Block 2
BASIC E/R DESIGN
(PART 2)

Debora Gil, Oriol Ramos, Alejandro Párraga, Carles Sánchez

Basic ER Design Contents

1. E-R Model Introduction

2. Basic Structures

    2.1 Entities

    2.2 Attributes

    2.3 Relationships

3. Relationships Features

    3.1 Cardinality
    3.2 Degree
    3.3 Participation

Basic ER Design Contents (Part II)

1. E-R Model Introduction

2. Basic Structures

   2.1 Entities

   2.2 Attributes

   2.3 Relationships

3. Relationships Features

   3.1 Cardinality

   3.2 Degree

   3.3 Participation

2. Basic Structures

2.3 Relationships

2.3 Relationships

Definition

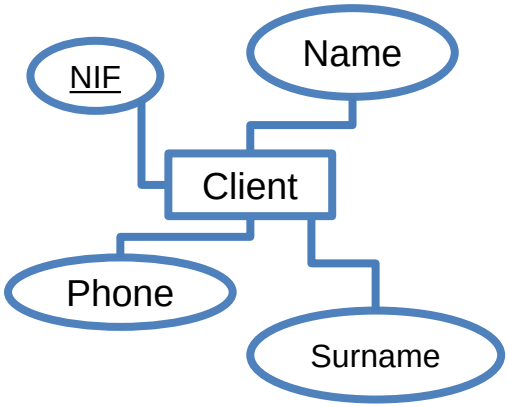
Association between different related entities instances. They are represented by rhombuses

Each instance of the relationship is defined by the values of the PKs of the associated entities instances

Relationships NEVER have PKs (they are already uniquely defined by the PKs of the two related instances)

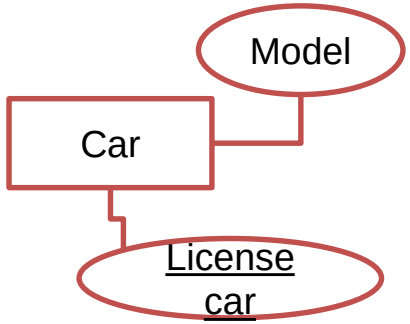
Client

NIF	Name	Surname	Phone
3676373L	Peio	Artola	938373893
4748474P	Dani	Alves	617232066
1233399Q	Alex	Morera	617188819
...	...	...	...



Car

Model	License car
Ka	3090 BKJ
Focus	7839 JKH
Escort	6677 PPL
...	...



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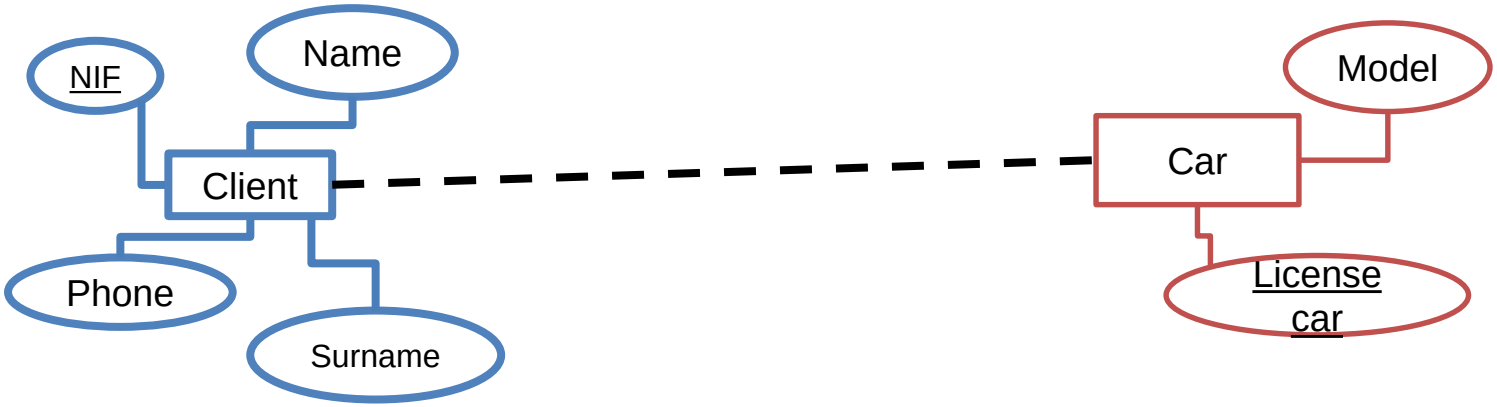

Correlation with the real world:

Relationships are correlated with the real world

Client

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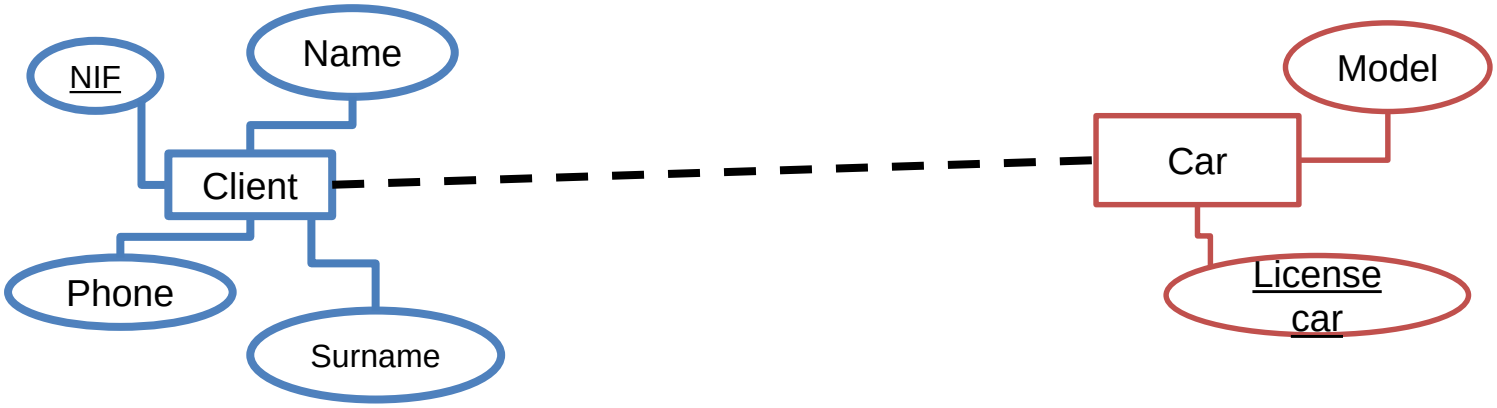

Real World:

- Peio Artola buys a Ka with license 3090 BKJ
- Dani Alves buys a Focus with license 7839 JKH and an Escort with license 6677 PPL
- ...

Symbolic representation:

Relationships are represented by rhombuses

Client

NIF	Name	Surname	Phone
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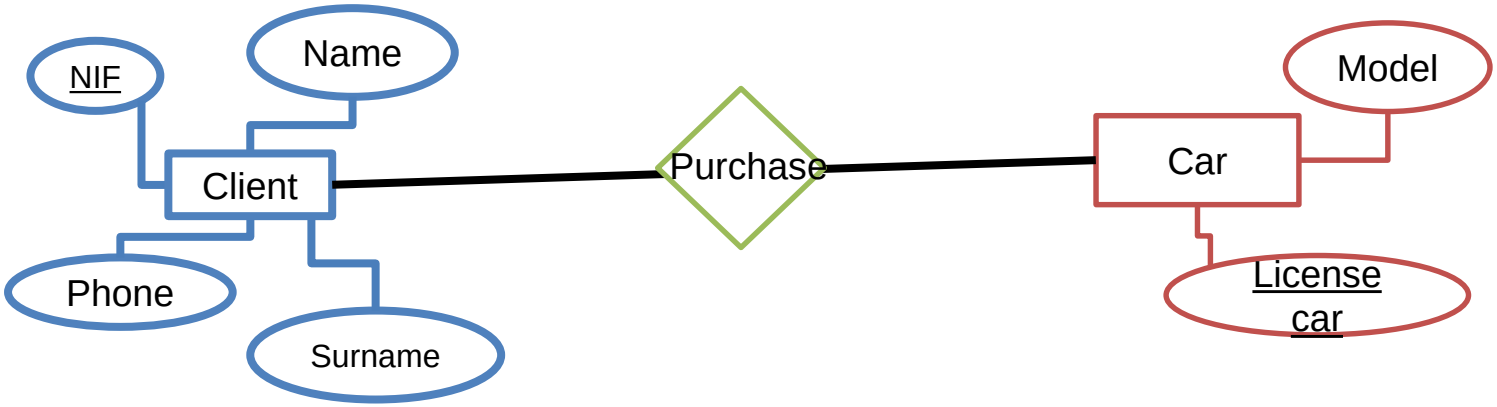

Real World:

- Peio Artola buys a Ka with license 3090 BKJ
- Dani Alves buys a Focus with license 7839 JKH and an Escort with license 6677 PPL
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Relationship Attributes:

Sometimes it may be appropriate to associate attributes with relationships in themselves ...

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NIF	Name	Surname	Phone
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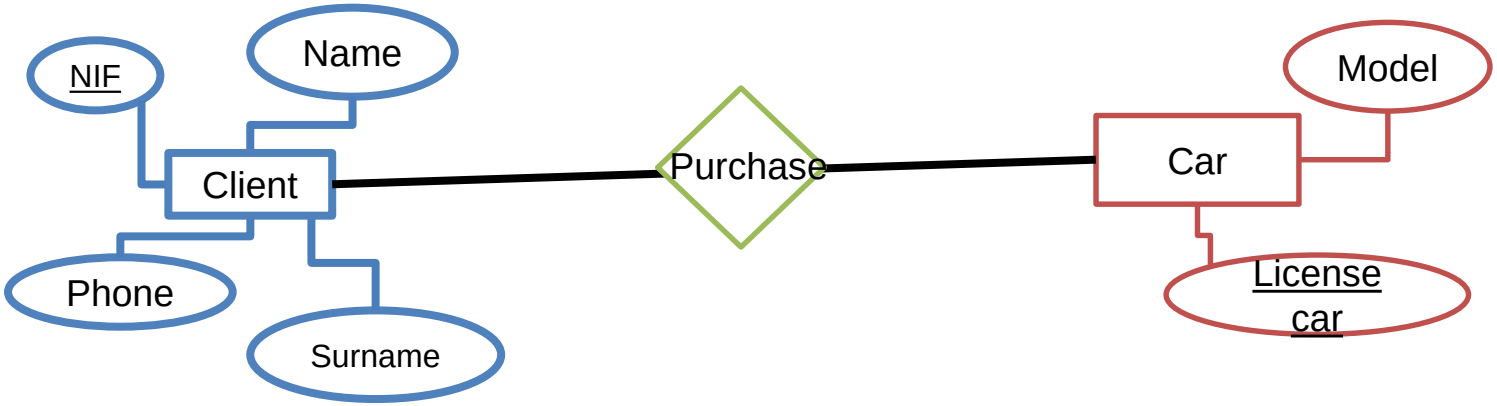

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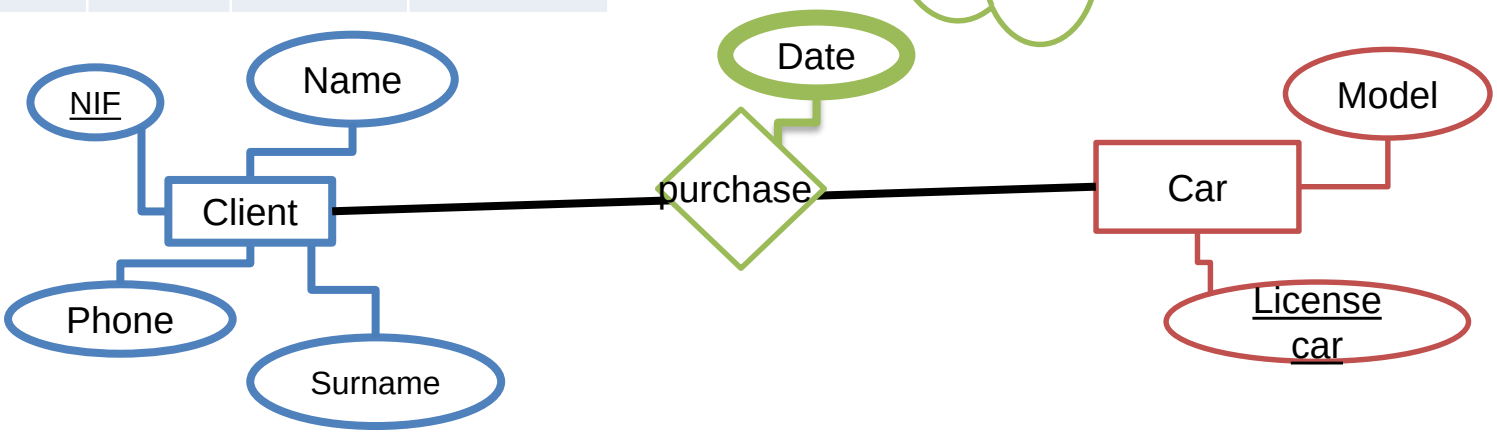
4748474P	Dani	Alves	617232066
1233399Q	Alex	Morera	617188819
...	...	...	...

Jan 25, 2015
June 18, 2016
Sept 24, 2016

Car

Model	License car
Ka	3090 BKJ
Focus	7839 JKH
Escort	6677 PPL
...	...



