CS 320 Introduction to
Software Engineering

Entity-Relationship (ER) Models

Slides adapted from Gordon Anderson

Learning Objectives

- Know what an Entity-Relationship (ER) model is.
- Learn the basic ER components.
- What business rules are and how they help determine relationship constraints.

ER Model

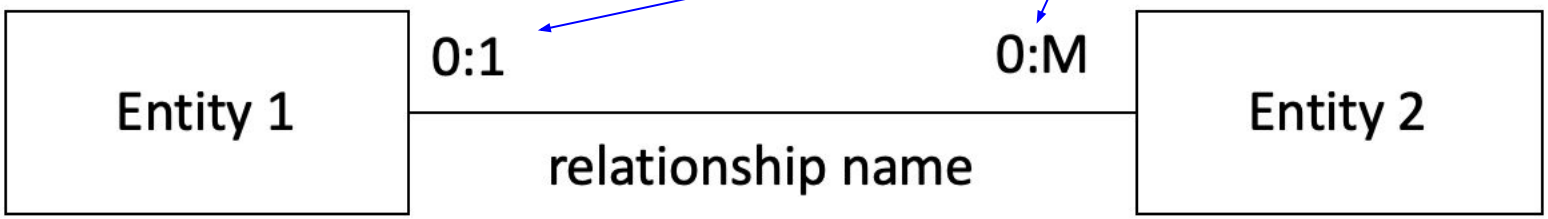
- An ER Model is **not** a database schema.

- An ER model is an **abstraction** that:
  - describes the **structure** a system's data
  - can be implemented as a database (relational or non-relational

- Note: Extended ER diagram can include impl details

ER Model: Basic Components

1. Entities
2. Attributes
3. Relationships
4. Constraints on relationship (***cardinalities***).



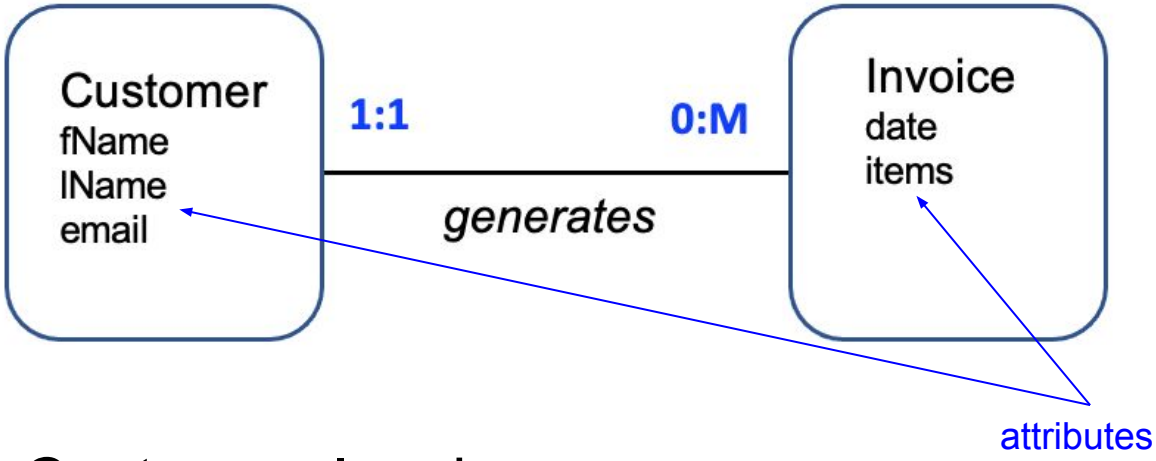
Notice cardinalities have ***lower and upper bounds***.

