
Data Modeling and Relational Database Design

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1

Introduction to Entities, Attributes, and Relationships

Overview

Why conceptual modeling?

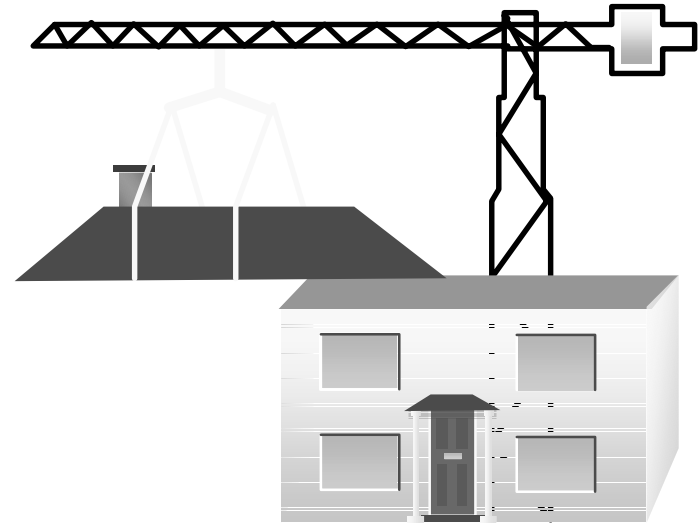
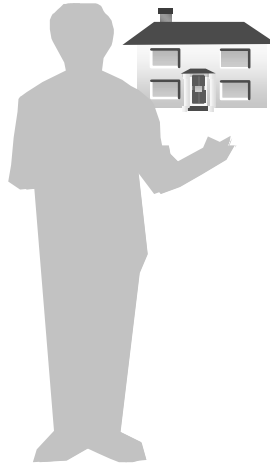
Introduction of the Key role players:

- **Entities**
- **Attributes**
- **Relationships**

Why Create a Conceptual Model?

- **It describes exactly the information needs of the business**
- **It facilitates discussion**
- **It helps to prevent mistakes, misunderstanding**
- **It forms important “ideal system” documentation**
- **It forms a sound basis for physical database design**
- **It is a very good practice with many practitioners**

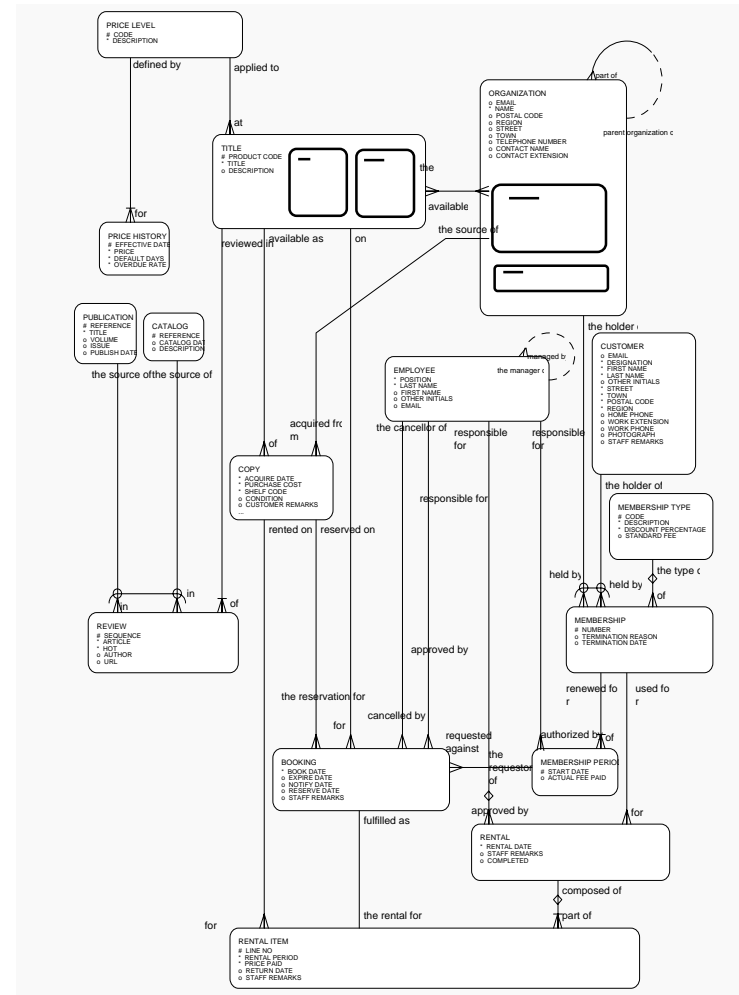
Between Dream and Reality...



Entity Relationship Modeling

- Models business, not implementation
- Is a well-established technique
- Has a robust syntax
- Results in easy-to-read diagrams...

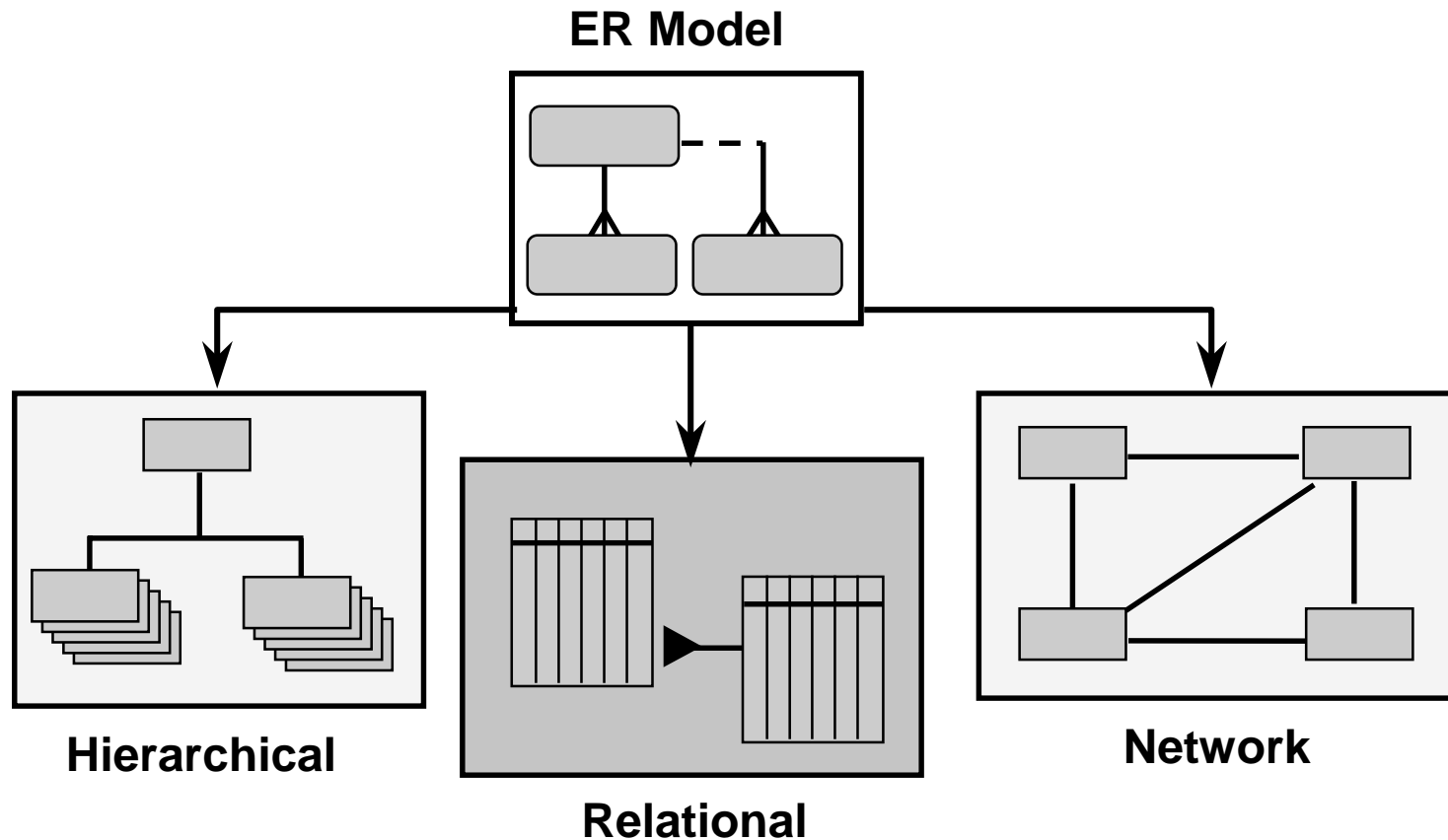
...although they may look rather complex at first sight



Goals of Entity Relationship Modeling

- Capture *all* required information
- Information appears *only* once
- Model *no* information that is derivable from other information already modeled
- Information is in a predictable, logical place

Database Types



Entity

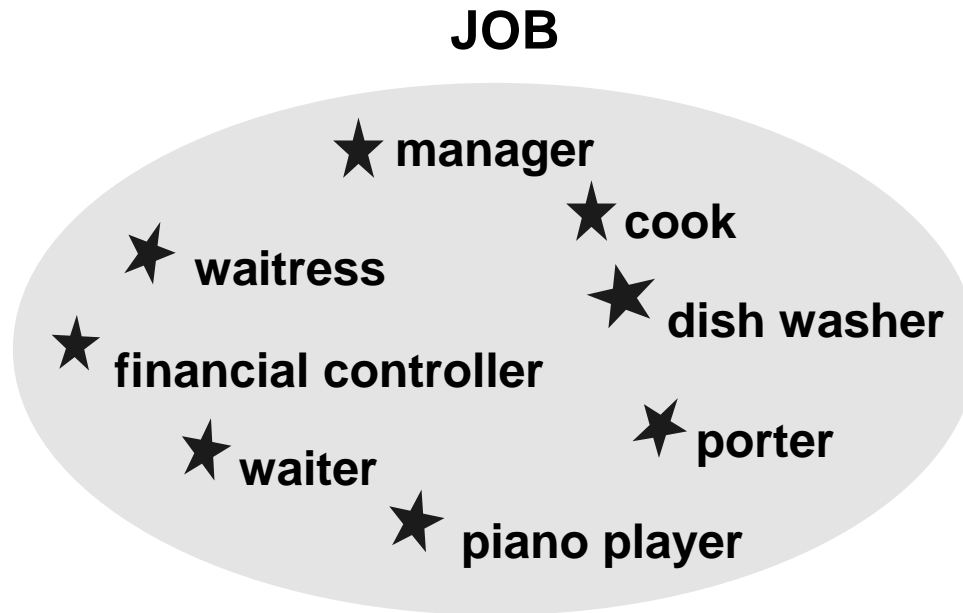
- **An Entity is:**
 - **“Something” of significance to the business about which data must be known**
 - **A name for the things that you can list**
 - **Usually a noun**
- **Examples: objects, events**
- **Entities have instances**

Entities and Instances

PERSON	Mahatma Gandhi
PRODUCT	2.5 x 35 mm copper nail
PRODUCT TYPE	nail
EMPLOYMENT CONTRACT	my previous contract
JOB	violinist
SKILL LEVEL	fluent
TICKET RESERVATION	tonight: Hamlet in the Royal
PURCHASE	the CD I bought yesterday
ELECTION	for parliament next fall
PRINTER PREFERENCE	...
DOCUMENT VERSION	...

Entities and Sets

An entity represents a set of instances that are of interest to a particular business.



Attribute

- **Also represents something of significance to the business**
- **Is a *single valued* property detail of an entity**
- **Is a specific piece of information that:**
 - **Describes**
 - **Quantifies**
 - **Qualifies**
 - **Classifies**
 - **Specifies an entity**

Attribute Examples

Entity	Attribute
EMPLOYEE	Family Name, Age, Shoe Size, Town of Residence, Email, ...
CAR	Model, Weight, Catalog Price, ...
ORDER	Order Date, Ship Date, ...
JOB	Title, Description, ...
TRANSACTION	Amount, Transaction Date, ...
EMPLOYMENT CONTRACT	Start Date, Salary, ...

Relationships

- **Also represent something of significance to the business**
- **Express how entities are mutually *related***
- **Always exist between *two* entities (or one entity *twice*)**
- **Always have two perspectives**
- **Are named at both ends**

Relationship Examples

EMPLOYEES *have* **JOB**S

JOBS *are held by* **EMPLOYEES**

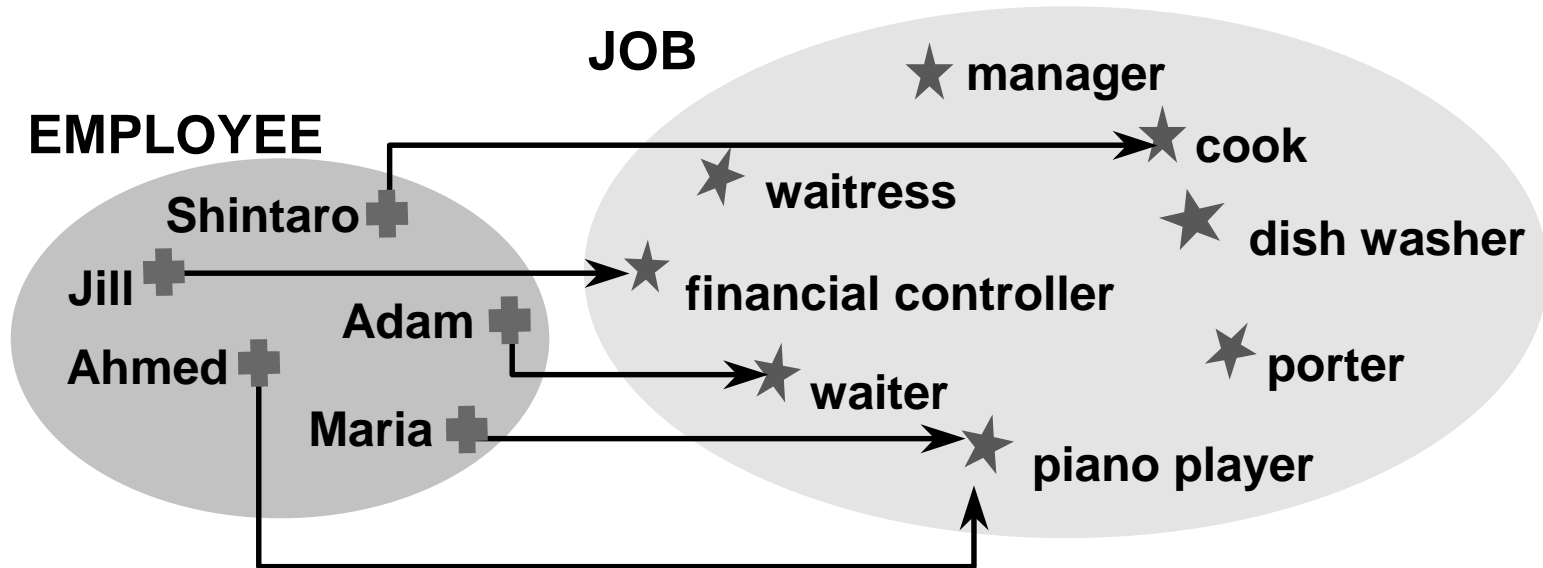
PRODUCTS *are classified by* a **PRODUCT TYPE**

PRODUCT TYPE *is a classification for* a **PRODUCT**

PEOPLE *make* **TICKET RESERVATIONS**

TICKET RESERVATIONS *are made by* **PEOPLE**

Employees have Jobs

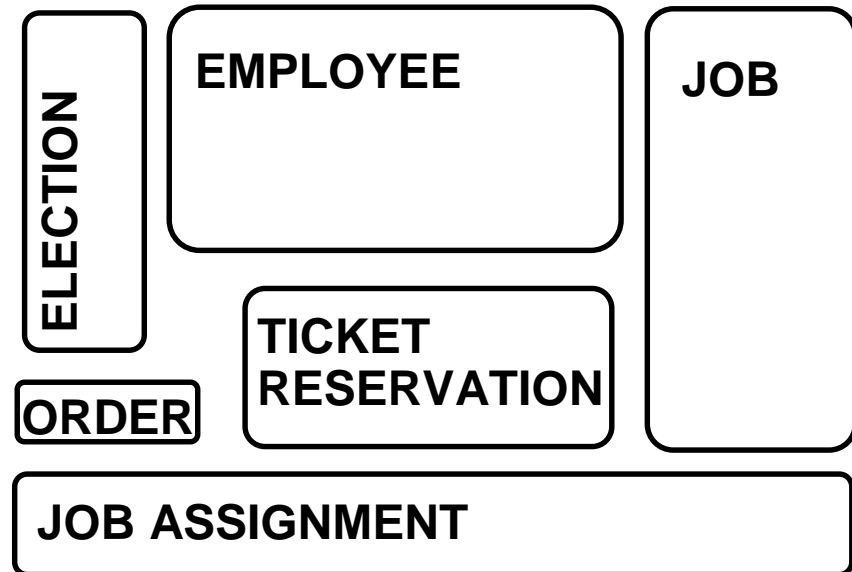


Numerical observation:

- **All EMPLOYEES have a JOB**
- **No EMPLOYEE has *more than one* JOB**
- ***Not all* JOBS are held by an EMPLOYEE**
- **Some JOBS are held by *more than one* EMPLOYEE**

Entity Representation in Diagram

- Drawn as a “softbox”
- Name singular
- Name inside
- Neither size, nor position has a special meaning

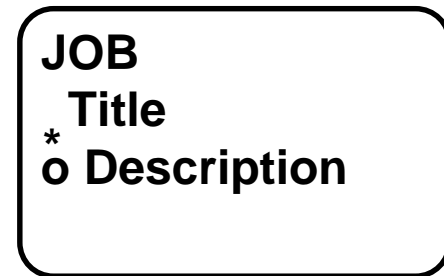
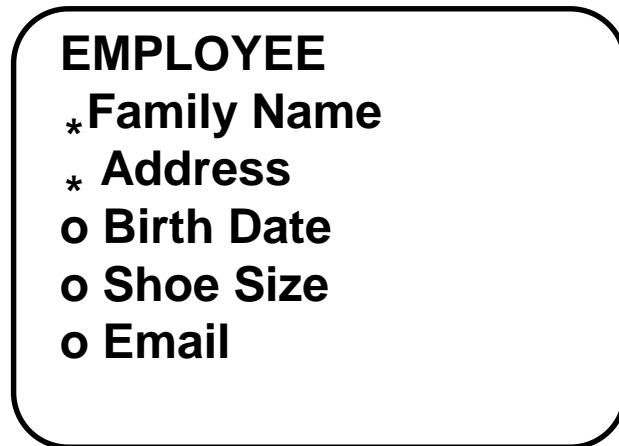


During design, entities usually lead to tables.

Attributes in Diagrams

Mandatory attribute, that is, known *and* available for every instance.

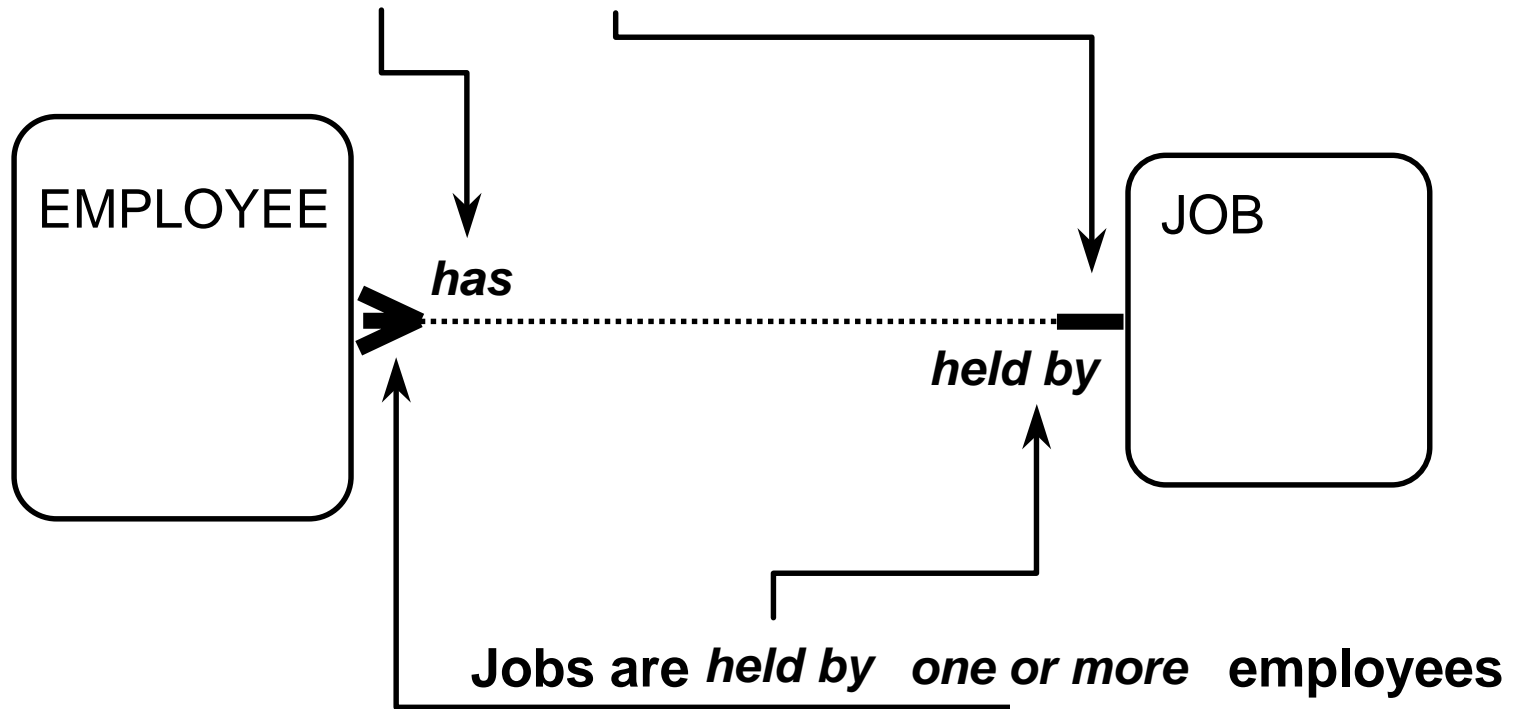
Optional attribute, that is, unknown *or* unimportant to know for some instances.



During design, attributes lead to columns.

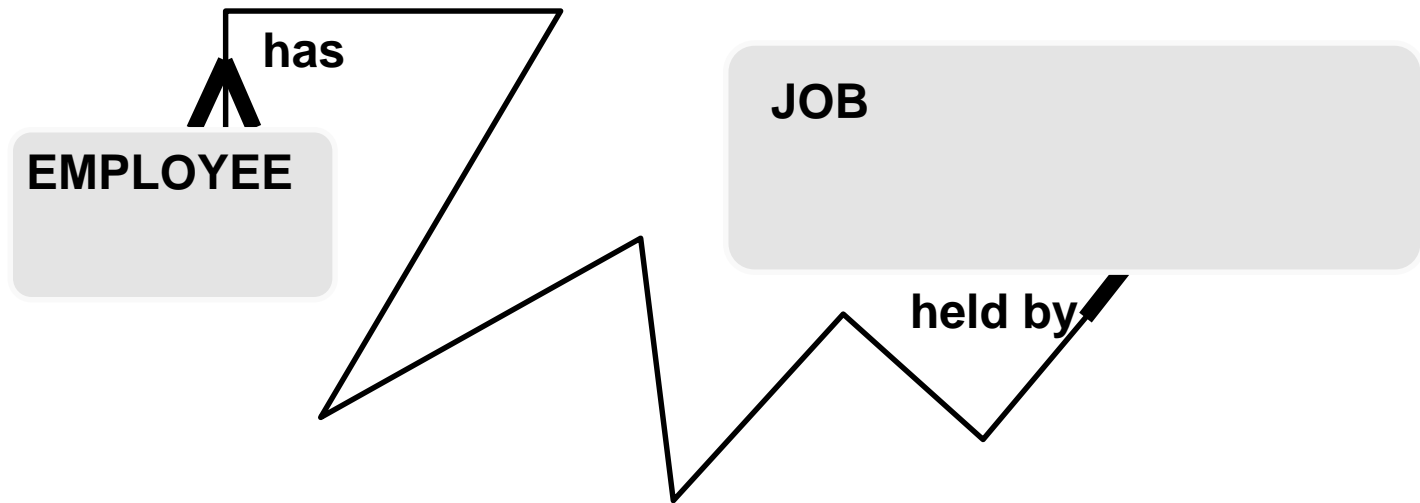
Relationship in Diagrams

An employee *has exactly one* job.



During design, relationships lead to foreign keys.

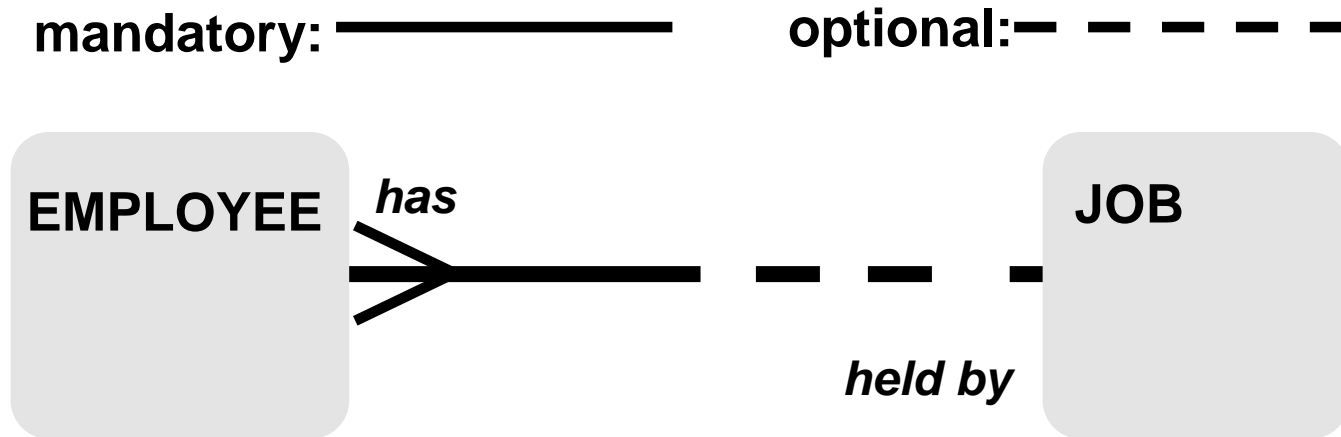
Diagrams Are To Communicate



Characteristics Of The Relationship Line

mandatory:  optional: 

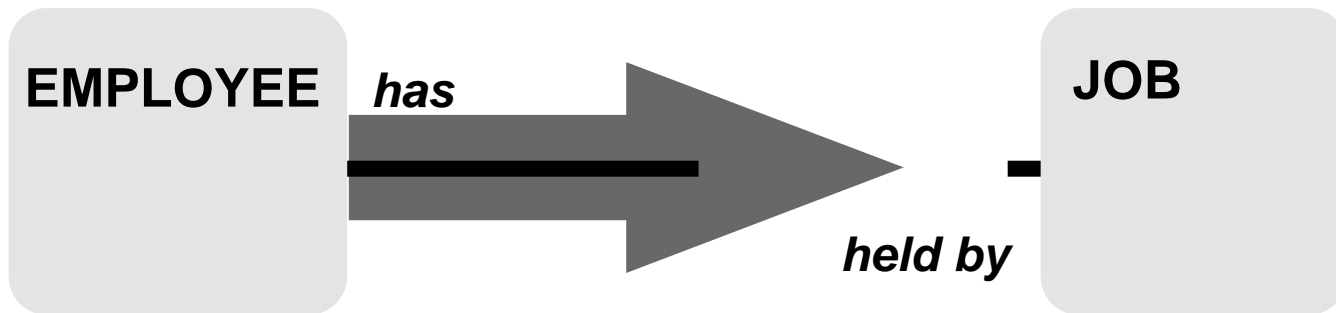
Two Perspectives



One Way

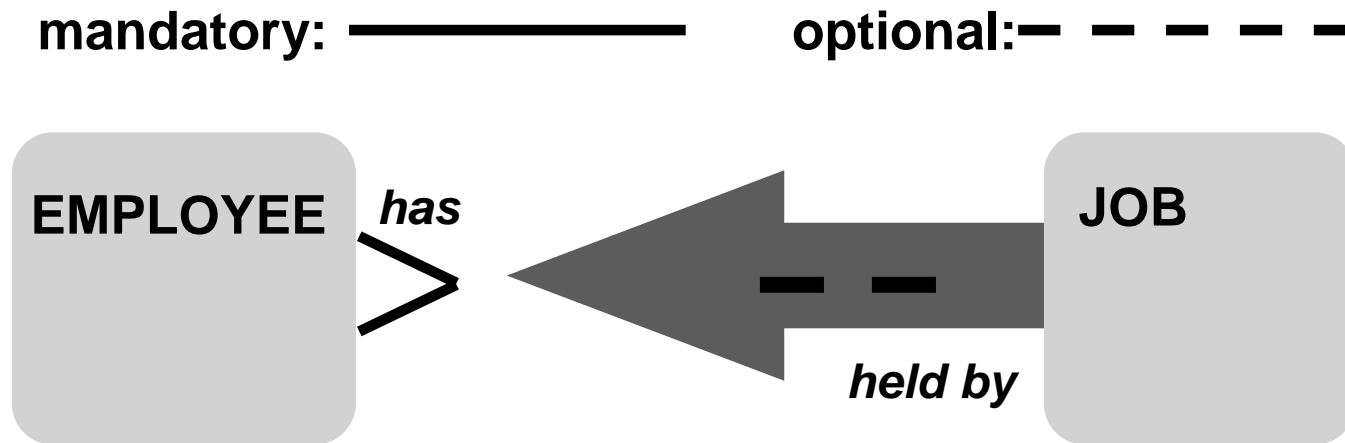
mandatory: —————

optional: - - - - -



Every EMPLOYEE *has* exactly one JOB

The Other Way

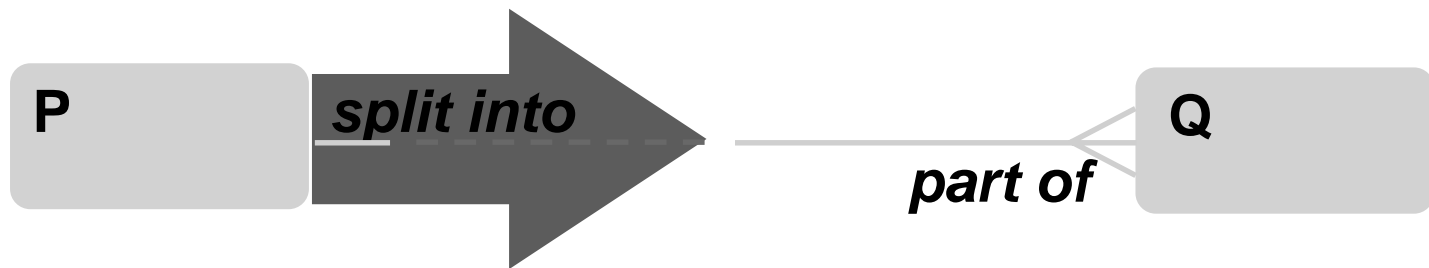


A JOB may be *held by* one or more EMPLOYEES

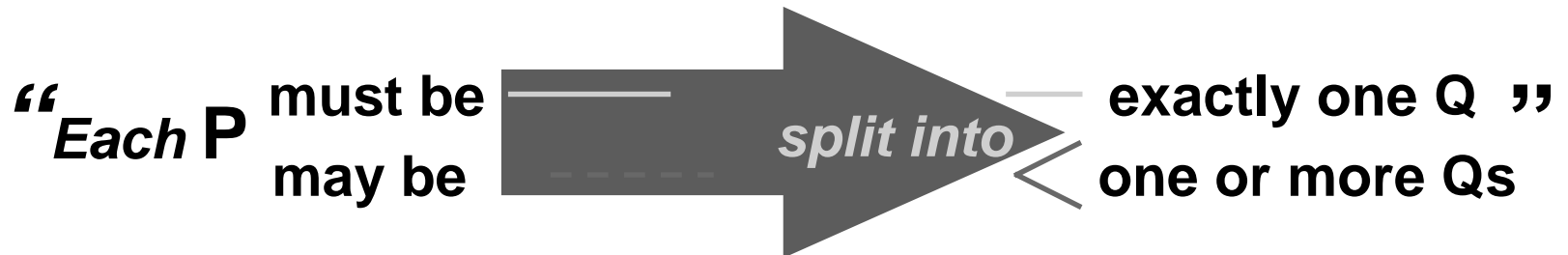
Reading a Relationship End



Reading a Relationship End



Reading a Relationship End

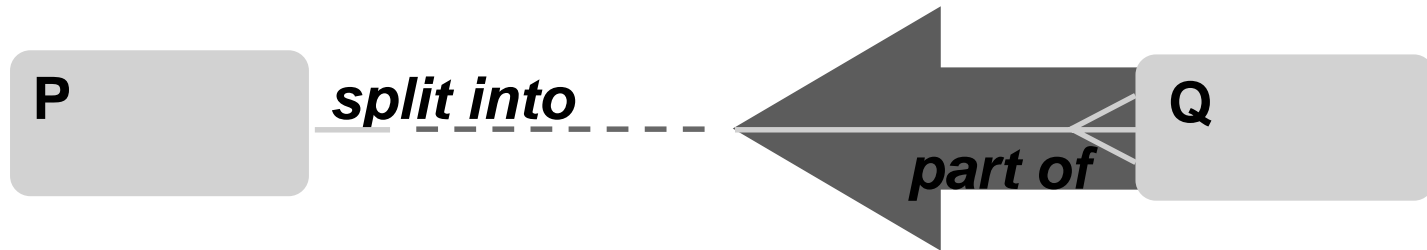


Reading a Relationship End



“Each P may be *split into* one or more Qs”

Reading a Relationship End



“Each P may be *split into* one or more Qs”

Reading a Relationship End



“Each P may be *split into* one or more Qs”

“Each Q must be exactly one P”
may be one or more Ps

Reading a Relationship End



“Each P may be *split into* one or more Qs”







“Each Q must be *part of* exactly one P”

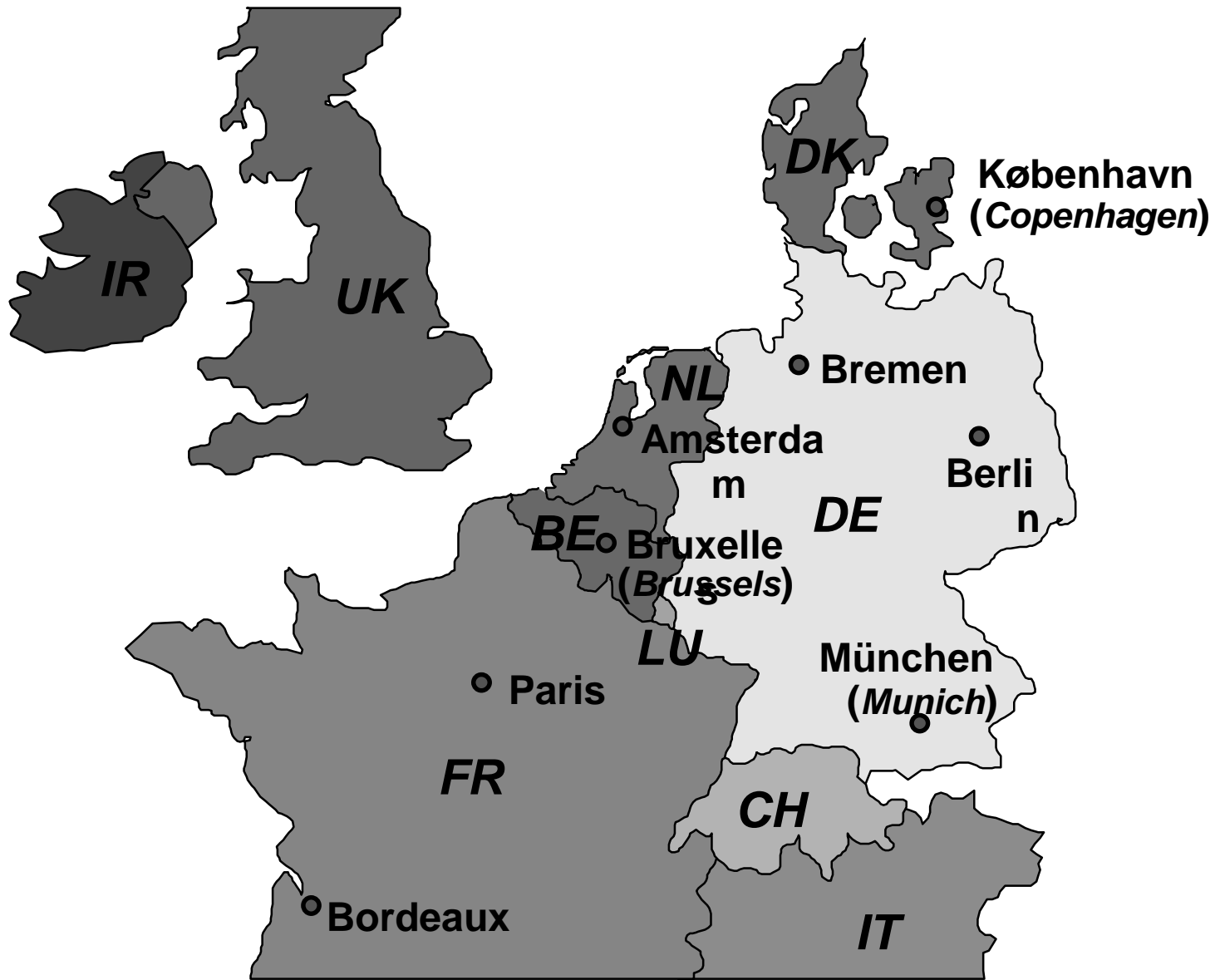
Functions Drive Data

- **Business functions are always present.**
 - **Explicit**
 - **Assumed**
- **Business functions need data.**
- **An entity, attribute, or relationship may be modeled because:**
 - **It is used by a business function.**
 - **The business need may arise in the near future.**

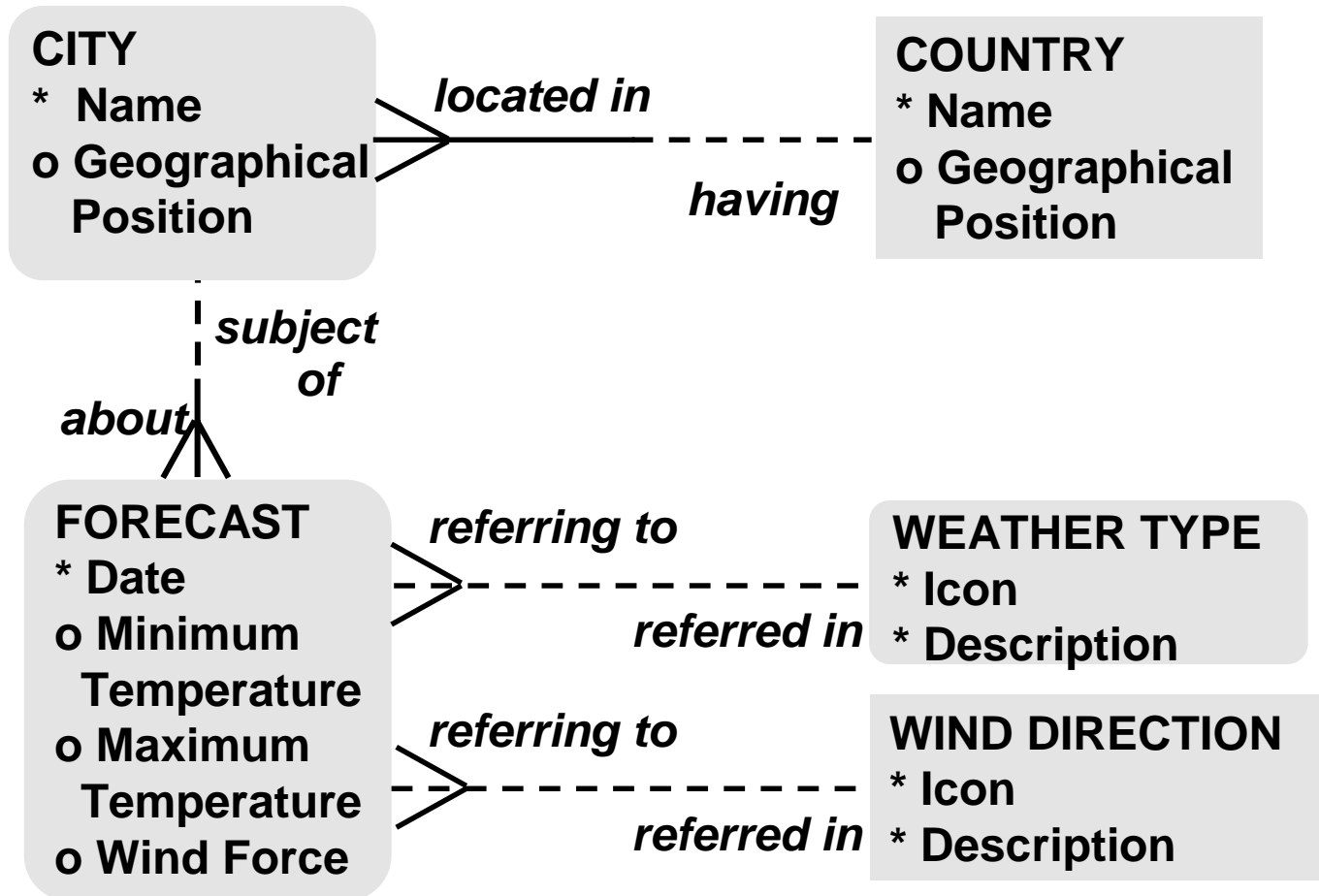
Weather Forecast

January 26

København		1/-5	➔ 3
Bremen		0/-3	↙ 4
Berlin		3/-1	← 3
München		5/-3	← 3
Amsterdam		8/3	↗ 4
Bruxelles		4/0	➔ 2
Paris		4/1	➔ 3
Bordeaux		7/2	↗ 3



Weather Forecast, a Solution



Graphical Elements of ER Diagram

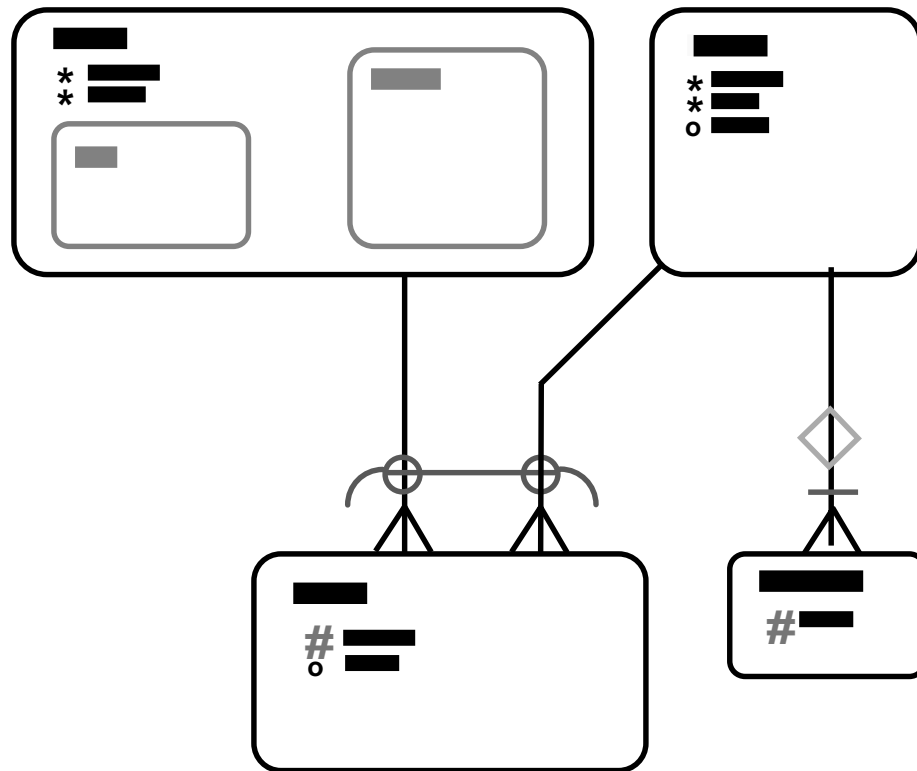
- ✓ Entity
- ✓ Attribute
- ✓ Relationship

Subtype

Unique identifier

Arc

Nontransferability



Summary

- **ER Modeling models information conceptually**
- **Based on functional business needs**
- **“What”, not “How”**
- **Diagrams provide easy means of communication**
- **Detailed, but not too much**

Practices

- **Instance or Entity**
- **Guest**
- **Reading**
- **Hotel**
- **Recipe**

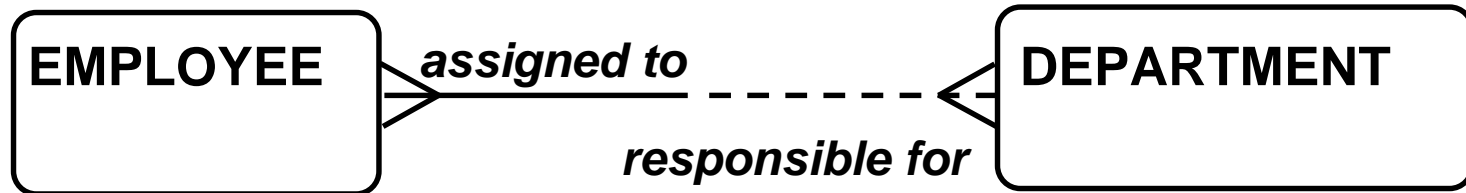
Practice: Instance or Entity?

Concept	E/A/I?	Example Instance or Entity
PRESIDENT		
ELLA FITZGERALD		
DOG		
ANIMAL		
HEIGHT		
	E	CAR
	A	CAR
	I	CAR

Practice: Guest

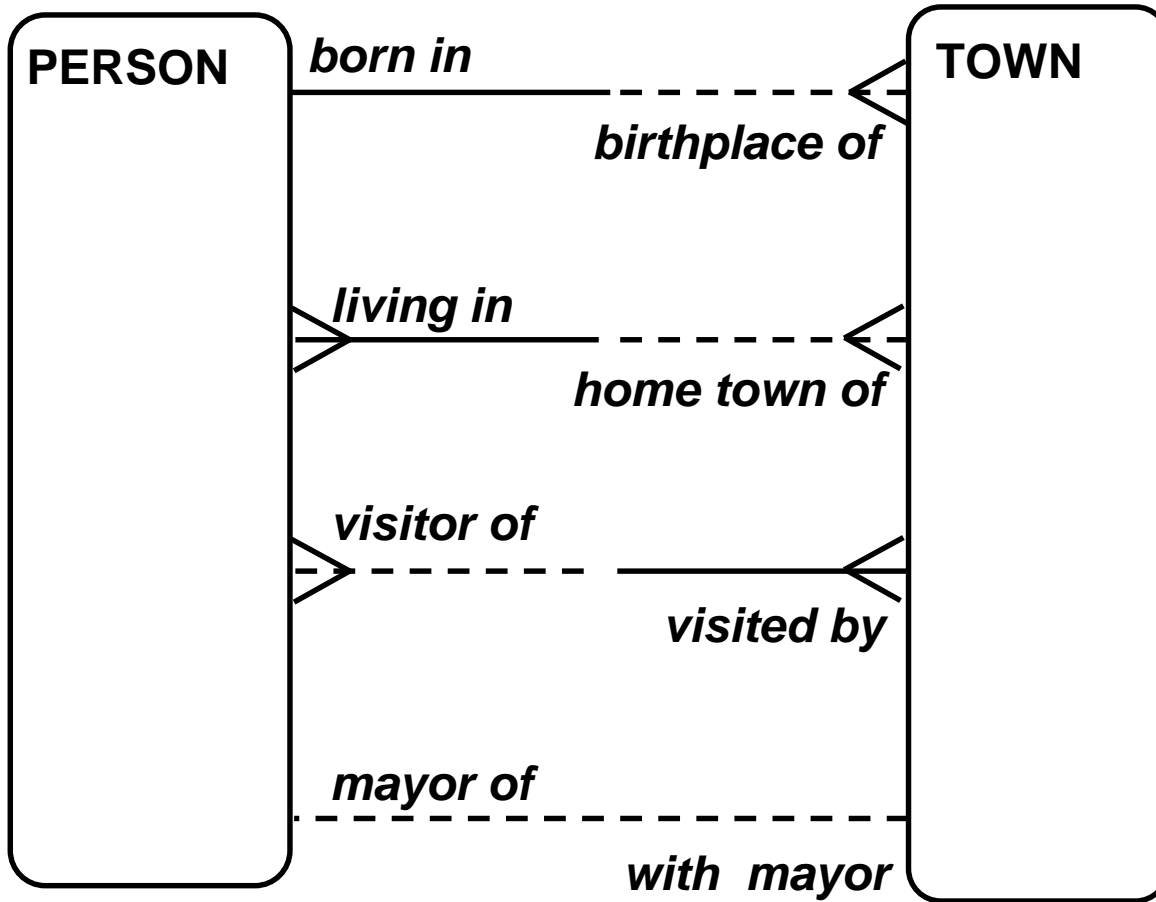
	Address
	Arrival Date
GUEST —————	Family Name
HOTEL	Room Number
ROOM	Floor Number
	Number of Beds
	Number of Parking Lots
	Price
	TV set available?

Practice: Reading

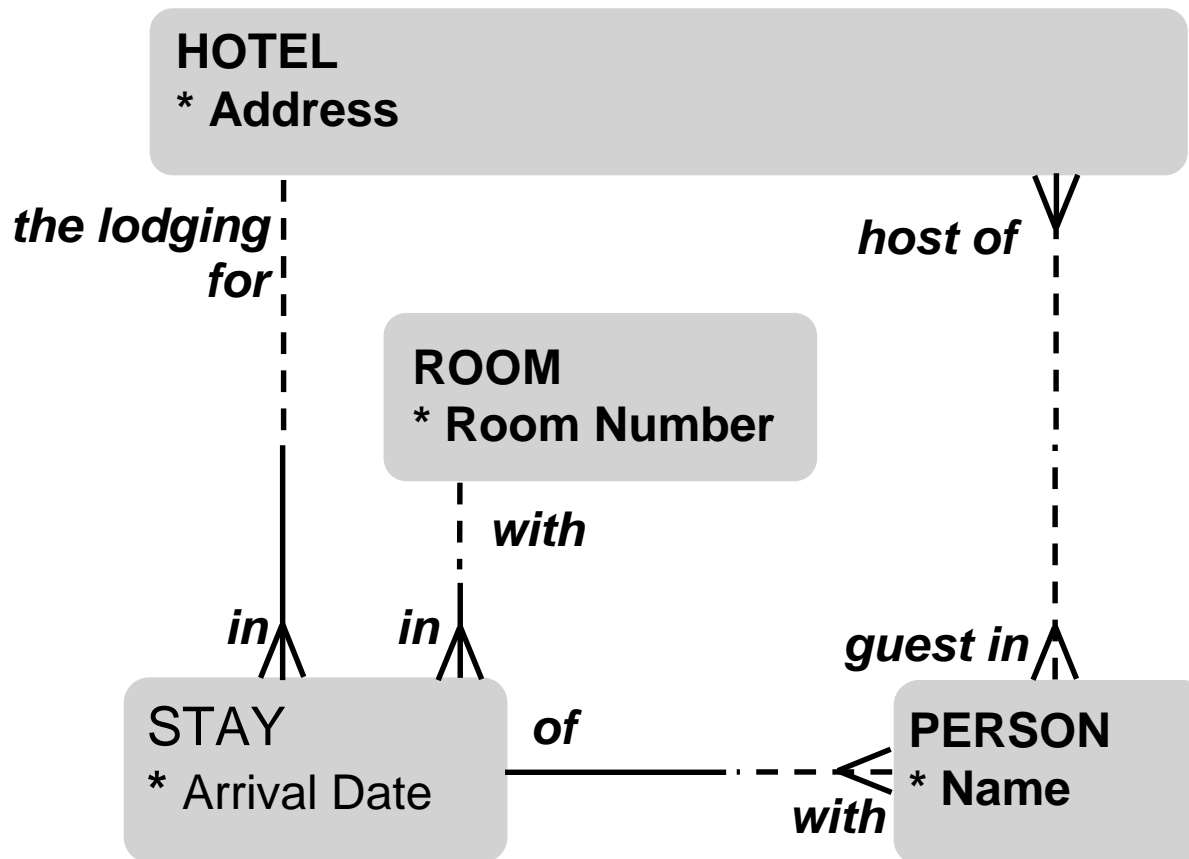


- A** Each EMPLOYEE may be assigned to one or more DEPARTMENTS
Each DEPARTMENT must be responsible for one or more EMPLOYEES
- B** Each EMPLOYEE must be assigned to one or more DEPARTMENTS
Each DEPARTMENT may be responsible for one or more EMPLOYEES
- C** Each EMPLOYEE must be assigned to exactly one DEPARTMENT
Each DEPARTMENT may be responsible for exactly one EMPLOYEE

Practice: Read and Comment



Practice: Hotel



Soups	Açorda alentejana bread soup from Portugal
vegetarian 15 min easy	For 4 persons: 1 onion 4 cloves of garlic 1 red pepper 1 liter of vegetable broth 4 tablespoons of olive oil 4 fresh eggs 1 handful of parsley or coriander salt, pepper 9-12 slices of (old) bread
Preparation	Cut the onion into small pieces and fry together with the garlic. Wash the red pepper, cut it in half, remove the seeds and fry it for at least 15.



Entities and Attributes in Detail

Overview

- **Data compared to information**
- **Entities and how to track them down**
- **Attributes**
- **Subtypes and supertypes**

Data Compared to Information

Data

- *Facts given from which other facts may be inferred*
- *Raw material*
- **Example: Telephone Directory**

Information

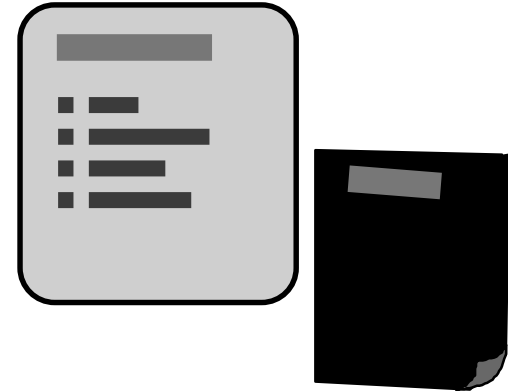
- *Knowledge, intelligence*
- **Example: Telephone number of florist**

Data

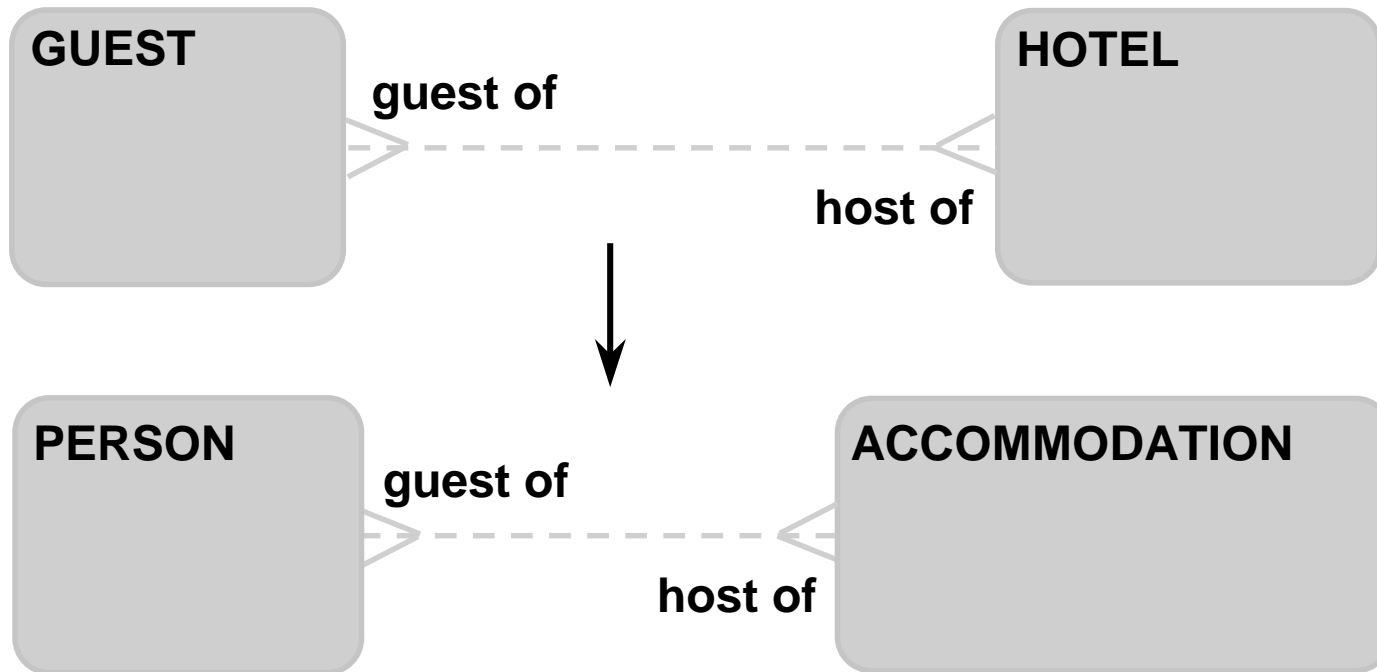
- ***Modeling, Conceptual***
Structuring data concepts into logical, coherent, and mutually related groups
- ***Modeling, Physical***
Modeling the structure of the (future) physical database
- ***Base***
A set of data, usually in a variety of formats, such as paper and electronically-based
- ***Warehouse***
A huge set of organized information

Entities

- **Give the entity a unique name**
- **Create a formal description of the entity**
- **Add a few attributes, if possible**
- **Be aware of homonyms**
- **Check entity names and descriptions regularly**
- **Avoid use of reserved words**
- **Remove relationship name from entity name**



Relationship Name in Entity Name



Some Background Information

“ElectronicMail (EM) wants to provide an attractive and user- friendly Web-based e-mail system. Important concepts are user and message.

