Politecnico di Torino

1859

DBMG

Master course

Distributed transactions in relational databases

DANIELE APILETTI

POLITECNICO DI TORINO

ACID properties

- Atomicity
  - It requires distributed techniques
    - 2 phase commit
- Consistency
  - Constraints are currently enforced only locally
- Isolation
  - It requires strict 2PL and 2 Phase Commit
- Durability
  - It requires the extension of local procedures to manage atomicity in presence of failure

Other issues

- *Distributed query optimization* is performed by the DBMS receiving the query execution request
    - It partitions the query in subqueries, each addressed to a single DBMS
    - It selects the execution strategy
        - order of operations and execution technique
        - order of operations on different nodes
            - transmission cost may become relevant
        - (optionally) selection of the appropriate replica
    - It coordinates operations on different nodes and information exchange

Atomicity

- All nodes (i.e., DBMS servers) participating to a distributed transaction must implement the same decision (commit or rollback)
  - Coordinated by 2 phase commit protocol
- Failure causes
  - Node failure
  - Network failure which causes lost messages
    - Acknowledgement of messages (ack)
    - Usage of timeout
  - Network partitioning in separate subnetworks

2 Phase Commit protocol

- Objective
  - Coordination of the conclusion of a distributed transaction
- Parallel with a wedding
  - Priest celebrating the wedding
    - Coordinates the agreement
  - Couple to be married
    - Participate to the agreement

2 Phase Commit protocol

- Distributed transaction
  - One coordinator
    - *Transaction Manager* (TM)
  - Several DBMS servers which take part to the transaction
    - *Resource Managers* (RM)
- Any participant may take the role of TM
  - Also the client requesting the transaction execution

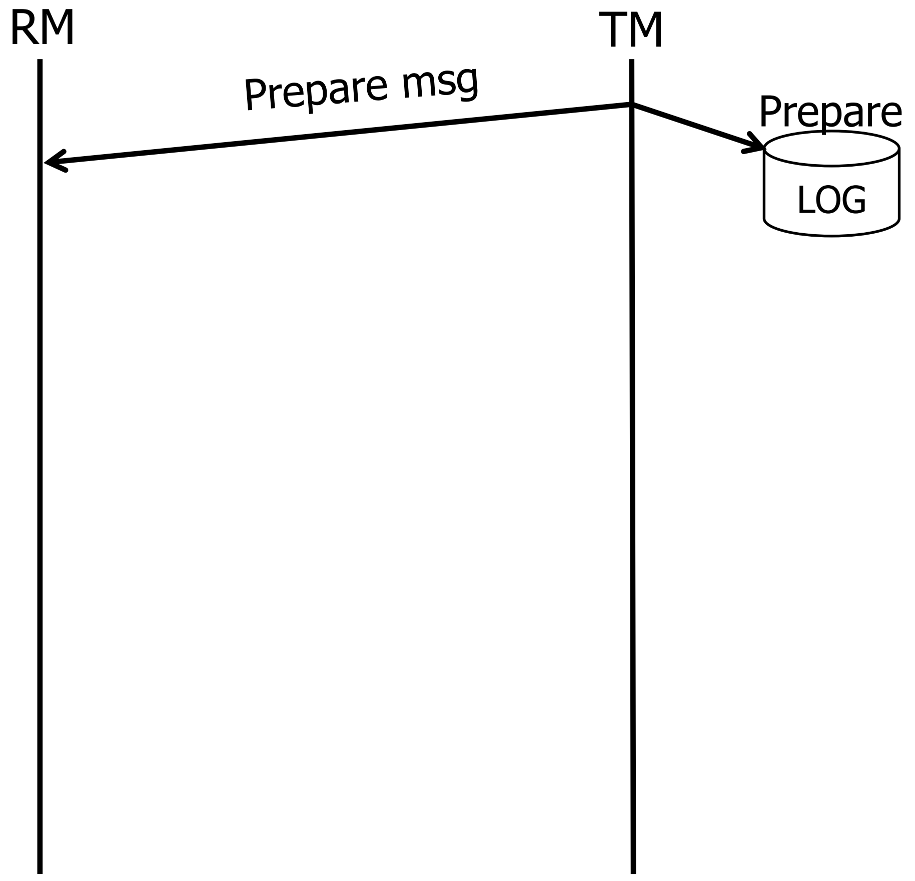
New log records

- TM and RM have *separate private* logs
- Records in the TM log
  - *Prepare*
    - it contains the identity of all RMs participating to the transaction (Node ID + Process ID)
  - *Global commit/abort*
    - final decision on the transaction outcome
  - *Complete*
    - written at the end of the protocol

