Entity Relationship Modelling

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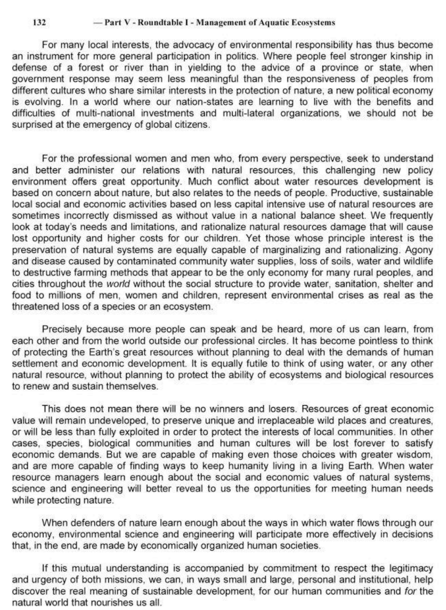
Goal: Identify Relations



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For many local interests, the advocacy of environmental responsibility has thus become an instrument for more general participation in politics. Where people feel stronger kinship in defense of a forest or river than in yielding to the advice of a province or state, when government response may seem less meaningful than the responsiveness of peoples from different cultures who share similar interests in the protection of nature, a new political economy is evolving. In a world where our nation-states are learning to live with the benefits and difficulties of multi-national investments and multi-lateral organizations, we should not be surprised at the emergency of global citizens.

For the professional women and men who, from every perspective, seek to understand and better administer our relations with natural resources, this challenging new policy environment offers great opportunity. Much conflict about water resources development is based on concern about nature, but also relates to the needs of people. Productive, sustainable local social and economic activities based on less capital intensive use of natural resources are sometimes incorrectly dismissed as without value in a national balance sheet. We frequently look at today's needs and limitations, and rationalize natural resources damage that will cause lost opportunity and higher costs for our children. Yet those whose principle interest is the preservation of natural systems are equally capable of marginalizing and rationalizing. Agony and disease caused by contaminated community water supplies, loss of soils, water and wildlife to destructive farming methods that appear to be the only economy for many rural peoples, and cities throughout the *world* without the social structure to provide water, sanitation, shelter and food to millions of men, women and children, represent environmental crises as real as the threatened loss of a species or an ecosystem.

Precisely because more people can speak and be heard, more of us can learn, from each other and from the world outside our professional circles. It has become pointless to think of protecting the Earth's great resources without planning to deal with the demands of human settlement and economic development. It is equally futile to think of using water, or any other natural resource, without planning to protect the ability of ecosystems and biological resources to renew and sustain themselves.

This does not mean there will be no winners and losers. Resources of great economic value will remain undeveloped, to preserve unique and irreplaceable wild places and creatures, or will be less than fully exploited in order to protect the interests of local communities. In other cases, species, biological communities and human cultures will be lost forever to satisfy economic demands. But we are capable of making even those choices with greater wisdom, and are more capable of finding ways to keep humanity living in a living Earth. When water resource managers learn enough about the social and economic values of natural systems, science and engineering will better reveal to us the opportunities for meeting human needs while protecting nature.

When defenders of nature learn enough about the ways in which water flows through our economy, environmental science and engineering will participate more effectively in decisions that, in the end, are made by economically organized human societies.

If this mutual understanding is accompanied by commitment to respect the legitimacy and urgency of both missions, we can, in ways small and large, personal and institutional, help discover the real meaning of sustainable development, for our human communities and *for* the natural world that nourishes us all.

Customer

Producer No	Producer City
3	London
22	Leeds

Producer

Customer No	Customer City
12	Edinburgh
34	Brighton

Product

Product ID	Name
323	Screws
127	Hammer

One Yuge Relation?

Open Orders				
Producer No	**Producer City**	**Product No**	**Price**	**Quantity**
3	London	52	65	4
22	Leeds	10	15	5
22	Leeds	12	4	11
3	London	44	43	32
3	London	43	3	27

Producers	
Producer No	**Producer City**
3	London
22	Leeds

Open Orders			
Producer No	**Product No**	**Price**	**Quantity**
3	52	65	4
22	10	15	5
22	12	4	11
3	44	43	32
3	43	3	27

Data Modelling

The process of developing a new database typically starts with a lengthy requirements phase involving eliciting and capturing the requirements of the customer and also a design and analysis phase that models the data that might be relevant. This can involve many meetings and iterations while choices are discussed and evaluated.

Of importance at this stage is to try to model the real-world and not to try to refine it into a particular implementation, for example, into the relational model.

We'll look at **Entity-Relationship modelling** and how to convert an E-R model into a relational model.

In Entity-Relationship modelling, we aim to create a diagram, the Entity Relationship Diagram (ERD) that represents the information needed for the database

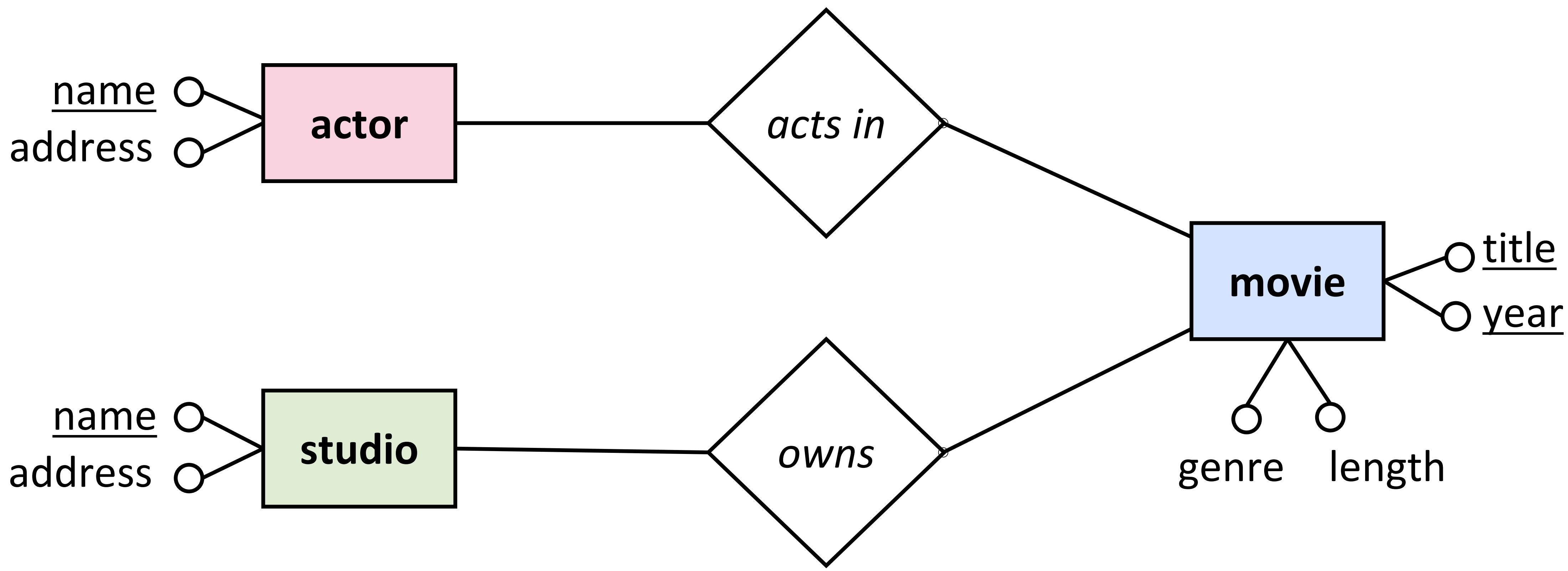
Unfortunately there is no universally accepted notation for ER diagrams.

Entities, Relationships, Attributes

The three main elements in an ERD are entity sets, relationship sets and attributes

Entity sets	An entity set is a set of distinguishable entities that share the same set of properties. Entities could be *physical* (e.g. car, room), an *event* (e.g. car sale, flight), or *conceptual* (e.g. goodwill). Normally correspond to **nouns**.	Rectangles
Relationship	A relationship set captures how **two or more** entity sets are related to one another (e.g. owns, tutors). Sometimes correspond to **verbs**. We can have more than one relationship set between entity sets (e.g. owns and drives). We can also have a relationship set on the same entity set (e.g. supervises). A relationship is a particular instance.	Diamonds
Attributes	Attributes are the properties of an entity (e.g. name, price). **Primary key attributes are underlined**. Relationship Sets can also have attributes (e.g. owned since). This is avoids putting them in an entity set.	Small Circles

Example



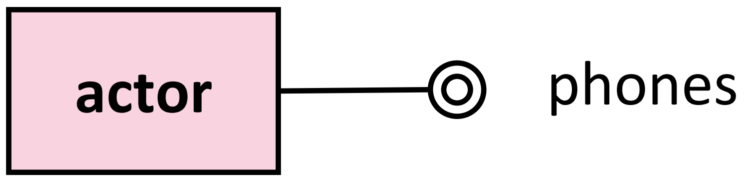
Attributes are normally drawn in ovals. We'll use small circles for clarity.