An EM user has a unique address of 30 characters at most and a password supplied by the person who set up the EM user. Who the person really is, we do not know, although we ask for some additional information, such as the name, country, birth date, line of business, and a few more things.

Some Background Information

Users must be able to send and receive mail messages. A mail message is usually a piece of straight text. A message may have attached files. An attachment is a file, like a spreadsheet, that is sent and kept with the message, but not created with our software.

Messages are kept in folders. Every user has three folders to start with: Inbox, Outbox, and Wastebasket. Additional folders can be created by the user.”



advertisement area

Compose

Folders

Addresses

Preferences

Get New Mail

Exit

advertisement area

Compose Template default

Subject: test Send

To: bipi, giovanni_papini@yahoo.com Save Draft

Cc: myself Save Template

Bcc: Cancel

Message
text: this is a test
and a text as well
walalalala
pompidom

Keep
Copy

Add
Signature

Attachments: Type:

abc.html	Hypertext Word document
xyz.doc	

sketch of screen to compose mail messages



advertisement area3

Compose

Folders

Addresses

Preferences

Get New Mail

Exit

advertisement area1

Addresses

Nicknames

Alias

Email

<u>Alias</u>	<u>Email</u>
apple	w.j.appletree@em.com
bipi	sabine_papini@yahoo.com
joe	j.suspender@last.com
myself	iticallywink@em.com

Group

friends

bipi
joe
giovanni_papini@yahoo.com
p.g.m.papini@em.com

sketch of screen to maintain addresses

Some Desired Functionality

- **“Users of ElectronicMail must be able to address messages to a mail list, for example, a group of e-mail addresses. The system should only keep one copy of the message sent (to save database space) plus information about whom the message was sent to.**
- **Users must be able to create templates for their messages. A template must be named and may contain everything a real message contains. A template may be used for new messages.**

Some Desired Functionality

- **Users must be able to reply to a message. By replying the user creates a new message to which the old message is added.**
- **Users must be able to create an alias for an e-mail address, to hide the often complex addresses behind an easy-to-remember nickname.”**

Evolution of an Entity Definition

- A message is a piece of text sent by a user.
- A message is a piece of text sent by *an EM* user.
- A message is a note that is sent by an EM user. *A message does not necessarily contain text, nor a subject, etc.*
- A message is a note that is sent by an EM user *or received by an EM user or both*. A message does not necessarily contain text, nor a subject, etc.
- A message is a note that is *received* by an EM user. A message does not necessarily contain text, nor a subject, etc.

Business Functions

- **“Users of ElectronicMail must be able to *address* messages to a mail list, for example, a group of e-mail addresses. The system should only keep one copy of the message sent (to save data base space) plus information about whom the message was sent to.**
- **Users must be able to *create* templates for their messages. A template must be named and may contain everything a real message contains. A template may be used for new messages.**

Business Functions

- **Users must be able to *reply* to a message. By replying the user *creates* a new message to which the old message is added.**
- **Users must be able to create an alias for an e-mail address, to hide the often complex addresses behind an easy-to-remember nickname.”**

An Attribute...

- **Always answers “of what?”**
- **Is the property of entity, not of relationship**
- **Must be single valued**
- **Has format, for example:**
 - **Character string**
 - **Number**
 - **Date**
 - **Picture**
 - **Sound**
- **Is an elementary piece of data**

Nouns, Entities, Attributes

- “ElectronicMail (EM) wants to provide an attractive and user friendly Web-based email system. Important concepts are user and message.
- An EM *USER* has a unique *address* of 30 characters at most and a password supplied by the *PERSON* who set up the EM user. Who the person really is, we do not know, although we ask for some additional information, like the *name*, *COUNTRY*, *birth date*, *line of business*, and a few things more.

Nouns, Entities, Attributes

- **Users must be able to send and receive mail *MESSAGES*. A mail message is usually a piece of straight *text*. A message may have attached files. An *ATTACHMENT* is a *file*, like a spreadsheet, that is sent and kept with the message, but not created with our software.**
- **Messages are kept in *FOLDERS*. Every user has three folders to start with: *Inbox*, *Outbox* and *Wastebasket*. Additional folders can be created by the user.”**

EM Entities and Attributes

Nouns

user
address
password
person
name
country
birth date
occupation
message
text
attachment
file
folder
inbox
outbox
wastebasket

Entities/Attributes/ Instances

USER
Address
Password
PERSON
Name
COUNTRY
Birth Date
Occupation
MESSAGE
Text
ATTACHMENT
File
FOLDER
Inbox
Outbox
Wastebasket

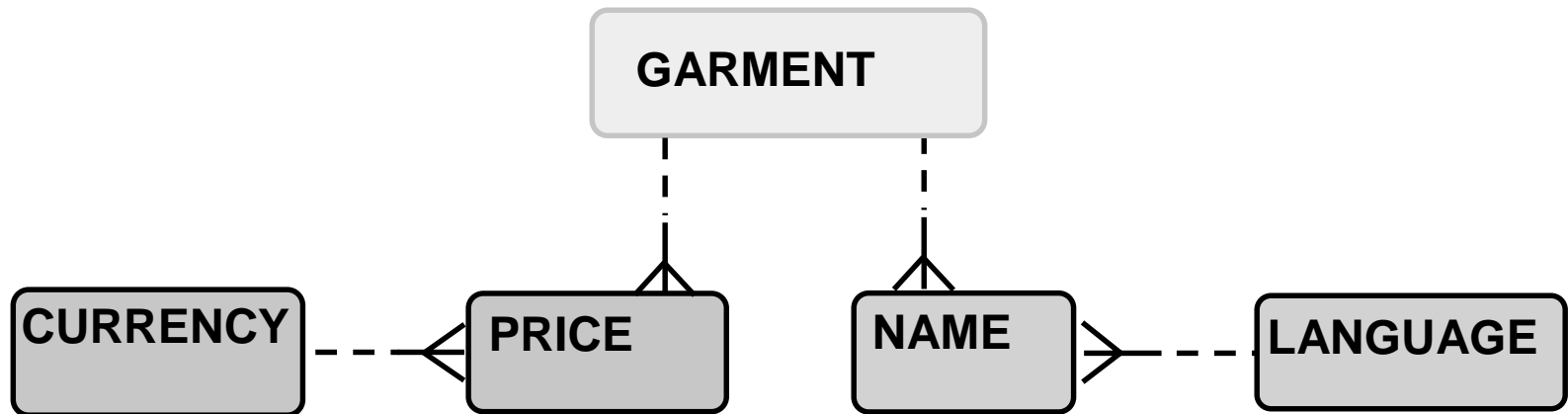
Entities with their Attributes

USER
- Address
- Password
PERSON
- Name
- Birth Date
- Occupation
COUNTRY
- Name
MESSAGE
- Text
ATTACHMENT
- Filename
FOLDER
- Name

Attribute and Entity



Attributes in one model can be entities in another.



Redundancy

COMMODITY

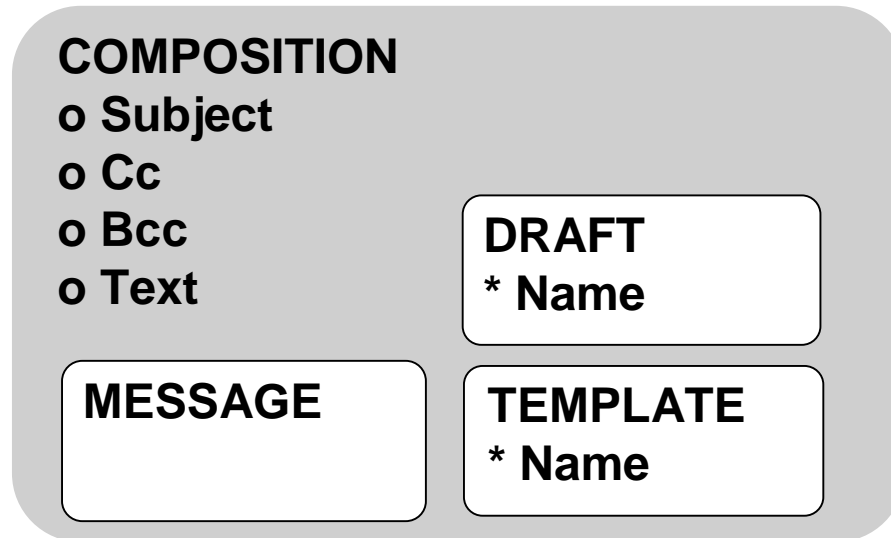
- * Name**
- * Price exclusive VAT**
- * Price inclusive VAT**
- * VAT %**

A Subtype ...

- **Inherits all attributes of supertype**
- **Inherits all relationships of supertype**
- **Usually has its own attributes or relationships or business functions**
- **Is drawn within supertype**
- **Never exists alone**
- **May have subtypes of its own**
- **Is also known as “Subentity”**



Subtype: Example



Subtype: Rules

Subtypes of the same entity must be:

- **Exhaustive:**
Every instance of a supertype is also instance of one of the subtypes.

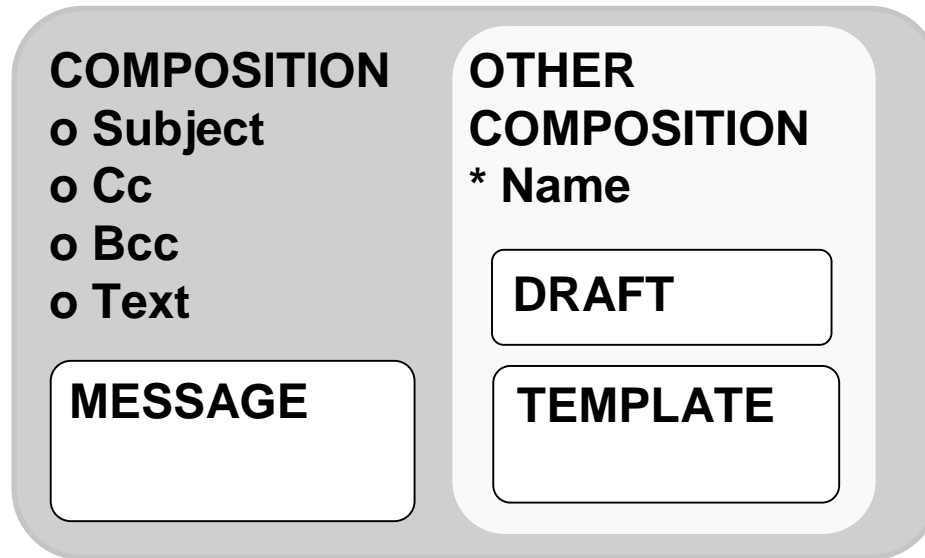
and

- **Mutually exclusive:**
Every instance of the supertype is of *one and only one* subtype.

Name subtypes adequately:



Subtypes: Three Levels

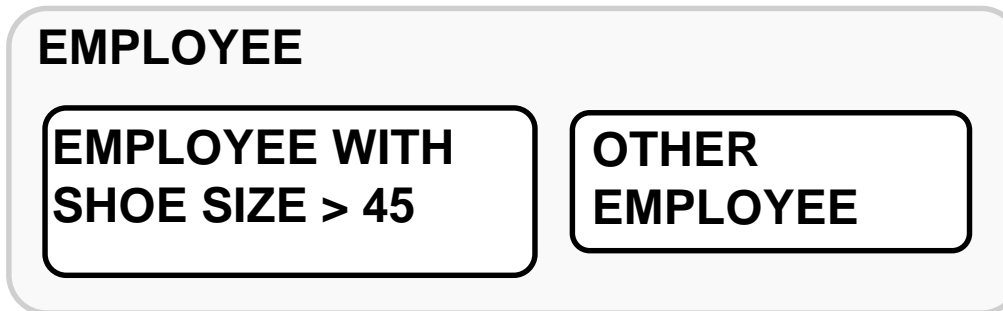


More on Subtypes

Subtypes *always* exist...



... but do not all make sense



Summary

Entities

- **Nouns in texts**
- **Tangible, intangible, events**

Attributes

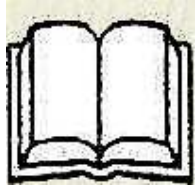
- **Single-valued qualifiers of entities**

Subtypes

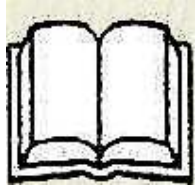
- **Inherit all attributes and relationships of supertype**
- **May have their own attributes and relationships**

Practices

- **Books**
- **Moonlight Coffees**
- **Shops**
- **Subtypes**
- **Schedule**
- **Address**



- 1. I have just finished writing a book. It's a novel about justice and power.**
- 2. We have just published this book. The hard cover edition is available now.**
- 3. Did you read that new book on Picasso? I did. It's great!**
- 4. If you like you can borrow my book.**
- 5. I have just started translating this book into Spanish. I use the modern English text as a basis and not the original, which is 16th century.**
- 6. I ordered that book for my parents.**



- 7. Yes, we have that book available. You should find it in Art books.**
- 8. A second printing of the book War and Peace is very rare.**
- 9. I think My name is Asher Lev is one of the best books ever written. Mine is autographed.**
- 10. I want to write a book on entity relationship modeling when I retire.**



Summary

- **Moonlight Coffees is a fast growing chain of high quality coffee shops with currently over 500 shops in 12 countries of the world. Shops are located at first-class locations, such as major shopping, entertainment and business areas, airports, railway stations, museums. Moonlight Coffees has some 9,000 employees.**

Products

- **All shops serve coffees, teas, soft drinks, and various kinds of pastries. Most shops sell nonfoods, like postcards and sometimes even theater tickets.**



Summary

Financial

Shop management reports sales figures on a daily basis to Headquarters, in local currency. Moonlight uses an internal exchange rates list that is changed monthly. Since January 1, 1999, the European Community countries must report in Euros.

Stock

Moonlight Coffees is a public company; stock is traded at NASDAQ, ticker symbol MLTC. Employees can participate in a stock option plan.



Shop List

Shoplister, ordered to date opened page 4

**181 The Flight, JFK Airport terminal 2, New York, USA,
212.866.3410, Airport, 12-oct-97**

**182 Hara, Kita Shinagawa, Tokyo, JP, 3581.3603/4,
Museum, 25-oct-97**

**183 Phillis, 25 Phillis Rd, Atlanta, USA, 405.867.3345,
Shopping Centre, 1-nov-97**

**184 JFK, JFK Airport terminal 4, New York, USA,
212.866.3766, Airport, 1-nov-97**



Shop List

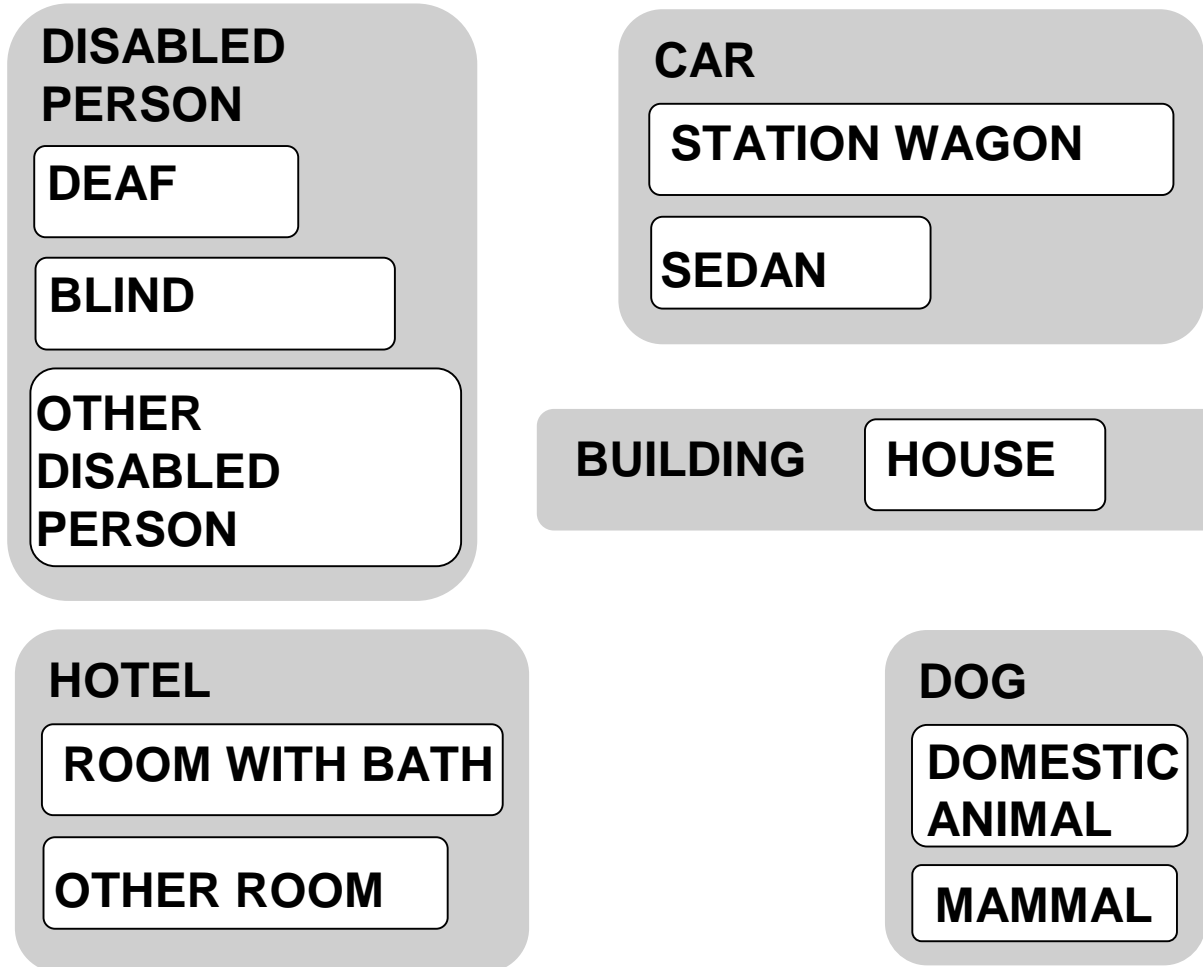
**185 VanGogh, Museumplein 24, Amsterdam, NL,
76.87.345, Museum, 10-nov-97**

**186 The Queen, 60 Victoria Street, London, UK,
203.75.756, Railway Station, 25-nov-97**

**187 Wright Bros, JFK Airport terminal 1, New York,
USA, 212.866.9852, Airport, 6-jan-98**

**188 La Lune, 10 Mont Martre, Paris, FR, 445 145 20,
Entertainment, 2-feb-98**

Subtypes



van Gogh, Museumplein, Amsterdam

Schedule Oct 12 - Oct 18				prepared by Janet			
Shift	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Annet S			2		2	2	1
Annet B	1				1	1	
Dennis	2	2	1	2	3		
Jürgen						5	4
Kiri		3			4	4	
Wil							

Practice: Address (1/2)

**Rheingasse 123
53111 Bonn
Germany**

**34 Oxford Road
Reading
Berkshire RG1 8JS
UK**

**1020 Maple Drive
Kirkland WA 98234
USA**

Practice: Address (2/2)

**P.O. Box 66708
Nairobi
Kenya**

**c/o Mrs Smith
Maude Street
Sandton
Johannesburg 2144
South Africa**

3 Relationships in Detail

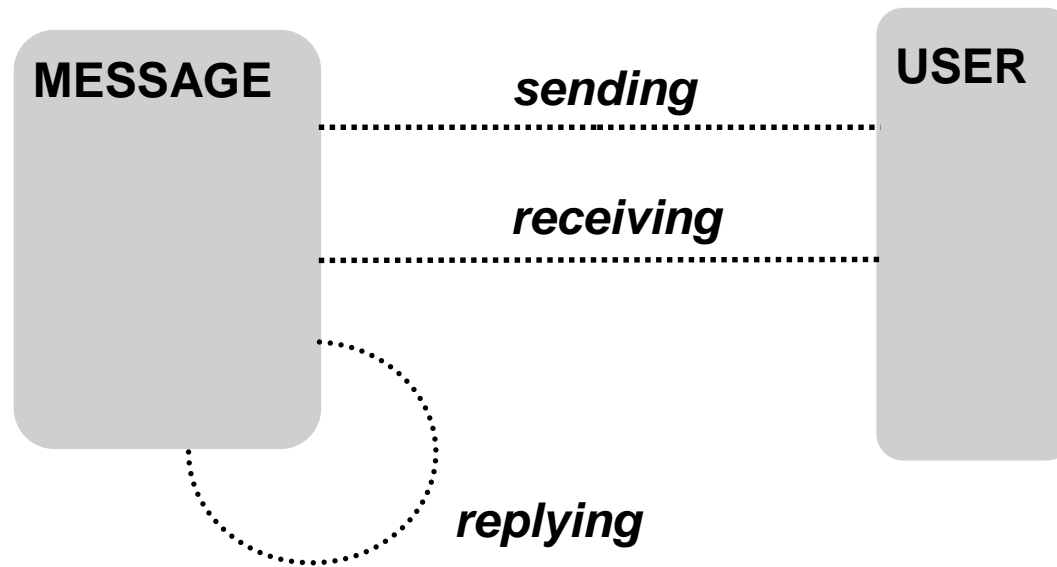
Overview

- **Relationships**
- **Ten different relationship types**
- **Nontransferability**
- **Relationships that seem to have attributes**
- **Rules of Normalization**

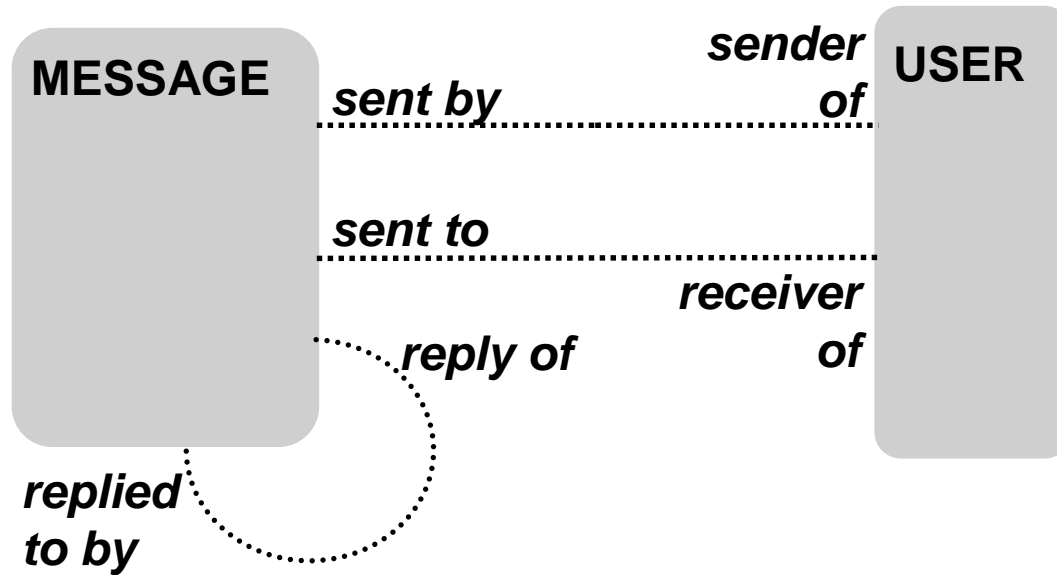
Establishing a Relationship

- **Determine the existence of a relationship**
- **Choose a name for the relationship from both perspectives**
- **Determine optionality**
- **Determine degree**
- **Determine nontransferability**

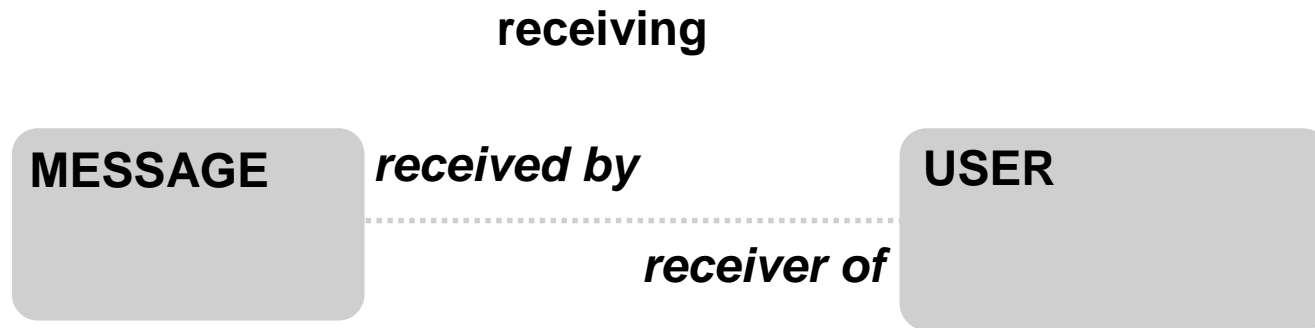
Establishing the Relationship



Relationship Names

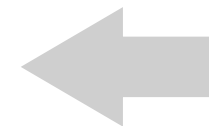


Naming the Relationship

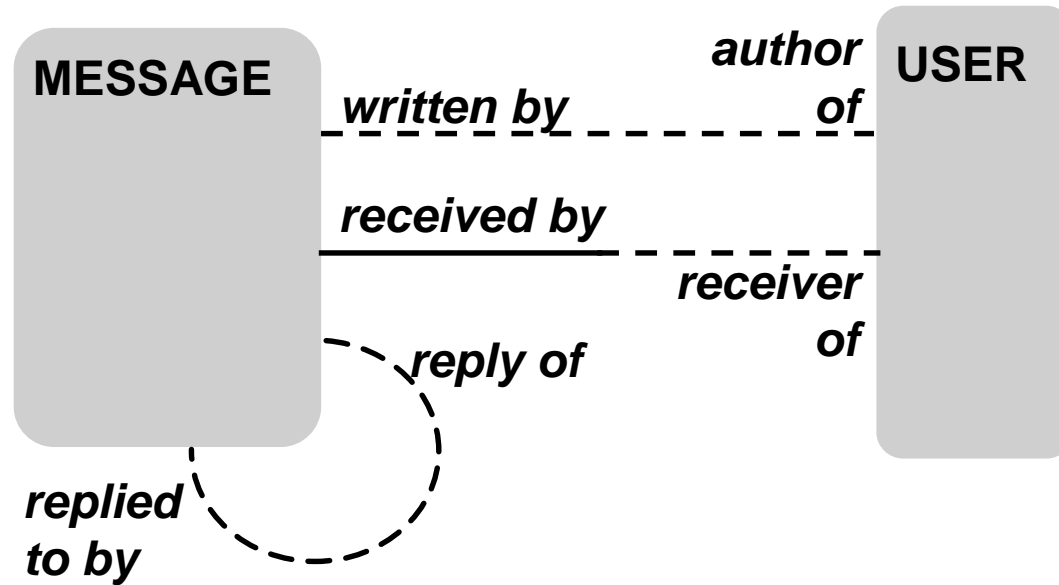


A MESSAGE is *received by* a USER

A USER is *receiver of* a MESSAGE

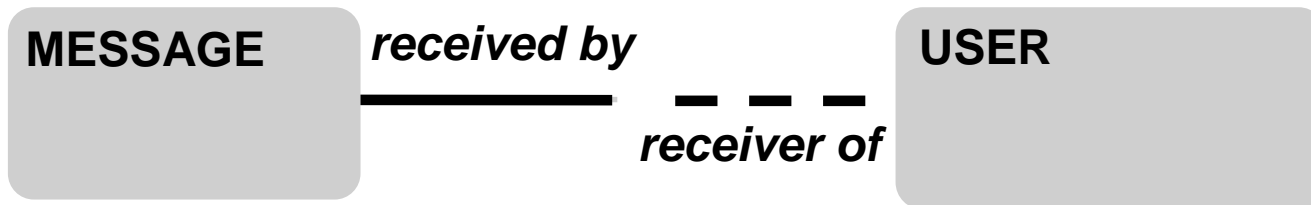


Optionality



Optionality

No: - - - - . Yes: _____



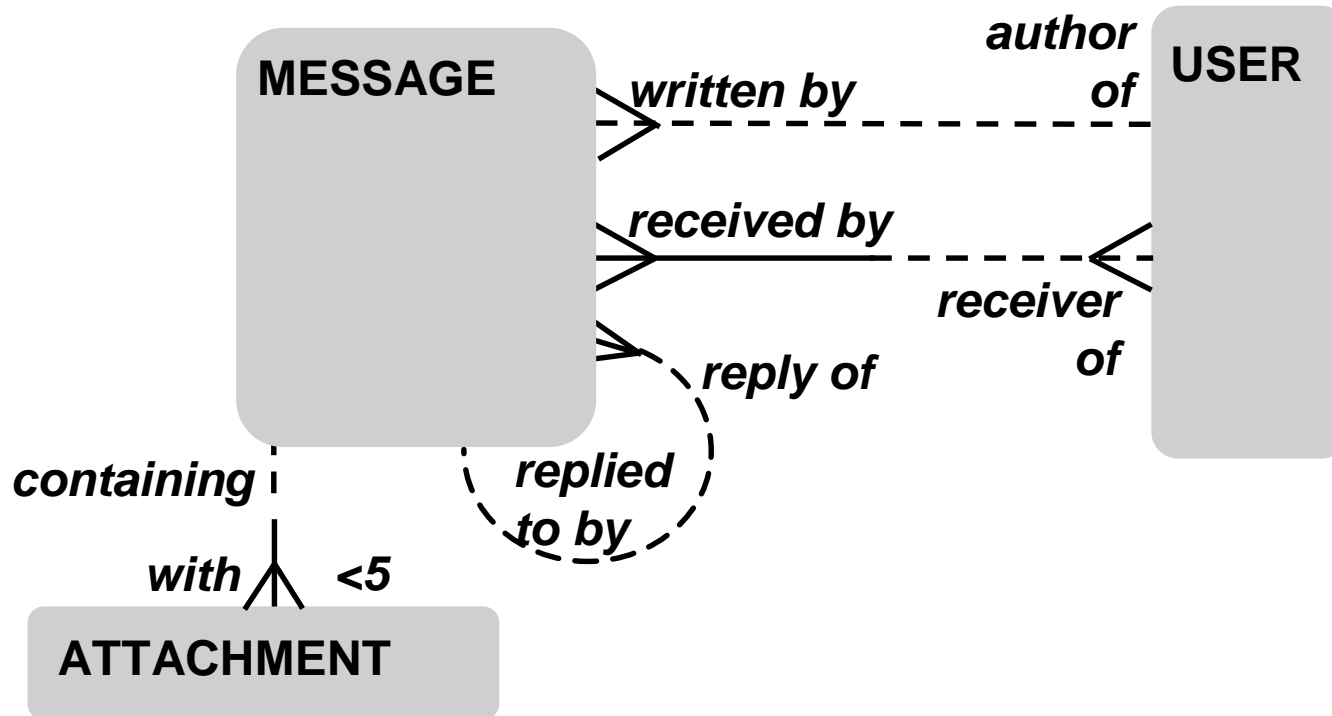
- ***Must every MESSAGE be received by a USER?* Yes**
- ***Must every USER be receiver of a MESSAGE?* No**

Mandatory 1: Mandatory m



- Every A must be *split into* at least one B
- Every B must be *part of* exactly one A

Degree

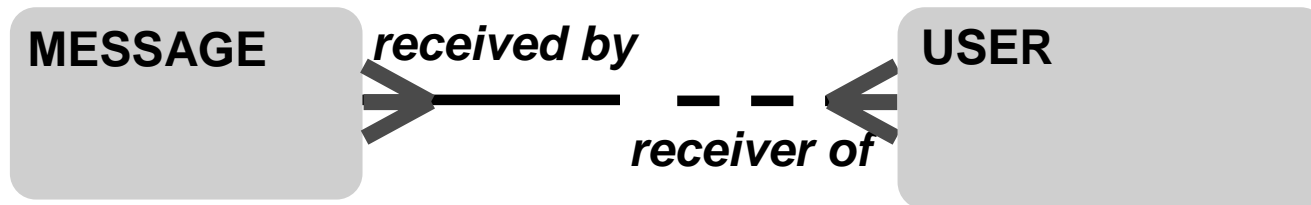
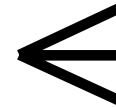


Degree

One:

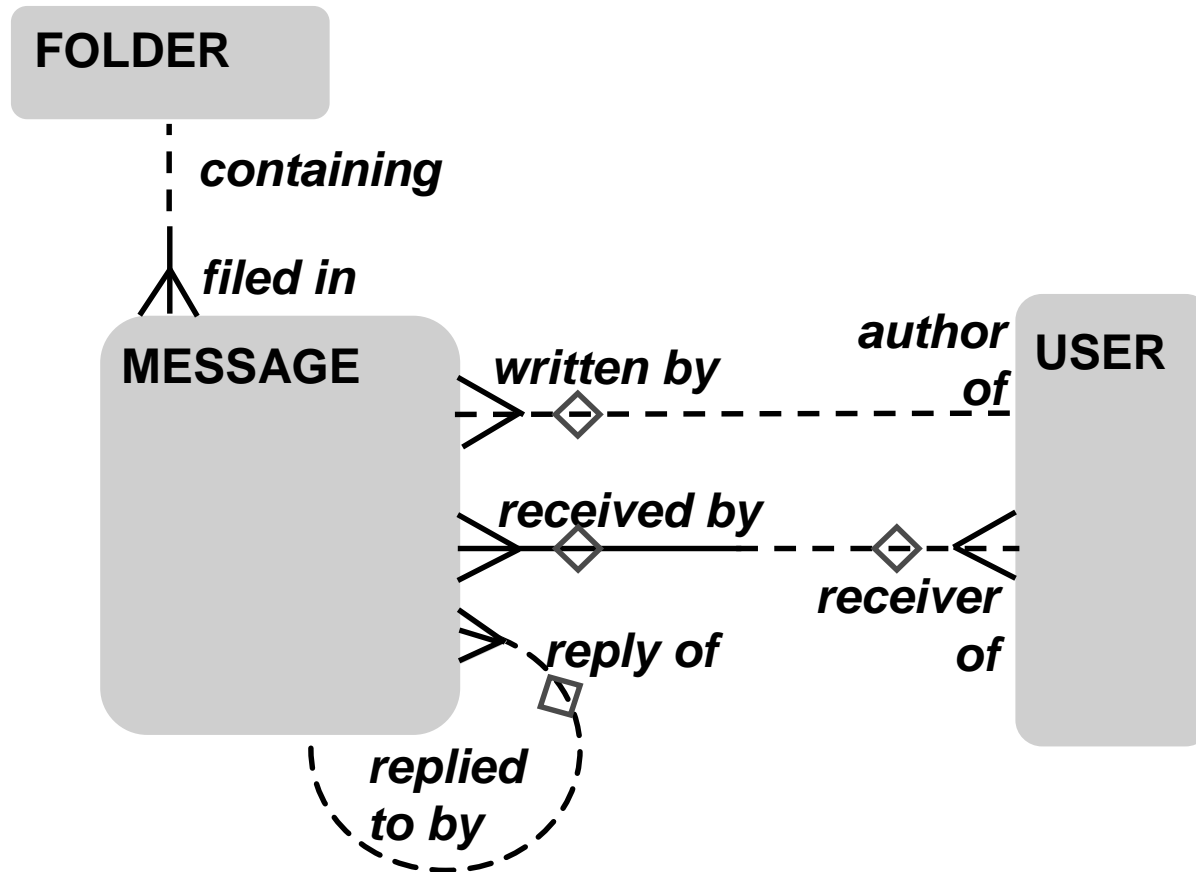


One or more:



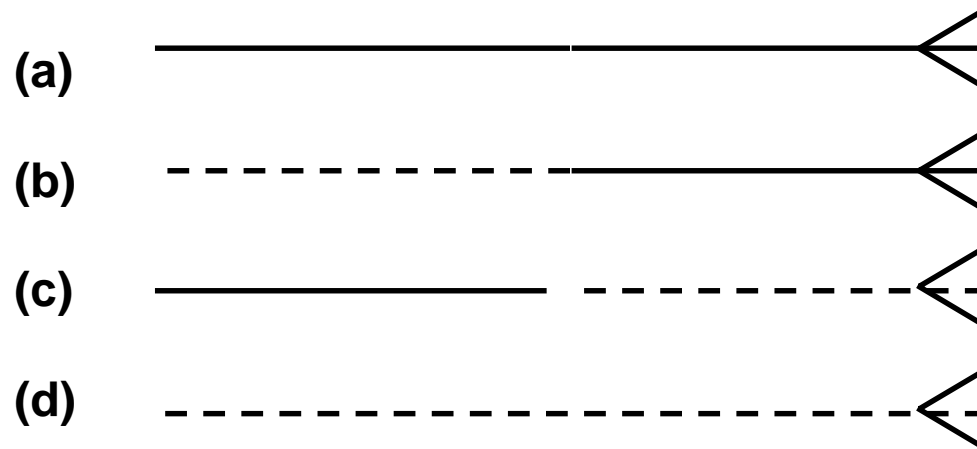
- **Can a MESSAGE be received by *more than one* USER?** **Yes**
- **Can a USER be the receiver of *more than one* MESSAGE ?** **Yes**

Nontransferability



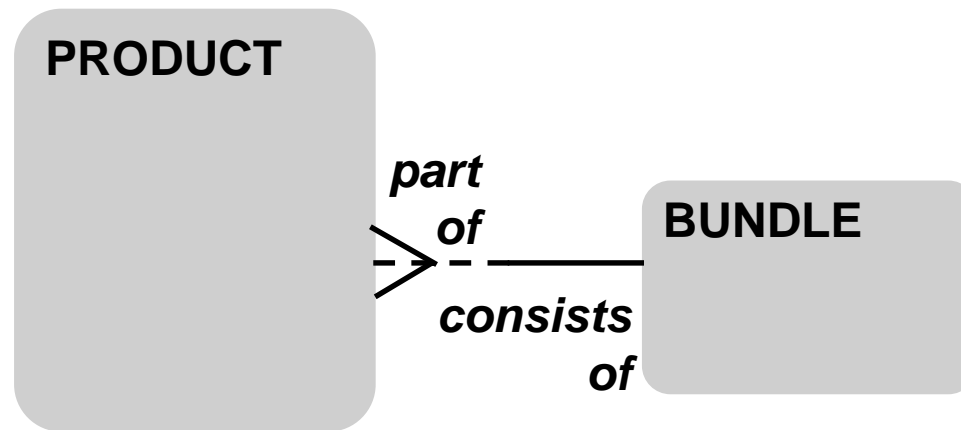
Relationship Types

1:m



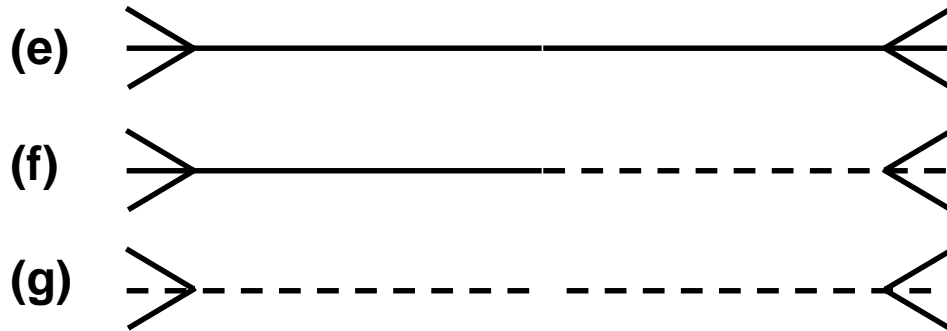
Relationship Types

m:1



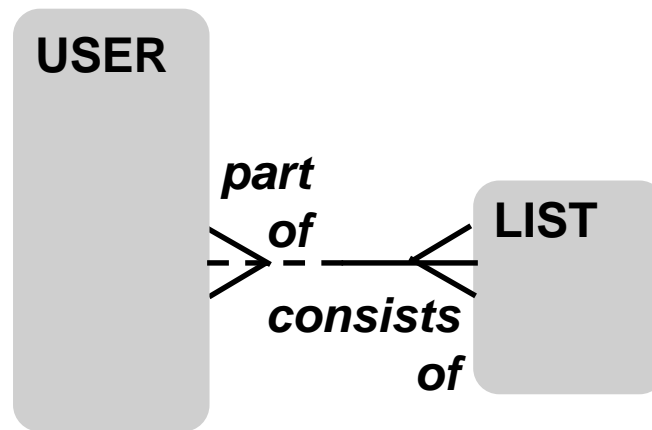
Relationship Types

m:m



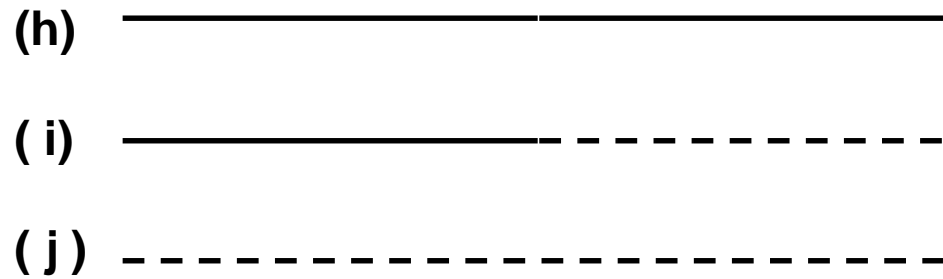
Relationship Types

m:m



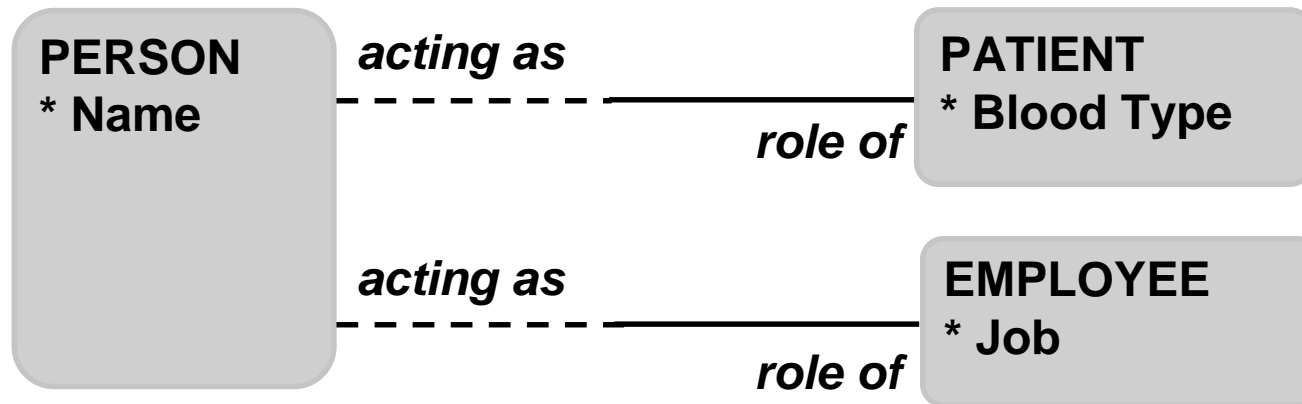
Relationship Types

1:1

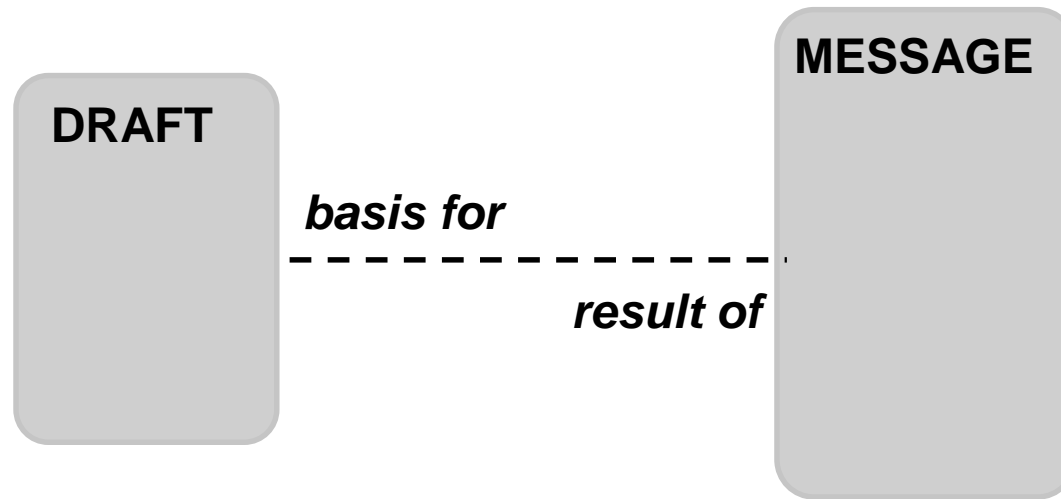


1:1 Relationships

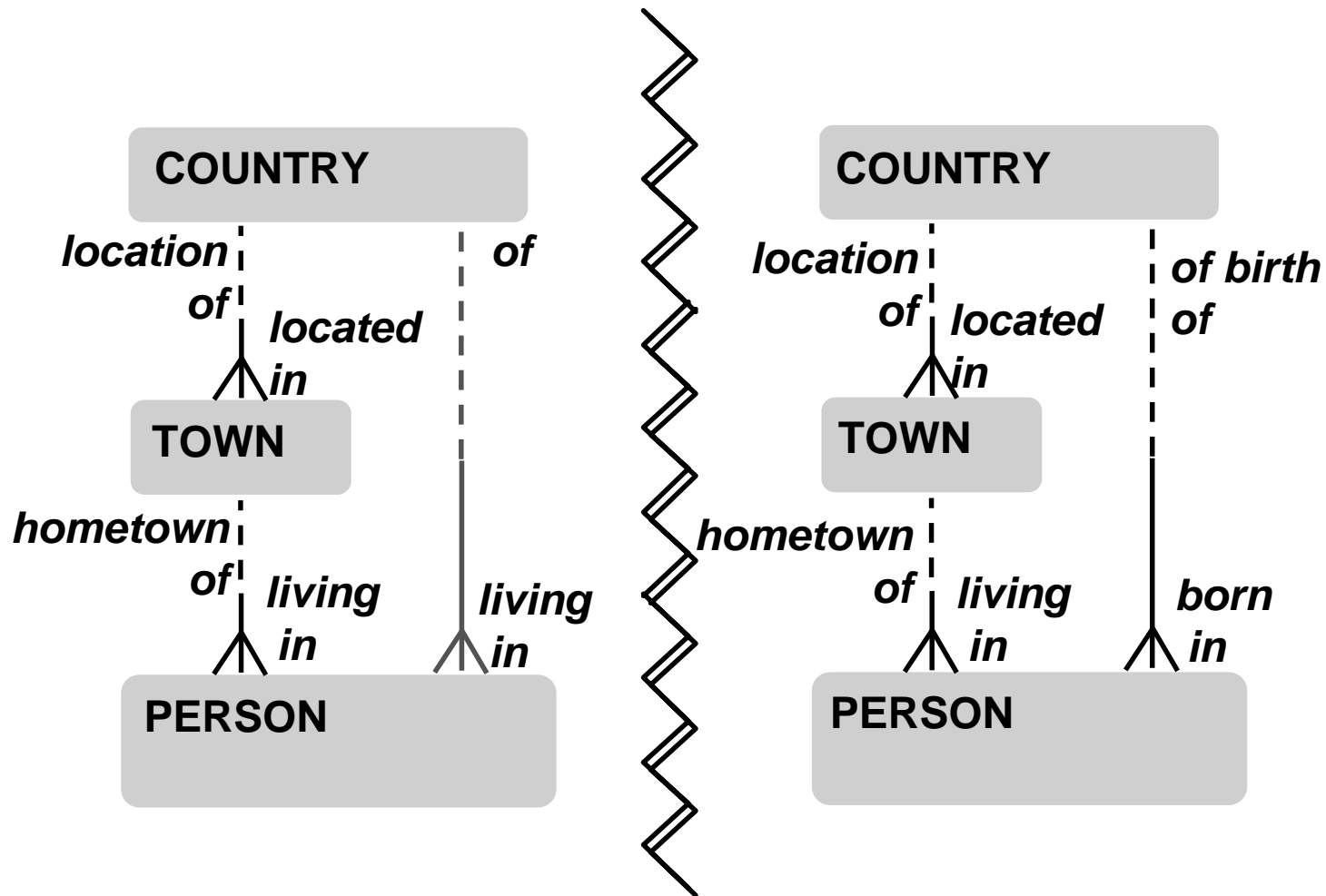
Roles



1:1 Relationships Process

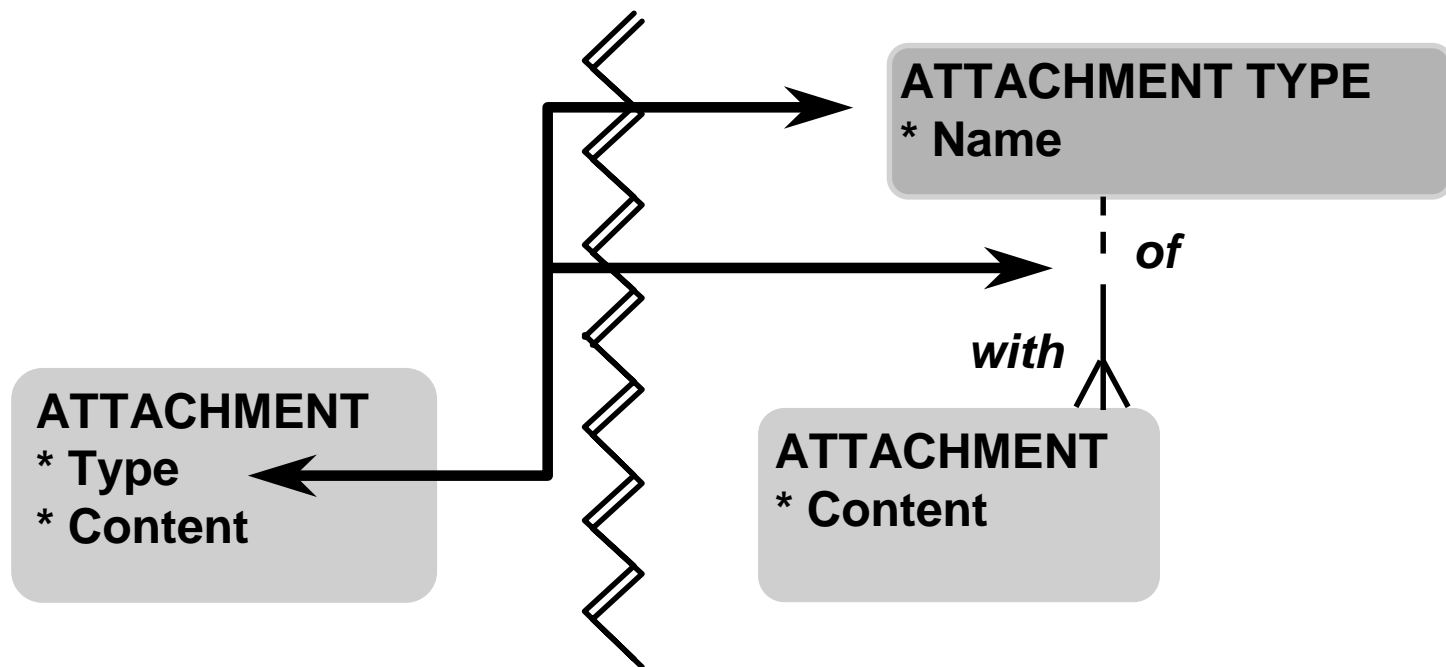


Redundant Relationships



Relationships and Attributes

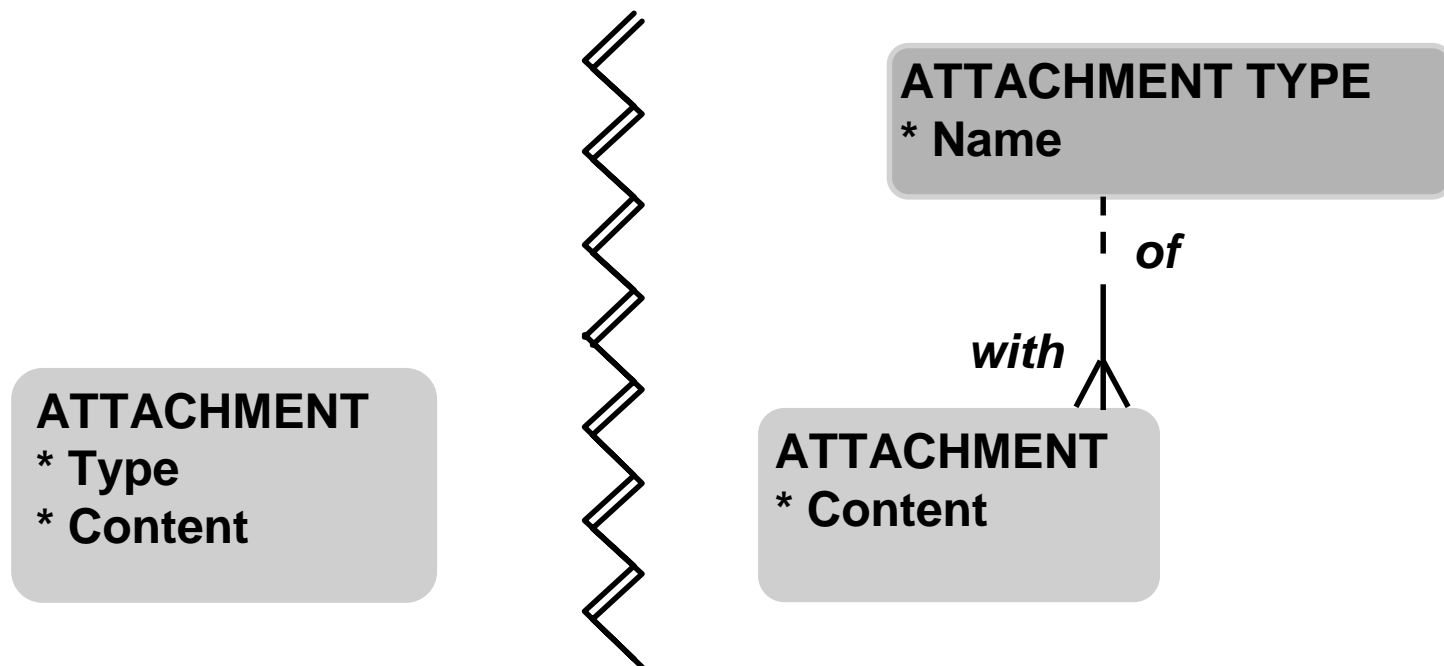
- An attribute can hide a relationship
- Relationship can be “downgraded” to attribute



