Database Management Systems
Session 3

Instructor: Vinnie Costa
vcosta@optonline.net

The Entity-Relationship Model

Chapter 2 - Redux

How To Design A Database - In Six "Easy" Steps!

1. Requirements Analysis
2. Conceptual Database Design
3. Logical Design
4. Schema Refinement
5. Physical Database Design
6. Application And Security Design

Requirements Analysis

- This is the most difficult step
- Source of most problems
- What does the user want?
- Discussions, study of current environment, expectations (need to be managed), history, resources available, etc.
- Elicitation Methodologies
- Bit of an art form

Conceptual Database Design

- High-level description of data to be stored…
- … and constraints over the data
- Diagrams – semantic data model
  - What are the *entities* and *relationships* in the enterprise?
  - What information about these entities and relationships should we store in the database?
  - What are the *integrity constraints* or *business rules* that hold?
  - A database `schema' in the ER Model can be represented pictorially (*ER diagrams*).
- Can map an ER diagram into a relational schema[1]

(1) DBDesigner4 – excellent tool to translate ER Model in MySQL tables

Logical Database Design

- Choose a DBMS – we use Relational Only
- Convert the ER schema into a relational database schema
- Result is a conceptual schema also called the **logical schema**

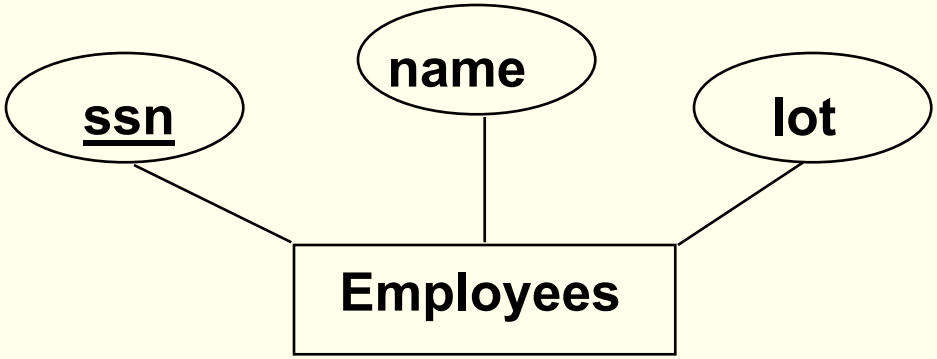
The "Systems" Steps

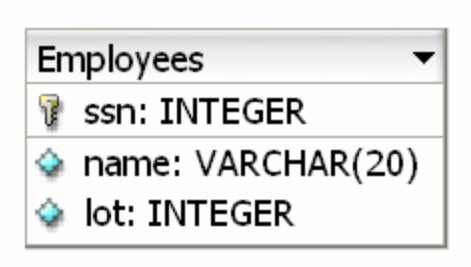
- **Schema Refinement** – identify problems and refine the schema – eliminate redundancy through **normalization**
- **Physical Database Design** – workload analysis, scaling, indexing and clustering of tables, database tuning
- **Application and Security Design** – the "big" picture in design, workflow, role based security, transparency

ER Model Basics

- ***Entity:*** Real-world object distinguishable from other objects. An entity is described (in DB) using a set of ***attributes***.
- ***Entity Set***: A collection of similar entities. E.g., all employees.
  - All entities in an entity set have the same set of attributes.
  - Each entity set has a ***key***.
  - Each attribute has a ***domain***.

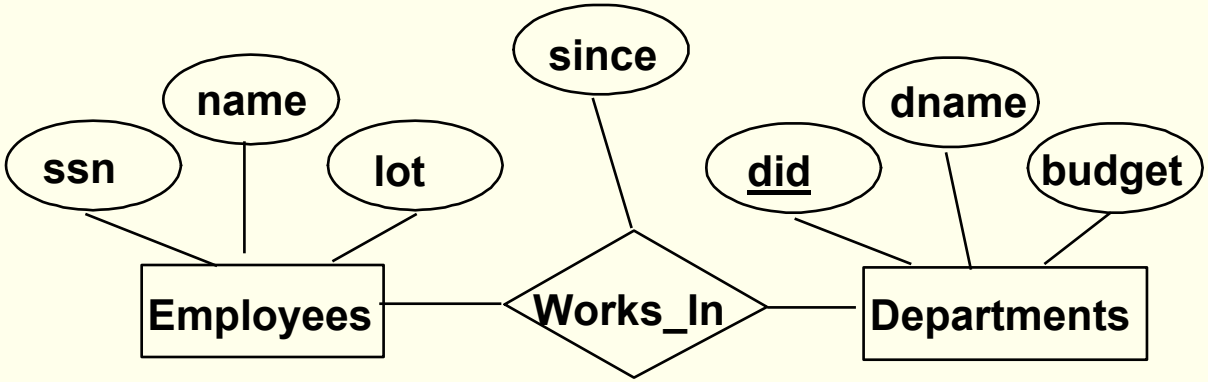
ER Model Basics





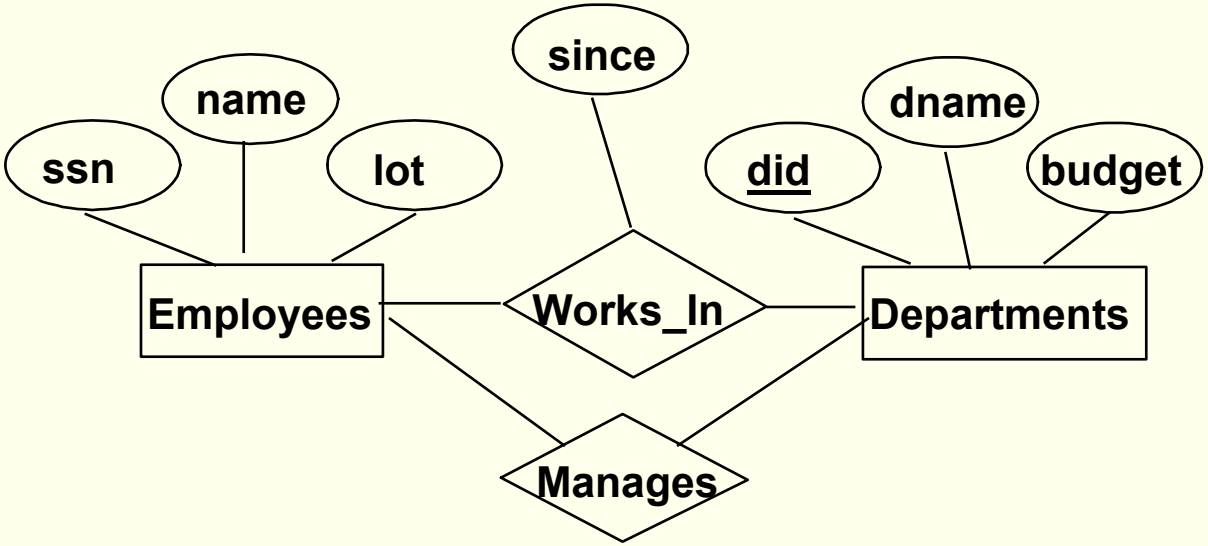
ssn	name	lot
123-22-3666	Attishoo	48
231-31-5368	Smiley	22
131-24-3650	Smethurst	35

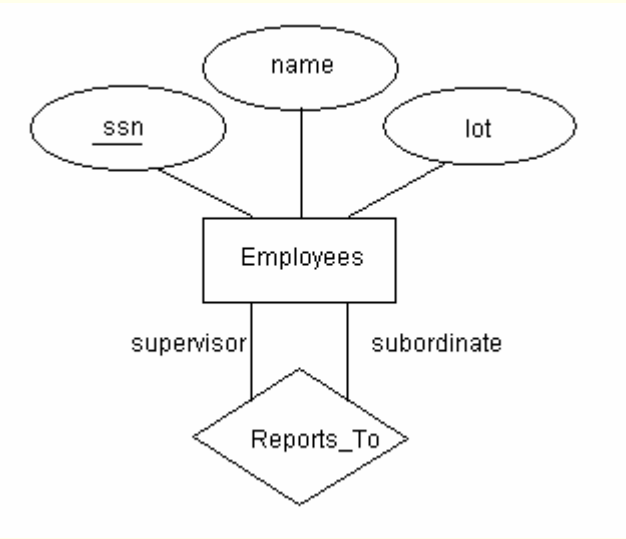
ER Model Basics



- **Relationship -** Association among two or more entities. e.g., Attishoo works in the Pharmacy department.
- This can be viewed as a **set** of **2-tuples**:
  $\{(e_1,e_2) \mid e_1 \in E_1, e_2 \in E_2\}$
- In other words, Works_In = {(e,d) | e ∈ Employees, d ∈ Departments}
- Works_In = {(Attishoo, Pharmacy), (Pat, Hardware), (Sue, Automotive), …}
- This can also be called a **Relationship Set**

ER Model Basics

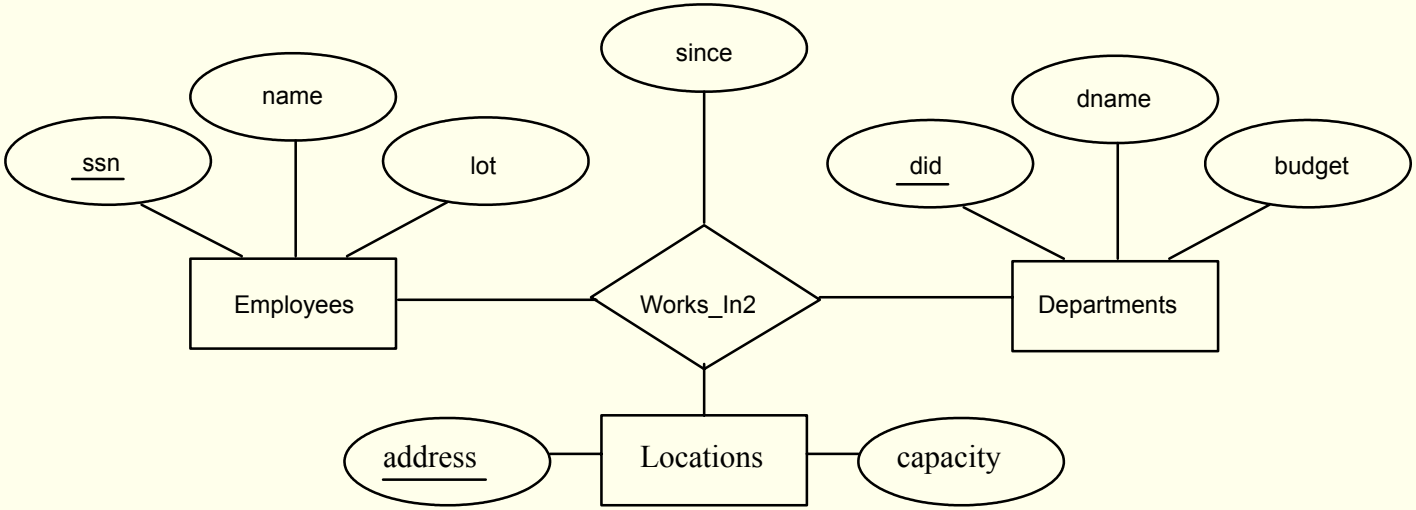




- **Relationship Set** - Collection of similar relationships.
  - An n-ary relationship set R relates n entity sets E1 ... En; each relationship in R involves entities $e_1 \in E_1$, ..., $e_n \in E_n$
  - Same entity set could participate in different relationship sets, or in different "roles" in same set. **supervisor** and **subordinate** are **role indicators**

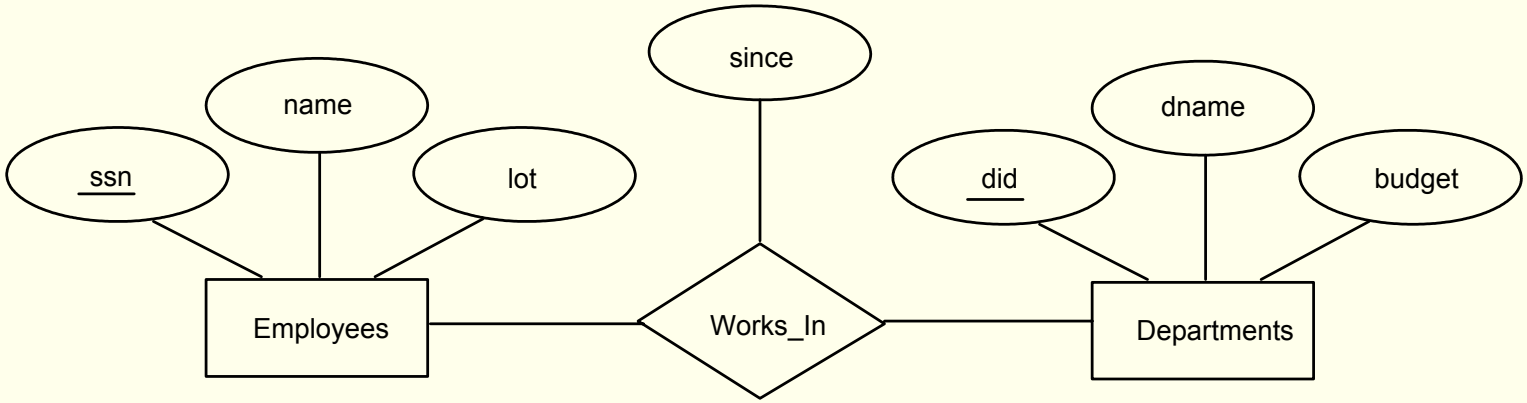
ER Model Basic

- An **instance** is a snapshot of the relationship set at some instant in time.
- Suppose each department has offices in several locations, then we can record an association between an employee, a department, and a location – a 3-tuple. This would be a **ternary** relationship.

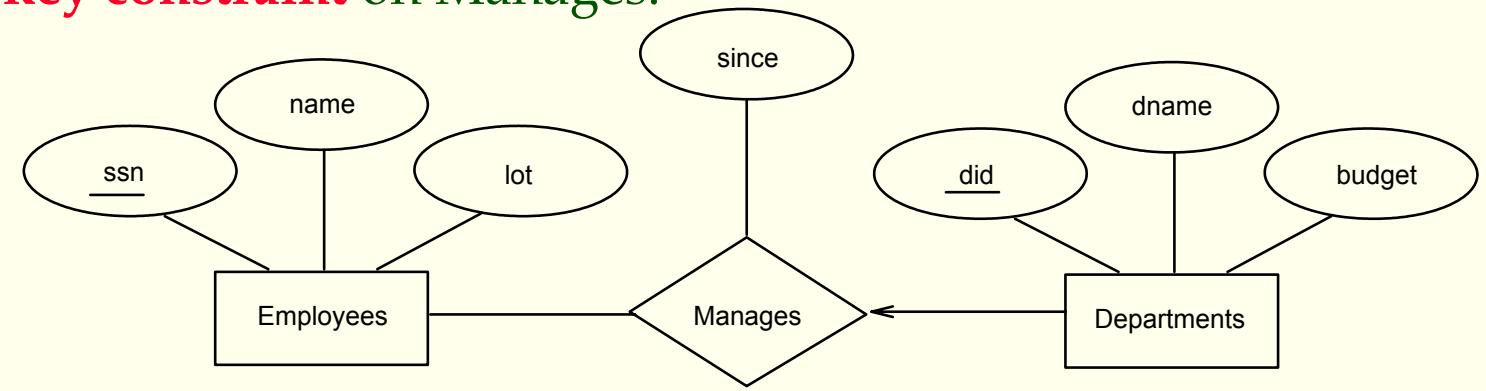


ER Model Features – Key Constraints

- Consider Works_In: An employee can work in many departments; a dept can have many employees.

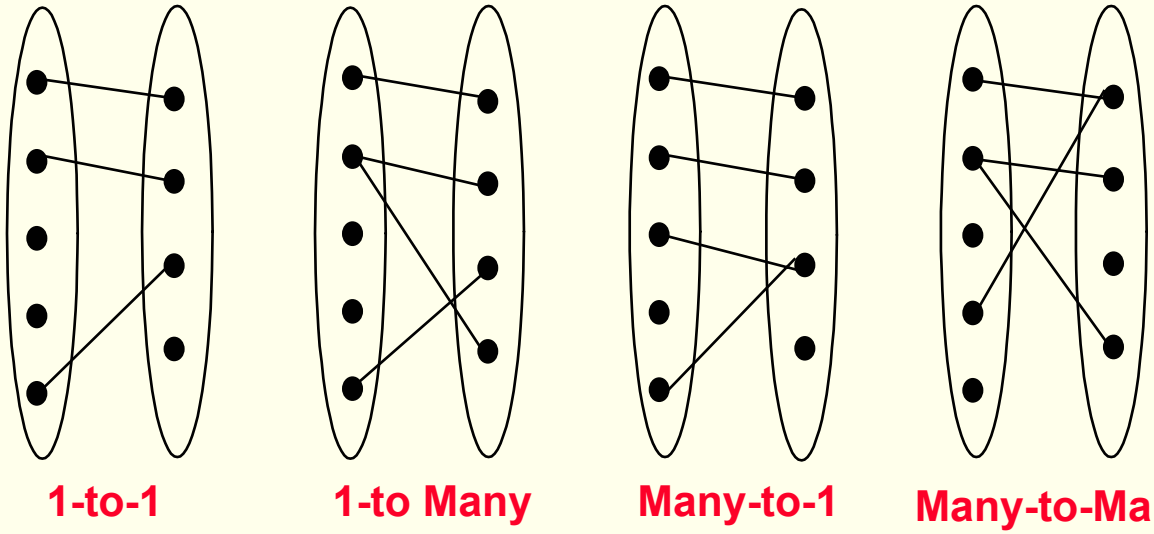


- In contrast, each dept has at most one manager, according to the **key constraint** on Manages.



