This Lecture

- More 2PC
  - [BN97] Ch 9
- Starting MOM and Message Brokers
  - [ACKM04] Section 2.5
  - [BN97] Ch 4

2-Phase Commit

- Phase 1:
  - Coordinator sends PREPARE to all participants and waits for responses
  - Participants reply YES or NO, or fail to reply

2-Phase Commit

- Phase 2:
    - Coordinator decides YES iff received YES votes from all participants
    - Coordinator sends decision to all participants
    - Participants reply DONE
    - Coordinator frees resources after receiving DONE from all participants

2-Phase Commit - Blocking

- Correctness:
  - After voting NO participant may abort
  - After voting YES participant may not commit or abort until receiving the coordinator decision -- *in doubt*
  - What if coordinator fails while some participants are in doubt? *Blocked!*

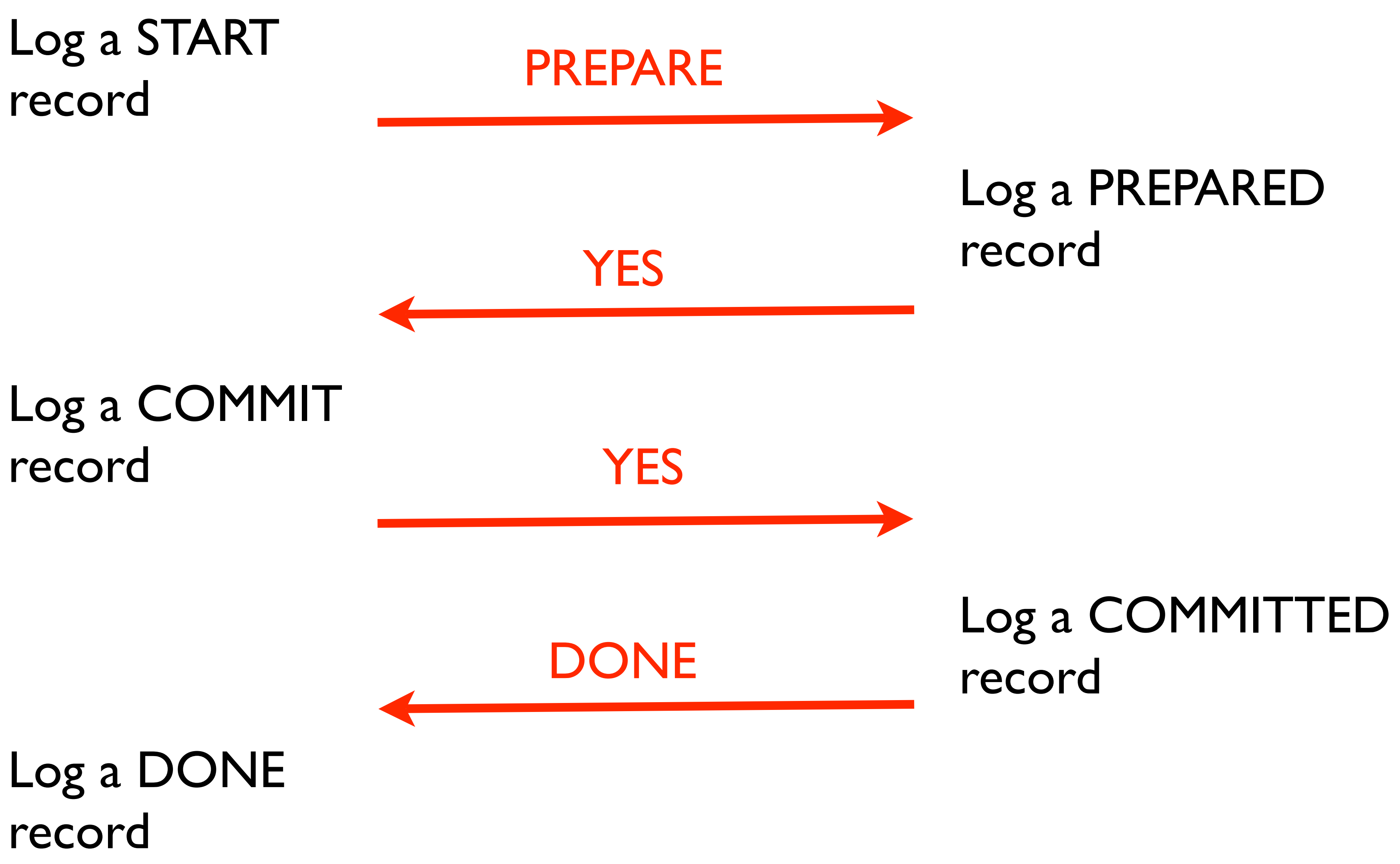
2-Phase Commit - Theorems

- For every possible distributed commit protocol, a communication failure can cause a participant to become blocked.
- No distributed commit protocol can guarantee *independent recovery* (recovery without cooperation from coordinator) of failed participants.

