Entity Relationship Model (ERM)

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CS3200

Lecture 2

What is the goal of Modeling?

- Derive a logical description of our data.
- Understand the various ways in which the data is used.
- Identify the important or central data.
- Make decisions about the relationships between data and how to decompose a design.
- Organize the data to facilitate its uses.
- Be reasonably efficient.
- *Allow for efficiency of implementation.*

Why use a model?

- The data is probably reasonably complex.
- There are several different sorts of accesses.
- The data and design will evolve over time:
  - You want a history of this evolution.
  - You want to be able to make changes without constantly dumping and loading your data.
  - Good mental structuring will lead to good physical structure.
- The act of organizing will make people think of things that got dropped on the floor.

How do you develop a model ?

Steps to model development

- Identify the entities.
- Determine all significant interactions.
- Analyze the nature of the interactions.

Entity relationship model (ERM)

- Maps nicely into a relational data model.
- Provides a set of terminology and a graphical display of the data.
- Fairly simple to understand.
- Alternatives
  - Process and data flow analysis.
  - Seat of the pants methodology.
    - That's sloppy thought
    - Leads to a sloppy database with excessive redundancy, poor performance, and inability to get the job done.

The ER Model: Entity

- Entities: All the world is a set of *things*.
  - **Represented by a rectangle.**
  - They have their attributes and relationships.
  - An entity is one object, it is described via its attributes.
- Entity Set: A collection of similar entities, e.g., all movies.
  - Typically, All entities in an entity set have the same set of attributes.
    - (Exception: ISA hierarchies violate this condition.)
  - Each entity set has a key.

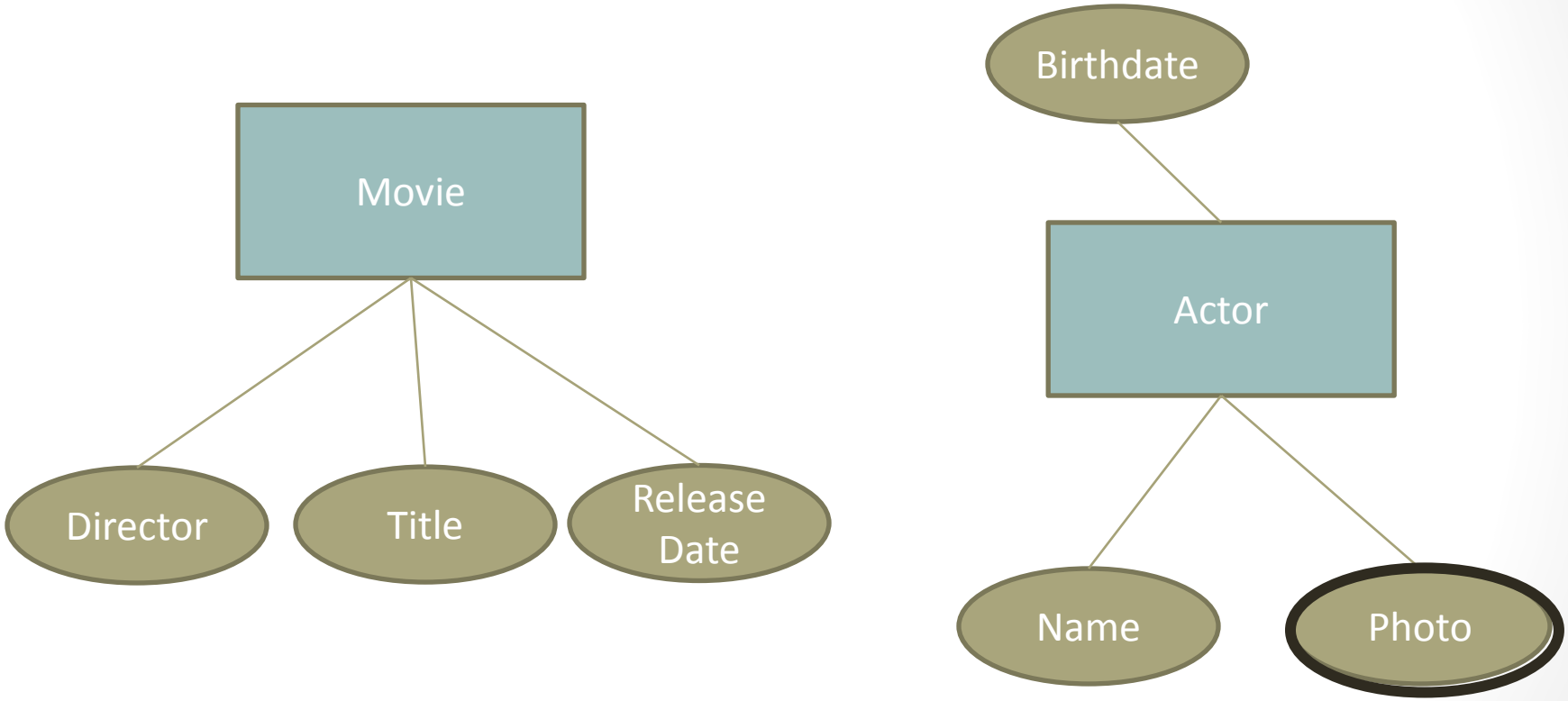
The ER Model: Attributes

- Attributes:
  - Describe the entities.
  - There are many different types of attributes
  - **Represented by an oval. Attached to entities with a line.**
  - Each attribute has a domain.
    - A set of potential values.
  - Analogies:
    - Fields in a record
    - Elements of a data structure or class object

