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Due: Thursday, 22nd January 2009
*before* the lecture, i.e., 2:10pm

# Embedded Systems 08/09 – Problem Set 8

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## Problem 1 - Periodic multiprocessor scheduling I (30 pts.)

Consider the following periodic task set:

| **Task** $i$ | **Computation time** $C_i$ | **Period** $T_i$ |
|---|---|---|
| 1 | 2 | 4 |
| 2 | 4 | 6 |
| 3 | 6 | 6 |
| 4 | 3 | 4 |
| 5 | 8 | 8 |

Assume a four-processor architecture with no task migration time. Apply the scheduling algorithm from the lecture by answering the following questions:

1. Compute the total utilization. What can you immediately deduce from that? (5 pts.)
2. Compute a suitable time slice length and the execution rates of each task in each time slice. (5 pts.)
3. Find a feasible *periodic* schedule. (20 pts.)

## Problem 2 - Periodic multiprocessor scheduling II (25 pts.)

Consider the following periodic task set:

| **Task** $i$ | **Computation time** $C_i$ | **Period** $T_i$ |
|---|---|---|
| 1 | 6 | 8 |
| 2 | 7 | 8 |
| 3 | 6 | 8 |
| 4 | 5 | 8 |
| 5 | 8 | 8 |

Assume a four-processor architecture with a task migration cost of **one** time unit. Find a feasible *periodic* schedule.

## Problem 3 - Hardware/software partitioning (15 pts.)

A set of function objects $\{o_1, \ldots, o_n\}$ can either be implemented in hardware (HW) or software (SW). Each object $o_i$ has HW costs $c_h(i)$, SW costs $c_s(i)$, HW computation time $d_h(i)$, and SW computation time $d_s(i)$.
Please perform the following tasks:

1. Encode the described partitioning problem as an integer programming problem, where cost and computation time are weighted "$u$ USD per second" in the cost function. (5 pts.)
2. Extend your problem such that the total costs must not exceed $C_{max}$ and the total computation time must not exceed $D_{max}$. (5 pts.)
3. Extend your problem such that the total number of function object implementations in HW must not exceed $H_{max}$. (5 pts.)

## Problem 4 - Design space exploration (40 pts.)

A manufacturer is planning to develop a new monitoring device that should be capable of storing data over time. Naturally, the production costs should be low while the memory capacity should be high at the same time. The following memory chips are available on the market:

| **Chip $i$** | **Type** | **Energy consumption $e_i$ [mW]** | **Price $p_i$ [USD]** | **Memory $m_i$ [MB]** |
|---|---|---|---|---|
| 1 | A | 50 | 1 | 16 |
| 2 | A | 90 | 3 | 32 |
| 3 | A | 60 | 6 | 32 |
| 4 | B | 150 | 5 | 64 |
| 5 | B | 120 | 10 | 64 |
| 6 | B | 250 | 20 | 128 |

The chosen system architecture implies the following constraints on the choice of the chips:

- There are exactly two type A sockets and two type B sockets available. Sockets can also be unpopulated.
- The total energy consumption should not be higher than 320 mW.
- At least a total capacity of 140 MB is required.

The marketing department established a selling price of 1 USD per 2 MB. In this context, perform the following tasks:

1. Encode the given optimization problem as an integer programming problem. (20 pts.)
2. Find the optimal solution. (20 pts.)