


Carnegie Mellon Univ.
 Dept. of Computer Science
 15-415/615 - DB Applications


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 Lecture#2: E-R diagrams



Problem

- Develop an application for U.G. admin:
 - Student info
 - Who-takes-what class
 - Class rosters
 - Transcripts
- How do you proceed?
 - (Which role(s) are you playing?)


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Database Design

- Requirements Analysis
- Conceptual Design
- Logical Design
- Schema Refinement
- Physical Design
- Security Design

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Database Design

<ul style="list-style-type: none"> • Requirements Analysis • Conceptual Design • Logical Design • Schema Refinement • Physical Design • Security Design 	<p>user's needs</p> <p>high level (ER)</p> <p>Tables</p> <p>Normalization</p> <p>Indices etc</p> <p>Access controls</p>
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Maintain Problem'

- Develop an application for U.G. admin:
 - Student info
 - Who-takes-what class
 - Class rosters
 - Transcripts
- If you are the *new* DBA, what would you rather inherit:

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This or this ?

```

drop table if exists student;
create table student
(ssn fixed,
 name char(20));
drop table if exists takes;
create table takes
(ssn fixed,
 cid char(10),
 grade fixed);

```

```


graph TD
  Student[Student] --- Takes{Takes}
  Takes --- Course[Course]

```

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True story




- Health insurance company
- Wants to catch (some of the abundant) fraud
- Schema:
 - patients, visit doctors, get medicine,
 - Doctors perform operations, ...
 - Nurses monitor patients, ...
 - etc etc
- Q: How many tables do you think it spans?

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True story




- Schema:
 - patients, visit doctors, get medicine,
 - Doctors perform operations, ...
 - Nurses monitor patients, ...
 - etc etc
- Q: How many tables do you think it spans?
10? 20? 30?

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True story




- Schema:
 - patients, visit doctors, get medicine,
 - Doctors perform operations, ...
 - Nurses monitor patients, ...
 - etc etc
- Q: How many tables do you think it spans?
10? ~~30?~~
- A: **120 PAGES** of schema

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Motivation & upcoming conclusion:

- E-R diagrams are excellent documentation tools



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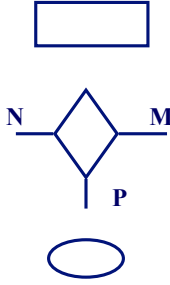

Overview

- concepts
 - – Entities
 - Relationships
 - Attributes
 - Specialization/Generalization
 - Aggregation
 - ER modeling questions

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Tools

- Entities ('entity sets')**
- Relationships ('rel. sets') and mapping constraints**
- attributes**

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Example

Students, taking courses, offered by instructors; a course may have multiple sections; one instructor per section

nouns -> entity sets
verbs -> relationship sets

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Example

Students, taking courses, offered by instructors; a course may have multiple sections; one instructor per section

nouns -> entity sets
verbs -> relationship sets

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Example

Students, taking courses, offered by instructors; a course may have multiple sections; one instructor per section

