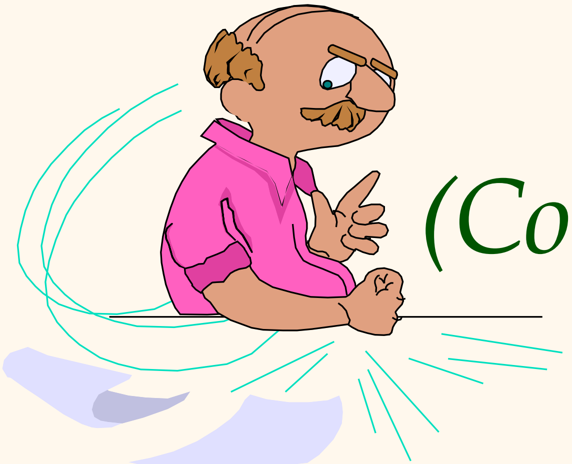
Introduction to Data Management



Lecture #3
(Conceptual DB Design)

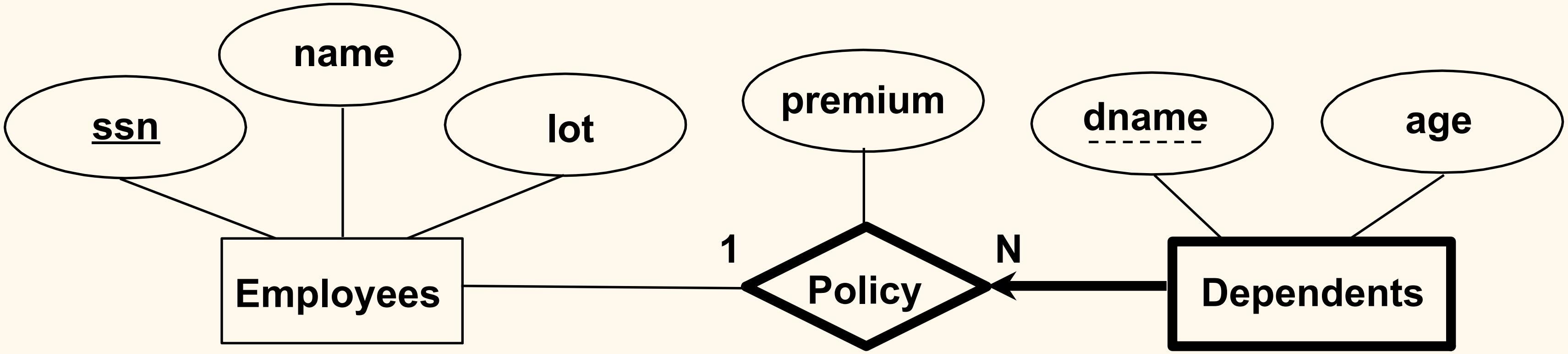
Instructor: Chen Li

Announcements

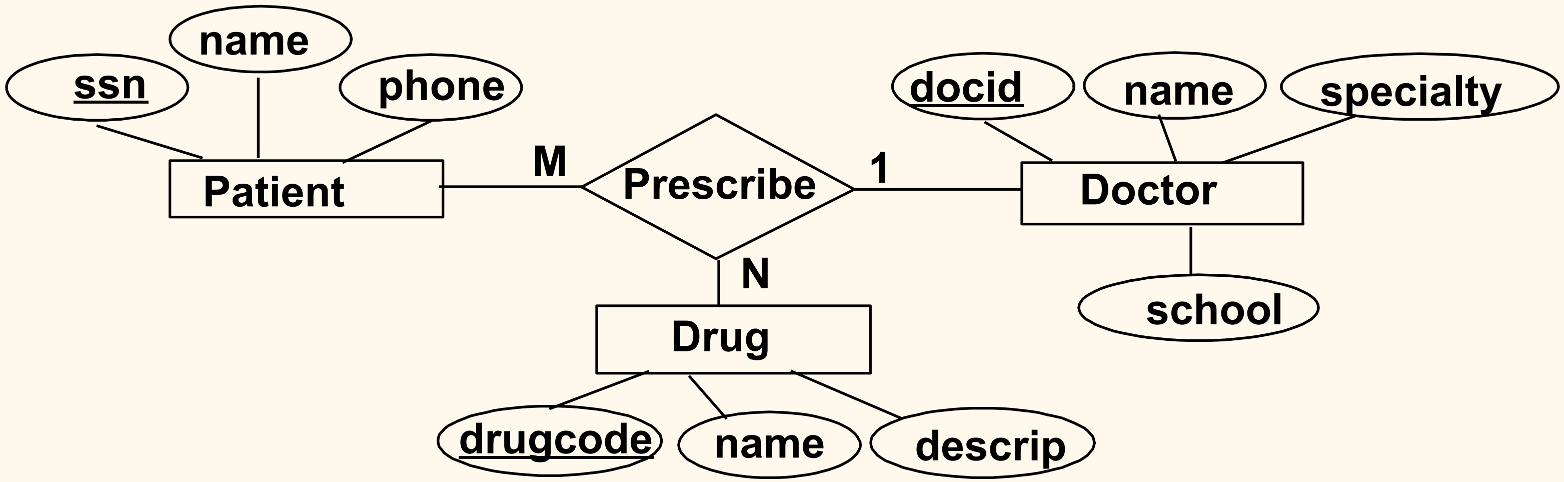
- HW #1 is now available
- Today's plan – Conceptual DB design, *cont*.
  - Advanced ER concepts

