How to design E/R models?
Guidelines

- Be faithful to the specification of the application.
- Avoid redundancy.
- Keep the entities and relationship simple.
- Select the right relationships.
- Select the right type of element.
Be Faithful to the Specification

- Do not use meaningless or unnecessary attributes
- Define the multiplicity of a relationship appropriately
  - What is the multiplicity of the relationship Take between Students and Courses?
  - What is the multiplicity of the relationship Teach between Professors and Courses?
Avoid Redundancy

- Redundancy occurs when we express the same fact in two or more ways

- Redundancy wastes space

- Redundancy can lead to inconsistency if we change one instance but not the other
Select the Right Relationships

- Do not add unnecessary relationships.
- It may be possible to deduce one relationship from another.
Select the Right Relationships

- Do we need the relationship Instruct between Professors and Students?
Select the Right Relationships

- Do we need the relationship Instruct between Professors and Students?
  - No! We can deduce it from Take and Teach
Select the Right Relationships

- Do we need the relationships Take and Teach?
  – Yes actually. Why?
Select the right kind of element

- Attribute or Entity or Relationship
- Can we make Professor an attribute of Courses and remove the relationship Teach?
Select the right kind of element

- Attribute or Entity or Relationship
- What about now?
Select the right kind of element

- Attribute or Entity or Relationship
- What about now?

Research signifies a research project the student is working on with a professor
Converting an Entity Set into an Attribute

- **If** an entity set $E$ satisfies the following properties:
  - All relationships involving $E$ have arrows entering $E$
  - The attributes of $E$ collectively identify an entity (i.e., no attribute depends on another)
  - No relationship involves $E$ more than once

- **Then** we can replace $E$ as follows:
  - If there is a many-one relationship $R$ from an entity set $F$ to $E$, remove $R$ and make the attributes of $E$ be attributes of $F$
  - If there is a multiway relationship $R$ with an arrow to $E$, make $E$’s attributes be new attributes of $R$ and remove the arrow from $R$ to $E
Types of Constraints

- **Keys** are attributes or sets of attributes that uniquely identify an entity within its entity set.

- **Single-value constraints** require that a value be unique in certain contexts.

- **Referential integrity constraints** require that a value referred to actually exists in the database.

- **Degree constraints** specify what set of values an attribute can take.

- **General constraints** are arbitrary constraints that should hold in the database.

- **Constraints are part of the schema of a database.**
Keys in the E/R Model

- A key for an entity set $E$ is a set $K$ of one or more attributes such that given any two entities $e_1$ and $e_2$ in $E$, $e_1$ and $e_2$ cannot have identical values for all the attributes in $K$.
- $E$ can have multiple keys. We designate one as the primary key.
- In an isa-hierarchy?
  - the root entity set must have all the attributes needed for a key.
- In an E/R diagram, underline the attributes that form the primary key
Keys: Example

Diagram showing relationships between Students, Courses, Professors, and associated attributes such as Name, Address, Classroom, DeptName, Number, Research, Evaluation, Teach, and Age.
Keys: Example
Single Value Constraints

- There is at most one value in a given context

- Each attribute of an entity set has a single value
  - If the value is missing, we can invent a "null" value
  - E/R models cannot represent the requirement that an attribute cannot have a null value

- A many-one relationship implies a single value constraint
Referential Integrity Constraint

- Asserts that exactly one value exists in a given context
  - Usually used in the context of relationships
- Example: Many-one Advises relationship between Students and Professors
  - Many-one requirement says that no student may have more than one advising professor
  - Referential integrity constraint says that each student must have exactly one advising professor and that professor must be present in the database
Referential Integrity Constraint

- Asserts that exactly one value exists in a given context
  - Usually used in the context of relationships
- If R is a (many-to-one or one-to-one) relationship from E to F, we use a rounded arrowhead pointing to F to indicate that we require that the entity in F related by R to an entity in E must exist
Example: Referential Integrity Constraint

- Each department has at most one chairperson who is its head (there are times when a department may not have a chairperson)
- Each chairperson can be the head of at most one department and this department must exist in the database
- Where do we put arrows?

Diagram:

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Departments -- Heads -- Chairpersons
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Example: Referential Integrity Constraint

- Each department has at most one chairperson who is its head (there are times when a department may not have a chairperson)
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- Where do we put arrows?
Enforcing Referential Integrity Constraints

- We forbid the deletion of a referenced entity (e.g., a professor) until the professor advises no students.
- We require that if we delete a referenced entity, we delete all entities that reference it.
- When we insert a (student, professor) pair into the Advises relationship, the professor must exist in the Professors entity set.
Degree Constraints

- Indicates limits on the # of entities that can be connected
- For example,

  - Limits number of stars in each move to <=10
Degree Constraints

- Indicates limits on the # of entities that can be connected
- So you can think of

![Diagram]

- AS

![Diagram]
Weak Entity Sets

- A weak entity set is an entity set whose key contains attributes from one or more other entity sets.
- It is possible that all attributes in a weak entity set's key come from other entity sets.
- Primary causes for weak entity sets:
  - Hierarchy of entity sets (not caused by inheritance).
Example of Weak Entity Set

- Each department teaches multiple courses. Each course has a number. What is the key for the entity set Courses?
Example of Weak Entity Set

- Each department teaches multiple courses. Each course has a number. What is the key for the entity set Courses?
Finding the Key for a Weak Entity Set

- E is a weak entity set if its key consists of
  - Zero or more of its own attributes
  - Key attributes from supporting relationships for E

- A relationship R from a weak entity set E to F is supporting if
  - R is a binary, many-one relationship from E to F
  - R has referential integrity from E to F
Finding the Key for a Weak Entity Set contd...

- How does F help E?
  - F supplies its key attributes to define E's key
  - If F is itself a weak entity set, some of its key attributes come from entity sets to which F is connected by supporting relationships

- Representation in the E/R diagram
  - Weak entity set: rectangle with a double border
  - Supporting relationship: diamond with a double border