Class Review and Sample Exam Questions

CSE 237A

Prof. Tajana Simunic Rosing
Class Overview

• Plan for today:
  – Class review and sample questions from previous exams

• Upcoming:
  – HW3 due today
  – Exam the last day of class; no book/notes
    • Bring one 8 ½ x 11” sheet of paper with handwritten notes
  – Course evaluations are out!!!!!
    • Please provide your feedback re. course – we take your feedback very seriously and look forward to hearing from you!
Course Objectives

• Develop an understanding of the technologies behind the embedded computing systems
  – technology capabilities and limitations of the hardware, software components
  – methods to evaluate design tradeoffs between different technology choices.
  – design methodologies

• Overview of a few exciting research topics in embedded systems
Topics covered

• Embedded development platforms
  – ARM, RPi, Android, Arduino
• CPUs, GPUs, DSPs, FPGAs
• Memory
  – Caching, scratch pad, ARM mem. hierarchy, NVMs
• Interfacing with peripherals
  – Pooling, interrupts, DMA, GPIO, I2C, serial protocols
• AD/DA conversion
  – Nyquist theorem, aliasing, quantization
• Sensors, actuators (e.g. motors, servos, stepper motors, PWM)
• Timing & real-time scheduling
  – Clock synchronization, logical clocks
  – Independent processes: EDF, RM etc.; Dependent processes: ASAP, ALAP, List scheduler
  – Priority inversion and inheritance
• Real-time operating systems & Middleware
  – VxWorks, FreeRTOS, RT-Linux; PALOS, TinyOS; uCOS-II, eCOS
• Real-time IO
  – Profibus, CAN, ARINC, TTP/A & C, FlexRay; wireless
• HW/SW codesign
• Models of Computation
  – StateCharts, SDL, PetriNets, data flow, SDFs, Esterel, Verilog/VHDL, UML
Logical clocks

• What are the scalar and vector time representation of point x?
# Real-time Schedulers

<table>
<thead>
<tr>
<th>Task</th>
<th>WCET</th>
<th>Period=Deadline</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>unknown</td>
</tr>
</tbody>
</table>

Min period of C for RM schedule = 8

<table>
<thead>
<tr>
<th>Time</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>B</td>
</tr>
<tr>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>2</td>
<td>A</td>
</tr>
<tr>
<td>3</td>
<td>C</td>
</tr>
<tr>
<td>4</td>
<td>B</td>
</tr>
<tr>
<td>5</td>
<td>A</td>
</tr>
<tr>
<td>6</td>
<td>A</td>
</tr>
<tr>
<td>7</td>
<td>C</td>
</tr>
<tr>
<td>8</td>
<td>B</td>
</tr>
<tr>
<td>9</td>
<td>C</td>
</tr>
<tr>
<td>10</td>
<td>A</td>
</tr>
<tr>
<td>11</td>
<td>A</td>
</tr>
<tr>
<td>12</td>
<td>B</td>
</tr>
<tr>
<td>13</td>
<td>C</td>
</tr>
<tr>
<td>14</td>
<td>A</td>
</tr>
<tr>
<td>15</td>
<td>B</td>
</tr>
<tr>
<td>16</td>
<td>A</td>
</tr>
<tr>
<td>17</td>
<td>C</td>
</tr>
<tr>
<td>18</td>
<td>B</td>
</tr>
<tr>
<td>19</td>
<td>C</td>
</tr>
</tbody>
</table>
Dependent Task Scheduling

- Add/Sub = 1 cycle  Mul = 2 cycles;
- Assume there are 2 multipliers, one adder
- Design a list schedule using mobility as a task priority metric

\[
\begin{align*}
O_1 &:= i_1 \cdot i_2 + i_3 \cdot i_4 \\
O_2 &:= O_1 + i_5 \\
O_3 &:= i_6 + i_7 \\
O_4 &:= O_3 \cdot i_8 \\
O_5 &:= O_2 + O_4
\end{align*}
\]
StateChart Problem
Exam Review: Petri Net

• Initial marking: \([ 1 \ 0 \ 0 \ 0 \ 0 ]\)
SDF

A \rightarrow B \rightarrow C

\begin{align*}
\begin{array}{ccc}
A & B & C \\
\hline
a & 2 & -4 & 0 \\
b & 0 & 6 & -4 \\
c & 0 & -3 & 2 \\
d & 6 & 0 & -8 \\
e & -3 & 0 & 4 \\
\end{array}
\end{align*}

A = 2B
3B = 2C
3A = 4B
5B = 4C
4C = 6B

AAAABBCC
\begin{bmatrix}
\phi & \phi & 6 & \phi & 12 \\
\end{bmatrix}
\text{initial state}

\begin{bmatrix}
8 & 12 & 6 & 24 & 12 \\
\end{bmatrix}
\text{min. buf. size}
Resources and SDF

- Find the fastest and lowest energy schedule assuming SDF tasks have to be executed sequentially, on following HW:

<table>
<thead>
<tr>
<th>Task</th>
<th>Sensor node</th>
<th>DSP</th>
<th>CPU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task A</td>
<td>1</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Task B</td>
<td></td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Task C</td>
<td></td>
<td>8</td>
<td>4</td>
</tr>
</tbody>
</table>

Power consumption
- Static power: 1W, 3W, 5W
- Dynamic power: 1W, 1W, 20W

\[\text{min } T = 4.2 + 4.1 + 12.1 S + 4.3 + 4.4 + 12.3 D + 4.5 + 4.5 + 12.25 C\]
Module Test
Input A, B, C, D, F, H;
Output E, G, O;

abort
  loop
    await B || await C
    present D emit E else
    abort
    await F; emit G;
    when H
  end
when A do
  emit O;
end module;