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.
  - Dependent identifier is unique only *within* owner context (_ _ _ _ _ _ _), so its fully qualified key here is (ssn, dname)

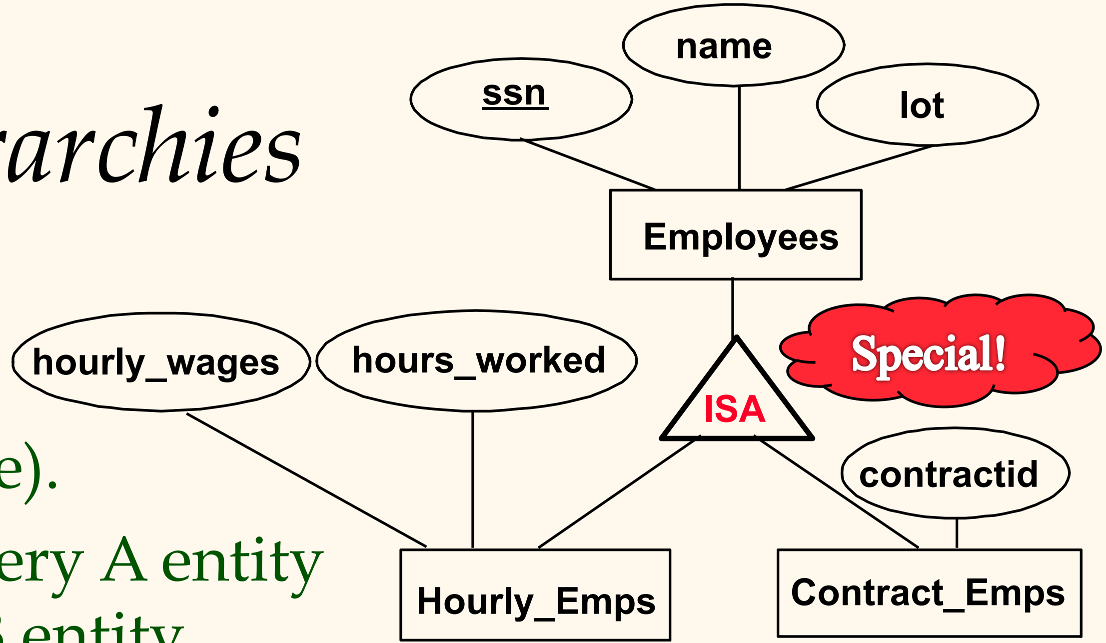


Ternary Relationships (and beyond)



- A prescription is a 3-way relationship between a patient, a doctor, and a drug; with the cardinality constraints above:
  - A given patient+drug will be associated with *one* doctor (1)
  - A given patient+doctor may be associated with *several* drugs (N)
  - A given doctor+drug may be associated with *several* patients (M)
- ***(General) note:*** Relationship key ≤ (entity keys)