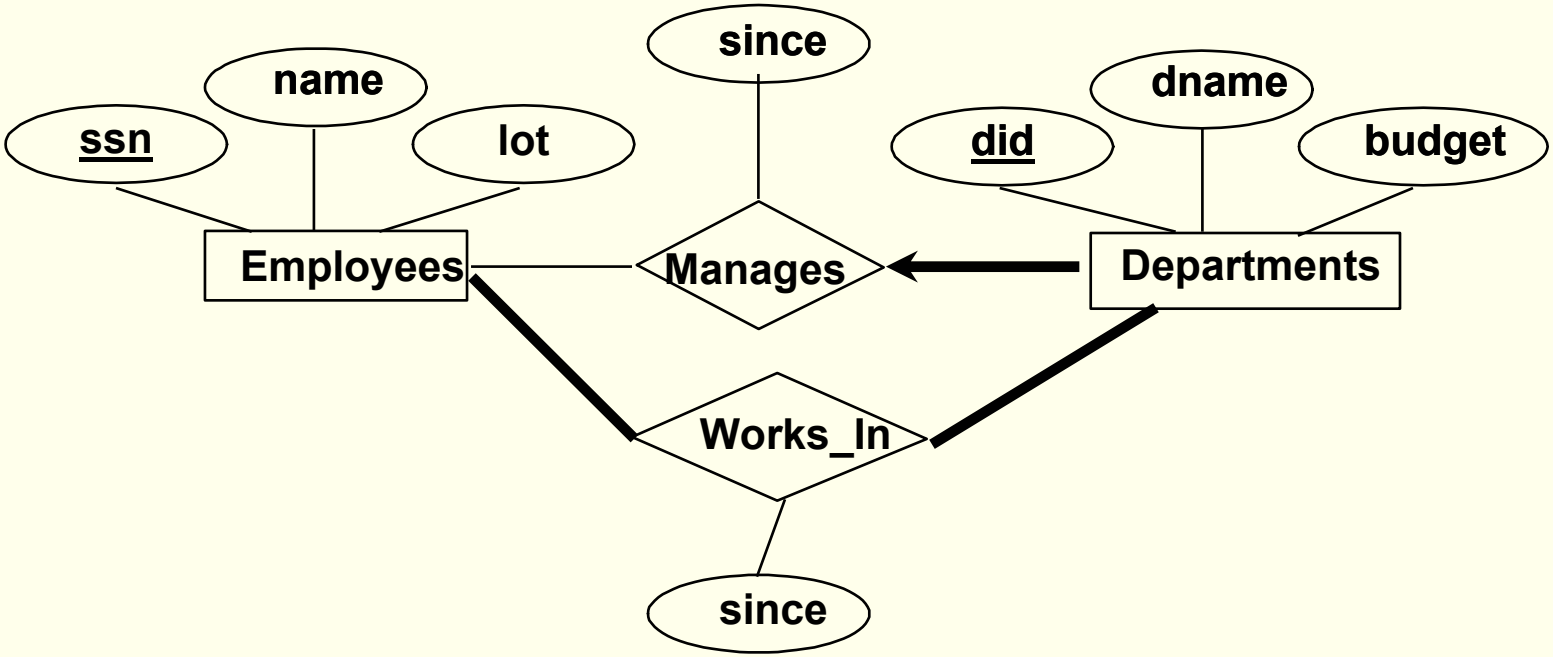
ER Model Features – Key Constraints

- Relationship set like **Manages** is said to be **one-to-many**: *one* employee can be associated with *many* departments
- In Contrast, **Works_In**, where an employee is allowed to work in several departments and a department is allowed to have several employees is said to be **many-to-many**



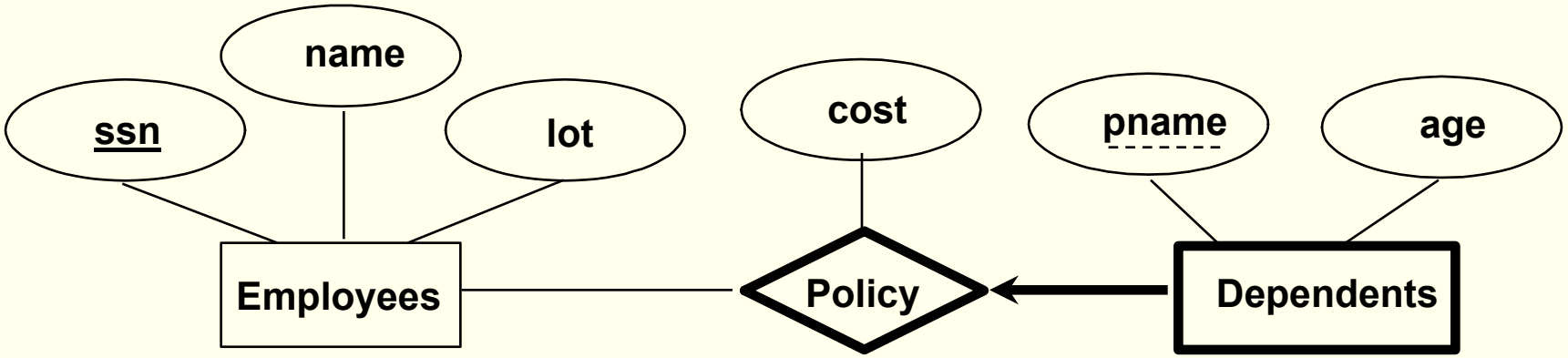
ER Model - Participation Constraints

- Does every department have a manager?
- If so, this is a **participation constraint**: the participation of Departments in Manages is said to be **total** (vs. **partial**).
  - Every Departments entity must appear in an instance of the Manages relationship.
- **Thick line** indicates **total** participation



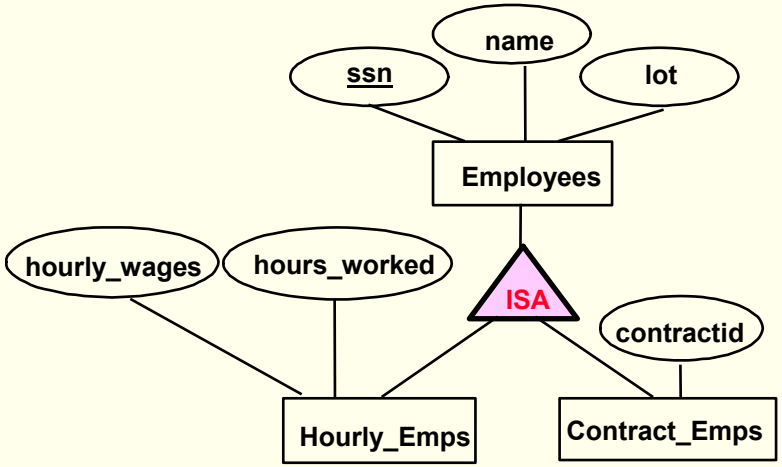
ER Model Features - Weak Entities

- A **weak entity** can be identified uniquely only by considering the primary key of another (**owner**) entity.
- Owner entity set and weak entity set must participate in a one-to-many relationship set (one owner, many weak entities).
- Weak entity set must have total participation in this **identifying relationship** set.
- pname is a **partial key** for the weak entity set
- Dependents is a weak entity and Policy is its identifying relationship. This is indicated by a **thick black line**



ER Model – Class Hierarchies

- It is natural to classify the entities in an entity set into subclasses
- **Hourly_Emps** and **Contract_Emps** **inherit** the attributes of the entity set **Employees**
- If we declare A **ISA** B, every A entity is also considered to be a B entity, i.e., Hourly_Emps **ISA** Employees
- We could add a second ISA node for **Senior_Emps**



ER Model – Class Hierarchies

Two ways to view class hierarchies:

- Employees is **specialized** into subclasses – identify subsets of an entity set (the **superclass**) that share some distinguishing characteristic (top-down)
- Hourly_Emps and Contract_Emps are **generalized** by Employee – create new entity that has common characteristics of the subclasses (bottom-up)

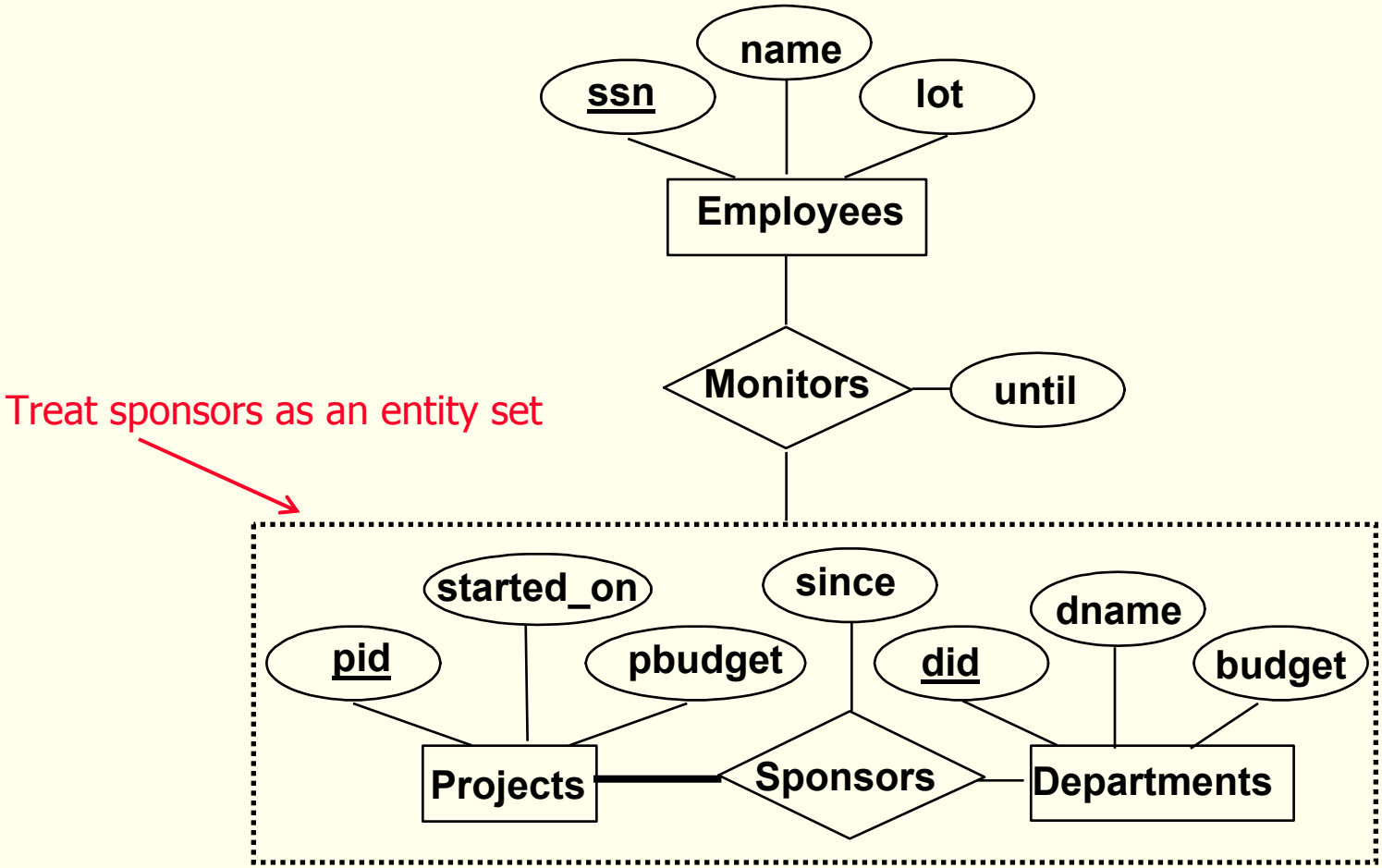
Two kinds of constraint:

- **Overlap** – do two subclasses contain the same entity? Assume **no**, otherwise write '___ OVERLAPS ___'
- **Covering** – do the entities in the subclasses collectively include all the entities in the superclass? Assume **no**, otherwise write '___ AND ___ COVER ___'

ER Model - Aggregation

- Used when we have to model a relationship involving **entitity sets** and a **relationship set** (instead of another entityset).
- **Aggregation** allows us to treat a relationship set as an entity set for purposes of participation in (other) relationships.
- Used to express a relationship among relationships
- *Aggregation vs. ternary relationship*: Could we make Sponsors a ternary relationship?
  - Monitors is a distinct relationship, with a descriptive attribute (until) and Sponsors has a unique attribute (since)
  - Also, we can say that each sponsorship is monitored by at most one employee

ER Model - Aggregation



Conceptual Design Using the ER Model

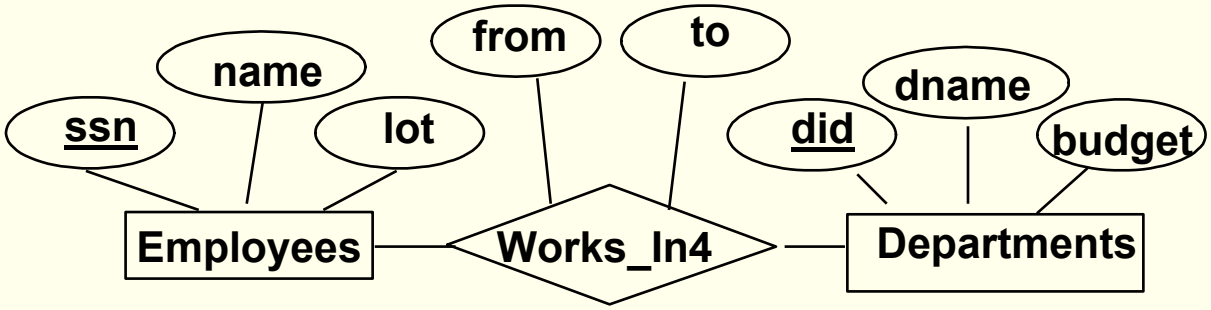
- **Design choices:**
  - Should a concept be modeled as an **entity** or an **attribute**?
  - Should a concept be modeled as an **entity** or a **relationship**?
  - Identifying relationships: **Binary** or **ternary**? **Aggregation**?
- Constraints in the ER Model:
  - A lot of data semantics can (and should) be captured.
  - But **some constraints cannot be captured** in ER diagrams.

Entity vs. Attribute

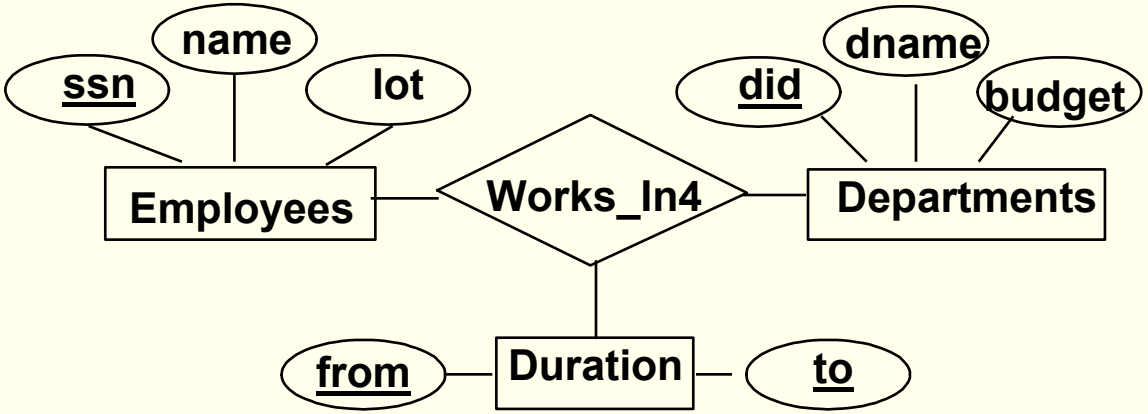
- Should ***address*** be an attribute of Employees or an entity (connected to Employees by a relationship)?
- Depends upon the use we want to make of address information, and the semantics of the data:
  - If we have several addresses per employee, *address* must be an entity
  - If the structure (city, street, etc.) is important, e.g., we want to retrieve employees in a given city, *address* must be modeled as an entity (since attribute values are atomic).

Entity vs. Attribute (Contd.)

- Works_In4 does not allow an employee to work in a department for two or more periods.

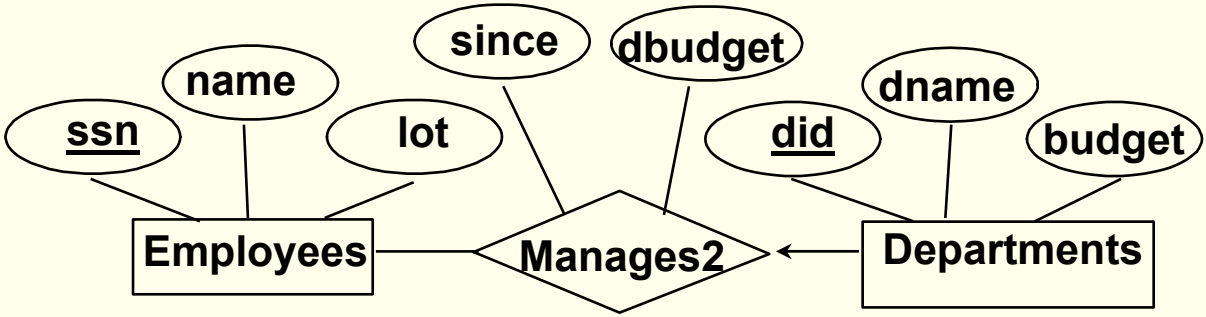


- Similar to the problem of wanting to record several addresses for an employee: We want to record *several values of the descriptive attributes for each instance of this relationship.* Accomplished by introducing new entity set, Duration.