Complex Attributes

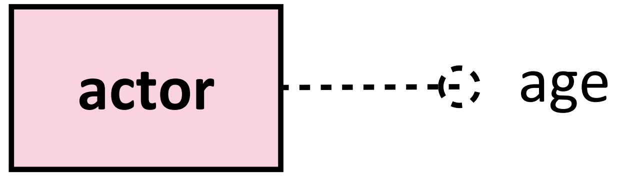
In E-R modelling, attributes need not be simple. Simple attributes are atomic, e.g. year, first name, credit card number. Complex attributes can be:

Composite. These can be subdivided, e.g. address into road, city, postcode

Multivalued. A set of values, e.g. several phones, supervisors



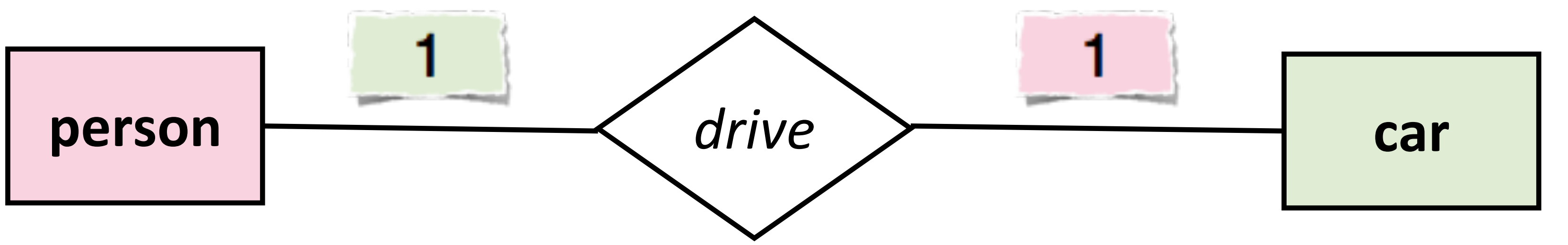
Derived. Computed from other values, e.g. age computed from date of birth



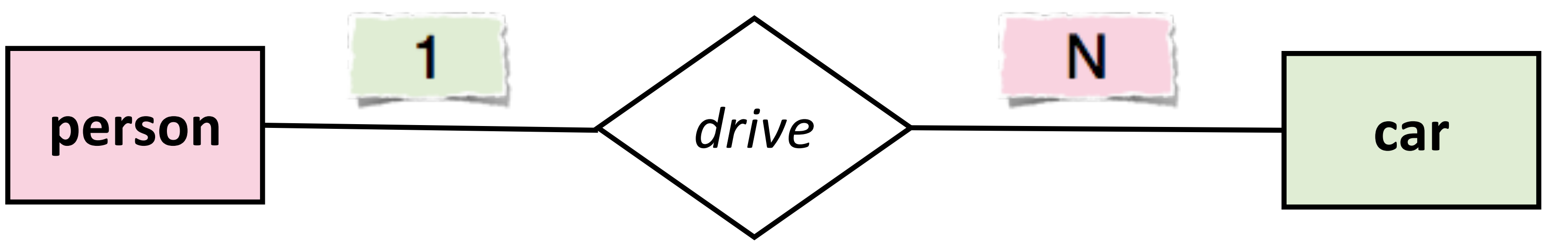
Cardinality Constraints

In E-R modelling, it is important to impose constraints on the number of entities that can be in a relationship. A relationship between two entity sets (a **binary relationship**) can be:

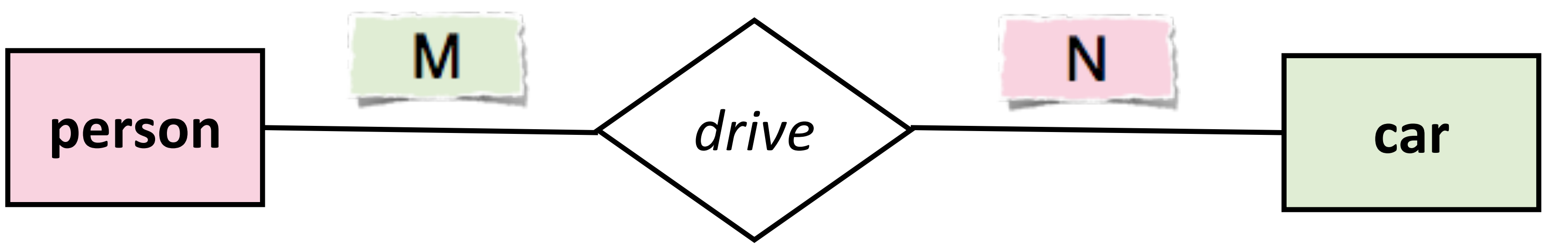
One-to-One. A person can drive 1 car. A car can be driven by 1 person.



One-to-Many. A person can drive **many** (N) cars. A car can be driven by 1 person.

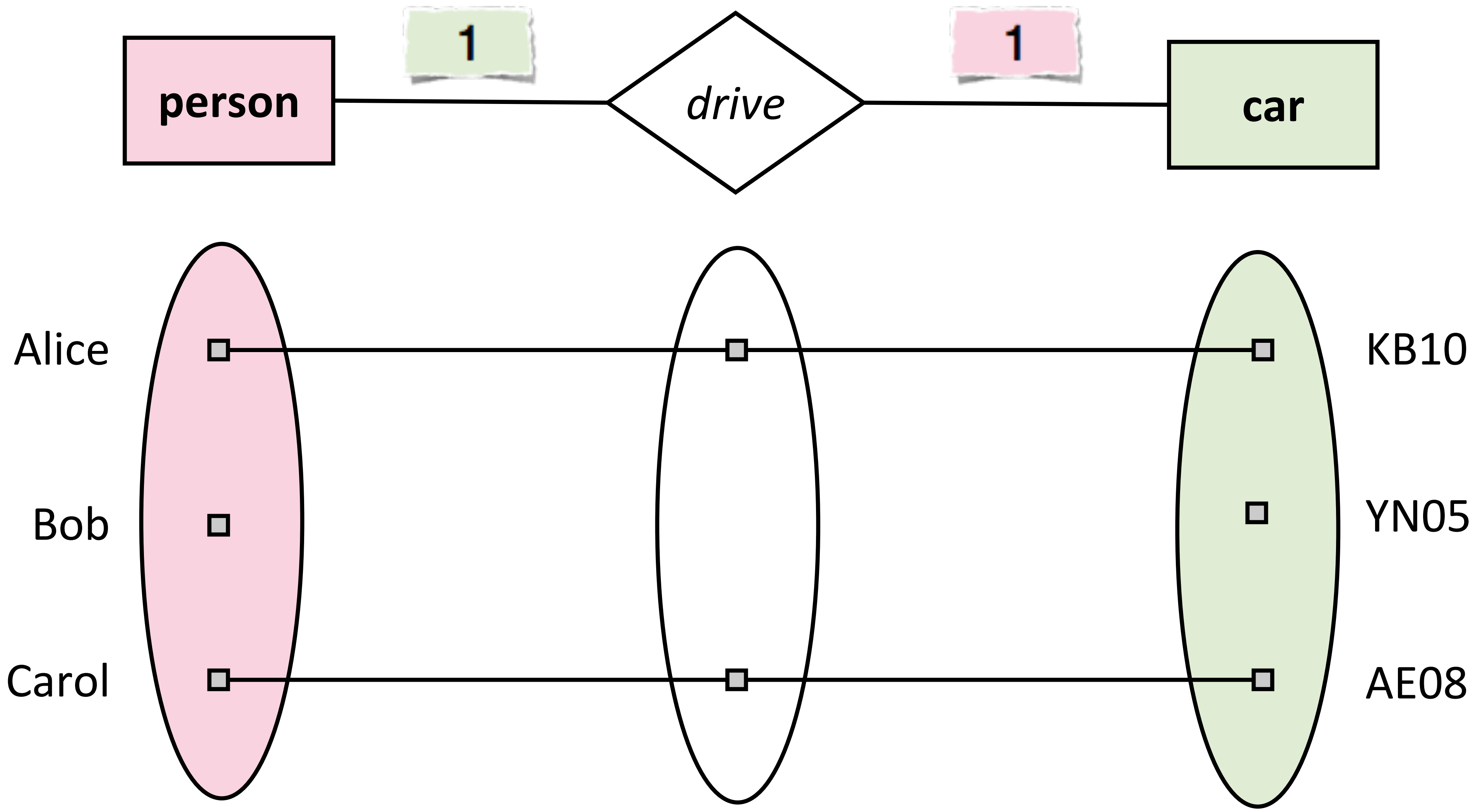


Many-to-Many. A person can drive **many** cars. A car can be driven by **many** people.