ER Model: Relationships

Entities can be related in several ways:

- 1:1 one to one
  - e.g., Company - CEO
- 1:M one to many
  - e.g., Customer - Invoices
- M:M (often shown as M:N) many to many
  - e.g., Student - Courses

ER Example



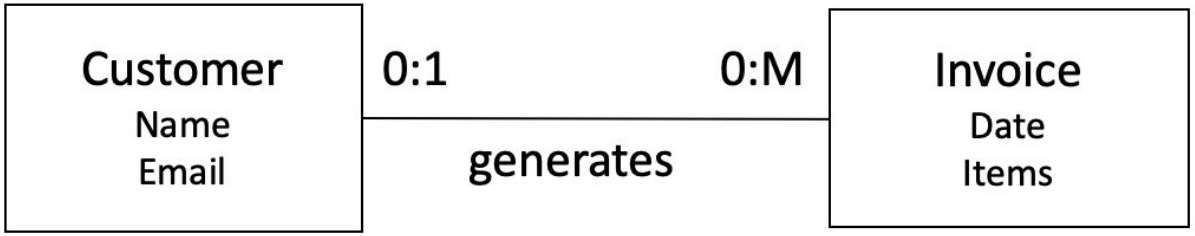
Entities: Customer, Invoice.

Relationship: “generates”, a 1:M relationship.

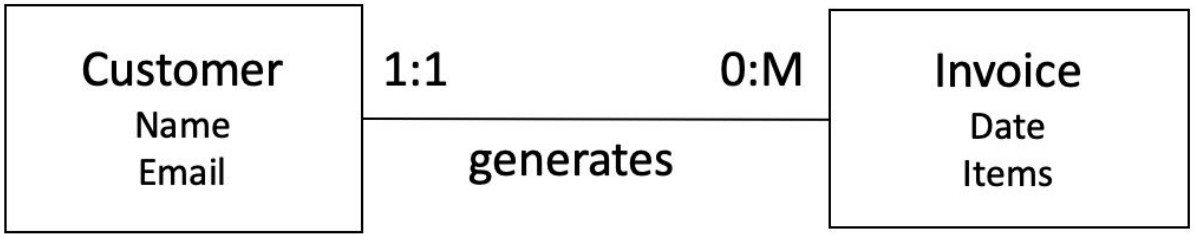
- Each Customer *generates* **0** to **many** Invoices.
- Each Invoice *is generated by* **1** and only **1** Customer

ER Cardinality Examples

Most flexible



Invoice cannot exist without a Customer.



Most constrained: Customer cannot exist without an Invoice



The importance of the lower bound.

Business Rules

- Verbal description of how two entities are related to each other.
- Helps understand cardinalities of a relationship.
- There are **2 rules** for each relationship- each rule describes a ***direction***.

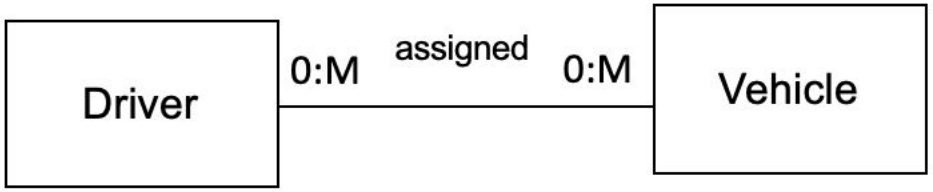
Guidelines for Writing Business Rules

- Nouns -> entities.
- Verbs -> relationships
- Bidirectional; ***Two questions*** to answer:
  - One instance of A is related to how many instances of B?
  - One instance of B is related to how many instances of A?

Many to Many Example:

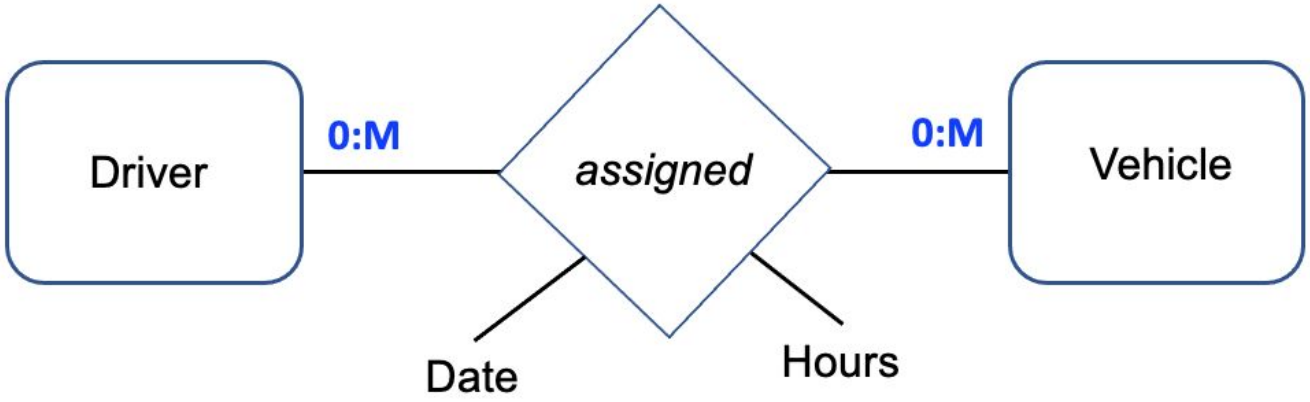
- Scenario: *"Our drivers can be assigned to any of our vehicles".*