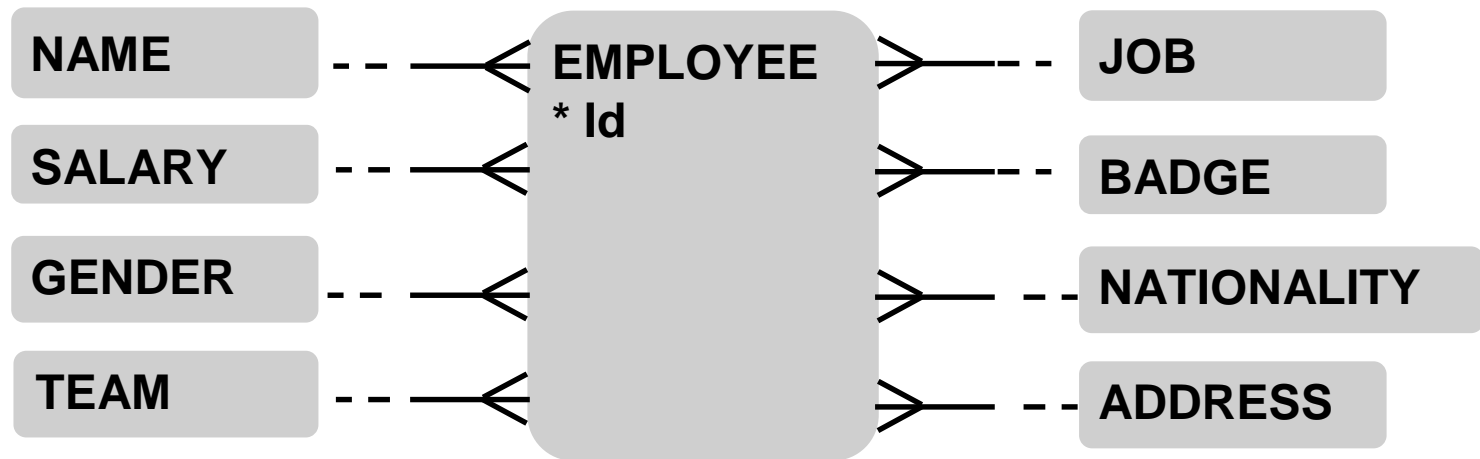
Attribute Compared to Relationship

- Easy model
- Fewer tables
- No join

- Value control
- List of values
- Other relationships

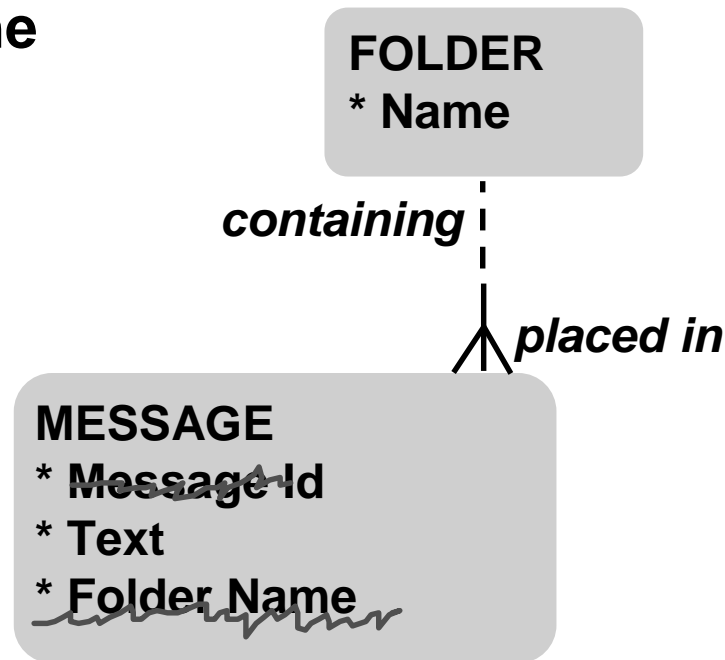


Attribute or Entity

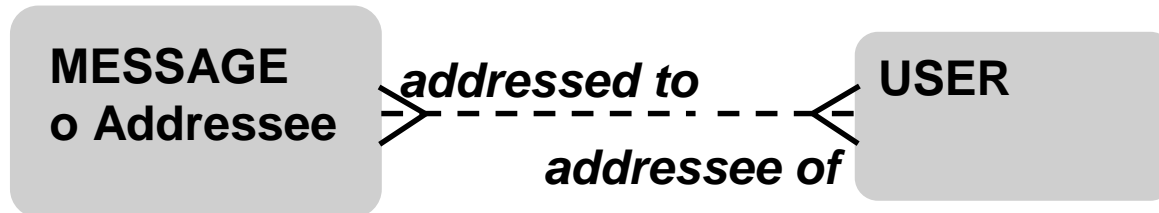
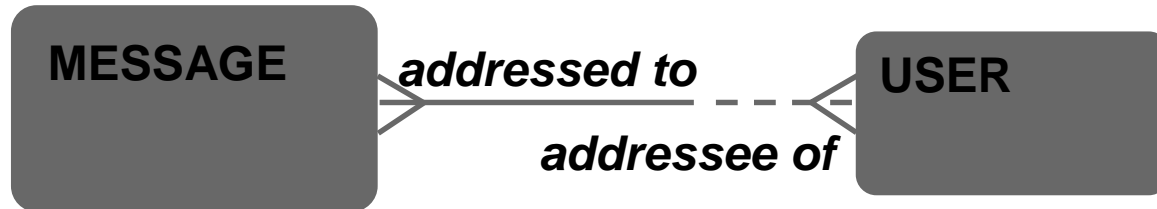


Attribute Compared to Relationship

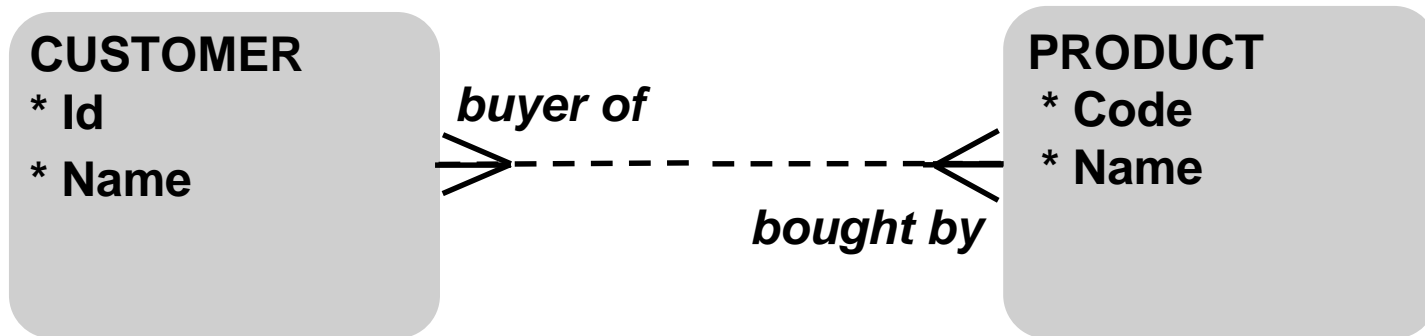
- There is no such thing as a foreign key attribute
- Usually, the attribute name should not contain an entity name



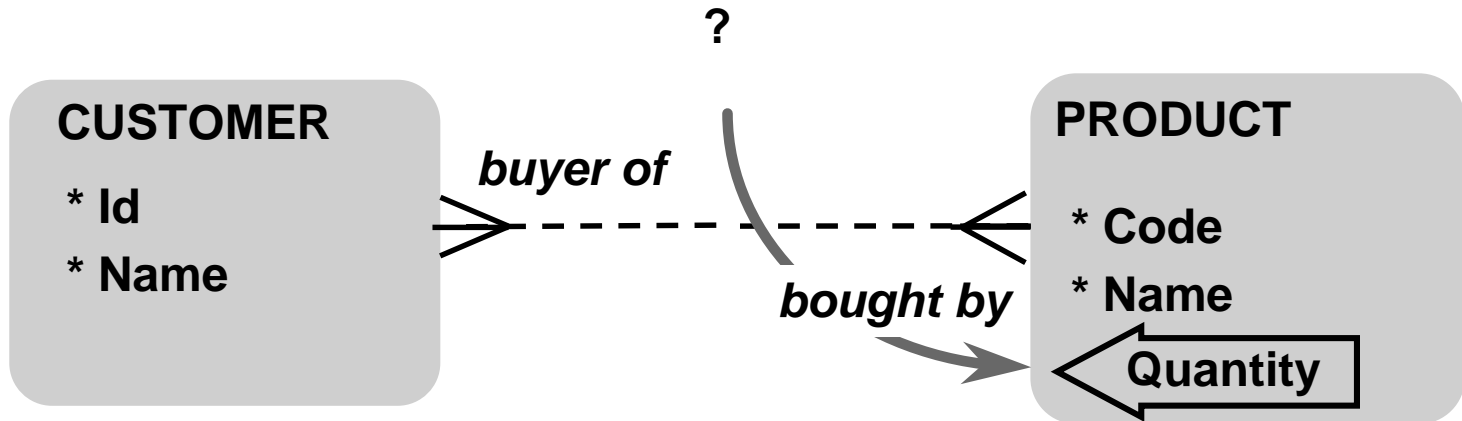
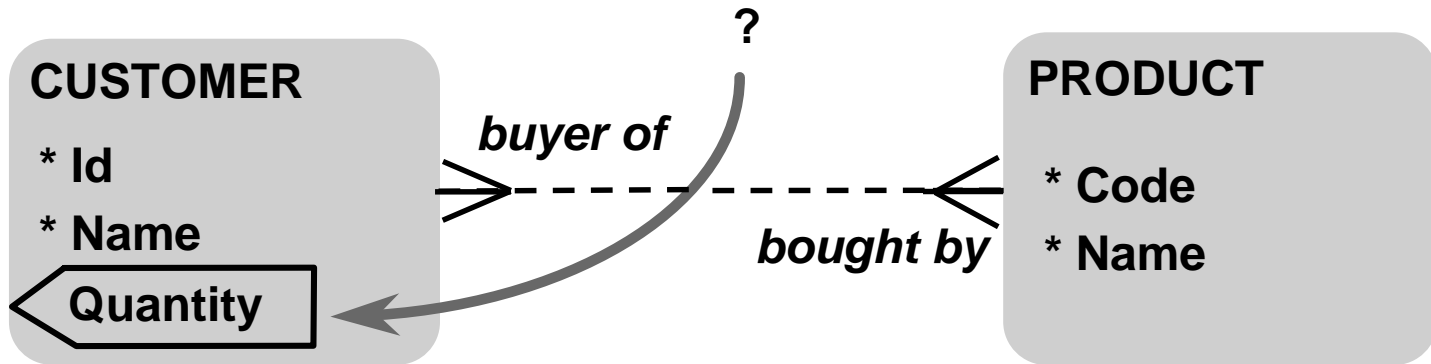
Relationship Compared to Attribute



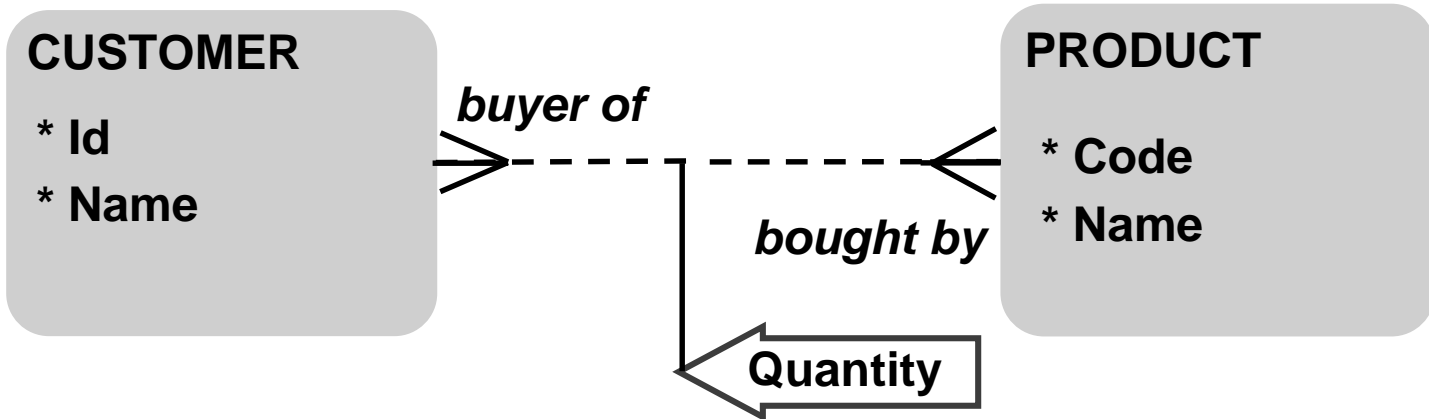
m:m Relationships May Hide Something



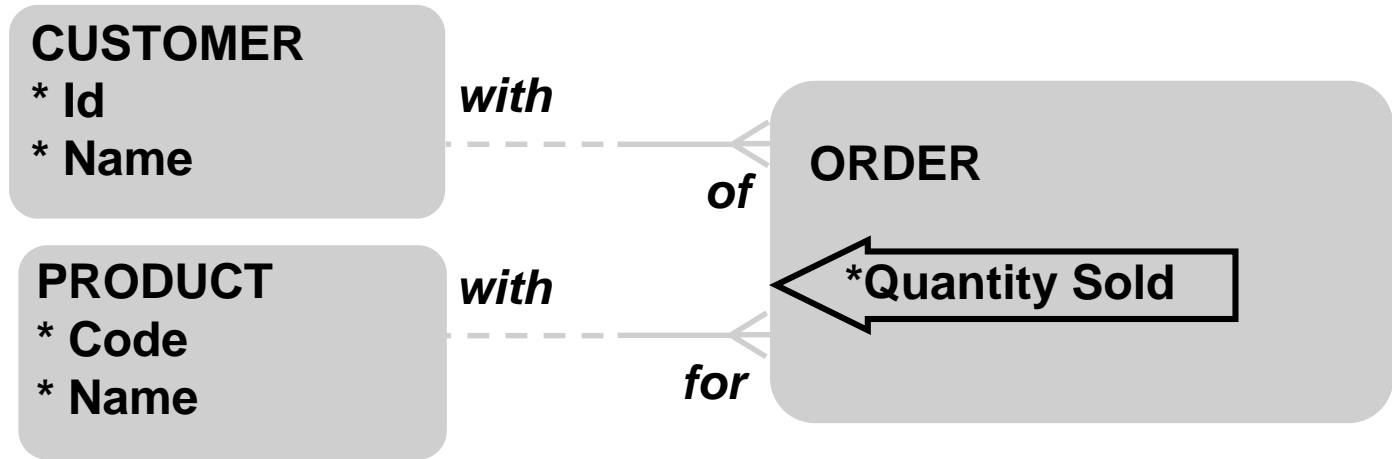
Quantity Is Attribute of ...



Attribute of Relationship ?



New Entity ORDER



CUSTOMERS

Id	Name
1	Sanchez
2	Lowitch
3	Yomita
4	

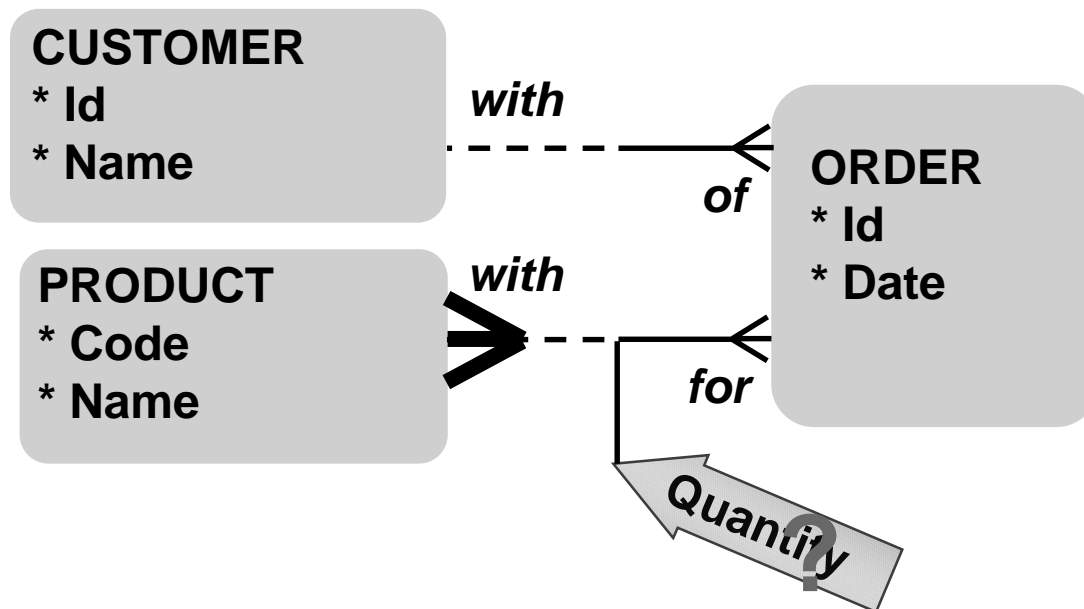
PRODUCTS

Code	Name
1	Jeans
2	Shirt
3	Tie
4	

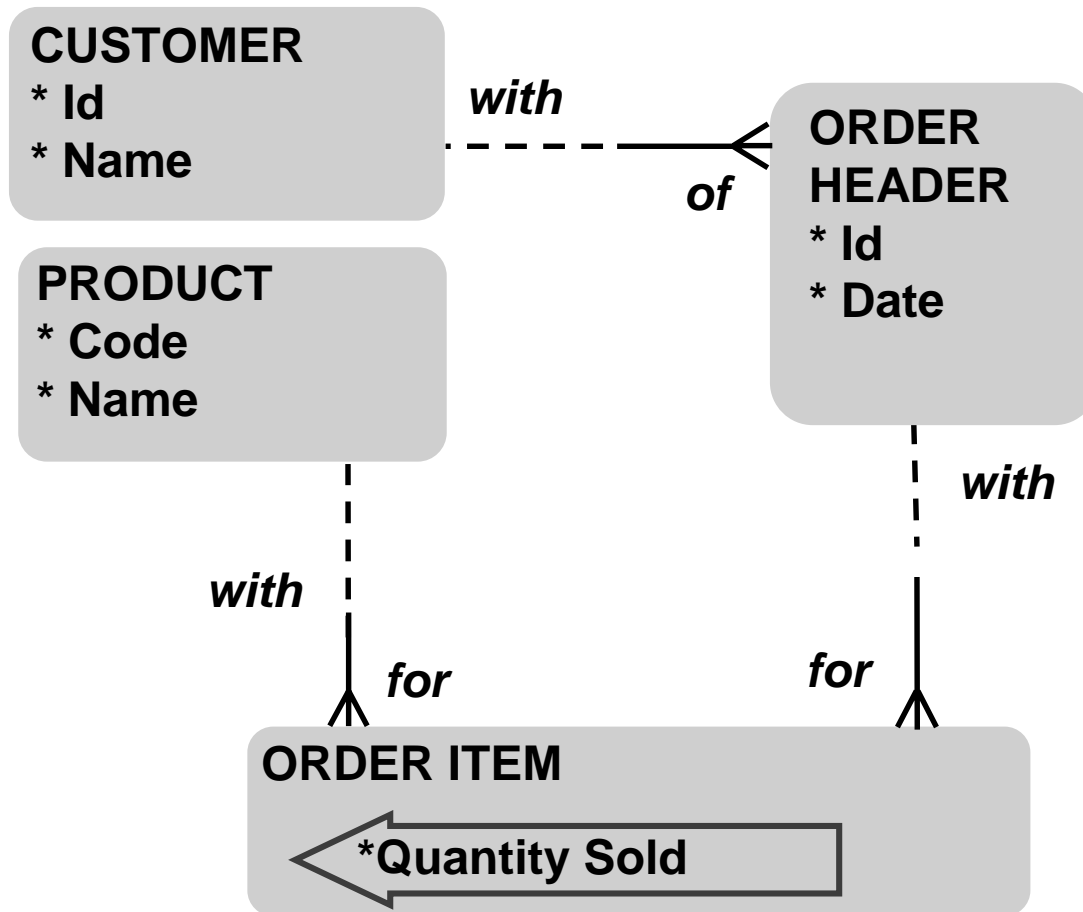
ORDERS

Ctr_id	Pdt_code	Quantity_sold
1	2	2
1	3	2
2	2	1
3		

Multiple PRODUCTS for an ORDER



Another New Entity: ORDER ITEM



Tables

CUSTOMERS

Id	Name
1	Sanchez Lowitch
2	Yomita

ORDER_HEADERS

Id	Ctr_id	Date_ordered
1	1	25-MAY-1999
		25-MAY-1999
2	2	25-MAY-1999

ORDER_ITEMS

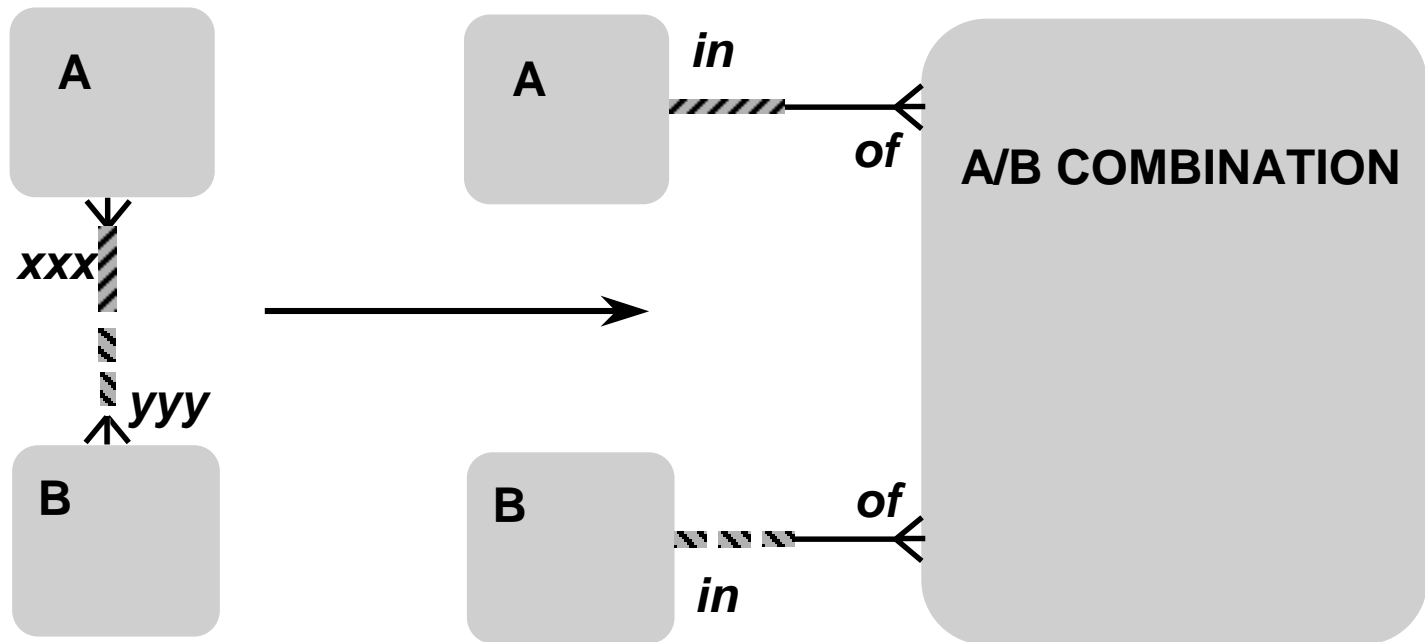
Ohd_id	Pdt_code	Quantity_sold
1	2	2
		2
2	2	1

PRODUCTS

Code	Name
1	Jeans
2	Shirt
3	Tie

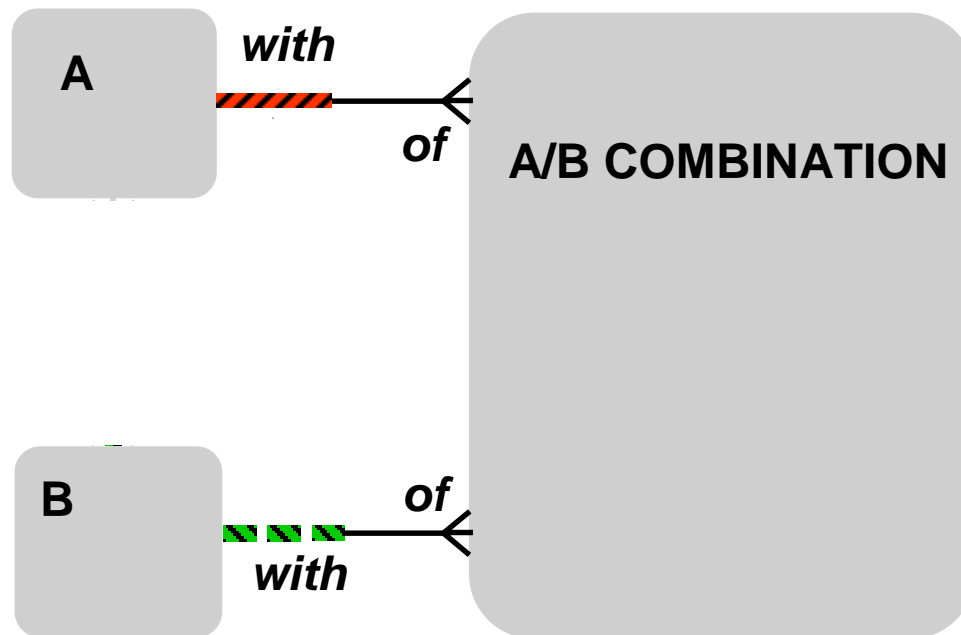
Resolving m:m Relationship

- Create new intersection entity
- Create two m:1 relationships, derive optionality
- Remove m:m relationship

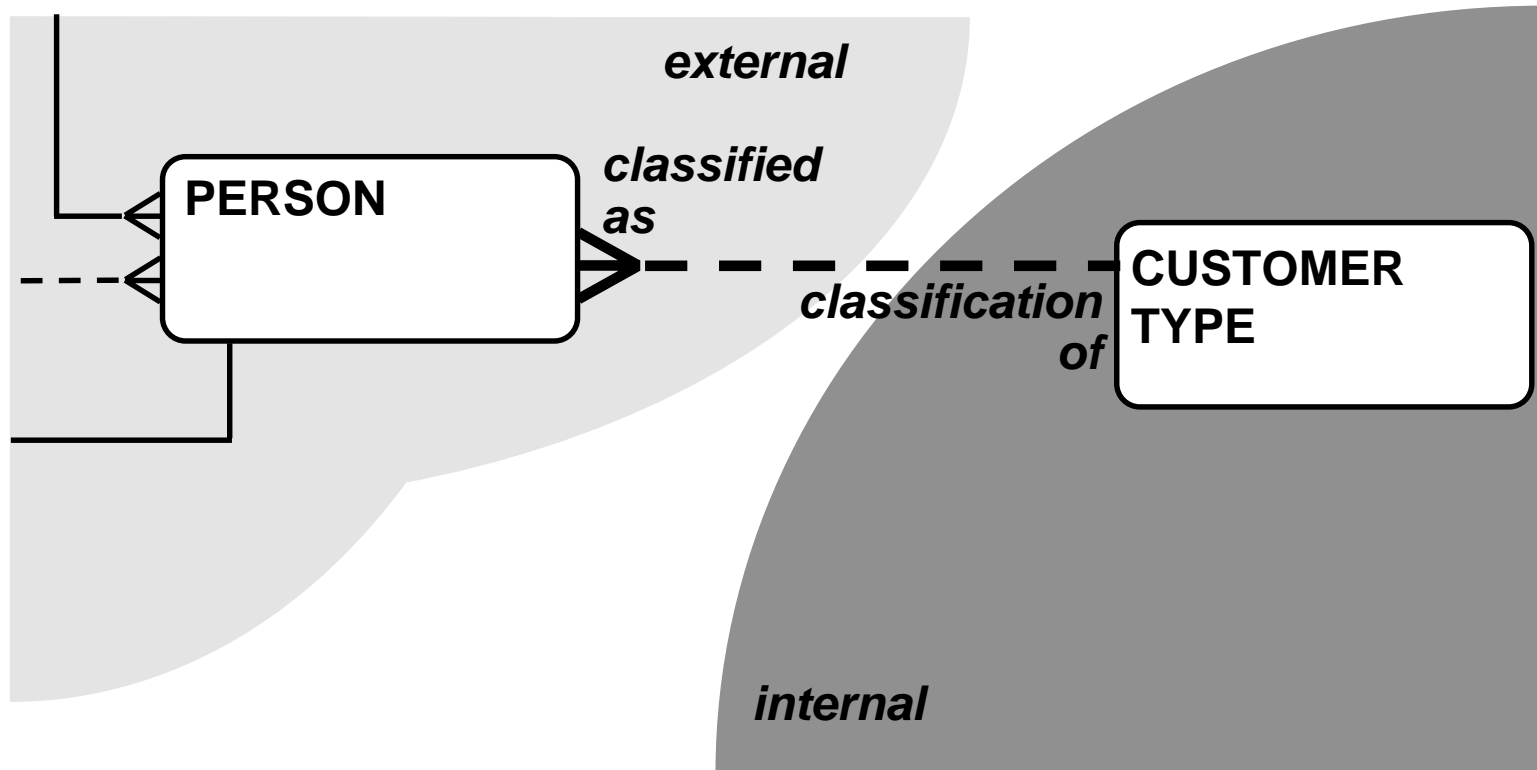


Resolving m:m Relationship

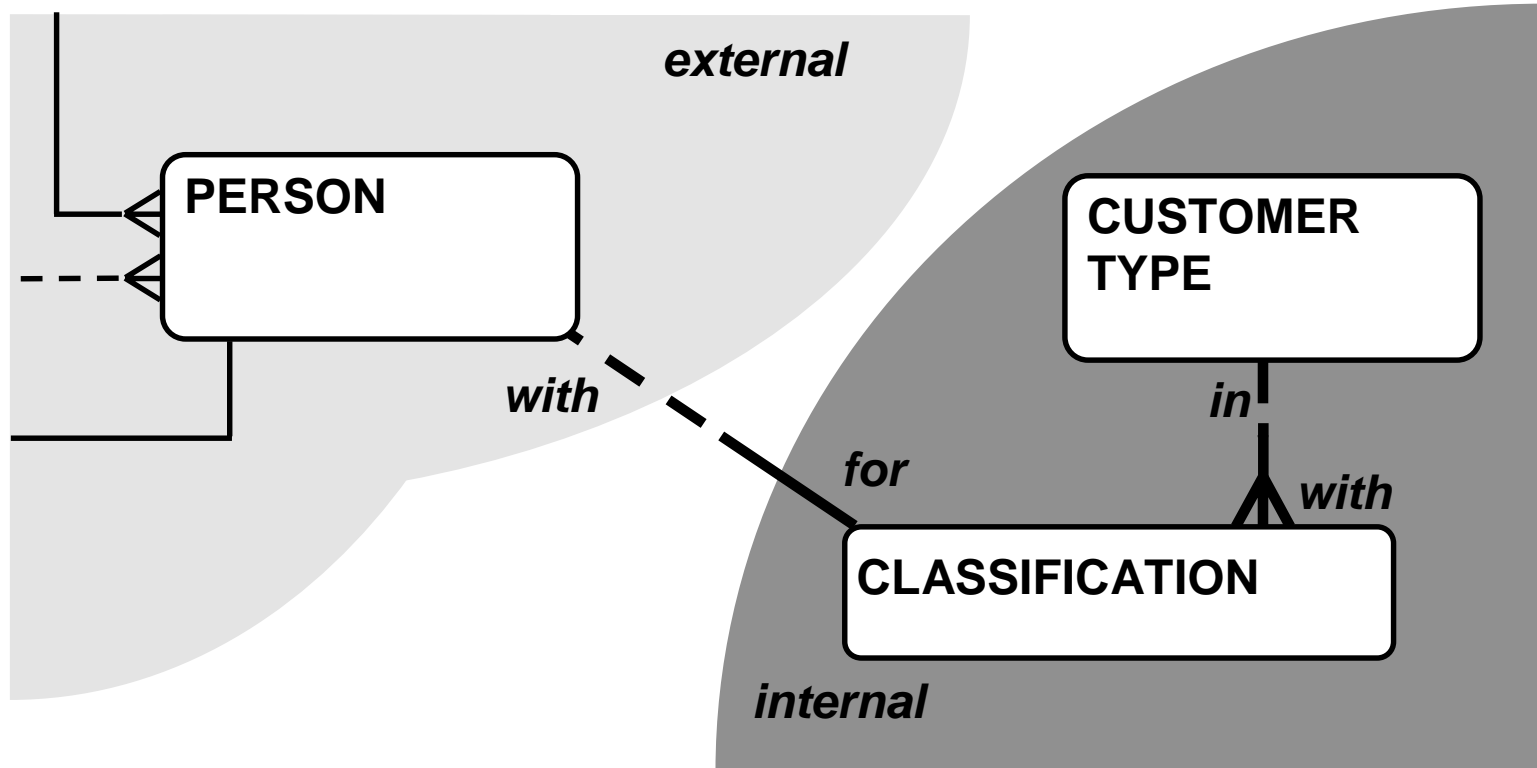
- Create new intersection entity
- Create two m:1 relationships, derive optionality
- Remove m:m relationship



Resolving m:1 Relationship



Resolving m:1 Relationship



Normalization Rules

Normal Form Rule	Description
First Normal Form	All attributes are single valued.
Second Normal Form (2NF)	An attribute must be dependent upon entity's entire unique identifier.
Third Normal Form (3NF)	No non-UID attribute can be dependent on another non-UID attribute.

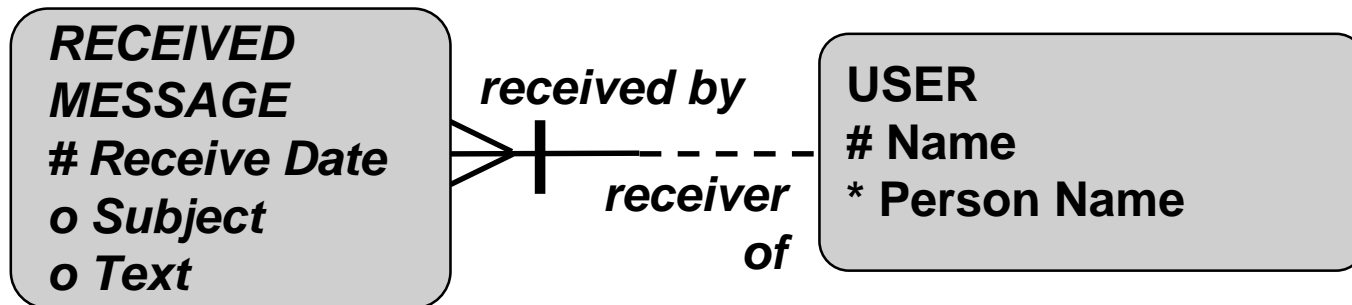
“A normalized entity-relationship data model automatically translates into a normalized relational database design”

“Third normal form is the generally accepted goal for a database design that eliminated redundancy”

First Normal Form in Data Modeling

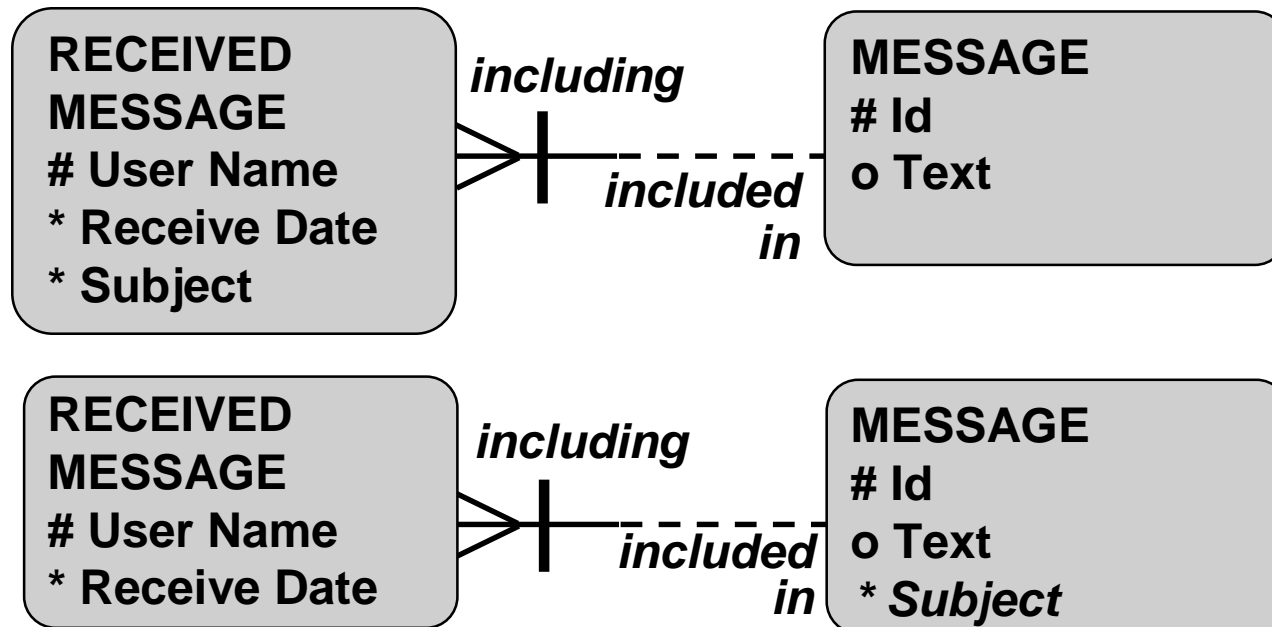
USER
Name
* Person Name
* Message Receive Date
o Message Subject
o MessageText

All attributes must be single-valued.



Second Normal Form in Data Modeling

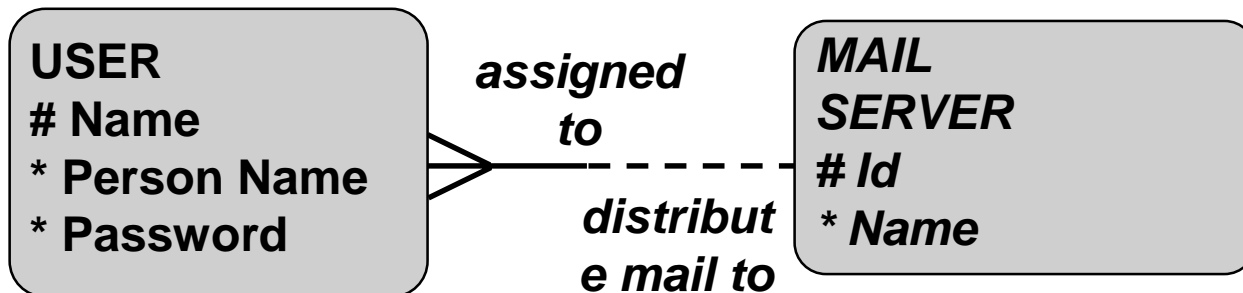
An attribute must be dependent upon its entity's entire unique identifier.



Third Normal Form in Data Modeling

USER
Name
* Person Name
* Password
* Server Id
* Server Name

No non-UID attribute can be dependent upon another non-UID attribute.



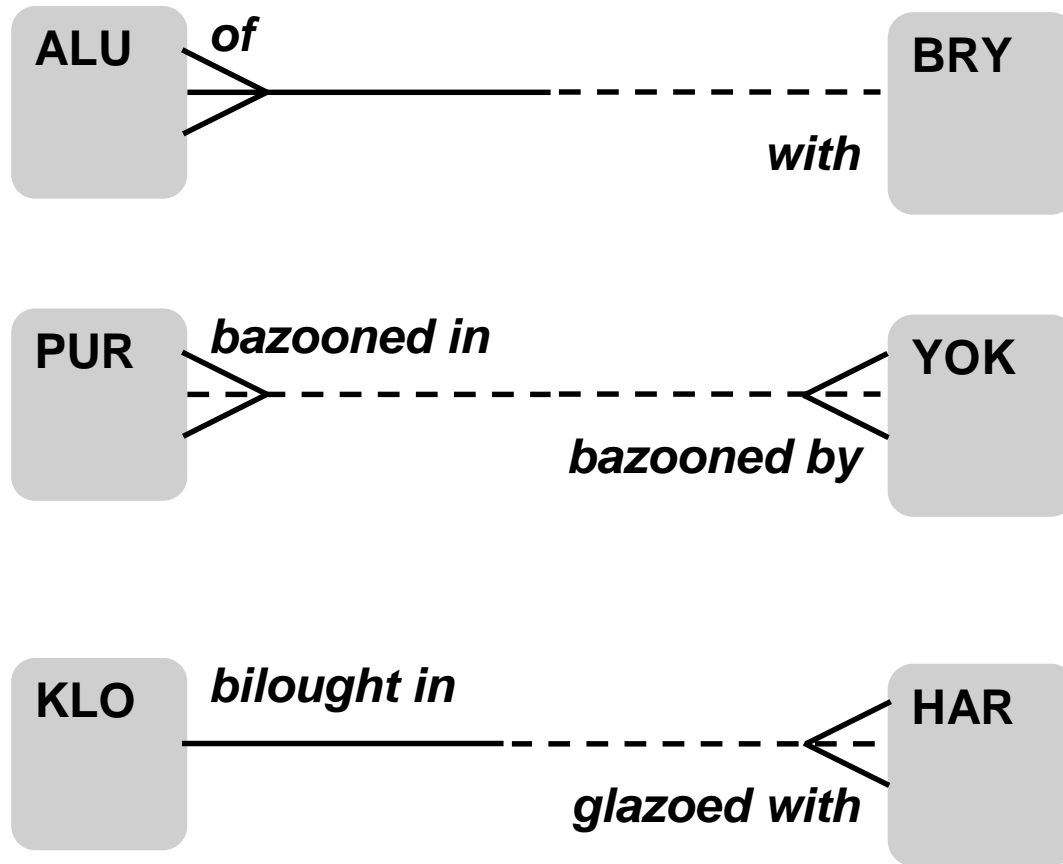
Summary

- **Relationships express how entities are connected.**
- **Initially relationships often seem to be of type m:m.**
- **Finally relationships are most often of type m:1.**
- **Relationships can be resolved into:**
 - **Two new relationships**
 - **One intersection entity**
- **Third Normal form is generally accepted standard.**

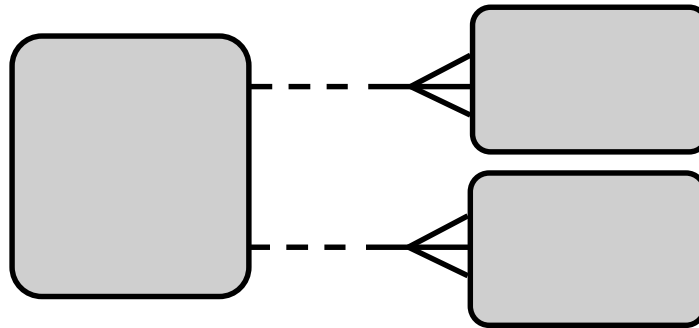
Practices

- **Read the Relationship**
- **Find a Context**
- **Name the Intersection Entity**
- **Receipt**
- **Moonlight P&O**
- **Price List**
- **Email**
- **Holiday**

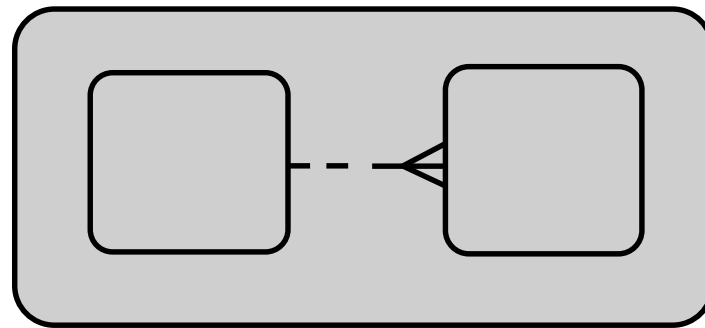
Practice: Read the Relationship



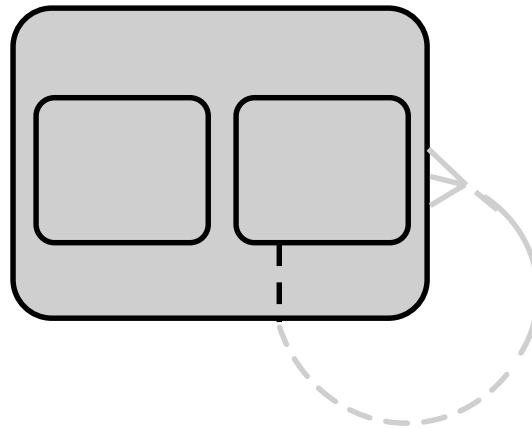
Find a Context (1)



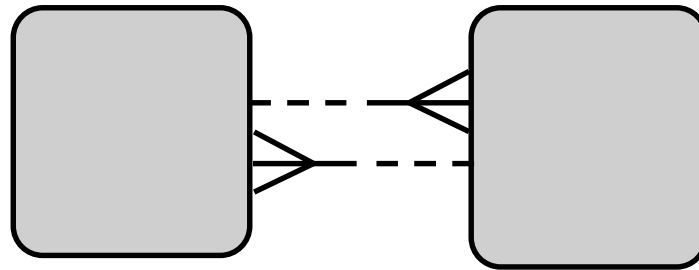
Find a Context (2)



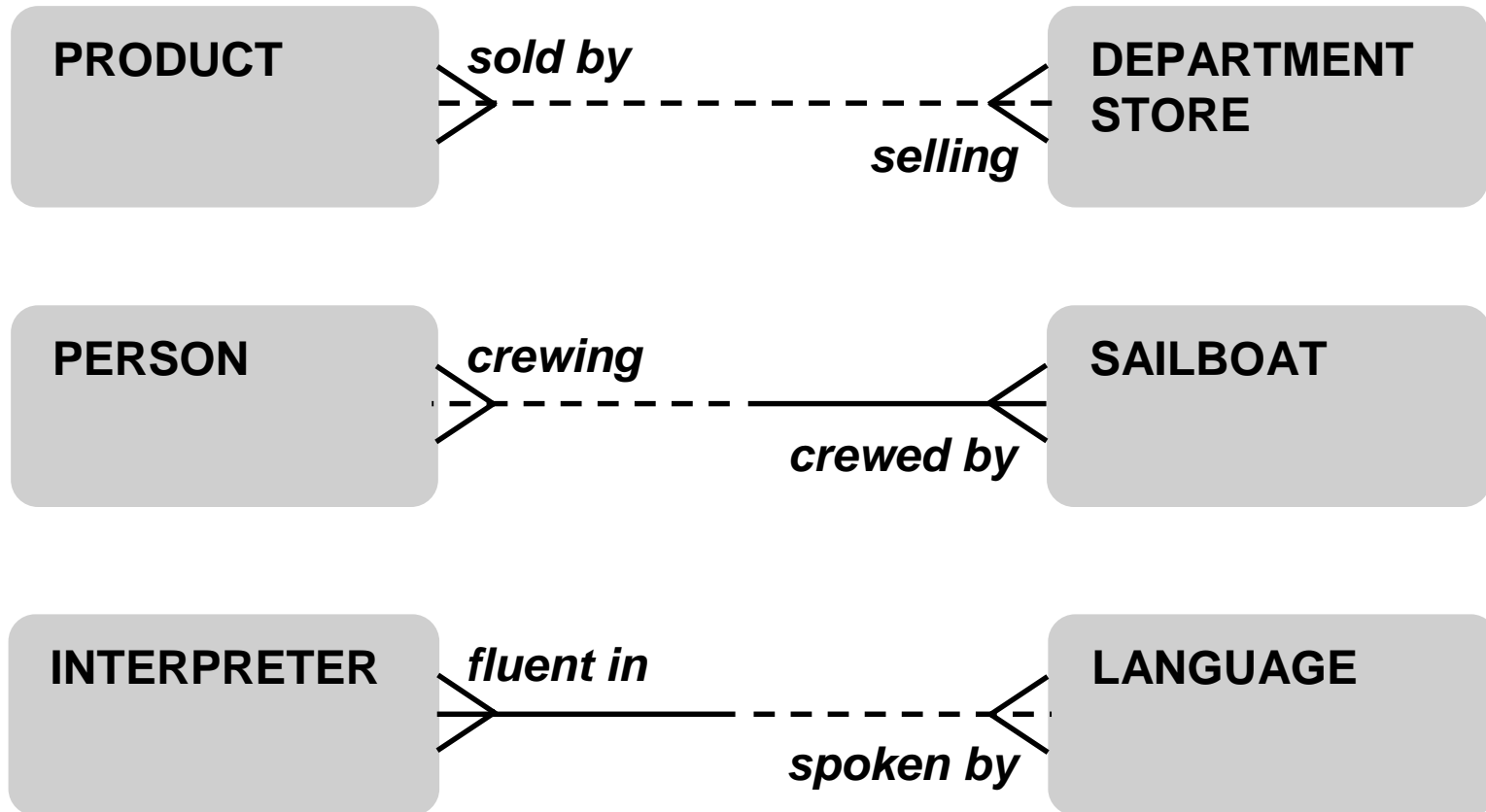
Find a Context (3)



Find a Context (4)



Practice: Name the Intersection Entity



Practice: Receipt

Served by: Dennis

Till: 3 Dec 8, 4:35 pm

```
-----  
CAPPUCC M    3.60  
              * 2    7.20  
CREAM         .75  
              * 2    1.50  
APPLE PIE           3.50  
BLACKB MUF        4.50  
    <SUB>           16.70  
    tax 12%         2.00  
    <TOTAL>        18.70  
              =====  
    CASH           20.00  
    RETURN         1.30
```

```
-----  
Hope to serve you again  
@MOONLIGHT COFFEES  
25 Phillis Rd, Atlanta
```

Practice: Moonlight P&O

- **All Moonlight Coffee employees work for a department such as “Global Pricing” or “HQ”, or for a shop. All employees are at the payroll of one of our country organizations. Jill, for example, works as a shop manager in London; Werner is a financial administrator working for Accounting and is located in Germany.**
- **All shops belong to one country organization (“the countries”). There is only one country organization per country. All countries and departments report to HQ, except HQ itself.**
- **Employees can work part time. Lynn has had an 80% assignment for Product Development since the 1st September. Before that she had a full-time position.**

price list

25 Phillis Road, Atlanta

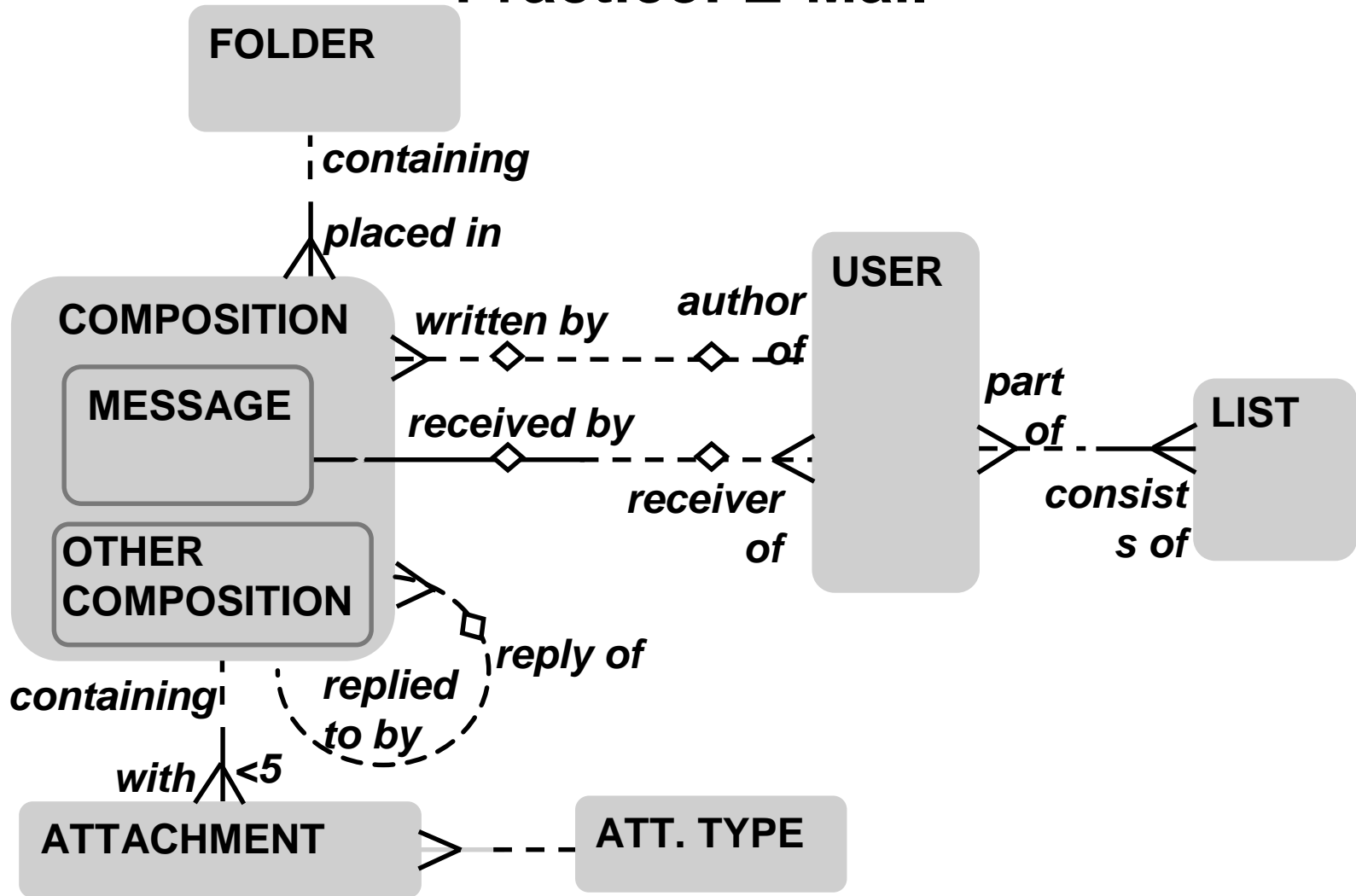
visit us at www.moonlight.com

Practice: Price List

	small	medium	large	
regular coffee	2.25	2.90	3.50	
cappuccino	2.90	3.60	4.20	
café latte	2.60	3.20	3.90	
special coffee	3.10	3.70	4.40	
espresso	2.25	2.90	3.50	
coffee of the day	2.00	2.50	3.00	
<i>decaffeinated</i>	<i>.25</i>	<i>.50</i>	<i>.75</i>	<i>extra</i>
black tea	2.25	2.90	3.50	
infusions	2.60	3.20	3.90	
herbal teas	2.90	3.60	4.20	
tea of the day	2.00	2.50	3.00	
<i>decaffeinated</i>	<i>.25</i>	<i>.50</i>	<i>.75</i>	<i>extra</i>
milk	1.25	1.90	2.50	
soft drinks	2.25	2.90	3.50	
soda water	2.25	2.90	3.50	
mineral water	2.90	3.60	4.20	
apple pie				3.50
strawberry cheesecake			3.50	
whole wheat oats muffin with almonds				3.90
blackberry muffin				4.50
fruitcake				4.50
cake of the day				4.00
additional whipped cream				.75

Sales Tax included
September 16

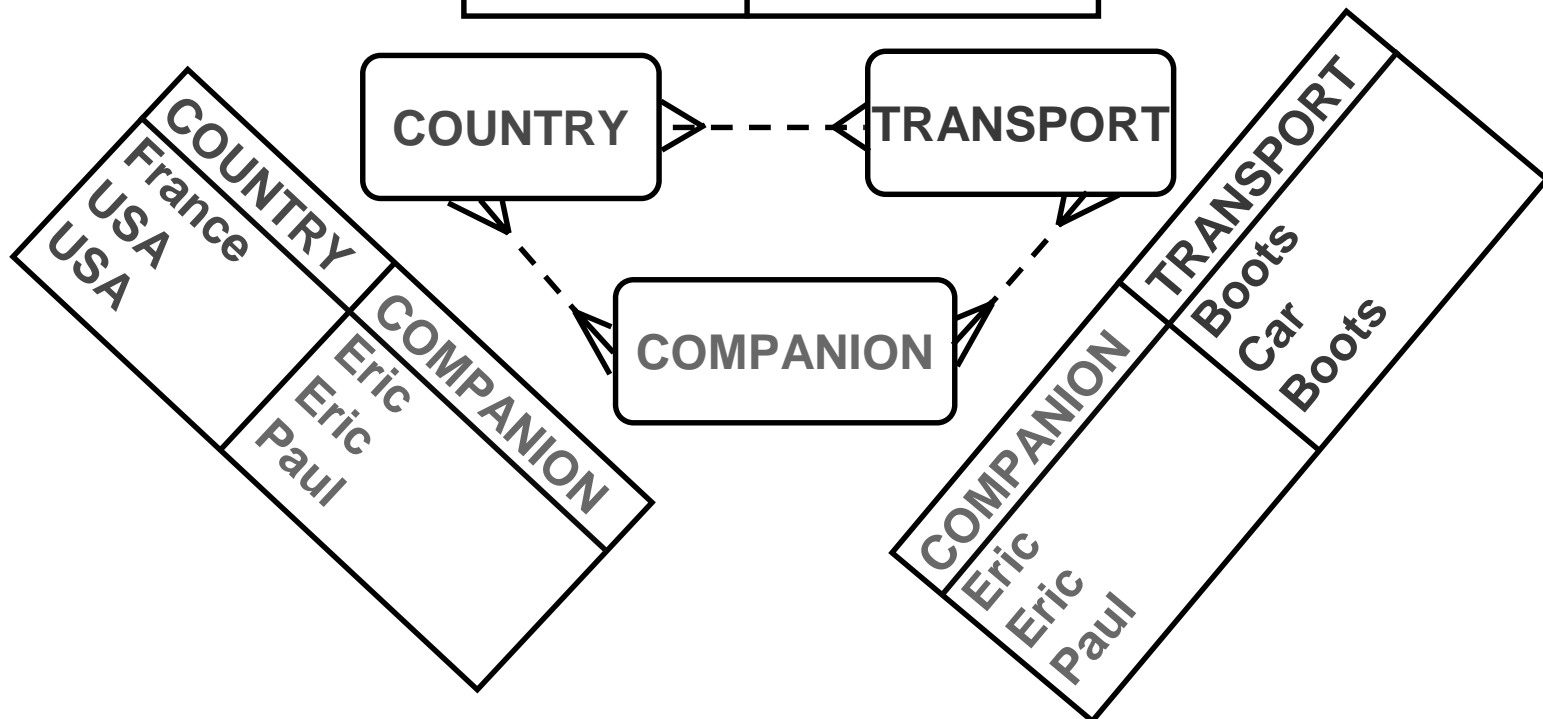
Practice: E-Mail



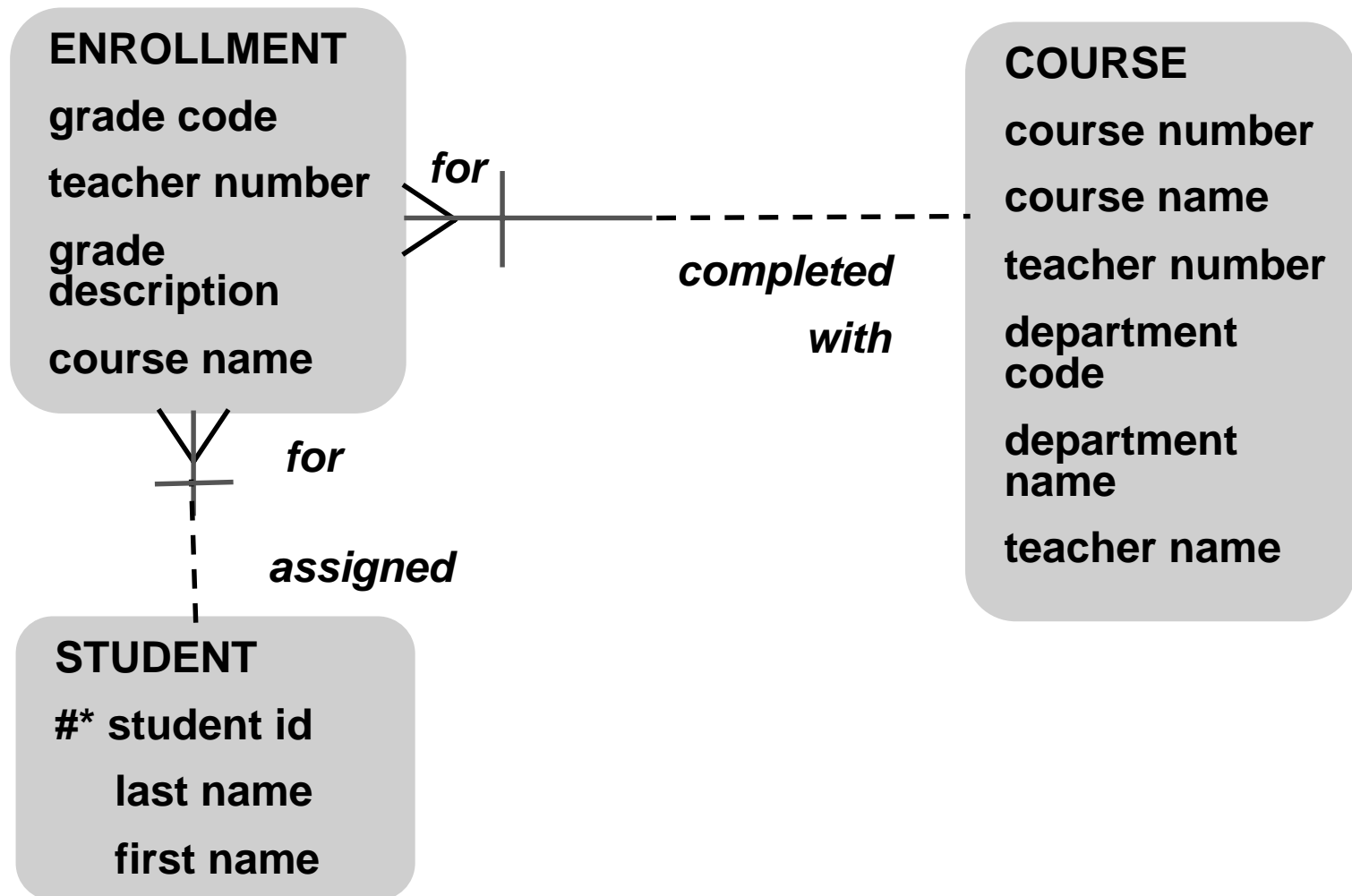
Practice: Holiday

“Paul and I hiked in the USA. Eric and I hiked in France and we rented a car in the USA last year.”

