

Exercise 1: Entity-Relationship Model

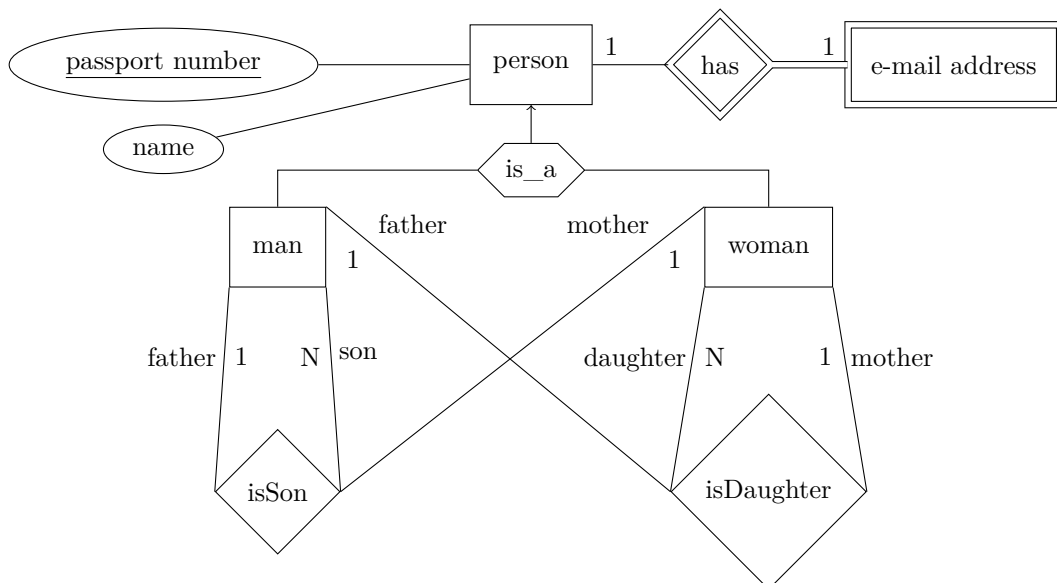
Solution

The exercises marked with * will be discussed in the exercise session. You can solve the other exercises as practice, ask questions about them in the session, and hand them in for feedback. **All exercises may be relevant for the exam.**

Ask **Ingo** (ingo.mueller@inf.ethz.ch) for feedback on this week's exercise sheet or give it to the TA of your session (preferably stapled and with your e-mail address).

1 Understanding Entity-Relationship Models*

Consider the following entity-relationship (ER) model.



For each of the following groups of statements, pick the one that coincides best with the model.

1. A. Each person has at least one e-mail address.
 B. Each person has at most one e-mail address.
 C. Each person has exactly one e-mail address.
 D. None of the above is true.

Explanation: A relation, even of type 1:1, *optionally* connects entities. If it is weak, only the weak entity needs to participate in such a relation. Since person is not the weak entity here, a person may not have an e-mail address. However, due to the cardinalities, each person may have at most one e-mail address.

2. A. Each e-mail address belongs to at least one person.
 B. Each e-mail address belongs to at most one person.
 C. Each e-mail address belongs to exactly one person.
 D. None of the above is true.

Explanation: The e-mail entity is the weak entity of the has relationship, so it must participate in this relationship. Furthermore, the cardinalities restrict it to participate at most once (as with any weak entity).

3. A. Each person has at least one passport number.
 B. Each person has at most one passport number.
 C. Each person has exactly one passport number.
 D. None of the above is true.

Explanation: Each entity has exactly one value for each attribute.

4. A. Each man has at least one father.
 B. Each man has at most one father.
 C. Each man has exactly one father.
 D. None of the above is true.

Explanation: Entities may or may not participate in relationships, so a man may not have a father. Furthermore, the same man entity can participate several times as son in the isSon relationship as long as it is with a different father *and* a different mother. This is because the 1:1:N cardinality of the isSon relationship only limits the number of man entities in the role of father to 1, *given a man entity in the son role and a woman entity*.

For each of the following statements, say whether it is true or false in the model.

5. Each passport number belongs to at most one person. ☒ **True** ☐ **False**

Explanation: Passport number is the key of the person entity, so each passport number is unique and used only by one person.