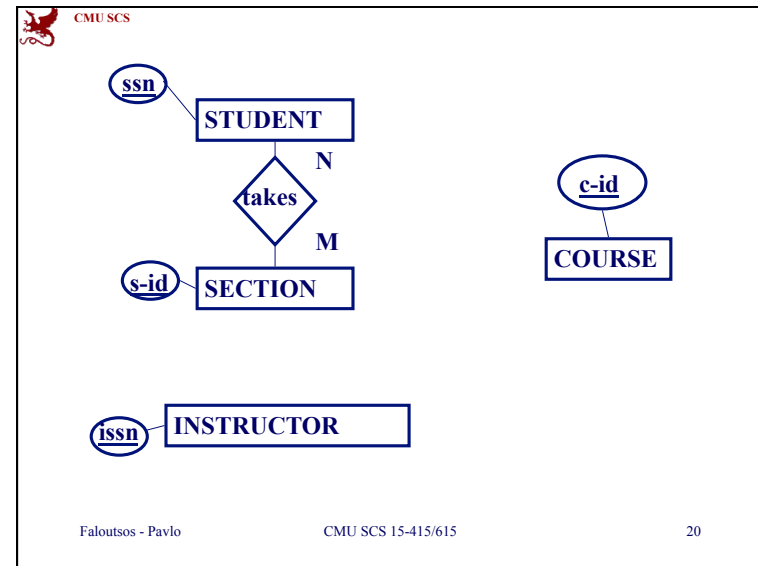
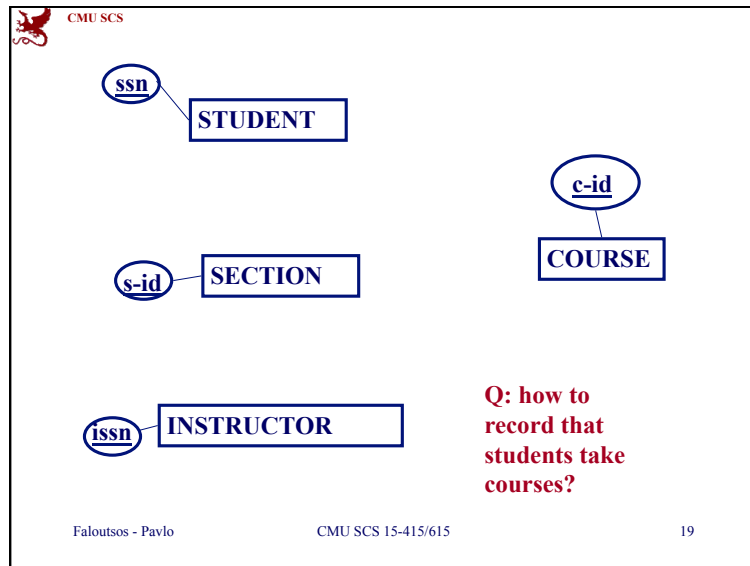
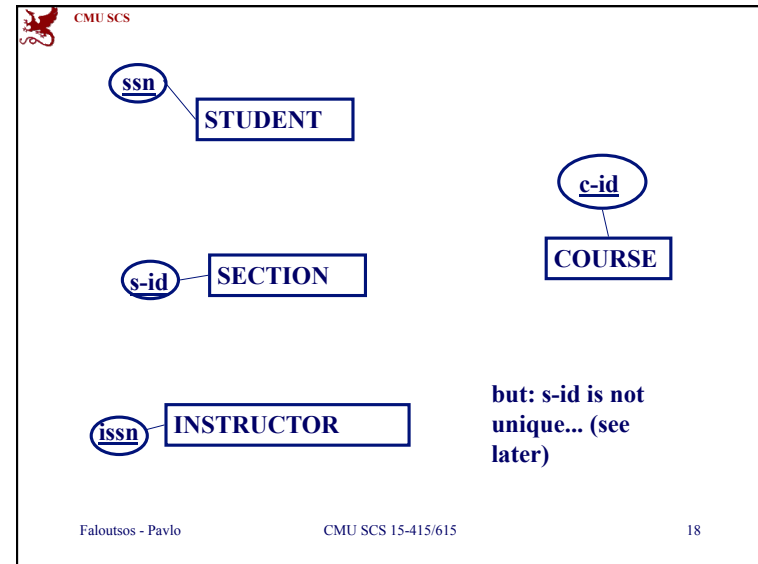
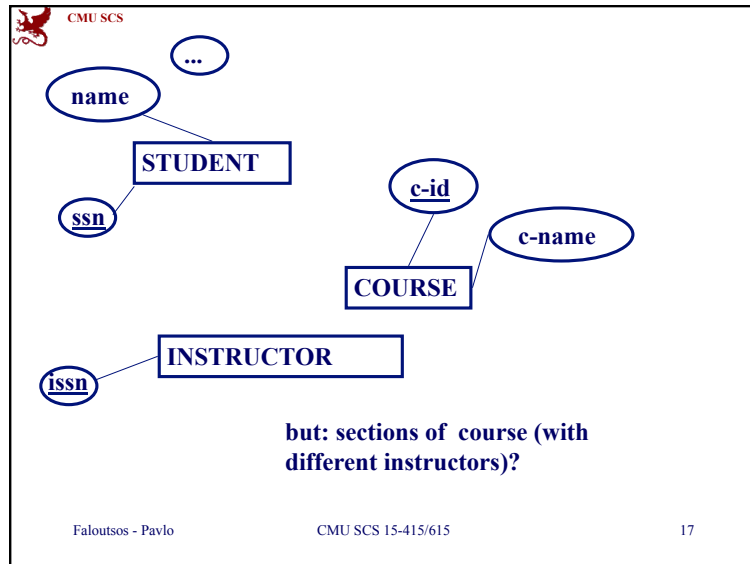
nouns -> entity sets
verbs -> relationship sets

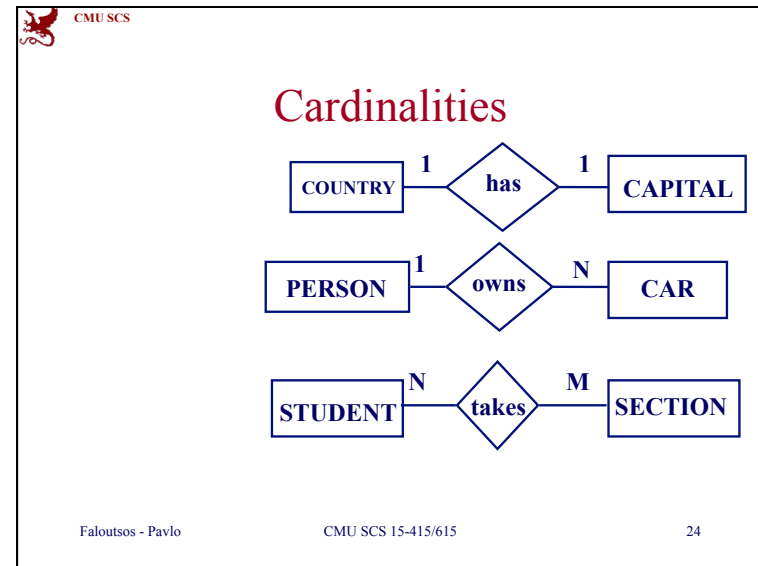
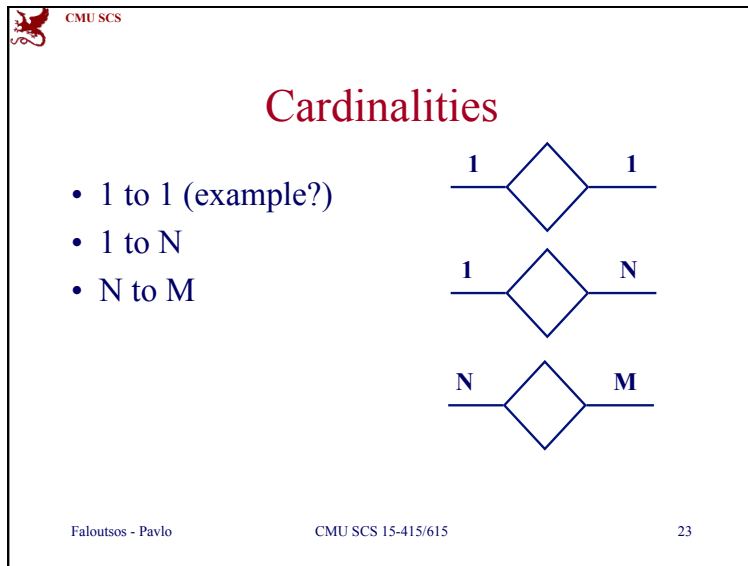
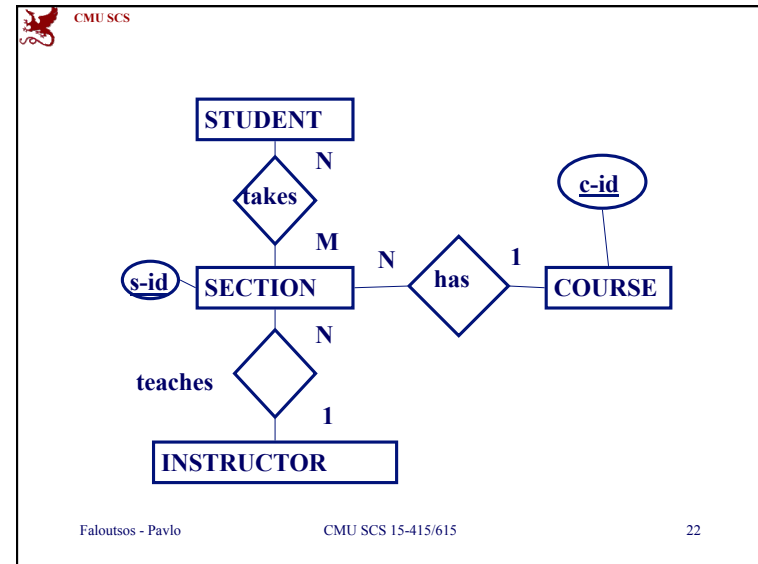
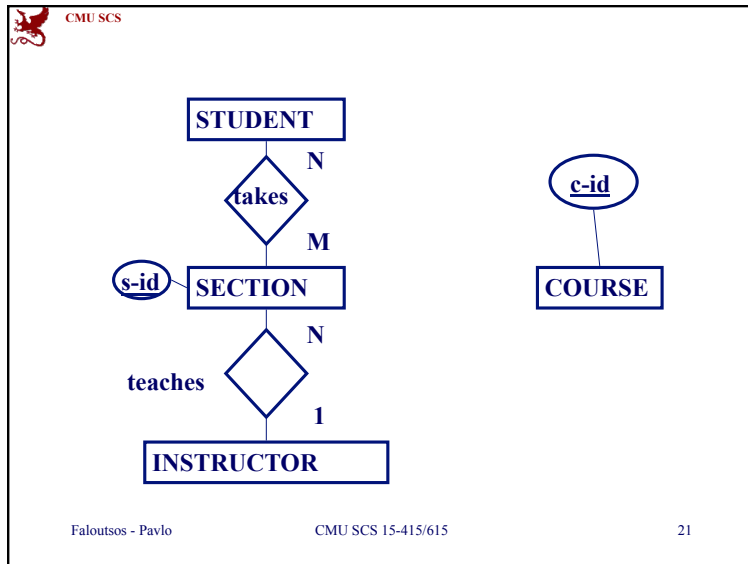
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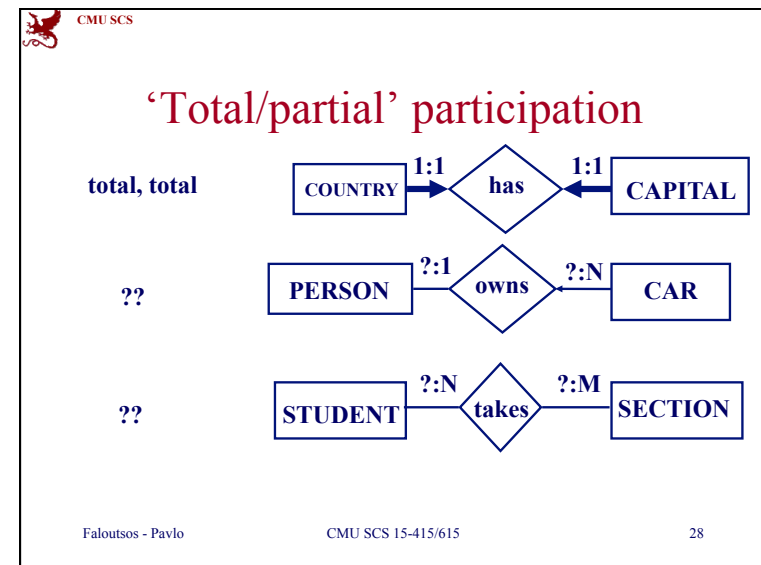
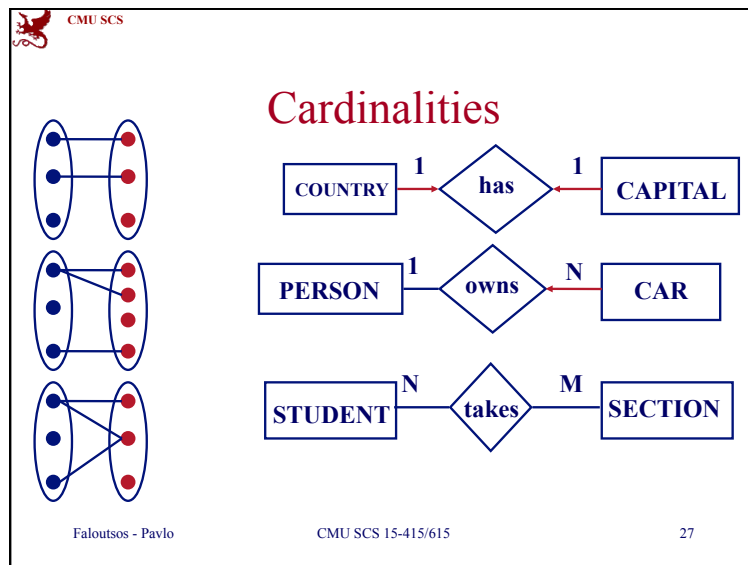
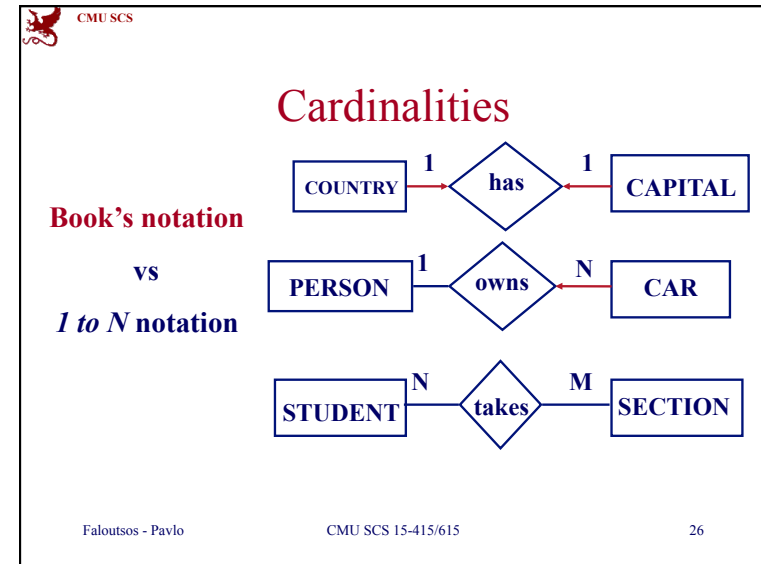
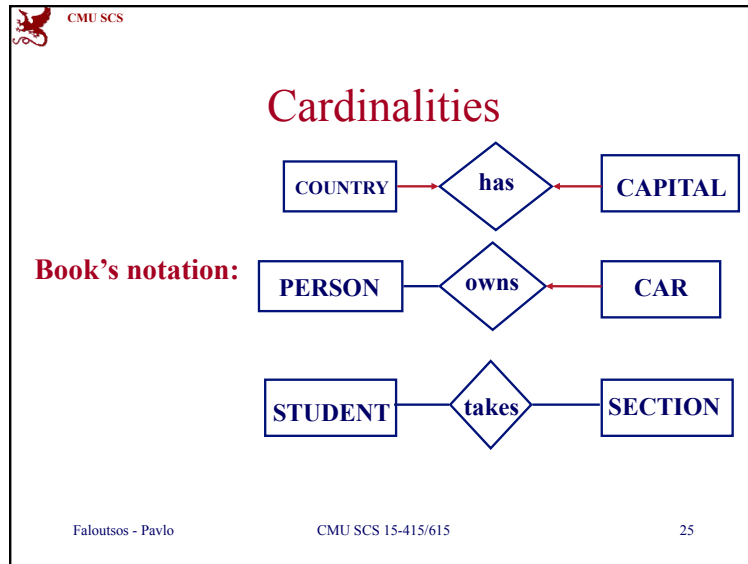
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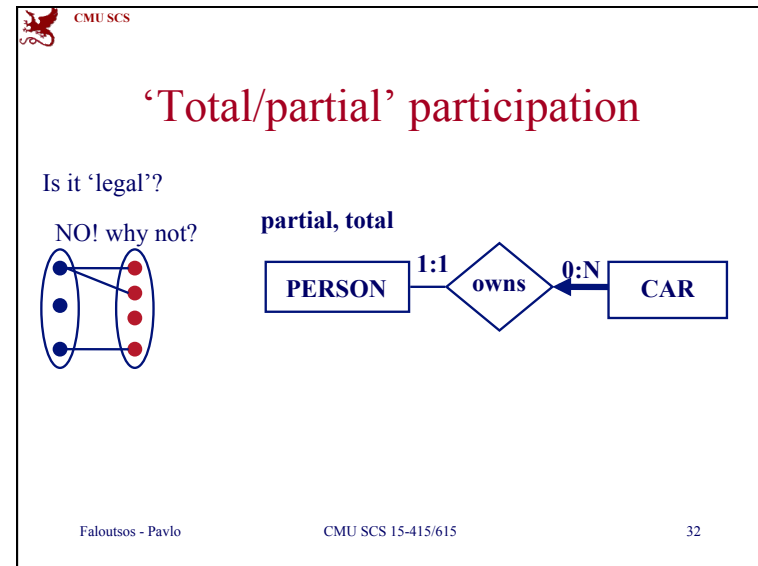
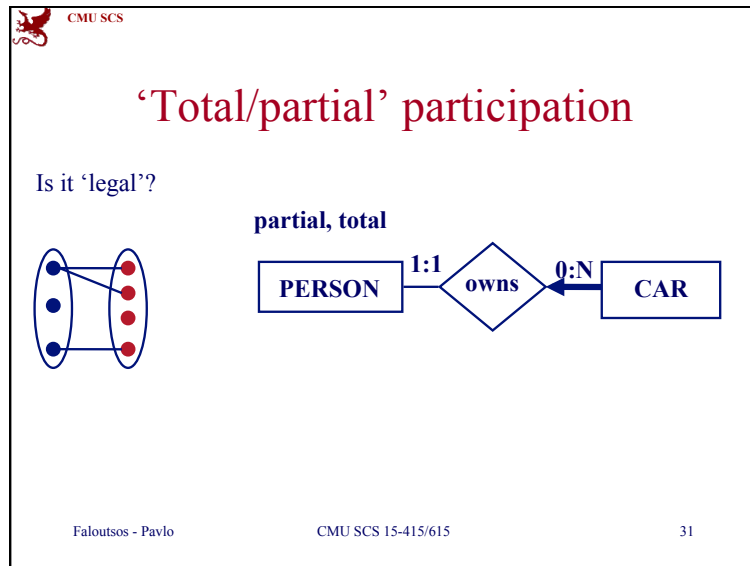
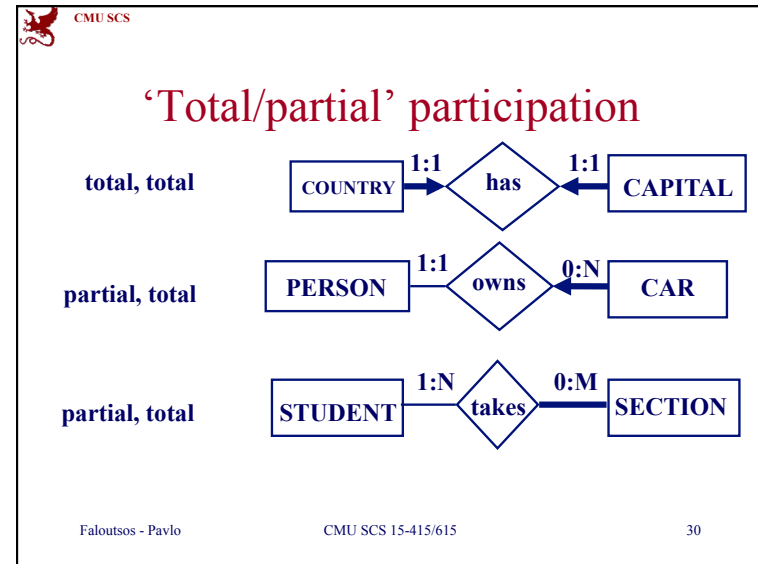
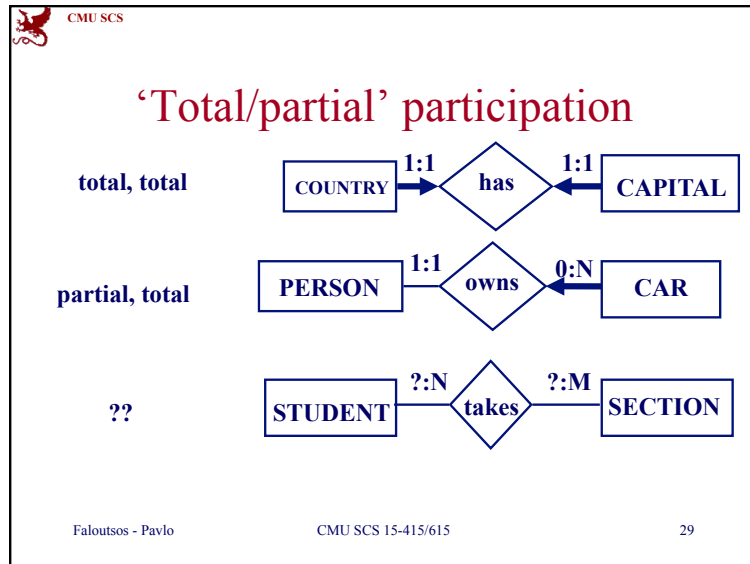
primary key =
unique identifier ->
underline