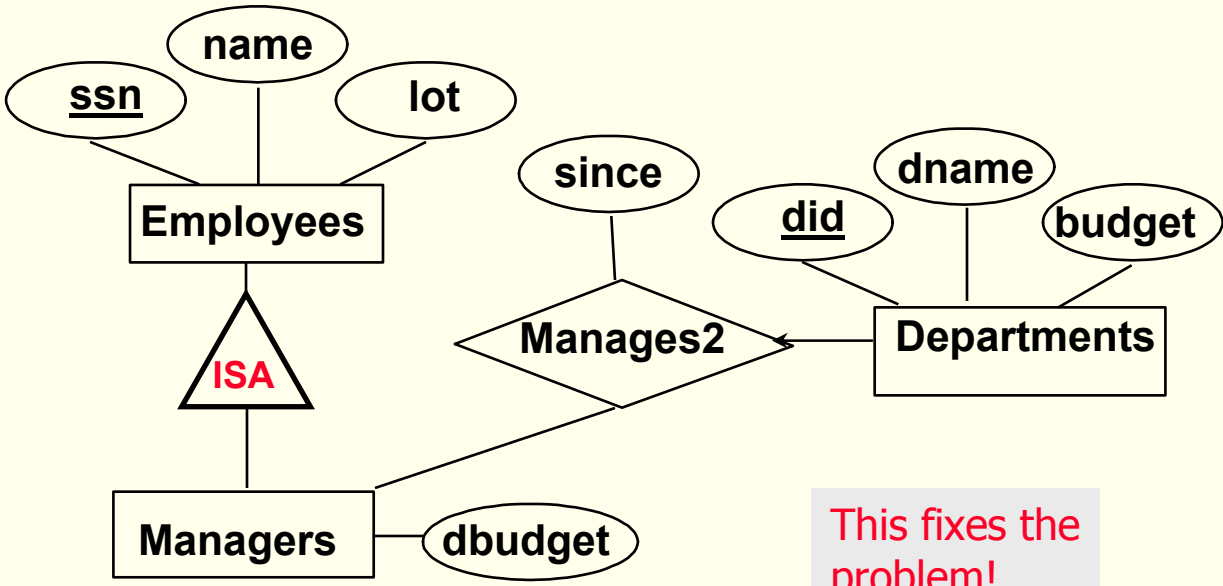


Entity vs. Relationship

- First ER diagram OK if a manager gets a separate discretionary budget for each dept



- What if a manager gets a discretionary budget that covers *all* managed depts?
  - **Redundancy** - *dbudget* stored for each dept managed by manager
  - **Misleading** - Suggests *dbudget* associated with department-mgr combination

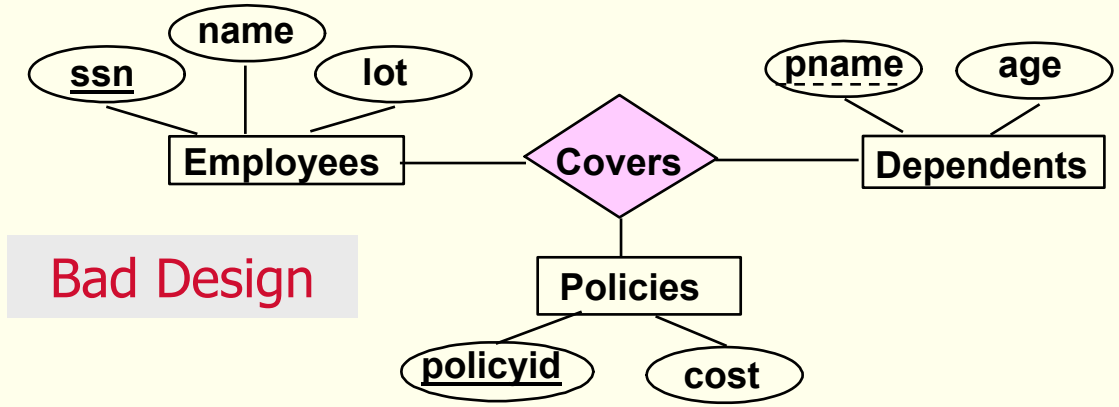


This fixes the problem!

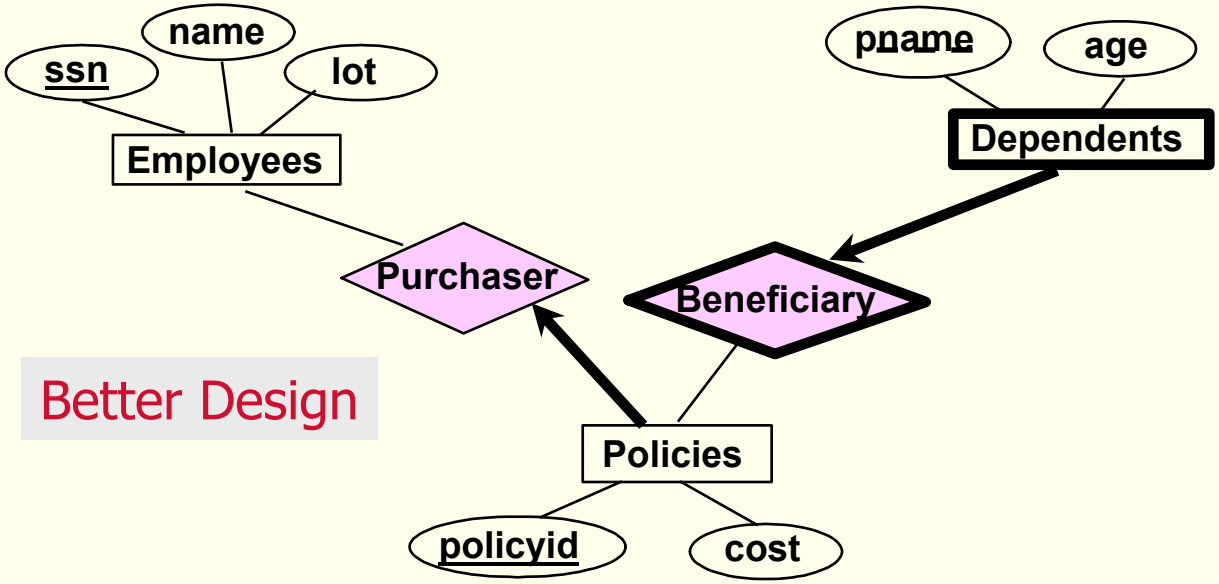
Binary vs. Ternary Relationships

- If each policy is owned by just 1 employee, and each dependent is tied to the covering policy, first diagram is inaccurate

- What are the **additional constraints** in the 2nd diagram?



Bad Design



Better Design

Binary vs. Ternary Relationships (Contd.)

- Previous example illustrated a case when two binary relationships were better than one ternary relationship

- An example in the other direction: a ternary relation **Contracts** relates entity sets Parts, Departments and **Suppliers**, and has descriptive attribute *qty*. No combination of binary relationships is an adequate substitute:
  - S "can-supply" P, D "needs" P, and D "deals-with" S does not imply that D has agreed to buy P from S.
  - How do we record *qty*?

Summary of Conceptual Design

- **Conceptual design** follows **requirements analysis**,
  - Yields a high-level description of data to be stored
- **ER model popular** for conceptual design
  - Constructs are expressive, close to the way people think about their applications
- **Basic constructs**: **entities**, **relationships**, and **attributes** (of entities and relationships)
- Some **additional constructs**: **weak entities**, **ISA hierarchies**, and **aggregation**
- Note: There are many variations on ER model.

Summary of ER (Contd.)

- Several kinds of **integrity constraints** can be expressed in the ER model: **key constraints**, **participation constraints**, and **overlap/covering constraints** for ISA hierarchies. Some **foreign key constraints** are also implicit in the definition of a relationship set
- Some constraints (notably, **functional dependencies**) **cannot** be expressed in the ER model
- Constraints play an important role in determining the best database design for an enterprise

Summary of ER (Contd.)

- ER design is ***subjective***. There are often many ways to model a given scenario! Analyzing alternatives can be tricky, especially for a large enterprise. Common choices include:
  - **Entity** vs. **attribute**, **entity** vs. **relationship**, **binary** or **n-ary relationship**, whether or not to use **ISA hierarchies**, and whether or not to use **aggregation**

- **To ensure good database design:** resulting relational schema should be analyzed and refined further. FD information and normalization techniques are especially useful

Useful Websites

- http://www.omg.org/ - information about UML
- Edgar (Ted) Codd – biographical sketch
- Modeling Tools – good list of available tools – checkout: DIA, ERwin, DBDesigner4, SmartDraw

Homework

- Read Chapter Two
- Exercises p.52: 2.1, 2.2 (1-5)

Exercise 2.1

- Explain the following terms briefly: *attribute, domain, entity, relationship, entity set, relationship set, one-to-many relationship, many-to-many relationship, participation constraint, overlap constraint, covering constraint, weak entity set, aggregation*, and *role indicator*.

Exercise 1.1

- *Attribute* - a property or description of an entity. A toy department employee entity could have attributes describing the employee's name, salary, and years of service.
- *Domain* - a set of possible values for an attribute.
- *Entity* - an object in the real world that is distinguishable from other objects.
- *Relationship* - an association among two or more entities.
- *Entity set* - a collection of similar entities such as all of the toys in the toy department.
- *Relationship set* - a collection of similar relationships
- *One-to-many relationship* - a key constraint that indicates that one entity can be associated with many of another entity. An example of a one-to-many relationship is when an employee can work for only one department, and a department can have many employees.

Exercise 1.1

- *Many-to-many relationship* - a key constraint that indicates that many of one entity can be associated with many of another entity. An example of a many-to-many relationship is employees and their hobbies: a person can have many different hobbies, and many people can have the same hobby.
- *Participation constraint* - a participation constraint determines whether relationships must involve certain entities. An example is if every department entity has a manager entity. Participation constraints can either be total or partial. A total participation constraint says that every department has a manager. A partial participation constraint says that every employee does not have to be a manager.
- *Overlap constraint* - within an ISA hierarchy, an overlap constraint determines whether or not two subclasses can contain the same entity.
- *Covering constraint* - within an ISA hierarchy, a covering constraint determines whether the entities in the subclasses collectively include all entities in the superclass. For example, with an Employees entity set with subclasses HourlyEmployee and SalaryEmployee, does every Employee entity necessarily have to be within either HourlyEmployee or SalaryEmployee?

Exercise 1.1

- *Covering constraint* - within an ISA hierarchy, a covering constraint determines whether the entities in the subclasses collectively include all entities in the superclass. For example, with an Employees entity set with subclasses HourlyEmployee and SalaryEmployee, does every Employee entity necessarily have to be within either HourlyEmployee or SalaryEmployee?
- *Weak entity set* - an entity that cannot be identified uniquely without considering some primary key attributes of another identifying owner entity. An example is including Dependent information for employees for insurance purposes.
- *Aggregation* - a feature of the entity relationship model that allows a relationship set to participate in another relationship set. This is indicated on an ER diagram by drawing a dashed box around the aggregation.
- *Role indicator* - If an entity set plays more than one role, role indicators describe the different purpose in the relationship. An example is a single Employee entity set with a relation Reports-To that relates supervisors and subordinates.

Exercise 2.2

A university database contains information about professors (identified by social security number, or SSN) and courses (identified by courseid). Professors teach courses; each of the following situations concerns the Teaches relationship set. For each situation, draw an ER diagram that describes it (assuming no further constraints hold).

1. Professors can teach the same course in several semesters, and each offering must be recorded.
2. Professors can teach the same course in several semesters, and only the most recent such offering needs to be recorded. (Assume this condition applies in all subsequent questions.)
3. Every professor must teach some course.
4. Every professor teaches exactly one course (no more, no less).
5. Every professor teaches exactly one course (no more, no less), and every course must be taught by some professor.

Exercise 2.2

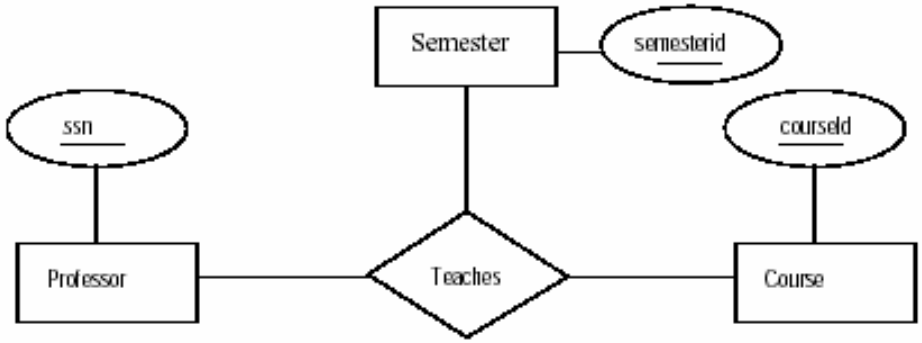


Figure 2.1 ER Diagram for Exercise 2.2, Part 1

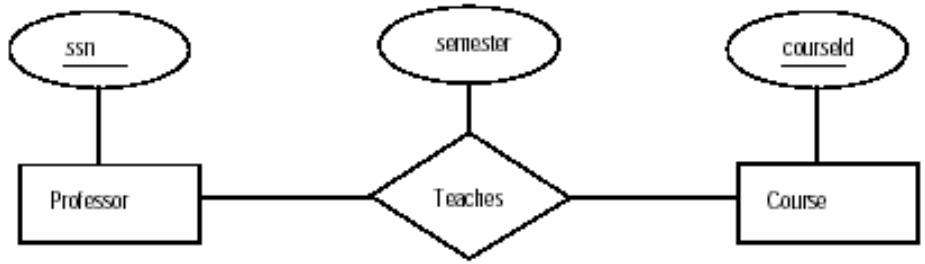


Figure 2.2 ER Diagram for Exercise 2.2, Part 2

Exercise 2.2

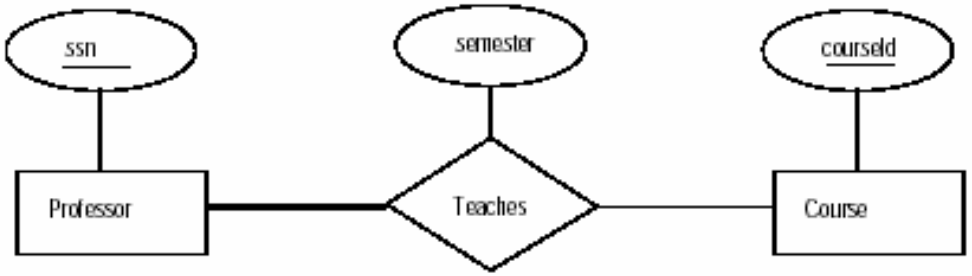


Figure 2.3 ER Diagram for Exercise 2.2, Part 3

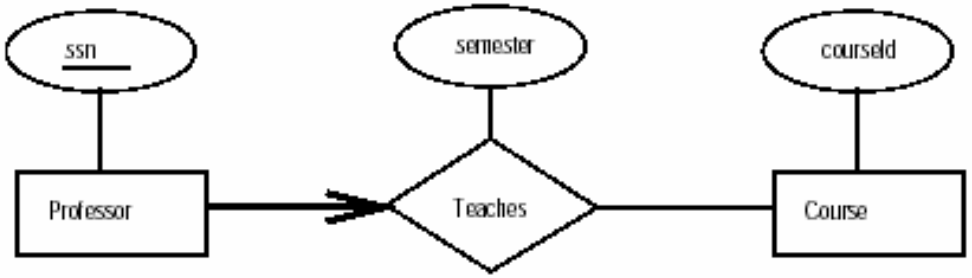


Figure 2.4 ER Diagram for Exercise 2.2, Part 4

Exercise 2.2

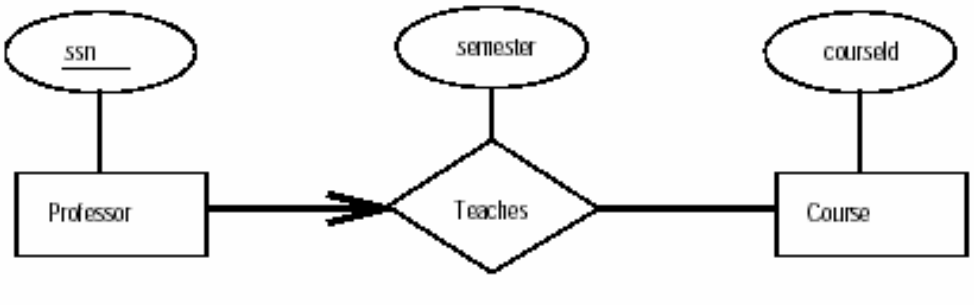


Figure 2.5 ER Diagram for Exercise 2.2, Part 5

Term Paper

- Due Saturday, Oct 8
- Should be about 3-4 pages (9 or 10 font)
- This should be an opportunity to ***explore*** a selected area
- **Please submit your topics!!!**

Practicum

- Install Apache
- Install Nvu
- …on our way to WAMP!!!

