technische universität dortmund

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Embedded and Real-time Operating Systems

(slides are based on Prof. Dr. Chen and Prof. Dr. Marwedel)

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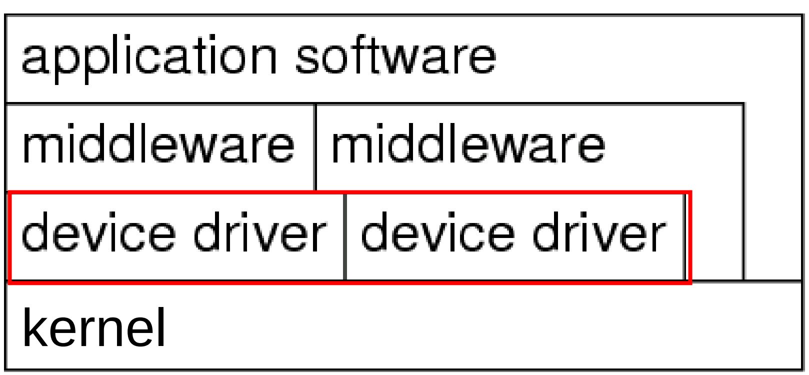
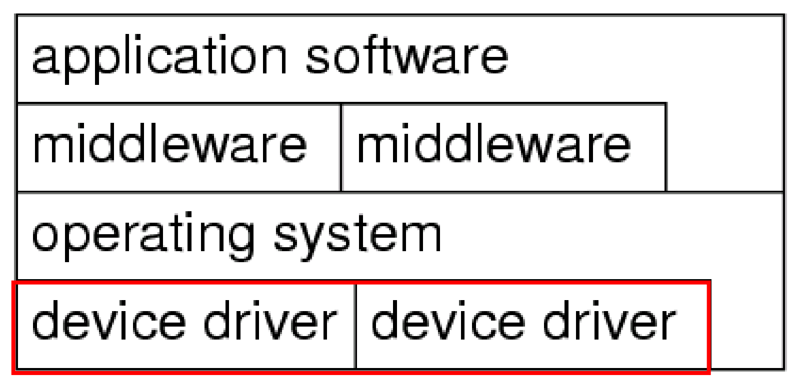
Embedded operating systems
- Characteristics: Disk and network handled by tasks -

- **Effectively no device needs to be supported by all variants of the OS**, except maybe the system timer.
- Many ES without disk, a keyboard, a screen or a mouse.
- Disk & network handled by tasks instead of integrated drivers.

Embedded OS



Standard OS

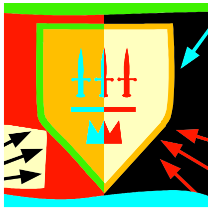


Embedded operating systems
- Characteristics: Protection is optional-

Protection mechanisms not always necessary:

ES typically designed for a single purpose,
untested programs rarely loaded, SW considered reliable.

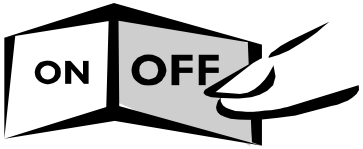
Privileged I/O instructions not necessary and tasks can do their own I/O.



Example: Let **`switch`** be the address of some switch
Simply use

```
load register,switch
```

instead of OS call.



However, protection mechanisms may be needed for safety and security reasons.

Embedded operating systems
- Characteristics: Interrupts not restricted to OS -

Interrupts can be employed by any process

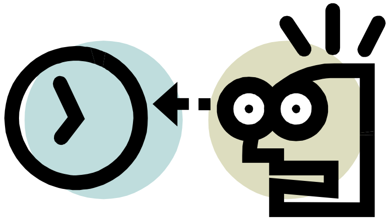
For standard OS: serious source of unreliability.

Since

- embedded programs can be considered to be tested,
- since protection is not always necessary and
- since efficient control over a variety of devices is required,
- it is possible to let interrupts directly start or stop SW (by storing the start address in the interrupt table).
- More efficient than going through OS services.
- Reduced composability: if SW is connected to an interrupt, it may be difficult to add more SW which also needs to be started by an event.

Embedded operating systems
- Characteristics: Real-time capability-

Many embedded systems are real-time (RT) systems and, hence, the OSs used in these systems must be **real-time operating systems (RTOSs).**



RT operating systems - Definition and requirement 1: predictability -

Def.: *(A) real-time operating system is an operating system that supports the construction of real-time systems.*

The following are the key requirements

1. **The timing behavior of the OS must be predictable.**
   $\forall$ services of the OS: Upper bound on the execution time!
   RTOSs must be timing-predictable:
   - (for hard disks:) contiguous files to avoid unpredictable head movements.

