Database Management Systems

Part III: Database Design

Lecture 12

The Entity/Relationship Model

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Introduction

- The entity/relationship model is the best-known example of a class of data models usually known as extended or semantic models.
- Semantic modelling ideas can be useful as an aid to systematic database design even in the absence of direct DBMS support for those ideas.
- Design methodologies that are based on semantic modelling ideas are often referred to as top-down methodologies.

An Overview of the E/R Model

- One of the best known approaches to the application of semantic modelling ideas to the problem of database design is the so-called entity/relationship (E/R) approach.
- The E/R approach is based on the entity/relationship model introduced by Chen in 1976.
- The E/R model includes analogs of all of the semantic objects: entity, property, relationship, subtype.

An Overview of the E/R Model (Cont.)

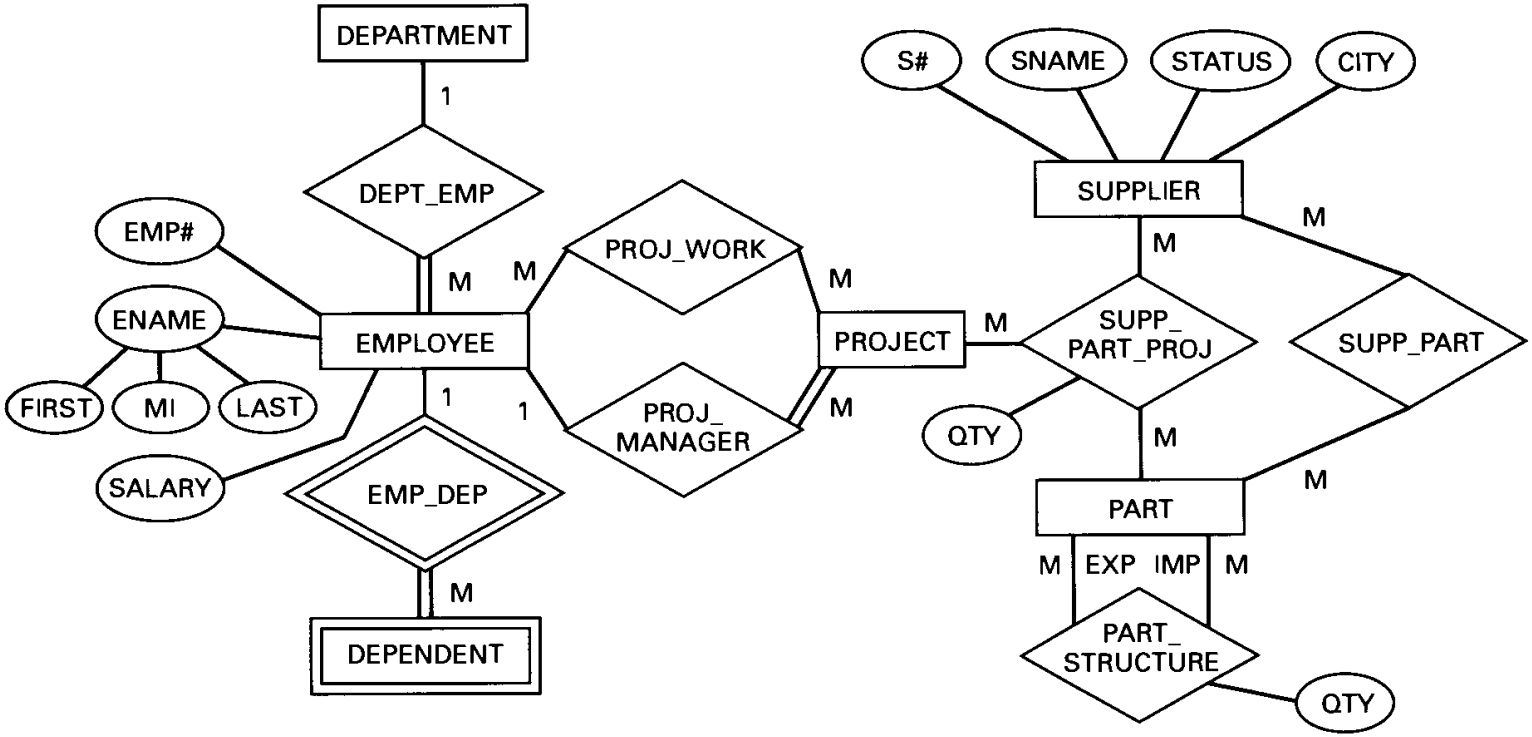
Entities

- An entity is a thing which can be distinctly identified.
- It can be classified into regular entities and weak entities.
- A weak entity is an entity that is existence-dependent on some other entity, in the sense that it cannot exist if that other entity does not also exist.

An Overview of the E/R Model (Cont.)

Entities

- Figure shows an example of the entity/relationship diagram.



An Overview of the E/R Model (Cont.)

Entities

- For example, referring to the figure, an employee's dependents might be weak entities – they cannot exist if the relevant employee does not exist.
- In particular, if a given employee is deleted, all dependents of that employee must be deleted also.
- A regular entity, by contrast, is an entity that is not weak.
- For example, employees might be regular entities.

An Overview of the E/R Model (Cont.)

Properties/Attributes

- Entities and relationships have properties.
- All entities of a given type have certain kinds of properties in common – for example, all employees have an employee number, a name, a salary, and so on.
- Each kind of property draws its values from a corresponding value set.

An Overview of the E/R Model (Cont.)

Properties/Attributes

- Furthermore, properties can be:
  - ✓ Simple or composite
  - ✓ Key
  - ✓ Single- or multi-valued
  - ✓ Missing
  - ✓ Base or derived

An Overview of the E/R Model (Cont.)

Relationships

- A relationship is defined as an association among entities.
- For example, there is a relationship (DEPT_EMP) between departments and employees, representing the fact that a given department employs a given set of employees.
- As with entities, it is necessary in principle to distinguish between relationship types and relationship instances.

An Overview of the E/R Model (Cont.)

Relationships

- The entities involved in a given relationship are said to be the participants in that relationship.
- The number of participants in a given relationship is called the degree of that relationship.

An Overview of the E/R Model (Cont.)

Relationships

- Let R be a relationship type that involves entity type E as a participant.
- If every instance of E participates in at least one instance of R, then the participation of E in R is total, otherwise it is partial.
- For example, if every part must be supplied by at least one supplier, then the participation of parts in SUPP_PART is total; but if it is possible for a given part to be supplied by no supplier at all, then the participation of parts in SUPP_PART is partial.

An Overview of the E/R Model (Cont.)

Relationships

- An E/R relationship can be one-to-one, one-to-many (also known as many-to-one), or many-to-many.
- The relational model can be think of many-to-many case as the only one that is a genuine relationship since that case is the only one that demands representation by means of a separate relation.
- One-to-one and one-to-many relationships can always be represented by means of a foreign key in one of the participant relations.

An Overview of the E/R Model (Cont.)

Subtypes

- Any given entity is of at least one entity type but an entity can be of several types simultaneously.
- For example, if some employees are programmers, then PROGRAMMER is a subtype of the EMPLOYEE supertype.
- All properties of employees apply automatically to programmers, but the converse is not true.
- Similarly, programmers automatically participate in all relationships in which employees participate, but the converse is not true.

An Overview of the E/R Model (Cont.)

