Embedded Motion Control 4K450

Lecture 2 – Chapter 4:
Introduction to real-time operating systems

Group 2

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Where innovation starts

Introduction

Real-time operating systems (RTOS)

- **A brief history of operating systems**
- **A definition of a RTOS**
- **Scheduler**
- **Objects**
- **Services**
- **Key characteristics**
- **Summary**

History of Operating Systems

- **Early days: interact with hardware directly**
- **Later: abstraction of underlying hardware**
  - **General-Purpose OS:**
    - **UNIX**
    - **Windows**
  - **Real-Time OS**
    - **VxWorks**

Similarities GPOS & RTOS

- **Multitasking**
- **Resource Management**
- **Provision of OS services to applications**
- **Abstract hardware from software**

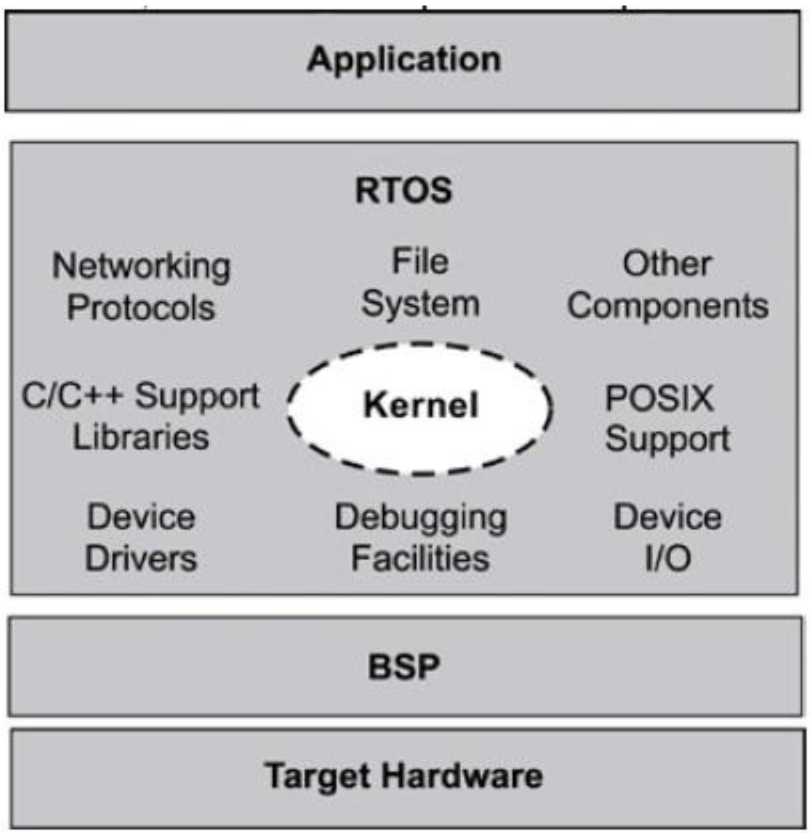
Differences RTOS

- Better reliability
- Ability to scale up or down
- Faster performance
- Reduced memory requirements
- Scheduling policies tailored for real-time embedded systems
- Better portability

Defining Real-Time OS (1/2)

- **Program that schedules execution in a timely manner, manages system resources, and provides a consistent foundation for developing application code**

Defining Real-Time OS (2/2)



Every RTOS:

- **Kernel**

Most RTOS kernels:

- **Scheduler**
- **Objects**
- **Services**

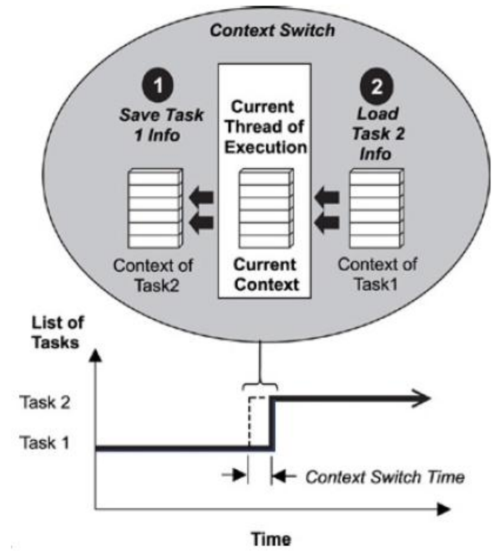
The Scheduler

- **Provides the algorithms to determine which task executes when.**

- **Scheduable entities**
  - **Kernel objects that compete for execution time**
- **Task or Process**
  - **Independent thread that contains independently scheduable instructions**

