27/10/2015

PRACTICA 1

Laboratori Sistemes distribuïts
DISTRIBUTED SYSTEMS AULA 2

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Phase 1.1 TSAE protocol exercise

Lets suppose that there are 3 hosts (A, B, C) that use TSAE protocol to exchange operations. At the initial time (t_0) all hosts have the same state:

Summary A = A2,B1,C3 Log A = A1,A2,B1,C1,C2,C3
Summary B = A2,B1,C3 Log B = A1,A2,B1,C1,C2,C3
Summary C = A2,B1,C3 Log C = A1,A2,B1,C1,C2,C3

A1 means that it is the first operation from host A. C2 means that it is the second operation from host C.

Suppose that each anti-entropy session starts and ends at the same instant.

Exercise 1.

Show for each case (a and b):

- The data structures and operations exchanged during the anti-entropy sessions.
- The data structures (log and summary) at each host after each anti-entropy session
- Indicate if final state is consistent, i.e. all hosts have received the same operations.

  In case it is not consistent, indicate which sessions should be done to reach a consistent state. (Note: log is not purged)

I will use the red color for the new operations and values.

a)

• At time t1, host B executes operation B2

SummaryA = A2,B1,C3 LogA = A1,A2,B1,C1,C2,C3
SummaryB = A2,B2,C3 LogB = A1,A2,B1,C1,C2,C3,B2
SummaryC = A2,B1,C3 LogC = A1,A2,B1,C1,C2,C3

• At time t2, host A executes operation A3

SummaryA = A3,B1,C3 LogA = A1,A2,B1,C1,C2,C3,A3
SummaryB = A2,B2,C3 LogB = A1,A2,B1,C1,C2,C3,B2
SummaryC = A2,B1,C3 LogC = A1,A2,B1,C1,C2,C3

• At time t3, host B executes operation B3

SummaryA = A3,B1,C3 LogA = A1,A2,B1,C1,C2,C3,A3
SummaryB = A2,B3,C3 LogB = A1,A2,B1,C1,C2,C3,B2,B3
SummaryC = A2,B1,C3 LogC = A1,A2,B1,C1,C2,C3

• At time t4, host A does an anti-entropy session with host C

SummaryA = A3,B1,C3 LogA = A1,A2,B1,C1,C2,C3,A3
SummaryC = A2,B1,C3 LogC = A1,A2,B1,C1,C2,C3

After exchange:
SummaryA = A3,B1,C3 LogA = A1,A2,B1,C1,C2,C3,A3
SummaryB = A2,B3,C3 LogB = A1,A2,B1,C1,C2,C3,B2,B3
SummaryC = A3,B1,C3 LogC = A1,A2,B1,C1,C2,C3,A3

- At time t5, host A does an anti-entropy session with host B

SummaryA = A3,B1,C3 LogA = A1,A2,B1,C1,C2,C3,A3
SummaryB = A2,B3,C3 LogB = A1,A2,B1,C1,C2,C3,B2,B3

After exchange:
SummaryA = A3,B3,C3 LogA = A1,A2,B1,C1,C2,C3,A3,B2,B3
SummaryB = A3,B3,C3 LogB = A1,A2,B1,C1,C2,C3,B2,B3,A3
SummaryC = A3,B1,C3 LogC = A1,A2,B1,C1,C2,C3,A3

- At time t6, host B does an anti-entropy session with host C

SummaryB = A3,B3,C3 LogB = A1,A2,B1,C1,C2,C3,B2,B3,A3
SummaryC = A3,B1,C3 LogC = A1,A2,B1,C1,C2,C3,A3

After exchange:
SummaryA = A3,B3,C3 LogA = A1,A2,B1,C1,C2,C3,A3,B2,B3
SummaryB = A3,B3,C3 LogB = A1,A2,B1,C1,C2,C3,B2,B3,A3
SummaryC = A3,B3,C3 LogC = A1,A2,B1,C1,C2,C3,A3,B2,B3

The final state is consistent because the summary is the same in all principals A, B and C.

b)

- At time t1, host A executes operation A3

Summary A = A3,B1,C3 Log A = A1,A2,B1,C1,C2,C3,A3
Summary B = A2,B1,C3 Log B = A1,A2,B1,C1,C2,C3
Summary C = A2,B1,C3 Log C = A1,A2,B1,C1,C2,C3

- At time t2, host C executes operation C4

Summary A = A3,B1,C3 Log A = A1,A2,B1,C1,C2,C3,A3
Summary B = A2,B1,C3 Log B = A1,A2,B1,C1,C2,C3
Summary C = A2,B1,C4 Log C = A1,A2,B1,C1,C2,C3,C4

- At time t3, host B executes operation B2

Summary A = A3,B1,C3 Log A = A1,A2,B1,C1,C2,C3,A3
Summary B = A2,B2,C3 Log B = A1,A2,B1,C1,C2,C3,B2
Summary C = A2,B1,C4 Log C = A1,A2,B1,C1,C2,C3,C4

- At time t4, host A does an anti-entropy session with host B

Summary A = A3,B1,C3 Log A = A1,A2,B1,C1,C2,C3,A3

Summary B = A2,B2,C3 Log B = A1,A2,B1,C1,C2,C3,B2

After exchange:
Summary A = A3,B2,C3 Log A = A1,A2,B1,C1,C2,C3,A3,B2
Summary B = A3,B2,C3 Log B = A1,A2,B1,C1,C2,C3,B2,A3
Summary C = A2,B1,C4 Log C = A1,A2,B1,C1,C2,C3,C4

