강 의 계 획 서

2020 학년도 제 2 학기

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강의시간	화13:30-14:45 목13:30-14:45	강의실	대연21.25	수강대상		컴퓨터공학과 3학년	

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1. 교과목 개요

목 표	실세계 환경의 요구조건을 분석하여 의미적 모델링을 한 후에 데이터베이스 스키마를 설계하고 평가할 수 있고, SQL과 고급 프로그래밍 언어를 이용하여 데이터베이스 응용을 설계하고 구현할 수 있으며, 상용 데이터베이스 관리 시스템(DBMS)의 구현 기술을 이해하고 데이터베이스 및 응용 프로그래밍에 활용할 수 있도록 한다.
단 원	주 요 내 용
1	Intorduction to Databases
2	Overview of Database Languages and Architecture
3	The Basic Relational Model
4	SQL: Data Definition, Constraints, and Basic Queries and Updates
5	Advanced Queries, Assertions, Triggers, and Views
6	Formal Relational Languages: Algebra and Calculus
7	Conceptual Data Modeling Using Entities and Relationships
8	Mapping a Conceptual Design into a Logical Design
9	UML for Database Application Design
10	Object and Object-relational Databases
12	SQL Application Programming Using C and Java
14	Database Design Theory: Normalization Using Functional Dependencies
15	Database Design Theory: Normalization Algoruthms
16	Database File Organizations
17	Database File Indexing Techniques
18	Introduction to Query processing
20	Foundations of Database Transaction processing

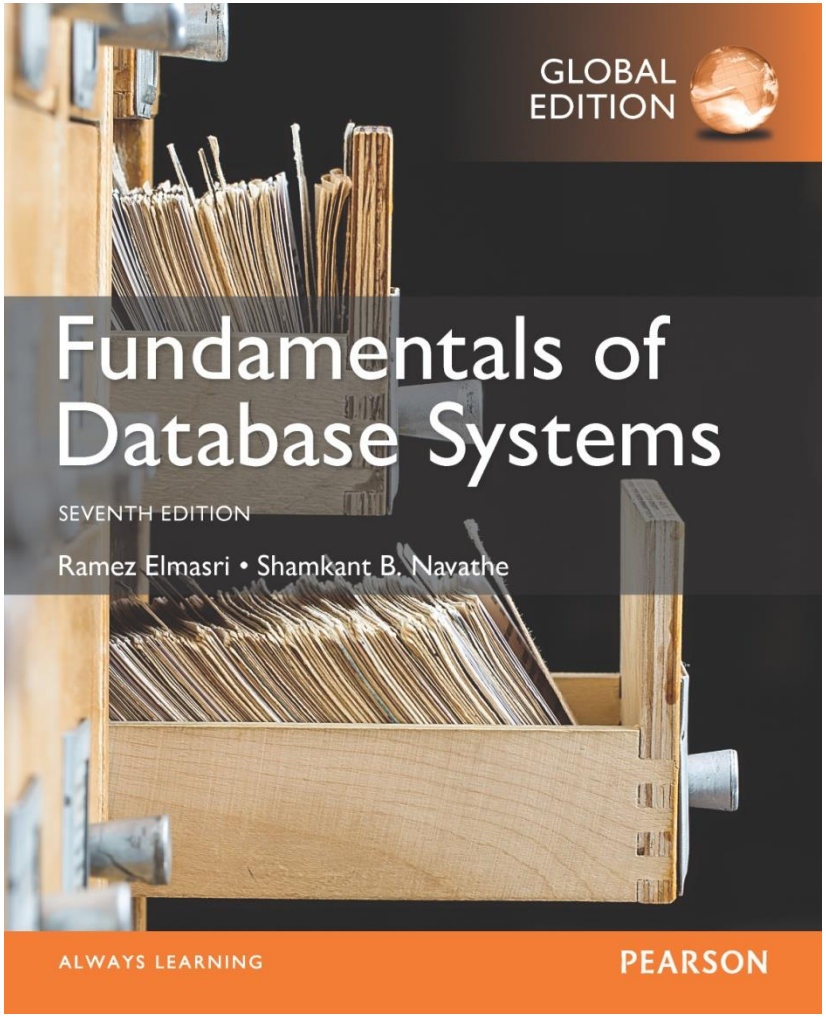
2. 교재 및 참고도서

가. 교 재 : Database Systems 7ed.(R. Elmasri and S.B. Navathe, Addison Wesley)

