Database Design: ER and UML Diagrams

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CS411: Database Systems

October 3, 2018

Announcements

- HW 2 will be posted today
- Project Track 1 – Stage 1 is due today

TRAVEL GRANTS, FELLOWSHIPS, AWARDS, OH MY!

Mark your calendar for these upcoming deadlines:

October 10 CRA Outstanding Undergrad Researcher
EXTENDED!

October 10 Illinois Office of Undergrad Research: Conference Travel Grant
*apply directly to OUR, http://go.illinois.edu/OUR_CTG

October 25 Illinois Office of Undergrad Research: Research Support Grant
*apply directly to OUR, http://go.illinois.edu/OUR_RSG

Find details at: http://go.cs.illinois.edu/AwardDeadlines

Questions? Contact Samantha at shendon@illinois.edu

ILLINOIS
Computer Science

THERE ARE STILL FUNDING OPPORTUNITIES OUT THERE!

Mark your calendar for these upcoming deadlines:

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October 10 CRA Outstanding Undergrad Researcher

October 15 ACM/Kuck PhD & MS Dissertation Awards

October 15 IBM PhD Fellowship

October 29 Google Fellowship

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Overview of Database Design

- Conceptual design: (ER & UML Models are used for this.)
  - What are the entities and relationships we need?
- Logical design:
  - Transform ER design to Relational Schema
- Schema Refinement: (Normalization)
  - Check relational schema for redundancies and related anomalies.
- Physical Database Design and Tuning:
  - Consider typical workloads; (sometimes) modify the database design; select file types and indexes.

We'll cover this today

And introduce this

Agenda

- Finish with weak entity sets
- Design principles
- Translating basic ER diagrams to a relational schema
- Functional dependences

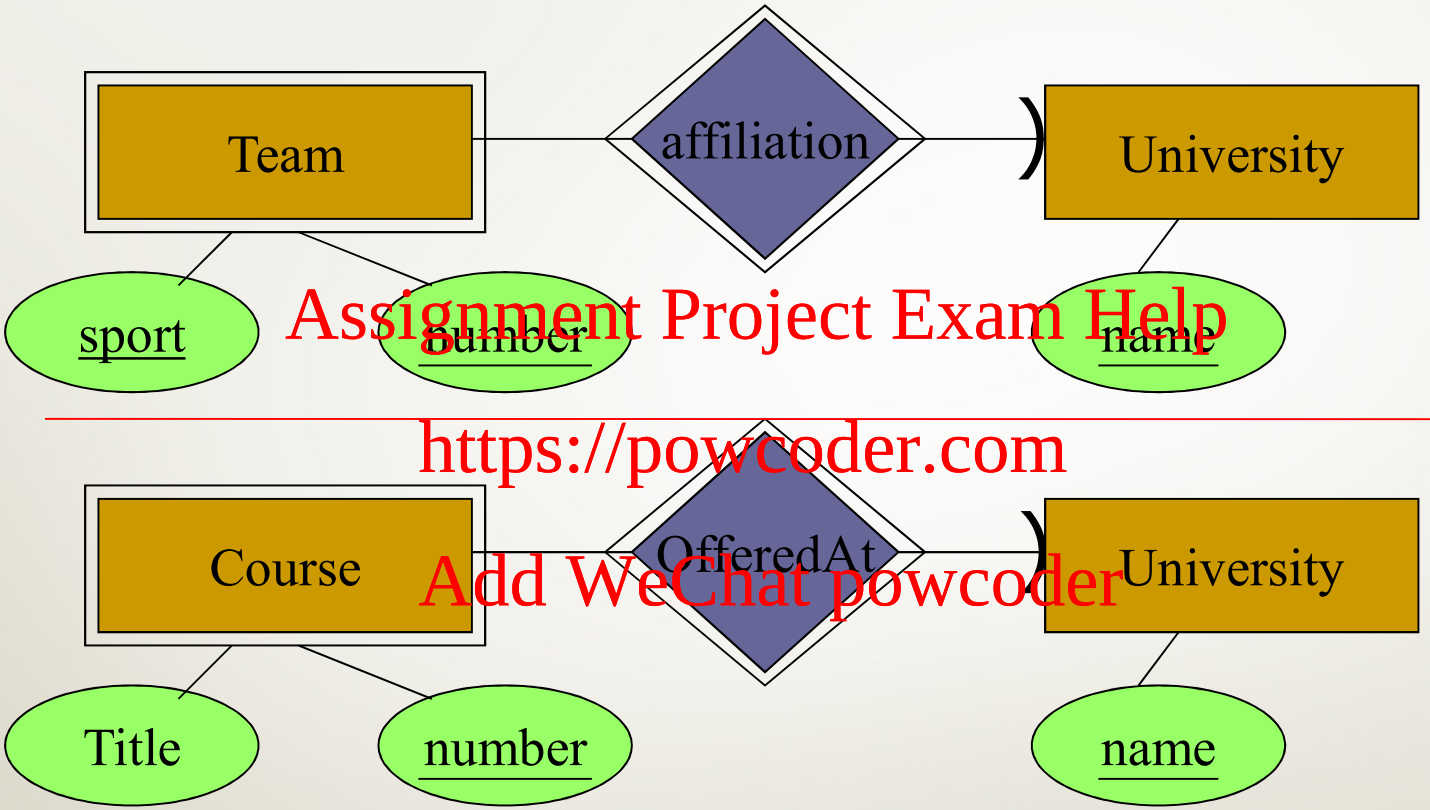
Weak Entity Sets

- Occasionally, entities of an entity set need "help" to identify them uniquely.

- Entity set E is *weak* if in order to identify entities of E uniquely, we need to follow one or more many-one relationships from E and include the key of the related entity sets.

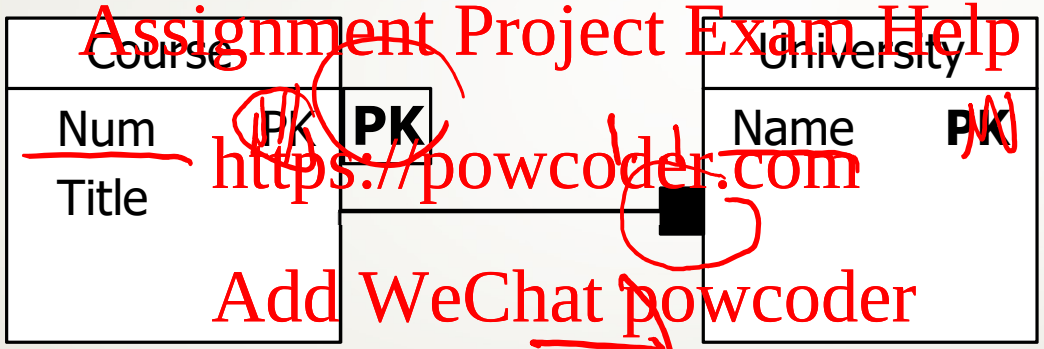
- Note: not an is-a relationship because E is not a "subclass" of F: Univ and Team

