ICS 321 Fall 2009

Introduction to Database Design

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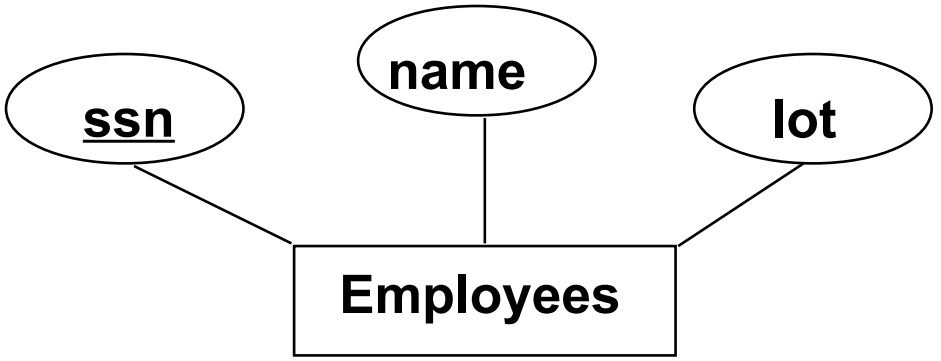
Overview of Database Design

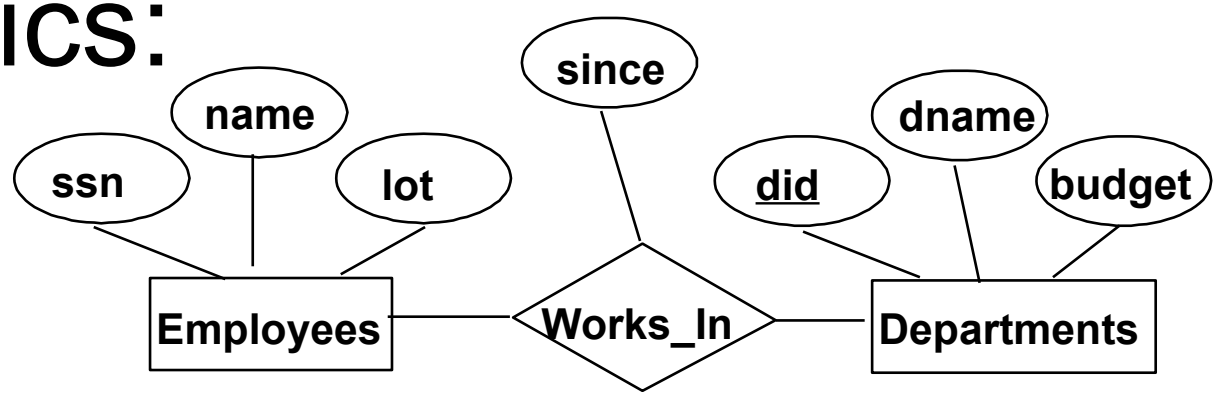
- Conceptual Design
  - Use entity-relationship (aka ER) model represented pictorially as ER diagrams
  - Map ER model to relational schema
- Questions to ask yourself
  - What are the *entities* and *relationships* in the enterprise?
  - What information about these entities and relationships should we store in the database?
  - What are the *integrity constraints* or *business rules* that hold?

ER Model Basics: Entities



- *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. (Until we consider ISA hierarchies, anyway!)
  - Each entity set has a *key*.
  - Each attribute has a *domain*.