COUNTRY	TRANSPORT
France	Boots
USA	Boots
USA	Car



Practice: Normalize an ER Model



4 Constraints

Overview

- **Unique Identifiers**
- **Arcs**
- **Domains**
- **Various other constraints**

Rembrandt



Identification and Representation

G. Papini, please?

EMPLOYEES

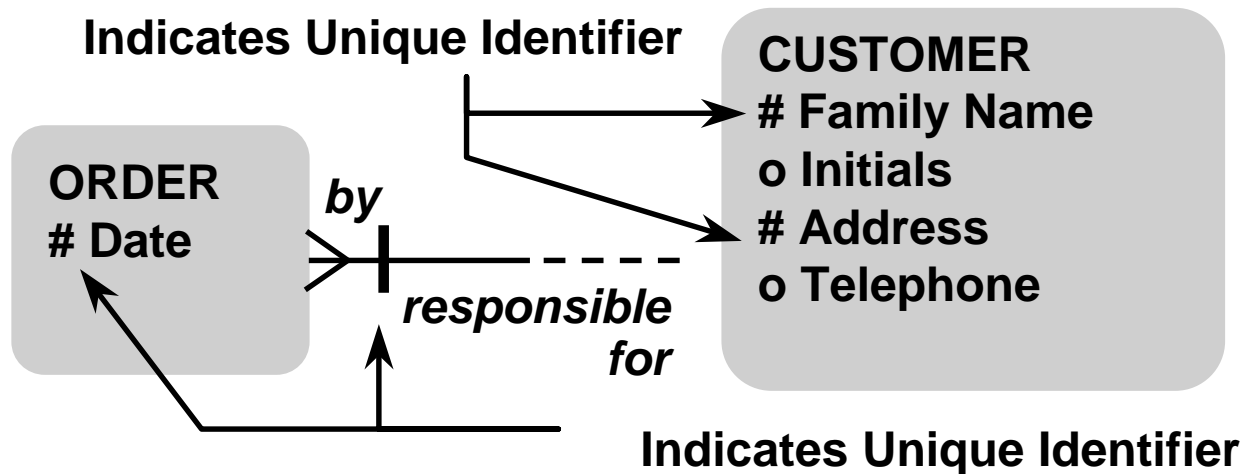
Name	Initials	Birthdate
PAPINI	G.	02-FEB-1954
HIDE	T.M.	11-JUN-1961
PAPINI	G.	02-FEB-1945
BAKER	S.J.T.	24-SEP-1958



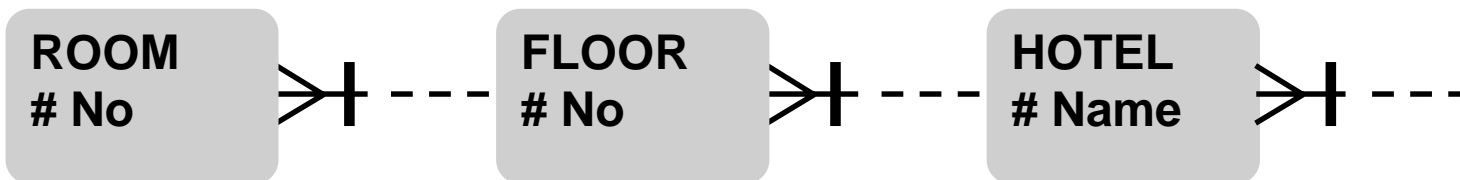
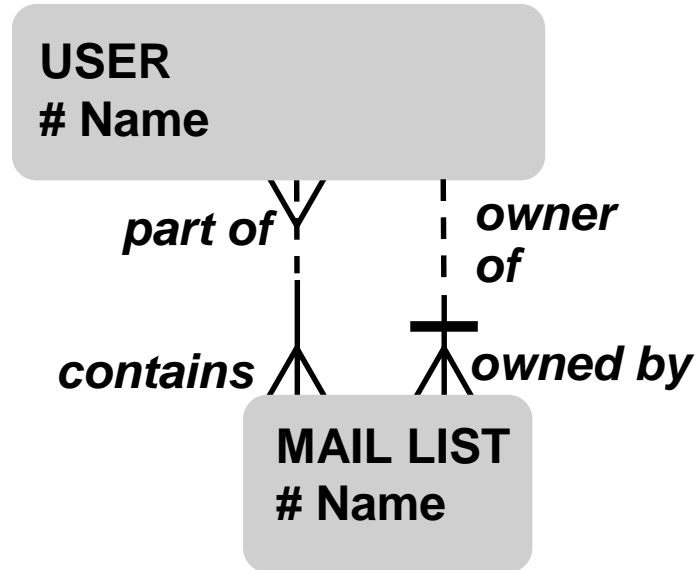
Unique Identifier Examples

	JOB	Name
COMPUTER IN NETWORK		IP Address
	TELEPHONE	Country code, Area code, Telephone number
	EMPLOYEE	Employee number <i>or</i> Name, Initials, Birth Date
	MAIL LIST	Name, Owner

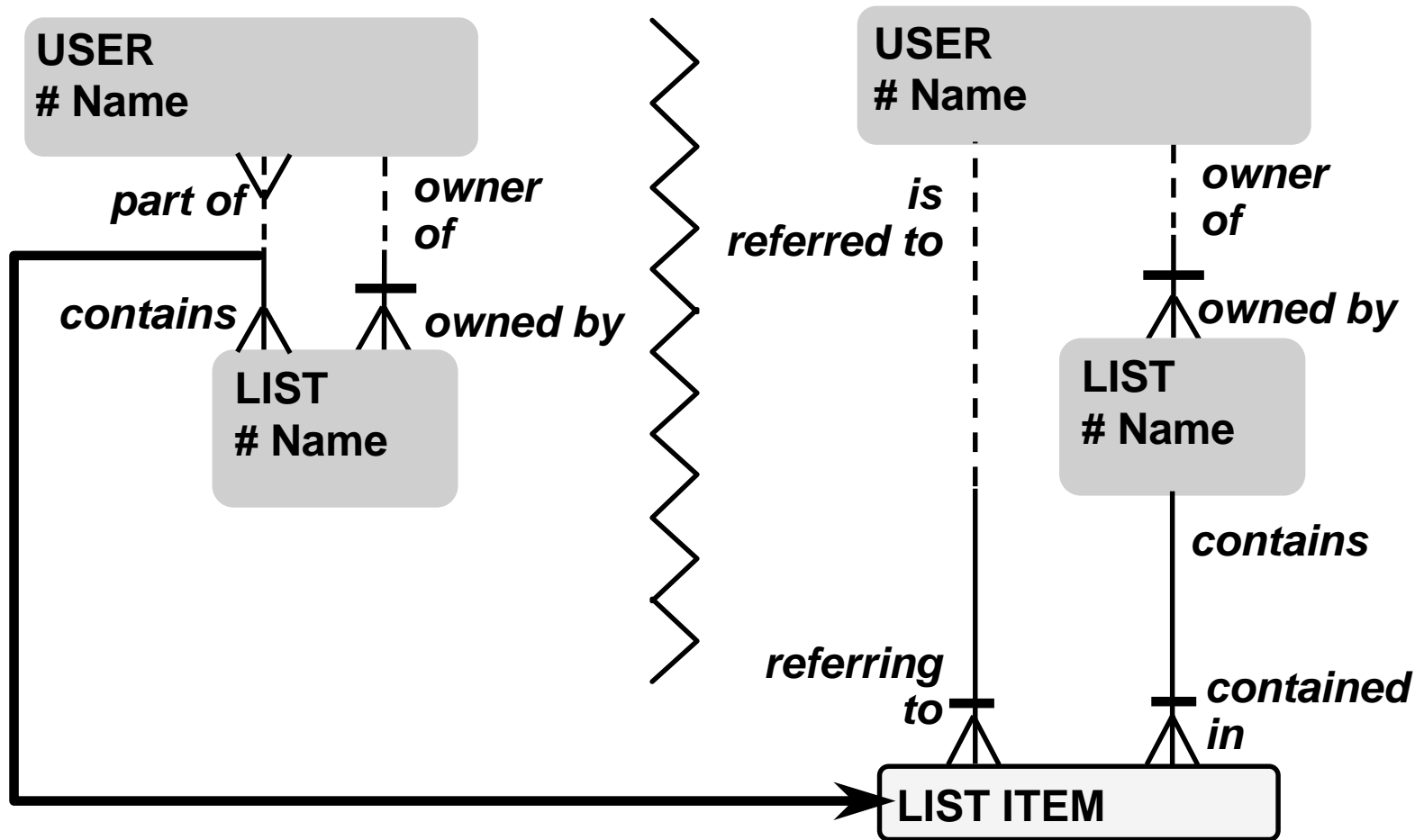
Unique Identifier



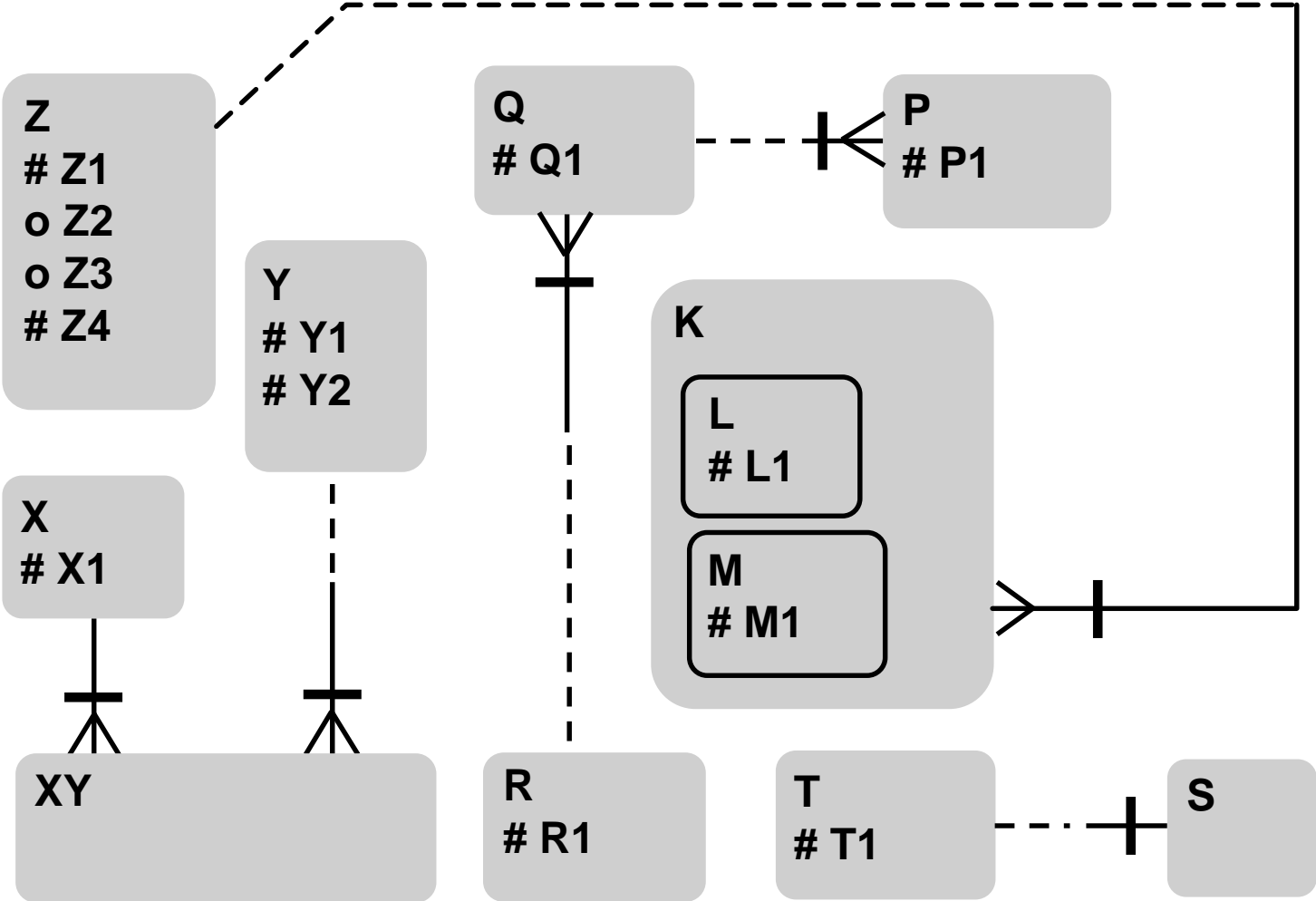
Unique Identifiers



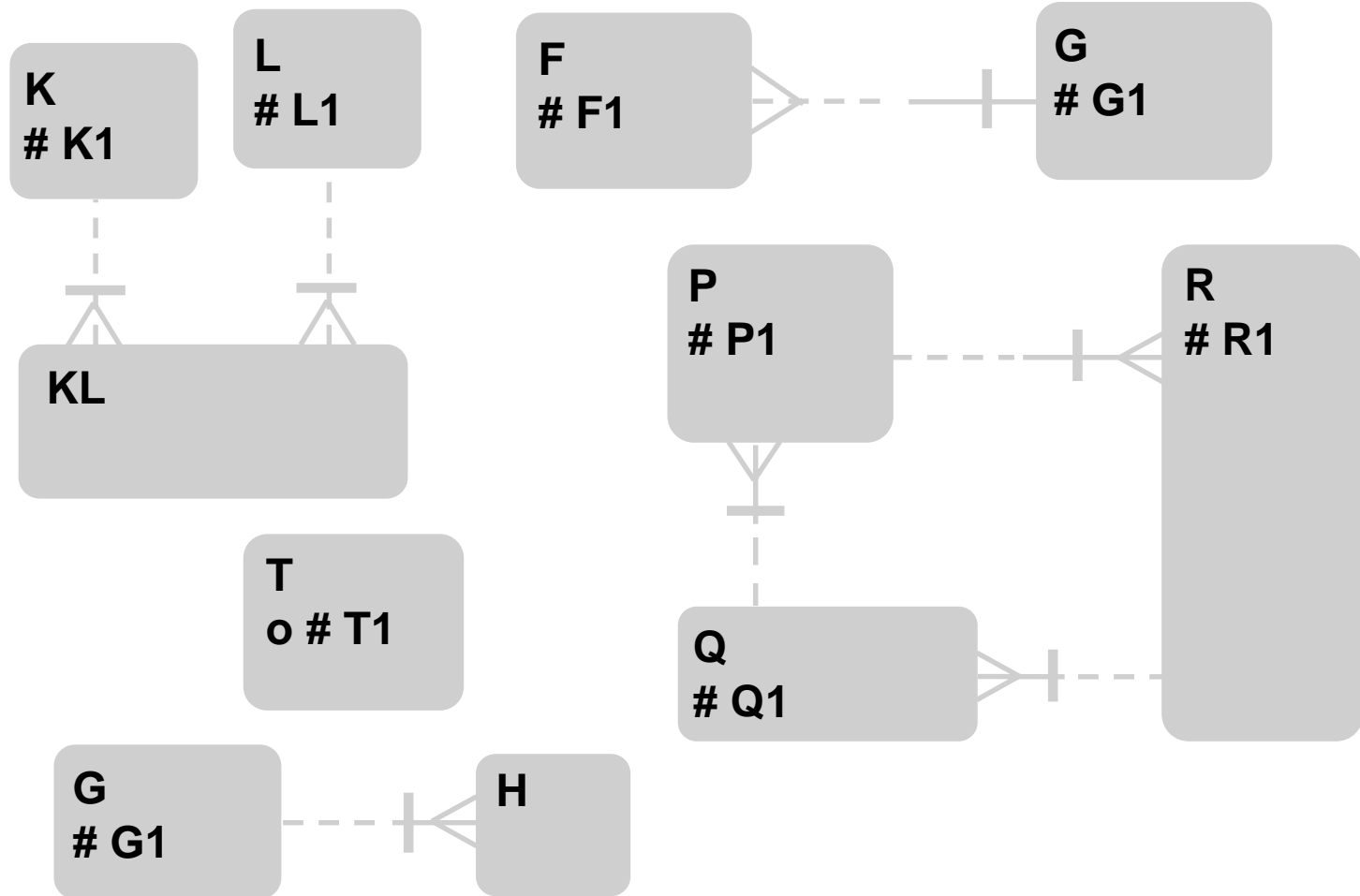
Multiple Relationship UID



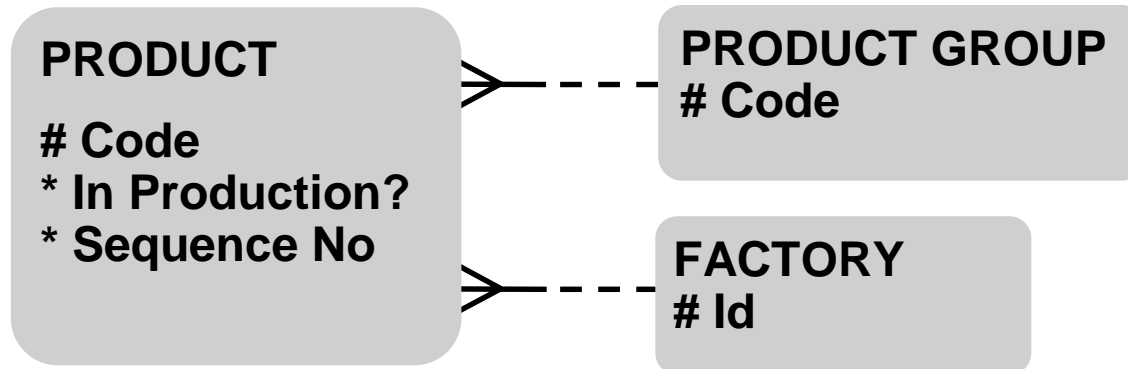
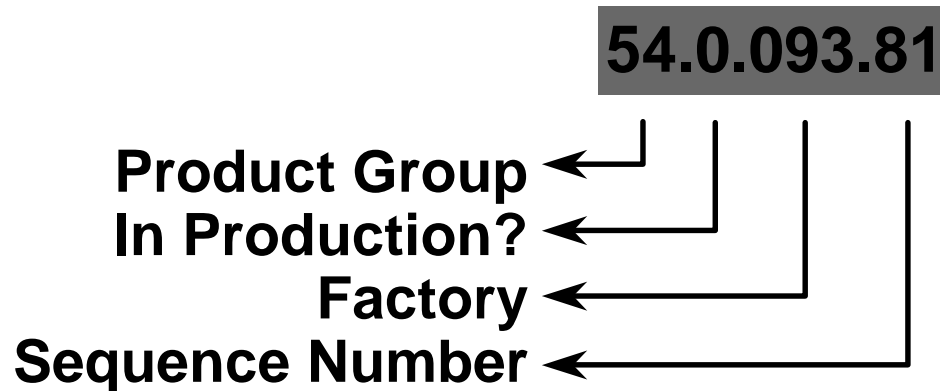
Well-defined Unique Identifiers



Incorrect Unique Identifiers



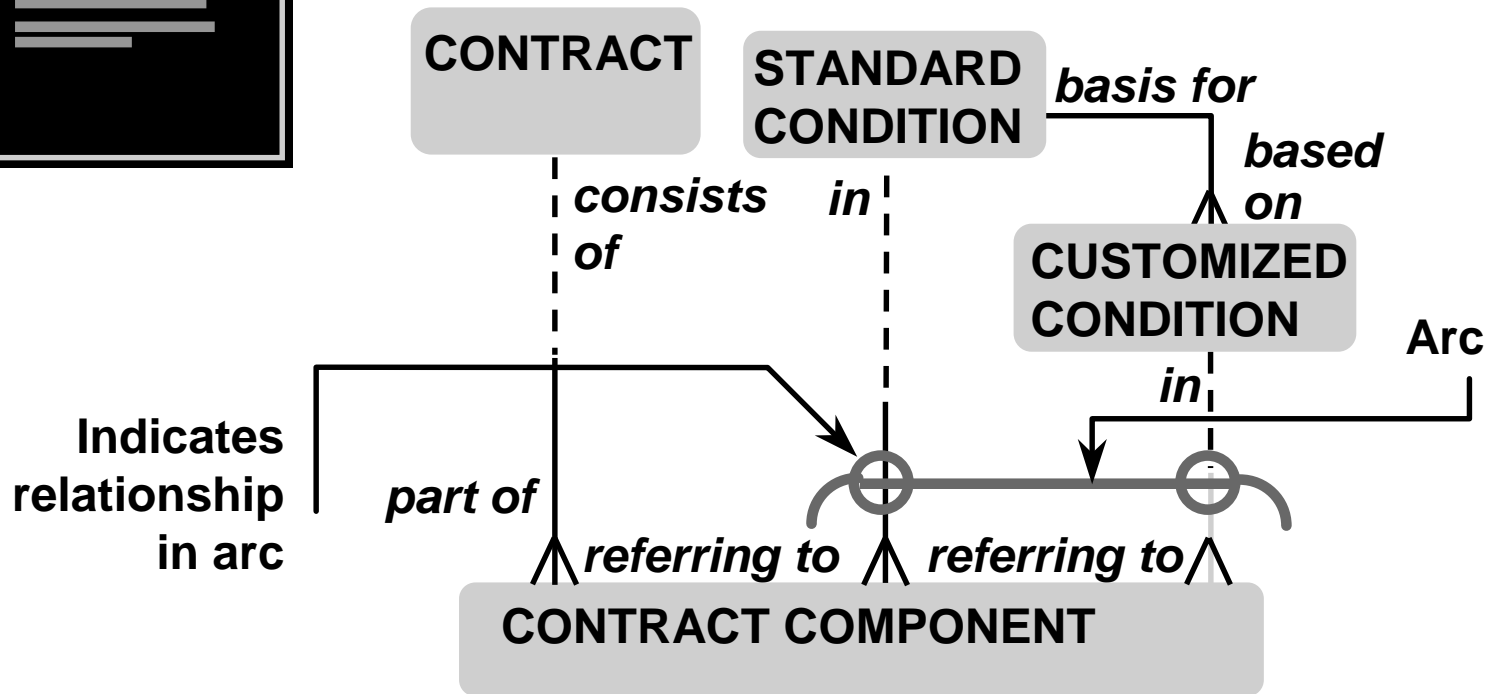
Information-Bearing Codes



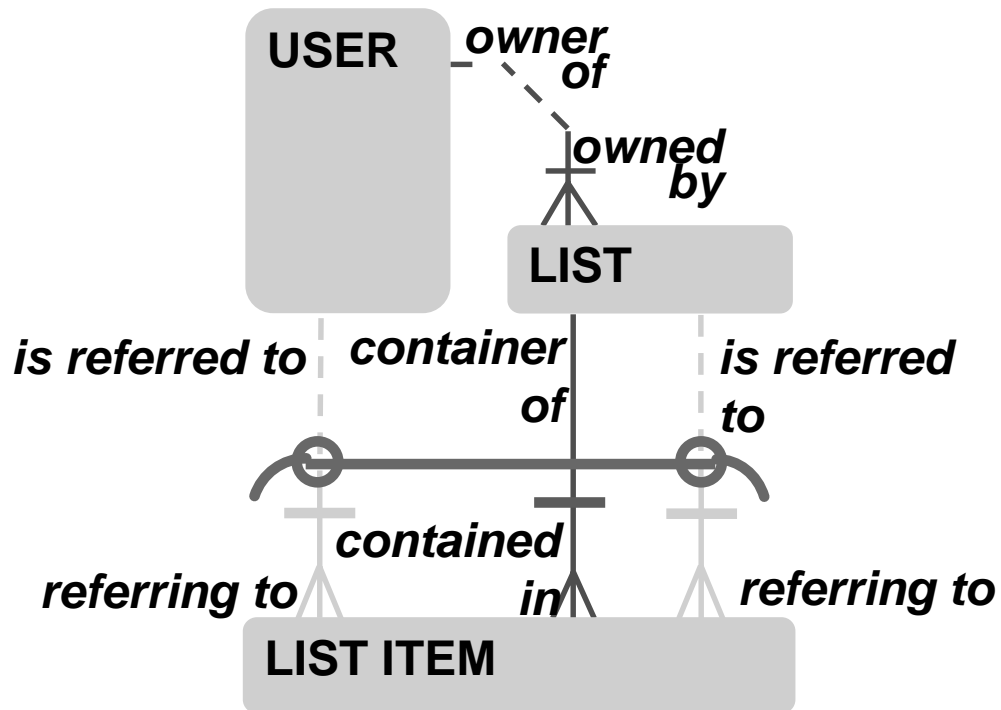
Arcs



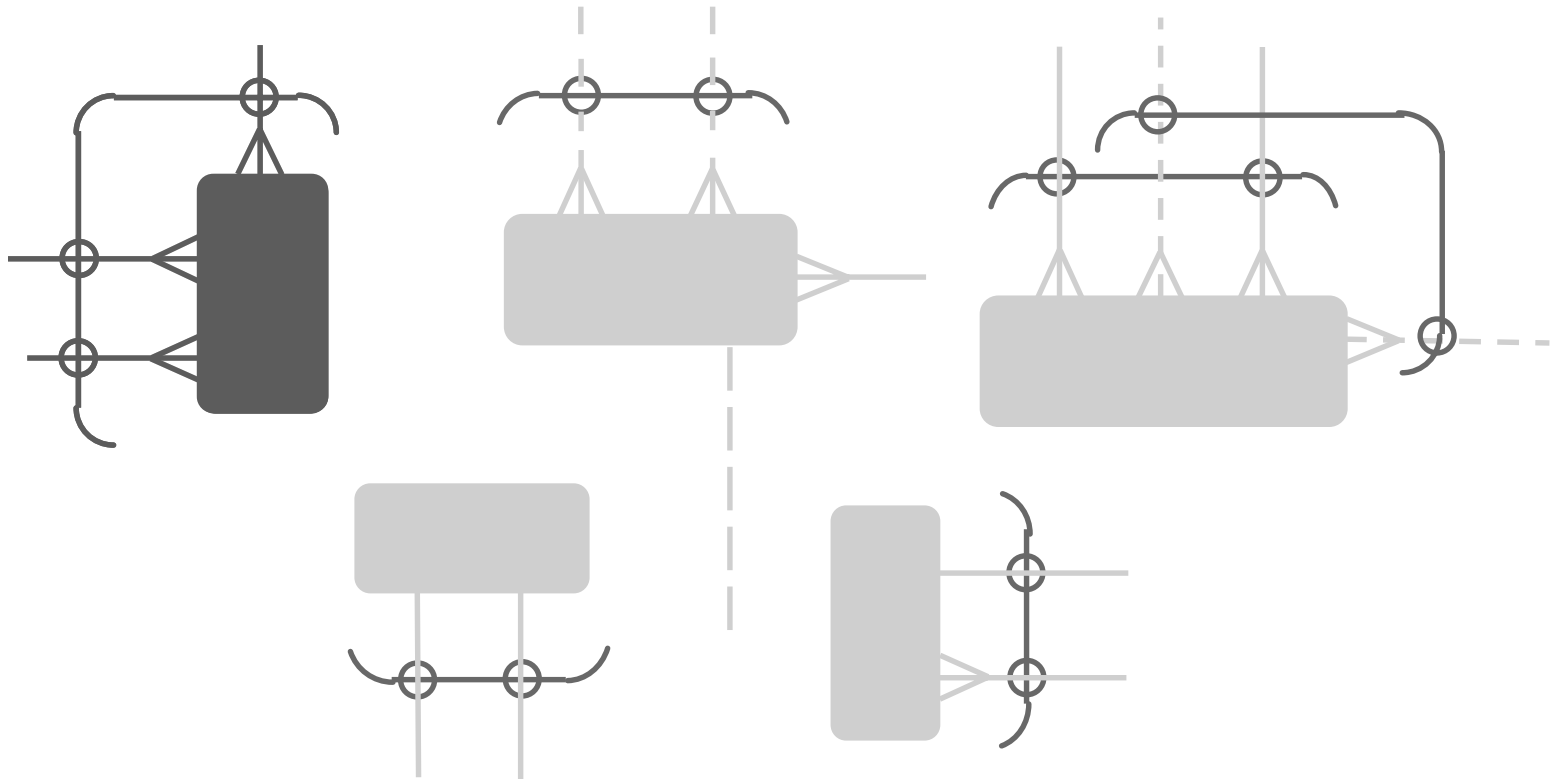
“A contract consists of contract components; these are standard conditions or customized conditions”



Exclusive Arc

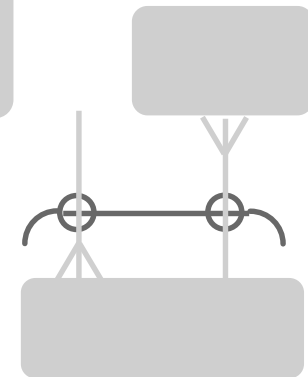
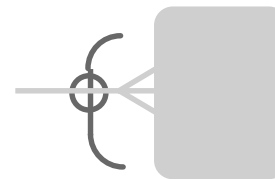
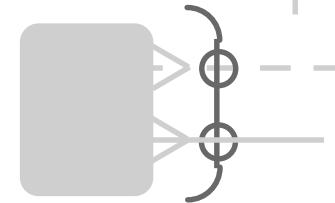
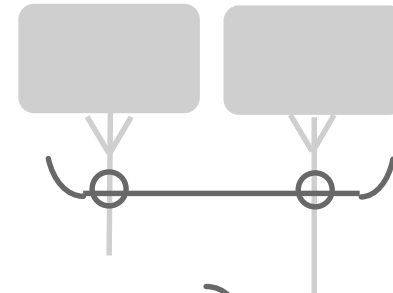


Possible Arc Constructs



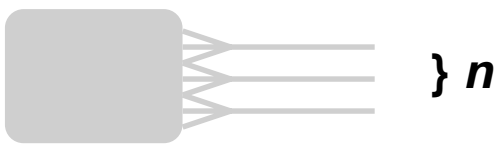
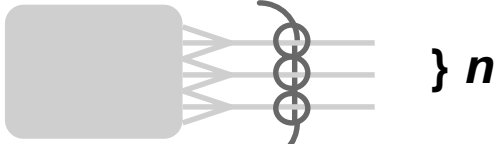
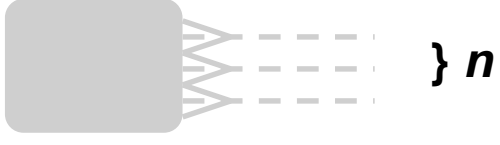

Some Incorrect Arc Constructs

- The arc “belongs” to one entity
- Relationships in the arc must be of the same optionality
- Arcs must contain at least two relationships

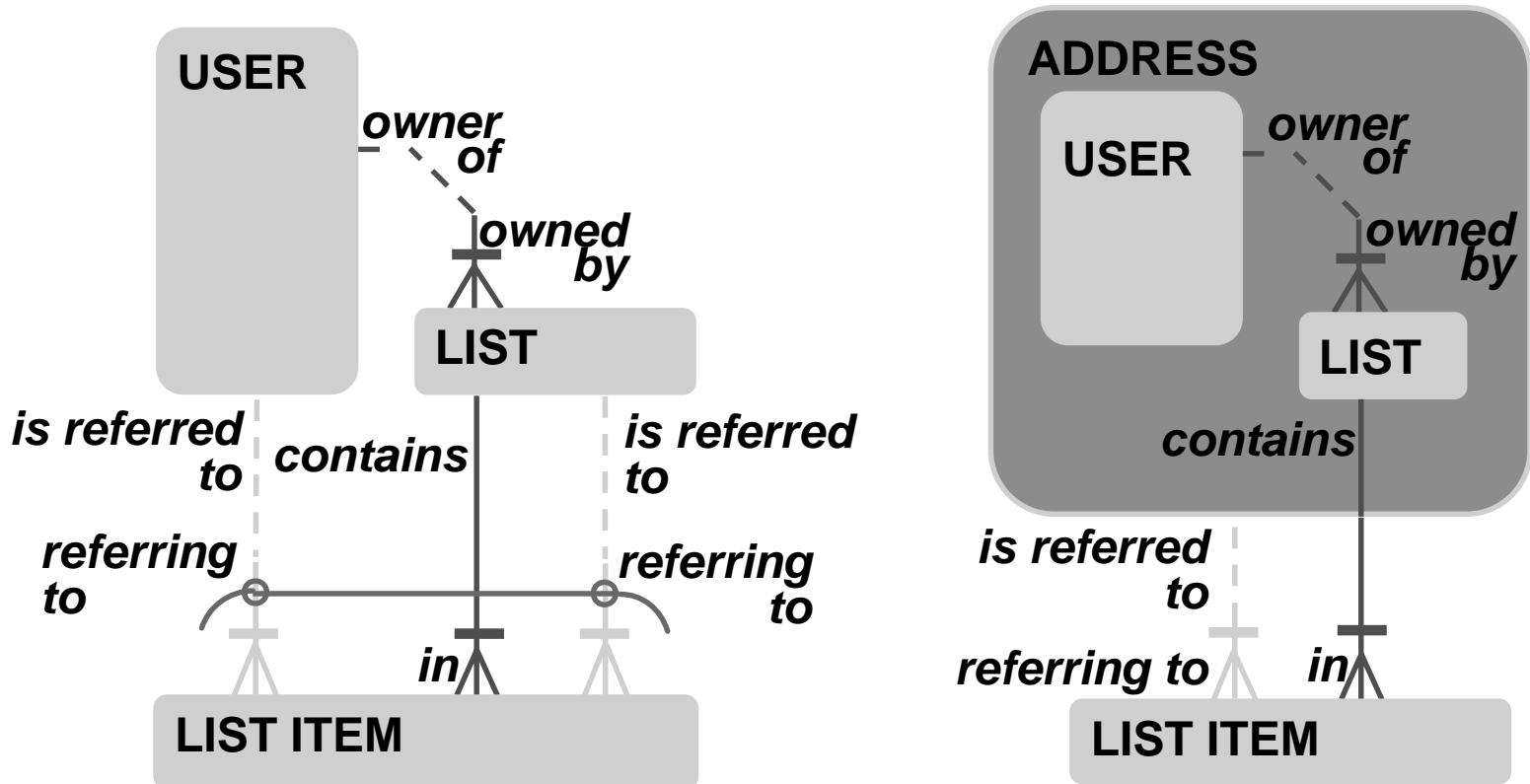


An arc may be correct, but is quite difficult to implement ...

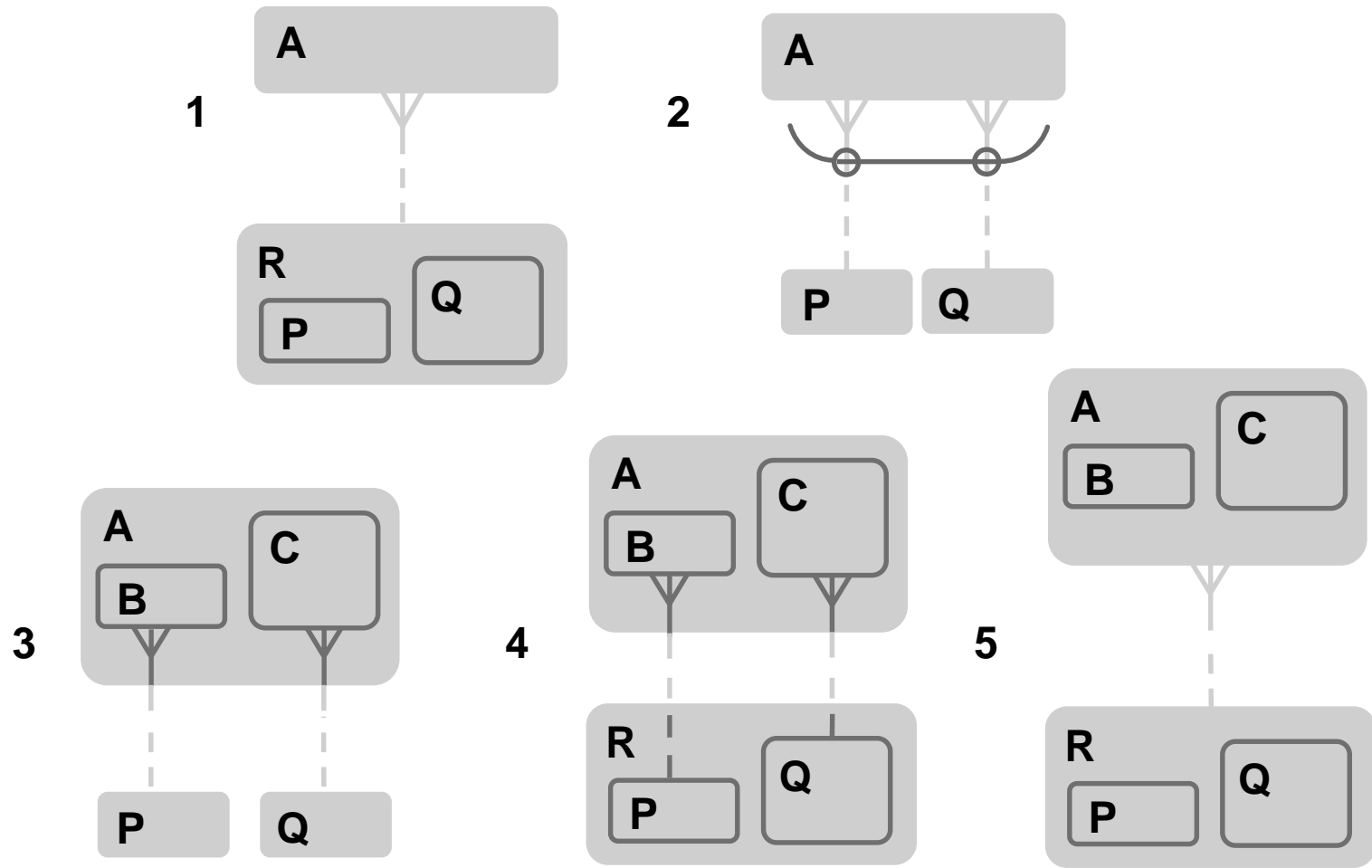
Some Incorrect Arc Constructs

Number of Valid Relationships in Arc Per Entity Instance	Minimum	Maximum
	n	n
	1	1
	0	n
	0	1

Arc or Subtype

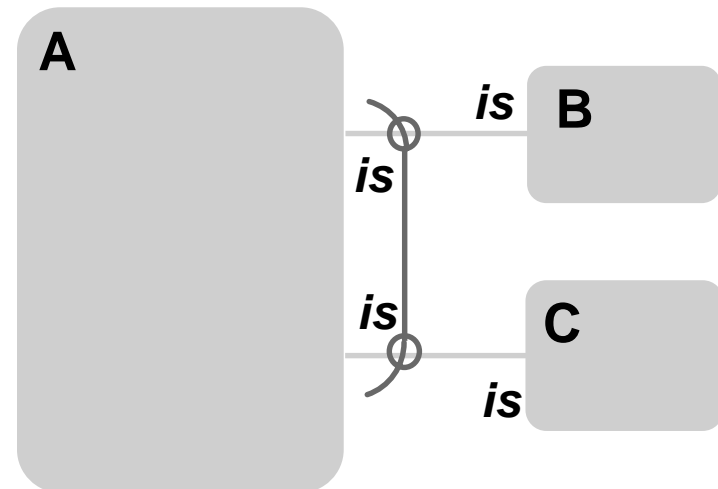
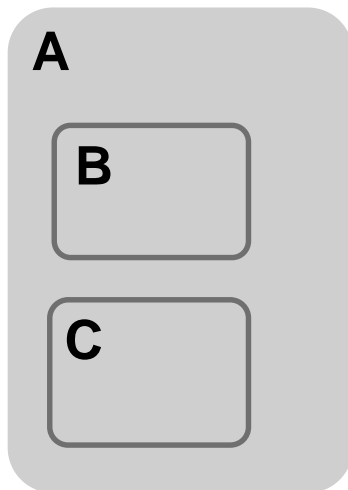


Arc and Subtypes

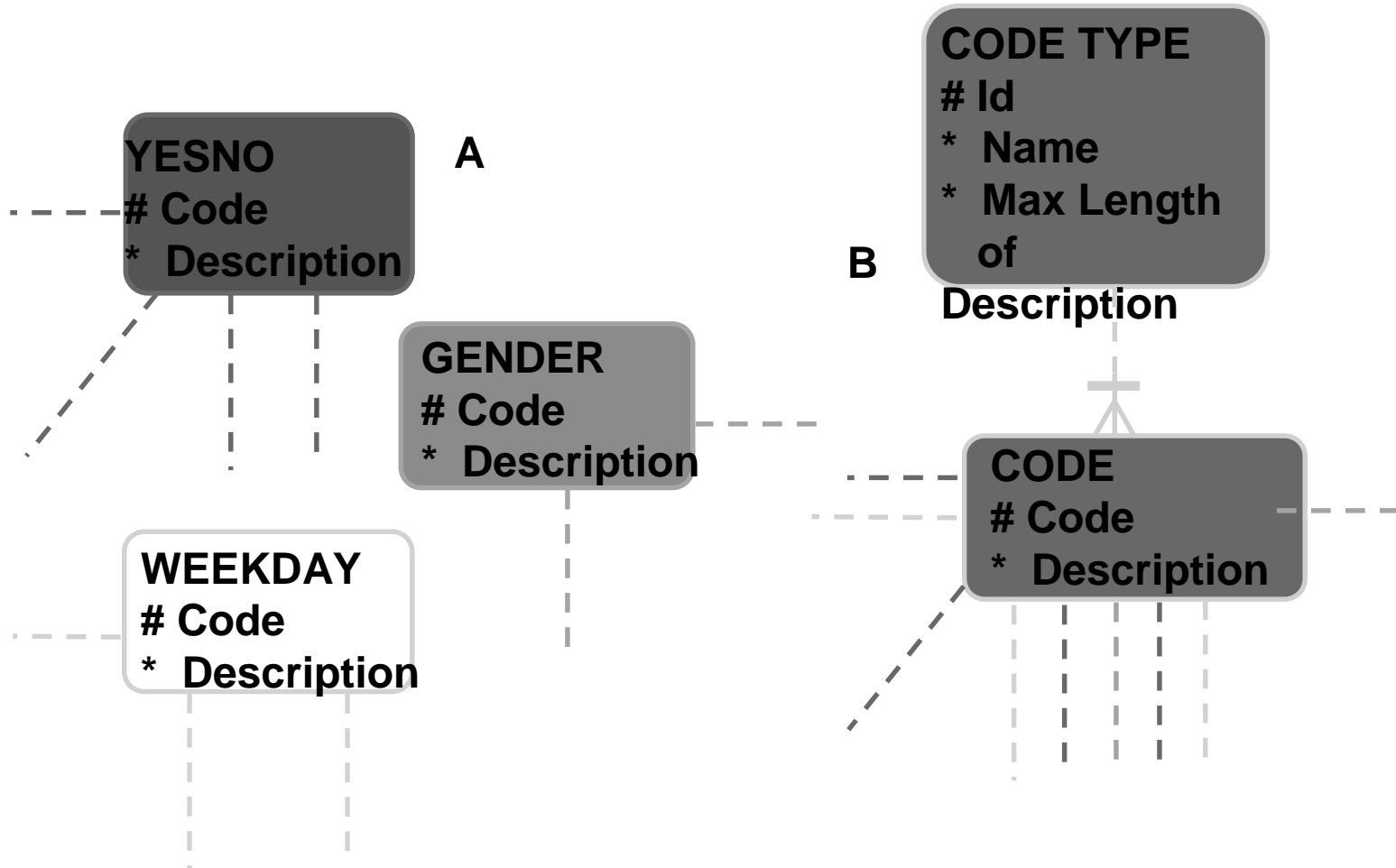


Subtypes Hide Relationships in Arc

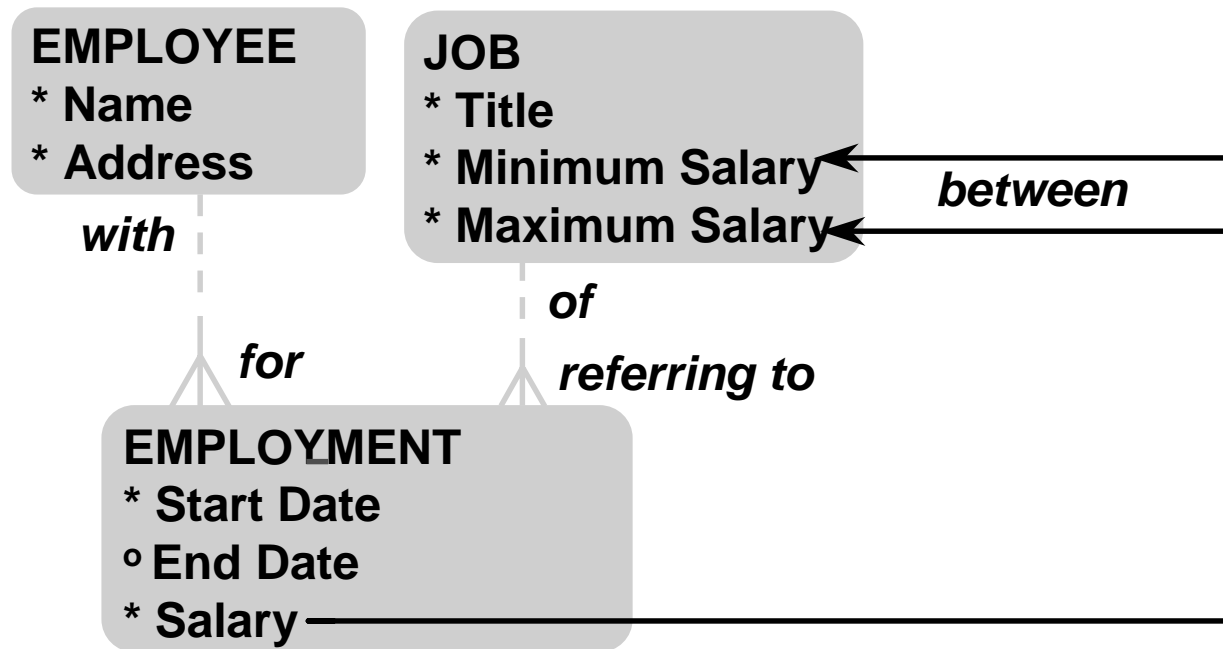
- Every A is either a B or a C
- Every B is an A
- Every C is an A
- Every A must *be* a B or *be* a C
- Every B must *be* an A
- Every C must *be* an A



Value sets



Other Constraints: Range Check

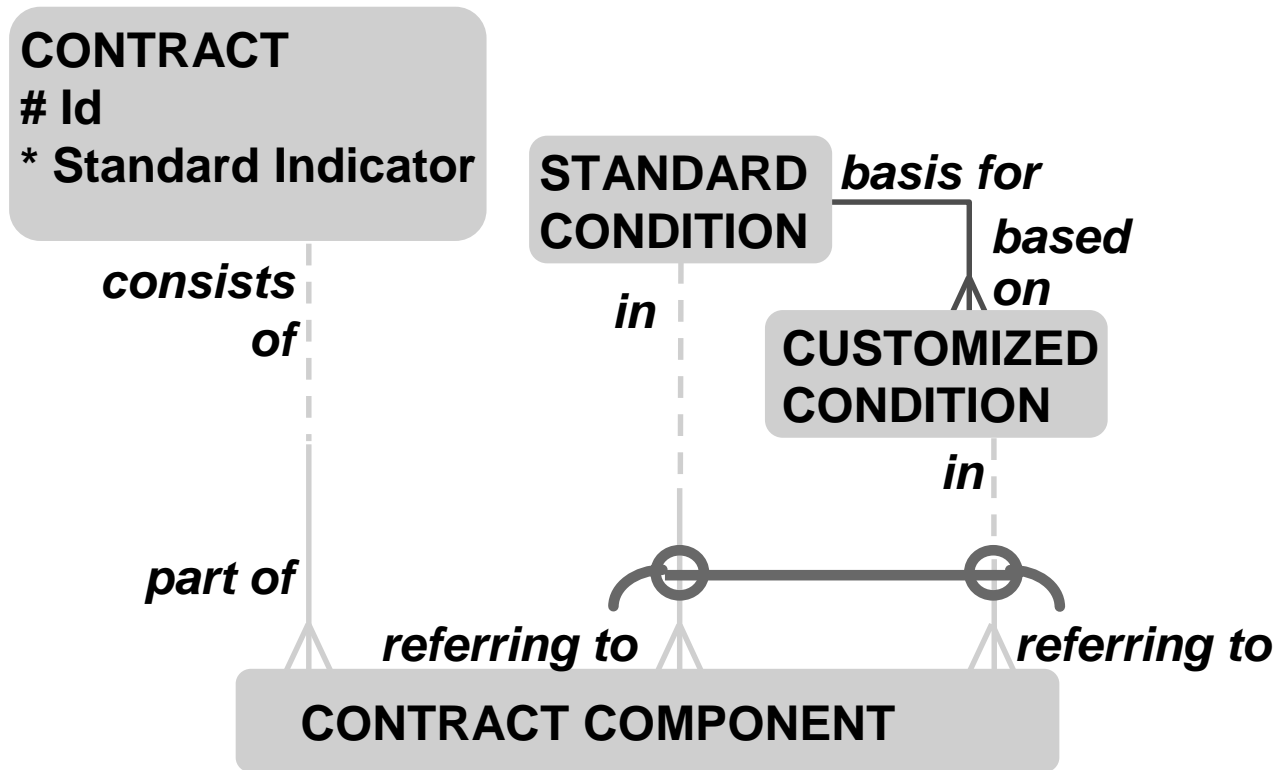


Other Constraints: State Value Transition

- EMPLOYEE**
- * Name
 - * Address
 - * Current Marital Status

Possible Marital Status Transitions	to				
	Sin	Mar	Wid	Div	DP
Single m		✓			✓
Married			✓	✓	
Widowed		✓			✓
Divorced		✓			✓
Domestic Partnership	✓	✓			

Conditional Relationship



Boundaries

unrelated entity

EXTERNAL
Id
*** Description**
*** Value**

and possible implementation

EXTERNALS

Id	Description	Value
1	Value added tax %	15
2	Maximum available Space per Mail User in Mbyte	500
3	Maximum level of Nested Mail Folders	3
4	Maximum level of Nested Mail Lists	16

Summary

- **Identification**
 - **Can be a real problem in the real world**
 - **Models cannot overcome this**
- **Entities must have at least one Unique Identifier**
- **Unique Identifiers consist of attributes or relationships or both**
- **Arcs**
- **Many types of constraint are not represented in ER model**