Apache

- 

- httpd.apache.org

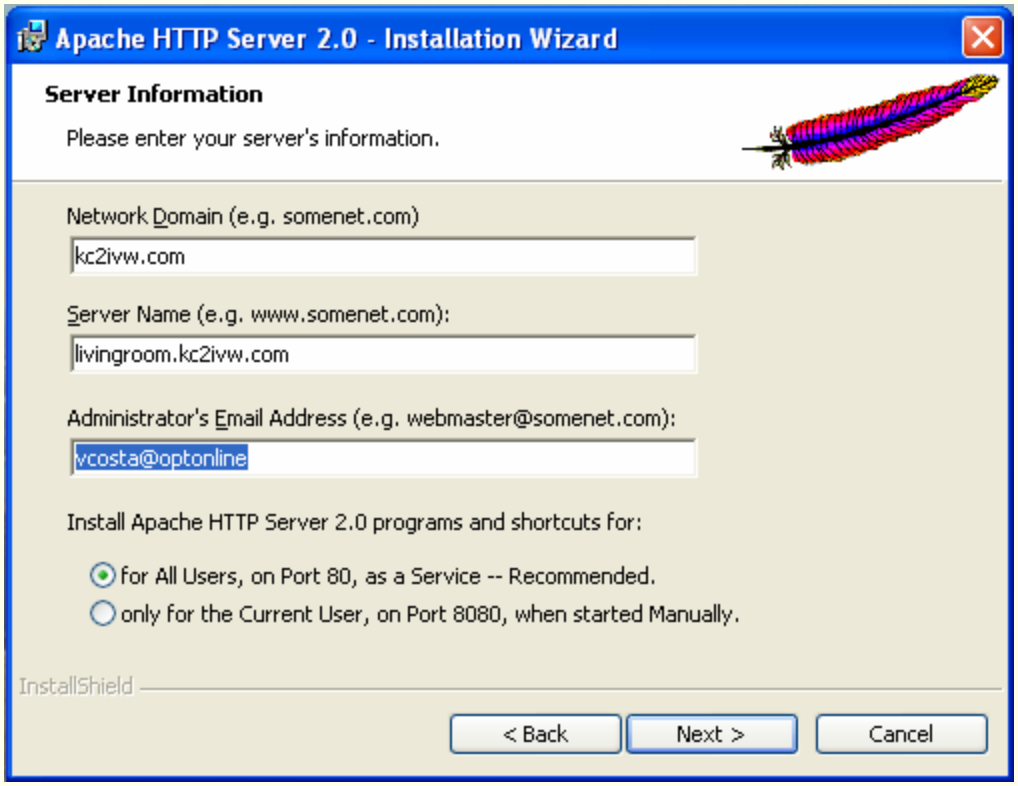
- The Apache HTTP Server Project is an effort to develop and maintain an open-source HTTP server for modern operating systems including UNIX and Windows NT. The goal of this project is to provide a secure, efficient and extensible server that provides HTTP services in sync with the current HTTP standards.

- Apache has been the **most popular web server on the Internet since April of 1996**. More than 68% of the web sites on the Internet are using Apache, thus making it more widely used than all other web servers combined.

Install Apache

- http://httpd.apache.org/docs/2.0/platform/windows.html
- Installing apache is easy if you download the Microsoft Installer (.msi) package. Just double click on the icon to run the installation wizard. Click next until you see the Server Information window. You can enter localhost for both the Network Domain and Server Name. As for the administrator's email address you can enter anything you want.
- If using Windows XP, installed Apache as Service so every time I start Windows Apache is automatically started.

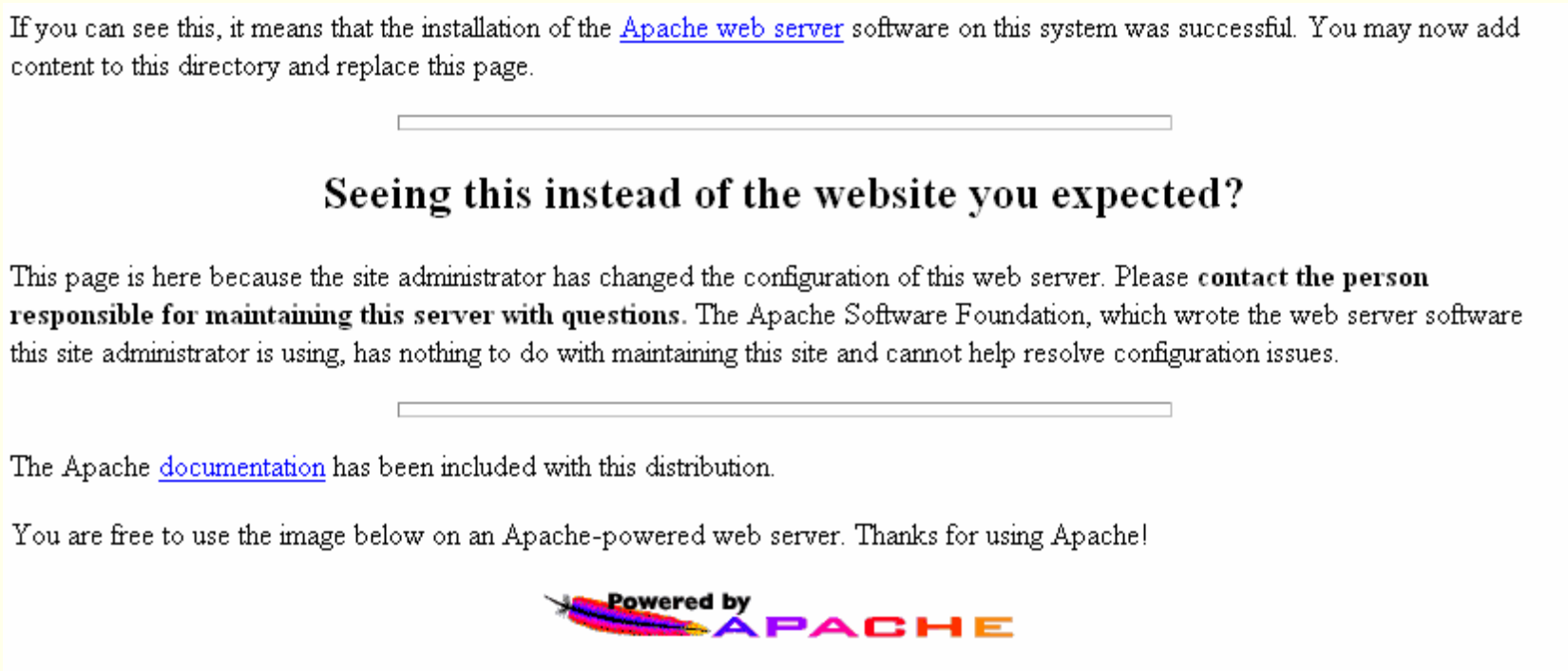
Installing Apache



- Click the **Next** button and choose **Typical installation**. Click Next one more time and choose where you want to install Apache (I installed it in the default location C:\Program Files\Apache Group). Click the Next button and then the Install button to complete the installation process.

Installing Apache

- To see if you Apache installation was successful open up you browser and type http://localhost (or http://127.0.0.1) in the address bar. You should see something like this :



Installing Apache

- By default Apache's **document root** is set to **htdocs** directory. The document root is where you must put all your PHP or HTML files so it will be process by Apache (and can be seen through a web browser). Of course you can change it to point to any directory you want. The configuration file for Apache is stored in `C:\Program Files\Apache Group\Apache2\conf\httpd.conf` (assuming you installed Apache in `C:\Program Files\Apache Group`) . It's just a plain text file so you can use Notepad to edit it.
- For example, if you want to put all your PHP or HTML files in `C:\www` just find this line in the `httpd.conf` :

  ```
  DocumentRoot "C:/Program Files/Apache Group/Apache2/htdocs"
  ```

  and change it to :

  ```
  DocumentRoot "C:/www"
  ```

- After making changes to the configuration file you have to restart Apache (Start > Programs > Apache HTTP Server 2.0 > Control Apache Server > Restart) to see the effect.

Installing Apache

- Another configuration you may want to change is the **directory index.** This is the file that Apache will show when you request a directory. As an example if you type `http://www.php-mysql-tutorial.com/` without specifying any file the `index.php` file will be automatically shown.
- Suppose you want apache to use `index.html, index.php or main.php` as the directory index you can modify the DirectoryIndex value like this :

```
DirectoryIndex index.html index.php main.php
```

- Now whenever you request a directory such as `http://localhost/` Apache will try to find the `index.html` file or if it's not found Apache will use `index.php`. In case `index.php` is also not found then `main.php` will be used.

Installing Nvu

- www.nvu.com/
- A complete Web Authoring System for Linux Desktop users as well as Microsoft Windows and Macintosh users to rival programs like FrontPage and Dreamweaver.
- **Nvu** (pronounced N-view, for a "new view") makes managing a web site a snap. Now anyone can create web pages and manage a website with no technical expertise or knowledge of HTML.

Make A Home Page

- Create an `index.html` page with Nvu
- Copy `C:\Program Files\Apache Group\Apache2\htdocs` to `old_htdocs`
- Put the `index.html` into `htdocs`
- Test with `http://localhost` or `http://127.0.0.1`
- Explore Cascading Style Sheets (CSS)

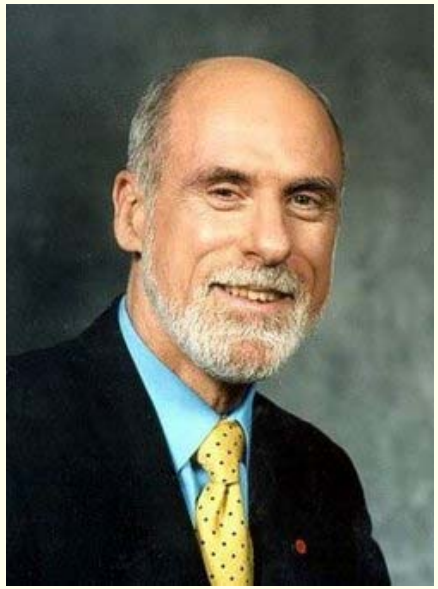
Useful Websites

- www.w3.org/Style/CSS/ - the authoritative source
- http://www.w3.org/Style/Examples/011/firstcss – *Starting with HTML + CSS* – good beginners guide
- www.csszengarden.com – A demonstration of what can be accomplished visually through CSS-based design

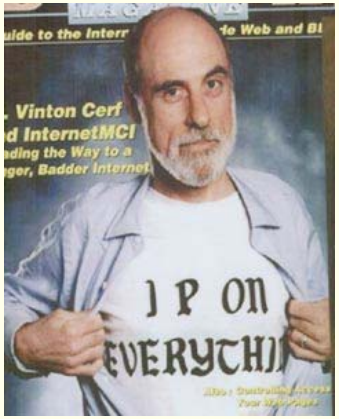
Homework

- Install Apache On Your System
- Install Nvu
- Create your own home page
- Play with HTML
- Play with CSS
- Play, play, play, …

Google's Major Coup



- September 8, 2005 – Google Inc. today announced that it hired Vinton (Vint) Cerf, the longtime technologist who is widely known as a "founding father" of the Internet, as Chief Internet Evangelist.
- He played a key role in leading the development of the TCP/IP protocols and the Internet.



Side Effects

http://www.thinkgeek.com/tshirts/

The Relational Model

Chapter 3

Why Study the Relational Model?

- Most widely used model
  - Vendors: IBM, Microsoft, Oracle, Sybase, MySQL
- Started with Ted Codd's pioneering work in '70s
- *Legacy systems* in older models
  - e.g., IBM's IMS
- Recent competitor: object-oriented model
  - ObjectStore, Versant, Ontos
  - A synthesis emerging: *object-relational model*
    - Informix Universal Server, UniSQL, O2, Oracle, DB2
- Another Competitor: XML Data Stores

Relational Database: Definitions

- **Relational database**: a set of **relations**
- **Relation** is made up of two parts:
  - **Schema** - specifies name of relation, plus name and type (domain) of each column (field or attribute)
    `Students(`*`sid`*`:`**`string`**`, `*`name`*`:`**`string`**`, `*`login`*`:`**`string`**`, `*`age`*`:` **`integer`**`, `*`gpa`*`:` **`real`**`)`
  - **Instance** - a **table**, with rows and columns
    Number of rows = **cardinality**
    Number of fields = **degree / arity**
- Can think of a relation as a **set** of rows or **tuples** (i.e., all rows are distinct).

Example Instance of Students Relation

sid	name	login	age	gpa
53666	Jones	jones@cs	18	3.4
53688	Smith	smith@eecs	18	3.2
53650	Smith	smith@math	19	3.8

- Cardinality = 3, degree = 5, all rows distinct
- Do all columns in a relation instance have to be distinct?
- **Domain** of a field is essentially the **type**

Relational Query Languages

- A major strength of the relational model: supports simple, powerful *querying* of data.
- Queries can be written intuitively, and the DBMS is responsible for efficient evaluation.
  - The key: precise semantics for relational queries.
  - Allows the optimizer to extensively re-order operations, and still ensure that the answer does not change.

The SQL Query Language

- Developed by IBM (system R) in the 1970s
- Need for a standard since it is used by many vendors
- Standards:
  - SQL-86
  - SQL-89 (minor revision)
  - SQL-92 (major revision)
  - SQL-99 (major extensions, current standard)

The SQL Query Language

- Ask a question, get an answer!
- To find all 18 year old students, we can write:

```
SELECT  *
FROM  Students S
WHERE  S.age=18
```

sid	name	login	age	gpa
53666	Jones	jones@cs	18	3.4
53688	Smith	smith@ee	18	3.2

- To find just names and logins, replace the first line:

```
SELECT  S.name, S.login
```

Querying Multiple Relations

- What does the following query compute?

```
SELECT  S.name, E.cid
FROM    Students S, Enrolled E
WHERE   S.sid=E.sid AND E.grade="A"
```

Given the following instances of Enrolled and Students:

sid	name	login	age	gpa
53666	Jones	jones@cs	18	3.4
53688	Smith	smith@eecs	18	3.2
53650	Smith	smith@math	19	3.8

sid	cid	grade
53831	Carnatic101	C
53831	Reggae203	B
53650	Topology112	A
53666	History105	B

we get:

S.name	E.cid
Smith	Topology112

Creating Relations in SQL

- Creates the Students relation. Observe that the type (**domain**) of each field is specified, and enforced by the DBMS whenever tuples are added or modified.

```
CREATE TABLE Students
       (sid:    CHAR(20),
        name:   CHAR(20),
        login:  CHAR(10),
        age:    INTEGER,
        gpa:    REAL)
```

- As another example, the Enrolled table holds information about courses that students take.

```
CREATE TABLE Enrolled
       (sid:    CHAR(20),
        cid:    CHAR(20),
        grade:  CHAR(2))
```

Destroying and Altering Relations

```
DROP TABLE  Students
```

- Destroys the relation Students. The schema information *and* the tuples are deleted

```
ALTER TABLE  Students
      ADD COLUMN firstYear: integer
```

- The schema of Students is altered by adding a new field; every tuple in the current instance is extended with a **null** value in the new field

Adding and Deleting Tuples

- Can insert a single tuple using:

```
INSERT INTO  Students (sid, name, login, age, gpa)
VALUES  (53688, 'Smith', 'smith@ee', 18, 3.2)
```

- Can delete all tuples satisfying some condition (e.g., name = Smith):

```
DELETE
FROM Students S
WHERE S.name = 'Smith'
```

Integrity Constraints (ICs)

- **IC** - condition that must be true for *any* instance of the database; e.g., **domain constraints**.
  - ICs are **specified** when schema is **defined**.
  - ICs are **checked** when relations are **modified**.
- A **legal** instance of a relation is one that satisfies all specified ICs.
  - DBMS should not allow illegal instances.
- If the DBMS checks ICs, stored data is more faithful to real-world meaning.
  - Avoids data entry errors, too!

Primary Key Constraints

- A set of fields is a **candidate key** for a relation if :
  1. No two distinct tuples can have same values in all key fields, and
  2. This is not true for any subset of the key.
- If part 2 false? A **superkey**.
  {*sid, name*} is an example of a superkey

sid	name	login	age	gpa
53666	Jones	jones@cs	18	3.4
53688	Smith	smith@eecs	18	3.2
53650	Smith	smith@math	19	3.8

Primary Key Constraints

- If there's >1 key for a relation, one of the keys is chosen (by DBA) to be the **primary key**
- e.g., *sid* is a key for Students. (What about *name*?) The set {*sid, gpa*} is a superkey

sid	name	login	age	gpa
53666	Jones	jones@cs	18	3.4
53688	Smith	smith@eecs	18	3.2
53650	Smith	smith@math	19	3.8

Primary and Candidate Keys in SQL

- Possibly many **candidate keys** (specified using UNIQUE), one of which is chosen as the **primary key**.
- "For a given student and course, there is a single grade." vs. "Students can take only one course, and receive a single grade for that course; further, no two students in a course receive the same grade."

```
CREATE TABLE Enrolled
    (sid CHAR(20)
     cid  CHAR(20),
     grade CHAR(2),
     PRIMARY KEY  (sid,cid) )
```

Better!

```
CREATE TABLE Enrolled
    (sid CHAR(20)
     cid  CHAR(20),
     grade CHAR(2),
     PRIMARY KEY  (sid),
     UNIQUE (cid, grade) )
```

- Used carelessly, an IC can prevent the storage of database instances that arise in practice!

