

18.3 Describe the purpose of the main steps in the physical design methodology presented in this chapter.

Step 1 clear understanding of the database usage patterns

Step 2 Choosing the Database Management System (DBMS)

Step 3 Produces a relational database schema from the logical data model. This includes integrity rules.

Step 4 Determines the file organizations for the base relations. This takes account of the nature of the transactions to be carried out, which also determine where secondary indexes will be of use. As a result of analyzing the transactions, the design may be altered by incorporating controlled redundancy into it.

Step 5 Designs the user views for the database implementation.

Step 6 Designs the security measures for the database implementation.

18.4 a) Discuss when index may improve the efficiency of the system.

Frequent Search Queries

Queries Using WHERE Clauses

JOIN Operations

Sorting and Ordering (ORDER BY)

Range Queries

Unique Constraints

Aggregation Functions (GROUP BY, COUNT, etc.)

Partial Indexes (Conditional Indexing)

Multi-column Indexes (Composite Indexes)

Covering Indexes

b) Why do we need to analyze transactions at the physical database design level?

Analyzing transactions at the physical database design level is crucial for optimizing system performance, scalability, and efficiency. It helps identify frequently accessed data, guiding decisions on indexing, file organization, and controlled redundancy to improve query speed. By understanding the nature of reads, writes, and updates, designers can balance transaction load, reduce I/O bottlenecks, and optimize concurrency control. It also informs security measures, backup strategies, and capacity planning, ensuring the system meets real-world demands while maintaining high performance and minimizing storage overhead. Ultimately, this analysis leads to a well-tuned database that efficiently supports the expected workload.

19.2 a) Under what circumstances would you want to denormalize a logical data model? Use examples to illustrate your answer.

Example: In an e-commerce system, instead of maintaining separate Customers, Orders, and OrderDetails tables (3rd normal form), you could denormalize by embedding customer information (such as name and address) directly in the Orders table. This avoids the need to join tables when retrieving order information along with customer details, significantly speeding up query performance.

Examples:

If queries on staff always require the branch address, this attribute could be posted into staff. The effect on updating would be minimal if branch data was relatively static, and it removes a join from the query.

b) When should we consider denormalization?

Denormalization should be considered when performance optimization outweighs the need for strict normalization, particularly in read-heavy systems or scenarios involving complex joins, distributed databases, or frequent aggregations. It can improve query performance by reducing the need for costly joins, pre-aggregating data for faster reporting, or caching frequently accessed data. Denormalization is also useful in distributed systems to avoid cross-node joins, and in cases where real-time data access, such as in analytics or reporting systems, is critical. However, it comes with trade-offs like increased redundancy and potential update complexity, so it should be applied judiciously based on specific performance needs.

c) What are some of the disadvantages of denormalization?

The main disadvantages of denormalization are increased data redundancy and the potential for data inconsistencies, as the same data may be stored in multiple places. This redundancy leads to higher storage costs and makes data maintenance more complex, especially during updates, as changes need to be propagated across multiple tables or records. Denormalization can also slow down write operations because updating or inserting data involves updating redundant copies, which increases the risk of synchronization errors. Additionally, maintaining data integrity becomes more challenging, and the overall complexity of database management may increase.

d) 1) What is partitioning relations?

Partitioning relations refers to the process of dividing a large database table (or relation) into smaller, more manageable pieces, called partitions, based on certain criteria. This helps improve performance, scalability, and manageability by spreading the data across multiple storage units or disks. The main goal is to optimize query performance, especially for large datasets, and to manage data more efficiently.

2) When would you use it?

Partitioning relations is useful when managing large datasets, improving query performance, and ensuring scalability. It allows for efficient handling of data by dividing large tables into smaller, more manageable segments, making queries faster by scanning only relevant partitions. Partitioning also aids in parallel processing, load distribution, and balancing, particularly in distributed systems. It enhances data management by enabling easier archiving, backup, and data removal for older partitions without affecting active data. Additionally, partitioning can help with minimizing locking and contention, improving availability, and complying with regulatory requirements, making it ideal for high-performance systems, data warehouses, and applications with large, complex datasets.