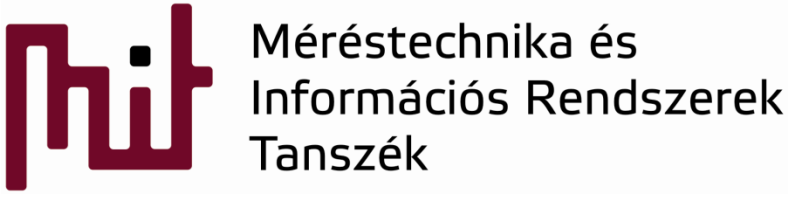
Embedded and Ambient Systems
2021. 11. 09.

Portable code, virtualization



Portable code

- A certain functionality can be reused in several environment, e.g.:
  - Different HW
  - Different compiler
  - Different operation system,
  - Different library functions
- Portability requirements of a code:
  - Only slight HW dependence is allowed
  - Contains only few HW specific parts (as few as possible)
  - Exploits only minimal specialties of a certain compiler or SW environment (IDE)
- Advantages:
  - Most of the functions are implemented in SW -> code reuse is important
  - Development time can be reduced, code parts can be reused with small overhead
  - Less amount of errors: a tested, frequently used code should be reused
- Structured programming (see: robust- and structured programming lectures)

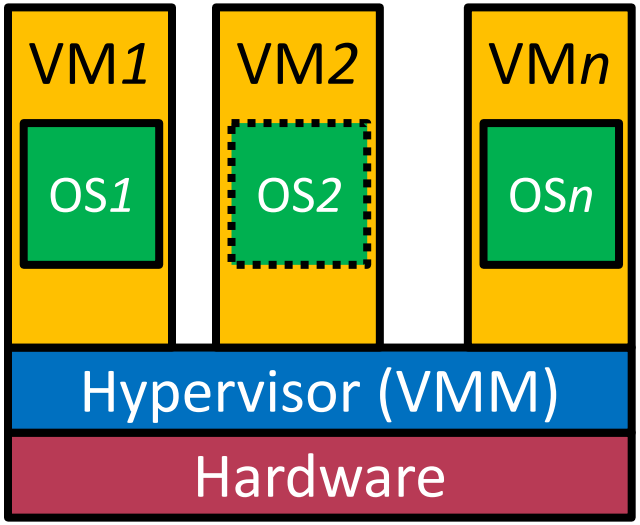
Portable code

- Operation systems (OS):
  - A large step toward portability
  - The application program uses only the functions of the OS, low-level HW handling remains hidden
  - Tailoring of the OS to a certain processor (porting) is done by someone else (e.g. processor manufacturer)
  - Proliferation of Linux in embedded systems:
    - Supports real-time operation
    - Scalable
    - Low-level programming is possible

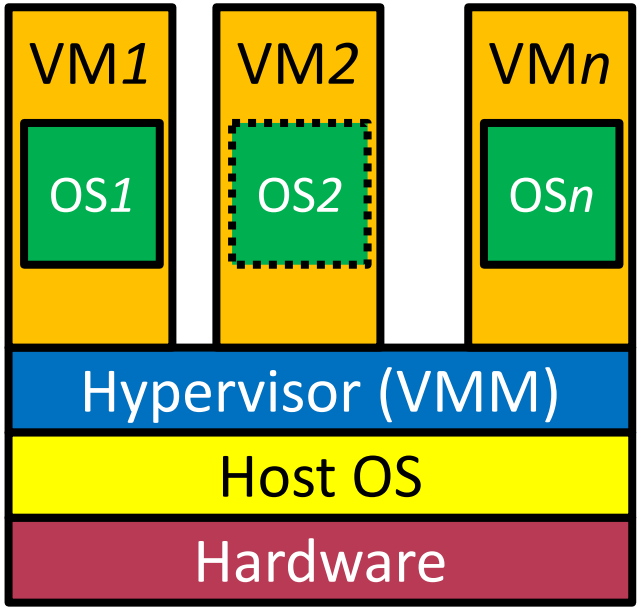
Virtualization

- The application SW shall be run on the processor via a uniform platform
  - In a PC environment a good example is Java (JVM: Java Virtual Machine), that offers access to the resources of the computer independently of the OS
- Proliferation of visualization can be seen not only in PC but also in embedded environment
  - Processors become more and more powerful
  - Wide spectrum of the processors
  - Several applications
  - Time to market is an important issue