Foreign Keys, Referential Integrity

- **Foreign key** - Set of fields in one relation that is used to *refer* to a tuple in another relation. (Must correspond to primary key of the second relation.) Like a **logical pointer**.

- e.g. *sid* is a foreign key referring to Students:
  - Enrolled(*sid*: string, *cid*: string, *grade*: string)
  - If all foreign key constraints are enforced, **referential integrity** is achieved, i.e., no dangling references.

- Can you name a data model w/o referential integrity? …
- …*Links in HTML!*

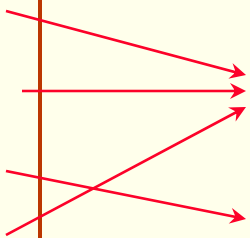
Foreign Keys in SQL

- Only students listed in the Students relation should be allowed to enroll for courses

```
CREATE TABLE Enrolled ( sid   CHAR(20),
                        cid   CHAR(20),
                          grade CHAR(2),
                        PRIMARY KEY  (sid,cid),
                        FOREIGN KEY (sid) REFERENCES Students )
```

Enrolled

sid	cid	grade
53666	Carnatic101	C
53666	Reggae203	B
53650	Topology112	A
53666	History105	B



Students

sid	name	login	age	gpa
53666	Jones	jones@cs	18	3.4
53688	Smith	smith@eecs	18	3.2
53650	Smith	smith@math	19	3.8

Enforcing Referential Integrity

Consider Students and Enrolled; *sid* in Enrolled is a foreign key that references Students.

Options:

1. What should be done if an Enrolled tuple with a non-existent student id is inserted? (*Reject it!*)
2. What should be done if a Students tuple is deleted?
   - Also delete all Enrolled rows that refer to it
   - Disallow deletion of a Students rows that is referred to
   - Set sid in Enrolled rows that refer to it to a **default sid**
   - Set sid in Enrolled rows that refer to it to a special value **null**, denoting **unknown** or **inapplicable**
3. Similar if primary key of Students rows is updated

Referential Integrity in SQL

- SQL/92 and SQL:1999 support all 4 options on deletes and updates.
  - Default is NO ACTION (*delete/update is rejected*)
  - CASCADE (also delete all rows that refer to deleted row)
  - SET NULL / SET DEFAULT (sets foreign key value of referencing row)

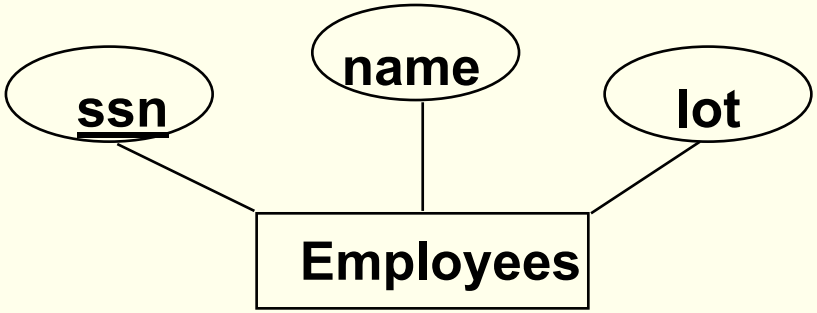
```
CREATE TABLE Enrolled
    (sid CHAR(20),
     cid CHAR(20),
     grade CHAR(2),
     PRIMARY KEY  (sid,cid),
     FOREIGN KEY (sid)
       REFERENCES Students
        ON DELETE CASCADE
        ON UPDATE SET DEFAULT )
```

Where do ICs Come From?

- ICs are based upon the semantics of the real-world enterprise that is being described in the database relations.
- We can check a database instance to see if an IC is violated, but we can NEVER infer that an IC is true by looking at an instance.
  - An IC is a statement about *all possible* instances!
  - From example, we know *name* is not a key, but the assertion that *sid* is a key is given to us.
- Key and foreign key ICs are the most common; more general ICs supported too.

Logical DB Design: ER to Relational

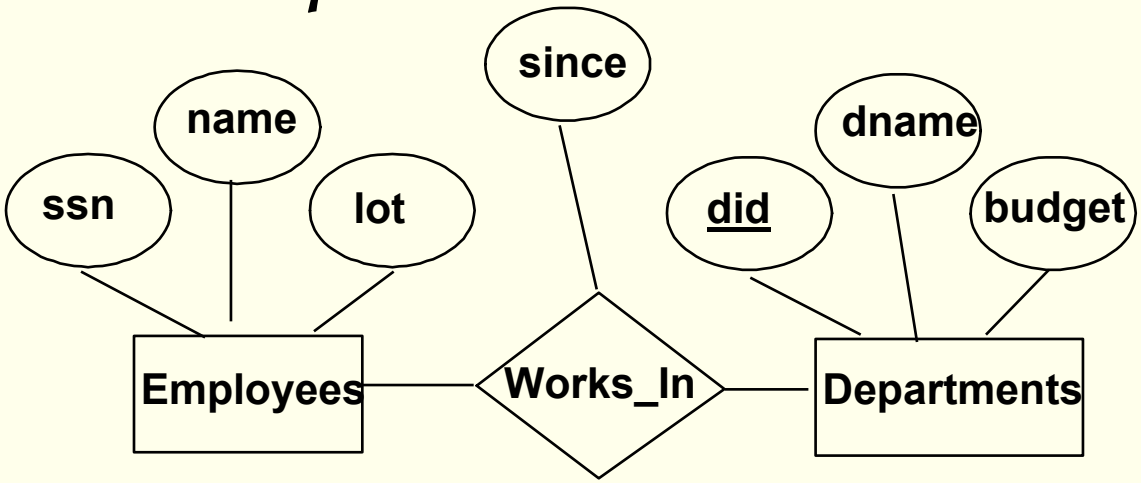
- Translating entity sets into tables:



ssn	name	lot
123-22-3666	Attishoo	48
231-31-5368	Smiley	22
131-24-3650	Smethurst	35

```
CREATE TABLE Employees
            (ssn  CHAR(11),
             name CHAR(20),
             lot  INTEGER,
             PRIMARY KEY  (ssn))
```

Relationship Sets to Tables



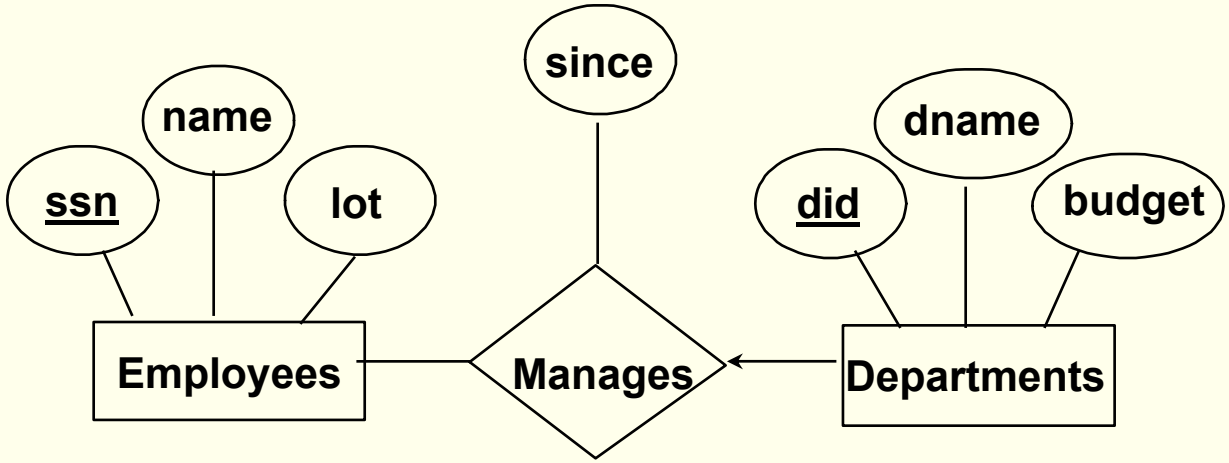
In translating a relationship set to a relation, attributes of the relation must include:

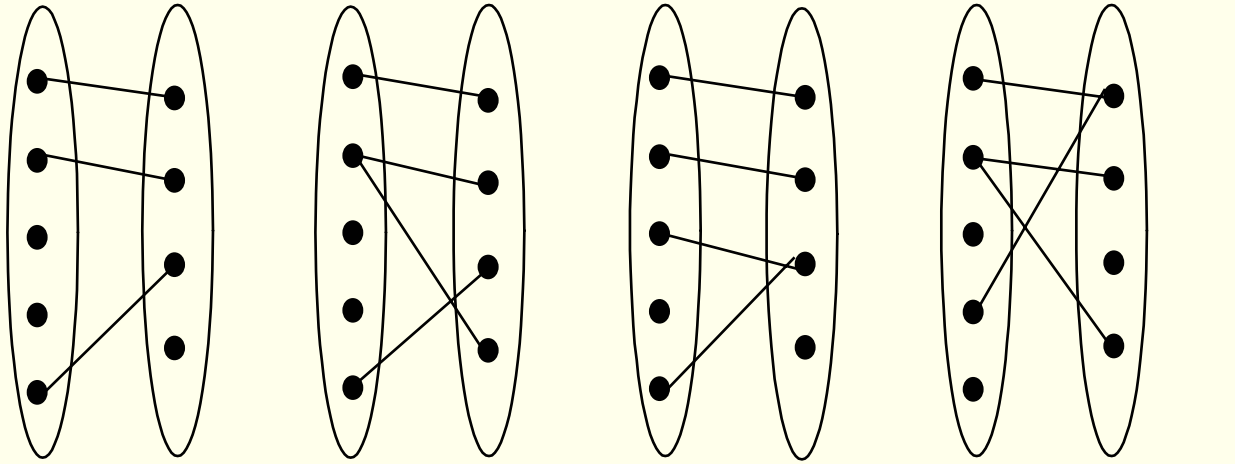
- Keys for each participating entity set (as foreign keys).
  This set of attributes forms a **superkey** for the relation.
- All descriptive attributes.

```
CREATE TABLE Works_In (ssn     CHAR(11),
                       did     INTEGER,
                       since   DATE,
                       PRIMARY KEY (ssn, did),
                       FOREIGN KEY (ssn) REFERENCES Employees,
                       FOREIGN KEY (did) REFERENCES Departments)
```

Review: Key Constraints

- Each dept has at most one manager, according to the **key constraint** on Manages.






```
<1,1,x>
<2,2,x>
<1,3,x>
<2,3,x>
```

Translation to relational model?

Translating ER Diagrams with Key Constraints

- Map relationship to a table:
  - Note that **did** is the key now!
  - Separate tables for Employees and Departments

```
CREATE TABLE  Manages(
   ssn     CHAR(11),
   did     INTEGER,
   since   DATE,
   PRIMARY KEY (did),
   FOREIGN KEY (ssn) REFERENCES Employees,
   FOREIGN KEY (did) REFERENCES Departments)
```

- Since each department has a unique manager, we could instead **combine Manages and Departments** (usually a better approach)

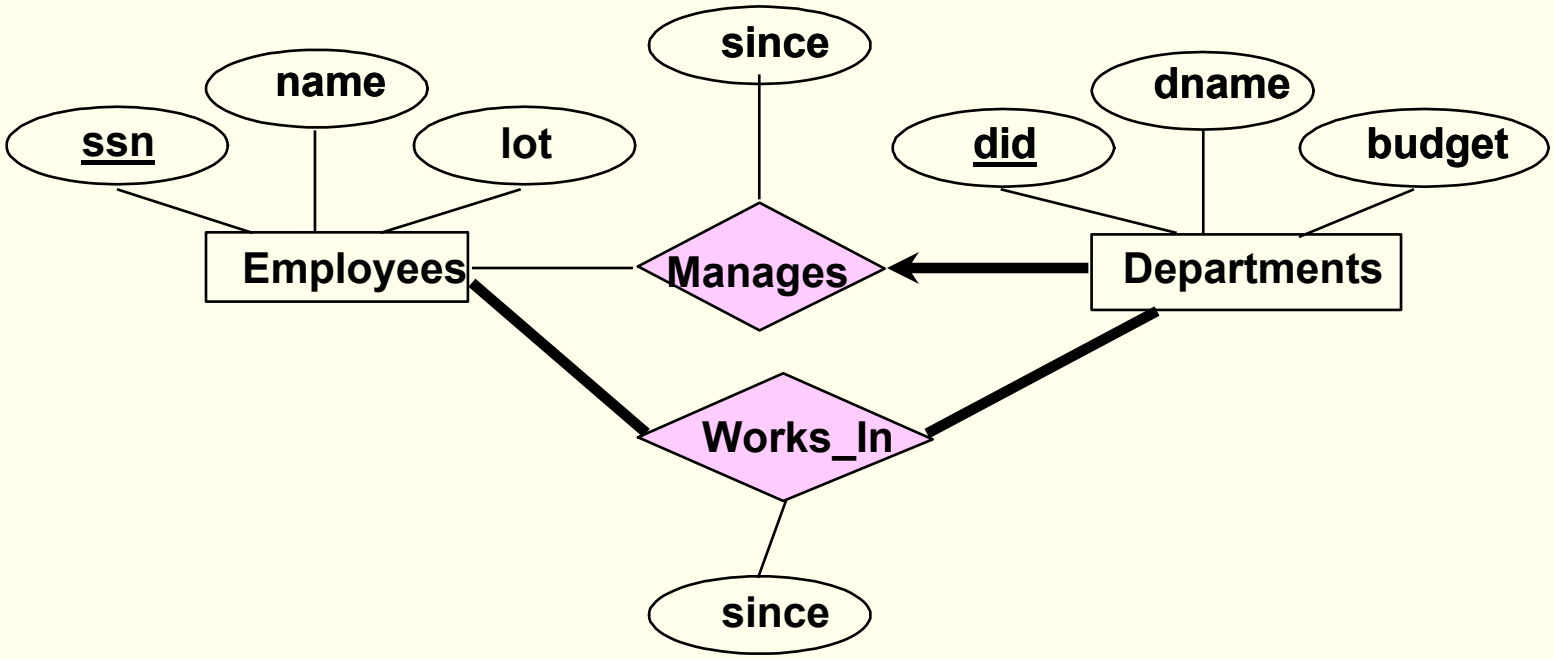
```
CREATE TABLE  Dept_Mgr(
   did     INTEGER,
   dname   CHAR(20),
   budget  REAL,
   ssn     CHAR(11),
   since   DATE,
   PRIMARY KEY  (did),
   FOREIGN KEY (ssn) REFERENCES Employees)
```

- Eliminates need for a separate Manages relation

Translating Participation Constraints

Does every department have a manager?

- If so, this is a **participation constraint** - the participation of Departments in Manages is said to be **total** (vs. **partial**).
- Every ***did*** value in Departments table must appear in a row of the Manages table (with a non-null ***ssn*** value!)



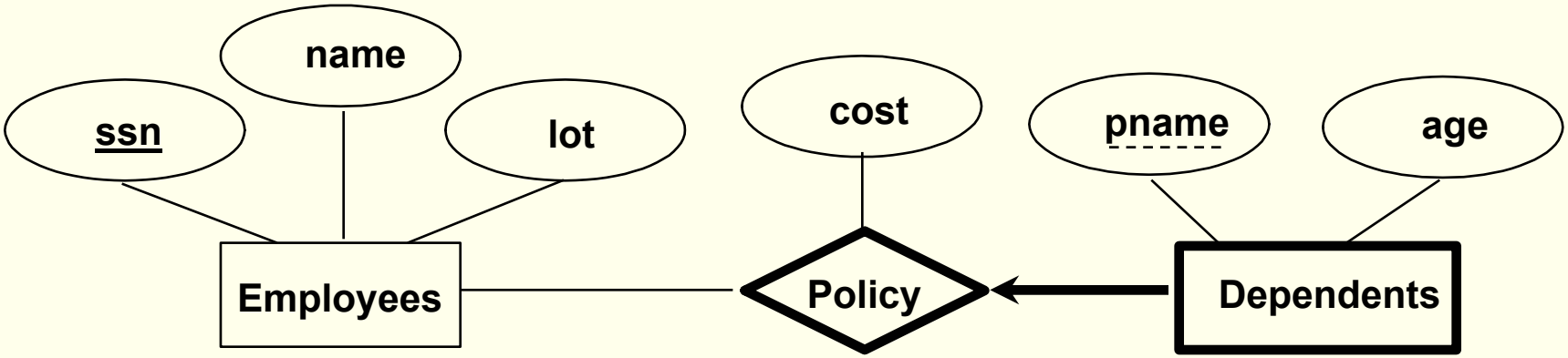
Participation Constraints in SQL

- We can capture participation constraints involving one entity set in a binary relationship, but little else (without resorting to table constraints or assertions).

```
CREATE TABLE  Dept_Mgr(
   did     INTEGER,
   dname   CHAR(20),
   budget  REAL,
   ssn     CHAR(11) NOT NULL,
   since   DATE,
   PRIMARY KEY  (did),
   FOREIGN KEY  (ssn) REFERENCES Employees,
      ON DELETE NO ACTION)
```

Translating Weak Entities

- A **weak entity** can be identified uniquely only by considering the primary key of another **owner** entity (remember partial key)
- Owner entity set and weak entity set must participate in a **one-to-many relationship** set (1 owner, many weak entities).
- Weak entity set must have **total participation** in this **identifying** relationship set.



