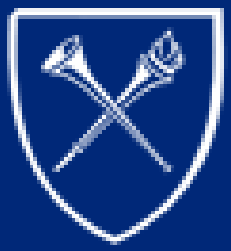

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Overview of Computer Hardware: Introduction to Basic Terms & Concepts

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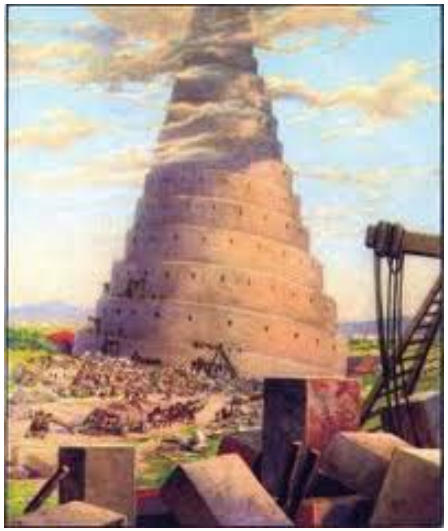
Goals of Lecture

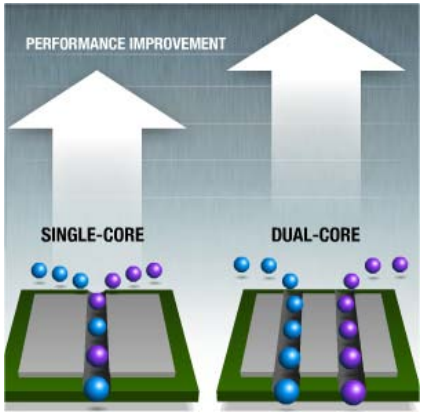
- **Provide very brief overview of certain terms and concepts that may be used throughout the day**

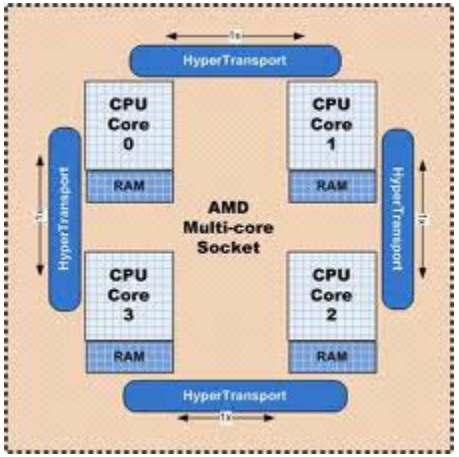
- **Begin our ascent up the tower of Babel of Informatics**



CPUs

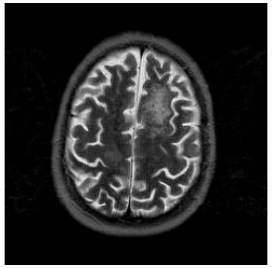
- Serves as the basic computation engine (brain) for the machine
- Intel and AMD make processors used in most healthcare applications
- Many machines now have “multi-core”, meaning a single chip contains several individual CPUs
- More cores != faster performance unless underlying programs can work in parallel





Serial vs Parallel Operations

- Have a 1 million line document and want to count # of times “diabetes” appear
- Can start from the top…. and have the computer keep going (serial operation)
- Parallel version: Split document into equal parts, and have each “core” or “node” count up their part and assemble the results
- Some problems are easier to parallelize than others e.g. run same analysis on different patients



GPU

- Graphics Processing Unit
- Specialized piece of hardware that is very good at processing certain types (generally 3D image) data
- Examples in clinical practice would be GPU-accelerated DICOM workstation for rendering/viewing 3-D image reconstructions

Networking

- Computers are now networked together to allow sharing of resources (printers/disks/etc)
- Wired vs wireless
- Networks can span different scopes: home → office → department → University (intranet) → the world (Internet)
- Amount of information that can be transmitted (bandwidth) can vary dramatically
- Slower/congested networks = longer times to load files → particularly noticeable when transferring imaging data (e.g. radiology)

RAM Memory vs Hard Drive

- Random Access Memory(RAM)- Serves as short term storage for calculations & programs
- Most RAM is volatile– turning off computer deletes this data
- More RAM generally means better performance, especially with large data sets/many programs open
- Hard Disk– generally spinning platters that store information at high density– non-volatile
- Access time for RAM is generally 10x to 100x's of times faster than corresponding disk access… allowing processors to not "wait" for information

vs

vs

Storage Types & Networking

- Local vs network storage
- Local storage is physically part of the computer– generally faster than network storage
- Network/shared storage: Use existing network infrastructure and files “live” in a different physical location but can be directly accessed
- Has many advantages as backups/redundancy can be engineered as part of the system
- Disadvantage is that slow networks and/or network outages = no access to files