Model of operation



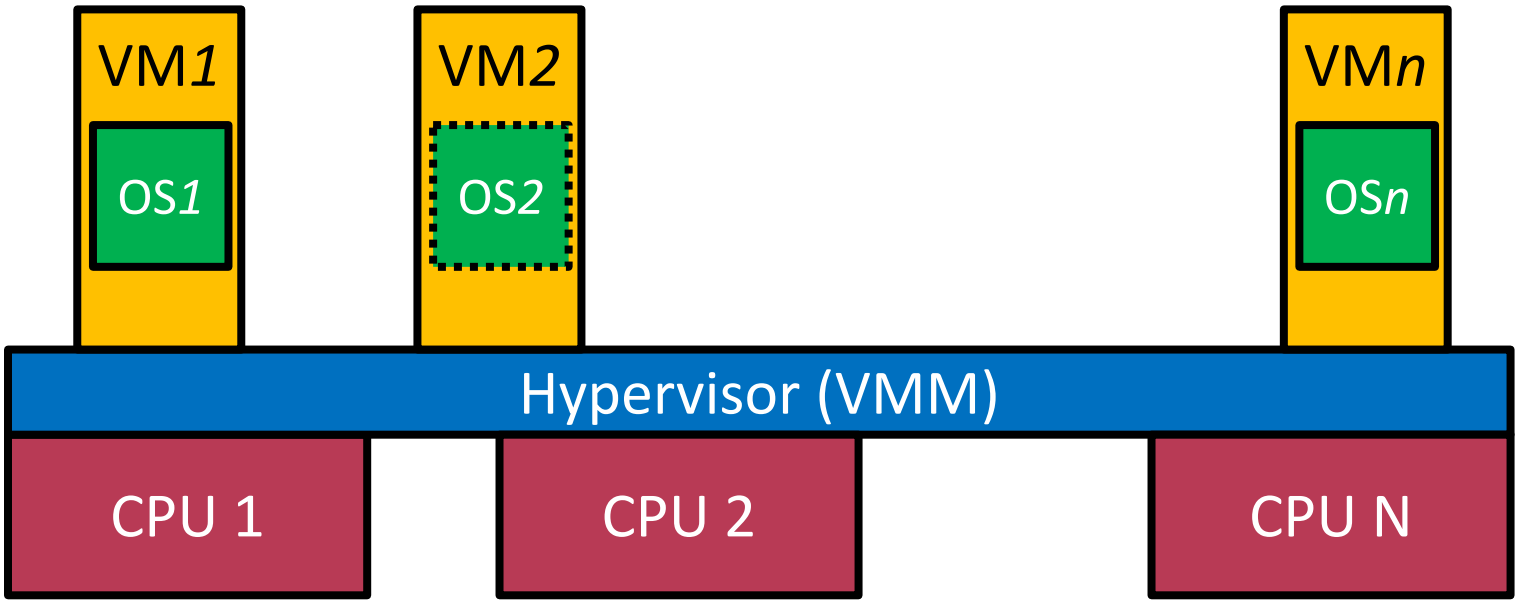
Type 1: hypervisor runs directly on HW



Type 2: hypervisor runs on a host OS

- Hypervisor = virtual machine monitor (VMM)
  - Supervises the virtual machines and program components
  - Offers a supervised access to the system resources
- VM: Virtual Machine
  - May run an operation system or a simple code

Extended model (e.g. SoC)



- Code can be run on *or tasks can be distributed among* more than only one CPU platform
- Different processors may be dedicated to different tasks (e.g. communications, signal processing, graphics)

