Data Modeling and the Entity-Relationship Model

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Introduction to Database Management
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Notes

Outline

Notes

Overview of E-R Model

Used for (and designed for) database (conceptual schema) design

$\Rightarrow$ Proposed by Peter Chen in 1976

World/enterprise described in terms of

- entities
- attributes
- relationships

Visualization: **E-R diagram**

N.B. Many variant notations are in common use

Notes

Basic E-R Modeling

Entity: a *distinguishable* object

Entity set: set of entities of same type
Examples:

- students currently at University of Waterloo
- flights offered by Air Canada
- burglaries in Ontario during 1994

Graphical representation of entity sets:

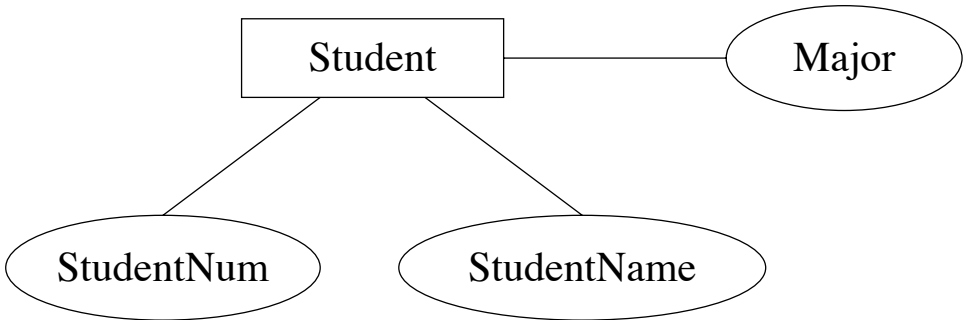
Notes

Basic E-R Modeling (cont'd)

Attributes: describe properties of entities
Examples (for Student-entities): StudentNum, StudentName, Major, ...

Domain: set of permitted values for an attribute

Graphical representation of attributes:



Notes

Basic E-R Modeling (cont'd)

Relationship: representation of the fact that certain entities are related to each other

Relationship set: set of relationships of a given type

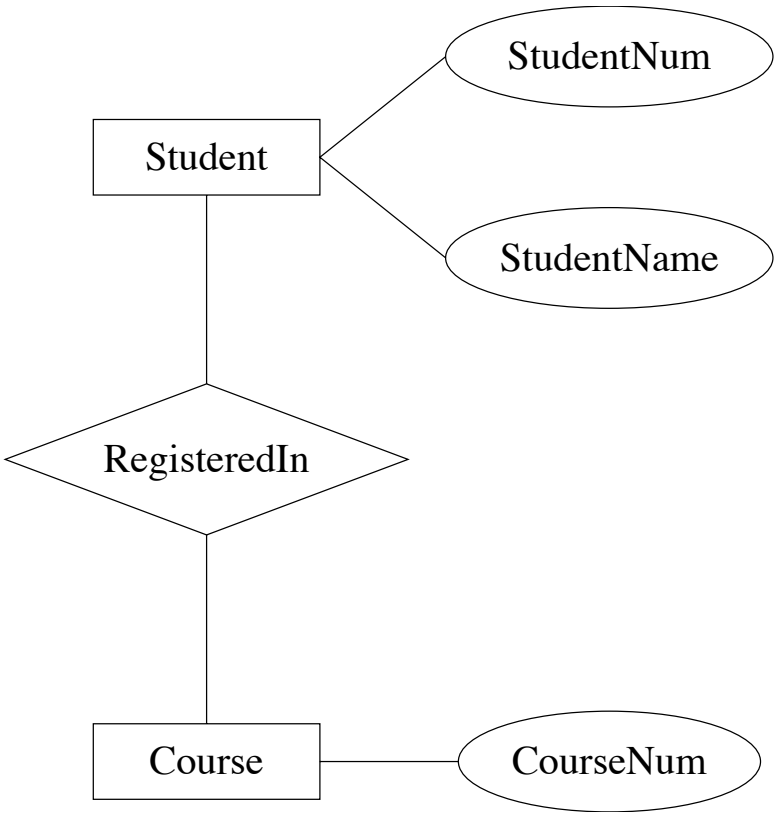
Examples:

- students registered in courses
- passengers booked on flights
- parents and their children
- bank branches, customers and their accounts

In order for a relationship to exist, the participating entities must exist.

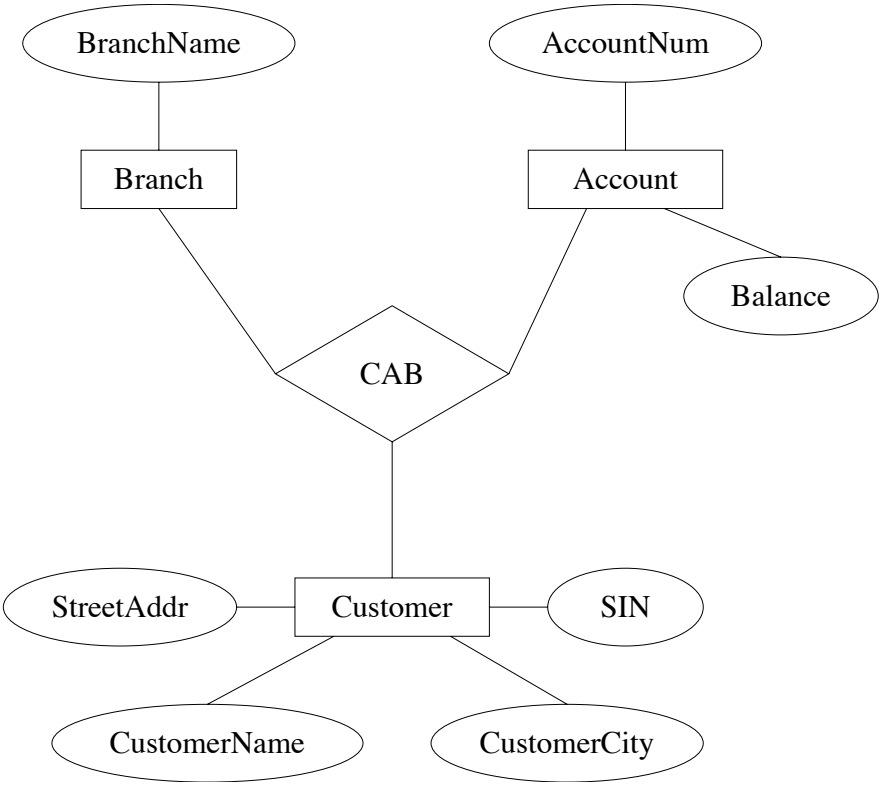
Notes

Graphical Representation



Notes

Graphical Representation (cont'd)



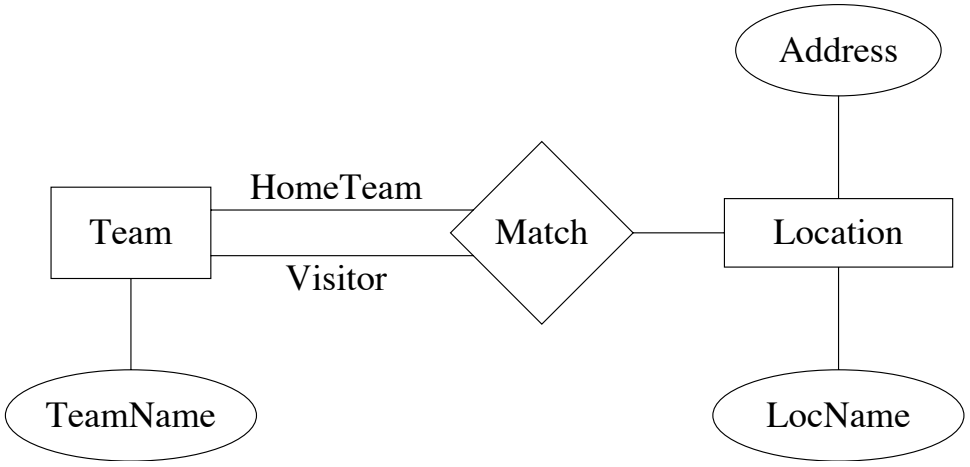
Notes

Multiple Relationships and Role Names

Role: the function of an entity set in a relationship set

Role name: an explicit indication of a role

Example:



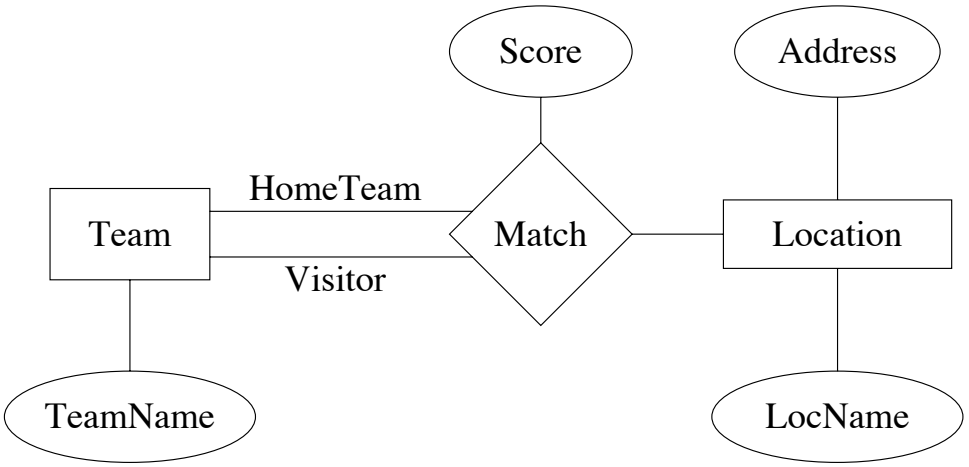
Role labels are needed whenever an entity set has multiple functions in a relationship set.

Notes

Relationships and Attributes

Relationships may also have attributes

Example:



Notes

Constraints in E-R Models

- Primary keys
- Relationship types
- Existence dependencies
- General cardinality constraints

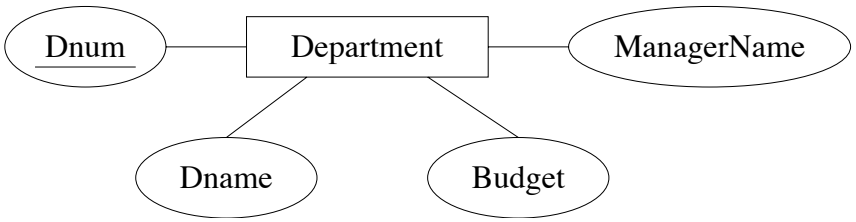
Notes

Primary Keys

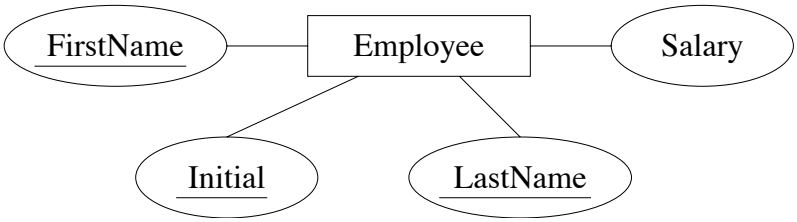
Each entity must be distinguishable from any other entity in an entity set by its attributes

Primary key: selection of attributes chosen by designer values of which determines the particular entity.

Example 1:



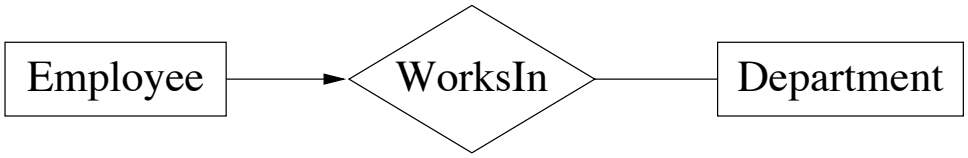
Example 2:



Notes

Relationship Types

- **many-to-many (N:N)**: an entity in one set can be related to many entities in the other set, and vice versa
  (This is the interpretation we have used so far.)
- **many-to-one (N:1)**: each entity in one set can be related to at most one entity in the other, but an entity in the second set may be related to many entities in the first



- **one-to-many (1:N)**: similar
- **one-to-one (1:1)**: each entity in one set can be related to at most one entity in the other, and vise versa

Notes

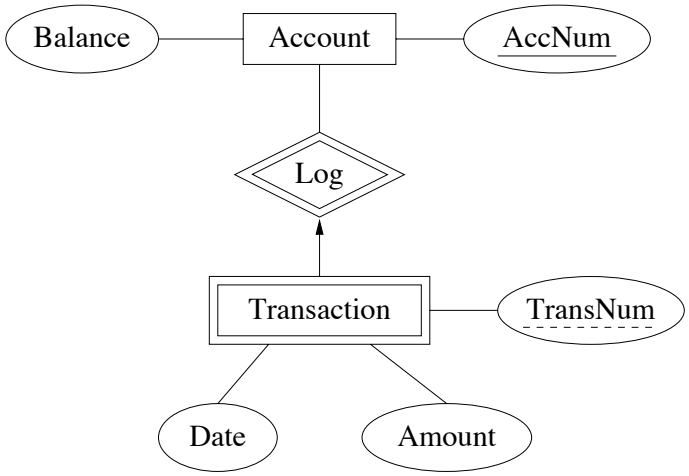
Existence Dependencies

Sometimes the existence of an entity depends on the existence of another entity

If x is **existence dependent** on y, then

- y is a **dominant entity**
- x is a **subordinate entity**

Example: "Transactions are existence dependent on accounts."



Notes

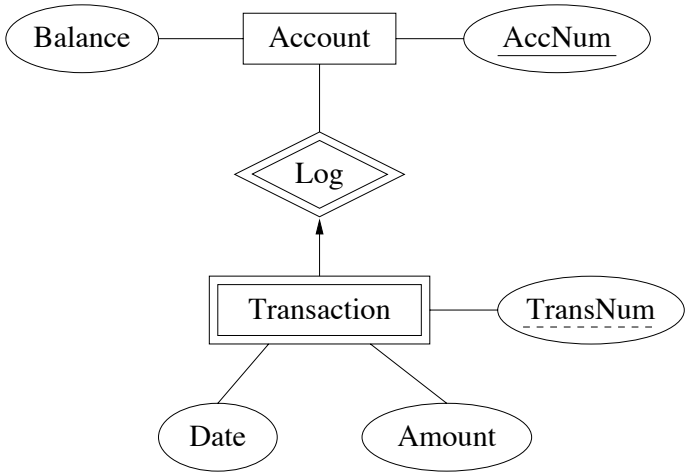
Identifying Subordinate Entities

Weak entity set: an entity set containing subordinate entities

Strong entity set: an entity set containing no subordinate entities

Attributes of weak entity sets only form key relative to a given dominant entity

Example: "All transactions for a given account have a unique transaction number."

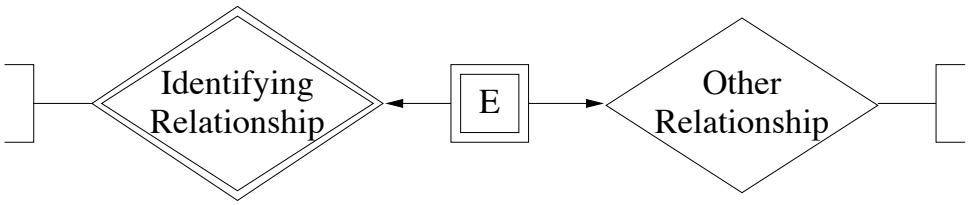


Notes

Identifying Subordinate Entities (cont'd)

A weak entity set must have a many-to-one relationship to a distinct entity set

Visualization: (distinguishing an identifying relationship)



Discriminator of a weak entity set: set of attributes that distinguish subordinate entities of the set, for a particular dominant entity

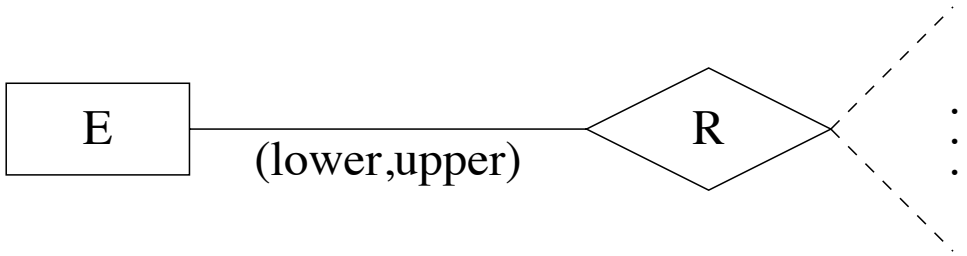
Primary key for a weak entity set: discriminator + primary key of entity set for dominating entities