Real World:

- Peio Artola buys a Ka with license 3090 BKJ **on 25/01/2015**
- Dani Alves buys a Focus with license 7839 JKH **on 18/06/2016**
- and an Escort with license 6677 PPL **on 24/09/2016**
- ...

Relationship Primary Key (PK)

Relationships NEVER have PKs (they are already uniquely defined by the PKs of the two related instances)

Client

NIF	Name	Surname	Phone
3676373L	Peio	Artola	938373893
4748474P	Dani	Alves	617232066
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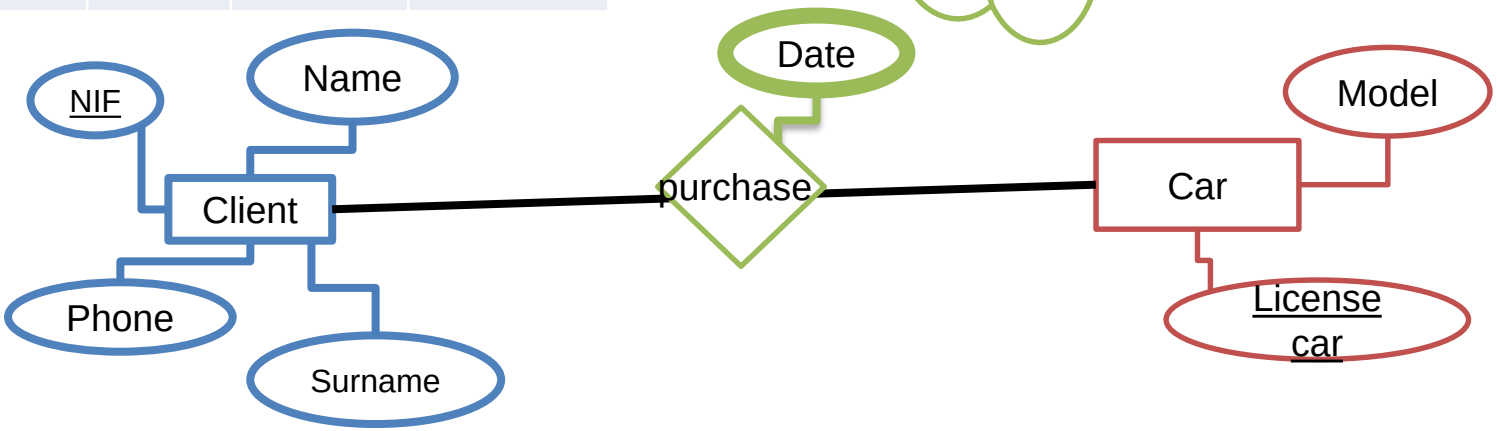

Real World:

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- Dani Alves buys a Focus with license 7839 JKH **on 18/06/2016**
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- ...

Examples

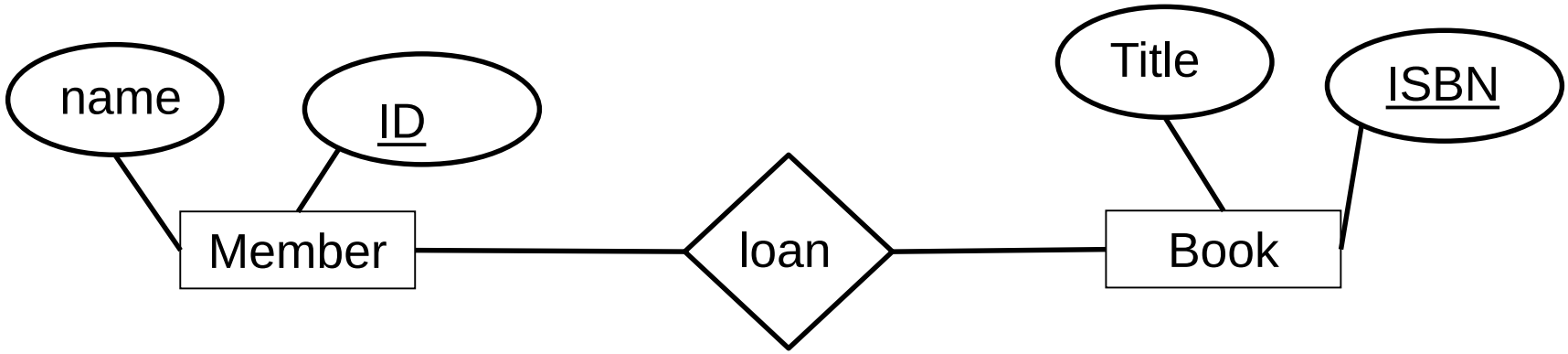
Example 1.
Information contained in the relationship

Library

We want to manage a library network loans and know the free copies.
From a book we want to save the ISBN and the title.
From a member we want to save name and ID.
We want to know what books each member has.

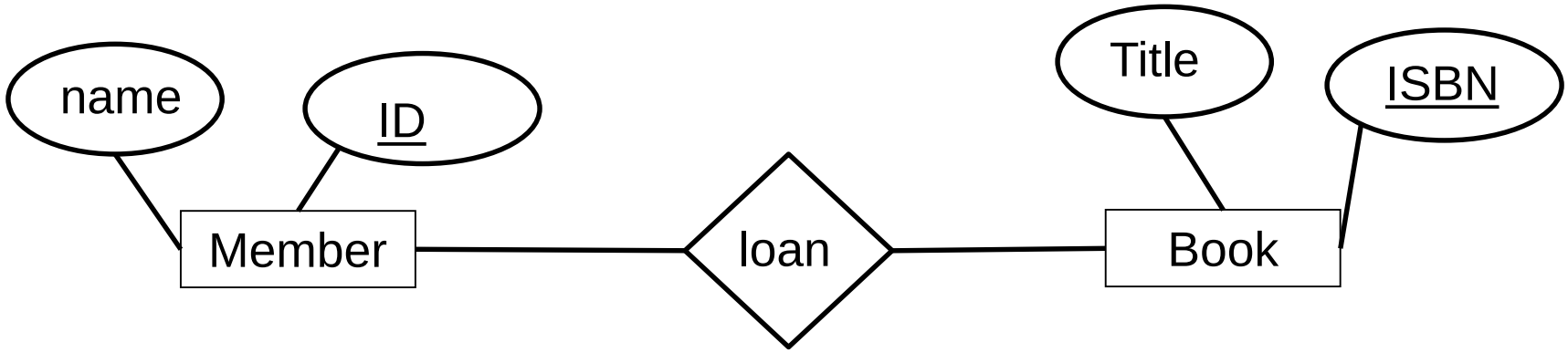
Entities??
Relationships??
Attributes??

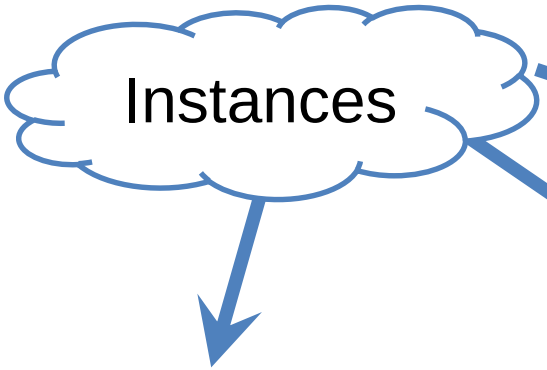
Example 1. Information contained in the relationship



Entities: Member, book
Relationship: Book loan

Example 1. Information contained in the relationship





Entities: Member, book
Relationship: Book loan

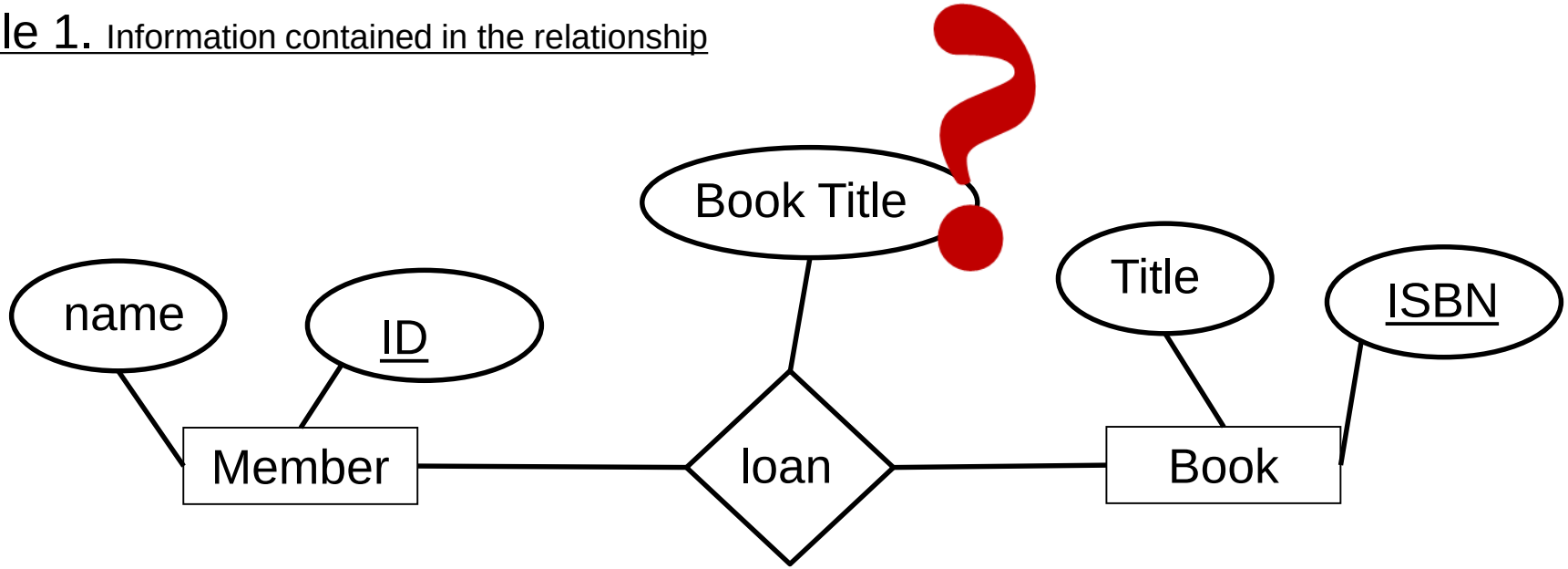
ID	Name
3333333	Debo Rios
4605644	Eric Palac
1133333	Oriol Goil

ID	ISBN
3333333	123
1133333	001

Title	ISBN
Quixote	001
Malcom X	002
Travels	123

Obs: Not all instances must participate in the relationship, only the loaned books.

Example 1. Information contained in the relationship

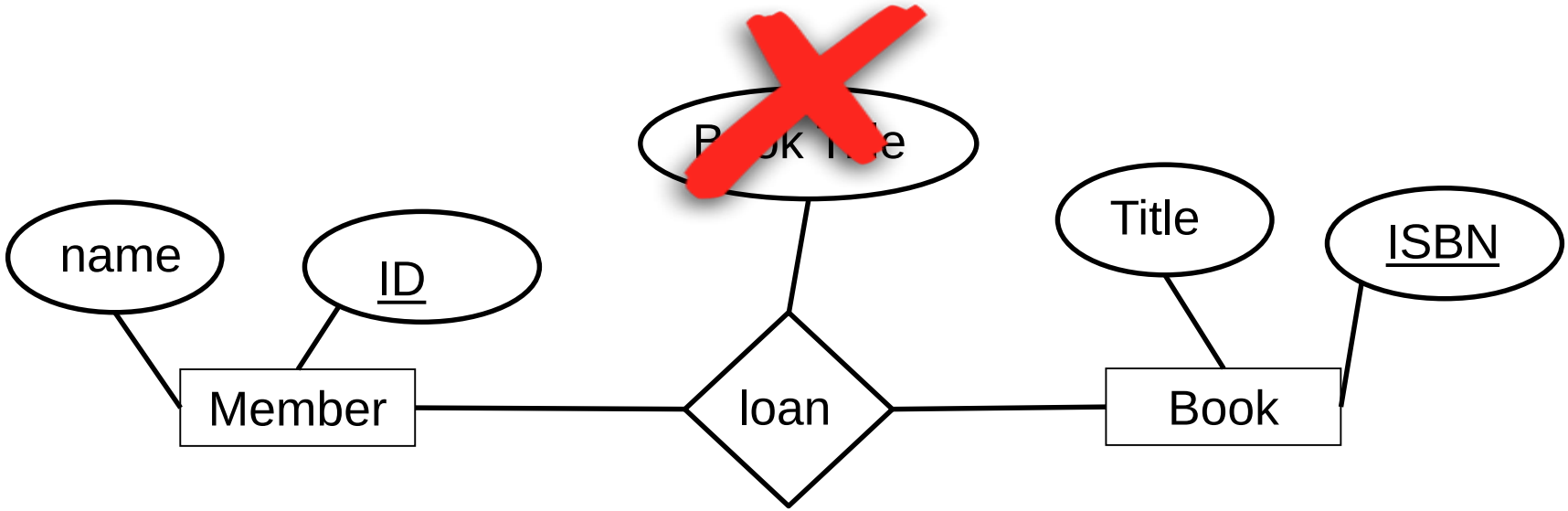


With this design, can we know the titles of the books that are on loan?

How would you modify it?

Should the title of the book be incorporated as an attribute of the "loan" relationship?