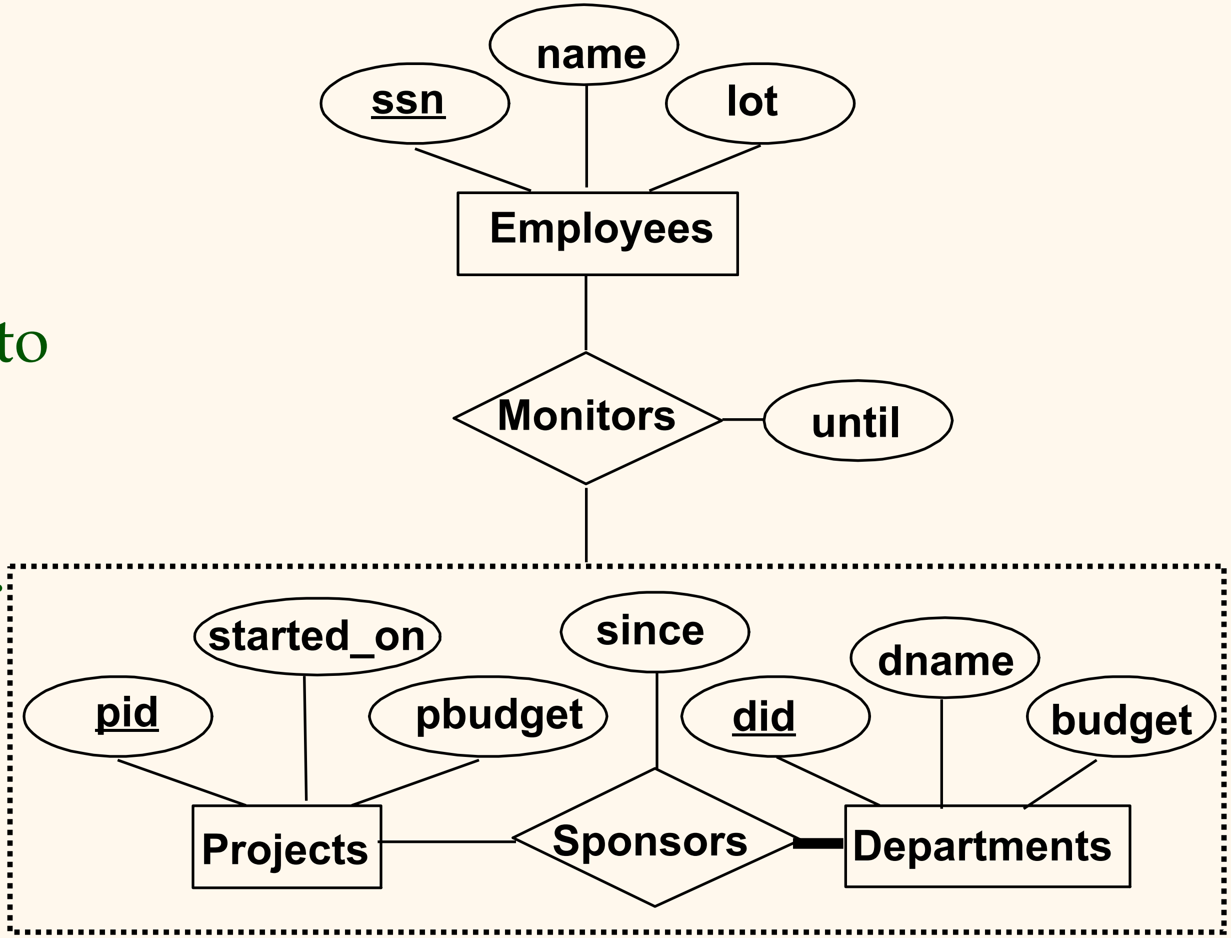
ISA ("is a") Hierarchies



- As in C++ or other PLs ER attributes are inherited (including the key attribute).
- If we declare A **ISA** B, every A entity is also considered to be a B entity.
- *Overlap constraints: Can Joe be an Hourly_Emps as well as a Contract_Emps entity? (Allowed or **disallowed**)*
  - *Ex:* Hourly_Emps OVERLAPS Contract_Emps (else pick 1 of the **3** types)
- *Covering constraints: Does every Employees entity also have to be either an Hourly_Emps or a Contract_Emps entity? (Yes or **no**)*
  - *Ex:* Hourly_Emps AND Contract_Emps COVER Employees (pick 1 of **2** vs. 1 of 3)
- Reasons for using ISA:
  - To add descriptive attributes specific to a subclass.
  - To identify subclasses that participate in a relationship.
- Design: specialization (top-down), generalization (bottom-up)

Aggregation

- Used when we have to model a relationship involving (entity sets and) a *relationship set*.
  - *Aggregation* allows us to treat a relationship set as an entity set for purposes of participating in (other) relationships.

