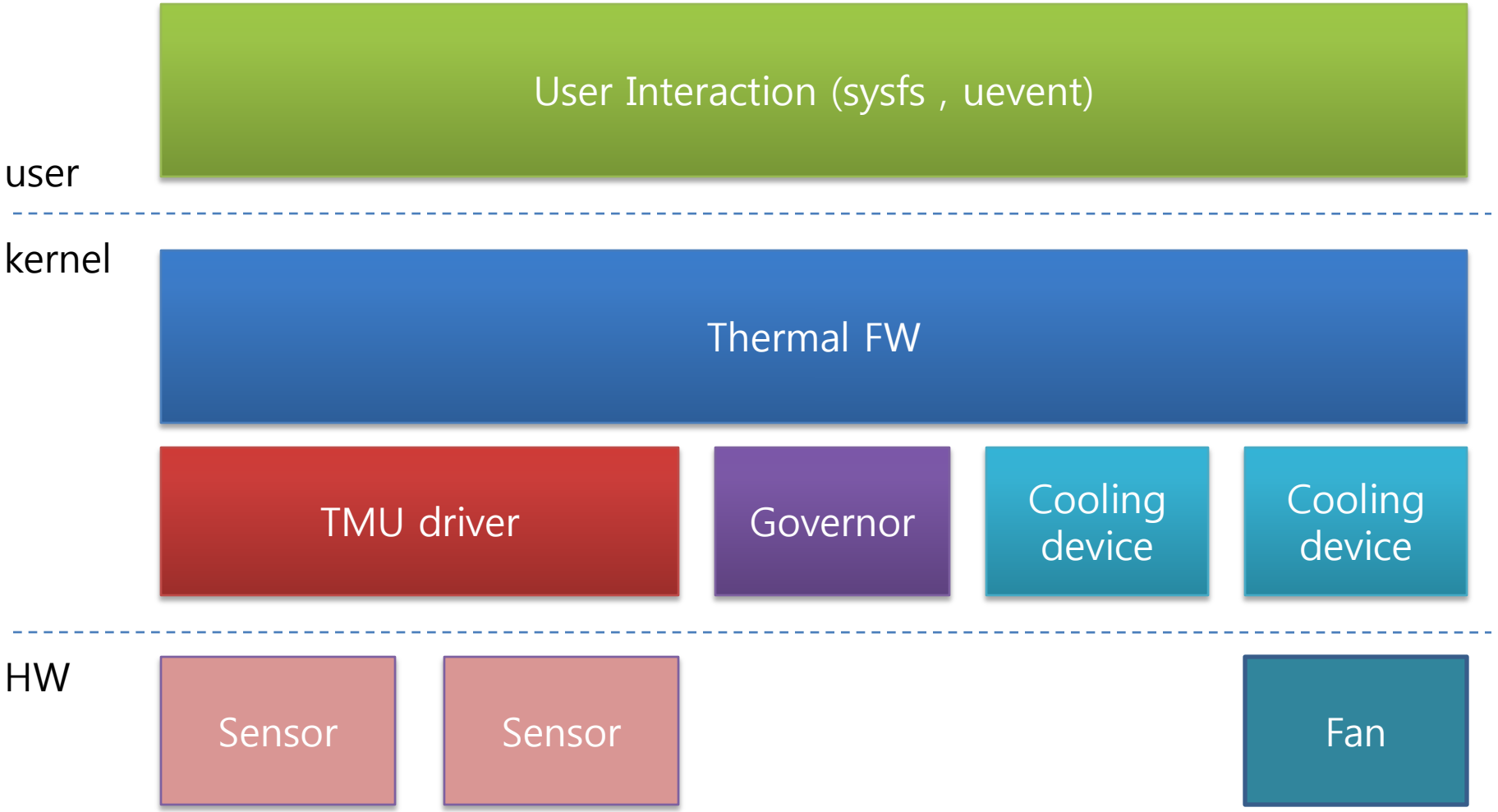
- Generic Thermal Framework
  - Thermal zone device
  - Cooling device
  - Binding & Thermal instance
  - Governors
  - SYSFS interfaces
- Thermal management
  - CPU Cooling device
  - EXYNOS thermal driver

THERMAL FRAMEWORK

Thermal Framework

- Thermal zone
- Thermal sensor unit
- Cooling device
- Governor
  - Fair share
  - Step wise
  - User
- SYSFS interface

