CS582 Distributed Systems
Quiz 1 A

Student Name:		**Student ID:**
Time Allowed: 20 mins.	**Total Marks:** 12	**Marks Obtained:**

1. (6 marks) Suppose your TAs, Maryam and Hamna, developed a social network application for discussing food options on campus. Initially, they had only TAs and students of CS 582 on the application. They deployed the application on a small cluster in the CS department and used an all-to-all heartbeat model for failure detection of nodes, with a hard timeout value of 1 second (after which receiving no heartbeat means the node has crashed).

   (i) (1 mark) Every node sends a heartbeat message to every other node at 20 ms intervals. The maximum one way delay is estimated to be 22 ms and the minimum is 5 ms. Assuming a synchronous setting, what is the minimum timeout value they should set to ensure there are no false positives in failure detection?

   20 + (22 - 5) = 37
   1 mark for right answer

   (ii) As the application gains popularity, Maryam and Hamna decide to expand their social network to include all students at LUMS. To accommodate this growth, they plan to switch to a ring-based system with phi (ϕ) accrual failure detection

   (2 marks) Briefly explain the rationale behind choosing a ring-based model over an all-to-all model for their expanded network?

   1 mark for each:
   Scalable / load per node decreased
   Network overhead reduction / less likelihood of congestion / less delays

   (iii) (3 marks) A node has received a significant number of heartbeats over the last 3 days and is logging the inter-arrival times of heartbeat messages. The most recent three heartbeat messages from a node B were received at the following times: 12:00:03, 12:00:34, 12:01:07
   Based on this information: (a) What would the value of phi ϕ be at 12:00:56 for node B, and (b) Using this phi value, assess the likelihood that the node B was still alive at 12:00:56. The table below provides relevant information about the cumulative distribution function of the inter-arrival times of the heartbeat messages. Let X be the random variable representing these inter-arrival times.

Note:
$P(X < 11s) = 0.1275$
$P(X < 22s) = 0.7454$
$P(X < 53s) = 0.9671$

   At 12:00:56, last heartbeat was recieved at 12:00:34. Time since = 22s — **0.5 marks**
   P_{later}(22) = 1-P(X<22) — **1 mark**
   = 1-0.7454 = 0.2546 **(0.5 marks if 0.2546 not calculated)**
   $-log_{10}(0.2546) = 0.594 \rightarrow \phi$ — **0.5 marks**
   Low value implies high likelihood of the node being alive — **1 mark**

2. (2 marks) What will the following code print? Explain your answer:

```
package main
import("fmt")

var c = make(chan int)

func f(x int) {
    c <- x
}

func main() {
    go f(1)
    go func(){
        c <- 2
    }()
    go f(3)
    for i := 0; i < 3; i++ {
        fmt.Println(<-c)
    }
}
```

Listing 1: Go code

1 mark → random because of unpredictability of which go routine will execute first
1 mark → 3 digits printing

3. **(4 marks) Which of the following statements is correct? (there can be multiple correct statements.)**

   A. Given two events a and b in a distributed system, if C(a) < C(b), meaning the Lamport Clock timestamp of event a is lower than that of event b, then this necessarily implies that event a physically occurred before event b in real time.
   They could also be concurrent.

   B. All-to-all heartbeat ensures completeness.
   Correct.

   C. Synchronous RPC is a blocking call.
   Sync means it waits for the RPC to end, hence it will block at the callee

   D. Clock drift rate is the difference between the time of a clock and a reference atomic clock.
   It's the rate of change of the clock's frequency from its expected value

   E. An increment operation: x++ is an idempotent operation.
   Applying it twice does not have the same effect as applying it once.

