



# COLLEGE OF MANAGEMENT & INFORMATION TECHNOLOGY

## BACHELOR IN INFORMATION TECHNOLOGY

**ASSIGNMENT ON**

**Real Time System**

**ASSIGNMENT NUMBER: 1**

**Submitted by:**

Name: Jenisha Munikar
Year/ Semester: 3rd / 5th
LCID: LC00017000520

**Submitted to:**

Saroj Ghimire

**Date: 2021/05/17**

1. **State whether the following statements are TRUE or FALSE. Justify your answer.**

   a. **A hard real time application consists of only hard real-time tasks.**

      **False**. A hard real time application may also consist of other several non-real time tasks such as logging activities. (Mall, 2010)

   b. **Every safety critical real time system contains a fail-safe state.**

      **False.** It is meaningless to have fail-safe state in safety critical real time system. When safety critical real time system fails, it can cause several damages. Example: a navigation system on-board an aircraft. (Mall, 2010)

   c. **A deadline constraint between two stimuli is a behavioral constraint on the environment of the system.**

      **True.** A deadline constraint between two stimuli is a behavioral constraint on the environment of the system since the constraint is imposed on the second stimulus event. (Mall, 2010)

   d. **A good algorithm for scheduling of hard real time tasks tries to complete each task in the shortest possible time.**

      **False.** A good scheduling algorithm for hard real time tasks is only concerned with completing the tasks before the deadlines. Moreover, there is no special benefit in completing each task in the shortest possible time.

   e. **All hard real time systems usually are safety critical in nature.**

      **False.** There are some hard real time systems that are not safety critical in nature. Example: computer games.

   f. **Soft real time tasks do not have any associated time bounds.**

      **False.** Soft real time tasks have associated time bounds. Instead of absolute values n of time, the constraints are expressed in terms of the average response times required. (Mall, 2010)

2. **What is the difference between a performance constraint and a behavioral constraint in a real-time system?**

   The difference between a performance constraint and a behavioral constraint in a real - time system are:

   - The constraints that are imposed on the response of the system are called performance constraints whereas the constraints that are imposed on the stimuli generated by the system are called behavioral constraints. (Mall, 2010)
   - Performance constraints ensure that the computer system performs satisfactorily whereas behavioral constraints ensure that the environment of a system is well-behaved. (Mall, 2010)
   - Performance constraints basically describe the overall performance of the system whereas behavioral constraints basically describe the behavior of the environment. (pp_pankaj, 2020)

3. **What is understood by jitter associated with a periodic task? Mention techniques by which jitter can be overcome.**

   Jitter is the variation between the expected timing and the actual timing for a task. It occurs both when actual timing is later than expected timing and when actual timing is earlier than expected timing for a task. (Determinism and Jitter in a Real-Time System, 2020)A periodic task is the one in which a set of jobs are executed repeatedly at regular intervals. In periodic task, jitter occurs when there is changes it the task's periodic behavior. It can occur both at arrival time and completion time of a periodic task. When there is variation in arrival time of a task i.e., the task deviates from arriving at the precise periodic time of arrival, the arrival time jitter occurs. It may be caused by imprecise clocks, network congestions and many other factors. Likewise, the completion time jitter occurs when the completion of time deviates from precise periodic points. It may be caused by the specific scheduling algorithm used which takes a task for scheduling as per convenience and load at an instant rather than scheduling at some strict time instants. (Mall, 2010)

Following two techniques can be used to overcome jitter:

- Prioritizing the tasks i.e., providing higher priority to tasks which have tight jitter requirements can be done to overcome jitter. This technique is suitable only when there are few number of tasks. In case of larger number of tasks in which the tasks are barely schedulable, it may result in some tasks missing their respective deadlines.
- For application having large number of tasks in which the tasks are barely schedulable, jitter can be minimized by splitting each tasks into two parts: one which calculates the output but does not pass it on and one which passes the output on. This technique involves setting the priority of second task to very high values and its period same as that of the first task. The task scheduled with this approach will run one cycle behind schedule, but the tasks will have tight completion time jitter. (Mall, 2010)

4. **Explain real time application with its working mechanism and use if any block diagram.(it must include one each of soft and hard real time system)**

The real time applications are:

i. Aerospace Application
ii. Telecommunication system
iii. Automated Manufacturing System
iv. Signal Processing System
v. Industrial Application
vi. Defense Application
vii. Medical Science Application
viii. Internet and Multimedia Applications
ix. Vehicle Control System
x. Peripheral Equipment Application

### i. Aerospace Application

The applications of real-time systems in aerospace are: flight simulation, airline cabin management systems, computer on-board an aircraft, satellite tracking system, air traffic control system, etc.