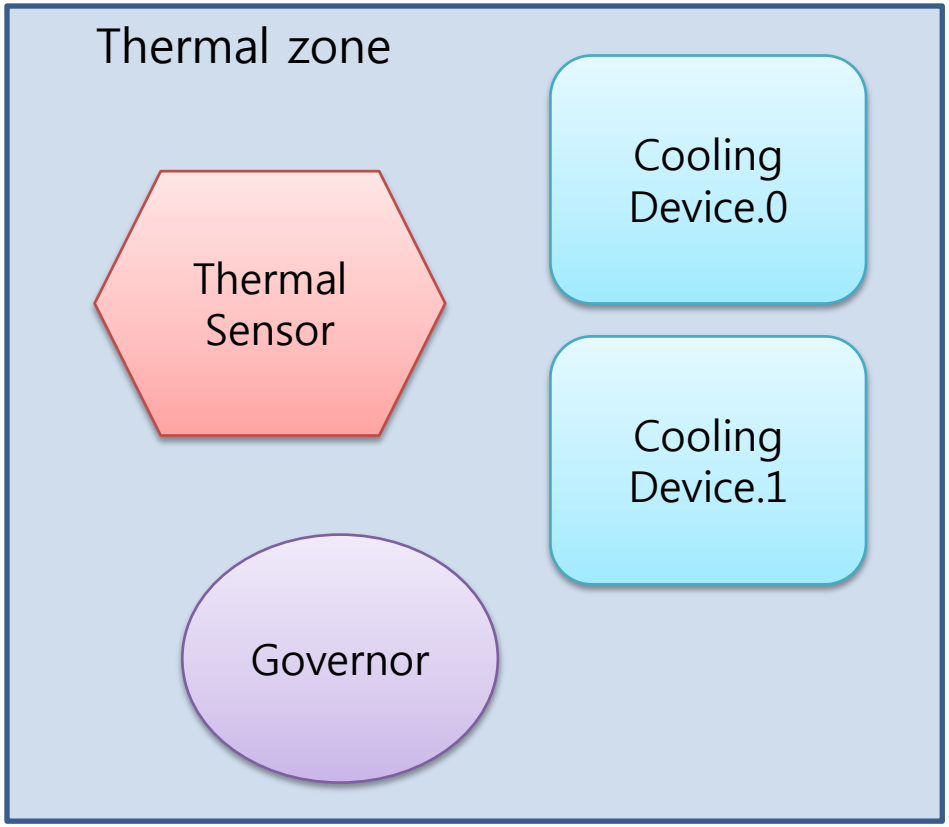
Thermal FW diagram (example)