Operating Systems

- Software framework that manages/controls basic operations on a given CPU allowing communication between users and underlying hardware
- Examples: Windows 7, Mac OSX, Unix/Linux and derivatives
- Programs written for a given OS generally can only be run on that platform
- Linux/Unix is sometimes used for specific high-end uses (like Radiology workstation)

DISK Storage

- Serve as main storage for files/programs/pictures/images/etc
- Much slower than memory
- New “FLASH” drives use non-volatile RAM similar to what’s used in a camera and can be used to store frequently used data and allow quicker access than conventional spinning disks

Network

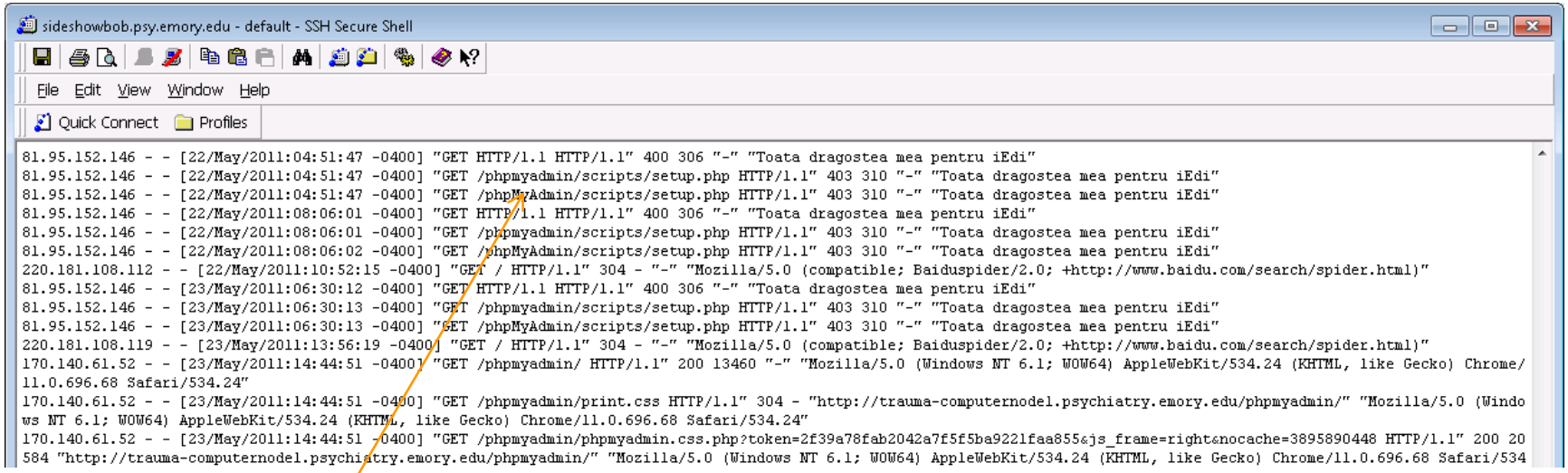
- General infrastructure that allows computers to send information to and from each other
- Can have different scopes/purposes
- Bluetooth network: Short range communication
- Intranet:

Firewalls

"A **firewall** is a device or set of devices designed to permit or deny network transmissions based upon a set of rules and is frequently used to protect networks from unauthorized access while permitting legitimate communications to pass"

- Can be lax to very restrictive (block access to the entire web)
- Mandatory in clinical settings to protect patient data
- Can allow access to certain resources only at specific locations

Why firewalls can be important!



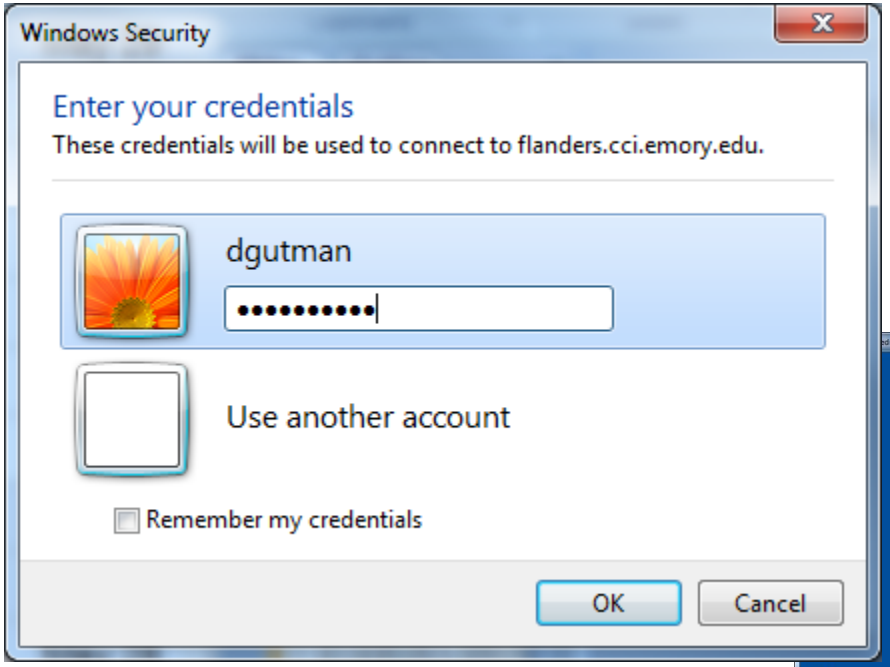
Looks like someone from Europe is trying to access one of my servers by doing a "scan"