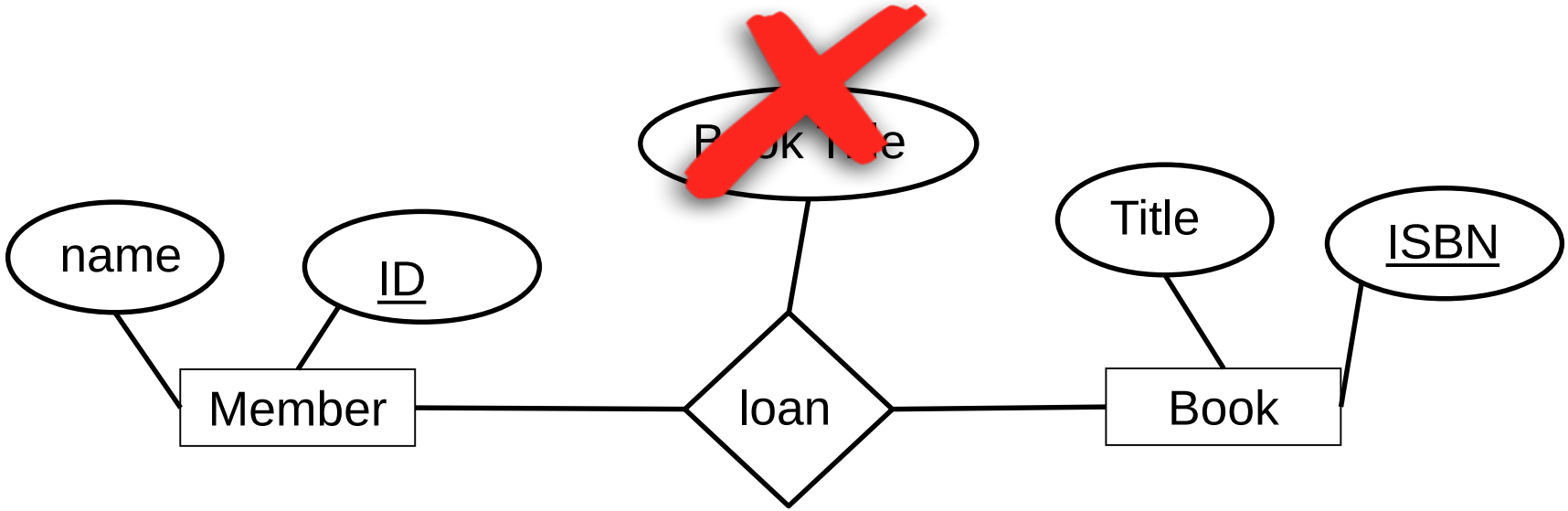
Example 1. Information contained in the relationship



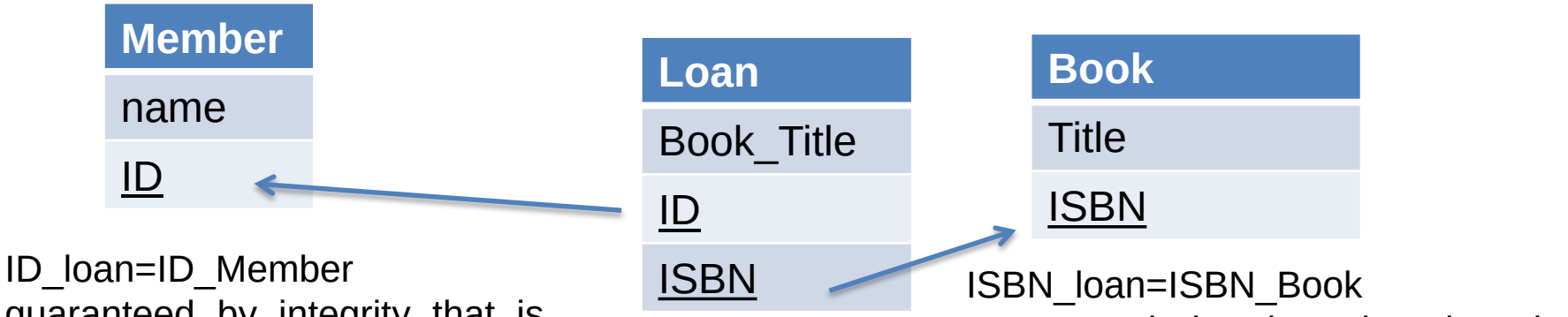
Relationship contains (indirectly, through the PKs of the related entities) all the information (attributes) of the entities that it relates.

You do **NOT** need attributes to the link that are already in the related entities.

Example 1. Information contained in the relationship



In addition, these repetitions introduce redundancy of attributes that the DBMS will not handle (updates, FK modifications only) and may violate integrity

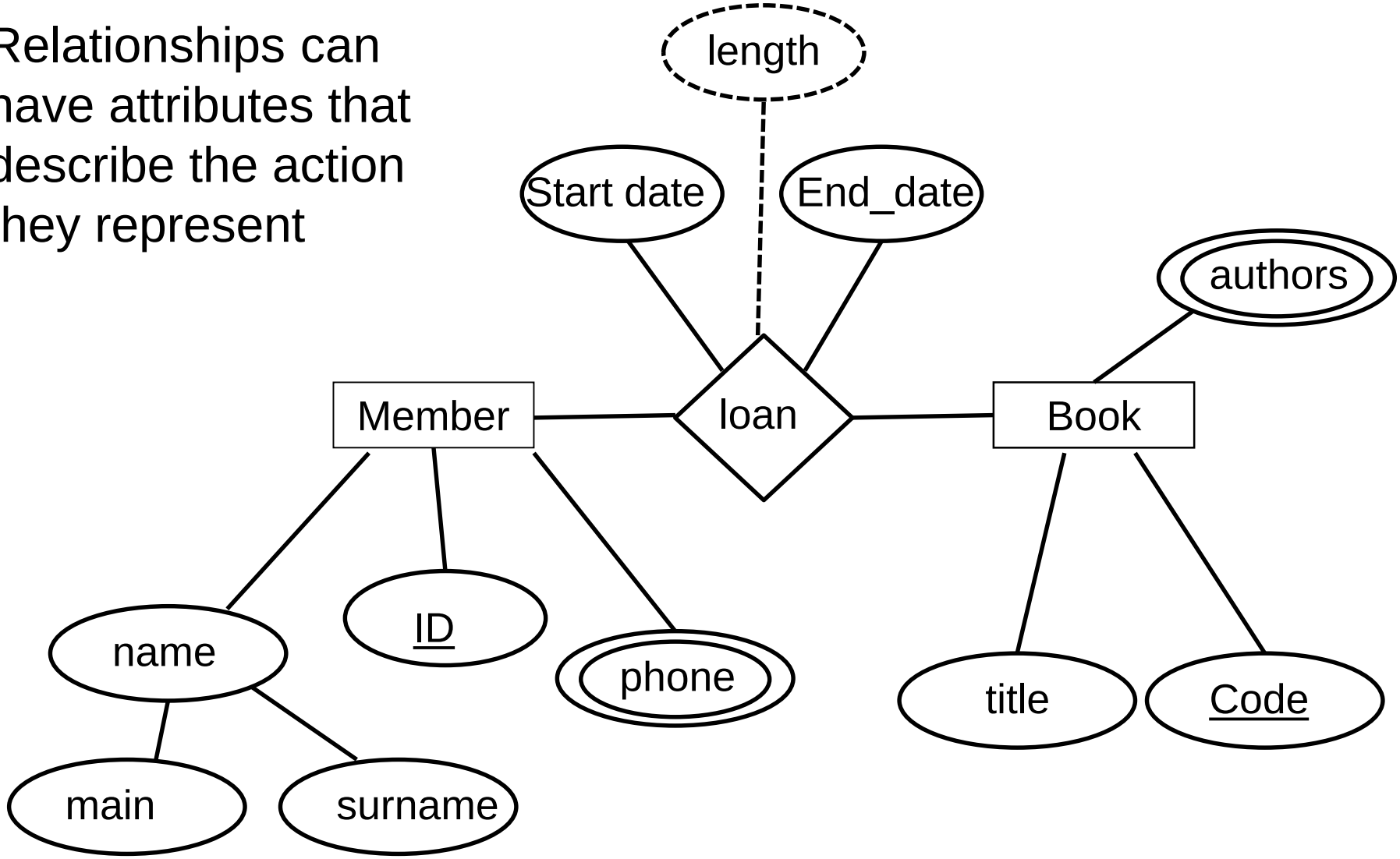


ID_loan=ID_Member guaranteed by integrity that is managed by DBMS

ISBN_loan=ISBN_Book guaranteed by integrity that is managed by DBMS

Example 1. Information contained in the relationship

Relationships can have attributes that describe the action they represent



Example 3. Identify entities and relationships

Database subjects

The students of this subject are distributed in different groups according to type of teaching (theory, problems and practices).
Each of these courses is taught by a teacher (which can always be the same). In addition, depending on the number of students more than one teacher can do the same type of teaching.
And several evaluation tests will be performed for each type of teaching

Entities?

Relationships?

Example 3. Identify entities and relationships

Database subjects

The **students** of this subject are distributed in different **groups** according to type of **teaching** (theory, problems and practices).
Each of these **teachings** is taught by a **professor** (which can always be the same).
In addition, depending on the number of students more than one **professor** can do the same type of **teaching**.
And several **evaluation tests** will be performed for each type of **teaching**

Entities

- Students
- Groups
- Teaching
- Professor
- Evaluation test

Relationships?

Example 3. Identify entities and relationships

Database subjects

The **students** of this subject are distributed in different **groups** according to type of **teaching** (theory, problems and practices).
Each of these **teachings** is taught by a **professor** (which can always be the same).
In addition, depending on the number of students more than one **professor** can do the same type of **teaching**.
And several **evaluation tests** will be performed for each type of **teaching**

Entities

- Students
- Groups
- Teaching
- Professor
- Evaluation test

Relationships

- Students are distributed in groups
- Groups vary by teaching
- Teachers teach various types of teaching
- …

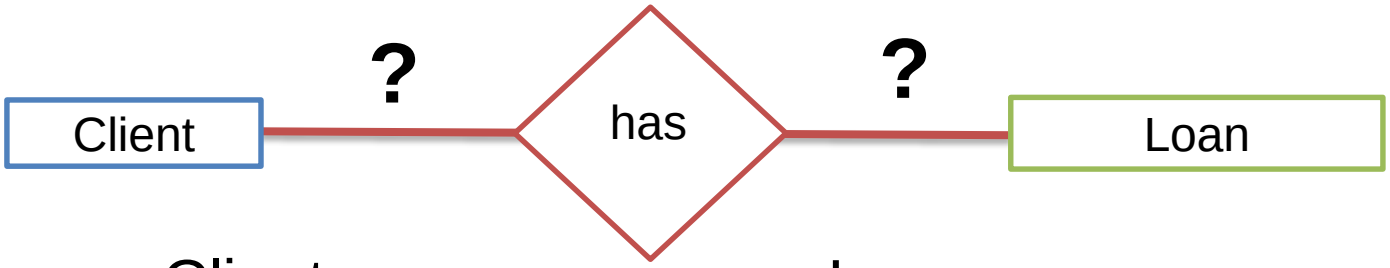
3. Relationships Properties

3.1 Cardinality

3.1 Cardinality

Definition

Cardinality is the maximum number of instances of an entity that may be associated with an instance of the other entity involved in a relationship (there are several types)



Client

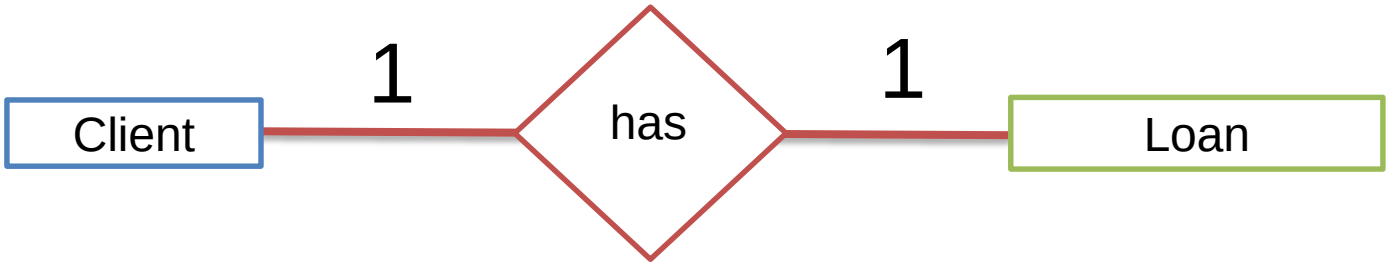
Name	NIF
D. Alves	4748474P
R. Forns	6788900H
E. Walter	6112888L
R. Zabalo	7282944P
...	...

Loan

Code	Quantity
PO7678-9	200.000
DF9383-9	540.000
GR9292-9	23.000
LK93034-0	1.200.000
...	...

Cardinality is the maximum number of instances of an entity that may be associated with an instance of the other entity involved in a relationship (there are several types)

Cardinality 1-1: a client can only have one loan (and one loan can only be took by one client)



Client

Name	NIF
D. Alves	4748474P
R. Forns	6788900H
E. Walter	6112888L
R. Zabalo	7282944P
...	...