   F. Lower ϕ threshold means higher likelihood of false positives
   Lower ϕ threshold (e.g. 1) means more nodes classified as dead (e.g. in the range 1<x<3, which still implies high confidence the node is alive), even though there's a high likelihood they are not, hence false positive (false positive means the node is marked as dead when its actually not)

All correct - 4 marks
Three correct one wrong - 3 marks
Two correct only - 3 marks
Two correct one wrong - 2 marks
Two correct two wrong - 1 mark
One correct - only 1.5 marks
One correct 1 wrong - 1 mark
One correct 2 wrong - 0.5 marks
All wrong - 0 marks

CS582 Distributed Systems
Quiz 1 B

Student Name:		**Student ID:**
Time Allowed: 20 mins.	**Total Marks:** 12	**Marks Obtained:**

1. (6 marks) Suppose your TAs, Maryam and Hamna, developed a social network application for discussing food options on campus. Initially, they had only TAs and students of CS 582 on the application. They deployed the application on a small cluster in the CS department and used an all-to-all heartbeat model for failure detection of nodes.

   (i) (1 mark) Every node sends a heartbeat message to every other node at 10 ms intervals. The max one way delay is estimated to be 12ms and the minimum is 3ms. Assuming a synchronous setting, what is the smallest timeout value they could set such that there will no false positives in failure detection?

   10 + (12 - 3) = 19
   1 mark for right answer

   (ii) As the application gained popularity, Maryam and Hamna decided to expand their social network to include all students at LUMS. To accommodate this growth, they plan to switch to a ring-based system with phi (ϕ) accrual failure detection

   (2 marks) Briefly explain the rationale behind choosing a ring-based model over an all-to-all model for their expanded network?

   1 mark for each:
   Scalable / load per node decreased
   Network overhead reduction / less likelihood of congestion / less delays

   (iii) (3 marks) A significant number of heartbeats have been received over 3 days and a distribution has been plotted. Here is a subset of that data. Heartbeats were received at: 12:00:07, 12:00:36, 12:01:05.
   What was the value of phi as calculated at 12:01:02. Also comment on the likelihood of the node being alive.

Note:
$P_{later}(3) = 0.9875$
$P_{later}(26) = 0.2843$
$P_{later}(55) = 0.0342$

   At 12:01:02, last heartbeat was recieved at 12:00:36. Time since = 26s — **0.5 marks**
   $P_{later}(26) = 0.2843$ — **0.5 mark**
   $-log_{10}(0.2843) = 0.546 \rightarrow \phi$ — **0.5 marks**
   Low value implies high likelihood of the node being alive — **1.5 mark**

2. (2 marks) What will the following code print? Explain your answer:

```
package main
import("fmt")

var c = make(chan int)

func f(x int) {
    c <- x
}

func main() {
    go func(){
        c <- 1
    }()
    go f(2)
    go f(3)
    for i := 0; i < 3; i++ {
        fmt.Println(<-c)
    }
}
```

Listing 1: Go code

1 mark → random because of unpredictability of which go routine will execute first
1 mark → 3 digits printing

3. (4 marks) Which of the following statements is correct? (there can be multiple correct statements.)

   A. In a distributed system for any given pair of events, a and b, either a → b, or b → a
   They could also be concurrent.

   B. Centralized heartbeat ensures completeness.
   Server could fail

   C. A get() operation is an idempotent operation.
   Applying it twice has the same effect as applying it once.

   D. To cater to the negative offset value in Berkeley algorithm, we decrease clock value.
   Decreasing clock value can cause problems in the system, instead we decrease clock speed

   E. Higher ϕ threshold means higher likelihood of false negative
   Higher ϕ threshold (e.g. 5) means more nodes classified as alive (e.g. in the range 3<x<5, which still implies low confidence the node is alive), even though there's a high likelihood they are not, hence false negative (false negative means the node is marked as alive when its actually not)

   F. RPC is a non-blocking call.
   Async means it doesnt wait for the RPC to end, hence it will not block at the callee

All correct - 4 marks
Three correct one wrong - 3 marks
Two correct only - 3 marks
Two correct one wrong - 2 marks
Two correct two wrong - 1 mark
One correct - only 1.5 marks
One correct 1 wrong - 1 mark
One correct 2 wrong - 0.5 marks
All wrong - 0 marks