RTDS408 Tutorial Problems #2 - Time Handling and Temporal Relations

1. A *master-slave clock algorithm* was used to synchronize a slave processor clock. At the start of the update cycle the master clock had a time of 10:00:00.000000 and the slave received the master's clock after 10 μsec at its clock time of 10:00:00.000500. In the second phase of the update cycle, the slave responds with a time of 10:00:00.001000 which is transmitted to the master in 30 μsec where the master clock reads 10:00:00.000540. Assuming that nothing is known about the slave clock errors apart from the assumption of a zero-mean Gaussian distribution, what is the clock update that would be sent from the master to the slave?

2. With a *master-slave clock algorithm*, show that a bound on the maximal clock error between slaves would be given by the following expression:

$$\left|2\tau \max_j(\delta_j)\right| + \left|2 \max_j(\epsilon_j)\right|$$

where j = 1 .. number of slaves

δ_j = the drift rate (in sec/sec) for slave j

$\epsilon_j = (\bar{\mu}_i^j - \bar{\mu}_j^i)/2 - (\bar{E}_j^1 - \bar{E}_j^2)/2$

τ = update period (sec)

$\bar{\mu}_i^j$, $\bar{\mu}_j^i$ = mean master-slave and slave-master communication times respectively

$\bar{E}_j^1$, $\bar{E}_j^2$ = mean slave clock error distribution times

3. Given a *fundamental ordering distributed clock algorithm*, develop a bound for the variation of each clock in a distributed network with a communication graph of diameter *d*. Calculate this bound for a case with a clock drift rate of 0.001, message update rate of 10 msec, upper bound on message delays of 10 μsec, and a communication graph diameter of 10 hops.

4. With a *distributed clock algorithm* that uses a *minimize maximum error approach*, determine what clock update is performed from node *j* given the following states at node *i* and node *j* at the time of the update cycle:

   At node *i*: let the reset time be 00:00:00.000000, the count time is 00:00:00.001000, the drift rate is estimated at 0.01, and the estimated discretization error is 5 μsec.

   At node *j*: let the reset time be 00:00:00.000000, the count time is 00:00:00.001020, the drift rate is estimated at 0.01, and the estimated discretization error is 20 μsec. The response delay from node *i* to node *j* is 5 μsec.