7. Distributed Database Systems

7.1 Introduction

What is DDB?

A DDB is a collection of correlated data which are spread across a network and managed by a software called DDBMS.

Two kinds:

(1) Distributed physically, centralized logically (general DDB)

(2) Distributed physically, distributed logically too (FDBS)

We take the first as main topic in this course.

Features of DDBS :

- Distribution
- Correlation
- DDBMS

The advantages of DDBS:

- Local autonomy
- Good availability (because support multi copies)
- Good flexibility
- Low system cost
- High efficiency (most access processed locally, less communication comparing to centralized database system)
- Parallel process

The disadvantages of DDBS:

- Hard to integrate existing databases
- Too complex (system itself and its using, maintenance, etc. such as DDB design)

The main problems in DDBS:

Compared to centralized DBMS, the differences of DDBS are as follows:

- Query Optimization (different optimizing goal)
- Concurrency control (should consider whole network)
- Recovery mechanism (all sub-transactions must commit or abort simultaneously)

Another problem specially for DDBS:

- Data distribution

7.2 Data Distribution

7.2.1 Strategies of Data Distribution

(1) Centralized: distributed system, but the data are still stored centralized. It is simplest, but there is not any advantage of DDB.

(2) Partitioned: data are distributed without repetition. (no copies)

(3) Replicated: a complete copy of DB at each site. Good for retrieval-intensive system.

(4) Hybrid (mix of the above): an arbitrary fraction of DB at various sites. The most flexible and complex distributing method.

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Comparison of four strategies

1 2 3 4

flexibility

complexity

Advantage of DDBS

Problems with DDBS

7.2.2 Unit of Data Distribution

(1) According to relation(or file), that means non partition

(2) According to fragments

- Horizontal fragmentation: tuple partition
- Vertical fragmentation: attribute partition
- Mixed fragmentation: both

The criteria of fragmentation:

(1) Completeness: every tuple or attribute must has its reflection in some fragments.

(2) Reconstruction: should be able to reconstruct the original global relation.

(3) Disjointness: for horizontal fragmentation.

7.2.3 Problems Caused by Data Distribution

1) Multi copies' consistency
2) Distribution consistency

Mainly the change of tuples' store location resulted by updating operation. Solution:

(1) Redistribution

After Update: Select->Move->Insert->Delete

(2) Piggybacking

Check tuple immediately while updating, if there is any inconsistency it is sent back along with ACK information and then sent to the right place.

3) Translation of Global Queries to Fragment Queries and Selection of Physical Copies.

4) Design of Database Fragments and Allocation of Fragments.

Above 1)~3) should be solved in DDBMS.

While 4) is a problem of distributed database design.

