Entity-Relationship Models

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Entity-Relationship Models

- Entities
- Attributes
- Relationships

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The Role of Conceptual Models

High-level but concrete view of data understandable by end users and database developers

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Database Design Process

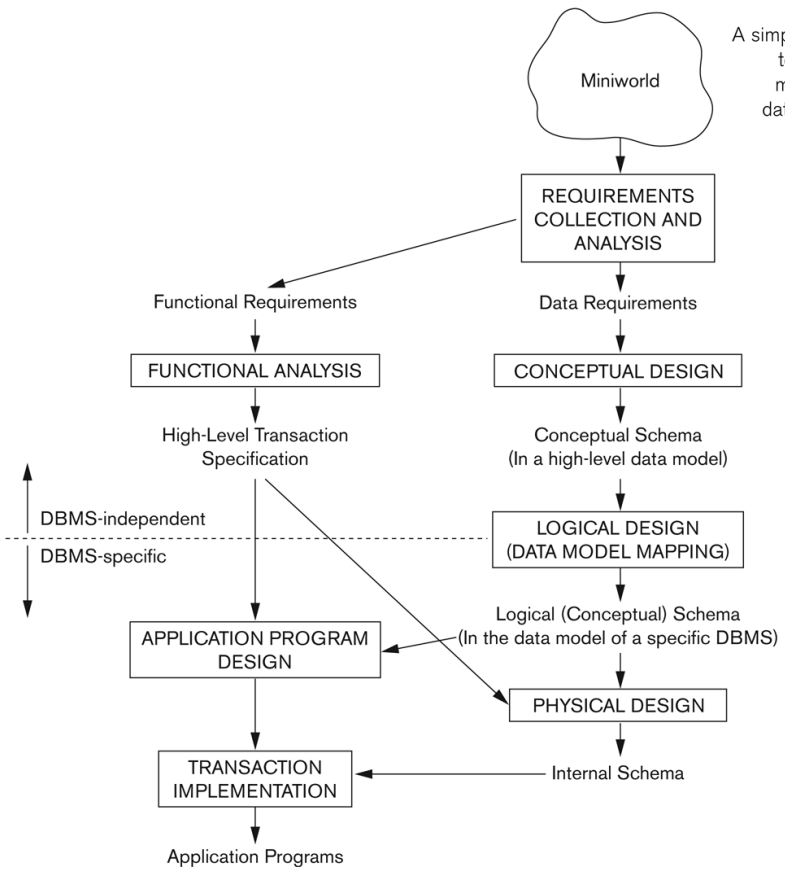

Figure 3.1
A simplified diagram to illustrate the main phases of database design.

ER modeling is the box labeled "Conceptual Design."

Entities and Entity Types

An entity is a real or abstract thing with an independent existence in the world.

- Person (real)
- Building (real)
- Job (abstract)
- Course (abstract)

In ER models we often say "entity" when we mean "entity type."

- An entity type is a set of entities (instances) with the same attributes, i.e., properties of entities.
- An entity set or entity collection is the set of instances of an entity type in a partcular database.

Entity types are depicted with a rectangle.

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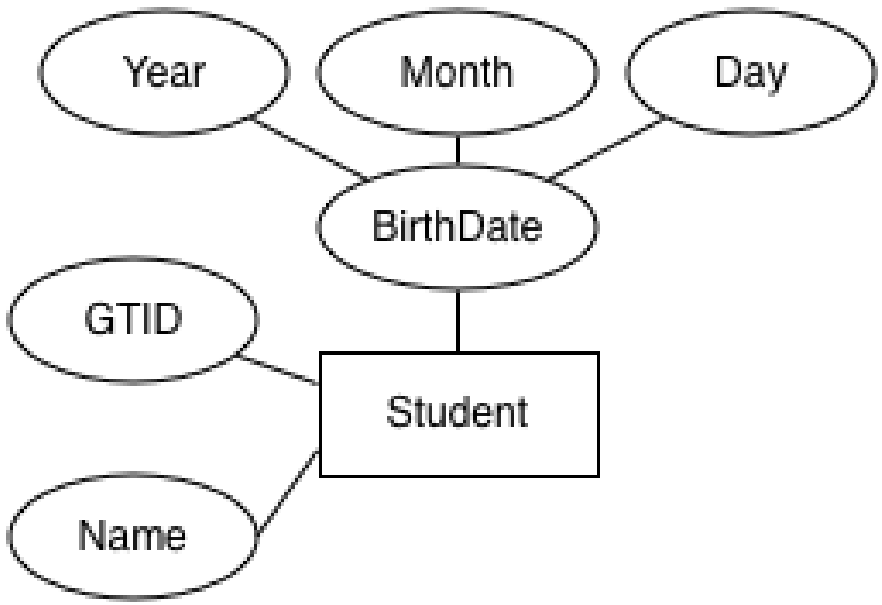
Atomic vs. Composite Attributes