- **Air Traffic Control System:** Air traffic control system (ATC) is a service provided by ground-based air traffic controllers who direct aircraft on the ground and through controlled airspace, and can provide advisory services to aircraft in non-controlled airspace. (Wikimedia Foundation, 2021) The air traffic controllers work from the air traffic control tower and is responsible for observing the location of aircraft, controlling the aircraft environment and landing the aircraft safely in the airport. Throughout the flight, they communicate with pilots by transmitting information back and forth using large system of computers, radars, radios and visual references and provide various air controls such as communicating with pilot regarding weather forecast and providing clearance for the flight's route (preflight), giving the airplane clearance to take off, transferring the flight control to terminal radar after the aircraft takes off, giving oversight to a radar system which supervises flights within the area, descending the aircraft and giving clearance for landing and directing pilots through taxiways. (How air traffic control systems work, 2019) All these air controls are required to be completed within a few milliseconds in order to prevent any catastrophic failures.

### ii. Telecommunication System

The applications of real time systems in telecommunication are: cellular systems, cable modems, video conferencing, etc.

- **Cellular System:** Cellular system is one of the most popular means of mobile communication. In this system, a city is divided into cells, each cell consists of a base station and each base station monitors all the mobile handsets present in its particular cell. The base station also performs other several tasks such as locating a user, sending and receiving control messages to a mobile handset, keeping track of call details for billing purposes, etc. In addition, it is also

responsible for handing off of calls as the mobile moves from one cell to another, which means as a mobile moves away from a base station, the received signal strength(RSS) of the mobile decreases. The base station keeps track of this and as soon as the RSS falls below a certain threshold value, it hands-off the details of the on-going call of the mobile handset to the base station of the cell to which the mobile has moved. This hand-off process must be completed within a small predefined time interval so that the user does not experience any temporary disruption of service during hand-off. The call hand-off is required to be completed within a few milliseconds. (Lesson 28 Introduction to Real-Time Systems)

### iii. Industrial Application

Some examples of industrial applications of real time systems are: process control systems, industrial automation systems, test and measurement equipment and robotic equipment.

- **Chemical Plant Control:** Chemical plant control system is a type of process control system. In an automated chemical plant, a real-time computer periodically monitors plant condition which is determined on the basis of certain parameters i.e., the current reading of pressure, temperature or chemical concentration and carries out the action required within a certain predefined time bound. These parameters are sampled periodically. Based on the current sampled value of these parameters, the automated chemical plant system decides on the correct and necessary action required and carries out this action for maintaining chemical reaction at a certain rate. Each time the plant condition is sampled, the sample value of the parameters can change and according to the changing value of the parameters (pressure, temperature or chemical concentration), the automation system should decide on the exact instantaneous corrective actions required and carry out this action within a certain predefined time bound. The time bound for this system ranges from few microseconds to several milliseconds. (Lesson 28 Introduction to Real-Time Systems)

**iv. Internet and Multimedia Application**

Some examples of internet and multimedia applications of real time systems are: video conferencing, internet routers and switches, computer games, etc.

- **Video Conferencing:** The video conferencing application performs through cameras and microphones. Cameras generate video signals and microphones generate audio signals. The data received through these devices are sampled at a certain pre-specified frame rate and are compressed and sent as packets to the receiver end over a network. The receiver end receives these packets in an ordered and decompressed form and then played. At the receiver end, there is time constraint i.e., the receiver must process and play the received frames at a pre-specified constant rate. Thus, if thirty frames are to be shown per minute, the next frame must be played within two seconds of the previous frame's completion. (Lesson 28 Introduction to Real-Time Systems)

**v. Defense Application**

The use of real time systems in defense applications are: missile guidance system, anti-missile system, satellite-based surveillance system, etc.

- **Missile Guidance System:** Missile guidance system is a type of defense application. In this system, a computer is installed on the missile for keeping track of it and providing guidance to that missile. This installed computer performs tasks such as calculating the deviation from the required trajectory and effecting the track changes of the missile. The target sensing and track correction tasks must be activated frequently enough to prevent the missile from diverging from the target, which places a time constraint on the computer-based guidance. The target sensing and track correction tasks are typically required to be completed within a few hundreds of microseconds or even lesser time depending on the speed of the missile and the type of the target. (Lesson 28 Introduction to Real-Time Systems)

5. **Give two different explanation of why the periodic tasks (2,1), (4,1) and (8,2) are schedulable by the rate monotonic algorithm.**

   Rate monotonic algorithm is a fixed-priority algorithm that assigns priority to tasks based on their periods. It assigns higher priority to tasks which have shorter periods and tasks which have higher rate of occurrence and vice versa.

   The schedulability of the periodic tasks (2,1), (4,1) and (8,2) under rate monotonic algorithm can be checked by the following sufficient condition or Liu and Layland's condition:

$$\sum_{i=1}^{n} u_i \leq n(2^{1/n} - 1)$$

   Now, $\sum_{i=1}^{3} u_i$ = 1/2 + 1/4 + 2/8 = 1

   $n(2^{1/n} - 1)$ = 3 ( 2^1/3 -1 ) = 0.78

   Therefore, 1 <= 0.78. Here, 1 is not less than 0.78 so the above task set is not schedulable under Liu and Layland's condition.