6. There are no two persons with the same name. ☐ **True** ☒ **False**

Explanation: Name is not a key of the person entity, so its values are not restricted and can occur multiple times.

7. Each person who is not a man is a woman. ☐ **True** ☒ **False**

Explanation: In this ER model, a person can be neither a man nor a woman. In general, there may be entities of the general entity type of a generalization.

8. Each person who is a man is not a woman. ☐ **True** ☒ **False**

Explanation: In this ER model, a person can be both a man and a woman at the same time. In general, an entity of the general entity type of a generalization may also be an entity of multiple different specializations. In other words, the definition of generalization in ER says that the set of entities of each special type (here: “man” and “woman”) is a subset of the entities of the general type (here: “person”), but it does not say anything about whether the subset of the special types overlap or not. (It also does not require that each entity of the general type is an entity of one of the special types.)

9. Each woman is a person. ☒ **True** ☐ **False**

Explanation: By definition of “is-a”.

10. A man can be his own father. ☒ **True** ☐ **False**

Explanation: There is no constraint that prevents the same man entity to participate both in the man role and in the son role in the isSon relationship.

11. If a woman has a father, she also has a mother. ☒ **True** ☐ **False**

Explanation: In an isDaughter relationship, there is always exactly one woman entity in the mother role, one woman entity in the daughter role, and one man entity in the father role.

12. Each man is a father. ☐ True ☒ **False**

Explanation: A man entity may or may not participate in the isSon relationship (in either role).

13. Each father is a man. ☒ **True** ☐ False

Explanation: Only man entities can take the father role of the isSon relationship.

14. Each son is a man. ☒ **True** ☐ False

Explanation: Only man entities can take the son role of the isSon relationship.

15. Each woman has at least one daughter. ☐ True ☒ **False**

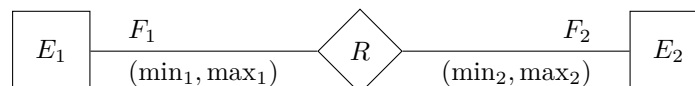
Explanation: A woman entity may or may not participate in the isDaughter relationship (in either role).

16. Each woman has at most one daughter. ☐ True ☒ **False**

Explanation: The 1:1:N relationship allows a woman entity arbitrarily many participations in the mother role, for example each time with a different woman entity in the daughter role (or with the same daughter, but a different father).

2 Cardinalities in Min/Max Notation*

Consider the following ER model where the two notations of cardinalities from the lecture are superposed: F_1 and F_2 represent numbers in the notation of functionalities whereas (\min_i, \max_i) follows the (\min, \max) notation.



For the given cardinality in the form " $F_1 : F_2$ ", give the equivalent cardinality in the min/max notation by completing the following table.

$F_1 : F_2$	(\min_1, \max_1)	(\min_2, \max_2)
1 : 1	(0, 1)	(0, 1)
1 : N	(0, *)	(0, 1)
N : 1	(0, 1)	(0, *)
N : M	(0, *)	(0, *)

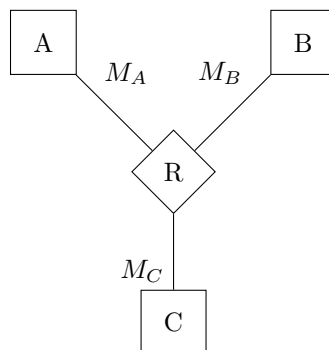
Explanation: This table makes it clear that the two notations have to be read “the opposite way”. Let us look closely at what the “1” means in the case of “1 : N ”. In the notation of the cardinalities, it means that there is *one* E_1 for each entity E_2 . We write the “1” *on the side of* E_1 (and not on the side of E_2). This is because, in relationships with more than two entities, a “1” means that there is *one* E_1 for each set of *the other entities* (see discussion of next question). In order to express the “1” in the min/max notation, we can only limit the number of occurrences of each entity in isolation. In the example of the exercise, we have to say that E_2 can occur at most once, which implies the fact that there can be at most one E_1 for that E_2 . This is written as “ $(\min_2, \max_2) = (0, 1)$ ” *on the side of* E_2 (since it is the entity we put the limit on).

Can you establish such an equivalence for ternary relationships?