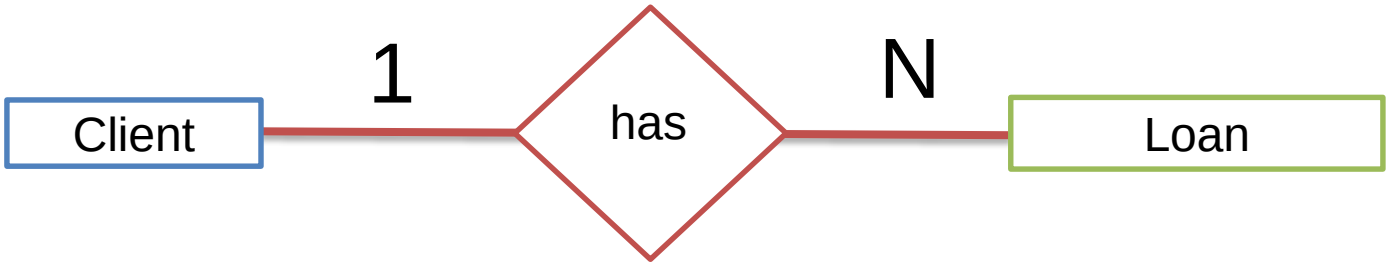
One to one (1-1)

Loan

Code	Quantity
PO7678-9	200.000
DF9383-9	540.000
GR9292-9	23.000
LK93034-0	1.200.000
...	...

Cardinality is the maximum number of instances of an entity that may be associated with an instance of the other entity involved in a relationship (there are several types)

Cardinality 1-N: A client can have more than one loan (and a loan can only be took by a client)



Client

Name	NIF
D. Alves	4748474P
R. Forns	6788900H
E. Walter	6112888L
R. Zabalo	7282944P
...	...

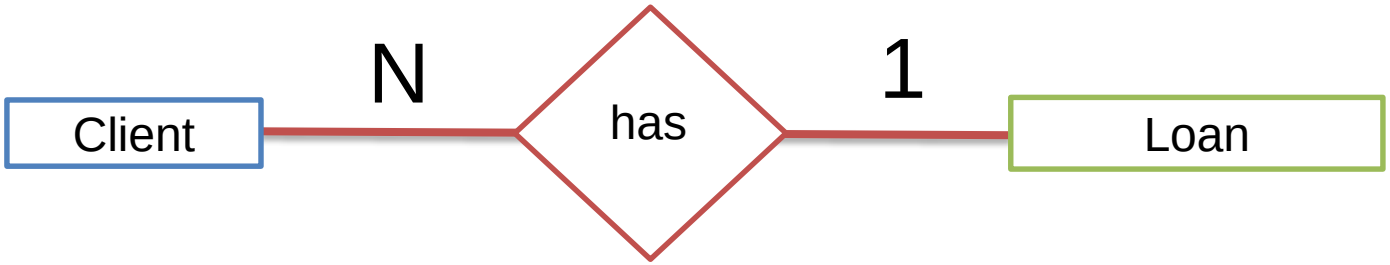
One to many (1-N)

Loan

Code	Quantity
PO7678-9	200.000
DF9383-9	540.000
GR9292-9	23.000
LK93034-0	1.200.000
...	...

Cardinality is the maximum number of instances of an entity that may be associated with an instance of the other entity involved in a relationship (there are several types)

Cardinality N-1: a loan can be shared among multiple clients (but one client cannot have more than one loan)



Client

Name	NIF
D. Alves	4748474P
R. Forns	6788900H
E. Walter	6112888L
R. Zabalo	7282944P
...	...

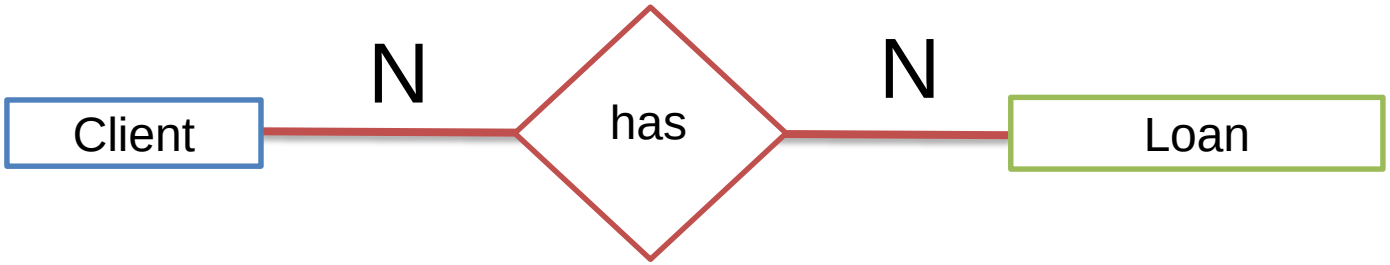
many to 1 (N-1)

Loan

Code	Quantity
PO7678-9	200.000
DF9383-9	540.000
GR9292-9	23.000
LK93034-0	1.200.000
...	...

Cardinality is the maximum number of instances of an entity that may be associated with an instance of the other entity involved in a relationship (there are several types)

Cardinality N-N: no restrictions (one loan can be shared between multiple clients and one client can take more than one loan)



Client

Name	NIF
D. Alves	4748474P
R. Forns	6788900H
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R. Zabalo	7282944P
...	...

many to many (N-N)

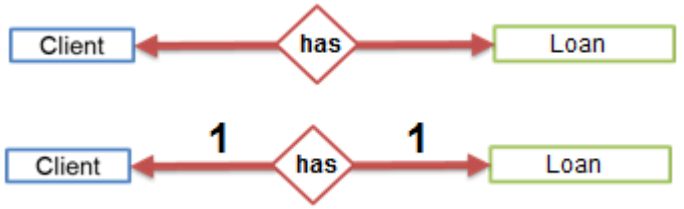
Loan

Code	Quantity
PO7678-9	200.000
DF9383-9	540.000
GR9292-9	23.000
LK93034-0	1.200.000
...	...

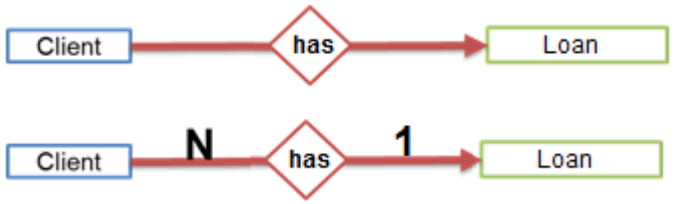
Symbolic representation:

The simple or directed line (arrow) serves to distinguish between many-to-many, many-to-one, or one-to-many relationships.

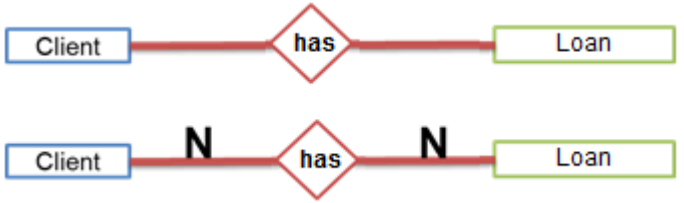
The double arrow indicates a **one-to-one** relationship



A simple arrow indicates a **many-to-one** relationship.



A simple line indicates a **many-to-many** relationship



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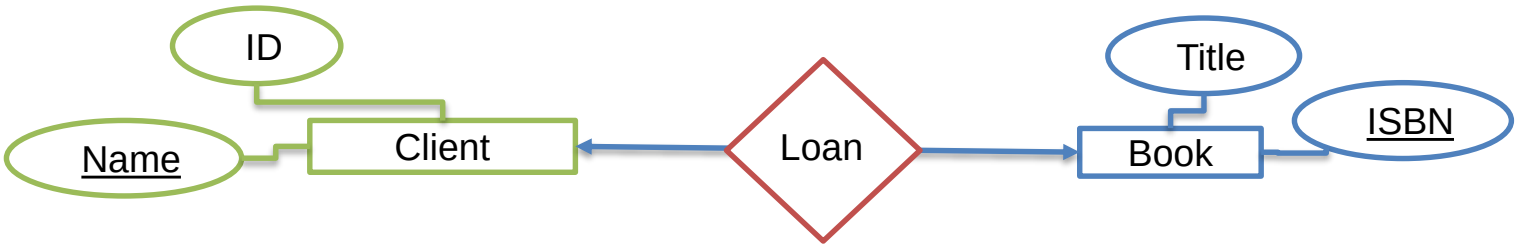
Examples

Example 4. Cardinality type

Consider the E-R design where the "Loan" relationship has **1-1** cardinality



Client

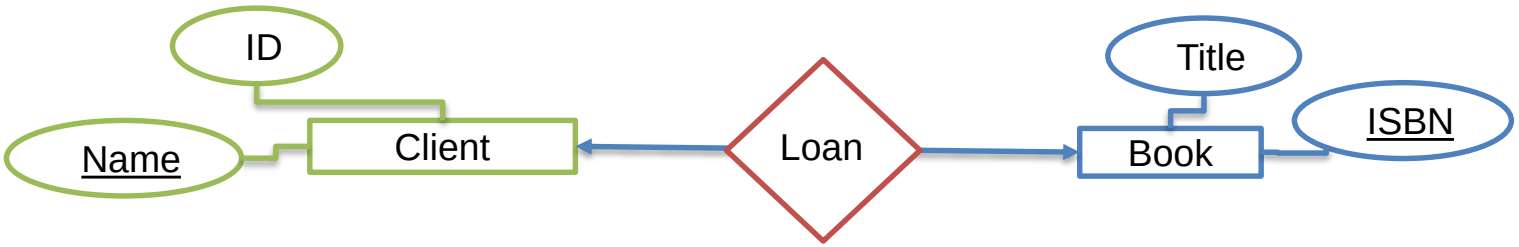
ID	Name
2321323N	Pepe
7484849P	Paco
2342312Q	Kike
4848994J	Montse
...	...

Book

Title	ISBN
Quixot	0011
BBDD	0022
Postres	1122
Hamlet	2829
...	...

Example 4. Cardinality type

Consider the E-R design where the "Loan" relationship has **1-1** cardinality



Client

ID	Name
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2342312Q	Kike
4848994J	Montse
...	...

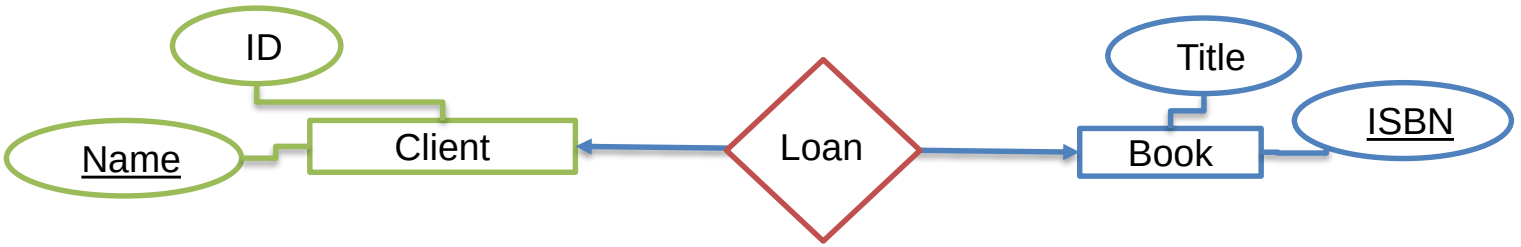
Book

Title	ISBN
Quixot	0011
BBDD	0022
Postres	1122
Hamlet	2829
...	...

Example 4. Cardinality type

Consider the E-R design where the "Loan" relationship has 1-1 cardinality

Does this design allow Montse or Paco to take Don Quixote?



CLient

ID	Name
2321323N	Pepe
7484849P	Paco
2342312Q	Kike
4848994J	Montse
...	...

?

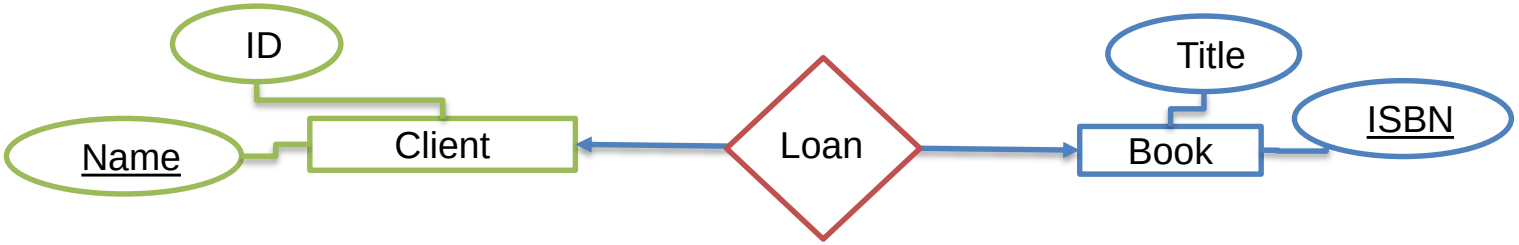
Book

Title	ISBN
Quixot	0011
BBDD	0022
Postres	1122
Hamlet	2829
...	...

Example 4. Cardinality type

Consider the E-R design where the "Loan" relationship has 1-1 cardinality

Does this design allow Montse or Paco to take Don Quixote?
NO: because one book could be load by one client.



Client

ID	Name
2321323N	Pepe
7484849P	Paco
2342312Q	Kike
4848994J	Montse
...	...