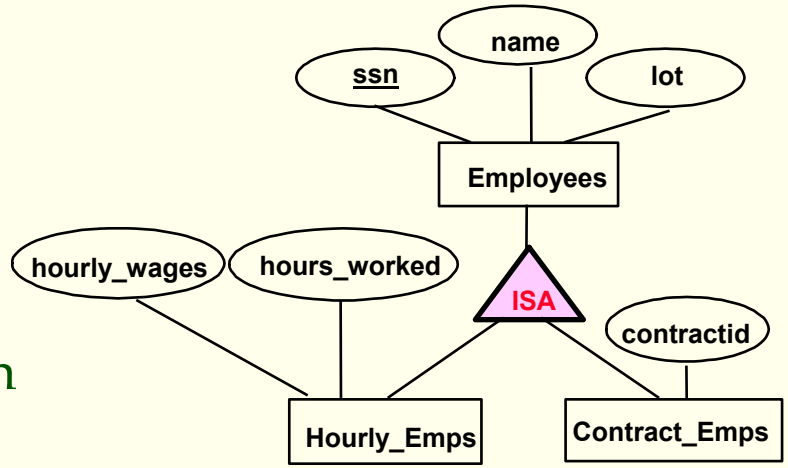
Translating Weak Entity Sets

- Weak entity set and identifying relationship set are translated into a single table.
- When the **owner entity** is **deleted**, **all owned weak entities** must also be **deleted**.

```
CREATE TABLE  Dep_Policy (
              pname CHAR(20),
              age   INTEGER,
              cost  REAL,
              ssn   CHAR(11) NOT NULL,
              PRIMARY KEY  (pname, ssn),
              FOREIGN KEY  (ssn) REFERENCES Employees,
                    ON DELETE CASCADE)
```

ER Model – Class Hierarchies

- **Hourly_Emps** and **Contract_Emps** **inherit** the attributes of the entity set **Employees**
- If we declare A **ISA** B, every A entity is also considered to be a B entity, i.e., Hourly_Emps **ISA** Employees



Two kinds of constraints:

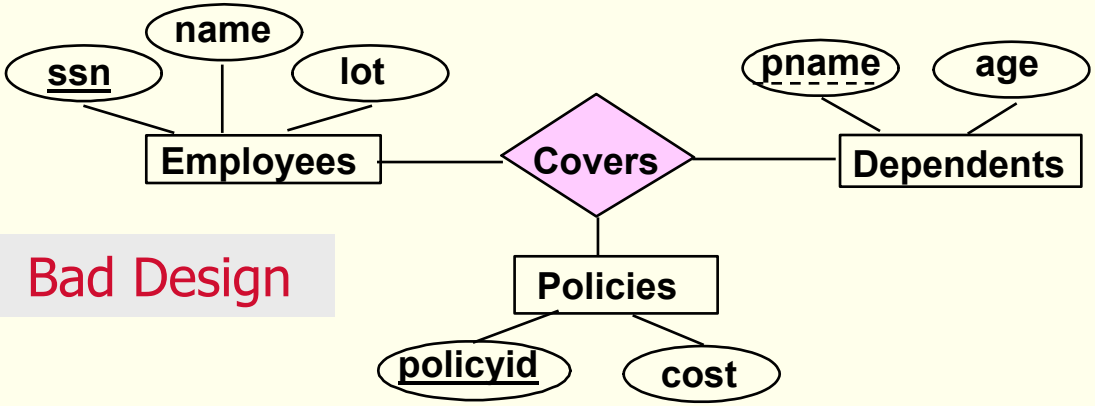
- **Overlap constraints** - Can Joe be an Hourly_Emps as well as a Contract_Emps entity? (*Allowed/disallowed*)
- **Covering constraints** - Does every Employees entity also have to be an Hourly_Emps or a Contract_Emps entity? *(Yes/no)*

Translating ISA Hierarchies to Relations

- **General approach:**
  - 3 relations: **Employees**, **Hourly_Emps** and **Contract_Emps**
    - **Hourly_Emps**: Every employee is recorded in Employees. For hourly emps, extra info recorded in Hourly_Emps (*hourly_wages*, *hours_worked*, *ssn*); must delete Hourly_Emps row if referenced Employees row is deleted)
    - Queries involving all employees easy, those involving just Hourly_Emps require a join to get some attributes

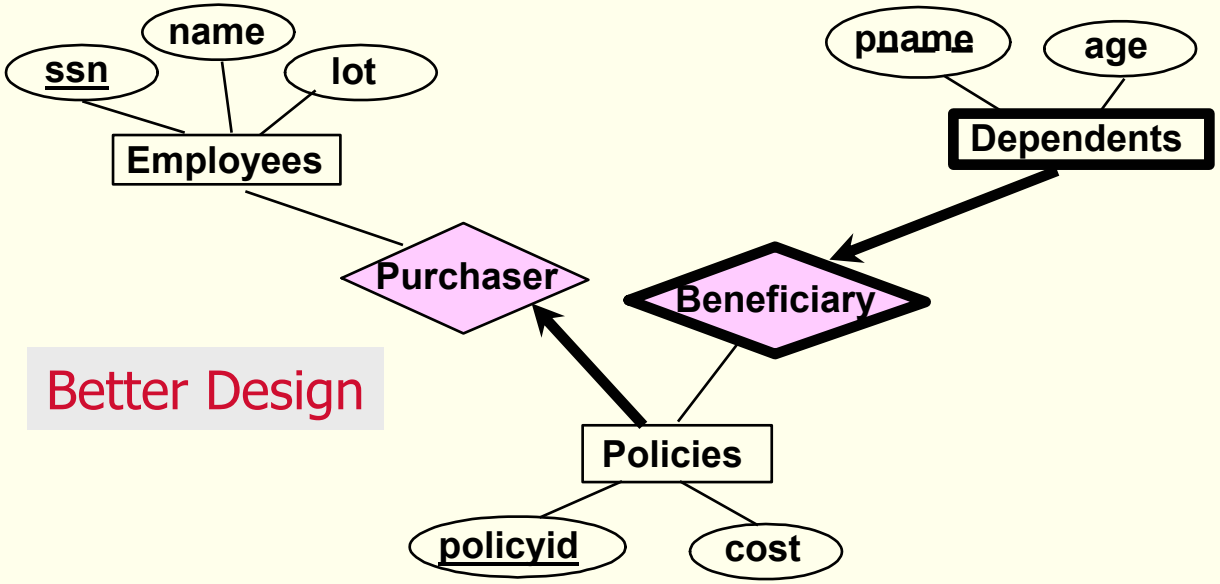
- **Alternative:**
  - Just **Hourly_Emps** and **Contract_Emps**
    - **Hourly_Emps**: *ssn, name, lot, hourly_wages, hours_worked.*
    - Each employee must be in one of these two subclasses.

Review: Binary vs. Ternary Relationships



Bad Design

- What are the additional constraints in the 2nd diagram?



Better Design

Binary vs. Ternary Relationships

The key constraints allow us to combine **Purchaser** with **Policies** and **Beneficiary** with **Dependents**

```
CREATE TABLE Policies (
   policyid INTEGER,
   cost     REAL,
   ssn      CHAR(11)  NOT NULL,
   PRIMARY KEY (policyid),
   FOREIGN KEY (ssn) REFERENCES Employees,
      ON DELETE CASCADE)
```

Participation constraints lead to **NOT NULL** constraints.

```
CREATE TABLE Dependents (
   pname    CHAR(20),
   age      INTEGER,
   policyid INTEGER,
   PRIMARY KEY (pname, policyid).
   FOREIGN KEY (policyid)REFERENCES Policies,
      ON DELETE CASCADE)
```

Views

- A **view** is just a relation, but we store a **definition**, rather than a set of tuples

```
CREATE  VIEW  YoungActiveStudents (name, grade)
        AS  SELECT S.name, E.grade
            FROM   Students S, Enrolled E
            WHERE  S.sid = E.sid and S.age<21
```

- Views can be dropped using the **DROP VIEW** command

Views and Security

- Views can be used to present necessary information (or a summary), while hiding details in underlying relation(s)

- Given **YoungStudents**, but not **Students** or **Enrolled**, we can find students s who have are enrolled, but not the *cid's* of the courses they are enrolled in

Relational Model: Summary

- A **tabular** representation of data
- Simple and intuitive, currently the most widely used
- **Integrity constraints** can be specified by the DBA, based on application semantics. DBMS checks for violations.
  - Two important **ICs**: **primary** and **foreign keys**
  - In addition, we *always* have **domain constraints**
- Powerful and natural query languages exist
- Rules (and tools) to translate ER to relational model

PHP

- 

- www.php.net
- **PHP** is a popular open-source, reflective programming language used mainly for developing server-side applications and dynamic web content. It was originally developed in 1994 and PHP stood for "**P**ersonal **H**ome **P**age". In 2000 the Zend Engine was added and now the official meaning is the recursive acronym "**P**HP **H**ypertext **P**reprocessor".
- PHP is currently one of the most popular server-side scripting systems on the Web. It has been widely adopted since the release of version 4. On the desktop it has been favored by some new programmers as a rapid prototyping environment.

Installing PHP

- www.php.net/downloads.php#v4
- We want to install PHP 4.4.0 and use the ZIP package
- Extract the PHP package (PHP 4.4.0 zip package). Extract the package in the directory where Apache was installed (`C:\Program Files\Apache Group\Apache2`). Change the newly created directory name to `php` (just to make it shorter).
- Then copy the file `php.ini-dist` in PHP directory to you windows directory (`C:\Windows` or `C:\Winnt` depends on where you installed Windows) and rename the file to `php.ini`. This is the PHP configuration file and we'll take a look what's in it later on.
- Next, move the `php4ts.dll` file from the newly created php directory into the `sapi` subdirectory.

Installing PHP

- Apache doesn't know that you just installed PHP. We need to tell Apache about PHP and where to find it. Open the Apache configuration file in `C:\Program Files\Apache Group\Apache2\conf\httpd.conf` and add the following three lines :

```
LoadModule php4_module php/sapi/php4apache2.dll
AddType application/x-httpd-php .php
AddType application/x-httpd-php-source .phps
```

- The first line tells Apache where to load the dll required to execute PHP and the second line means that every file that ends with `.php` should be processed as a PHP file. The third line is added so that you can view your php file source code in the browser window.
- Now restart Apache for the changes to take effect (`Start > Programs > Apache HTTP Server 2.0.50 > Control Apache Server > Restart`).

Installing PHP

- Now we want to test PHP to verify our installation. Create a new file using Nvu, name it `hello.php`, and put it in document root directory (`C:\Program Files\Apache Group\Apache2\htdocs`). The content of this file should be:

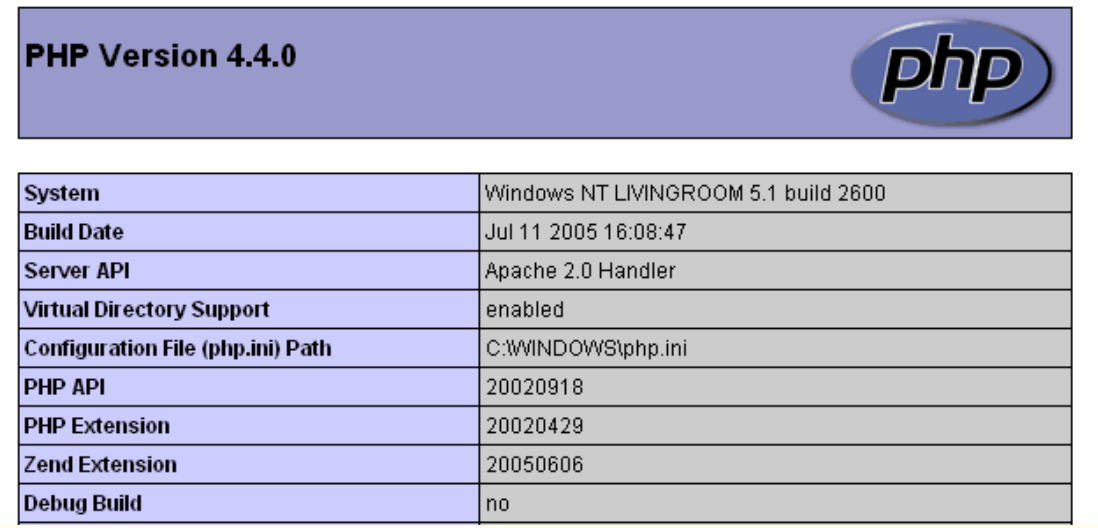
```
<?php
echo 'Hello World!';
?>
```

  (Note: Nvu will do the php encapsulation for you)
- Type `http://localhost/hello.php` on your browser's address bar and if everything works well you should see the traditional "Hello World!" display in your browser.
- Another common test is to create a new file named `test.php` and put it in document root directory The content of this file is:

```
<?php
phpinfo();
?>
```

Installing PHP

- **phpinfo()** is the infamous PHP function which will spit out all kinds of stuff about PHP and your server configuration. Type `http://localhost/test.php` on your browser's address bar and if everything works well you should see something like this :



PHP Version 4.4.0

System	Windows NT LIVINGROOM 5.1 build 2600
Build Date	Jul 11 2005 16:08:47
Server API	Apache 2.0 Handler
Virtual Directory Support	enabled
Configuration File (php.ini) Path	C:\WINDOWS\php.ini
PHP API	20020918
PHP Extension	20020429
Zend Extension	20050606
Debug Build	no

MySQL

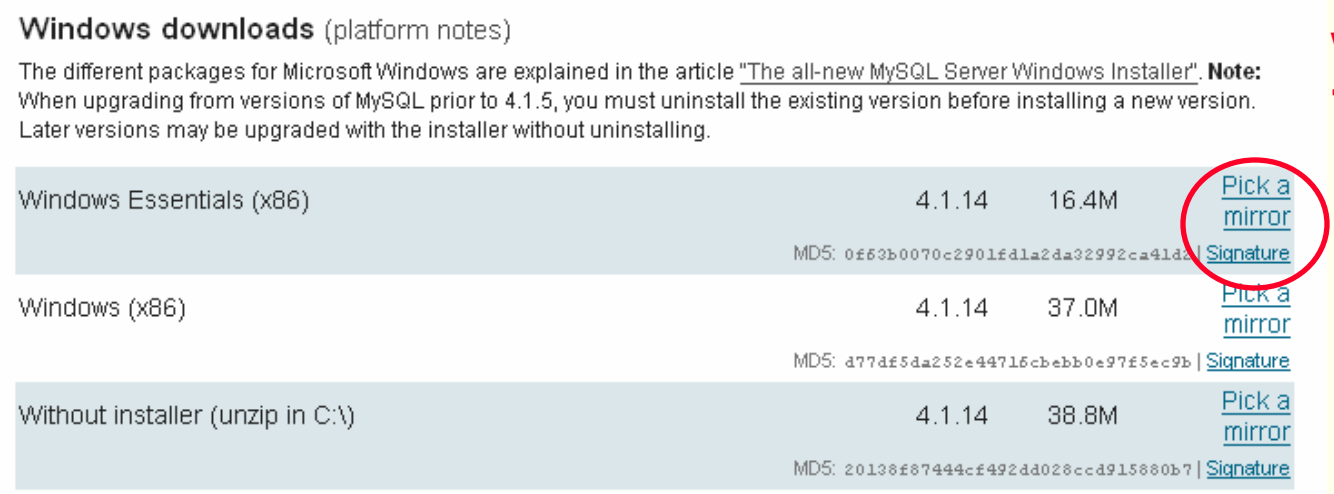
- 

- www.mysql.com
- dev.mysql.com/doc/ - MySQL Reference Manual
- **MySQL** is a multithreaded, multi-user, SQL (Structured Query Language) Database Management System (DBMS) with an estimated six million installations. MySQL is open source software available either under the GNU General Public License (GPL) or under other licenses when the GPL is inapplicable to the intended use. [1]
- Unlike projects such as Apache, where the software is developed by a public community, and is essentially not owned by anyone, MySQL is owned and sponsored by a single for-profit firm, the Swedish company MySQL AB. The company develops and maintains the system, selling support and service contracts, as well as commercially-licensed copies of MySQL, and employing people all over the world who work together via the Internet. Two Swedes and a Finn founded MySQL AB: David Axmark, Allan Larsson and Michael "Monty" Widenius.[2]

(1) - en.wikipedia.org/wiki/MySQL
(2) – WikiPedia is based on MySQL. There are more than 200 million queries and 1.2 million updates per day with peak loads of 11,000 queries per second

Installing MySQL

- http://dev.mysql.com/downloads/
- We want:
  - **MySQL database server & standard clients**
    - MySQL 4.1 -- Generally Available (GA) release (recommended)
- This should bring us to this page: http://dev.mysql.com/downloads/mysql/4.1.html
- Scroll down to this section:



This is what we want - Essentials

Installing MySQL

- We will be downloading: mysql-essential-4.1.14-win32.msi
- Fill in the form if you want and go to the closest US mirror. The download will take a few minutes. When finished, you should have the .msi file on your desktop.
- Double-Click the newly downloaded .msi file
- Accept the typical installation
- You'll be prompted to create a MySQL account (recommended) – monthly newsletter - save this info
- When the install finishes you'll get a configuration option window. Be sure it is checked.