[Takada, 2001]

Real-time operating systems requirement 2: Managing timing

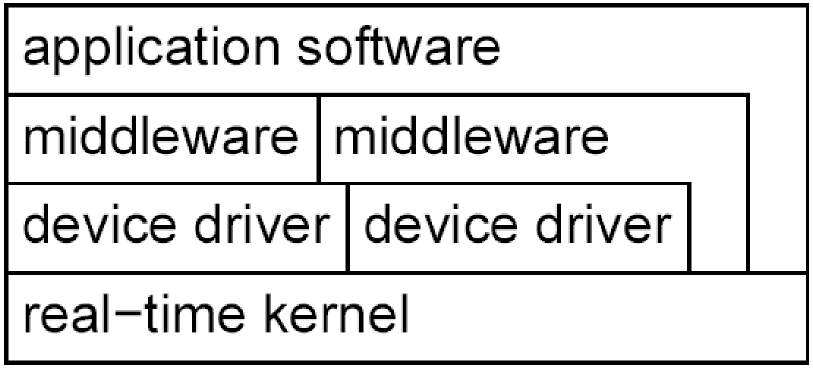
2. **OS should manage the timing and scheduling**
   - OS possibly has to be aware of task deadlines; (unless scheduling is done off-line).

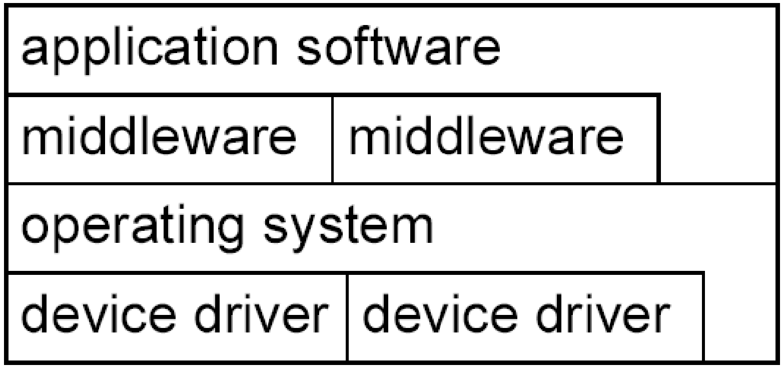
[Takada, 2001]

RTOS-Kernels

Distinction between

- real-time kernels and modified kernels of standard OSes.





Distinction between

- general RTOSs and RTOSs for specific domains,

Functionality of RTOS-Kernels

Includes

- processor management,
- memory management,
- and timer management;

} resource management

- task management (resume, wait etc),
- inter-task communication and synchronization.

Classes of RTOSs:
1. Fast proprietary kernels

For complex systems, these kernels are inadequate, because they are designed to be fast, rather than to be predictable in every respect

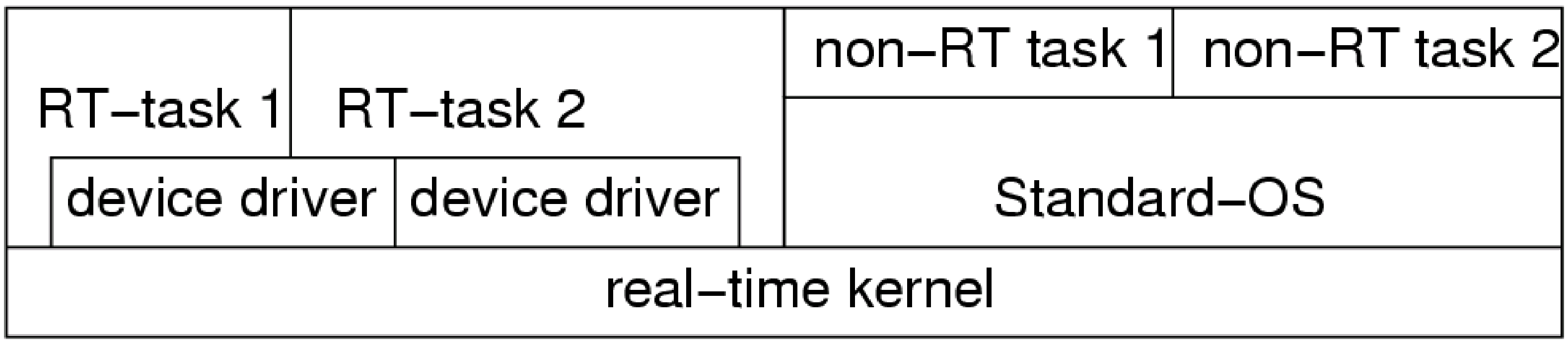
[R. Gupta, UCI/UCSD]

Examples include

QNX, PDOS, VCOS, VTRX32, VxWORKS.