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Subtle concept: Weak entities

- 'section' has no unique-id of its own! (?)

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Weak entities

- 'weak' entities: if they need to borrow a unique id from a 'strong entity - **thick** box.
- 'c-id' + 's-id': unique id for SECTION
- partial key** (eg., 's-id') - dashed underline
- identifying relationship** (eg., 'has')

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Weak entities

- Other example(s) of weak entities?

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Weak entities

- Other example(s) of weak entities?

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More details

- self-relationships - example?

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More details

- self-relationships - example?

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More details

- self-relationships - example?

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More details

- 3-way and k-way relationships?

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More details

- 3-way and k-way relationships? Rare, but possible:

```

    erDiagram
        EMPLOYEE ||--o{ uses : N
        TOOL ||--o{ uses : M
        PROJECT ||--o{ uses : P
    
```

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More details

- 3-way and k-way relationships? Rare, but possible:

```

    erDiagram
        ?? ||--o{ ?? : N
        ?? ||--o{ ?? : M
        ?? ||--o{ ?? : P
    
```

Other cases?

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More details

- 3-way and k-way relationships? Rare, but possible:

```

    erDiagram
        user ||--o{ reviews : N
        keyword ||--o{ reviews : M
        app ||--o{ reviews : P
    
```

App-store/amazon reviews

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Overview

- concepts
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More details - attributes

- **key** (or **primary key**): unique identifier
- underlined, in the ER diagram
- [not in textbook - FYI:
 - **multivalued** or set-valued attributes (eg., 'dependents' for EMPLOYEE)
 - **derived** attributes (eg., 15% tip)

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Overview

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Basic

Advanced/
rare

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Specialization

- eg., students: part time (#credit-hours) and full time (major)

```

graph TD
    STUDENT[STUDENT] --- name((name))
    STUDENT --- ssn((ssn))
    STUDENT -- IS-A --> FT_STUDENT[FT-STUDENT]
    STUDENT -- IS-A --> PT_STUDENT[PT-STUDENT]
    FT_STUDENT --- major((major))
    PT_STUDENT --- credits((#credits))
  
```

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Observations

- Generalization: exact reverse of 'specialization'
- attribute inheritance
- could have **many** levels of an IS-A hierarchy

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More details

- Overlap constraints
- Covering constraints

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More details

- Overlap constraints
 - can an entity belong to both 'B' and 'C'?
- Covering constraints
 - can an 'A' entity belong to neither 'B' nor 'C'?