One-to-One Relationships

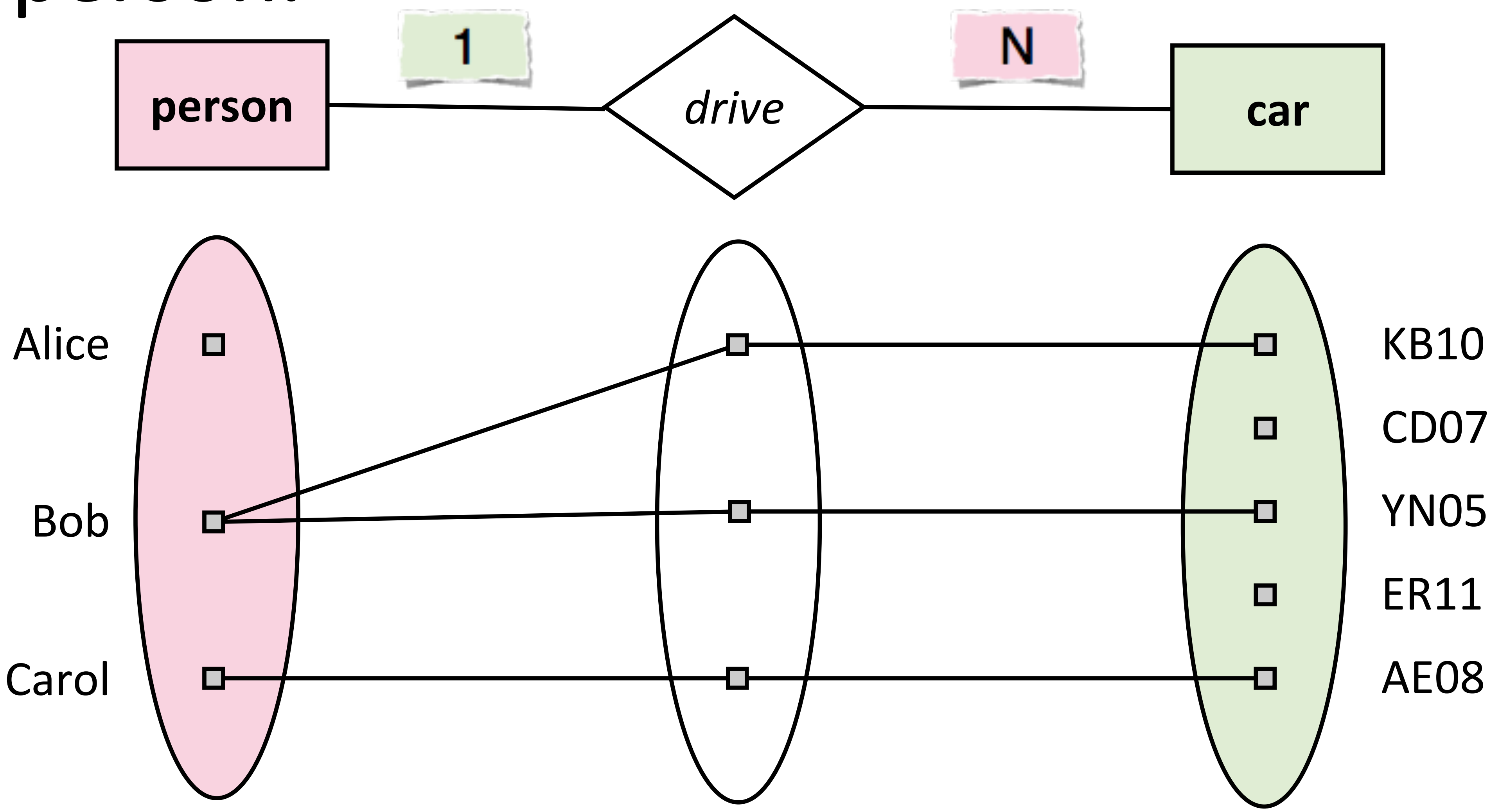
A person can drive 1 car. A car can be driven by 1 person.



There is no requirement for every person or every car to be associated with the *drive* relationship. All relationships in *drive* must be connected to 1 person and 1 car.

One-to-Many Relationships

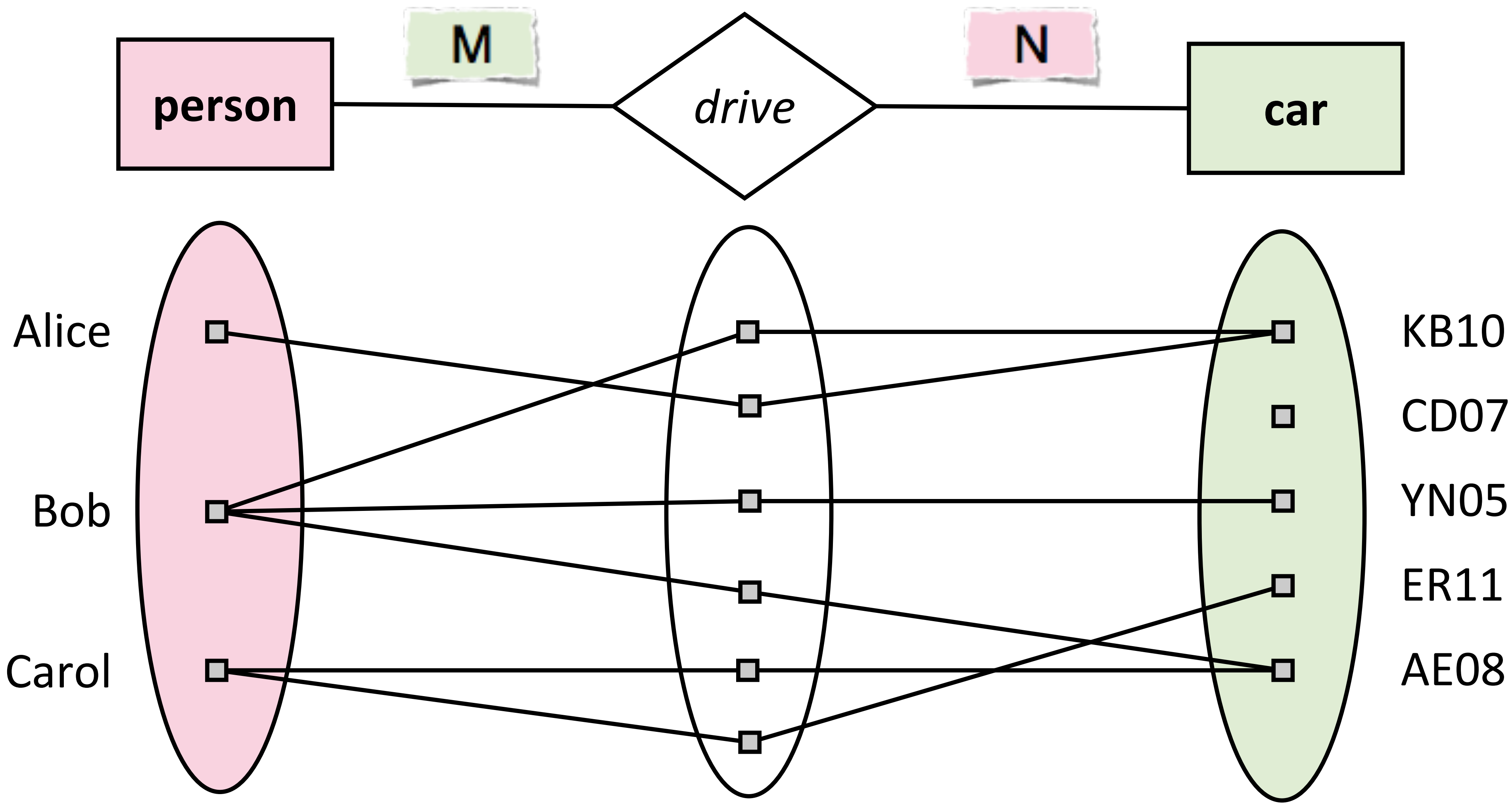
A person can drive **many** cars. A car can be driven by 1 person.



