UMBC

AN HONORS UNIVERSITY IN MARYLAND

CMSC 461, Database Management Systems
Spring 2018

Lecture 10 - Chapter 7 Entity Relationship Model

These slides are based on "Database System Concepts" 6th edition book and are a modified version of the slides which accompany the book (http://codex.cs.yale.edu/avi/db-book/db6/slide-dir/index.html), in addition to the 2009/2012 CMSC 461 slides by Dr. Kalpakis

Dr. Jennifer Sleeman

https://www.csee.umbc.edu/~jsleem1/courses/461/spr18

Logistics

- HW2 key will be available Mon March 5th
- Start phase 2 sooner vs. later due Wed 3/7/2018
- HW3 will be released this week
- See the project page for a description of the rest of the phases

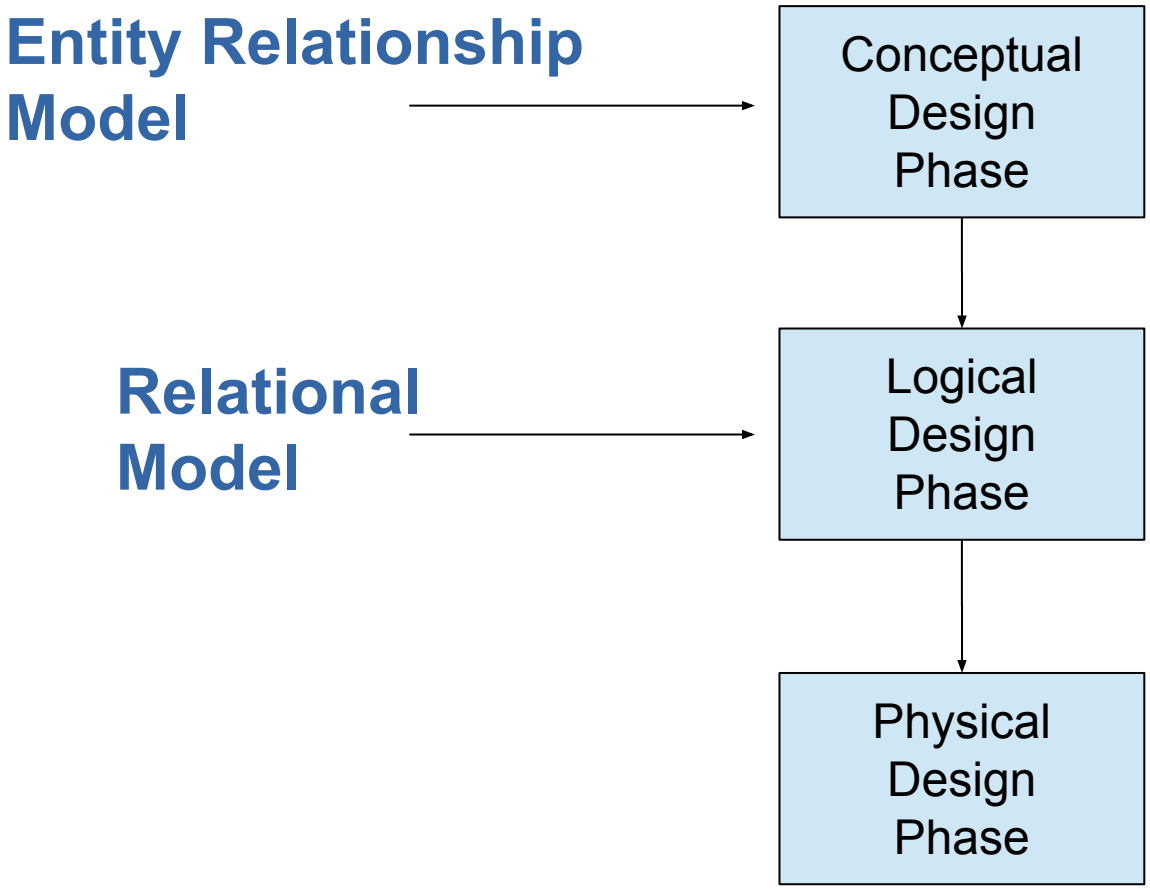
Lecture Outline

- Review and Clarification
- Reduction to Relational Schemas
- Design Issues
- Extended ER Features
- Database Design Tools

Lecture Outline

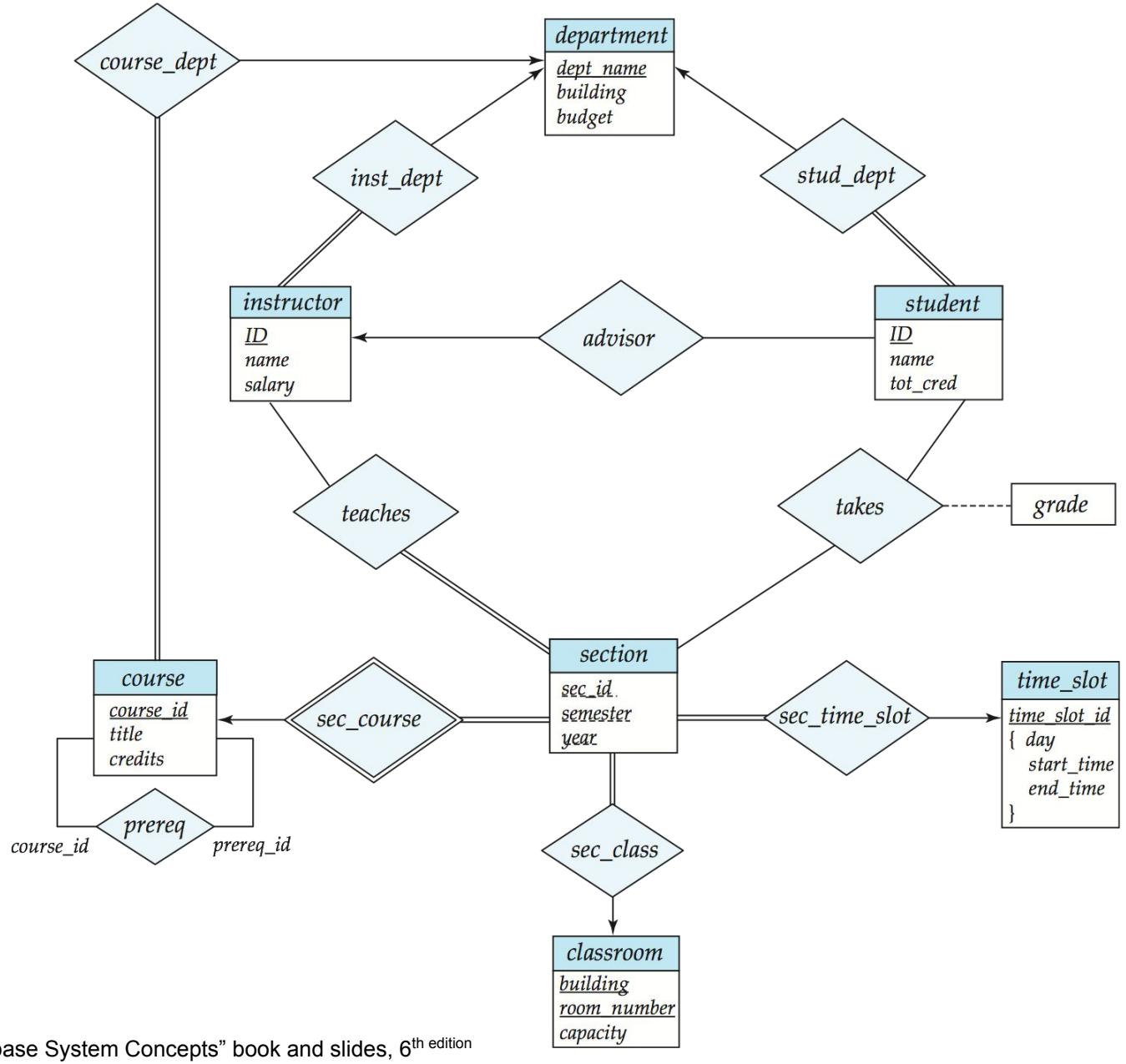
- ***Review and Clarification***
- Reduction to Relational Schemas
- Design Issues
- Extended ER Features
- Database Design Tools

Database Design Phases



Three levels of modeling

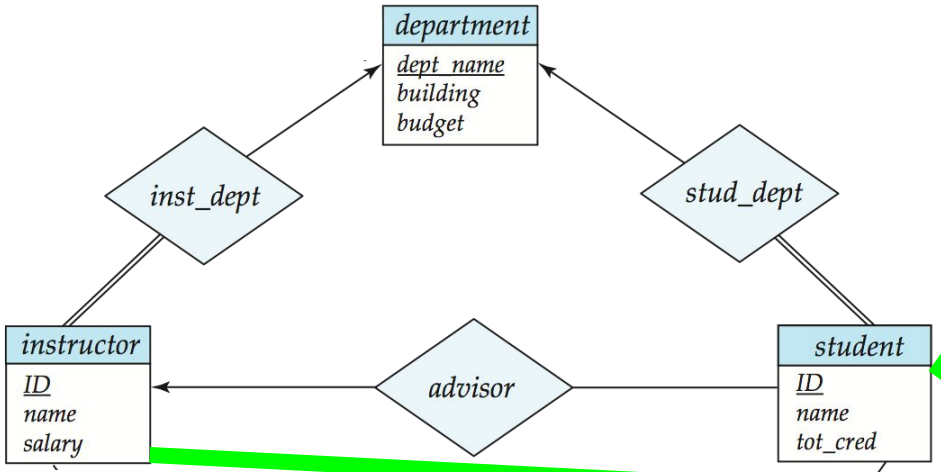
Redundancy Revisited

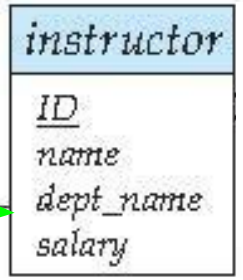


Based on and image from "Database System Concepts" book and slides, 6th edition

Redundancy Revisited

- We first identify entity sets
- Then we choose identifying attributes
- And relationship sets among entities
- This results in redundant attributes across entity sets
- Try to remove
  - During the ER modeling phase

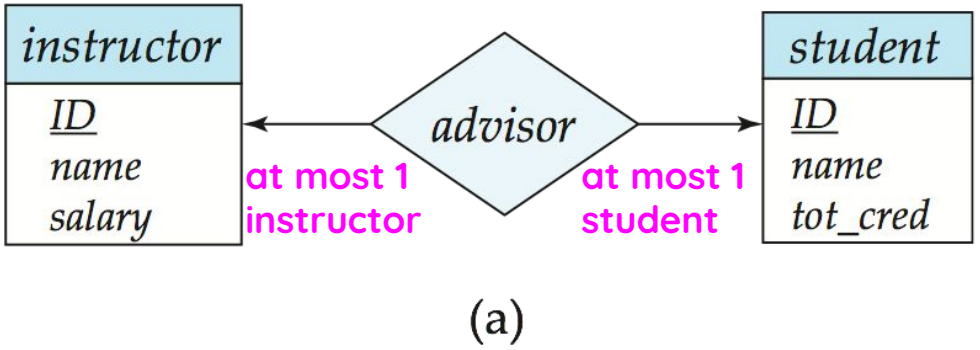




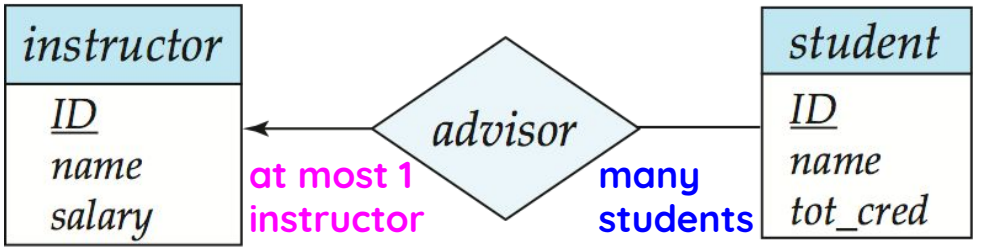
Based on and image from "Database System Concepts" book and slides, 6th edition

Cardinality Revisited

- draw directed line (→)
  - signifying “one”
- undirected line (—),
  - signifying “many”
- Between the relationship set and the entity set



(a)



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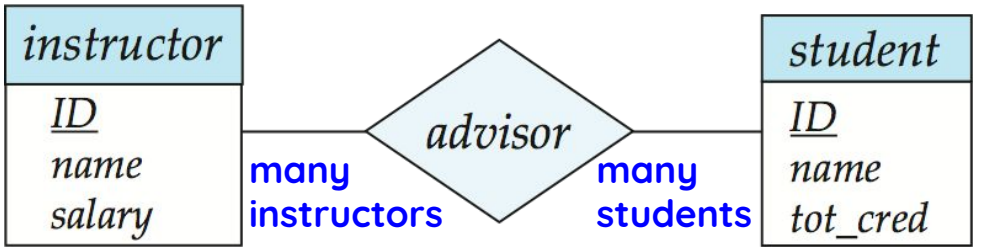