Notations for weak entity set

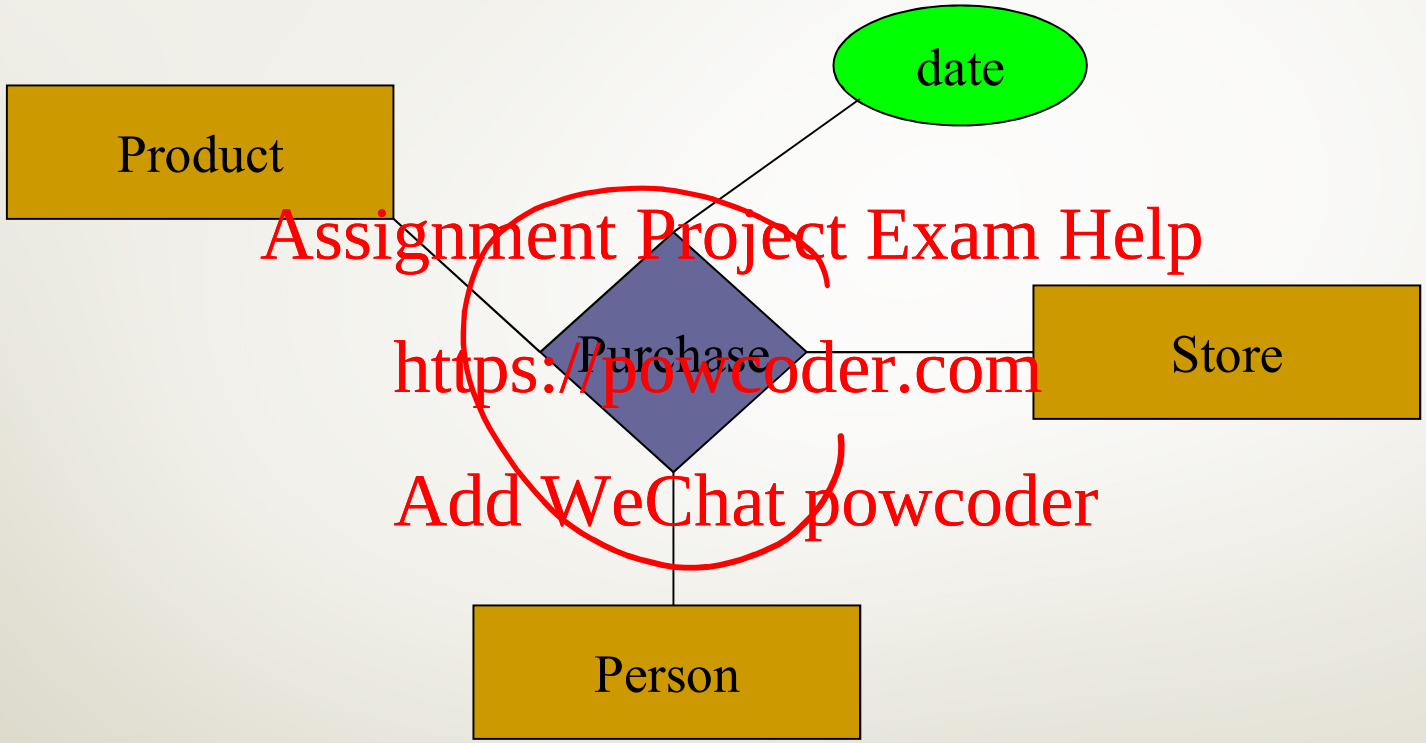


- "University" is a "supporting entity set" for "Team".
- "Affiliation" is a "supporting relationship".

