Chapter 5 −Synchronization

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- Clock Synchronization Algorithms
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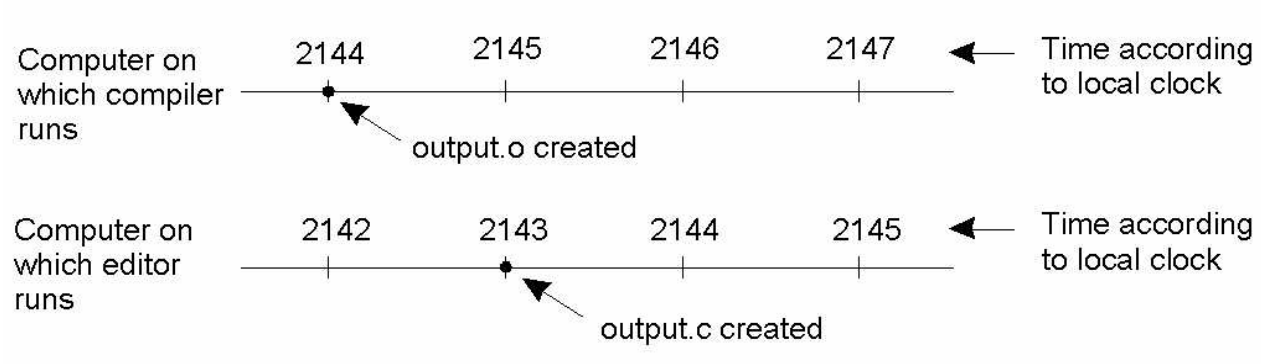
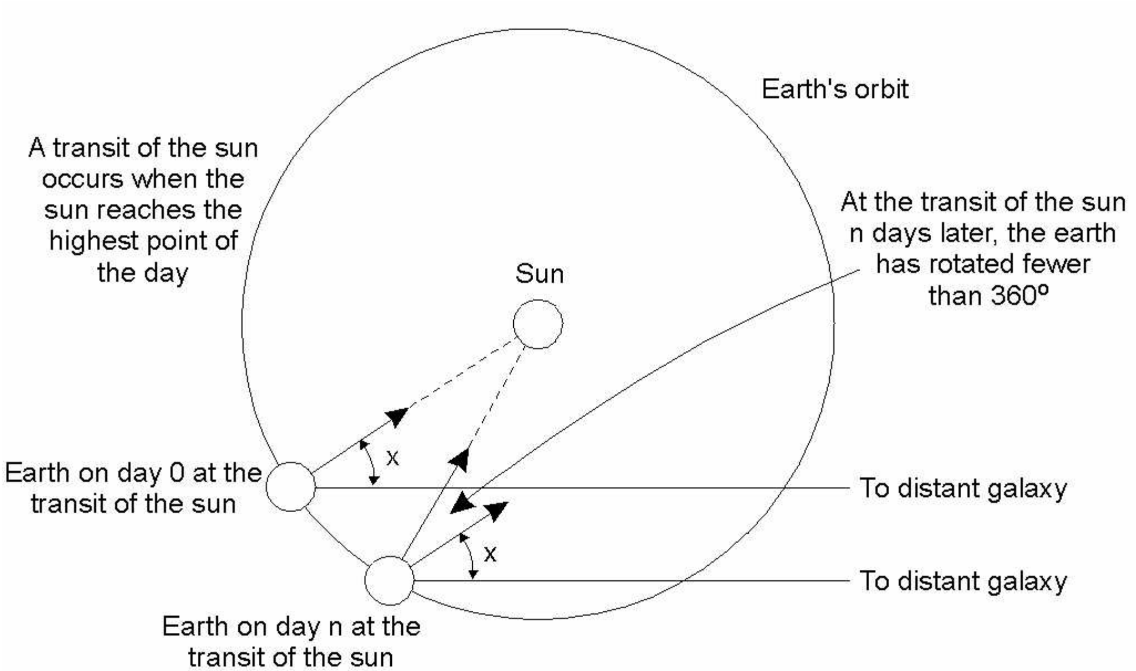
Clock Synchronization



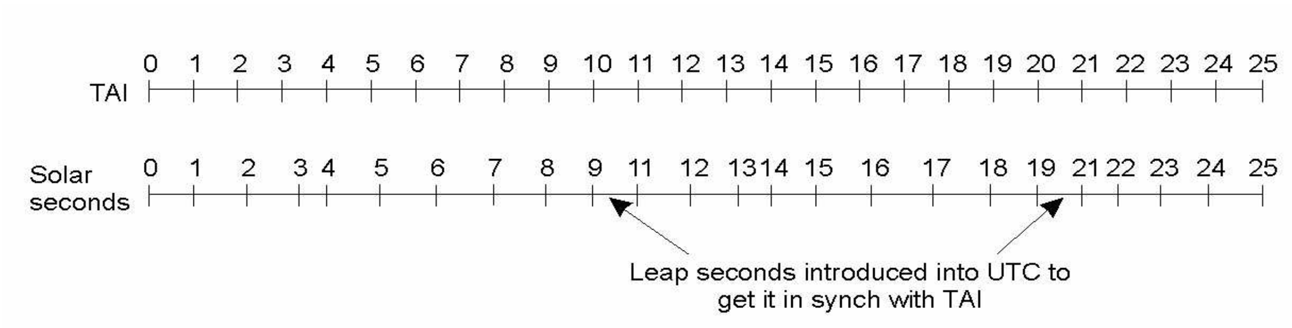
When each machine has its own clock, an event that occurred after another event may nevertheless be assigned an earlier time.

Physical Clocks (1)



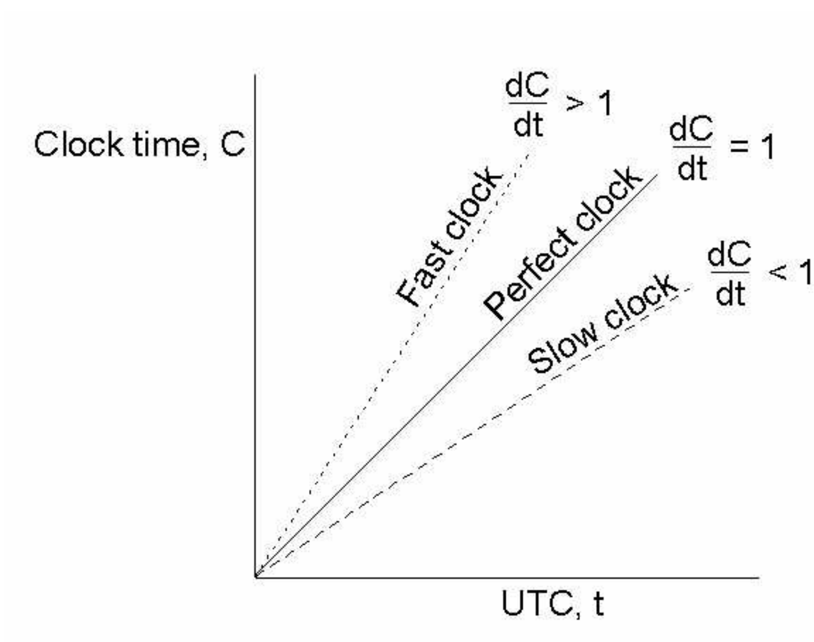
Computation of the mean solar day.