나. 참고도서: Database Management Systems (R. Ramakrisnan and J. Gehrke, McGRAW Hill)

3. 평가방법

중간고사	기말고사	과 제 물	출 결	기 타	합 계	비 고
30 %	30 %	20 %	10 %	10 %	100 %	



CHAPTER 1

Databases and Database Users

OUTLINE

- Types of Databases and Database Applications
- Basic Definitions
- Typical DBMS Functionality
- Example of a Database (UNIVERSITY)
- Main Characteristics of the Database Approach
- Types of Database Users
- Advantages of Using the Database Approach
- Historical Development of Database Technology
- Extending Database Capabilities
- When Not to Use Databases

Types of Databases and Database Applications

- Traditional Applications:
  - Numeric and Textual Databases
- More Recent Applications:
  - Multimedia Databases
  - Geographic Information Systems (GIS)
  - Biological and Genome Databases
  - Data Warehouses 사용자의 의사결정에 도움(다양한 시스템에서 추출, 변환, 통합, 요약된 데이터베이스)
  - Mobile databases
  - Real-time and Active Databases
- First part of book focuses on traditional applications
- *Recent applications (Chapters 24,25,26,27,28,29)*

Recent Developments (1)

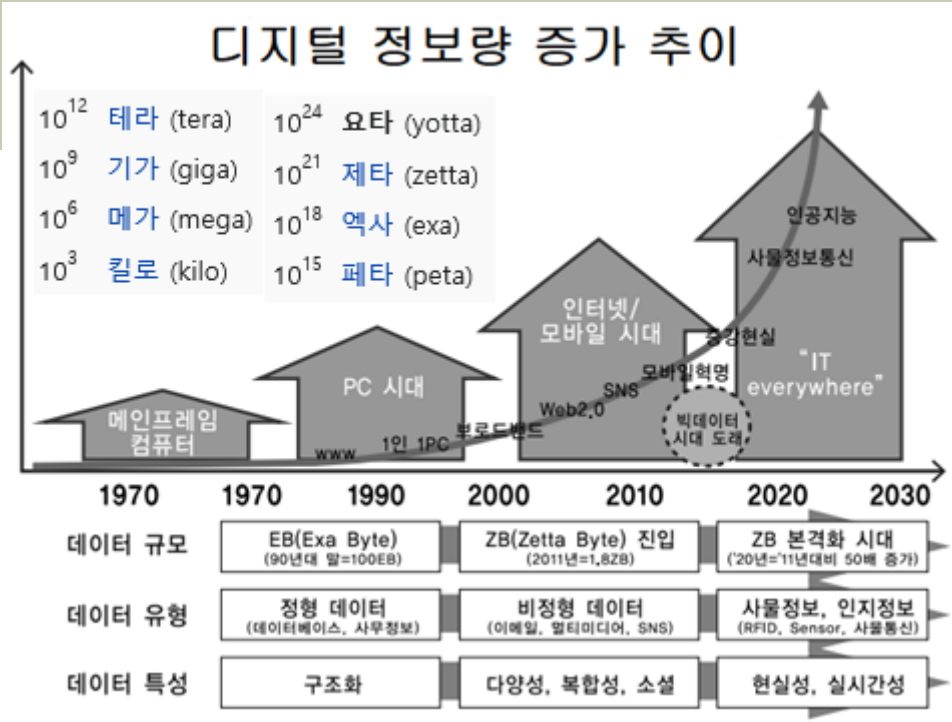
- Social Networks started capturing a lot of information about people and about communications among people-posts, tweets, photos, videos in systems such as:

- Facebook
- Twitter
- Linked-In 세계 최대 비즈니스 전문 SNS(2002년, 리드 호프만)

- Search Engines- Google, Bing(MS 검색엔진), Yahoo : collect their own repository of web pages for searching purposes

Recent Developments (2)

- New Technologies are emerging from the so-called non-database software vendors to manage vast amounts of data generated on the web:
- Big Data storage systems involving large clusters of distributed computers (Chapter 25)
- NOSQL (Not Only SQL) systems (Chapter 24)
  - 고속 문서 검색, 소셜네트워크에서 거대 그래프 처리, 비구조화 데이터 처리, 빅데이터 저장 등
- A large amount of data now resides on the "cloud" which means it is in huge data centers using thousands of machines.



데이터의 과거-현재-미래

정보화 시대 vs. 스마트 시대의 데이터 관련 이슈 변화

구 분	정보화 시대(1세대)	스마트 시대(2세대)
저장	관계형/정형 데이터베이스, 데이터웨어하우스	비관계형/비정형 데이터베이스, 가상화, 클라우드 서비스
검색	검색엔진(text), 포털 서비스	자연어/음성 · 영상/시멘틱 검색서비스
관리 · 공유	KMS, Web 2.0	플랫폼, 소셜 네트워크, 집단지성
분석	경영정보/고객정보/자산정보 분석 (ERP, CRM, 데이터마이닝 등)	빅데이터 분석 (소셜 분석, 고급 분석, BI, 시각화)
추론	-	상황인식 서비스(미래전망, 사전대응, 자동화 서비스), 개인화 서비스

출처 : 빅데이터 시대 <한국정보화진흥원 2013. 2.>

지식 관리 시스템(Knowledge Management System, KMS)은 지식베이스, 지식 스키마, 지식 맵 등 3가지 요소로 구성되어 있다. 지식베이스가 원시데이터를 저장하는 데이터베이스에 비유된다면 지식스키마는 원시데이터에 대한 메타데이터를 담고 있는 데이터 사전 또는 데이터베이스 스키마에 비유될 수 있다.

비즈니스 인텔리전스(Business Intelligence, BI)은 기업에서 데이터를 수집, 정리, 분석하고 활용하여 효율적인 의사결정을 할 수 있는 방법에 대해 연구하는 학문이다.

Basic Definitions

- **Database:**
  - A collection of related data.
- **Data:**
  - Known facts that can be recorded and have an implicit meaning.
- **Mini-world:**
  - Some part of the real world about which data is stored in a database. For example, student grades and transcripts at a university.
- **Database Management System (DBMS):**
  - A software package/ system to facilitate the creation and maintenance of a computerized database.
- **Database System:**
  - The DBMS software together with the data itself. Sometimes, the applications are also included.

Impact of Databases and Database Technology

- Businesses: Banking, Insurance, Retail 소매, Transportation, Healthcare, Manufacturing
- Service Industries: Financial, Real-estate 부동산, Legal, Electronic Commerce, Small businesses
- Education : Resources for content and Delivery
- More recently: Social Networks, Environmental and Scientific Applications, Medicine and Genetics
- Personalized Applications: based on smart mobile devices

Simplified database system environment

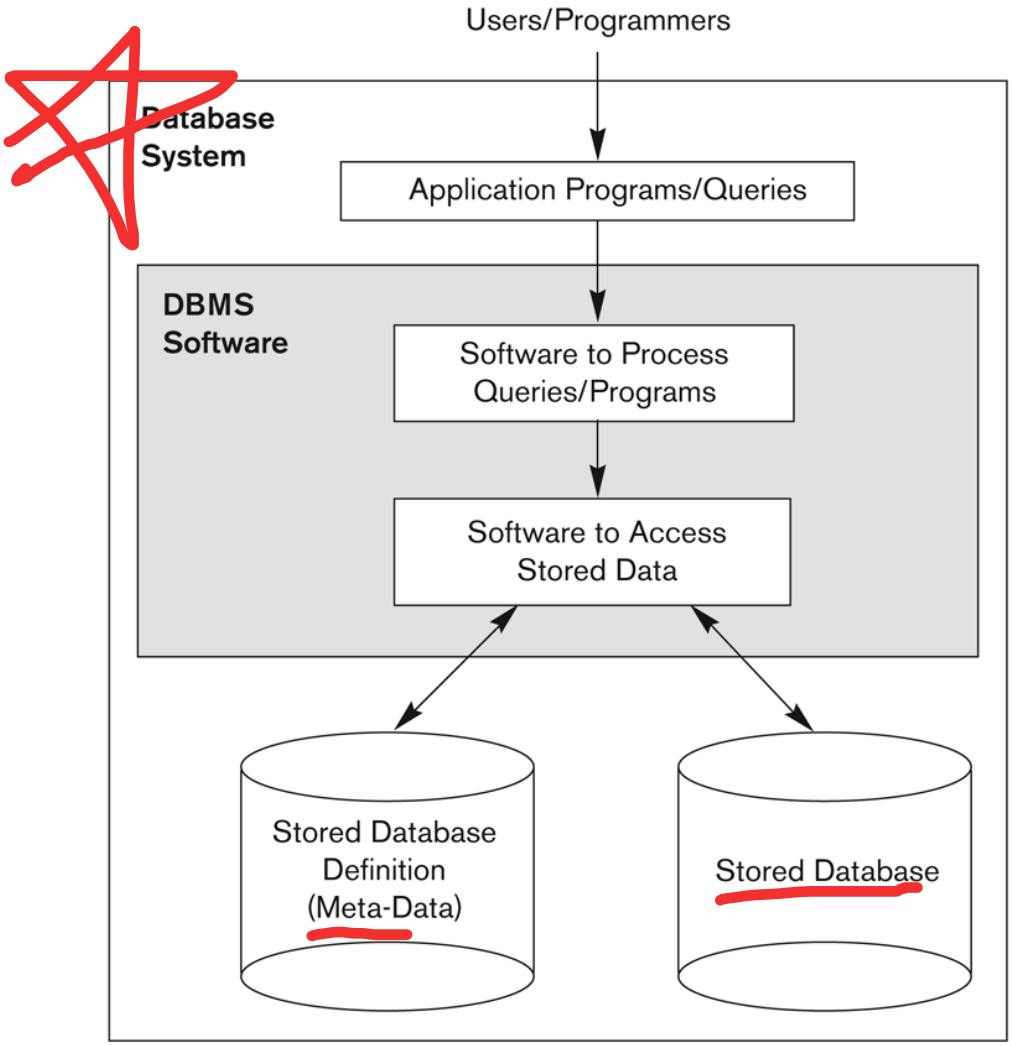


Figure 1.1
A simplified database system environment.

Typical DBMS Functionality

- **Define** a particular database in terms of its **data types**, **structures**, and **constraints**
- **Construct** or Load the initial database contents on a secondary storage medium HDD, SSD
- **Manipulating** the database:
  - Retrieval: Querying, generating reports 데이터 주출
  - Modification: Insertions, deletions and updates to its content
  - Accessing the database through Web applications
- **Processing** and **Sharing** by a set of concurrent users and application programs – yet, keeping all data valid and consistent

여러 유저 사이의 데이터베이스 이용 컨트롤

Application Activities Against a Database

- Applications interact with a database by generating
  - Queries: that access different parts of data and formulate the result of a request
  - Transactions: that may read some data and "update" certain values or generate new data and store that in the database
- Applications must not allow unauthorized users to access data
- Applications must keep up with changing user requirements against the database

유저 요구사항에 쉽게 변화할수 있어야함

Additional DBMS Functionality

- DBMS may additionally provide:
  - Protection or Security measures to prevent unauthorized access
  - "Active" processing to take internal actions on data
  - Presentation and Visualization of data
  - Maintenance of the database and associated programs over the lifetime of the database application
    - Called database, software, and system maintenance

Example of a Database (with a Conceptual Data Model)

- **Mini-world for the example:**
  - Part of a UNIVERSITY environment.
- **Some mini-world *entities*:**
  - STUDENTs
  - COURSEs
  - SECTIONs (of COURSEs)
  - (academic) DEPARTMENTs
  - INSTRUCTORs

Example of a Database (with a Conceptual Data Model)

- **Some mini-world *relationships*:**
  - SECTIONs *are of specific* COURSEs
  - STUDENTs *take* SECTIONs
  - COURSEs *have prerequisite* COURSEs
  - INSTRUCTORs *teach* SECTIONs
  - COURSEs *are offered by* DEPARTMENTs
  - STUDENTs *major in* DEPARTMENTs

- Note: The above entities and relationships are typically expressed in a conceptual data model, such as the ENTITY-RELATIONSHIP data model (see Chapters 3, 4)

Example of a simple database

COURSE

Course_name	Course_number	Credit_hours	Department
Intro to Computer Science	CS1310	4	CS
Data Structures	CS3320	4	CS
Discrete Mathematics	MATH2410	3	MATH
Database	CS3380	3	CS

SECTION

Section_identifier	Course_number	Semester	Year	Instructor
85	MATH2410	Fall	04	King
92	CS1310	Fall	04	Anderson
102	CS3320	Spring	05	Knuth
112	MATH2410	Fall	05	Chang
119	CS1310	Fall	05	Anderson
135	CS3380	Fall	05	Stone

GRADE_REPORT

Student_number	Section_identifier	Grade
17	112	B
17	119	C
8	85	A
8	92	A
8	102	B
8	135	A

PREREQUISITE

Course_number	Prerequisite_number
CS3380	CS3320
CS3380	MATH2410
CS3320	CS1310

Figure 1.2
A database that stores student and course information.

Main Characteristics of the Database Approach

자기자신을 설명

- **Self-describing nature of a database system:**
  - A DBMS **catalog** stores the description of a particular database (e.g. data structures, types, and constraints)
  - The description is called **meta-data***.
  - This allows the DBMS software to work with different database applications.

차폐막

- **Insulation between programs and data:**
  - Called **program-data independence**.
  - Allows changing data structures and storage organization without having to change the DBMS access programs.

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* Some newer systems such as a few NOSQL systems need no meta-data: they store the data definition within its structure making it self describing

Example of a simplified database catalog

RELATIONS

Relation_name	No_of_columns
STUDENT	4
COURSE	4
SECTION	5
GRADE_REPORT	3
PREREQUISITE	2

COLUMNS

Column_name	Data_type	Belongs_to_relation
Name	Character (30)	STUDENT
Student_number	Character (4)	STUDENT
Class	Integer (1)	STUDENT
Major	Major_type	STUDENT
Course_name	Character (10)	COURSE
Course_number	XXXXNNNN	COURSE
….	….	…..
….	….	…..
….	….	…..
Prerequisite_number	XXXXNNNN	PREREQUISITE

Note: Major_type is defined as an enumerared type with all known majors. XXXXNNNN is used to define a type with four alpha characters followed by four digits

Figure 1.3
An example of a database catalog for the database in Figure 1.2.

Main Characteristics of the Database Approach (continued)

- **Data Abstraction:**
  - A **data model** is used to hide storage details and present the users with a conceptual view of the database.
  - Programs refer to the data model constructs rather than data storage details
- **Support of multiple views of the data:**
  - Each user may see a different view of the database, which describes **only** the data of interest to that user.

Abstraction only

Main Characteristics of the Database Approach (continued)

- **Sharing of data and multi-user transaction processing:**
  - Allowing a set of **concurrent users** to retrieve from and to update the database.
  - **Concurrency control** within the DBMS guarantees that each **transaction** is correctly executed or aborted
  - **Recovery** subsystem ensures each completed transaction has its effect permanently recorded in the database
  - **OLTP** (Online Transaction Processing) is a major part of database applications. This allows hundreds of concurrent transactions to execute per second.

Database Users

- Users may be divided into
  - Those who actually use and control the database content, and those who design, develop and maintain database applications (called “Actors on the Scene”), and
  - Those who design and develop the DBMS software and related tools, and the computer systems operators (called “Workers Behind the Scene”).

Database Users – Actors on the Scene

- Actors on the scene
  - **Database administrators:**
    - Responsible for authorizing access to the database, for coordinating and monitoring its use, acquiring software and hardware resources, controlling its use and monitoring efficiency of operations.
  - **Database Designers:**
    - Responsible to define the content, the structure, the constraints, and functions or transactions against the database. They must communicate with the end-users and understand their needs.

Database End Users

- Actors on the scene (continued)
  - **End-users**: They use the data for queries, reports and some of them update the database content. End-users can be categorized into:
    - **Casual**: access database occasionally when needed 때때로 사용하는 중상급
    - **Naïve** or Parametric: they make up a large section of the end-user population.
      - They use previously well-defined functions in the form of "canned transactions" against the database.
      - Users of Mobile Apps mostly fall in this category
      - Bank-tellers or reservation clerks are parametric users who do this activity for an entire shift of operations.
      - Social Media Users post and read information from websites

Database End Users (continued)

- **Sophisticated:**
  - These include business analysts, scientists, engineers, others thoroughly familiar with the system capabilities.
  - Many use tools in the form of software packages that work closely with the stored database.
- **Stand-alone:**
  - Mostly maintain personal databases using ready-to-use packaged applications.
  - An example is the user of a tax program that creates its own internal database.
  - Another example is a user that maintains a database of personal photos and videos.

Database Users – Actors on the Scene (continued)

- **System Analysts and Application Developers**

  This category currently accounts for a very large proportion of the IT work force.

  - **System Analysts**: They understand the user requirements of naïve and sophisticated users and design applications including canned transactions to meet those requirements. 이미 만들어진 프로그램
  - **Application Programmers:** Implement the specifications developed by analysts and test and debug them before deployment.
  - **Business Analysts**: There is an increasing need for such people who can analyze vast amounts of business data and real-time data ("Big Data") for better decision making related to planning, advertising, marketing etc.

Database Users – Actors behind the Scene

- **System Designers and Implementors:** Design and implement DBMS packages in the form of modules and interfaces and test and debug them. The DBMS must interface with applications, language compilers, operating system components, etc.
- **Tool Developers**: Design and implement software systems called tools for modeling and designing databases, performance monitoring, prototyping, test data generation, user interface creation, simulation etc. that facilitate building of applications and allow using database effectively.
- **Operators and Maintenance Personnel:** They manage the actual running and maintenance of the database system hardware and software environment.

Advantages of Using the Database Approach

- Controlling redundancy (분산된 중복된 데이터) in data storage and in development and maintenance efforts.
  - Sharing of data among multiple users.
- Restricting unauthorized access to data. Only the DBA staff uses privileged commands and facilities.
- Providing persistent storage for program Objects
  - E.g., Object-oriented DBMSs make program objects persistent– see Chapter 12.
- Providing Storage Structures (e.g. indexes) for efficient Query Processing – see Chapter 17.

Advantages of Using the Database Approach (continued)

- Providing optimization of queries for efficient processing.
- Providing backup and recovery services.
- Providing multiple interfaces to different classes of users.
- Representing complex relationships among data.
- Enforcing integrity constraints on the database.
무결성 제약조건
- Drawing inferences and actions from the stored data using deductive and active rules and triggers.

Additional Implications of Using the Database Approach

- Potential for enforcing standards:
  - This is very crucial for the success of database applications in large organizations. **Standards** refer to data item names, display formats, screens, report structures, meta-data (description of data), Web page layouts, etc.
- Reduced application development time:
  - Incremental time to add each new application is reduced.

Additional Implications of Using the Database Approach (continued)

- Flexibility to change data structures:
  - Database structure may evolve as new requirements are defined.
- Availability of current information:
  - Extremely important for on-line transaction systems such as shopping, airline, hotel, car reservations.
- Economies of scale:
  - Wasteful overlap of resources and personnel can be avoided by consolidating data and applications across departments.

Historical Development of Database Technology

- Early Database Applications:
  - The Hierarchical and Network Models were introduced in mid 1960s and dominated during the seventies.
  - A bulk of the worldwide database processing still occurs using these models, particularly, the hierarchical model using IBM's IMS system.
- Relational Model based Systems:
  - Relational model was originally introduced in 1970, was heavily researched and experimented within IBM Research and several universities.
  - Relational DBMS Products emerged in the early 1980s.

Historical Development of Database Technology (continued)

- Object-oriented and emerging applications:
  - Object-Oriented Database Management Systems (OODBMSs) were introduced in late 1980s and early 1990s to cater to the need of complex data processing in CAD and other applications.
    - Their use has not taken off much.
  - Many relational DBMSs have incorporated object database concepts, leading to a new category called *object-relational* DBMSs (ORDBMSs)
  - *Extended relational* systems add further capabilities (e.g. for multimedia data, text, XML, and other data types)

Relational + OODBMS이 거의 쓰임

Historical Development of Database Technology (continued)

- Data on the Web and E-commerce Applications:
  - Web contains data in HTML (Hypertext markup language) with links among pages.
  - This has given rise to a new set of applications and E-commerce is using new standards like XML (eXtended Markup Language). (see Ch. 13).
  - Script programming languages such as PHP and JavaScript allow generation of dynamic Web pages that are partially generated from a database (see Ch. 11).
    - Also allow database updates through Web pages

Extending Database Capabilities (1)

- New functionality is being added to DBMSs in the following areas:
  - Scientific Applications – Physics, Chemistry, Biology - Genetics
  - Earth and Atmospheric Sciences and Astronomy
  - XML (eXtensible Markup Language)
  - Image Storage and Management
  - Audio and Video Data Management
  - Data Warehousing and Data Mining – a very major area for future development using new technologies (see Chapters 28-29)
  - Spatial Data Management and Location Based Services
  - Time Series and Historical Data Management
- The above gives rise to **new research and development** in incorporating new data types, complex data structures, new operations and storage and indexing schemes in database systems.

Extending Database Capabilities (2)

- Background since the advent of the 21st Century:
  - First decade of the 21st century has seen tremendous growth in user generated data and automatically collected data from applications and search engines.
  - Social Media platforms such as Facebook and Twitter are generating millions of transactions a day and businesses are interested to tap into this data to "understand" the users
  - Cloud Storage and Backup is making unlimited amount of storage available to users and applications

Extending Database Capabilities (3)

- Emergence of Big Data Technologies and NOSQL databases
  - New data storage, management and analysis technology was necessary to deal with the onslaught of data in petabytes a day (10**15 bytes or 1000 terabytes) in some applications – this started being commonly called as “Big Data”.
  - Hadoop (which originated from Yahoo) and Mapreduce Programming approach to distributed data processing (which originated from Google) as well as the Google file system have given rise to Big Data technologies (Chapter 25). Further enhancements are taking place in the form of Spark based technology.
  - NOSQL (Not Only SQL- where SQL is the de facto standard language for relational DBMSs) systems have been designed for rapid search and retrieval from documents, processing of huge graphs occurring on social networks, and other forms of unstructured data with flexible models of transaction processing (Chapter 24).

When not to use a DBMS

- Main inhibitors (costs) of using a DBMS:
  - High initial investment and possible need for additional hardware.
  - Overhead for providing generality, security, concurrency control, recovery, and integrity functions.
- When a DBMS may be unnecessary:
  - If the database and applications are simple, well defined, and not expected to change.
  - If access to data by multiple users is not required.
- When a DBMS may be infeasible:
  - In embedded systems where a general purpose DBMS may not fit in available storage

When not to use a DBMS

- When no DBMS may suffice:
  - If there are stringent real-time requirements that may not be met because of DBMS overhead (e.g., telephone switching systems)
  - If the database system is not able to handle the complexity of data because of modeling limitations (e.g., in complex genome and protein databases)
  - If the database users need special operations not supported by the DBMS (e.g., GIS and location based services).

Chapter Summary

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- Advantages of Using the Database Approach
- Historical Development of Database Technology
- Extending Database Capabilities
- When Not to Use Databases