- Business Rules:
  - A driver may be assigned to drive zero to many vehicles. (why zero lower bound?)
  - Each vehicle can be driven by zero to many drivers. (again, why zero as a lower bound?)



Many to Many Example:

- The **date/*time*** of an assignment is usually important in this kind of relationship.
- Attribute of the “assigned” relationship, not the driver or vehicle
- A ***diamond shape*** can be used to add attributes to a relationship.



Added the number of hours the assignment lasted.

Relationship as an Entity

An ER Model where the *assigned* relationship becomes an entity:



This creates two relationships, which have their own sets of cardinalities:

generates:

Each Driver is assigned to 0 to many Assignments.

Each Assignment assigns 1 and only 1 Driver.

lists:

Each Vehicle is listed by 0 to many Assignments.

Each Assignment lists 1 and only 1 Vehicle.

Modeling Scenario 1:

Scenario: *“Our employees can work in only one of our stores”.*

Business Rules ?

1. ?
2. ?

ER Diagram ?

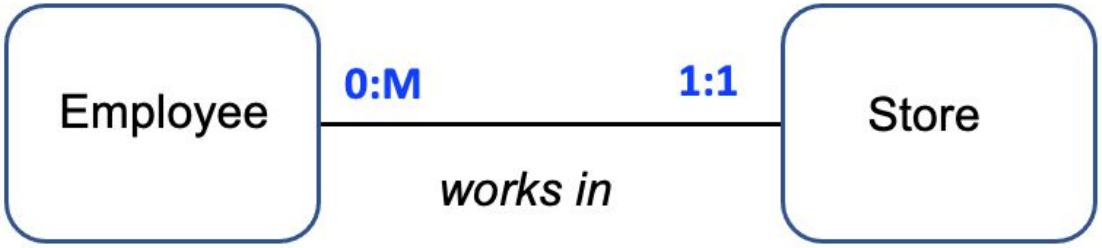
Modeling Scenario 1:

Scenario: *"Our employees can work in only one of our stores".*

Business Rules

1. Each Employee works in 1 and only 1 Store.
2. Each Store has 0 to many Employees working in it.

ER Diagram:



We assume a store can exist before employees are assigned to it, and that an Employee has to be assigned to work in a store.

Modeling Scenario 2:

Scenario: *“Students register for courses”.*

Business Rules ?

1. ?
2. ?

ER Diagram ?

Modeling Scenario 2:

Scenario: *"Students register for courses".*

Business Rules:

1. Each Student registers for 0 to many Courses.
2. Each Course is registered for by 0 to many Students.

ER Diagram:



We assume a Student can exist before registering for any courses, and that a Course can exist before any students have registered for it.

Summary: ER Basic Components

1. Entity: anything about which data are to be collected and stored.

2. Attribute: a characteristic of an entity.
   - Example: CUSTOMER First Name, Last Name, Address, Phone Number.

Summary: ER Basic Components

3. Relationship: describes an association among entities
   - One-to-many (1:M) relationship:
     CUSTOMER-generates-INVOICE
   - Many-to-many (M:N or M:M) relationship:
     STUDENT-takes-CLASS
   - One-to-one (1:1) relationship:
     EMPLOYEE-manages-STORE

4. Constraints on relationships (cardinalities) have upper and lower bounds.