Weak entity set in UML



Another scenario where weak e.s. arises



A Multi-way relationship …

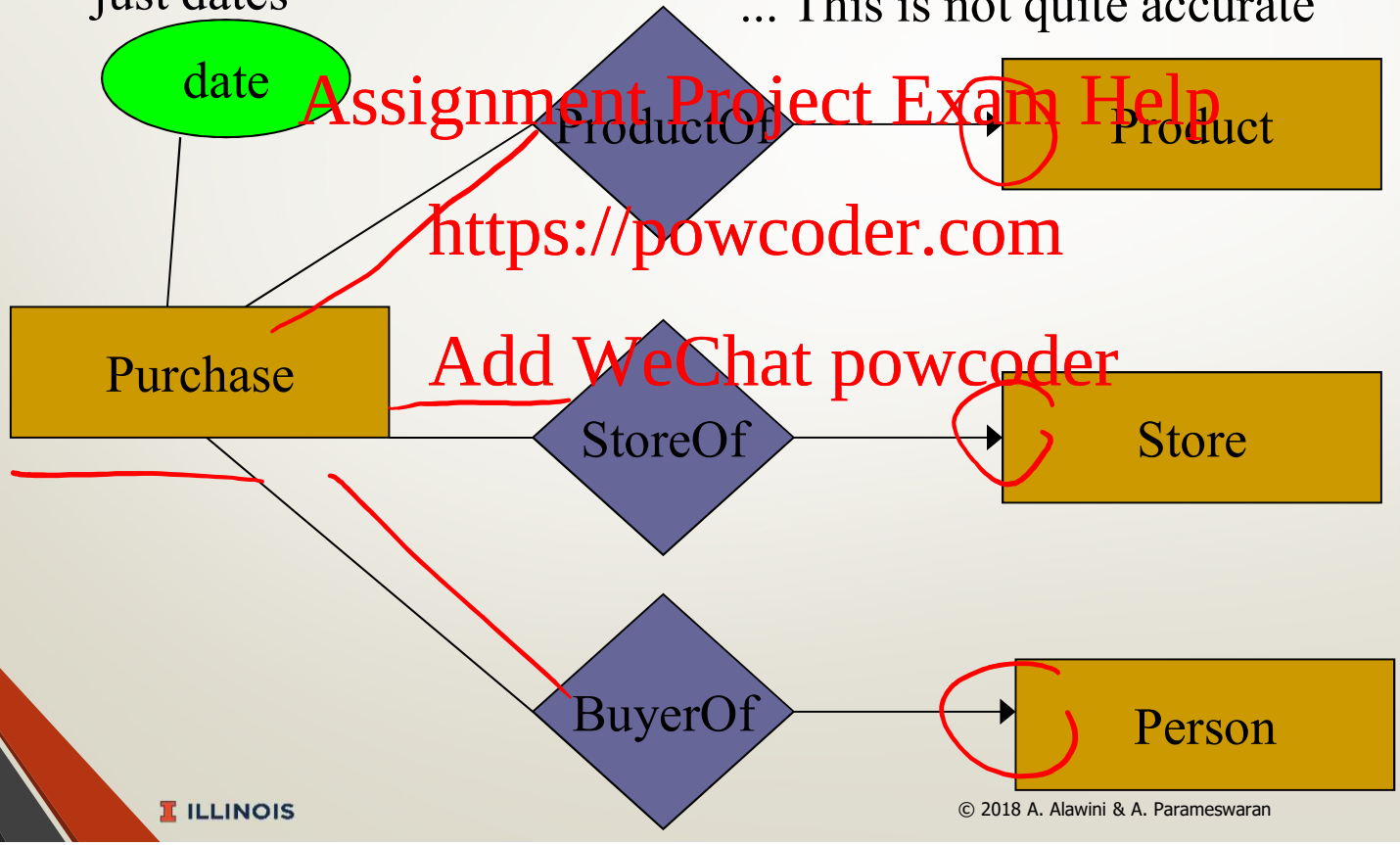
Another scenario where weak e.s. arises

Not sufficient to identify purchase via just dates

… converted to binary relationships

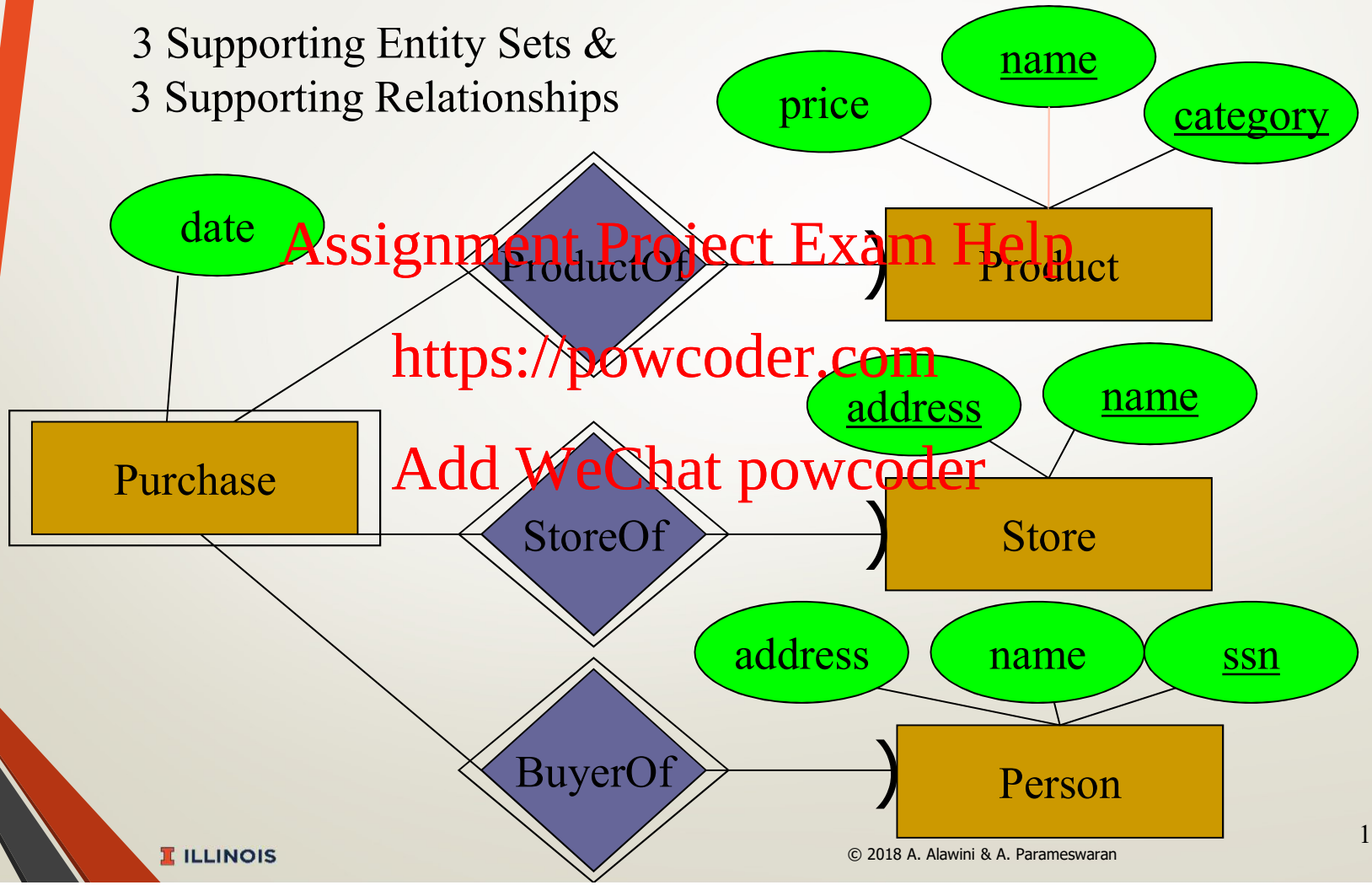
Remember this is what we had …

... This is not quite accurate



Another scenario where weak e.s. arises

3 Supporting Entity Sets &
3 Supporting Relationships



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Design Principles

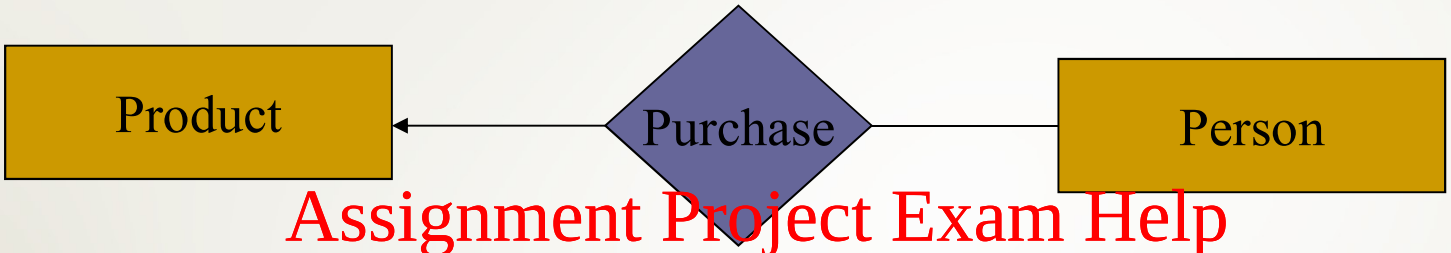
- Be Faithful to Reality
- Avoid Redundancy
- Pick the Right Kind of Element

Also:

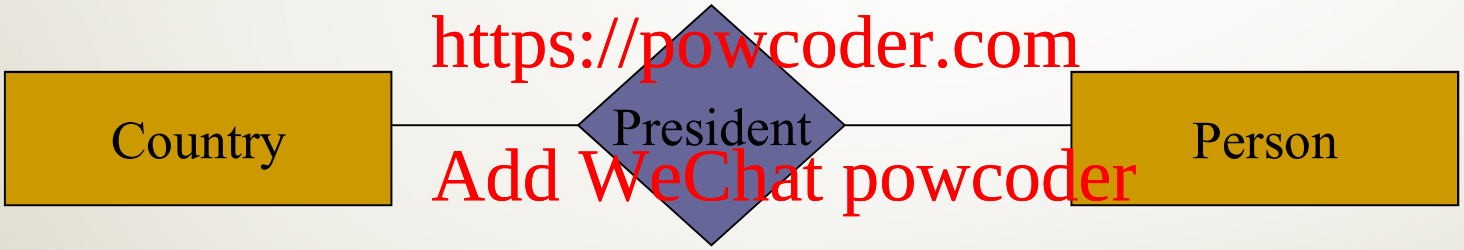
- Simplicity
- Choose the Right Relationships

(See Textbook for examples…)

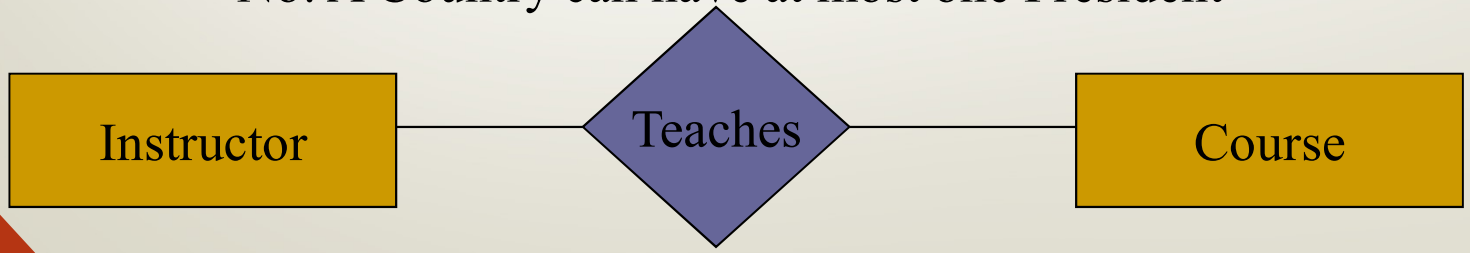
Design Principles:
Principle 1: Be Faithful To Reality



No: A Person may purchase multiple Products



No: A Country can have at most one President



Yes if multiple instructors, No if not.