Physical Clocks (2)



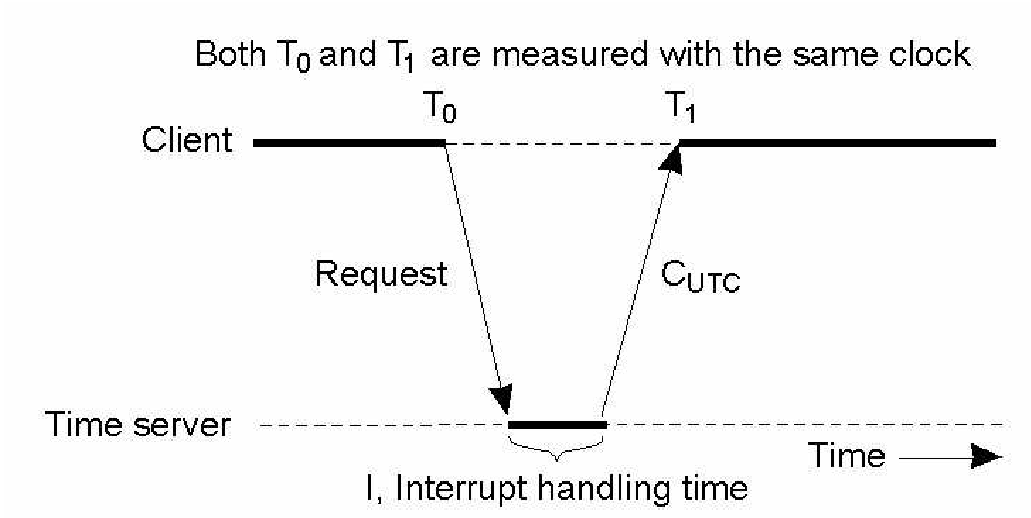
TAI seconds are of constant length, unlike solar seconds. Leap seconds are introduced when necessary to keep in phase with the sun.

Clock Synchronization Algorithms



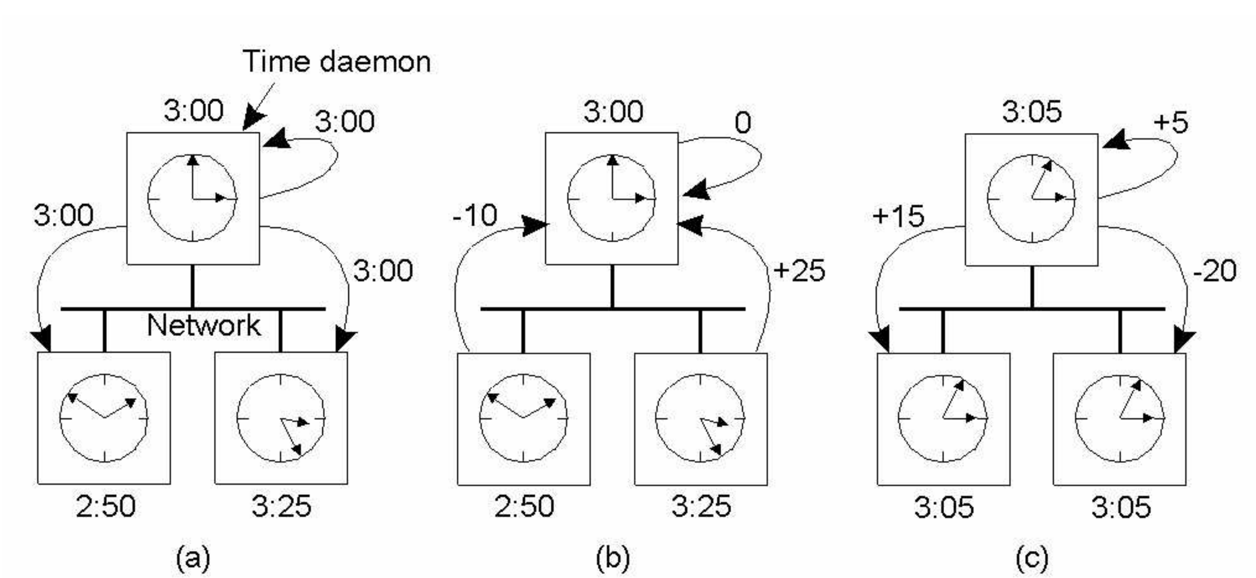
The relation between clock time and UTC when clocks tick at different rates.

Cristian's Algorithm



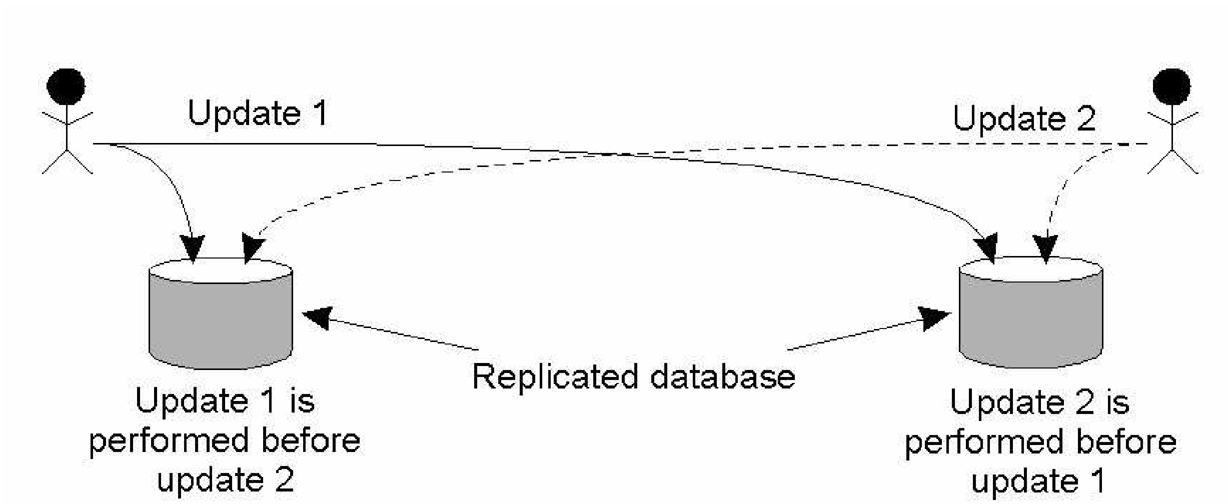
Getting the current time from a time server.

