

# Chapter 12

## Databases

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## Data

- What are data?
  - A datum is a single piece of information
  - A datum represents an attribute of an object
    - a numeric value for a measurement against a specific scale
    - a phone number
    - a seat on an airplane
    - an image of a cat
    - a mark in a course
  - Multiple datum collected together make up data.
- Why do we collect data?
  - So we can extract information *from/about* the data

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# Data

How do people keep track of data?

- Card indexes (Rolodex): old school but it works!
- Excel spreadsheets

Or

- In applications which were designed to store information in a format which facilitates asking questions about the data
  - These are called **database management systems**

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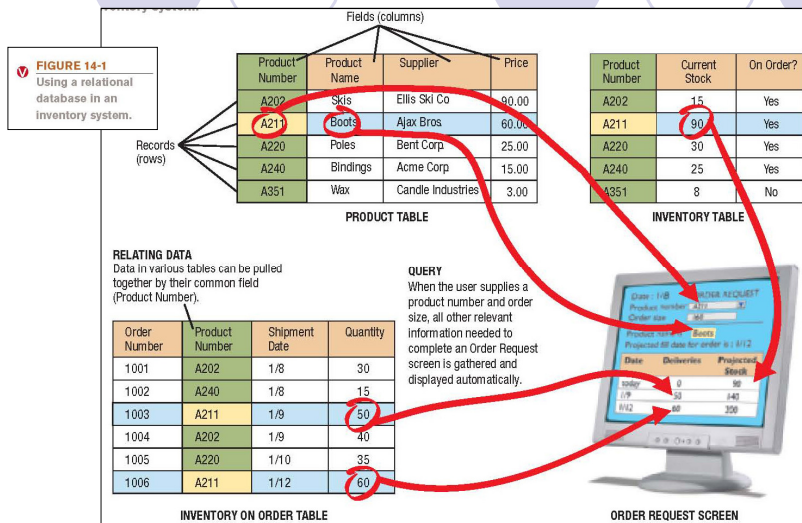
# What Is a Database?

- Database: A collection of related data stored in a manner so it can be retrieved as needed
- Database management system (DBMS): Software used to create, maintain, protect, and access databases
- A database typically consists of:
  - Tables: Collection of related records
  - Records (rows): Collection of related fields in a database (all the fields for one customer, for example)
  - Fields (columns): Single category of data to be stored in a database (name, telephone number, etc.)
- Relational database: Data from **several** tables tied together (related) using field(s) that the tables have in common

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# A Simple Relational Database Example

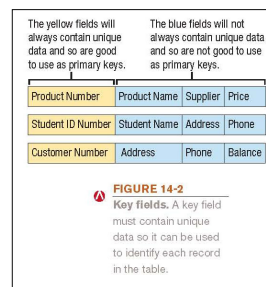


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## What Is a Database?

- Primary key: Specific field(s) that uniquely identifies a record in a database table
  - Used in a relational database to relate tables together
  - Must be unique and the field(s) cannot change
- PC DBMSs include:
  - Microsoft Access, Corel Paradox, Lotus Approach, MySQL
- Comprehensive enterprise DBMSs
  - Oracle Database, IBM DB2, Microsoft SQL Server



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# What Is a Database?

- Individuals involved with a DBMS:
  - Database Designers
    - Design the database
  - Database Developers
    - Create the database
  - Database Programmers
    - Write the programs needed to access the database or tie the database to other programs
  - Database Administrators
    - Responsible for managing the databases within an organization
  - Users
    - Individuals who enter data, update data, and retrieve information out of the database

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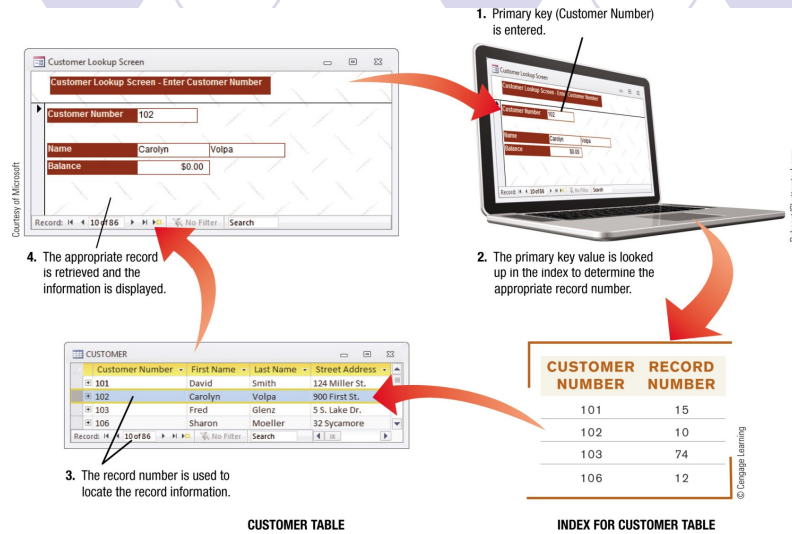
# Data Concepts and Characteristics