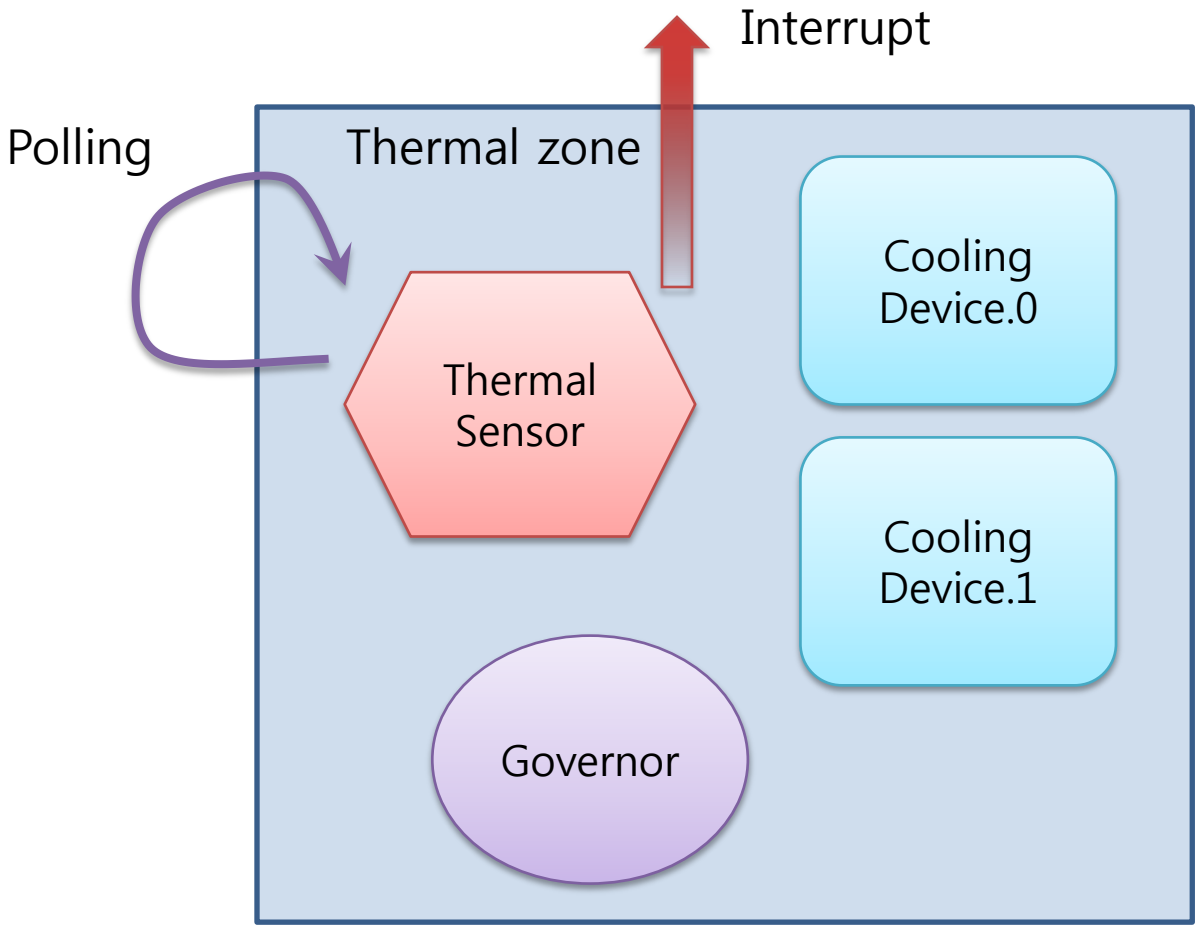
Devices in Thermal FW

- Thermal zone device
  - Represents a region managed by thermal framework.
  - Includes a thermal sensor and multiple cooling devices.

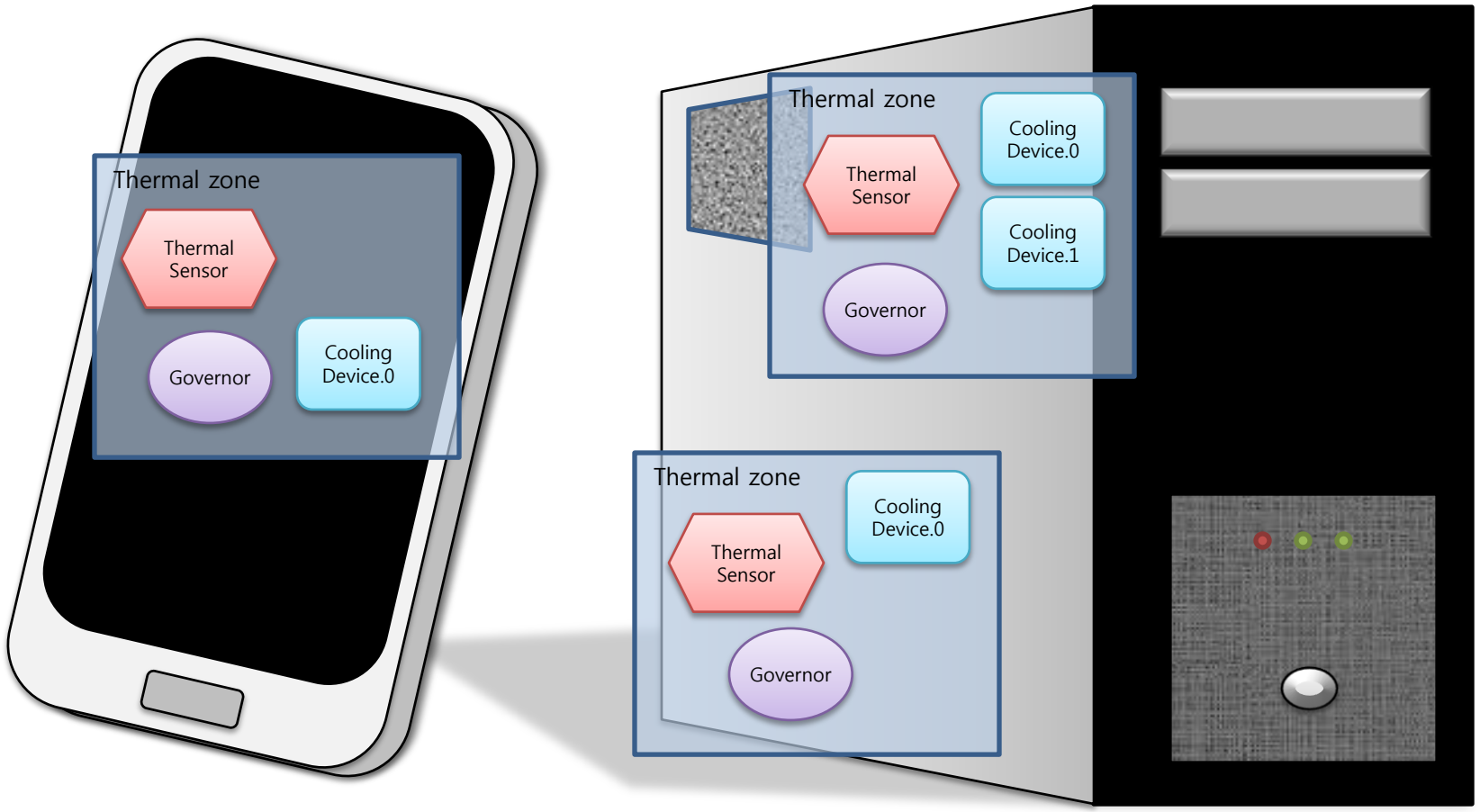
Thermal zone diagram



Thermal zone diagram



Thermal zone diagram



Devices in Thermal FW

- Cooling devices
  - Actual functional units for cooling down the thermal zone.
  - Can be hardware devices and also be software method.
    - Hardware : Fans, various physical cooler
    - Software : CPU frequency control

Binding

- Thermal zone devices and cooling devices will work after proper binding.
- Binding happens when any of thermal devices is newly registered.
- As a succeed result of binding, thermal instance would be created.