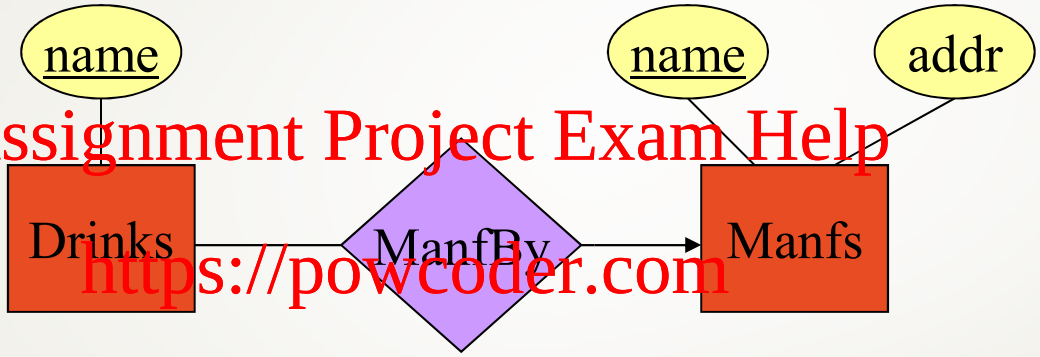
Avoiding Redundancy

- Redundancy occurs when we say the same thing in two different ways.

- Redundancy wastes space (as we will see) and (more importantly) encourages inconsistency.

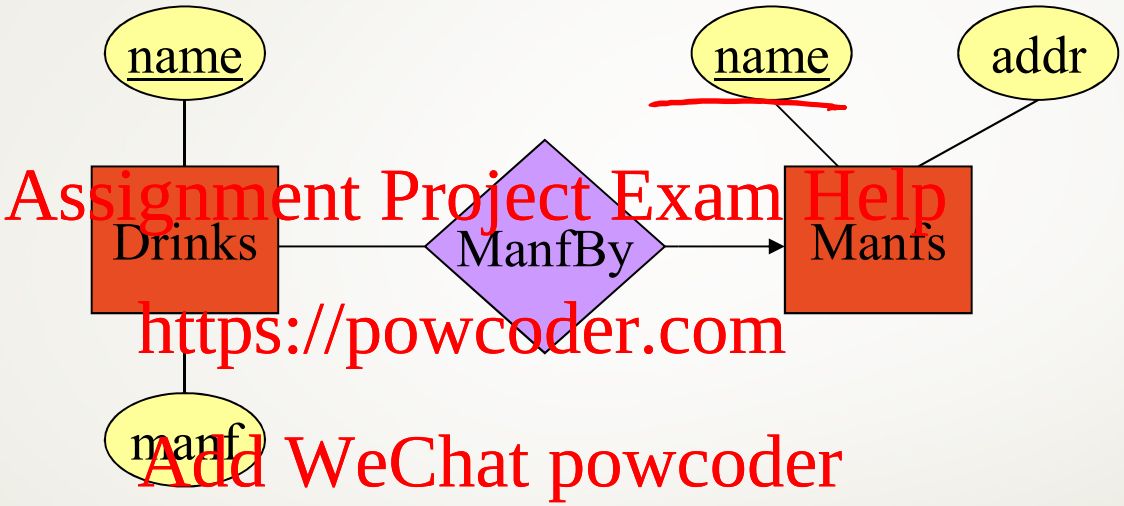
  - The two instances of the same fact may become inconsistent if we change one & forget to change the other.

Example: Good



This design gives the address of each manufacturer exactly once.

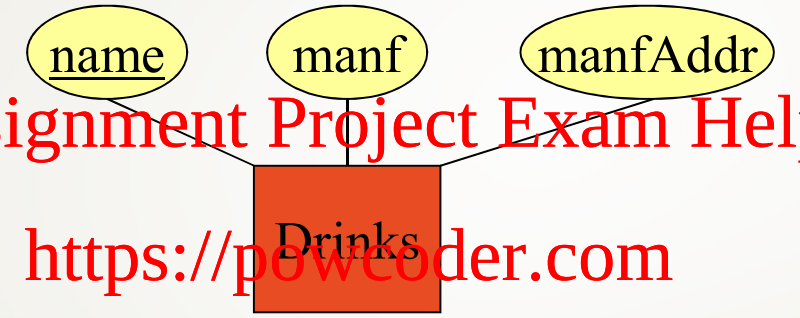
Example: Bad



This design states the name of the manufacturer of a drink twice: as an attribute and as a related entity.

Update issues, Wasteful, …

Example: Bad



This design repeats the manufacturer's address once for each beer (wasteful, update anomalies);

Also loses the address if there are temporarily no drinks for a manufacturer.

Principle 2: Entity Sets Versus Attributes

- An entity set should satisfy at least one of the following conditions:
  - It is more than the name of something
    - i.e., it has at least one non-key attribute.
    Or
  - It is the "many" in a many-one or many-many relationship.

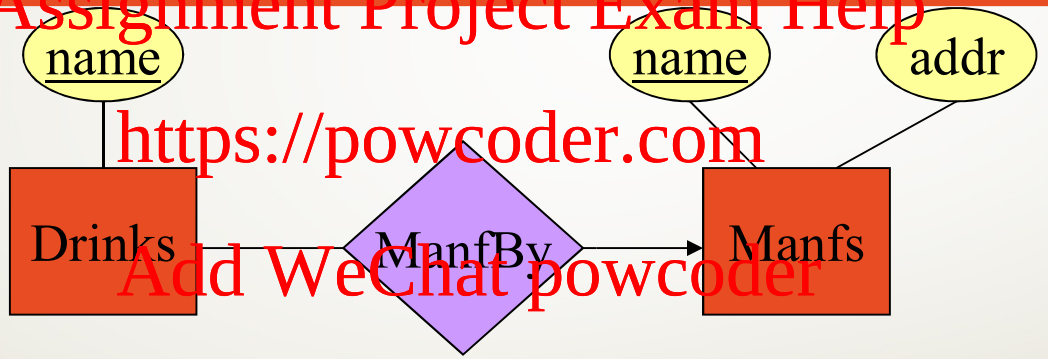
Examples will illustrate why, but also think why each of these rules actually make sense.

Example: Good

- An E.S. is more than the name of something;
  - i.e., it has at least one non-key attribute.

OR

- An E.S is the "many" in a many-one or many-many relationship.



- *Manfs* deserves to be an entity set because of the nonkey attribute *addr*.

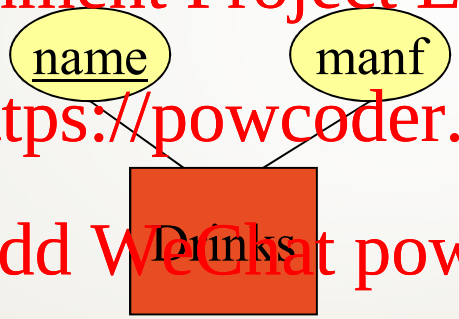
- *Drinks* deserves to be an entity set because it is the "many" of the many-one relationship *ManfBy*. Can you see why?

Example: Good

- An E.S. is more than the name of something;
  - i.e., it has at least one non-key attribute.

OR

- An E.S is the "many" in a many-one or many-many relationship.



If we had no manufacturer address information…

There is no need to make the manufacturer an entity set, because we record nothing about manufacturers besides their name.

Example: Bad

- An E.S. is more than the name of something;
  - i.e., it has at least one non-key attribute.