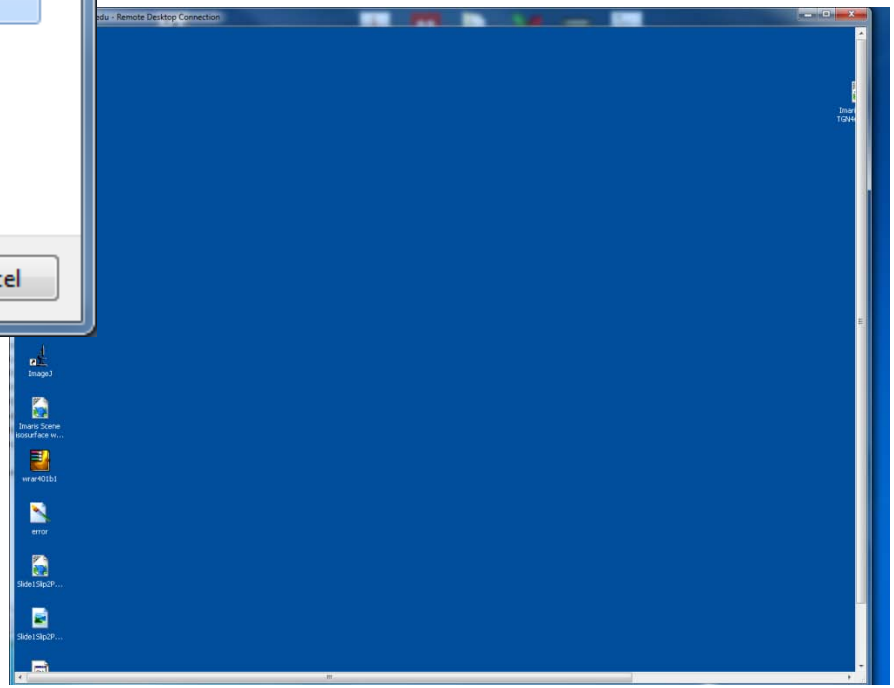
Virtualization / Virtual Machines

- Separates the applications/operating system from the underlying hardware and creates a “virtual” copy
- This virtual machine can be transferred to any computer/hardware that can host the image in case of hardware failure
- Copies/snapshots can be made of the image to facilitate backup/rollbacks/testing
- Allows pooling of resources– a single machine can host several virtual hosts
- Performance of a “virtual machine” is no longer significantly slower than a “real” machine for many applications
- Relatively inexpensive machines can be used as a “thin” client to access a VM

Examples:

Remote Desktop to my virtual machine





Application at Emory

- Emory uses a CITRIX based “virtual” desktop for many/most clinical programs
- This common framework greatly simplifies administration/backup/security
- Installation of programs is also simplified for IT as a VM can be copied and deployed
- Can access same files/applications from home (if in the firewall), at Emory Clinic, at the Hospital, etc
- Has many advantages in certain scenarios, although can prevent challenges in research environments
- Severely limits ability for clinicians/staff to install/modify programs

The Cloud

- With the rapid advancement of virtualization technology and fast networks, no need to run virtual machines locally
- Many “commodity” calculations / services can be outsourced to online service providers (Amazon S3, Godaddy, Gmail, Dropbox, etc)
- Specific machine/hardware an app runs on is controlled dynamically and can be migrated automatically in case of hardware failure at the hosting provider**
- Commodity model of software + hardware/pay as you go

Scripts/Programming

Script/Macro – A program (set of commands) that performs relatively simple action automatically

For example… can open a list of files/documents, looking for the word "diabetes" and "hypertension" and generate co-occurrence statistics vs making a medical student or resident scan through documents manually