Solution: No, you cannot. Consider the seminar example from the lecture: the entity types “student”, “professor”, and “topic” are in a N:1:1 relationship “supervise”. The “1” for the topic entity type means that, given an entity of type professor and an entity of type student, there is at most one entity of type “topic” (i.e., a student can only take one topic with a professor). You may be tempted to express this as $(0, 1)$ in the min/max notation, which would mean that each topic can be supervised at most once. However, in the N:1:1 relationship “supervise”, each topic entity may participate several times—just not with the same student. In the min/max notation, there is no way to express a N:1:1 relationship exactly. At the same time, other situations may only be expressible using the min/max notation, so we may need both depending on what we want to do.

3 Cardinalities on Ternary Relationships

Consider the following entity-relationship (ER) model, where the cardinalities of relationship R are given as variables M_A , M_B , and M_C . For example, if $M_A = M_B = M_C = 1$, then R is a 1:1:1 relationship.



The table below shows entities of type A, B, and C respectively that are connected through relationship R. For example, the first tuple $\langle m, o, x \rangle$ indicates that entity m of type A, entity o of type B, and entity x of type C are connected through R.

We are now interested in the question which are valid sets of tuples for R with different cardinalities M_A , M_B , and M_C .

For each assignment of cardinalities in the table, select a maximal subset of tuples that form a valid set R . Select a tuple by adding a checkmark to the corresponding cell. If a tuple cannot be in R , write down the number of the tuple with which it conflicts.

tuple number	tuple			$\langle A, B, C \rangle \in R$ for given cardinality?			
				$M_A = N$ $M_B = M$ $M_C = O$	$M_A = 1$ $M_B = N$ $M_C = M$	$M_A = 1$ $M_B = 1$ $M_C = N$	$M_A = 1$ $M_B = 1$ $M_C = 1$
	A	B	C				
1	m	o	x	✓	✓	✓	✓
2	n	o	z	✓	✓	✓	✓
3	m	q	y	✓	✓	✓	✓
4	n	p	z	✓	✓	2	2
5	n	o	x	✓	1	1	1
6	m	q	z	✓	✓	✓	3

Explanation:

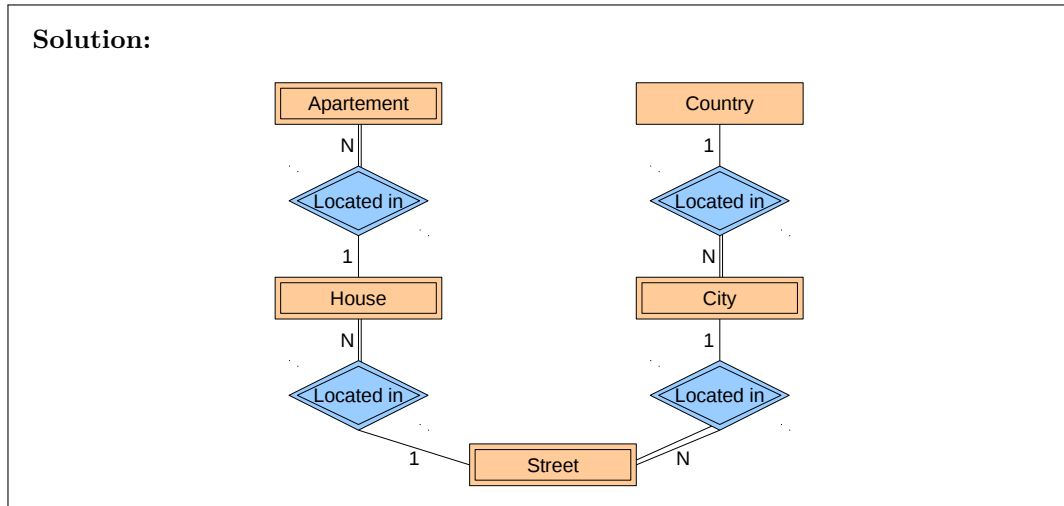
We fill the table column by column:

- $M_A = N, M_B = M, M_C = O$: If we take two entities out of the three entity types A, B, or C, there can be N tuples in R with these two entities. This means that any set of tuples is allowed for R (but it must be a set), so we select all tuples.
- $M_A = 1, M_B = N, M_C = M$: For any two entities of types B and C respectively, there may only be a single entity of type A; and there are no other constraints. However, entity o of type B and entity x of type C participate in R with entities m and n of type A, so we can only select one of the two (we select tuple 1).
- $M_A = 1, M_B = 1, M_C = N$: We have the same constraint on entities of type A as before, so we can only select the tuples that we selected previously. Additionally, for any two entities of types A and C respectively, there may only be a single entity of type B. Since entity n of type A and entity z of type C participate in R with entities o and p of type B, we can only select one of them (we select tuple 2).
- $M_A = 1, M_B = 1, M_C = 1$: We have the same constraint on entities of types A and B as before, so we can only select the tuples that we selected previously. Additionally, for any two entities of types A and B respectively, there may only be a single entity of type C. Since entity m of type A and entity q of type B participate in R with entities y and z of type C, we can only select one of them (we select tuple 3).

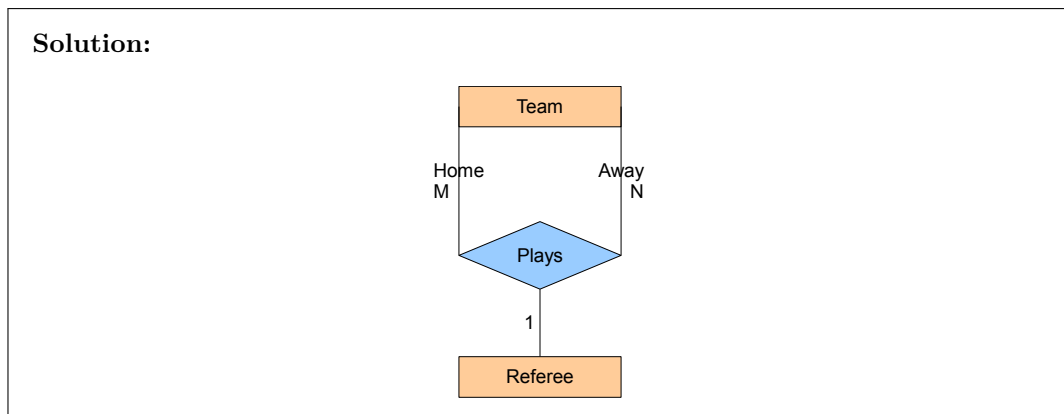
4 Modelling Miniworlds: Getting Started*

Model the following relationships in ER.

