



Module 20

Partha Pratim  
Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

Design Issues

Entities vs Attributes

Entities vs  
Relationship

Binary vs Non-Binary

Design Decisions

ER Notation

Module Summary

# Database Management Systems

## Module 20: Entity-Relationship Model/3

Partha Pratim Das

Department of Computer Science and Engineering  
Indian Institute of Technology, Kharagpur

*ppd@cse.iitkgp.ac.in*



## Module 20

Partha Pratim  
Das

### Objectives & Outline

#### ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

#### Design Issues

Entities vs Attributes

Entities vs  
Relationship

Binary vs Non-Binary

Design Decisions

ER Notation

#### Module Summary

- ER Diagram for ER Models
- Translation of ER Models to Relational Schema



## Module 20

Partha Pratim  
Das

### Objectives & Outline

#### ER Features

Non-binary

Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

#### Design Issues

Entities vs Attributes

Entities vs  
Relationship

Binary vs Non-Binary

Design Decisions

ER Notation

#### Module Summary

- To understand extended features of ER Model
- To discuss various design issues



## Module 20

Partha Pratim  
Das

### Objectives & Outline

#### ER Features

Non-binary  
Relationship  
Specialization  
Specialization as  
Schema  
Generalization  
Aggregation

#### Design Issues

Entities vs Attributes  
Entities vs  
Relationship  
Binary vs Non-Binary  
Design Decisions  
ER Notation

#### Module Summary

- Extended ER Features
- Design Issues



## Module 20

Partha Pratim  
Das

Objectives &  
Outline

### ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

### Design Issues

Entities vs Attributes

Entities vs  
Relationship

Binary vs Non-Binary

Design Decisions

ER Notation

### Module Summary

# Extended ER Features



# Non-binary Relationship Sets

## Module 20

Partha Pratim  
Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

Design Issues

Entities vs Attributes

Entities vs  
Relationship

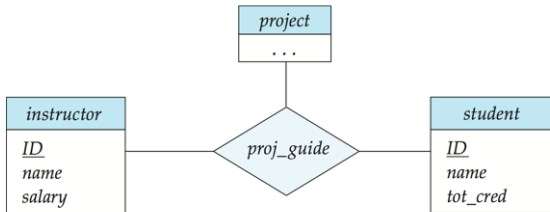
Binary vs Non-Binary

Design Decisions

ER Notation

Module Summary

- Most relationship sets are binary
- There are occasions when it is more convenient to represent relationships as non-binary
- ER Diagram with a Ternary Relationship





# Cardinality Constraints on Ternary Relationship

## Module 20

Partha Pratim  
Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

Design Issues

Entities vs Attributes

Entities vs  
Relationship

Binary vs Non-Binary

Design Decisions

ER Notation

Module Summary

- We allow at most one arrow out of a ternary (or greater degree) relationship to indicate a cardinality constraint
- For example, an arrow from *proj\_guide* to *instructor* indicates each student has at most one guide for a project
- If there is more than one arrow, there are two ways of defining the meaning.
  - For example, a ternary relationship  $R$  between  $A$ ,  $B$  and  $C$  with arrows to  $B$  and  $C$  could mean
    - a) Each  $A$  entity is associated with a unique entity from  $B$  and  $C$  or
    - b) Each pair of entities from  $(A, B)$  is associated with a unique  $C$  entity, and each pair  $(A, C)$  is associated with a unique  $B$
  - Each alternative has been used in different formalisms
  - To avoid confusion we outlaw more than one arrow



# Specialization: ISA

## Module 20

Partha Pratim  
Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

Design Issues

Entities vs Attributes

Entities vs  
Relationship

Binary vs Non-Binary

Design Decisions

ER Notation

Module Summary

- **Top-down design process:** We designate sub-groupings within an entity set that are distinctive from other entities in the set
- These sub-groupings 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: ISA (2)

## Module 20

Partha Pratim  
Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

Design Issues

Entities vs Attributes

Entities vs  
Relationship

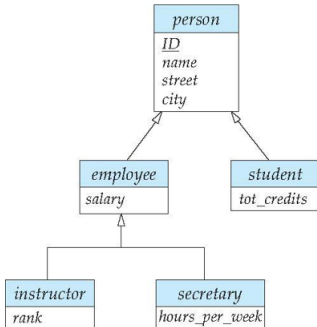
Binary vs Non-Binary

Design Decisions

ER Notation

Module Summary

- **Overlapping:** *employee* and *student*
- **Disjoint:** *instructor* and *secretary*
- Total and Partial





# Representing Specialization via Schema

## Module 20

Partha Pratim  
Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

Design Issues

Entities vs Attributes

Entities vs  
Relationship

Binary vs Non-Binary

Design Decisions

ER Notation

Module Summary

- 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



# Representing Specialization as Schema (2)

## Module 20

Partha Pratim  
Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

Design Issues

Entities vs Attributes

Entities vs  
Relationship

Binary vs Non-Binary

Design Decisions

ER Notation

Module Summary

- Method 2:

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

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

- Drawback: *name*, *street* and *city* may be stored redundantly for people who are both students and employees



# Generalization

## Module 20

Partha Pratim  
Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

**Generalization**

Aggregation

Design Issues

Entities vs Attributes

Entities vs  
Relationship

Binary vs Non-Binary

Design Decisions

ER Notation

Module Summary

- **Bottom-up design process:** Combine a number of entity sets that share the same features into a higher-level entity set
- Specialization and generalization are simple inversions of each other; they are represented in an ER diagram in the same way
- The terms specialization and generalization are used interchangeably



# Design Constraints on a Specialization / Generalization

## Module 20

Partha Pratim  
Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

Design Issues

Entities vs Attributes

Entities vs  
Relationship

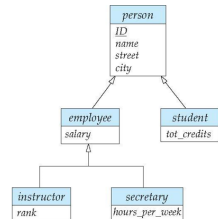
Binary vs Non-Binary

Design Decisions

ER Notation

Module Summary

- **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
- Partial generalization is the default. We can specify total generalization in an ER diagram by adding the keyword **total** in the diagram and drawing a dashed line from the keyword to the corresponding hollow arrow-head to which it applies (for a total generalization), or to the set of hollow arrow-heads to which it applies (for an overlapping generalization).
- The *student* generalization is total. All student entities must be either graduate or undergraduate. Because the higher-level entity set arrived at through generalization is generally composed of only those entities in the lower-level entity sets, the completeness constraint for a generalized higher-level entity set is usually total.





# Aggregation

## Module 20

Partha Pratim  
Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

Design Issues

Entities vs Attributes

Entities vs  
Relationship

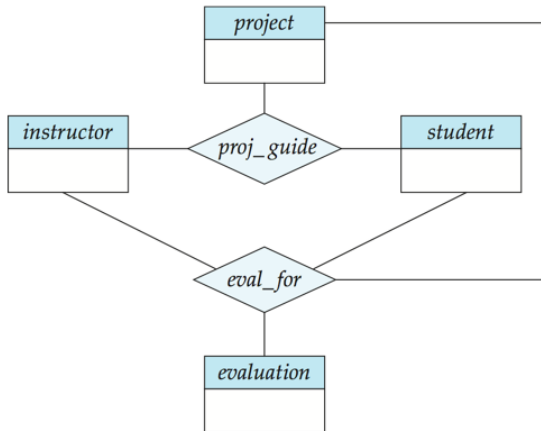
Binary vs Non-Binary

Design Decisions

ER Notation

Module Summary

- Consider the ternary relationship *proj\_guide*, which we saw earlier
- Suppose we want to record evaluations of a student by a guide on a project





# Aggregation (2)

## Module 20

Partha Pratim  
Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

Design Issues

Entities vs Attributes

Entities vs  
Relationship

Binary vs Non-Binary

Design Decisions

ER Notation

Module Summary

- Relationship sets *eval\_for* and *proj\_guide* represent overlapping information
  - Every *eval\_for* relationship corresponds to a *proj\_guide* relationship
  - However, some *proj\_guide* relationships may not correspond to any *eval\_for* relationships
    - ▷ So we cannot discard the *proj\_guide* relationship
- Eliminate this redundancy via *aggregation*
  - Treat relationship as an abstract entity
  - Allows relationships between relationships
  - Abstraction of relationship into new entity



# Aggregation (3)

## Module 20

Partha Pratim  
Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

Design Issues

Entities vs Attributes

Entities vs  
Relationship

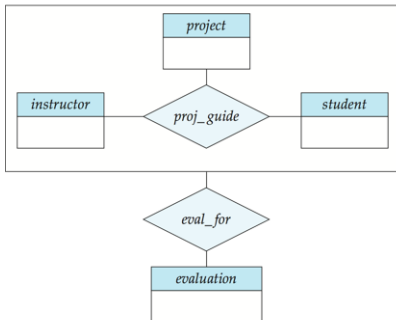
Binary vs Non-Binary

Design Decisions

ER Notation

Module Summary

- Eliminate this redundancy via *aggregation* without introducing redundancy, the following diagram represents:
  - A student is guided by a particular instructor on a particular project
  - A student, instructor, project combination may have an associated evaluation







# Representing Aggregation via Schema

## Module 20

Partha Pratim  
Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

Design Issues

Entities vs Attributes

Entities vs  
Relationship

Binary vs Non-Binary

Design Decisions

ER Notation

Module Summary

- To represent aggregation, create a schema containing
  - Primary key of the aggregated relationship,
  - The primary key of the associated entity set
  - Any descriptive attributes
- In our example:
  - The schema *textiteval\_for* is:  
*eval\_for (s\_ID, project\_id, i\_ID, evaluation\_id)*
  - The schema *proj\_guide* is redundant