- At time t5, host B executes operation B3

Summary A = A3,B2,C3 Log A = A1,A2,B1,C1,C2,C3,A3,B2
Summary B = A3,B3,C3 Log B = A1,A2,B1,C1,C2,C3,B2,A3,B3
Summary C = A2,B1,C4 Log C = A1,A2,B1,C1,C2,C3,C4

- At time t6, host A does an anti-entropy session with host C

Summary A = A3,B2,C3 Log A = A1,A2,B1,C1,C2,C3,A3,B2
Summary C = A2,B1,C4 Log C = A1,A2,B1,C1,C2,C3,C4

After exchange:
Summary A = A3,B2,C4 Log A = A1,A2,B1,C1,C2,C3,A3,B2,C4
Summary B = A3,B3,C3 Log B = A1,A2,B1,C1,C2,C3,B2,A3,B3
Summary C = A3,B2,C4 Log C = A1,A2,B1,C1,C2,C3,C4,A3,B2

- At time t7, host B does an anti-entropy session with host C

Summary B = A3,B3,C3 Log B = A1,A2,B1,C1,C2,C3,B2,A3,B3
Summary C = A3,B2,C4 Log C = A1,A2,B1,C1,C2,C3,C4,A3,B2

After exchange:
Summary A = A3,B2,C4 Log A = A1,A2,B1,C1,C2,C3,A3,B2,C4
Summary B = A3,B3,C4 Log B = A1,A2,B1,C1,C2,C3,B2,A3,B3,C4
Summary C = A3,B3,C4 Log C = A1,A2,B1,C1,C2,C3,C4,A3,B2,B3

In this second scenario the log and the summary on the Principal A is different from B and C. In order to obtain consistency, host A needs an anti-entropy session with host A or C.

Exercise 2.

Imagine a situation with 5 hosts with unsynchronized clocks and purging of the log. Hosts A and D have the following content:

AckSummary A= A:{A3, B3, C3, D1, E3}
B:{A2, B3, C2, D1, E1}
C:{A1, B3, C2, D0, E1}
D:{A1, B3, C1, D0, E3}
E:{A1, B3, C1, D1, E1}

AckSummary E= A:{A1, B1, C3, D1, E1}
B:{A2, B2, C1, D3, E2}
C:{A2, B1, C2, D3, E1}
D:{A1, B2, C3, D3, E2}
E:{A2, B3, C3, D3, E3}

Ack Summary

Principal A						Principal E				
A	B	C	D	E		A	B	C	D	E
A3	A2	A1	A1	A1		A1	A2	A2	A1	A2
B3	B3	B3	B3	B3		B1	B2	B1	B2	B3
C3	C2	C2	C1	C1		C3	C1	C2	C3	C3
D1	D1	D0	D0	D1		D1	D3	D3	D3	D3
E3	E1	E1	E3	E1		E1	E2	E1	E2	E3

To obtain the log I remove all the operations that are in acksummary of the other principals. In other words, the messages/operations that already has been observed in all the principals.

Which is the content of Log in host A?

LogA = {A2,A3,C2,C3,D1,E2,E3}

Which is the content of Log in host E?

LogE = {A2,B2,B3,C2,C3,D2,D3,E2,E3}

A and E do an anti-entropy session:

- Which operations are exchanged?

If we compare the summary of Principal A and E, we find the operations that each Principal has to send to the other Principal.

Principal A sends to principal E the operation A3.
Principal E sends to principal A the operations D2 and D3.

- Which AckSummary and log have each host after ending the session?

The AckSummary will be the result of the merging the two matrix taken the maximum values.

Source:

	Principal A						Principal E				
A	B	C	D	E		A	B	C	D	E
A3	A2	A1	A1	A1		A1	A2	A2	A1	A2
B3	B3	B3	B3	B3		B1	B2	B1	B2	B3
C3	C2	C2	C1	C1		C3	C1	C2	C3	C3
D1	D1	D0	D0	D1		D1	D3	D3	D3	D3
E3	E1	E1	E3	E1		E1	E2	E1	E2	E3

Merged:

	Principal A						Principal E				
A	B	C	D	E		A	B	C	D	E
A3	A2	A2	A1	A3		A3	A2	A2	A1	A3
B3	B3	B3	B3	B3		B3	B3	B3	B3	B3
C3	C2	C2	C3	C3		C3	C2	C2	C3	C3
D3	D3	D3	D3	D3		D3	D3	D3	D3	D3
E3	E2	E1	E3	E3		E3	E2	E1	E3	E3

The log at the end of the session on A and E is:

Source:

LogA = {A2,A3,C2,C3,D1,E2,E3}
LogE = {A2,B2,B3,C2,C3,D2,D3,E2,E3}

Operations exchanged:
Principal A sends to principal E the operation A3.
Principal E sends to principal A the operations D2 and D3.

Result:
LogA = {A2,A3,C3,E2,E3}
LogE = {A2,A3,C3,E2,E3}

Phase 1.2 Implementation of log and timestamp vector data structures

Implement methods from Log and TimestampVector data structures.
In this phase only add operations are issued. Don't implement the functionality to purge the log. Annex A includes details about the timestamps used in this practical assignment.

See doc report_template in \doc and code in \sol