Final Exam (ECE 493/593 Sensor Networks (I), Dec 7, Monday, 11:30 AM, Fall 2009**)**

Name:

Grade: X/100

Rules: Open book & notes; No discussions; No laptops;
Total: 2.5 hours; Maximum: 100 points;
Write your solution in a concise, clear and complete way.

Question 1: On Time Synchronization (20 pts)

1.1 (2%) Why do different sensors have clock differences when time goes on?

1.2 (2%) "Absolute synchronization" means that
(fill out the blank) _____

While "relative synchronization" means that _____

1.3 (4%) Suppose a sensor's clock function is as follows:

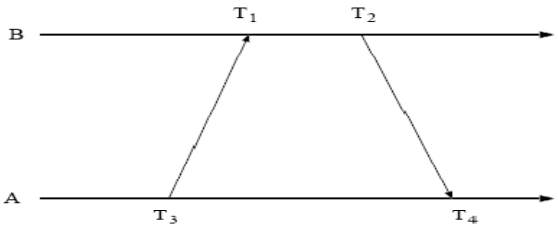
$$C(t) = 3t + 20$$

Where *t* represents global standard time. What are the **clock frequency** and **clock skew**, respectively?

1.4 (6%) Use the following figure to explain how **NTP** achieves time synchronization.

Server 1

Server 2

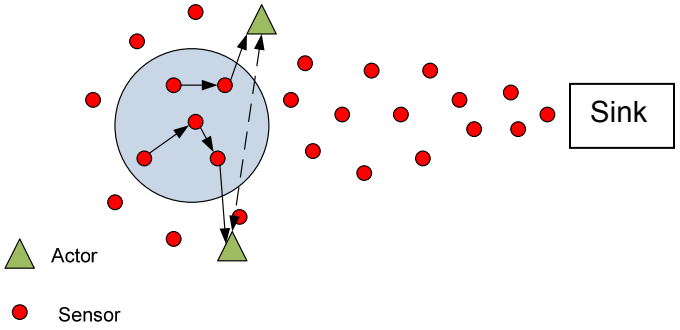


1.5 (6%) Explain how **RBS** achieves time synchronization. (**Draw a picture first**)

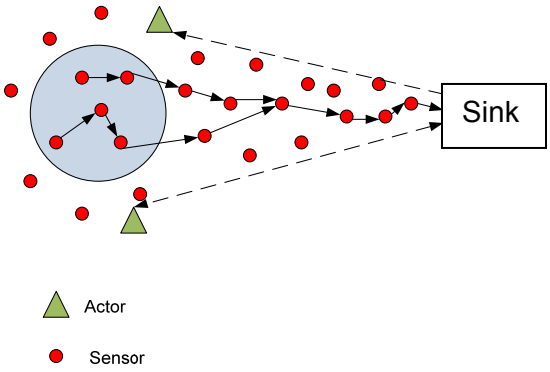
Question 2: On Wireless Sensor and Actor Networks. (10 pts)

2.1 (3%) What are the main features of wireless sensor and actor networks?

2.2 (3%) Observing the following two figures on sensor-actor communication modes, can you explain the differences between them?

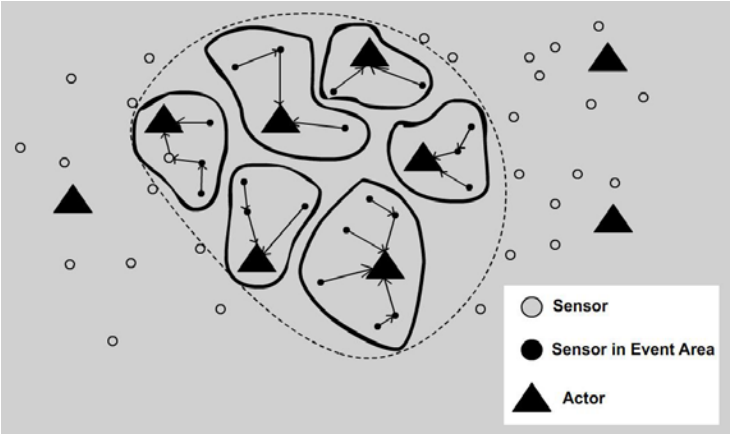


(a)



(b)

2.3 (4%) The following figure shows that all actors need to determine who should go which event area when multiple event areas exist. Can you suggest a good way to partition the event area to different actors? (Note: consider several factors: such as energy, routing, delay, position, etc.)



Question 3: On Localization (20 pts)

3.1 (2%) Why GPS doesn't work well in sensor localization?

3.2 (4%) How do we use RSSI (Received Signal Strength Indication) to determine the distance? **Show math**.

3.3 (4%) How do we use TDoA (Time Difference of Arrival) to determine distance? **Show a figure.**

3.4 (4%) How do we determine a sensor's location based on its distance to nodes whose positions are known?

3.5 (6%) Suppose 3 nodes: A (100, 100), B (50, 50), C (80, 70). And the distances between a sensor S and those 3 nodes are: S-A = 25, S-B = 20, S-C = 20. Calculate the sensor's location based on multi-lateration theory.

Question 4: Security (30 pts)

4.1 (4%) Explain differences between symmetric and asymmetric cryptography schemes (mention their definitions, pros and cons).

4.2 (4%) In the class we talked about on-line banking security. When a user inputs username and password, another person could listen to all communications between the user and the bank. How does the on-line banking achieve secure user password receiving and secure account information transfer?

4.3 (4%) Explain the benefit of using one-way hash function. Does TCP packet **Checksum** (for error detection) qualify for a hash function?

4.4 (8%) Explain the entire procedure of Micro-Tesla for broadcast authentication.

4.5 (5%) Suppose in the beginning we preload all sensors with the same key, K_0. All sensors can use a pseudo-random function f(.) and K_0 to generate a key (given a sensor ID): K = f(K0, ID). Now we drop all sensors to a battlefield. How do we make sure that each pair of neighbors show a key (called pairwise key)? Show the principle.

4.6 (5%) In the class we said that we could use Polynomial f(x,y) = (a + b(x + y) + cxy) mod p to calculate pairwise key (shared key). Suppose we have the following parameters:

- 2 sensors with the following id's 15, 10 respectively
- P = 21, a = 10, b=9, c=3

Calculate the shared key between them.

Question 5: Transport Layer (10 pts)

5.1 (3%) For ESRT scheme, if we have η_{now} = 0.7, and f_{now} = 60 samples / minute, also assume f_{oop} = 15 samples / minute, f_{peak} = 25 samples / minute, show the adjustment procedure of f_{now}.

5.2 (3%) If a single hop has wireless loss rate 8%, what is the loss rate for a 4-hop transmission?

5.3 (4%) How do we integrate TCP and ESRT together to achieve a congestion-aware reliability?

Question 6: (10 pts) Miscellaneous

6.1 (3%) How do we overcome exposed terminal problem? (**show a diagram**)

6.2 (3%) Use an example to define social-technique networks (from your term paper).

6.3 (4%) Explain how you can use LEACH's concept to achieve sensor/actor communications in wireless sensor and actor networks.