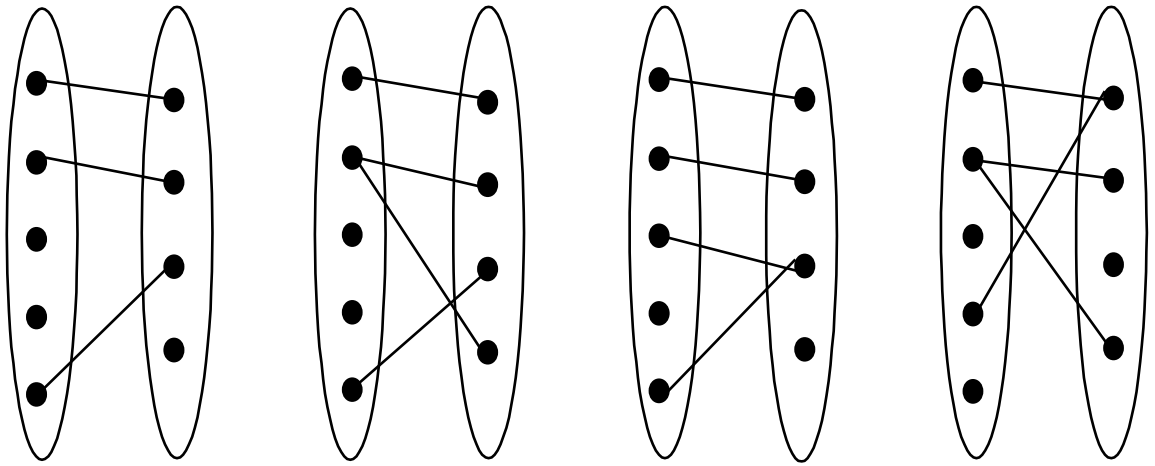
ER Model Basics: Relationships



- *Relationship*: Association among two or more entities.
- *Relationship Set*: Collection of similar relationships.
  - An n-ary relationship set R relates n entity sets E1 ... En; each relationship in R involves entities e1 E1, ..., en En
  - Same entity set could participate in different relationship sets, or in different "roles" in same set.

Cardinality Ratios of Relationships

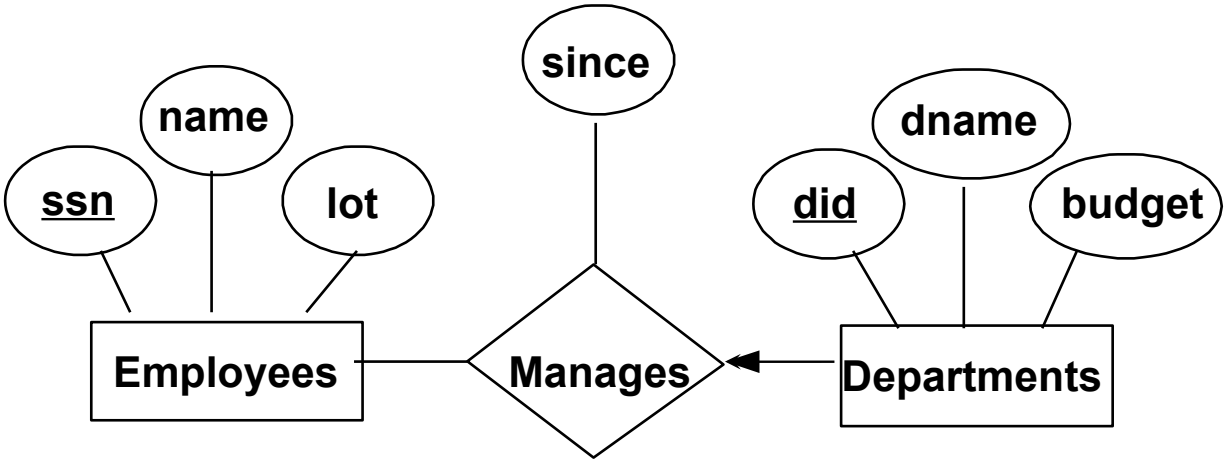
- Consider binary relationships, i.e., between two entity sets
- Alternate notation: 1:1, 1:M, M:1, M:N