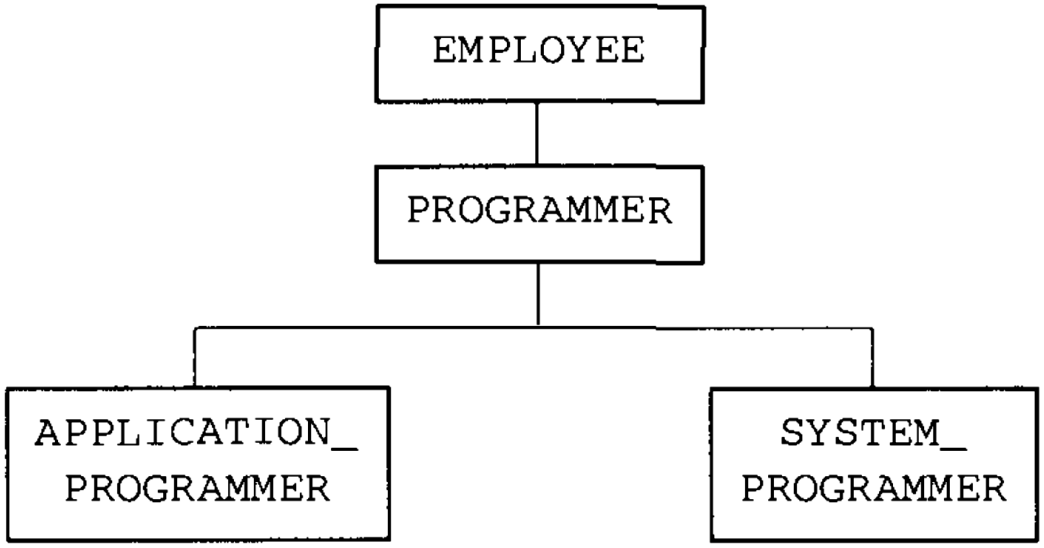
Subtypes

- The properties and relationships that apply to the supertype are inherited by the subtype.
- An entity subtype is still an entity type and can thus have subtypes of its own.
- A given entity type and its immediate subtypes, their immediate subtypes and so on together constitute the type hierarchy for the entity type in question.

An Overview of the E/R Model (Cont.)

Subtypes

- Figure shows an example of a type hierarchy.



E/R Diagrams

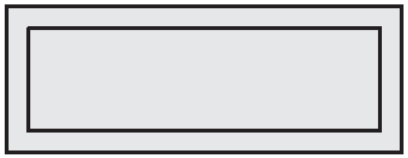
- Entity/Relationship Diagrams (E/R Diagrams) constitute a technique for representing the logical structure of a database in a pictorial manner.
- They provide a simple and readily understood means of communicating the main features of the design of any given database.

E/R Diagrams (Cont.)

Entities

- Each entity type is shown as a rectangle, labelled with the name of the entity type in question.
- For a weak entity type, the rectangle is doubled.

Entity 

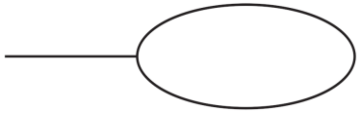
Weak Entity 

E/R Diagrams (Cont.)

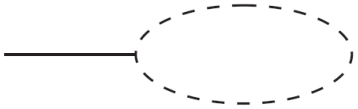
Properties/Attributes

- Properties are shown as ellipses, labelled with the name of the property in question and attached to the relevant entity (or relationship) by means of a continuous line.
- The ellipse is dotted if the property is derived and doubled if the property is multivalued.

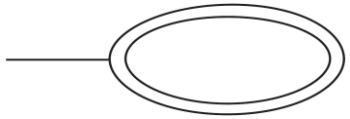
Property



Derived Property



Multivalued Property

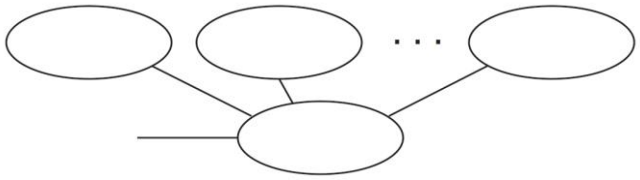


E/R Diagrams (Cont.)

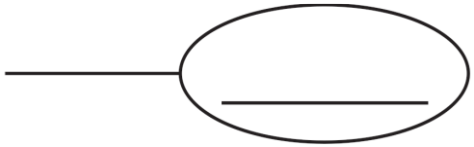
Properties/Attributes

- If property is composite, its component properties are shown as further ellipses, connected to the ellipse for the composite property in question by means of further continuous line.
- Key properties are underlined.
- Value sets are not shown.

Composite Property



Key Property

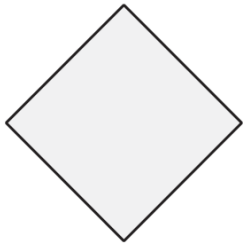


E/R Diagrams (Cont.)