Types of Attribute

- **Simple**: indivisible (like a native type). Examples?
- **Composite**: decomposable or structured. Examples?
- **Single-valued**: only one per entity. Examples?
- **Multi-valued**: zero or more per entity. Examples?
  - **Represented by a double oval**
- **Domain of an attribute: it's possible values**
- **Key**: subset of attributes that uniquely identifies an entity (candidate key)

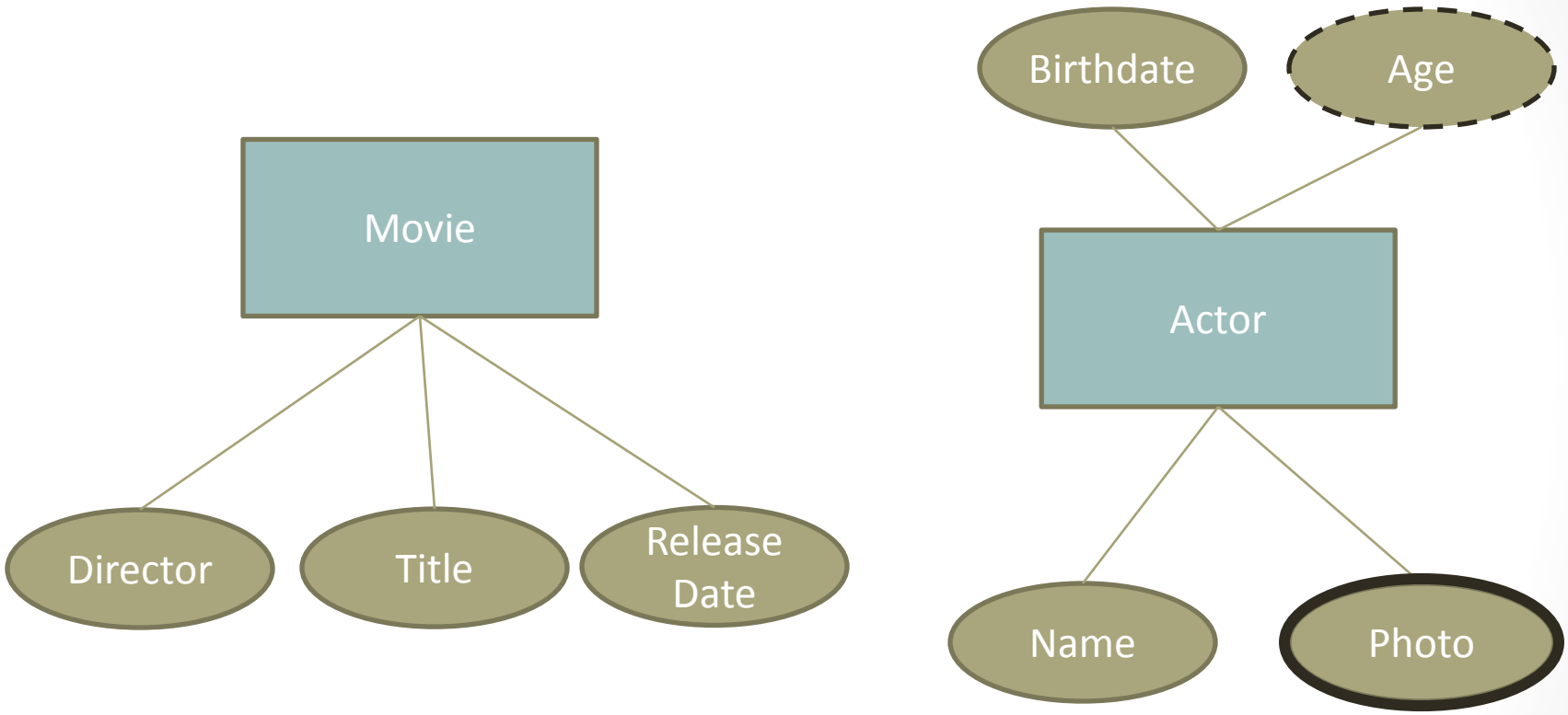
Example: from IMDB



Attribute details

- Null attributes
  - Do not know the value (NA).
  - Attribute does not exist (e.g., children).
- Derived values
  - An attribute that can be computed from other attribute(s)
  - **Represented by a dashed oval.**