- Entity: Something of importance to the organization
  - E.g. customers, students, books, cars, etc.
  - Entities can be thought of as *nouns*
  - Entities typically becomes a table in a database
  - Attributes: Characteristics of an entity
    - Typically become fields in the entity's database table
- Indexes
  - Indexes are high performance structures which relate the value of a datum to the record that contains it.
  - The index structure can be searched significantly faster than the entity/table. This leads to significant performance improvement.
  - Any field upon which searches will be performed should be indexed

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# Data Concepts and Characteristics



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# Data Concepts and Characteristics

- Physical Data Hierarchy (storage)
  - Bit: single location of memory (1 or 0)
  - Byte: group of 8 bits
  - Word: Initially 2 bytes (16 bits) but now 8 bytes (64 bits)
- Logical Data hierarchy (meaning)
  - Characters
  - Fields/columns: Hold single pieces of data
  - Records/rows: Groups of related fields
  - Tables: Collection of related records
  - Database: Contains a group of related tables

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## Data Concepts and Characteristics

- Data Definition: The process of describing the properties of data to be included in a database table
  - During data definition, each field is assigned:
    - Name (must be unique within the table)
    - Data type (such as Text, Boolean, Number, Currency, Date/Time, etc.)
    - Description (optional description of the field)
    - Properties (field size, format of the field, allowable range, if field is required, etc.)
    - Indexed? Primary/unique?
- Finished specifications for a table become the table structure

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## Data Concepts and Characteristics

- Data Dictionary:
  - A set tables that contains the information describing the contents, format, and structure of a database and the relationship between its elements
  - Used to control access to and manipulation of the database.
  - Much of it created automatically by the DBMS
  - Table structures
    - Names, types and properties of each field, indexes
  - Security information (passwords, etc.)
  - Current information about each table, such as number of records
  - Does not contain any of the data in the tables
    - Metadata: Data about the database tables
  - Ensures that data being entered into the database does not violate some specified criteria
  - Helps to provide data integrity, data security, and data privacy

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# Data Concepts and Characteristics

- Data Integrity
  - A measure of the accuracy of data
  - Quality of data input determines the quality of retrieved information
  - 1) Data Validation
    - Process of ensuring that data entered into the database is valid
    - Record validation rules: Checks all fields before changes to a record are saved
    - Referential Integrity: e.g., you cannot assign a student to a non-existing course or look up a student without a student number
  - 2) Database Locking
    - Prevents two individuals from changing the same data at the same time
    - Important for concurrency control (addresses conflicts with the simultaneous accessing (and/or altering) of data that can occur in a multi-user system)

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# Data Concepts and Characteristics

- Data Security
  - Protecting data against destruction and misuse
  - Protects against unauthorized access
  - Database activity monitoring programs can be used to detect possible intrusions
  - Should include strict backup and disaster-recovery procedures (disaster-recovery plan)
    - Protects against data loss
- Data Availability
  - Protect against downtime when mission critical, including life-and-limb data, is not accessible.
  - Live, hot-standby, alternate database replicas

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## Data Concepts and Characteristics

- Data Privacy
  - Growing concern because of the vast amounts of personal data stored in databases today
  - Many states require businesses to notify customers when their personal data has been compromised
  - Data breaches can be costly
- Data organization: arranging data for efficient retrieval
  - Indexed organization: uses an index to keep track of where data is stored
  - Direct organization:
    - Uses hashing algorithms to specify the exact storage location
    - Location is based on primary key
  - Sometimes a combination of indexing and direct organization is used within a database system

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## Database Classifications

- Single-User vs. Multiuser Database Systems
  - Single-User Database System
    - Located on a single computer
    - Designed to be accessed by one user
    - Widely used for personal applications and very small businesses
  - Multiuser Database System
    - Designed to be accessed by multiple users (most business databases today)

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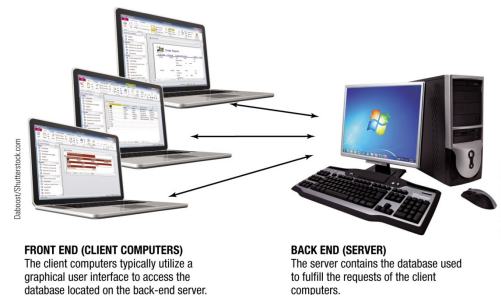