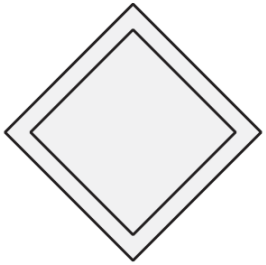
Relationships

- Each relationship type is shown as a diamond, labelled with the name of the relationship type in question.
- The diamond is doubled if the relationship in question is that between a weak entity type and the entity type on which its existence depends.

Relationship



Identifying Relationship

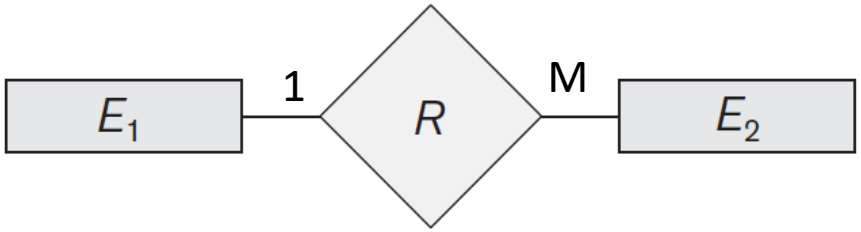


E/R Diagrams (Cont.)

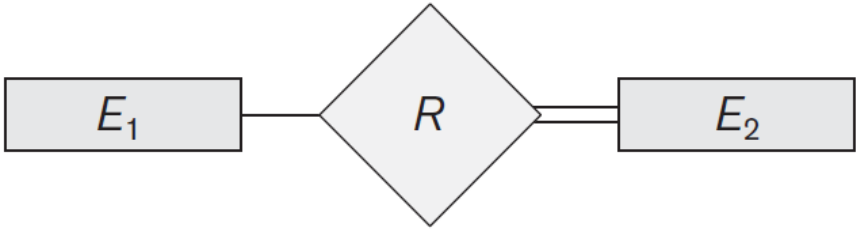
Relationships

- The participants in each relationship are connected to the relevant relationship by means of continuous lines; each such line is labelled "1" or "M" to indicate whether the relationship is one-to-one, many-to-one, etc.
- The line is doubled if the participation is total.

One-to-one and many-to-one



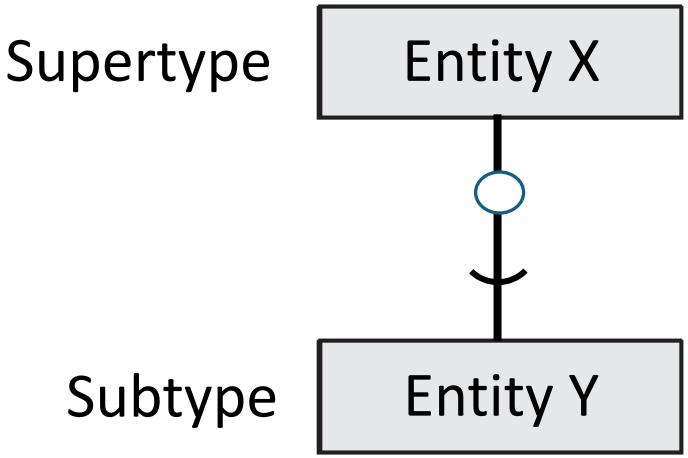
Total participation of E2 in R



E/R Diagrams (Cont.)

Subtypes and Supertypes

- Let Y be a subtype of X. Then, we draw a continuous line from Y to X, marked with a hook to represent the mathematical "subset of" operator.



Summary

- Database design mainly involves the design of the database schema.
- The entity-relationship (E/R) data model is a widely used data model for database design.
- It provides a convenient graphical representation to view data, relationships, and constraints.

Textbook and References

Textbook

- C. J. Date, “An Introduction to Database Systems”, 6th Edition, 1994.

Additional References

- Abraham Silberschatz, Henry F. Korth, S. Sudarshan, “Database System Concepts”, 6th Edition, 2011.
- Ramez Elmasri, Shamkant B. Navathe, “Fundamentals of Database Systems”, 6th Edition, 2010.