Internet Book Store Example

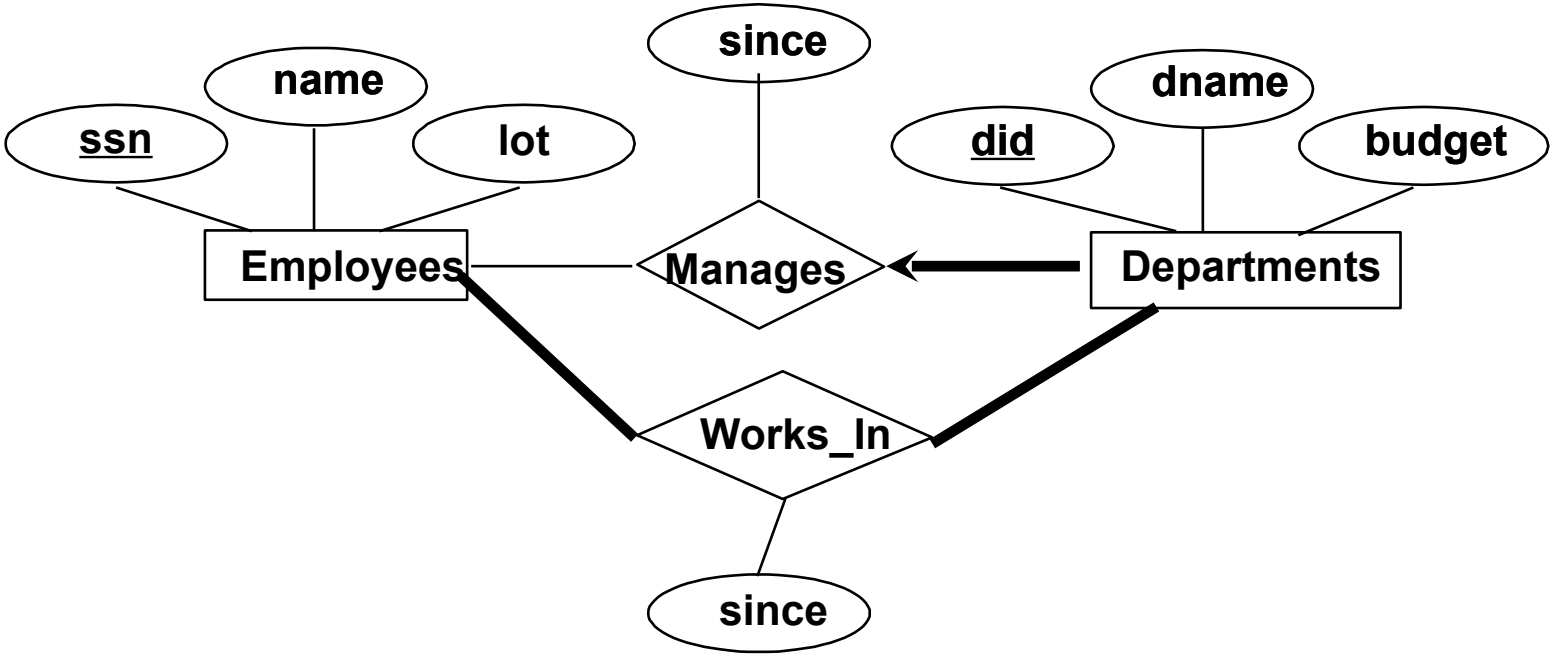
- Catalog of books
  - ISBN, title, author, qty_in_stock, price, year_published
- Customers
  - CID, Name, address
- Orders
  - ISBN, CID, cardnum, qty, order_date, ship_date

Key Constraints



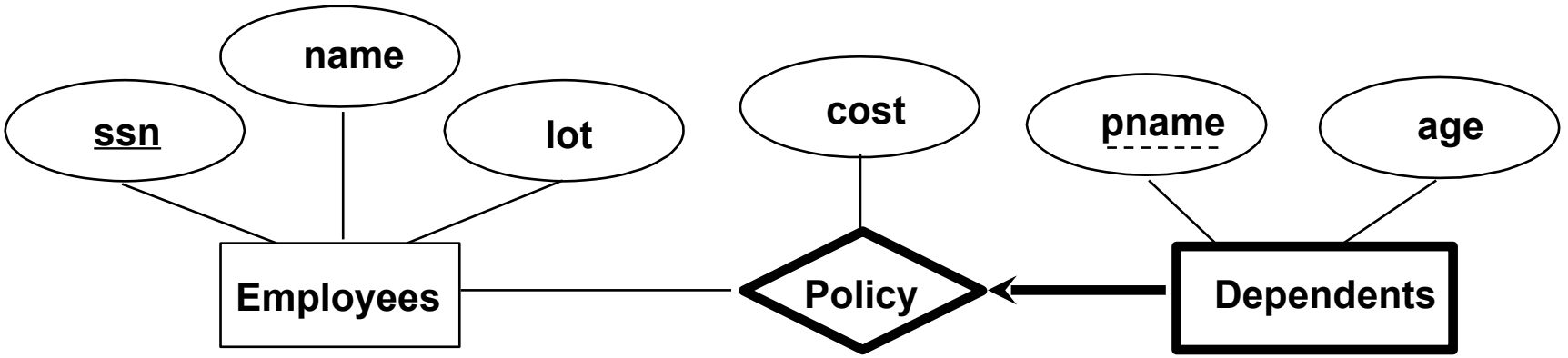
- Consider Works_In: An employee can work in many depts; a dept can have many employees.
- In contrast, each dept has at most one manager, according to the *key constraint* on Manages.
- Denoted by an arrow: given a dept entity we can uniquely identify the manages relationship in which it appears