The Berkeley Algorithm



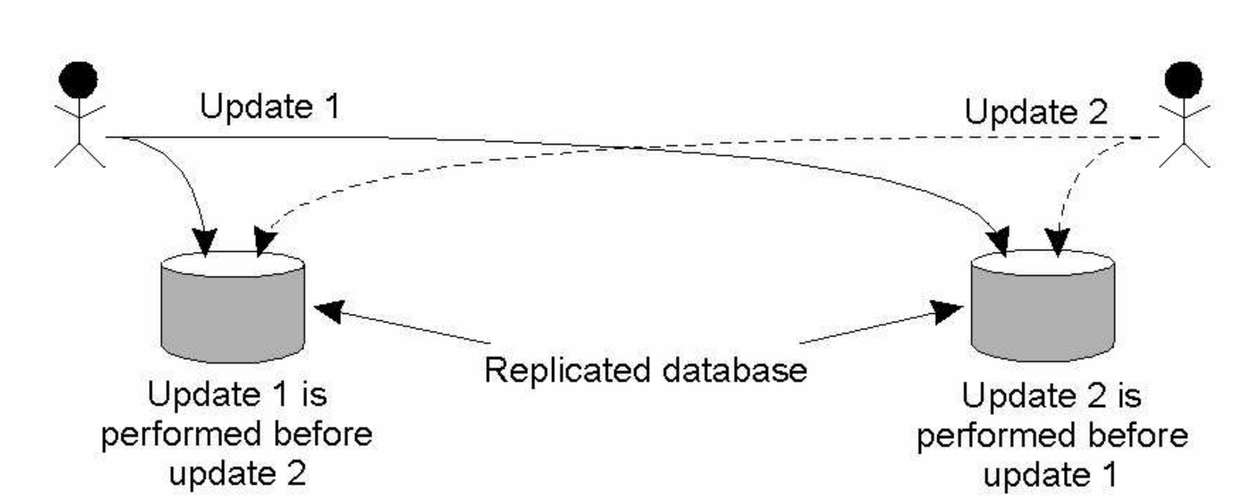
a) The time daemon asks all the other machines for their clock values
b) The machines answer
c) The time daemon tells everyone how to adjust their clock

Lamport Timestamps



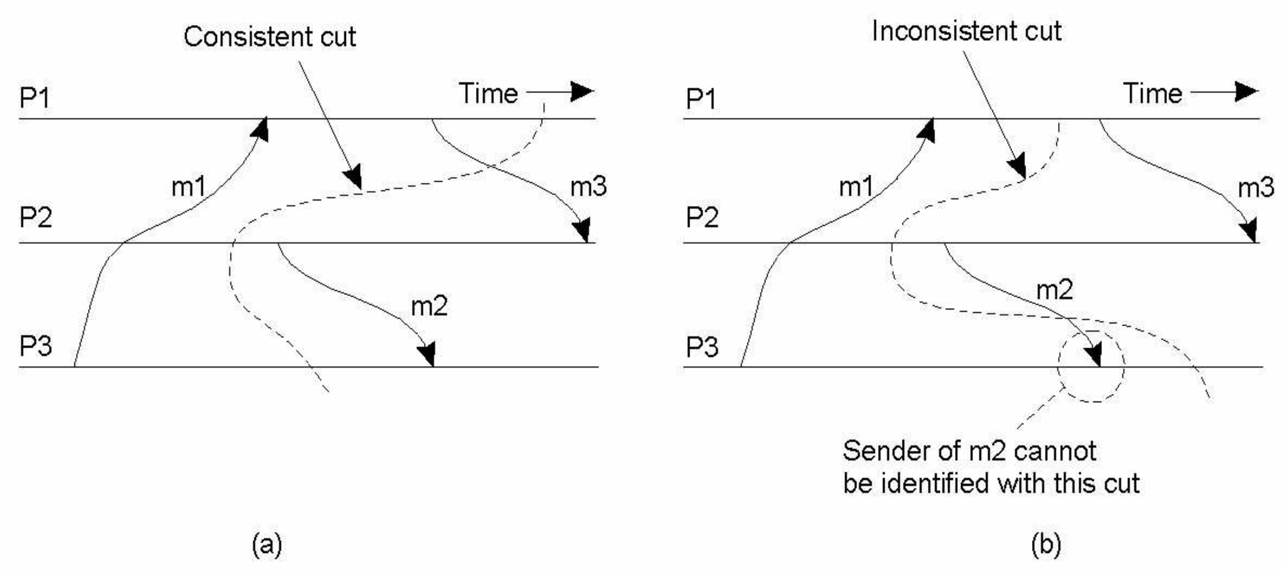
a) Three processes, each with its own clock. The clocks run at different rates.
b) Lamport's algorithm corrects the clocks.

Example: Totally−Ordered Multicasting



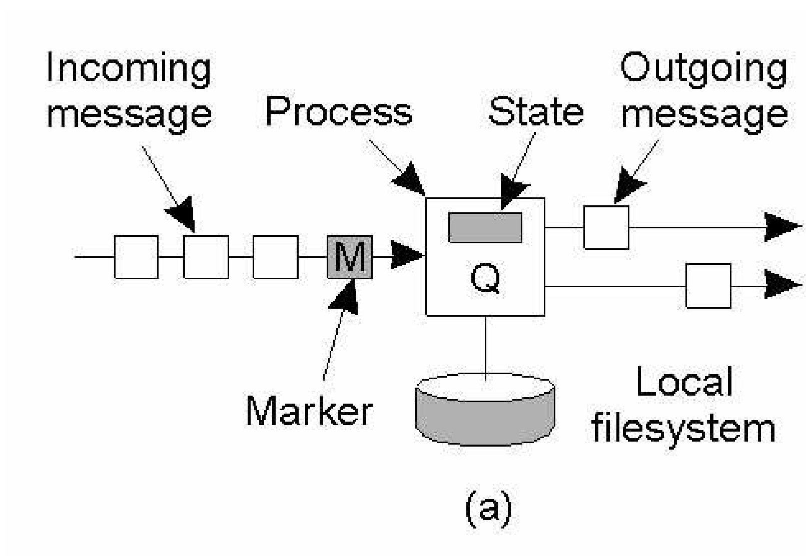
Updating a replicated database and leaving it in an inconsistent state.

Global State (1)



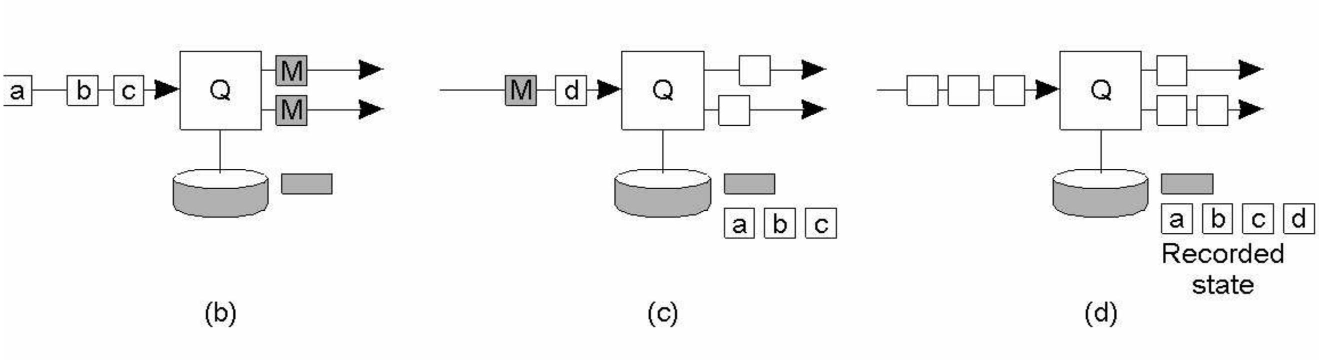
a) A consistent cut
b) An inconsistent cut