Or…

Scripting in the wild / why we need Firewalls

85.114.135.121 - - [16/May/2011:08:44:09 -0400] "GET //scripts/setup.php HTTP/1.1" 404 302 "-" "Mozilla/4.0 (compatible; MSIE 6.0; Windows 98)"
85.114.135.121 - - [16/May/2011:08:44:09 -0400] "GET //admin/scripts/setup.php HTTP/1.1" 404 308 "-" "Mozilla/4.0 (compatible; MSIE 6.0; Windows 98)"
85.114.135.121 - - [16/May/2011:08:44:09 -0400] "GET //admin/pma/scripts/setup.php HTTP/1.1" 404 312 "-" "Mozilla/4.0 (compatible; MSIE 6.0; Windows 98)"
85.114.135.121 - - [16/May/2011:08:44:10 -0400] "GET //admin/phpmyadmin/scripts/setup.php HTTP/1.1" 404 319 "-" "Mozilla/4.0 (compatible; MSIE 6.0; Windows
85.114.135.121 - - [16/May/2011:08:44:10 -0400] "GET //db/scripts/setup.php HTTP/1.1" 404 305 "-" "Mozilla/4.0 (compatible; MSIE 6.0; Windows 98)"
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85.114.135.121 - - [16/May/2011:08:44:10 -0400] "GET //myadmin/scripts/setup.php HTTP/1.1" 404 310 "-" "Mozilla/4.0 (compatible; MSIE 6.0; Windows 98)"
85.114.135.121 - - [16/May/2011:08:44:10 -0400] "GET //mysql/scripts/setup.php HTTP/1.1" 404 308 "-" "Mozilla/4.0 (compatible; MSIE 6.0; Windows 98)"
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85.114.135.121 - - [16/May/2011:08:44:13 -0400] "GET //php-my-admin/scripts/setup.php HTTP/1.1" 404 315 "-" "Mozilla/4.0 (compatible; MSIE 6.0; Windows 98)"
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85.114.135.121 - - [16/May/2011:08:44:13 -0400] "GET //phpmyadmin/s
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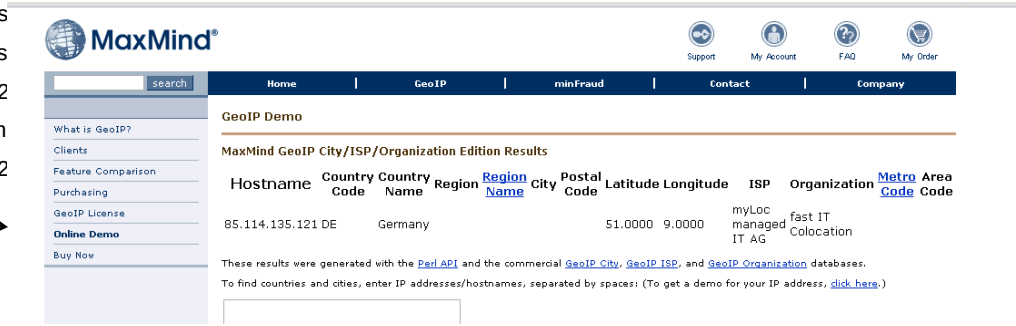

Databases and Spreadsheets

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Learning curve of spreadsheets is low, however search and query capability is extremely limited

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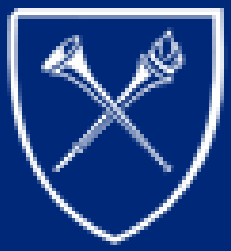

EMORY UNIVERSITY

Introduction to Data Management

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Center for Comprehensive Informatics
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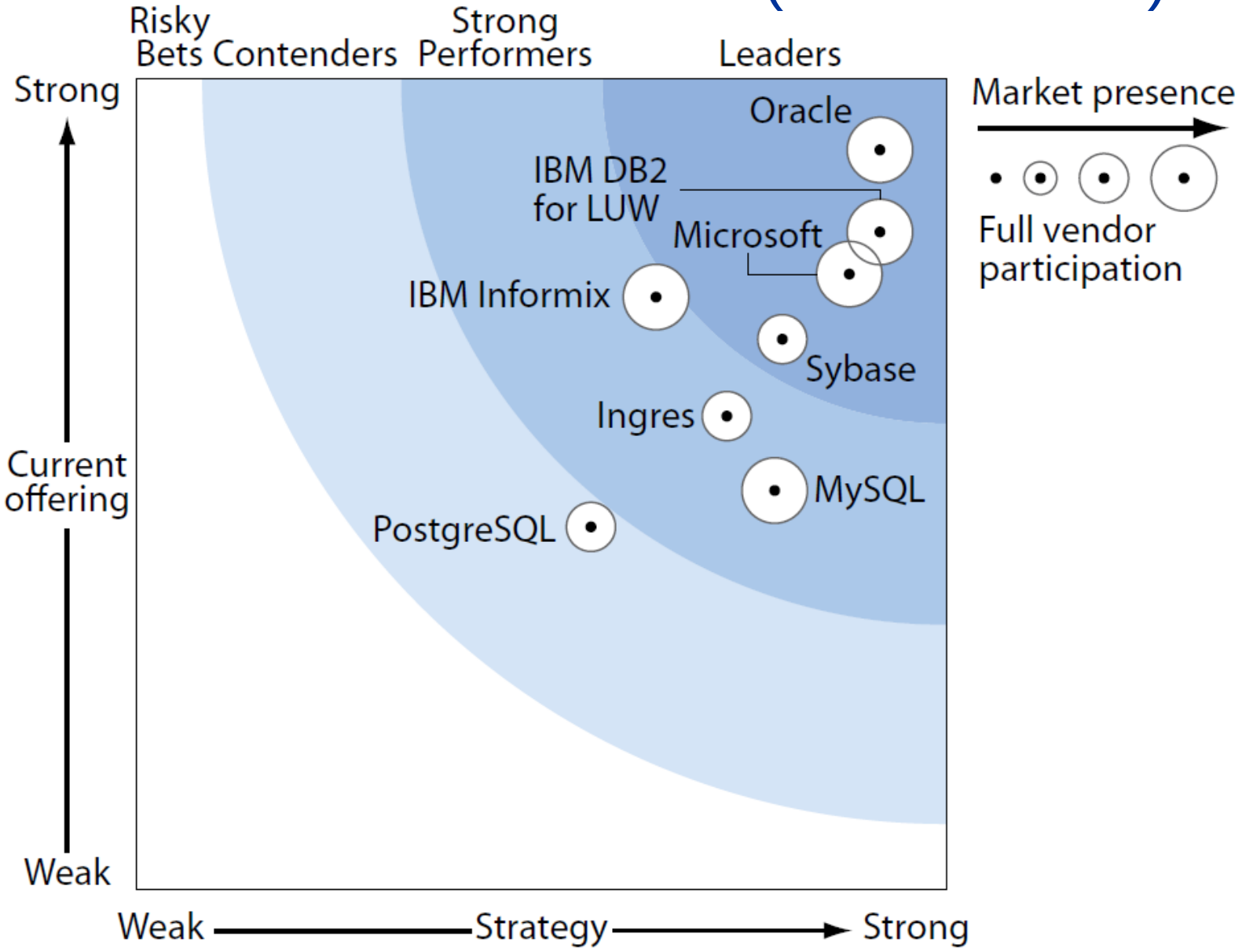
Why Databases?