Example: from IMDB



Relationships

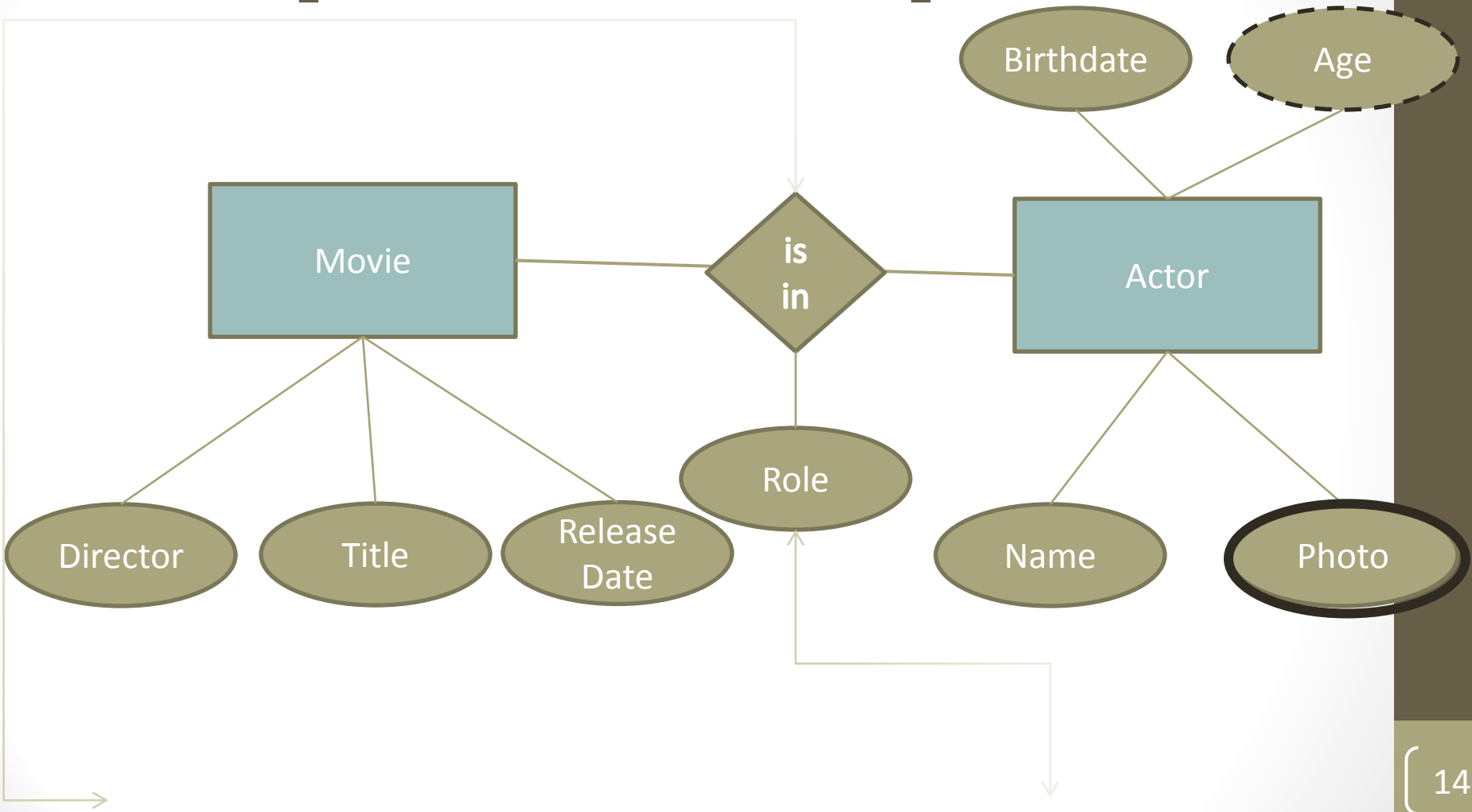
- A relationship is a mapping or an association between two or more entities.
  - **Relationship represented as a line connecting two entities or entity sets**.
- A Relationship set: a collection of similar relationships, mapping between 2 entity sets.
  - **Represented by diamonds**

Key design issue: distinguishing between entities and relationships -- seems obvious but isn't always.

Degree of a Relationship

- Degree of relationship identifies the **number of entities that participate in the relationship.**
  - Binary relationships are most common.
  - Higher degree relationships can be modeled as a set of binary relationships.