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*). Denoted by thick/double line
- Meaning that every Departments entity must appear in an instance of the Manages relationship

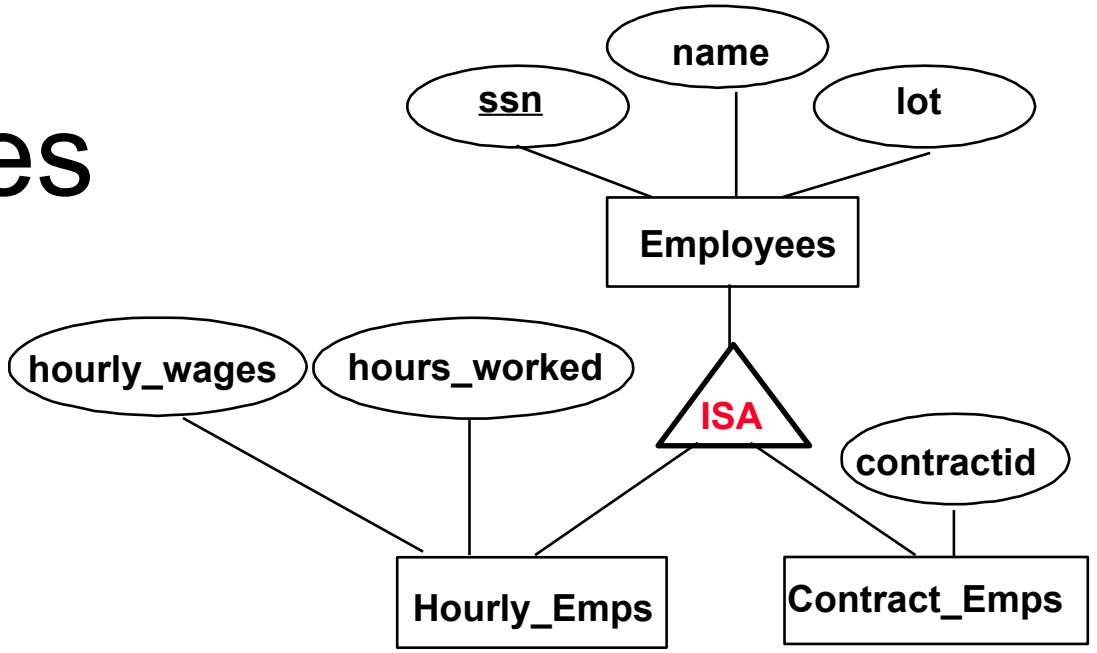
Weak Entities



- 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.
- Denoted by a box with double or thick lines

IS-A Hierarchies

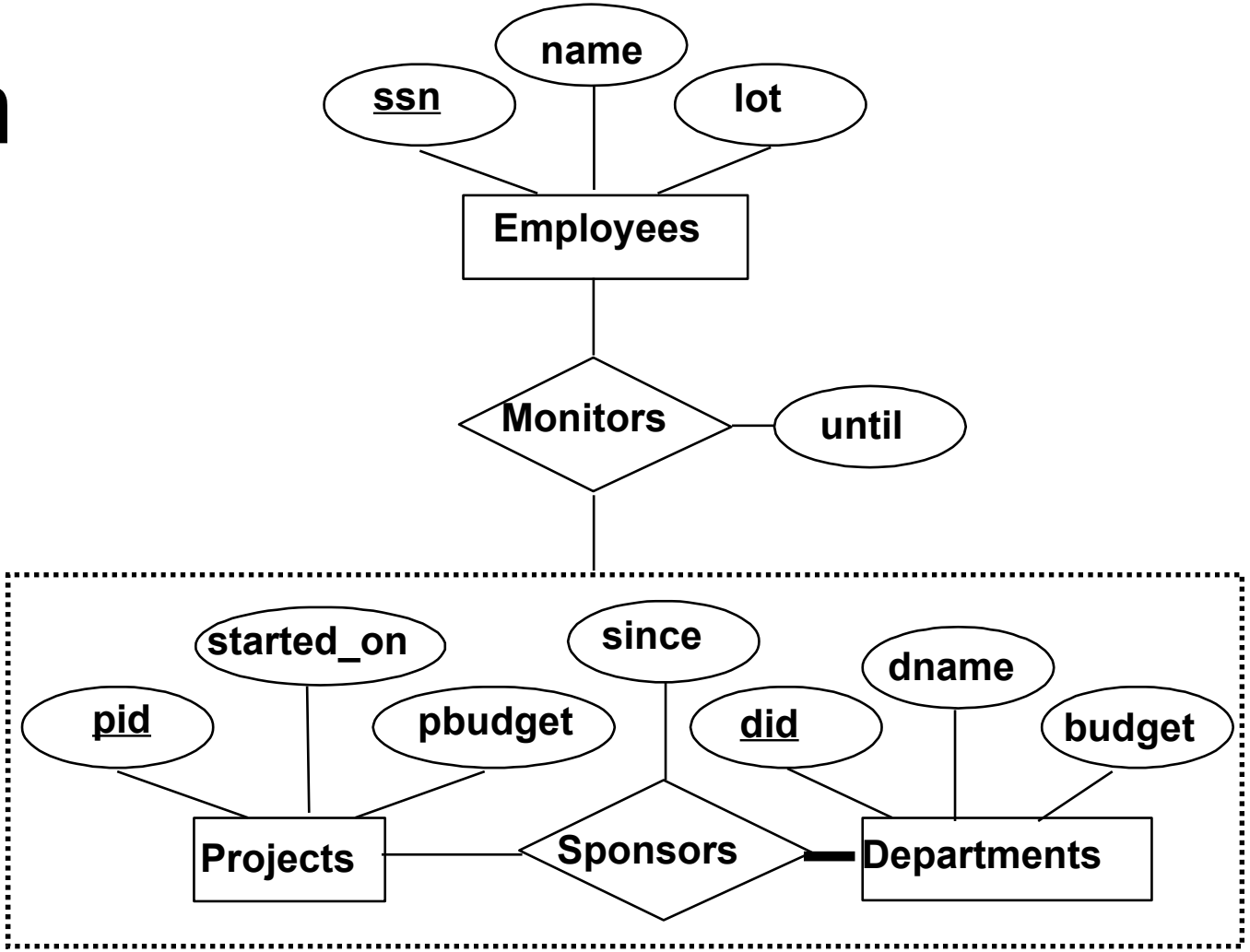
- If we declare A **ISA** B, every A entity is also considered to be a B entity.



- *Overlap constraints*: Can Joe be an Hourly_Emps as well as a Contract_Emps entity? (*Allowed/disallowed*)
- *Covering constraints*: Does every Employees entity also have to be an Hourly_Emps or a Contract_Emps entity? *(Yes/no)*
- Reasons for using ISA:
  - To add descriptive attributes specific to a subclass.
  - To identify entitities that participate in a relationship.

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 participation in (other) relationships.



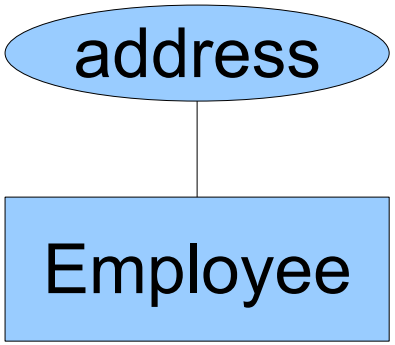
Aggregation vs. ternary relationship:

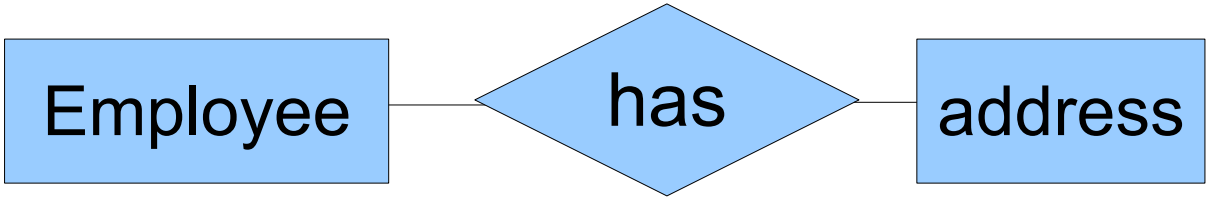
- Monitors is a distinct relationship, with a descriptive attribute.
- Also, can say that each sponsorship is monitored by at most one employee.

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?
- How much semantics to capture in the form of constraints ?

Entity vs. Attribute

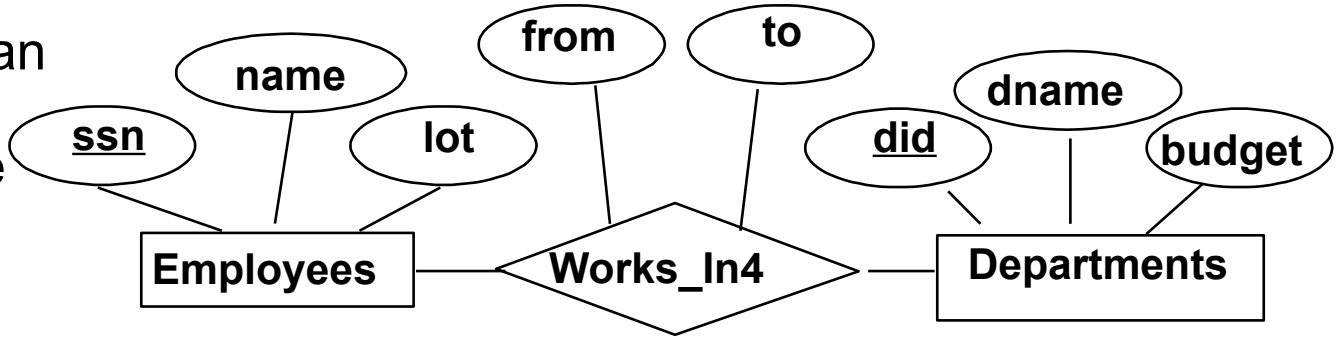




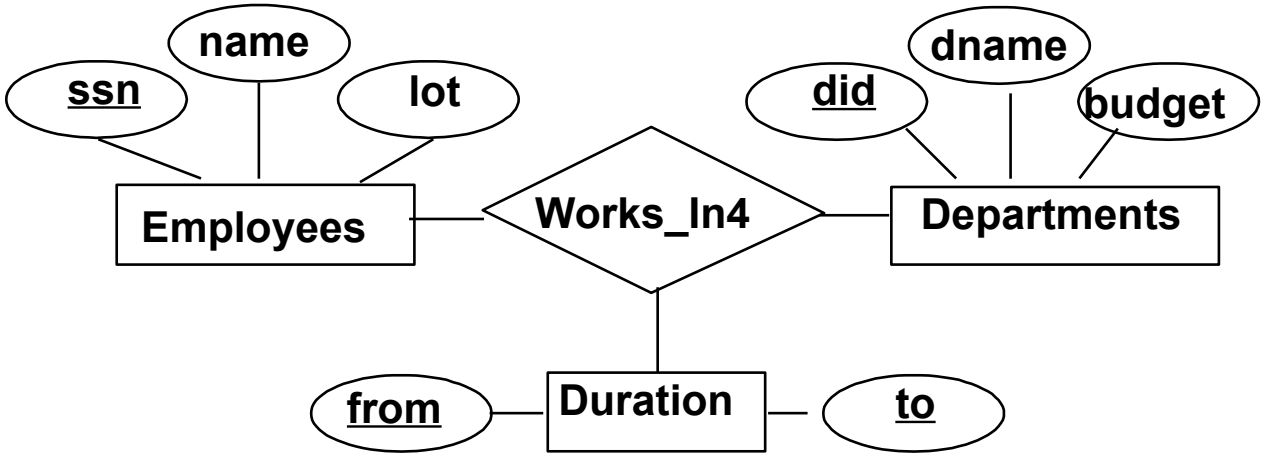
- Depends upon how we want to use the address information, and the semantics of the data:
  - If we have several addresses per employee, *address* must be an entity (since attributes cannot be set-valued).
  - If the structure (city, street, etc.) is important, e.g., we want to retrieve employees in 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.