1. An apartment is located in a house in a street in a city in a country.



2. Two teams play football against each other. A referee makes sure the rules are followed.

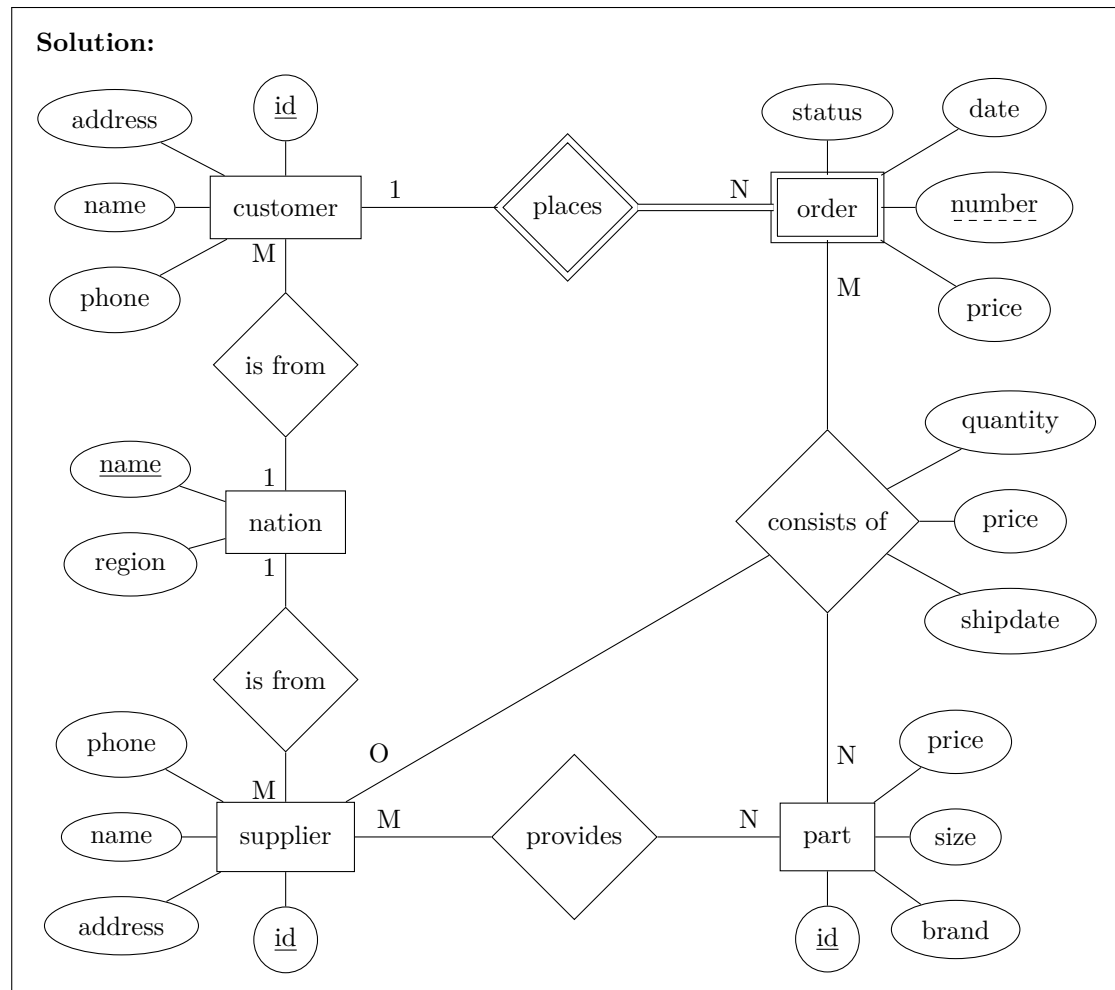


5 Miniworld: International Wholesale Supplier*

Model the following miniworld of an international wholesale supplier in ER. Identify the keys and give the functionalities of all relationships (e.g. 1:1, N:1, N:M)

The wholesale supplier has customers that place orders, which are placed on a particular date and have a total price, current status, and an order number (starting from 1 for each customer). In each order, a customer can order several parts (products), each in a different quantity and at a (possibly discounted) price. We also want to model the date on which each of the parts has been sent. The parts are provided by suppliers. Each part may be provided by several suppliers