- Data can be stored using multiple methods such as text files, comma delimited data files, spreadsheets, databases
- Benefits of using a database:
  - A standard interface for accessing data
  - Multiple users could simultaneously insert, update and delete data
  - Data could be changed without risk of losing data and its consistency
  - Efficiently handle huge volumes of data
  - Tools for data backup, restore and recovery
  - Security
  - Reduce redundancy
  - Data independence

Database Management Systems (DBMS)

- A Database Management System (DBMS) is a software system designed to store, manage, and facilitate access to databases
- A relational DBMS (RDBMS) is a DBMS that is based on the relational model
- Objectives of DBMS
  - Representing information: data modeling
  - declarative language for querying data: SQL, XQuery…
  - Efficient support of queries with access methods
  - Controlling concurrent access
  - Reliable data storage

The Current RDBMS Market (Forrester'09)

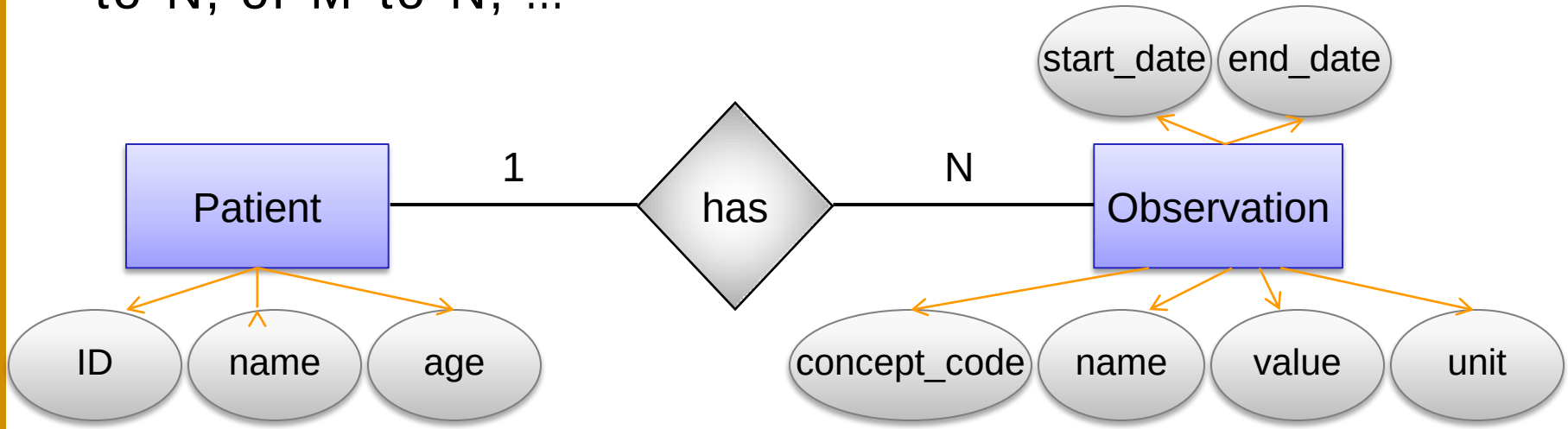


Data Model

- Define how data is to be represented, structured linked, and constrained
  - Independent of specific implementations and protocols
- Types of data models
  - Hierarchical model, network model
  - Relational model – invented by E. F. Codd from IBM
  - Entity Relational (ER) model
  - Object-oriented model
  - Semi-structured (XML) model
- Relational model
  - describes data as a collection of relations
  - Focuses on providing better data independence
  - Implemented by most DBMS in the market

