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CSE 461

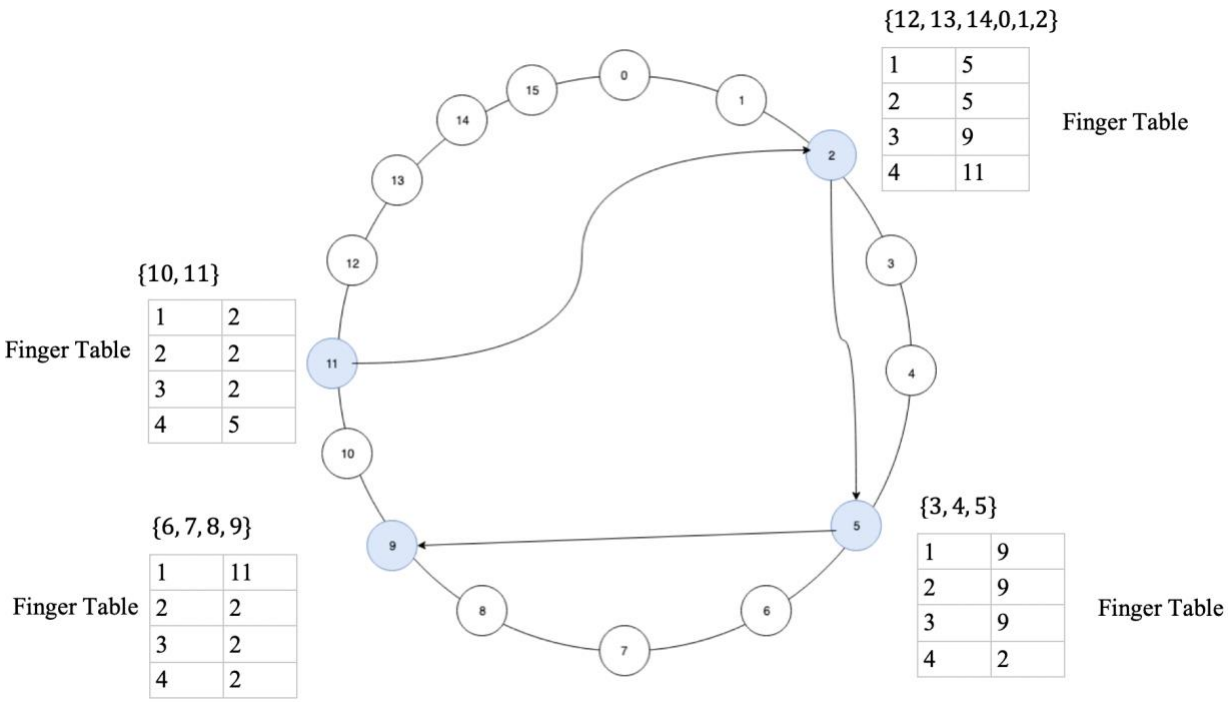
Homework 3

1. A DHT Chord network uses 4 bits (i.e. m = 4) to identify machines and keys of entities. At a certain time, machines with identifiers 2, 5, 9, and 11 are attached to and active in the network.

   a. Draw a diagram to show the machine ids and keys of the network.
   b. Find the finger table of each of the machines.
   c. An application running in node 11 is looking for the entity with key value

   Solution:

   Perform a linear search starting from node $11 \rightarrow 2 \rightarrow 5 \rightarrow 9$, and we find the value 7 in node 9.



2.

a. Would you consider a URL such as http://www.acme.org/index.html to be location independent? What about http://www.acme.nl/index.html?

b. Consider the behavior of two machines in a distributed system. Both have clocks that are supposed to tick 1000 times per millisecond. One of them actually does, but the other ticks only 990 times per millisecond. If UTC updates come in once a minute, what is the maximum clock skew that will occur?