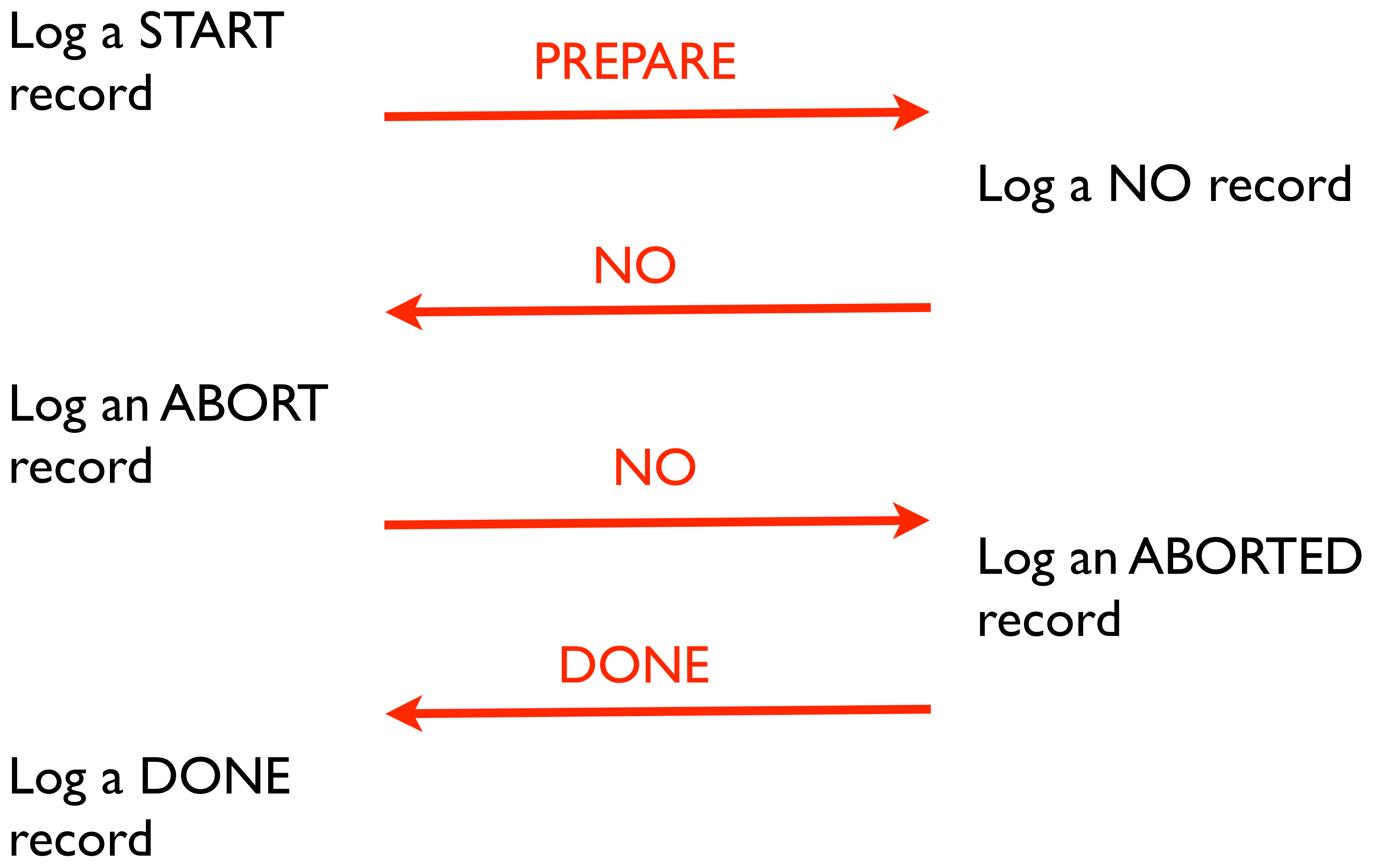
Logging in 2PC

- Coordinator and participants must log enough information to enable recovery if a failure occurs during execution of the 2PC protocol
- Participant P is not prepared to commit txn T unless all after-images for T are in stable storage at P
- No participant may commit unless all are prepared

Logging in 2PC



Logging in 2PC



Error Handling - Coordinator

- Broadcast PREPARE
  - No error possible
- Receive replies from all participants
  - Any replies timeout => assume NO
- Decide to commit or abort
  - No error possible
- Broadcast decision (COMMIT or ABORT)
  - No error possible

Error Handling - Coordinator

- Receive DONE from all participants
  - Timeout => re-solicit DONE messages from all participants, infinite loop
- Free all resources associated with transaction
  - No error possible

