CENG 448 — Real Time Operating Systems

Introduction

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Embedded Systems

Any computer system who's primary goal is not general-purpose computation.

Computing systems with tightly coupled hardware and software integration, that are designed to perform a dedicated function.

- Microwave Oven
- CD/DVD/BluRay player
- Mobile phone
- Smart Television
- Network router
- Printer
- SatNav
- and many, many more.

Embedded Processors

Processors intended for embedded applications are different from processors intended for general purpose computing.

- Usually do not support virtual memory.
- Usually have moderate or low power requirements.
- Usually run at relatively slow clock rates (20-800 MHz).
- Often have 16-bit or even 8-bit data and address busses.
- May have special instructions to accelerate certain tasks.

Size, power consumption, performance, and price.

High Performance Embedded Processors

However, some embedded processors are designed for high performance.

One class of embedded processor is designed for Digital Signal Processing (DSP). DSP chips have high-performance, specialized arithmetic units.

Many embedded processors are available as System-On-Chip (SoC) packages.

The embedded system designer often has to search through SoC catalogs to find the cheapest one that provides what is needed for their target system.

Hardware/Software Co-Design

Hardware and Software are often designed together, with feedback between the two teams.

Helps uncover design flaws.

Results in better overall design.

Cross-Platform Development

The code is developed/compiled on a system (the host) that is different from the system that it will run on (the target).

Cross Toolchain:

- Compiler(s) – gcc, clang, Keil, ...
- Assembler – GNU, LLVM, Keil, ...
- Linker – GNU, LLVM, Segger, Keil, ...
- Build System – make, ninja, cmake, Segger, ...
- Debugger – gdb, lldb, Ozone, ...

Standard file formats allow some freedom in tool choice. ELF, COFF, etc.

Target Platform

The code may be stored on the target device in several ways.

- Mask Programmed Read Only Memory (ROM)
- Field Programmable ROM (PROM)
- Erasable Programmable ROM (EPROM)
- Electrically Erasable Programmable ROM (EEPROM)
- Flash Memory: A variation of EEPROM, which allows block-level programmability, and is much faster than EEPROM.

Target devices usually also have one or more type of Random Access Memory (RAM).

- Dynamic RAM (DRAM)
- Static RAM (SRAM)
- Non-Volitile RAM (NVRAM) (battery backed or EEPROM backed)

Real-Time System

Inputs and Outputs:

- Single or Multiple
- Synchronous or Asynchronous

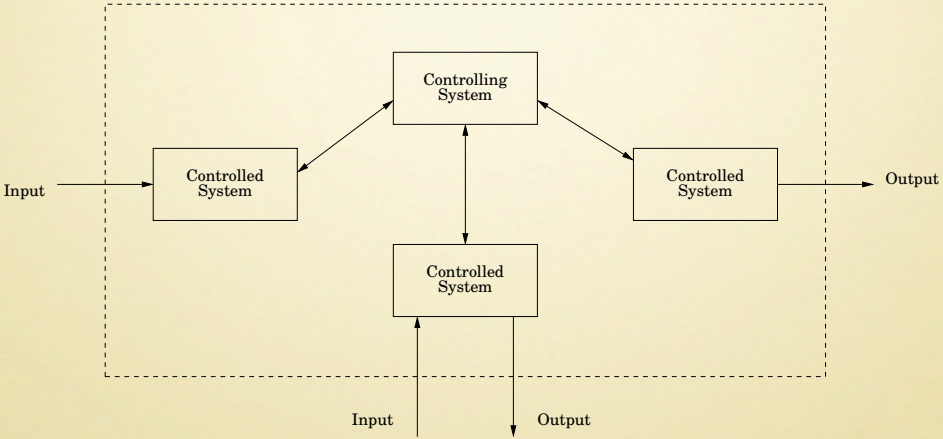
It is a real time system if there are timing constraints between the inputs and outputs.

Controlling system and at least one controlled system. Interaction can be:

Periodic: Initiated by the controlling system at fixed intervals.

Aperiodic: Initiated by the controlled system whenever it needs attention or has new data.

Real-Time Embedded Systems



Missile Defense System

Command and Decision system (C&D) controls two other systems.

- The radar system scans, and sends coordinates of potential targets to the C&D system.
- The C&D system determines threat level (threat classification). If threat is imminent, calculate velocity of threat, and probable impact location. Calculate a box around the flight path.
- Activate weapons firing control system closest to the probable impact location, and give it the data, updating periodically. It will fire continuously, scanning across the box, until the target is destroyed.

Hard vs Soft Real-Time

A real-time system needs *funtional correctness* and *timing correctness*.

Hard real time systems must meet deadlines with a near-zero degree of flexibility. Missing a deadline is catastrophic. Results obtained after the deadline are either useless, or have a high rate of depreciation.

Soft real time systems have a degree of flexibility. Missing a deadline is undesirable, but not catastrophic. Results obtained after the deadline have a moderate rate of depreciation. Late results can have a cost associated with them.