- Atomic attributes have a single for an entity instance, e.g., `GTID`.
- Composite attributes are composed of one or more compents, e.g., `BirthDate`

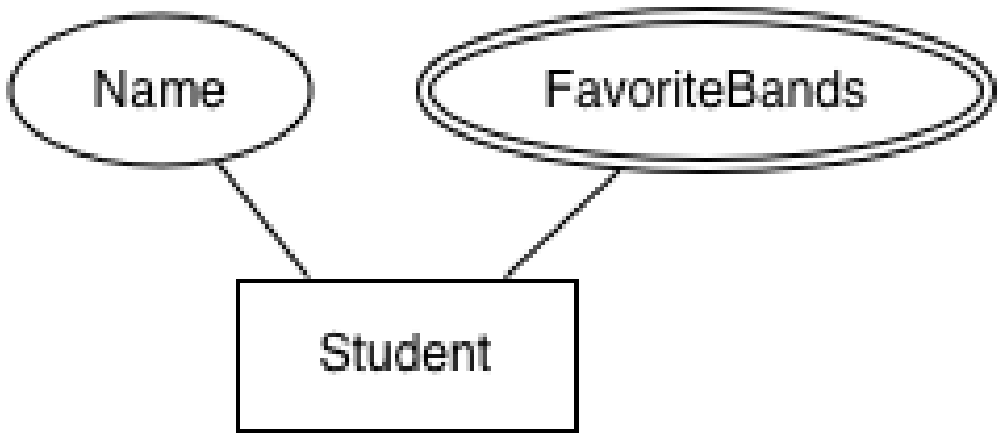


An instance of Student might look like:

```
("Tom Jones", 902109021, BirthDate(2000, 01, 25))
```

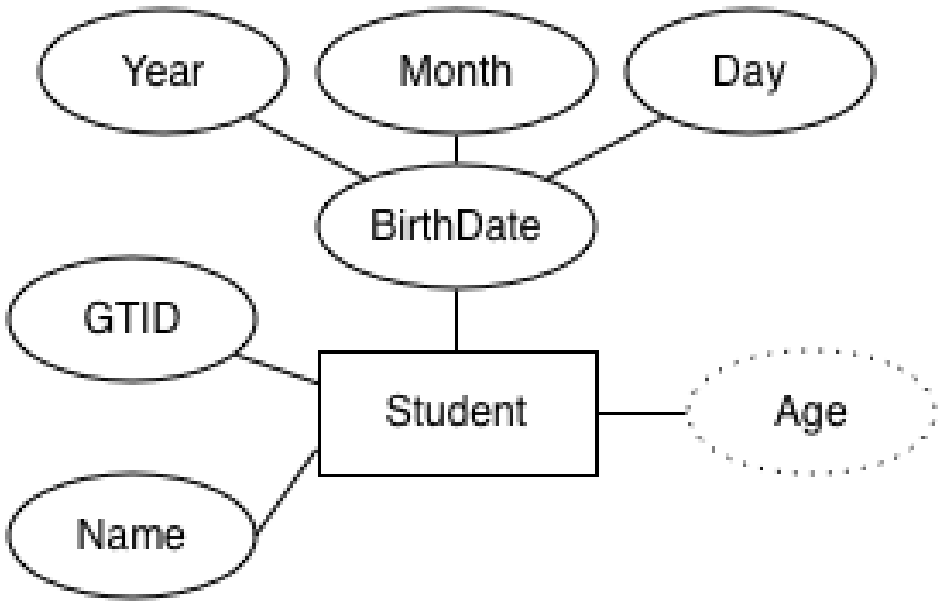
Single-valued vs. Multi-valued Attributes

- Single-valued attributes have one (atomic or composite) value for each instance.
- Multi-valued attributes have a set of (atomic or composite) values for each instance.