Binding

- Thermal instance
  - Describes how cooling devices work at certain trip point in the thermal zone.
  - Created at binding time of thermal zone devices and cooing devices.
  - Added to thermal devices' own thermal instances list.
  - Governor handles the thermal instance not thermal devices.

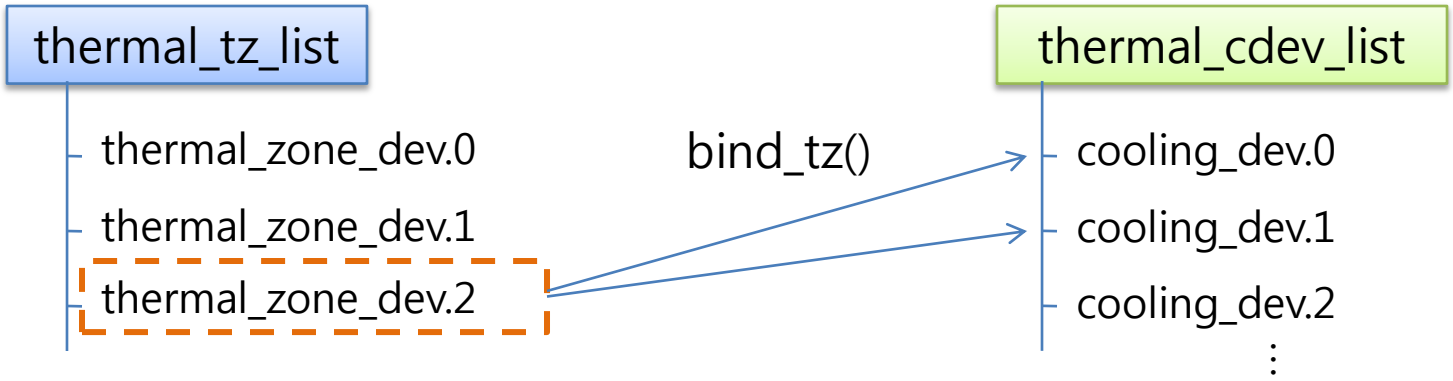
Binding


thermal_tz_list
thermal_zone_dev.0
thermal_zone_dev.1
thermal_cdev_list
cooling_dev.0
cooling_dev.1
cooling_dev.2

Binding

- Newly thermal zone device is registered.
- After attaching to the list, it seeks cooling devices which can be bound to it.

Binding



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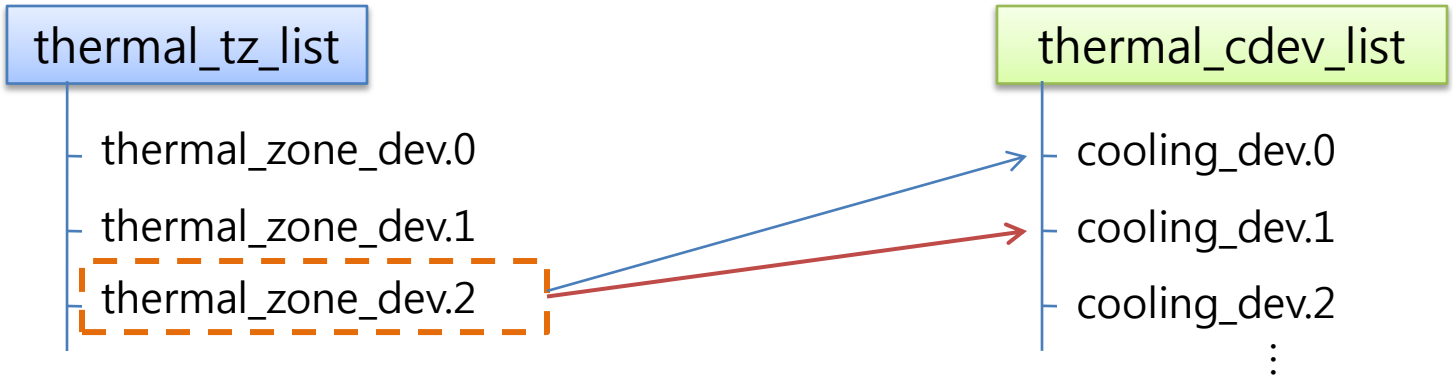
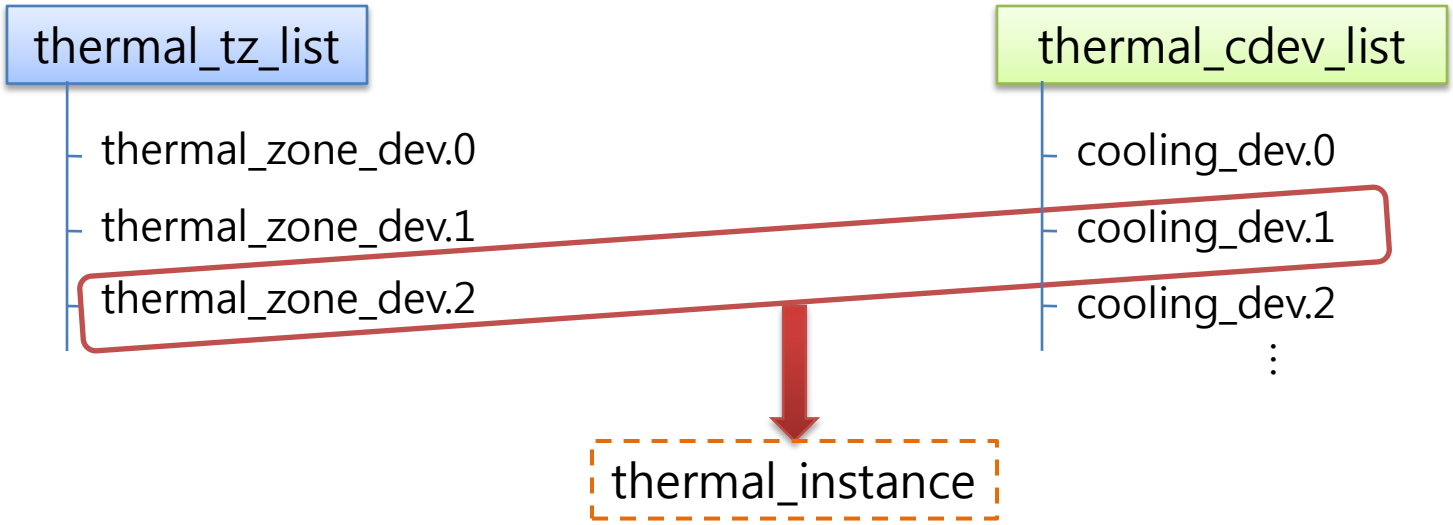
Binding