Global State (2)



a) Organization of a process and channels for a distributed snapshot

Global State (3)

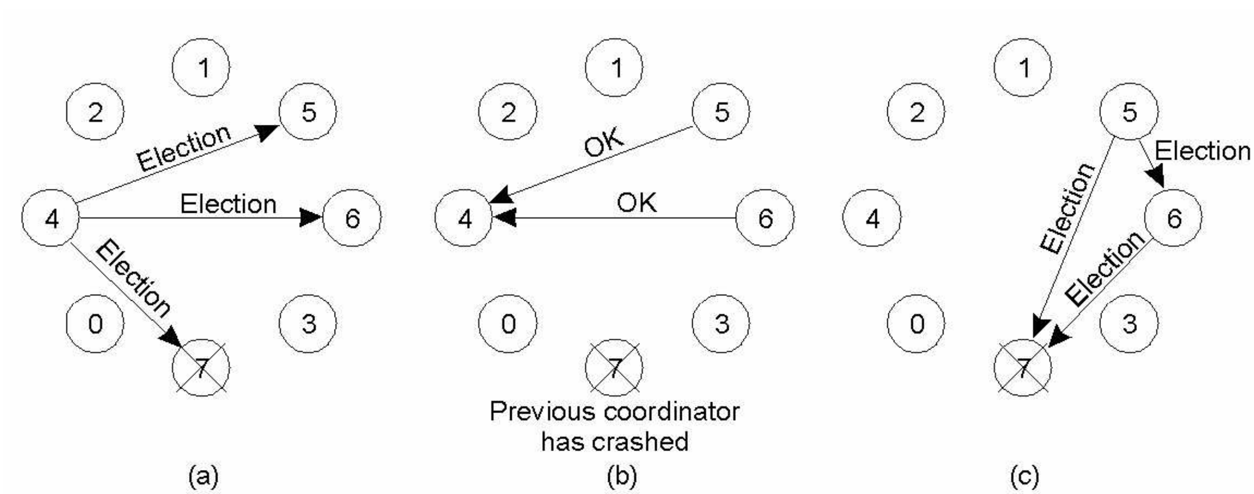


a) Process Q receives a marker for the first time and records its local state

b) Q records all incoming message

c) *Q* receives a marker for its incoming channel and finishes recording the state of the incoming channel

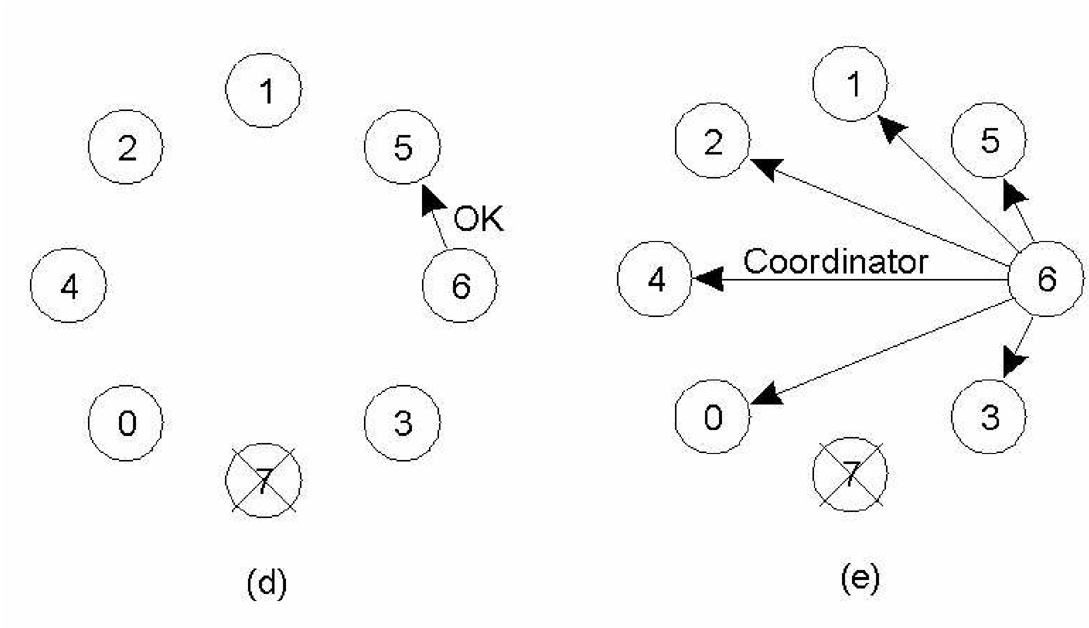
The Bully Algorithm (1)



The bully election algorithm

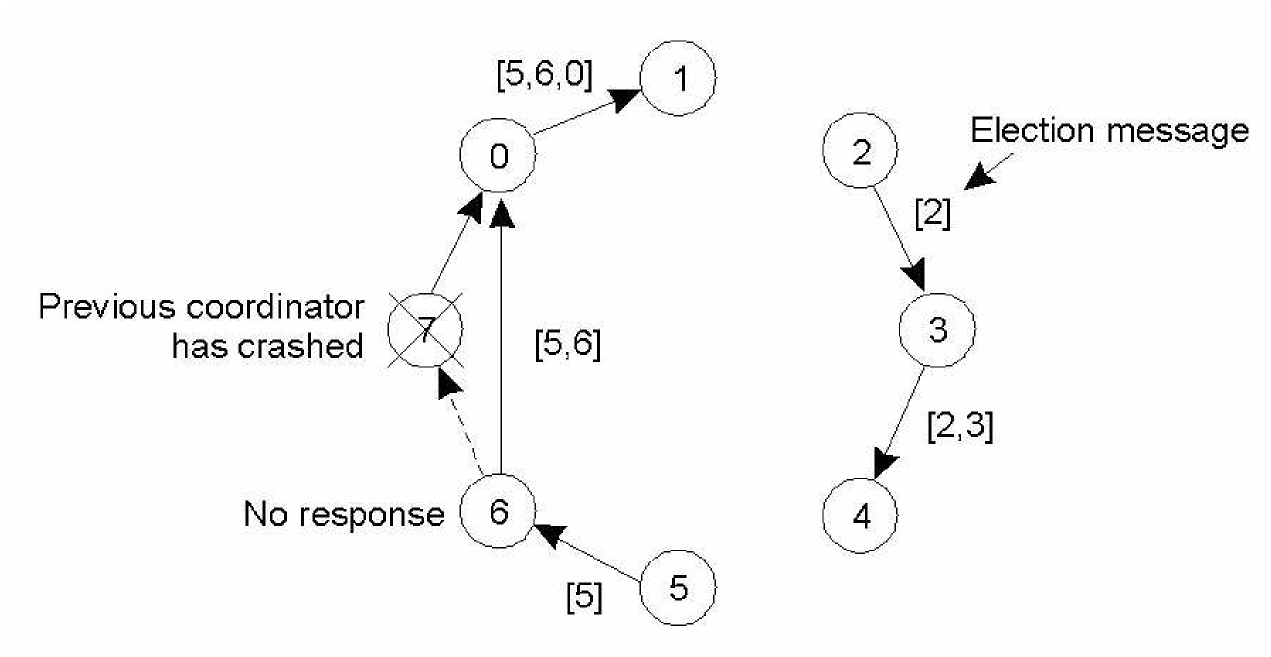
- Process 4 holds an election
- Process 5 and 6 respond, telling 4 to stop
- Now 5 and 6 each hold an election

