Chivit Chhoeun, AmirAbbas Sherafatian, Kayahan Kaya
Distributed Systems: Task 2
Spring 2021

1. Consider the following wireless network (sensor network). Assuming that source (g) starts a simple election for a leader. What is the actual path used to inform the source about the most suitable leader? Illustrate the election process with figures in each step. (20 pts)

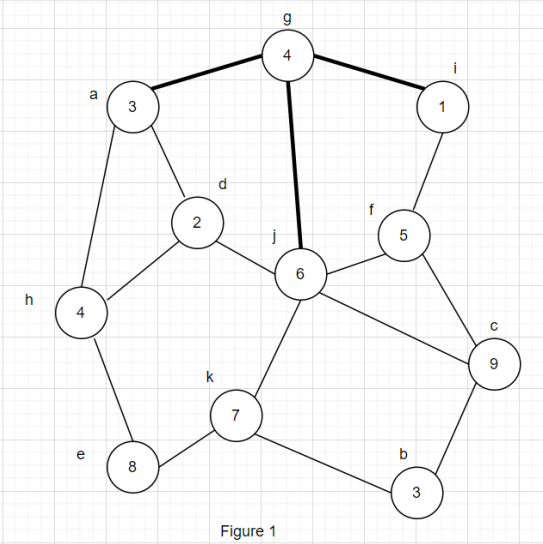

Figure 1

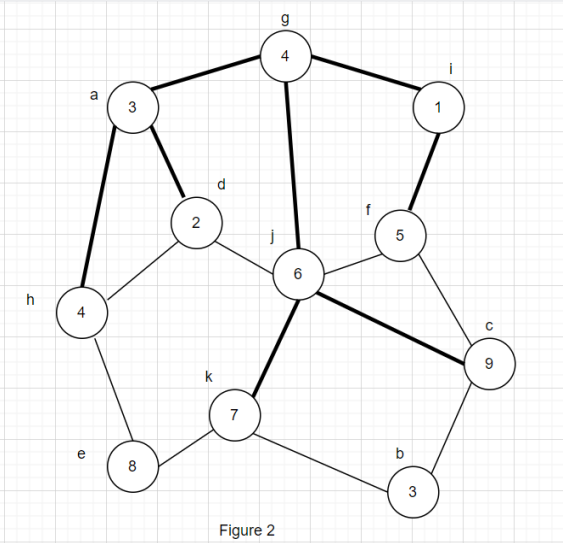

Figure 2

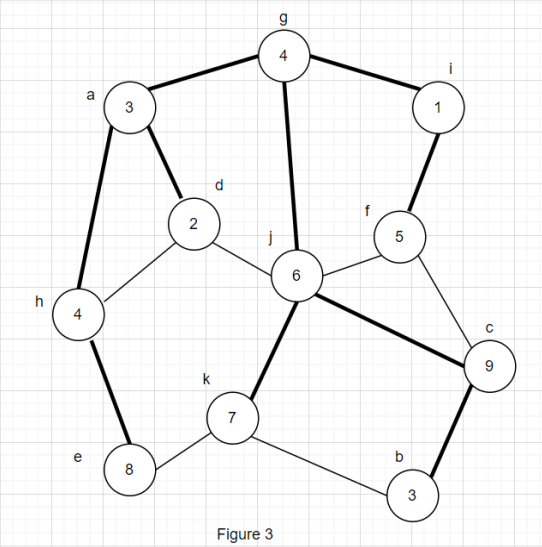

Figure 3

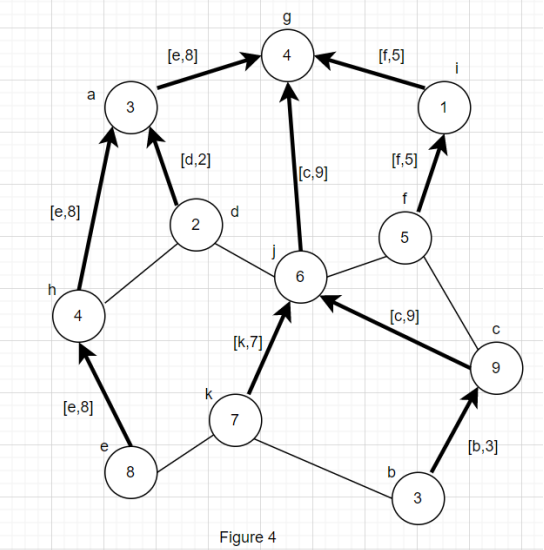

Figure 4

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2. By using different amounts of processes (1000, 10000, 100000, 1000000), compare the performance of using election in a ring vs election by bully for selecting a coordinator. Model the performance of each algorithm by estimating the number of messages sent in each case. No implementation is needed (20 pts)

   We can compare the number of required messages to be sent to select new coordinator for both algorithms;

Bully Algorithm;

- N^2 messages are required in the **worst-case** scenario.
- N-1 messages are required in the **best-case** scenario.