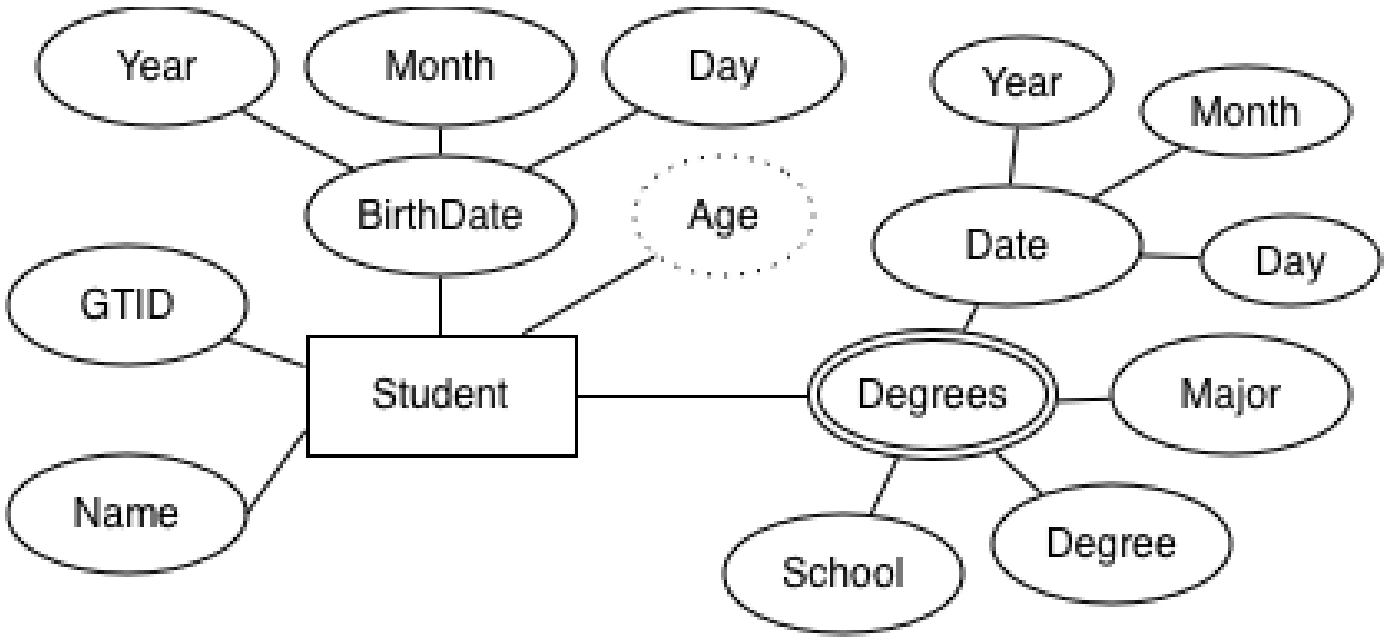
Stored vs. Derived Attributes

- All the attribute types we've seen so far are stored. A derived attribute gets its value from stored attributes and is not stored.
- Age is derived from BirthDate.



Complex Attributes

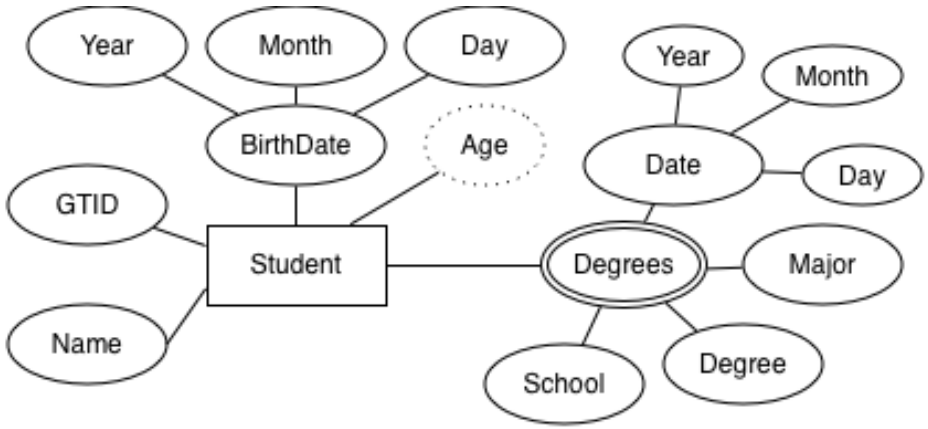
- Composite and multi-value attribtes can be arbitrarily nested. Such attributes are called complex attributes.



NULL values represent the absence of data. Can mean unknown or not applicable.

Semantic Constraints

What if we wanted to ensure that no degree date were before the student's birthdate?



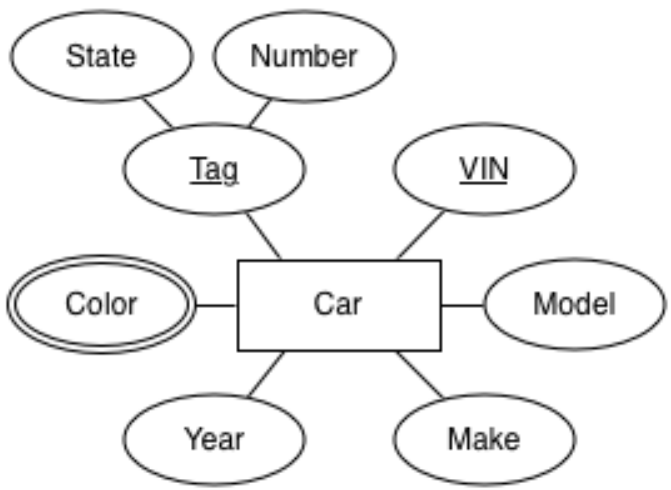
- In general ER models can't express constraints on the values of particular attributes
  - Can only express contstraints on structure – attributes of an entity type, sets for multi-valued attributes, components for composite attributes, single values for atomicattributes.
- To express constraints on the values of attributes (often in relation to the values of other attributes) we use a sematic constraint. For example:

  The `Date` *for any* `Degree` *of a* `Student` *instance cannot be prior to the* `BirthDate` *of the* `Student` *instance.*

Keys

A key is a(n) (set of) attribute(s) whose value uniquely identifies an entity instance.