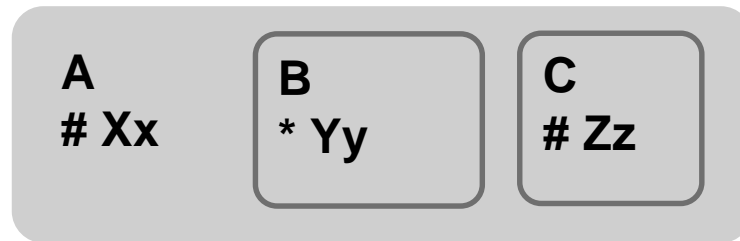
Practices

- **Identification Please**
- **Identification**
- **Moonlight UID**
- **Tables**
- **Modeling Constraints**

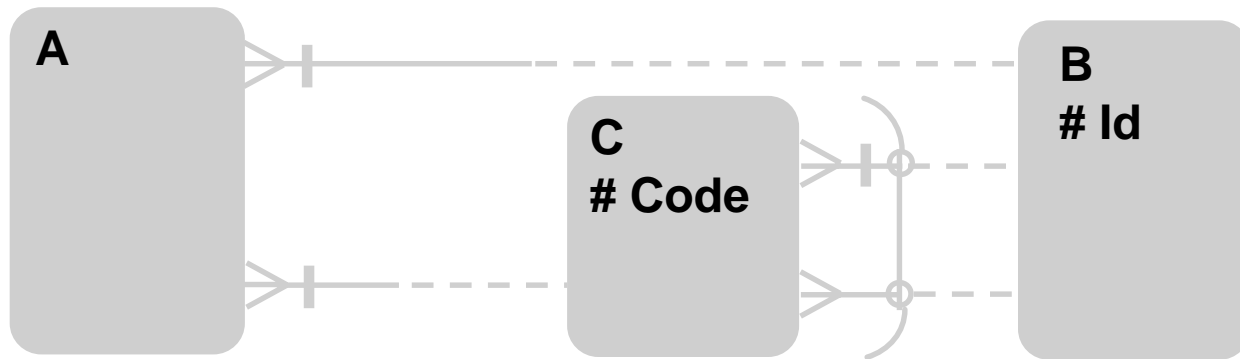
Practice: Identification Please

- **A city**
- **A contact person for a customer**
- **A train**
- **A road**
- **A financial transaction**
- **An Academy Award (Oscar)**
- **A painting**
- **A T.V. show**

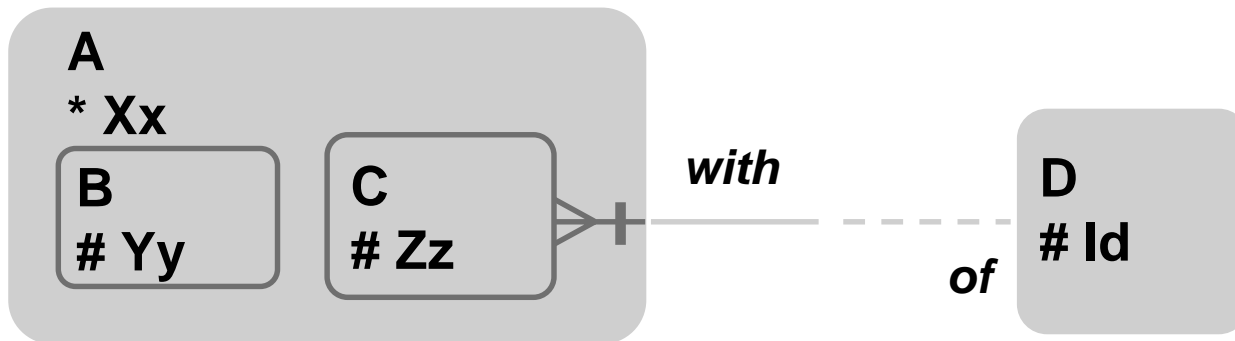
Practice: Identification 1



Practice: Identification 2



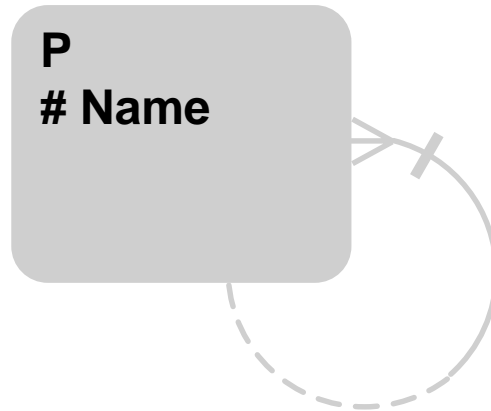
Practice: Identification 3



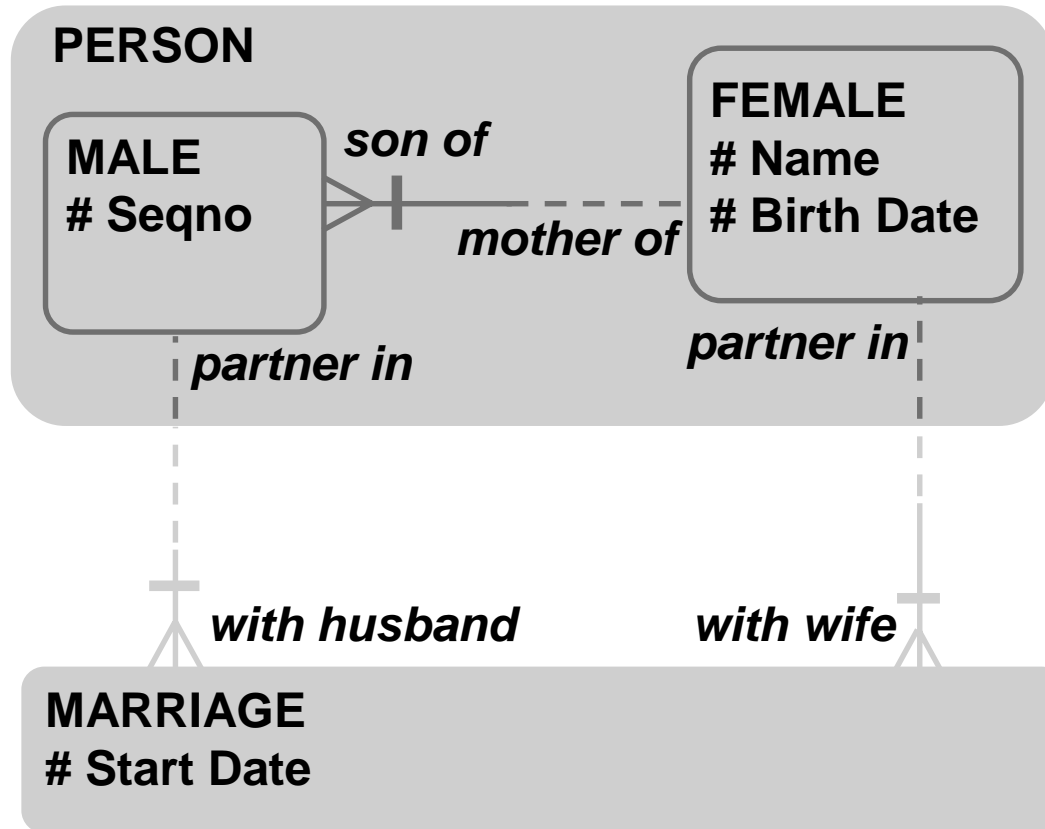
Practice: Identification 4



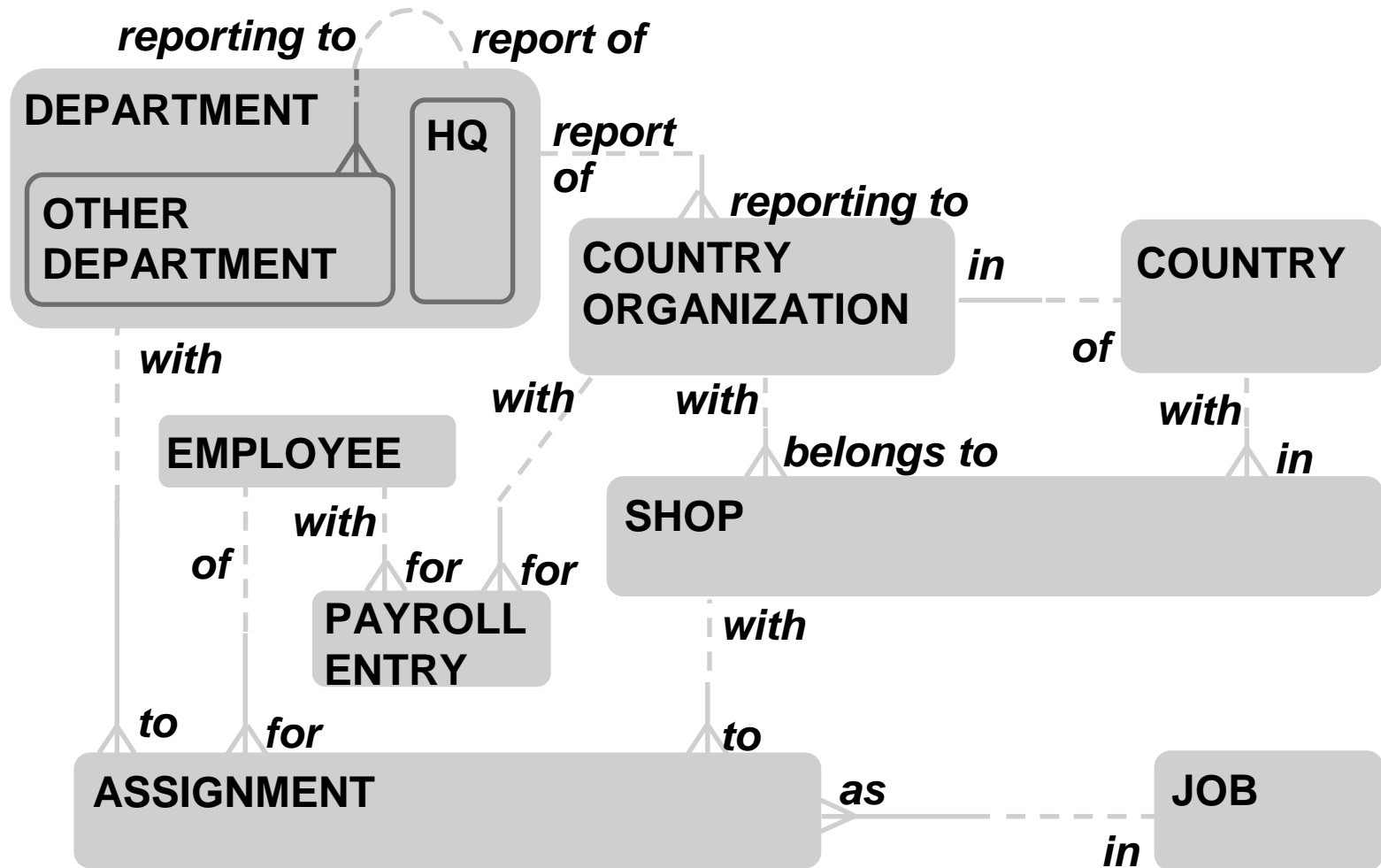
Practice: Identification 5



Practice: Identification 6



Practice: Moonlight UID



Practice: Table 1

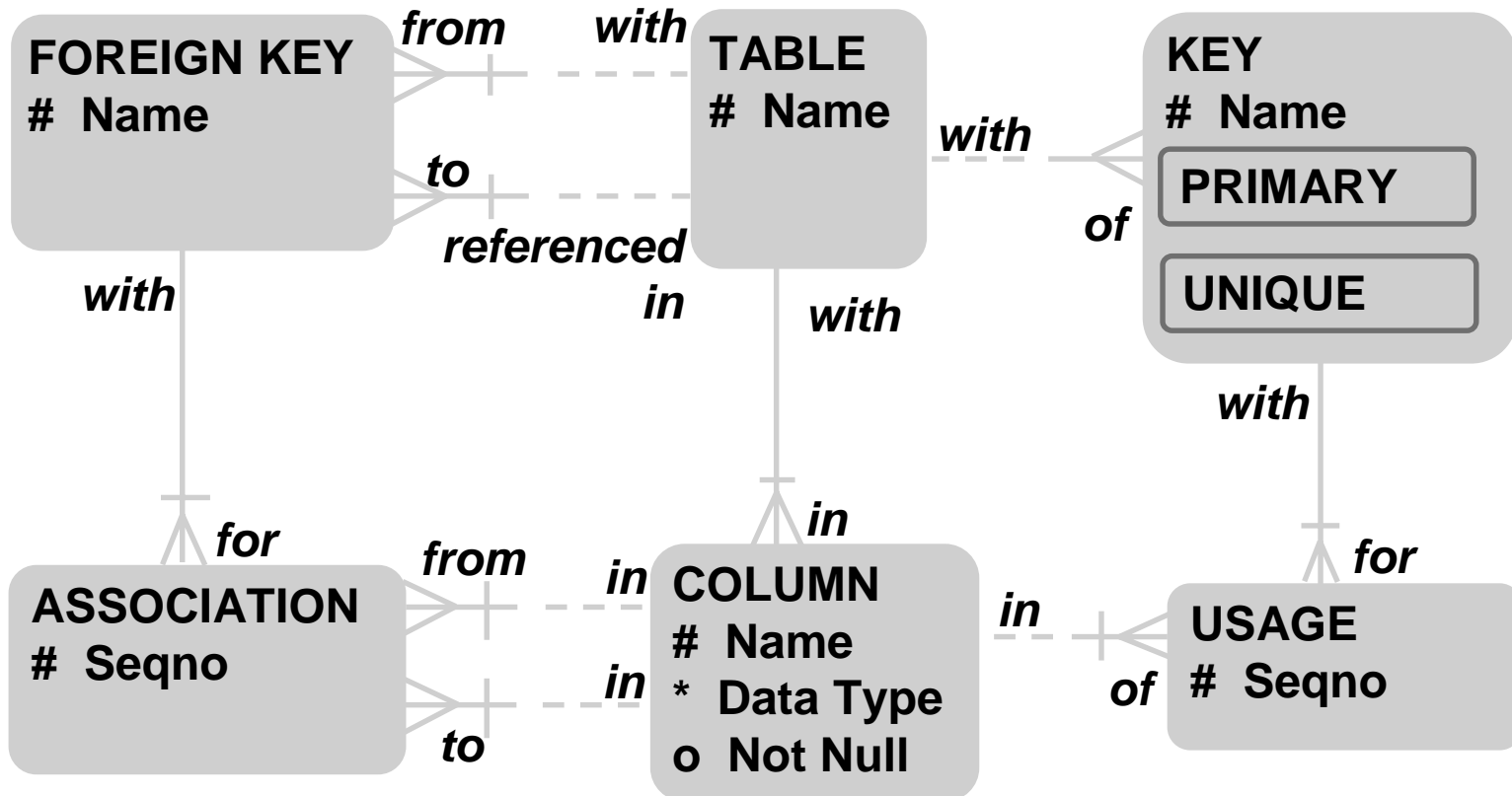
- **“In a relational database system, data is stored in tables. Tables of a database user must have a unique name. A table must have at least one column. A column has a unique name within the table. A column must have a data type and may be Not Null.**
- **Tables can have one primary key and any number of unique keys. A key contains one or more columns of the table. A column can be part of more than one key.**

Practice: Table 1

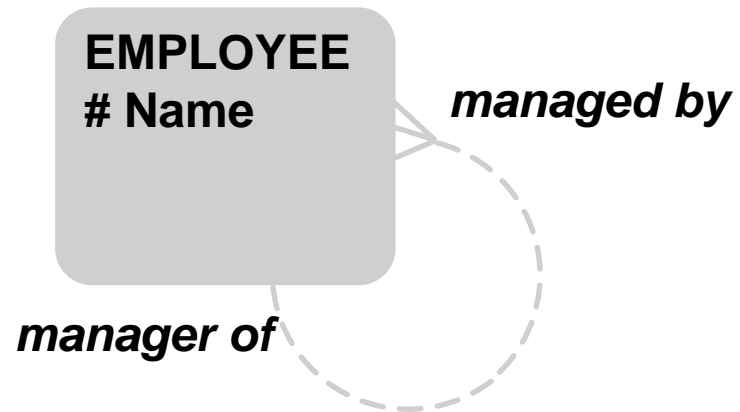
A table can have foreign keys. A foreign key always connects one table with another. A foreign key consists of one or more columns of the one table that refers to key columns of the other table.

“The sequence of columns within the key and foreign key is important.”

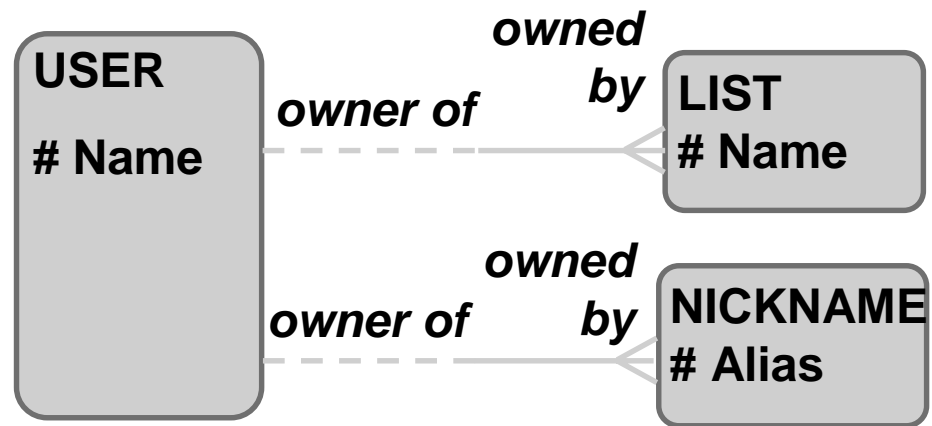
Practice: Table 2



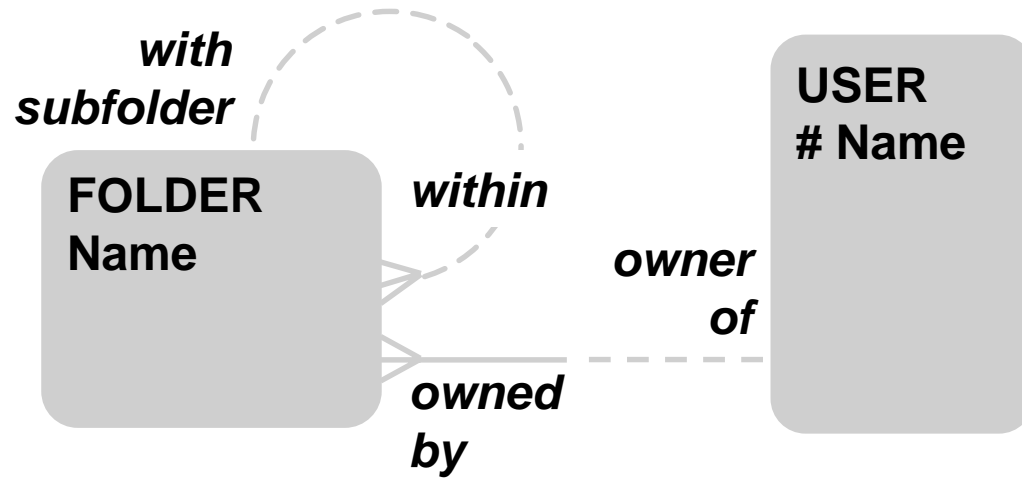
Practice: Constraints 1



Practice: Constraints 2



Practice: Constraints 3



5 Modeling Change

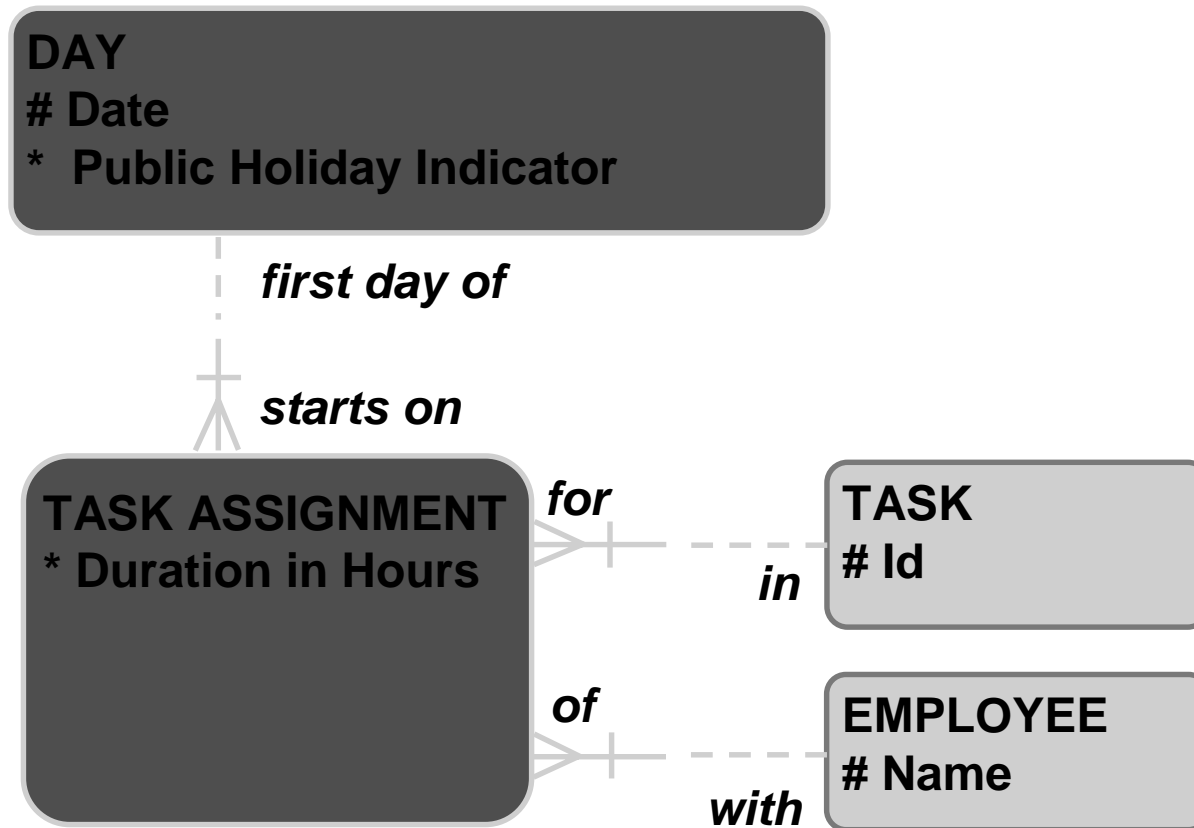
Overview

- **Date and time**
- **Modeling change over time**
- **Prices change**
- **Journaling**

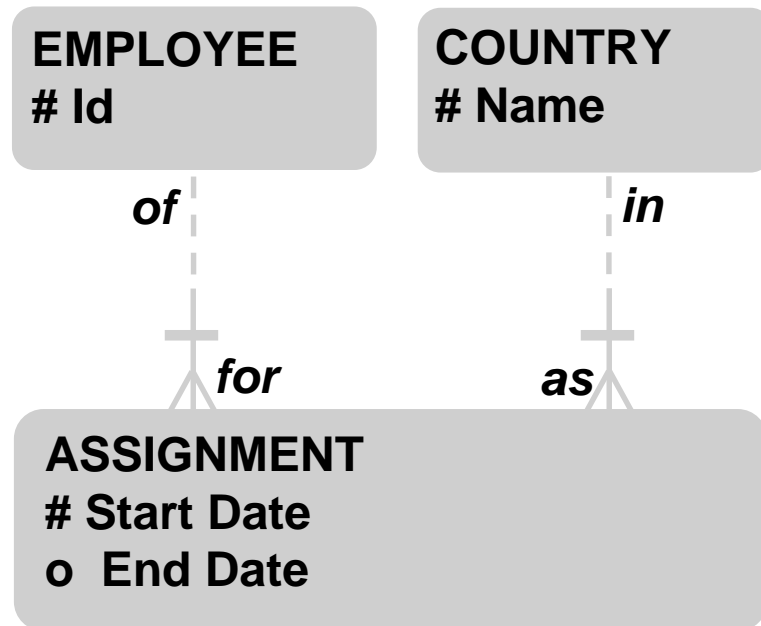
Change and Time

- **Every update means loss of information.**
- **Time in your model makes the model more complex.**
- **There are often complex join conditions.**
- **Users can work in advance.**
- **When do you model date/time as an entity?**
- **What constraints do arise?**
- **How do you handle journaling?**

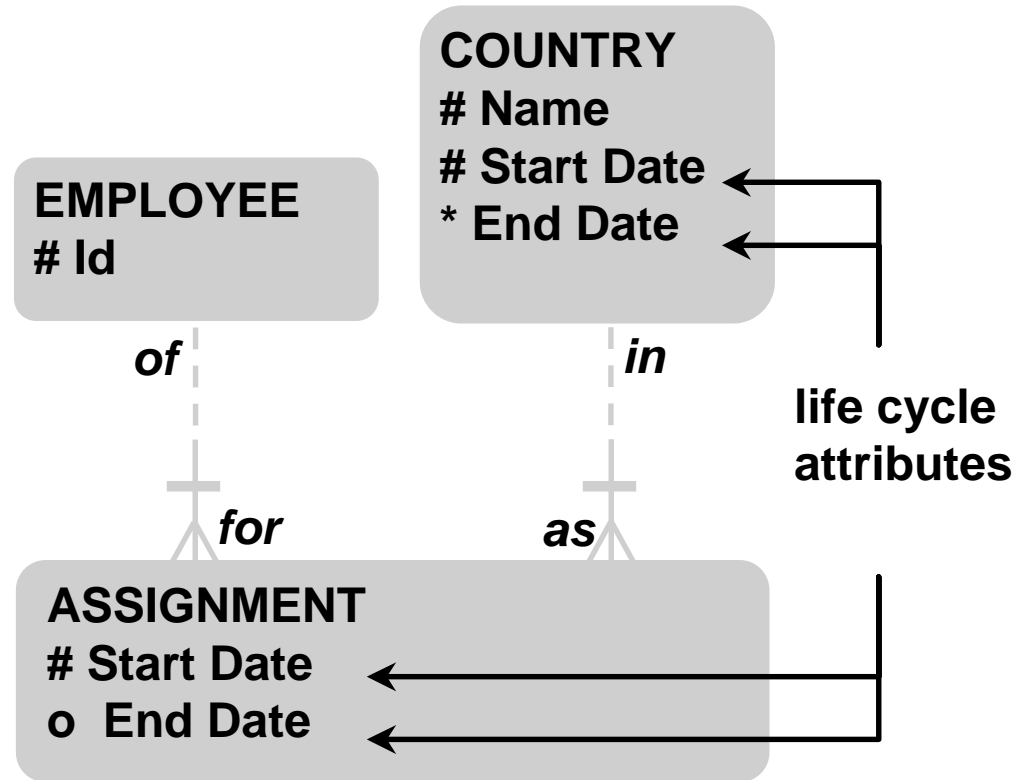
Entity DAY



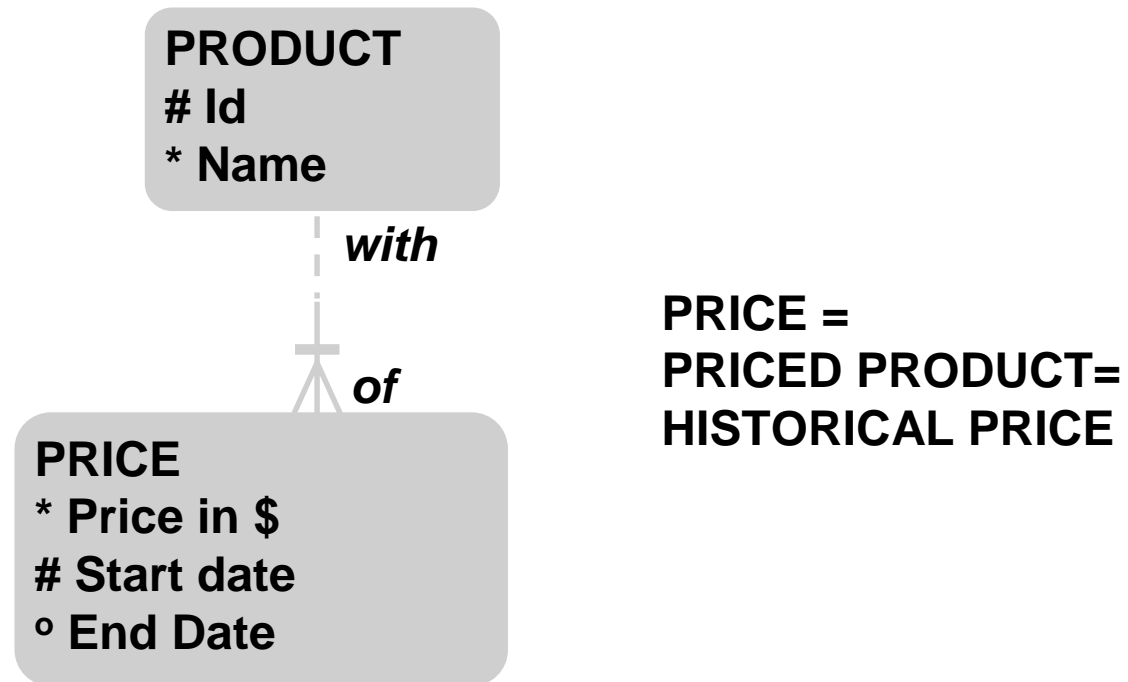
Modeling Change



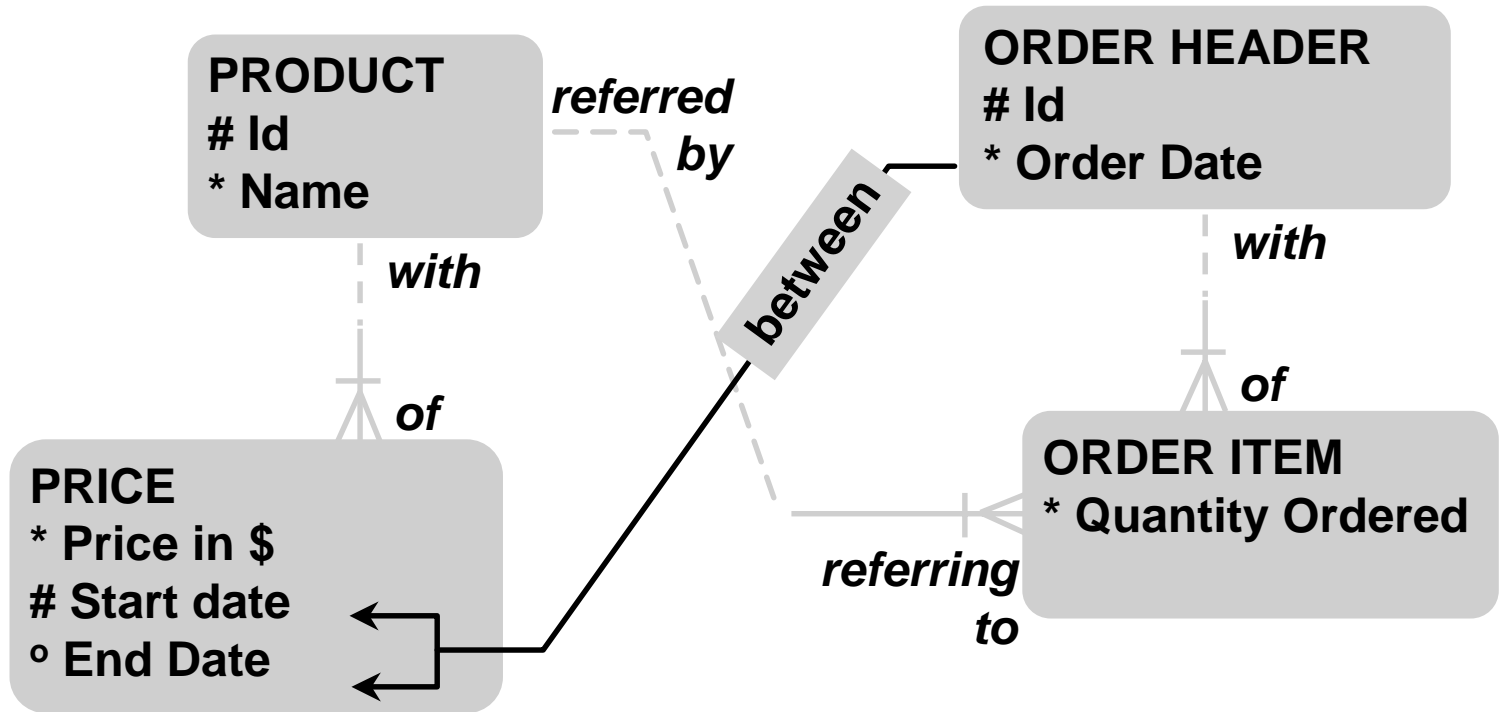
Even a Country Has a Life Cycle



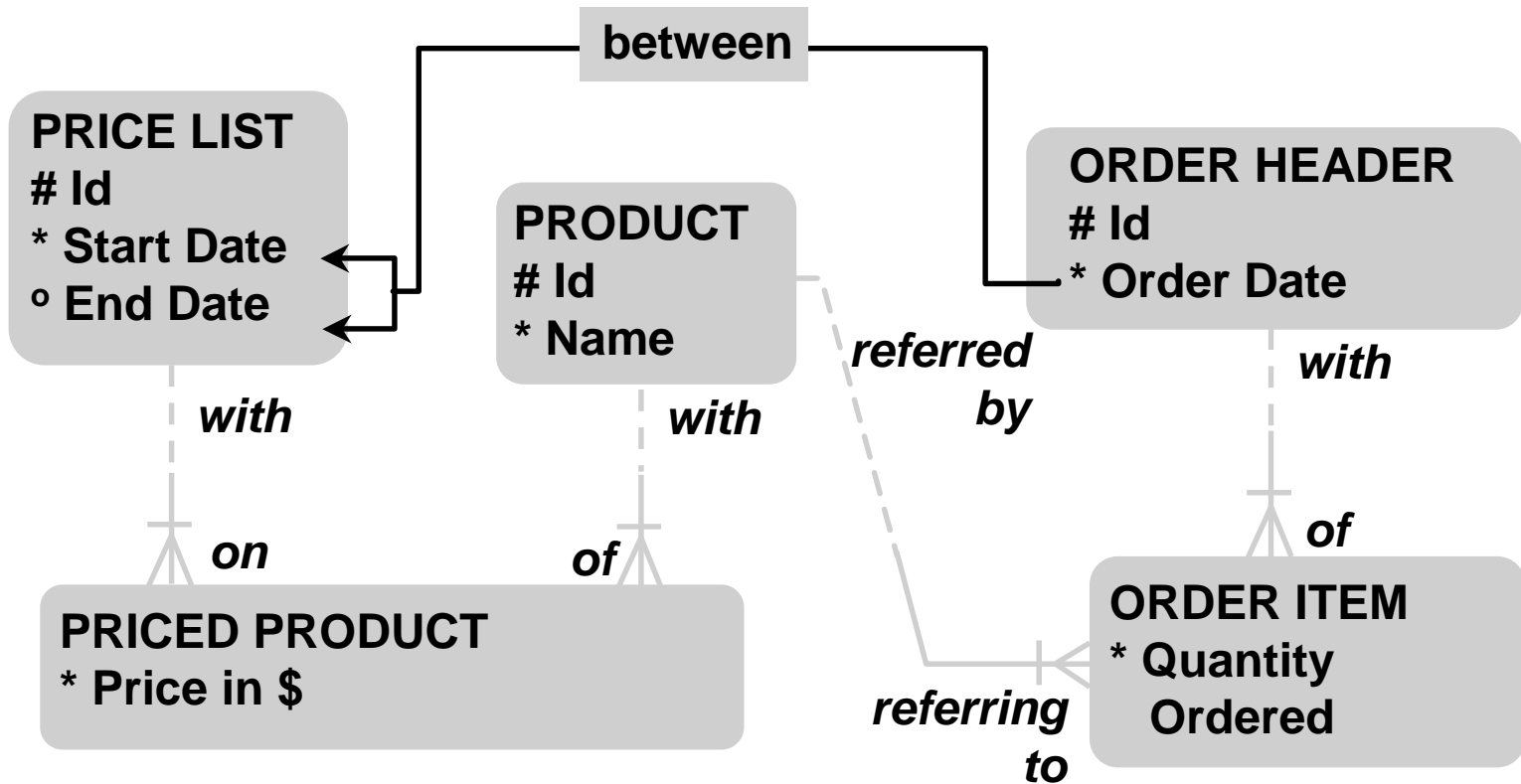
Products and Prices



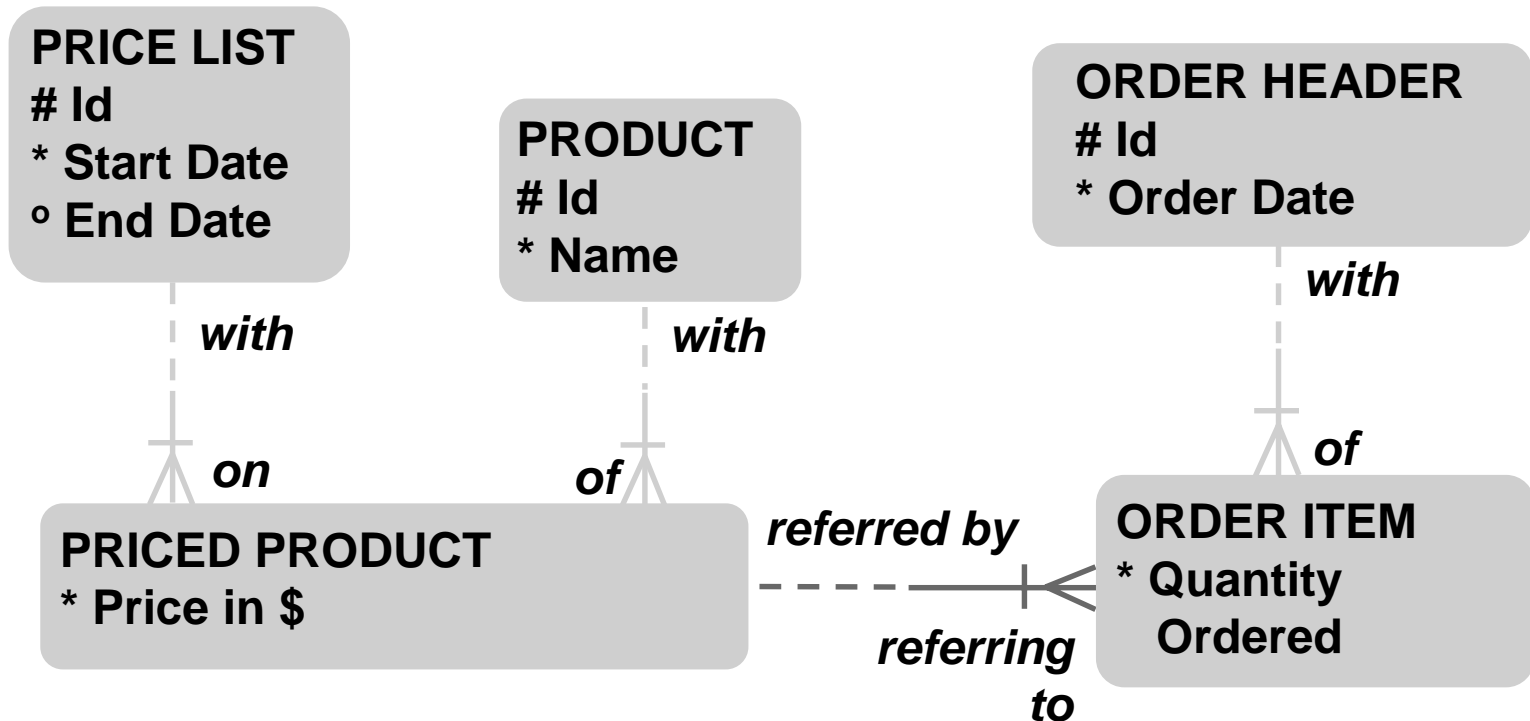
What Price to Pay?



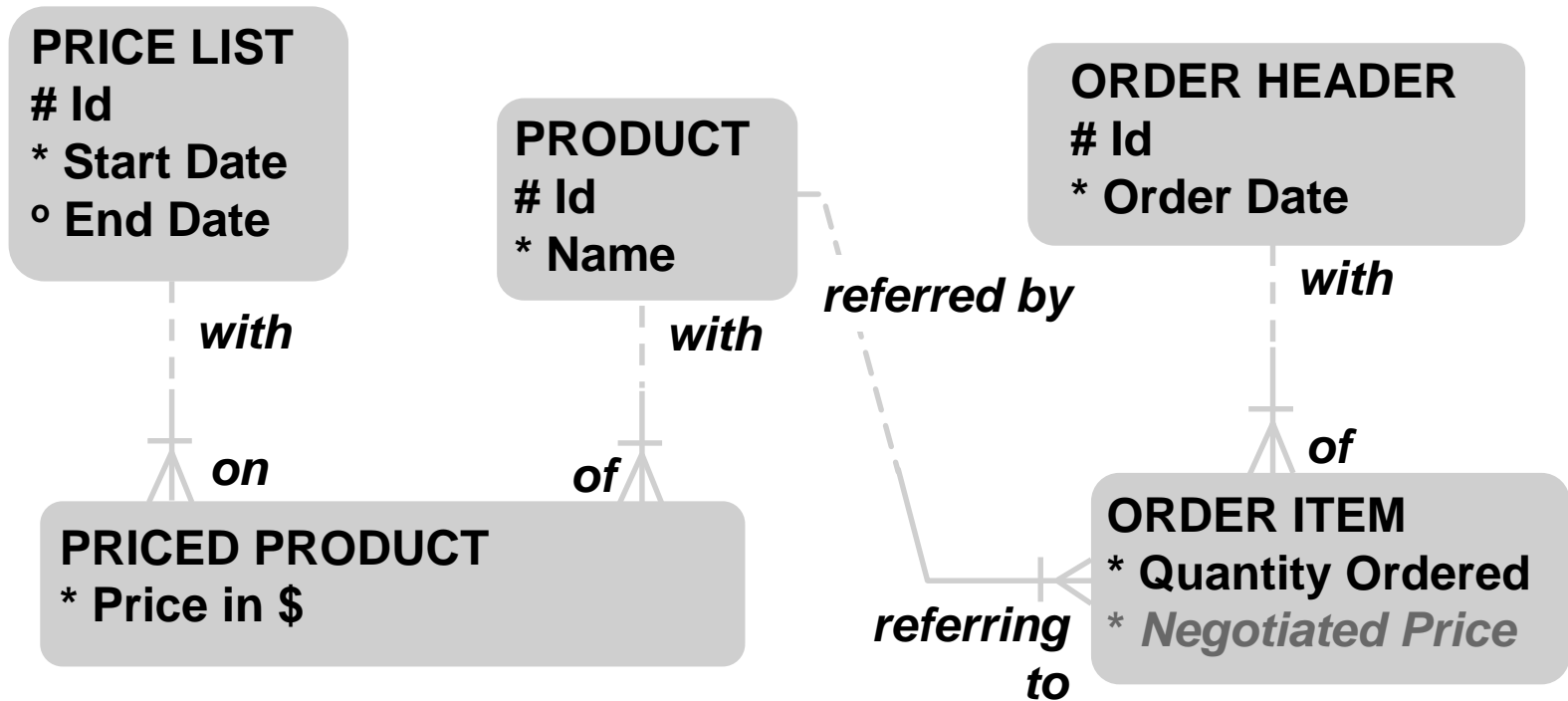
Price List Search



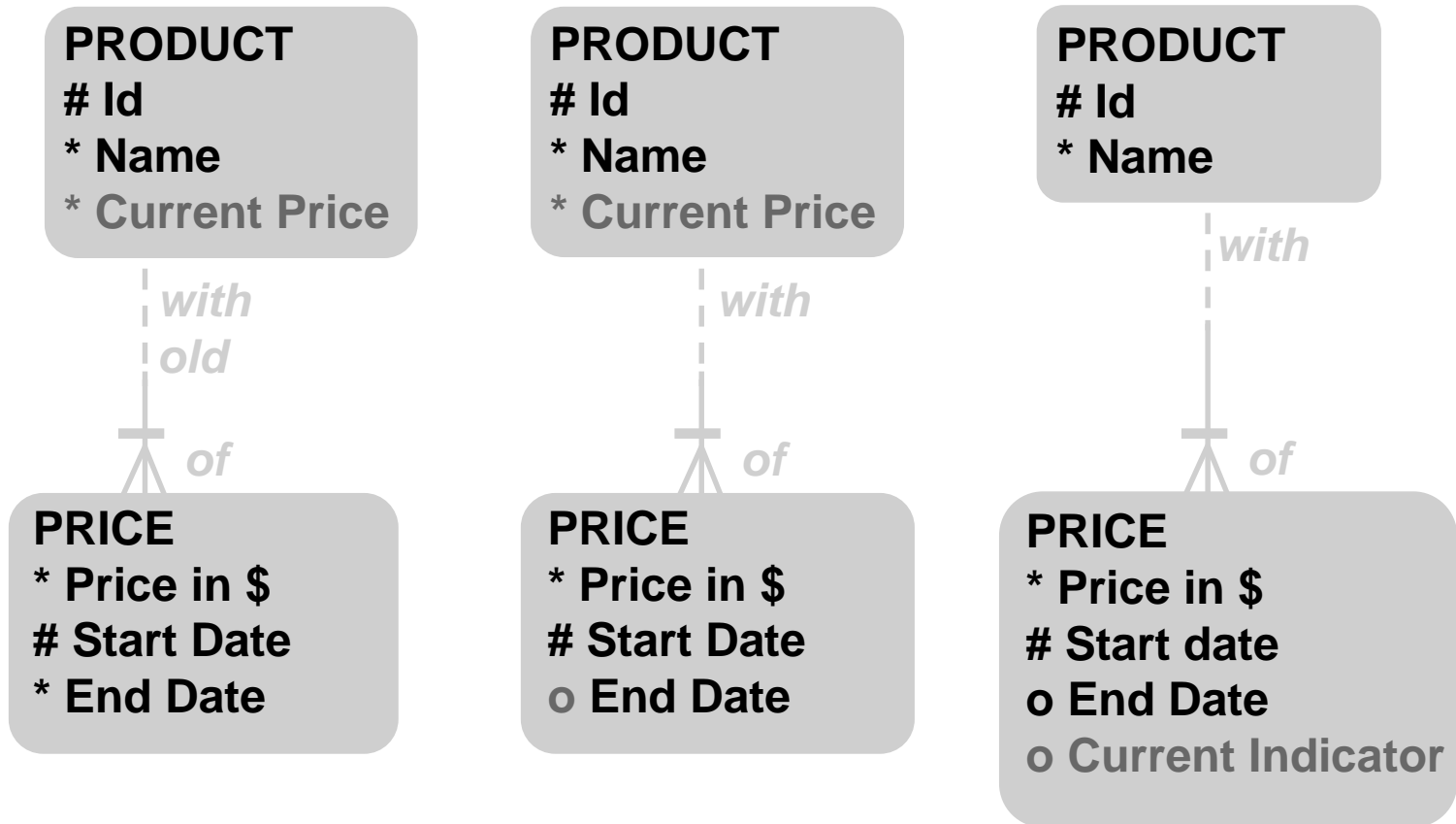
Order for Priced Products



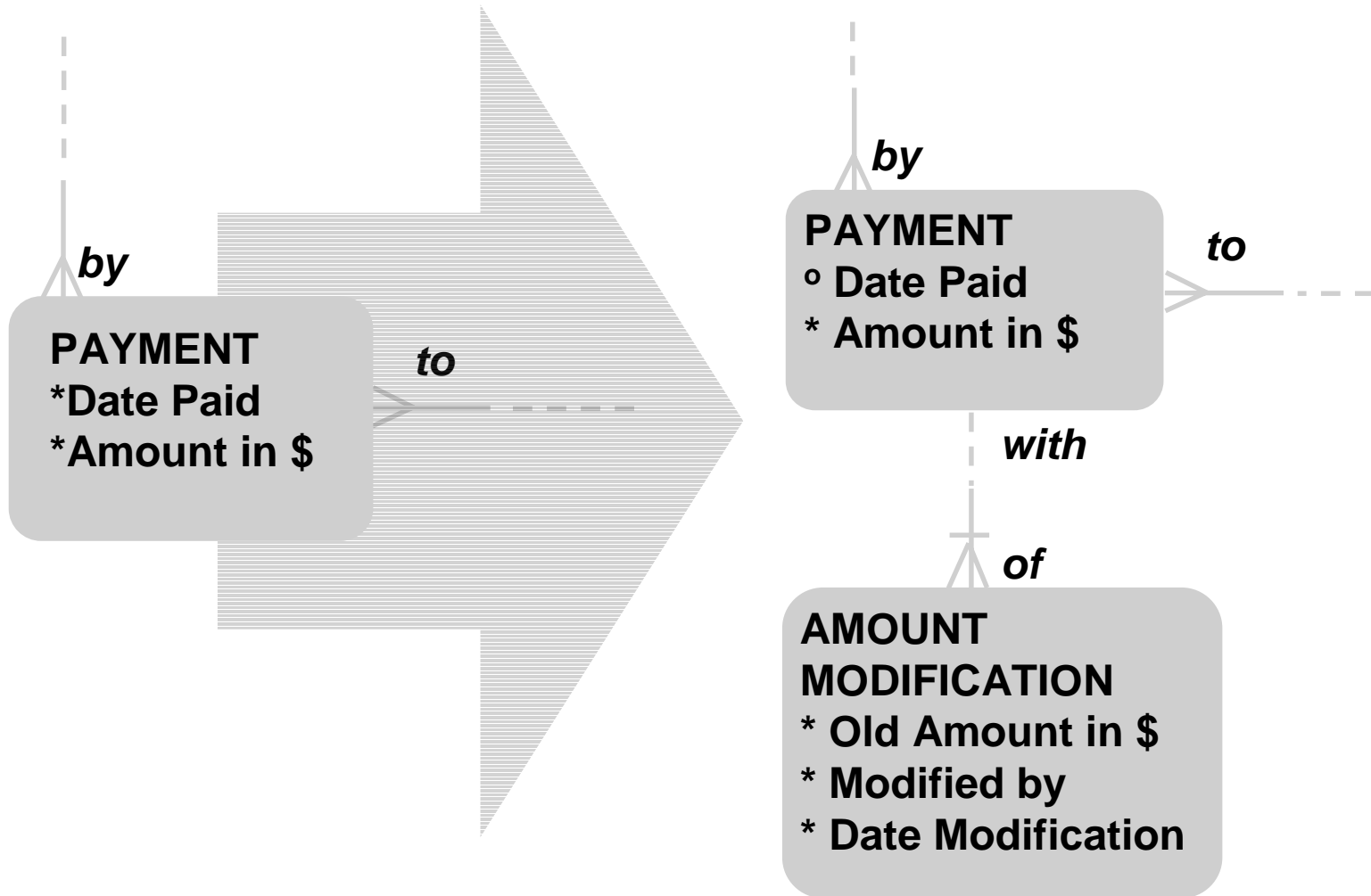
Negotiated Prices



Current Prices



Journaling



Summary

- **Consider the need for keeping old values**
- **Time in your model is complicated:**
 - **Implicit versions**
 - **References**
- **Journaling**

Practices

- **Shift**
- **Strawberry Wafer**
- **Bundles**
- **Product Structure**

Practice: Shift

Museumplein, Amsterdam, March 21

Shift	1	2	3	4	5
Mon	6:30 11:30	11:30 16:00	16:00 20:30	20:30 23:00	-
Tue	7:00 11:30	11:30 16:00	16:00 20:30	20:30 23:00	-
Wed	7:00 11:30	11:30 16:00	16:00 20:30	20:30 23:00	-
Thu	7:00 11:30	11:30 16:00	16:00 20:30	20:30 23:00	-
Fri	7:00 11:30	11:30 16:00	16:00 20:30	20:30 24:00	-
Sat/Sun	8:00 11:30	11:30 15:00	15:00 18:00	18:00 21:00	21:00 24:00

Practice: Strawberry Wafer

- **Prices are at the same level within a country; prices are determined by the Global Pricing Department. Usually the prices for regular, global products are re-established once a year.**
- **Prices and availability for local specialties are determined by the individual shops. For example, the famous Norwegian Vafler med Jordbær (a delicious wafer with fresh strawberries) is only available in summer. Its price depends on the current local market price of fresh strawberries.**

prijzlijst

de Keyzer, Keyzerlei 15, Antwerpen
bezoekt ons op 't Web: www.moonlight.com

Practice: Price list

	klein	middel	groot	
gewone koffie	60	90	120	
cappuccino	90	110	140	
koffie verkeerd	75	100	130	
speciale koffies	99	125	150	
espresso	60	95	110	
koffie van de dag	45	75	100	
<i>caffeine vrij</i>	<i>5</i>	<i>10</i>	<i>15</i>	<i>toeslag</i>
zwarte thees	60	100	120	
vruchten thees	75	110	130	
kruiden thees	80	120	140	
dag thee	50	85	100	
<i>caffeine vrij</i>	<i>5</i>	<i>10</i>	<i>15</i>	<i>toeslag</i>
frisdranken	60	100	130	
diverse sodas	60	100	130	
mineraal water	75	120	140	
appel taart				180
brusselse wafel				150
portie chocolade bonbons				150
koekje van eigen deeg				120
portie slagroom				30

inclusief BTW
16 September

Practice: Bundles(1)

A SweetTreat(tm) consists of a large soft drink plus cake of the day.

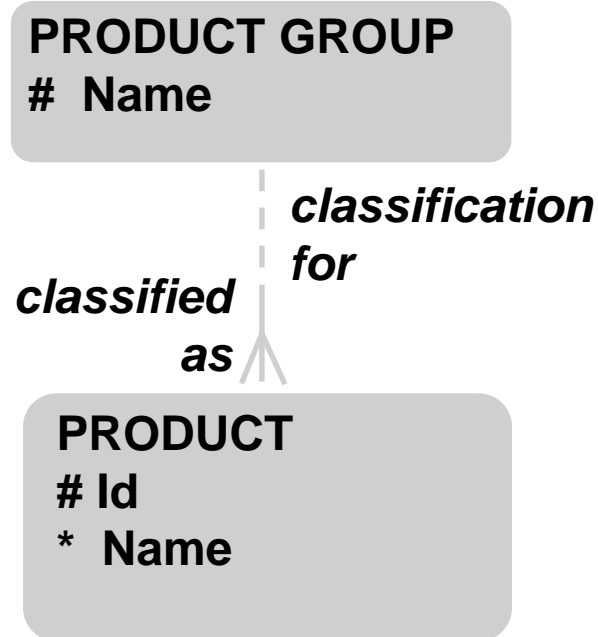
A BigBox(tm) consist of a large coffee of the day plus two cakes of the day.

A SuperSweetTreat(tm) consists of a SweetTreat(tm) plus whipped cream (on the cake).

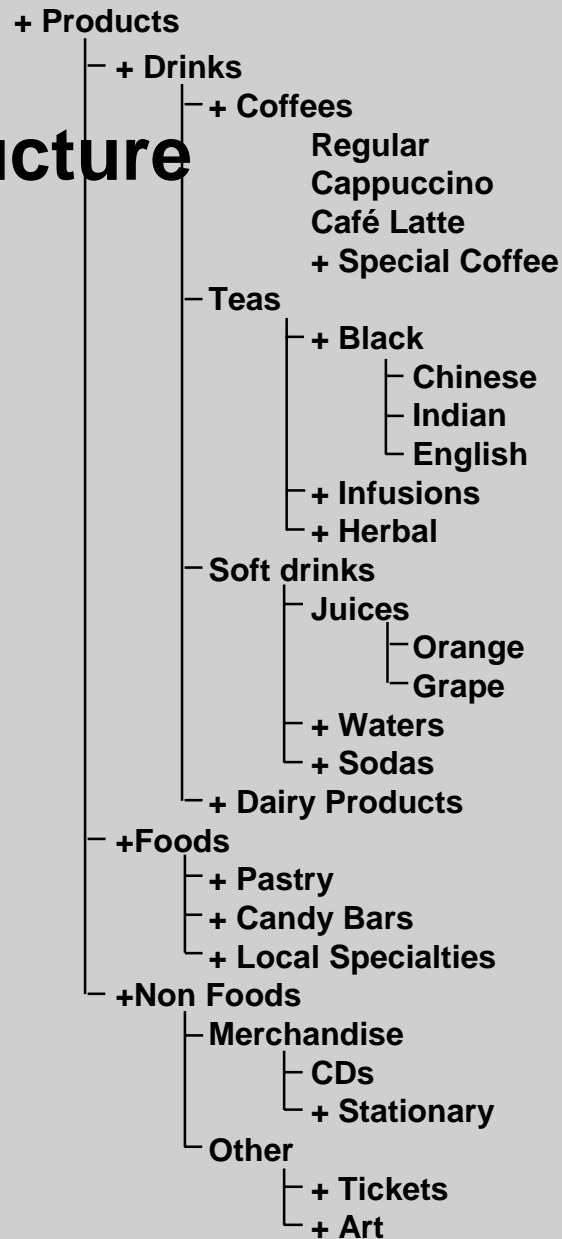
A FamilyFeast(tm) consists of two BigBoxes(tm) plus two SweetTreats™ plus a small surprise.

