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HALMSTAD UNIVERSITY

Center for Research on Embedded Systems (CERES)

Embedded Systems Programming

Final Examination, January 10, 2014 (08:00-12:00)

Instructions. No reading material, computer or calculator is allowed into the examination; you may only use a paper-based dictionary. The exam comprises 5 questions in 2 pages and will take 2 hours, but you are allowed to use the 4 hours allocated to the exam, if you like. Before starting to answer the questions, please make sure that your copy is properly printed. Good luck!

Question 1 (10/100 points). a. Explain what a deferrable server is and how it can be used. (**5 points**) **b.** Explain the concept of mutual exclusion and give an example of it in a code snippet. (**5 points**).

Question 2 (30/100 points). a. Explain the difference between synchronous and asynchronous call; motivate your answer by a simple code snippet. (**10 points**) **b.** Give the possible output(s) of the following program and explain how it (they) can be produced. (**20 points**)

```
#include "TinyTimber.h"

typedef struct {
    Object super;
    int value;
} Counter;

#define initCounter(en) { initObject(), en }

int inc( Counter *self, int arg ) {
    int i;
    i = self->value;
    self->value = i + arg;
    return self->value;
}

int dec( Counter *self, int arg ) {
    int i;
    i = self->value;
    self->value = i - arg;
    return self->value;
}

Counter cnt = initCounter(100);

int main(){
    ASYNC( &cnt, inc, 50 );
    ASYNC( &cnt, dec, 20 );
    printf("The final value is: %d",cnt->value);
    return 0;
}
```

Question 3 (20/100 points). Consider the following specification of 3 periodic tasks.

Task	Execution Time	Period = Deadline
A	1	5
B	1	3
C	1.5	4

3.a. Is this set of tasks schedulable using the Rate Monotonic and/or Earliest Deadline First scheduling regimes? Motivate your answer using utilization-based schedulability analysis (you may assume: $2^{(1/2)}$ = 1.4, $2^{(1/3)}$ = 1.3 and $2^{(1/4)}$ = 1.2). (**10 points**)

3.b. Show the scheduling of this task set up to 12 units of time, using both the Rate Monotonic and the Earliest Deadline First algorithm. Assume that the first instance of all three tasks arrive simultaneously. (**10 points**)

Question 4 (20/100 points). Write the program (using the Tiny Timber library) for an object `port_obj` of class `Port` containing an 8-bit integer `cur_val`. Instantiate this object in the main and write a periodic task which reads a memory location at the address `INPADDR` (defined as a macro) every 10 milliseconds and updates the value of `port_obj.cur_val` in by adding 90 percent of the value stored at `INPADDR` to 10 percent of the old value of `cur_val`. Define another periodic tasks which reads `cur_val` and copies it to the output port mapped to the memory address `OUTPADDR` every 5 milliseconds.

Question 5 (20/100 points). Write a code snippet for an Android application that upon pressing the submit button, reads a text box, calculates the integer value typed in an edit box and shows in a notification its factorial (the factorial of each positive integer n is n * (n-1) * … * 1 and the factorial of 0 is defined as 1). The calculation of the factorial should take place in a worker thread.

Answer 1

a. It is a scheduling technique that accommodates for sporadic tasks. A periodic task with period T (minimum inter-arrival time of sporadic tasks) is created with a maximum capacity C. The task is used as a server for sporadic tasks that arrive. Once a sporadic task arrives, it uses the capacity of the server, if available when the server is scheduled. The capacity is replenished at the beginning of the server's period.

b. Mutual exclusion is a technique used to make sure that a critical resource (e.g., a memory location) is only accessible to at most one thread at a time. For an example, see the mutex example in the last slides of lecture 3.

Answer 2

a. In an asynchronous call, different calls to the methods same object are serialized while calls to the methods of different objects are executed in parallel threads. However, synchronous calls to methods of same and different objects are all serialized.

b. Possible outputs of the program are:

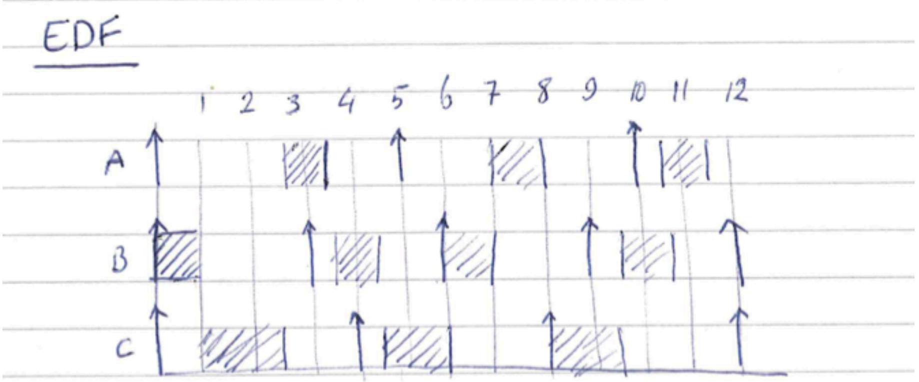
```
The final value is: 100
The final value is: 150
The final value is: 80
The final value is: 130
```

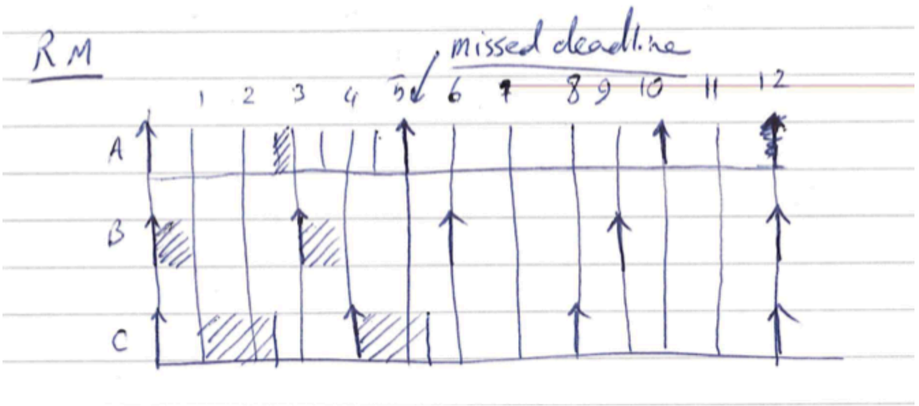
The reason is that the two calls are serialized but may be executed in any possible order, interleaved with the main thread.

Answer 3

a. The utilization of the task set is calculated as follows:
$1/5 + 1/3 + 1.5/4 = 0.91 > 3(2^{1/3} – 1) =3(1.3-1) = .9$
The task set is most likely not schedulable using RM; it is schedulable using EDF.

b.


EDF
1
2
3
4
5
6
7
8
9
10
11
12
A
B
C


RM
missed deadline
1
2
3
4
5
6
7
8
9
10
11
12
A
B
C