# Database Classifications

- Client-Server and N-Tier Database Systems

- Client-Server Database Systems

- Has both clients (front end) and at least one database server (back end)



**FIGURE 14-9**  
Client-server database systems.

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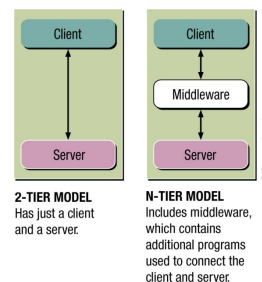
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# Database Classifications

- N-Tier Database System

- Has more than two tiers
  - Middleware contain one or more programs stored on one or more computers
    - Responsible for translating between the various types of clients and the database
    - Offloads the work from the database server
    - Provides scalability as number of clients increase
    - Provides flexibility for the numerous hardware and software options
  - Increasing in importance

**FIGURE 14-10**  
A 2-tier vs. an n-tier database model.



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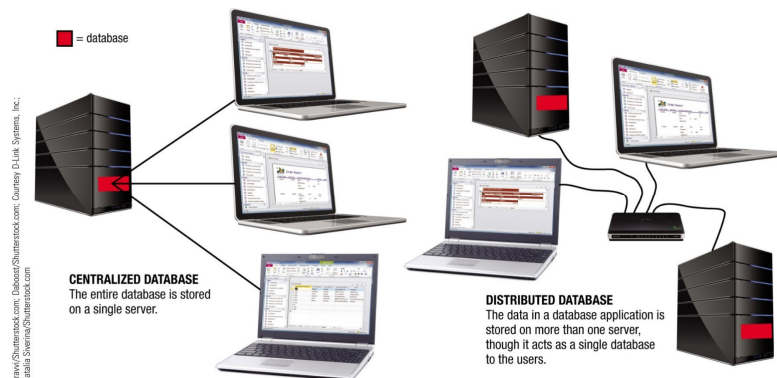
# Database Classifications

- Centralized vs. Distributed Database Systems
  - Centralized Database System
    - Database is located on a single computer, such as a server or mainframe
  - Distributed Database System
    - Data is physically divided among several computers connected by a network, but the database logically looks like it is a single database

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# Database Classifications



**FIGURE 14-11**  
Centralized vs. distributed databases.

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# Database Models

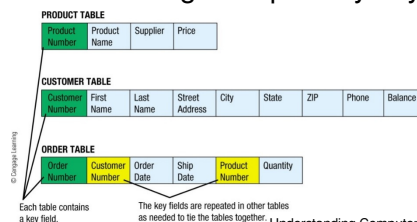
- Two older models:
  - Hierarchical databases: Store data in the form of a tree, with typically a one-to-many relationship between data entities
  - Network databases: Show the relationship between data elements usually as either one-to-many or many-to-many
  - Neither is used much these days
- Relational database management system (RDBMS)
  - Data is organized in tables related by common fields
  - Most widely used database model today

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# The Relational Database Model

- Creating a relational database:
  - Create the database file
  - Create the structure of each individual table
  - Enter data
    - Existing data can be migrated to the new database
    - New data can be added via form
  - Once all tables have been created, they can be related to one another using their primary keys



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# The Relational Database Model

- Retrieving information from database
  - Query: A request to see information from a database that matches specific criteria
    - Specifies which records should be retrieved by specifying criteria
    - Can specify the fields to be displayed
    - Many programs have wizards or other tools to make it easy to create a query
    - Must be designed to extract information as efficiently as possible
    - Queries are saved so they can be retrieved again when needed; proper results are displayed each time the query is run
    - The results of a query is a table

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# The Relational Database Model

**1. ORIGINAL TABLE**  
The original table contains data for all records.

Product Number	Product Name	Supplier	Price
A202	Skis	Ellis Ski Co.	\$90.00
A211	Boots	Aljas Bros.	\$60.00
A220	Poles	Bent Corp.	\$25.00
A240	Bindings	Acme Corp.	\$15.00
A351	Wax	Candle Industries	\$3.00

**2. CREATING THE QUERY**  
Queries can be created using the query design screen or by typing SQL code.

The query design screen is used to specify the fields and records that should be displayed in the query results.

The underlying SQL code for a query can be viewed and edited using the View button on the Home tab.

```

SELECT PRODUCT.Product Name, PRODUCT.Product Number, PRODUCT.Price
FROM PRODUCT
WHERE ((PRODUCT.Price) < 20)
ORDER BY PRODUCT.Product Name;
                    
```

**3. QUERY RESULTS**  
Only the specified fields and the records meeting the criteria listed in the query are displayed when the query is opened.

