RoboLab Real-Time Scheduling

Lab Report

Preparatory Questions

Question 1

Explain the mechanism behind the cyclic scheduling. What does cyclic schedule consist of?

The cyclic schedule consists of a major cycle which consists of several minor cycles. Processes are put into the minor cycles in the order they should be executed and the order of the minor cycles determine the overall order of the process executions. The schedule is created offline and uses static parameters.

What is the difference between a minor and a major cycle in a schedule?

The major cycle is repeated in infinity and consists of several minor cycles. By placing process executions in different minor cycles, you determine when a certain process should be run in the major cycle.

How are they determined?

The minor cycle is determined by the greatest common devisor between the processes periods. The major cycle is determined by the least common multiplier between the processes periods.

If the periods are not harmonic, then two different approaches can be taken. Either you push processes backwards in time when they clash or you run a process more often than it requires.

Outline the cyclic schedule for the RoboLab task set. What is the major and minor cycle?

The cyclic schedule we use in the lab is shown by Figure 1. The figure illustrates the major cycle with the first to fourth and the last minor cycle displayed. All minor cycles between the fourth and the last are equal. Each minor cycle is 50 ms and the major cycle is 1 s. This means that the major cycle consists of 20 minor cycles. The numbers on the planner process indicates the steps.

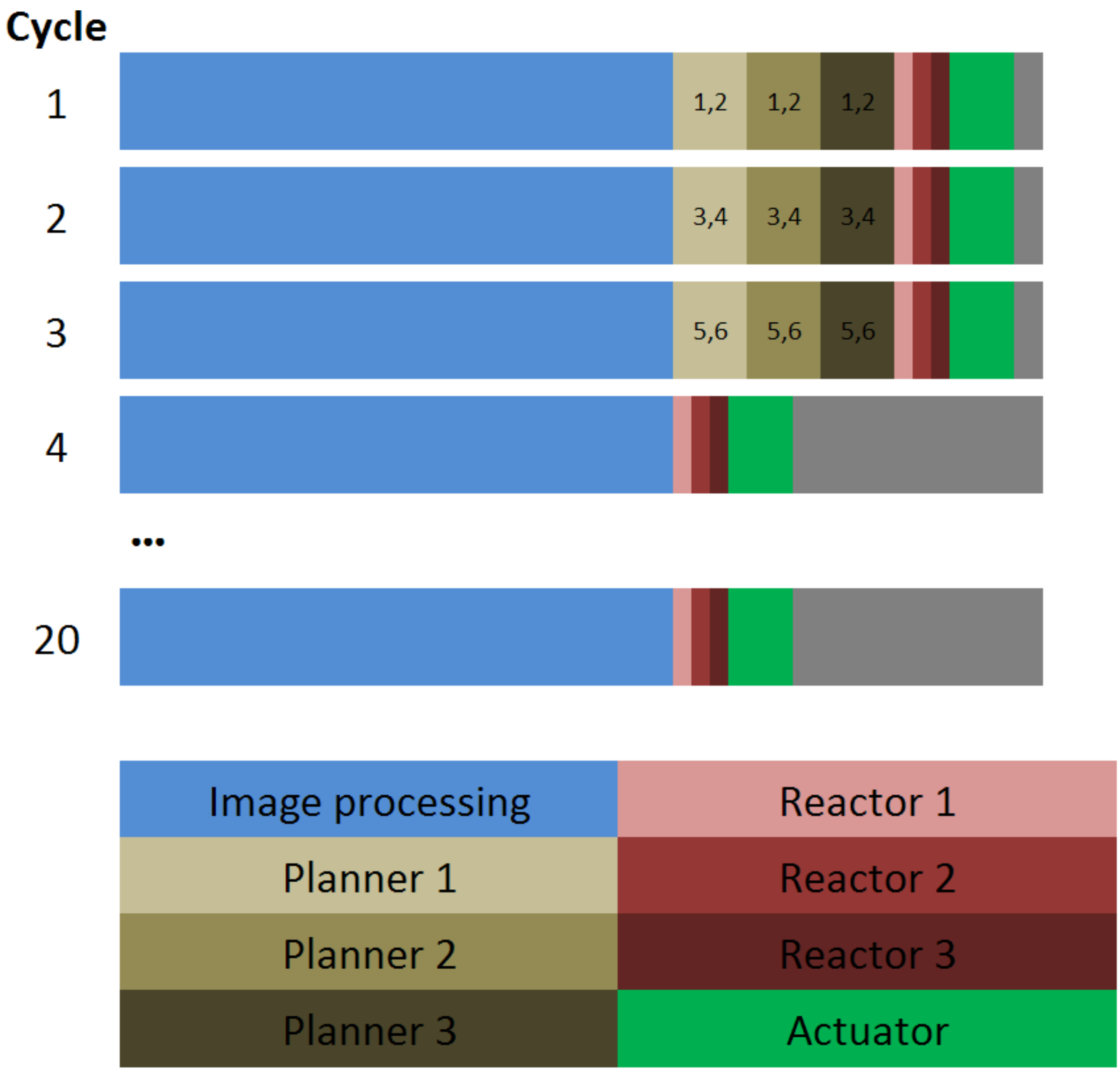

Figure 1: Cyclic schedule for the RoboLab task set.

When creating this schedule we have used 30 ms as WCET for the Image processing.

Question 2

What is the difference between RMS and EDF scheduling with respect to implementation and performance?

RMS uses static priorities which are determined offline. The priorities are determined by the periods of the processes, longer period gives lower priority. EDF uses dynamic priorities and are therefore determined online. The priorities are determined by which process that has the closest relative deadline, closer deadline gives higher priority.

EDF requires more overhead at runtime and therefore RMS can be run faster. But EDF can manage to schedule task sets that RMS is not able to schedule because it gives higher processor utilization.

Question 3

Outline the steps in the RMS and EDF scheduling process, preferably with a sequence chart (or a pseudocode, or a flowchart).

The steps of the RMS scheduling process are shown by Figure 2 and EDF by

Figure 3.

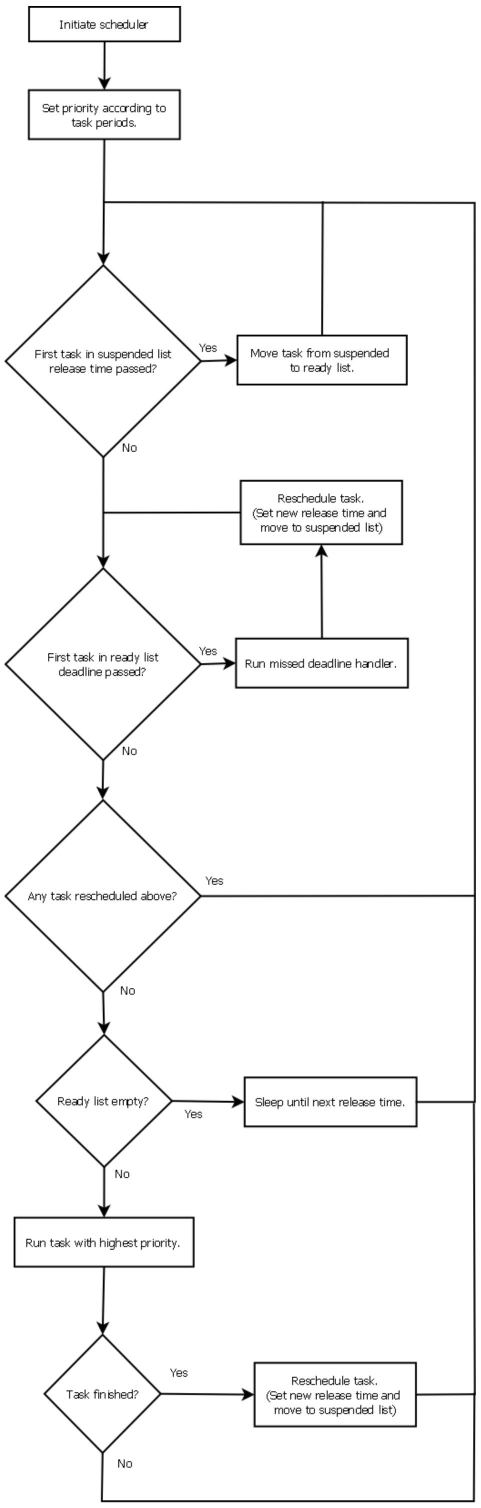
Initiate scheduler
Set priority according to task periods.
First task in suspended list release time passed?
Yes
Move task from suspended to ready list.
No
Reschedule task. (Set new release time and move to suspended list)
First task in ready list deadline passed?
Yes
Run missed deadline handler.
No
Any task rescheduled above?
Yes
No
Ready list empty?
Yes
Sleep until next release time.
No
Run task with highest priority.
Task finished?
Yes
Reschedule task. (Set new release time and move to suspended list)
No

Figure 2: RMS flow chart.

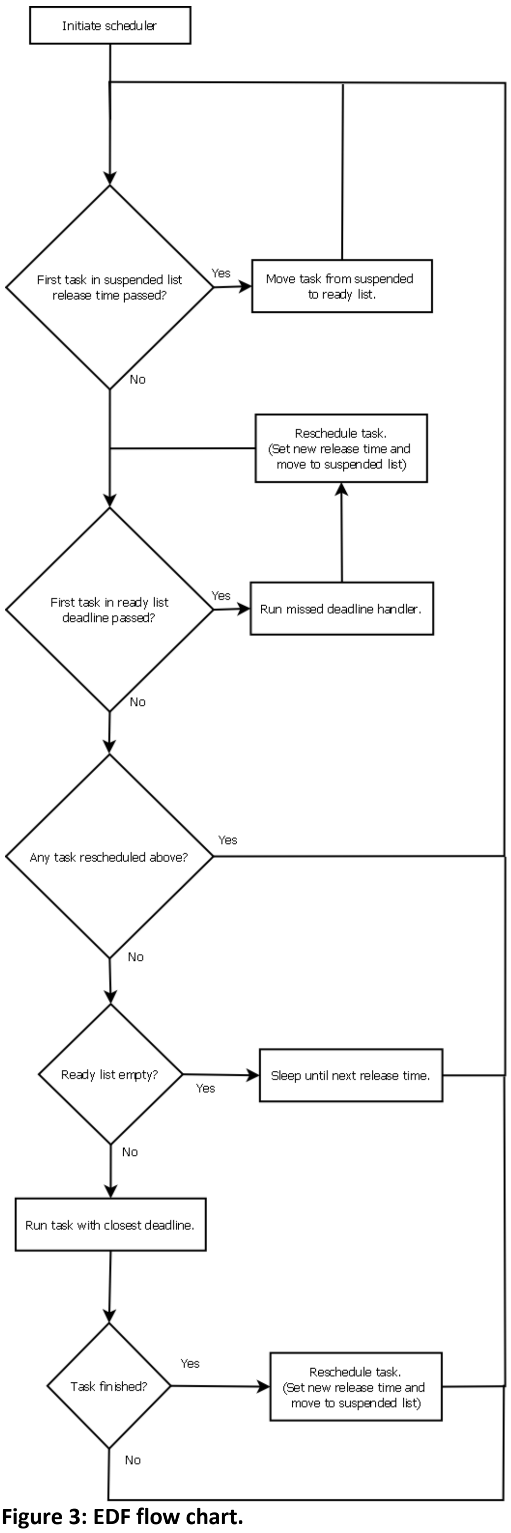
Initiate scheduler
First task in suspended list release time passed?
Yes
Move task from suspended to ready list.
No
Reschedule task. (Set new release time and move to suspended list)
First task in ready list deadline passed?
Yes
Run missed deadline handler.
No
Any task rescheduled above?
Yes
No
Ready list empty?
Yes
Sleep until next release time.
No
Run task with closest deadline.
Task finished?
Yes
Reschedule task. (Set new release time and move to suspended list)
No

Figure 3: EDF flow chart.

What has to be done off-line (i.e. before you run the scheduler) and on-line (i.e. during run-time)?

When using RMS scheduling, you need to prioritize all processes/tasks offline. Online the scheduler only changes to the ready process with the highest priority as shown in Figure 2.