Solution:

a. Both URLs are location independent because there is no telling where their locations are by simply looking at the address. Although in the second URL refers to the Netherlands due to the '.nl', it still does not decide that it is actually coming from the Netherlands.

b. $1000\frac{times}{msec} \times 1000\frac{msec}{sec} \times 60\frac{sec}{min} = 60{,}000{,}000\frac{times}{min}$

$990\frac{times}{msec} \times 1000\frac{msec}{sec} \times 60\frac{sec}{min} = 59{,}400{,}000\frac{times}{min}$

$60{,}000{,}000\frac{times}{min} - 59{,}400{,}000\frac{times}{min} = 600{,}000\frac{times}{min}$

The maximum clock skew that will occur is $600{,}000\frac{times}{min}$.

3. If each process uses a different value for d in the Lamport's clock and vector clock equations, will the logical clocks and vector clocks schemes satisfy the total order relation => and the relation:

$$a \rightarrow b \; iff \; t^a < t^b$$

Explain your argument in detail.

Solution:

Both Lamport's logical clock and vector clock schemes satisfies the relations.

For the case of Lamport's logical clock scheme, if events a and b are coming from the same process P_i and the value $d > 0$ then $C_i(b) = C_i(a) + d$ where $C_i(a)$ is the timestamp of event a in the process P_i. This means that the value d is unaffected when it goes from event a to event b and the property $C_i(a) < C_i(b)$ holds true. If event a is any event in process P_i and event b is any event in process P_j then $C_i(a) <$

$C_j(b)$ holds true which satisfies the total order relation $a => b$ since $C_j = max(C_j, t_m + d)$ where $t_m = C_i(a)$.

For the vector clocks scheme, if event a and b are in process P_i then $C_i(b)[i] = C_i(a)[i] + d$ where $d > 0$ which again the value d is unaffected. If event a at process P_i is sending a message m to process P_j which event b is receiving m then $t_m = C_i(a)$ is assigned to m and P_j updates C_j by $C_j(b)[k] = \max(C_j(b)[k], t_m[k])$ for all k then for all $i, j : C_i[i] \geq C_j[i]$ at any instant where the events are casually related if $t^a < t^b$ which satisfies the total order relation $a => b$ and $a \rightarrow b \; iff \; t^a < t^b$.

4. Suppose Process P_1 has events
   e_{11}, e_{12}, e_{13}, e_{14}, e_{15} e_{16} e_{17}
   P_2 has events
   e_{21}, e_{22}, e_{23}, e_{24}, e_{25}, e_{26}
   P_3 has events
   e_{31}, e_{32}, e_{33}, e_{34}, e_{35}, e_{36}
   There are message transits from e_{12} to e_{22}, e_{24} to e_{15}, e_{21} to e_{32}, e_{35} to e_{25}. Suppose the vector time clocks for e_{11}, e_{21}, and e_{31} are

$$\begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}, \quad \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}, \quad \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

   respectively.

   a) Draw a diagram to show all the transitions and events.

   b) Find the vector clocks of all the events.

   c) Give an example for each of the following:

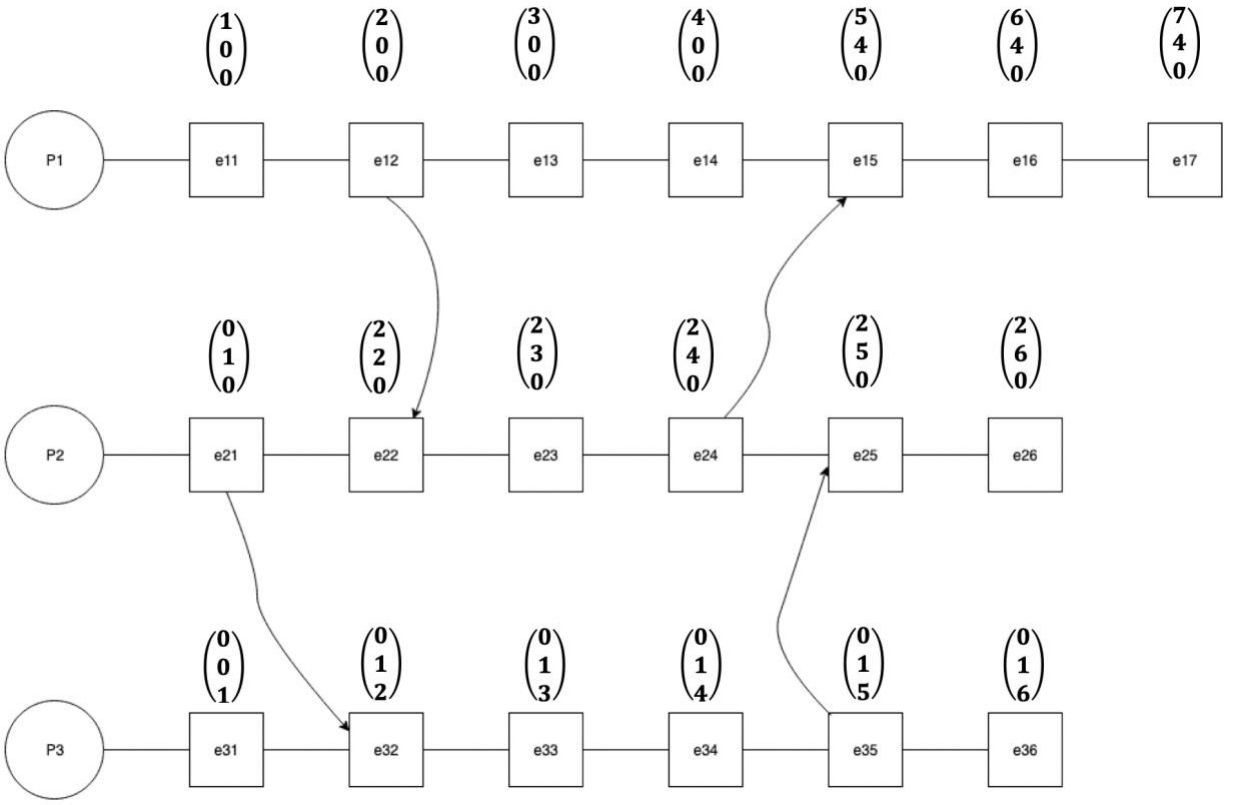
      i) a strongly consistent state

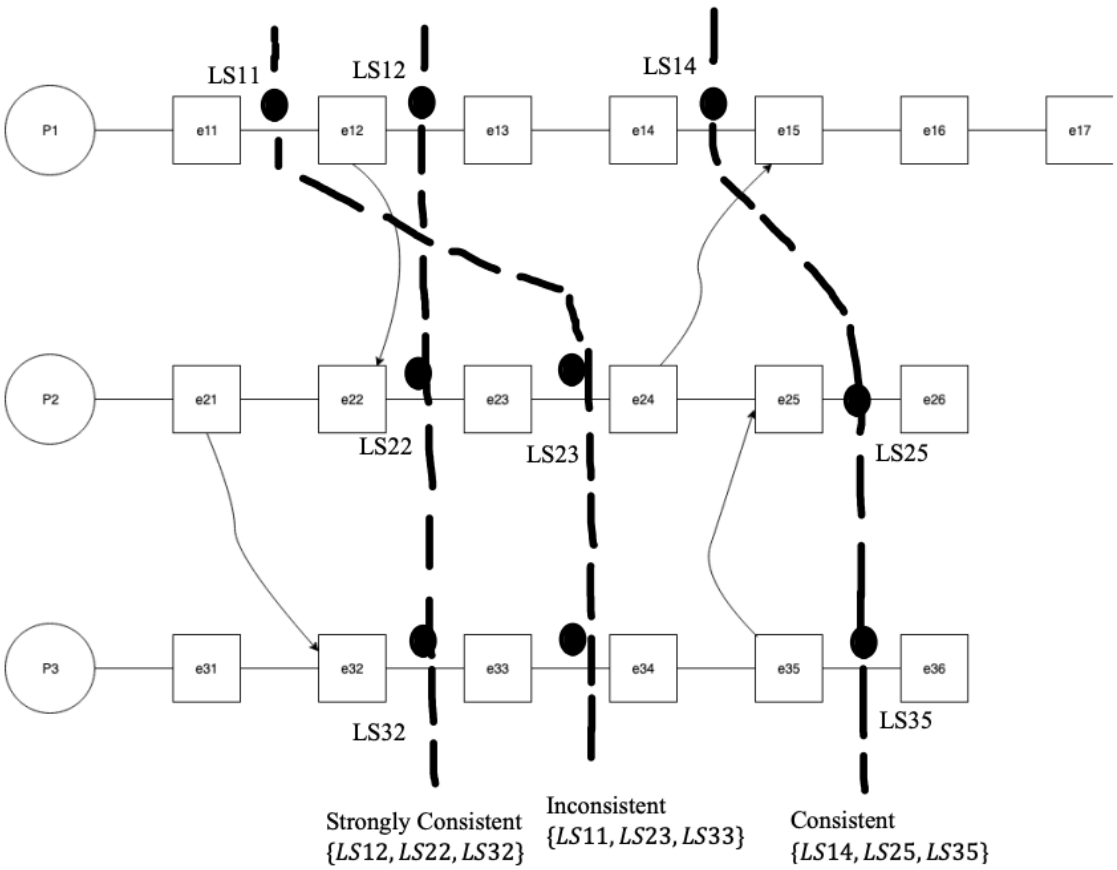
      ii) a consistent but not strongly consistent state

      iii) an inconsistent state

   Your global state should be consisted of the the events given (e.g. e_{11}) but should **not** contain any event that is sending (e.g. e_{12}) or receiving a message (e.g. e_{22}).

Solution:


$\begin{pmatrix}1\\0\\0\end{pmatrix}$
$\begin{pmatrix}2\\0\\0\end{pmatrix}$
$\begin{pmatrix}3\\0\\0\end{pmatrix}$
$\begin{pmatrix}4\\0\\0\end{pmatrix}$
$\begin{pmatrix}5\\4\\0\end{pmatrix}$
$\begin{pmatrix}6\\4\\0\end{pmatrix}$
$\begin{pmatrix}7\\4\\0\end{pmatrix}$
P1
e11
e12
e13
e14
e15
e16
e17