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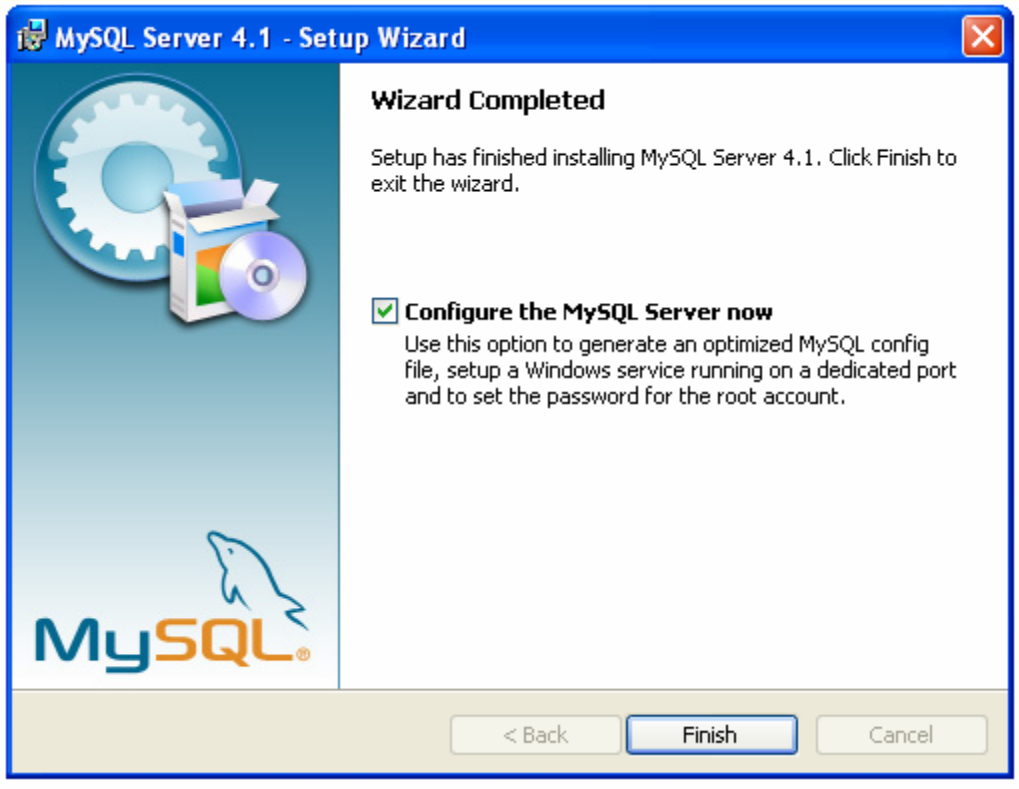
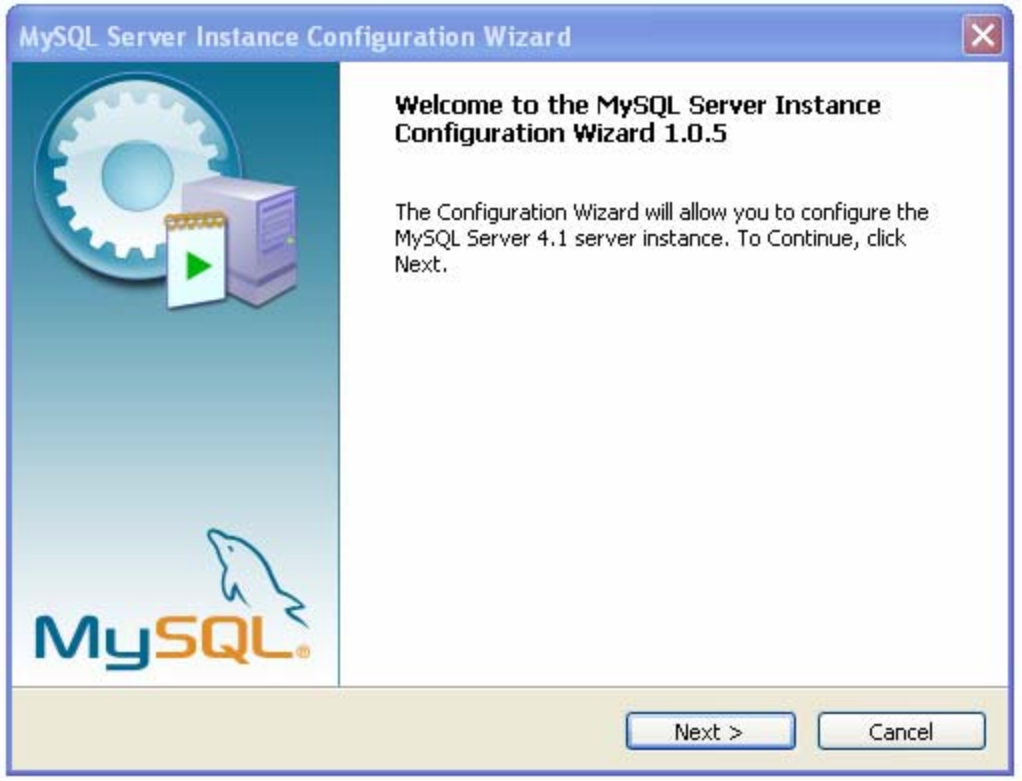


Installing MySQL



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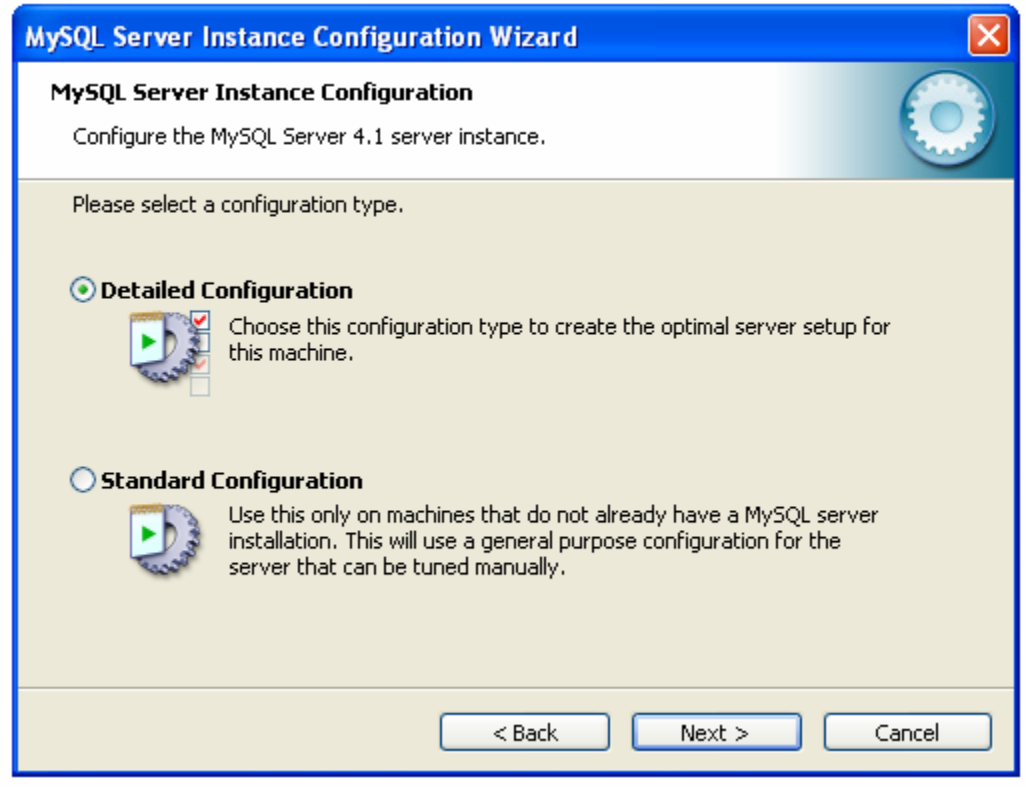

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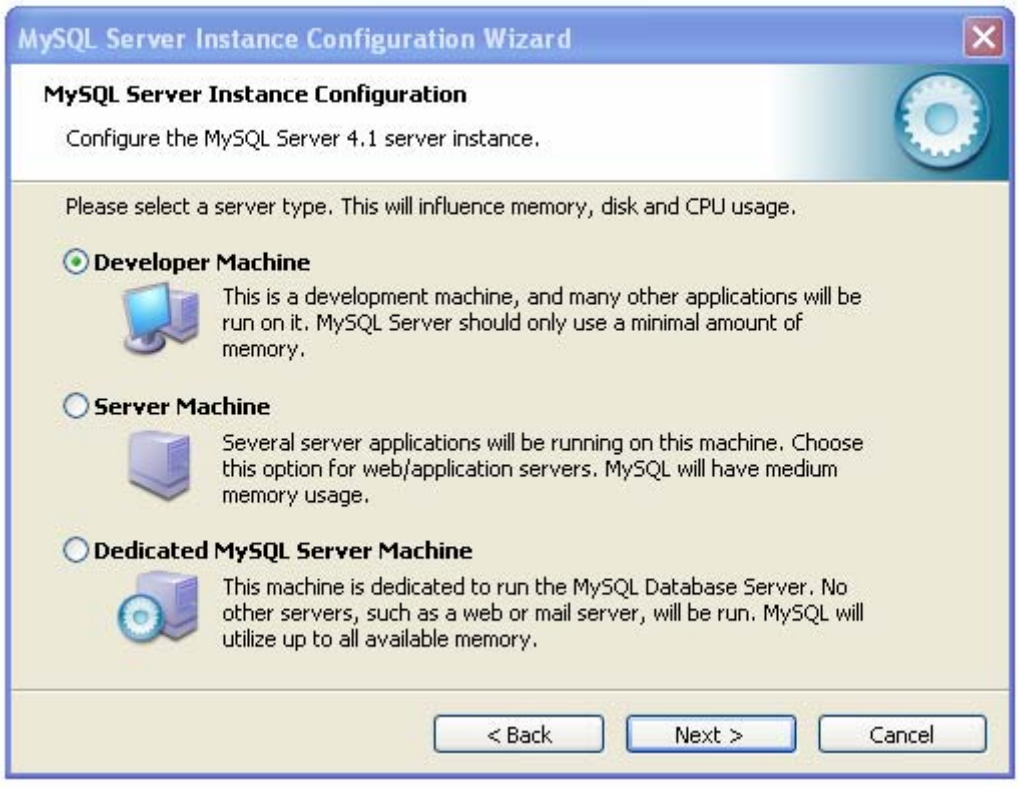

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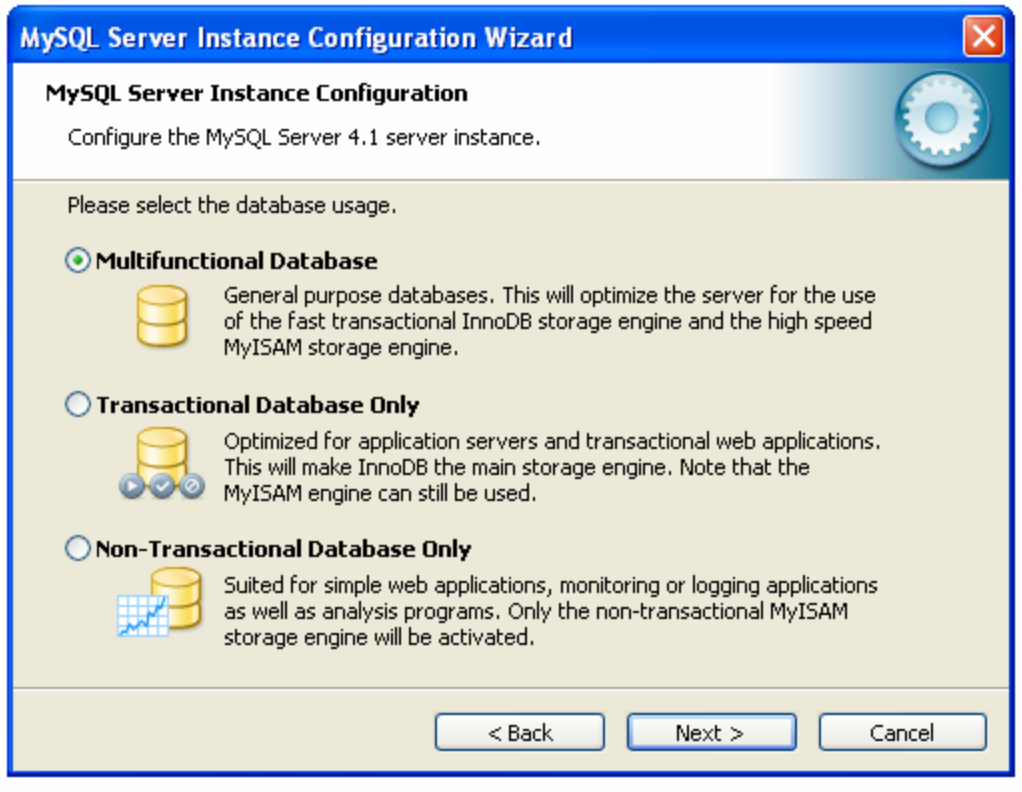

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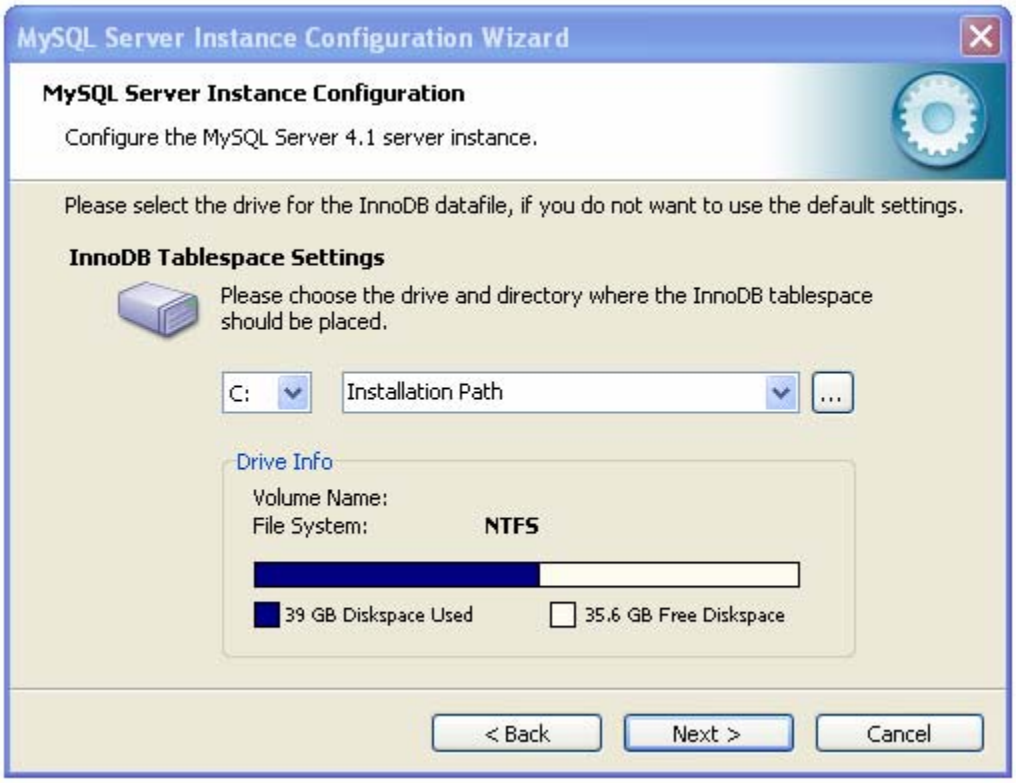

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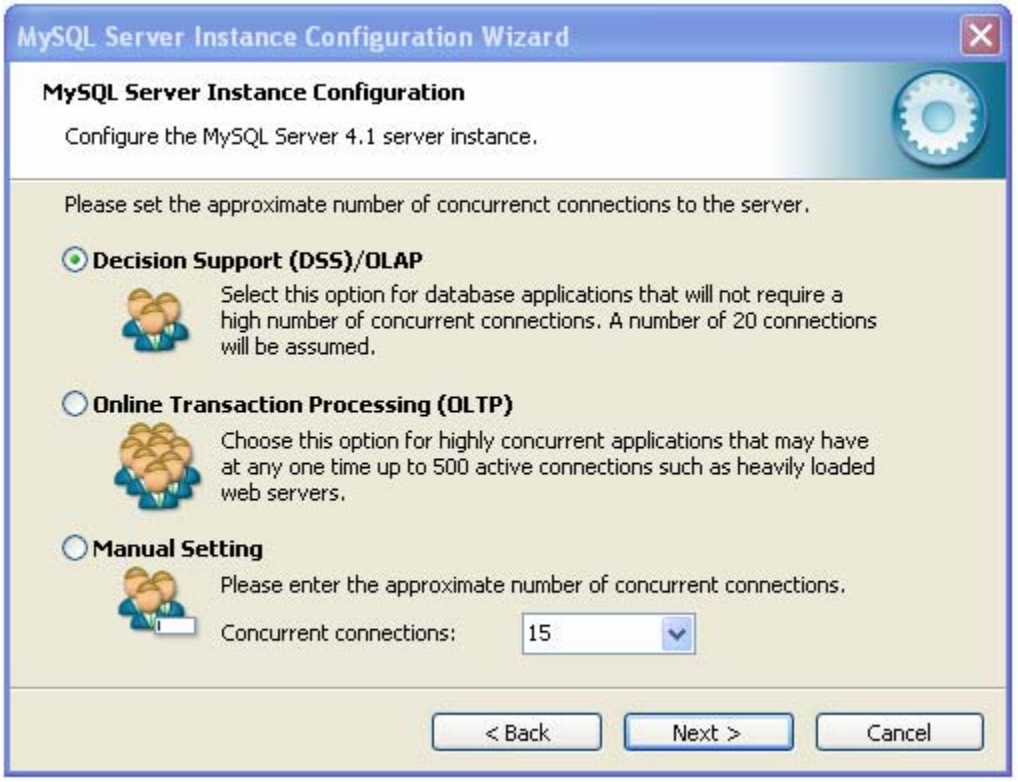