Global State (3)



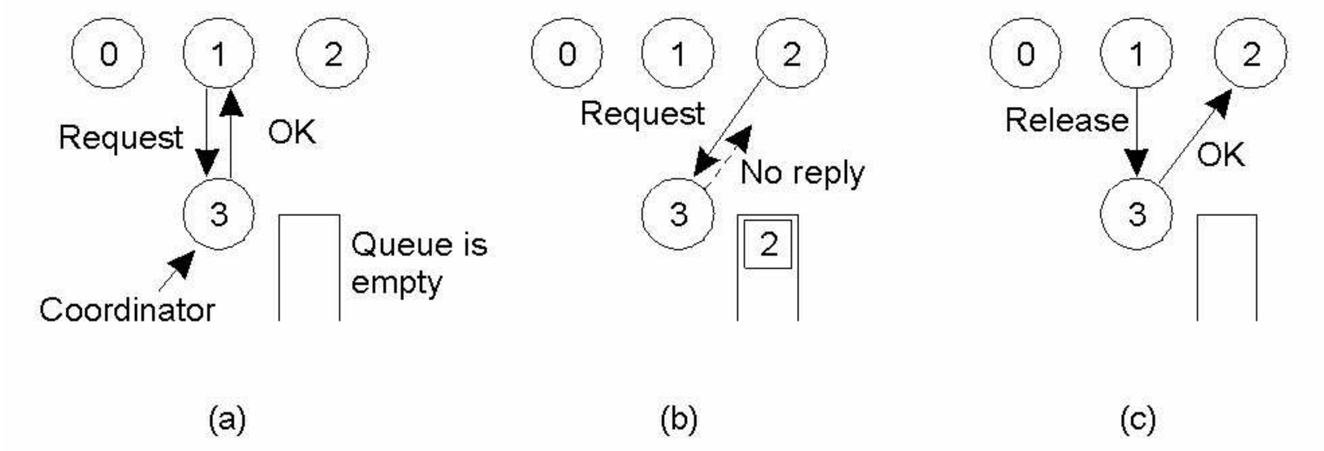
a) Process 6 tells 5 to stop
b) Process 6 wins and tells everyone

A Ring Algorithm



Election algorithm using a ring.

Mutual Exclusion: A Centralized Algorithm

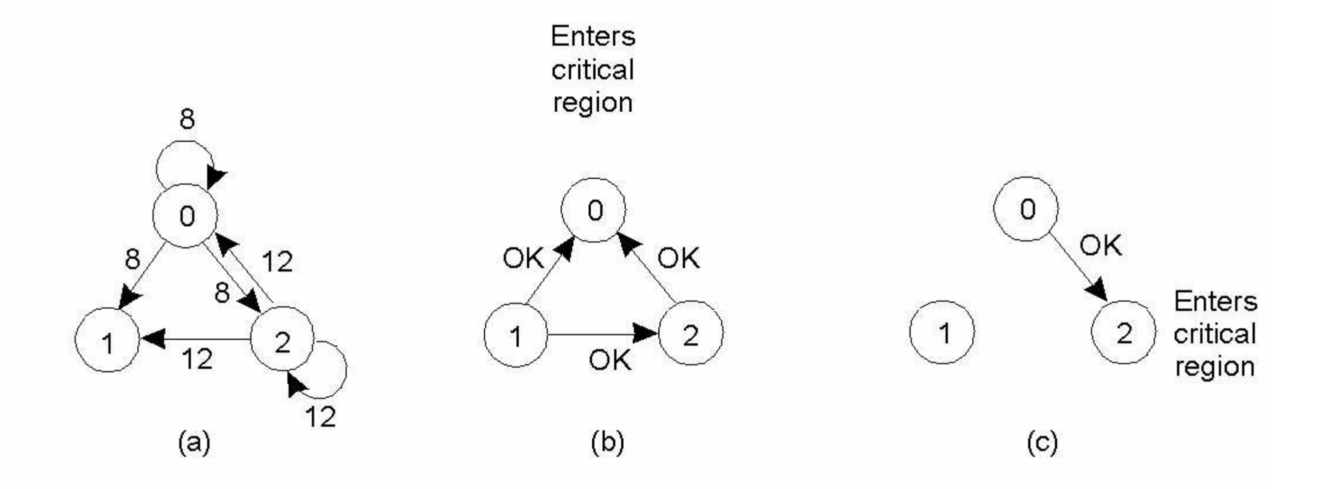


a) Process 1 asks the coordinator for permission to enter a critical region. Permission is granted

b) Process 2 then asks permission to enter the same critical region. The coordinator does not reply.

c) When process 1 exits the critical region, it tells the coordinator, when then replies to 2

A Distributed Algorithm

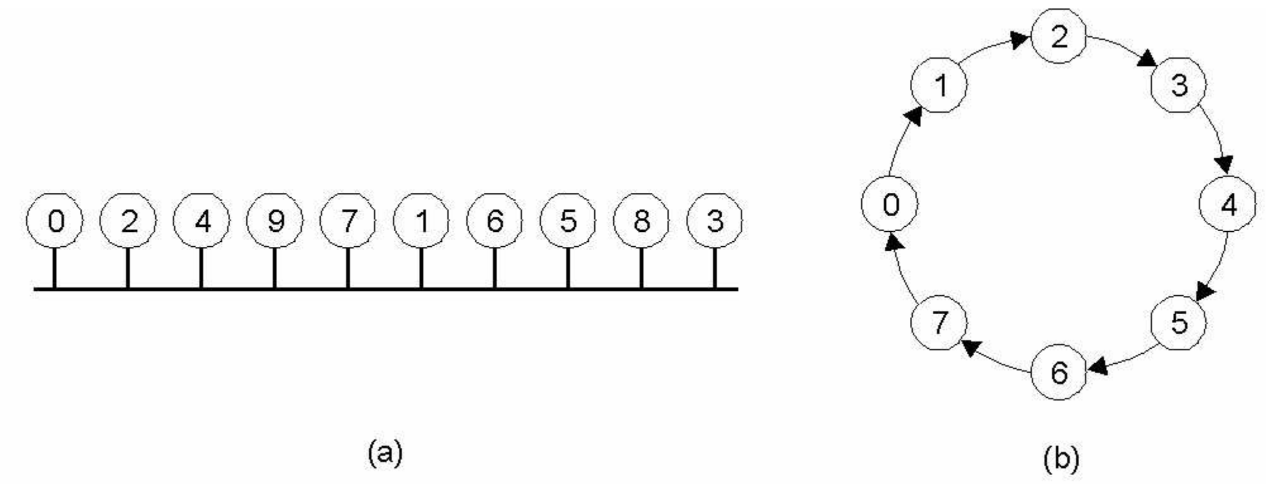


a) Two processes want to enter the same critical region at the same moment.

b) Process 0 has the lowest timestamp, so it wins.

c) When process 0 is done, it sends an OK also, so 2 can now enter the critical region.