New log records

- New records in the RM log
  - *Ready*
    - The RM is willing to perform commit of the transaction
    - The decision *cannot be changed* afterwards
    - The node has to be in a reliable state
      - WAL and commit precedence rules are enforced
      - Resources are locked
    - After this point the RM *loses its autonomy* for the current transaction

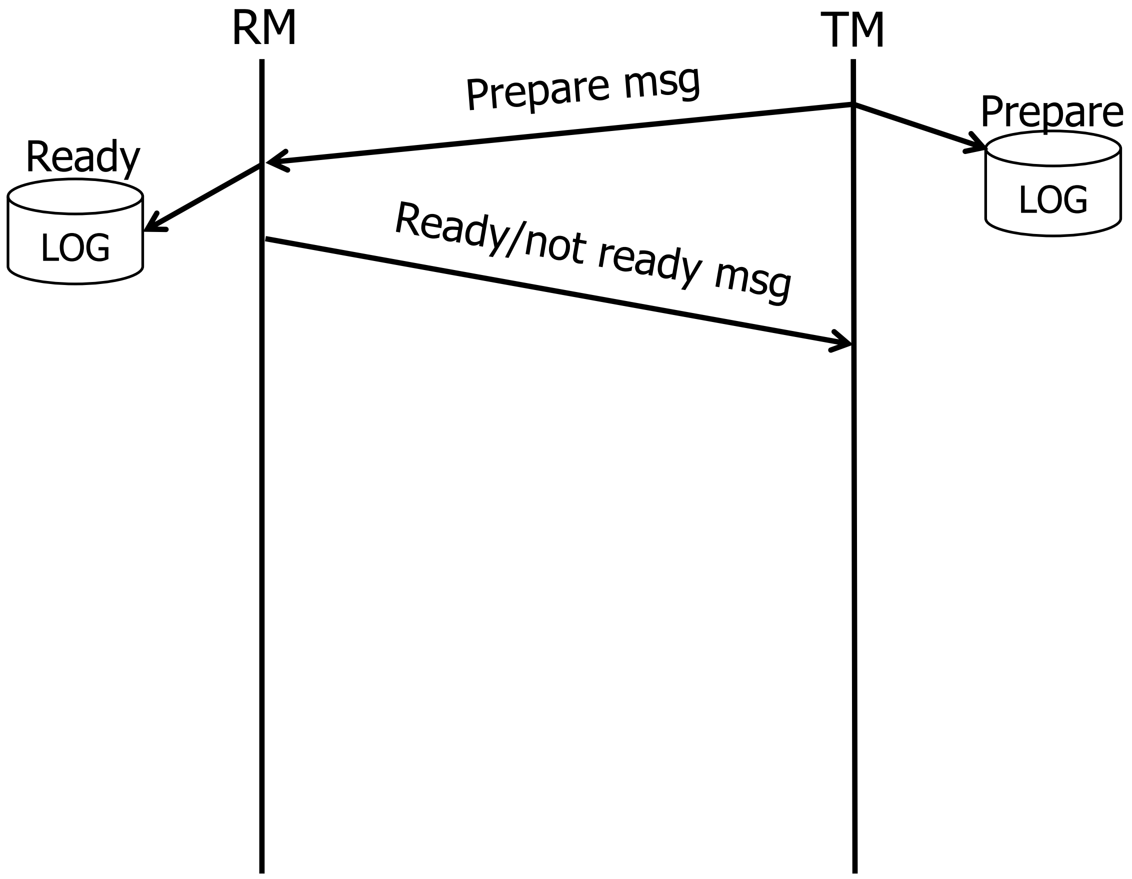
2 Phase Commit protocol



Phase I

1. The TM
   - Writes the prepare record in the log
   - Sends the prepare message to all RM (participants)
   - Sets a timeout, defining maximum waiting time for RM answer