Notes

General Cardinality Constraints

General cardinality constraints determine lower and upper bounds on the number of relationships of a given relationship set in which a component entity may participate

Visualization:



Example:

Notes

Extensions to E-R Modeling

- Structured attributes
- Aggregation
- Specialization
- Generalization
- Disjointness

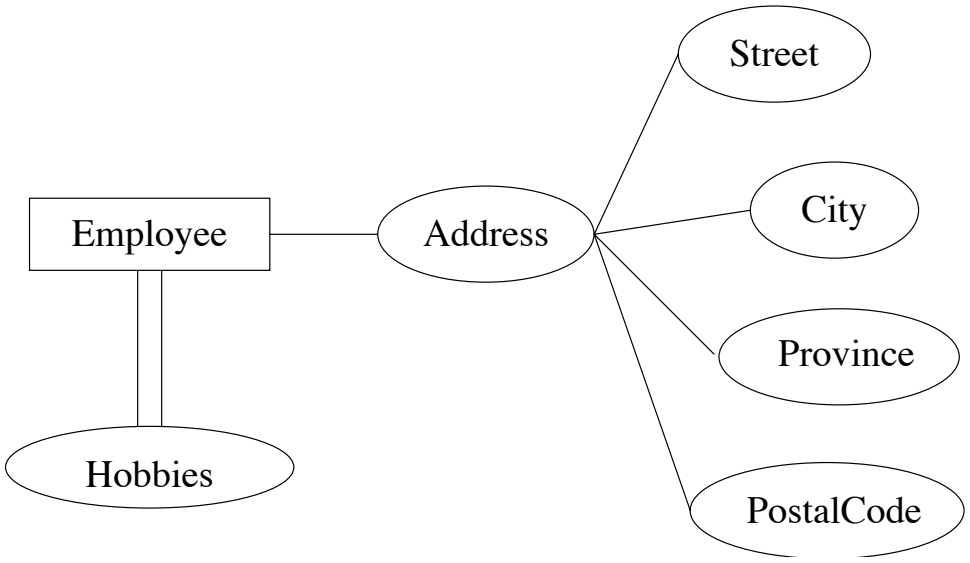
Notes

Structured Attributes

Composite attributes: composed of fixed number of other attributes

Multi-valued attributes: attributes that are set-valued

Example:

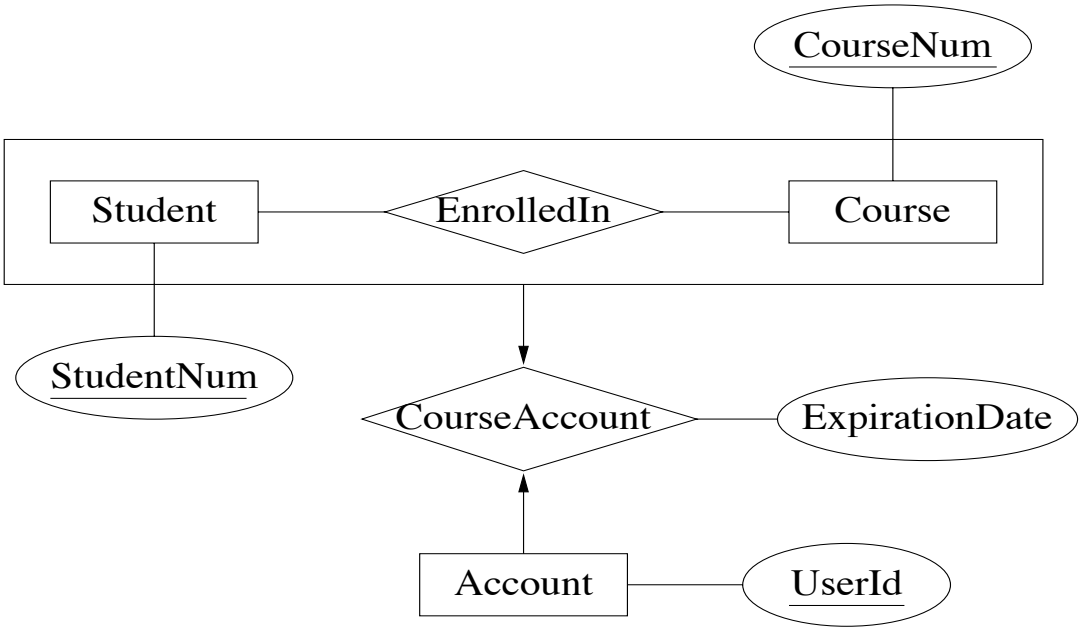


Notes

Aggregation

Relationships can be viewed as higher-level entities

Example: "Accounts are assigned to a given student enrollment."

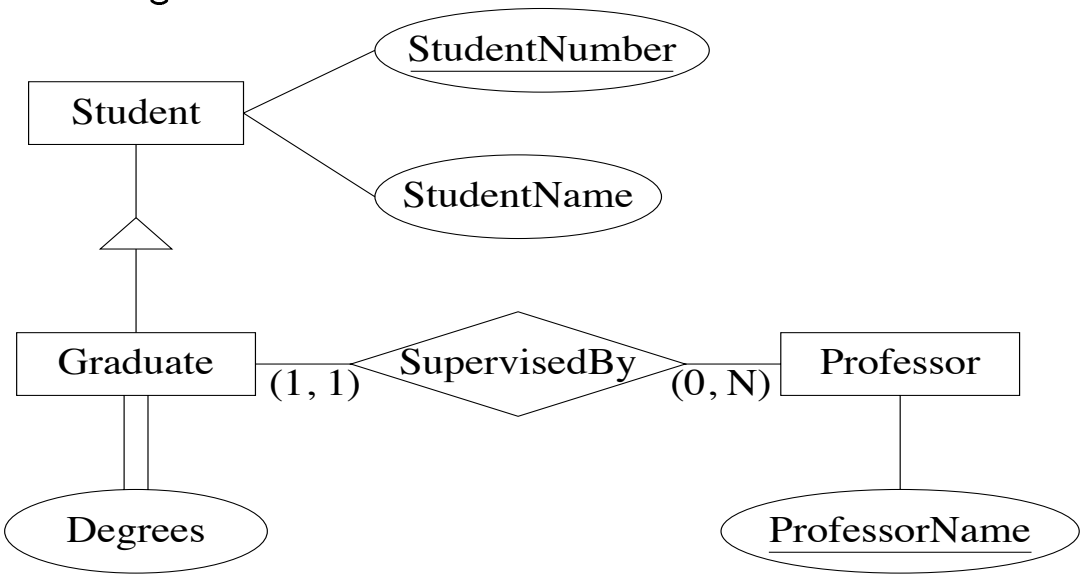


Notes

Specialization

A specialized kind of entity set may be derived from a given entity set

Example: "Graduate students are students who have a supervisor and a number of degrees."

