Embedded Information Systems Homework 2021

1. Scheduling algorithms

1.1. Please show how tasks $\tau 1$, $\tau 2$, $\tau 3$ and $\tau 4$ having periods 8*p1, 16*p1, 32*p1 and 64*p1 msec, and computation times 2*p1, 2*p1, 4*p1 and 10*p1 msec, are scheduled using the ***Rate Monotonic*** (RM) algorithm, if the task which performs scheduling has a period of 1 msec, and computation time 0.1 msec. Since the scheduler starts its run only at discrete time instants, the known schedulabilty tests cannot be applied. What is the minimum length of the time interval for which schedulability is to be checked to be able to state the feasibility of the schedule? Check the schedulability of the tasks for this interval! The initial phases of the tasks are 0, p1*p1, p2*p1 and p3*p1 msec, respectively, i.e., the tasks are ready to run after such a delay following the system start. The initial phase of the scheduler is zero. Please also give the response time of the tasks (max *5 points*)!

1.2. Please give the time instants and intervals where the processor is idle (max *1 point*)! Please calculate the processor utilization factor (max *1 point*)! Please give the schedule of 1.1 also for that case where the scheduler task consumes processor time only if the other tasks need scheduling. (Starting, restarting). In case of simultaneous requests only a single run of the scheduler task is assumed (max *3 points*). Also, for this case, please give the time instants and intervals where the processor is idle and compute the processor utilization factor (max *2 points*)!

1.3. Please compute the worst-case response time of task $\tau 4$ for the case when the initial phases are not known! Following a proper modification, please apply the DMA analysis method to this problem (max *4 points*)!

1.4. Please show how the ***Earliest Deadline First*** (EDF) algorithm would schedule the tasks of 1.1, if their deadlines equal to their periods, and all the further conditions remain the same! In case of coincidence of the deadlines apply such a solution which results in fewer context switches (max *3 points*)!

1.5. Please solve problems 1.1-1.4 assuming that the computation time of the scheduler is zero. What is your experience (max. *3 points*)?

1.6. Execution of aperiodic requests is planned to use the remaining free processor capacity. Using the RM strategy, specify a server task for the case when assumption in Problem 1.5 is valid (max. *2 points)*!

1.7. By applying the ***Deferrable Server*** (DS) algorithm, give schedule to aperiodic requests using the server task specified in Problem 1.6. The aperiodic requests arrive at p1*p1 msec, (p2+1)*p1 msec, and (p3+1)*p1 msec, their computation time 2*p1 msec each (max. *3 points*).

1.8. By applying the ***Total Bandwidth Server*** (TBS) algorithm, give schedule to aperiodic requests assuming the condition given in Problem 1.5. The aperiodic requests arrive at p1*p1 msec, (p2+1)*p1 msec, and (p3+1)*p1 msec, the computation time is 2*p1 msec for each (max. *4 points*).

Please give all the schedules in graphical form indicating time instants and durations exactly.

.

2. Dynamic Power Management

We assume that the power consumption $P(f)$ of a given CMOS processor at frequency f is:

$$P(f) = a + bf^3$$

where the unit of power is $[mW]$, and the unit of frequency is $[MHz]$. To reduce power consumption the execution frequency can be changed. The maximum available frequency is $f_{max} = 1000MHz$, while the minimum $f_{min} = 50MHz$. Changing frequency has negligible overhead and the processor can operate at any frequency between f_{max} and f_{min}. It is possible to turn the processor to the sleep mode to reduce power consumption. In this case it consumes no power. Turning the processor on to sleep mode consumes no energy. Turning the processor on to the run mode it requires additional $3 * 10^{-5}$Joule. Turning on/off the processor is performed instantly.

2.1. The energy needed to execute C cycles is $\frac{CP(f)}{f}$. There is an optimal frequency within the operation range at which the energy needed to execute any C cycles is minimum. What is the optimum frequency f_{opt} of the processor (max 2 points)?
2.2. When the processor is idle at frequency f_{min} for t seconds, then its energy consumption is $P(f_{min}) * t$. The *break-even time* is defined as the minimum interval for which it worth turning the processor off. What is the break-even time of this processor (max 2 points)?
2.3. Assuming as clock frequency f_{opt} and the processor in run state, please calculate the total energy consumption of the processor executing the tasks of Problem 1.1 for the time interval of the schedulability analysis/check (max 2 points)?
2.4. To reduce/minimize energy consumption, if possible, please modify the schedule without disturbing the deadlines and calculate the corresponding total energy consumption for the time interval specified in 2.3! You can neglect the time required by the scheduler if you want to! Where it results in the reduction of energy consumption, please apply the sleeping mode! The number of cycles should be determined under the assumption that the given computation times are given for the case of clock frequency f_{opt} (max 4 points)!

Date of publishing: **September 28, 2021.**
Deadline of submission**:** **November 30, 2021.**

High quality documentation is expected: please do not submit handwritten texts if possible!
Please also indicate your name Neptun code and email!

Submission is requested to the portal: https://hf.mit.bme.hu as a single file in ***pdf*** format.

Condition of acceptance: min. **16 points** (40%). **Good luck!**

Neptun	p1	p2	p3	a	b
A6YM7P	3	6	9	10	5*10^-6
ACEBT1	2	5	8	20	10^-5
BC3T5J	1	9	2	40	2*10^-5
BGMNTE	2	8	1	40	2.5*10^-6
CHQF4Y	3	6	9	80	5*10^-6
CS4RHN	3	5	8	160	10^-5
D8RPQD	2	6	9	40	2.5*10^-6
DLHO6B	1	4	7	10	5*10^-6
DNBMQJ	2	1	4	10	5*10^-6
E6VS3R	2	8	1	20	10^-5
ELYJ9R	6	8	1	40	2*10^-5
EYXF6J	3	5	8	40	2.5*10^-6
EZXFWK	1	9	2	80	5*10^-6
F9MFQD	2	1	4	160	10^-5
FLCAVT	3	1	4	20	10^-5
FM8VEU	3	4	7	40	2*10^-5
FTLEXZ	1	4	7	40	2.5*10^-6
G78CZO	3	6	9	80	5*10^-6
GTBHX0	2	1	4	10	5*10^-6
HIHR3Z	2	8	1	20	10^-5
HJ7U0U	6	8	1	40	2*10^-5
HTAEOU	1	9	2	40	2*10^-5
IQ6W7J	2	8	1	40	2.5*10^-6

K6T9KG	3	6	9	80	5*10^-6
KZQF74	3	5	8	160	10^-5
L2N9IX	2	6	9	40	2.5*10^-6
LZ7EAM	3	5	8	10	5*10^-6
MGQXGS	2	1	4	10	5*10^-6
N47SEN	2	8	1	20	10^-5
NIT3N1	6	8	1	40	2*10^-5
NQC17Y	3	5	8	40	2.5*10^-6
O17U94	1	9	2	80	5*10^-6
O90KJF	2	1	4	160	10^-5
PAM2VC	3	1	4	20	10^-5
PUOJTG	3	4	7	40	2*10^-5
R0E5RV	1	4	7	40	2.5*10^-6
RMPSYJ	3	6	9	80	5*10^-6
S8912J	3	4	7	10	5*10^-6
T7E1J8	3	8	1	20	10^-5
VH0JMU	2	6	9	40	2*10^-5
W9BYWT	1	0	3	40	2.5*10^-6
WE32MN	5	1	4	80	5*10^-6
X2BP98	1	1	4	160	10^-5
XJJUK4	2	7	0	40	2.5*10^-6
XQRCSM	1	0	3	10	5*10^-6
XUB49I	2	1	4	10	5*10^-6