

# Physical Database Design

## (ch. 16 & ch. 3)

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## Introduction

- The purpose of physical database design is to translate the logical description of data into the technical specifications for storing and retrieving data.
- The goal is to create a design for storing data that will provide adequate performance and insure database integrity, security and recoverability.

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## Inputs to Physical Design

- Normalized relations.
- Volume estimates.
- Attribute definitions.
- Data usage: entered, retrieved, deleted, updated.
- Response time requirements.
- Requirements for security, backup, recovery, retention, integrity.
- DBMS characteristics.

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## Physical Design Decisions

- Specifying attribute data types.
- Modifying the logical design.
- Specifying the file organization.
- Choosing indexes.

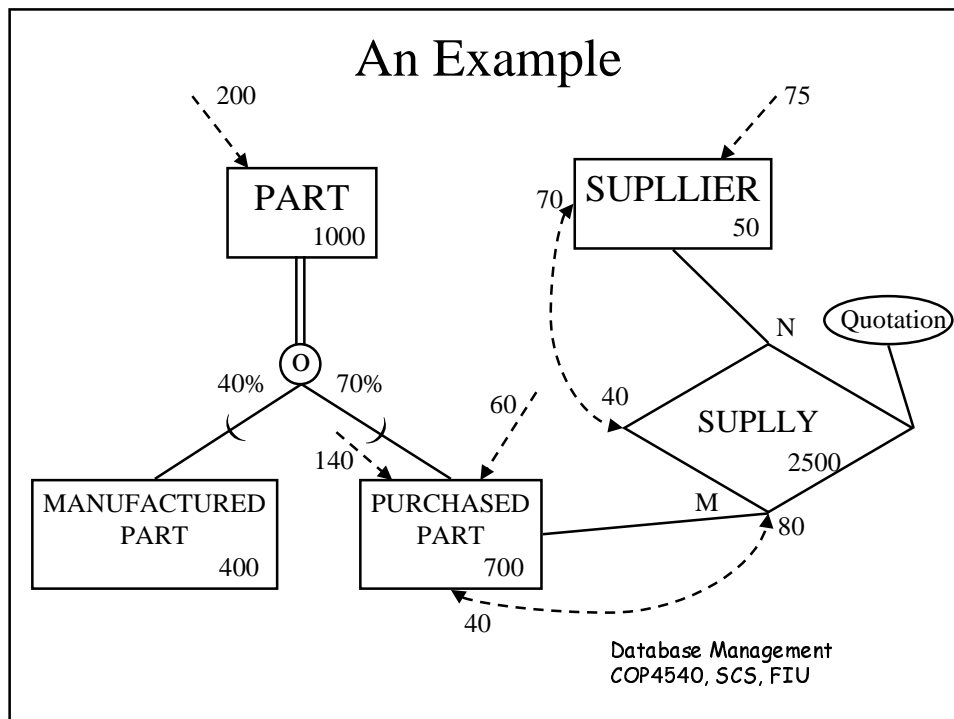
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## Data Volumes and Query Frequencies

- Data volumes: estimation of number of data records in each entity
- Query frequencies: estimation of number of queries per hour towards each entity

**These two types of information are useful for determining the storage requirements and performance requirements, which are needed to make physical design decisions.**

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## Designing Fields

- Choosing data type -- Char(8), Date, etc.
- Coding, compression, encryption.
- Controlling data integrity.
  - Default value.
  - Range control.
  - Null value control.
  - Referential integrity.

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## An example of code look-up table

PRODUCT File

Product_No	Description	Finish	...
B100	Chair	C	
B120	Desk	A	
M128	Table	C	
T100	Bookcase	B	
...	...	...	

FINISH Look-up Table

Code	Value
A	Birch
B	Maple
C	Oak

Coding is a way to achieve compression

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## Designing Fields

- Handling missing data.
  - Substitute an estimate of the missing value.
  - Trigger a report listing missing values.
  - In programs, ignore missing data unless the value is significant.

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## Physical Records

- Physical Record: A group of fields stored in adjacent memory locations and retrieved together as a unit.
- Page: The amount of data read or written in one I/O operation. A page contains usually a number of physical records.
- Blocking Factor: The number of physical records per page.