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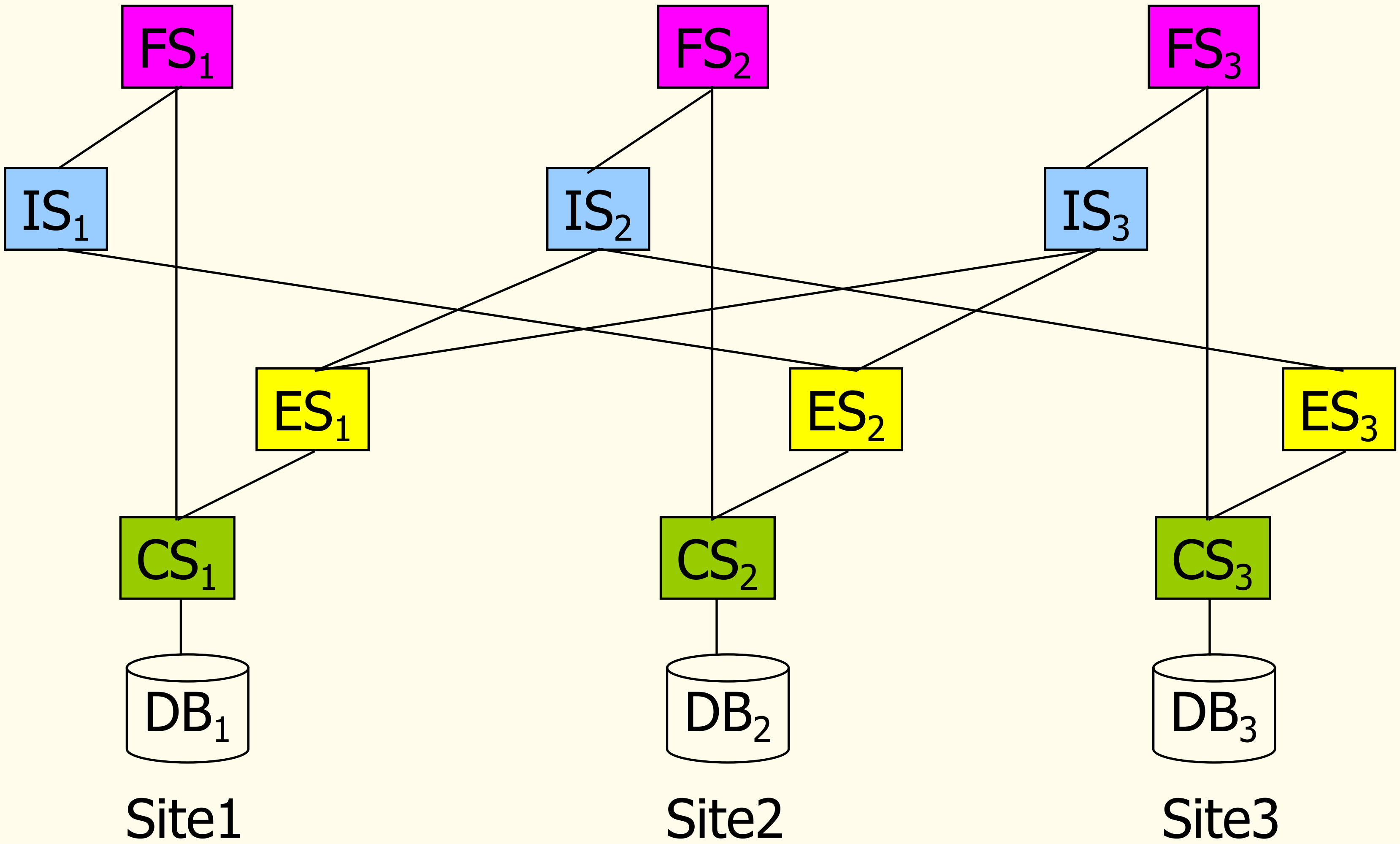
7.3 Federated Database

- In practical applications, there are strong requirements for solving the integration of multi existing, distributed and heterogeneous databases.
- The database system in which every member is autonomic and collaborate each other based on negotiation --- federated database system.
- No global schema in federated database system, every federated member keeps its own data schema.
- The members negotiate each other to decide respective input/output schema, then, the data sharing relations between each other are established.

The schema structure in federated database System



- $FS_i = CS_i + IS_i$
- FS_i is all of the data available for the users on $site_i$.
- IS_i is gained through the negotiation with ES_j of other sites ($j \neq i$).
- User's query on $FS_i \Rightarrow$ the sub-queries on CS_i and IS_i $\Rightarrow$ the sub-queries on corresponding ES_j.
- The results gained from $ES_j \Rightarrow$ the result forms of corresponding IS_i, and combined with the results get from the sub-queries on CS_i, then synthesized to the eventual result form of FS_i.

7.4 Query Optimization in DDBMS

- Optimization goal: minimize the transmission cost on network
- Algebra optimization
- Translation of global queries to fragment queries and selection of physical copies
- Query Decomposition
- Global query plan

An example of global query optimization

R1

Site1

R2

Site2

Select *
From R1,R2
Where R1.a = R2.b;

Global query optimization may get an execution plan based on cost estimation, such as:

(1) send R2 to site1, R'

(2) execute on site1:

Select *

From R1, R'

Where R1.a = R'.b;

7.5 Recovery Mechanism in DDBMS

- The basic principle is the same as that in centralized DBMS
- Distributed transactions : the key of distributed transaction management is how to assure all sub-transactions either commit together or abort together.
- Realize the sub-transactions' harmony with each other relies on communication, while the communication is not reliable.
- Two phase commitment protocol
- Combination of failures

7.6 Concurrency Control in DDBMS

- The basic principle is the same as that in centralized DBMS, demand concurrent transactions to be scheduled serializably
- Because of multi copies, need locking globally
- Communication overhead
- Global deadlock