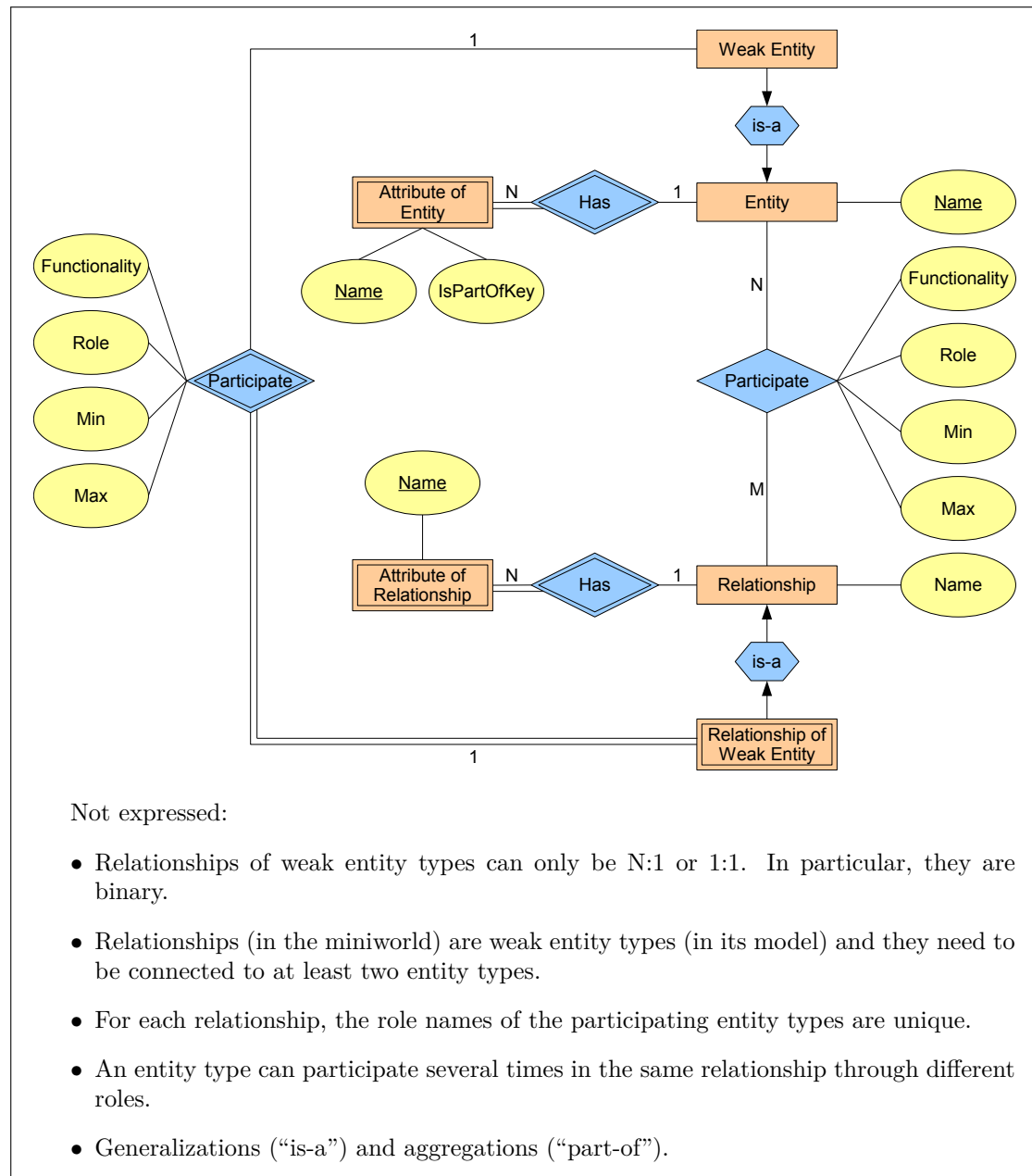
and customers may order the same part of different suppliers in the same order, but in this case, they may have different (retail) prices. Customers and suppliers have a name, an address, a phone number, and a customer/supplier number and they come from a certain nation, which in turn is from a particular region (of the world). Parts have a brand, a size, and a retail price.



6 Miniworld: Entity-Relationship Model*

Model ER in ER.

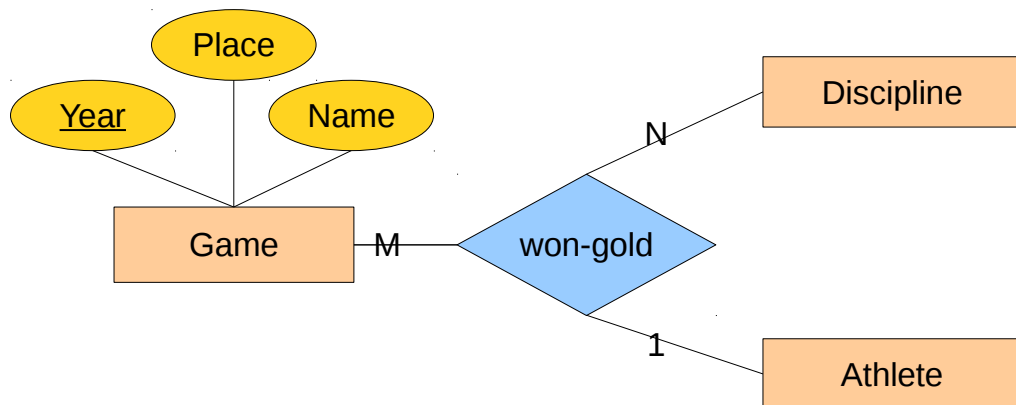
Solution:



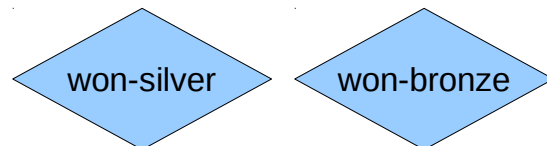
7 Miniworld: Olympics

Olympic games happen in a certain year at a certain place. Each year, there is at most one instance of Olympic games. In each discipline of an olympic game, there is exactly one gold medalist, one silver medalist, and one bronze medalist. All these medalists are athletes. Give an ER model for this mini world. Identify the keys and give the functionalities of all relationships.