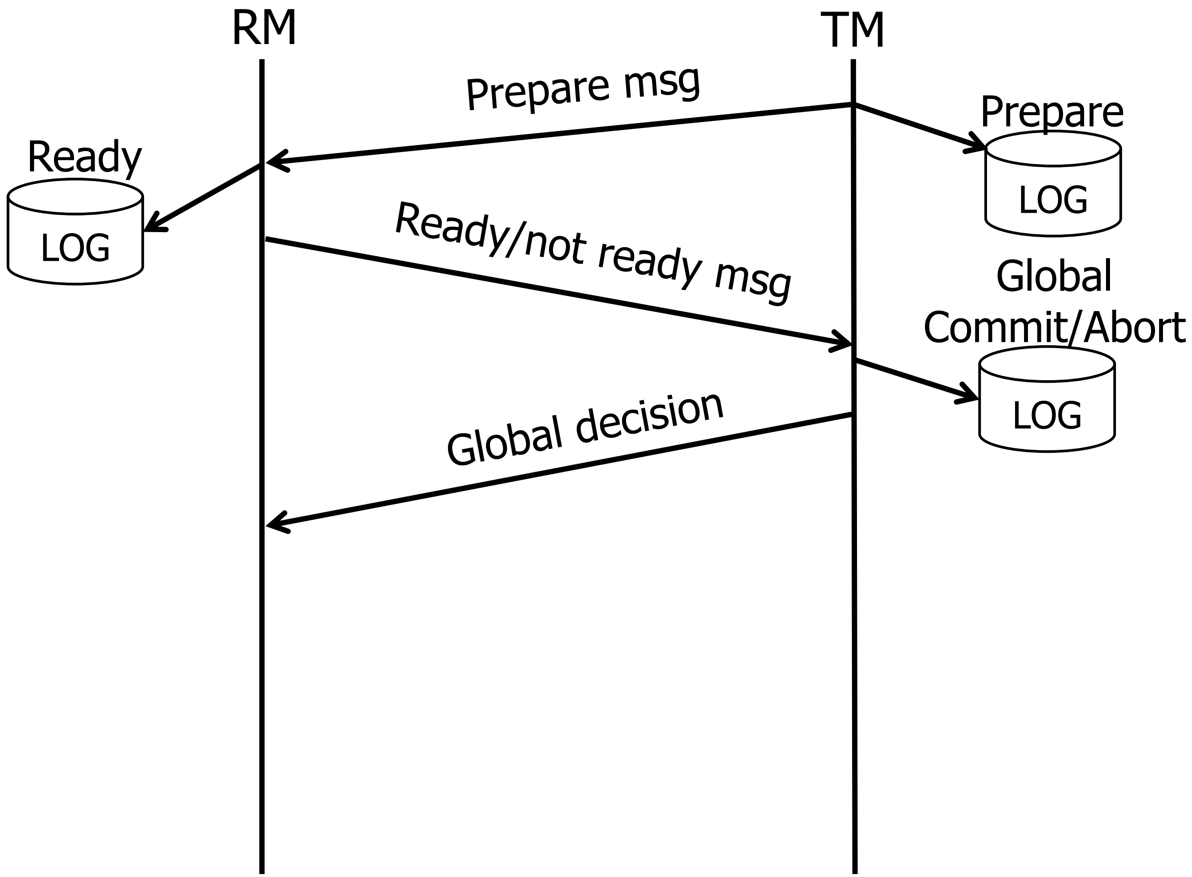
2 Phase Commit protocol



Phase I

- The RMs
  - Wait for the prepare message
  - When they receive it
    - If they are in a reliable state
      - Write the ready record in the log
      - Send the ready message to the TM
    - If they are not in a reliable state
      - Send a not ready message to the TM
      - Terminate the protocol
      - Perform local rollback
    - If the RM crashed
      - No answer is sent

2 Phase Commit protocol



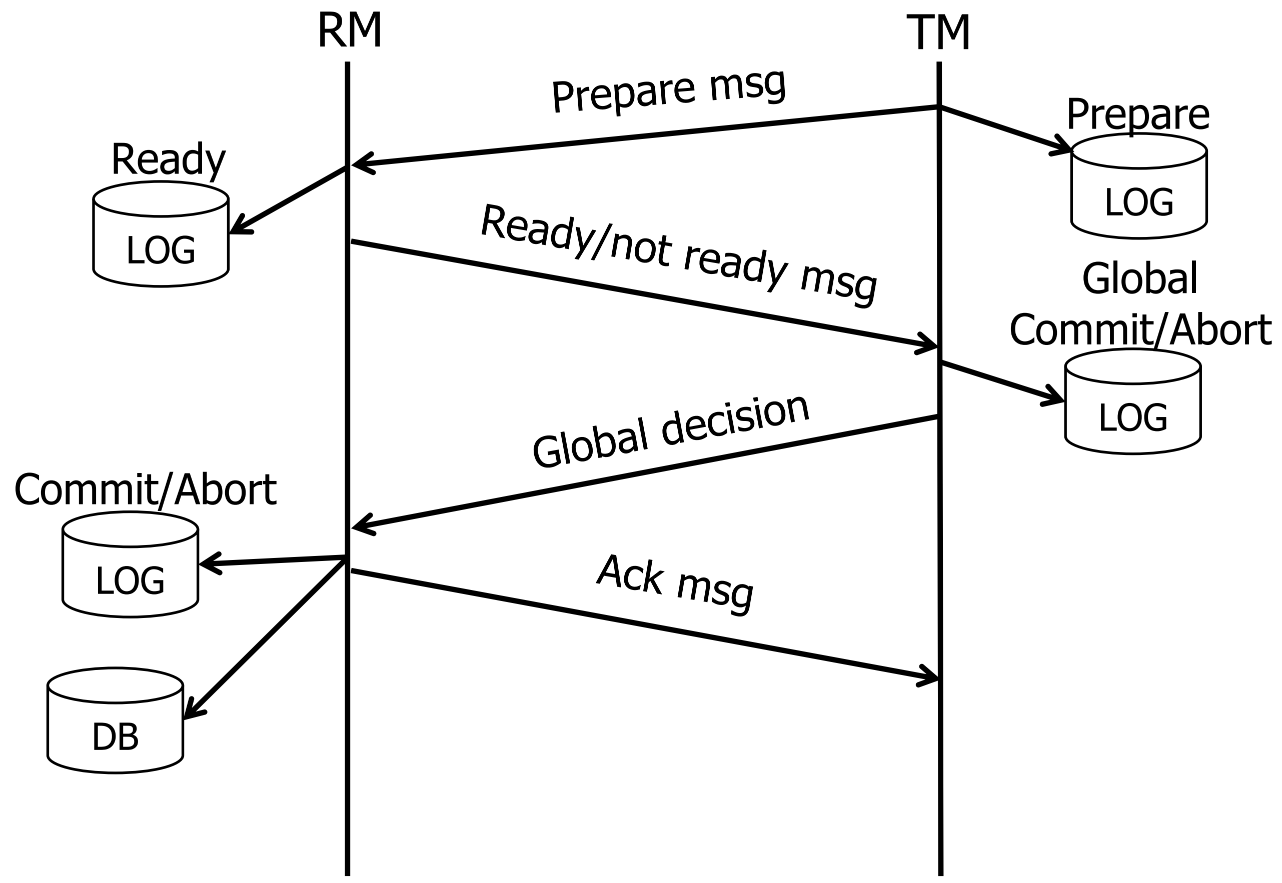
Phase I

3. The TM
   - Collects all incoming messages from the RMs
   - If it receives ready from *all* RMs
     - The commit global decision record is written in the log
   - If it receives one or more not ready or the timeout expires
     - The abort global decision record is written in the log

