1. (40 Points) In a real-time system, there are three processes creating periodical events. Their burst-times, deadlines, and periods are given in the table below:

<table>
<thead>
<tr>
<th>Process</th>
<th>Arrival</th>
<th>Burst Time</th>
<th>Period/deadline</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>@0</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>P2</td>
<td>@15</td>
<td>25</td>
<td>35+35*</td>
</tr>
<tr>
<td>P3</td>
<td>@35</td>
<td>20</td>
<td>90</td>
</tr>
</tbody>
</table>

35* indicates that a new P2 event will be initiated 35 ticks after the current event is done, however its effective period (or its deadline) is set to 70.

a) Compute the CPU utilization rate.

b) Can the given situation be admitted by the operating system if an earliest-deadline first scheduling is applied? To illustrate your work, you need to draw Gantt chart up to t=350.

c) If part (b) can be admitted, process P4 starts at t=0 creating periodical events with a period of 100 units will be added. If P4 events are expected to be admitted, what is the longest burst time P4 can have? You must show your work and justify your answer.

2. (35 Points) P₁, P₂ ... P₆ are 6 hosts in a distributed system and ID(Pᵢ) > ID(Pⱼ) if i > j. If Pᵢ and Pⱼ are directly connected, their communication-latency is given as CL(Pᵢ, Pⱼ). Given:

\[
\begin{align*}
\text{CL}(P₁, P₂) &= 8, & \text{CL}(P₁, P₄) &= 5, & \text{CL}(P₁, P₆) &= 7, \\
\text{CL}(P₂, P₃) &= 6, & \text{CL}(P₂, P₅) &= 5, & \text{CL}(P₃, P₄) &= 7, \\
\text{CL}(P₃, P₆) &= 5, & \text{CL}(P₄, P₅) &= 6, & \text{CL}(P₅, P₆) &= 4.
\end{align*}
\]

If Pᵢ and Pⱼ are not directly connected, then a path with minimum latency will be used. Assume that the host with the highest ID is the system coordinator by default and a new coordinator will be elected by the Ring Algorithm if the current coordinator is down. Assume that each host periodically requests resources every 45 ticks and P₁ starts at t=0, P₂ starts at t=13 tick, P₃ starts at t=18 tick, P₄ starts at t=23 tick, and P₅ starts at t=27 tick. If a host goes down, its associated communication gears remain intact. If P₆ goes down at t=127, answer the following questions.

a) Who is the first host that finds out the coordinator is down? When does this occur?

b) When will a new coordinator Pₖ send out the declaration messages? Assume a token ring is set as \{P₁ \rightarrow P₄ \rightarrow P₃ \rightarrow P₂ \rightarrow P₅ \rightarrow P₆ \rightarrow P₁\}.

3. (25 Points) Assume that every program in a computer system contains 400,000 assembly-code instructions. To execute an instruction, it takes 5 cycles. Assume that this system always keeps 250 active processes in its ready queue, and each active process needs to be executed at least once every 1/20 seconds. It implies that while a process is ending, a new process will be created. Assume that the O.S. is running under a Round-Robin non-preemptive scheduling and each time-quantum is divided into 50 ticks, and the system is running under 250 MHZ. What is the burst time in ticks for each process when it is executed, and what is the average waiting time? Assume that we do not need to worry about I/O and page faults.
1. (30 Points) In a real-time system, there are three processes creating periodical events. Their burst-times, deadlines, and periods are given in the table below:

<table>
<thead>
<tr>
<th>Process</th>
<th>Burst Time</th>
<th>Period/deadline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pl</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>P2</td>
<td>25</td>
<td>35+45*</td>
</tr>
<tr>
<td>P3</td>
<td>30</td>
<td>100</td>
</tr>
</tbody>
</table>

45* indicates that a new P2 event will be initiated 45 ticks after the current event is done, however its effective period (or its deadline) is set to 80.

d) (05) Compute the CPU utilization rate.

e) (25) Can the given situation be admitted by the operating system if an earliest-deadline first scheduling is applied? To illustrate your work, you need to draw Gantt chart up to t=350.