A DecafPunch(tm) consists of a regular decaffeinated coffee or a regular decaffeinated tea, plus a blackberry muffin.

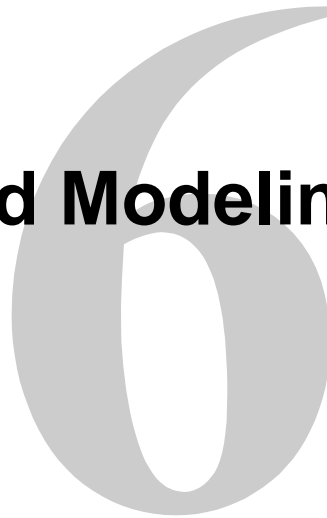
Practice: Bundles(2)



Practice: Product Structure



Advanced Modeling Topics

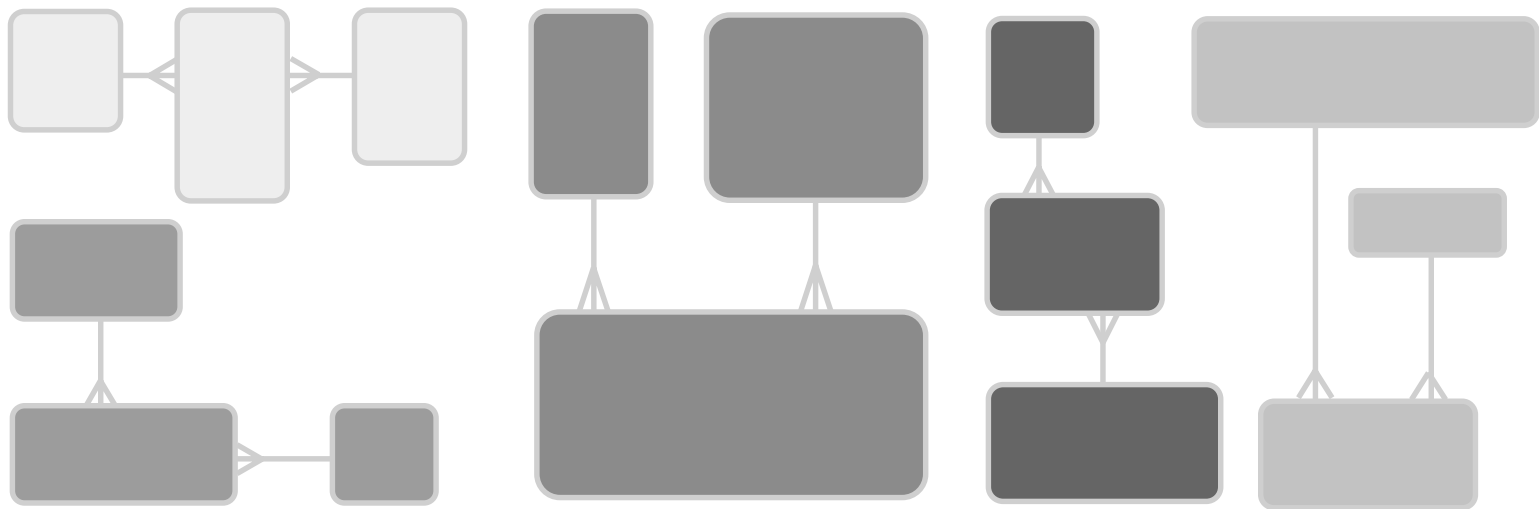


Overview

- **Patterns**
- **Drawing conventions**
- **Generic modeling**

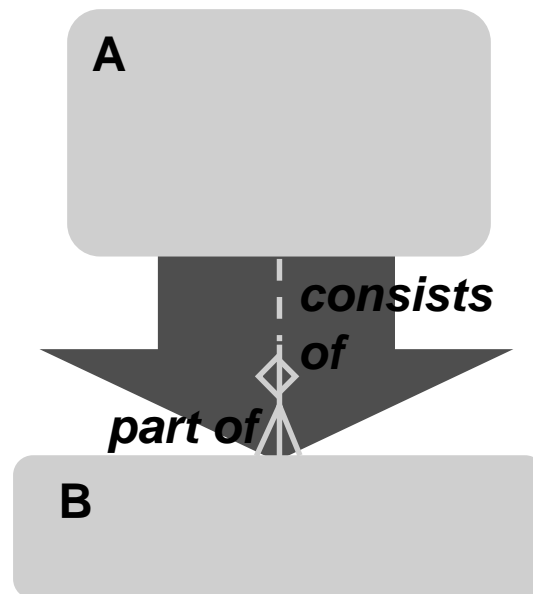
Patterns

- **Similar structure**
- **Similar rules and constraints?**



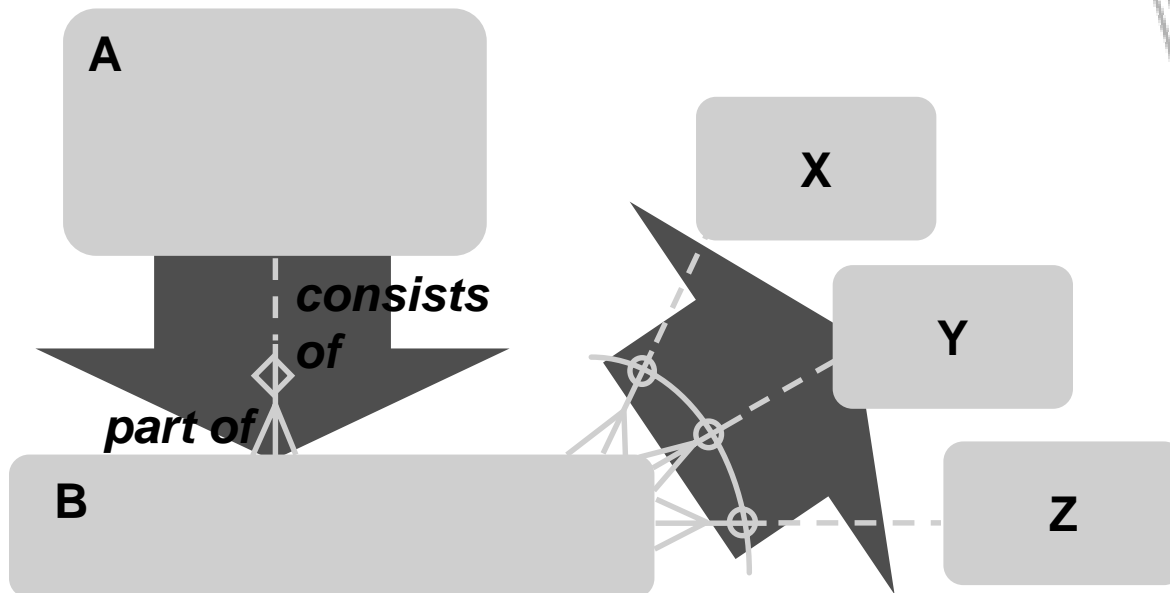
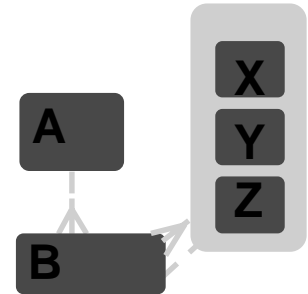
Patterns: Master–Detail

- **Characteristic:** *consists of*
An instance of B only exists in the context of an A
- **Metaphor:** Master – Detail



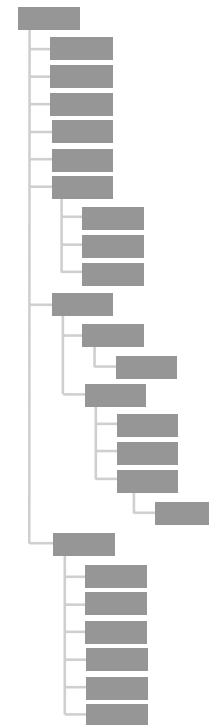
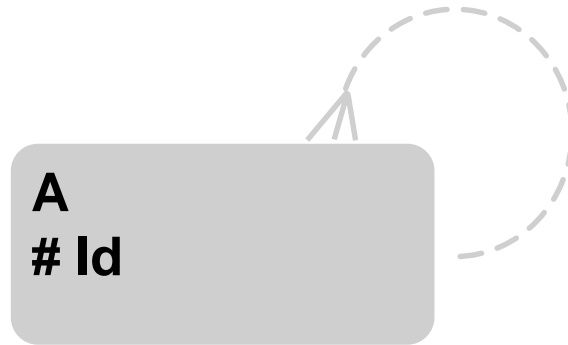
Pattern: Basket

- **Characteristic:**
container for various types of items
- Items may be of different types
- **Metaphor: Shopping Basket**



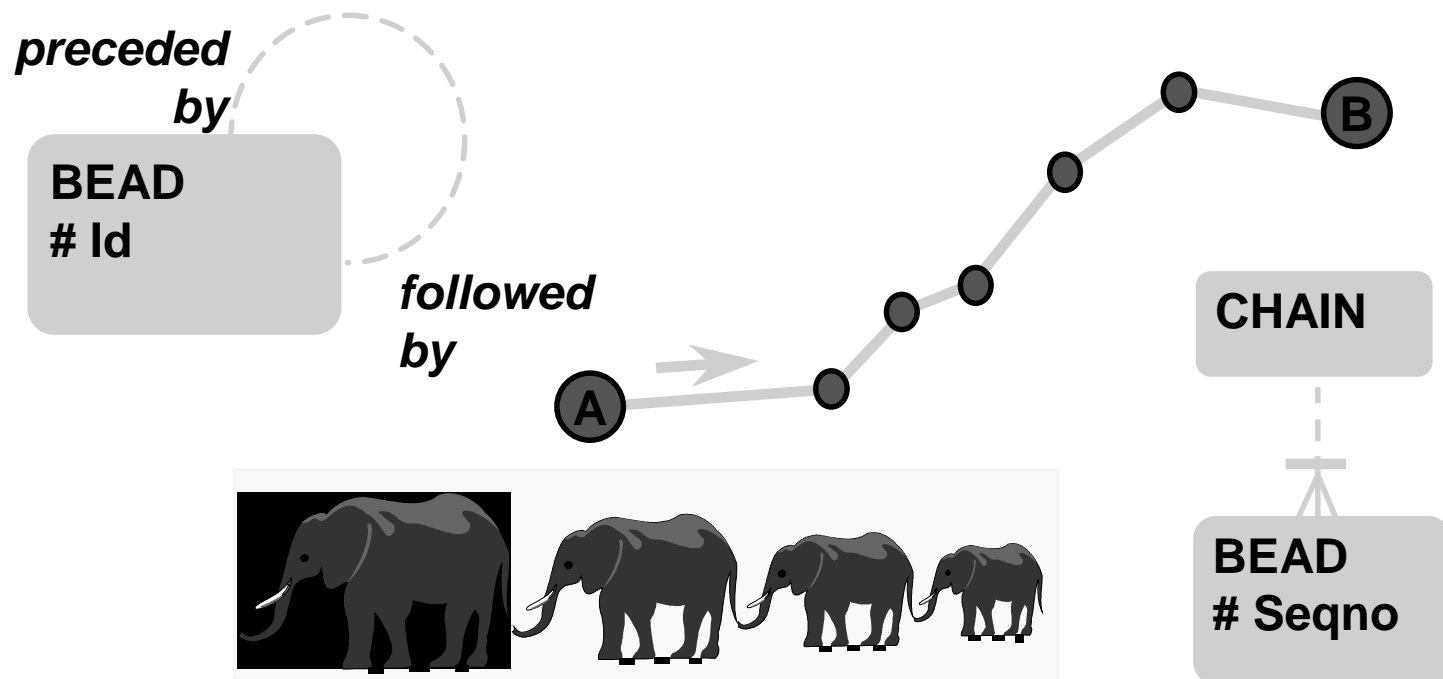
Patterns: Hierarchy

- **Characteristic:** *manager of / subordinate of*
- **Additional constraints to guard hierarchical nature**
- **Metaphor: Mother–Child**



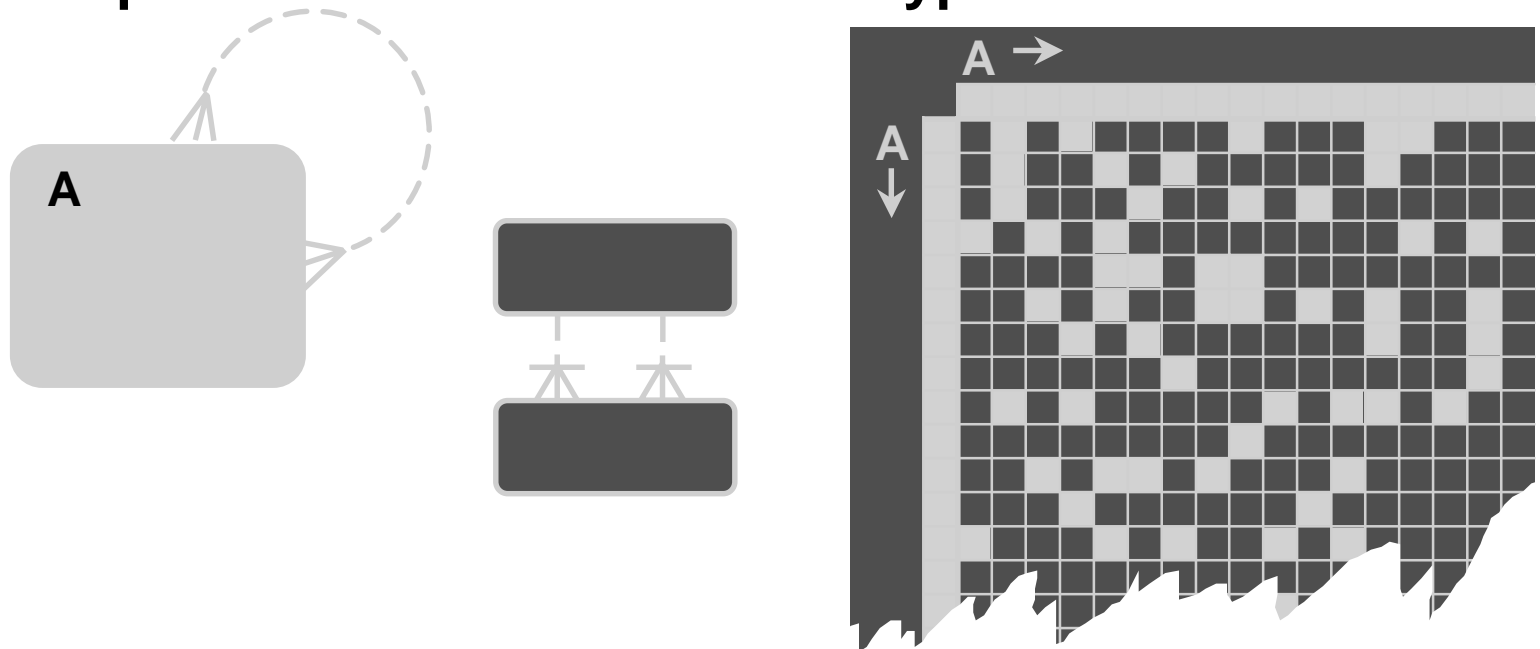
Patterns: Chain

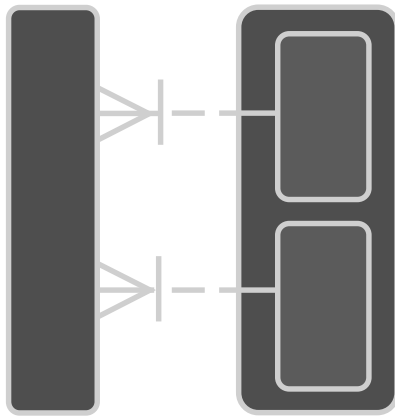
- **Characteristic:** *preceded by / followed by*
- **Sequence is important**
- **Metaphor: Elephants**



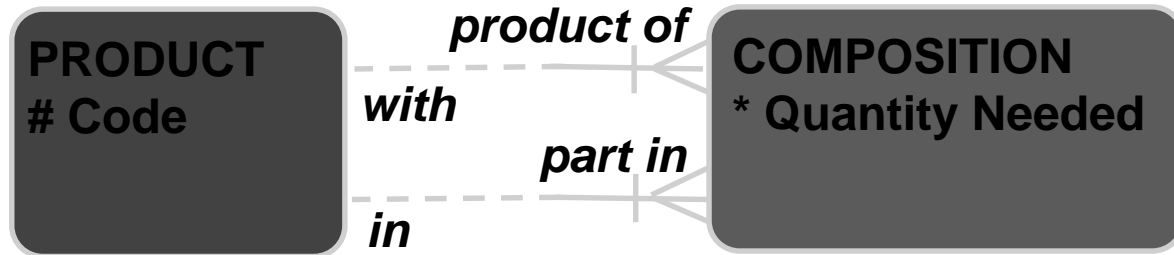
Patterns: Network

- **Characteristic: *pairs***
Every A can be connected to every A
(sometimes: to every *other* A)
- **Metaphor: Web Document with Hyperlinks**





Bill of Material



PRODUCTS

Code	Name
914.53	AAAAAAAAA
914.54	AAA
914.55	BBBBBBBBB
914.56	B

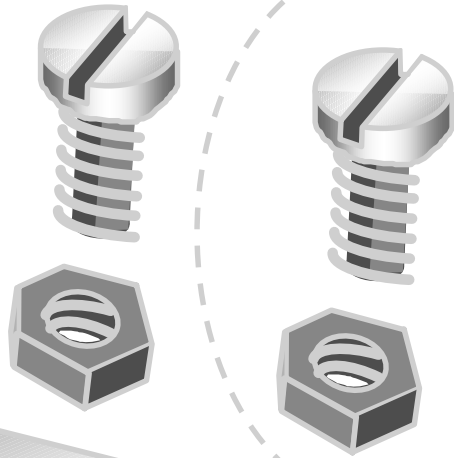
DDDDD

COMPOSITIONS

Prod_code	Part_code	Quantity
854.01	604.18	1
854.01	604.19	1
854.01	914.54	2
914.54	914.55	1
914.54	914.56	1

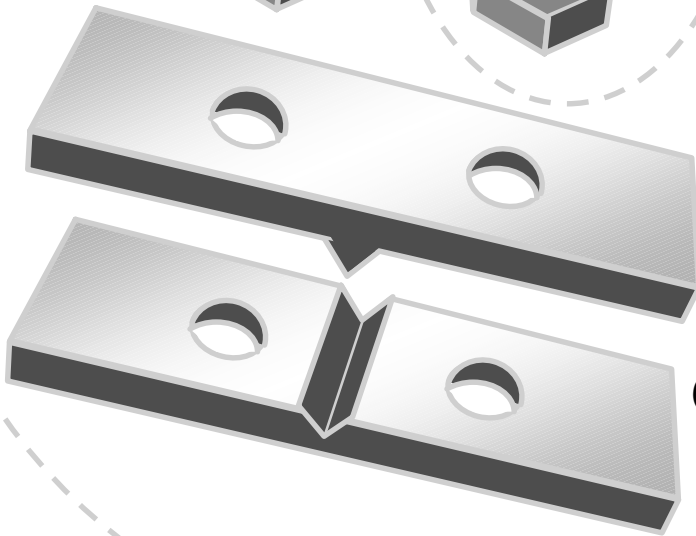
Bill of Material - Example

854.01



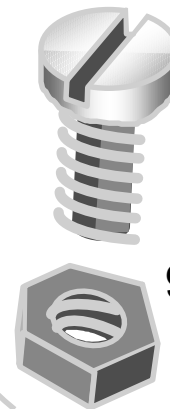
914.54

914.54



604.18

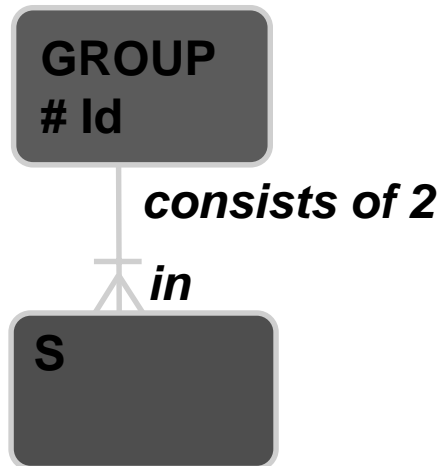
604.19



914.55

914.56

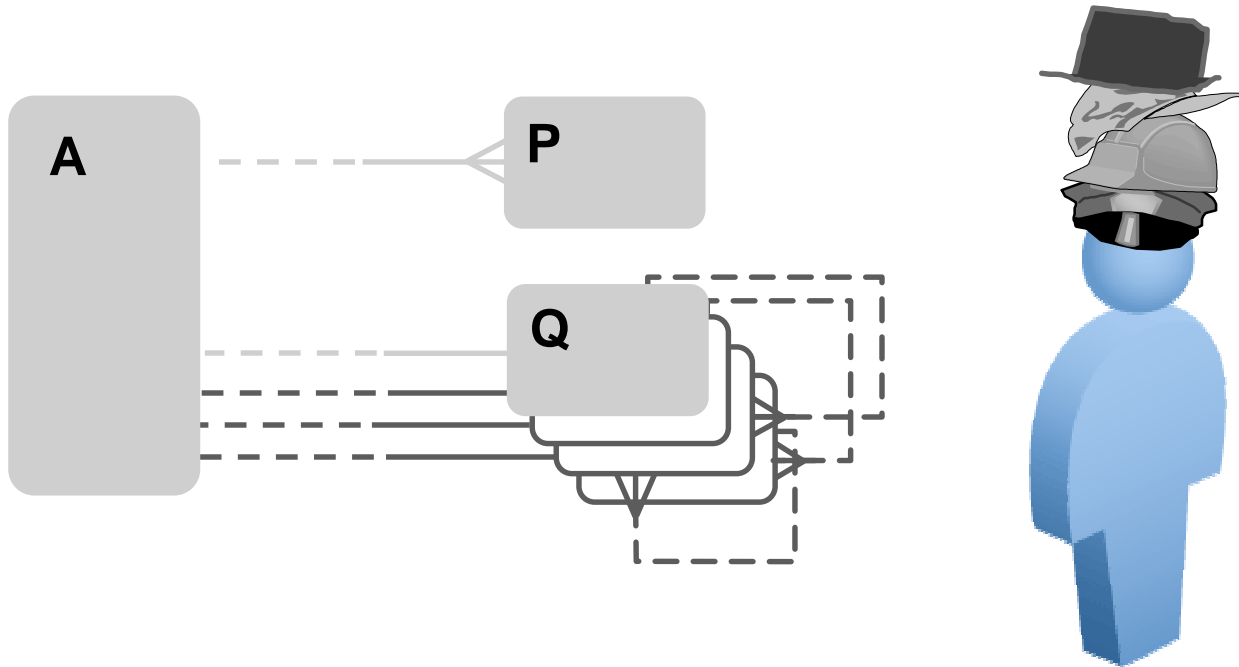
Symmetric Relationship



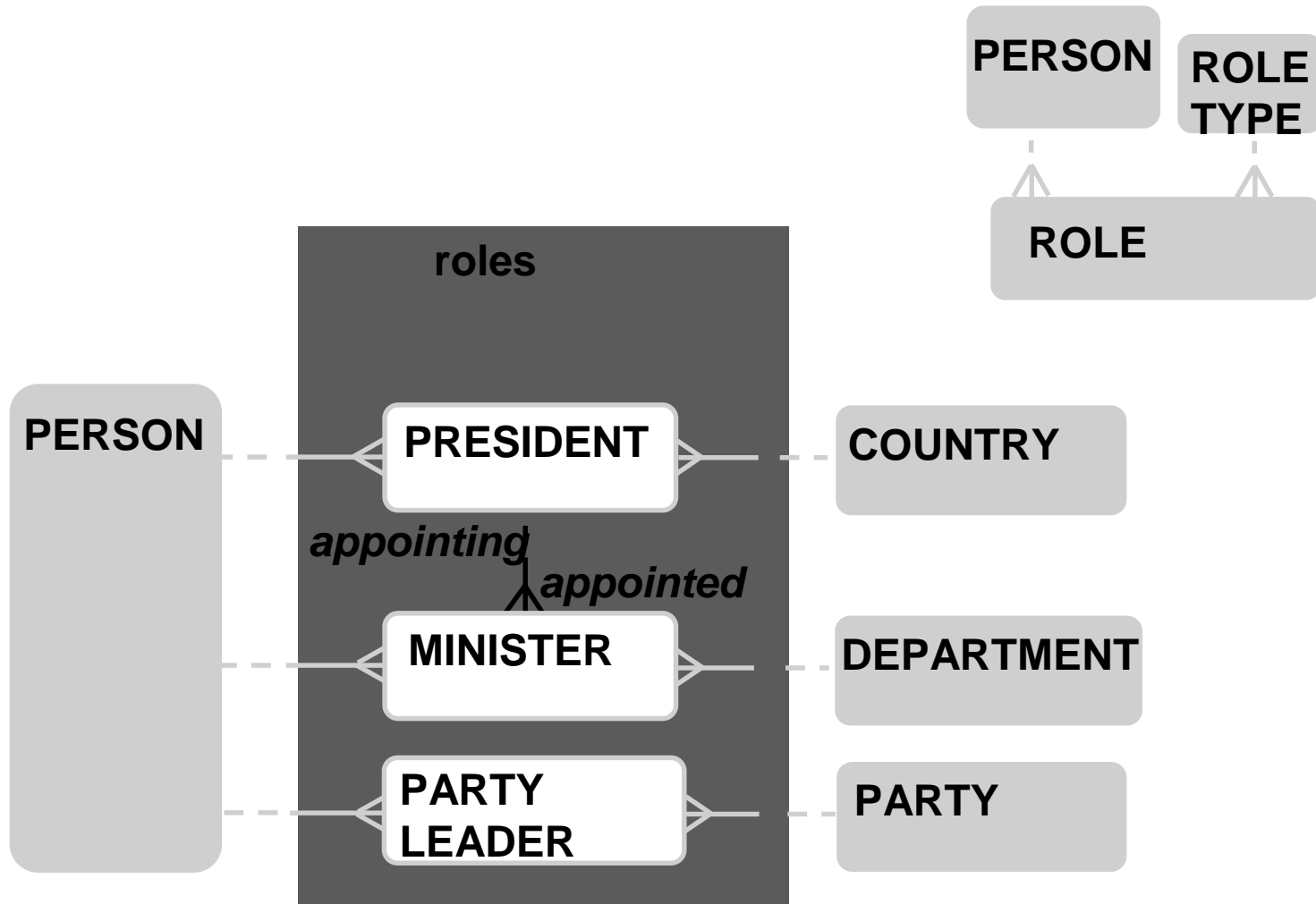
Group_id	S
1	S ₁
1	S ₂
2	S ₃
2	S ₄
3	S ₅
3	S ₆

Patterns: Roles

- **Characteristic:** *is / is* 1:m (or 1:1) relationships
- **Metaphor:** Person–Many Hats (not necessarily concurrent...)

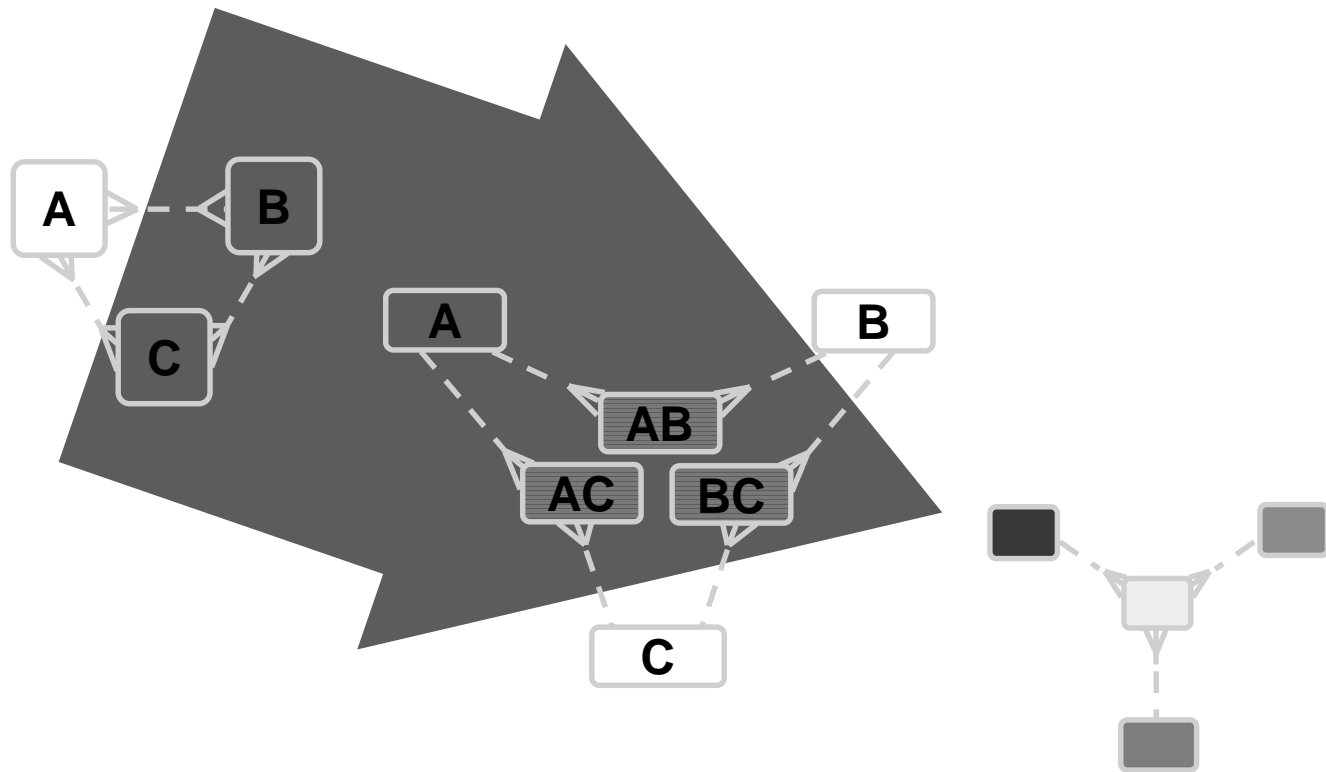


Roles

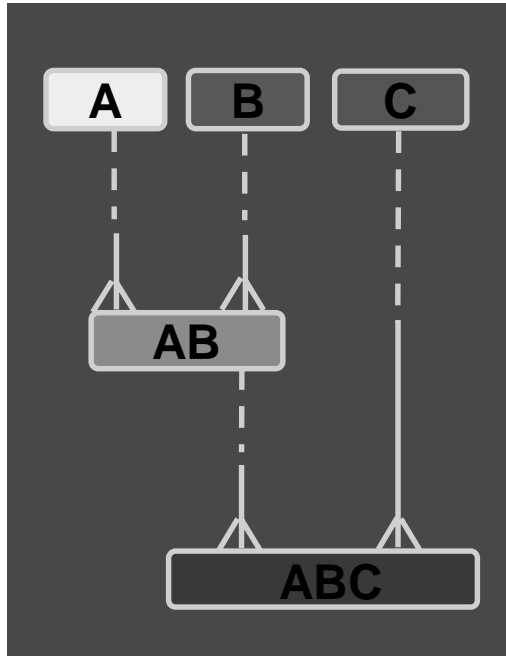


Fan Trap

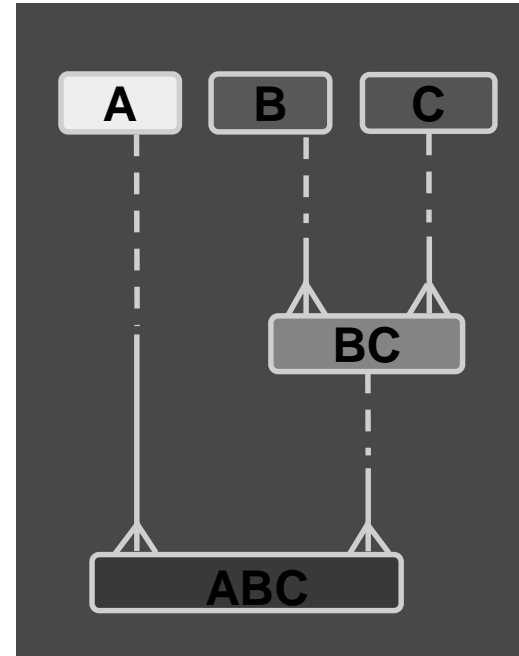
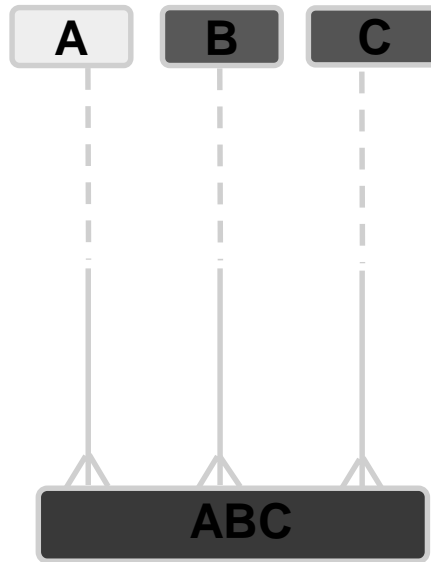
- **Characteristic: ring of m:m related entities**
- **Metaphor: ABC Combination**



Fan Trap Resolved



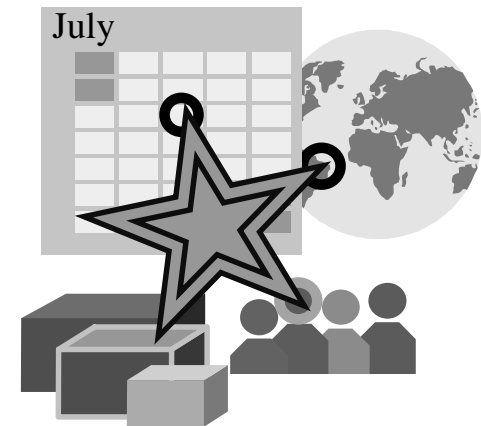
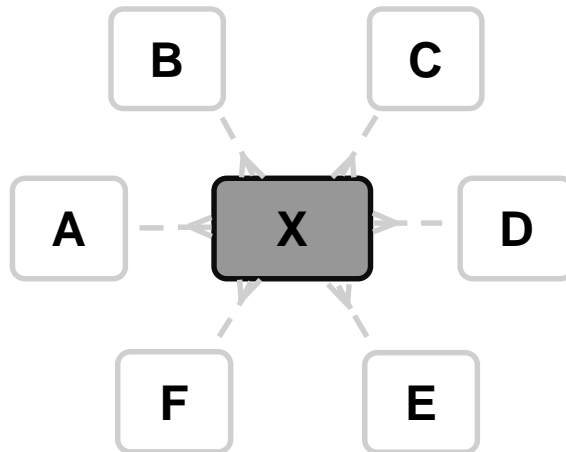
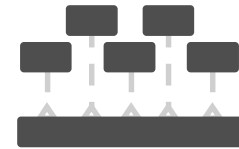
**AB functions as
list of values**



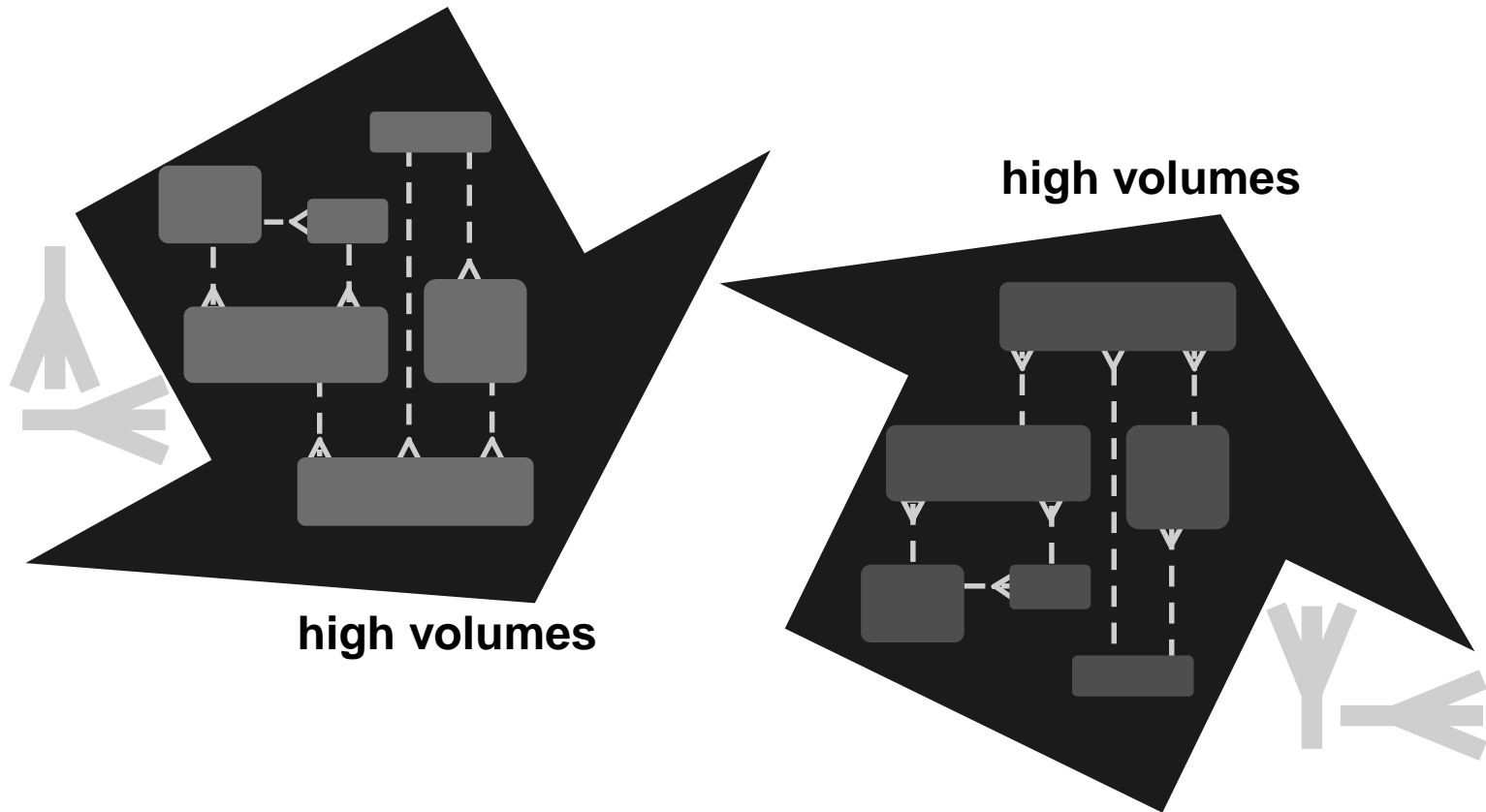
**BC functions as
list of values**

Patterns: Data Warehouse

- **Characteristic:** *multidimensional*, many, many detail instances
- **Metaphor:** *star* model
Stars may be strangely shaped:
- **Snowflake model**

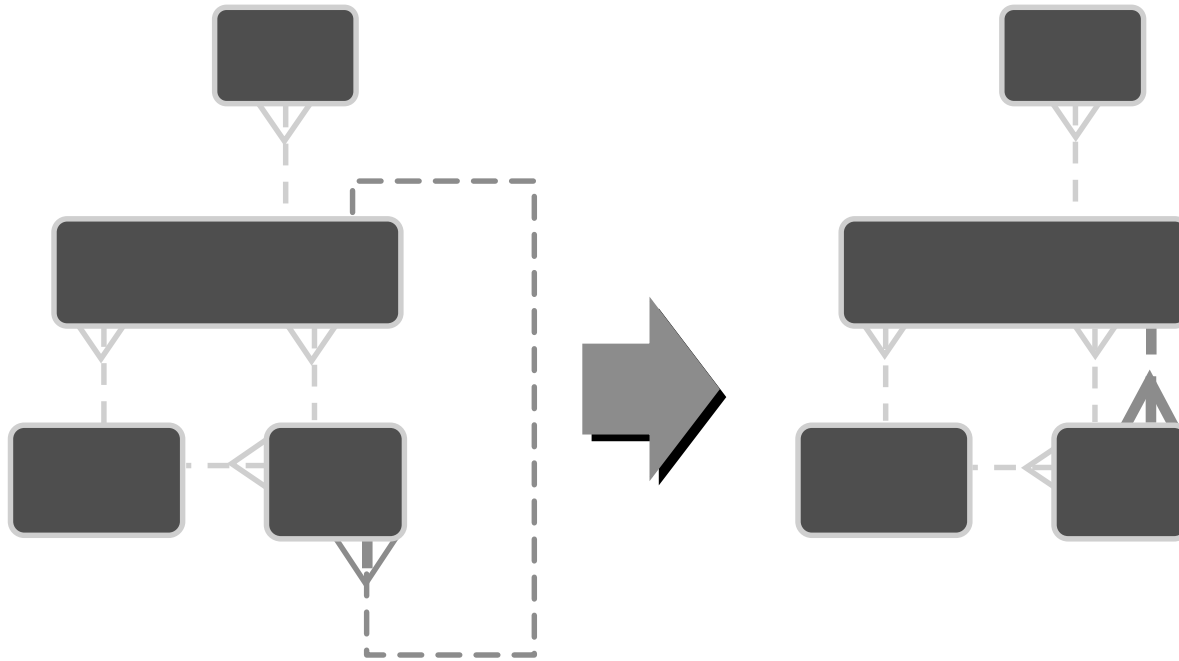


Drawing Conventions



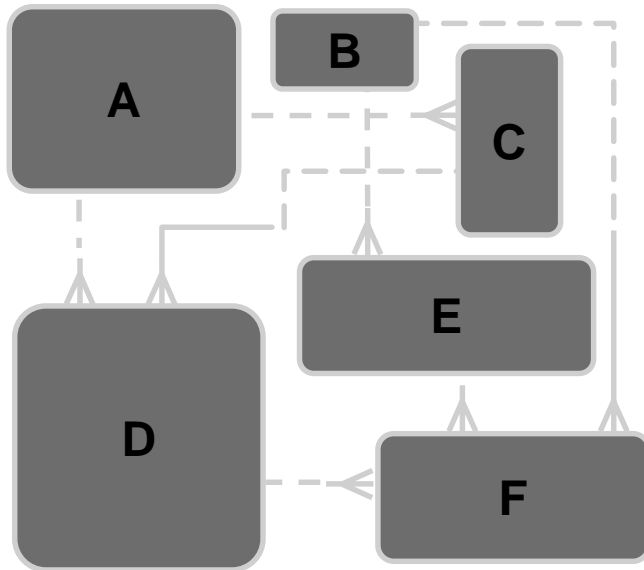
Not important *which* convention you choose, as long as you follow one of them

Use Conventions Sensibly

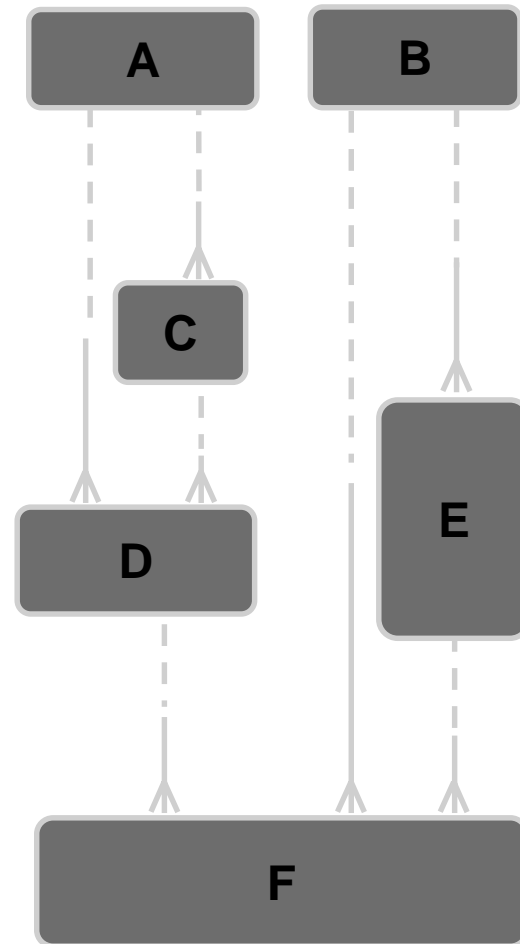


But:
Readability first

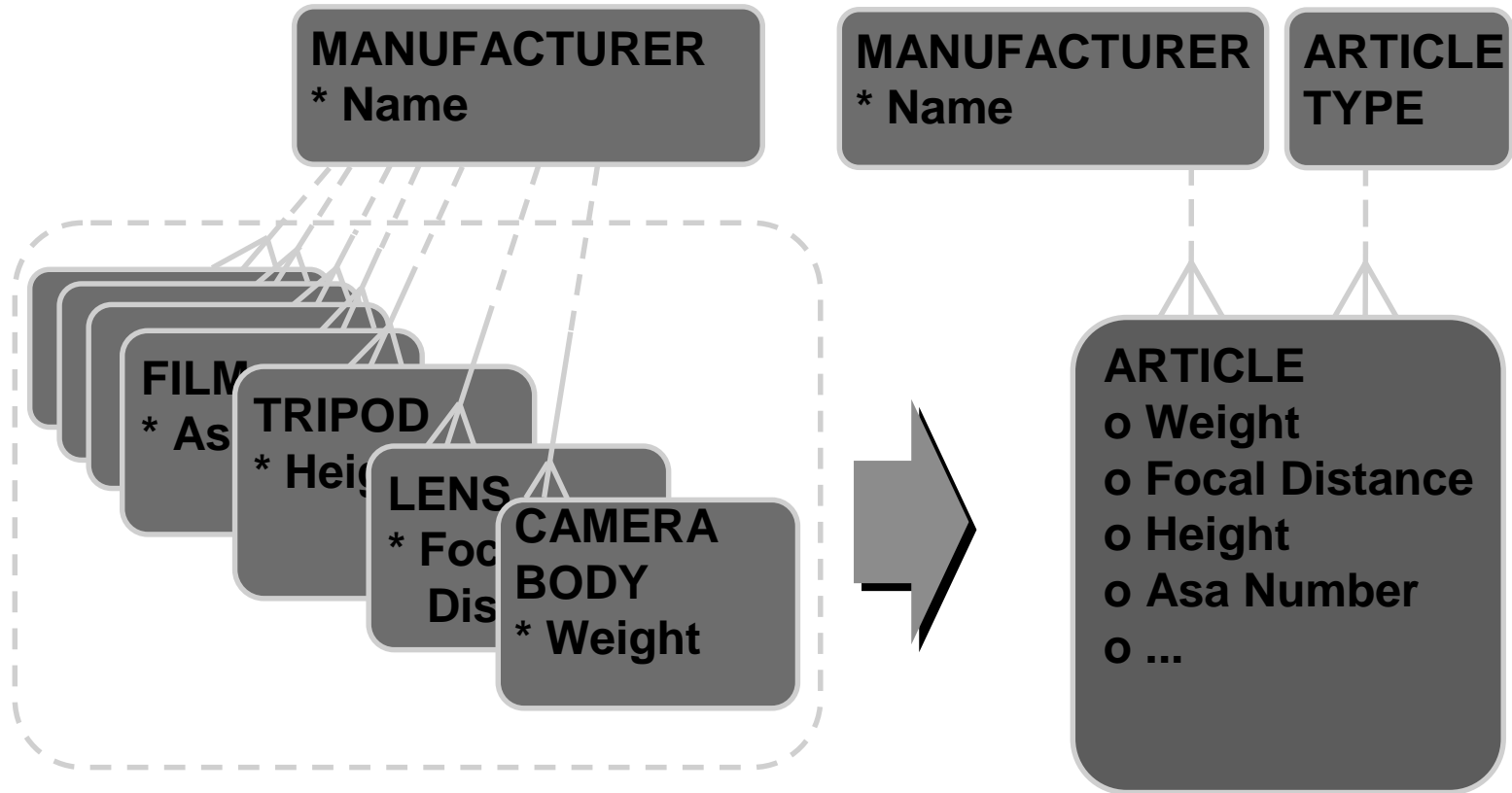
Model Readability



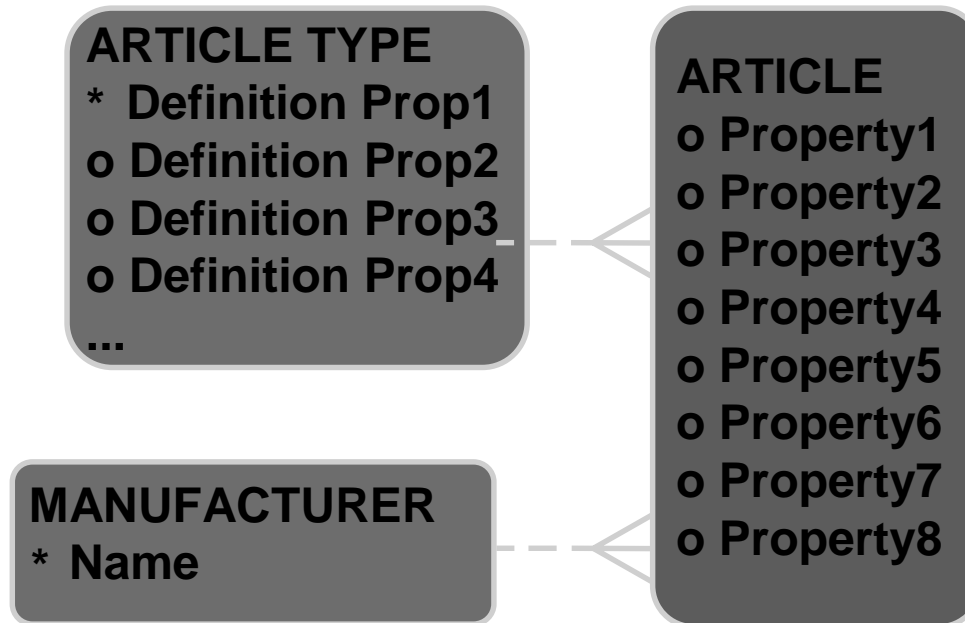
- **Takes space**
- **Subject to taste**



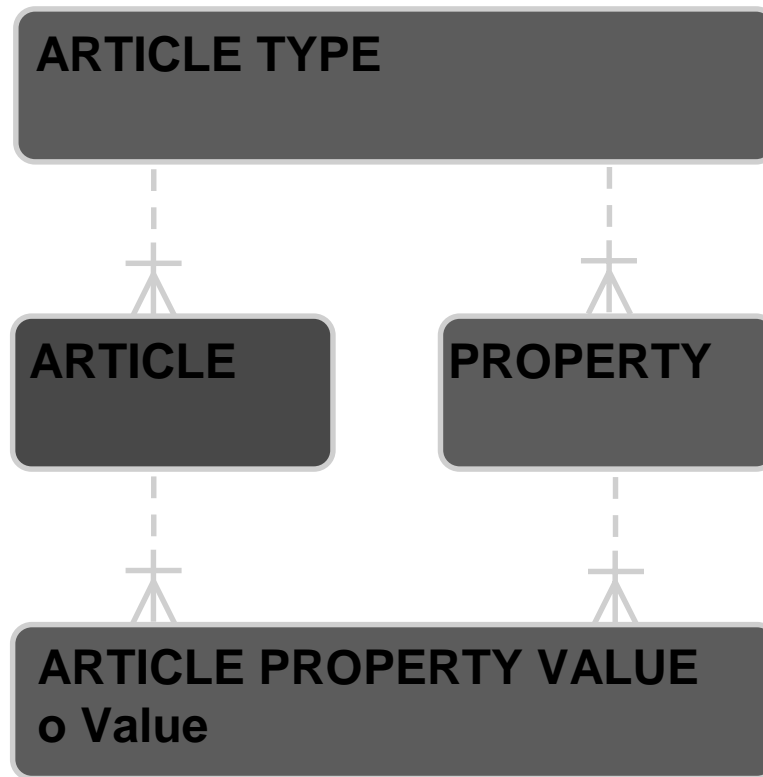
Generic Modeling



Generic Modeling



Generic Model



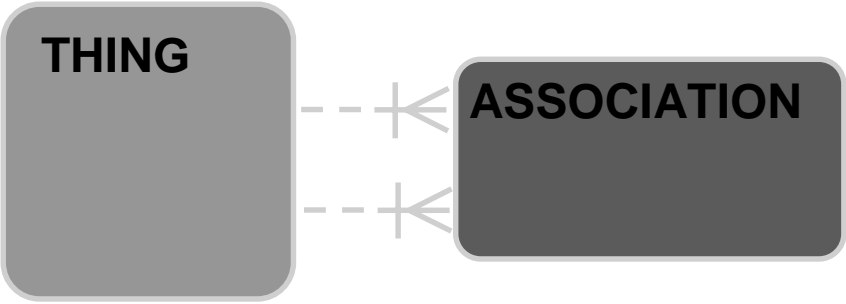
Generic

*having some kind of
relationship with*

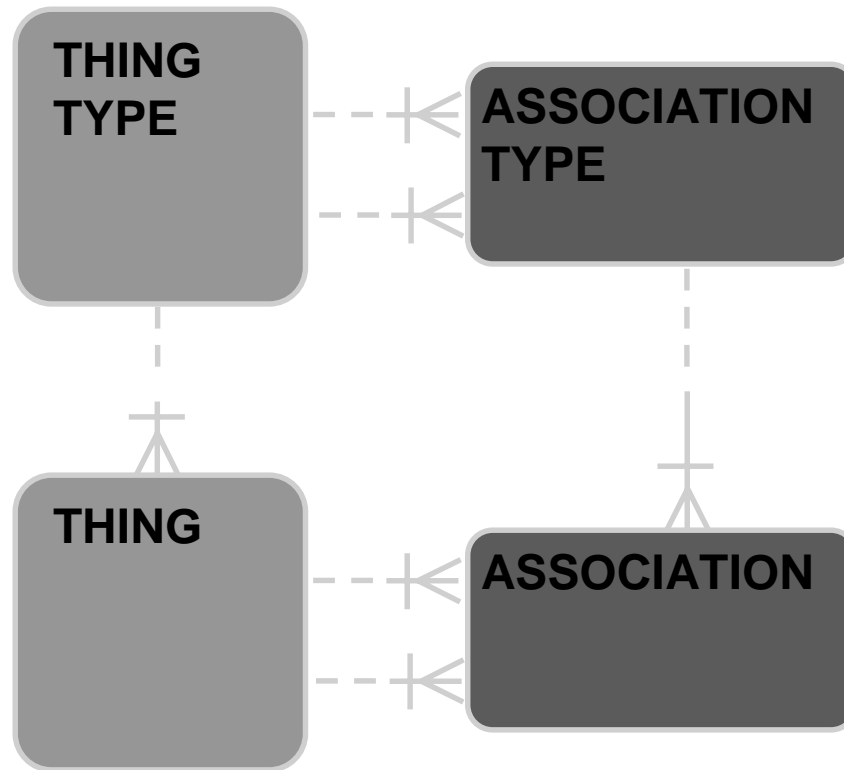


*having some kind of
relationship with*

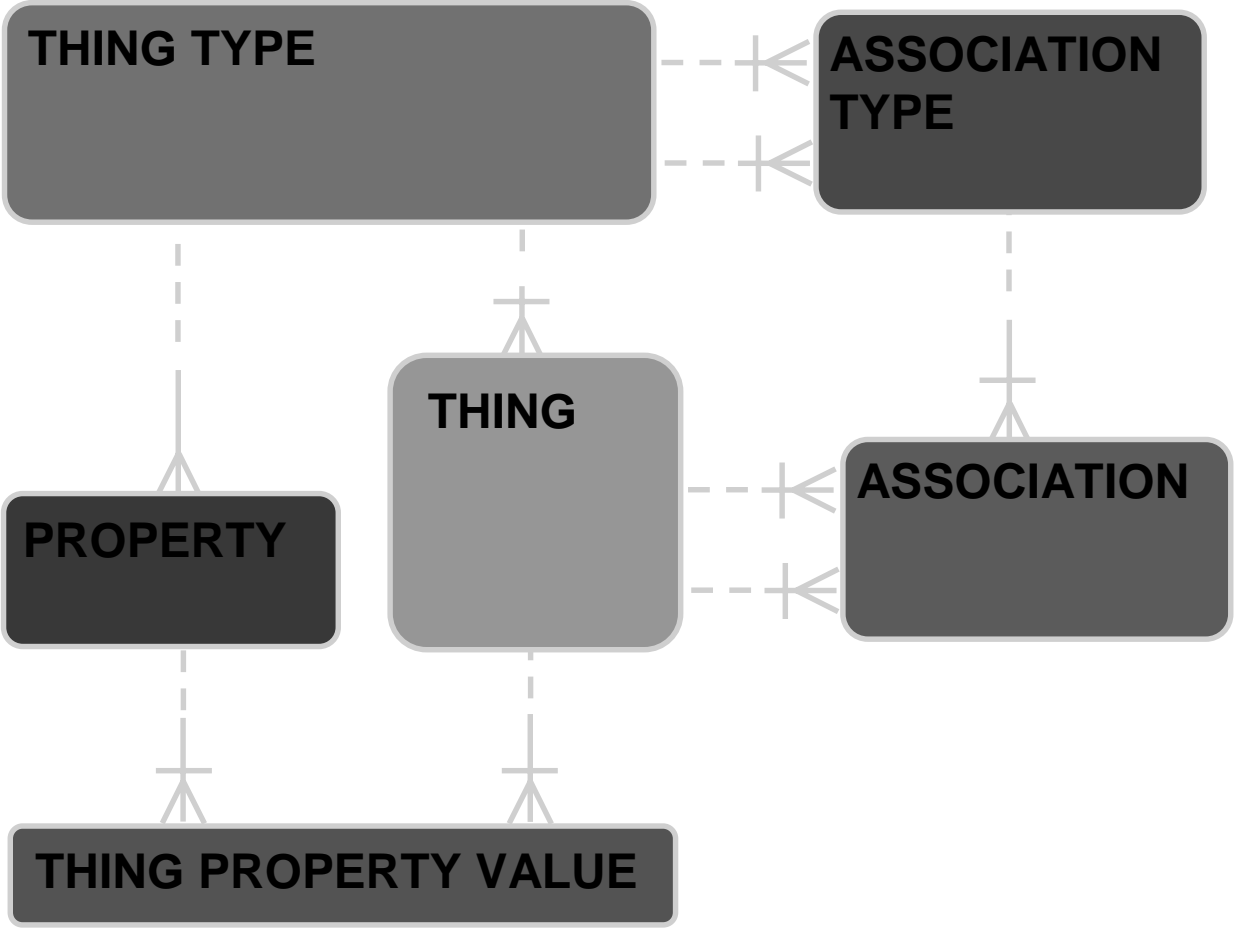
More Generic



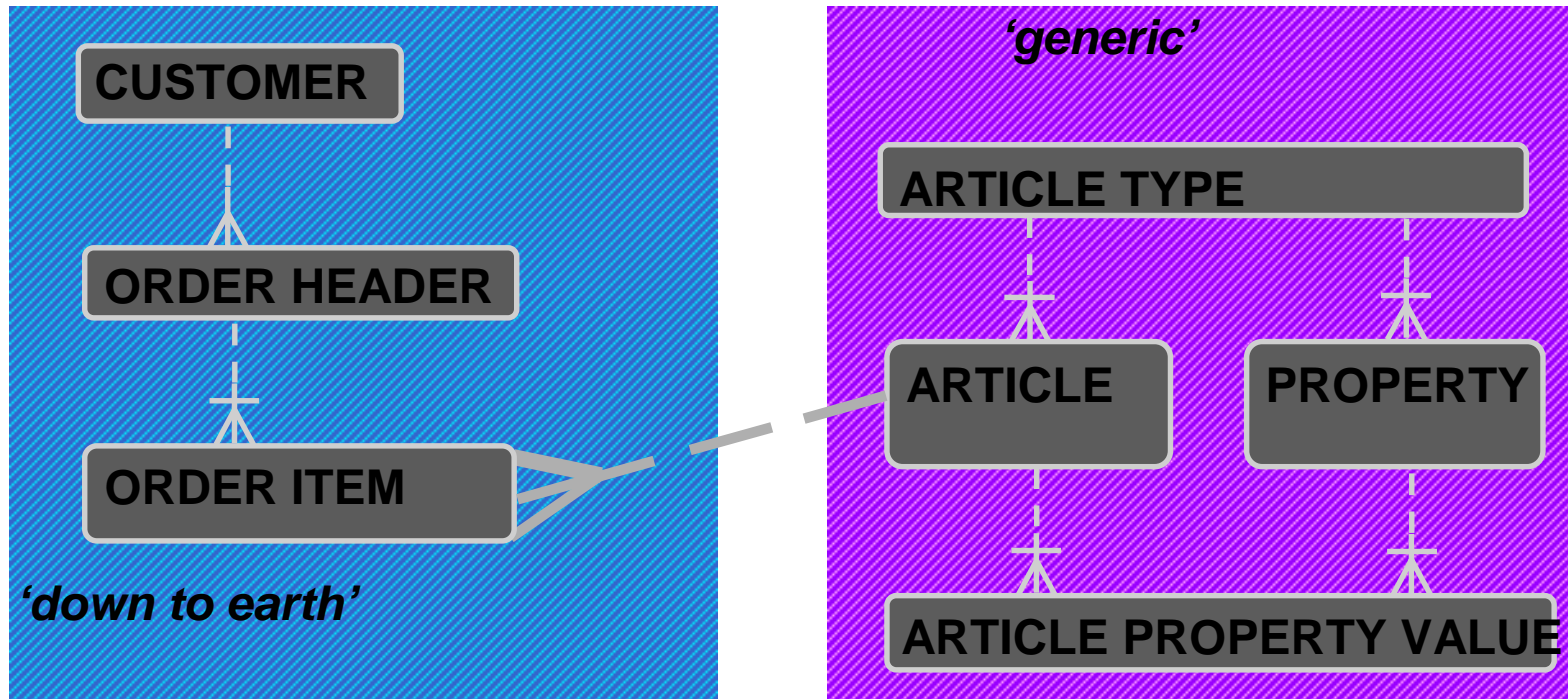
More Generic Plus



Most Generic?