Example: Relationships

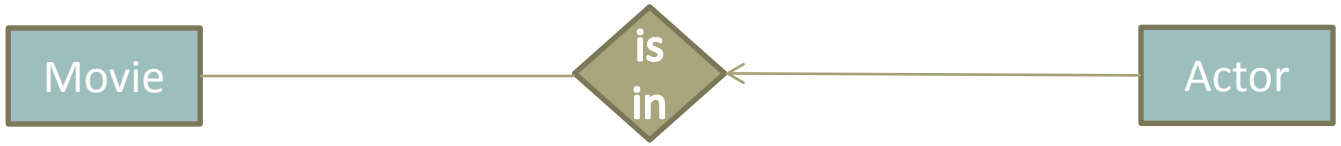


Relationships can have attributes too

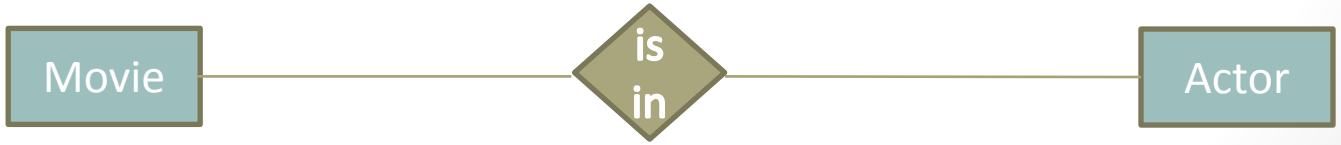
Relation Constraints: Cardinality

- The logical structure of the data may impose constraints – ERM allows you to represent these constraints
- Cardinality: defines the relationship between the entities in terms of #'s
- 1 to 1: represented as 2 arrows pointing into the relationship

- 1 to many: one arrow emanating from the entity set with the cardinality of many (or pointing to the 1 cardinality)

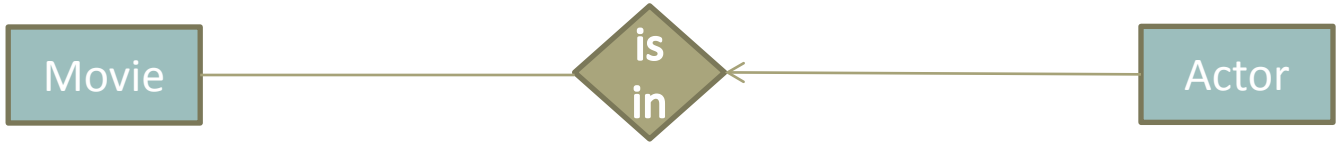


- Many to many



Describe the wacky Movie world

Each actor can be in 1 movie and each movie has 1 actor.



Each actor can only be in 1 movie but a movie can have 0, 1, or n actors.

A movie can have 0, 1, or n actors and an actor can appear in 0, 1, or n movies.

Constraints: Existence

- Entity X is *existent dependent* on Entity Y if X can only exist if Y exists.
  - Has implications for deletion:
  - Deleting Y must force delete of X as well.
- In this example:
  - X is the *subordinate* entity
  - Y is the *dominant* entity

Constraints: Participation

- If every entity in an entity set E must be part of a relationship R, then E *participates totally* (as opposed to *partially*).
- Total participation often indicates existence dependencies.
- **Total participation represented by a double line.**

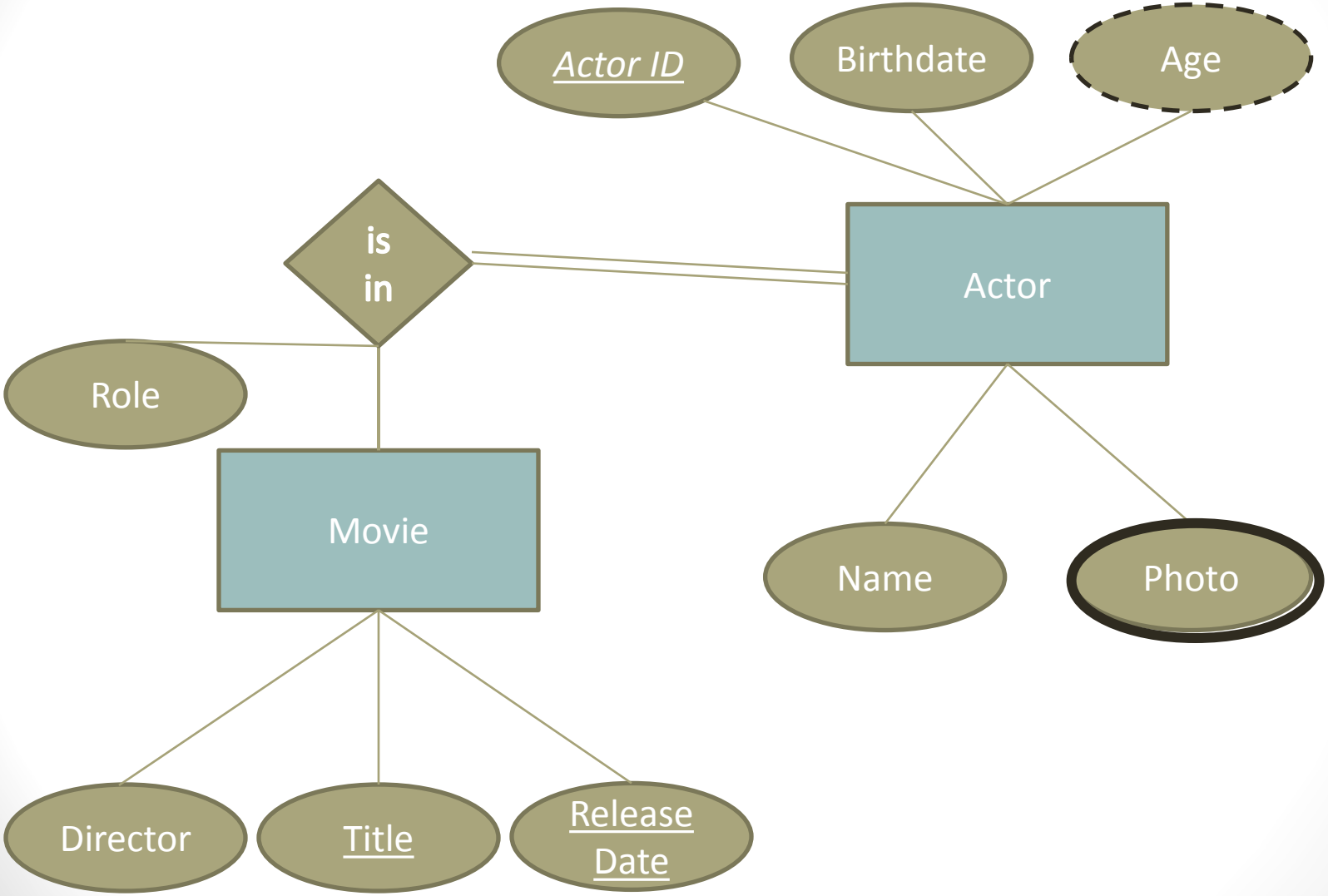
Existence: Example

- Assume actors only exist in the IMDB database if they have been in at least one movie
- If you delete a movie from IMDB
  - Must also delete actors that only appeared in that one movie

Types of Keys

- **Superkey**: an attribute or set of attributes that uniquely identifies an entity--there can be many of these
  - **Candidate key**: a superkey such that no proper subset of its attributes is also a superkey (minimal superkey – has no unnecessary attributes)
- **Primary key**: the candidate key chosen to be used for identifying entities and accessing records. Unless otherwise noted "key" means "primary key“
  - **Represented with an underline**
  - Used for physical clustering of data
- **Alternate key**: a candidate key not used for primary key
- **Secondary key**: attribute or set of attributes commonly used for accessing records, but not necessarily unique
- **Composite key**: a key requiring more than one attribute