OR

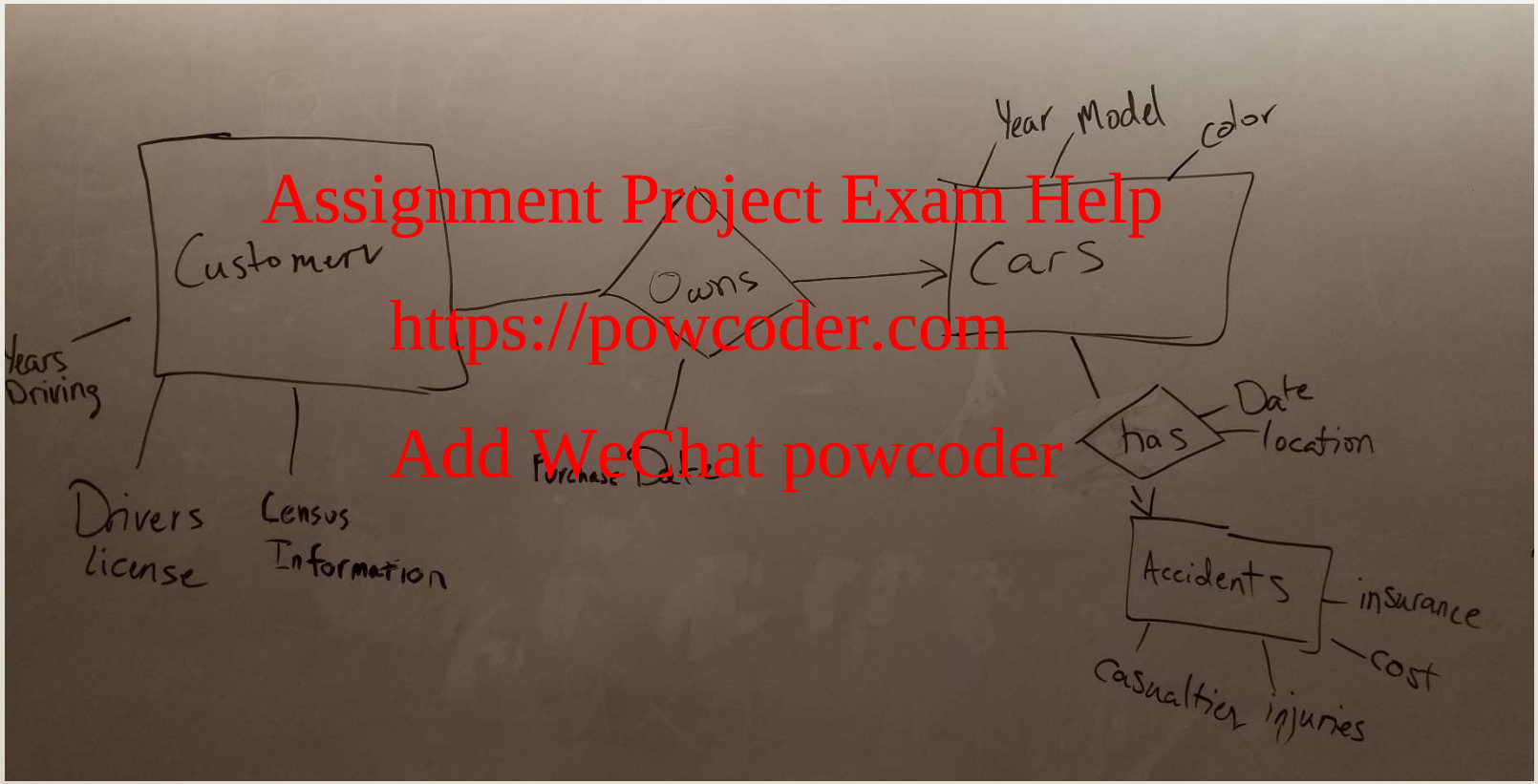
- An E.S is the "many" in a many-one or many-many relationship.

Since the manufacturer is nothing but a name, and is not at the "many" end of any relationship, it should not be an entity set.

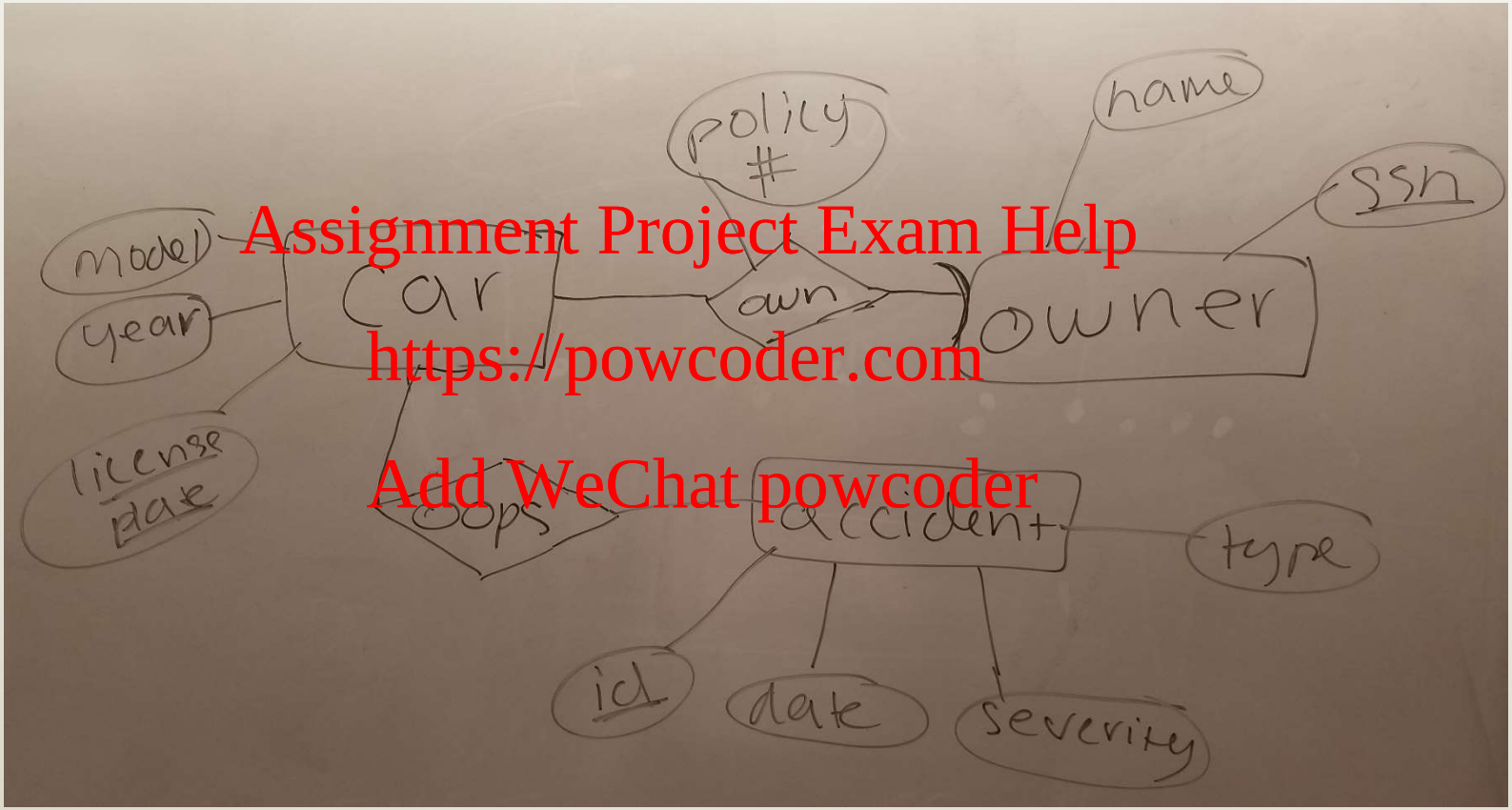
ERD Exercise

Construct an E-R diagram for a car-insurance company whose customers own one or more cars each. Each car has associated with it zero to any number of recorded accidents.

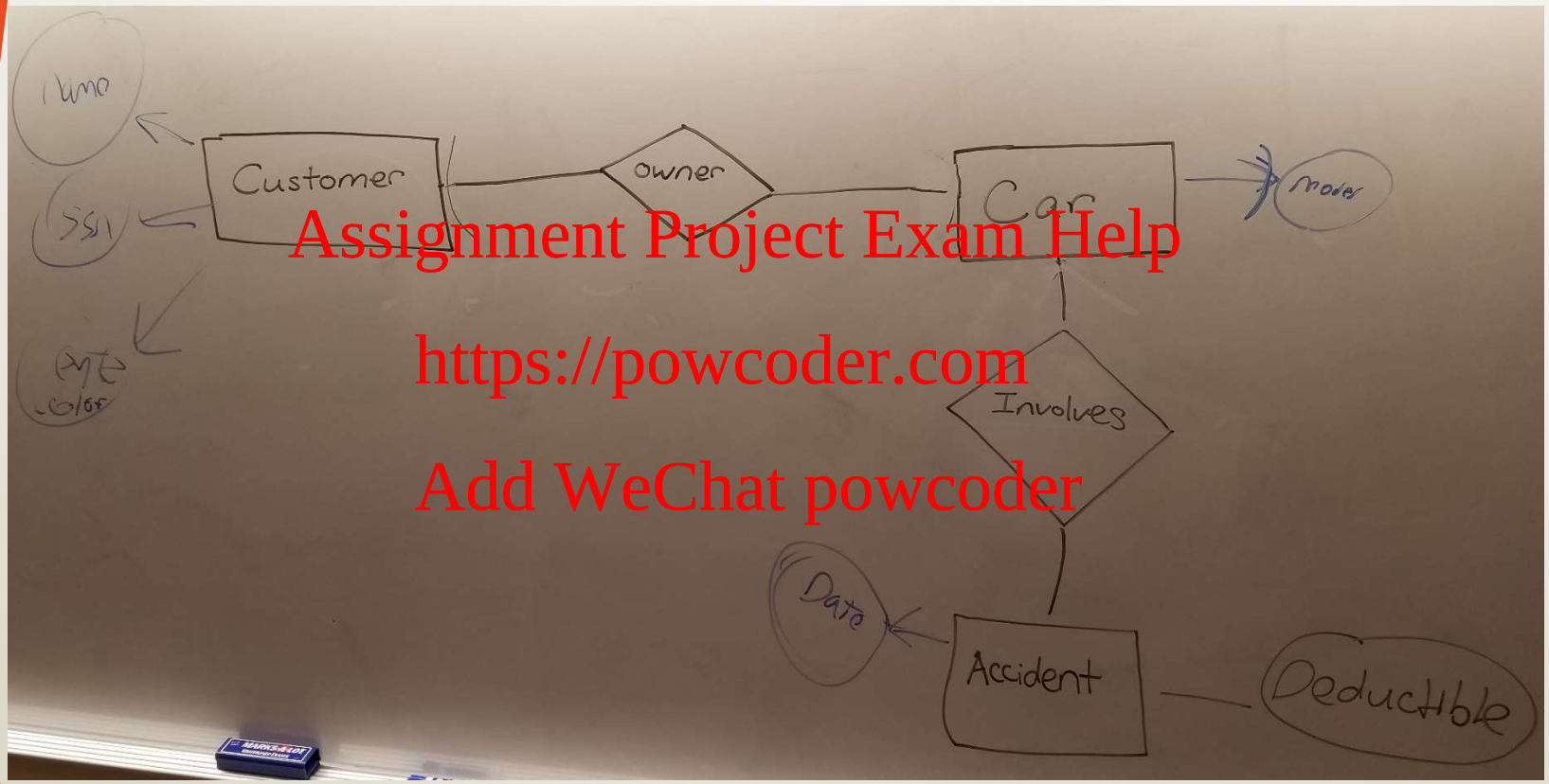
ERD Exercise Student Solution 1



ERD Exercise Student Solution 2



ERD Exercise Student Solution 3



ER Review

- Basics of ER and UML
  - entity, attribute, entity set
  - relation: binary, multiway, converting from multiway
  - relationship roles, attributes on relationships
  - subclasses (is-a)
- Constraints
  - on relations
    - many-one, one-one, many-many
    - limitations of arrows
  - keys, single-valued, ref integrity, domain & general constraints

Agenda

- ✓ Finish with weak entity sets
- ✓ Design principles
- Translating basic ER diagrams to a relational schema
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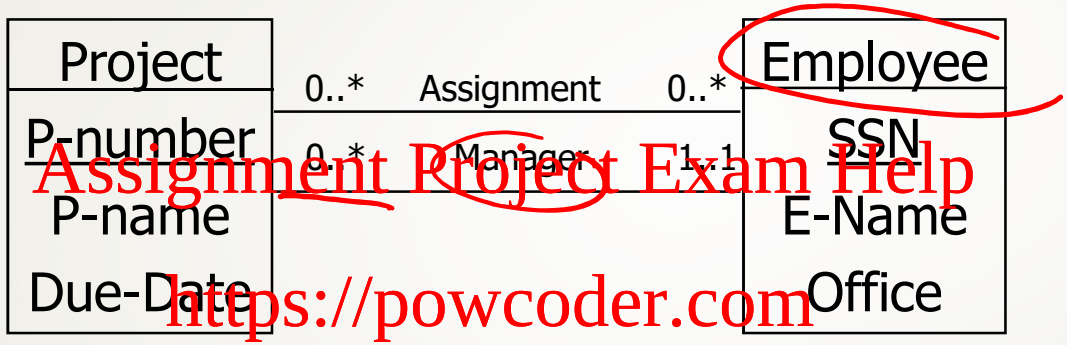
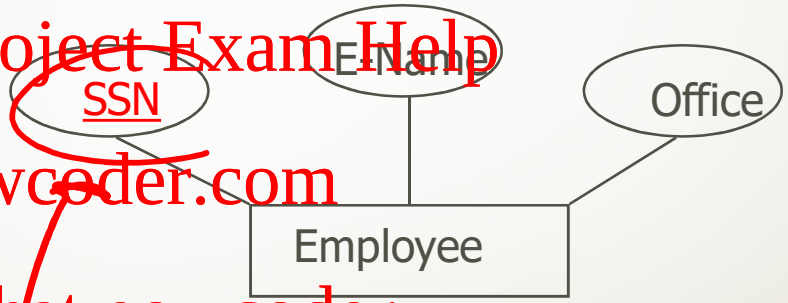
Converting ER to Relational Schema



1. Translate each entity set into a table, with keys.

- Entity set:
  - can be represented as a table in the relational model
  - has a key … which becomes a key for the table

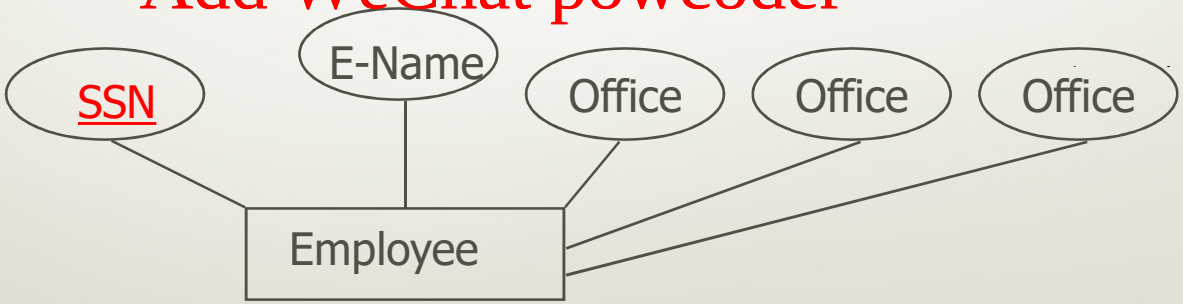



```
CREATE TABLE Employee
      (SSN CHAR(11) NOT NULL,
      E-Name CHAR(20),
      Office  INTEGER,
      PRIMARY KEY  (SSN))
```

Multi-valued Attribute

Didn't see this case when discussing ER diagrams

One or more values of same attribute for an entity



2. Create a table for the multi-valued attribute.

Most relational DBMSs do not allow multi-valued attributes.

How many offices can one employee have?

Project(P-number, P-name, Due-Date)

Employee(SSN, E-Name, Office)

vs.

Project(P-number, P-name, Due-Date)

Employee(SSN, E-Name)

Office-Assignment(SSN, Office)

Sample Data

Project(P-number, P-name, Due-Date)

Employee(SSN, E-Name, **Office**)

12	Smith	O-105
15	Wei	O-110

Just One

Project(P-number, P-name, Due-Date)

Employee(SSN, E-Name)

12	Smith
15	Wei

More than one

Office-Assignment(SSN, Office)

12	O-105
12	O-106
15	O-110

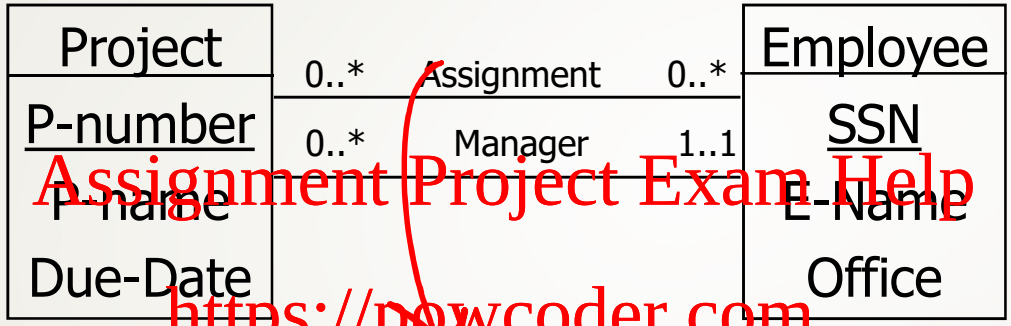
3. Translate each many-to-many relationship set into a table

What are the attributes and what is the key for Assignment?

Project(P-number, P-name, Due-Date)

Employee(SSN, E-Name, Office)

3. Translate each many-to-many relationship set into a table



Answer: Assignment(P-Number, SSN)

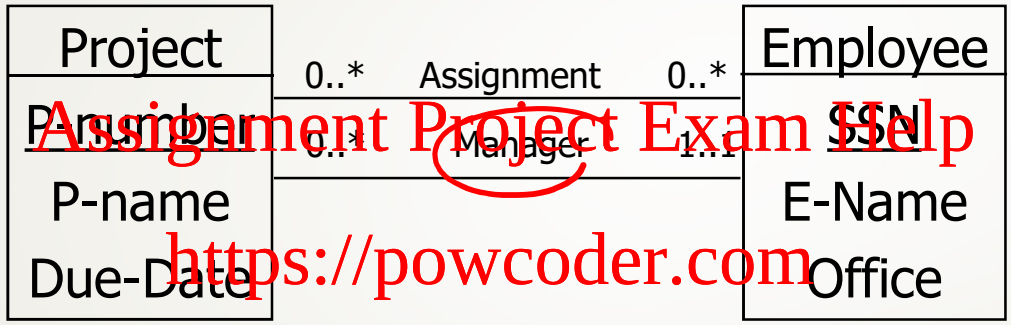
P-Number is a foreign key for Project

SSN is a foreign key for Employee

Project(P-Number, P-Due-Date)

Employee(SSN, E-Name, Office)

What should we do with each **one-to-many** relationship set?

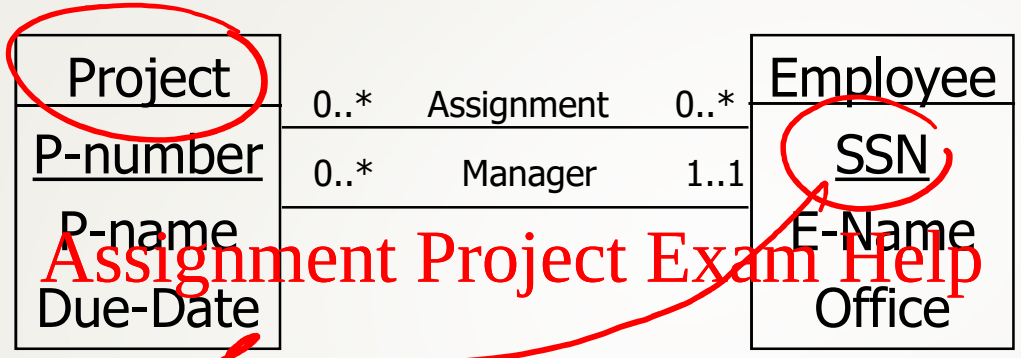


Manager (?)

Project(P-number, P-name, Due-Date)

Employee(SSN, E-Name, Office)

4. Create a foreign key for a 1-to-many relationship set.



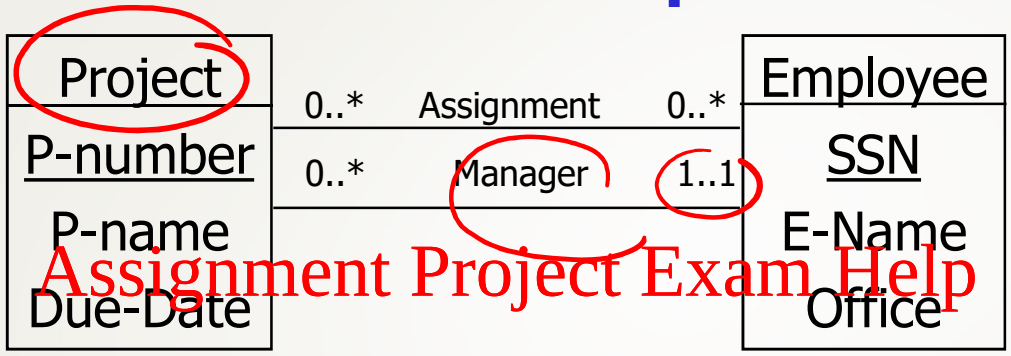
Project(P-number, P-name, Due-Date, MgrSSN)

Employee(SSN, E-Name, Office)

MgrSSN is a foreign key (referencing the Employee relation)

value of Manager must match an SSN

4. Create a foreign key for a 1-to-many relationship set.



Project(P-number, P-name, Due-Date, MgrSSN)

Employee(SSN, E-Name, Office)

Vs.

Project(P-number, P-name, Due-Date)

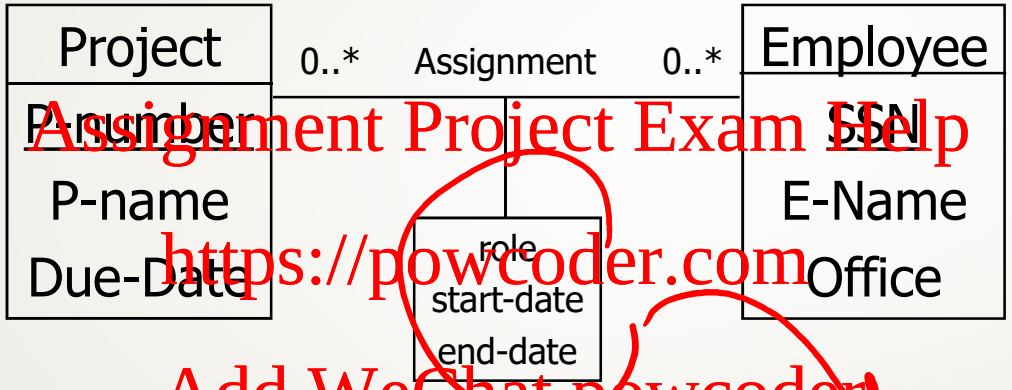
Employee(SSN, E-Name, Office)

Manager(P-number, SSN)

What are the tradeoffs between these two?

Note:
P-number
is the key
for Manager

What do we do when a many-to-many relationship set has an attribute?

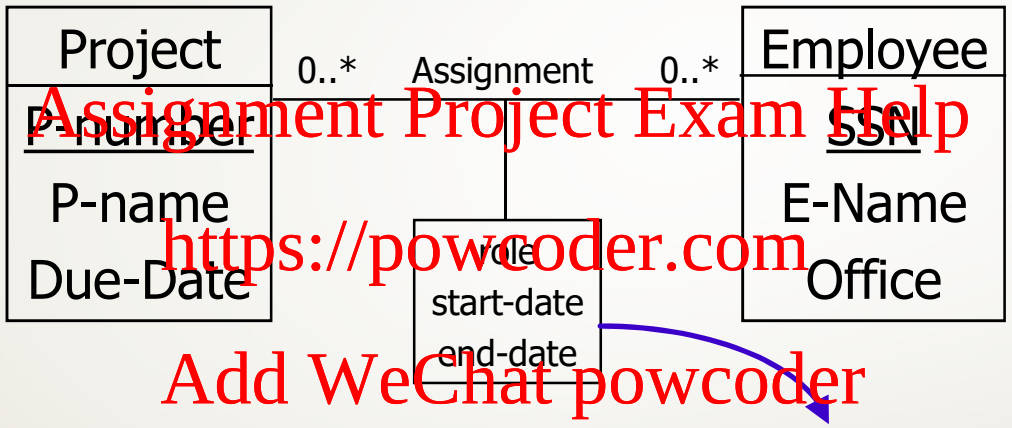


Assignment(P-number, SSN)

Project(P-number, P-name, Due-Date)

Employee(SSN, E-Name, Office)

What do we do when a **many-to-many** relationship set has an attribute?

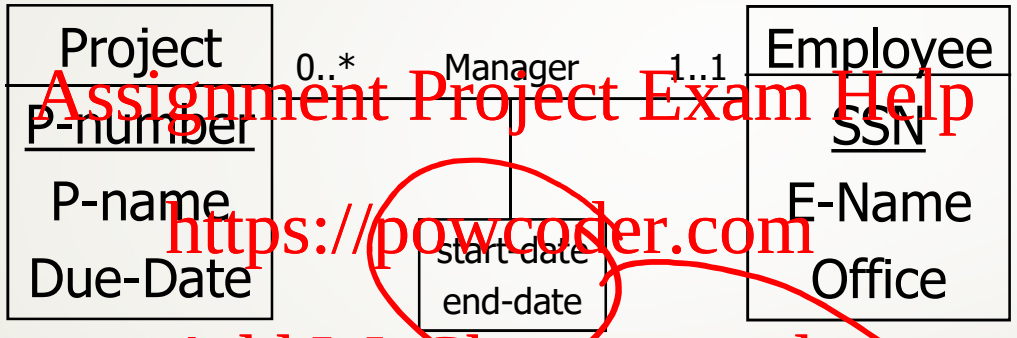


Assignment(P-number, SSN, role, start-date, end-date)

Project(P-number, P-name, Due-Date)

Employee(SSN, E-Name, Office)

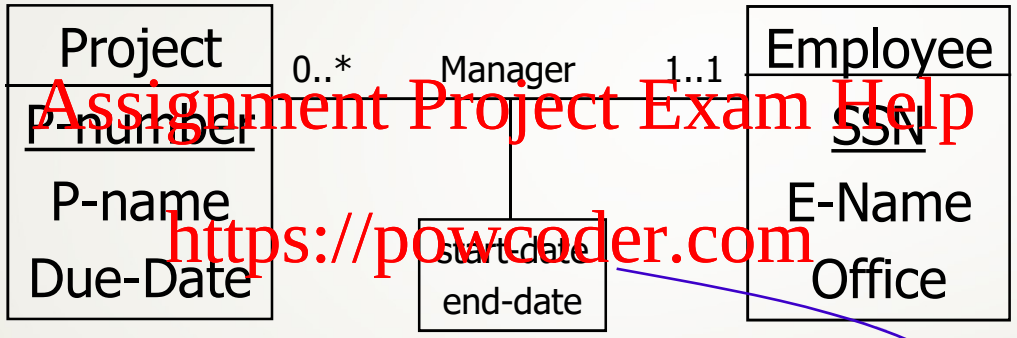
What do we do when a 1-to-many relationship set has an attribute?



Project(P-number, P-name, Due-Date, MgrSSN)

Employee(SSN, E-Name, Office)

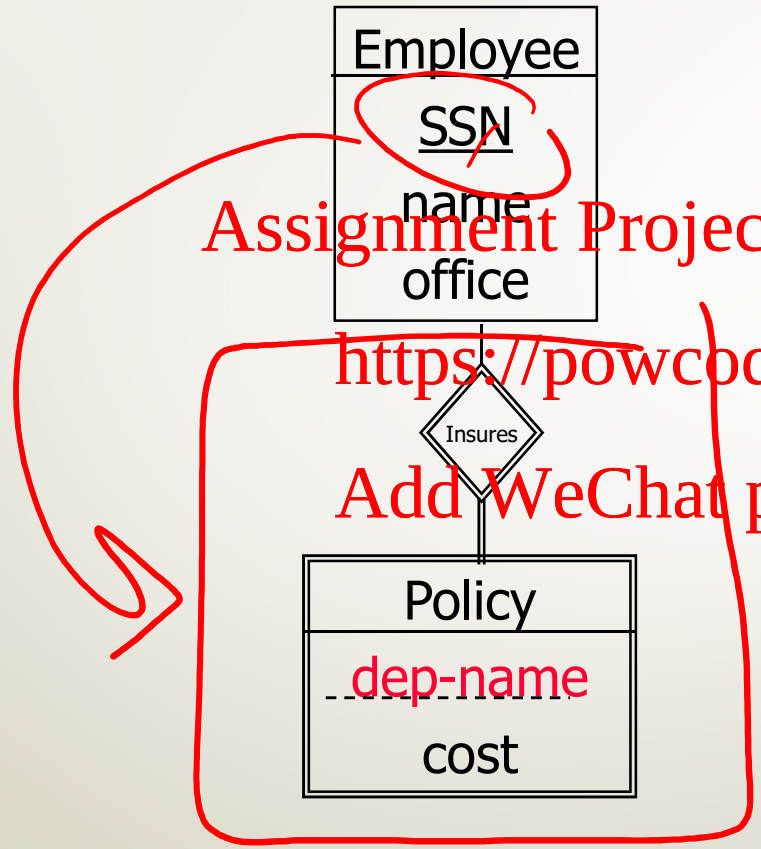
What do we do when a 1-to-many relationship set has an attribute?



Project(P-number, P-name, Due-Date, MgrSSN, start-date, end-date)

Employee(SSN, E-Name, Office)

Weak Entity Sets



supporting entity set

supporting relationship set

weak Entity set

Translating Weak Entity Sets

- Weak entity sets and supporting relationship sets are translated into a single table. Must include key of supporting entity set, as a foreign key.
- When the owner entity is deleted, all owned weak entities must also be deleted.


```
CREATE TABLE Insurance_Policy (
  dep-name      CHAR(20),
  cost          REAL,
  ssn           CHAR(11) NOT NULL,
  PRIMARY KEY   (dep-name, ssn),

  FOREIGN KEY (ssn) REFERENCES Employee,
    ON DELETE CASCADE)
```

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