# Scheduling Algorithms (1)

Real-Time and Embedded Systems (M)

Tutorial 2

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# Tutorial Outline

- Review of problem set 1
- Review of lectures
- Worked examples
- Question & answer

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# Review of Problem Set 1

- Question 1: Briefly describe what is a real time system, and outline the difference between hard and soft real time systems. With the aid of an example, discuss whether the distinction between hard and soft real time systems is always clear cut. [5 marks]

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# Review of Problem Set 1

- Question 2: A system comprises three periodic tasks: $T_1 : p_1 = 5$, $e_1 = 1$, $T_2 : p_2 = 10$, $e_2 = 3$, and $T_3 : p_3 = 3$, $e_3 = 1$. Calculate the hyper-period and total utilization for this system, explaining how you arrive at your answers. [4 marks]

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# Review of Problem Set 1

- Question 3: We considered several priority-driven scheduling algorithms. It was noted that these algorithms make *locally optimal* decisions about which job to run, but the resulting schedules are often not globally optimal. Explain the difference between locally and globally optimal, and discuss why priority-driven scheduling algorithms typically do not produce globally optimal schedules. [4 marks]

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# Review of Problem Set 1

- Question 4: It was noted that priority-driven scheduling is difficult to validate, since *scheduling anomalies* can occur. Explain what is a scheduling anomaly, and outline a situation when one might occur. [2 marks]

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# Review of Problem Set 1

- Any other questions about the problem set?

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# Review of Lectures

- Lecture 4: Clock-Driven Scheduling
  - Assumption: fixed set of periodic tasks
  - Cyclic scheduling; computing frame size
  - Slack stealing for aperiodic jobs
  - Acceptance test for sporadic jobs
  - Advantages and disadvantages
- Lecture 5: Priority-Driven Scheduling of Periodic Tasks (1)
  - Rate- and deadline-monotonic
  - Earliest deadline first; least slack time
  - Maximum schedulable utilization
- Lecture 6: Priority-Driven Scheduling of Periodic Tasks (2)
  - More general schedulability tests
  - Critical instants and time-demand analysis
  - Outline of practical factors

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# Key Learning Outcomes

- Understanding of when and how to use clock-driven scheduling
- Understanding of when and how to use priority-scheduling
  - Rate monotonic
  - Deadline monotonic
  - Earliest deadline first
  - Least slack time
- Understanding how to prove that a system is schedulable
  - Maximum schedulable utilization for a range of algorithms
  - Time-demand analysis

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# Proving Schedulability: Example 1

- Is the system of 5 independent, preemptable, tasks $T_1$=(1.0, 0.25), $T_2$=(1.25, 0.1), $T_3$=(1.5, 0.3), $T_4$=(1.75, 0.07) and $T_5$=(2.0, 0.1) schedulable using the rate monotonic algorithm?

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# Proving Schedulability: Example 2

- Is the system of 3 independent, preemptable, tasks $T_1$=(8, 3), $T_2$=(9, 3) and $T_3$=(15, 3) schedulable using the rate monotonic algorithm?

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# Proving Schedulability: Example 3

- Is the system of 3 independent, preemptable, tasks $T_1$=(8, 4), $T_2$=(12, 4) and $T_3$=(20, 4) schedulable using the rate monotonic algorithm or the EDF algorithm?

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# Proving Schedulability: Examples

- Aim of the examples has been to demonstrate how to perform schedulability analysis, show when it is necessary to simulate a system

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# Any Further Questions?

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