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More details

- Overlap constraints - examples?

No overlap

with overlap

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More details

- Covering constraints - examples?

Total coverage

Partial coverage

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Overview

- concepts
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Aggregation

- computer model (w/ CPU and HD)
- and Maker (eg., Dell, HP)

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Aggregation

- treat a relationship as an entity
- used to express a relationship among relationships

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Overview

- concepts
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 - – ER modeling questions

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Conceptual design

- Entity vs attribute
- Entity vs relationship
- Binary or ternary relationships?
- Aggregation?

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Entity vs. attribute

- Entity EMPLOYEE (w/ emp#, name, job_code, ...)
- Q: How about 'spouse' - entity or attribute?
- Q: How about 'dependents'?

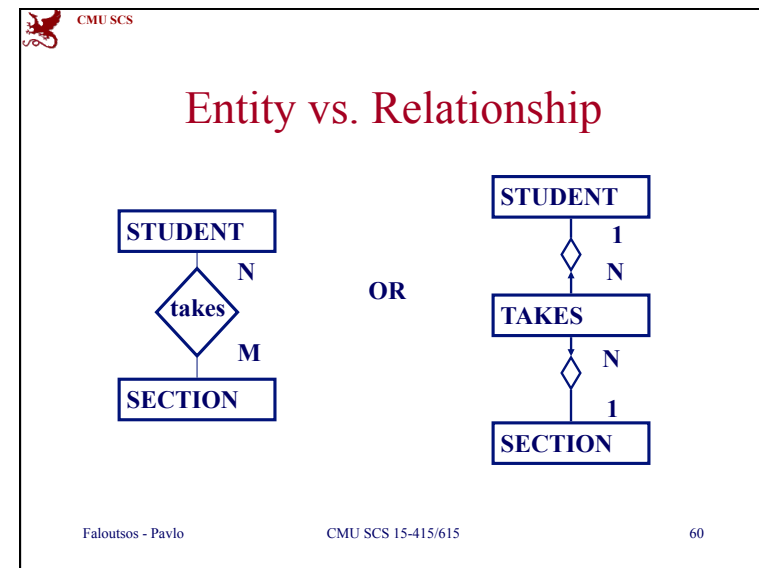
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Entity vs. attribute

- Entity EMPLOYEE (w/ emp#, name, job_code, ...)
- Q: How about 'spouse' - entity or attribute?
- A: probably, 'attribute' is enough
- Q: How about 'dependents'?
- A: Entity - we may have many dependents

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Binary vs Ternary Relationships

- usually, binary relationships are ‘cleaner’:

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Binary vs. Ternary Relationships

If each policy is owned by just 1 employee:

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Binary vs. Ternary Relationships

If each policy is owned by just 1 employee:

Bad design

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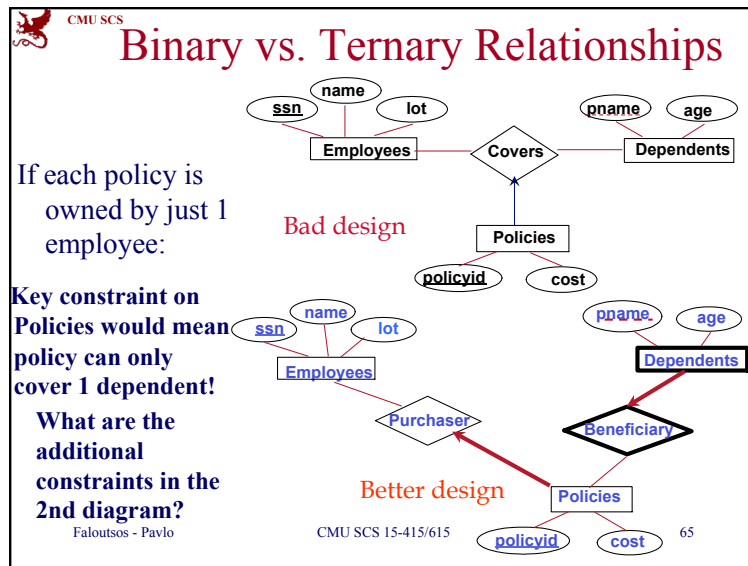
Binary vs. Ternary Relationships

If each policy is owned by just 1 employee:

Bad design

Key constraint on Policies would mean policy can only cover 1 dependent!