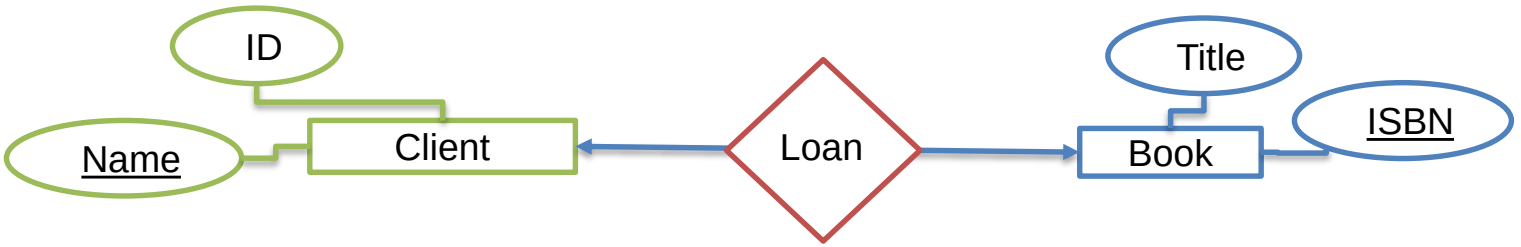
Book

Title	ISBN
Quixot	0011
BBDD	0022
Postres	1122
Hamlet	2829
...	...

Example 4. Cardinality type

Consider the E-R design where the "Loan" relationship has **1-N** cardinality

Does this design allow keeping Montse to take Don Quixote?



Client

ID	Name
2321323N	Pepe
7484849P	Paco
2342312Q	Kike
4848994J	Montse
...	...

?

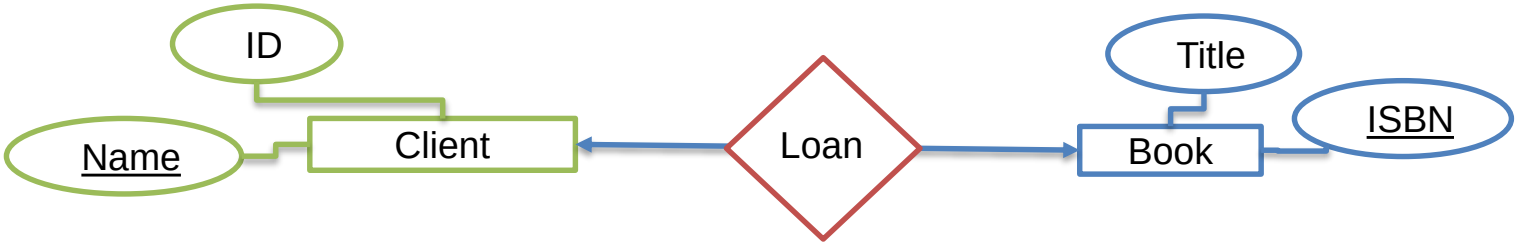
Book

Title	ISBN
Quixot	0011
BBDD	0022
Postres	1122
Hamlet	2829
...	...

Example 4. Cardinality type

Consider the E-R design where the "Loan" relationship has **1-N** cardinality

Does this design allow keeping Montse to take Don Quixote?
YES: One member can have more than 1 book on loan and one book can only be loaned to 1 member



Client

ID	Name
2321323N	Pepe
7484849P	Paco
2342312Q	Kike
4848994J	Montse
...	...

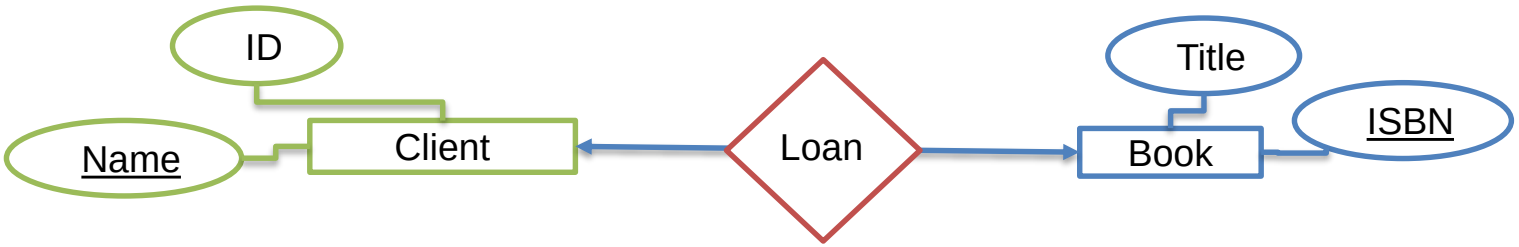
Book

Title	ISBN
Quixot	0011
BBDD	0022
Postres	1122
Hamlet	2829
...	...

Example 4. Cardinality type

Consider the E-R design where the "Loan" relationship has **N-1** cardinality

Does this design allow keeping Montse to take Don Quixote?



Client

ID	Name
2321323N	Pepe
7484849P	Paco
2342312Q	Kike
4848994J	Montse
...	...

?

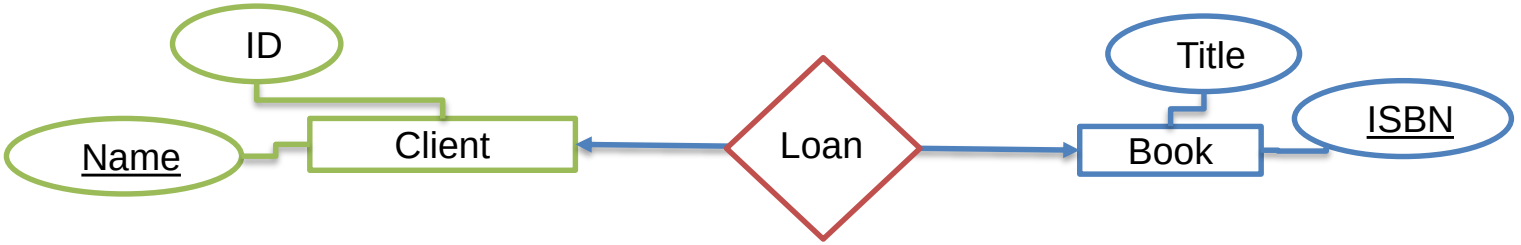
Book

Title	ISBN
Quixot	0011
BBDD	0022
Postres	1122
Hamlet	2829
...	...

Example 4. Cardinality type

Consider the E-R design where the "Loan" relationship has **N-1** cardinality

Does this design allow keeping Montse to take Don Quixote? **Only** if we remove from the DB the book that Montse already has on loan



Client

ID	Name
2321323N	Pepe
7484849P	Paco
2342312Q	Kike
4848994J	Montse
...	...

Book

Title	ISBN
Quixot	0011
BBDD	0022
Postres	1122
Hamlet	2829
...	...

Example 5. Attributes Definition

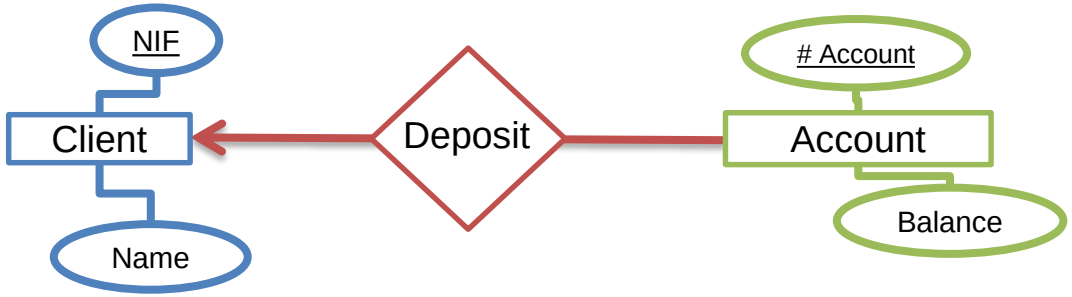
Where is it more convenient to define an attribute?

The cardinality of a relationship can determine where it is more convenient to define an attribute

Example 5. Attributes definition

Consider the E-R design where the cardinality of the “deposit” relationship is 1-N (one to many)

Suppose we want to keep access date for each bank account…



Client

Name	NIF
D. Alves	4748474P
R. Forns	6788900H
E. Walter	6112888L
R. Zabalo	7282944P
...	...

Deposit

Account

# Account	Balance
CTB-246800	500
CTB-357900	1.250
CTB-135700	13.000
CTB-975300	100.056
...	...

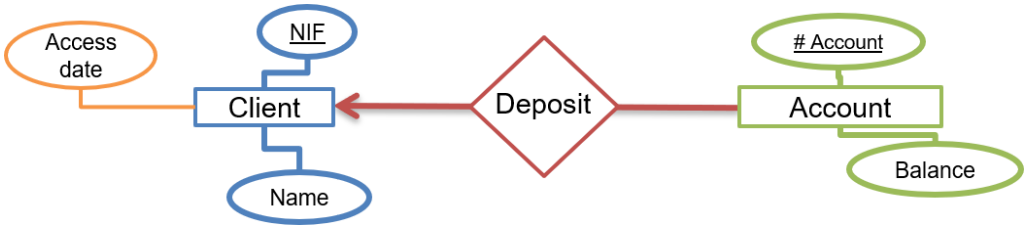
Example 5. Attributes definition

Consider the E-R design where the cardinality of the “deposit” relationship is 1-N (one to many)

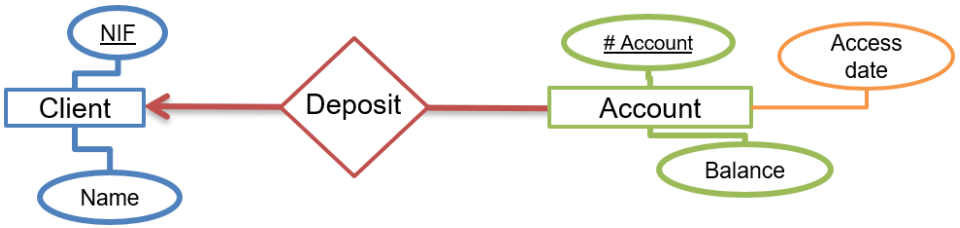
Suppose we want to keep access date for each bank account…

There are 3 options:

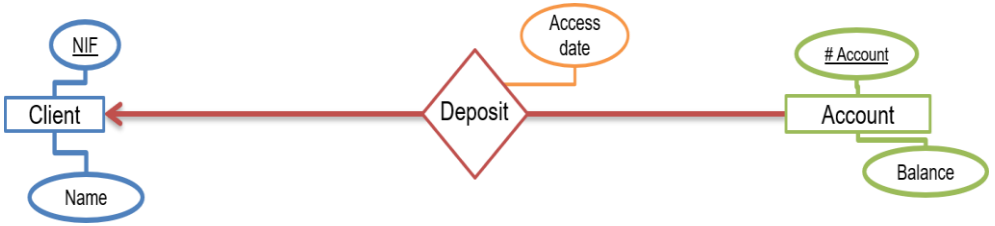
(a)



(b)



(c)

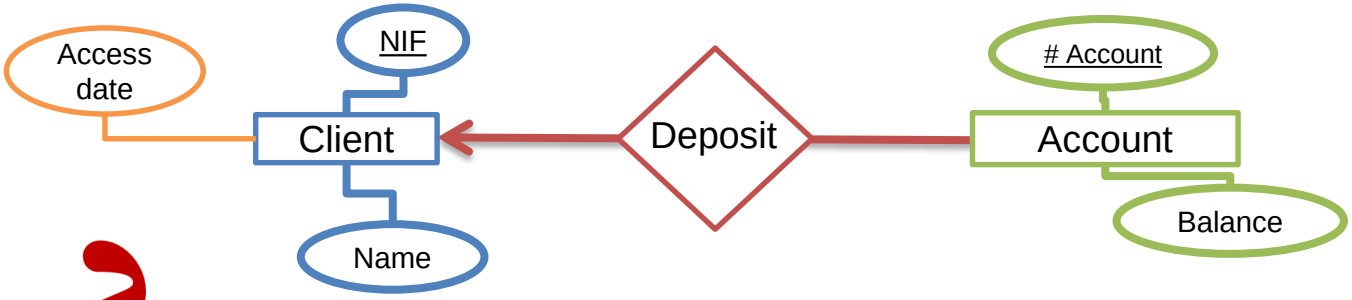


Example 5. Attributes definition

Consider the E-R design where the cardinality of the “deposit” relationship is 1-N (one to many)

Suppose we want to keep access date for each bank account…

Option (a)



?

Client

Access date	Name	NIF
22-05-2016	D. Alves	4748474P
15-04-2016	R. Forns	6788900H
22-02-2017	E. Walter	6112888L
25-01-2017	R. Zabalo	7282944P
...	...	...

Deposit

Account

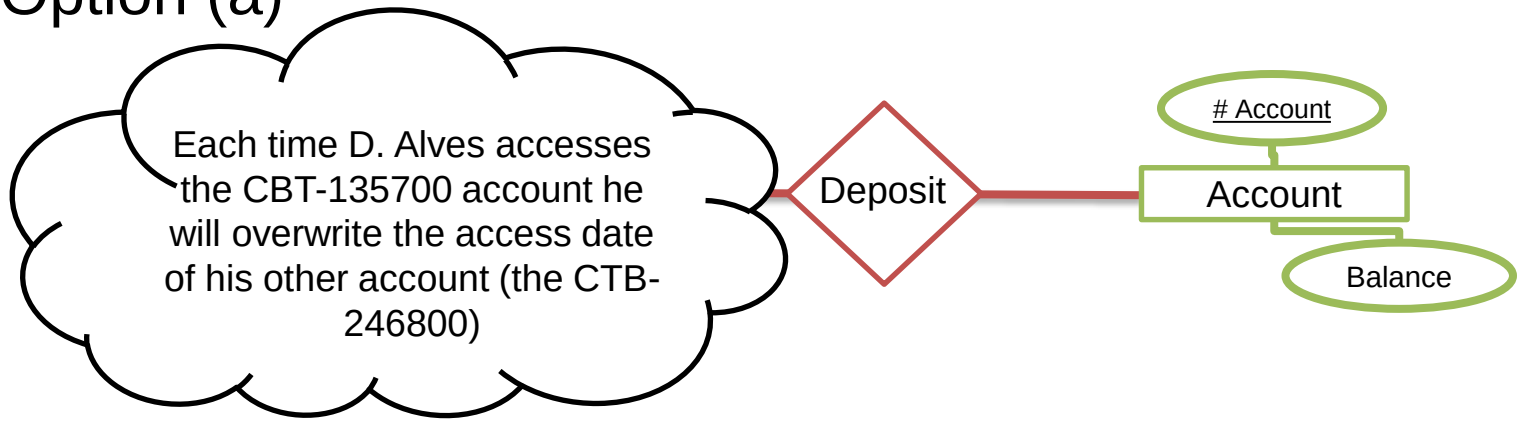
# Account	Balance
CTB-246800	500
CTB-357900	1.250
CTB-135700	13.000
CTB-975300	100.056
...	...