Each person can be in more than one relationship (e.g. 2 for Bob).
However each car can only be in 1 relationship.

Many-to-Many Relationships

A person can drive **many** (N) cars. A car can be driven by **many** (M) people.

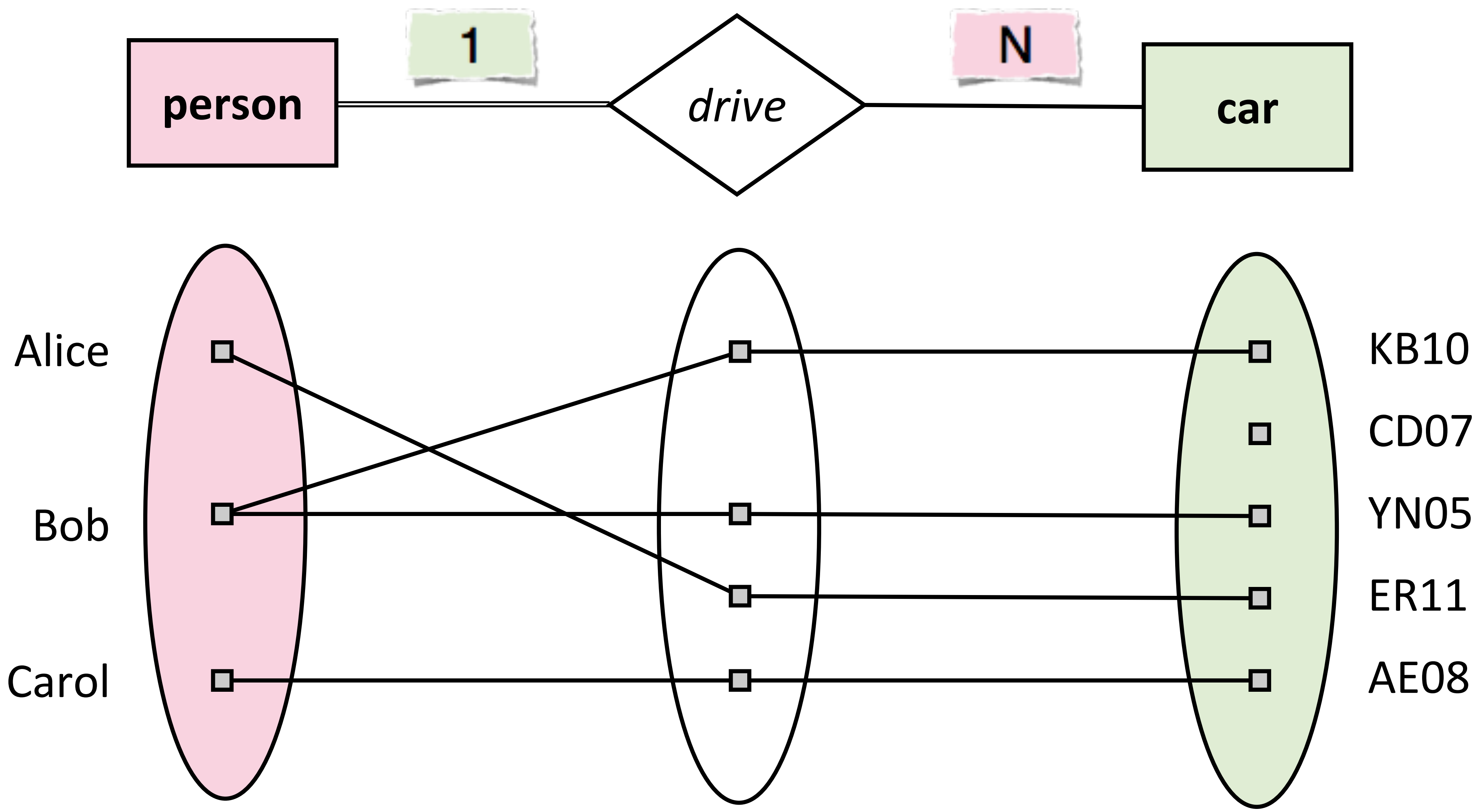


Alice drives 1 car, Bob drives 3 cars, Carol drives 2 cars.

KB10 has 2 drivers, YN05 has 1 driver, ER11 has 1 driver, AE08 has 2 drivers

Entity Set Participation

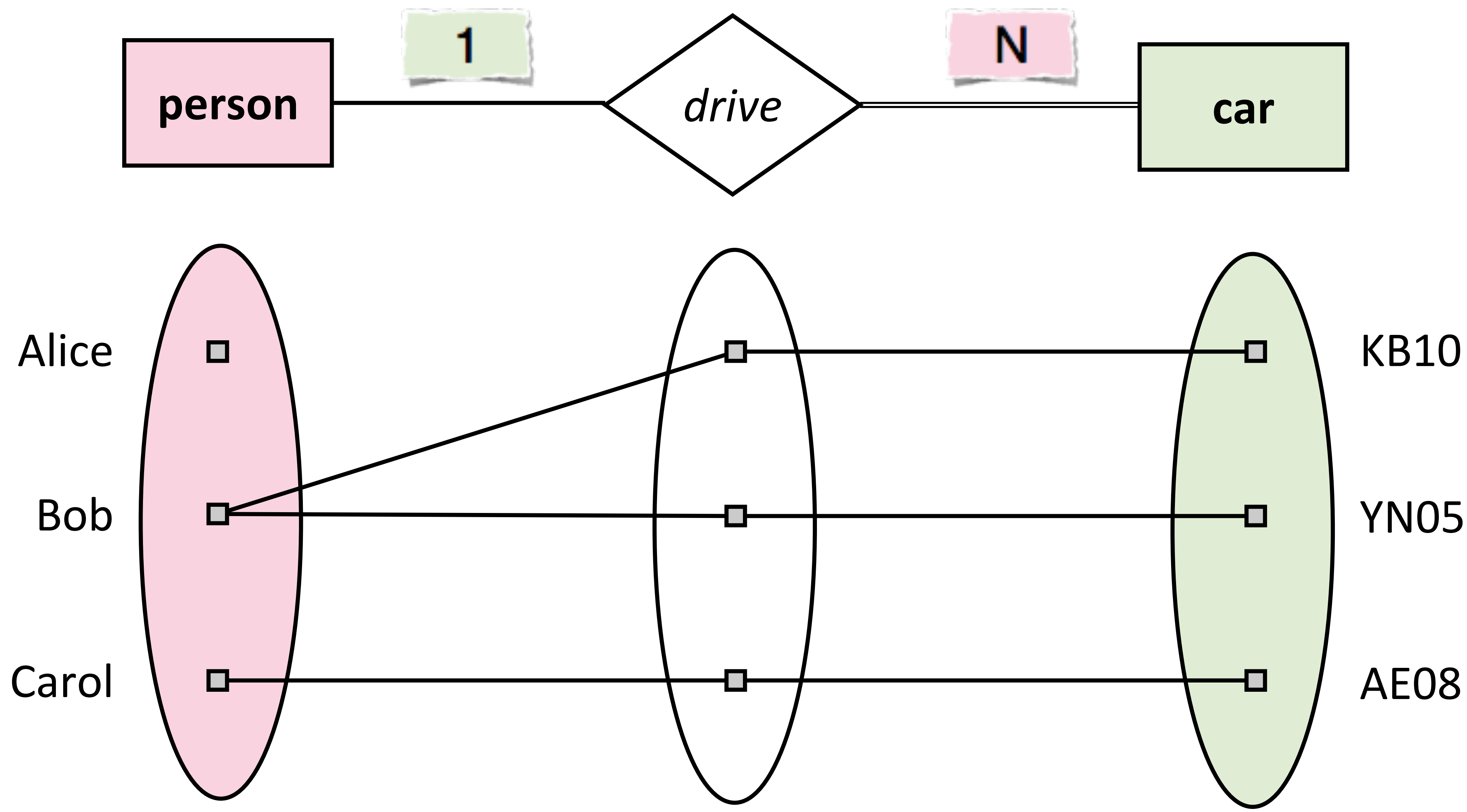
We can indicate that all entities in an entity set must participate in a relationship by using a double line from the entity set to the relationship set. This is called **total participation**.



Every person drives at least one car. A car can have at most 1 driver.

