Aperiodic Scheduling

Earliest Deadline Due, Latest Deadline First, Earliest Deadline First

Exercise class 5

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Gliederung

Organisation

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
Acceptance Tests

	Deadline equals period ($D_i = T_i$)	Deadline smaller than period ($D_i \leq T_i$)
static priority	$\sum_{i=1}^{n} \dfrac{C_i}{T_i} \leq n\left(2^{1/n} - 1\right)$ (sufficient but not necessary)	(1) $\sum_{i=1}^{n} \dfrac{C_i}{D_i} \leq n\left(2^{1/n} - 1\right)$ (sufficient but not necessary) (2) smallest R_i that satisfies $R_i = C_i + \sum_{j=1}^{i-1} \left\lceil \dfrac{R_i}{T_j} \right\rceil C_j$ for all tasks i and $R_i \leq D_i$ (necessary and sufficient)
dynamic priority	$\sum_{i=1}^{n} \dfrac{C_i}{T_i} = U \leq 1$ (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 $U = \sum\limits_{i=1}^{n} \dfrac{C_i}{T_i}$ 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: $\dfrac{C_s}{T_s} + \sum\limits_{i=1}^{n} \dfrac{C_i}{T_i} \leq (n+1)(2^{1/(n+1)} - 1)$

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):*

  ▶ $d_4 = \max(r_4, d_0) + 2/0.25 = 0 + 8 = 8$
  ▶ $d_6 = \max(r_6, d_4) + 1/0.25 = 10 + 4 = 14$
  ▶ $d_5 = \max(r_5, d_6) + 1/0.25 = 15 + 4 = 19$
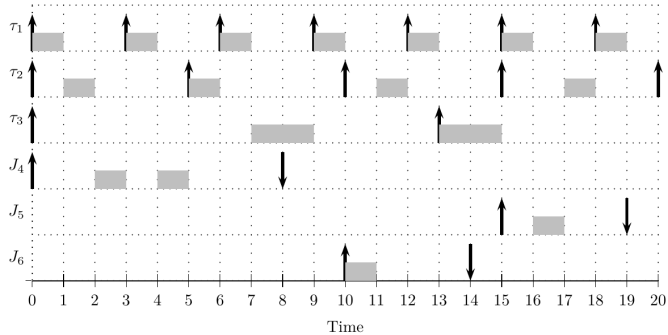
Solution 1.3:

Figure 1: EDF schedule solution for Task 1

Task 2

Task 2 I

Schedulability Test for Fixed Priorities – Rate Monotonic (RM)

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Task 3

Task 3 I
Scheduling with Polling Server

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Literature

Bücher

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