$\begin{pmatrix}0\\1\\0\end{pmatrix}$
$\begin{pmatrix}2\\2\\0\end{pmatrix}$
$\begin{pmatrix}2\\3\\0\end{pmatrix}$
$\begin{pmatrix}2\\4\\0\end{pmatrix}$
$\begin{pmatrix}2\\5\\0\end{pmatrix}$
$\begin{pmatrix}2\\6\\0\end{pmatrix}$
P2
e21
e22
e23
e24
e25
e26
$\begin{pmatrix}0\\0\\1\end{pmatrix}$
$\begin{pmatrix}0\\1\\2\end{pmatrix}$
$\begin{pmatrix}0\\1\\3\end{pmatrix}$
$\begin{pmatrix}0\\1\\4\end{pmatrix}$
$\begin{pmatrix}0\\1\\5\end{pmatrix}$
$\begin{pmatrix}0\\1\\6\end{pmatrix}$
P3
e31
e32
e33
e34
e35
e36


LS11
LS12
LS14
P1
e11
e12
e13
e14
e15
e16
e17
P2
e21
e22
e23
e24
e25
e26
LS22
LS23
LS25
P3
e31
e32
e33
e34
e35
e36
LS32
LS35
Strongly Consistent
{LS12, LS22, LS32}
Inconsistent
{LS11, LS23, LS33}
Consistent
{LS14, LS25, LS35}