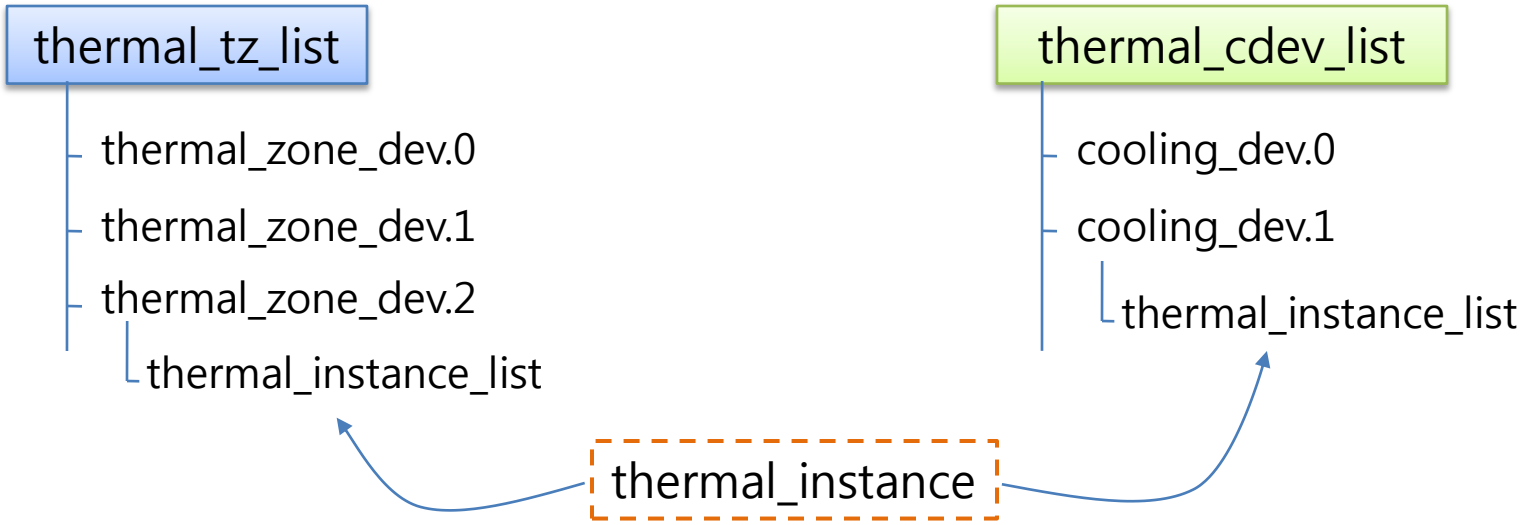
- Binding can be done with
  - platform data's matching function (.match( ))
  - driver's binding function (.bind( ))

Binding



- After succeed binding, thermal instance will be created.

Binding



- Lastly, it adds thermal instance to related device's list
- It is almost same when cooling device is registered.

