Physical Database Design and Tuning

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Physical Database Design

- It is the process of transforming a logical data model into a physical model of a database.
- Unlike a logical design, a physical database design is optimized for data-access paths, performance requirements and other constraints of the target environment, i.e. hardware and software.

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Physical Database Design

- Before you can begin the physical design, you must have:
  - (1) logical database design
    - minimally third normal form
  - (2) Transaction characterization, such as
    - most frequent transactions
    - most complex or resource-insensitive transactions
    - distributions of transactions, over time
    - mix of insert, update, delete and select statements
    - most critical transactions to the applications

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Physical Database Design

- (3) Performance requirements

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Physical dB design activities

- 1. Defining Tables and Columns –
  - The initial transformation of the logical model into a physical model, including naming objects, choosing data types and lengths, and handling null values.
- 2. Defining Keys –
  - Choosing primary and foreign keys, including the use of surrogate keys.

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Physical dB design activities

- 3. Identifying Critical Transactions –
  - Identifying business transactions that are high-value, mission-critical, frequently performed, or costly in terms of computing resources.
- 4. Adding Redundant Columns –
  - The first of a series of denormalization techniques: adding columns to tables that exist in other tables.

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Physical dB design activities

- 5. Adding Derived Columns –
  - Adding a column to a table based on the values or existence of values in other columns in any table.
- 6. Collapsing Tables –
  - Combining two or more tables into one table.
- 7. Splitting Tables –
  - Partitioning a table into two or more disjoint tables. Partitioning may be horizontal (row-wise) or vertical (column-wise)

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Physical dB design activities

- 8. Handling Supertypes and Subtypes
  - Deciding how to implement tables that are involved in a supertype-subtype relationship in the logical model.
- 9. Duplicating Parts of Tables –
  - Duplicating data vertically and / or horizontally into new tables.
- 10. Adding Tables for Derived Data –
  - Creating new tables that hold data derived in columns from other tables

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Physical dB design activities

- 11. Handling Vector Data –
  - Deciding how to implement tables that contain plural attributes or vector data. Row-wise and column-wise implementations are discussed.
- 12. Generating Sequence Numbers –
  - Choosing a strategy to generate sequence numbers, and the appropriate tables and columns to support the strategy.

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Physical dB design activities

- 13. Specifying Indexes –
  - Specifying indexes to improve data access performance or to enforce uniqueness.
- 14. Maintaining Row Uniqueness –
  - Maintaining the uniqueness or primarykey values.
- 15. Handling Domain Restriction –
  - Defining SQL Server rules and defaults on the columns of a table to maintain valid data values in columns.

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Physical dB design activities

- 16. Handling Referential Integrity –
  - Deciding how to handle primary-key updates and deletes, and foreign-key inserts and updates. Using triggers to ensure referential integrity.
- 17. Maintaining Derived and Redundant Data –
  - Specifying how data integrity will be maintained if the data model contains derived or redundant data.

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Physical dB design activities

- 18. Handling Complex Integrity Constraints –
  - Deciding how to handle complex business rules such as sequence rules, cross-domain business rules, and complex data domain rules. Using triggers to implement complex business rules.
- 19. Controlling Access to Data –
  - Restricting access to commands and data.

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Physical dB design activities

- 20. Managing Object Sizes –
  - Calculating the estimated size of a database and its objects.
- 21. Recommending Object Placement
  - Allocating databases and their objects on available hardware to achieve optimal performance.

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Physical dB design goals

- improve system performance
  - reduce disk I/O
  - reduce joins
- embed business rules into the database design
  - through defaults, rules, constraints, stored procedures, or triggers
- make it understandable to users
  - use meaningful and indicative names for tables and columns

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Defining Keys

- If there are more than one candidate key in a table, select the primary key as below:
  - select the key which transactions will know about most often. This will avoid additional lookups.
  - select the shortest length key when used in indexes
  - consider what other keys are available in other tables on which to join.

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Identify Critical Transactions

- To understand the transactions and performance requirements, you need to know:
  - types of transactions (select, insert, update, delete)
  - tables and column affected by each transaction
  - select criteria – fixed or variable (i.e. pre-defined queries or ad-hoc queries)
  - frequency and volume of each transaction

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Identify Critical Transactions

- how many rows (percentage) are typically affected (select or modified)
- size (no. of rows and total bytes) of tables involved
- when the transaction is executed
  - during the day or after office hours
- relative importance of each transaction
  - who use it, how often, how critical is it to the business process
- response time or throughput desired

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Identify Critical Transactions

- security and integrity
- how many tables will be joined
- sort order

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Adding Redundant Columns

- required when an unaccepted number of joins is needed to perform a critical transaction.
- add redundant columns in order to reduce the no. of joins. –
  - It is a de-normalization process. Tables will not be in 3NF.
- The concept of strong FD, weak FD, relax-replicated 3NF relation can be used as the theory for this process.

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Adding Redundant Columns

- Benefits:
  - better response time
  - The chance to eliminate a foreign key –
  - The reduction of lock contention;
    - this cut down blocking or deadlock situations.

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Adding Derived Columns

- Derived data may include:
  - column data aggregated with SQL aggregate function such as sum(), avg(), over N detail rows
  - column data which is calculated using formulas over N rows.
  - counts of details rows matching specific criteria
- **Example**: Total-sales in Titles table Titles (title-id, title, type, pub-id, price, **Total_sales**, pubdate, pubname)

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Collapsing Tables

- Required when the application program must frequently access data in multiple tables in a single query.
  - **e.g.** Combining the publishers and Titles tables will improve the performance of the critical query
- de-normalization
- similar to adding redundant columns
- in order to get better performance

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Splitting tables

- Required when it is more advantageous to access a subset of data.
- **Vertical table splits**:
  - e.g. Emp (Eno, name, salary, tax, mgr#, dept#) can be split to 2 tables: Emp_bio (Eno, name, mgr#, dept#) Emp_comp (Eno, salary, tax)
  - The rows are smaller. This allows more rows to be stored on each data page, therefore no. of I/Os is reduced.