Product Name	Product Number	Price
Bindings	A240	\$15.00
Wax	A351	\$3.00

Queries are saved; click a saved query to see the results.

Click to open the query design screen.

The three specified fields will be displayed.

The records in the query results will be sorted in alphabetical order by Product Name.

The query result will display only the records for which the price is less than \$20.

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## The Relational Database Model

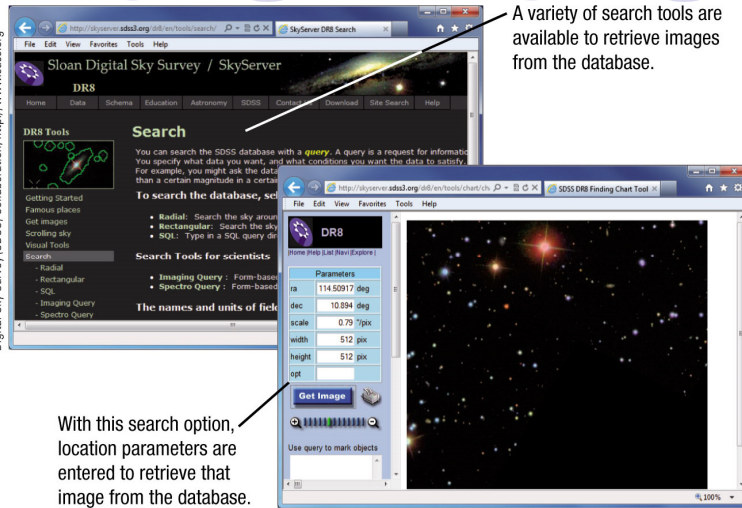
- Report: Formatted means of looking at a database table or the results of a query
  - Reports can pull data from more than one table
  - Many programs have wizards or other tools to make it easy to create a report
  - Can be modified and customized
  - Reports are saved so they can be retrieved again when needed; proper results are displayed each time the query is run

## The Object-Oriented Database Model

- Object-oriented database management system (OODBMS)
  - Database system in which multiple types of data are stored as objects along with their related code
  - Objects contain data along with the methods that can be taken with that data
  - Objects in an OODBMS can contain virtually any type of data—video clip, photograph with a narrative, text with music, and so on—along with the methods to be used with that data
  - Objects can be retrieved using queries
    - OQL – Object Query version of SQL
    - Objects can be reused in other applications to create new applications quickly

# The Object-Oriented Database Model

Courtesy Astrophysical Research Consortium (ARC) and the Sloan Digital Sky Survey (SDSS) Collaboration, <http://www.sdss.org>



A variety of search tools are available to retrieve images from the database.

With this search option, location parameters are entered to retrieve that image from the database.

**FIGURE 14-19**  
Object-oriented databases. The database shown here contains images and information from the Sloan Digital Sky Survey.

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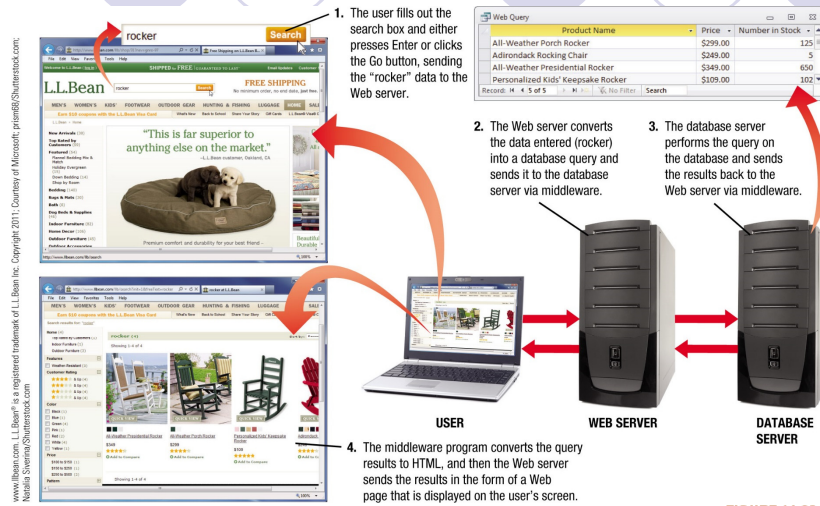
## Databases and the Web

- How Web Databases Work
  - User makes request via a Web page connected to a Web server
    - Search form
    - Logging on to personalize site
  - Web server converts the request into a database query, passes it onto the database server, and then sends the results back to the user
  - Middleware
    - Software used to connect the clients to the Web server and database.
    - Commonly written as scripts
      - JavaScript, VBScript, CGI , Active Server Pages (ASP). PHP Scripts

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# Databases and the Web



**FIGURE 14-22**  
A Web database in action.

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