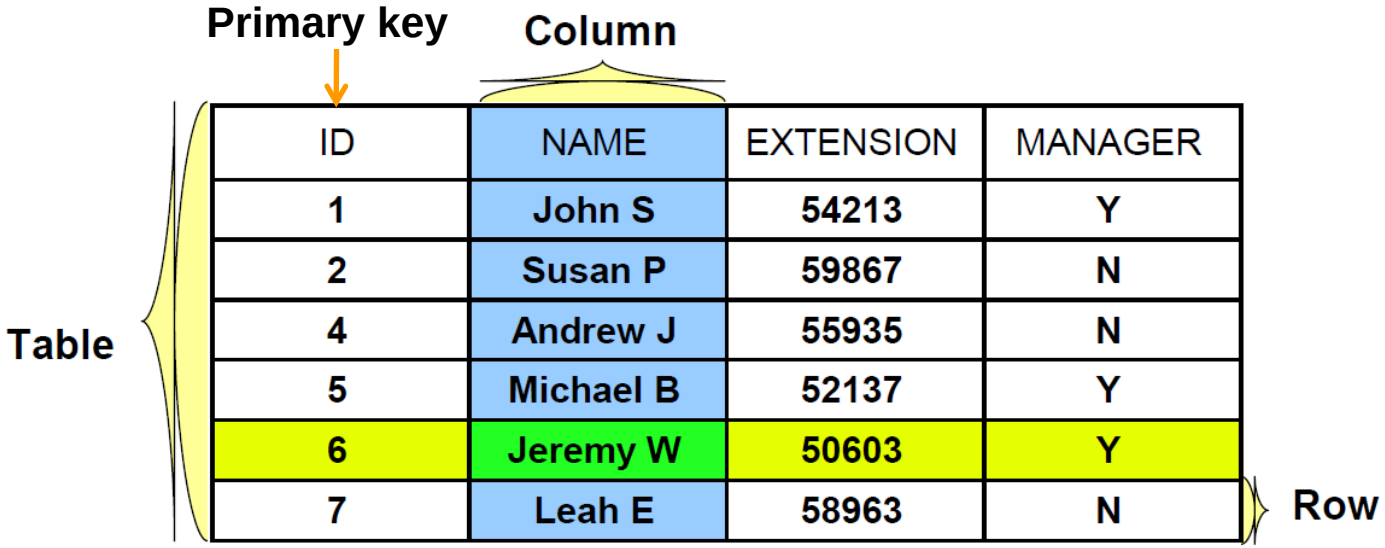
ER Model

- A popular conceptual model for database design
- A database be thought of a collection of instances of entities, independent of any other entities in the database
- Entities have attributes to characterize the entity
- There could be relationships between entities: 1-to-1, 1-to-N, or M-to-N, …



Relational Database with Relational Model

- A relational database is implemented based on relational data model
- Data stored in tables, consists of columns and rows
- Each column has a specific data type
- Constrained can be specified: primary key, uniqueness,...
- Relationships can be defined with foreign keys



ID	NAME	EXTENSION	MANAGER
1	John S	54213	Y
2	Susan P	59867	N
4	Andrew J	55935	N
5	Michael B	52137	Y
6	Jeremy W	50603	Y
7	Leah E	58963	N

SQL: Standard Language for RDBMS

- SQL (Structured Query Language) is the standard language of relational database access
- Multiple standard revisions and multiple flavors (implementations) exist
- Procedure SQL (PL/SQL, SQL PL, …) adds programming capabilities into SQL
- A SQL query is compiled and executed by the DBMS engine and the result is sent to the client
- Many approaches to optimize SQL query performance: indexes, parallel disk readings, normalization, etc.