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Splitting tables

- Horizontal table splits
  - **e.g.** You can form horizontal fragments of the Supplier table.
- Benefits of splitting:
  - reduces the no. of index pages read in a query
  - The table split corresponds to an actual physical separation of the data rows, as in different geographical sites.
  - Table splitting achieves specific distribution of data on the available physical media

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Adding Tables for Derived Data

- Many applications or reports call for data summaries, often at more than one level of grouping for the same source data.
- generating summaries with large tables, may become a performance bottleneck.
- **Example** Summary table
  - Titles (title-id, title, type, pub-id, price, pubdate) Summary-table (type, total-sales)

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Specifying Indexes

- Indexes can be used to improve data access performance
- Indexes may be clustered or non clustered, unique or non unique, or concatenated.
- A table's indexes must be maintained with every insert, update, and delete operation performed on the table.
- Be careful not to over index.

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Specifying Indexes

- Incorrect index selection can adversely affect the performance.
- The greatest problem will be deriving the best set of indexes for the database when conflicting applications exist (i.e. applications whose access needs and priorities are in conflict).

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Specifying Indexes

- Tables that should be considered as candidates for indexes are:
  - tables that are used in critical transactions and that have a set of search criteria (or limit ranges)
  - tables involved in multi-table joins
  - tables with a large no. of rows
  - tables that require enforcement of uniqueness

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Specifying Indexes

- Identifying Columns for Indexes
  - columns used to specify range in the *where* clause (clustered index)
  - columns used to join one or more tables, usually primary and foreign keys
  - columns likely to be used as search arguments
  - columns used to match an equi-join query
  - columns used in aggregate functions
  - columns used in a *group by* clause
  - columns used in an *order by* clause

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Database tuning

- Database tuning is comprised of a group of activities used to optimize and regulate the performance of a database.
- It refers to configuration of the database files, the database management system (DBMS), as well as the hardware and operating system on which the database is hosted.

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Database tuning

- The goal of database tuning is to maximize the application of system resources in an attempt to execute transactions as efficiently and quickly as possible.
- The large majority of DBMS are designed with efficiency in mind; however, it is possible to enhance a database's performance via custom settings and configurations.

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Database tuning

- The tuning of a database management system centers around the configuration of memory and the processing resources of the computer running the DBMS.
  - This can involve setting the recovery interval of the DMBS, establishing the level of concurrency control, and assigning which network protocols are used to communicate throughout the database.

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Database tuning

- Database performance can also be improved by using the cache to store execution procedures as they would not need to be recompiled with every transaction.
- By assigning processing resources to specific functions and activities, it is also possible to improve the concurrency of the system.

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Database tuning

- "Database concurrency controls ensure that transactions occur in an ordered fashion.
  - The main job of these controls is to protect transactions issued by different users/applications from the effects of each other.
  - They must preserve the four characteristics of database transactions: atomicity, isolation, consistency and durability"

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Database tuning

- Input/Output(I/O) tuning is another major component of database tuning.
  - I/O tuning mainly deals with database transaction logs.
  - Database transaction logs are files that are associated with temporary work spaces as well as both table and index file storage.
  - Transaction logs and temporary spaces are heavy consumers of I/O, and affect performance for all users of the database.

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Database tuning

- Placing them appropriately is crucial.
- The main goal of I/O tuning a database is to optimize and balance the read and write transactions of the system in order to achieve an increased speed in database transactions and a decreased database access time.

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Database tuning

- Another method of ensuring that a database is fast and reliable is the Use of RAID in the creation of the database.
- RAID stands for Redundant Array of Independent Disks.
- Here is an example as to why RAID is superior to a single disk.

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Database tuning

- If data are stored on one disk, the entire database is completely reliant on that one disk; if it were to fail, the database would not exist anymore.
- Another drawback to having it on a single disk is the read/write time.
- One hard disk can only be so fast. If there is a lot of I/O data being processed, it can be a lengthy process. One thing that RAID does is it divides and replicates the data onto several independent disks.

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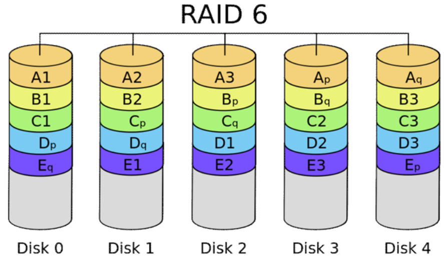
Database tuning

RAID 6



This shows the data layout for a RAID-6 array.

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Database tuning

- Another common part of database tuning revolves around maintenance.
  - Database maintenance includes things such as backing up the database as well as the defragmentation of the data residing within the database.
  - When a database is under heavy use, transaction log entries must be removed in order to create space for future entries.

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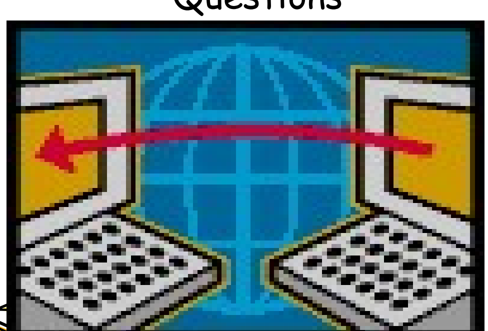
Questions



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