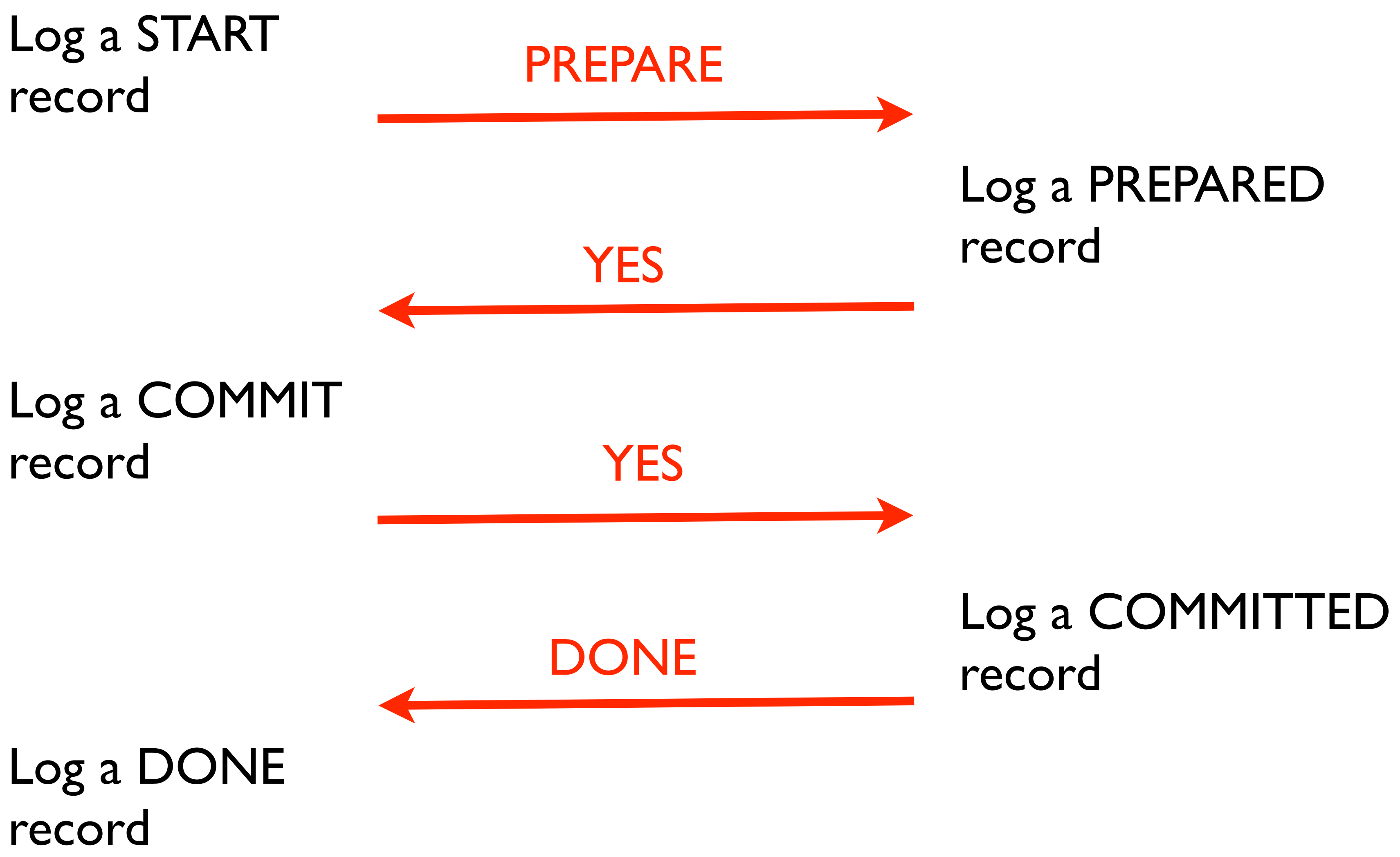
Error Handling - Participant

- Receive PREPARE from coordinator
    - Timeout without PREPARE request => abort the transaction unilaterally
    - Txn mentioned in PREPARE does not exist => just ignore the request
- Prepare the transaction for commit
    - No error possible
    - Result is commit vote (YES or NO)

Error Handling - Participant

- Send vote (YES or NO)
  - No error possible
- Receive decision
  - Timeout => *blocked*!
- Implement the decision (commit or abort) and send DONE
  - No error possible

Recovery



Log a START record

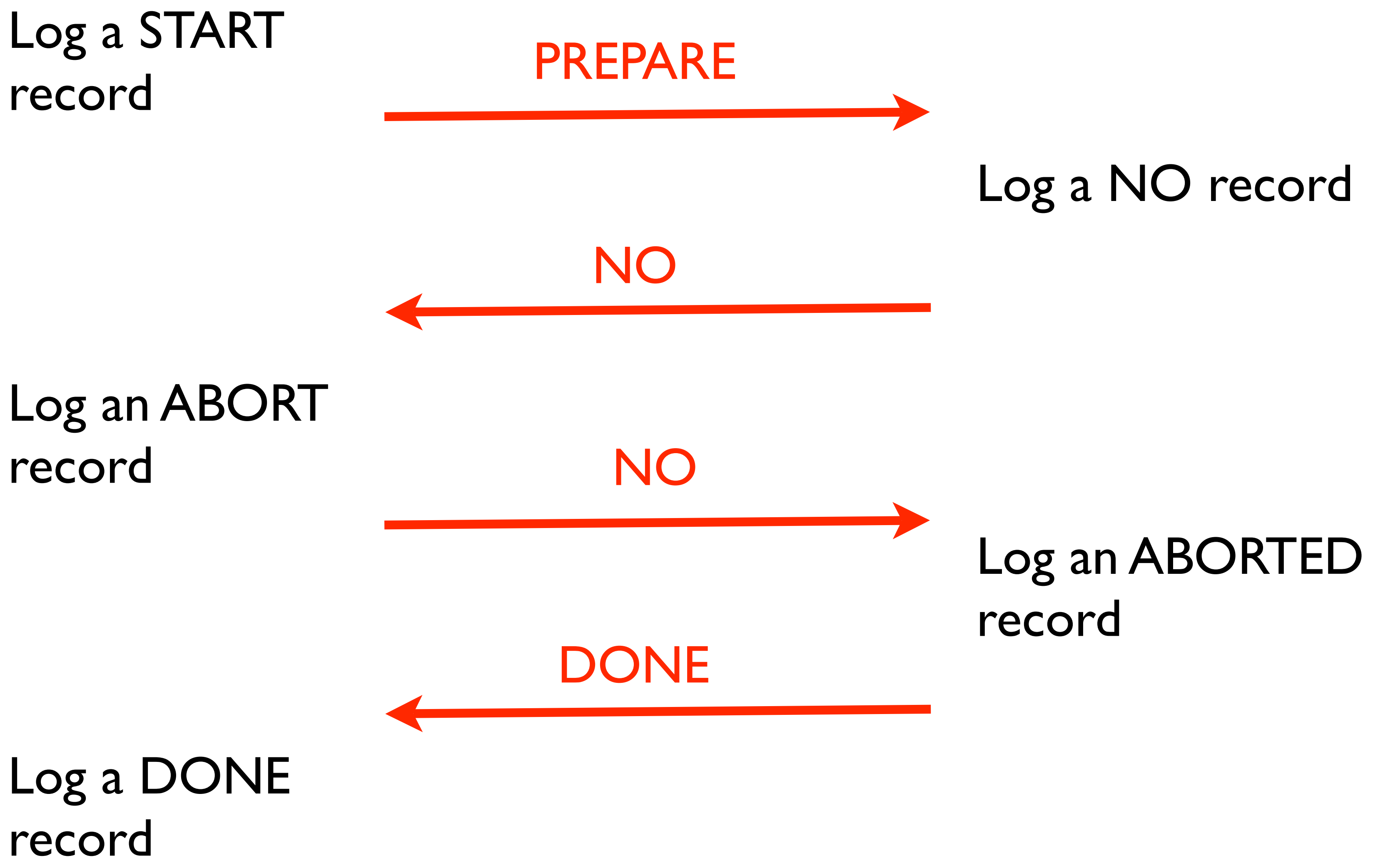
Log a PREPARED record

Log a COMMIT record

Log a COMMITTED record

Log a DONE record

Recovery



Log a START record

Log a NO record

Log an ABORT record

Log an ABORTED record

Log a DONE record

Recovery - Participant

- No START in log
  - Participants will eventually abort
- No COMMIT/ABORT in log
  - Broadcast NO
- No DONE in log
  - Broadcast decision from log (again?)
- Done in log
  - No action required

Recovery - Coordinator

- No PREPARED record in log
  - Abort unilaterally
- No COMMITED/ABORTED in log
  - Execute "Termination Protocol"
- COMMITED/ABORTED in log
  - Send DONE (again?)

Simple Termination Protocol

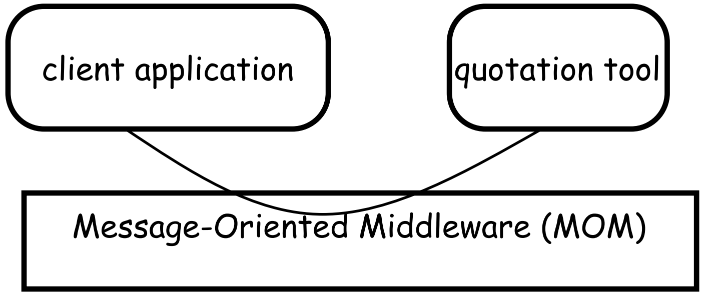
- Reestablish communication with coordinator (wait indefinitely for this)
- Resend vote
- Coordinator will resend decision
    - Cannot have forgotten the txn as it has not received a DONE message!

Message Oriented Systems

- MOM
- Message Brokers

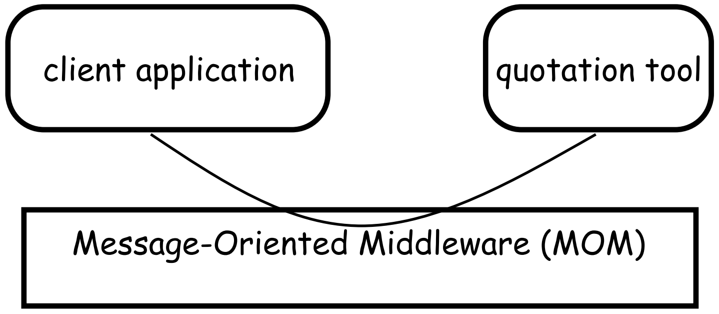
Async RPC as two messages

```
Message : quoteRequest {
 QuoteReferenceNumber: 325
 Customer: Acme,INC
 Item:#115 (Ball-point pen, blue)
 Quantity: 1200
 RequestedDeliveryDate: Mar 16,2003
 DeliveryAddress: Palo Alto, CA
}
```



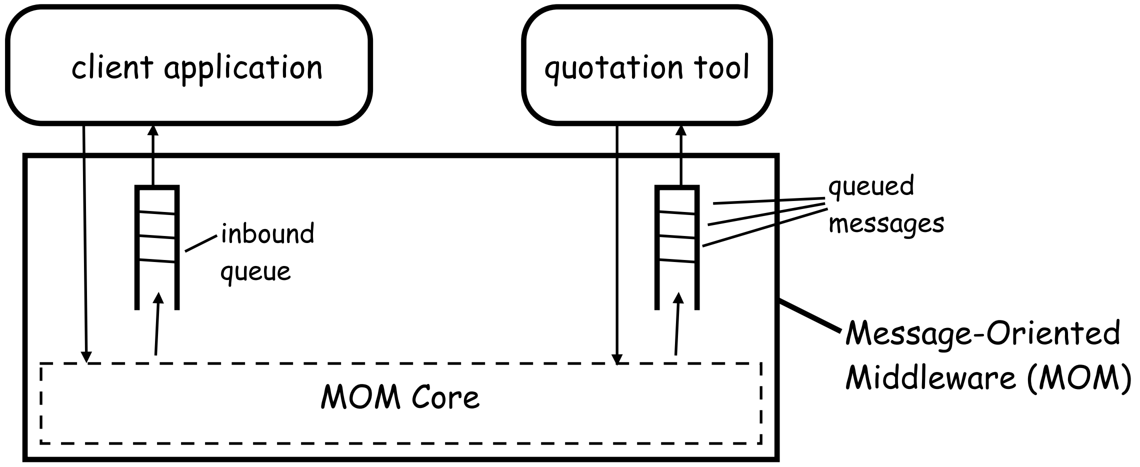
(a)

```
Message: quote {
 QuoteReferenceNumber: 325
 ExpectedDeliveryDate: Mar 12, 2003
 Price:1200$
}
```



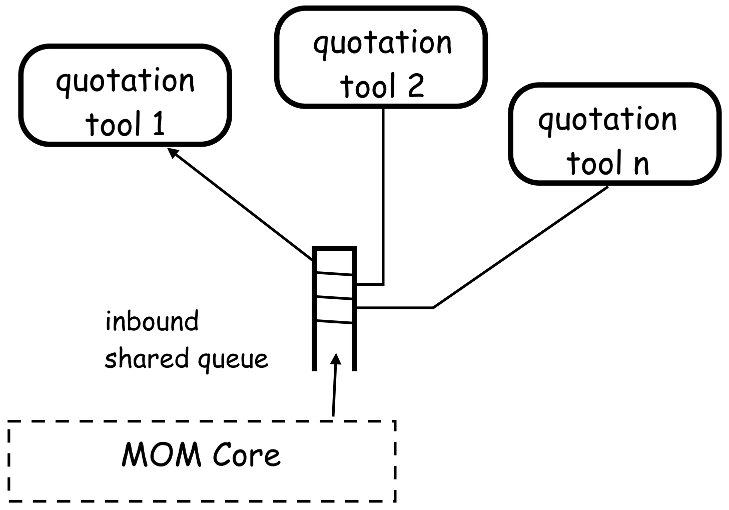
(b)

MOM



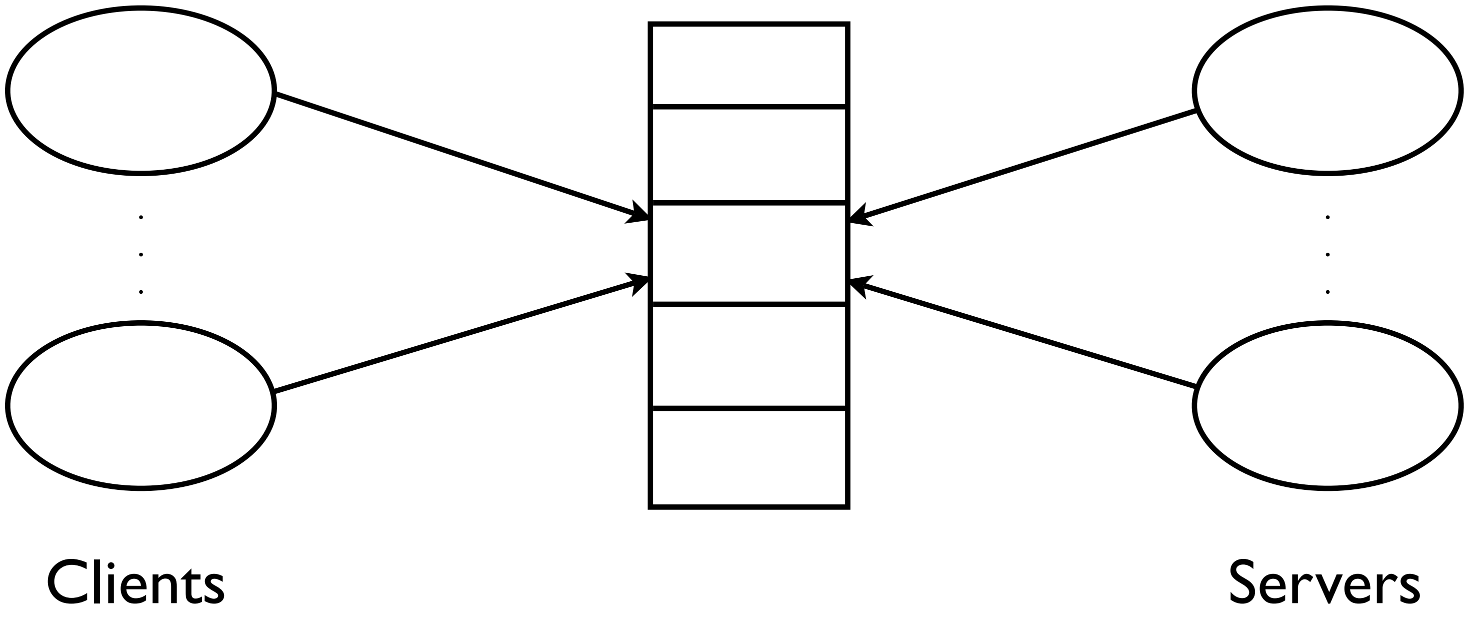
MOM routes messages and maintains input queues