- Key attributes are underlined.
- No two entity instances in a database can have the same values for their key attribues.
- An entity type may have multiple keys.
- Composite keys are modeled with composite attributes.
- Names of key attributes are underlined.
- An entity type must have at least one key, otherwise it is a weak entity type (more later).
- If no attributes are underlined, every attribute forms a composite key.



Domains/Value Sets

Each attribute has a type.

- A type is a set of values, e.g., the set of integers, the set of months, etc.
- The attribute value for an instance comes from the domain of the attribute.
- Legal attribute values can be further restricted, e.g., BirthDate cannot be a future date.
- Attribute types are not modeled in our ER diagram language but can be listed as semantic constraints.

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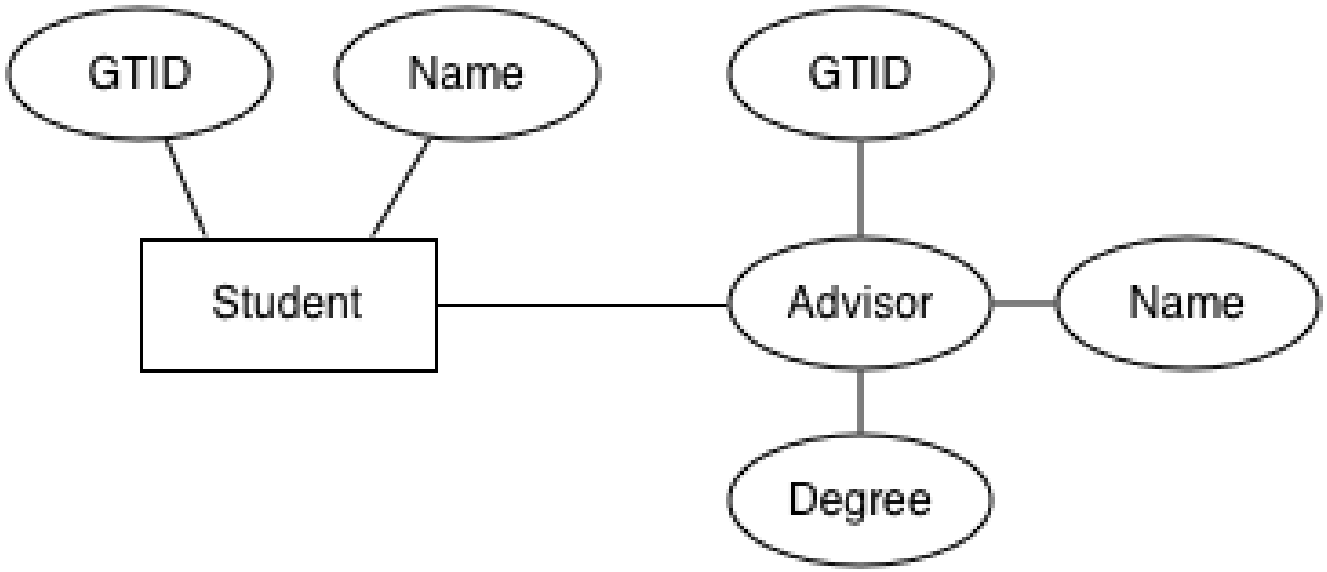
Relationship Types

Relationships between entity types are explicitly modeled. Relationships have

- Names
- Degree – the number of participating entity types (we'll only consider binary reltionships)
- Attributes (optional)
- Constraints
  - Cardinality
  - Participation