Entity Set Participation

Note the difference with the following:

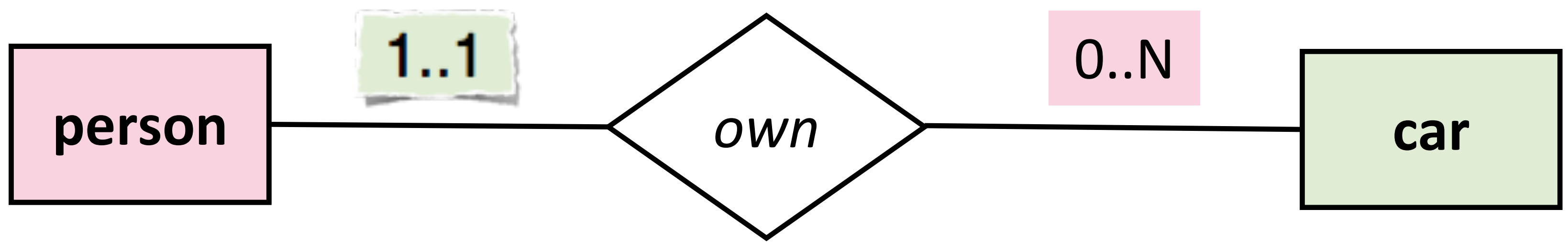


A person can drive many cars including none. Every car must have a driver.

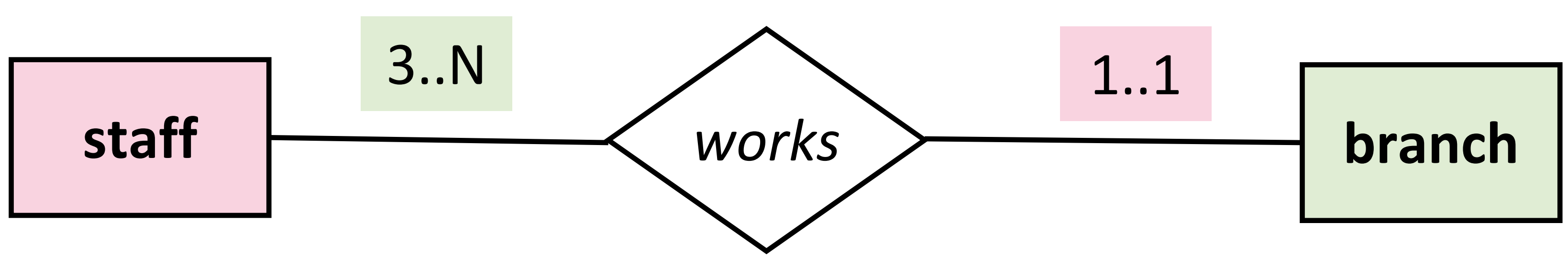
Participation Bounds

Rather than double lines some E-R notations allow explicit bounds on the degree of participation:

People can own 0 or more cars. Every car must have 1 owner.



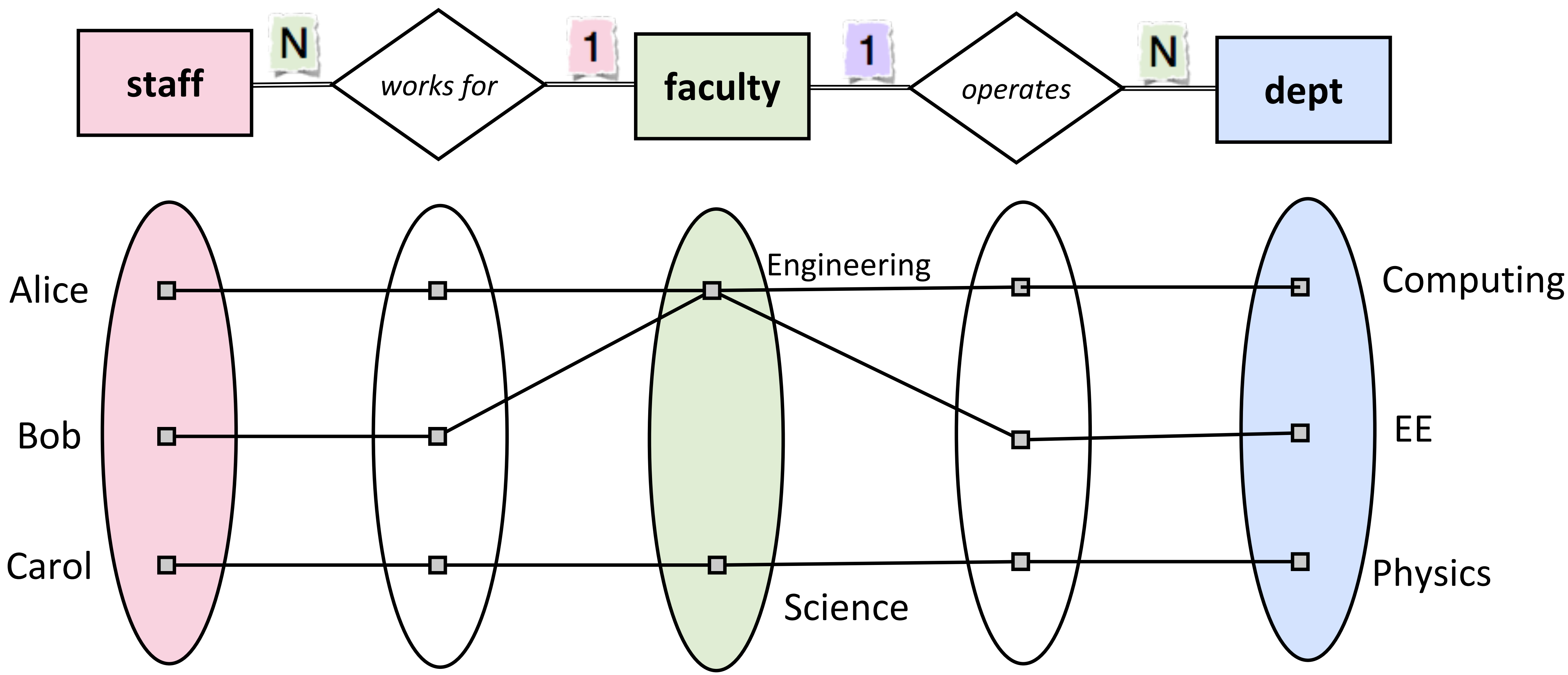
Staff work in 1 branch. Each branch must have at least 3 members of staff.



Note: In some ER notations, cardinality bounds are shown next to the entity set (**look here**) rather than on the other side of the relation (**look there**).