A Toke Ring Algorithm



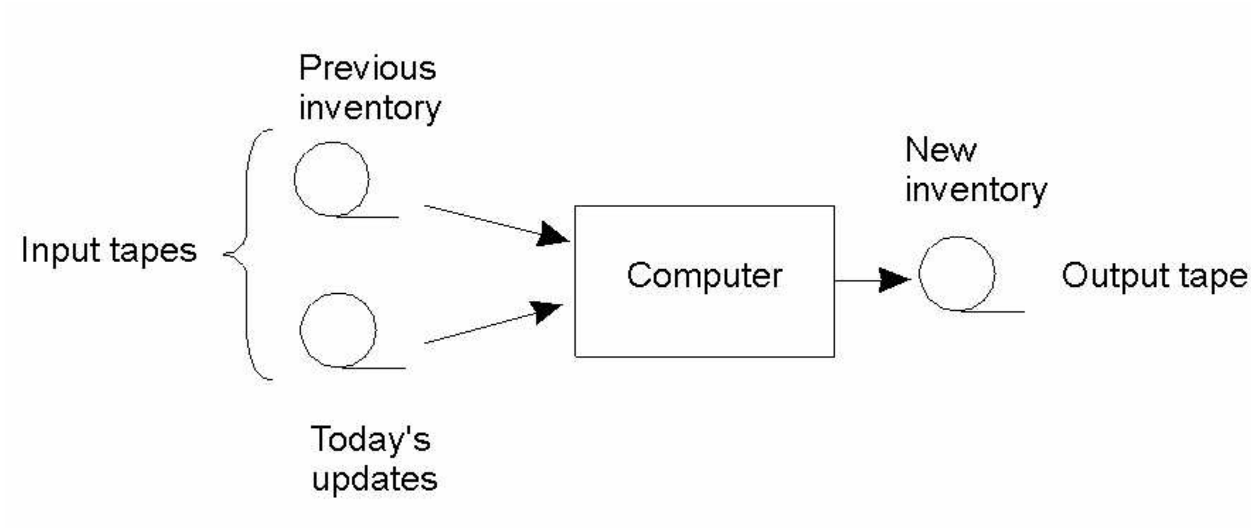
a) An unordered group of processes on a network.
b) A logical ring constructed in software.

Comparison

Algorithm	Messages per entry/exit	Delay before entry (in message times)	Problems
Centralized	3	2	Coordinator crash
Distributed	2 (n – 1)	2 (n – 1)	Crash of any process
Token ring	1 to ¥	0 to n – 1	Lost token, process crash

A comparison of three mutual exclusion algorithms.

The Transaction Model (1)



Updating a master tape is fault tolerant.

The Transaction Model (2)

Primitive	Description
BEGIN_TRANSACTION	Make the start of a transaction
END_TRANSACTION	Terminate the transaction and try to commit
ABORT_TRANSACTION	Kill the transaction and restore the old values
READ	Read data from a file, a table, or otherwise
WRITE	Write data to a file, a table, or otherwise

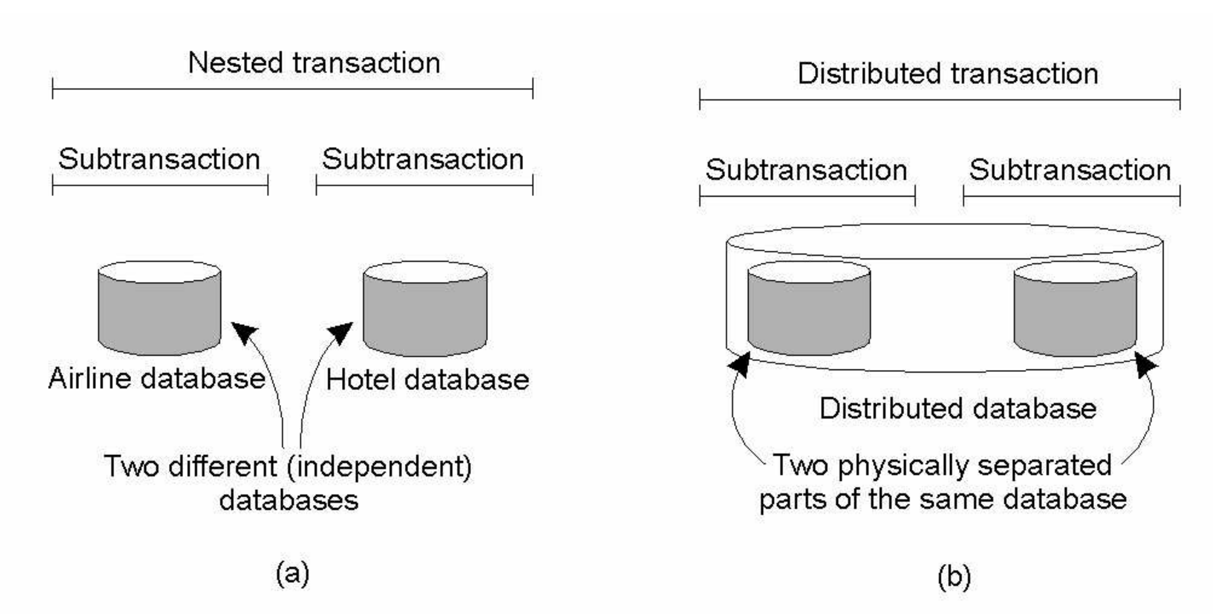
Examples of primitives for transactions.

The Transaction Model (3)

```
BEGIN_TRANSACTION               BEGIN_TRANSACTION
  reserve WP −> JFK;              reserve WP −> JFK;
  reserve JFK −> Nairobi;         reserve JFK −> Nairobi;
  reserve Nairobi −> Malindi;     reserve Nairobi −> Malindi full =>
END_TRANSACTION                 ABORT_TRANSACTION
          (a)                               (b)
```

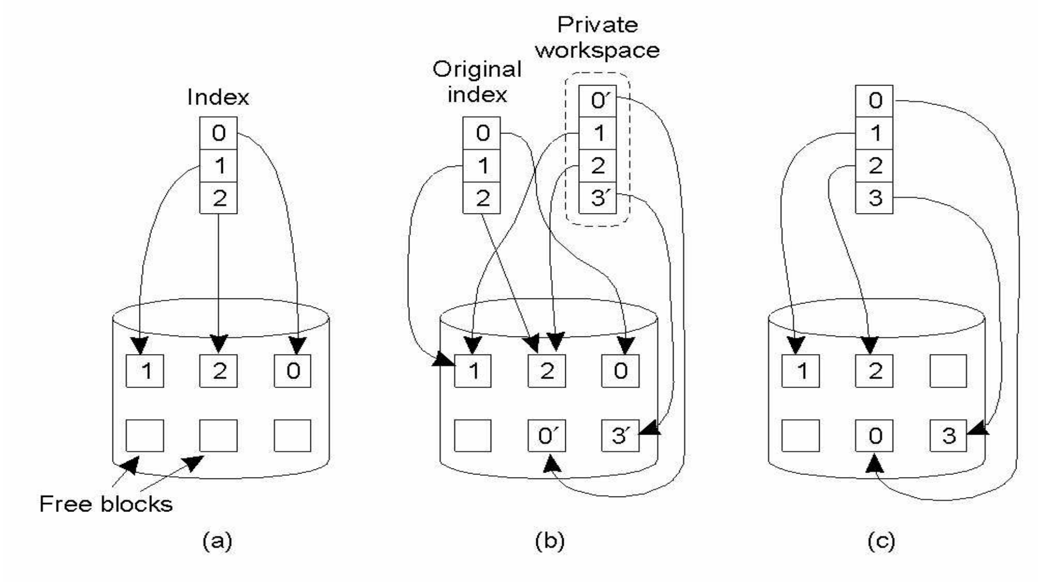
a) Transaction to reserve three flights commits
b) Transaction aborts when third flight is unavailable

Distributed Transactions



a) A nested transaction
b) A distributed transaction

Private Workspace



a) The file index and disk blocks for a three−block file

b) The situation after a transaction has modified block 0 and appended block 3

c) After committing

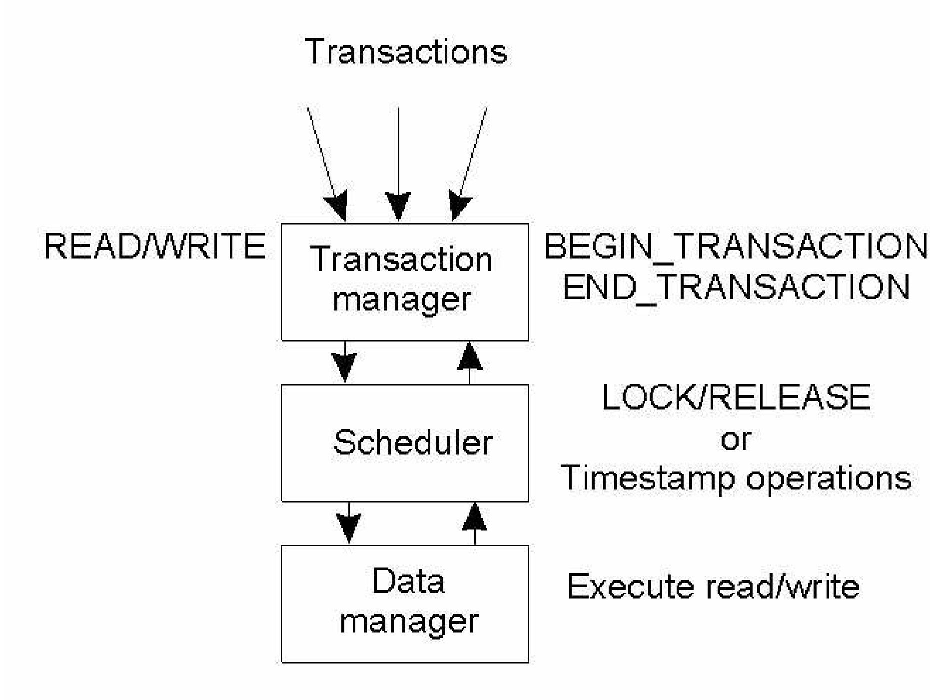
Writeahead Log

x = 0;	Log	Log	Log
y = 0;			
BEGIN_TRANSACTION;			
x = x + 1;	[x = 0 / 1]	[x = 0 / 1]	[x = 0 / 1]
y = y + 2		[y = 0/2]	[y = 0/2]
x = y * y;			[x = 1/4]
END_TRANSACTION;			
(a)	(b)	(c)	(d)

a) A transaction

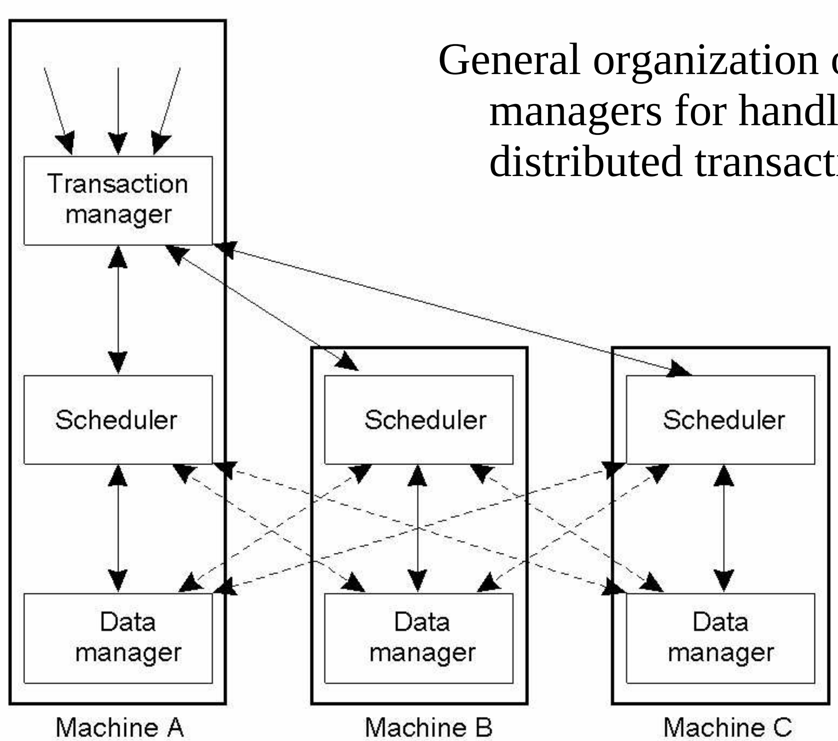
b) – d) The log before each statement is executed

Concurrency Control (1)



General organization of managers for handling transactions.

Concurrency Control (2)



General organization of managers for handling distributed transactions.

