Chapter 6

Foundations of Business Intelligence: Databases and Information Management

VIDEO CASES

Case 1a: City of Dubuque Uses Cloud Computing and Sensors to Build a Smarter, Sustainable City

Case 1b: IBM Smarter City: Portland, Oregon

Case 2: Data Warehousing at REI: Understanding the Customer

Case 3: Maruti Suzuki Business Intelligence and Enterprise Databases

Learning Objectives

- **Describe how the problems of managing data resources in a traditional file environment are solved by a database management system.**
- **Describe the capabilities and value of a database management system.**
- **Apply important database design principles.**
- **Evaluate tools and technologies for accessing information from databases to improve business performance and decision making.**
- **Assess the role of information policy, data administration, and data quality assurance in the management of firm’s data resources.**

Banco de Credito Del Peru Banks on Better Data Management

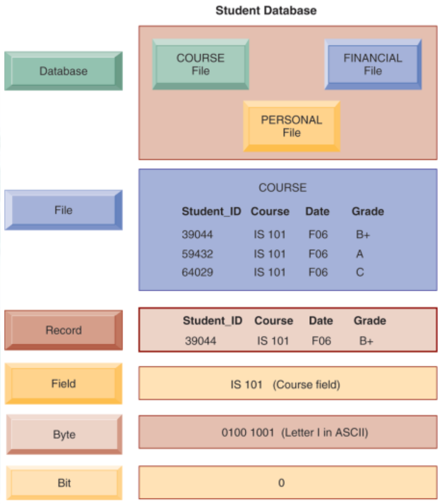
- **Problem:** Multiple outdated systems, duplicate, inconsistent data
- **Solutions:** Replace disparate legacy systems with single repository for business information
- **SAP integrated software suite** included modules for enterprise resource planning, and a data warehouse to support enterprise-wide tracking, reporting, and analysis
- Demonstrates IT’s role in successful data management
- Illustrates digital technology’ s ability to lower costs while improving performance

Organizing Data in a Traditional File Environment

- File organization concepts
  - Database: Group of related files
  - File: Group of records of same type
  - Record: Group of related fields
  - Field: Group of characters as word(s) or number
    - Describes an **entity** (person, place, thing on which we store information)
    - **Attribute:** Each characteristic, or quality, describing entity
      - Example: Attributes DATE or GRADE belong to entity COURSE

THE DATA HIERARCHY

A computer system organizes data in a hierarchy that starts with the bit, which represents either a 0 or a 1. Bits can be grouped to form a byte to represent one character, number, or symbol. Bytes can be grouped to form a field, and related fields can be grouped to form a record. Related records can be collected to form a file, and related files can be organized into a database.



Student Database

Database: COURSE File, FINANCIAL File, PERSONAL File

File: COURSE

Student_ID	Course	Date	Grade
39044	IS 101	F06	B+
59432	IS 101	F06	A
64029	IS 101	F06	C

Record:

Student_ID	Course	Date	Grade
39044	IS 101	F06	B+

Field: IS 101 (Course field)

Byte: 0100 1001 (Letter I in ASCII)

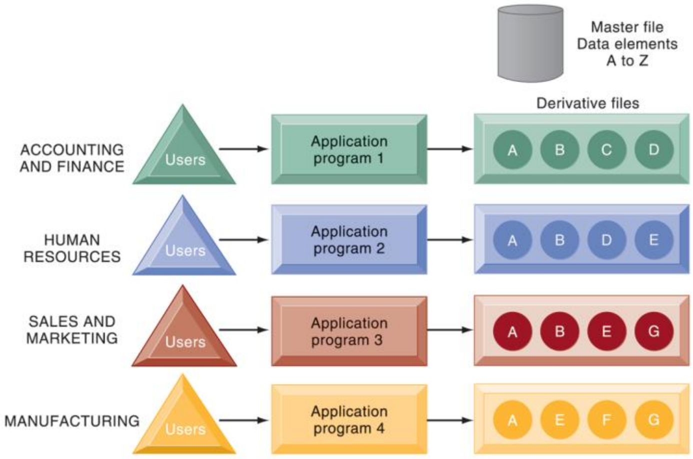
Bit: 0

FIGURE 6-1

Organizing Data in a Traditional File Environment

- **Problems with the traditional file environment (files maintained separately by different departments)**
  - **Data redundancy:**
    - Presence of duplicate data in multiple files
  - **Data inconsistency:**
    - Same attribute has different values
  - **Program-data dependence:**
    - When changes in program requires changes to data accessed by program
  - **Lack of flexibility**
  - **Poor security**
  - **Lack of data sharing and availability**

TRADITIONAL FILE PROCESSING



The use of a traditional approach to file processing encourages each functional area in a corporation to develop specialized applications. Each application requires a unique data file that is likely to be a subset of the master file. These subsets of the master file lead to data redundancy and inconsistency, processing inflexibility, and wasted storage resources.

FIGURE 6-2

The Database Approach to Data Management

- **Database**
  - **Serves many applications by centralizing data and controlling redundant data**
- **Database management system (DBMS)**
  - **Interfaces between applications and physical data files**
  - **Separates logical and physical views of data**
  - **Solves problems of traditional file environment**
    - Controls redundancy
    - Eliminates inconsistency
    - Uncouples programs and data
    - Enables organization to central manage data and data security

HUMAN RESOURCES DATABASE WITH MULTIPLE VIEWS

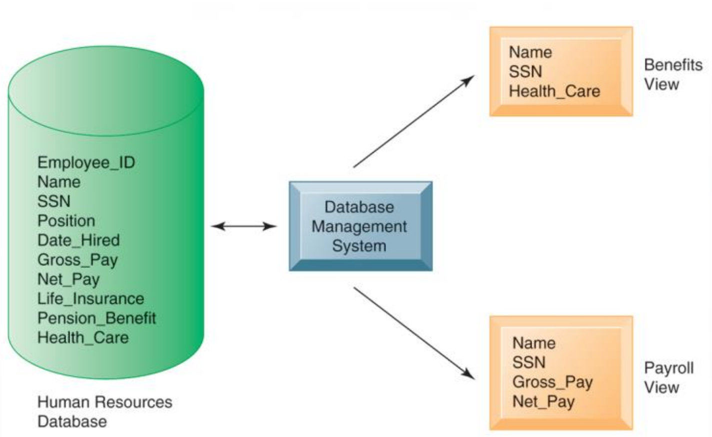


FIGURE 6-3 A single human resources database provides many different views of data, depending on the information requirements of the user. Illustrated here are two possible views, one of interest to a benefits specialist and one of interest to a member of the company's payroll department.

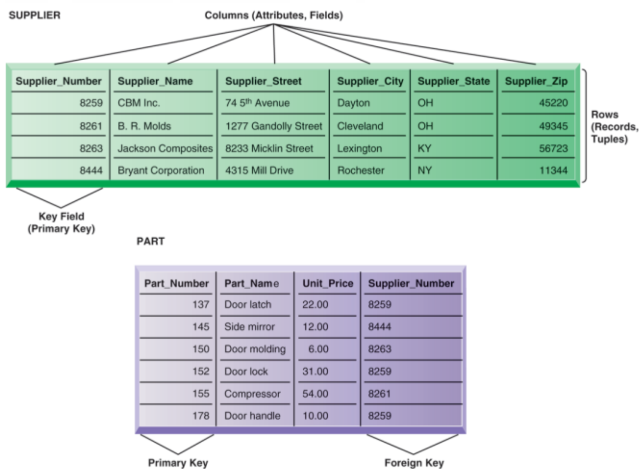
The Database Approach to Data Management

- **Relational DBMS**
  - Represent data as two-dimensional tables
  - Each table contains data on entity and attributes
- **Table: grid of columns and rows**
  - Rows (tuples): Records for different entities
  - Fields (columns): Represents attribute for entity
  - Key field: Field used to uniquely identify each record
  - Primary key: Field in table used for key fields
  - Foreign key: Primary key used in second table as look-up field to identify records from original table

Relational Database Tables

A relational database organizes data in the form of two-dimensional tables. Illustrated here are tables for the entities SUPPLIER and PART showing how they represent each entity and its attributes. Supplier Number is a primary key for the SUPPLIER table and a foreign key for the PART table.

FIGURE 6-4



SUPPLIER

Supplier_Number	Supplier_Name	Supplier_Street	Supplier_City	Supplier_State	Supplier_Zip
8259	CBM Inc.	74 5th Avenue	Dayton	OH	45220
8261	B. R. Molds	1277 Gandolly Street	Cleveland	OH	49345
8263	Jackson Composites	8233 Micklin Street	Lexington	KY	56723
8444	Bryant Corporation	4315 Mill Drive	Rochester	NY	11344

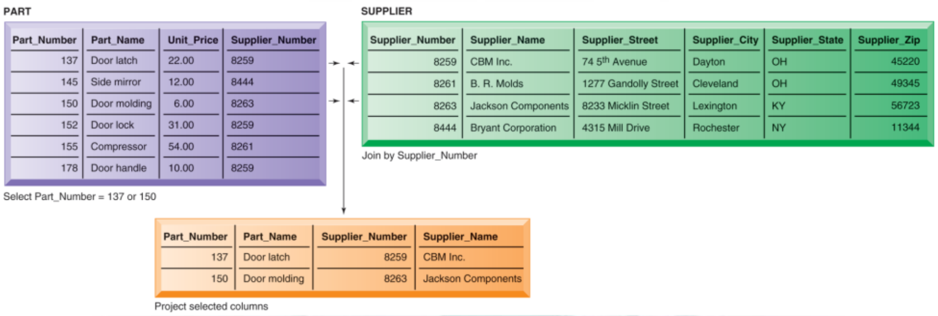
PART

Part_Number	Part_Name	Unit_Price	Supplier_Number
137	Door latch	22.00	8259
145	Side mirror	12.00	8444
150	Door molding	6.00	8263
152	Door lock	31.00	8259
155	Compressor	54.00	8261
178	Door handle	10.00	8259

The Database Approach to Data Management

- **Operations of a Relational DBMS**
  - **Three basic operations used to develop useful sets of data**
    - **SELECT:** Creates subset of data of all records that meet stated criteria
    - **JOIN:** Combines relational tables to provide user with more information than available in individual tables
    - **PROJECT:** Creates subset of columns in table, creating tables with only the information specified

THE THREE BASIC OPERATIONS OF A RELATIONAL DBMS



PART

Part_Number	Part_Name	Unit_Price	Supplier_Number
137	Door latch	22.00	8259
145	Side mirror	12.00	8444
150	Door molding	6.00	8263
152	Door lock	31.00	8259
155	Compressor	54.00	8261
178	Door handle	10.00	8259

Select Part_Number = 137 or 150

SUPPLIER

Supplier_Number	Supplier_Name	Supplier_Street	Supplier_City	Supplier_State	Supplier_Zip
8259	CBM Inc.	74 5th Avenue	Dayton	OH	45220
8261	B. R. Molds	1277 Gandolly Street	Cleveland	OH	49345
8263	Jackson Components	8233 Micklin Street	Lexington	KY	56723
8444	Bryant Corporation	4315 Mill Drive	Rochester	NY	11344

Join by Supplier_Number

Part_Number	Part_Name	Supplier_Number	Supplier_Name
137	Door latch	8259	CBM Inc.
150	Door molding	8263	Jackson Components

Project selected columns

FIGURE 6-5 The select, join, and project operations enable data from two different tables to be combined and only selected attributes to be displayed.

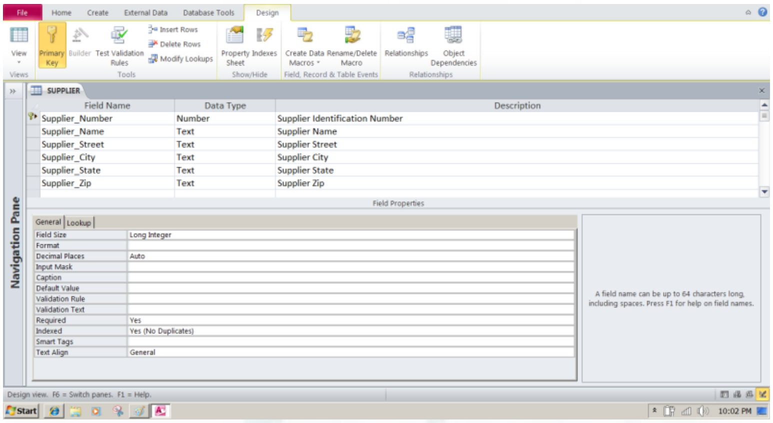
The Database Approach to Data Management

- Non-relational databases: “NoSQL”
  - More flexible data model
  - Data sets stored across distributed machines
  - Easier to scale
  - Handle large volumes of unstructured and structured data (Web, social media, graphics)
- Databases in the cloud
  - Typically, less functionality than on-premises DBs
  - Amazon Relational Database Service, Microsoft SQL Azure
  - Private clouds

The Database Approach to Data Management

- **Capabilities of database management systems**
  - **Data definition capability: Specifies structure of database content, used to create tables and define characteristics of fields**
  - **Data dictionary: Automated or manual file storing definitions of data elements and their characteristics**
  - **Data manipulation language: Used to add, change, delete, retrieve data from database**
    - Structured Query Language (SQL)
    - Microsoft Access user tools for generating SQL
  - **Many DBMS have report generation capabilities for creating polished reports (Crystal Reports)**

MICROSOFT ACCESS DATA DICTIONARY FEATURES



SUPPLIER

Field Name	Data Type	Description
Supplier_Number	Number	Supplier Identification Number
Supplier_Name	Text	Supplier Name
Supplier_Street	Text	Supplier Street
Supplier_City	Text	Supplier City
Supplier_State	Text	Supplier State
Supplier_Zip	Text	Supplier Zip

Field Properties

General | Lookup

Field Size	Long Integer
Format	
Decimal Places	Auto
Input Mask	
Caption	
Default Value	
Validation Rule	
Validation Text	
Required	Yes
Indexed	Yes (No Duplicates)
Smart Tags	
Text Align	General

A field name can be up to 64 characters long, including spaces. Press F1 for help on field names.

Design view. F6 = Switch panes. F1 = Help.

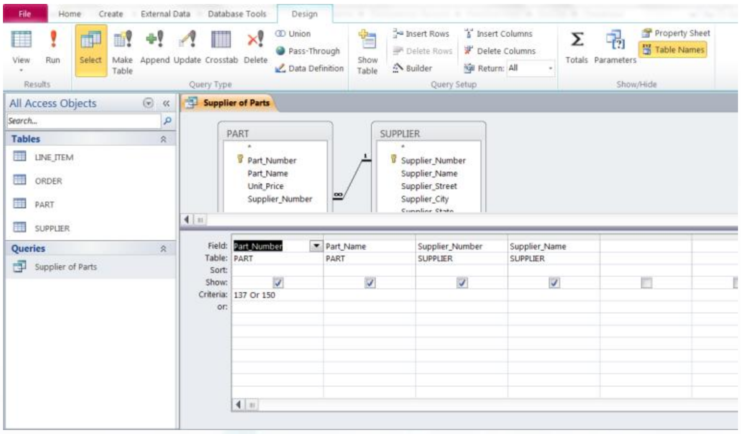
FIGURE 6-6 Microsoft Access has a rudimentary data dictionary capability that displays information about the size, format, and other characteristics of each field in a database. Displayed here is the information maintained in the SUPPLIER table. The small key icon to the left of Supplier_Number indicates that it is a key field.

EXAMPLE OF AN SQL QUERY

```
SELECT PART.Part_Number, PART.Part_Name, SUPPLIER.Supplier_Number,
SUPPLIER.Supplier_Name
FROM PART, SUPPLIER
WHERE PART.Supplier_Number = SUPPLIER.Supplier_Number AND
Part_Number = 137 OR Part_Number = 150;
```

FIGURE 6-7 Illustrated here are the SQL statements for a query to select suppliers for parts 137 or 150. They produce a list with the same results as Figure 6-5.

AN ACCESS QUERY



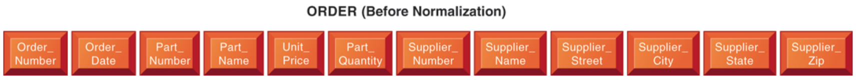
Field:	Part_Number	Part_Name	Supplier_Number	Supplier_Name
Table:	PART	PART	SUPPLIER	SUPPLIER
Sort:				
Show:	☑	☑	☑	☑
Criteria:	137 Or 150			
or:				

FIGURE 6-8 Illustrated here is how the query in Figure 6-7 would be constructed using Microsoft Access query building tools. It shows the tables, fields, and selection criteria used for the query.

The Database Approach to Data Management

- **Designing Databases**
  - Conceptual (logical) design: abstract model from business perspective
  - Physical design: How database is arranged on direct-access storage devices
- **Design process identifies:**
  - Relationships among data elements, redundant database elements
  - Most efficient way to group data elements to meet business requirements, needs of application programs
- **Normalization**
  - Streamlining complex groupings of data to minimize redundant data elements and awkward many-to-many relationships

AN UNNORMALIZED RELATION FOR ORDER

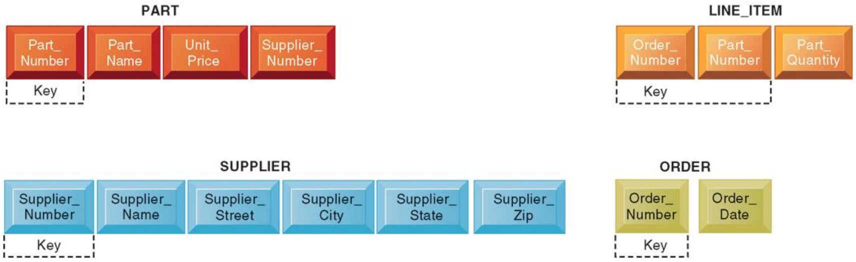


ORDER (Before Normalization)

Order_ Number	Order_ Date	Part_ Number	Part_ Name	Unit_ Price	Part_ Quantity	Supplier_ Number	Supplier_ Name	Supplier_ Street	Supplier_ City	Supplier_ State	Supplier_ Zip

FIGURE 6-9 An unnormalized relation contains repeating groups. For example, there can be many parts and suppliers for each order. There is only a one-to-one correspondence between Order_Number and Order_Date.

NORMALIZED TABLES CREATED FROM ORDER



PART

Part_ Number | Part_ Name | Unit_ Price | Supplier_ Number

Key

LINE_ITEM

Order_ Number | Part_ Number | Part_ Quantity

Key

SUPPLIER

Supplier_ Number | Supplier_ Name | Supplier_ Street | Supplier_ City | Supplier_ State | Supplier_ Zip

Key

ORDER

Order_ Number | Order_ Date

Key

FIGURE 6-10 After normalization, the original relation ORDER has been broken down into four smaller relations. The relation ORDER is left with only two attributes and the relation LINE_ITEM has a combined, or concatenated, key consisting of Order_Number and Part_Number.

The Database Approach to Data Management

- **Referential integrity rules**
  - **Used by RDMS to ensure relationships between tables remain consistent**
- **Entity-relationship diagram**
  - **Used by database designers to document the data model**
  - **Illustrates relationships between entities**

– **Caution: If a business doesn’t get data model right, system won’t be able to serve business well**

AN ENTITY-RELATIONSHIP DIAGRAM

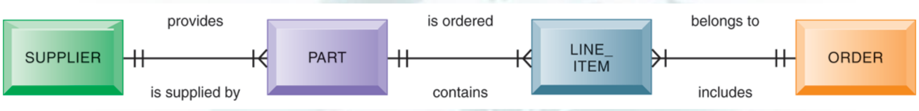


FIGURE 6-11 This diagram shows the relationships between the entities SUPPLIER, PART, LINE_ITEM, and ORDER that might be used to model the database in Figure 6-10.

Using Databases to Improve Business Performance and Decision Making

- **Big data**
  - **Massive sets of unstructured/semi-structured data from Web traffic, social media, sensors, and so on**
  - **Petabytes, exabytes of data**
    - Volumes too great for typical DBMS
  - **Can reveal more patterns and anomalies**

Using Databases to Improve Business Performance and Decision Making

- **Business intelligence infrastructure**
  - **Today includes an array of tools for separate systems, and big data**
- **Contemporary tools:**
  - **Data warehouses**
  - **Data marts**
  - **Hadoop**
  - **In-memory computing**
  - **Analytical platforms**

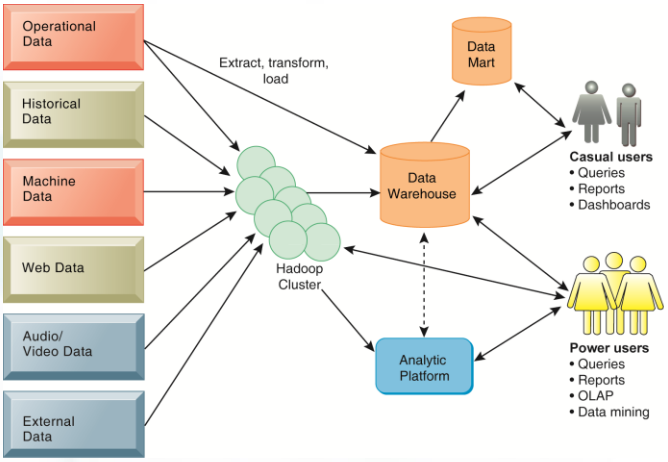
Using Databases to Improve Business Performance and Decision Making

- **Data warehouse:**
  - Stores current and historical data from many core operational transaction systems
  - Consolidates and standardizes information for use across enterprise, but data cannot be altered
  - Provides analysis and reporting tools
- **Data marts:**
  - Subset of data warehouse
  - Summarized or focused portion of data for use by specific population of users
  - Typically focuses on single subject or line of business

COMPONENTS OF A DATA WAREHOUSE

A contemporary business intelligence infrastructure features capabilities and tools to manage and analyze large quantities and different types of data from multiple sources. Easy-to-use query and reporting tools for casual business users and more sophisticated analytical toolsets for power users are included.

FIGURE 6-12



Using Databases to Improve Business Performance and Decision Making

- **Hadoop**
  - **Enables distributed parallel processing of big data across inexpensive computers**
  - **Key services**
    - Hadoop Distributed File System (HDFS): data storage
    - MapReduce: breaks data into clusters for work
    - Hbase: NoSQL database
  - **Used by Facebook, Yahoo, NextBio**

Using Databases to Improve Business Performance and Decision Making

- **In-memory computing**
  - **Used in big data analysis**
  - **Use computers main memory (RAM) for data storage to avoid delays in retrieving data from disk storage**
  - **Can reduce hours/days of processing to seconds**
  - **Requires optimized hardware**
- **Analytic platforms**
  - **High-speed platforms using both relational and non-relational tools optimized for large datasets**

Using Databases to Improve Business Performance and Decision Making

- **Analytical tools: Relationships, patterns, trends**
  - **Tools for consolidating, analyzing, and providing access to vast amounts of data to help users make better business decisions**
    - Multidimensional data analysis (OLAP)
    - Data mining
    - Text mining
    - Web mining

Using Databases to Improve Business Performance and Decision Making

- **Online analytical processing (OLAP)**
  - **Supports multidimensional data analysis**
    - Viewing data using multiple dimensions
    - Each aspect of information (product, pricing, cost, region, time period) is different dimension
    - Example: How many washers sold in East in June compared with other regions?
  - **OLAP enables rapid, online answers to ad hoc queries**

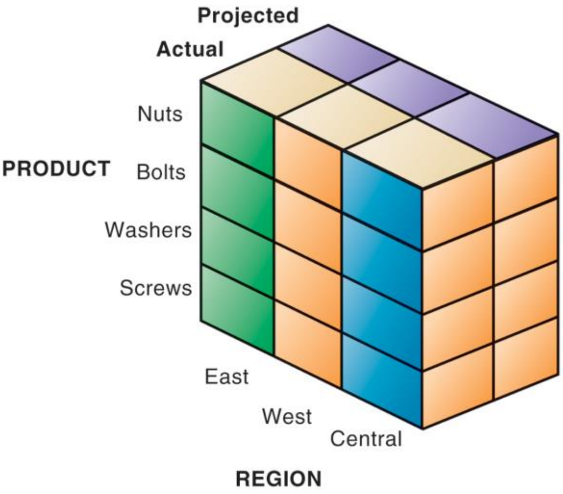
MULTIDIMENSIONAL DATA MODEL

"Data Cube" – "Turning the Cube"

four dimensions

The view that is showing is product versus region. If you rotate the cube 90 degrees, the face that will show product versus actual and projected sales. If you rotate the cube 90 degrees again, you will see region versus actual and projected sales. Other views are possible.