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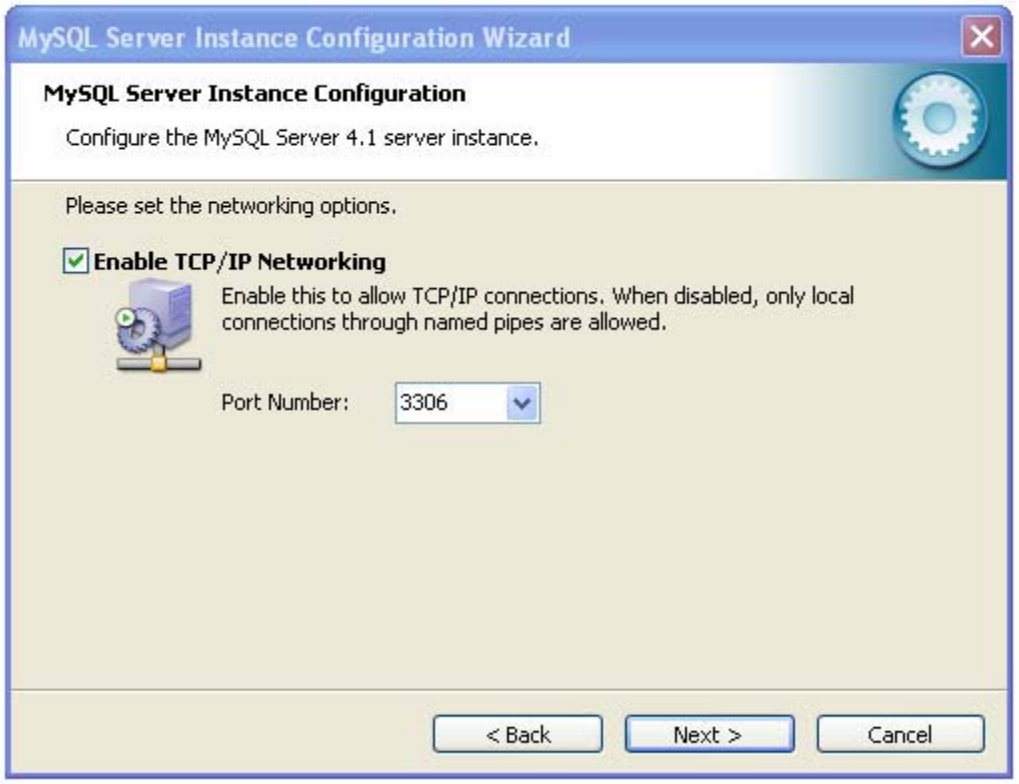

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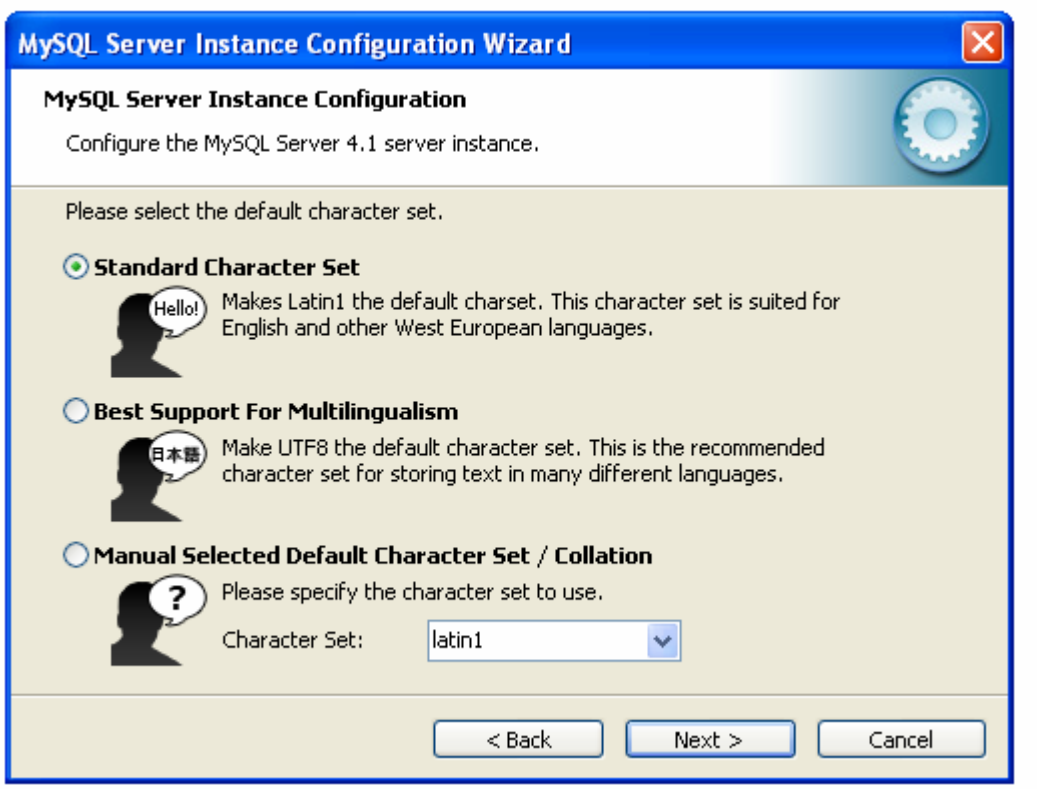

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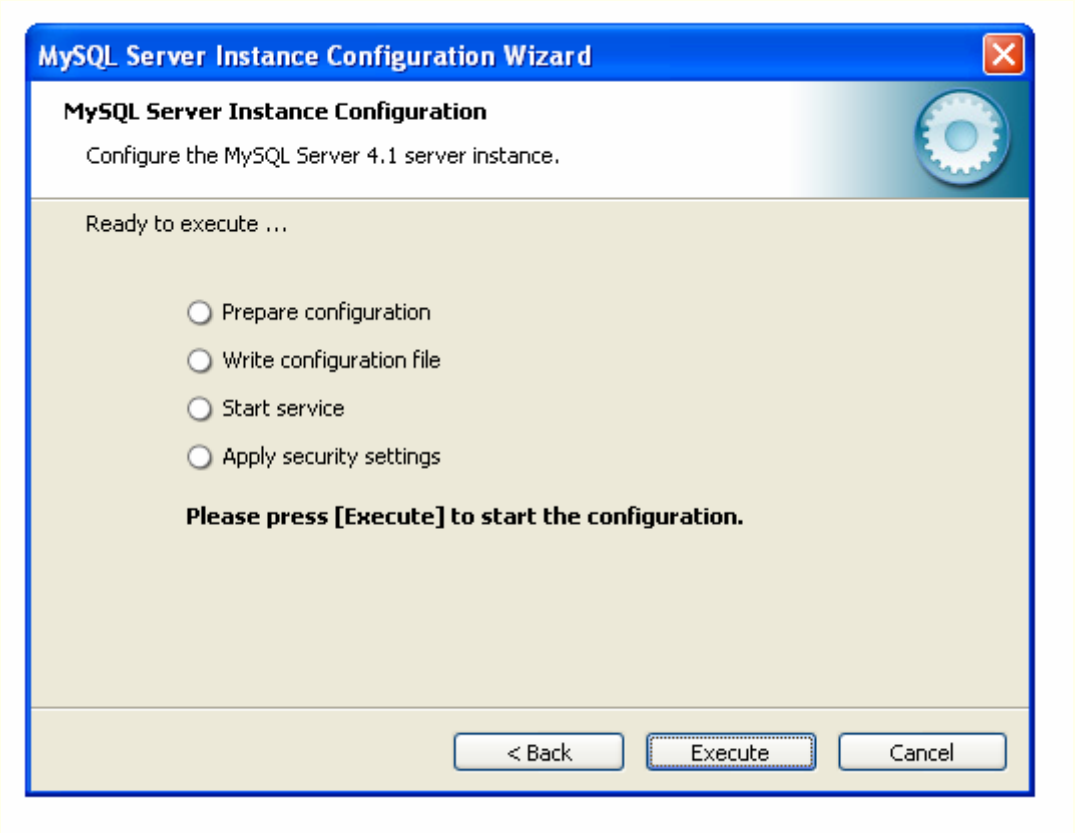

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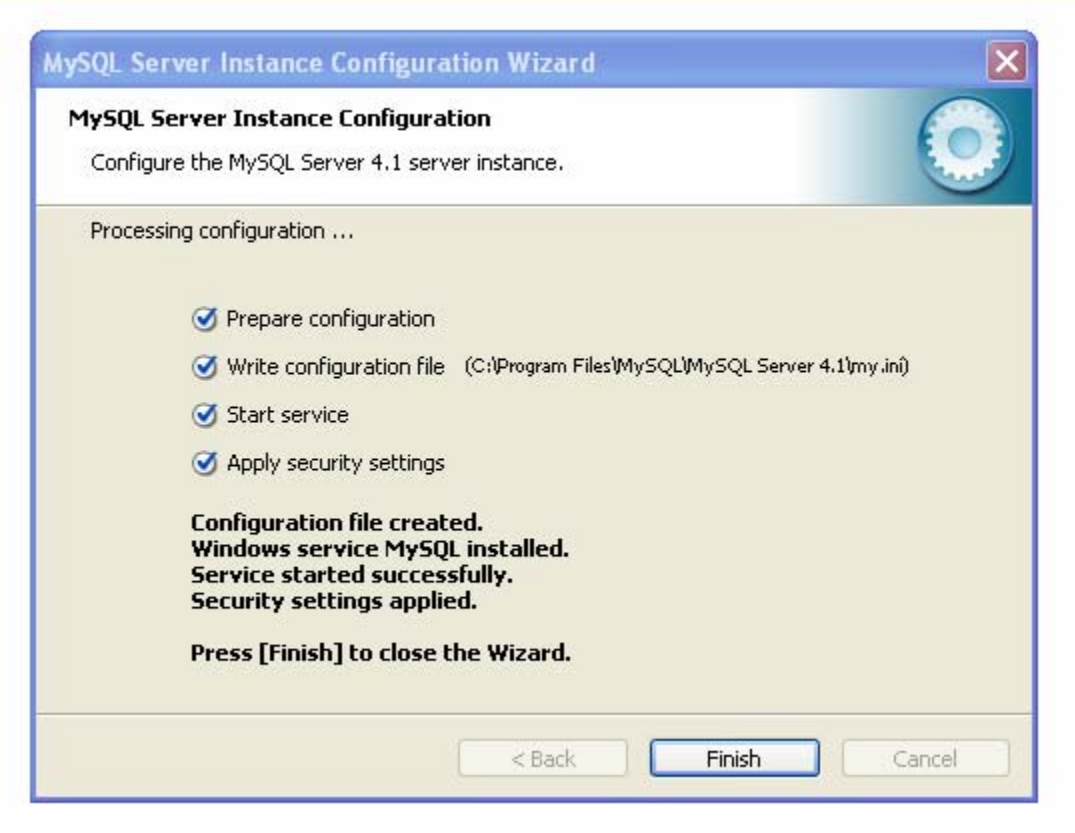
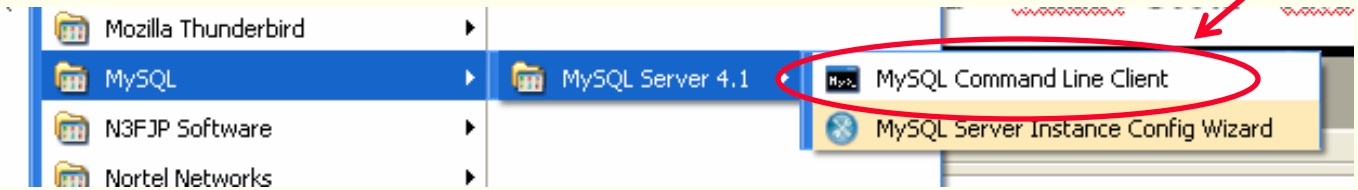
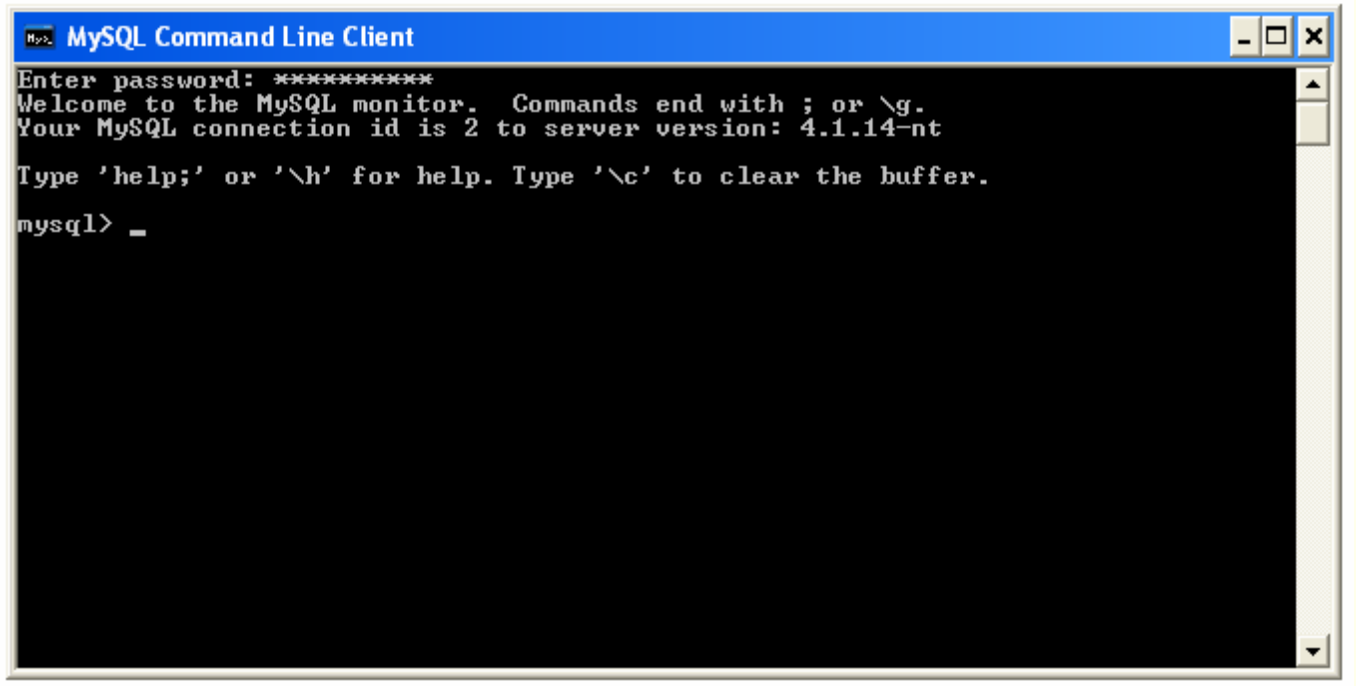


Installing MySQL

Command Line Interface





- Type "status" for info, then type "exit" to quit

Configuring PHP

- PHP stores all kinds of configuration information into a file called `php.ini`. Recall that we moved this to the `C:\Windows` directory.
- For now, **we do not needed to alter this file.**
- If you are interested in the *systems* side of DBMS, then read this file carefully.
- The following two slides are for reference only!

Configuring PHP

- **error_reporting** and **display_errors** – the default values that come with the installation are fine for development. When you go to production you'll want to change to:
  ```
  error_reporting = E_NONE
  display_errors = Off
  ```
  This is because in a production environment you don't want too much detail about your errors because it may reveal security error.
- **register_globals** – this value should be set to `Off`, which is the default, otherwise it exposes possible security problems.
- **session.save_path** – If you use sessions, something you may want to do as an advanced function, but not now, then this configuration tells PHP where to save the session data. You will need to set this value to an existing directory or you will not be able to use session. In Windows you can set this value as
  ```
  session.save_path = C:\WINDOWS\Temp\
  ```

Configuring PHP

- **extension –** PHP4 comes with many extensions such as Java, SSL, LDAP, Oracle, etc. These are not turned on automatically. If you need to use the extension, first you need to specify the location of the extensions and then uncomment the extension you want.

  For Windows you will need to uncomment the extension you want to use. In php.ini a comment is started using a semicolon (;). As an example if you want to use OpenSSL, then you must remove the semicolon at the beginning of ;
  `;extension=php_openssl.dll` to
  `extension=php_openssl.dll`

  Note: MySQL and ODBC support is now built in, so *no dll is needed for it.*
- **max_execution_time –** the default is 30 seconds

WAMP Install Completed

- That's it!
- You have finish installing and configuring Apache, MySQL and PHP on Windows
- Now we are ready to create, modify, and query tables using SQL under the Relational Model

Playing With MySQL

- Create Database
- Create, Modify, Delete Tables and Rows
- Delete Database

Homework

- Install PHP On Your System
- Install MySQL
- Create, Delete, Modify Tables
- Insert, Modify, Delete Data Into Tables
- Play with MySQL

Homework

- Read Chapter Three
- No exercises for next class; MidTerm instead

MidTerm Exam

- Due next class September 17
- No late submissions