Serializability

```
BEGIN_TRANSACTION
  x = 0;
  x = x + 1;
END_TRANSACTION
```

(a)

```
BEGIN_TRANSACTION
  x = 0;
  x = x + 2;
END_TRANSACTION
```

(b)

```
BEGIN_TRANSACTION
  x = 0;
  x = x + 3;
END_TRANSACTION
```

(c)

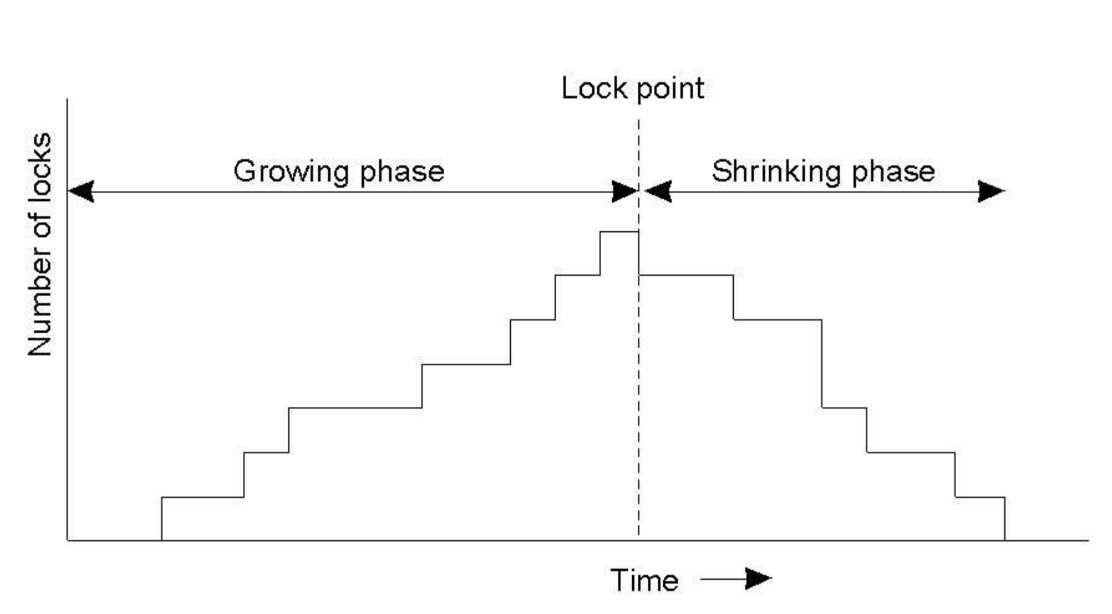
Schedule 1	x = 0; x = x + 1; x = 0; x = x + 2; x = 0; x = x + 3	Legal
Schedule 2	x = 0; x = 0; x = x + 1; x = x + 2; x = 0; x = x + 3;	Legal
Schedule 3	x = 0; x = 0; x = x + 1; x = 0; x = x + 2; x = x + 3;	Illegal

(d)

a) – c) Three transactions T_1, T_2, and T_3

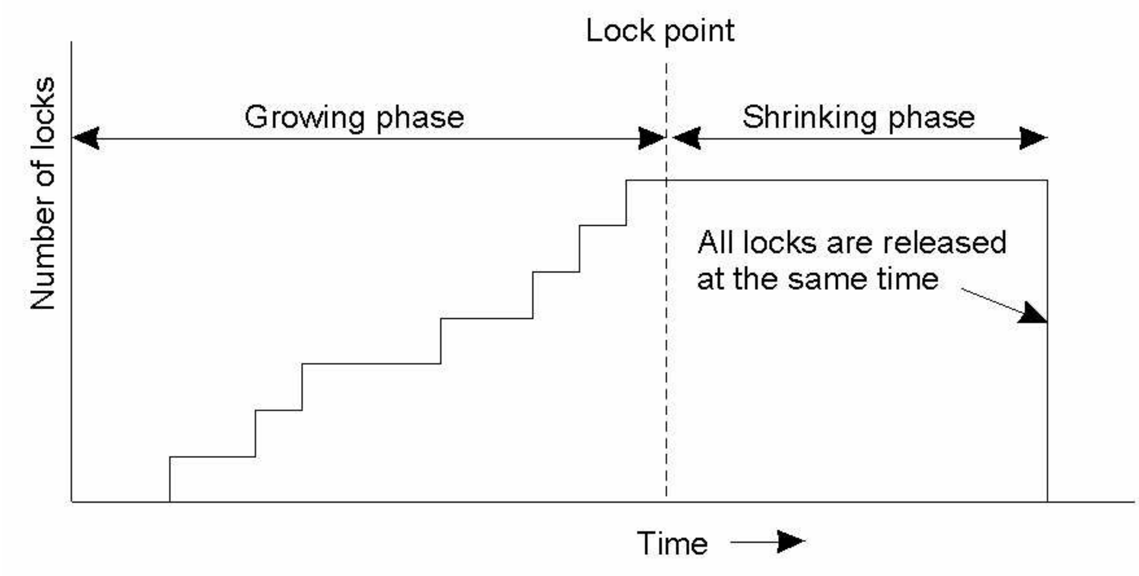
d) Possible schedules

Two−Phase Locking (1)



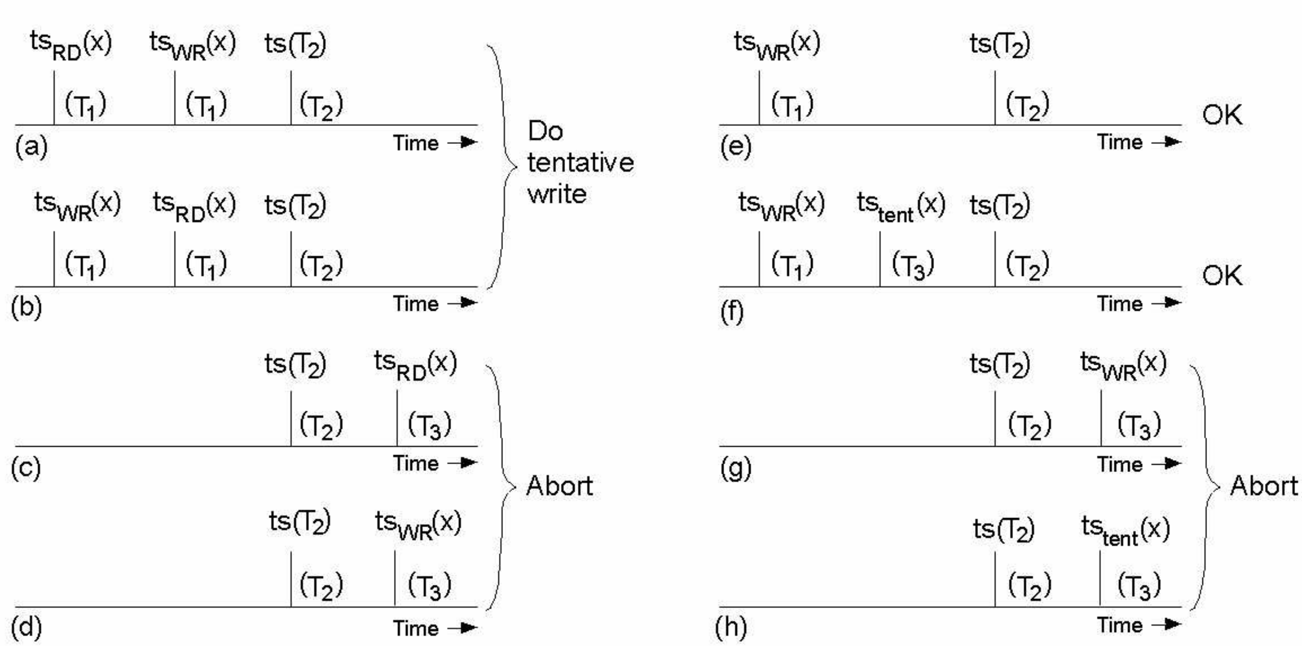
Two−phase locking.

Two−Phase Locking (2)



Strict two−phase locking.

Pessimistic Timestamp Ordering



Concurrency control using timestamps.