CS424 Final Exam

Please choose the best answer for each of the following multiple choice questions. Please e-mail the answers to zaher@cs.uiuc.edu by Thursday, Dec 17th, at 11:59pm Central time. Your e-mail should include your name followed by one question number and answer per line (e.g., "1. a" "2. b" "3.c" etc).

I. Schedulability: For each of the following task sets, consider the scheduling policies listed below in the following order: (a) FIFO, (b) rate monotonic, (c) deadline monotonic, (d) EDF. Answer (a), (b), (c), or (d) depending on the *first* scheduling policy (in the above order) for which the task set is found schedulable. If the task set is not schedulable by any of the four policies, answer (e) Not schedulable. Observe that multiple scheduling policies could make a task set schedulable. If so, you need to indicate only the first one. Note that you have the tools to analyze FIFO, but it may take a little bit of thought to do it right. In the sets below, T stands for task, C stands for computation time, P stands for period, and D stands for relative deadline. If D is not mentioned, then it is equal to the period.

1. Consider the set below:

T1: C1=5, P1=20
T2: C2=75, P2=101

a) FIFO b) Rate monotonic c) Deadline monotonic d) EDF e) Not schedulable

2. Consider the set below:

T1: C1=4, P1=10
T2: C2=2, P2=20, D2=5

a) FIFO b) Rate monotonic c) Deadline monotonic d) EDF e) Not schedulable

3. Consider the set below

T1: C1=0.5, P1=5
T2: C2=4, P2=16
T3: C3=7, P3=34
T4: C4=3, P4=60
T5: C5=40, P5=100

a) FIFO b) Rate monotonic c) Deadline monotonic d) EDF e) Not schedulable

4. Consider the set below:

T1: C1=1, P1=5
T2: C2=4, P2=11

a) FIFO b) Rate monotonic c) Deadline monotonic d) EDF e) Not schedulable

5. Consider the set below:

T1: C1=7, P1=10
T2: C2=3.5, P2=13

a) FIFO b) Rate monotonic c) Deadline monotonic d) EDF e) Not schedulable

II. Real-time Queuing Theory

6. In a highly utilized system, tasks have different deadlines drawn from a random distribution with a mean value of 10 seconds. EDF scheduling is used. According to real-time queuing theory, if every deadline is doubled, what happens to the miss ratio?

a) It doubles b) It is cut in half c) It changes to the square root d) It is raised to the power of 2

7. Please review the slide set on RTQT. Given the information in that set, in quantized EDF scheduling, how many priority levels would you say are needed to approximate true EDF well in terms of miss ratio? (By "well" assume that the difference is less than 10%.)

a) 1 level b) 2 levels c) 8 levels d) an infinity of levels

III. Energy

8. When does it save energy to operate a processor at a reduced frequency?

a) If it is the only processor in the system
b) If the processor does not have energy-saving idle or sleep modes
c) If the processor consumes zero energy when idle
d) If the length of the forbidden region is higher than the breakeven point

9. If a processor has sleep modes with a non-zero wake-up cost, which of the following might be an energy-optimal scheduling policy?

a) FIFO b) Rate monotonic c) EDF d) A certain non-work-conserving policy

10. A task with a period of 2 seconds runs on a processor where it has a computation time of 0.1 seconds at 1 GHz, 0.3 seconds at 0.5 GHz and 1 second at 0.2 GHz. The processor consumes 10 Watt, 8 Watt, and 7 Watt at the above three frequencies, respectively. It also has a 0 Watt sleep mode with a 25 Joule wake up cost. What is the energy optimal solution for executing this task? (Assume a scheduling policy is used that minimizes energy consumption.)

a) Run the processor at the highest frequency and sleep when idle.
b) Run the processor at 0.5 GHz and sleep when idle
c) Run the processor at 0.2 GHz and sleep when idle
d) Run the processor at 0.5 GHz without sleep
e) Run the processor at 0.2 GHz without sleep

11. The power consumption of a DVFS-capable processor is the sum of some function of frequency and a constant independent of frequency. Let that constant be K. Assume that voltage is scaled proportionally to frequency on this processor. Let f be the critical frequency of the processor defined as the frequency below which energy consumption will increase (assuming the processor has a good sleep mode and no wakeup cost). Let n be the energy-optimal number of processors if multiple processors are used to share workload. If K increases, what is the impact on f and n?

a) Both decrease
b) Both increase
c) f increases but n decreases
d) f decreases but n increases

IV. Control

12. In a server control loop where the objective is to control queue length by manipulating incoming request rate, which of the following most closely approximates the notion of server gain:

a) The expected change in queue-length when request rate is increased by 1 request per second.
b) The ratio of queue length to request rate
c) The request rate needed to produce 100% utilization
d) The queue length produced when the request rate is equal to the set point

13. A sensor that samples (at period T) a slowly changing continuous variable (whose rate of change is given by some slow frequency f), introduces an effective delay that is approximately equal to:

a) T/2 b) T c) 2T d) $2 \pi f T$

14. Which of the following statements most closely expresses a stability condition for feedback control loops involving control of server queues?

a) The system should have a zero steady state error
b) The loop must have a gain of 0.5
c) The loop must have a gain that is less than 1
d) The loop must have a gain that is less than 1 at the frequency at which the phase is -180 degrees

15. A control loop exhibits a non-zero steady state error for a fixed set point. Which of statements (a), (b) and (c), below, cannot be true of this loop? If more than one of these statements is not true, choose answer (d) or (e) accordingly.

a) The loop uses a PI controller
b) The loop controls server queue length by manipulating request rate
c) The loop controls server utilization by manipulating request rate
d) Both (a) and (b)
e) All of (a), (b) and (c)

16. The request rate on a server changes sinusoidally between 100 requests/second and 200 requests/second. Each cycle takes 1 minute. The service rate is 150 requests/second. Use the control-theoretic notions to determine the range of fluctuation in queue size (i.e., difference between maximum and minimum queue length). Which of the numbers below most closely approximates that range?

a) 100 requests b) 500 requests c) 1000 requests d) 5000 requests

17. In the problem above, what is the elapsed time between when the request rate peaks and when the server queue peaks?

a) 10 seconds b) 15 seconds c) 30 seconds d) 40 seconds

V. Tracking:

18. Several sensor networks of binary sensors are compared in terms of tracking accuracy. They differ in sensor density and range. Which network localizes targets to the lowest degree of error?

a) Density = 10 sensors/acre, Range = 100 meters
b) Density = 20 sensors/acre, Range = 80 meters
c) Density = 25 sensors/acre, Range = 60 meters
d) Density = 30 sensors/acre, Range = 45 meters

19. Consider a target that moves at a constant velocity in a straight line. Assume that the probability of target detection by a sensor of sensing range R increases proportionally with the time that the target spends in range of the sensor. While traversing a field, the target was detected by sensors of range 10, located at coordinates (20, 20), (20, 30), (60, 22), (82, 28). Determine the most likely hypothesis regarding target trajectory. Accordingly, which of the following points are most likely to be on the path of the target?

a) (60, 20) b) (20, 60) c) (40, 45) d) (30, 25) e) (25, 30)

20. Sensor A is twice more likely to fire when event E1 occurs compared to its average firing rate, and three times more likely to fire when event E2 occurs compared to its average firing rate. The odds of E1 occurring are 40% and the odds of E2 occurring is 30%. When the sensor fires, which event is more likely to have occurred?

a) E1 b) E2 c) Both have the same likelihood d) Not enough info to tell.

Good luck.