Governors

- Determines cooling policy.
- Currently, three candidates exist.
  - USER_SPACE
  - FAIR_SHARE
  - STEP_WISE
- Can be varied for each thermal zone.

Governors

- Step wise governor
  - Sets cooling state based on thermal trend.
    (STABLE, RAISING, DROPPING,
    RASING_FULL, DROPPING_FULL)
  - Allows only one step change for increasing or decreasing at decision time.

Governors

- Fair share governor
  - Sets cooling state according to its efficiency and potential ability and also current state.

$$\frac{Current\_trip}{total\_trips} \times max\_state \times \frac{weight}{100}$$

  - Gives the higher cooing state to more weighted device.

SYSFS interface

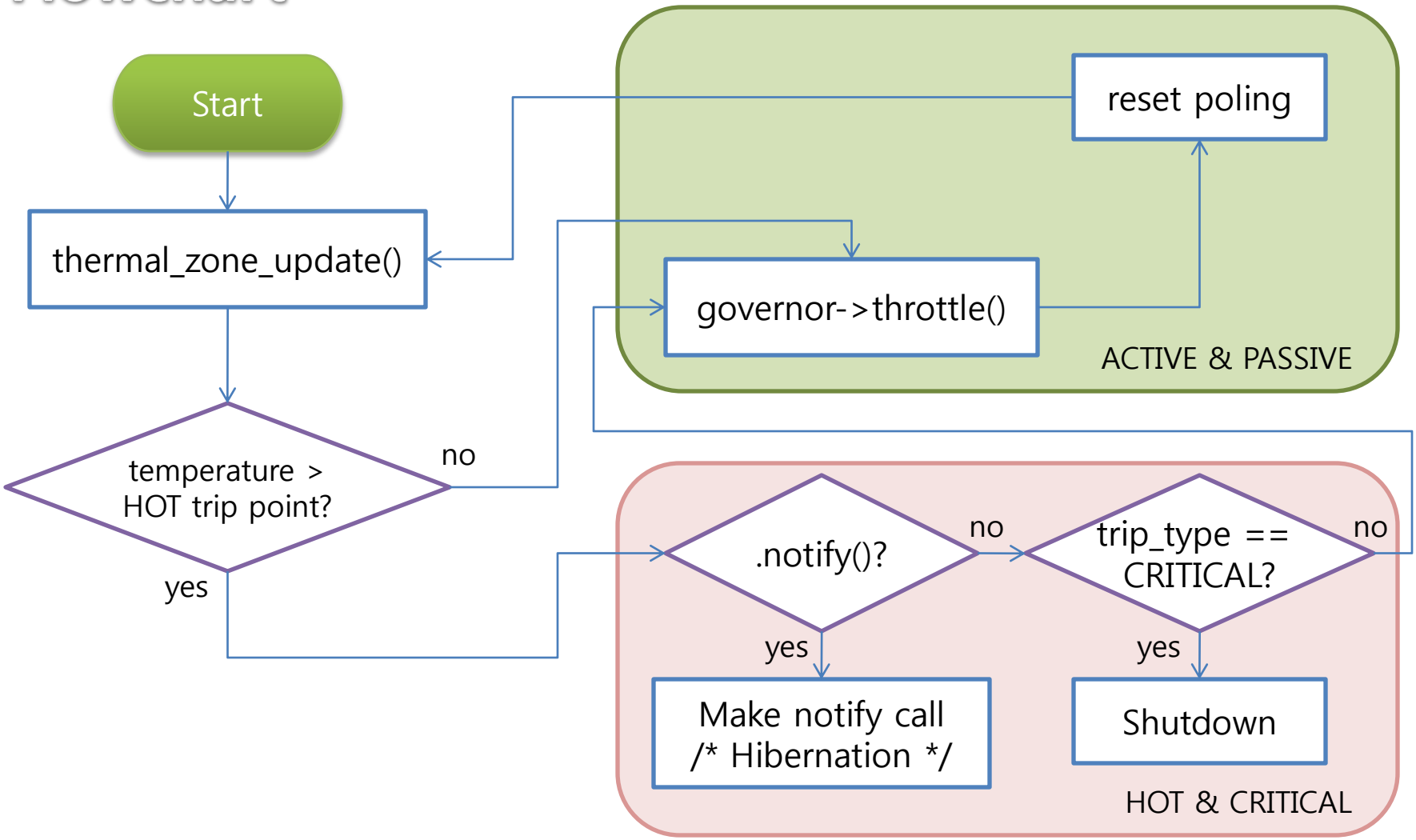
- Nodes under '/sys/class/thermal/thermal_zone'
  - Get basic information
    (name, enabling, cooling devices)
  - Manage how to work
    (set governor, trip temperature,
    passive, hysteresis, emulation)
  - Monitor current state
- Nodes under '/sys/class/thermal/cooling_device'
  - Get basic information (name)
  - Set/get cooling state

THERMAL MANAGEMENT

Thermal management

- Thermal management starts with updating thermal zone.
  - thermal_zone_device_update().
- Possible factors for updating thermal zone.
  - Polling
  - Interrupt
  - Passive