Multitasking

- The ability to handle multiple activities within set deadlines
- Threads might seem to be running concurrently, however the kernel is interleaving them sequentially
- Based on scheduling algorythm
- More tasks = higher requirements



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The Context Switch

- Task Control Block (TCB) is data structure for a task
- When the kernel switches from one task to another:
  - It saves task 1s context info in its TCB
  - It loads task 2s info from its TCB, this becomes current
  - Context of task 1 is frozen until scheduler switches to task 1 again
- Context switch time
  - Time it takes for scheduler to switch between tasks
  - Relatively insignificant, but excessive switching incurs unnecessary performance overhead

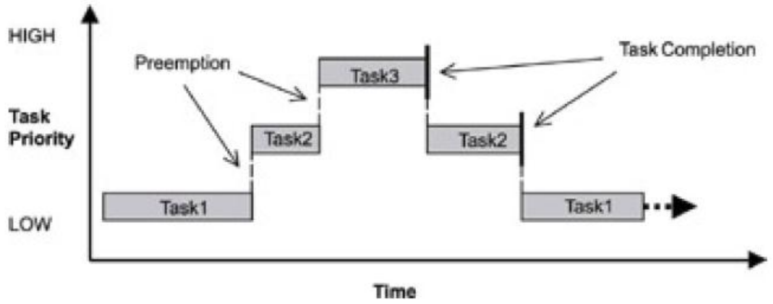
The Dispatcher

- Performs the context switching and changes the flow of execution
- Passes the flow of execution (control) through either an application task, through an ISR or through the kernel
- Which task should be executed is determined by the scheduling algorithm

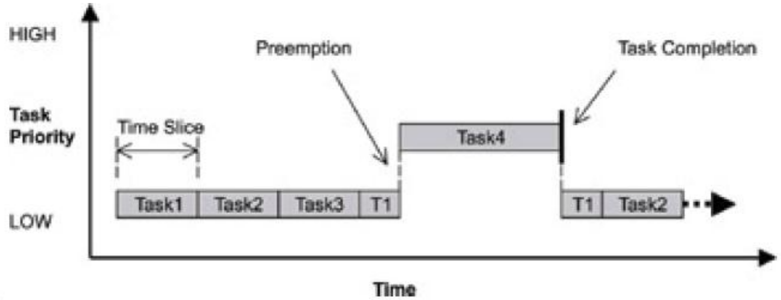
Scheduling algorithms

Scheduling algorithms support 256 priority levels

- **Preemptive priority-based scheduling**
  - **Scheduling of tasks with different priority levels**



- **Round-robin scheduling**
  - **Scheduling of tasks with equal priority levels**



Objects

Building blocks for application development

- **Taks**
  - **Concurrent and independent threads of execution**

- **Semaphores**
  - **Chapter 7**

- **Message Queues**
  - **Buffer-like data structures**

Services

- Application programming interface (API) calls
  - Bios

- Operations on kernel objects

- General:
  - Timer management
  - Interrupt handling
  - Device I/O
  - Memory management

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Key Characteristics of an RTOS

- **Reliability**
- **Predictability**
- **Performance**
- **Compactness**
- **Scalability**

Key Characteristics of an RTOS

- **Reliability**
  - **Different degrees**
  - **Downtime per year, availability**
- **Predictability**
- **Performance**
- **Compactness**
- **Scalability**

Number of 9s	Downtime per year
3 Nines (99.9%)	~9 hours
4 Nines (99.99%)	~1 hour
5 Nines (99.999%)	~5 minutes
6 Nines (99.9999%)	~31 seconds

Key Characteristics of an RTOS

- Reliability
- **Predictability**
  - **Deterministic RTOS**
  - **Small variance of response times**
- Performance
- Compactness
- Scalability

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Key Characteristics of an RTOS

- Reliability
- Predictability
- **Performance**
  - **Meet time requirements**
  - **Million Instructions Per Second (MIPS)**
  - **Throughput: rate, bps**
  - **Call-by-call basis**
- Compactness
- Scalability

Key Characteristics of an RTOS

- Reliability
- Predictability
- Performance
- Compactness
  - Application design constraints
  - Cost constraints
  - RTOS memory footprint
- Scalability

Key Characteristics of an RTOS

- Reliability
- Predictability
- Performance
- Compactness
- **Scalability**
  - **Meet application-specific requirements**
  - **Save time and money**

Summary

- RTOS vs GPOS
- RTOS definition
  - Schedule execution, manage system resources, provide foundation
- Kernels
  - Objects, services, scheduler
- Task scheduling
  - Preemptive, round-robin
- Key characteristics
  - Reliable, predictable, high performance, compact, scalable