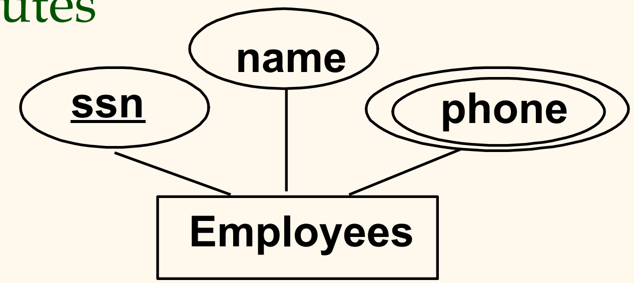


☛ *Aggregation vs. ternary relationship*:

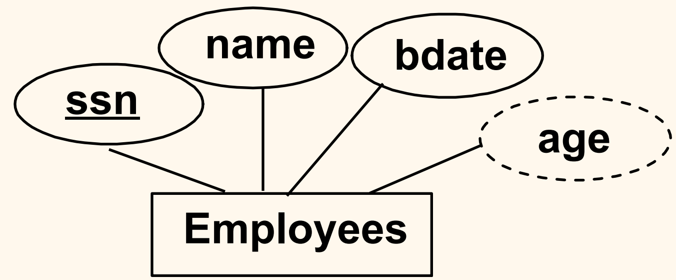
- Monitors is a distinct relationship; even has its own attribute here.
- Each sponsorship can monitored by zero or more employees (as above).

Additional Advanced ER Features

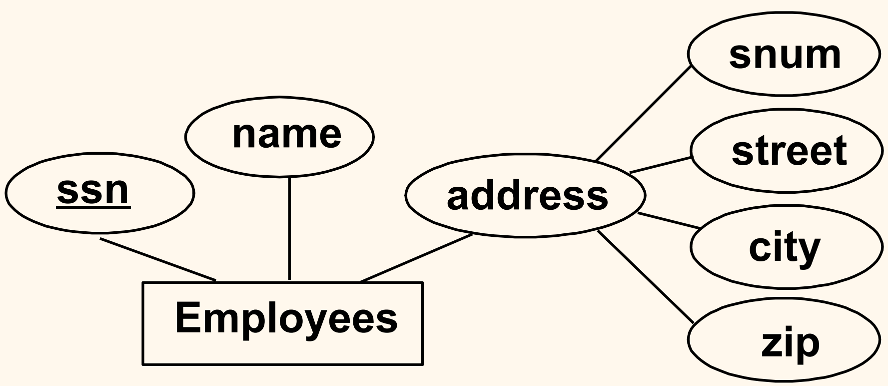
- Multi-valued (vs. single-valued) attributes



- Derived (vs. base/stored) attributes



- Composite (vs. atomic) attributes



NOTE: Can model (two of) these using additional entity and relationship types.

Conceptual Design Using the ER Model

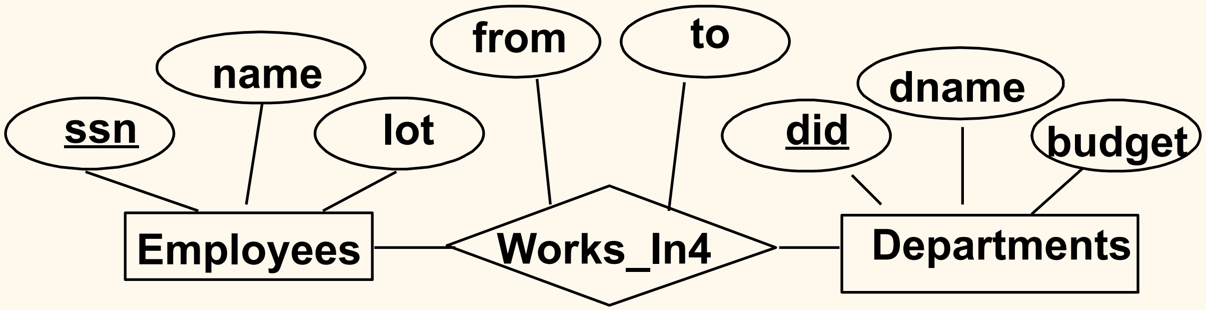
- Design choices:
  - Should a given concept be modeled as an entity or an attribute?
  - Should a given concept be modeled as an entity or a relationship?
  - Characterizing relationships: Binary or ternary? Aggregation? …
- Constraints in the ER Model:
  - A lot of data semantics can (and should) be captured.
  - But, not all constraints cannot be captured by ER diagrams. (*Ex:* Department heads from earlier…!)