Example 5. Attributes definition

Consider the E-R design where the cardinality of the “deposit” relationship is 1-N (one to many)

Suppose we want to keep access date for each bank account…

Option (a)



Client

Access date	Name	NIF
22-05-2016	D. Alves	4748474P
15-04-2016	R. Forns	6788900H
22-02-2017	E. Walter	6112888L
25-01-2017	R. Zabalo	7282944P
...	...	...

Deposit

Account

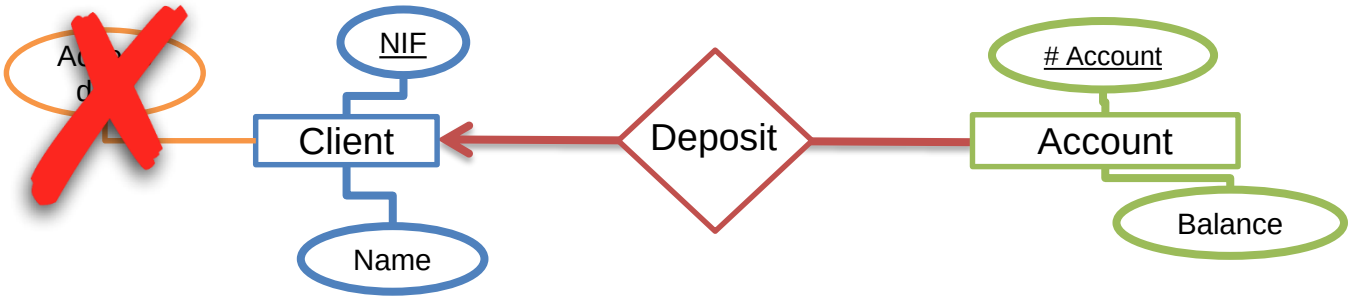
# Account	Balance
CTB-246800	500
CTB-357900	1.250
CTB-135700	13.000
CTB-975300	100.056
...	...

Example 5. Attributes definition

Consider the E-R design where the cardinality of the “deposit” relationship is 1-N (one to many)

Suppose we want to keep access date for each bank account…

Option (a)



Unable to record access dates

Access date	Name	NIF
22-05-2016	D. Alves	4748474P
15-06-2016	R. Forns	6788900H
22-12-2017	E. Walter	6112888L
15-01-2017	R. Zabalo	7282944P
...	...	...

Deposit

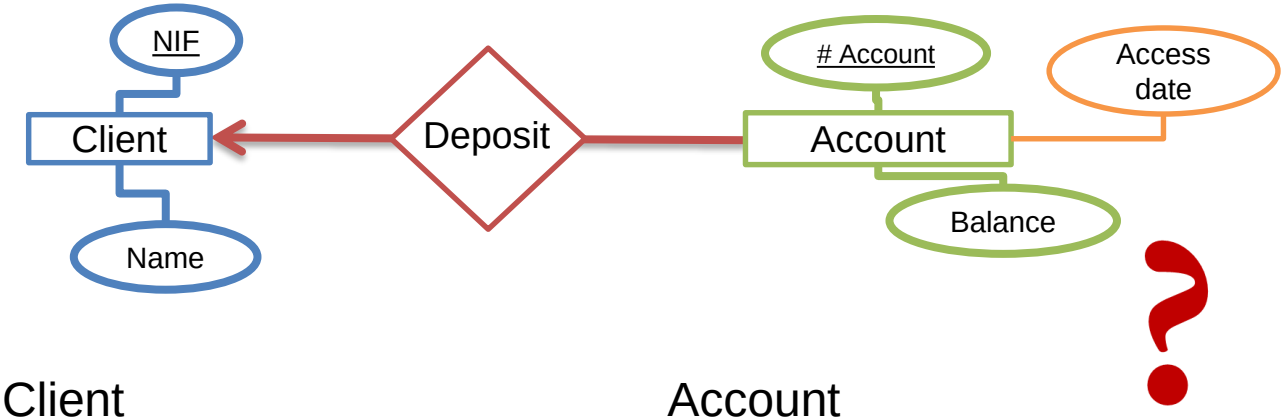
# Account	Balance
CTB-246800	500
CTB-357900	1.250
CTB-135700	13.000
CTB-975300	100.056
...	...

Example 5. Attributes definition

Consider the E-R design where the cardinality of the “deposit” relationship is 1-N (one to many)

Suppose we want to keep access date for each bank account…

Option (b)



Client

Name	NIF
D. Alves	4748474P
R. Forns	6788900H
E. Walter	6112888L
R. Zabalo	7282944P
...	...

Deposit

Account

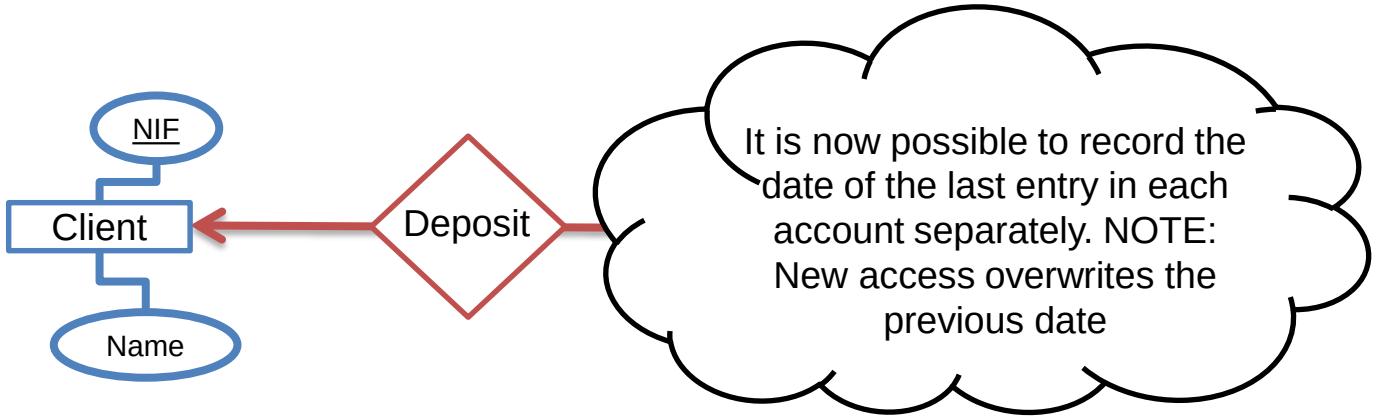
# Account	Balance	Access date
CTB-246800	500	22-05-2016
CTB-357900	1.250	15-04-2016
CTB-135700	13.000	22-02-2017
CTB-975300	100.056	25-01-2017
...	...	...

Example 5. Attributes definition

Consider the E-R design where the cardinality of the “deposit” relationship is 1-N (one to many)

Suppose we want to keep access date for each bank account…

Option (b)



Client

Name	NIF
D. Alves	4748474P
R. Forns	6788900H
E. Walter	6112888L
R. Zabalo	7282944P
...	...

Deposit

Account

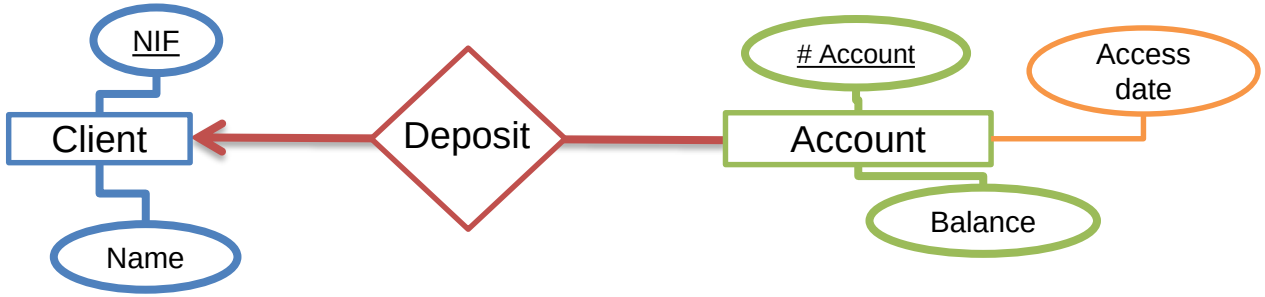
# Account	Balance	Access date
CTB-246800	500	22-05-2016
CTB-357900	1.250	15-04-2016
CTB-135700	13.000	22-02-2017
CTB-975300	100.056	25-01-2017
...	...	...

Example 5. Attributes definition

Consider the E-R design where the cardinality of the “deposit” relationship is 1-N (one to many)

Suppose we want to keep access date for each bank account…

Option (b)



In this case you get a possible solution (last access date)

Name	NIF
D. Alves	4748474P
R. Forns	6788900H
E. Walter	6112888L
R. Zabalo	7282944P
...	...

Deposit

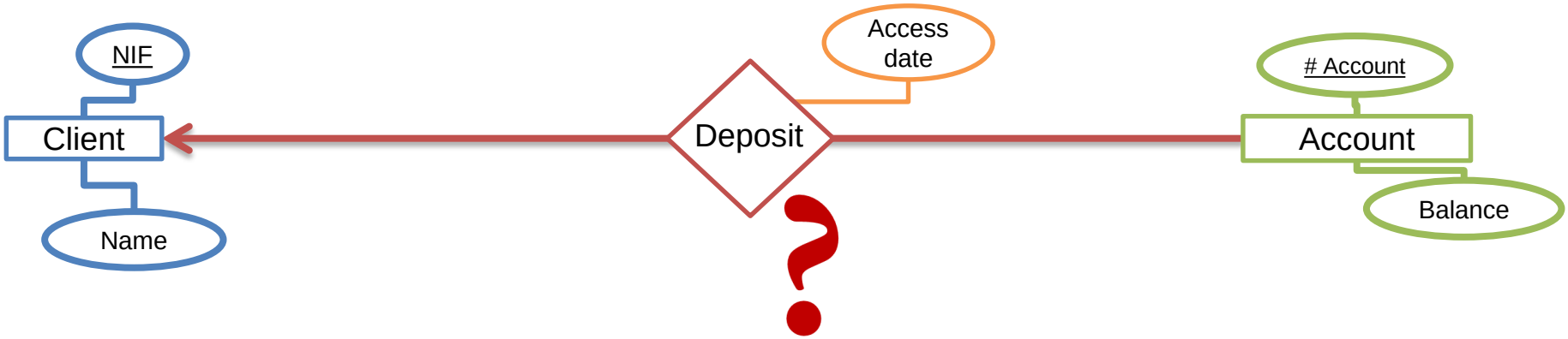
# Account	Balance	Access date
CTB-246800	500	22-05-2016
CTB-357900	1.250	15-04-2016
CTB-135700	13.000	22-02-2017
CTB-975300	100.056	25-01-2017
...	...	...

Example 5. Attributes definition

Consider the E-R design where the cardinality of the “deposit” relationship is 1-N (one to many)

Suppose we want to keep access date for each bank account…

Option (c)



Client

Name	NIF
D. Alves	4748474P
R. Forns	6788900H
E. Walter	6112888L
R. Zabalo	7282944P
...	...

Deposit

Access date
22-05-2016
15-04-2016
22-02-2017
25-01-2017
...

Account

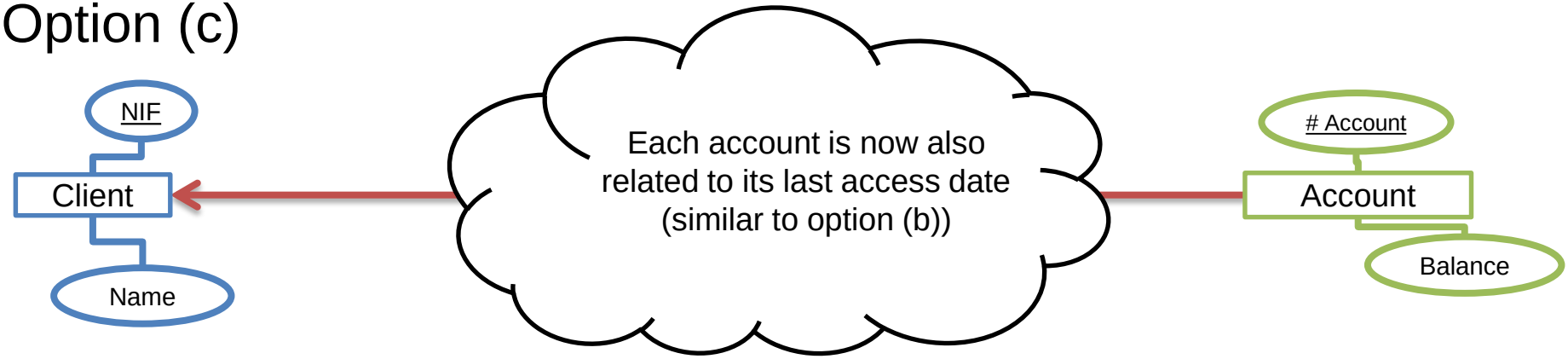
# Account	Balance
CTB-246800	500
CTB-357900	1.250
CTB-135700	13.000
CTB-975300	100.056
...	...