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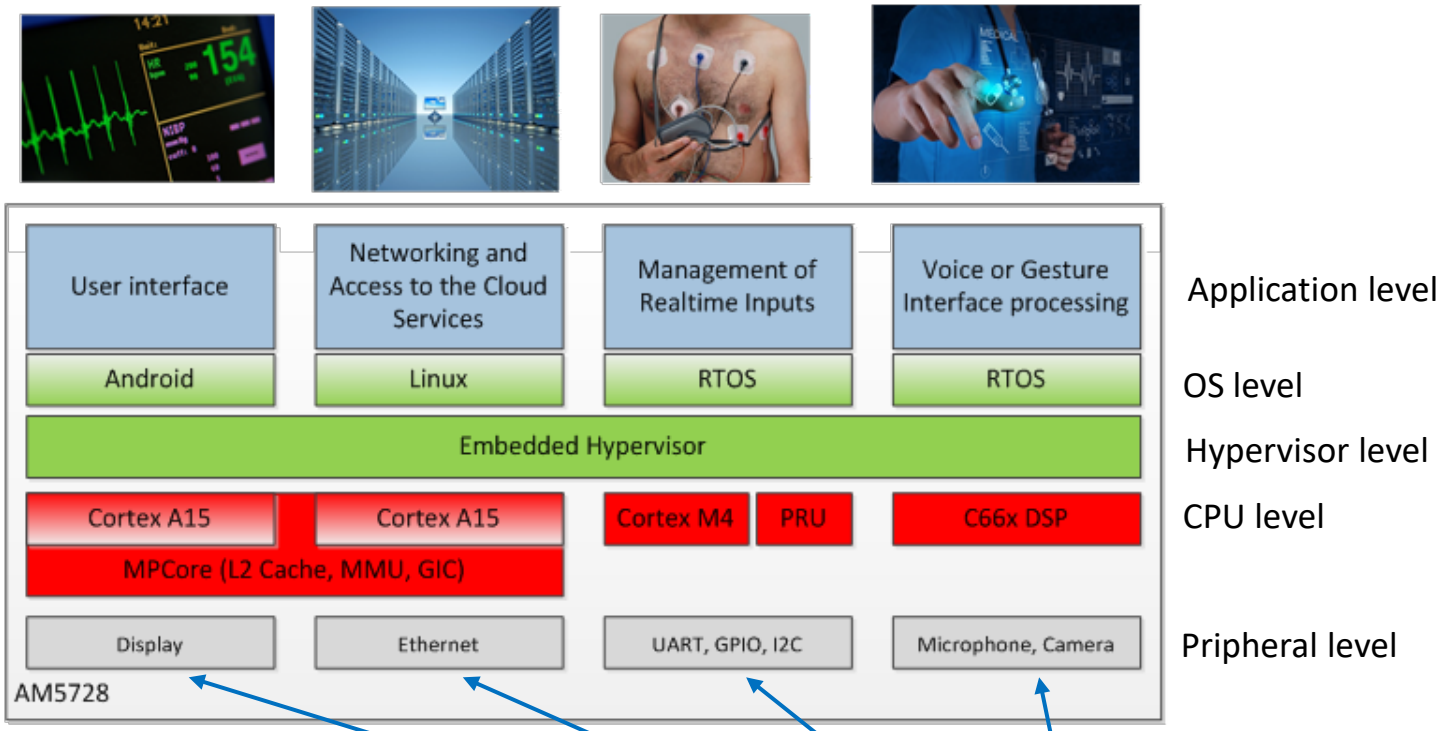

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Hypervisor

- Tasks:
  - Distribution of resources
  - Efficient communications between virtual machines
  - Scheduling
  - Interrupt distribution
  - Energy management
- Requirements:
  - Security
    - SW component must not get out of the surveillance of the hypervisor → → HW-based memory protection
  - Small size not to consume large memory
  - Rapid execution of tasks not to influence real-time operation

Virtualization

- More than one OS can run in a separated manner:
  - Protection to avoid one system affect an other system
  - The safety-critical and non-safety-critical tasks shall be handled separately
- Protection:
  - Memory: virtual address ranges, no direct memory access is allowed
  - Timing: hypervisor has an own timer, no application has the right to run arbitrarily long
  - OS services
  - HW resources: access is possible only via hypervisor
  - Unreliable codes shall be run in a separated manner (sandbox principle)

Disadvantages of virtualization

- Disadvantages:
  - Several abstraction layer -> larger uncertainty in timings
  - Increased resource consumption:
    - Memory
    - Processor time
  - More difficult to assure resource distribution (e.g. communications)
  - Virtualization platform must be free of errors and malfunctions to provide reliable operation for system components rely on the platform

HW-based support

- The entire functionality of protection and separation cannot be assured by only SW, therefore HW-based support is needed
- HW-based support:
  - Different privileges inside the processor (e.g. special registers that can be accessed in hypervisor mode)
  - Memory management