Best of Two Worlds



Summary

Patterns

- **Show similarities**
- **Invent your wheel only once**

Generic models

- **Reduce the number of entities dramatically**
- **Are more complex to implement**
- **Are very flexible**
- **Are usually the best choice in unstable situations**

Practices

- **Patterns**
- **Data Warehouse**
- **Argos and Erats**
- **Synonym**

Practice: Patterns

- **Model of moves in a chess game**
- **Model of tenders (quotations)**
- **Model of recipes**
- **Model of all people involved in college: students, teachers, parents, ...**
- **Rentals in a video shop**
- **Model of phases in a process**

Practice: Data Warehouse

- **What is the sales volume in \$ of coffee last month compared with the coffee sales volume same month last year?**
- **What is the sales volume in \$ of coffee per head in Japan compared with the average coffee sales volume in the Moonlight countries around the world?**
- **What is the growth of the sales volume in \$ of coffee in Sweden compared with the growth of sales volume of all products in the same geographical area? What is the growth in local currency?**

Practice: Data Warehouse

- **What was the total sales volume in \$ of coffee last month, compared with the total coffee sales volume in the same month last year, for the shops that have been open for at least 18 months?**
- **What is the growth of the sales volume in \$ of nonfoods compared to that of foods?**
- **What is the best day of the week for total sales in the various countries? How is that related to the average? Is the best day of the week dependent on the type of location?**

Practice: Data Warehouse

- **What products are most profitable per country? Globally?**
- **Does the service level (#employees per 1000 items sold) have influence on sales?**

Practice: Argos and Erats

"Erats have names that are unique. Erats can have argos. Argos have names as well. The name of an argo must be unique within the erat it belongs to. Erats mutually have rondels. There are only a few different types of rondels. Erats can have one or more ubins. A ubin always consists of one or more argos of the erat, one or more rondels of the erat, or combinations of the two."

Practice: Synonym

practice - exercise

order - command

entity - being

order - sequence

order - arrangement

command - demand



Mapping the Entity Model

Overview

- **Why use design modeling?**
- **Introduction to the components:**
 - **Tables**
 - **Columns**
 - **Constraints**
- **Basic Mapping**
- **Complex mapping**

Why Create a Data Design Model?

- **Closer to the implementation solution**
- **Facilitates discussion**
- **Ideal model can be adapted to an RDBMS model**
- **Sound basis for physical database design**

Presenting Tables

Table: EMPLOYEES

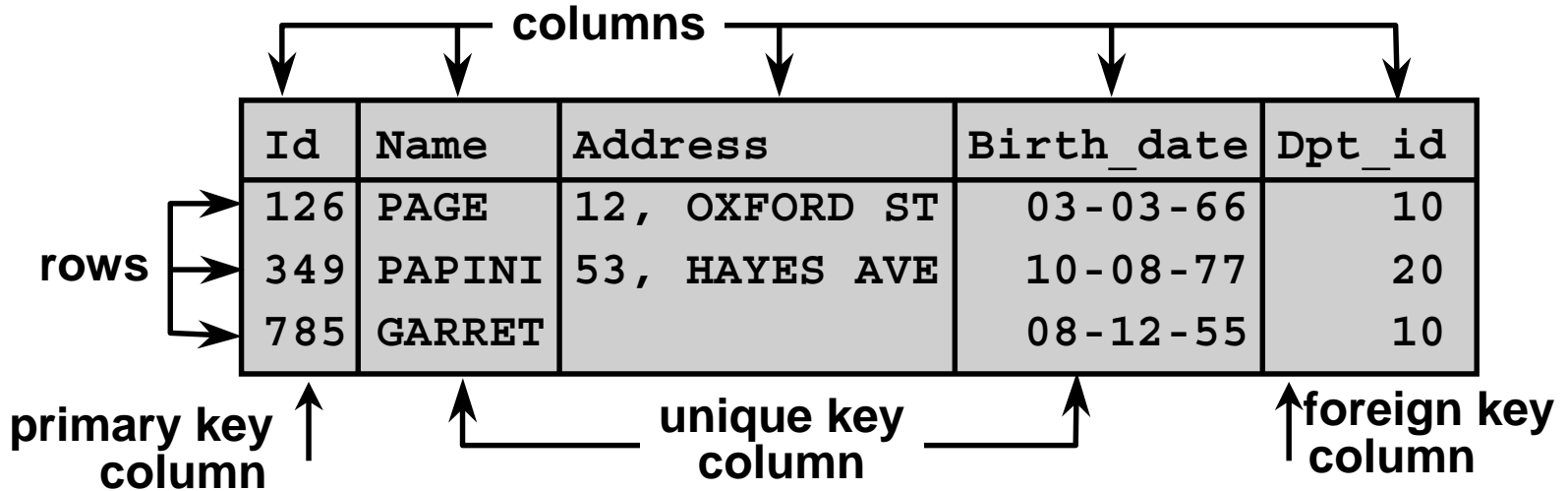
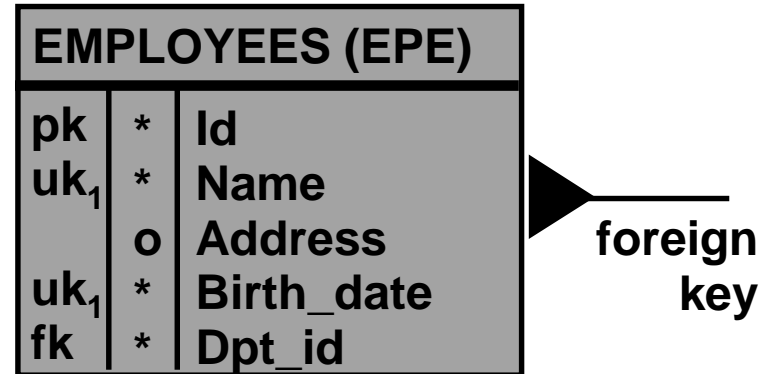
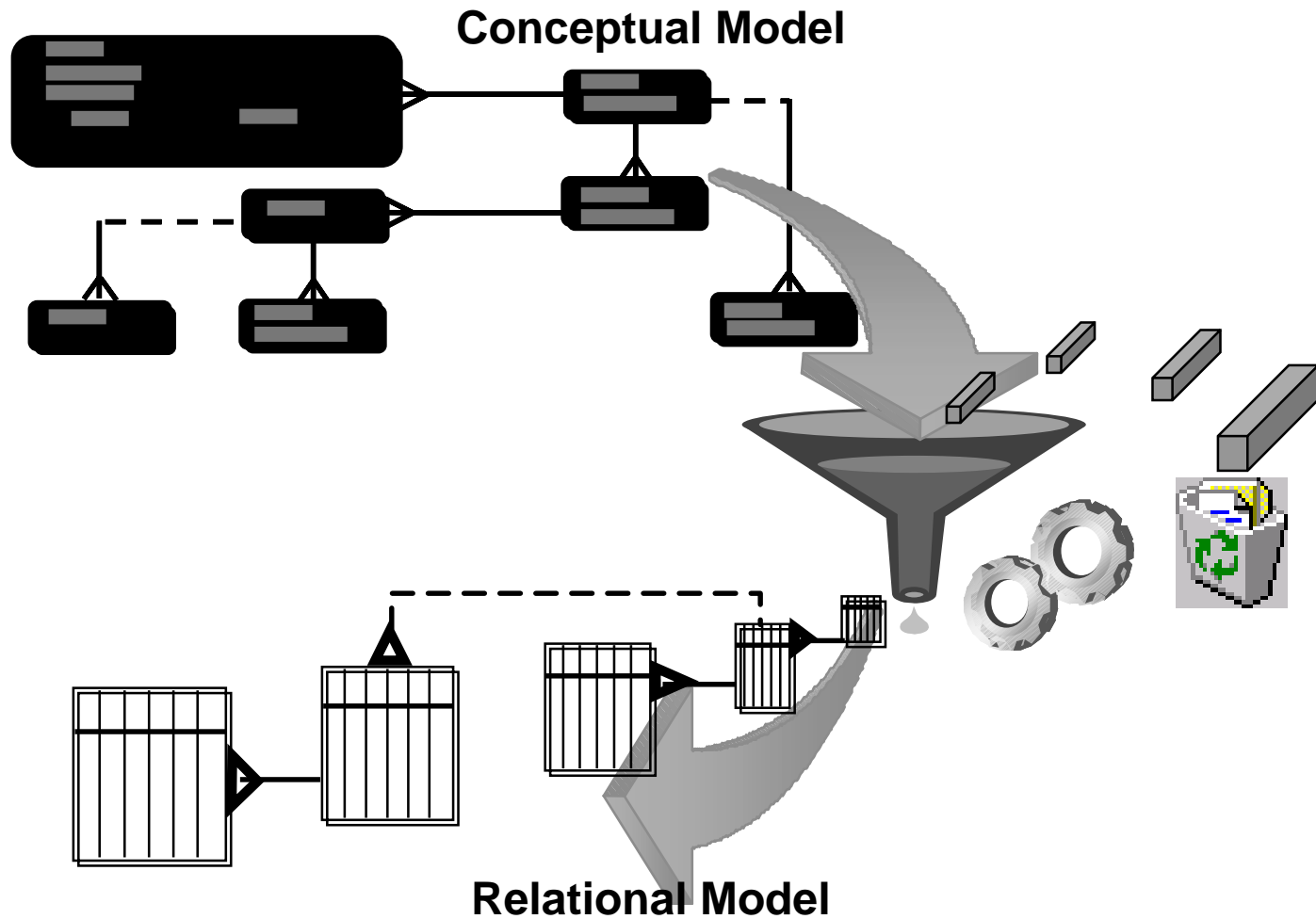


Table diagram: EMPLOYEES



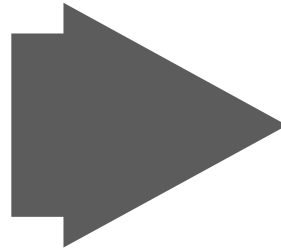
Transformation Process



Terminology Mapping

ANALYSIS

ER Model



DESIGN

Physical Design

Entity



Table

Attribute



Column

Primary UID



Primary Key

Secondary UID



Unique Key

Relationship



Foreign Key

Business Constraints



Check Constraints

General Naming Topics

Decide on a convention for:

- **Table names**
- **Special characters (% , * , # , - , space , ...)**
- **Table short names**
- **Column names**
- **Primary and Unique Key Constraint names**
- **Foreign Key Constraint names**
- **Foreign Key Column names**

Naming Restrictions with Oracle

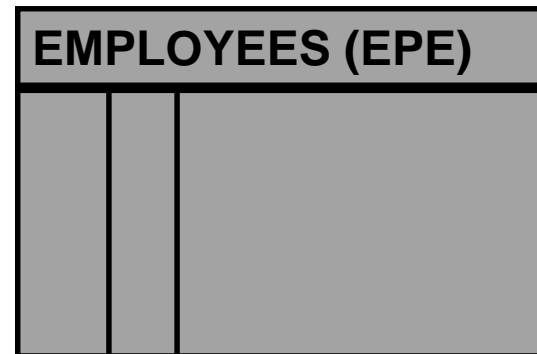
- **Table and column names:**
 - **Must start with a letter**
 - **May contain up to 30 alphanumeric characters**
 - **Cannot contain space or some special characters such as “!”**
- **Table names must be unique within a schema**
- **Column names must be unique within a table**

Basic Mapping for Entities

1 - Entities

Table Name: EMPLOYEES

Short Name: EPE



Basic Mapping for Attributes

1 - Entities

2 - Attributes

Table Name: EMPLOYEES

Short Name: EPE



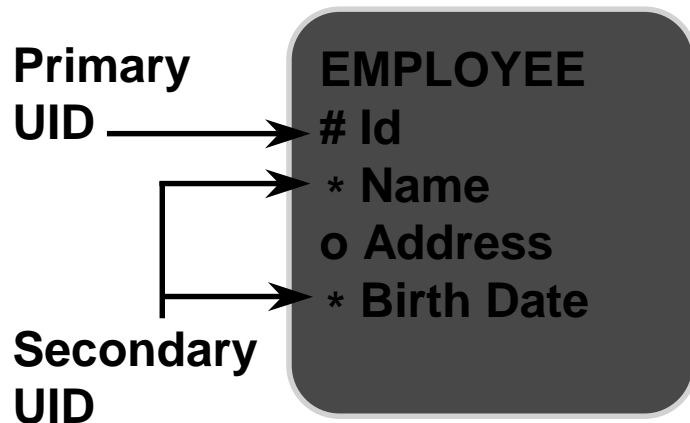
EMPLOYEES (EPE)		
	*	Id
	*	Name
	o	Address
	*	Birth_date

Basic Mapping for Unique Identifiers

- 1 - Entities
- 2 - Attributes
- 3 - Unique identifiers

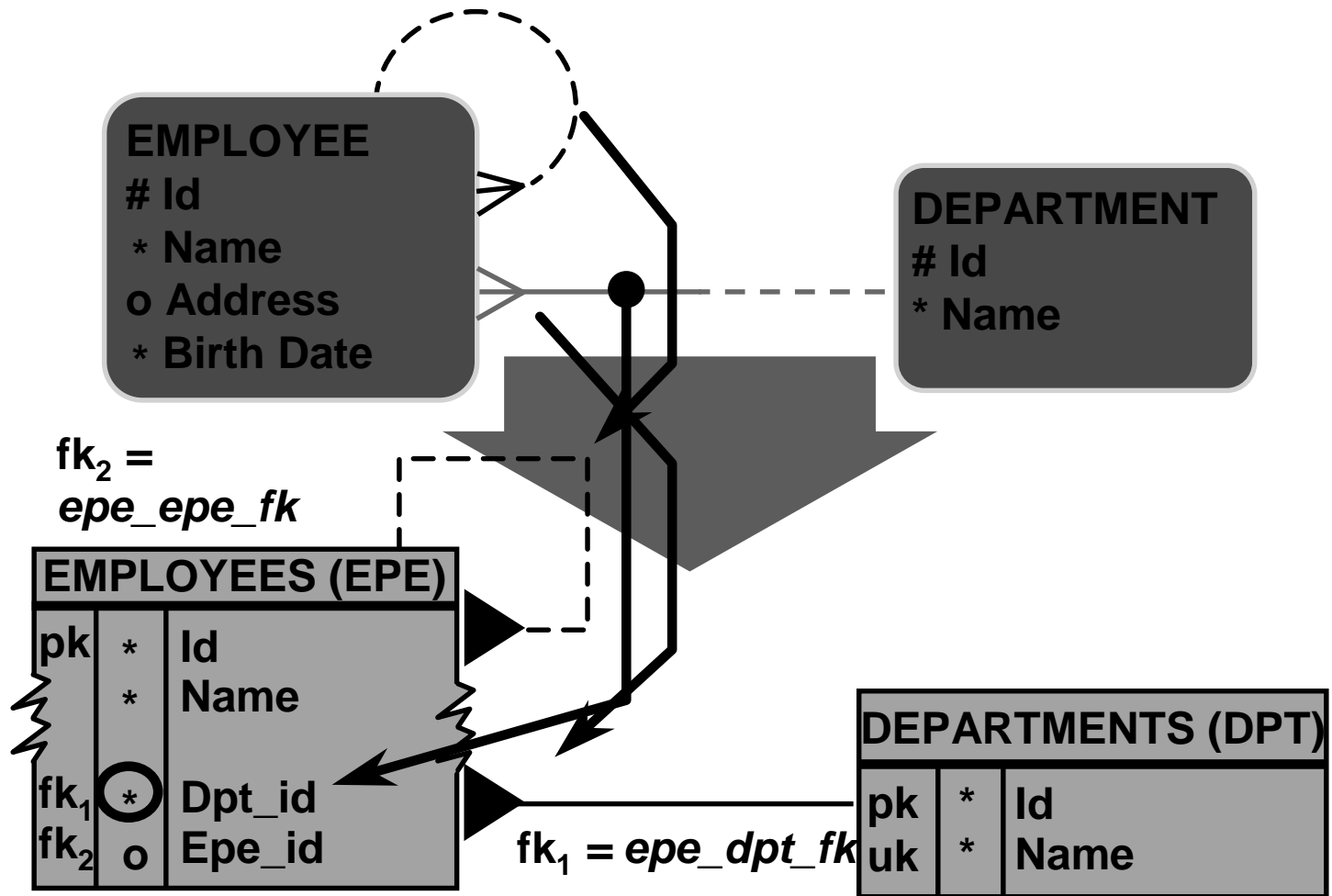
Table Name: EMPLOYEES

Short Name: EPE

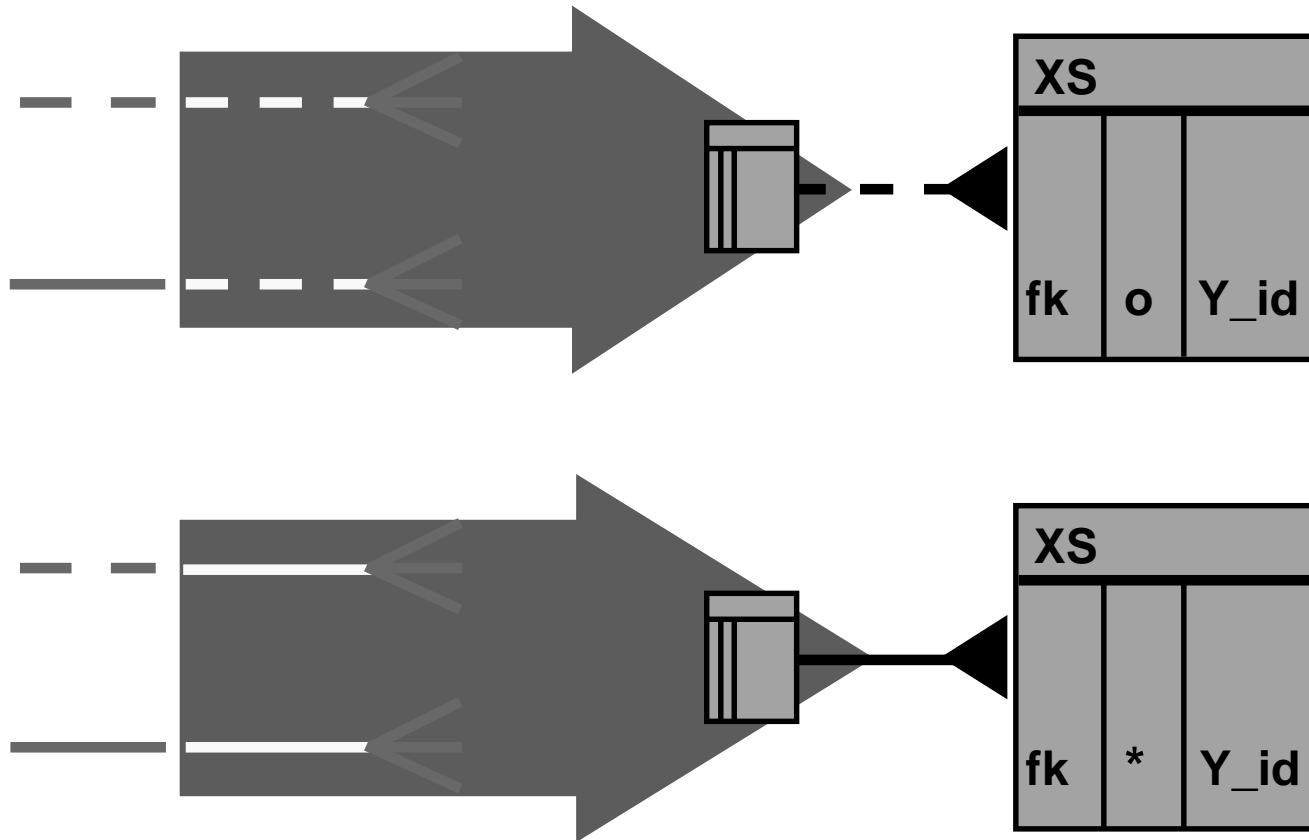


EMPLOYEES (EPE)		
pk	*	Id
uk ₁	*	Name
	o	Address
uk ₁	*	Birth_date

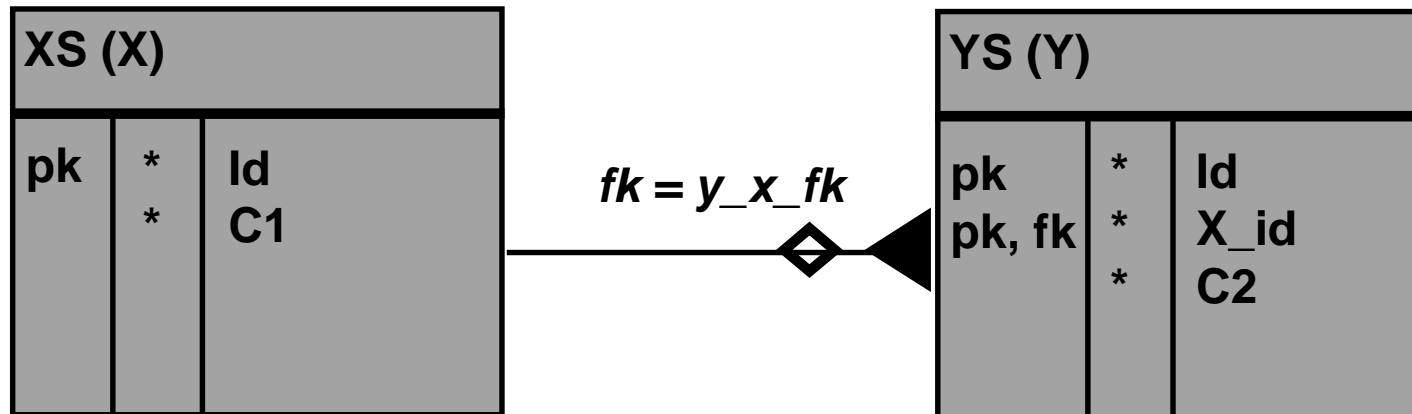
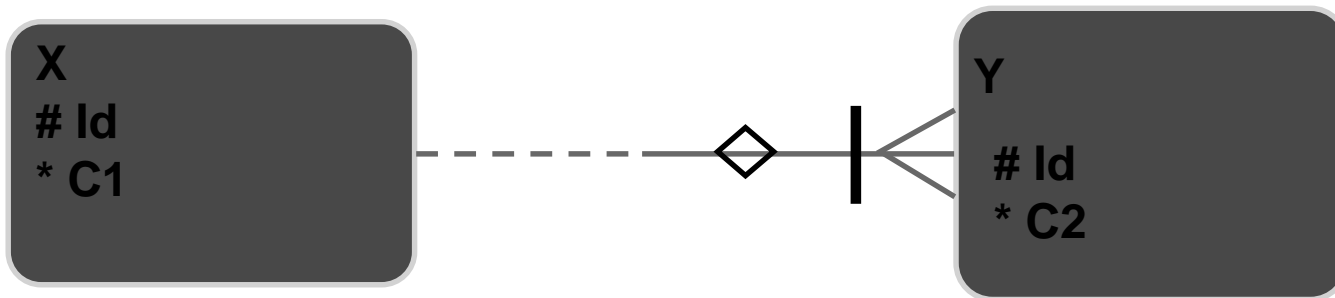
Rules for Relationships



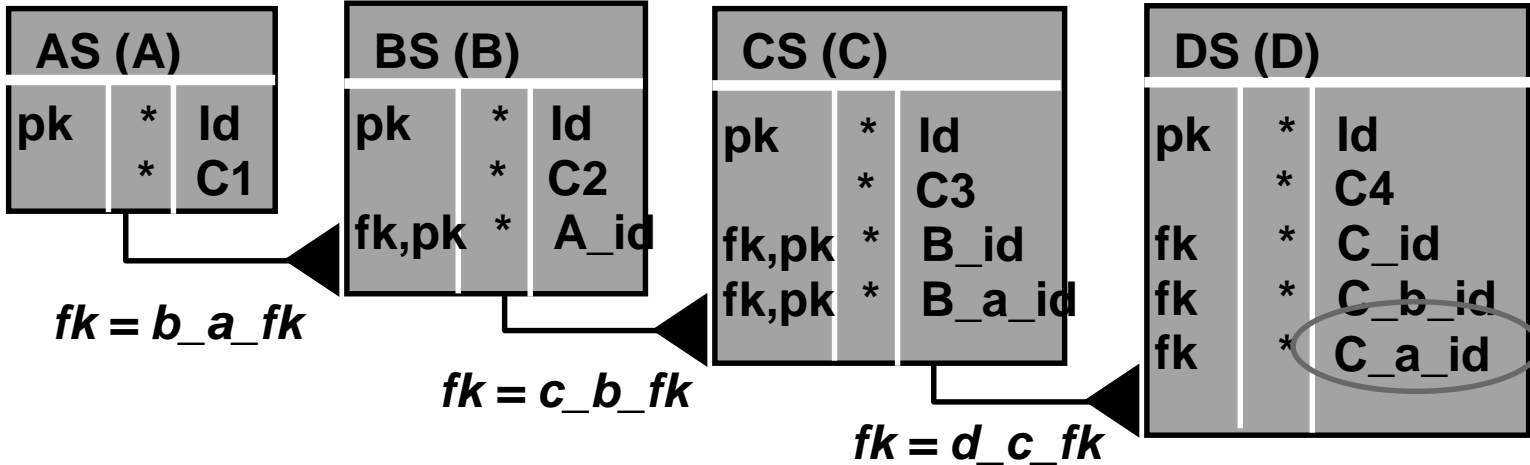
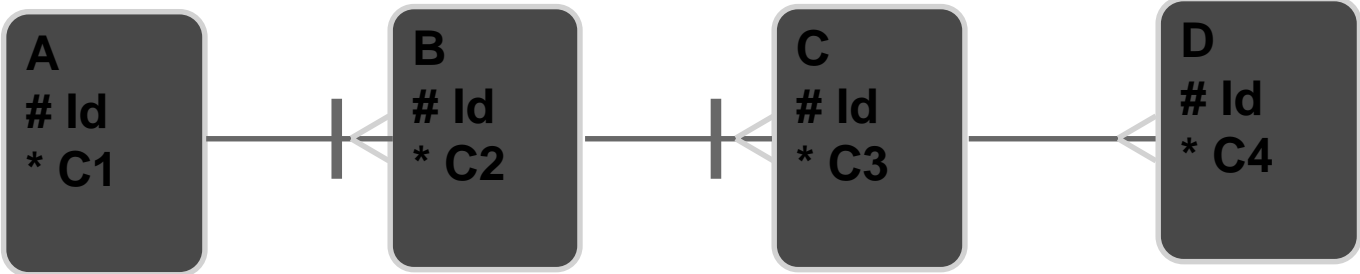
Mapping 1:m Relationships



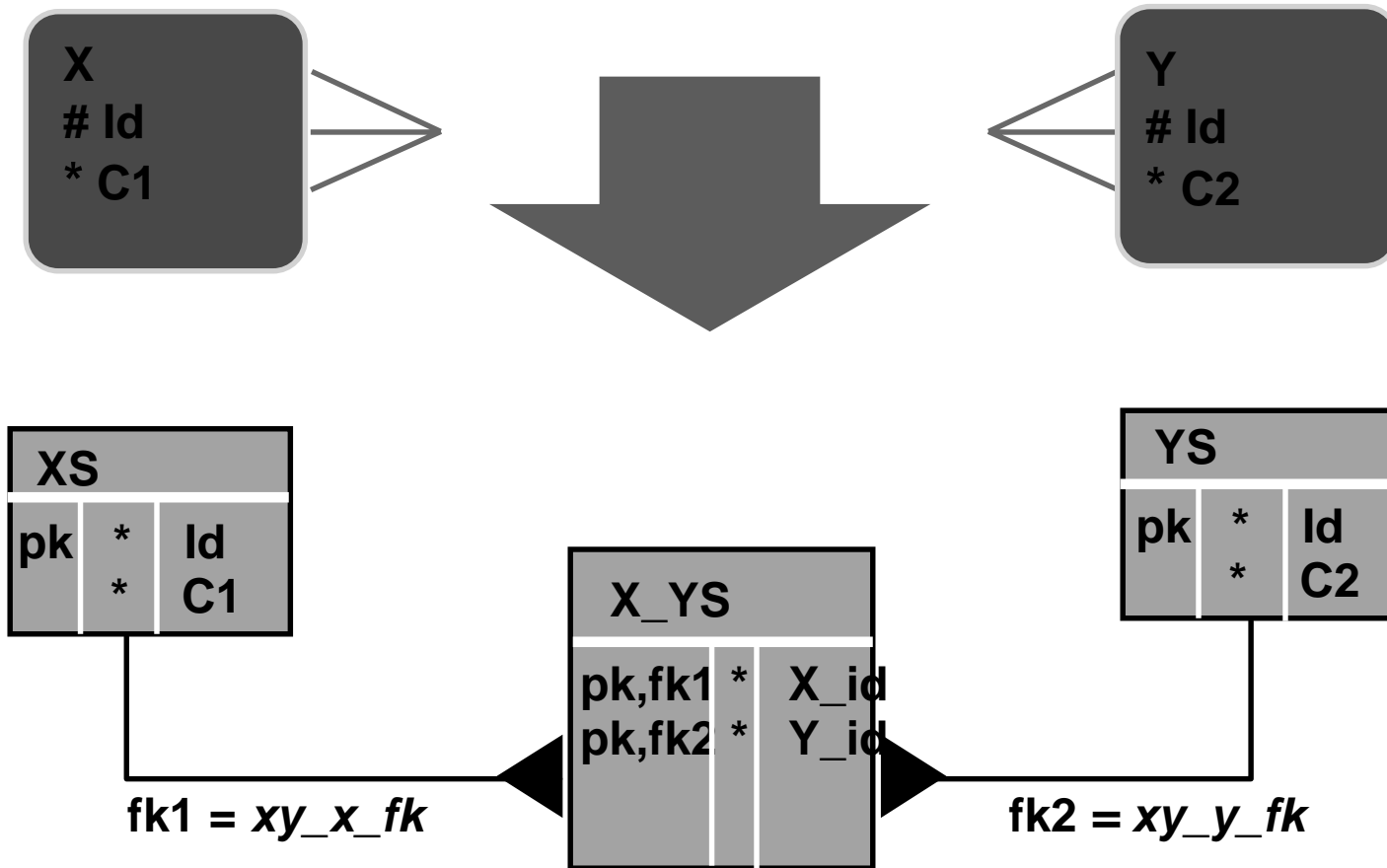
Mapping Barred and Nontransferable Relationships



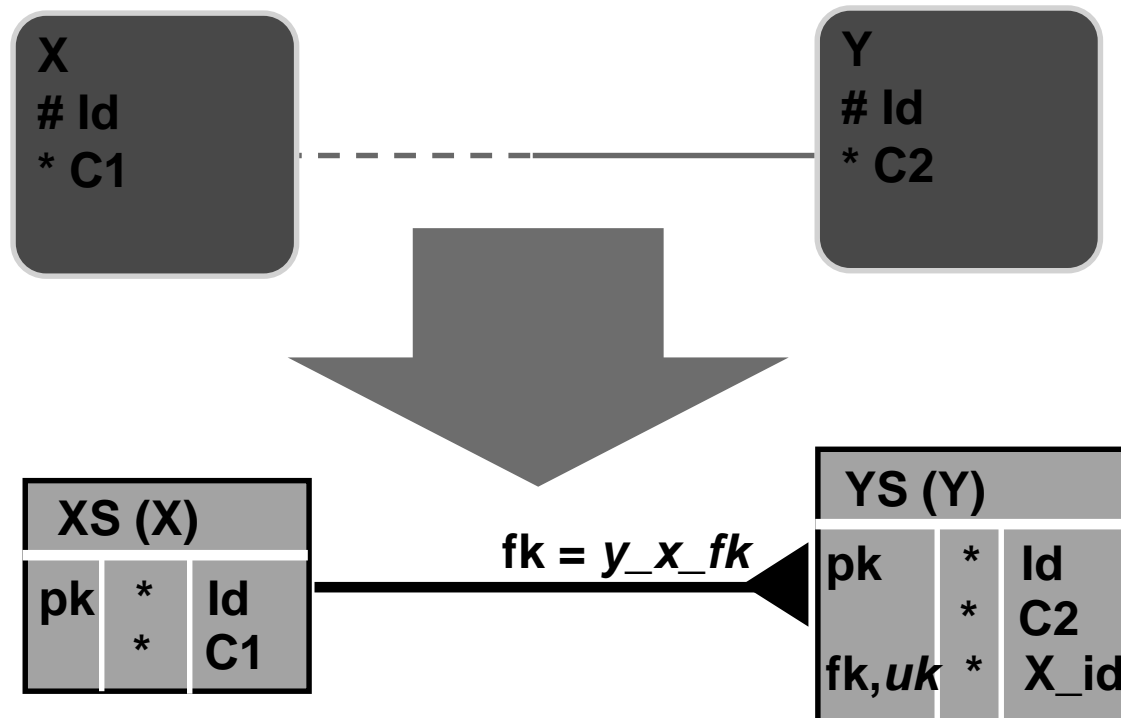
Mapping Cascade Barred Relationships



Mapping m:m Relationships



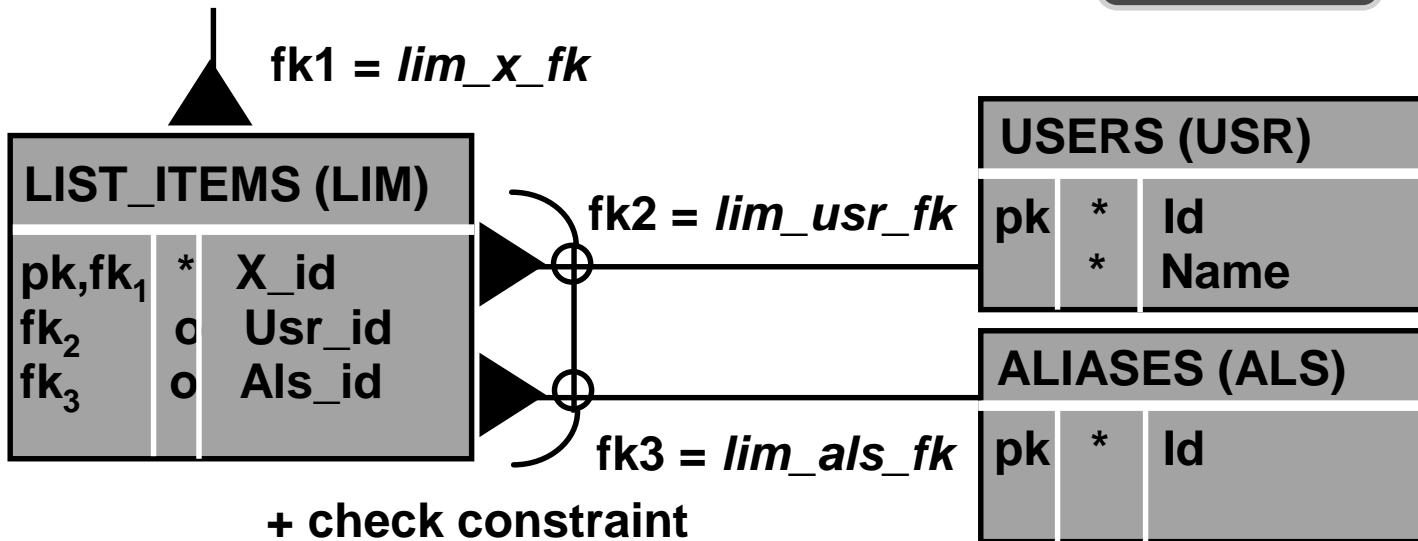
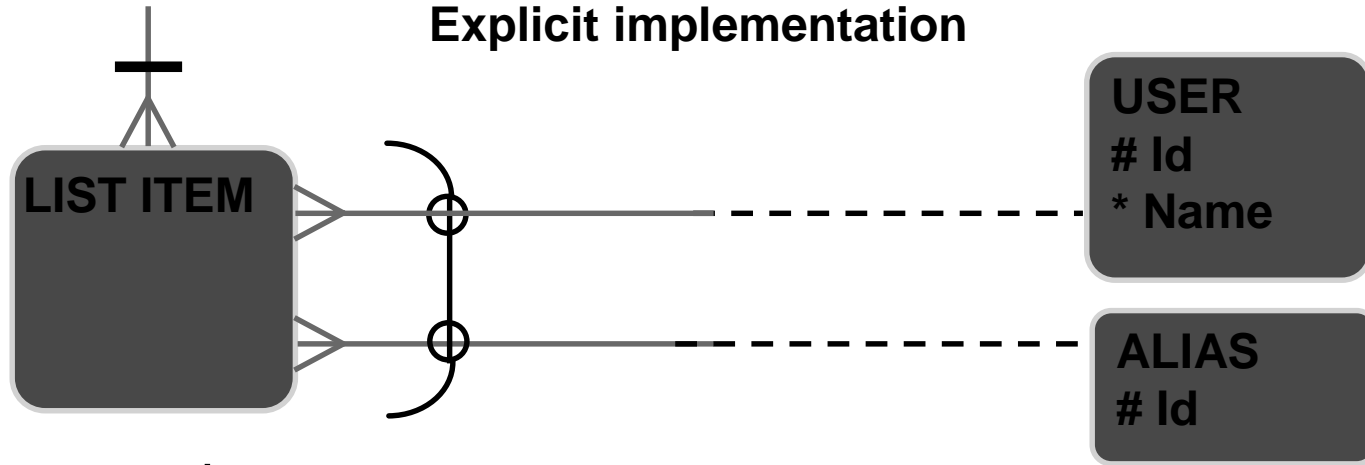
Mapping 1:1 Relationships



Choose which side for FK for other cardinalities

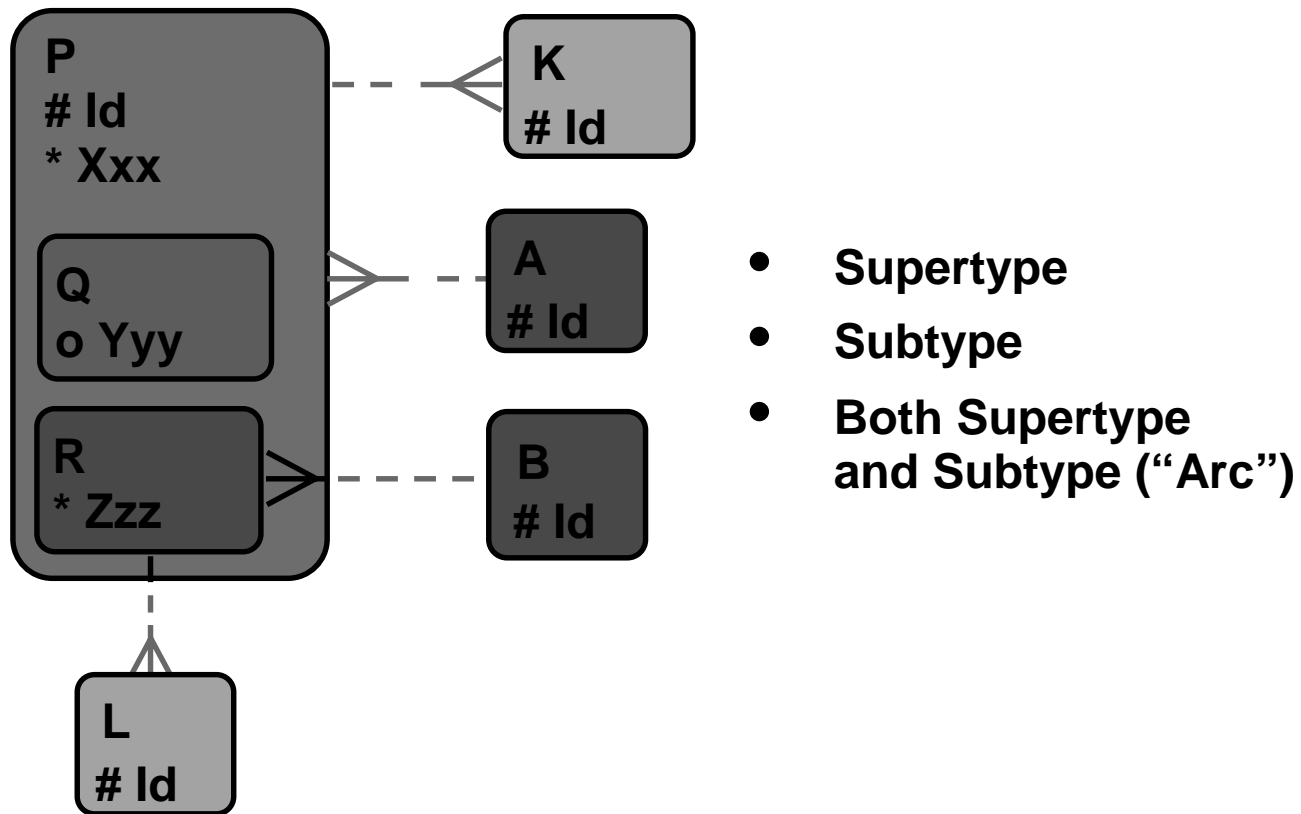
Mapping Arcs

Explicit implementation

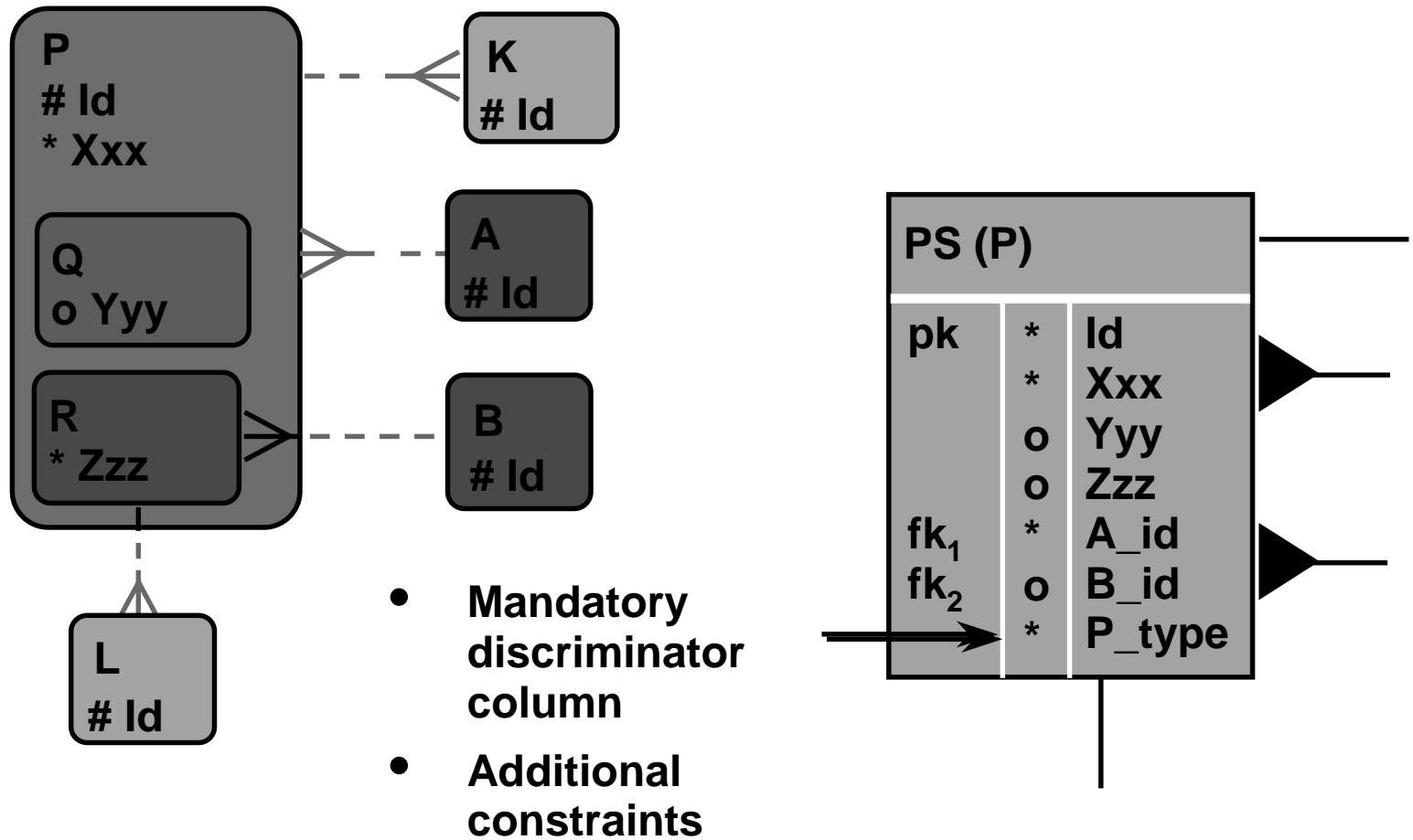


Mapping Subtypes

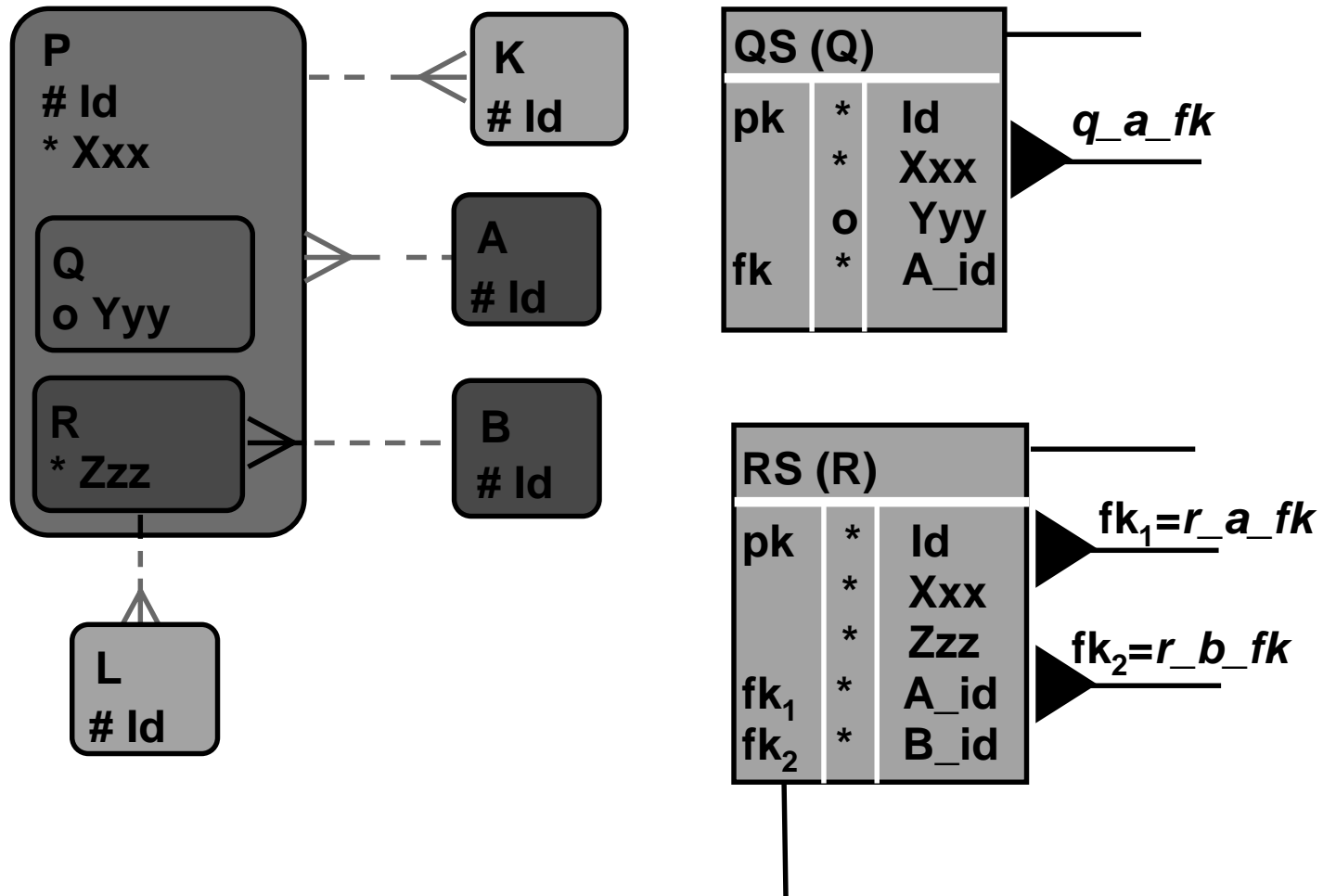
Variety of implementation choices



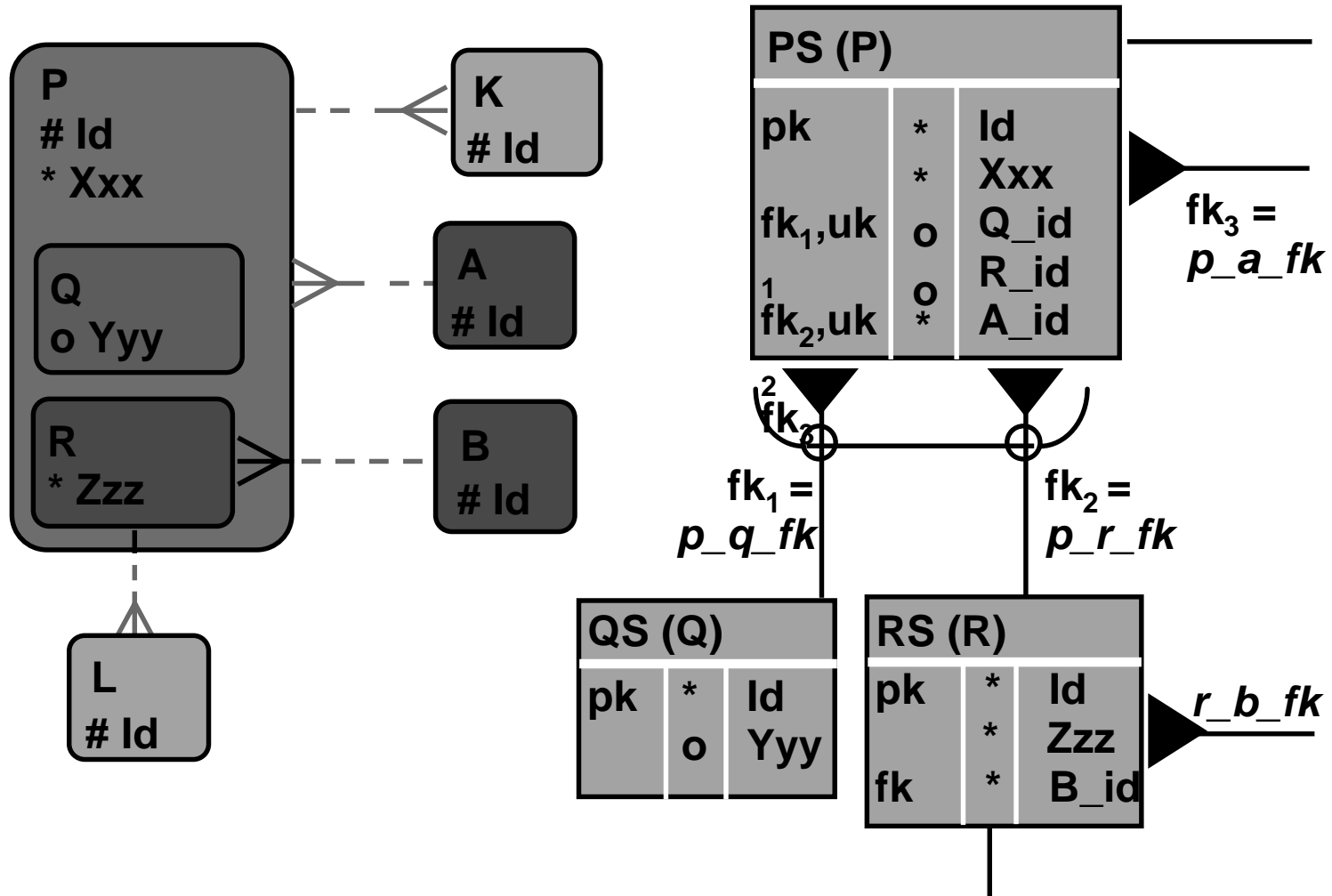
Supertype Implementation



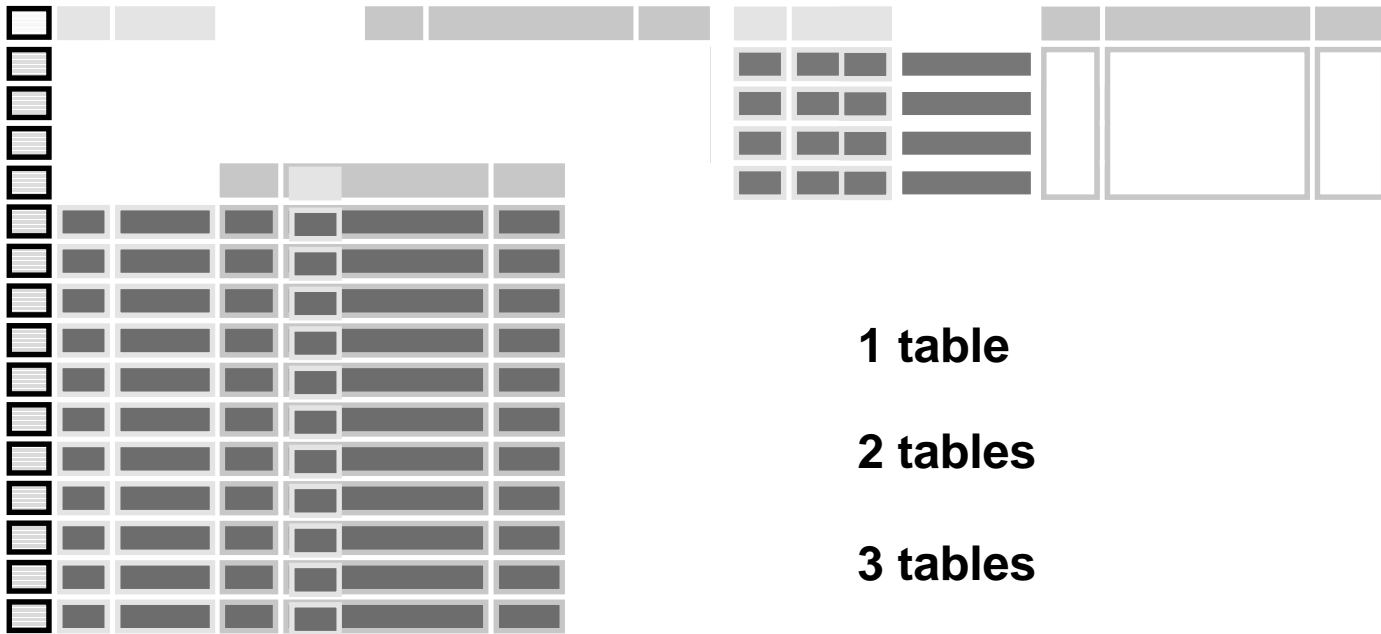
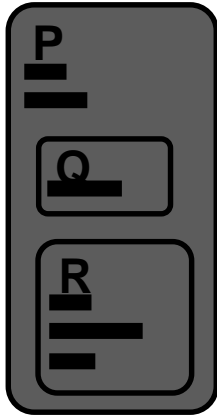
Subtype Implementation