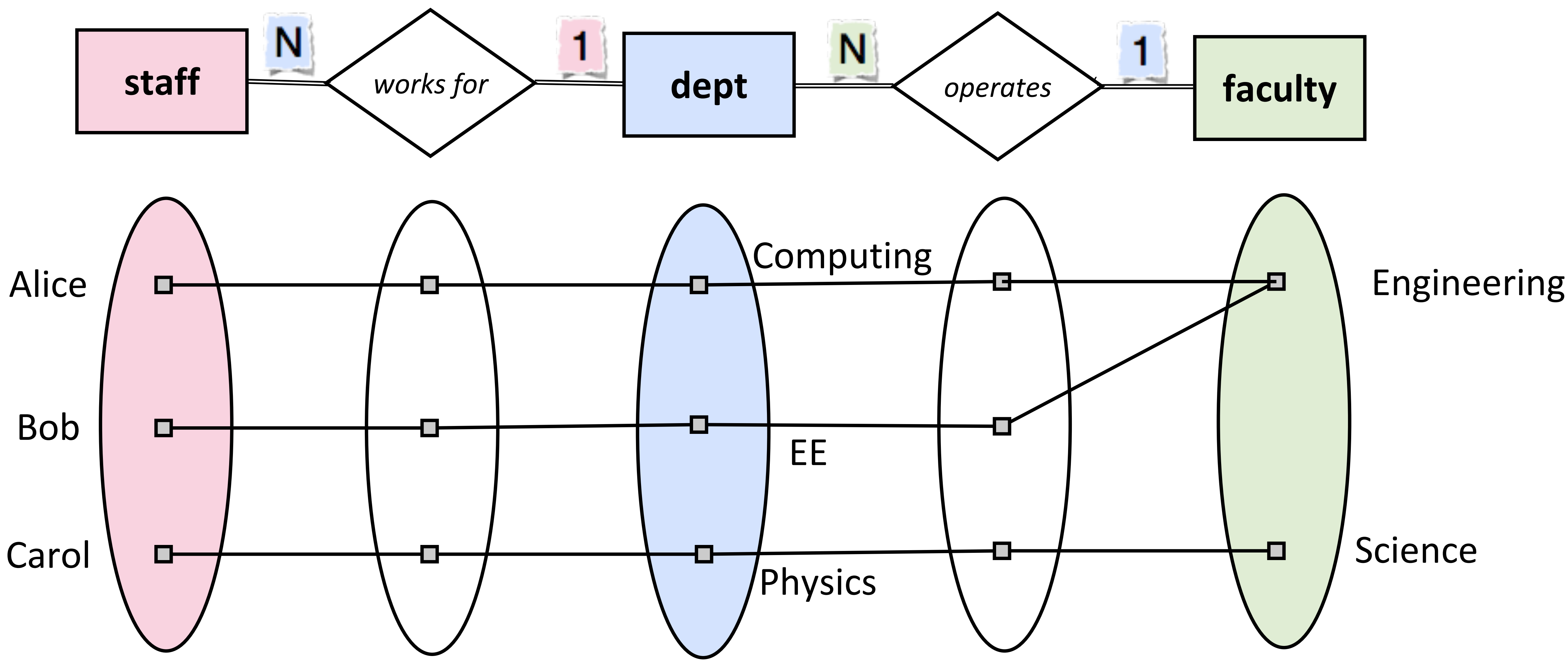
Fan Traps

We need to be careful that the E-R model provides a workable representation of the real world and not allow ambiguous paths between entities - a **fan trap**. Consider:



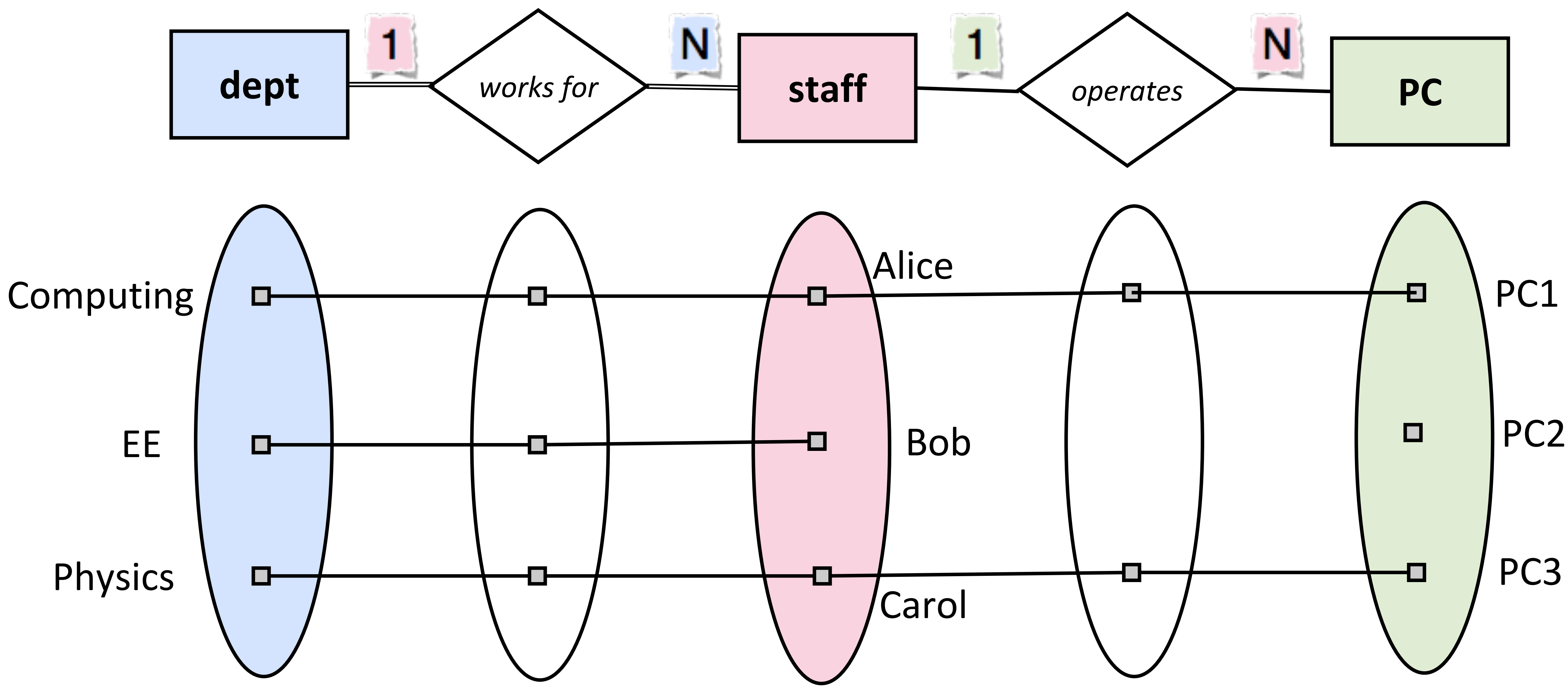
Fan Traps

We could resolve the fan-trap (multiple paths from staff to dept) by changing the structure to:



Chasm Traps

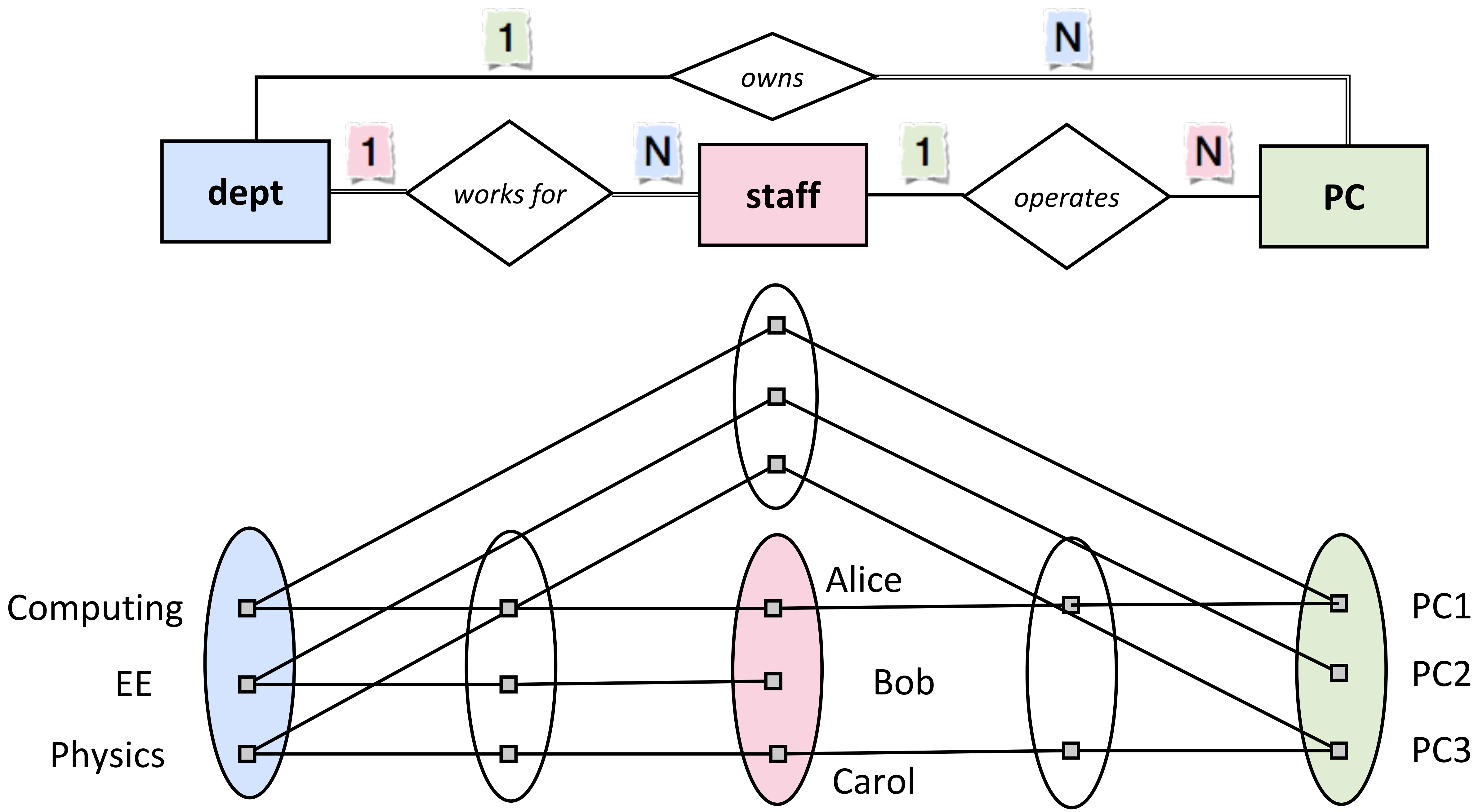
Problems can also occur if the model suggests a relationship between entities but one doesn't exist - a **chasm trap**. Consider the following:



Which Department does PC2 belong to?