Solution:



Same relationship for:



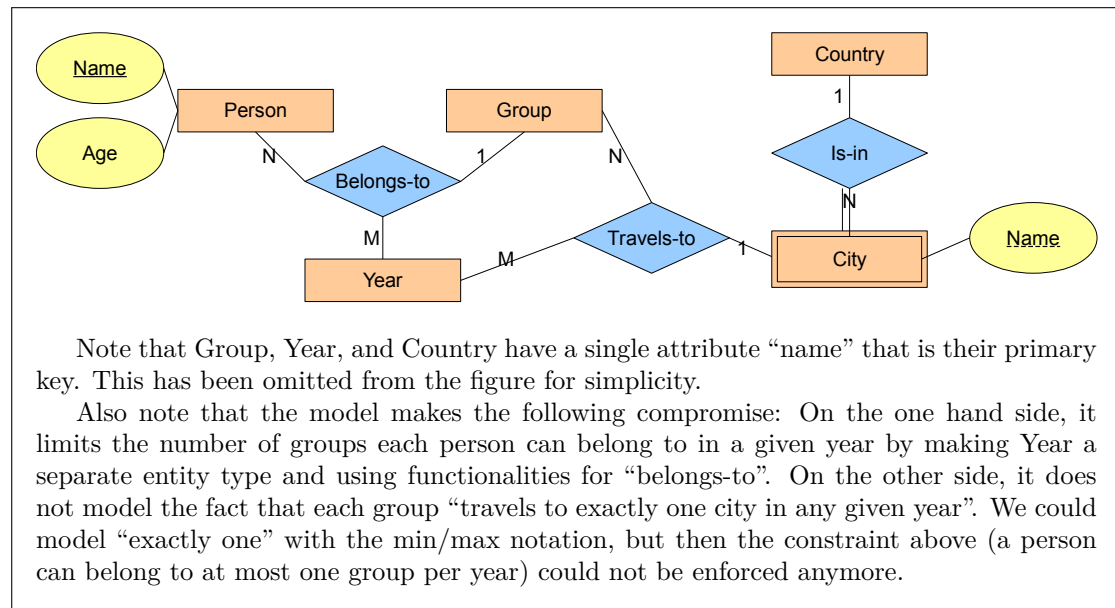
Some remarks:

- Note that if the key of Game would be based on year *and* place, the requirement that there is at most one event per year would be violated.
- The way the medalists are modeled is by creating three ternary relationships for Gold, Silver, and Bronze medals each (from which we pictured only one). While this solution fulfills the requirements, it also allows for the same athlete to win three medals in the same discipline. Can you find a more “elegant solution” without losing any constraints?

8 Miniworld: Travelling

Consider the following mini-world. A person has a name and an age. Cities have a name and are located in a country. Every year, persons can form groups in order to travel together to a city. A person may be part of the same or a different group in different years, but may be part of at most one group in any given year. Furthermore, a group travels to the same or different city in different years, but travels to exactly one city in any given year. Give an ER model for this mini-world. Identify the keys and give the functionalities of all relationships (e.g. 1:1, N:1, N:M).

Solution:



9 Miniworld: Library System

Assume there is a library system with the following properties. The library contains one or several copies of the same book. Every copy of a book has a copy number and is located at a specific location in a shelf. A copy is identified by the copy number and the ISBN number of the book. Every book has a unique ISBN, a publication year, a title, an author, and a number of pages. Books are published by publishers. A publisher has a name as well as a location. Within the library system, books are assigned to one or several categories. A category can be a subcategory of exactly one other category. A category has a name and no further properties. Each reader needs to provide his/her family name, his/her first name, his/her city, and his/her date of birth to register at the library. Each reader gets a unique reader number. Readers borrow copies of books. Upon borrowing the return date is stored. Create an ER diagram of this library system.

Solution:

