Aperiodic Scheduling

Earliest Deadline Due, Latest Deadline First, Earliest Deadline First

Exercise class 5

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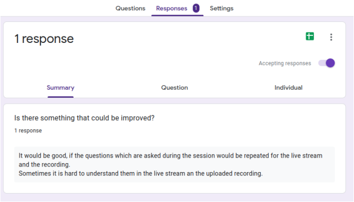
Gliederung

Organisation

Organisation I

- feedback for me: `https://forms.gle/f3YN8EFrZ1vsfPoC6`



- get the slides before the exercise class: `https://github.com/matthejue/Einfuehrung_in_ESE_Tutoratsfolien_out`
  - warning: the slides often get changed just shortly before the exercise class. Both the lecture and the exercise classes are pretty running edge

Overview Aperiodic Task Scheduling

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	Deadline equals period	Deadline smaller than period
static priority	RM (rate-monotonic)	DM (deadline-monotonic)
dynamic priority	EDF	EDF

Overview Aperiodic Task Scheduling

Schedulability test

	Deadline equals period ($D_i = T_i$)	Deadline smaller than period ($D_i \leq T_i$)
static priority	$\sum_{i=1}^{n} \frac{C_i}{T_i} \leq n\left(2^{1/n} - 1\right)$ (sufficient but not necessary)	(1) $\sum_{i=1}^{n} \frac{C_i}{D_i} \leq n\left(2^{1/n} - 1\right)$ (sufficient but not necessary) (2) smallest R_i that satisfies $R_i = C_i + \sum_{j=1}^{i-1} \left\lceil \frac{R_i}{T_j} \right\rceil C_j$ for all tasks i and $R_i \leq D_i$ (necessary and sufficient)
dynamic priority	$\sum_{i=1}^{n} \frac{C_i}{T_i} = U \leq 1$ (necessary and sufficient)	$\rightarrow$ Buttazzo, *Hard real-time computing systems: predictable scheduling algorithms and applications*

Mixed Task Sets

- So far: we differentiated between periodic and aperiodic tasks.
- Now: Consider a mixed task set!
- We want to be able to find a schedule when there's both periodic and aperiodic tasks.

Schedulability tests

Sufficient? Necesarry?

- We're interested in whether a given problem can be scheduled by algorithms.
- Depending on the algorithm we can derive sufficient and necesarry conditions.

  Sufficient: If $A \implies B$ then A is a sufficient condition for B.

  Necesarry: If $B \implies A$ then A is a necesarry condition for B.
- A necesarry and sufficient condition means, both statements are logically equivalent.

Schedulability tests

Utilization

Different kind of utilizations also play a big role in our analysis. We introduced the processor utilization factor $U = \sum_{i=1}^{n} \frac{C_i}{T_i}$ and later on U_s as the server utilization.

(More about servers later)

RM - Rate Monotonic Scheduling

Schedulability

- RM is optimal among all fixed-priority assignments in the sense that no other fixed-priority algorithm can schedule a task set that cannot be scheduled by RM.
- As in the lecture, we have $\sum_{i=1}^{n} \frac{C_i}{T_i} \leq n(2^{1/n} - 1)$ as a sufficient but not necesarry condition.

RM(PS) - Rate Monotonic Polling Server

- One way to handle both periodic and aperiodic tasks is to use a so called server.
- This PS (Polling Server) acts as a periodic task (meaning it is instantiated at regular intervals T_s) whose job it is to, once it has the highest priority, serve any pending aperiodic requests within the limits of a server capacity C_s.
- Since we introduce yet another periodic task, the schedulability analysis simply is the same as normal *RM* with one additional task. Again, we have the sufficient but not necesarry condition: $\frac{C_s}{T_s} + \sum_{i=1}^{n} \frac{C_i}{T_i} \leq (n+1)(2^{1/(n+1)} - 1)$

Task 1

Task 1 I

Earliest Deadline First (EDF) and Total Bandwidth Server (TBS)

Task 1.1:

- what can be the maximum value of U_s such that the whole set (i.e. periodic tasks and the TBS) is schedulable with EDF?

Task 1 II

Requirements 1.1:

Schedulability test:

Given a set of *n* periodic tasks with processor utilization U_p and a total bandwidth server with utilization U_s, the whole set is schedulable by EDF if and only if

$$U_p + U_s \leq 1$$

- *processor utilization factor:* $U = \sum_{i=1}^{n} \frac{C_i}{T_i}$

Solution 1.1:

- *Maximum utilization of the Total Bandwidth Server:*
  $U_{s,\max} = 1 - U_p = 1 - \left(\frac{1}{3} + \frac{1}{5} + \frac{2}{13}\right) = \frac{61}{195} \approx 0.3128$

Solution 1.2:

- *First, we need to order the tasks by increasing release time* r_i : J_4, J_6, J_5. *Then, we calculate the deadlines with* $d_i = \max(r_i, d_{k-1}) + \frac{C_k}{U_s}$, *where* d_{k-1} *denotes the previously calculated deadline* ($k-1$ *means the predecessor in the ordering according to the release time):*
  - $d_4 = \max(r_4, d_0) + 2/0.25 = 0 + 8 = 8$
  - $d_6 = \max(r_6, d_4) + 1/0.25 = 10 + 4 = 14$
  - $d_5 = \max(r_5, d_6) + 1/0.25 = 15 + 4 = 19$

Solution 1.3:

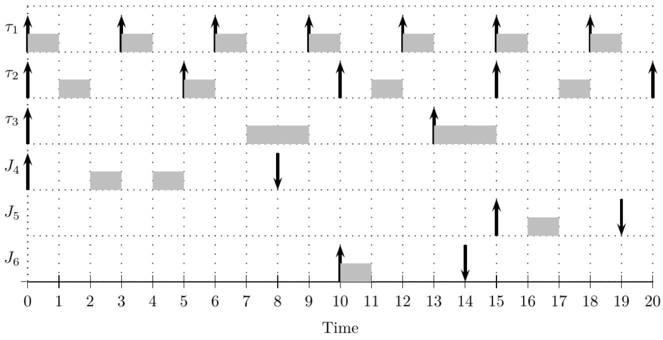

Figure 1: EDF schedule solution for Task 1

Task 2

Task 2 I

Schedulability Test for Fixed Priorities – Rate Monotonic (RM)

- asdff

Task 3

Task 3 I

Scheduling with Polling Server

- asdf

Literature

Bücher

Buttazzo, Giorgio C. *Hard real-time computing systems: predictable scheduling algorithms and applications*. Vol. 24. Springer Science & Business Media, 2011.