In the Eastern region, what are the actual and projected sales of our products (nuts, bolts, washers, and screws)



Using Databases to Improve Business Performance and Decision Making

- **Data mining:**
  - **Finds hidden patterns, relationships in datasets**
    - Example: customer buying patterns
  - **Infers rules to predict future behavior**
  - **Types of information obtainable from data mining:**
    - **Associations** Occurrences linked to single event
    - **Sequences** Events linked over time
    - **Classification** Recognizes patterns that describe group to which item belongs
    - **Clustering** Similar to classification when no groups have been defined; finds groupings within data
    - **Forecasting** Uses series of existing values to forecast what other values will be

Using Databases to Improve Business Performance and Decision Making

- **Text mining**
  - **Extracts key elements from large unstructured data sets**
    - Stored e-mails
    - Call center transcripts
    - Legal cases
    - Patent descriptions
    - Service reports, and so on
  - **Sentiment analysis software**
    - Mines e-mails, blogs, social media to detect opinions

Using Databases to Improve Business Performance and Decision Making

- **Web mining**
  - **Discovery and analysis of useful patterns and information from Web**
    - Understand customer behavior
    - Evaluate effectiveness of Web site, and so on
  - **Web content mining**
    - Mines content of Web pages
  - **Web structure mining**
    - Analyzes links to and from Web page
  - **Web usage mining**
    - Mines user interaction data recorded by Web server
    - Google Trends and Google Insights track the popularity of various words and phrases used in Google search queries, to learn what people are interested in and what they are interested in buying

Privacy Concerns

- Effective Data Mining requires large sources of data
- To achieve a wide spectrum of data, must link multiple data sources
- Linking sources leads can be problematic for privacy as follows: If the following histories of a customer were linked:
  - Shopping History
  - Credit History
  - Bank History
  - Employment History
- The users’ life story can be painted from the collected data
- Hiring, loan, other decision are made by data collected on individuals.
  - What happens if the data is not correct?
- Data aggregators (data brokers) – it’s legal to buy and sell personal data.
  - Is this ethical?

Big Data, Big Rewards

- Describe the kinds of big data collected by the organizations described in this case.
- List and describe the business intelligence technologies described in this case.
- Why did the companies described in this case need to maintain and analyze big data? What business benefits did they obtain?
- Identify three decisions that were improved by using big data.
- What kinds of organizations are most likely to need big data management and analytical tools?

Controversy Whirls Around the Consumer Product Safety Database

- What is the value of the CPSC database to consumers, businesses, and the U.S. government?
- What problems are raised by this database? Why is it so controversial? Why is data quality an issue?
- Name two entities in the CPSC database and describe some of their attributes.
- When buying a crib, or other consumer product for your family, would you use this database?

Managing Data Resources

- **Establishing an information policy**
  - **Firm’ s rules, procedures, roles for sharing, managing, standardizing data**
  - **Data administration**
    - Establishes policies and procedures to manage data
  - **Data governance**
    - Deals with policies and processes for managing availability, usability, integrity, and security of data, especially regarding government regulations
  - **Database administration**
    - Creating and maintaining database

Managing Data Resources

- **Ensuring data quality**
  - **More than 25% of critical data in Fortune 1000 company databases are inaccurate or incomplete**
    - Redundant data
    - Inconsistent data
    - Faulty input
  - **Before new database in place, need to:**
    - Identify and correct faulty data
    - Establish better routines for editing data once database in operation

Managing Data Resources

- **Data quality audit:**
  - **Structured survey of the accuracy and level of completeness of the data in an information system**
    - Survey samples from data files, or
    - Survey end users for perceptions of quality
- **Data cleansing**
  - **Software to detect and correct data that are incorrect, incomplete, improperly formatted, or redundant**
  - **Enforces consistency among different sets of data from separate information systems**