CS 425 Homework 1

Mukai Yu

February 8, 2022

1. (a) In worst case, In worst case, assuming process a crashes immediately after it sends out the last heartbeat (died right after SOS) :

$$e_{a\to b} = \max\{a \to b\} + \Delta_{a\to b} = 2\max\{a \to b\} - \min\{a \to b\}$$
$$T_b = T + e_{a\to b} = 50 + 10 = 60(s)$$
$$T_c = T + e_{a\to c} = 50 + 26 = 76(s)$$
$$T_d = T + e_{a\to d} = 50 + 19 = 69(s)$$

(b) Need to check all the path from **a** to other processes

$$\begin{aligned}
T'_b =& T + \min_{path}\{e_{a\to b},\\
& e_{a\to c} + \max\{b \to b\},\\
& e_{a\to d} + \max\{d \to b\},\\
& e_{a\to c} + \max\{c \to d\} + \max\{d \to b\},\\
& e_{a\to d} + \max\{d \to c\} + \max\{c \to b\}\}\\
=& 50 + \min\{10, 26 + 18, 19 + 13, 26 + 4 + 13, 19 + 4 + 18\}\\
=& 50 + 10\\
=& 60(s)
\end{aligned}$$

$$\begin{aligned}
T'_c =& T + \min_{path}\{e_{a\to c},\\
& e_{a\to b} + \max\{c \to c\},\\
& e_{a\to d} + \max\{d \to c\},\\
& e_{a\to b} + \max\{b \to d\} + \max\{d \to c\},\\
& e_{a\to d} + \max\{d \to b\} + \max\{b \to c\}\}\\
=& 50 + \min\{26, 10 + 18, 19 + 4, 10 + 13 + 4, 19 + 13 + 18\}\\
=& 50 + 23\\
=& 73(s)
\end{aligned}$$

$$
\begin{aligned}
T'_d =& T + \min_{path}\{e_{a\to d}, \\
& e_{a\to b} + \max\{b \to d\}, \\
& e_{a\to c} + \max\{c \to d\}, \\
& e_{a\to b} + \max\{b \to c\} + \max\{c \to d\}, \\
& e_{a\to c} + \max\{c \to b\} + \max\{b \to d\}\} \\
=& 50 + \min\{19, 10+13, 26+4, 10+18+4, 26+18+13\} \\
=& 50 + 19 \\
=& 69(s)
\end{aligned}
$$

(c) Protocol: each process sends heartbeat to 2 other nearest processes, where nearest process means a process that has the least worst case failure detection time of the current process.

(d) the minimal set of processes **a** must send heartbeats to $= \{b, d\}$

2. (a) i. The client should choose S_2 to achieve the lowest accuracy at:

$$skew(client, S_2) \leqslant \frac{RTT(S_2)}{2} + \min < \frac{RTT(S_2)}{2} = 12(ms)$$

ii. The longest time-period $= \frac{(90-12)\times 10^{-3}}{3\times 10^{-6}} = 26,000(s)$

(b) i. The lowest synchronization bound is:

$$\frac{(39-12)+(52-71)}{2} = 4$$

The corresponding estimated offset value of **B relative to A** is:

$$\frac{(39-12)-(52-71)}{2} = 23$$

So the estimated offset value of **A relative to B** is **-23**

ii. The tightest synchronization bound is:

$$\frac{75-60}{2} = 7.5$$

3. (a)

A	1
B	2
C	7
D	8
E	2
F	5
G	6
H	7
I	1
J	2
K	5
L	7
M	2
N	3
O	4
P	7

(b)

A	1 0 0 0
B	2 0 1 0
C	3 3 1 3
D	4 3 1 3
E	0 1 1 0
F	1 2 1 3
G	1 3 1 3
H	1 4 1 3
I	0 0 1 0
J	1 0 2 0
K	1 0 3 3
L	1 3 4 3
M	0 0 1 1
N	1 0 1 2
O	1 0 1 3
P	1 3 1 4

(c) i. A $||$ $e \in \{E, I, M\}$

ii. F $||$ $e \in \{B, J, K\}$

iii. K $||$ $e \in \{B, C, D, E, F, G, H, P\}$

iv. N $||$ $e \in \{B, E, J\}$

4. (a) E $||$ $e \in \{A, B, J, K, M, N, O\}$
So removing the events happened too early (events that happened before the last event right before real time 8, we have the following possible frontier events combination of cuts:

$$\{A, E, J, O\}$$
$$\{A, E, K, O\}$$
$$\{B, E, J, O\}$$
$$\{B, E, K, O\}$$

(b)

Frontier Cuts	Incoming channel of P_1	Incomming Channel of P_3
A, E, J, O	IB, OD	OK
A, E, K, O	IB, OD	
B, E, J, O	OD	OK
B, E, K, O	OD	