Relationships as Attributes

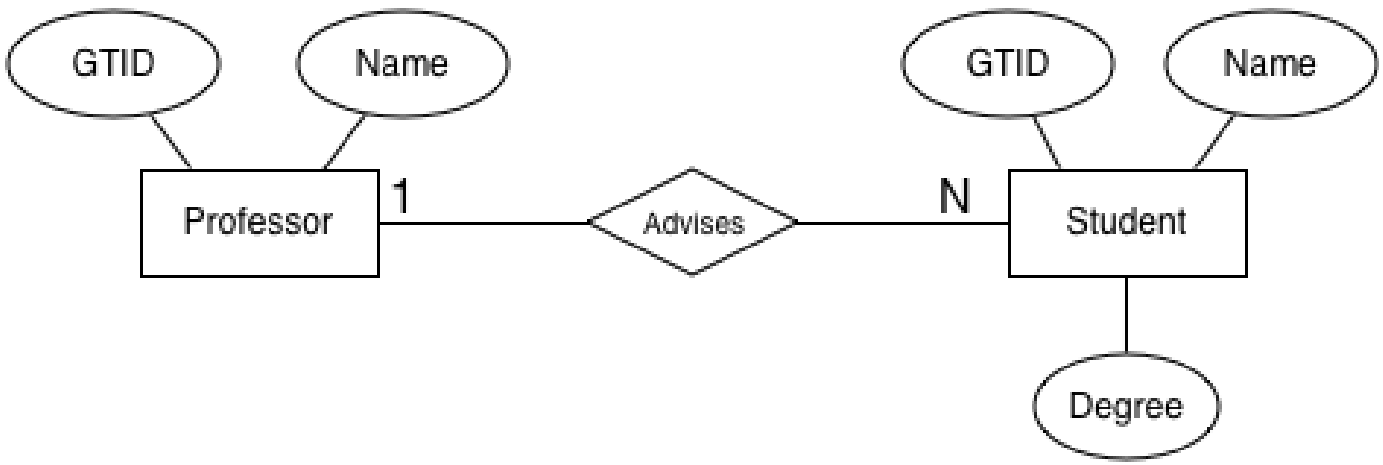
In this ER model a Student can have an Advisor.



- But an advisor is a professor, which is an entity that is related to many other entities.
- And if a professor advises many students, the professor's information will be repeated in the database.

Elevating Attributes to Relationships

The `advises` relationship type represents a relationship between Professor and Student.

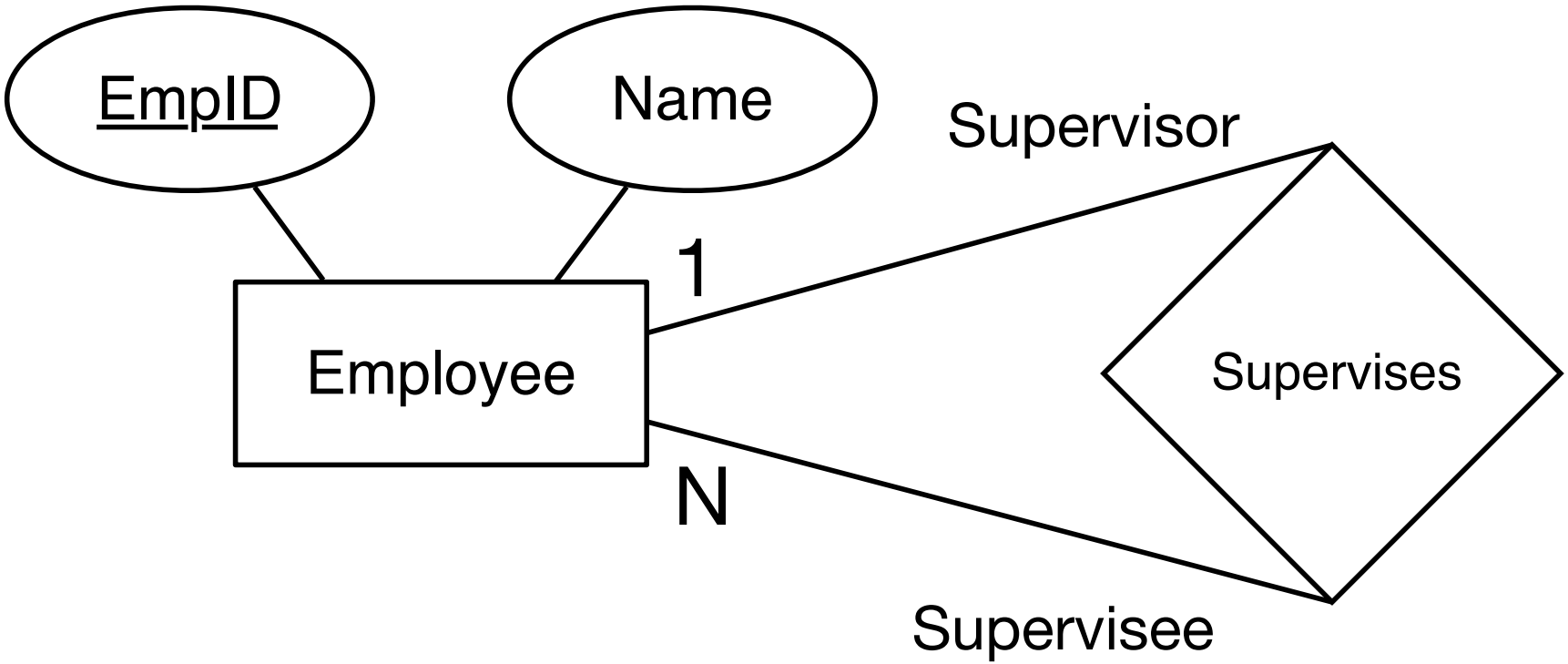


Relationship instances are represented as tuples of the key values of the related entity instances.