## Module 20

Partha Pratim  
Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

**Design Issues**

Entities vs Attributes

Entities vs  
Relationship

Binary vs Non-Binary

Design Decisions

ER Notation

Module Summary

# Design Issues



# Entities vs. Attributes

## Module 20

Partha Pratim  
Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

Design Issues

Entities vs Attributes

Entities vs  
Relationship

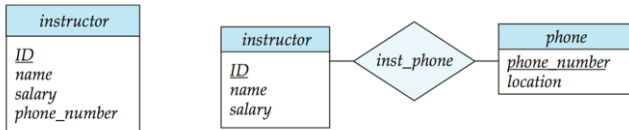
Binary vs Non-Binary

Design Decisions

ER Notation

Module Summary

- Use of entity sets vs. attributes



- Use of phone as an entity allows extra information about phone numbers (plus multiple phone numbers)



# Entities vs Relationship Sets

## Module 20

Partha Pratim Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

Design Issues

Entities vs Attributes

Entities vs  
Relationship

Binary vs Non-Binary

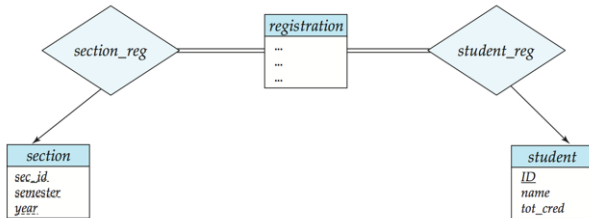
Design Decisions

ER Notation

Module Summary

- **Use of entity sets vs. relationship sets**

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



- **Placement of relationship attributes**

For example, attribute date as attribute of advisor or as attribute of student



# Binary vs Non-Binary Relationships

## Module 20

Partha Pratim  
Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

Design Issues

Entities vs Attributes

Entities vs  
Relationship

Binary vs Non-Binary

Design Decisions

ER Notation

Module Summary

- Although it is possible to replace any non-binary ( $n$ -ary, for  $n > 2$ ) relationship set by a number of distinct binary relationship sets, a  $n$ -ary relationship set shows more clearly that several entities participate in a single relationship
- Some relationships that appear to be non-binary may be better represented using binary relationships
  - For example, a ternary relationship *parents*, relating a child to his/her father and mother, is best replaced by two binary relationships, *father* and *mother*
    - ▷ Using two binary relationships allows partial information (e.g., only mother being known)
  - But there are some relationships that are naturally non-binary
    - ▷ Example: *proj\_guide*



# Binary vs Non-Binary Relationships (2): Conversion

## Module 20

Partha Pratim  
Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

Design Issues

Entities vs Attributes

Entities vs  
Relationship

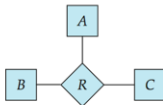
Binary vs Non-Binary

Design Decisions

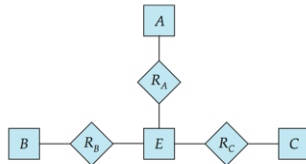
ER Notation

Module Summary

- In general, any non-binary relationship can be represented using binary relationships by creating an artificial entity set.
  - Replace  $R$  between entity sets  $A$ ,  $B$  and  $C$  by an entity set  $E$ , and three relationship sets:
    1.  $R_A$ , relating  $E$  and  $A$
    2.  $R_B$ , relating  $E$  and  $B$
    3.  $R_C$ , relating  $E$  and  $C$
  - Create an identifying attribute for  $E$  and add any attributes of  $R$  to  $E$
  - For each relationship  $(a_i, b_i, c_i)$  in  $R$ , create
    - a) a new entity  $e_i$  in the entity set  $E$
    - b) add  $(e_i, a_i)$  to  $R_A$
    - c) add  $(e_i, b_i)$  to  $R_B$
    - d) add  $(e_i, c_i)$  to  $R_C$



(a)



(b)



# Binary vs Non-Binary Relationships (3): Conversion

## Module 20

Partha Pratim  
Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

Design Issues

Entities vs Attributes

Entities vs  
Relationship

Binary vs Non-Binary

Design Decisions

ER Notation

Module Summary

- Also need to translate constraints
  - Translating all constraints may not be possible
  - There may be instances in the translated schema that cannot correspond to any instance of  $R$ .
    - ▷ Exercise: *add constraints to the relationships  $R_A$ ,  $R_B$  and  $R_C$  to ensure that a newly created entity corresponds to exactly one entity in each of entity sets —  $A$ ,  $B$  and  $C$*
  - We can avoid creating an identifying attribute by making  $E$ , a weak entity set (described shortly) identified by the three relationship sets