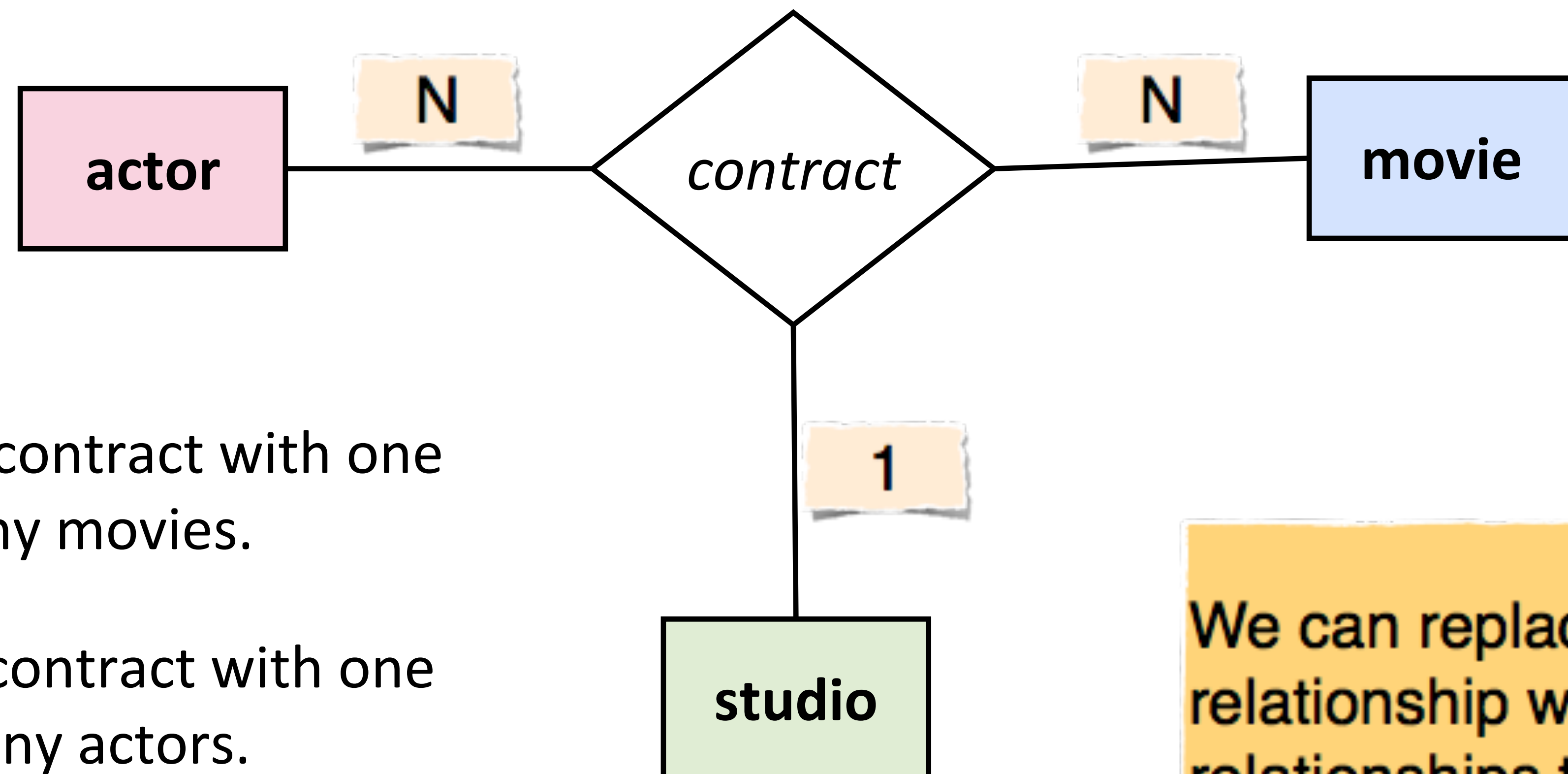
Chasm Traps

We can resolve the chasm trap by adding a relationship between **dept** and **PC**.



Multiway Relationships

Although rarer, a relationship can involve more than two entity sets:



An actor may contract with one studio for many movies.

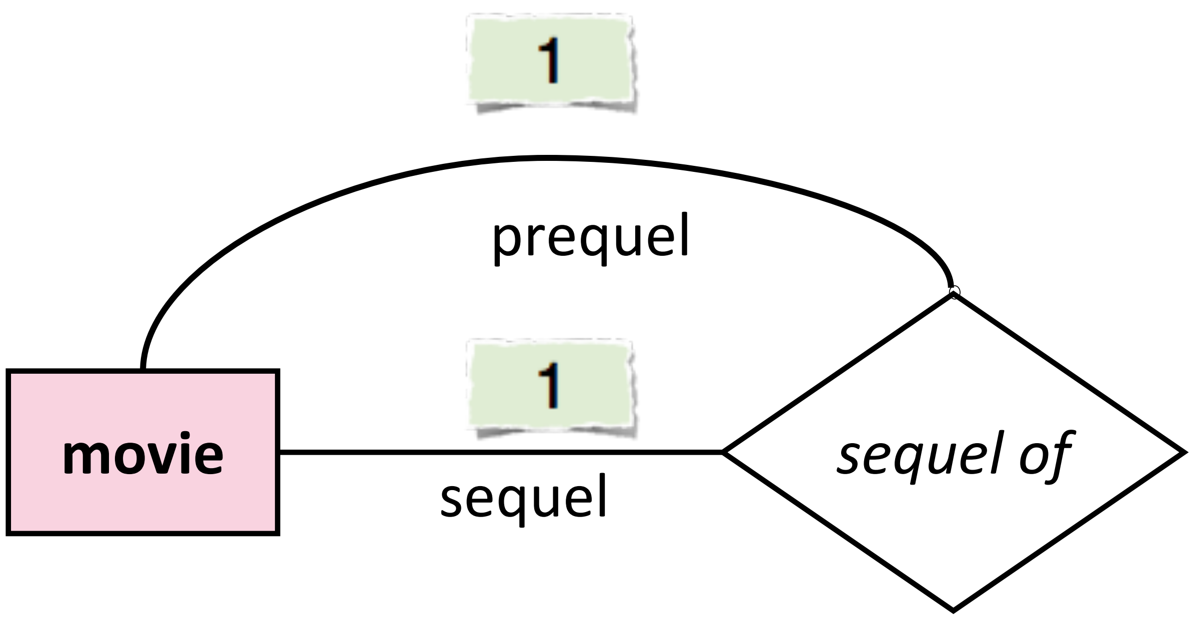
A movie may contract with one studio and many actors.

A studio may contract with many actors for many movies.

We can replace a ternary relationship with 3 binary relationships to a new entity set for the ternary relationship. We can't always translate cardinality constraints, however.

Roles in Relationships

If an entity set plays more than one role in a relationship, then we draw several lines from the entity set to the relationship set and label each line with the role.

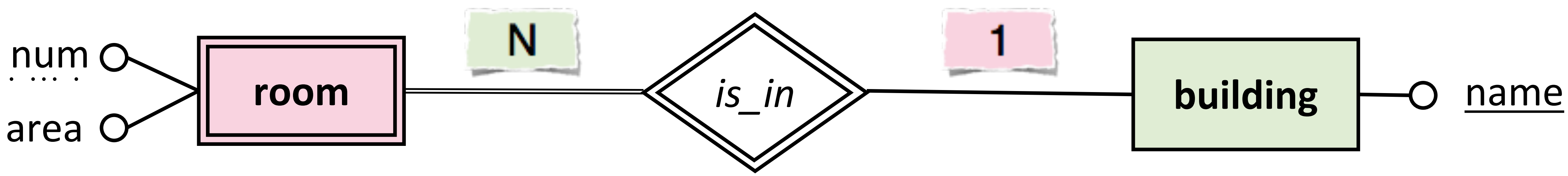


The *sequel of* relationship is between two movies, one of which is a sequel of the other.