- `(123456789, 987654321)` means the professor with GTID 123456789 is the advisor of the student with GTID 987654321.

Recursive Relationships

An entity type can be related to itself. Here every employee has one supervisor. A supervisor may have many supervisees.

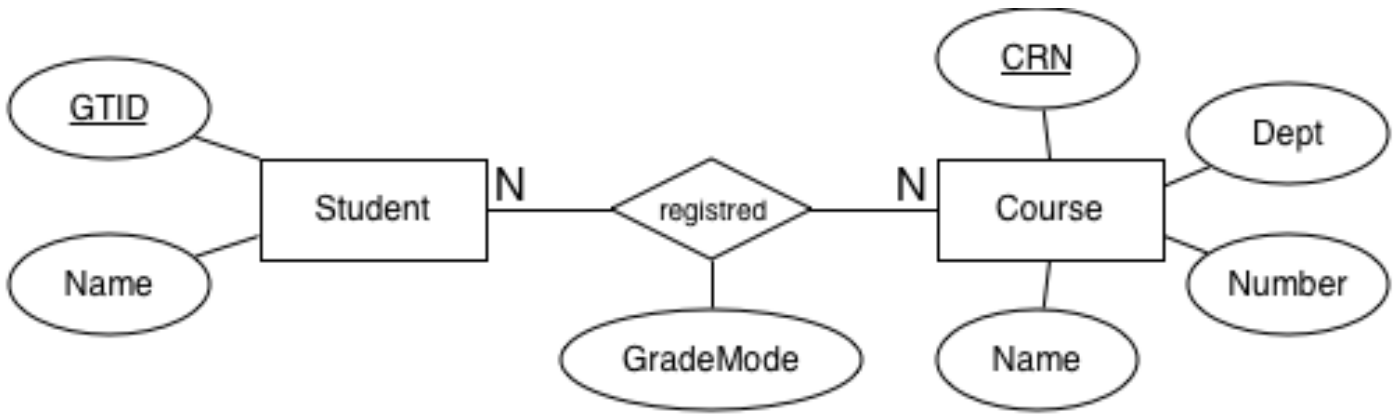


Cardinality Ratios

Two kinds of binary relationship constraints:

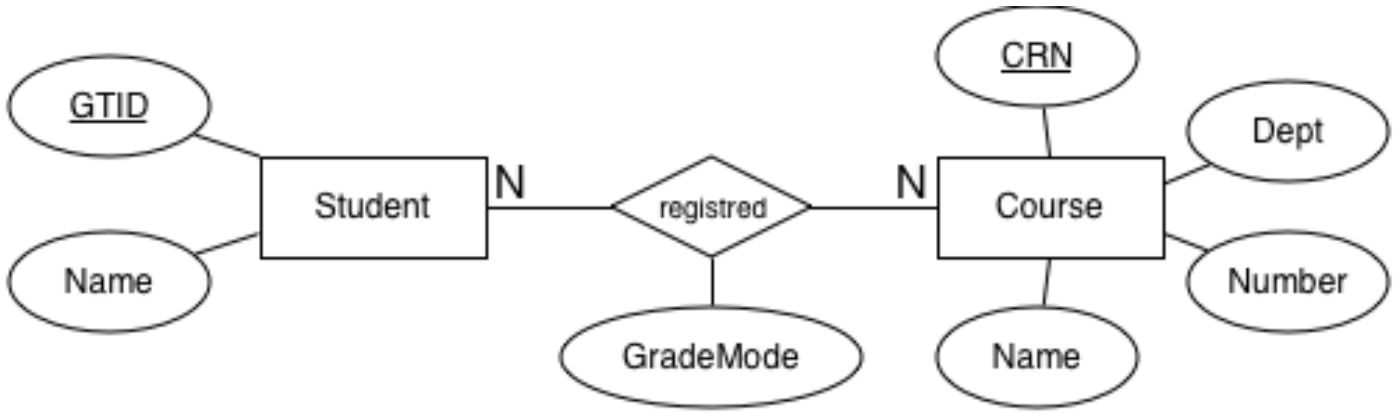
- Cardinality ratios
- Participation constraints

We've already seen 1-to-many cardinality ratios. Here's a many-to-many cardinality ratio:



Attributes of Relationship Types

Notice that the `registered` relationship has attributes.