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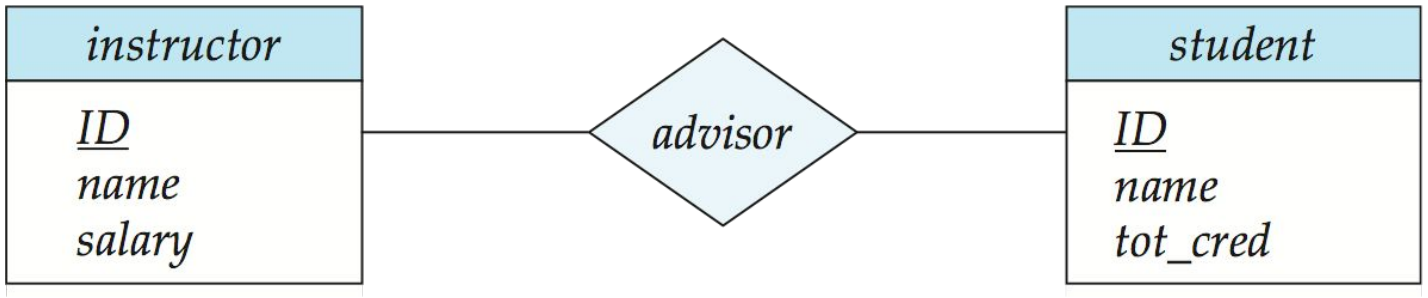
Based on and image from “Database System Concepts” book and slides, 6th edition

Total vs. Partial Participation Revisited

- There could be an entity that does not participate in a relationship set
- This means there is partial participation
- If we want to indicate that there must be total participation, use the double line:

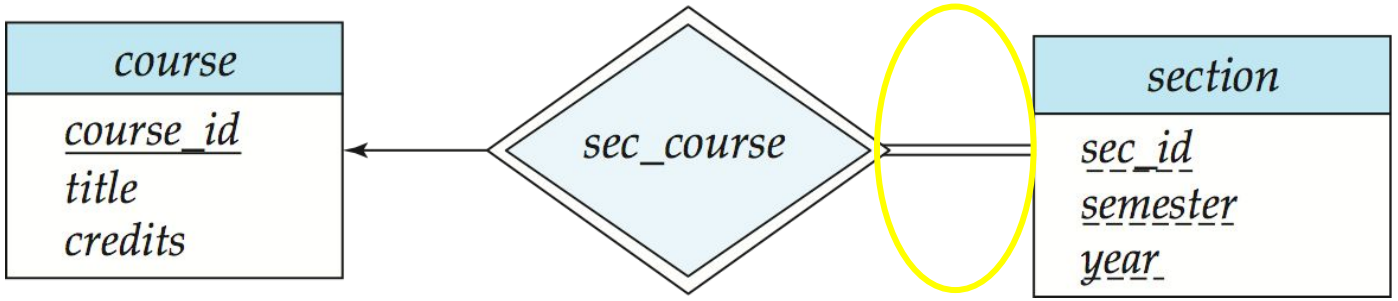
Total vs. Partial Participation Revisited

- Some entities may not participate in any relationship in the relationship set
  - Example: participation of *instructor* in *advisor* is partial

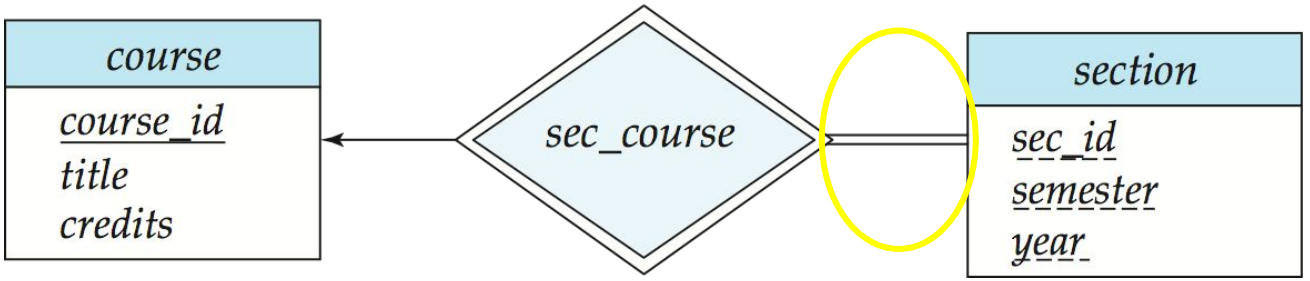


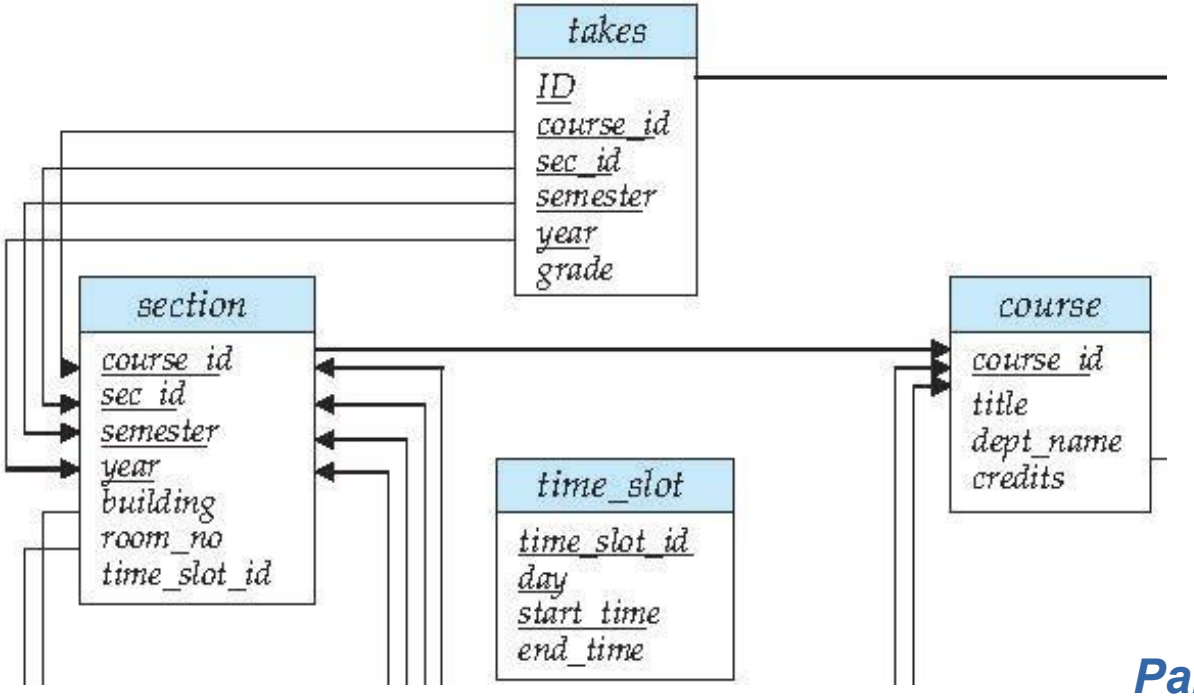
Total vs. Partial Participation Revisited

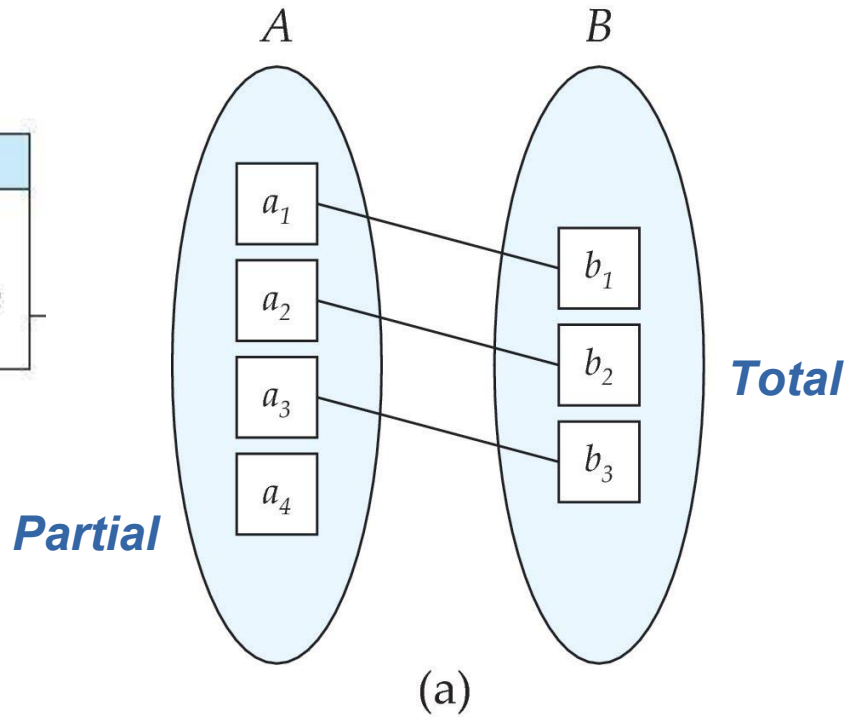
- Use double lines
- Every entity in entity set participates in at least one relationship in the relationship set
  - Example: participation of *section* in *sec_course* is total



Total vs. Partial Participation Revisited







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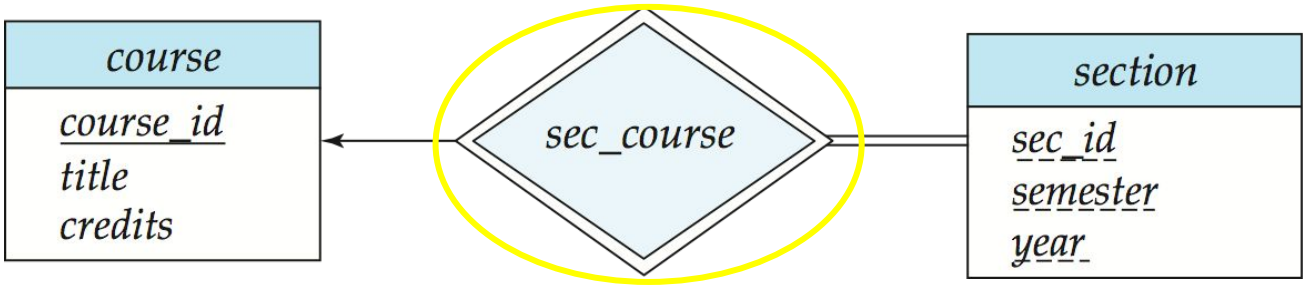
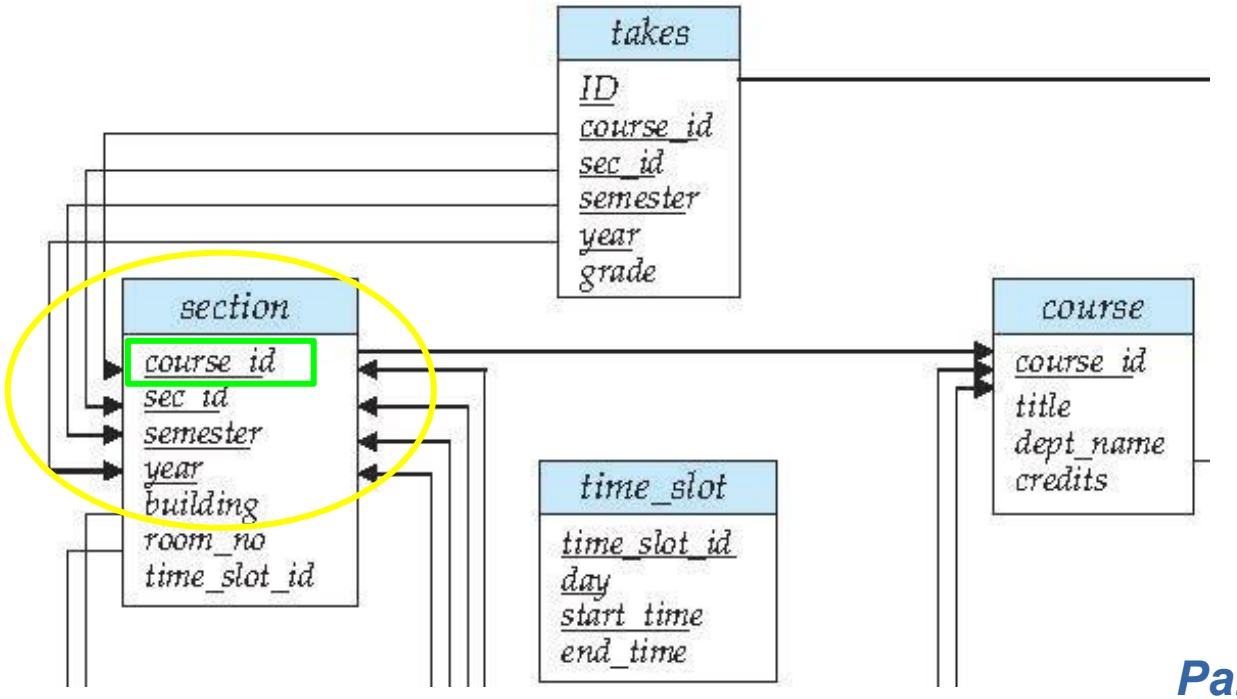
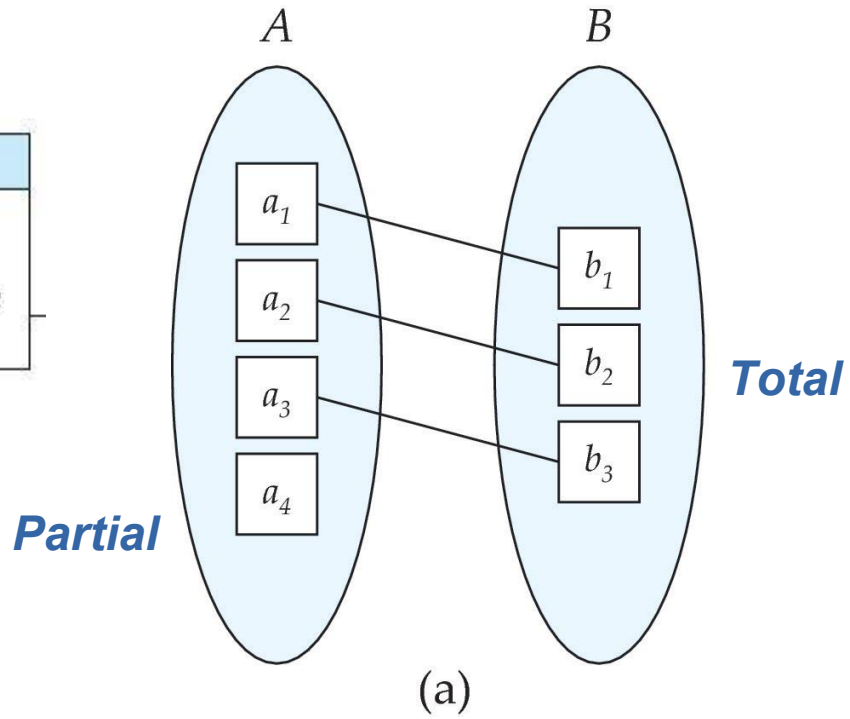
Strong vs Weak Entity Sets Revisited