Entity vs. Attribute

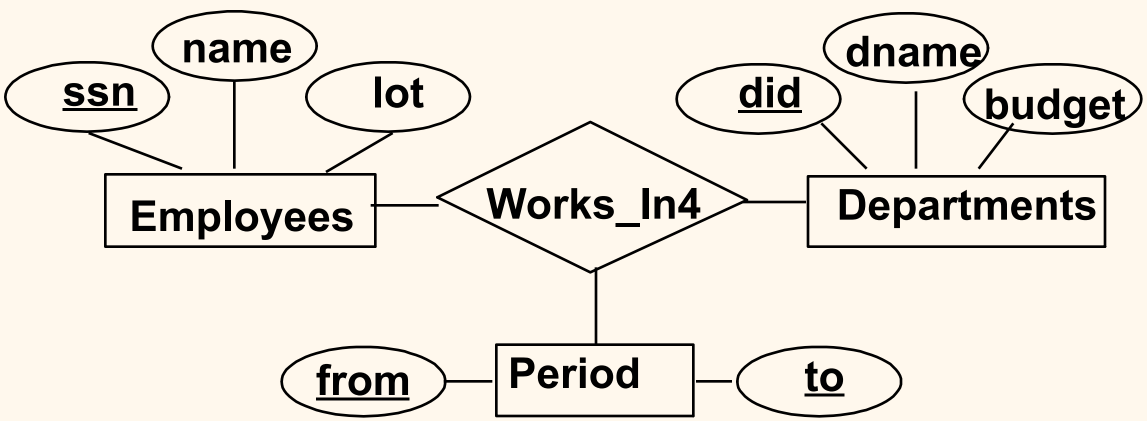
- Should *address* be an attribute of Employees or an entity (connected to Employees by a relationship)?
- Depends how we want to use address information, the data semantics, and also the model features:
  - If we have several addresses per employee, *address* must be an entity if we stick to basic E-R concepts (as attributes cannot be set-valued w/o advanced modeling goodies).
  - 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 w/o advanced modeling goodies).
  - If the address itself is logically separate (e.g., the property that's located there) and refer-able, it's <u>rightly</u> an entity in any case!

Entity vs. Attribute (Cont'd.)

- Works_In4 does not allow an employee to work in a department for two or more periods. (Q: Why...?)

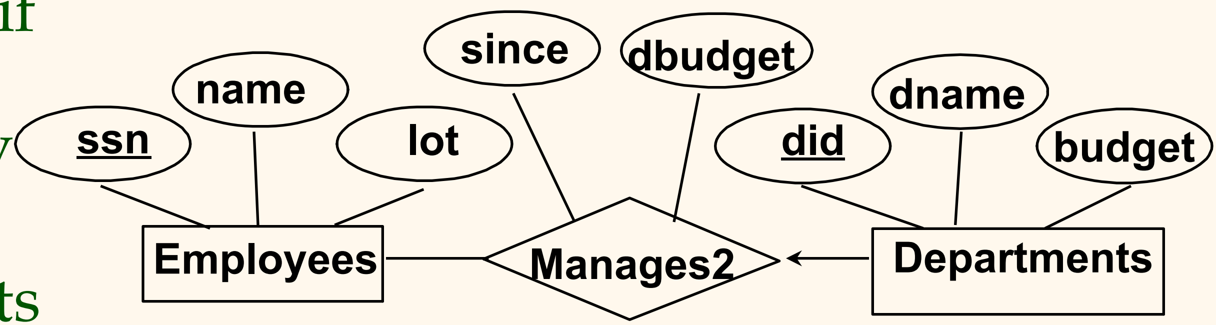


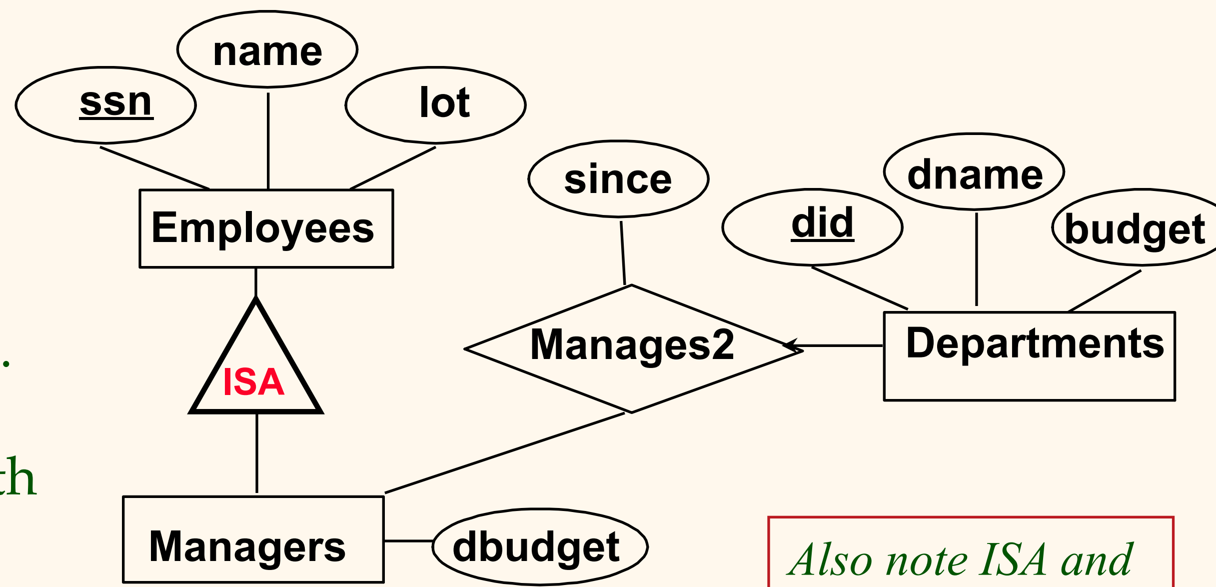
- Similar to the problem of wanting to record several addresses for an employee: We want to record *several values of the descriptive attributes for each instance of this relationship.* Could be accomplished by introducing a new entity set, Period.



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.