A tuple for an instance of the registered attribute would have a Student key value, a Course key value, and the values for the attributes of the relationship. For example:

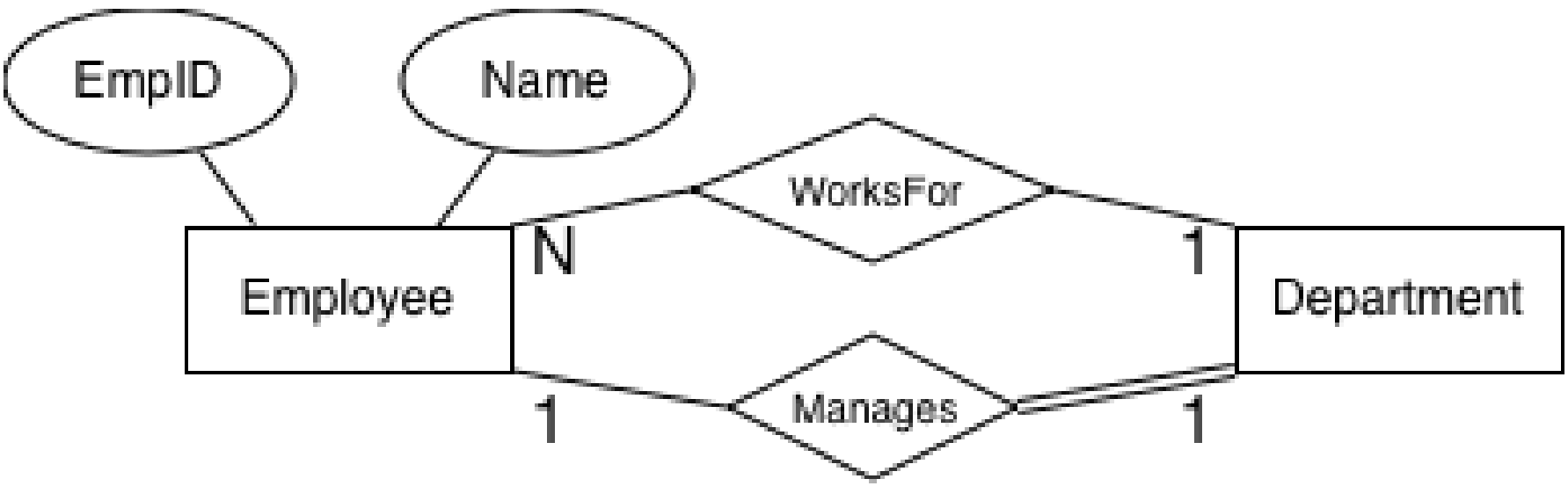
- `(123456789, 8675309, "P/F")` means the Student with GTID 123456789 is registered for the course with CRN 8675309 in Pass/Fail mode.

Participation Constraints

Two kinds of participatoin constraints.

- Total (existence): every entity in an entity set participates in a relationship
- Partial: some of the entities in an entity set participate in a relationship

Here a department must have a manager, but not every employee is required to be a manager.



Weak Entity Types

Weak Entity Types

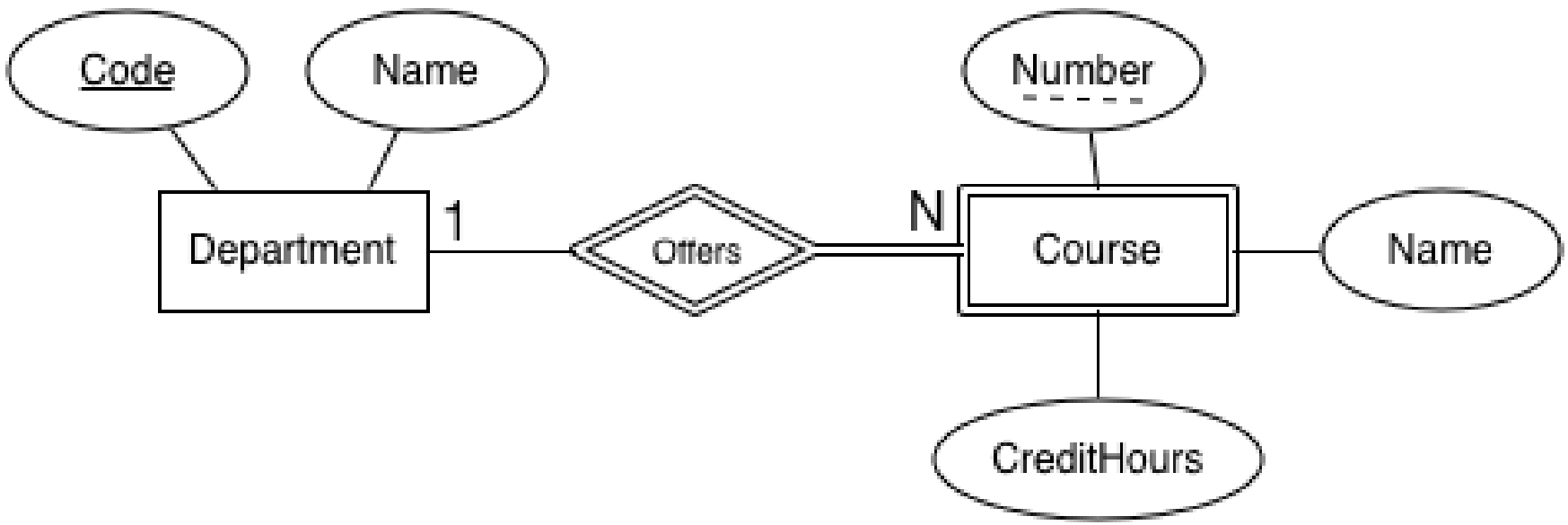
- Don't have keys
- May have partial keys
- Must have total participation with identifying entity type
- Identifiable by a composite key: identifying entity's key + weak entity's partial key

