Distributed Optimistic Algorithm

- Assumptions
  1. Synchronized clocks
  2. MTD (max, trans, delay) can be defined

- Step 1: Read

- Step 2: Compute

- Step 3: Transaction is broadcasted to all nodes at time \( \pi(V_i) \) (time when computation finishes and \( T_i \) is ready for validation)

- Step 4: At time \( \pi(V_i) + \text{MTD} \), all nodes start validation of \( T_i \). (Note \( \pi(V_i) \) is attached to \( T_i \)) and if \( T_i \) reaches before \( \pi(V_i) + \text{MTD} \), it must wait
Distributed Optimistic Algorithm

- **Step 5:**
  IF validation succeeds, all nodes write $S(w_i)$
  ELSE all nodes except “X” ignore $T_i$
  At node X, $T_i$ is restarted and repeated until $T_i$ validates

**THEOREM:**
The dist. opt. algorithm produces only correct histories at each node and all histories are identical.

**PROOF:**
ONLY correct histories are produced. Because of Theorem 1 ELSE UPDATE $S(R_i)$ and repeat from step 2
Centralized Optimistic Algorithm

A node(C) is chosen as central node

**CASE 1: Validation takes place only at central node**
*When Tᵢ arrives at a node “X”*

1. Read S(Rᵢ)
2. Execute (compute) and get S(wᵢ)
   Note S(wᵢ) is semantic write set (actual)
   Locking may require syntactic (potential) write set
   S'(wᵢ) ≤ S(wᵢ)

- Tᵢ goes to node C (if X ≠ C)
- If Tᵢ succeeds, send write set to all nodes
Centralized Optimistic Algorithm

CASE 2: Validation takes place at local node and then at central node

1. Same
2. Same
3. $T_i$ validates at $X$
4. IF successful, $T_i$ commits at $X$ and is sent to $C$
5. ELSE UPDATE $S(R_i)$ and repeat from step 2
6. If successful at $C$, send write set to all nodes
   ELSE UPDATE $S(R_i)$ at $C$ and execute at $C$ and repeat validation until successful.
Centralized Optimistic

CASE 1: Validation takes place only at central node only

CASE 2: Validation takes place at local node and then central node

Distributed Optimistic
   Validation takes place at all nodes after a delay of MTD (Max. transmission Delay)
When to synchronize (assert concurrency control)

- First access to an entity
  (locking, pessimistic validation)
- At each access
  (granularity level)
- After all accesses and before commitment
  (optimistic validation)
Information needed for synchronization

- Locks on database entities
  (system R, INGRES, Rosenkrantz,...)
- Time stamps on database entities
  (Thomas, Reed,...)
- Time stamps on transactions
  (Kung, SDD-1, Schlageter,...)

OBSERVATIONS

- Time stamps more fundamental than locking
- Time stamps carry more information
- Time stamp checking costs more than checking locks
Distributed DBMS

Optimistic CC.

\[
\begin{align*}
T_1 & \\
T_{11}: X & \leftarrow X + 1 \\
T_{12}: X & \leftarrow 2 \times X \\
T_2 & \\
T_{21}: X & \leftarrow X + 1 \\
\end{align*}
\]

History

Serial

\[
\begin{align*}
T_1 & T_2 \text{ or } T_2 T_1 \\
\downarrow & \\
f_{12}(f_{11}(f_{21}(x))) & \downarrow \\
f_{21}(f_{12}(f_{11}(x))) & \\
\end{align*}
\]

f: Herbrand fn.

non serializable

\[
\begin{align*}
T_{11}, T_{21}, T_{12} & \\
f_{12}(f_{21}(f_{11}(x))) & \\
\end{align*}
\]

So given interpretation of \(f_{ij}\)'s allows us to include histories which are not allowed by SERIALIZABILITY and hence allows us higher concurrency.
Figure 2
Locking Mechanism (Pessimistic)
Steps of a Transaction (Ti) Non-Locking Algorithm

1. The transaction (T_i) arrives in the system

2. The read S'(R_i) and write S'(W_i) set of the transaction is obtained. These sets are syntactic

3. The transaction goes to an I/O queue to obtain item values for read set S'(R_i)

4. The transaction goes to CPU queue and completes execution to obtain write set values. Also actual read set S(R_i) and write set S(wi) are determined. These sets represent semantic information

5. The transaction’s read sets are validated against other active transactions according consistency constraints (such as serializability)
Steps of a Transaction (Ti) ... (cont)

6. If validation fails due to conflict among transaction $T_i$ and some other transaction $T_j$, then one of the transaction is required to repeat its execution. For example, if consistency constraint is “strongly serializable”, then the transaction that arrived later (let us say $T_j$) is selected for re-execution. Moreover the conflict among $T_i$ and $T_j$ is resolved and the values of $S'(R_i)$ are updated with values from $S(W_j)$ at the time of validation. This is useful because $T_i$ does not have to go and do its I/O once again.

7. The transaction is sent to CPU queue to do its computation.

8. The transaction $T_i$’s write set is validated against write set of some transaction $T_j$ (that has not completed but arrived before $T_i$). If conflict occurs, then $T_i$ is delayed and writes after $T_j$ writes in the database.
Steps of a Transaction (Ti) ... (cont)

9. The transaction goes to an I/O queue and update its write set $S(W_i)$.

10. The transaction $T_i$ waits in memory for validation against transactions that arrived in the interval between its arrival time and validation time.
Performance Techniques

- Complexity
- Analytical
- Simulation
- Empirical
Parameters

1. Arrival rate
2. Base set (size of write set/read)
4. Size of database
5. Number of sets
6. Transmission delay
7. CPU time
8. I/O time
9. Retry delay
10. Read only trans/write & read trans ratio
11. Multiprogramming level
12. Degree of conflict