The Basics of Real-Time Systems

Real-Time and Embedded Systems (M)

Tutorial 1

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Tutorial Outline

- Review of material
- Worked examples
- Question & answer

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Review of Material

- Lecture 1:
  - Introduction to real-time and embedded systems
    - Examples of digital control, higher-level control, communication
  - Types of real-time system
    - Cyclic synchronous vs. asynchronous and unpredictable
  - Implementation considerations
- Lecture 2:
  - Outline of terminology and reference model
  - Hard and soft real-time systems
- Lecture 3:
  - Outline different approaches to scheduling and their constraints:
    - Clock-driven
    - Weighted round-robin
    - Priority-driven

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Identification of Jobs, Task Graphs

- Key learning outcomes from the first three lectures:
  - Understanding terminology; what is a real-time system?
  - Understanding importance of job scheduling; demonstration of timeliness
  - The ability to identify the jobs and tasks that form a system
  - The ability to draw a task graph showing dependencies between jobs
  - The ability to trace execution of the jobs forming a task

- Lecture 3 had an example of tracing the execution of a task
- Today: worked example of job identification and creation of task graphs

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Example: Helicopter Flight Digital Control

- Do the following in each 1/180-second cycle:
  - Validate sensor data and select data source; on failure reconfigure the system
  - Do the following 30-Hz avionics tasks, each once every 6 cycles:
    - Keyboard input and mode selection
    - Data normalization and coordinate transformation
    - Tracking reference update
  - Do the following 30-Hz computations, each once every 6 cycles
    - Control laws of the outer pitch-control loop
    - Control laws of the outer roll-control loop
    - Control laws of the outer yaw- and collective-control loop
  - Do each of the following 90-Hz computations once every 2 cycles, using outputs produced by the 30-Hz computations
    - Control laws of the inner pitch-control loop
    - Control laws of the inner roll- and collective-control loop
  - Compute the control laws of the inner yaw-control loop, using outputs from the 90-Hz computations
  - Output commands to control surfaces
  - Carry out built-in-test

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Example: Helicopter Flight Digital Control

- What are the jobs and tasks in this example?

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Example: Helicopter Flight Digital Control

- What does the corresponding task graph look like?
  - Note: nothing stated about task execution times, so assume:

    $e_1 = 0.2$

    $e_2 = 0.2$

    $e_3 = 0.1$

    $e_4 = 0.1$

    $e_5 = 0.3$

    $e_6 = 0.1$

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Example: Helicopter Flight Control

- Demonstrate how to identify the various parts of the system:
  - Two tasks: main control loop, reconfiguration task
  - Main control loop comprised of 6 inter-dependent tasks
- Demonstrate how to construct a task graph

- Shows how to abstract the system to its essential details, so it can be analysed

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Any Further Questions?

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