Classes of RTOSs:
2. RT extensions to standard OSs

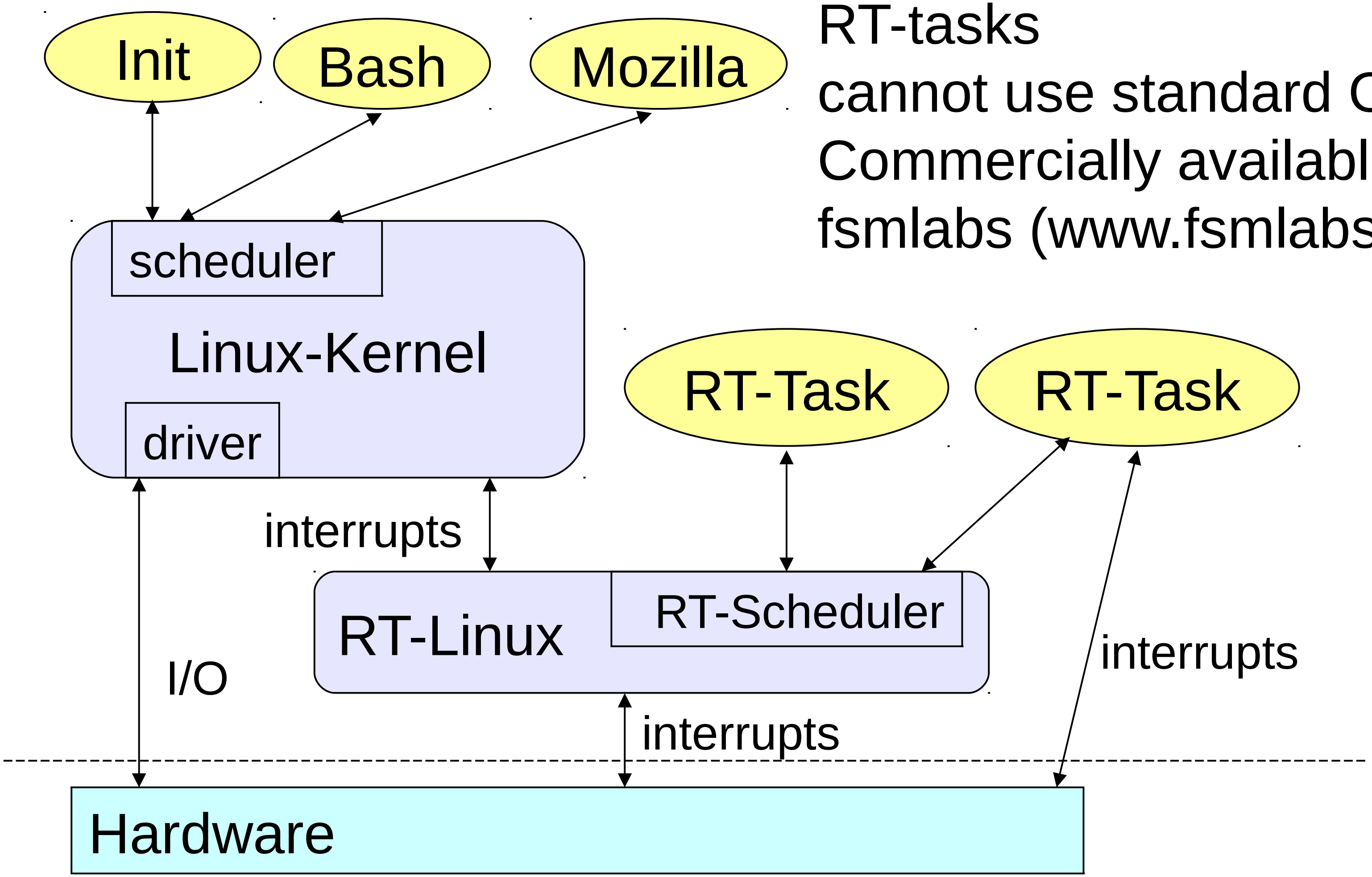
Attempt to exploit comfortable main stream OS.
RT-kernel running all RT-tasks.
Standard-OS executed as one task.



+ Crash of standard-OS does not affect RT-tasks;
- RT-tasks cannot use Standard-OS services;
  less comfortable than expected

Source: R. Gupta, UCSD

Example: RT-Linux



RT-tasks cannot use standard OS calls.
Commercially available from fsmlabs (www.fsmlabs.com)

Classes of RTOSs:
3. Research trying to avoid limitations

Research systems trying to avoid limitations.
Include MARS, Spring, MARUTI, Arts, Hartos, DARK, and Melody

Research issues [Takada, 2001]:

- low overhead memory protection,
- temporal protection of computing resources
- RTOSes for on-chip multiprocessors
- quality of service (QoS) control.