SQL (2)

- Data Definition Language (DDL), defines properties of data objects. e.g. creation of a table:

```
CREATE TABLE OBSERVATION_FACT (
   EONCOUNTER_NO INTEGER NOT NULL,
   PATIENT_ID    INTEGER,
   AGE           INTEGER,
   CONCEPT_CODE  VARCHAR(50),
   NAME          VARCHAR(50),
   VALUE         VARCHAR(50),
PRIMARY KEY(ENCOUNTER_NO, CONCEPT_CODE) );
```

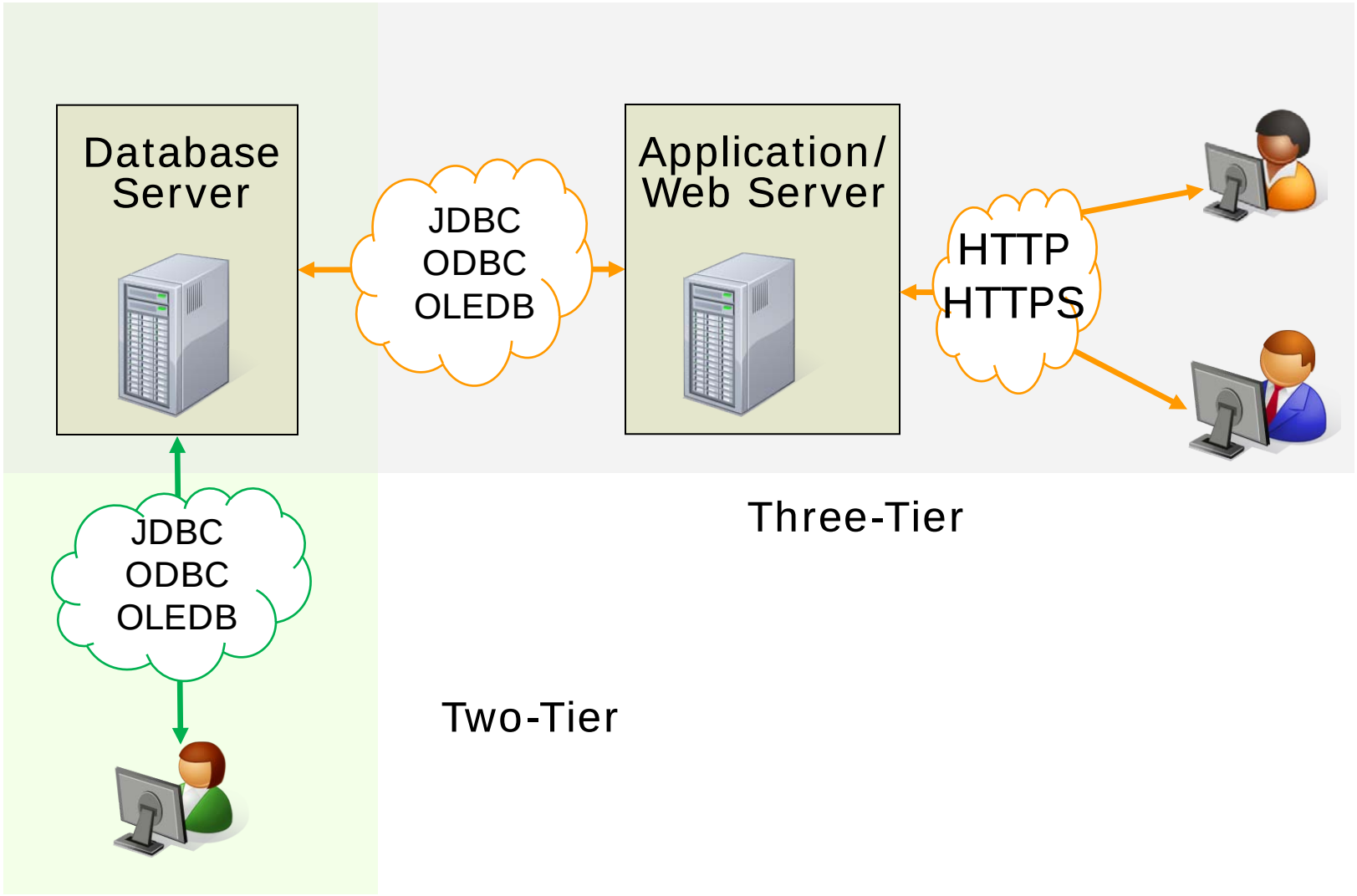
- Data manipulation language (DML): retrieve, insert, update and delete data

```
SELECT AGE, COUNT(*) FROM OBSERVATION_FACT
WHERE NAME ='CHEST PAIN'
GROUP BY AGE
ORDER BY AGE
```

Reliable Storage and High Availability

- Problems could happen: system outage, transaction failure, disk failure, disaster
- Backup/restore: DBMS tracks changes as logs, thus recovery is possible when failure happens
  - Full snapshot backup
  - Incremental backup: only changes since last successful full backup
  - Restore: rebuild database from backups + logs
- High availability: eliminate or minimize downtime
  - Creating and maintaining replica versions of database
  - Failover takes place when disaster happens

Access of Databases



Data Exchange: XML

- The e**X**tensive **M**arkup **L**anguage (XML) defines a generic syntax used to mark up data with simple, human-readable tags
- Standard language for data exchange over the Web
- HL7 CDA messaging in XML
- Data can be published directly in XML from DBMS

```
<component>
   <section>
      <templateId root="1.3.6.1.4.1.19376.1.5.3.1.3.4"/>
      <code code="10164-2" displayName="History of present illness"
            codeSystem="2.16.840.1.113883.6.1" codeSystemName="LOINC"/>
      <title> History of present illness </title>
      <text>Carcinoma of breast. Post operative diagnosis: same. left UOQ
breast mass. </text>
   </section>
</component>
```