Ring Algorithm;

- In ring algorithm; election always requires $2(N-1)$messages. $N-1$ messages needed for the round rotation of the election message, and another $N-1$messages for the coordinator message.

Analysis of estimating the number of messages sent in each case;

- **The number of 1000 processes;**

Bully algorithm requires $1000^2 = 10^6$ messages for the worst-case and $(1000 - 1 = 999)$ for the best case.
Ring algorithm requires $2x(1000 - 1 = 1998)$ for any cases.

- **The number of 10000 processes;**

Bully algorithm requires $10000^2 = 10^8$ messages for the worst-case and $(10000 - 1 = 9999)$ for the best case.
Ring algorithm requires $2x(10000 - 1 = 19998)$ for any cases.

- **The number of 100000 processes;**

Bully algorithm requires $100000^2 = 10^{10}$ messages for the worst-case and $(100000 - 1 = 99999)$ for the best case.
Ring algorithm requires $2x(100000 - 1 = 199998)$ for any cases.

- **The number of 1000000 processes;**

Bully algorithm requires $1000000^2 = 10^{12}$ messages for the worst-case and $(1000000 - 1 = 999999)$ for the best case.
Ring algorithm requires $2x(1000000 - 1 = 1999998)$ for any cases.

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(8 pts) BONUS POINTS: Consider the Figure below that shows five processes (P0, P1, P2, P3, P4) with events 1, 2, 3 ,... etc., and message events communicating between them. Assume that initial logical clock values are all initialized to 0

- (3 Points) List the Lamport timestamps for each event shown in the Figure below. Assume that each process maintains a logical clock as a single integer value as a Lamport clock. Provide timestamps for each labeled event.
- (3 Points) List the Vector Clock timestamps for each event shown in the Figure below. Provide timestamps for each labeled event.
- (2 Points) List the events that are concurrent and explain in detail why? Is there the potential for a causal violation? Reflect on both Lamport and Vector Clock algorithms and explain whether both approaches can be used to accurately identify concurrent events.

Answer:

In this question we have 35 special events occured in 5 processes. Each of the events in the particular process is running sequentially (one event after another). On the other hand if we consider the events which occured in different processes we could say that those events are running concurrently. For instance; event 1 and event 9 are running concurrently with 13 and 22. Based on this intuition, we could understand all the events which run concurrently. If we are using the Lamport algorithm we can not distinguish whether 2 events of different processes are concurrent or not. For example, timestamp for P4(event 29) is less than the timestamp for P1(event 11) does not mean that P4(event 29) happens before P1(event 11). Those events happen to be concurrent but we can not discern that by looking at Lamport timestamps. On the other hand the way that the Vector clock creates timestamps allow us to discern a casual relationship between events. This timestamp is not a single value as Lamport timestamp instead a vector of numbers, with each element corresponding to a process.

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Event Number	Lamport Timestamp	Vector Timestamp
1	[1]	[1,0,0,0,0]
2	[2]	[2,1,0,0,0]
3	[3]	[3,1,0,0,0]
4	[4]	[4,1,0,0,0]
5	[5]	[5,1,0,0,0]
6	[8]	[6,1,0,0,0]
7	[10]	[7,1,7,3,5]
8	[11]	[8,1,7,3,5]
9	[1]	[0,1,0,0,0]
10	[2]	[0,2,0,1,0]
11	[3]	[0,3,0,1,0]
12	[4]	[0,4,0,1,0]
13	[1]	[0,0,1,0,0]
14	[2]	[0,0,2,0,0]
15	[3]	[0,0,3,0,0]
16	[6]	[5,1,4,0,0]
17	[7]	[5,1,5,0,0]
18	[8]	[5,1,6,3,5]
19	[9]	[5,1,7,3,5]
20	[10]	[5,1,8,3,5]
21	[11]	[5,1,9,3,5]
22	[1]	[0,0,0,1,0]
23	[2]	[0,0,0,2,0]
24	[3]	[0,0,0,3,0]
25	[4]	[0,0,2,4,0]
26	[5]	[0,0,3,5,0]
27	[7]	[3,1,3,6,4]
28	[8]	[3,1,3,7,4]
29	[1]	[0,0,0,0,1]
30	[4]	[0,0,0,3,2]
31	[5]	[3,1,0,3,3]
32	[6]	[3,1,0,3,4]
33	[7]	[3,1,0,3,5]
34	[11]	[5,1,8,3,6]
35	[12]	[5,1,8,3,7]

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Resources;
http://ijarcsse.com/Before_August_2017/docs/papers/Volume_5/10_October2015/V5I10-0130.pdf
http://ijarcsse.com/Before_August_2017/docs/papers/Volume_5/10_October2015/V5I10-0130.pdf
https://www.cs.rutgers.edu/~pxk/417/notes/logical-clocks.html