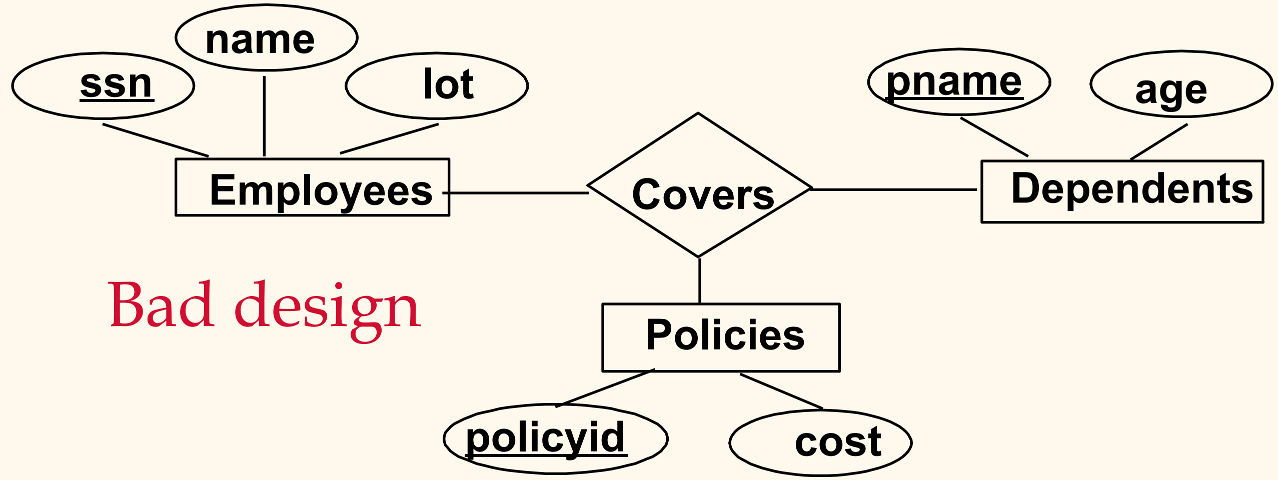




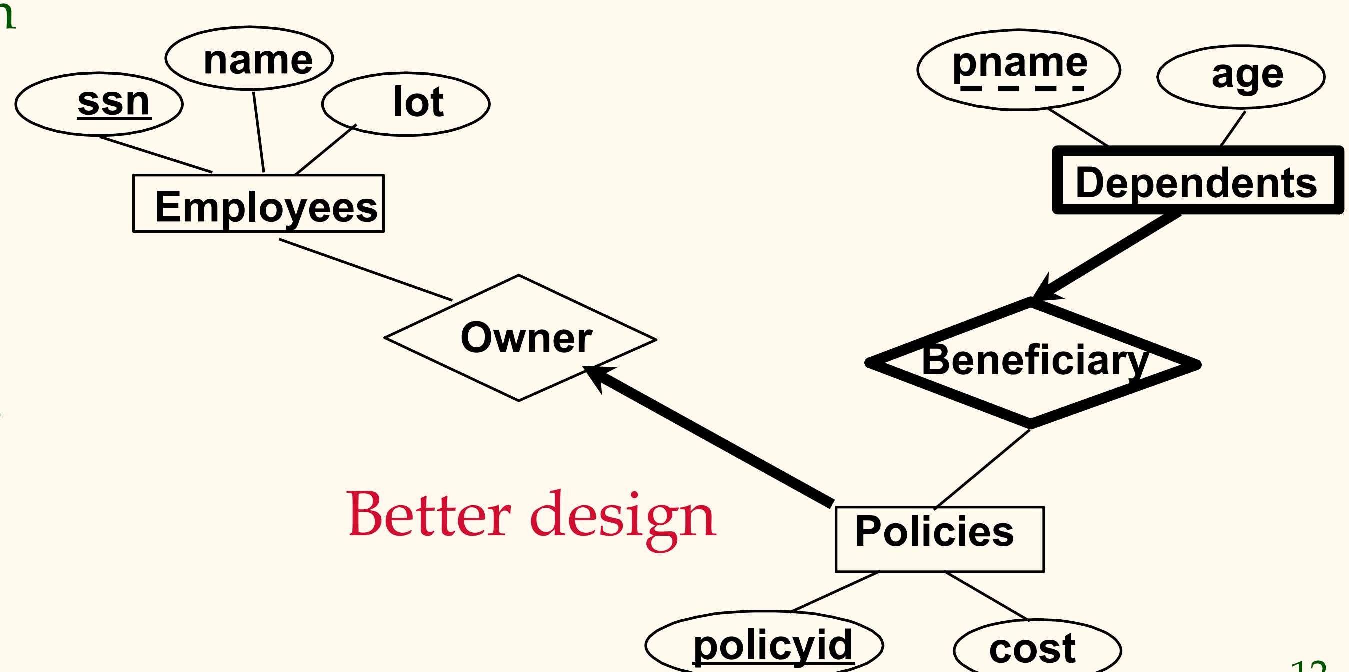
Also note ISA and the relationship...

Binary vs. Ternary Relationships

- If each policy is owned by just 1 employee, with each dependent tied to their covering policy, first diagram is inaccurate.
- ***Q:*** What are the additional constraints in the 2nd diagram? (And what else was wrong with the 1st diagram? ☺)



Bad design



Better design

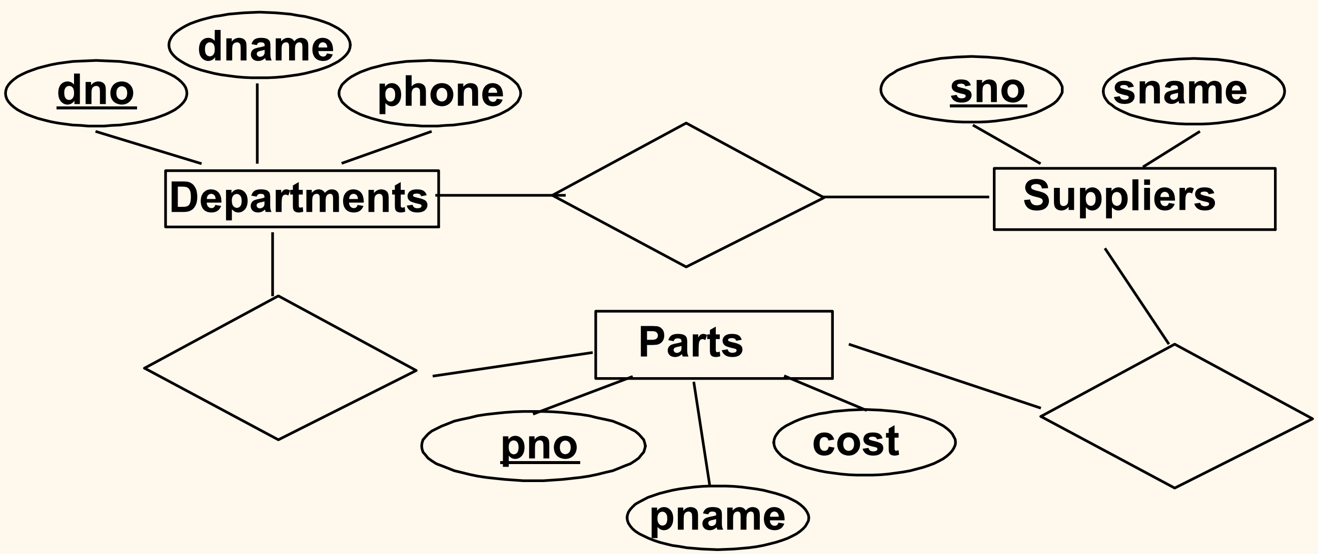
Binary vs. Ternary Relationships (Cont'd.)