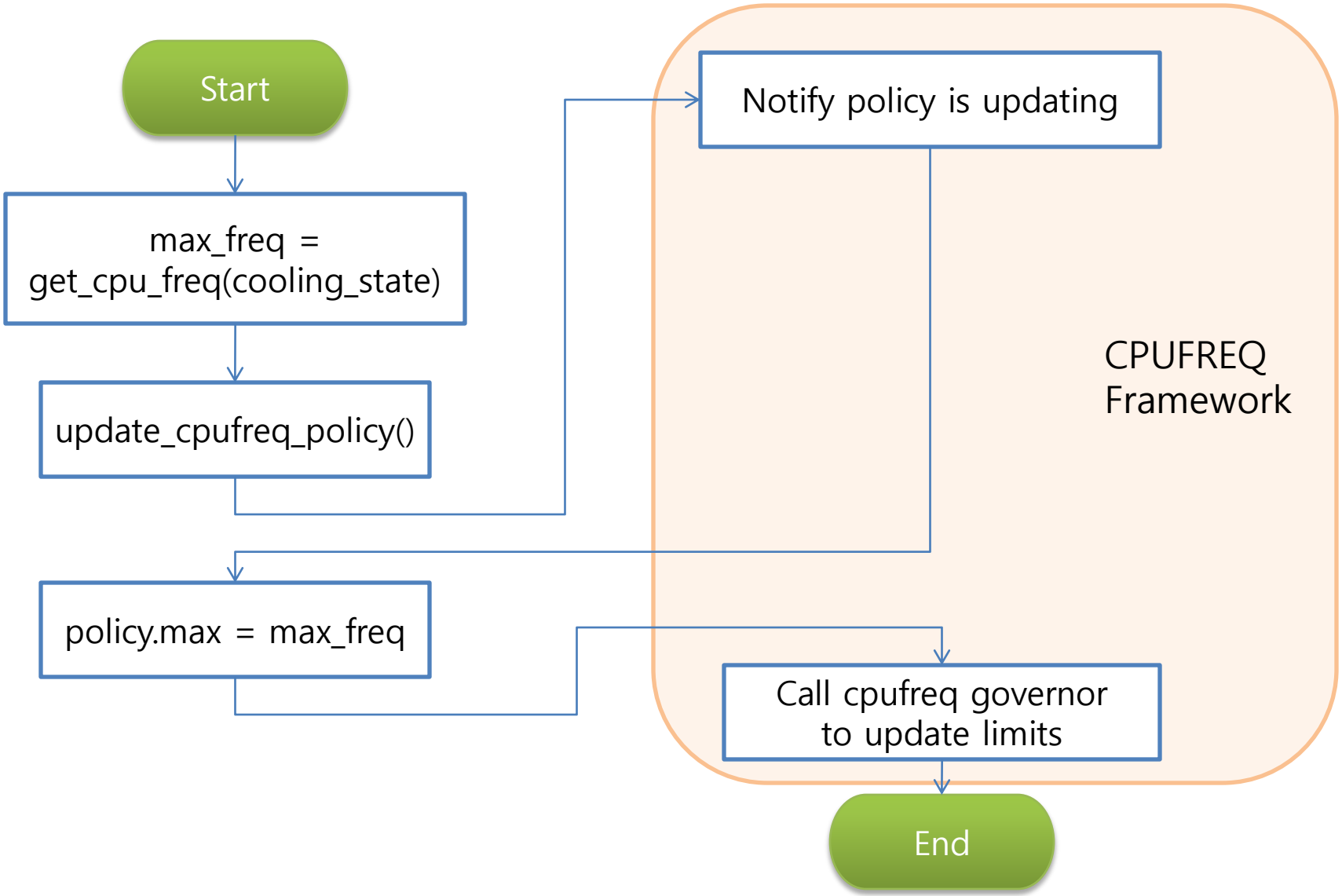
Thermal management Flowchart



Thermal management

- CPU cooling device
  - Controls CPU frequency according to cooling state.
  - Higher cooling state, lower frequency.
  - Limits the maximum CPU frequency with updating CPUFREQ policy. (Indirect)

CPU Cooling Flowchart



EXYNOS's thermal driver

- EXYNOS TMU(thermal management unit)
  - Features
    - HW interrupt (Falling/Raising)
    - Trip point (hardware)
    - Temperature history (currently not using)
    - Trimming
    - Emulation

EXYNOS's thermal driver

- Trimming
  - Trimming value is runtime value supported by HW. (TRIMINFO register)
  - Sensor's value can be calibrated with. (noise compensation)

T_ERROR = TRIM - 25

T(℃) = sensor_T – (T_ERROR)