   Since the schedulability test under Liu and Layland's test fails, it needs to be further tested using Lehoczky's test. This test states that a set of periodic real-time tasks is RMA schedulable under any task phasing, iff all the tasks meet their respective first deadlines under zero phasing. Using Lehoczky's test,

   **Testing for Task T1 (2,1):**

   e1 <= d1 i.e., 1 <= 2. Since e1 (1) is less than d1 (2) , T1 meets its first deadline.

   **Testing for Task T2 (4,1):**

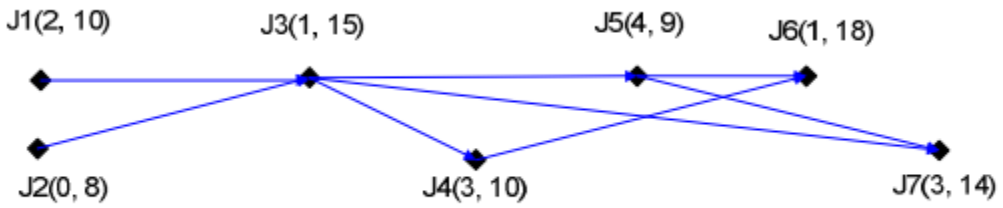
   T1 is its higher priority task and considering zero phasing, it would occur once before the deadline of T2. Therefore, (e1 + e2) <= d2 i.e., (1 + 1)= 2 and 2 <= 4. Since it satisfies, T2 meets its first deadline.

**Testing for Task T3 (8,2):**

T1 occurs four times and T2 occurs two times within the first deadline of T3. Therefore, ( 4 * e1 + 2 * e2 + e3 ) <= d3 i.e., ( 4 * 1 + 2 * 1 + 2) = 8 and 8 <=8. Since it satisfies, T3 meets its first deadline.

Since, all the three tasks meet their respective first deadlines, the task set is schedulable by rate monotonic algorithm according to Lehoczky's results. (Scheduling Algorithm, 2014)

6. **Consider a set of jobs J(r, d) with the release time and the deadline. The precedence constraints are shown as in the graph below. Derive the formula of calculating the effective release time and deadline. Calculate the effective release time and deadline for each job in the set.**




The formula of calculating the effective release time is:

- If a job has no predecessors then its effective release time is equal to its given release time.
- If a job has predecessors then its effective release time is equal to the maximum value among its given release time and the effective release times of all of its predecessors.

The formula of calculating the effective deadline is:

- If a job has no successors then its effective deadline is equal to its given deadline.
- If a job has successors then its effective deadline is equal to the minimum value among its given deadline and the effective deadlines of all of its successors.

The effective release time and effective deadline for each job of the above graph is calculated below:

**Calculation of effective release time**

- As J1 and J2 have no predecessors, their effective release times are their given release times i.e., 2 and 0 respectively.
- The given release time of J3 is 1, but the latest effective release time of its predecessors is 2 i.e., of J1. Hence, the effective release time of J3 is 2.
- Similarly, the effective release times of J4, J5, J6 and J7 are 3, 4, 4 and 4 respectively.

**Calculation of effective deadline**

- As J6 and J7 have no successors, their effective deadlines are their given deadlines i.e., 18 and 14 respectively.
- Since the effective deadlines of the successor of J4 and J5 are larger than their given deadlines, so the effective deadlines of J4 and J5 are equal to their given deadlines i.e., 10 and 9 respectively.
- The given deadline of J3 i.e., 15 is larger than the minimum value of its successors i.e., 9, so the effective deadline of J3 is 9.
- Similarly, the effective deadline of J1 and J2 are 9 and 8 respectively.

# References

*Determinism and Jitter in a Real-Time System*. (2020, April 9). Retrieved from NI: https://www.ni.com/documentation/en/labview-comms/5.0/rt-targets/determinism-real-time

*How air traffic control systems work*. (2019, November 27). Retrieved from Sheffield: https://www.sheffield.com/articles/how-air-traffic-control-systems-work

*Lesson 28 Introduction to Real-Time Systems.* (n.d.). Retrieved from Yumpu: https://www.yumpu.com/en/document/read/18818354/lesson-28-nptel

Mall, R. (2010, June 1). *NPTEL Course: Real-Time Systems.* Retrieved from NPTEL: https://nptel.ac.in/content/storage2/courses/106105036/assignments/Q_&_A.pdf

pp_pankaj. (2020, May 10). *Timing Constraints in Real-time System*. Retrieved from GeeksforGeeks: https://www.geeksforgeeks.org/timing-constraints-in-real-time-system

*Scheduling Algorithm.* (2014, October 26). Retrieved from DOCUMENTS: https://documents.pub/reader/full/scheduling-algorithm-558448812edf8

Wikimedia Foundation. (2021, May 9). *Air Traffic Control*. Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Air_traffic_control