- 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*.

Binary vs. Ternary Relationships (Cont'd.)

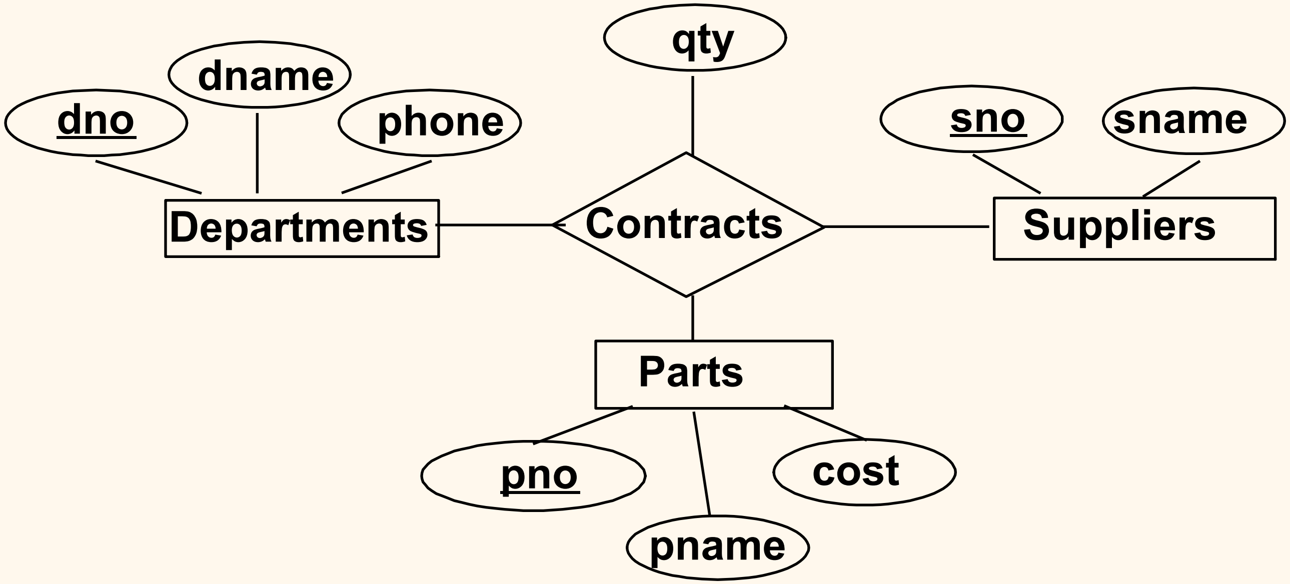
Bad design:

- S "can-supply" P, D "needs" P, and D "deals-with" S does not imply that D has agreed to buy P from S.
- And also, how we record *qty*?



Binary vs. Ternary Relationships (Cont'd.)

- An example in the other direction: a ternary relation Contracts relates entity sets Parts, Departments and Suppliers, and has descriptive attribute *qty*:



Database Design Process (Flow)

- Requirements Gathering (interviews)
- Conceptual Design (using ER)
- Platform Choice (which DBMS?)
- Logical Design (for target data model)
- Physical Design (for target DBMS, workload)
- Implement (and test, of course ☺)

(Expect backtracking, iteration, and also incremental adjustments – and, we will actually be giving you a bit of practice with that last one in the next few HW assignments…! ☺)

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 (and many notations in use as well) – and also, UML...

Summary of ER (Contd.)

- Several kinds of integrity constraints can be expressed in the ER model: *cardinality constraints*, *participation constraints*, and *overlap/covering constraints* for ISA hierarchies. Some *foreign key constraints* are also implicit in the definition of a relationship set (more about those will be coming soon).
  - 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 an ISA hierarchy, and whether or not to use aggregation.
- Ensuring good database design → The resulting relational schema should be analyzed and refined further. FD information and normalization techniques are especially useful (coming soon).