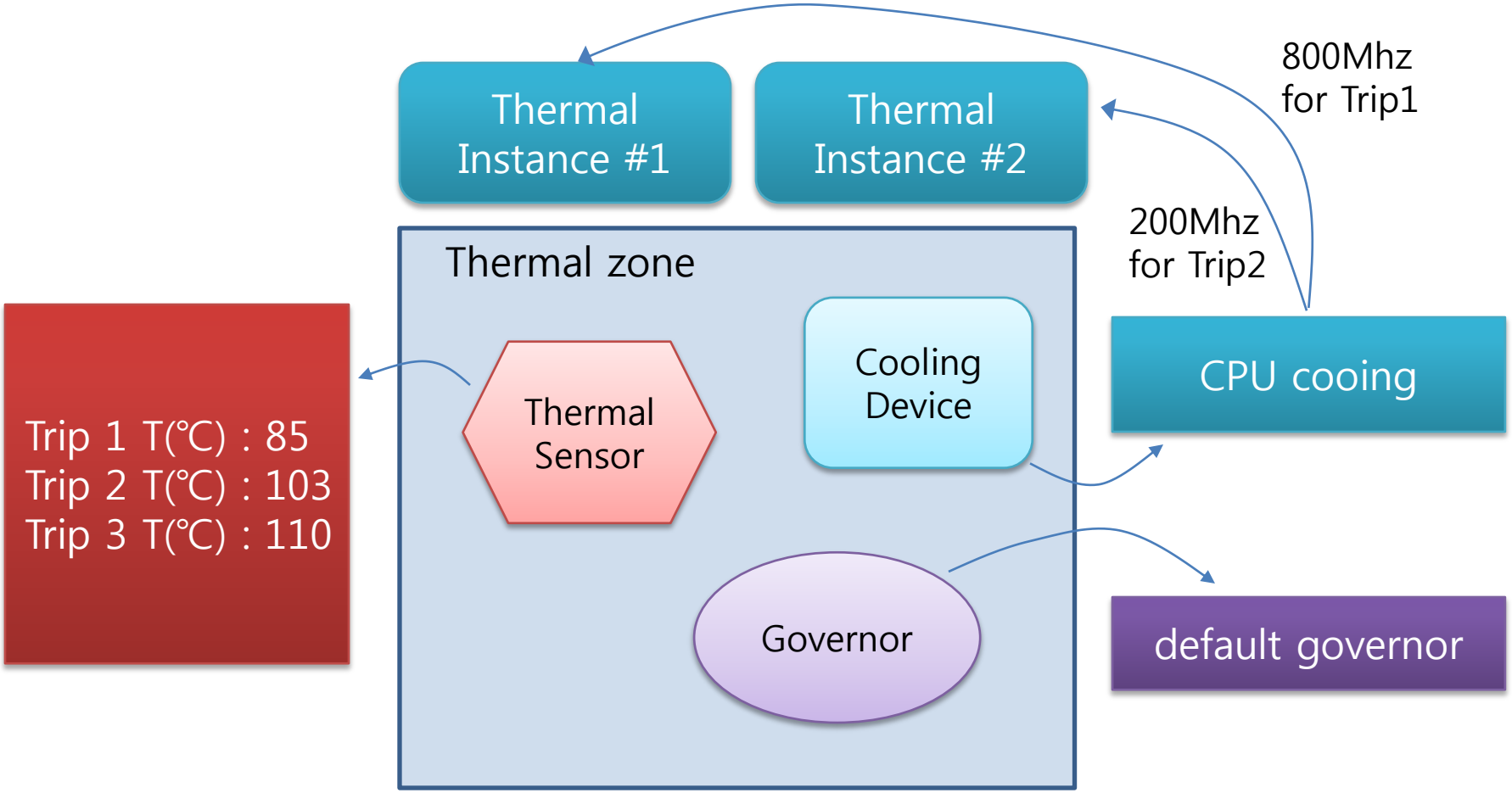
EXYNOS's thermal driver

- Emulation
  - For test purpose, EXYNOS TMU supports hardware emulation mode.
  - Emulation temperature can be set with sysfs node, 'emul_temp'.
  - Hardware interrupt also works in emulation mode.

EXYNOS's thermal driver

- Cooling device
  - Currently exynos_thermal driver uses CPU cooling device only.
  - When create CPU cooling device, it sets 0 for CPU mask. (Core 0)
  - At binding time, it creates multiple thermal instances based on number of ACTIVE trips.

EXYNOS's thermal driver



Thermal management in TIZEN

- Up to TIZEN 2.0, it doesn't support generic thermal framework.
  - It supports same functionality with private platform driver.
- Generic thermal framework will be supported from 3.0.

To do

- Thermal FW is isolated.
  - No available APIs to get thermal data.
  - Hard to know current thermal state.
- Solution can be one of followings,
  - Introducing APIs to get thermal data.
  - Implementing notification method.
  - Allowing to add own thermal handler.

In progress

- To open thermal data is now attempting.
  - [Patch] : 'Get thermal zone device by name'
- To separate sensor from thermal zone as a new thermal device. It'll enable,
  - multiple sensors in one thermal zone.
  - more intuitive binding of thermal zone units.

Q & A