Scheduling Algorithm and Analysis

Case Study
(Module 37)

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Linux Scheduling Pthread Attributes

- **3 scheduling classes set by sched_setscheduler()**
  - SCHED_FIFO and SCHED_RR (Round-robin) are real-time classes
  - SCHED_OTHER is for the rest (time-sharing)

- **Pthread_attr**
  ```c
  pthread_attr_init(&attr);
  pthread_attr_setschedpolicy(&attr, SCHED_FIFO);
  pthread_attr_getschedparam(&attr, &param))
  param.sched_priority = prio;
  pthread_attr_setschedparam(&attr, &param);
  err = pthread_create(&thrd->handler, &attr, thread_routine, (void *)thrd);
  ```

- **Schedule() in kernel/sched.c implements the scheduler and is called when**
  - Blocking call (sleep)
  - After every `ret_from_sys_call` or interrupt if need_resched is on
Case Study

- The target system responds to 6 events
  - each event is processed by an ISR and an application routine
  - ISRs are nonpreemption and set up event ready flags
  - Main program checks ready flags in round-robin manner
    - if flag is set, calls the application routing
Scheduling Discipline

wait for signals

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## Task Data

<table>
<thead>
<tr>
<th></th>
<th>$C_l$</th>
<th>$C_a$</th>
<th>$C$</th>
<th>$T$</th>
<th>$U$</th>
</tr>
</thead>
<tbody>
<tr>
<td>event 1</td>
<td>2.0</td>
<td>0.5</td>
<td>2.5</td>
<td>40</td>
<td>0.063</td>
</tr>
<tr>
<td>event 2</td>
<td>7.5</td>
<td>8.5</td>
<td>16</td>
<td>75</td>
<td>0.213</td>
</tr>
<tr>
<td>event 3</td>
<td>6.0</td>
<td>0.6</td>
<td>6.6</td>
<td>125</td>
<td>0.053</td>
</tr>
<tr>
<td>event 4</td>
<td>21.0</td>
<td>27.0</td>
<td>48.0</td>
<td>250</td>
<td>0.192</td>
</tr>
<tr>
<td>event 5</td>
<td>5.0</td>
<td>24.0</td>
<td>29.0</td>
<td>1050</td>
<td>0.028</td>
</tr>
<tr>
<td>event 6</td>
<td>3.0</td>
<td>1.0</td>
<td>4.0</td>
<td>4000</td>
<td>0.001</td>
</tr>
<tr>
<td>total</td>
<td></td>
<td></td>
<td>4.0</td>
<td>4000</td>
<td>0.550</td>
</tr>
</tbody>
</table>

- The total utilization is only 55% in the worst-case
A Possible Scenario

- Examine a possible scenario of event 1, 3 and 4
- The main program just checked the flag for event 3 and then three interrupts arrives

![Graph showing event scenarios]
Applying RMA in the Case Study

<table>
<thead>
<tr>
<th>Event</th>
<th>Period</th>
<th>Preempt {Hn}</th>
<th>Execute</th>
<th>Preempt {H1}</th>
<th>total (f_i)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1a</td>
<td>40</td>
<td></td>
<td>0.013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E2a</td>
<td>75</td>
<td></td>
<td>0.113</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E3a</td>
<td>125</td>
<td></td>
<td>0.005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E4a</td>
<td>250</td>
<td>0.198</td>
<td>0.108</td>
<td>0.254</td>
<td>0.56</td>
</tr>
<tr>
<td>E5a</td>
<td>1050</td>
<td></td>
<td>0.023</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E6a</td>
<td>4000</td>
<td></td>
<td>0.0003</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[
E4a = \left( \frac{2.0}{40} + \frac{7.5}{75} + \frac{6}{125} \right) + \frac{27}{250} + \left( \frac{0.5 + 8.5 + 0.6 + 24 + 1 + 21 + 5 + 3}{250} \right)
\]

\[
= 0.56
\]

- Event 4 application is schedulable (f_4 < 69%)
Improving Response Times

- Process events in RM order
  - go back to the main loop after completing an application routine
- Streamlined ISR
  - move the work done in ISR to application routines
- Preemptable services
## Analysis After Improvements

<table>
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<tr>
<th></th>
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<th>$T$</th>
<th>$U$</th>
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<td>0.5</td>
<td>2.5</td>
<td>40</td>
<td>0.063</td>
</tr>
<tr>
<td>event 2</td>
<td>1.5</td>
<td>14.5(1.7)</td>
<td>16</td>
<td>75</td>
<td>0.213</td>
</tr>
<tr>
<td>event 3</td>
<td>6.0</td>
<td>0.6</td>
<td>6.6</td>
<td>125</td>
<td>0.053</td>
</tr>
<tr>
<td>event 4</td>
<td>6.5</td>
<td>41.5(4.5)</td>
<td>48</td>
<td>250</td>
<td>0.192</td>
</tr>
<tr>
<td>event 5</td>
<td>5.0</td>
<td>24(3.9)</td>
<td>29</td>
<td>1050</td>
<td>0.028</td>
</tr>
<tr>
<td>event 6</td>
<td>3.0</td>
<td>1.0</td>
<td>4.0</td>
<td>4000</td>
<td>0.001</td>
</tr>
<tr>
<td>total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.550</td>
</tr>
</tbody>
</table>

$$E_{2a} = f_{2a} = \left( \frac{2.5}{40} + \frac{14.5}{75} + \frac{4.5 + 1.5 + 6.0 + 6.5 + 5 + 3.0}{75} \right) = 0.609$$

**Is it scheduable?**
Supplementary Slides