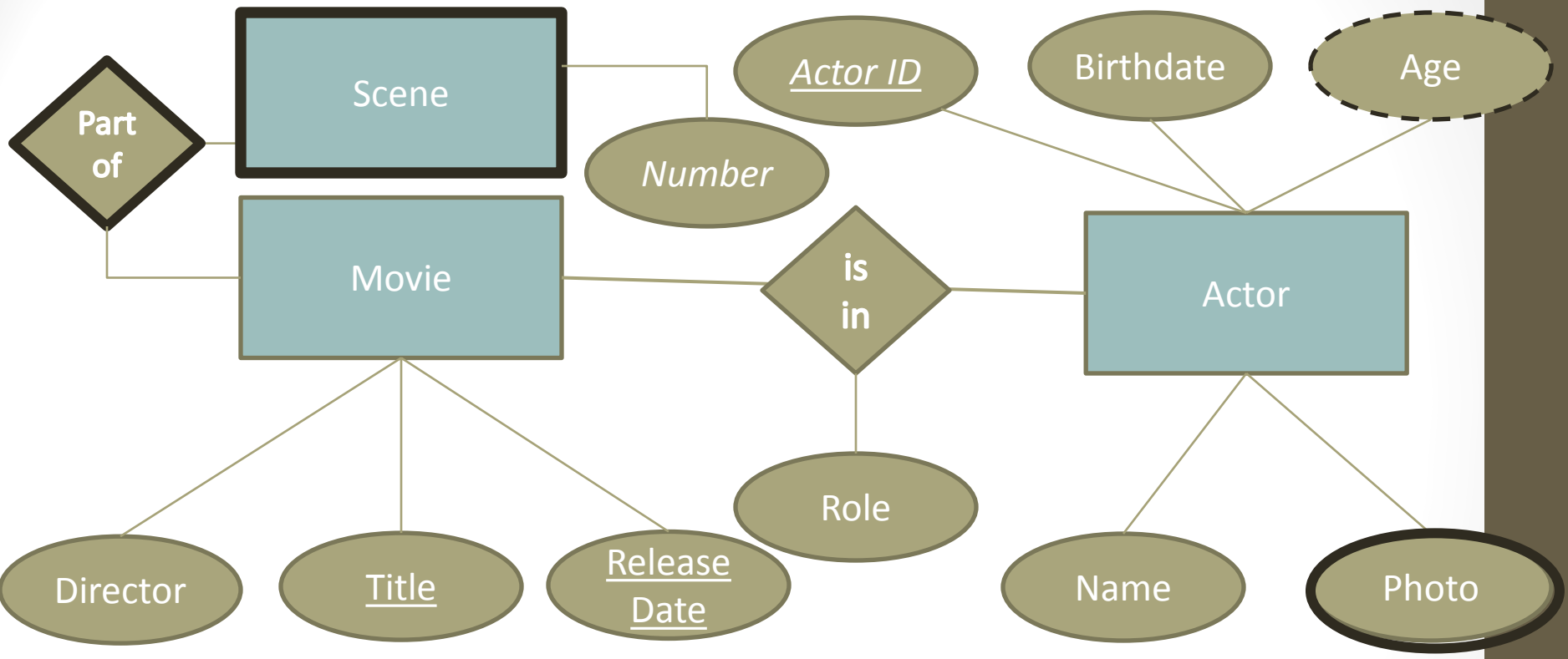
Example: Keys



Weak vs. Strong entity sets

- An entity set without a primary key is called a *weak entity set*
  - **Represented by a double rectangle**
  - **Corresponding relationship represented with a double diamond**
- A *discriminator* (*partial key*) distinguishes among elements of a weak entity set.
- An entity set with a primary key is called a *strong entity set*
- Members of the strong entity set are dominant; members of the weak entity set are subordinate

