



# Performance Tuning

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## Chapter 20



# Overview

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- After ER design, schema refinement, and the definition of views, we have the *conceptual* and *external* schemas for our database.
- The next step is to choose indexes, make clustering decisions, and to refine the conceptual and external schemas (if necessary) to meet performance goals.
- We must begin by understanding the workload:
  - The most important queries and how often they arise.
  - The most important updates and how often they arise.
  - The desired performance for these queries and updates.



# Decisions to Make

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- What indexes should we create?
  - Which relations should have indexes? What field(s) should be the search key? Should we build several indexes?
- For each index, what kind of an index should it be?
  - Clustered? Hash/tree?
- Should we make changes to the conceptual schema?
  - Consider alternative normalized schemas? (Remember, there are many choices in decomposing into BCNF, etc.)
  - Should we ``undo'' some decomposition steps and settle for a lower normal form? (*Denormalization.*)
  - Horizontal partitioning, replication, views ...



# Tuning the Conceptual Schema

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- The choice of conceptual schema should be guided by the workload, in addition to redundancy issues:
  - We may settle for a 3NF schema rather than BCNF.
  - Workload may influence the choice we make in decomposing a relation into 3NF or BCNF.
  - We may further decompose a BCNF schema!
  - We might *denormalize* (i.e., undo a decomposition step), or we might add fields to a relation.
  - We might consider *vertical decompositions*.
  - We might consider *horizontal decompositions*.
- If such changes are made after a database is in use, called *schema evolution*; might want to mask some of these changes from applications by defining *views*.

# Example Schemas

Contracts (Cid, Sid, Jid, Did, Pid, Qty, Val)  
Depts (Did, Budget, Report)  
Suppliers (Sid, Address)  
Parts (Pid, Cost)  
Projects (Jid, Mgr)

- We will concentrate on **Contracts**, denoted as **CSJDPQV**. The following ICs are given to hold:  
 $JP \rightarrow C$ ,  $SD \rightarrow P$ ,  $C$  is the **primary key**.
  - What are the candidate keys for CSJDPQV?
  - What normal form is this relation schema in?



# Settling for 3NF vs BCNF

- CSJDPQV can be decomposed into SDP and CSJDQV, and both relations are in BCNF. (Which FD suggests that we do this?)
  - Lossless decomposition, but not dependency-preserving.
  - Adding CJP makes it dependency-preserving as well.
- Suppose that this query is very important:
  - *Find the number of copies Q of part P ordered in contract C.*
  - Requires a join on the decomposed schema, but can be answered by a scan of the original relation CSJDPQV.
  - Could lead us to settle for the 3NF schema CSJDPQV.



# Denormalization

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- Suppose that the following query is important:
  - *Is the value of a contract less than the budget of the department?*
- To speed up this query, we might add a field *budget* B to Contracts.
  - This introduces the FD  $D \rightarrow B$  wrt Contracts.
  - Thus, Contracts is no longer in 3NF.
- We might choose to modify Contracts thus if the query is sufficiently important, and we cannot obtain adequate performance otherwise (i.e., by adding indexes or by choosing an alternative 3NF schema.)



# Decomposition of a BCNF Relation

- Suppose that we choose { *SDP*, *CSJDQV* }. This is in BCNF, and there is no reason to decompose further (assuming that all known ICs are FDs).
- However, suppose that these queries are important:
  - *Find the contracts held by supplier S.*
  - *Find the contracts that department D is involved in.*
- Decomposing *CSJDQV* further into *CS*, *CD* and *CJQV* could speed up these queries. (Why?)
- On the other hand, the following query is slower:
  - *Find the total value of all contracts held by supplier S.*



# Horizontal Decompositions

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- Our definition of decomposition: Relation is replaced by a collection of relations that are *projections*. Most important case.
- Sometimes, might want to replace relation by a collection of relations that are *selections*.
  - Each new relation has same schema as the original, but a subset of the rows.
  - Collectively, new relations contain all rows of the original. Typically, the new relations are disjoint.



## Horizontal Decompositions (Contd.)

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- Suppose that contracts with value  $> 10000$  are subject to different rules. This means that queries on Contracts will often contain the condition *val*  $> 10000$ .
- One way to deal with this is to build a clustered B+ tree index on the *val* field of Contracts.
- A second approach is to replace contracts by two new relations: LargeContracts and SmallContracts, with the same attributes (CSJDPQV).
  - Performs like index on such queries, but no index overhead.
  - Can build clustered indexes on other attributes, in addition!



# Masking Conceptual Schema Changes

```
CREATE VIEW Contracts(cid, sid, jid, did, pid, qty, val)
  AS SELECT *
  FROM LargeContracts
  UNION
  SELECT *
  FROM SmallContracts
```

- The replacement of Contracts by LargeContracts and SmallContracts can be masked by the view.
- However, queries with the condition *val* > 10000 must be asked wrt LargeContracts for efficient execution: so users concerned with performance have to be aware of the change.



# Tuning Queries and Views

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- If a query runs slower than expected, check if an index needs to be re-built, or if statistics are too old.
- Sometimes, the DBMS may not be executing the plan you had in mind. Common areas of weakness:
  - Selections involving **null values**.
  - Selections involving **arithmetic or string expressions**.
  - Selections involving **OR** conditions.
  - **Lack of evaluation features** like index-only strategies or certain join methods or poor size estimation.
- Check the plan that is being used! Then adjust the choice of indexes or **rewrite the query/view**.

# Rewriting SQL Queries

- *Use only one “query block”, if possible.*

<pre>SELECT DISTINCT *   FROM Sailors S WHERE S.sname IN       (SELECT Y.sname        FROM YoungSailors Y)</pre>	<b>=</b>	<pre>SELECT DISTINCT S.*   FROM Sailors S,         YoungSailors Y WHERE S.sname = Y.sname</pre>
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❖ *Not always possible ...*

<pre>SELECT *   FROM Sailors S WHERE S.sname IN       (SELECT DISTINCT Y.sname        FROM YoungSailors Y)</pre>	<b>≠</b>	<pre>SELECT S.*   FROM Sailors S,         YoungSailors Y WHERE S.sname = Y.sname</pre>
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# Summary

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- Database design consists of several tasks: *requirements analysis, conceptual design, schema refinement, physical design* and *tuning*.
  - In general, have to go back and forth between these tasks to refine a database design, and decisions in one task can influence the choices in another task.
- Understanding the nature of the *workload* for the application, and the performance goals, is essential to developing a good design.
  - What are the important queries and updates? What attributes/relations are involved?



# Summary

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- The conceptual schema should be refined by considering performance criteria and workload:
  - May choose 3NF or lower normal form over BCNF.
  - May choose among alternative decompositions into BCNF (or 3NF) based upon the workload.
  - May *denormalize*, or undo some decompositions.
  - May decompose a BCNF relation further!
  - May choose a *horizontal decomposition* of a relation.
  - Importance of dependency-preservation based upon the dependency to be preserved, and the cost of the IC check. (Needs additional tables, and non-BCNF).



# Summary (Contd.)

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- Over time, indexes have to be fine-tuned (dropped, created, re-built, ...) for performance.
  - Should determine the plan used by the system, and adjust the choice of indexes appropriately.
- System may still not find a good plan:
  - Null values, arithmetic conditions, string expressions, the use of ORs, etc. can confuse an optimizer.
- So, may have to rewrite the query/view:
  - Avoid nested queries, temporary relations, complex conditions, and operations like DISTINCT and GROUP BY.