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Lecture Outline

- Review and Clarification
- ***Reduction to Relational Schemas***
- Design Issues
- Extended ER Features
- Database Design Tools

Reduction to Relation Schemas

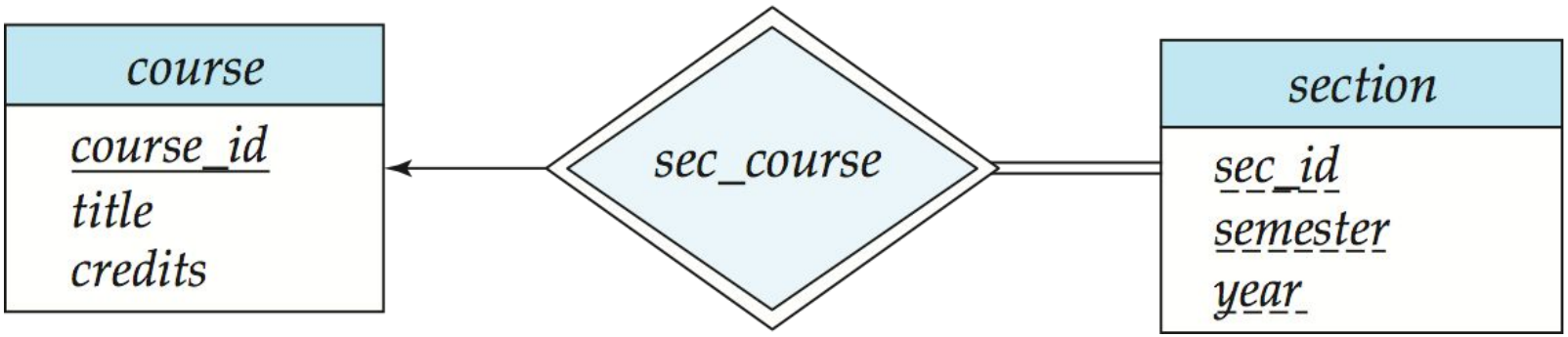
- Entity sets and relationship sets can be expressed as ***relation schemas***
  - represent the contents of the database
- Database conforms to an E-R diagram
  - represented by a collection of schemas

Reduction to Relation Schemas

- For each entity set and relationship set create a unique schema
  - name corresponds to entity set or relationship set
- For each schema create columns
  - corresponds to attributes

Representing Entity Sets With Simple Attributes

- A strong entity set reduces to a schema with the same attributes
  course(course_id, title, credits)
- A weak entity set becomes a table that includes a column for the primary key of the identifying strong entity set
  section (course_id, sec_id, sem, year)



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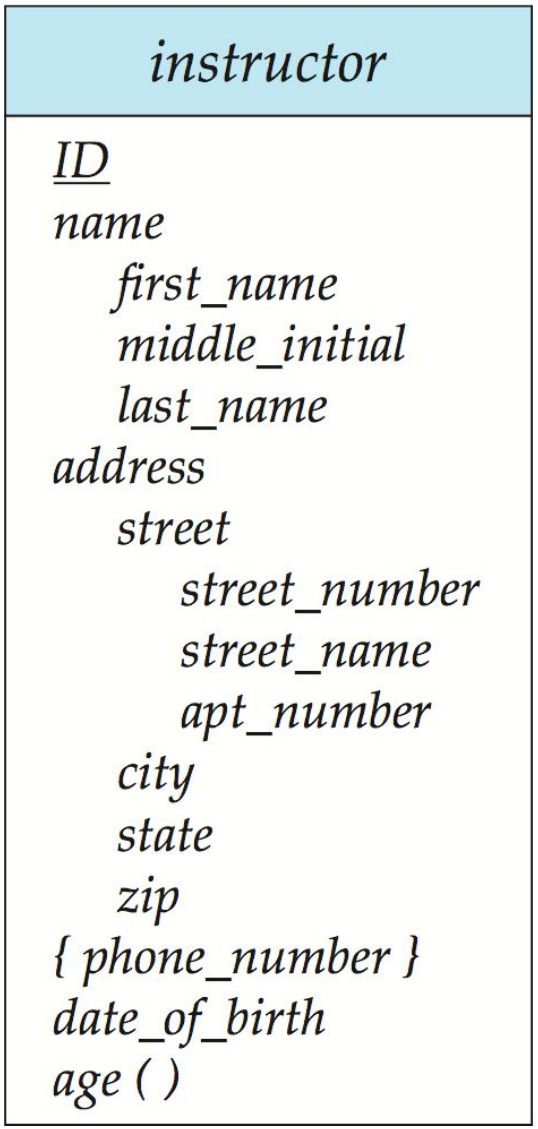
Composite and Multivalued Attributes



- Composite attributes are flattened out by creating a separate attribute for each component attribute
  - Example: given entity set *instructor* with composite attribute *name* with component attributes *first_name* and *last_name* the schema corresponding to the entity set has two attributes *name_first_name* and *name_last_name*
    - *Prefix omitted if there is no ambiguity*
- Ignoring multivalued attributes, extended instructor schema is
  - *instructor(ID, first_name, middle_initial, last_name, street_number, street_name, apt_number, city, state, zip_code, date_of_birth)*

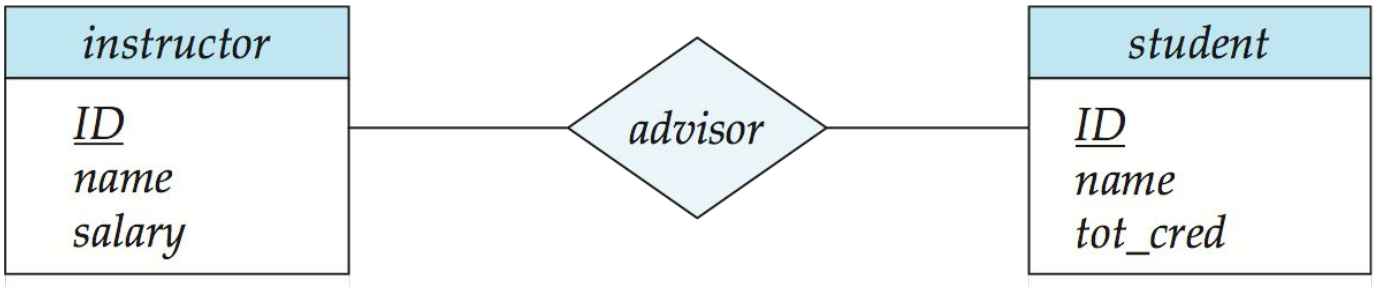
Composite and Multivalued Attributes

- A multivalued attribute *M* of an entity *E* is represented by a separate schema *EM*
  - Schema *EM* has attributes corresponding to the primary key of *E* and an attribute corresponding to multivalued attribute *M*
  - Example: Multivalued attribute *phone_number* of *instructor* is represented by a schema:
    inst_phone= (*ID*, *phone_number*)
  - Each value of the multivalued attribute maps to a separate tuple of the relation on schema *EM*
    - For example, an *instructor* entity with primary key 22222 and phone numbers 456-7890 and 123-4567 maps to two tuples:
      (22222, 456-7890) and (22222, 123-4567)

Representing Relationship Sets

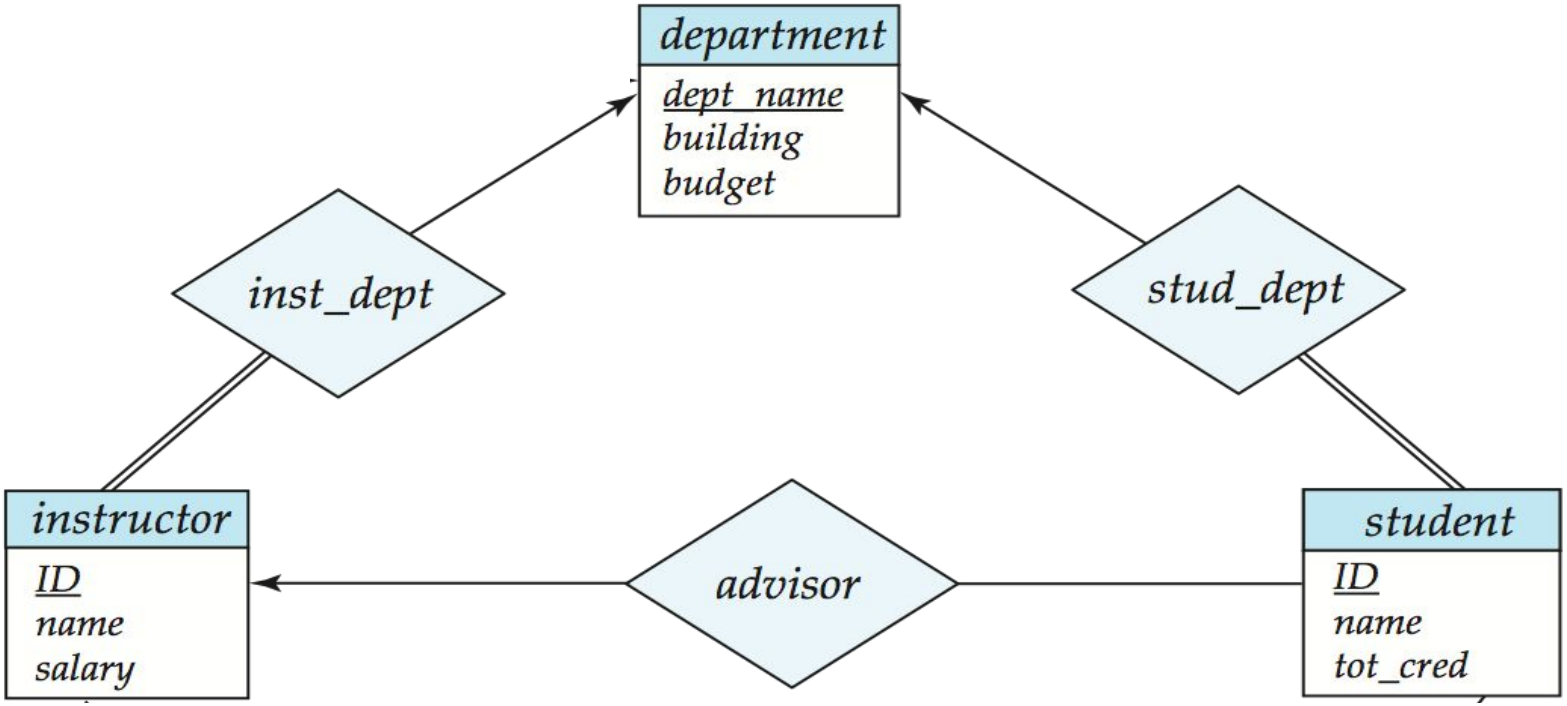
- A many-to-many relationship set is represented as a schema with attributes for the primary keys of the two participating entity sets, and any descriptive attributes of the relationship set.
- Example: schema for relationship set *advisor*

  advisor = (*s_id*, *i_id*)



Representing Relationship Sets

- Many-to-one and one-to-many relationship sets that are total on the many-side can be represented by adding an extra attribute to the "many" side, containing the primary key of the "one" side
- Example: Instead of creating a schema for relationship set *inst_dept*, add an attribute *dept_name* to the schema arising from entity set *instructor*

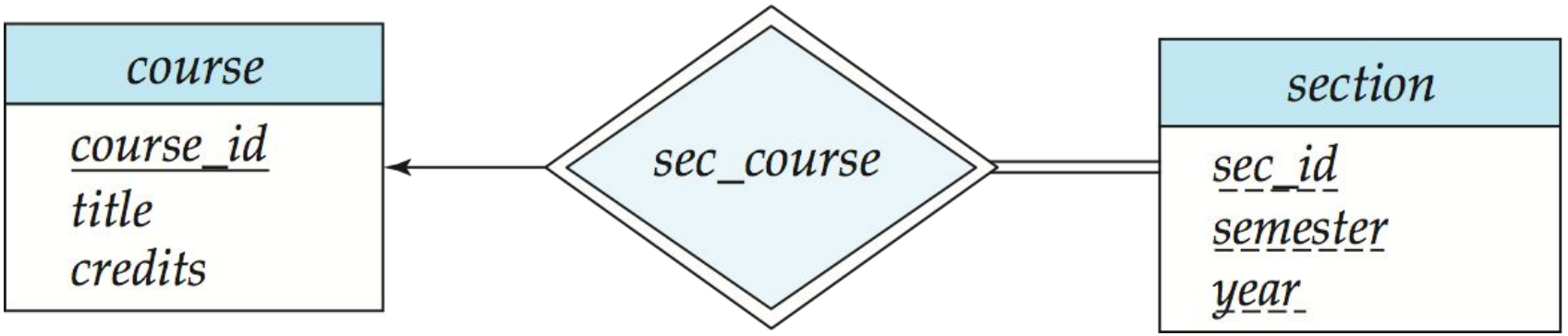


Representing Relationship Sets

- For one-to-one relationship sets, either side can be chosen to act as the “many” side
  - That is, extra attribute can be added to either of the tables corresponding to the two entity sets
- If participation is *partial* on the “many” side, replacing a schema by an extra attribute in the schema corresponding to the “many” side could result in null values

Redundancy of Schemas

- Schema for the relationship set linking a weak entity set to its corresponding strong entity set is redundant and doesn't need to be present in a relational database design



Combination of Schemas

- Consider a many-to-one relationship set AB
  - where A is an entity set and B is an entity set
- This would result in 3 schemas
  - A
  - B
  - AB
- If participation of A is total, then we can combine A and AB
  - Union of attributes between the 2 schemas

Example: A= instructor, B=department, schema *inst_dept* can be combined with the instructor schema
(ID, name, dept_name, salary)

Lecture Outline

- Review and Clarification
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- ***Design Issues***
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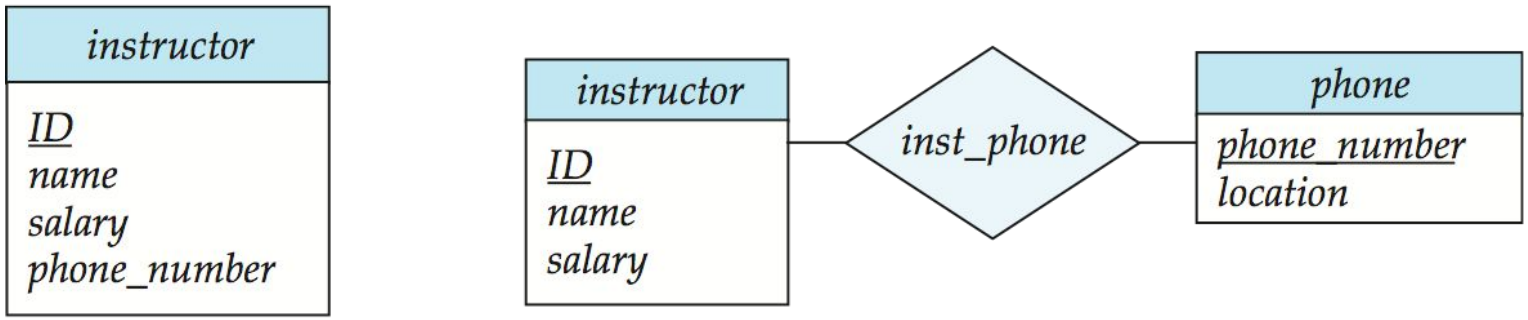
Design Issues – Entity Sets vs. Attributes

- Sometimes attributes can be seen as an entity on its own
  - Example: Use of phone as an entity allows extra information about phone numbers (plus multiple phone numbers)
- If we treat it as an attribute, constraints how many values for that attribute
- Else the concept of a phone number becomes more generalized



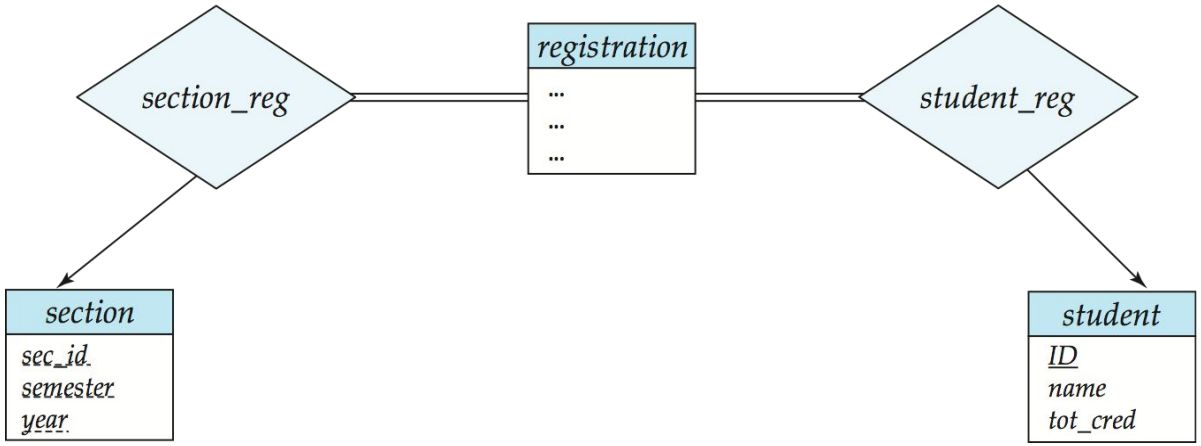
Based on and image from "Database System Concepts" book and slides, 6th edition

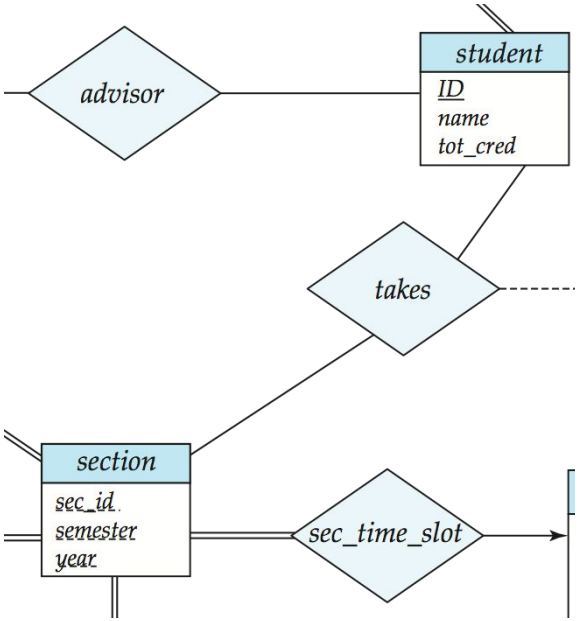
Design Issues – Entity Sets vs. Attributes

- Key Mistakes:
  - Using primary key of an entity set as an attribute of another entity set instead of a relationship
    - Student ID in Instructor relation
  - Designation of primary keys as attributes of the relationship set
    - Implied by the relationship set

Design Issues – Entity Sets vs. Relationship Sets

- Possible guideline is to designate a relationship set to describe an action that occurs between entities





Here we used a registration entity set instead of the takes relationship set.

Lecture Outline

- Review and Clarification
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- Design Issues
- ***Extended ER Features***
- Database Design Tools

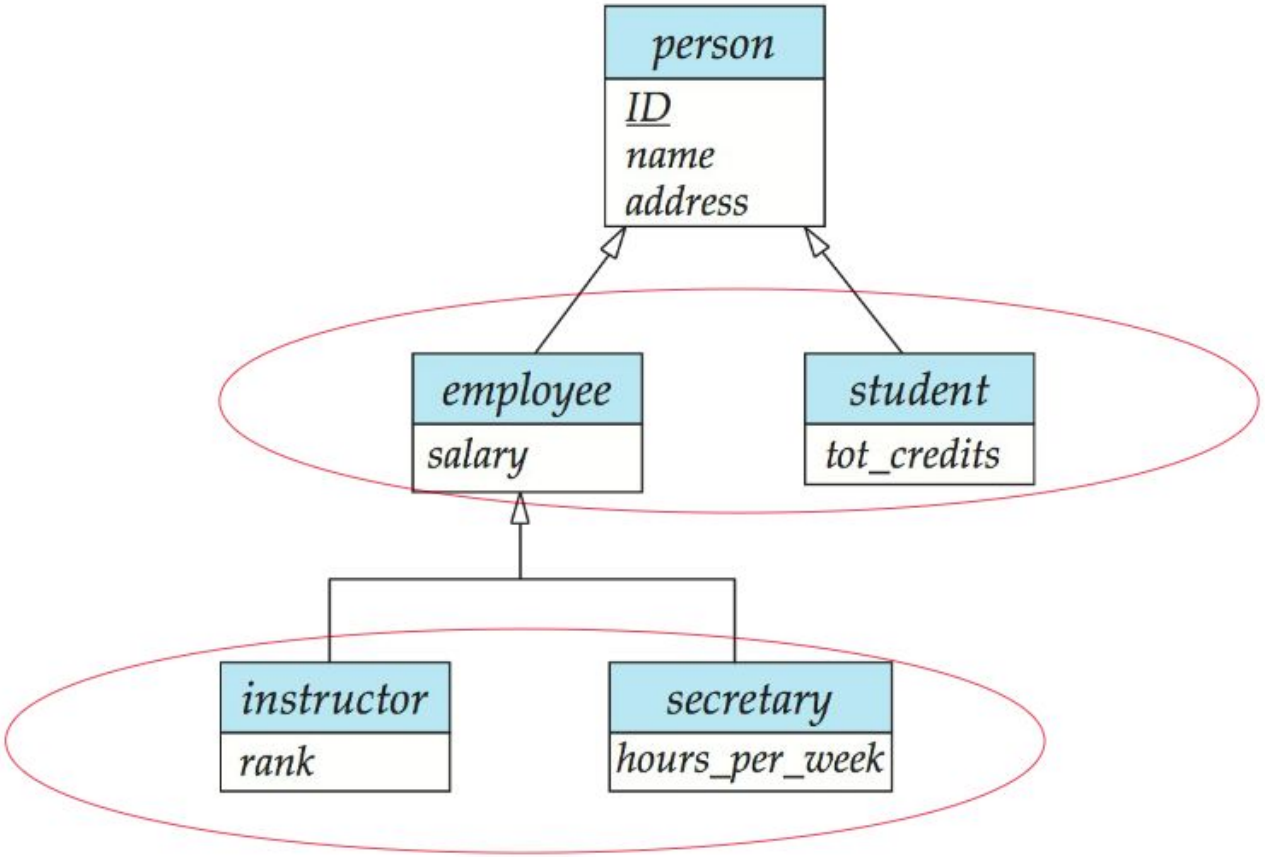
Extended ER Features

- Extensions to basic concepts
  - Specialization
  - Generalization
  - Higher/Lower level entity sets
  - Attribute Inheritance
  - Aggregation

Specialization

- ***Top down design process*** - designate subgroupings within an entity set that are distinctive from other entities in the set
- These subgroupings become lower-level entity sets that have attributes or participate in relationships that do not apply to the higher-level entity set
- Depicted by a triangle component labeled ISA (E.g., instructor “is a” person).
- ***Attribute inheritance*** - a lower-level entity set inherits all the attributes and relationship participation of the higher-level entity set to which it is linked

Specialization



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Specialization

- Entity set may be specialized by more than one distinguishing feature
  - Entities can belong to multiple specializations
- ***Overlapping specialization*** – multiple sets permitted
- ***Disjoint specialization*** – At most one specialized entity set

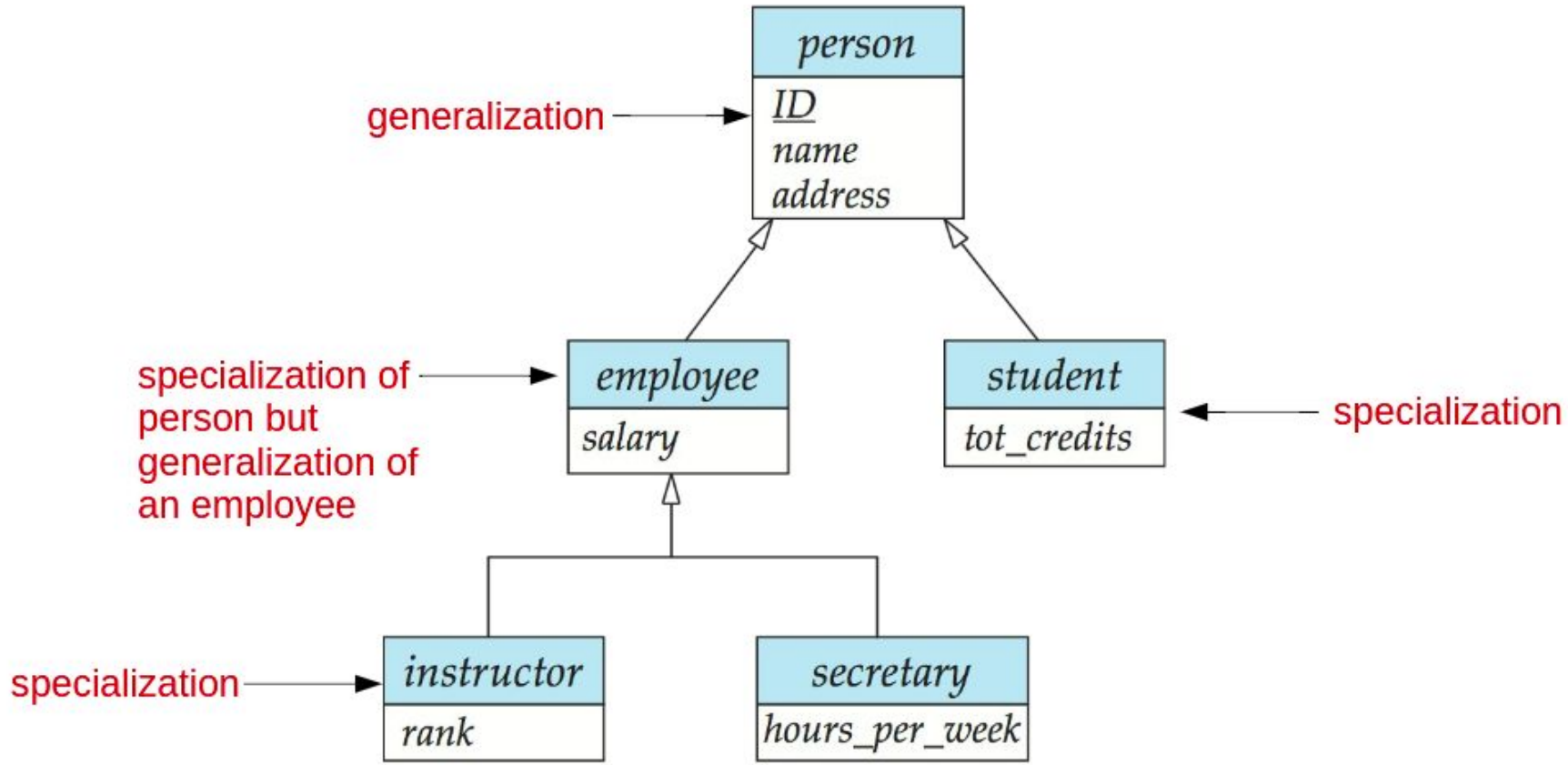
Generalization

- ***A bottom-up design process***
  - a number of entity sets that share same features
  - combine into higher-level entity set
- Specialization and generalization inversions of each other
  - represented in an E-R diagram in same way
- Specialization and generalization are used interchangeably

Generalization

- Can have multiple specializations of an entity set based on different features
  - permanent_employee vs. temporary_employee and instructor vs. secretary
- Each particular employee would be a member of
  - one of permanent_employee or temporary_employee
  - and also a member of instructor or secretary
- The ISA relationship also referred to as superclass/subclass relationship

Generalization vs Specialization



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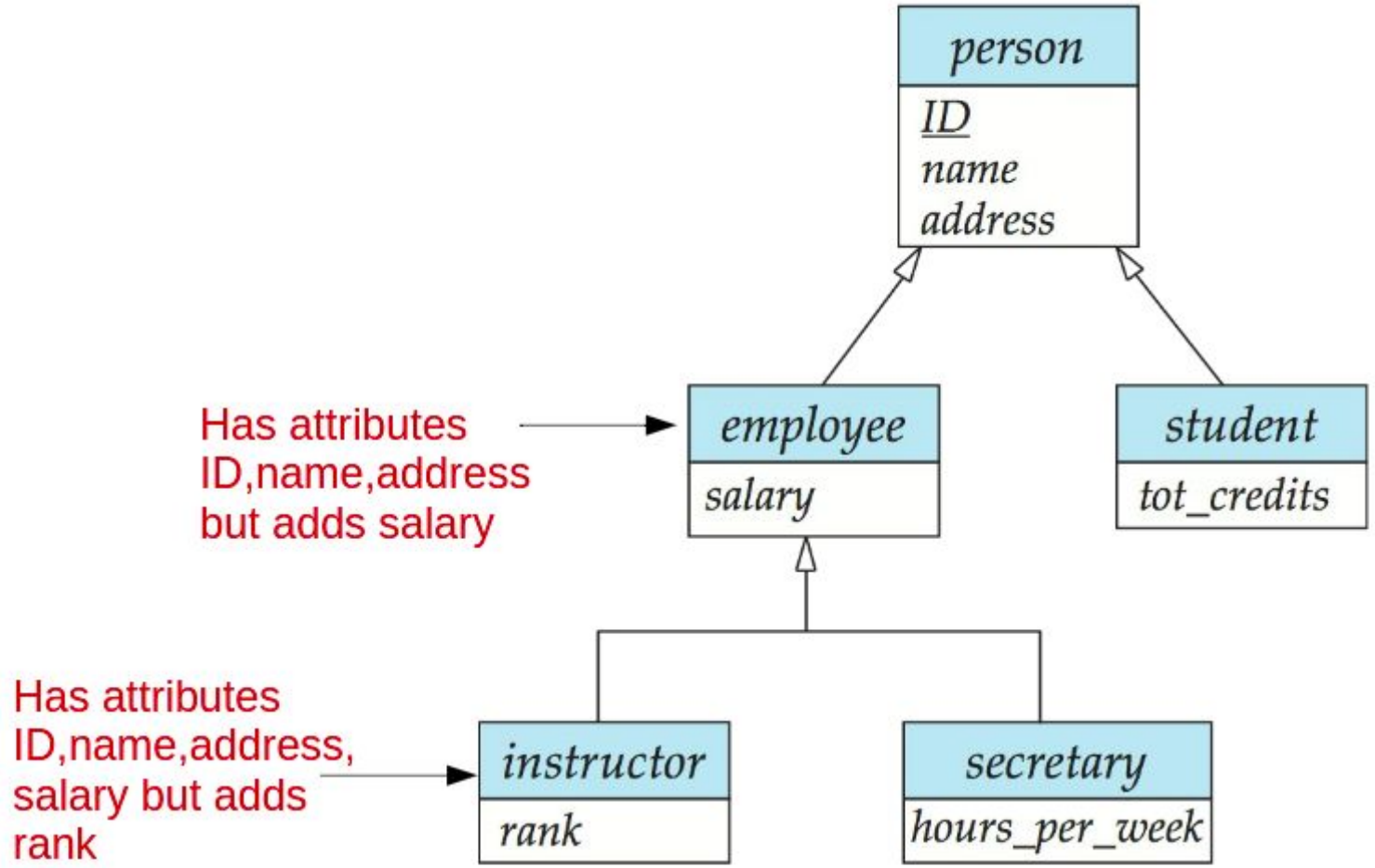
Attribute Inheritance

- Attributes of higher level entity sets inherited by lower level entity sets
- Participation also inherited
- Outcome:
  - High-level entity set with attributes and relationships, apply to low-level entity set
  - Lower-level entity sets with distinctive features

Attribute Inheritance



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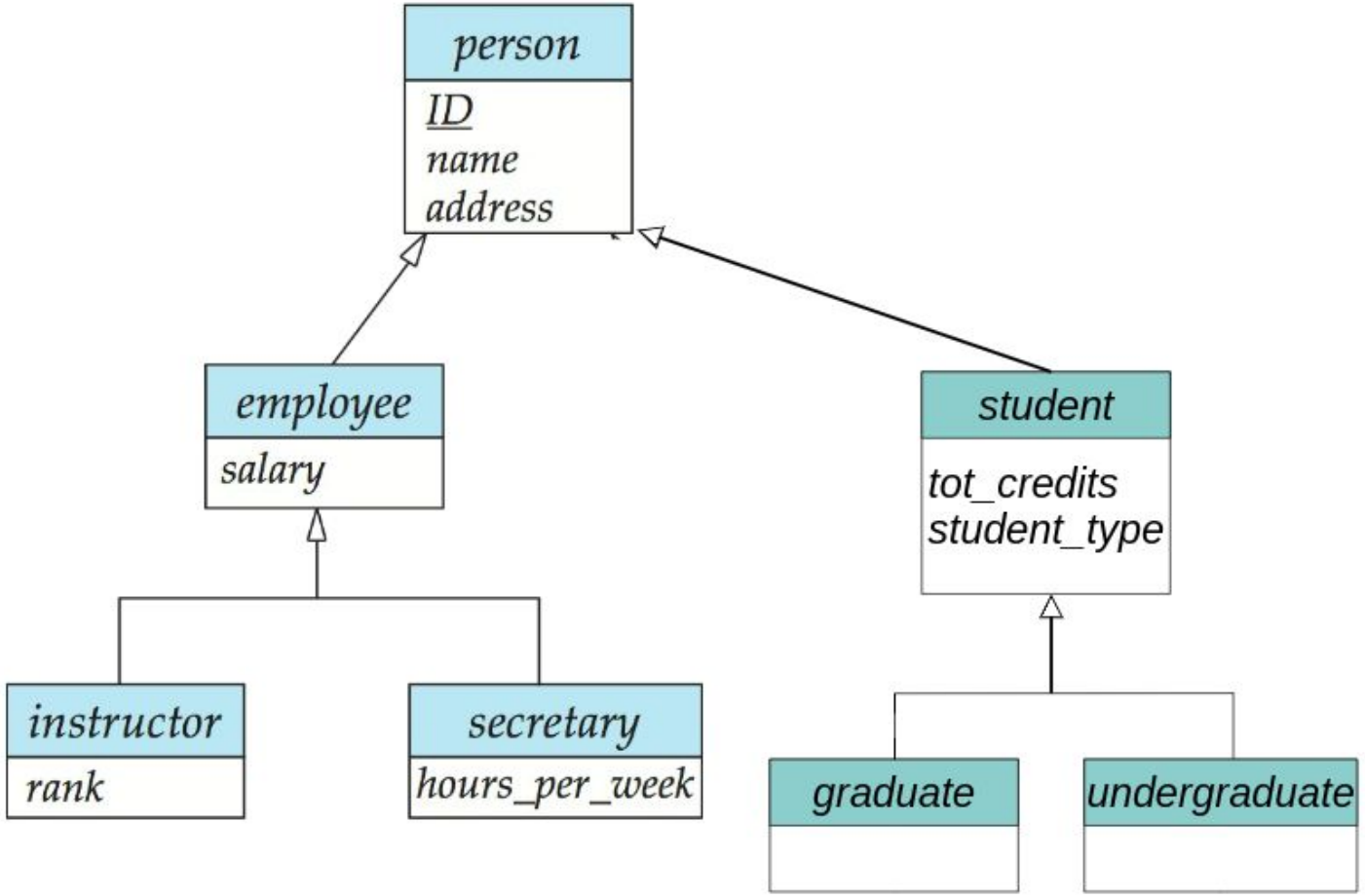
Specialization/Generalization Design Constraints

- Constraint on which entities can be members of a given lower- level entity set
  - ***condition-defined***
    - Example: all customers over 65 years are members of senior-citizen entity set; senior-citizen ISA person.
  - ***user-defined***

Specialization/Generalization Design Constraints



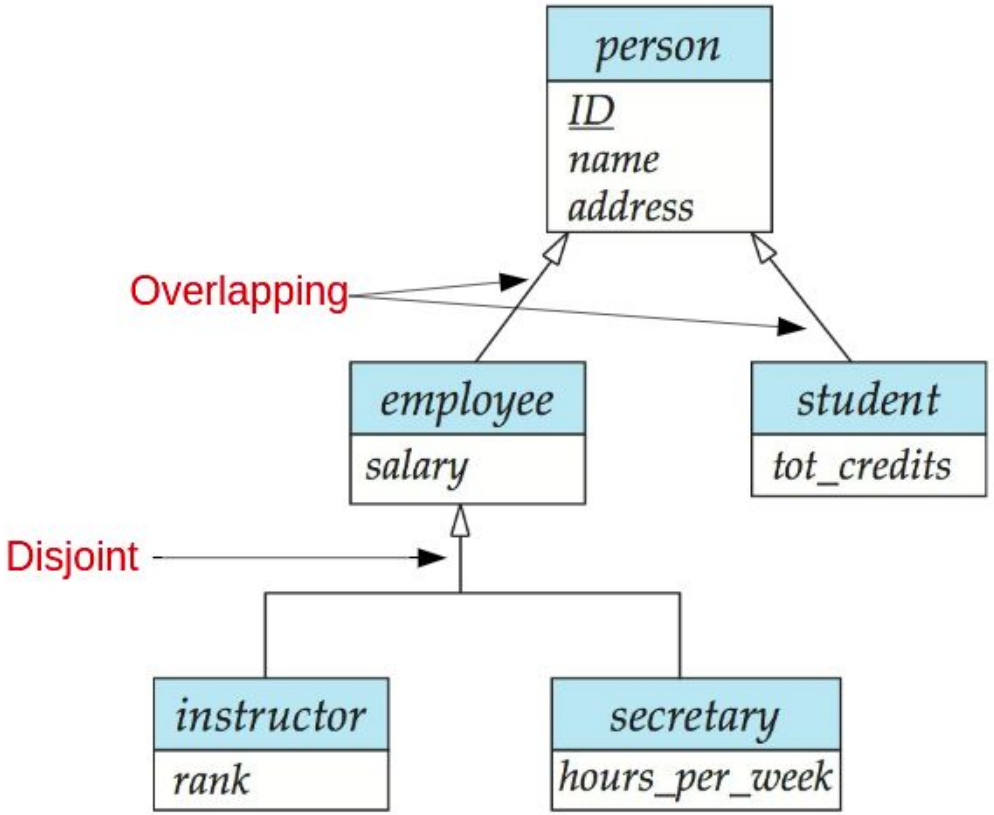
Conditioned: if
student_type='graduate' then type graduate or if
student_type='undergrad' then type undergraduate

Based on and image from "Database System Concepts" book and slides, 6th edition

Specialization/Generalization Design Constraints

- Constraint on whether or not entities may belong to more than one lower-level entity set within a single generalization
  - ***Disjoint***
    - an entity can belong to only one lower-level entity set
    - Noted in E-R diagram by having multiple lower-level entity sets link to the same triangle
  - ***Overlapping***
    - an entity can belong to more than one lower-level entity set

Specialization/Generalization Design Constraints



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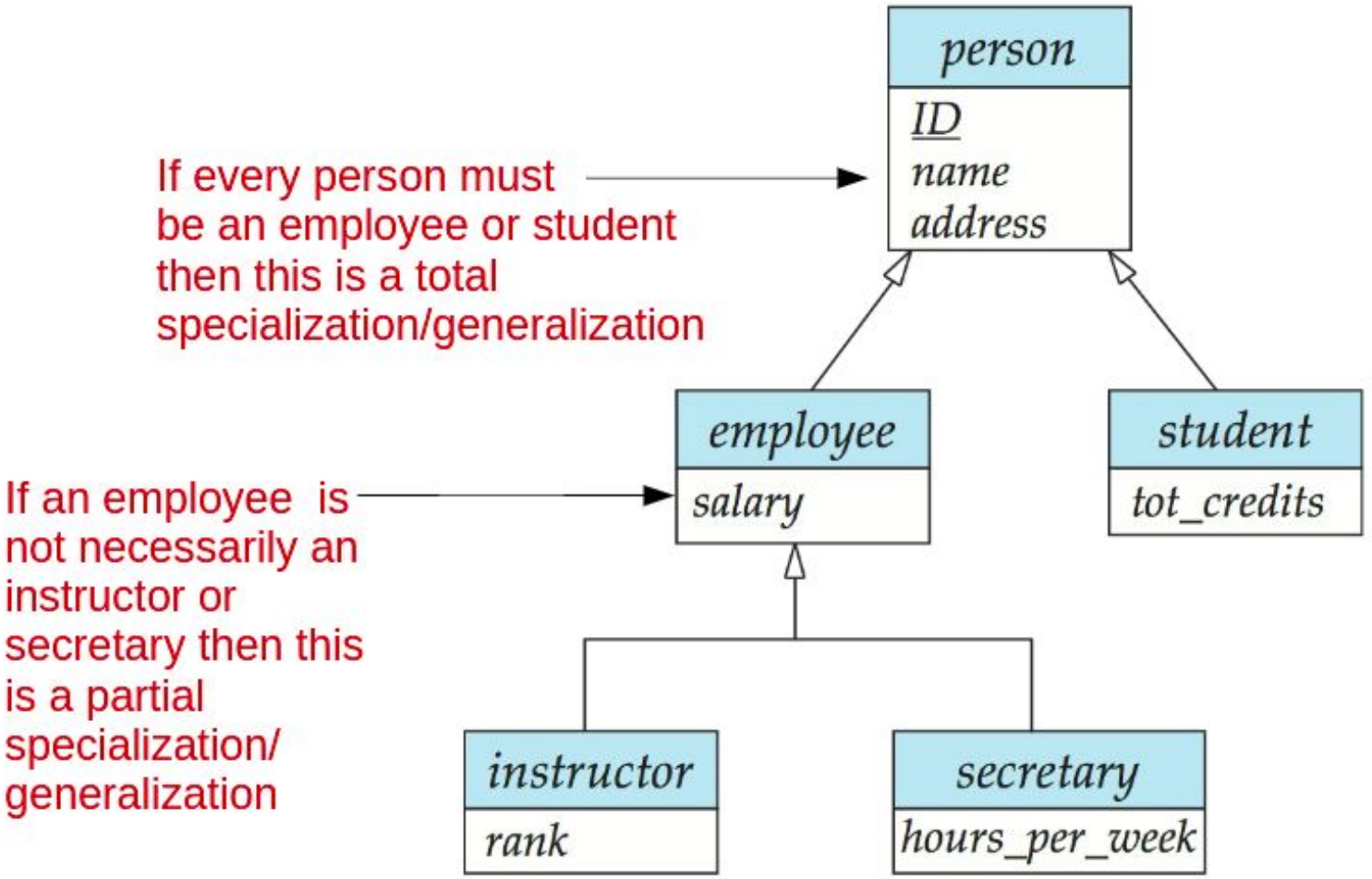
Specialization/Generalization Design Constraints

- Completeness constraint -- specifies whether or not an entity in the higher-level entity set must belong to at least one of the lower-level entity sets within a generalization
  - ***total***: an entity must belong to one of the lower- level entity sets
  - ***partial***: an entity need not belong to one of the lower-level entity sets

Specialization/Generalization Design Constraints



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Specialization via Schemas

Method 1:

- Form a schema for the higher-level entity
- Form a schema for each lower-level entity set, include primary key of higher-level entity set and local attributes

schema	*attributes*
person	*ID, name, street, city*
student	*ID, tot_cred*
employee	*ID, salary*

- Drawback: getting information about, an *employee* requires accessing two relations, the one corresponding to the low-level schema and the one corresponding to the high-level schema

Specialization via Schemas

Method 2:

- Form a schema for each entity set with all local and inherited attributes

schema	*attributes*
student	*ID, name, street, city, tot_cred*
employee	*ID, name, street, city, salary*

- If specialization is total and disjoint, the schema for the generalized entity set (*person*) not required to store information
  - Can be defined as a "view" relation containing union of specialization relations
  - But explicit schema may still be needed for foreign key constraints
- Drawback: *name, street* and *city* may be stored redundantly for people who are both students and employees

ER Design Decisions

- The use of an attribute or entity set to represent an object
- Whether a real-world concept is best expressed by an entity set or a relationship set
- The use of a strong or weak entity set
- The use of specialization/generalization – contributes to modularity in the design

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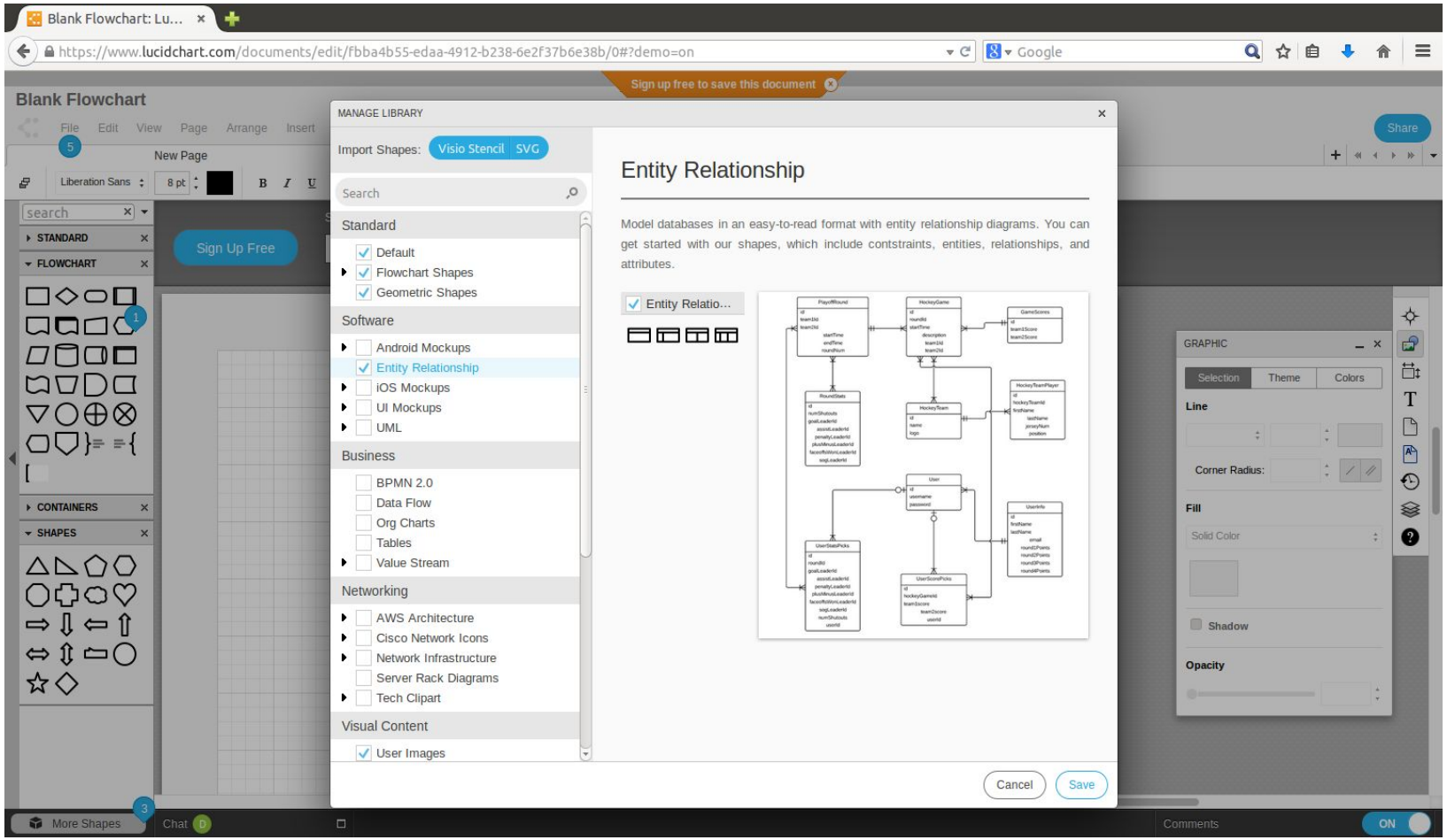
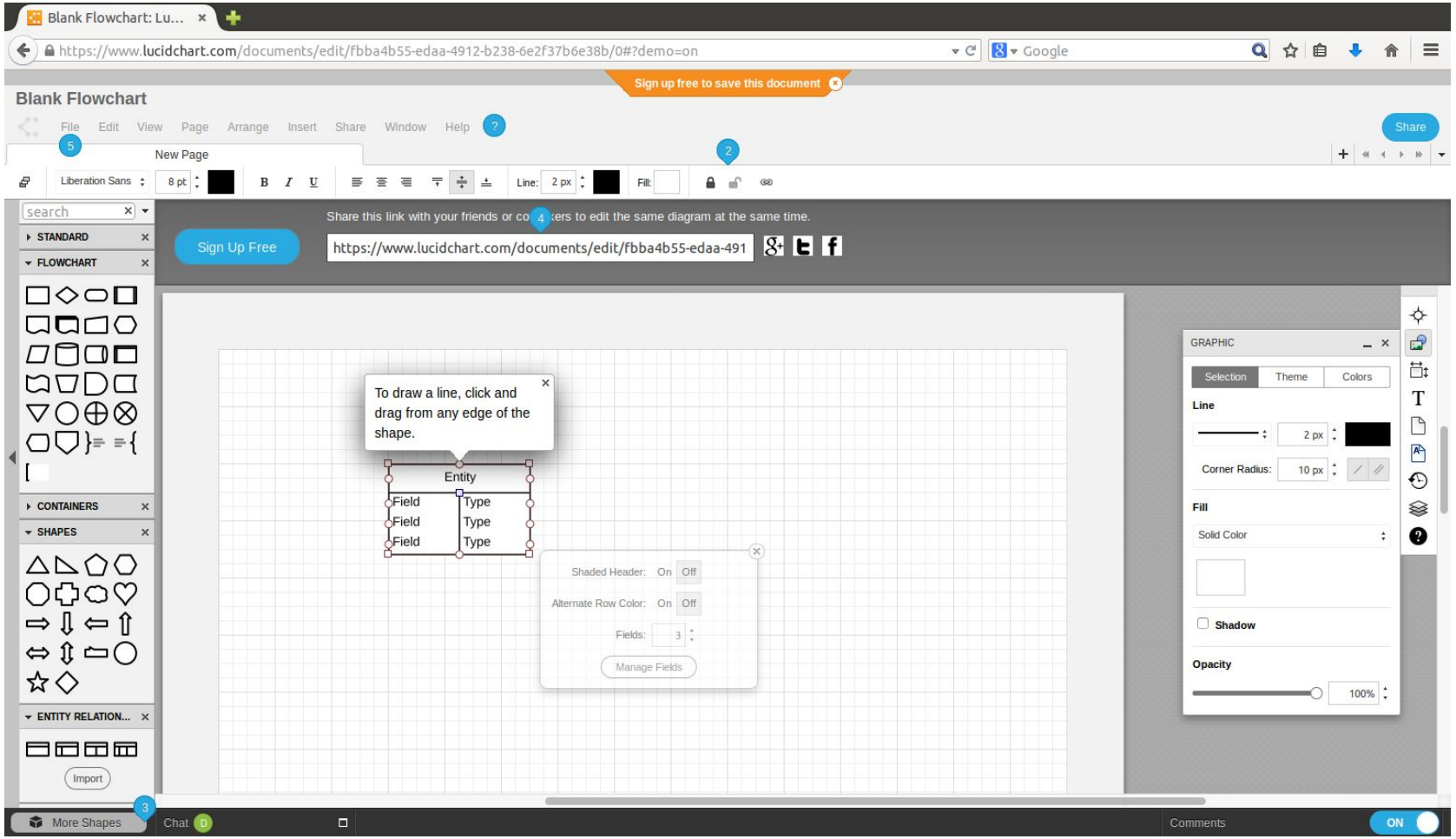
- ***Database Design Tools***

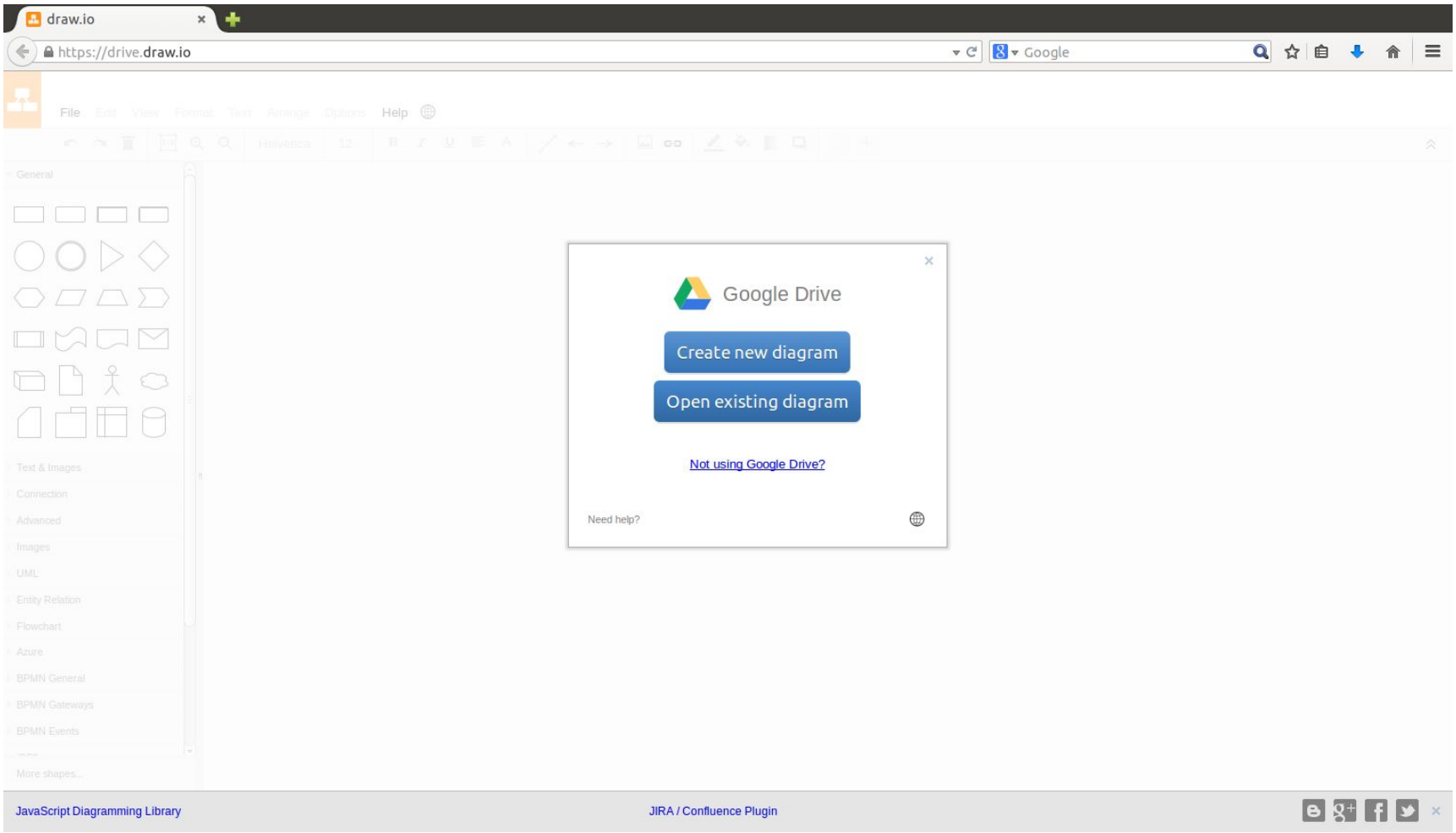
E-R Diagramming Tools - Lucid



E-R Diagramming Tools - Lucid



E-R Diagramming Tools – draw.io



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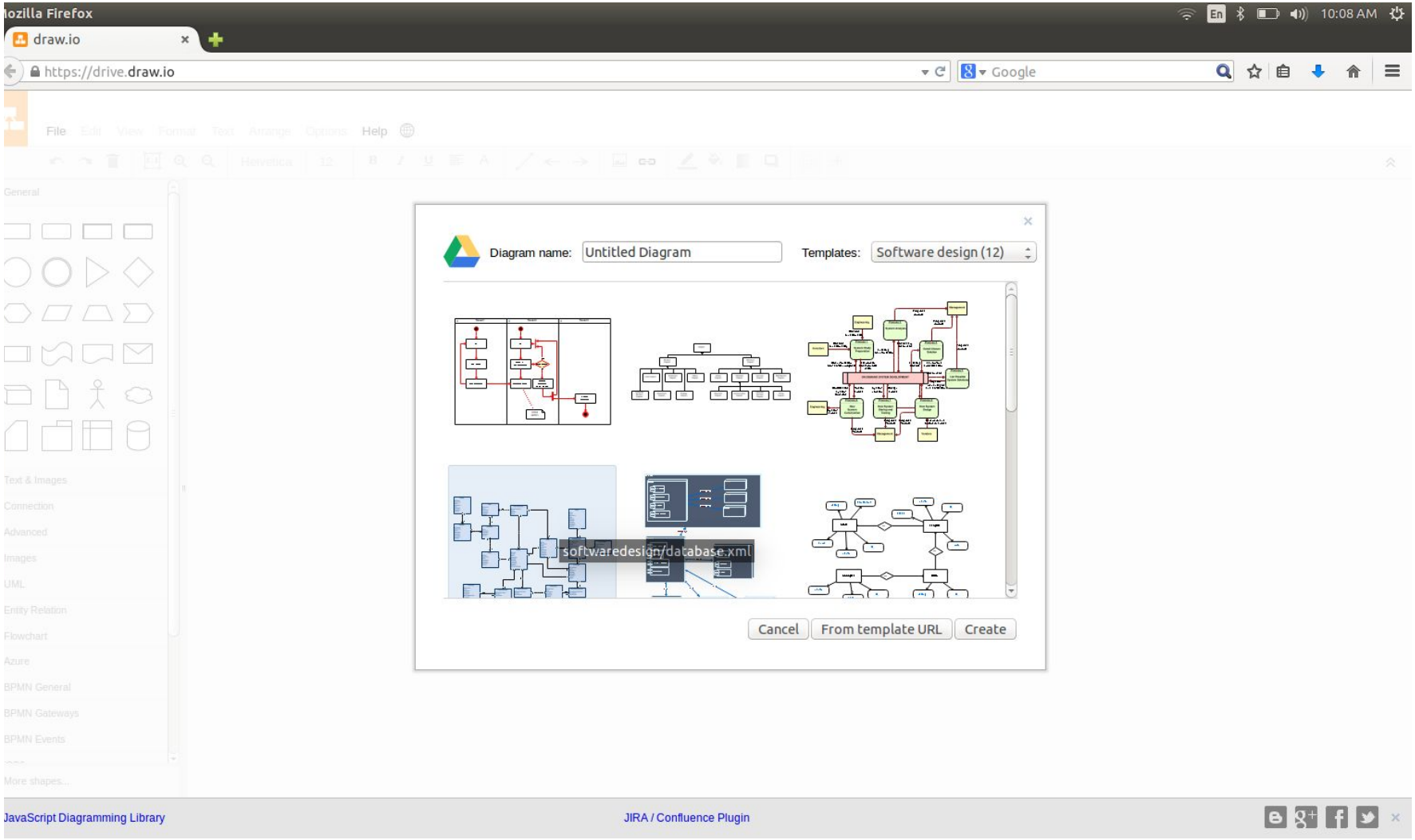

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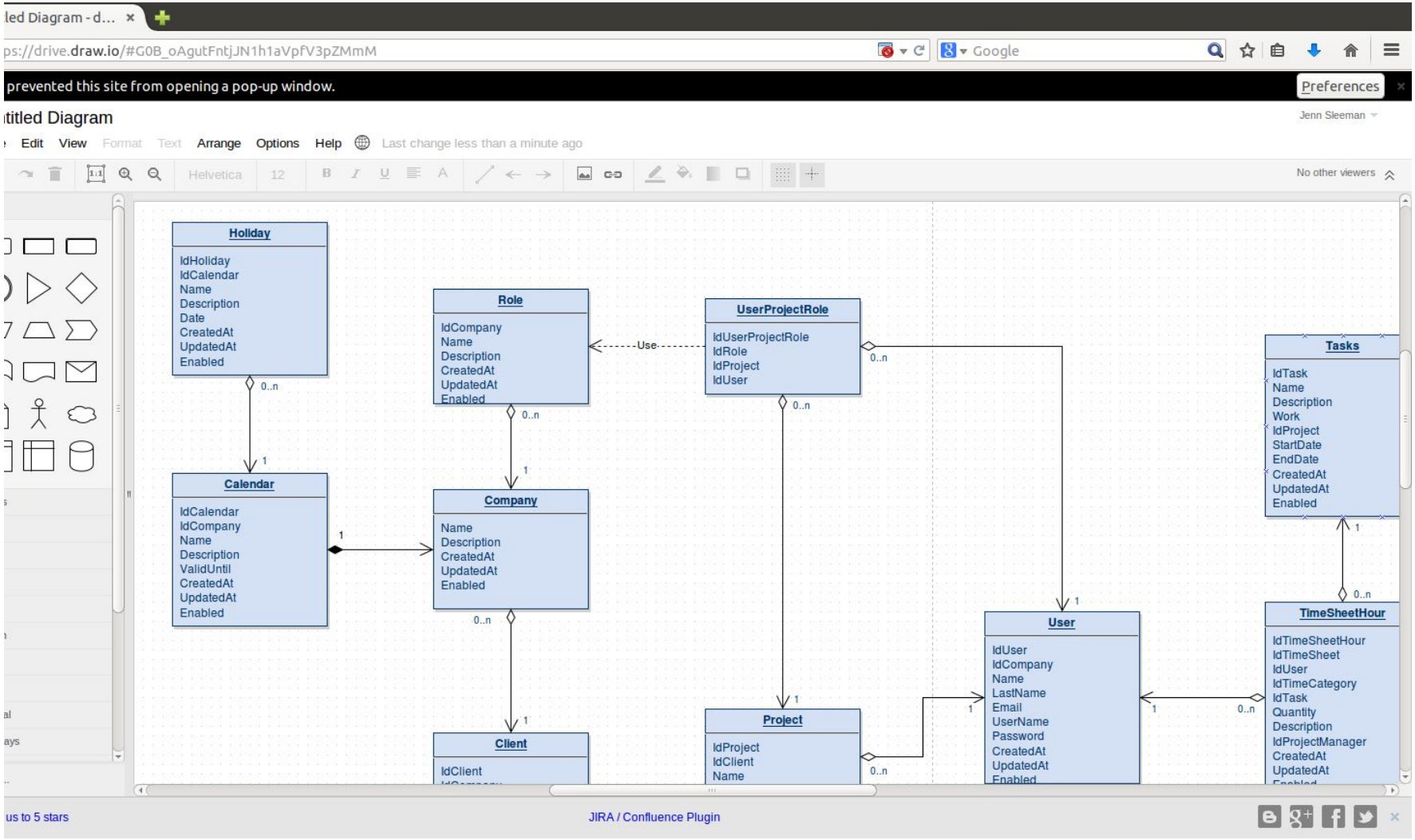
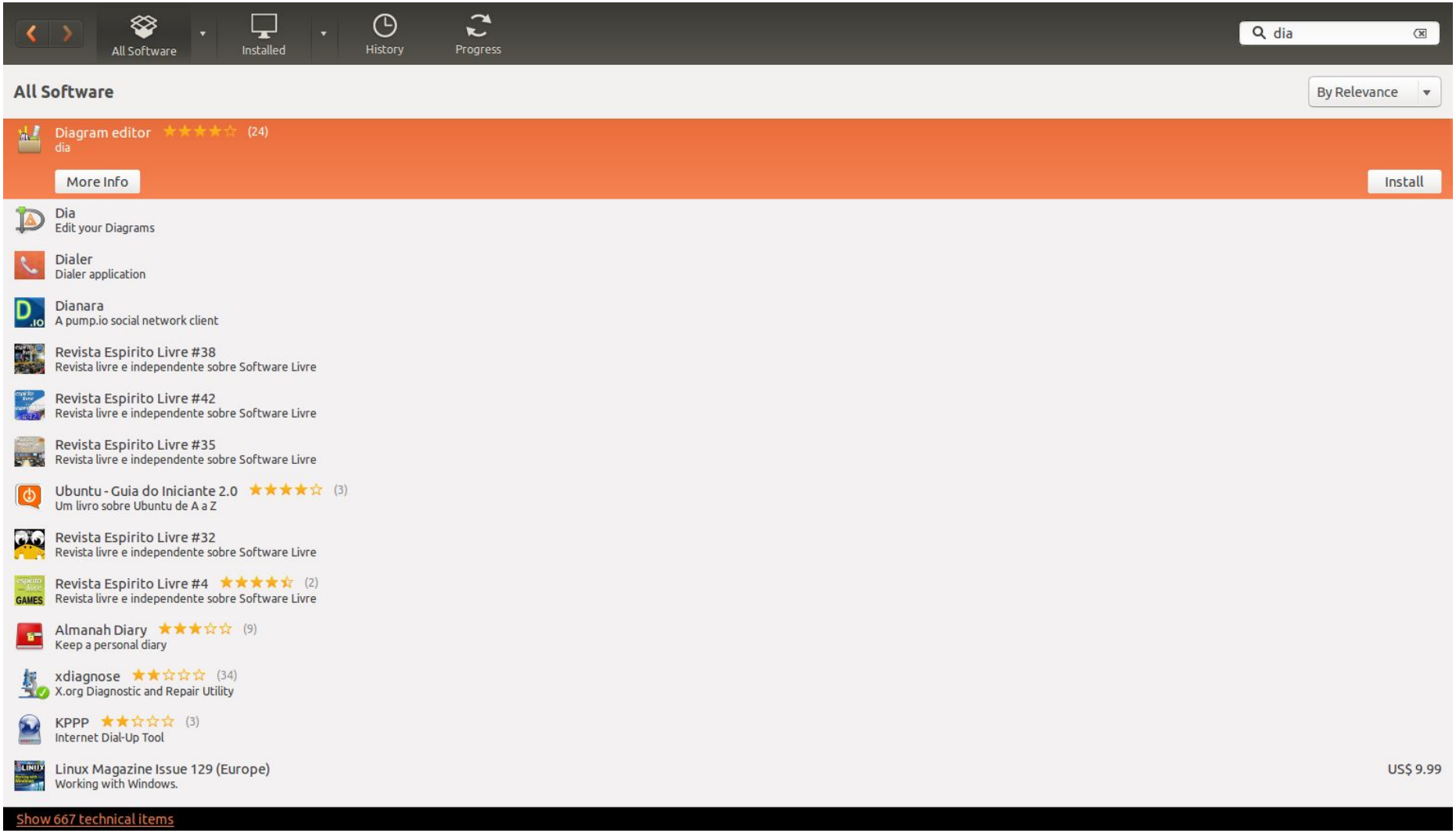


E-R Diagramming Tools – dia



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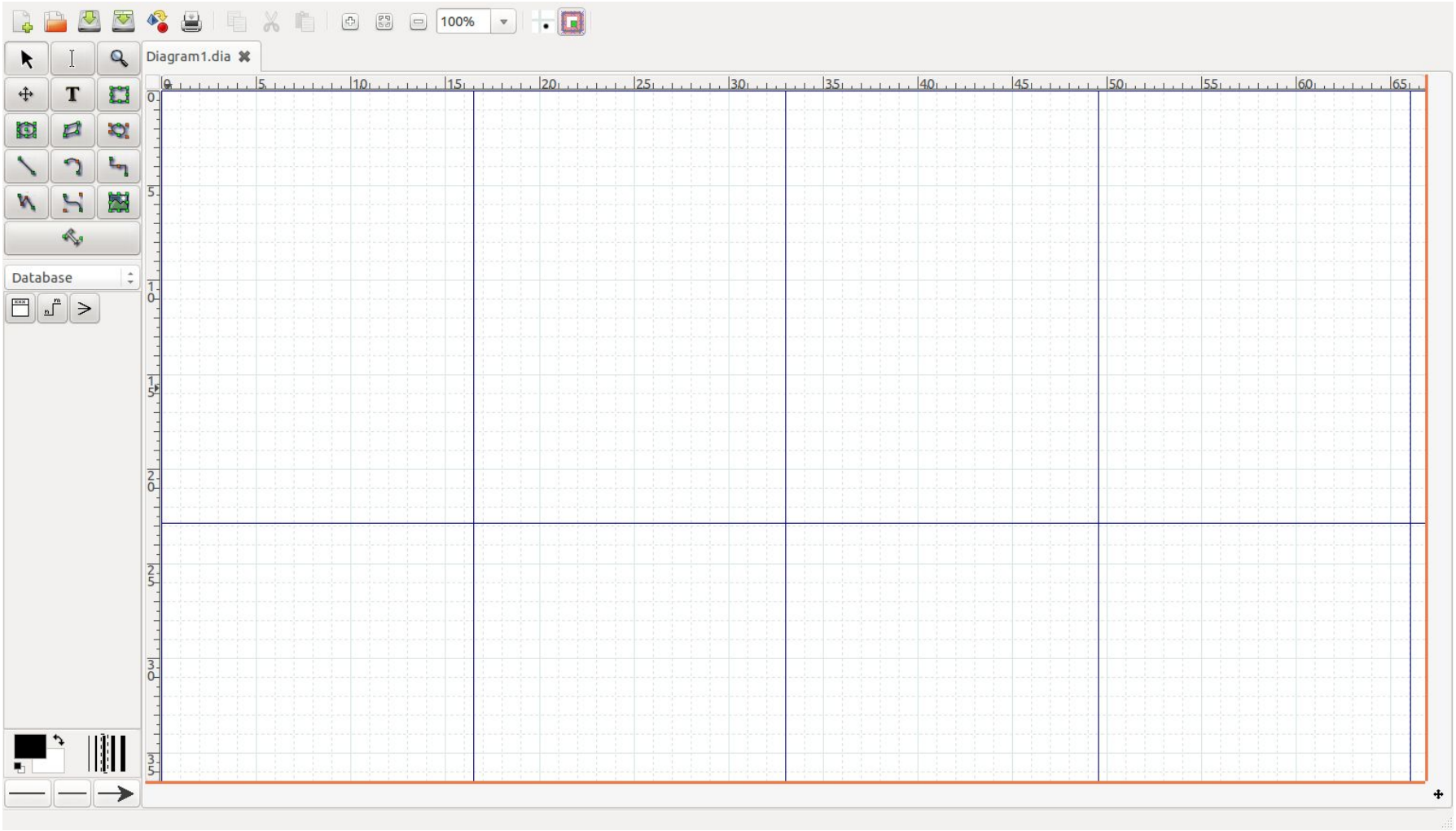
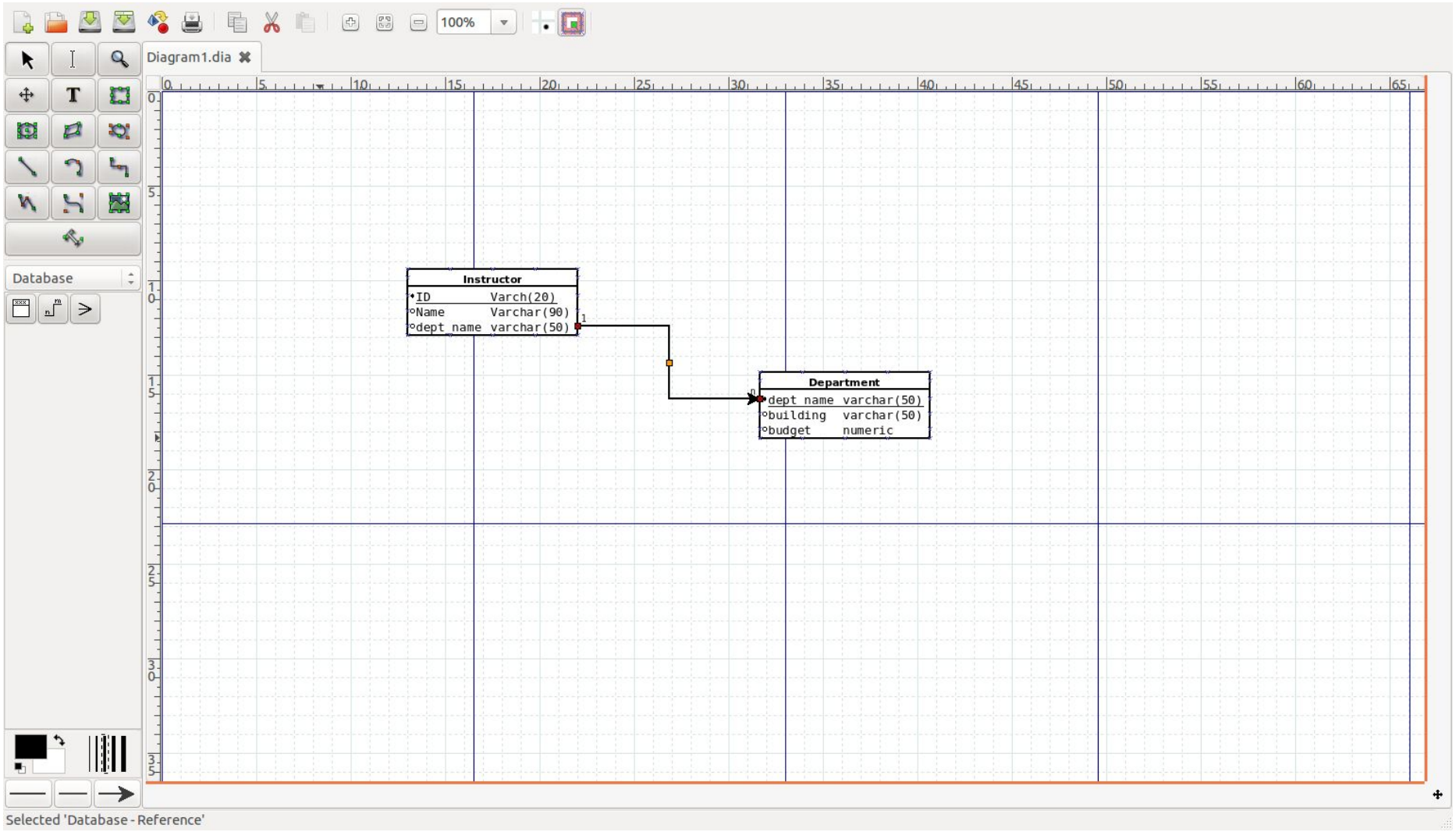
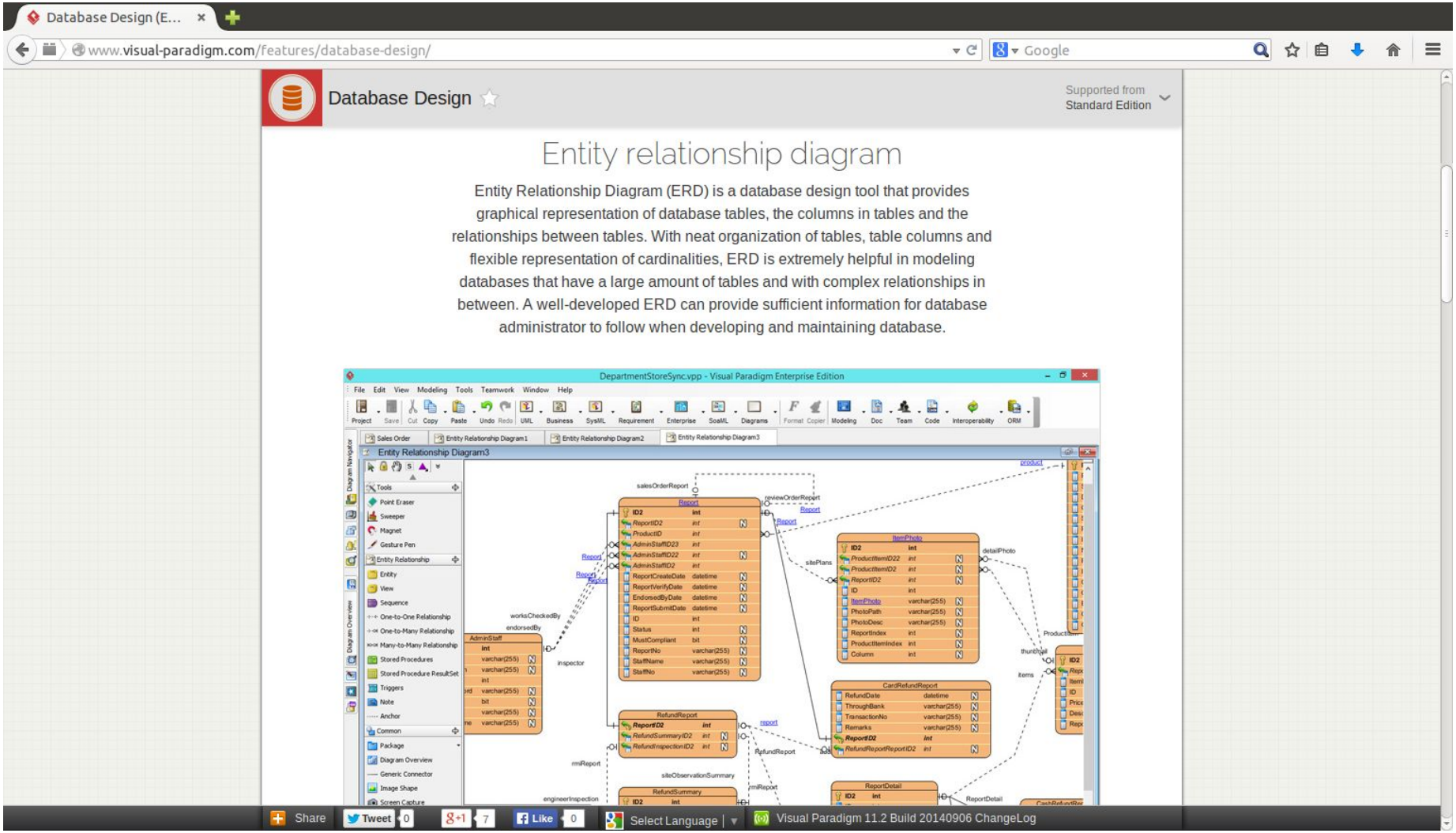


E-R Diagramming Tools – dia



E-R Diagramming Tools – Visual Paradigm



Working Example - Dog Shelter

I own a dog shelter and I want to build a system that can support me in managing the dogs and the families that adopt dogs. I like to know a lot of information about the people so I can make suggestions on what type of dog would be best for the family wishing to adopt. Some of my dogs have medical conditions I need to keep track of. After an adoption I like to check in with the family at different points in time to ensure the adoption was a success.

What are the entity sets and relationship sets involved?

Working Example - Dog Shelter

What you should consider:

1. Entity Sets
2. Relationship Sets
3. Attributes (Composite, Multi-valued, Derived)
4. Weak entity sets
5. Binary and non-binary relationships
6. Cardinality
7. Relationship set roles