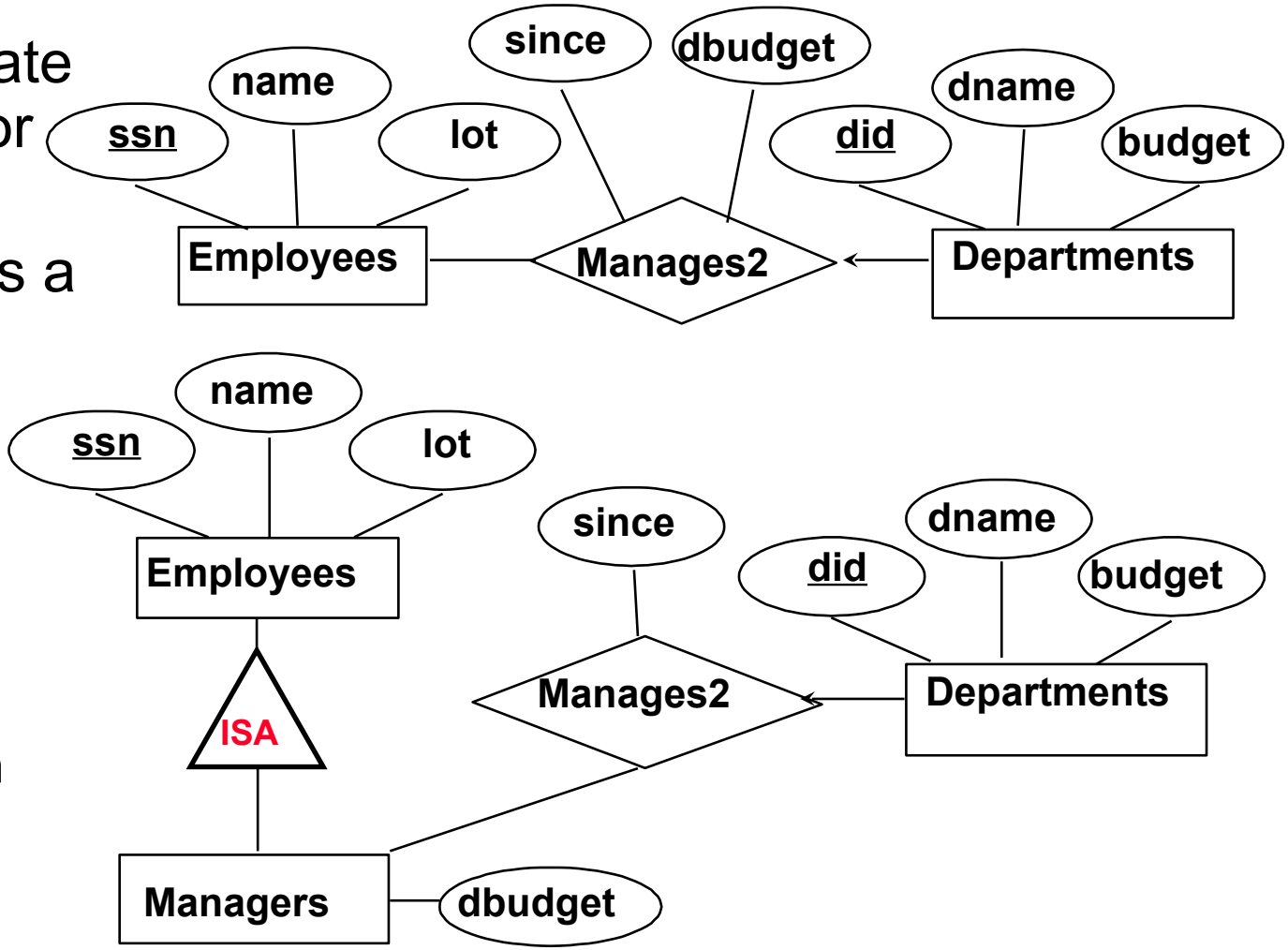


- Similar to the problem of wanting to record several addresses for an employee: We want to record *several values of the descriptive attributes for each instance of this relationship.* Accomplished by introducing new entity set, Duration.



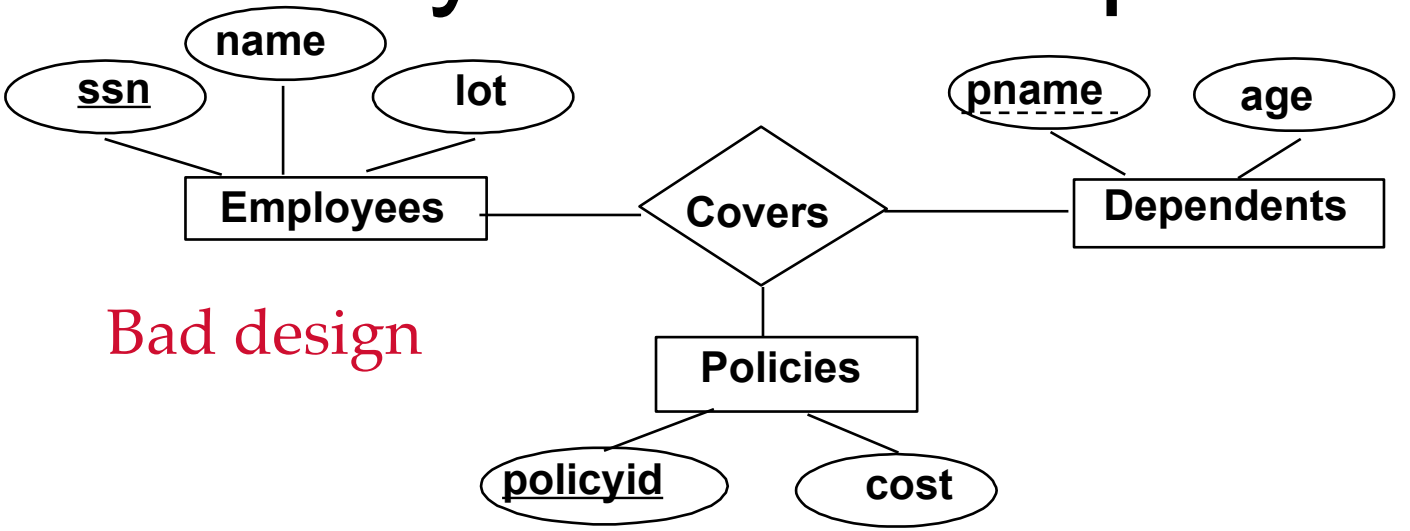
Entity vs. Relationship

- 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.

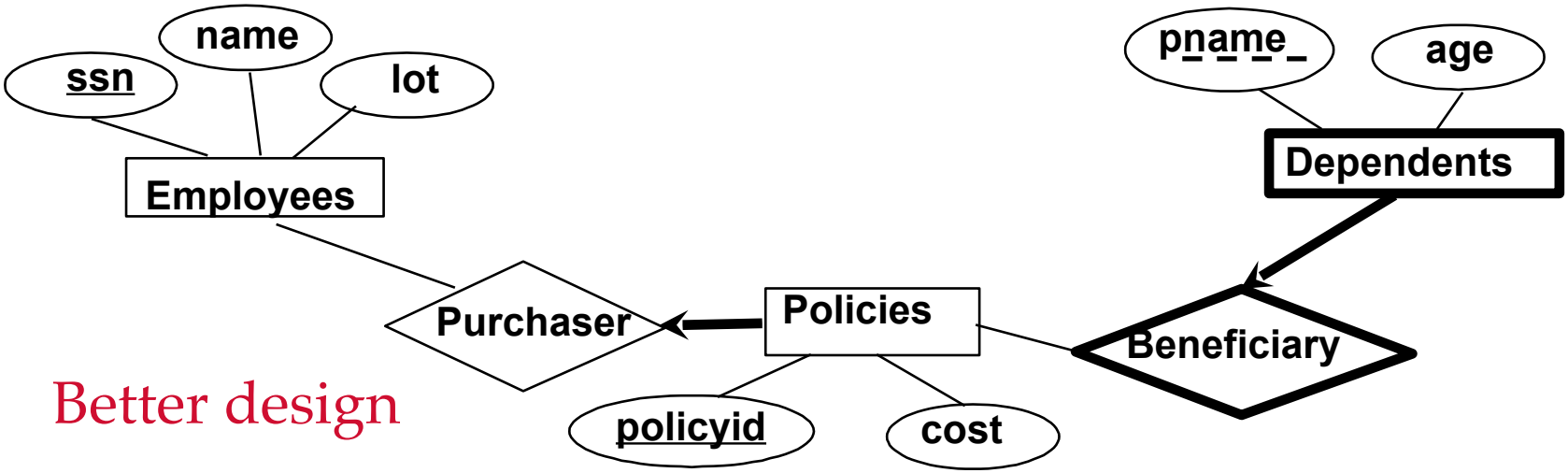


Binary vs. Ternary Relationships

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



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