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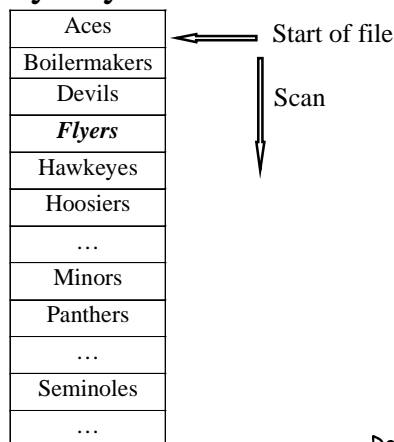
## Designing Physical Files

- Physical File: A file as stored on the disk.
- Constructs to link two pieces of data:
  - Sequential storage.
  - Pointers.
- File Organization: How the files are arranged on the disk.
- Access Method: How the data can be retrieved based on the file organization.

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## Sequential File Organization

- Records of the file are stored in sequence by the primary key field values.



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## Indexed File Organizations

- Index: an auxiliary file to improve access efficiency of the main data file.
- B-tree or B<sup>+</sup>-tree index.
- Bitmap index
  - Ideal for attributes that have even a few possible values
  - Often requires less storage space
  - Can be used for multiple keys

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## Bitmap Index on Product Price attribute

	<u>Product Table Row Number</u>									
Price	1	2	3	4	5	6	7	8	9	10
100	0	0	1	0	1	0	0	0	0	0
200	1	0	0	0	0	0	0	0	0	0
300	0	1	0	0	0	0	1	0	0	1
400	0	0	0	1	0	1	0	1	1	0

Product 3 and 5 have Price \$100

Product 1 has Price \$200

Product 2, 7, and 10 have Price 300

Product 4, 6, 8, and 9 have Price \$400

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## Hashed File Organization

- Hashing Algorithm: Converts a primary key value into a record address.
- Division-remainder method:
  - Given 1000 pages to store employee records
  - Choose the prime number closest to 1000, i.e., 997
  - The bucket number of each record is equal to the remainder of employee ID divided by 997
  - Finding the location of any employee record needs only a computation.

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## Comparison of File Organizations

- Sequential:
  - No waste space
  - Fast sequential retrieval
  - no random retrieval
  - update requires reorganization and slow

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## Comparison of File Organizations

- Indexed
  - require additional space for index
  - support random retrieval
  - deletion, addition, and update of records require modification of indexes

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## Comparison of File Organizations

- Hashed
  - May require overflow pages
  - sequential retrieval is impractical
  - random retrieval on primary key is very fast since it does not need to access index
  - deletion, addition, and modification of records are relatively easy

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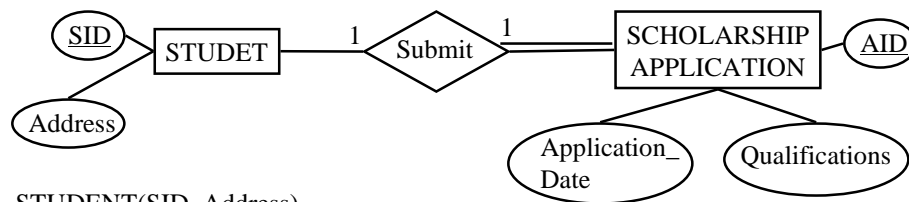
## Denormalization

- The reversal of normalization in order to increase query processing efficiency.
- During physical database design, denormalization is done if performance consideration dominates the issue of operational anomalies.

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### An example

- Two entities with a one-to-one relationship



STUDENT(SID, Address)

APPLICATION(AID, Application\_date, Qualification, *SID*)

Denormalized relation: STUDENT(SID, Address, AID, Application\_Date, Qualification)

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## Partitioning

- Horizontal Partitioning: Distributing the rows of a table into several separate files.
- Vertical Partitioning: Distributing the columns of a table into several separate files.
  - The primary key must be repeated in each file.

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## Partitioning

- Advantages of Partitioning:
  - Records used together are grouped together.
  - Each partition can be optimized for performance.
  - Security, recovery.
  - Partitions stored on different disks.
  - Take advantage of parallel processing capability.
- Disadvantages of Partitioning:
  - Slow retrievals across partitions.
  - Complexity.

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