Topics:
- Test Review

Multitasking

_An army travels only so far as its stomach allows._

Why multitask? What resources exist that constrain you? What Multitask schemes can you identify and describe?

Terms
- Polled Loop
- Interrupt Driven
  - Cyclic Executive
  - Round Robin
  - Pre-emptive Priority
- Context Switching
- Priority
  - Inversion
  - Inheritance
- Foreground/Background

Sample Questions
1. What type of multitasking would you use for the following situations?
   a) Thrust vectoring software needs attitude update every 40 msec or the system becomes unstable.
   b) Thermostat checks the temperature in a room and sends commands to the cooling/heating system.
   c) A subsystem on a spacecraft must perform the following tasks. Data Gathering task infrequently writes data from instruments to a shared buffer. Bus Management task must move data out of the input buffer before the buffer is filled but exact timing is not important. The data in the buffer is protected by a mutex. Every 12 hours a Communication task runs and downloads all processed data to the ground station. The Communication task can run for several hours depending on the amount of data.
2. Consider a pre-emptive priority system. The tasks in the system, time needed to complete and priority (5 is highest) are given in the table below. If the tasks become ready to run 5 msec apart in the task order A, B, C, D, then E, at what processor elapsed time does Task C complete?

<table>
<thead>
<tr>
<th>Task</th>
<th>Time Needed (msec)</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task A</td>
<td>20</td>
<td>3</td>
</tr>
<tr>
<td>Task B</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Task C</td>
<td>40</td>
<td>5</td>
</tr>
<tr>
<td>Task D</td>
<td>40</td>
<td>2</td>
</tr>
<tr>
<td>Task E</td>
<td>50</td>
<td>4</td>
</tr>
</tbody>
</table>

Inter-task Communication

Don’t kill the messenger

What must a processor do to efficiently divide its resources amongst different threads? What is a semaphore, and what is deadlock? Why would the processor move on to execute a different set of instructions in a real time system?

Terms
- Global Variable
- Mailbox, Buffer, Shared Memory
- Semaphore (Atomic)
- Mutual Exclusion
- Deadlock

Sample Questions
1. Using the table above, what would happen in the following situation? Task B starts running at time $t=0$ and using a semaphore that is also used by task C. (Assume task B will not release the semaphore until it is fully finished running.)
   - $t = 10$ msec, task C is ready to run
   - $t = 20$ msec, task D is ready to run
   - $t = 50$ msec, task A is ready to run
   - $t = 110$ msec, task E is ready to run
2. A system includes a sensor where data is available once every 30 msec and a polled loop that reads that data once every 40 msec. Are there any problems with this approach? If so, what would you do to fix it?

Fault Tolerance

Murphy: It's not just a rule; it's the law.
Fault Tolerance is required for many systems. What are some ways to minimize software and hardware failure? Why is making a redundant system worth the extra effort? What does adding more hardware do?

Terms

- Exception Handling
- Watchdog Timer
- Redundant Hardware
- N-Version Programming

Sample Questions

1. There are several exception handling techniques that would make this real time system code more robust. Discuss 2 ways.

```c
int altitude, old_altitude;
int get_sensor_data();
void sound_alarm();
while(1)
{
    old_altitude = altitude;
    altitude = get_sensor_data();
    if(old_altitude/altitude > 10)
    {
        sound_alarm();
    }
} /*end infinite loop*/
```

Abstract Data Types

Use the right weapon for the job.
Know the differences between Stacks, Queues, Lists, and Trees. Know how to add or delete an object to these data types. Cultivate the ability to create one of these data types from information given to you (such as a list of numbers)

Terms

- Node
- List, Queue, Stack, Tree
- Head/Tail, Root/Leaf/Branch
- Insert/Delete, Enqueue/Dequeue, Push/Pop
Sample Questions
1. Which Abstract Data Type do the following real-world situations represent? (Linked List, Sorted Linked List, Stack, Queue, Prioritized Queue)
   a) The first Krispy Kreme donut shop in New England has a drive-through window.
   b) The dock hands at the MIT Sailing Pavillion keep contact info for all sailors on index cards in a box on the front desk. You can look up a sailor by last name.
2. A Double-Linked List is a linked list with two pointers, for "next" and "previous", instead of just one pointer to "next" as discussed in class. The concept is illustrated below:
   a) Describe an "enqueue" operation on a doubly-linked list that is being used as a queue. Be sure to describe all changes in both the node being enqueued and any surrounding nodes or pointers.

Sorting and Searching
  THE HARDEST TASK IS NOT KILLING YOUR ENEMY. IT IS FINDING YOUR ENEMY, AND VERIFYING YOUR TARGET AS YOUR ENEMY.
  There are several methods to sort and search the array. Make sure you are able to point out the benefits and drawbacks to each. Which is better to perform first, a sort or a search?

Terms
  • Linear Search
  • Binary Search
  • Selection Sort
  • Bubble Sort
  • Merge Sort
  • Trees: Breadth first, Depth first
  • Order of Growth: Big O Notation

MINIMIZING YOUR EFFORT TO GET GOOD INFORMATION LEAVES YOUR RESOURCES FREE TO PURSUE THE IMPORTANT THINGS IN LIFE.
What is big O notation? Why is it important to tasks such as sorting and searching? What are the differences between calling an algorithm O (n) vs. O (log n)?