A movie can have one prequel and one direct sequel.

Weak Entities

Entities which cannot be uniquely identified using their own attributes are called **weak entities**, in contrast to entities that have a primary key which are known as **strong entities**. A weak entity is dependent on a strong entity for its existence. If a strong entity is deleted, any dependent weak entity would also have to be deleted.

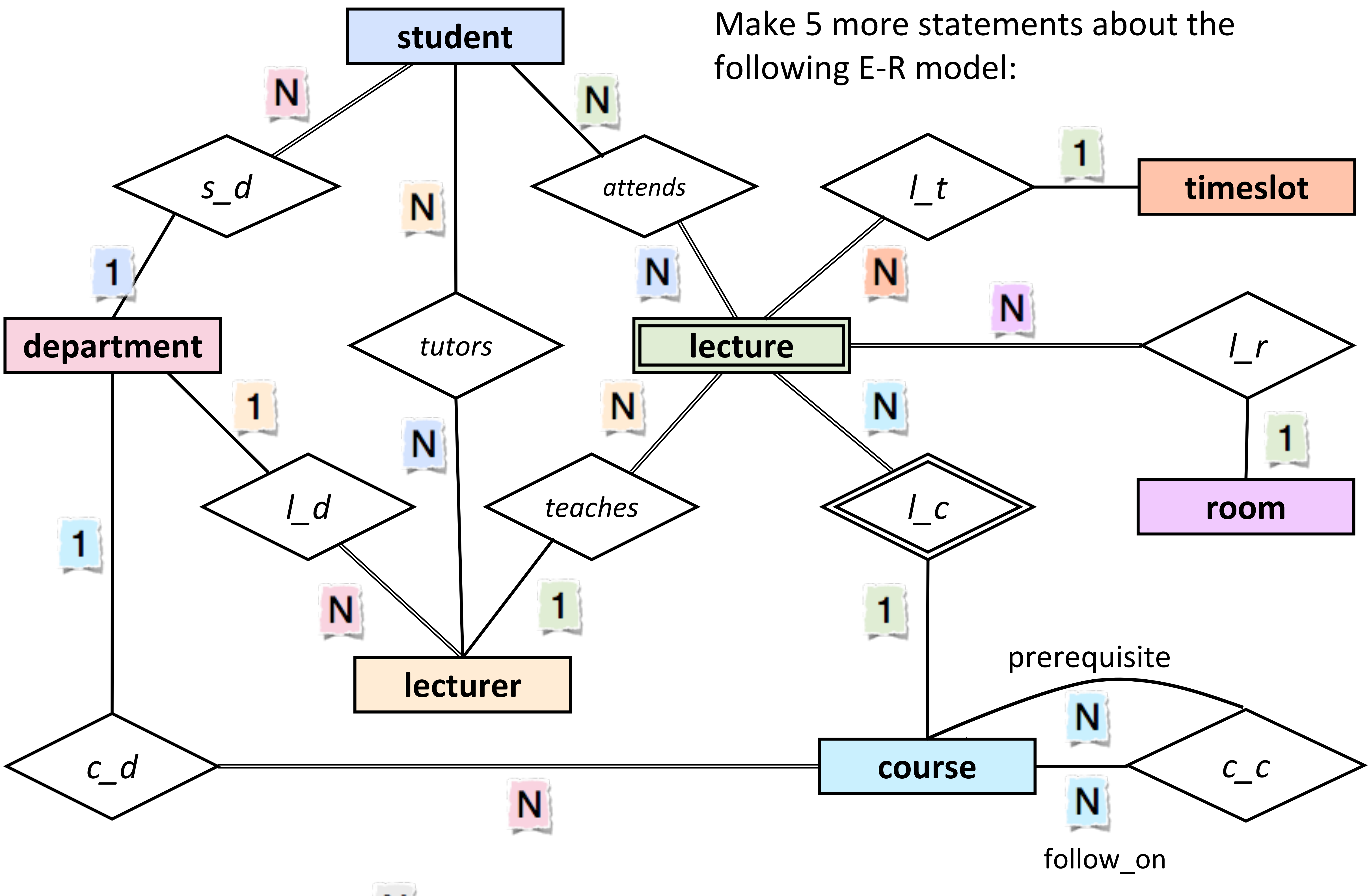


We indicate weak entity sets using a *double rectangle*, and the associated relationship to the strong entity set using a *double diamond*. The primary key for a weak entity set is formed using the primary key of the strong entity and one or more attributes of the weak entity set (shown with a *dashed underline*).

Note: The weak-strong entity relationship is always many-to-one from the weak-entity set to the strong entity set with the total participation of the weak entity set.

Exercise

Make 5 more statements about the following E-R model:



Exercise

Solution

- There are many statements captured by the E-R Diagram, for example:
  - Every student, every lecturer, every course is associated with 1 department.
  - Students can attend many lectures (or none).
  - Every lecture is associated with 1 timeslot, 1 room, 1 course and 1 lecturer, and at least 1 student.
  - Courses can have many prerequisites, many follow-ons and many lectures.

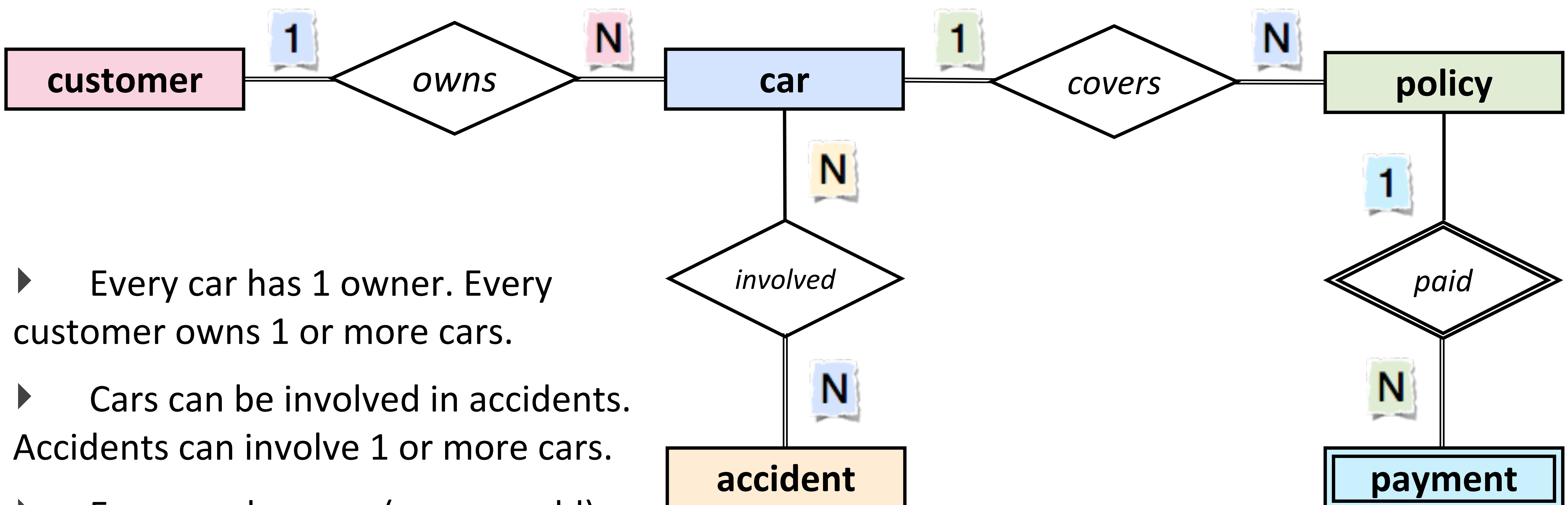
- Departments can have many students (or none).
- Departments can offer many courses or none.
- Lecturers have many tutees or none.
- Students have many tutors or none.
- Rooms can be used for many lectures (or not).
- Each timeslot can be used for a lecture (or not).
- Lectures are dependent on courses - deleting a course should delete the associated lectures.

Exercise

Construct an E-R diagram for a car insurance company where:

- Customers own one or more cars
- Each car can be associated with zero or more accidents.
- Each car insurance policy covers one car and can have several payments.

Solution



- Every car has 1 owner. Every customer owns 1 or more cars.
- Cars can be involved in accidents. Accidents can involve 1 or more cars.
- Every car has one (or more old) policies. Every policy covers 1 car.
- Policies have 0 or more payments. Payments are for 1 policy only.

- Note: In this solution payments are strongly dependent on policies. Deleting a policy deletes its payments! If this is not what's wanted, make payment into a strong entity.