Multiple Servers



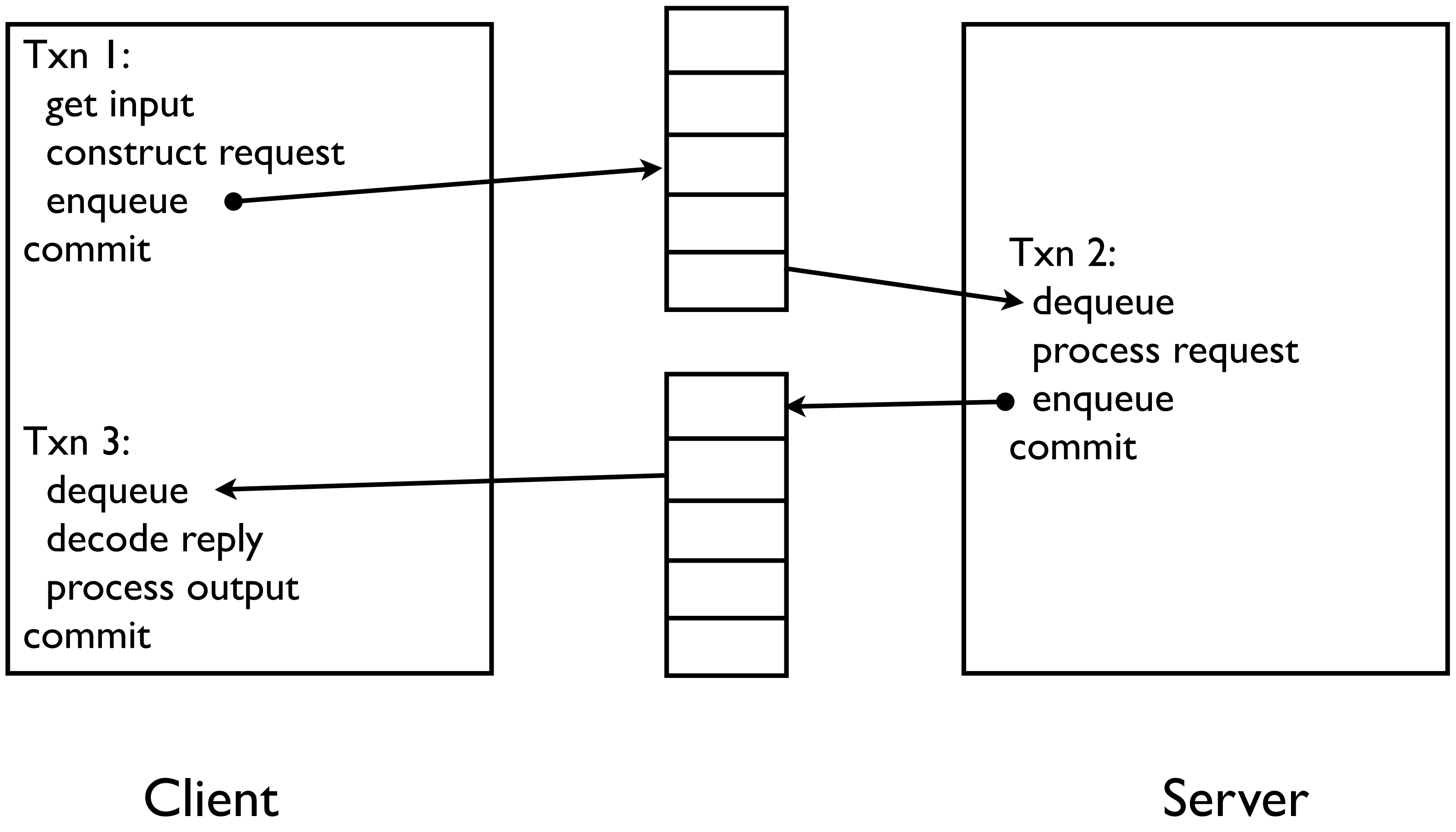
Queue acts as worklist for multiple processes

Multiple Clients and Servers



- Load balancing on both sides of queue

Multiple Clients and Servers


Txn 1:
get input
construct request
enqueue
commit
Txn 3:
dequeue
decode reply
process output
commit
Txn 2:
dequeue
process request
enqueue
commit
Client
Server