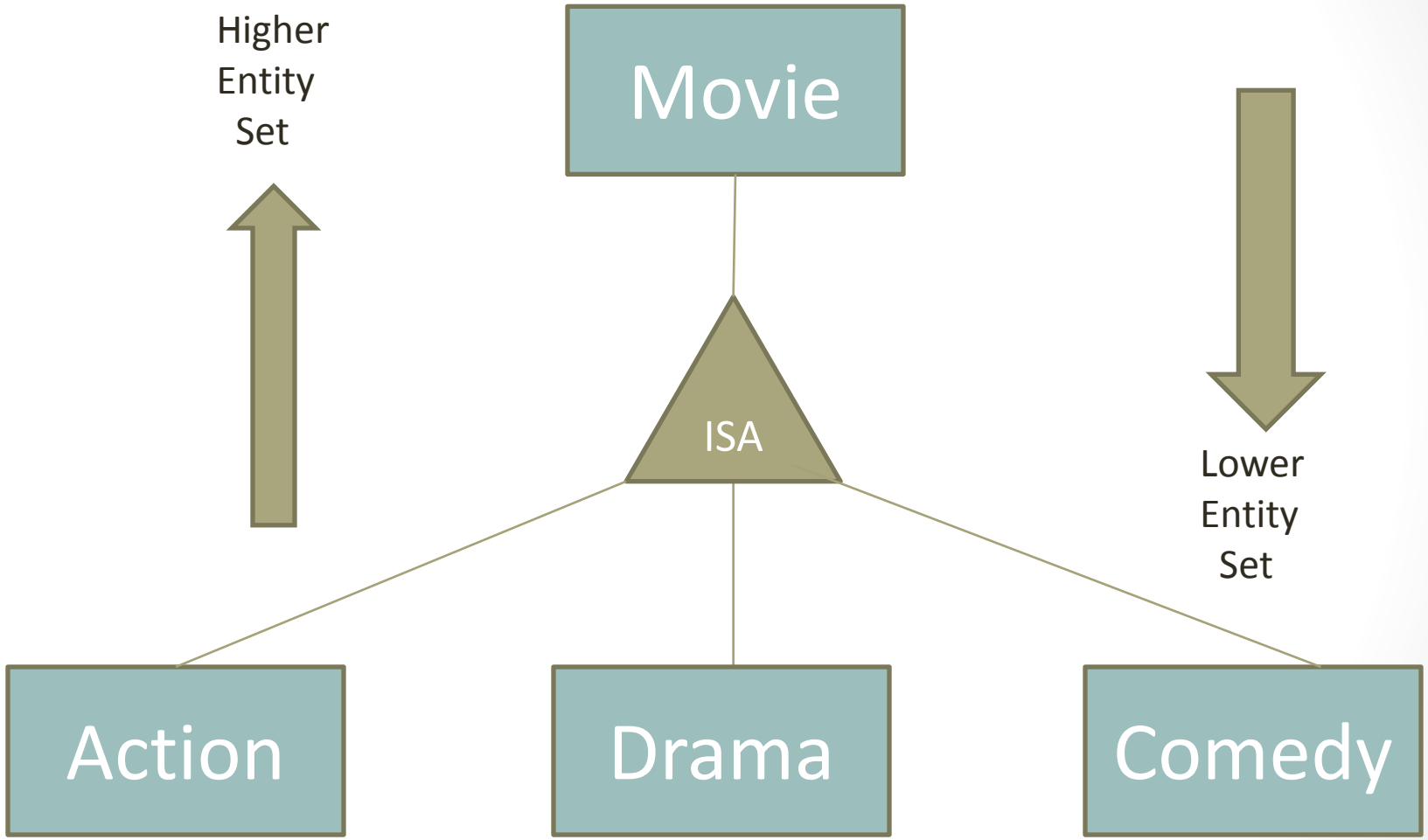
Example: Weak entity set



Extended features

- Specialization
  - Designating subgroups within an entity set (think subclasses or sub-typing).
  - A single entity set can have multiple specializations.
  - **Represented using a triangular ISA designator.**
- Generalization
  - Inverse of specialization.
  - Aggregates similar entity sets
  - **Represented using a triangular ISA designator.**
- Generalized entity set or the *basis* of a specialization is called a *higher level entity set*. (The others are *lower level entity sets*.)
  - Familiar if you have used objects:
  - Superclass/subclass.
  - Inheritance.
  - If the entire schema has only single inheritance, then the design is a hierarchy.
  - If the schema has multiple inheritance, it is a lattice.