Identifying relationship is represented with double-lined diamond.

Courses and Department

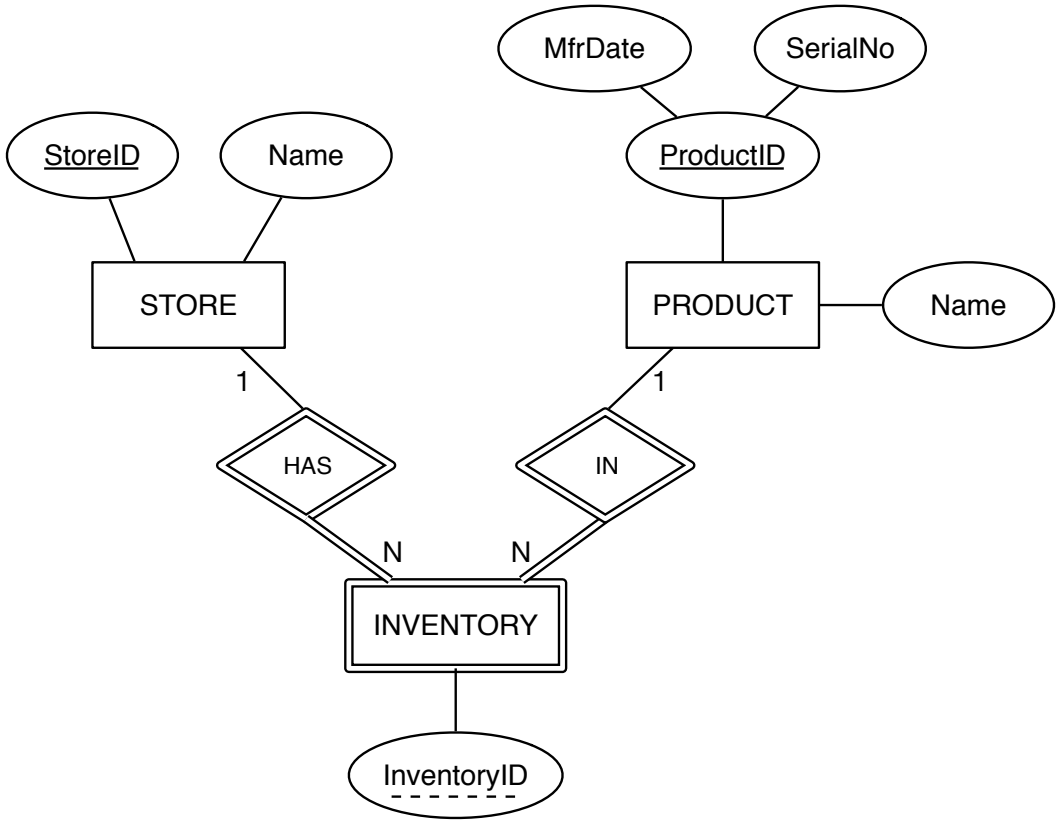
Here, a course is offered by a department.

- Courses in different departments can have the same number.
- The department key and the course number are sufficient to uniquely identify a course.
- A department will only have one course with a given number, so the number is a partial key.



Multiple Identifying Relationships

A weak entity type can be identified in relation to multiple entity types.



The key for an INVENTORY instance is

(StoreId, ProductId(MfrDate, SerialNo), InventoryId)

Fin

- Entity-relationship models express contents and constraints on data using
  - entities,
  - attributes, and
  - relationships.
- ER modeling is a part of conceptual design.
- ER models are understood by both technical and non-technical stakeholders (e.g., customers).
- Constraints that can't be modeled using in the ER modeling scheme can be expressed as semantic constraints.

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