# ER Design Decisions

## Module 20

Partha Pratim  
Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

Design Issues

Entities vs Attributes

Entities vs  
Relationship

Binary vs Non-Binary

**Design Decisions**

ER Notation

Module Summary

- 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 ternary relationship versus a pair of binary relationships
- The use of a strong or weak entity set
- The use of specialization/generalization – contributes to modularity in the design
- The use of aggregation – can treat the aggregate entity set as a single unit without concern for the details of its internal structure





# Symbols Used in ER Notation

## Module 20

Partha Pratim  
Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

Design Issues

Entities vs Attributes

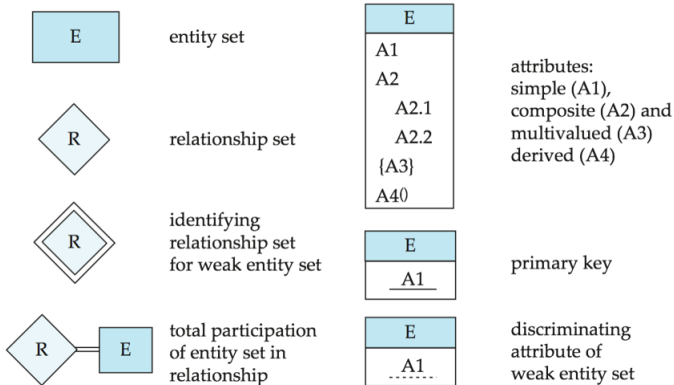
Entities vs  
Relationship

Binary vs Non-Binary

Design Decisions

ER Notation

Module Summary





# Symbols Used in ER Notation (2)

## Module 20

Partha Pratim  
Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

Design Issues

Entities vs Attributes

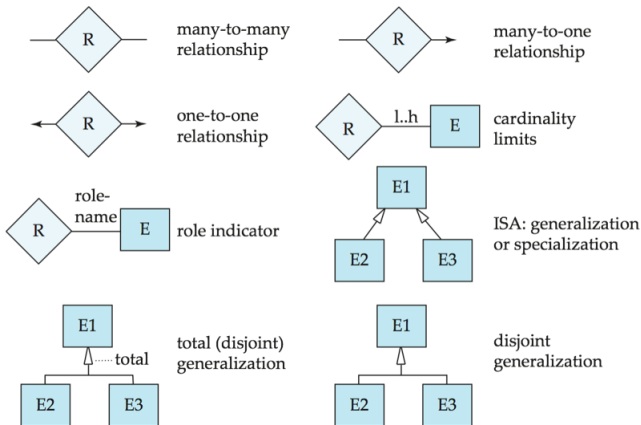
Entities vs  
Relationship

Binary vs Non-Binary

Design Decisions

ER Notation

Module Summary





# Symbols Used in ER Notation (3): Alternate

## Module 20

Partha Pratim  
Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

Design Issues

Entities vs Attributes

Entities vs  
Relationship

Binary vs Non-Binary

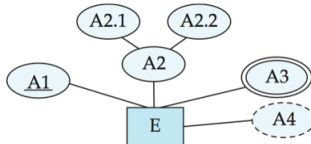
Design Decisions

ER Notation

Module Summary

- Chen, IDE1FX,...

entity set E with  
simple attribute A1,  
composite attribute A2,  
multivalued attribute A3,  
derived attribute A4,  
and primary key A1



weak entity set



generalization



total  
generalization





# Symbols Used in ER Notation (4): Alternates

## Module 20

Partha Pratim  
Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

Design Issues

Entities vs Attributes

Entities vs  
Relationship

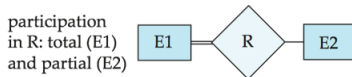
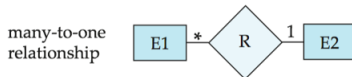
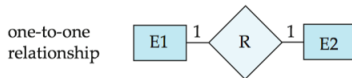
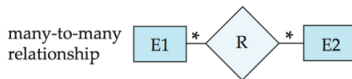
Binary vs Non-Binary

Design Decisions

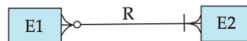
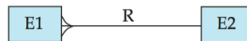
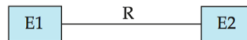
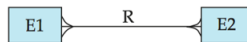
ER Notation

Module Summary

### Chen



### IDE1FX (Crows foot notation)





# Module Summary

## Module 20

Partha Pratim  
Das

Objectives &  
Outline

ER Features

Non-binary  
Relationship

Specialization

Specialization as  
Schema

Generalization

Aggregation

Design Issues

Entities vs Attributes

Entities vs  
Relationship

Binary vs Non-Binary

Design Decisions

ER Notation

Module Summary

- Discussed the extended features of ER Model
- Deliberated on various design issues