Example 5. Attributes definition

Consider the E-R design where the cardinality of the “deposit” relationship is 1-N (one to many)

Suppose we want to keep access date for each bank account…

Option (c)



Client

Name	NIF
D. Alves	4748474P
R. Forns	6788900H
E. Walter	6112888L
R. Zabalo	7282944P
...	...

Deposit

Access date
22-05-2016
15-04-2016
22-02-2017
25-01-2017
...

Account

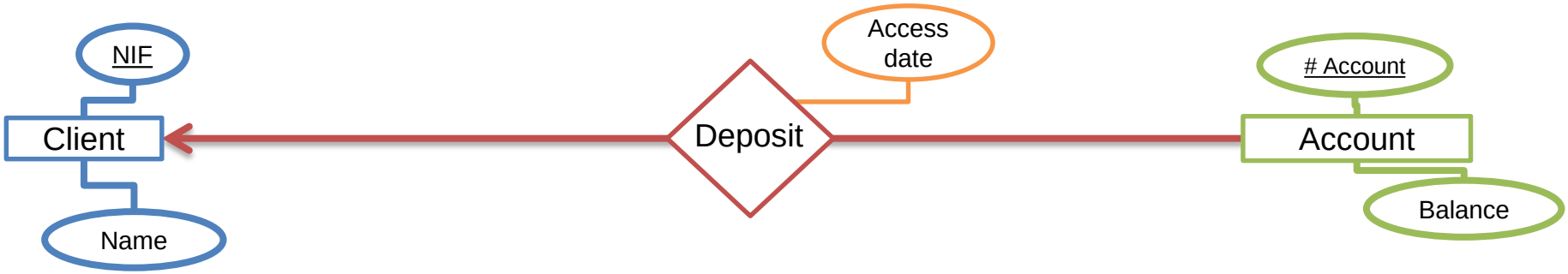
# Account	Balance
CTB-246800	500
CTB-357900	1.250
CTB-135700	13.000
CTB-975300	100.056
...	...

Example 5. Attributes definition

Consider the E-R design where the cardinality of the “deposit” relationship is 1-N (one to many)

Suppose we want to keep access date for each bank account…

Option (c)



In this case you also get a possible solution (last access date)

Name	NIF
D. Alves	4748474P
R. Forns	6788900H
E. Walter	6112888L
R. Zabalo	7282944P
...	...

Access date
22-05-2016
15-04-2016
22-02-2017
25-01-2017
...

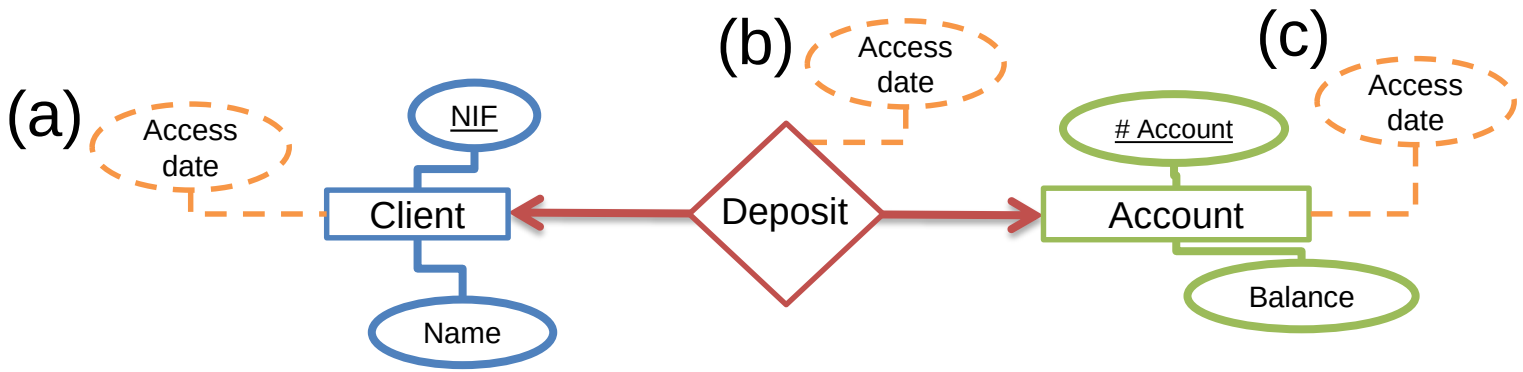
# Account	Balance
CTB-246800	500
CTB-357900	1.250
CTB-135700	13.000
CTB-975300	100.056
...	...

Example 5. Attributes definition

Consider the E-R design where the cardinality of the “deposit” relationship is 1-1 (one to one)

Suppose we want to keep access date for each bank account…

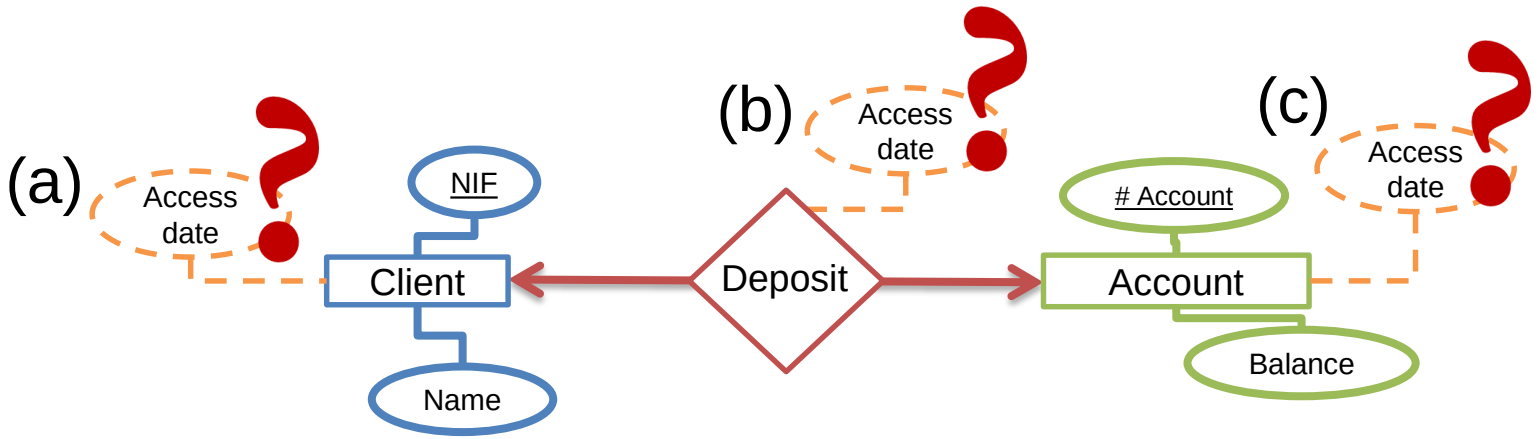
Again there are three possibilities:



Example 5. Attributes definition

Consider the E-R design where the cardinality of the “deposit” relationship is 1-1 (one to one)

Suppose we want to keep access date for each bank account…



Client

Name	NIF
D. Alves	4748474P
R. Forns	6788900H
E. Walter	6112888L
R. Zabalo	7282944P
...	...

Deposit

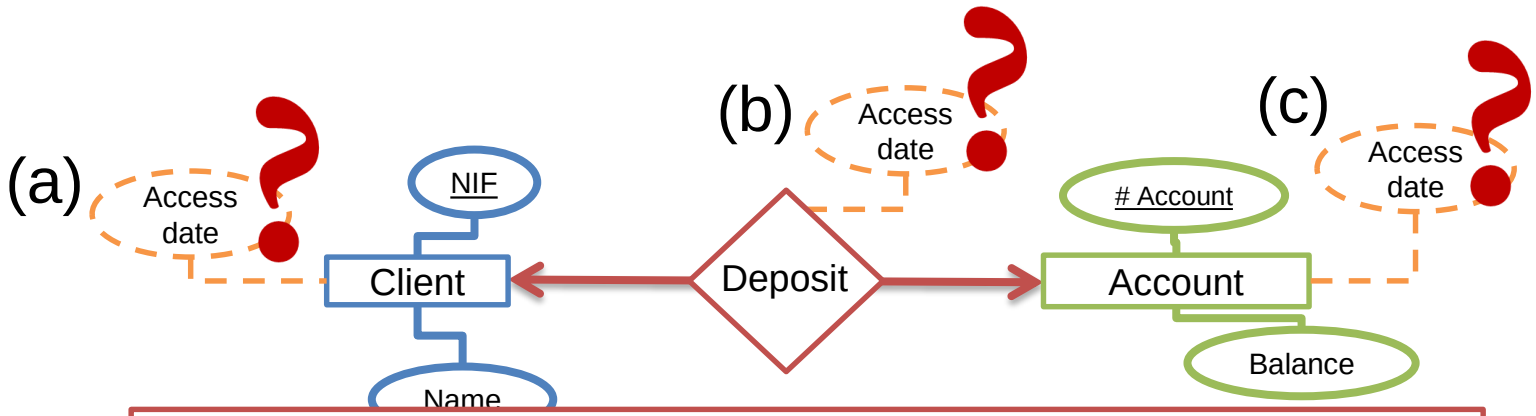
Account

# Account	Balance
CTB-246800	500
CTB-357900	1.250
CTB-135700	13.000
CTB-975300	100.056
...	...

Example 5. Attributes definition

Consider the E-R design where the cardinality of the “deposit” relationship is 1-1 (one to one)

Suppose we want to keep access date for each bank account…



In this case, all three designs retain the last access date for each account and are equivalent

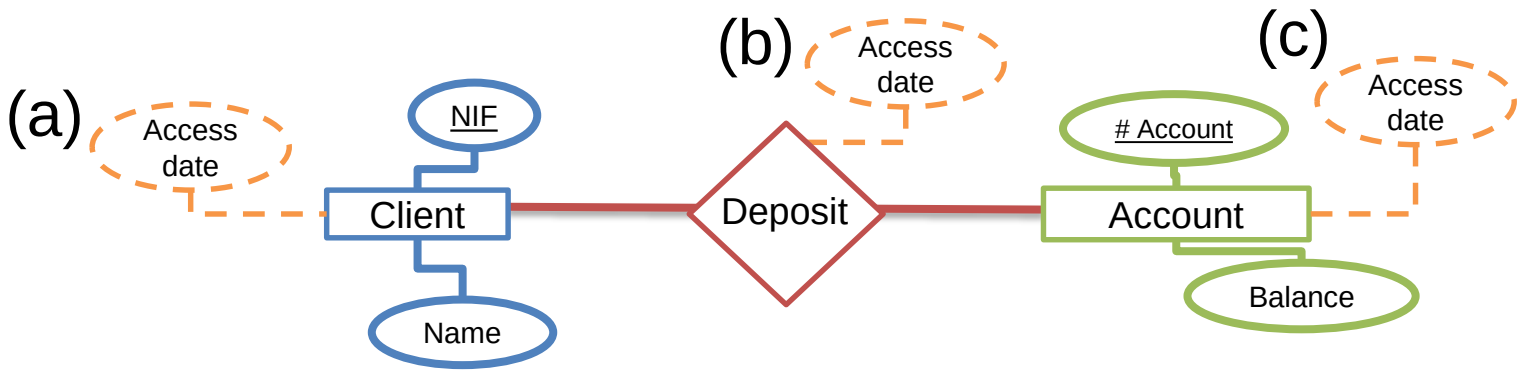
D. Alves	4748474P	CTB-246800	500
R. Forns	6788900H	CTB-357900	1.250
E. Walter	6112888L	CTB-135700	13.000
R. Zabalo	7282944P	CTB-975300	100.056
...	...	...	...

Example 5. Attributes definition

Consider the E-R design where the cardinality of the “deposit” relationship is **N-N** (many to many)

Suppose we want to keep access date for each bank account…

Again there are three possibilities:

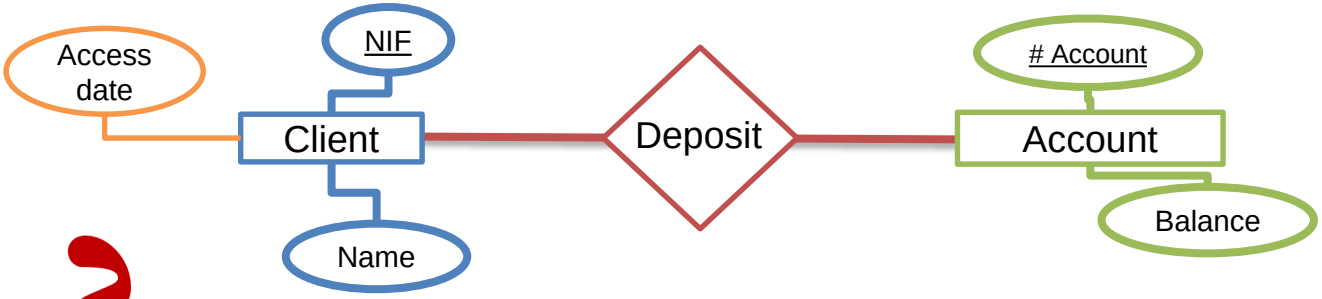


Example 5. Attributes definition

Consider the E-R design where the cardinality of the “deposit” relationship is N-N (many to many)

Suppose we want to keep access date for each bank account…

Option (a)



Client

Access date	Name	NIF
22-05-2016	D. Alves	4748474P
	R. Forns	6788900H
22-02-2017	E. Walter	6112888L
25-01-2017	R. Zabalo	7282944P
...	...	...

