Practice and Problem Solving: Control Recap

CS 424 November 30th, 2009

1. A control loop consists of a controller, actuator, process (which is a pure delay element), and sensor. The gain of the controller, actuator and sensor is 4, 0.2, and 2 respectively. Is the loop likely to be stable?

2. In the above loop, let the gain of the controller, actuator and sensor be 2, 0.2 and 2 respectively. Will the loop converge exactly to the set point? If yes, explain why. If not, what is the steady state error?

3. In the loop mentioned in question 2, the controller was replaced changed a proportional controller (where controller output, *m*, is given by $m = 2\,e$, where *e* is error), to a controller described by the equation $m = m + 2\,e$. Will the loop converge exactly to the set point? If yes, explain why. If not, what is the steady state error?

4. It is desired to control the queue length of a Web server. The server queue is modeled as an integrator of flow. The flow is controlled by a proportional controller (one whose output is proportional to the error in queue length). The queue length is measured in the number of requests waiting in the queue. The controller controls the incoming request rate by admitting at most N requests per second, where $N = K\,e$ and e = *Desired queue length – Measured queue length*. The actual queue length is measured every 5 seconds. What is the maximum value of *K* for which the control loop is stable?

5. A sporadic server is used to serve aperiodic requests. The server is allocated a percentage *U* of CPU. A variable number of tasks (of at least one unit of computation time each) arrive at the sporadic server. It is desired to control the task service rate (in tasks/second) such that it is kept at some desired value. The number of tasks served per second is measured once a minute and compared to the desired number. The difference, *e*, is used to adjust the utilization *U* allocated to the server as follows: $U = U + 0.25\,K\,e$. What value of K would you recommend?

6. The rate of incoming requests to a server oscillates cyclically between 100 and 500 requests/second. Each cycle takes 1 minute. The service rate remains constant at 300 requests per second. Intuitively, the server queue length will oscillate as well.

a) Use the control-theoretic concept of server gain to derive the difference between the maximum and minimum server queue length.

b) Use the control-theoretic concept of server phase to answer the following question: Will the server input request rate and server queue length reach a peak at the same time? If so, why? If not, what is the difference in seconds between the time the request rate reaches a peak and the time the queue length reaches a peak?