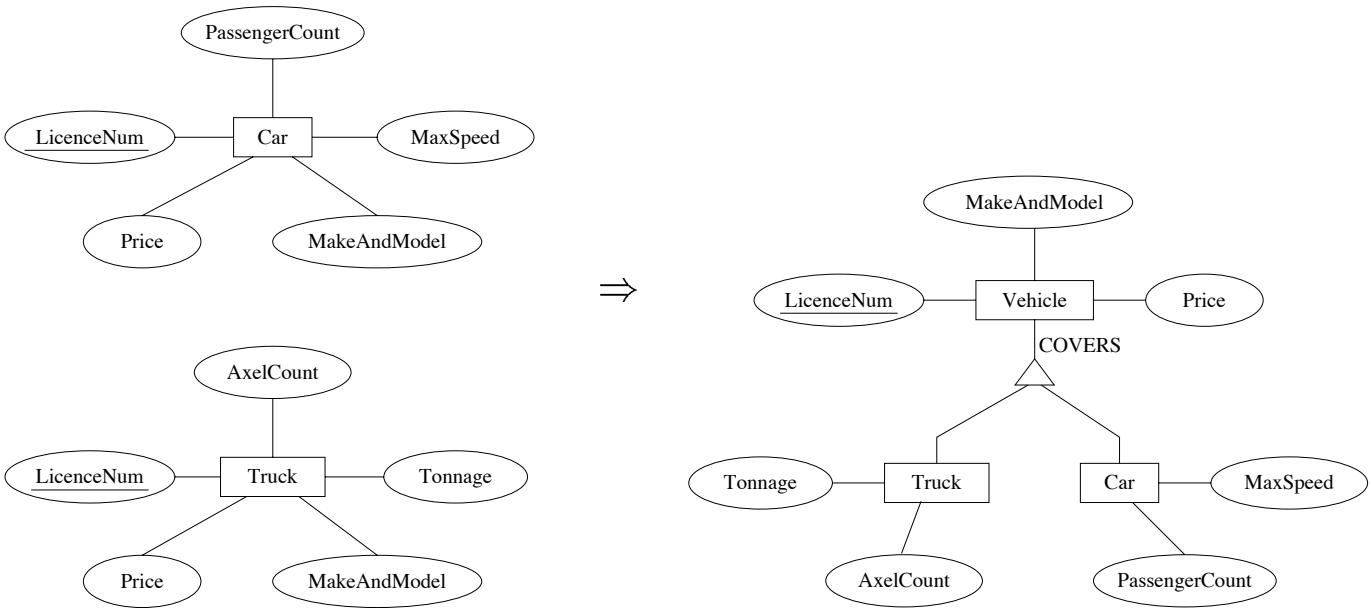


Notes

Generalization

Several entity sets can be abstracted by a more general entity set

Example: "A vehicle abstracts the notion of a car and a truck."

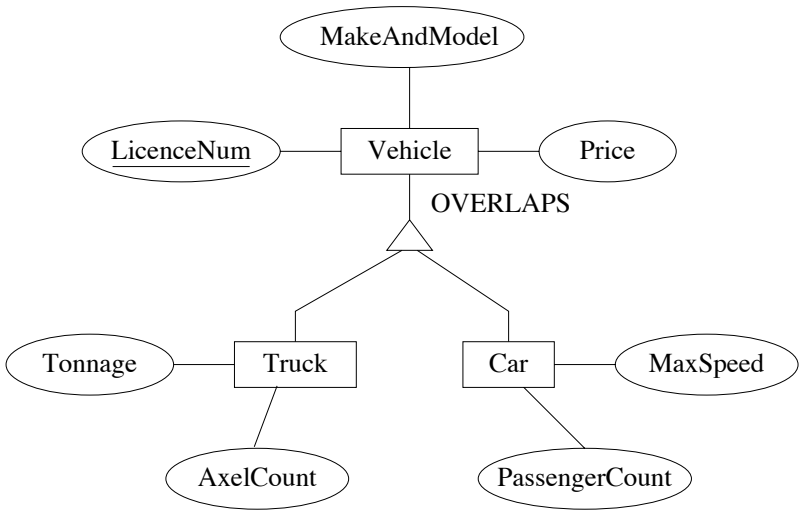


Notes

Disjointness

Specialized entity sets are usually disjoint but can be declared to have entities in common

- By default, specialized entity sets are disjoint.
  Example: We may decide that nothing is both a car and a truck.
- However, we can declare them to overlap (to accommodate utility vehicles, perhaps).



Notes

Designing An E-R Schema

Usually many ways to design an E-R schema
Points to consider

- use attribute or entity set?
- use entity set or relationship set?
- degrees of relationships?
- extended features?

Notes

Attributes or Entity Sets?

Example: Should one model employees' phones by a PhoneNumber attribute, or by a Phone entity set related to the Employee entity set?

Rules of thumb:

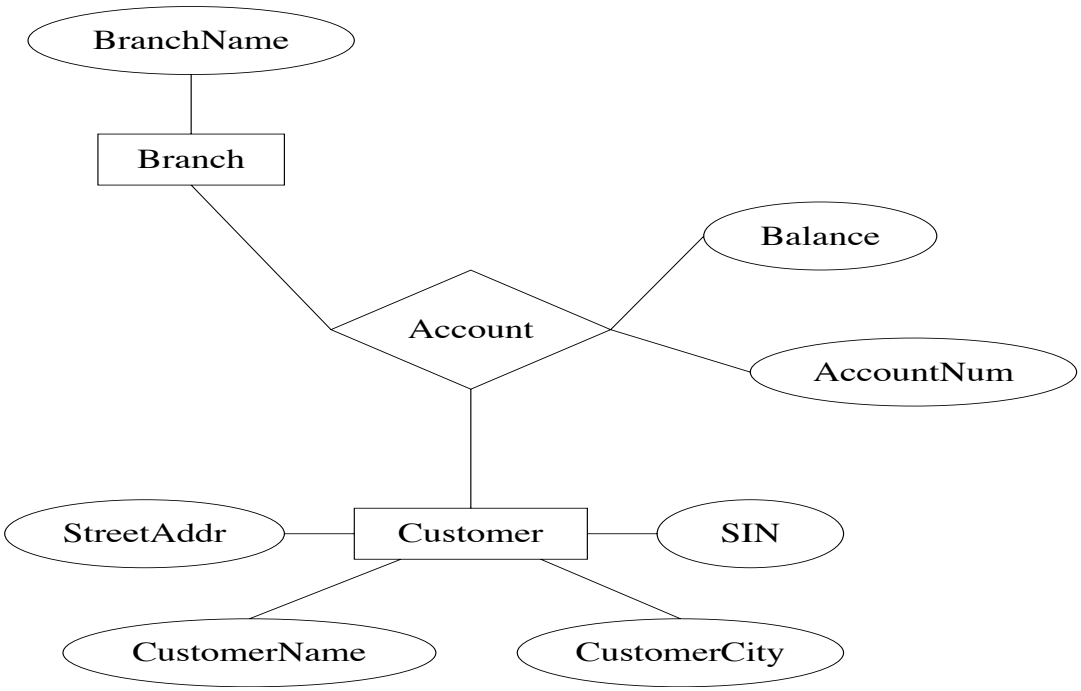
- Is it a separate object?
- Do we maintain information about it?
- Can several of its kind belong to a single entity?
- Does it make sense to delete such an object?
- Can it be missing from some of the entity set's entities?
- Can it be shared by different entities?

An affirmative answer to any of the above suggests a new entity set.

Notes

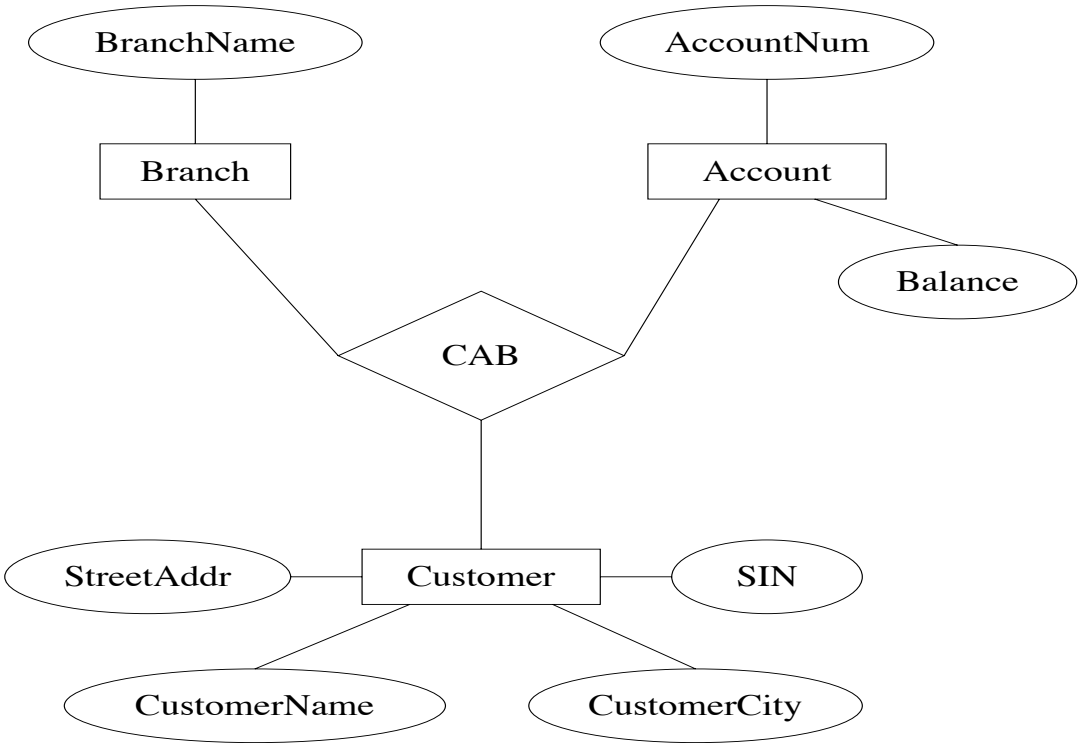
Entity Sets or Relationships?