Generalization Specialization



ISA function defines a Hierarchy

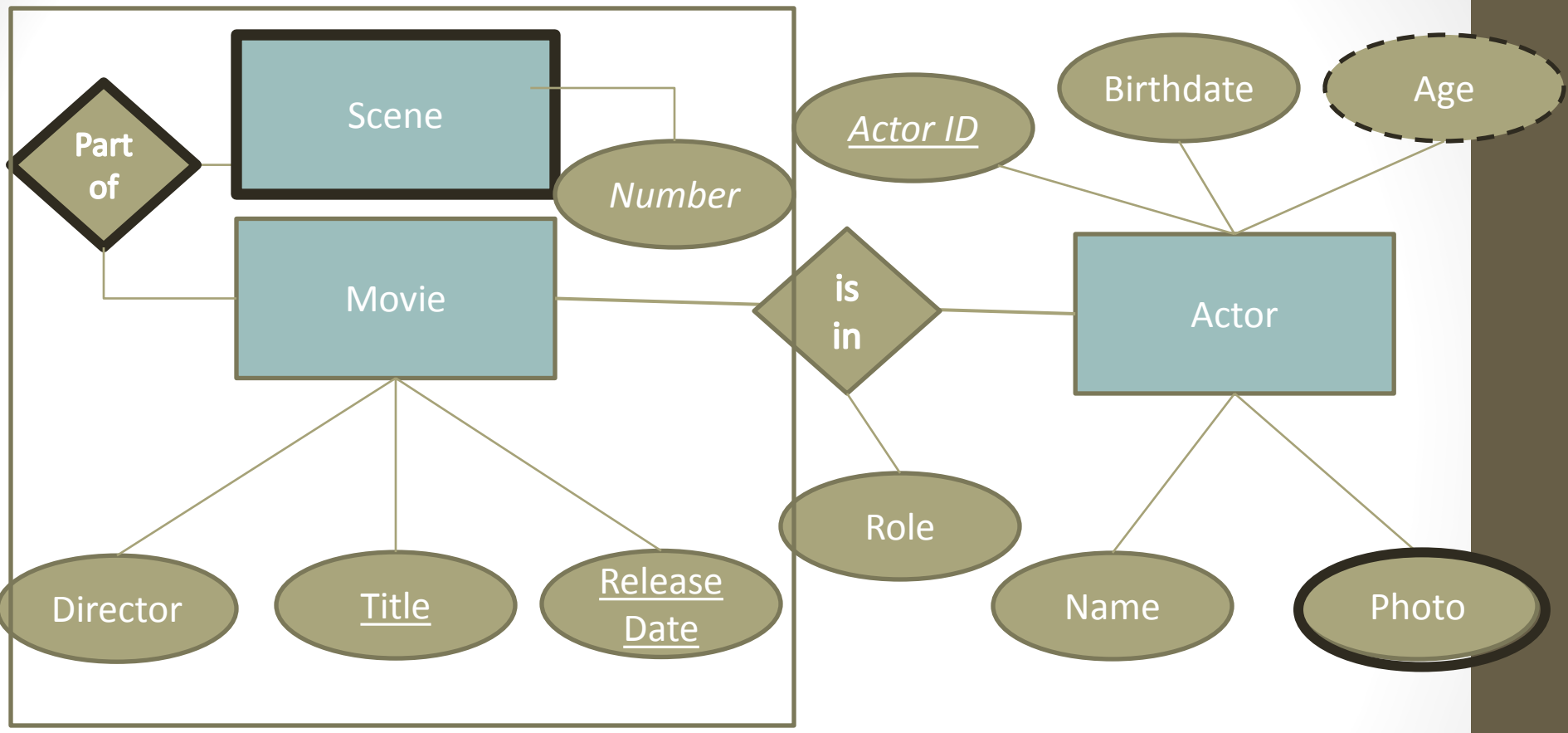
Generalization constraints

- Membership
  - Condition-defined: membership in the generalization or (specialization) is based on a **predicate**.
  - User-defined: membership is defined manually.
- Cardinality
  - Disjoint: each entity belongs to a single lower level entity set.
    - Single genre for a movie
  - Overlapping: entities may belong to multiple lower level entity sets.
    - Movie classified using multiple genres
- Completeness
  - Total: every higher level entity must belong to a lower level entity set.
    - All movies have at least one genre.
  - Partial: higher level entities may or may not belong to lower level entity sets.
    - Some movies do not fall into any movie genre.

Aggregation

- When relationship sets have their own relationships
- Provides a method to build up complicated entities
- Allows us to treat a relationship set as an entity set
  - **Represented as a box around the relationship**

Example: Aggregation



Other examples?

Summary of Conceptual design

- Conceptual design follows requirements analysis
  - Yields a high-level description of data to be stored
  - ER model popular for conceptual design
  - Constructs are expressive, close to the way people think about their applications
  - Basic constructs: entities, relationships, and attributes (of entities and relationships)
  - Some additional constructs: weak entities, ISA hierarchies, and aggregation
    - Note: There are many variations on ER model

Summary of ER

- ER design is subjective. There are often many ways to model a given scenario. Analyzing alternatives can be tricky, especially for a large enterprise.
- Common choices include:
  - Entity vs. attribute
    - Key for the entity / to store or discard an attribute
  - Entity vs. relationship
  - Binary or n-ary relationship
  - Use of ISA hierarchies
  - Use of aggregation

Concepts: Part 1

- *Entity*: a thing (abstract or concrete).
- *Relationship*: mapping among entities.
- *Enterprise Schema*: overall logical schema of a database.

- *Entity set*: a collection of entities all of which have the same attributes.
- *Relationship set*: the mapping between entity sets
- *Extension*: the individual entities that comprise an entity set.

- *Attribute(s):* properties that describe an entity or relationship.
  - *Domain (value set):* permitted values of an attribute.
  - *Simple attribute*: indivisible type.
  - *Composite attribute*: attribute may be further broken down into subfields.
  - *Single-valued attribute*: only one entry for the attribute of a specific entity.
  - *Multi-valued attribute*: may have multiple entries for the attribute, all for a specific entity (e.g., phone numbers: work, home, cell, fax).
  - *Derived attribute*: attribute whose value can be determined based upon other data (e.g., a database that includes birthdate and age; age can be a derived attribute given birthdate).
  - *Base attribute*: an attribute from which you derive another attribute.
  - *Descriptive Attributes*: attributes added to a relationship.

Concepts: Part 2

- *Participation*: the act of an entity belonging to a relationship
  - *Total participation*: all entities participate in the relation.
  - *Partial participation*: not all entities participate in the relation.
- *Role*: when an entity has a relationship with itself. The role distinguishes how an entity is treated in a relationship.
- *Mapping cardinality* (1:1, 1:many, many:1, many:many)
- *Existence dependencies*: requiring an entity to exist if another entity exists.
  - *Subordinate entity*: the dependent entity in an existence dependency.
  - *Dominant entity*: the entity on which the subordinate entity exists.

Concepts: Part 3

- *Superkey*: a set of attributes that uniquely identifies an entity.
- *Candidate key*: the minimal set of attributes that forms a superkey.
- *Primary key*: a designated candidate key.

- *Weak entity set*: an entity set without a candidate key.
- *Strong entity set*: an entity set with a candidate key.
- *Discriminator*: a set of attributes that distinguishes between the elements of a weak entity set.

Concepts: Part 4

- *Specialization*: extracting a subclass from an entity set.
- *Generalization*: combining one or more entity sets into a higher level entity.
  - *Disjoint generalization*: an entity belongs to at most one lower level entity set.
  - *Overlapping generalization*: entities may belong to multiple lower level entities.

- *Hierarchy*: each entity set is only the object of one "ISA" relationship.
- *Lattice*: entity sets may belong to multiple "ISA" relationships.

- *Condition-defined constraint*: defines membership in a subclass via a predicate.
- *User-defined constraint*: membership is manually defined.
- *Completeness constraint*: all entities belong to a lower level entity.

- *Total constraint*: all entities belong to lower level entity sets.
- *Partial Constraint*: entities not required to belong to lower level entity set.

- *Aggregation*: grouping part of a schema into a larger unit.

In Class Work

Layout an ERM diagram for a university. The university consists of a number of departments, in particular (Engineering, Humanities, Math, Science) . Each department offers several majors. A collection of courses define the minimal collection of courses that satisfy a specific major. Students declare a specific major and take courses towards the completion of that major. Each course is taught by a professor from the appropriate department.