Deposit

Account

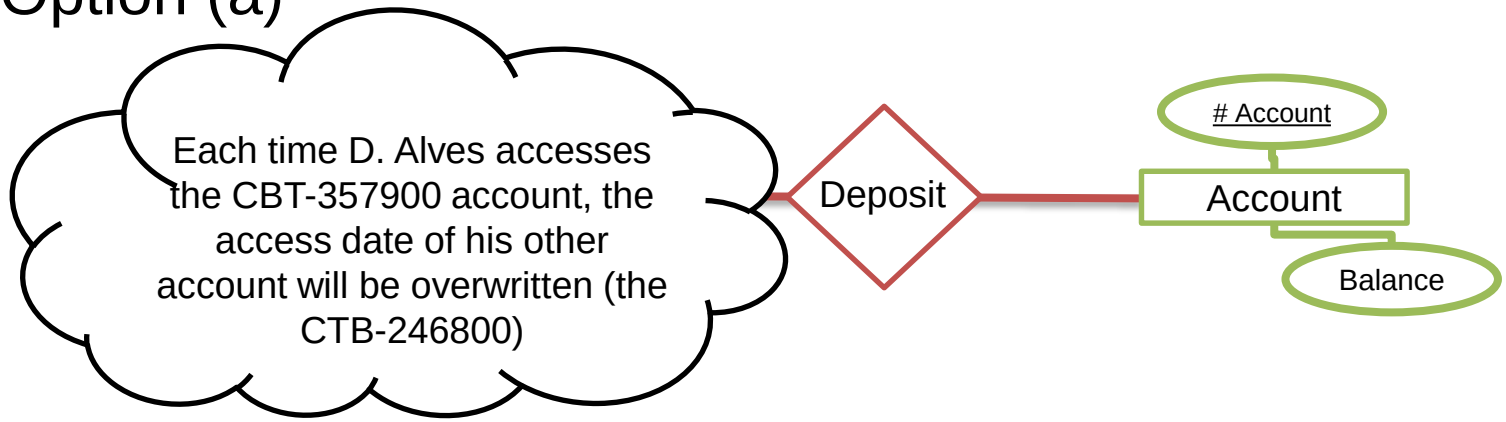
# Account	Balance
CTB-246800	500
CTB-357900	1.250
CTB-135700	13.000
CTB-975300	100.056
...	...

Example 5. Attributes definition

Consider the E-R design where the cardinality of the “deposit” relationship is N-N (many to many)

Suppose we want to keep access date for each bank account…

Option (a)



Client

Access date	Name	NIF
22-05-2016	D. Alves	4748474P
	R. Forns	6788900H
22-02-2017	E. Walter	6112888L
25-01-2017	R. Zabalo	7282944P
...	...	...

Deposit

Account

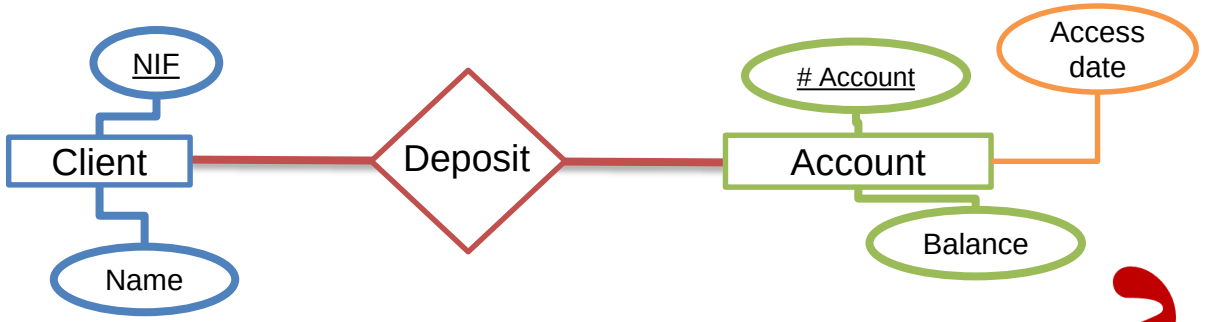
# Account	Balance
CTB-246800	500
CTB-357900	1.250
CTB-135700	13.000
CTB-975300	100.056
...	...

Example 5. Attributes definition

Consider the E-R design where the cardinality of the “deposit” relationship is N-N (many to many)

Suppose we want to keep access date for each bank account…

Option (b)



?

Client

Name	NIF
D. Alves	4748474P
R. Forns	6788900H
E. Walter	6112888L
R. Zabalo	7282944P
...	...

Deposit

Account

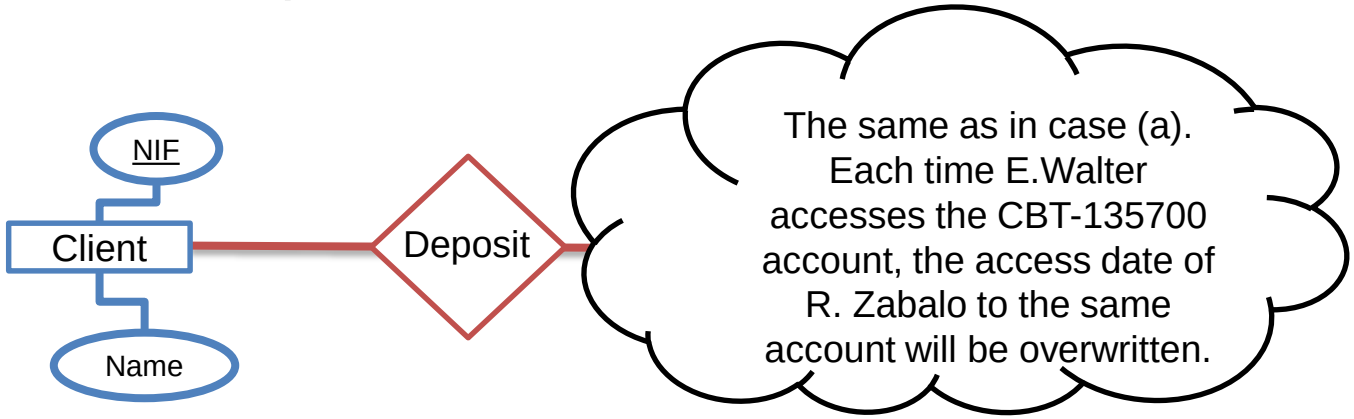
# Account	Balance	Access date
CTB-246800	500	22-05-2016
CTB-357900	1.250	15-04-2016
CTB-135700	13.000	22-02-2017
CTB-975300	100.056	25-01-2017
...	...	...

Example 5. Attributes definition

Consider the E-R design where the cardinality of the “deposit” relationship is N-N (many to many)

Suppose we want to keep access date for each bank account…

Option (b)



Client

Name	NIF
D. Alves	4748474P
R. Forns	6788900H
E. Walter	6112888L
R. Zabalo	7282944P
...	...

Deposit

Account

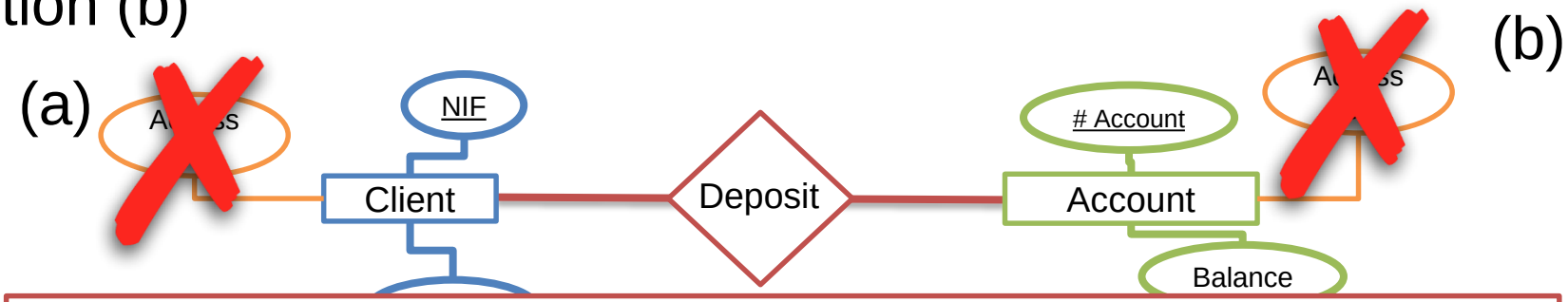
# Account	Balance	Access date
CTB-246800	500	22-05-2016
CTB-357900	1.250	15-04-2016
CTB-135700	13.000	22-02-2017
CTB-975300	100.056	25-01-2017
...	...	...

Example 5. Attributes definition

Consider the E-R design where the cardinality of the “deposit” relationship is N-N (many to many)

Suppose we want to keep access date for each bank account…

Option (b)



In no case (a) and (b) it is possible to register the clients and the dates of access to their respective accounts

Access date	Name	NIF
22-[illegible]-2016	D. Alves	4748474P
	R. Forns	6788900H
22-[illegible]-2017	E. Walter	6112888L
[illegible]-01-2017	R. Zabalo	7282944P
...	...	...

Deposit

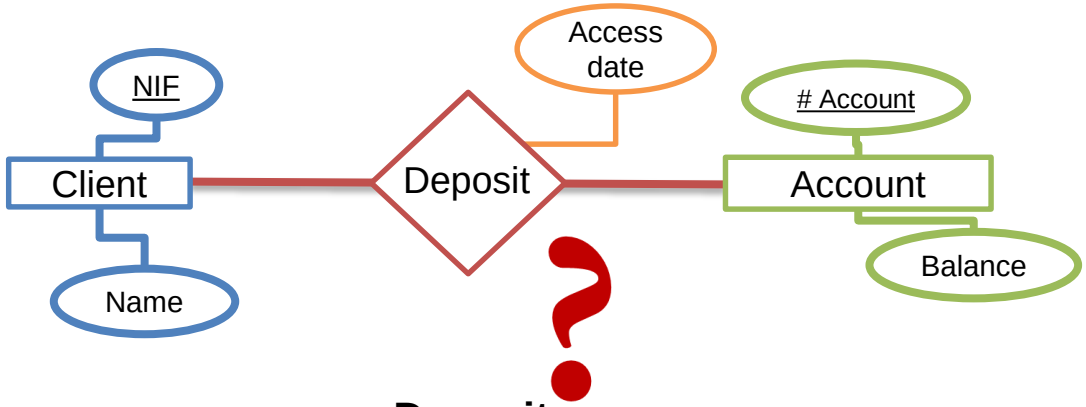
# Account	Balance	Access date
CTB-246800	500	22-[illegible]-2016
CTB-357900	1.250	15-[illegible]-2016
CTB-135700	13.000	22-[illegible]-2017
CTB-975300	100.056	[illegible]-01-2017
...	...	...

Example 5. Attributes definition

Consider the E-R design where the cardinality of the “deposit” relationship is N-N (many to many)

Suppose we want to keep access date for each bank account…

Option (c)



Client

Name	NIF
D. Alves	4748474P
R. Forns	6788900H
E. Walter	6112888L
R. Zabalo	7282944P
...	...

Deposit

Access date
22-05-2016
15-04-2016
22-02-2017
25-01-2017
...

Account

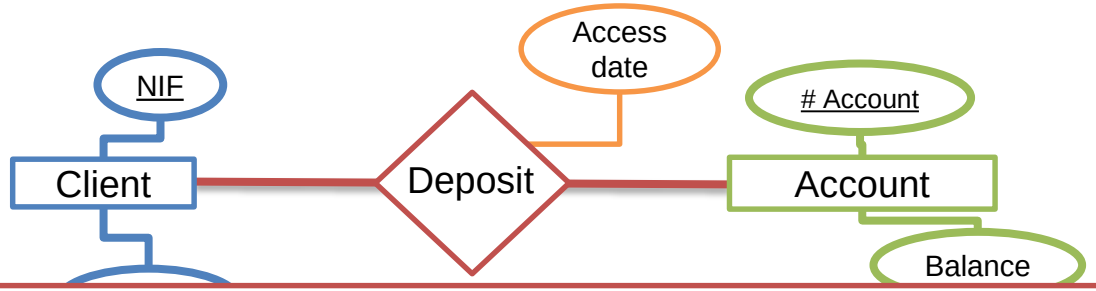
# Account	Balance
CTB-246800	500
CTB-357900	1.250
CTB-135700	13.000
CTB-975300	100.056
...	...

Example 5. Attributes definition

Consider the E-R design where the cardinality of the “deposit” relationship is N-N (many to many)

Suppose we want to keep access date for each bank account…

Option (c)



This is the only case where it is possible to register the clients and the last dates of access to their respective accounts

Name	NIF
D. Alves	4748474P
R. Forns	6788900H
E. Walter	6112888L
R. Zabalo	7282944P
...	...

Access date
22-05-2016
15-04-2016
22-02-2017
25-01-2017
...

# Account	Balance
CTB-246800	500
CTB-357900	1.250
CTB-135700	13.000
CTB-975300	100.056
...	...

Example 5. Attributes definition

Final Exam Question: Is it possible for these designs to record a "history" of clients that includes all access dates to their respective accounts?