Instead of representing accounts as entities, we could represent them as relationships



Notes

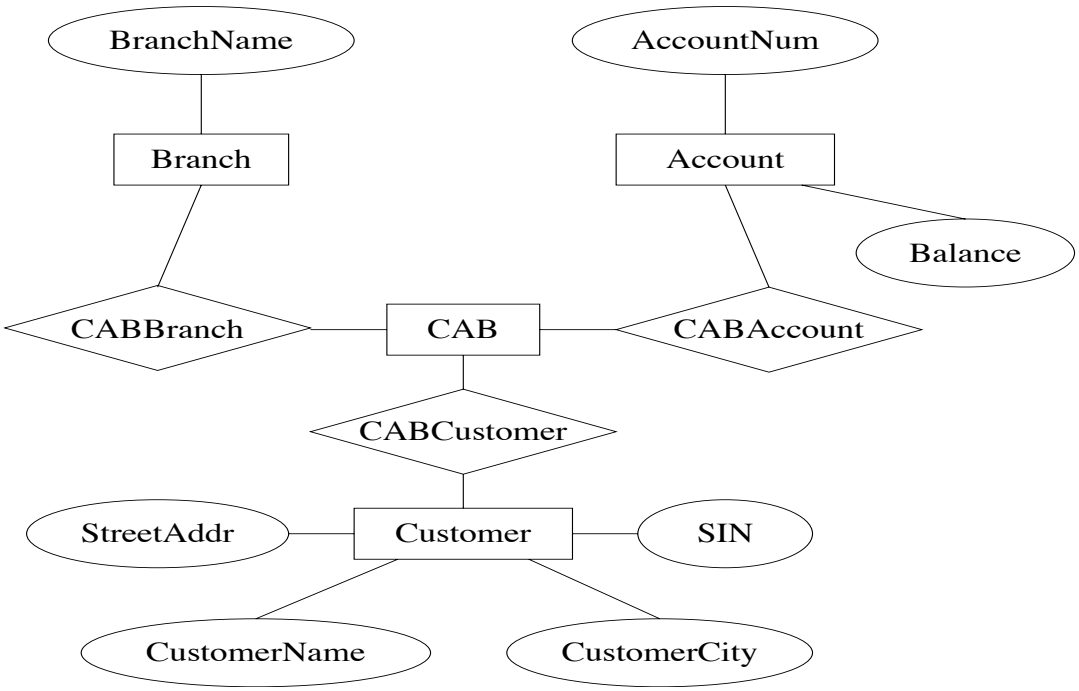
Binary vs. N-ary Relationships?



Notes

Binary vs. N-ary Relationships (cont'd)

We can always represent a relationship on n entity sets with n binary relationships



Notes

A Simple Methodology

1. Recognize entity sets
2. Recognize relationship sets and participating entity sets
3. Recognize attributes of entity and relationship sets
4. Define relationship types and existence dependencies
5. Define general cardinality constraints, keys and discriminators
6. Draw diagram

For each step, maintain a log of assumptions motivating the choices, and of restrictions imposed by the choices

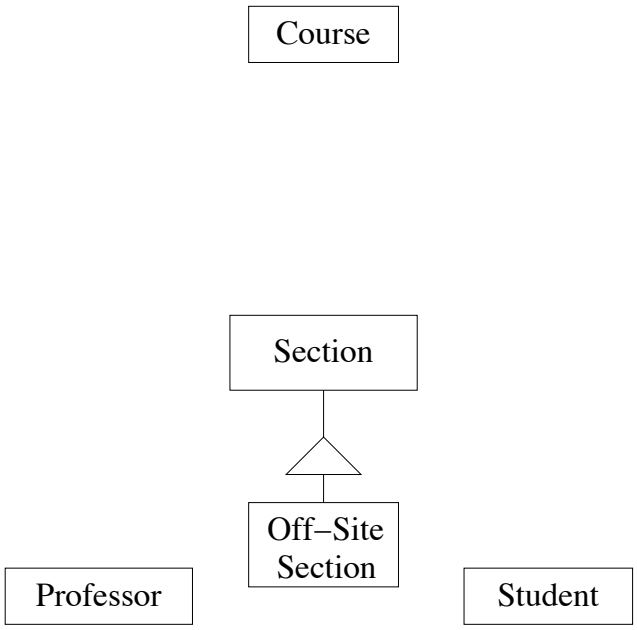
Notes

Example: A Registrar's Database

- Zero or more sections of a course are offered each term. Courses have names and numbers. In each term, the sections of each course are numbered starting with 1.
- Most course sections are taught on-site, but a few are taught at off-site locations.
- Students have student numbers and names.
- Each course section is taught by a professor. A professor may teach more than one section in a term, but if a professor teaches more than one section in a term, they are always sections of the same course. Some professors do not teach every term.
- Up to 50 students may be registered for a course section. Sections with 5 or fewer students are cancelled.
- A student receives a mark for each course in which they are enrolled. Each student has a cumulative grade point average (GPA) which is calculated from all course marks the student has received.

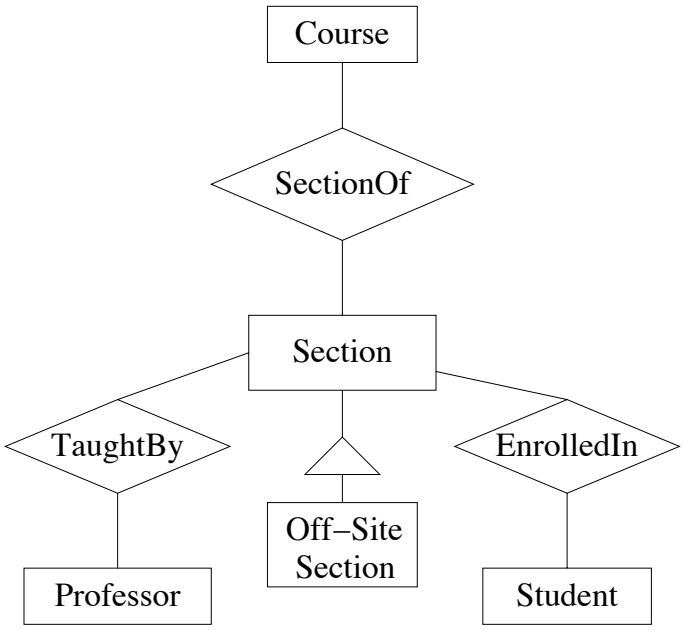
Notes

Example: A Registrar's Database (cont'd)



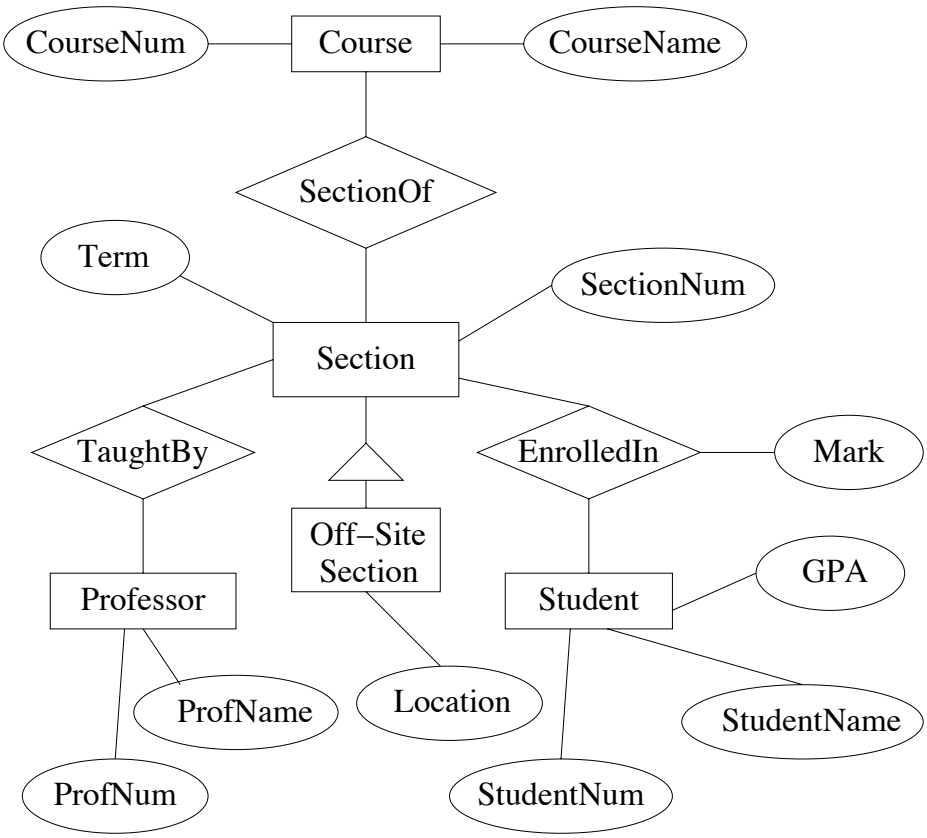
Notes

Example: A Registrar's Database (cont'd)



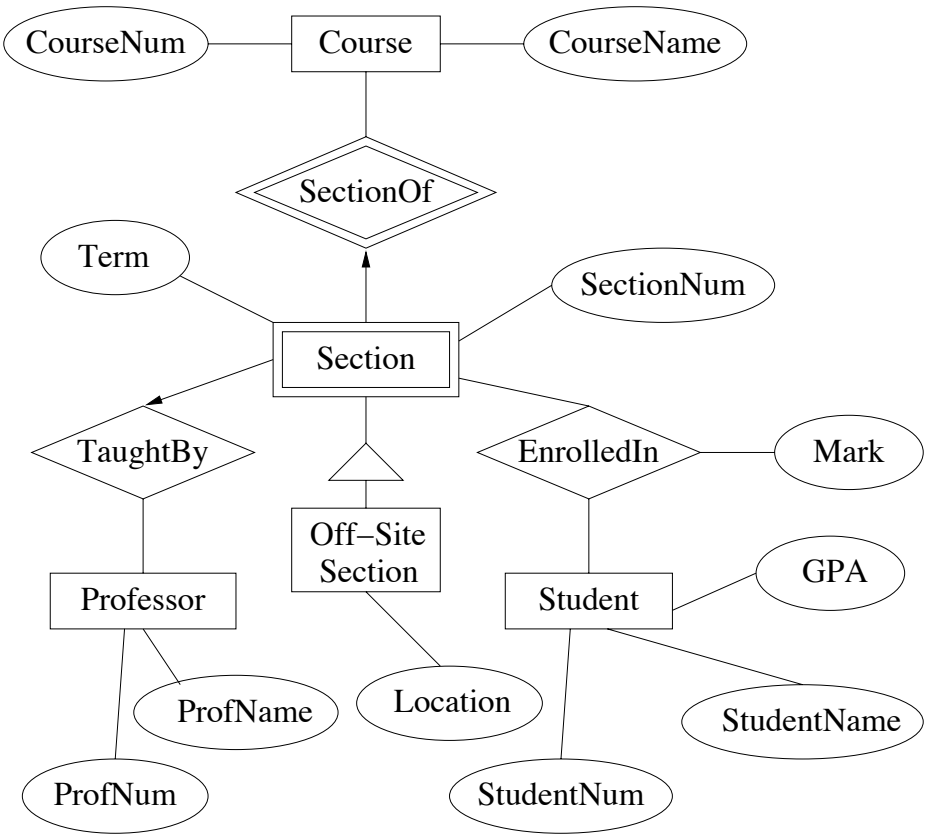
Notes

Example: A Registrar's Database (cont'd)



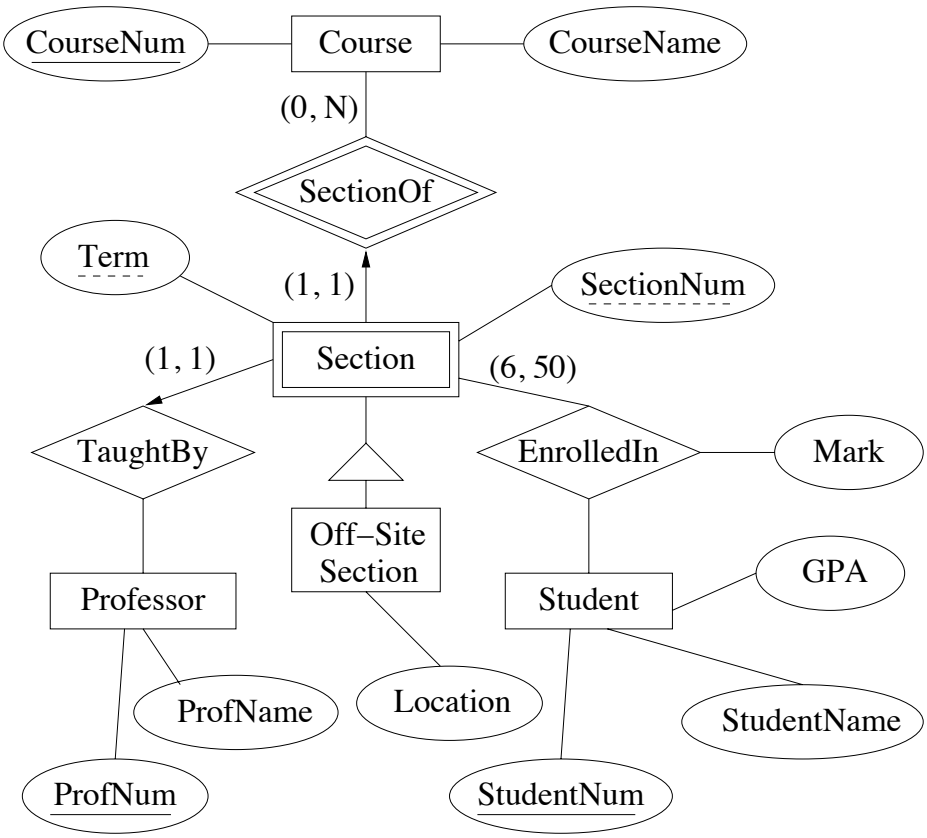
Notes

Example: A Registrar's Database (cont'd)



Notes

Example: A Registrar's Database (cont.'d)



Notes

E-R Diagram to Relational Schema

Main ideas:

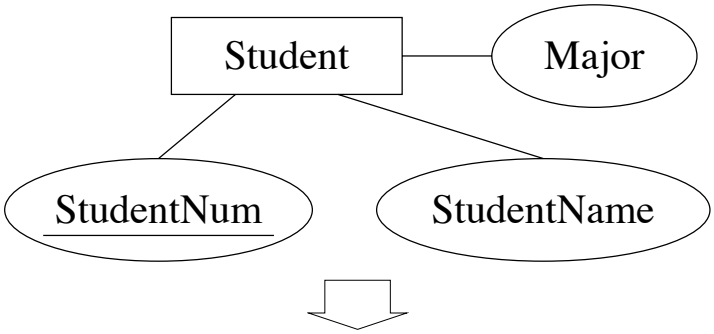
- Each entity set maps to a new table
- Each attribute maps to a new table column
- Each relationship set maps to either new table columns or to a new table

Notes

Representing Strong Entity Sets

Entity set E with attributes $a_1, \ldots, a_n$ translates to table E with attributes $a_1, \ldots, a_n$

Entity of type $E \leftrightarrow$ row in table E
Primary key of entity set $\rightarrow$ primary key of table
Example:



Student

StudentNum	StudentName	Major

Notes

Representing Weak Entity Sets

Weak entity set E translates to table E

Columns of table E should include

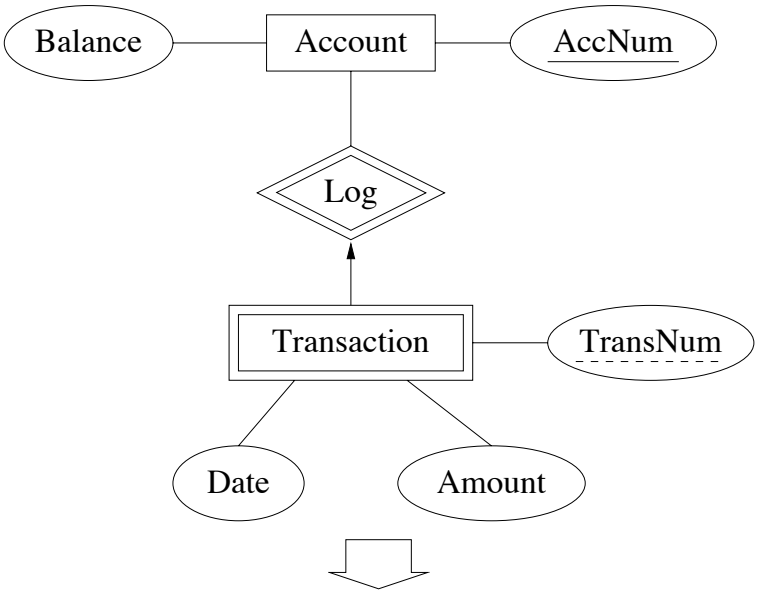
- Attributes of the weak entity set
- Attributes of the identifying relationship set
- Primary key attributes of entity set for dominating entities

Primary key of weak entity set $\rightarrow$ primary key of table

Notes

Representing Weak Entity Sets (cont.)

Example:



Account

AccNum	Balance

Transaction

TransNum	AccNum	Date	Amount

Notes

Representing Relationship Sets

- If the relationship set is an identifying relationship set for a weak entity set then no action needed
- If we can deduce the general cardinality constraint (1,1) for a component entity set E then add following columns to table E
  - Attributes of the relationship set
  - Primary key attributes of remaining component entity sets
- Otherwise: relationship set $R \rightarrow$ table R

Notes

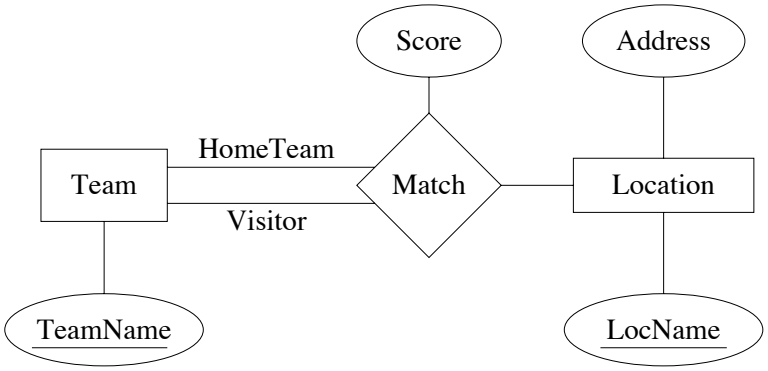
Representing Relationship Sets (cont.)

- Columns of table R should include
  - Attributes of the relationship set
  - Primary key attributes of each component entity set
- Primary key of table R determined as follows
  - If we can deduce the general cardinality constraint (0,1) for a component entity set E, then take the primary key attributes for E
  - Otherwise, choose primary key attributes of each component entity

Notes

Representing Relationship Sets (cont.)

Example:



Team

TeamName

Location

LocName	Address

Match

HomeTeamName	VisitorTeamName	LocName	Score

Note that the role name of a component entity set should be prepended to its primary key attributes, if supplied.

Notes

Representing Aggregation

Tabular representation of aggregation of R

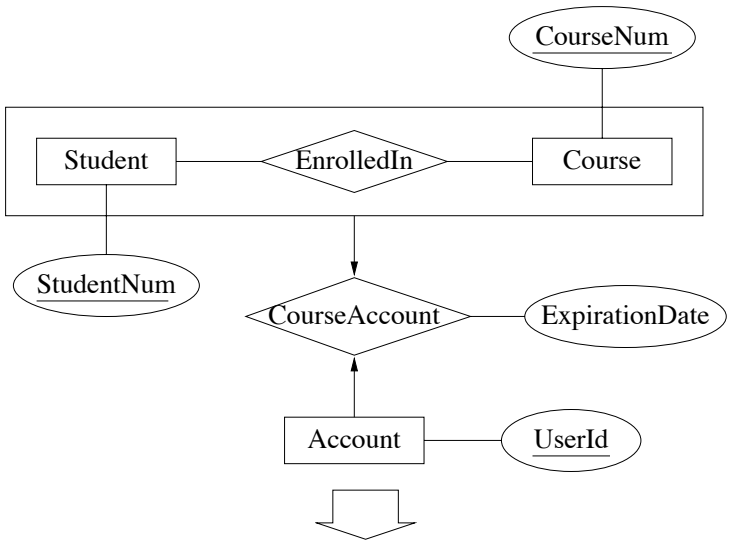
$$= \text{tabular representation for relationship set } R$$

To represent relationship set involving aggregation of R, treat the aggregation like an entity set whose primary key is the **primary key** of the table for R

Notes

Representing Aggregation (cont.)

Example:



Student

StudentNum

Course

CourseNum

Account

UserId

EnrolledIn

StudentNum	CourseNum

CourseAccount

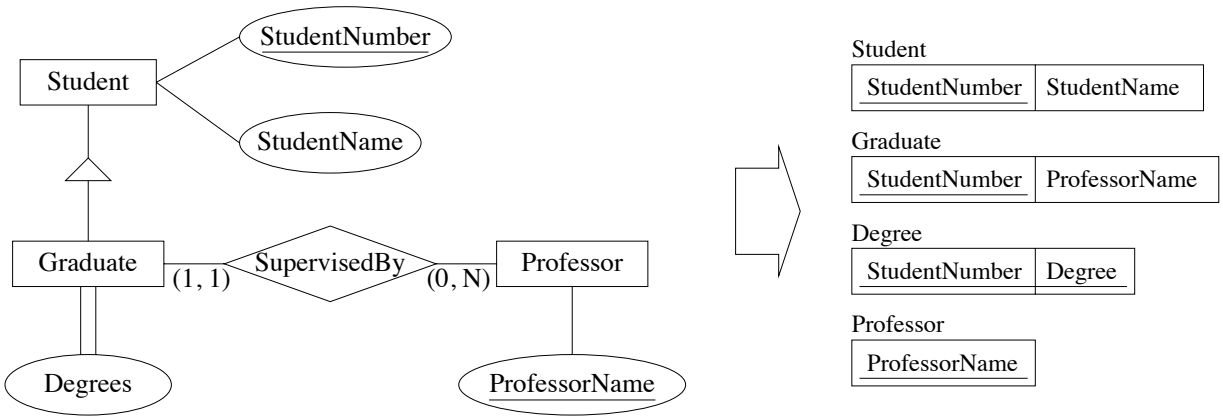
UserId	StudentNum	CourseNum	ExpirationDate

Notes

Representing Specialization

Create table for higher-level entity set, and treat specialized entity subsets like weak entity sets (without discriminators)

Example:



Notes

Representing Generalization (Approach #1)

Create a table for each lower-level entity set only

Columns of new tables should include

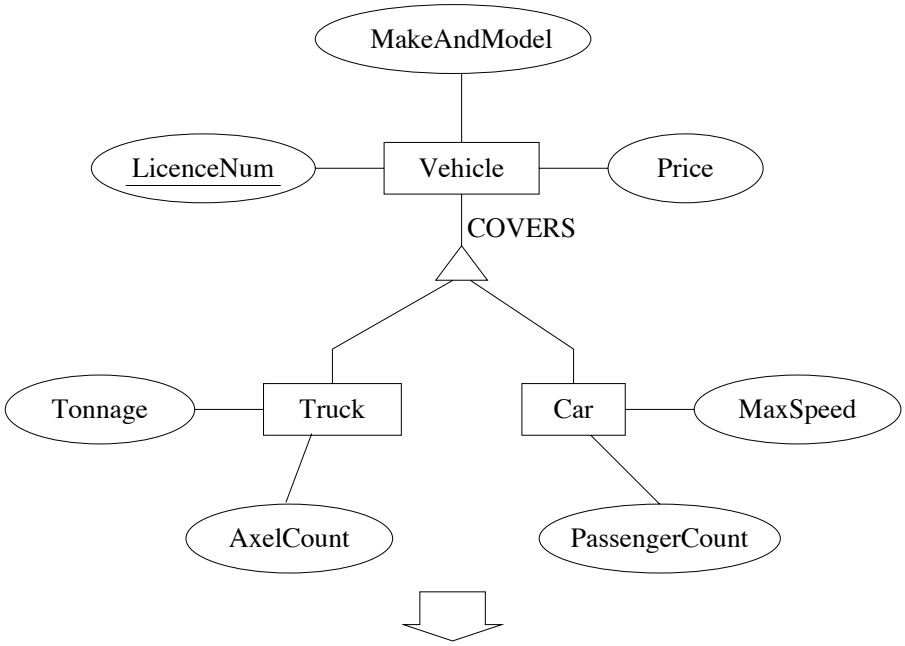
- Attributes of lower level entity set
- Attributes of the superset

The higher-level entity set can be defined as a view on the tables for the lower-level entity sets

Notes

Representing Generalization (Approach #1)

Example:



Truck

LicenceNum	MakeAndModel	Price	Tonnage	AxelCount

Car

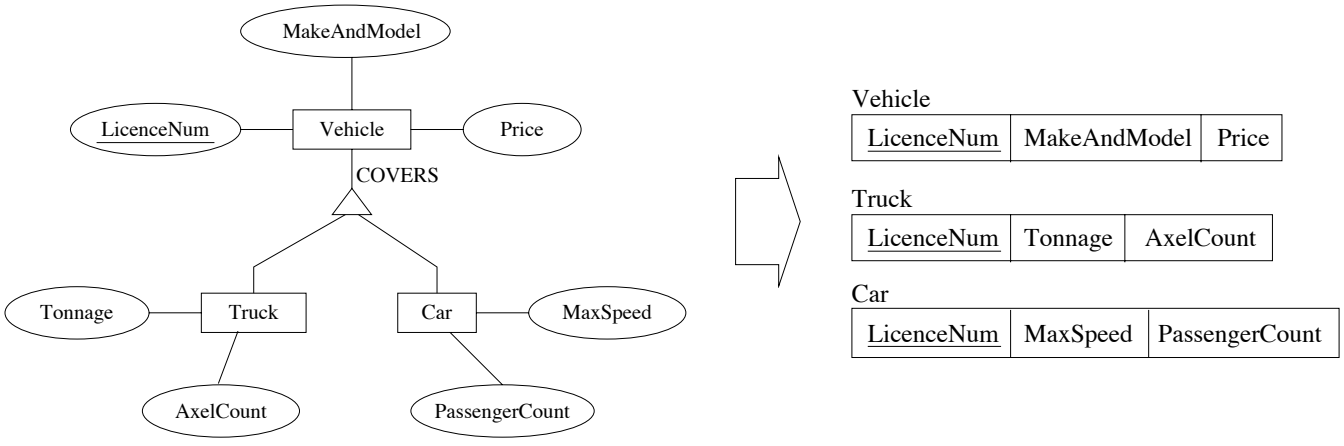
LicenceNum	MakeAndModel	Price	MaxSpeed	PassengerCount

Notes

Representing Generalization (Approach #2)

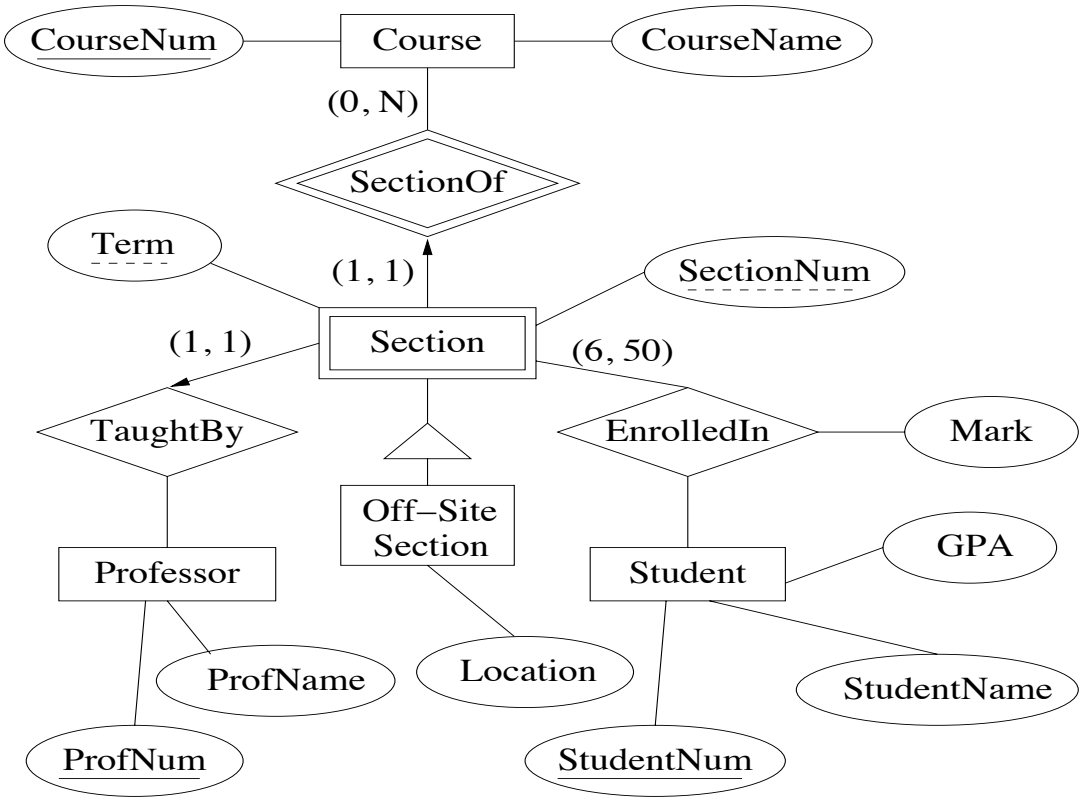
Treat generalization the same as specialization.

Example:



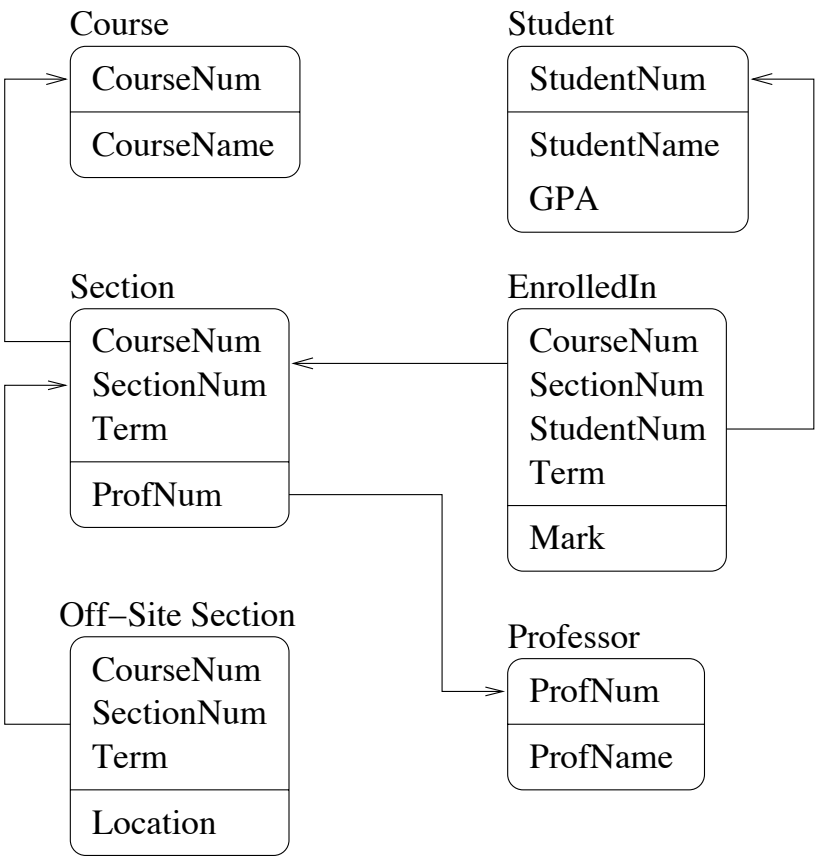
Notes

Example Translation: ER Diagram



Notes

Example Translation: Relational Diagram



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