2. (35 Points) P₁, P₂ ... P₅ are 5 hosts in a distributed system and ID(Pᵢ) > ID(Pⱼ) if i > j. If Pᵢ and Pⱼ are directly connected, their communication-latency is given as CL(Pᵢ, Pⱼ). Given:

- CL(P₁, P₃)=5
- CL(P₁, P₅)=3
- CL(P₂, P₃)=2
- CL(P₂, P₄)=3
- CL(P₂, P₅)=4
- CL(P₃, P₄)=4
- CL(P₄, P₅)=5

If Pᵢ and Pⱼ are not directly connected, then a path with minimum latency will be used. Assume that the host with the highest ID is the system coordinator and a new coordinator will be elected by the Ring Algorithm if the current coordinator is down. Assume that each host periodically requests resources: P₁ for every 66 ticks, P₂ for every 53 ticks, P₃ for every 80 ticks, and P₄ for every 47 ticks, all starting at t=0. If a host goes down, its associated communication gears remain intact. If P₅ goes down at t=352, answer the following questions.

c) Who is the first host that finds out the coordinator is down? When does this occur?

d) When will a new coordinator Pₖ send out the declaration messages? Assume a token ring is set as P₁→P₅→P₂→P₄→P₃→P₁.

3. (35 Points) Assume that the page reference string is made by recording the virtual page number every 2 ticks while a process is executing. Assume that P₁, P₂, and P₃ arrived just before t=0 with the arriving order of {P₁, P₂, P₃}. P₁ and P₂ execute Pₐ, and P₃ execute P₉. Assume that all processes execute the same program, and their page reference strings are not the same. Let P₁ has the following page reference string: {7, 8, 8, 21, 22, 8, 21, 22, 21, 22, 9}. P₂ has their own page reference string shown as: {7, 8, 8, 21, 22, 8, 21, 22, 22, 9}. P₃ will have the page reference string shown below: {6, 6, 6, 7, 8}. Assume that the system needs 5 ticks to handle each page fault, and they are handled in a first-come-first-serve manner. Draw a Gantt chart illustrating the scheduling of these processes and find the number of page faults for each process if a Round-Robin non-preemptive scheduling with a time quantum of 4 ticks is used. Note that each process has a working set of 3 pages, and the page replacement algorithm is FIFO. Show the contents of the progressing working sets.
CS630 Operating System Design: Final Exam (f10)

Name: ____________________________      Class Code: ___________

1. (40 Points) In a real-time system, there are three processes creating periodical events. Their burst-
times, deadlines, and periods are given in the table below:

<table>
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<tr>
<td>Pl</td>
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<tr>
<td>P2</td>
<td>25</td>
<td>35+45*</td>
</tr>
<tr>
<td>P3</td>
<td>20</td>
<td>90</td>
</tr>
</tbody>
</table>

45* indicates that a new P2 event will be initiated 45 ticks after the current event is done,
however its effective period (or its deadline) is set to 80.

f) (05) Compute the CPU utilization rate.

g) (20) Can the given situation be admitted by the operating system if an earliest-deadline first
scheduling is applied? To illustrate your work, you need to draw Gantt chart up to t=350.

h) (15) If the current events can be admitted, a new process P4 creating periodical events with a
period of 110 units will be added. If P4 events are expected to be admitted, what is the
longest burst time P4 can have? You must show your work and justify your answer.

2. (20 Points) Assume that every program in a system contains 40,000 machine-code instructions.
To execute an instruction, it takes 4 machine cycles. Assume that a computer system constantly
keeps 150 active processes in execution, and each active process needs to be executed at least
once every 1/20 seconds. It implies that while a process is ending, a new process will be created.
Assume that the O.S. is running under a Round-Robin non-preemptive scheduling and each
time-quantum is divided into 50 ticks, and the system is running under 1 GHZ. What is the
burst time in ticks for each process when it is executed, and what is the average waiting time?

3. (40 Points) Assume that the page reference string is made by recording the virtual page number
every 2 ticks while a process is executing. Assume that P1, P2, and P3 arrived just before t=0
with the arriving order of {P1, P2, P3}. Assume that all processes execute the same program, and
their page reference strings are not the same. Let P1 has the following page reference string:

{7,  8,  9,  8,  21,  22,  8,  21,  22,  21,  22,  9}.

P2 has their own page reference string shown as:

{7,  8,  9,  8,  21,  22,  21,  22,  21,  22,  9}.

P3 will have the page reference string shown below:

{7,  8,  21,  8,  8,  8,  8,  9}.

Assume that the first instruction on page 21 causes a disk I/O. Assume that the system needs 4
ticks to handle each I/O or page fault, and they are handled in a first-come-first-serve manner.
Draw a Gantt chart illustrating the scheduling of these processes and find the number of page
faults for each process if a Round-Robin non-preemptive scheduling with a time quantum of 5
ticks is used. Note that each process has a working set of 3 pages, and the page replacement
algorithm is FIFO. Show the contents of the progressing working sets.

4. (20 Points) We want to implement a real time subsystem in a distributed system. If it can be
done, how to proceed with the idea?