Specialized DBMSs

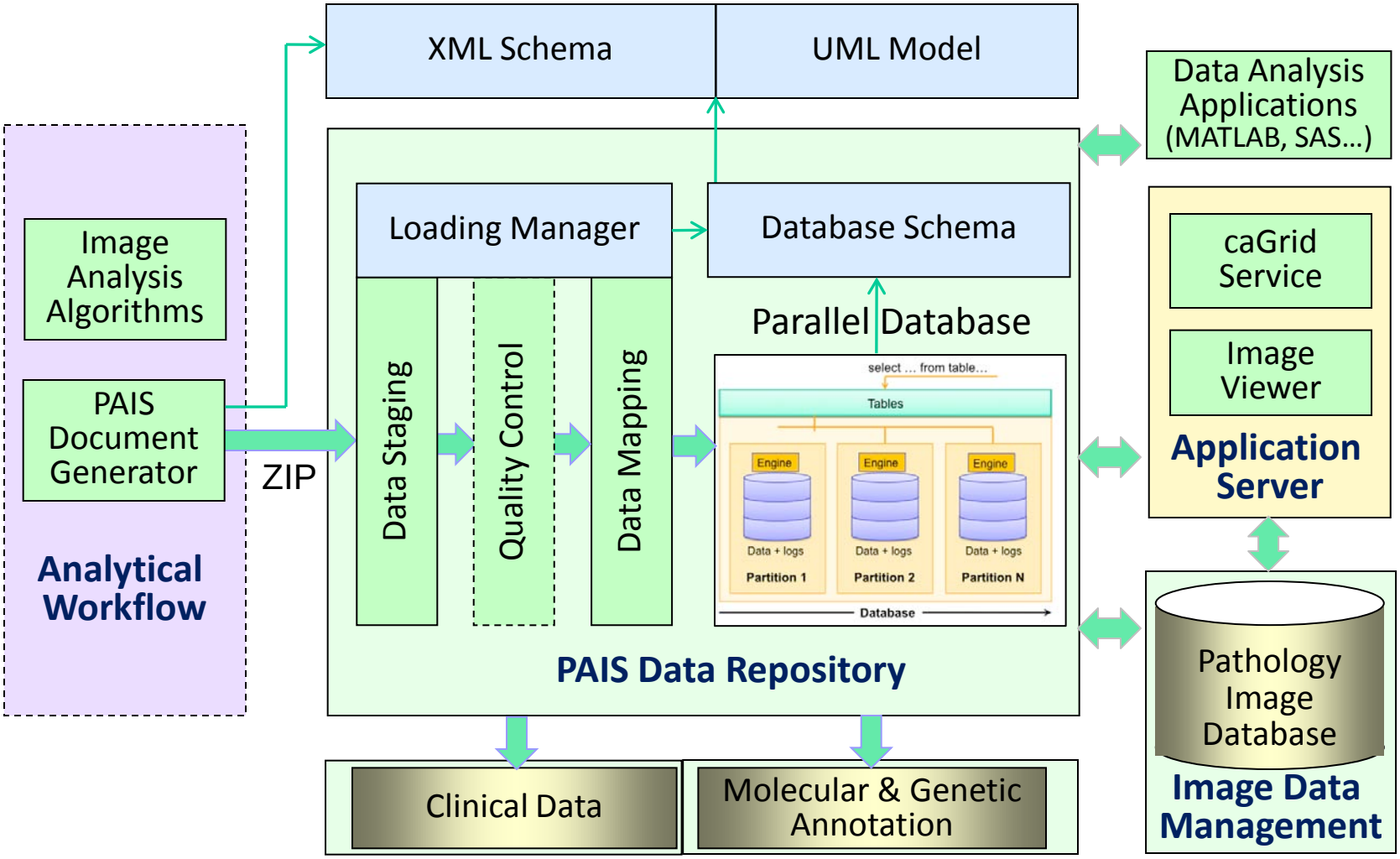
Special data models/data types/queries:

- XML DBMS: manage XML data directly in XML model and query language
  - e.g.: DB2 pureXML, Oracle XML DB
- Spatial DBMS: manage location related information. E.g., find patients located within 10 miles radius
  - e.g.: Oracle Spatial, ArchGIS, DB2 Spatial
- Temporal DBMS: manage temporal oriented information. e.g.: what drugs have been prescribed with Proventil?
  - TeraData, DB2 TemporalDB

Parallel DBMS: use data partitioning and parallel data access to increase I/O bandwidth for scalability

– Oracle RAC, DB2 DPF, DB2 pureScale, TeraData

Example Database: PAIS



Questions?