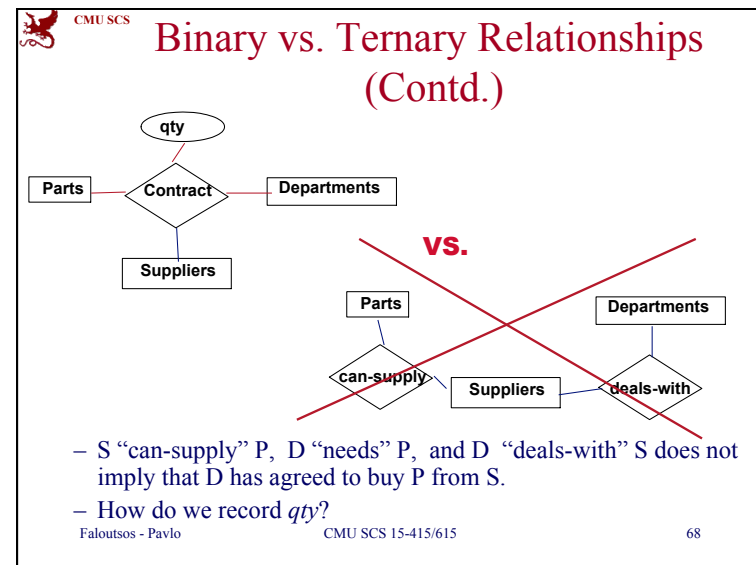
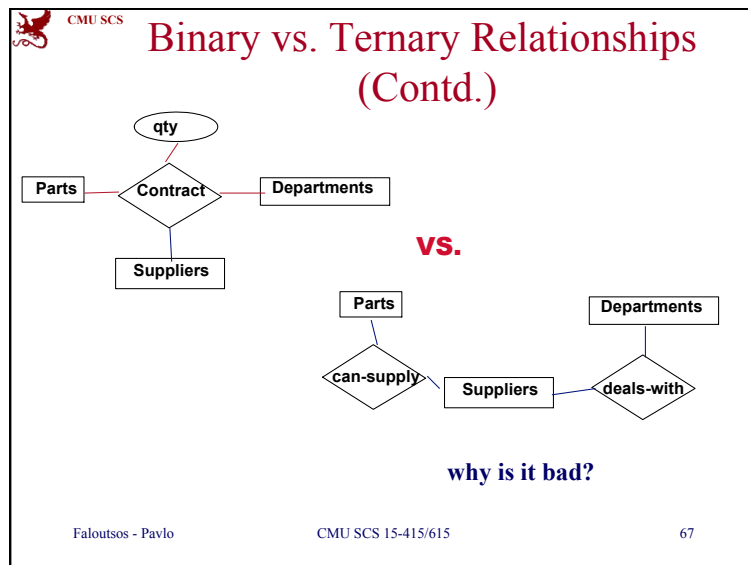
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Binary vs Ternary Rel.

- But sometimes ternary rel. can not be replaced by a set of binary rel's:

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Not in textbook:
in practice, often:

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CMU SCS **Binary vs. Ternary Relationships (Contd.)**

Not in textbook:
in practice, often:

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CMU SCS **Binary vs. Ternary Relationships (Contd.)**

Not in textbook:
in practice, often:

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CMU SCS **Ternary vs. aggregation**

- use aggregation, if we want to attach a relationship to a relationship
- (see book for example)
- (in practice, again we create a unique-id and resort to binary relationships)

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Ternary vs. aggregation

- How would you handle this case?

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Ternary vs. aggregation

- How would you handle this case?

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Ternary vs. aggregation

- How would you handle this case?

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Ternary vs. aggregation


- How would you handle this case?

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Summary

- E-R Diagrams: a powerful, user-friendly tool for data modeling:
 - Entities (strong, weak)
 - Attributes (primary keys, discriminators, derived, multivalued)
 - Relationships (1:1, 1:N, N:M; multi-way)
 - Generalization/Specialization; Aggregation




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Summary

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POPULAR {



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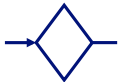

Summary - cont'd



 (strong) entity set  weak entity set  relationship set  identifying rel. set for weak entity		 attribute  primary key  partial key
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Summary - cont'd

 cardinalities
 partial/total


 cardinalities
 cardinalities with limits

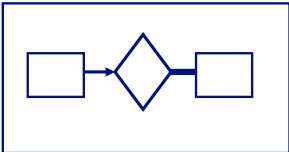
(not in textbook - FYI)

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Summary - cont'd

 IS-A

 aggregation

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