Phase II

1. The TM
   - Sends the global decision to the RMs
   - Sets a timeout for the RM answers

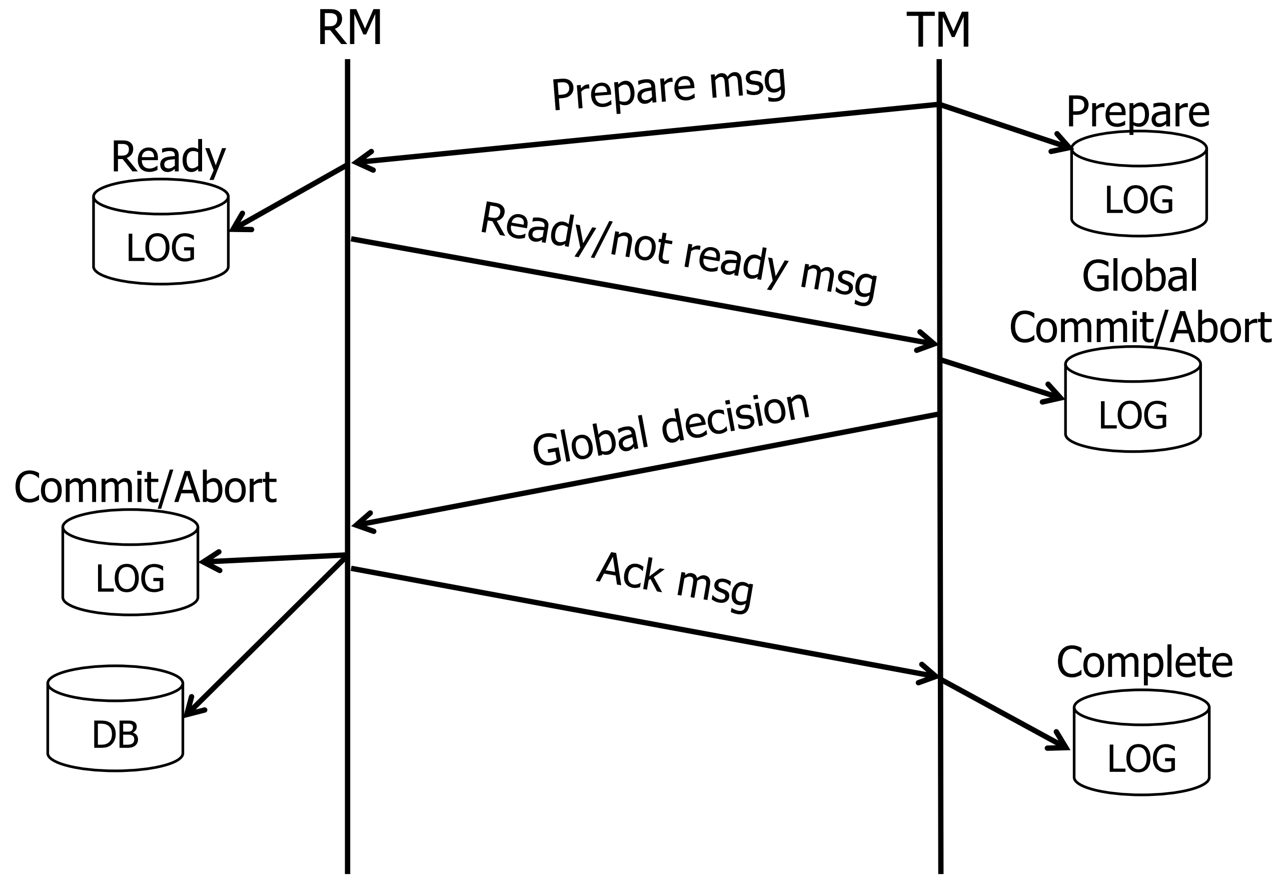
2 Phase Commit protocol



Phase II

2. The RM
   - Waits for the global decision
   - When it receives it
     - The commit/abort record is written in the log
     - The database is updated
     - An ACK message is sent to the TM

