## **CS 354 Fall 2025** **Homework 3**

1. Suppose three separate groups of processes will use the high-level message passing

facility:

Group A: four processes will exchange messages through a port P1

Group B: six processes will exchange messages through another port P2

Group C: two processes will exchange messages through yet another port P3

Assume that group A can store up to 16 messages, group B can store up to 9 messages, and group C can store up to 5 messages.

1. What system call must be made before any of the groups can proceed to use the port facility, and what argument or arguments should be passed?

The system call is ptinit, and it must be passed the total number of messages that can be stored across all ports, at least 16 + 9 + 5 = 30 to meet the requirements for the groups.

1. How many semaphores will be allocated when the port system is first initialized? (i.e., before any ports are created)?

0

1. After groups A, B, and C have each created a port, how many semaphores will have been created in total, and to what do they correspond?

6 semaphores will have been created in total. Each port has two semaphores: one initialized to 0, for waiting when there are no messages to receive, and one initialized to the port's message limit, for waiting when the port is full.

(d) How much memory (in bytes) will have been allocated to hold messages when the system has been initialized?

- You may provide a formula instead of a single number.

- Just count the message nodes, not any head or tail pointers.

maxmsgs \* sizeof(struct ptnode)where maxmsgs is the argument passed to ptinit and struct ptnode consists of a 4-byte message and a 4-byte pointer, totaling 8 bytes per node.

2. Suppose process Z from group A created the port for the group to use and received a port ID` .

1. Describe one way that process Z can use to let other processes in group A know which port the group is using.

Process Z can use Xinu's low-level message passing to send the port ID directly to the PIDs of the other processes in group A (via the send system call).

1. Describe another way that process Z can use to let other processes in group A know which port the group is using.

Process Z can store the port ID in a global variable that is accessible to all processes in group A, as Xinu processes share the address space.

3. Suppose group C consists of processes X and Y. Also assume that they create a port to use and somehow both learn the port ID. Also assume that X generates a series of positive numbers and uses ptsend to send each value in the sequence to Y followed by a termination value of -1. Finally, assume Y runs a loop that repeatedly calls ptrecv and uses kprintf to print the value in the message if the value is greater than zero or exits when it finds a negative value.

1. If X has higher priority than Y, will Y be able to receive all the values that X sends, without missing any of the values? Explain.

Yes, because if the port becomes full, X will block on send until Y receives a message and frees a slot. The semaphores ensure no overflow or lost messages.

1. Does your answer to part (a) change if X and Y have equal priority? Explain.

No, the answer does not change. With equal priorities, Xinu does not preempt for equal-priority processes, so the running process continues until it blocks, but the bounded buffer still prevents message loss.

1. Does your answer to part (a) change if Y has higher priority than X? Explain.

No, the answer does not change, the higher priority of Y ensures it runs when a message is available, but the synchronization still guarantees all messages are received without loss.

(d) Suppose that X has higher priority than Y. What sequence of process execution will occur? (i.e., describe how many messages X will send and Y will receive each time they run).

Assuming the port can hold M messages, X will initially send M messages and block. Y will receive 1 message, signaling a free slot and causing preemption by X (higher priority). X will then send 1 more message and block again. This pattern repeats (Y receives 1, X sends 1) until X has no more messages to send, after which Y receives any remaining messages in the port.

4. What is the name of the standard process coordination problem X and Y have to solve in the previous problem?

Producer consumer problem

5. Before it waits on a semaphore, the ptrecv function assigns a local variable named seq the sequence number of the port being used.

1. What is the meaning of the sequence number in a port?

The sequence number identifies the current version of the port and is incremented on creation, deletion, or reset to detect changes during operations.

1. When a process is waiting to receive a message from the port, is it possible that the sequence number of a port changes while waiting? Explain.

Yes, it is possible if another process deletes or resets the port while the receiving process is waiting on the semaphore. Upon wakeup, ptrecv checks if the sequence number has changed and aborts if it has.

The following question refers to Xinu's sleeping process queue (delta list). Each subproblem is independent of one another, except that (g) depends on (f).

6. Conceptually, each item on the queue of sleeping processes has two parts: a process ID and a delay for that process. We can represent the two values as a tuple:

(process ID, delay)

For example, at some point in time, the sleeping process queue might contain:

head ----> (3, 4) (2, 5) (4, 0)

where the first item represents a process of ID 3 and a delay of 4 clock ticks. For this question, we will assume that each clock tick is one millisecond, which means the delay given in the first item is 4 milliseconds and the delay in the second item is 5 milliseconds.

1. What does the delay in the second item represent?

It represents the additional delay beyond the cumulative delay of the previous item, (process 2 will awaken after 4 + 5 = 9 mls).

1. How many milliseconds will pass before process 4 awakens? Explain.

9 mls will pass. The delta list accumulates delays, so process 4 awakens after the cumulative delay of 4 + 5 + 0 = 9 mls from the current time.

1. Assume a new process, process 19, is inserted into the sleeping process list and scheduled to awaken in 8 milliseconds. What will the list contain? Write the list with tuple notation, such as (1, 3) (2, 4).

(3, 4) (19, 4) (2, 1) (4, 0)

1. Start from the original sleep queue. Suppose a new process 13 is added to the sleep queue and sleeps for one second. What will the sleep queue contain? Write the queue with tuple notation.

(3, 4) (2, 5) (4, 0) (13, 991)

(e) Suppose a Xinu system has sleeping processes as follows:

process 5 sleeps for 5 milliseconds

process 6 sleeps for 6 milliseconds

process 7 sleeps for 7 milliseconds

process 8 sleeps for 8 milliseconds

process 9 sleeps for 9 milliseconds

What will the sleep queue contain? Write the queue with tuple notation.

(5, 5) (6, 1) (7, 1) (8, 1) (9, 1)

1. Suppose a Xinu system contains three sleeping processes 8, 9, and 10 (in that order), that will all awaken exactly 60000 milliseconds from now. What will the sleep queue contain? Write the queue with tuple notation.

(8, 60000) (9, 0) (10, 0)

1. For the situation in (f), suppose that the NULL process (which is currently running) and the three sleeping processes are the only processes. When 60000 milliseconds elapse, if process 8 is the first process in the sleep queue, will process 8 execute first? Explain.

Yes. When the clock interrupt handler processes the delta list after 60000 mls, it will decrement until the first item's delta reaches 0, then dequeue and ready process 8 first, followed by 9 and 10. Assuming same priorities, the ready queue maintains FIFO order for equal priorities, so process 8 (first dequeued) will be at the front and execute first when rescheduling occurs.

## **Submission**

You must submit a directory named hw3that contains a PDF file (created using dedicated PDF creator or converter):

* questions.pdf, containing your answers.

Go to the directory where hw3 is a subdirectory.

For example, if /homes/alice/cs354/hw3 is your directory structure, go to /homes/alice/cs354.

Type the following command to submit the directory with turnin:

turnin -c cs354 -p hw3 hw3

Be sure the file inside the directory is named exactly questions.pdf.

You can check/list the submitted files using  
  
turnin -c cs354 -p hw3 -v