If EDF is used, nothing needs to be done offline. Online, the scheduler needs to prioritize the tasks in the ready queue. This is done by checking closest relative deadline. This is done when a task is released or has finished as shown in

Figure 3. This is the only difference to a RMS scheduler.

Question 4

Where and how do you look for deadline overruns in RMS and EDF?

The scheduler checks the deadline when the running process yields. It also checks the deadlines of the tasks in the ready queue when a new task should be started. In RMS, all tasks in the ready queue needs to be checked. In EDF, only the tasks up to a task which has not missed its deadline needs to be checked.

What has to be done when a deadline overrun has occurred?

The task needs to be stopped and rescheduled for its next deadline.

Qualifying Questions

Question 1

What can you conclude about the cyclic scheduling in dynamic environments? Have you experienced any drawbacks or benefits of this type of scheduler in the RoboLab environment? Relate the theory on cyclic scheduling with your experience with the labs.

It is hard to make any conclusions based on the games since the teams are equally bad. However, this means that the static cyclic scheduling or RMS seems to work as good as the dynamic EDF scheduler in the dynamic environment. We cannot make any conclusions based on the miss ratios because we have not calculated that for the cyclic scheduling, only for RMS and EDF.

One benefit we did find with cyclic scheduling was that it was really easy to implement. If the image processing task had not overrun its WCET given in the lab PM, we surely would have noticed some drawbacks on the performance of cyclic scheduling compared to RMS or EDF. We probably would have noticed that the planners would succeed more often because they could have been run when there was time in RMS and EDF and not in specific time slots as in cyclic scheduling (if these time slots are taken up by a long running image processing task (still shorter than 0.1 second) the planners will not get a second chance).

Question 2

Compare the result of your simulations with the theoretical performance of the scheduling algorithms. Is the task set schedulable? How can the deadline miss ratio be explained? Where the results expected? Why or why not?

First of all, the WCET for image processing task given in the lab PM is 100 000 µs. It was said that this execution time was very rare and it was possible to estimate WCET to 30 000 µs. However, when we ran the task in the lab environment, it exceeded 100 000 µs about 50% of the executions and exceeded 30 000 µs about 75% of the executions. In spite of this we still used 30 000 µs as WCET in cyclic scheduling because it said so in the instructions.

When we use 30 000 µs as WCET for the image processing task as stated above, then it is theoretically schedulable with cyclic scheduling because it is possible to create a cyclic schedule according to Figure 1. However, since the image processing task exceeds 30 000 µs about 75% of the time, this really does not hold. If we would have calculated with the true WCET, then the task set would not have been schedulable since WCET is greater than the period.

When we use 30 000 µs as WCET for the image processing task again and check whether the task set is schedulable with EDF, we use the formula below.

Since the result is less than one, the task set is theoretically schedulable with EDF. (If the real WCET had been used, then the result would have been greater than one).

If the utilization is less than the guarantee level, the task set is also schedulable with RMS. But as seen in the calculation below, the utilization is greater than the guarantee level and therefore we must use the exact analysis.

Exact analysis:

Process	Name
P_1	Image processing
P_2	Planner for player 1
P_3	Planner for player 2
P_4	Planner for player 3
P_5	Reactor for player 1
P_6	Reactor for player 2
P_7	Reactor for player 3
P_8	Actuator

The task set is schedulable (or rather, it would have been if the image processing task took 30 000 µs).

Question 3

If you were the real-time system designer asked to implement a scheduler for an environment similar to RoboLab lab environment, what scheduling algorithm would you use? Motivate your answer based on your lab experiences.

Since processes in the RoboLab environment misses their deadlines quite often, we do not think a cyclic scheduler is recommended. The reason for this is that processes with long periods will suffer greatly if another task in the same minor cycle overruns.

The effect of changing between RMS and EDF is not that big since the only difference is when the deadline of the planners are close. If the deadlines of the short period tasks are closer than those of the planners, then RMS and EDF will choose the same task to run next. The other possibility (that the deadlines of the planners are closer) will happen very rarely since these task have had the chance to run and will (most probably) have finished before.

Our choice is therefore the RMS since the overhead is less than in EDF.