2 Phase Commit protocol

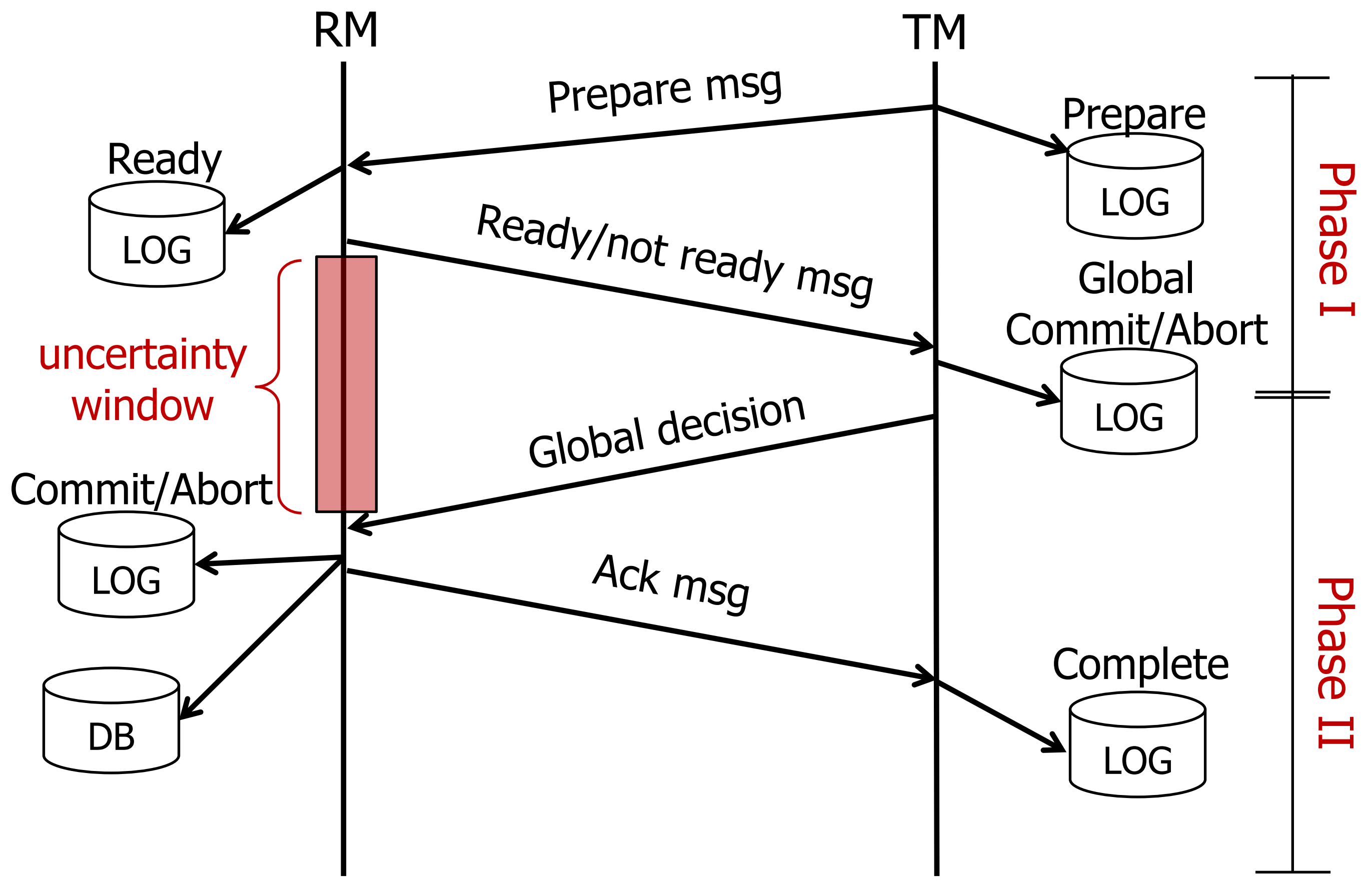


Phase II

3. The TM
   - Collects the ACK messages from the RMs
   - If *all* ACK messages are received
     - The complete record is written in the log
   - If the timeout expires and some ACK messages are missing
     - A new timeout is set
     - The global decision is resent to the RMs which did not answer

   until all answers are received

2 Phase Commit protocol



Uncertainty window

- Each RM is affected by an *uncertainty window*
  - Start after ready msg is sent
  - End upon receipt of global decision
- Local resources in the RM are locked during the uncertainty window
  - It should be small

Failure of a participant (RM)

- The warm restart procedure is modified with a new case
  - If the last record in the log for transaction T is "ready", then T does not know the global decision of its TM
- Recovery
  - READY list
    - new list collecting the IDs of all transactions in ready state
  - For all transactions in the ready list, the global decision is asked to the TM at restart
    - Remote recovery request

Failure of the coordinator (TM)

- Messages that can be lost
  - Prepare (outgoing)
  - Ready (incoming) } I Phase
  - Global decision (outgoing) } II Phase
- Recovery
  - If the last record in the TM log is prepare
    - The global abort decision is written in the log and sent to all participants
    - Alternative: redo phase I (not implemented)
  - If the last record in the TM log is the global decision
    - Repeat phase II

Network failures

- Any network problem in phase I causes global abort
  - The prepare or the ready msg are not received
- Any network problem in phase II causes the repetition of phase II
  - The global decision or the ACK are not received