Supertype and Subtype (Arc) Implementation



Storage Implication



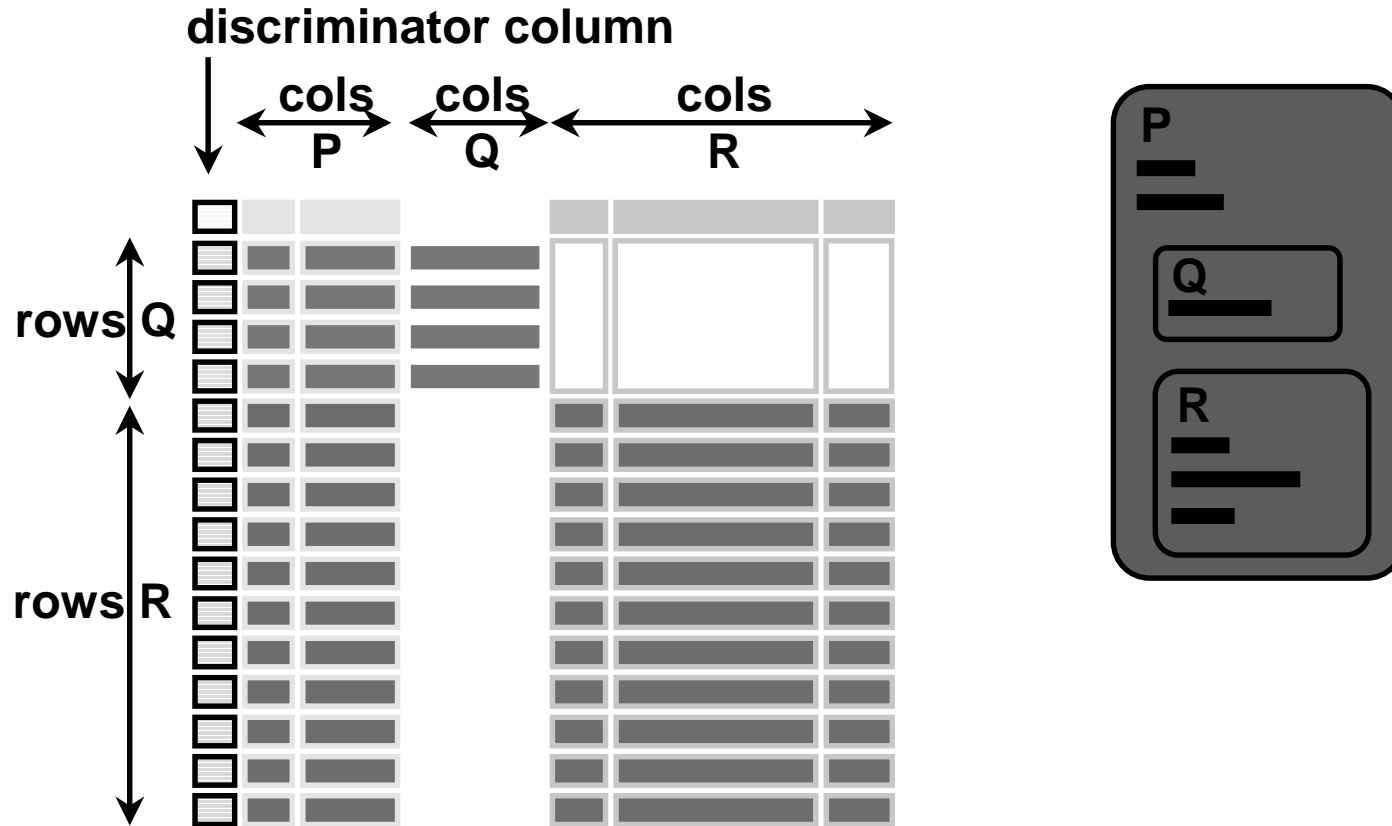
1 table

2 tables

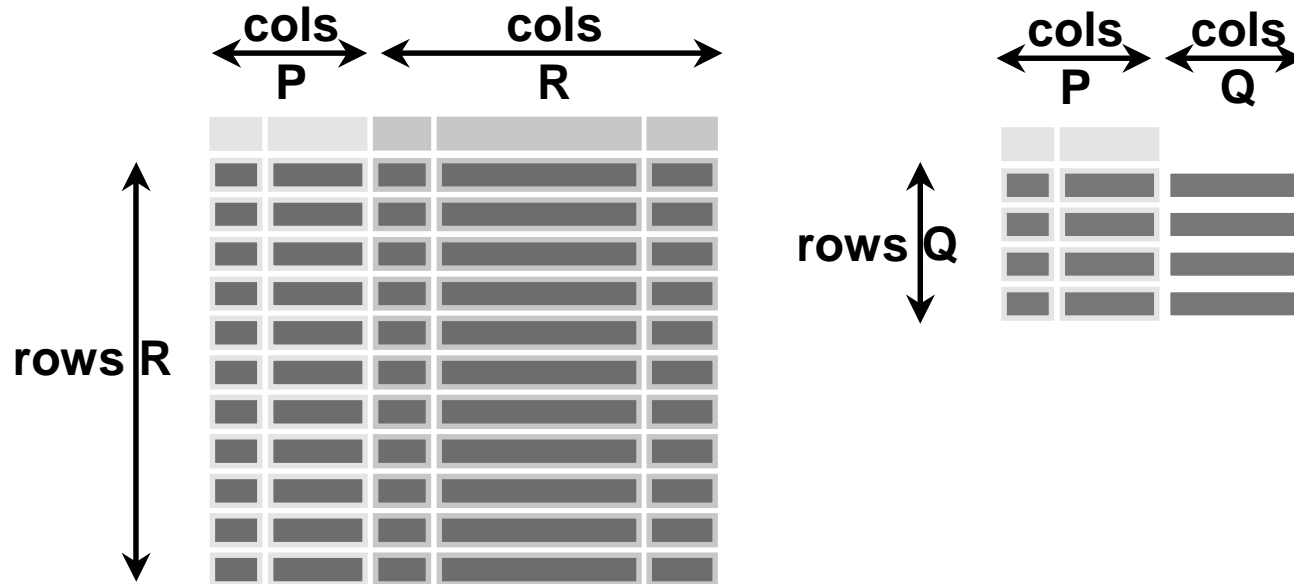
3 tables

Storage Implication

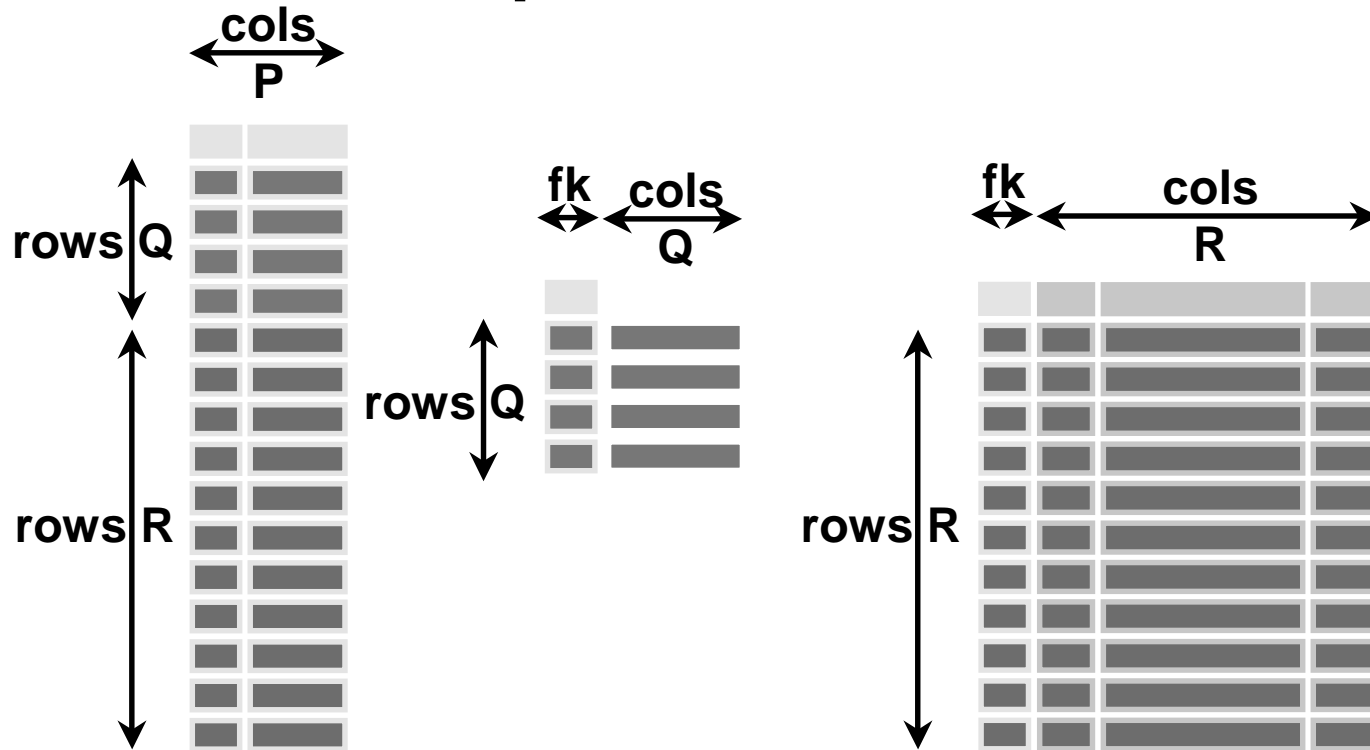
Supertype Implementation



Storage Implication Subtype Implementation



Storage Implication Supertype and Subtype (Arc) Implementation



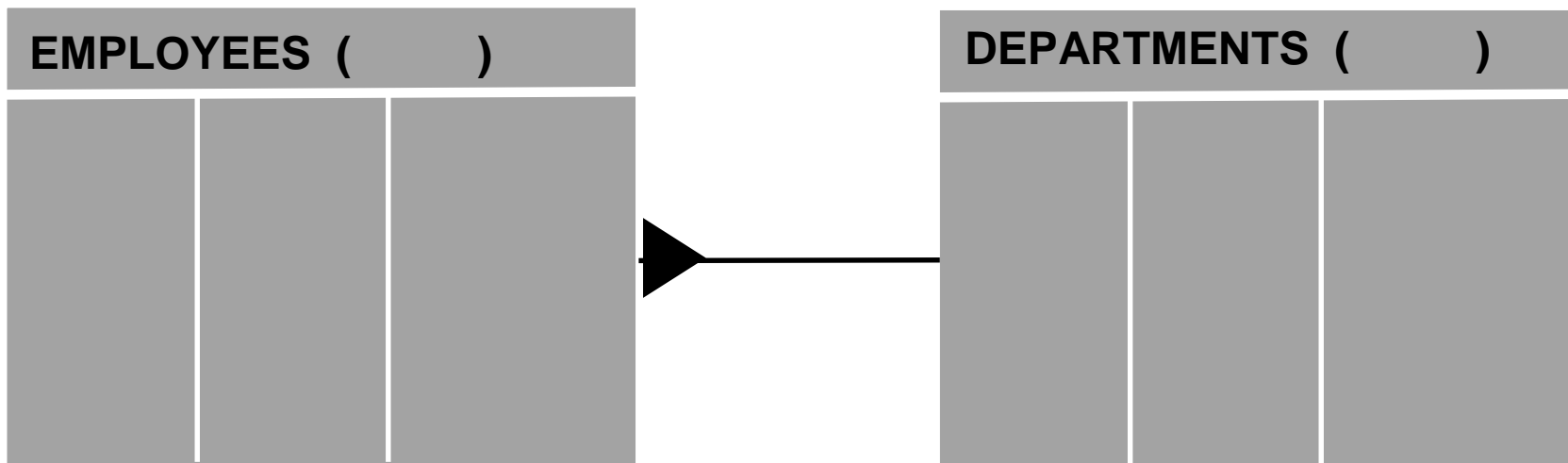
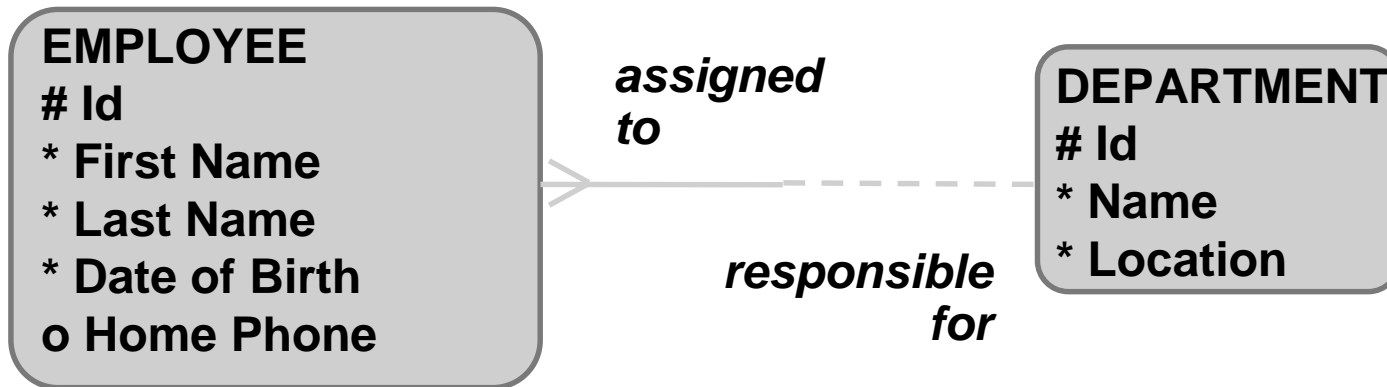
Summary

- **Relational concepts**
- **Naming rules convention**
- **Basic mapping**
- **Complex mapping**

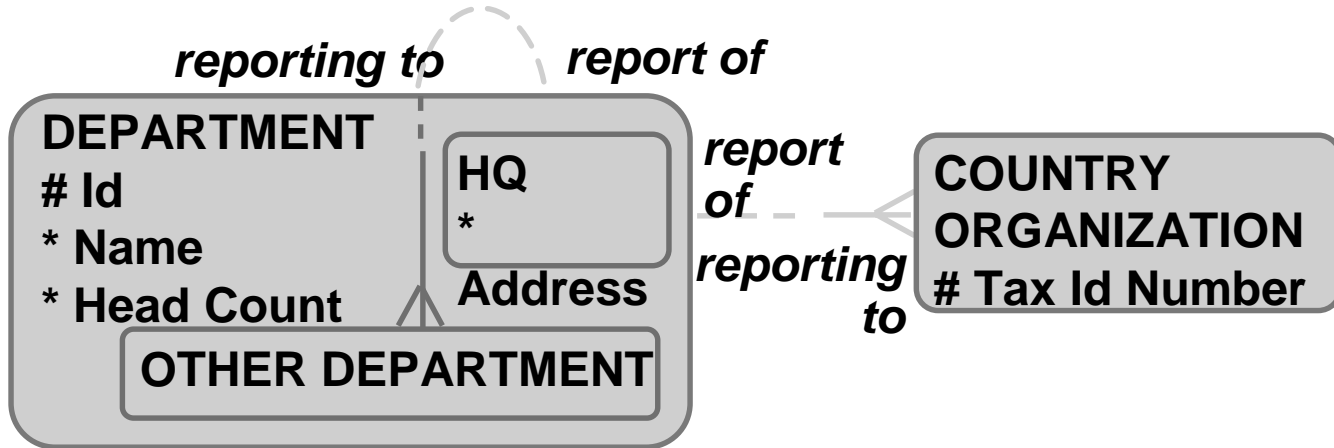
Practice

- **Mapping basic Entities, Attributes and Relationships**
- **Mapping Supertype**
- **Quality Check
Subtype Implementation**
- **Quality Check
Supertype and Subtype (Arc) Implementation**
- **Mapping Primary Keys and Columns**

Practice: Mapping basic Entities, Attributes and Relationships

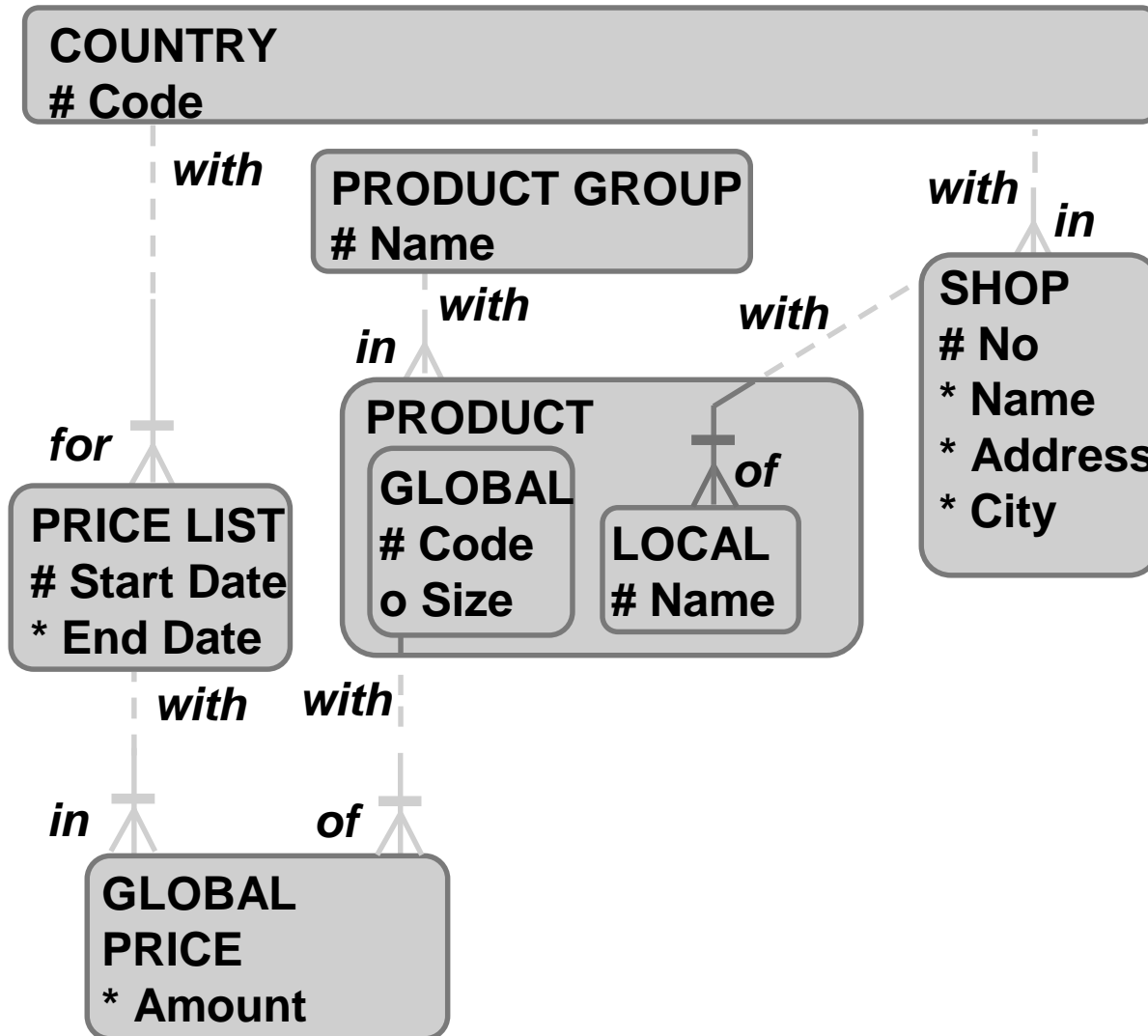


Practice: Mapping Supertype

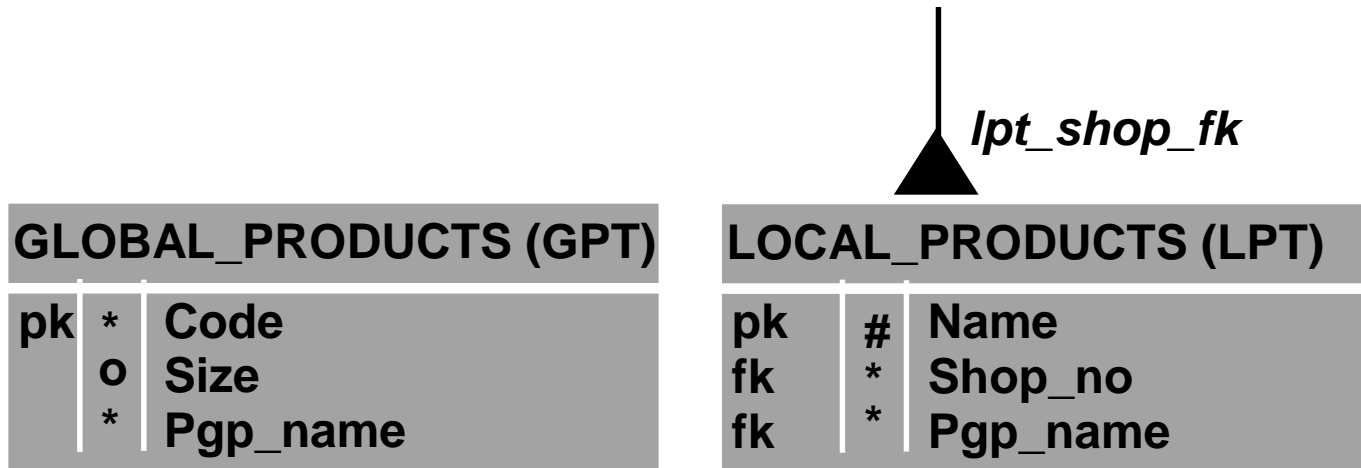


DEPARTMENTS ()		

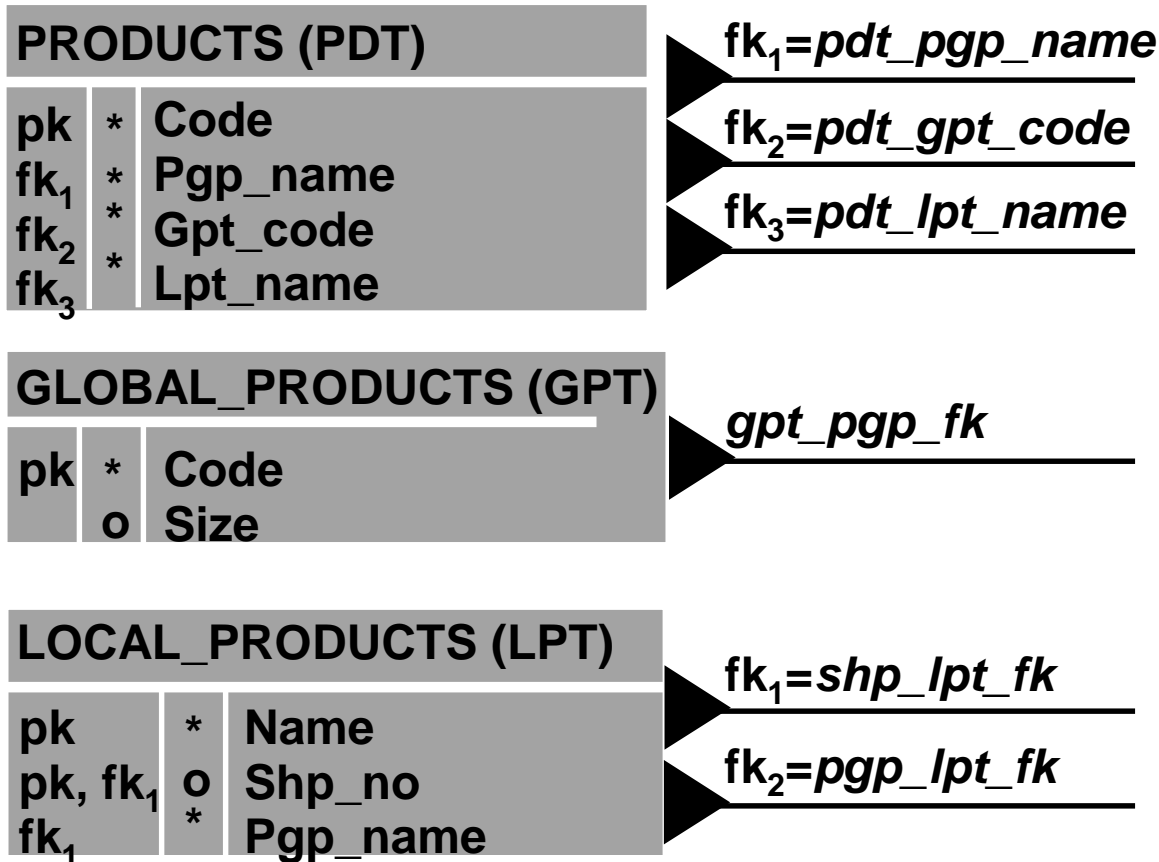
Partial ER model Moonlight



Practice: Quality Check Subtype Implementation



Practice: Quality Check Arc Implementation



Practice: Mapping Primary Keys and Columns

GLOBAL_PRICES ()		

8

Denormalized Data

Overview

- **Denormalization**
- **Benefits**
- **Types of denormalization**

Denormalization Overview

Denormalization

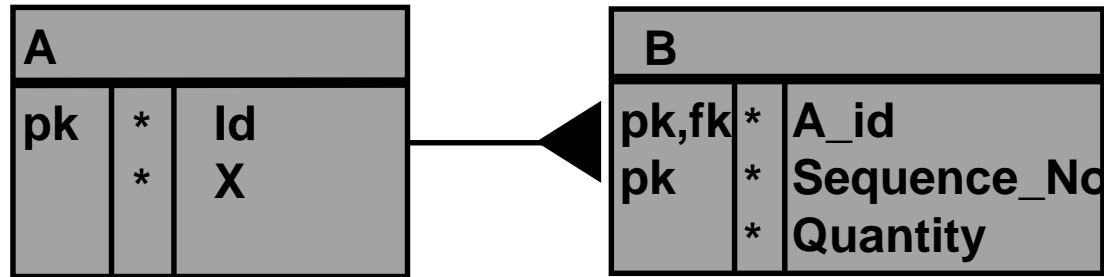
- **Starts with a “normalized” model**
- **Adds “redundancy” to the design**
- **Reduces the “integrity” of the design**
- **Application code added to compensate**

Denormalization Techniques

- **Storing Derivable Values**
- **Pre-joining Tables**
- **Hard-Coded Values**
- **Keeping Details with Master**
- **Repeating Single Detail with Master**
- **Short-Circuit Keys**

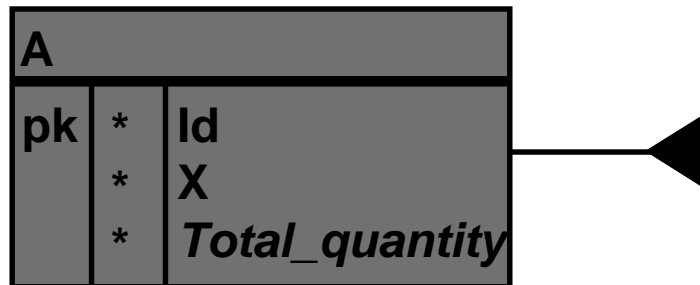
Storing Derivable Values

Before



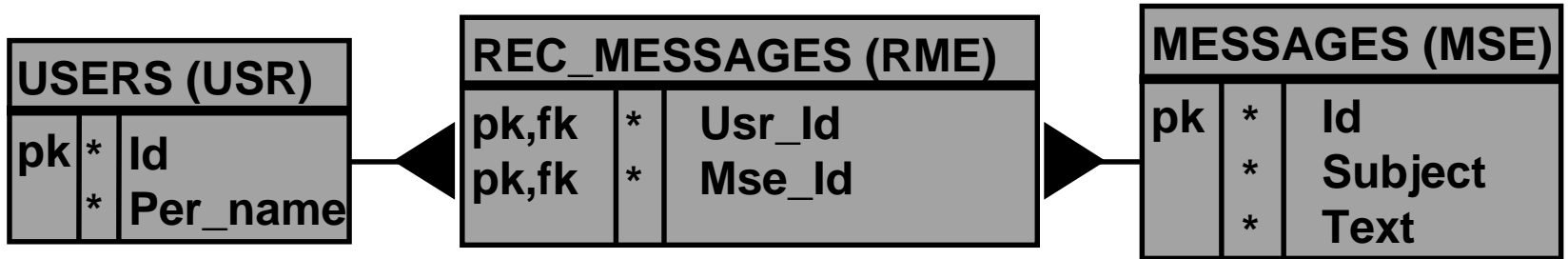
Add a column to store derivable data in the “referenced” end of the foreign key.

After

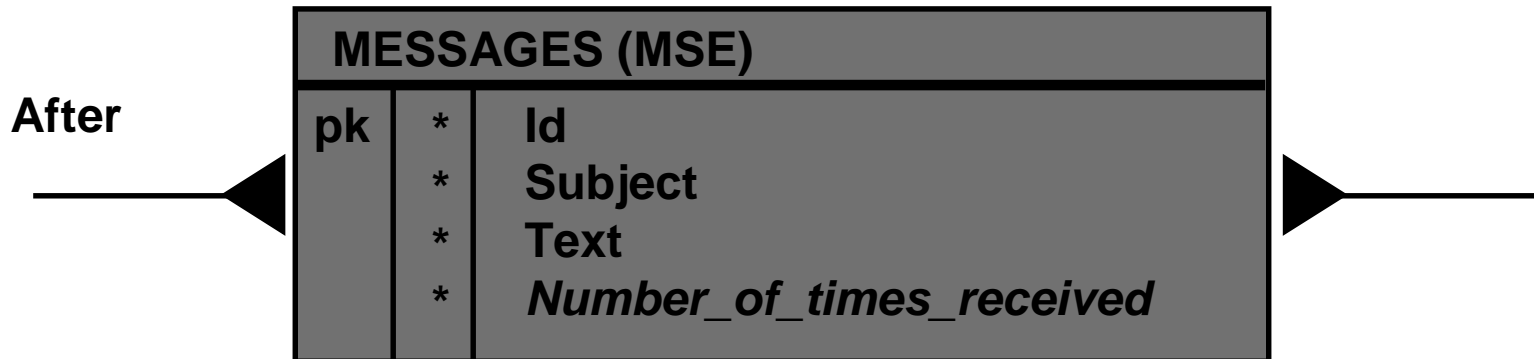


EMail Example of Storing Derivable Values

Before

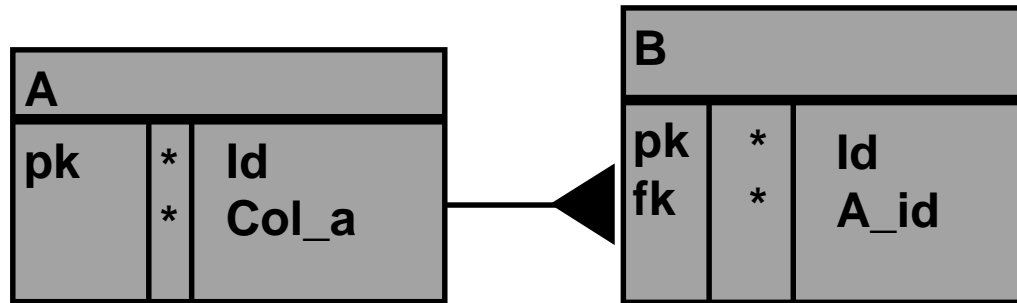


Store derivable column in the 'referenced' end of the foreign key.



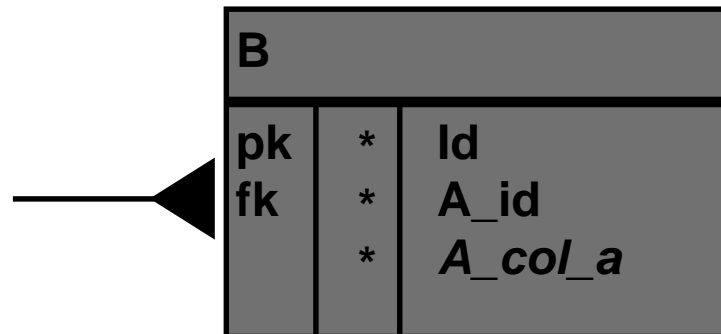
Pre-Joining Tables

Before



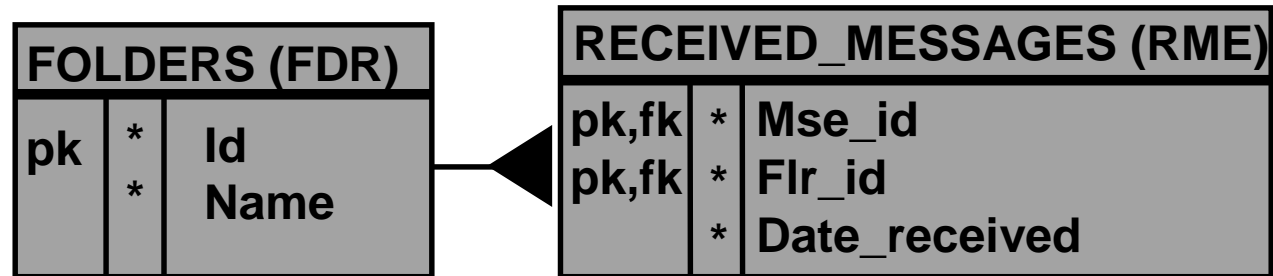
Add the non_key column to the table with the foreign key.

After



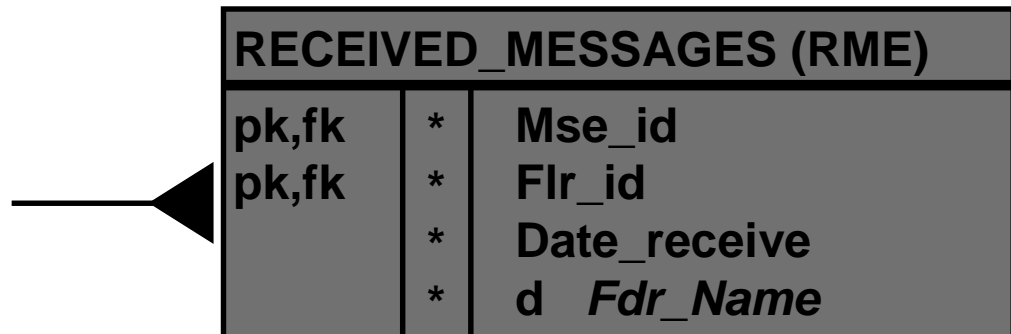
Email Example of Pre-Joining Tables

Before



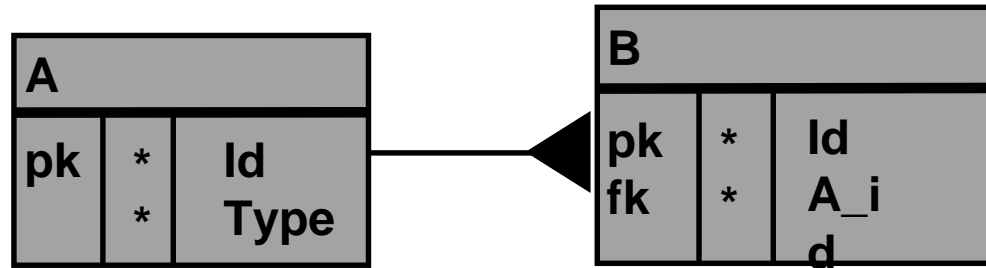
Create a table with all the frequently queried columns.

After



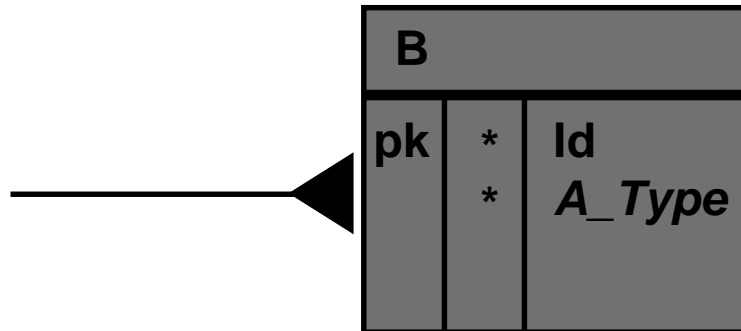
Hard-Coded Values

Before



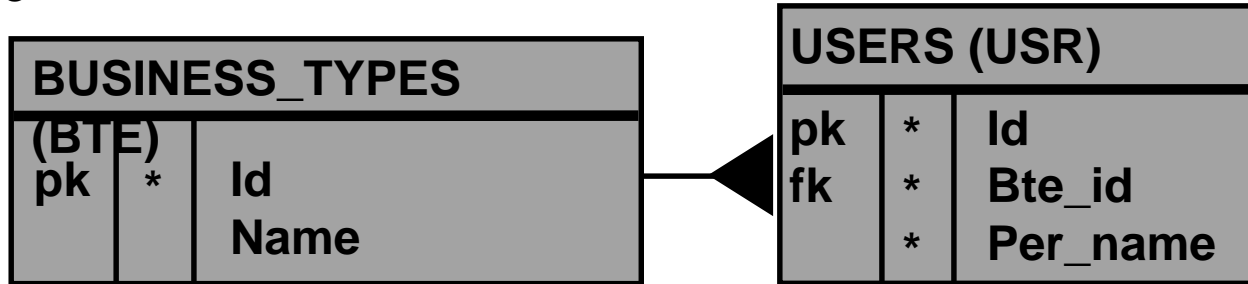
Remove the foreign key and hard code the allowable values and validation in the application.

After



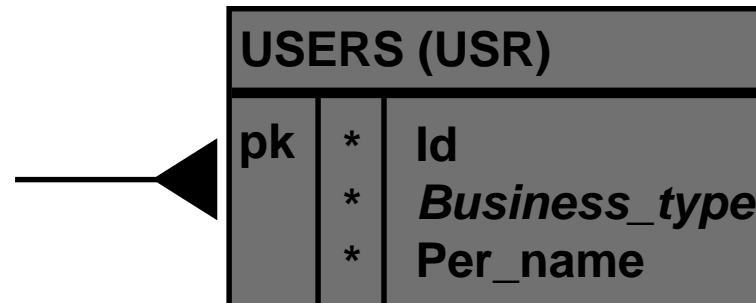
Email Example of Hard-Coded Values

Before



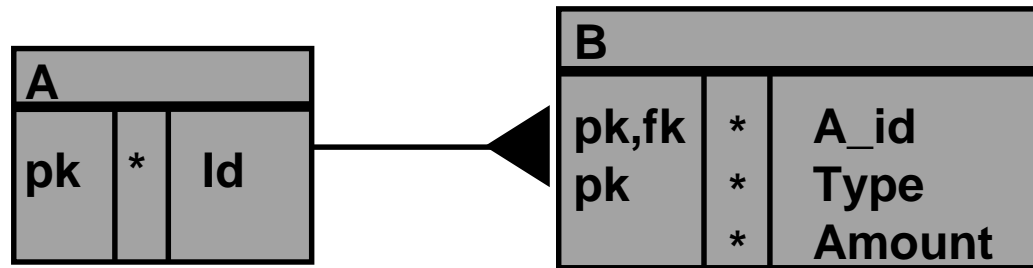
Hard code the allowable values and validation in the application.

After



Keeping Details with Master

Before



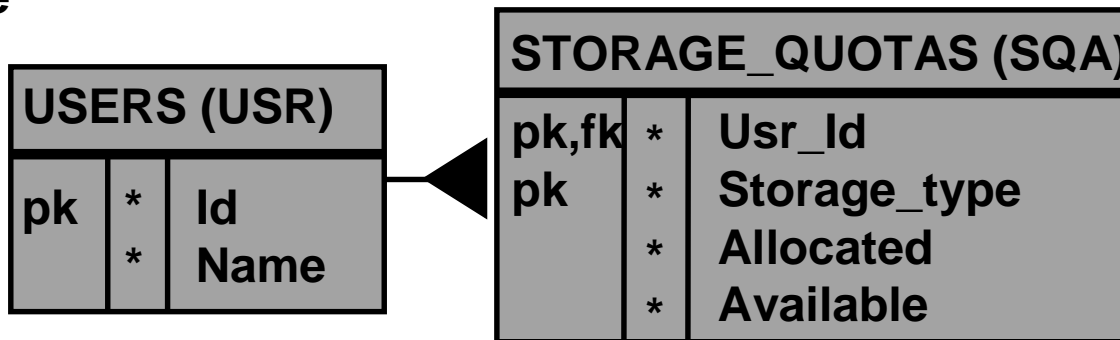
Add the repeating detail columns to the master table.

After

A		
pk	*	Id
	*	<i>Amount_1</i>
	*	<i>Amount_2</i>
	*	<i>Amount_3</i>
	*	<i>Amount_4</i>
	*	<i>Amount_5</i>
	*	<i>Amount_6</i>

Email Example Keeping Detail with Master

Before



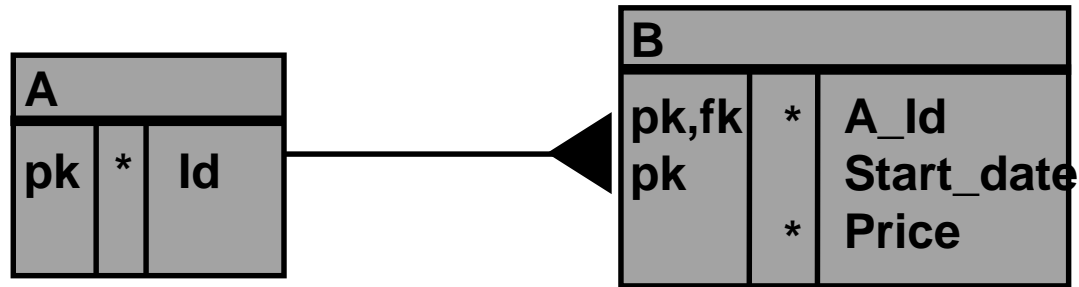
Add the repeating detail columns to the master table.

After

USERS (USR)		
pk	*	Id
	*	Name
	*	<i>Message_Quota_Allocated</i>
	*	<i>Message_Quota_Available</i>
	*	<i>File_Quota_Allocated</i>
	*	<i>File_Quota_Available</i>

Repeating Current Detail with Master

Before



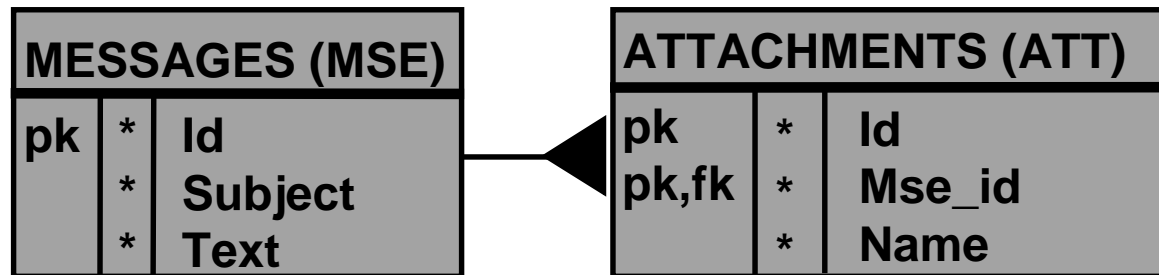
Add a column to the master to store the most current details.*

After



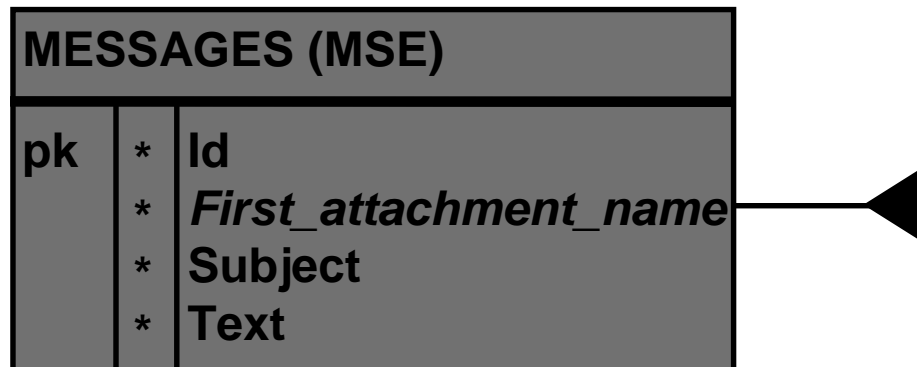
Email Example of Repeating Single Detail with Master

Before



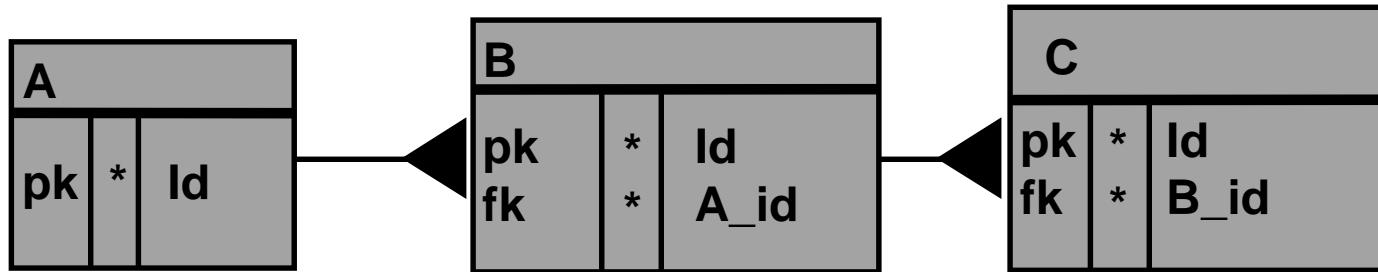
Add a column to the master to store the most current details.

After



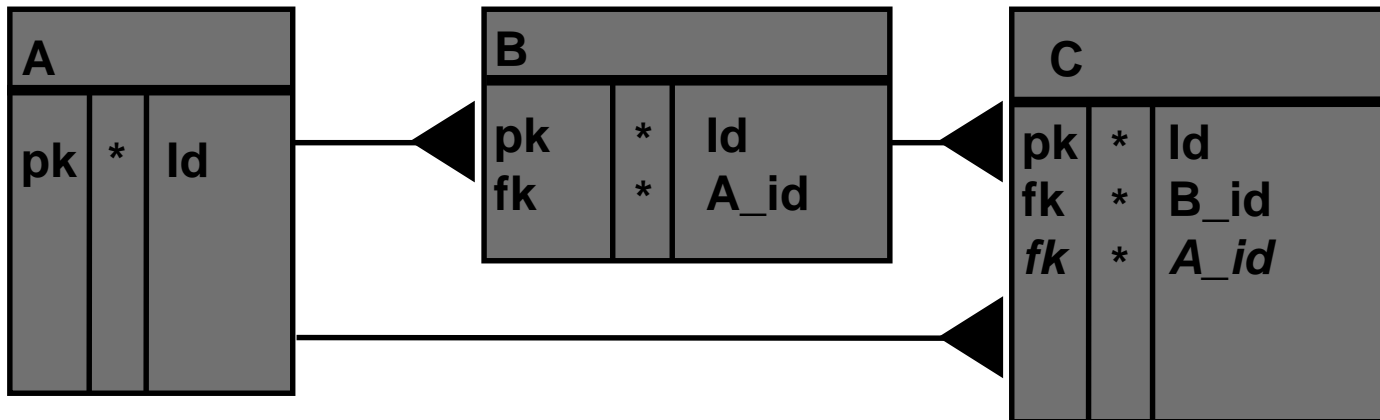
Short-Circuit Keys

Before



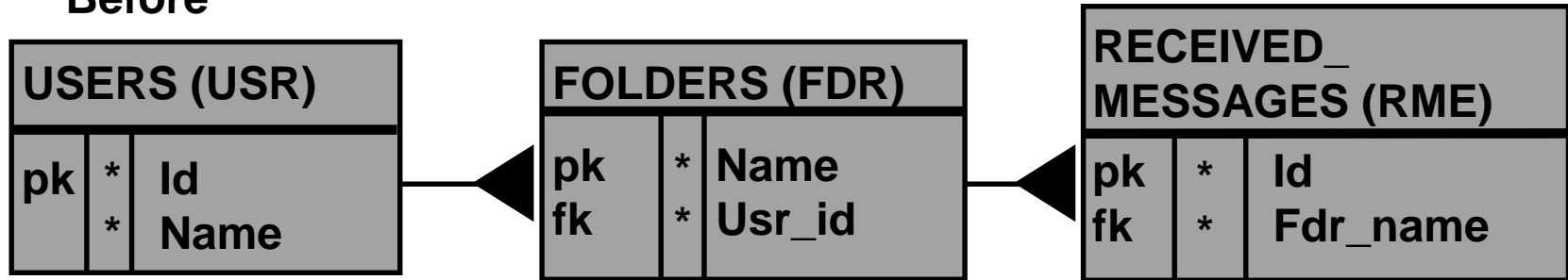
Create a new foreign key from the lowest detail to the highest master.

After



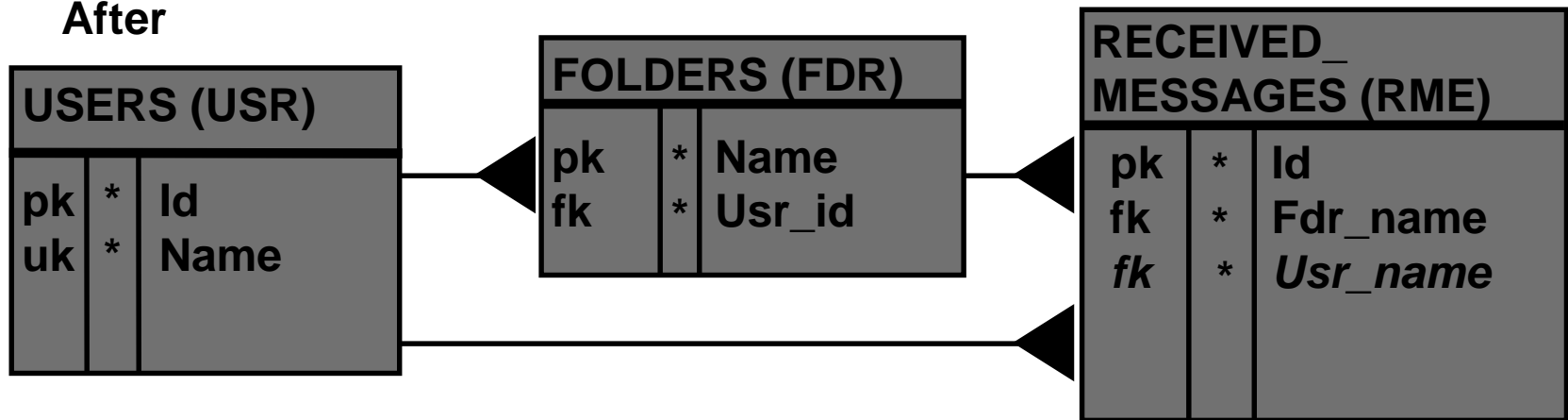
Email Example of Short-Circuit Keys

Before



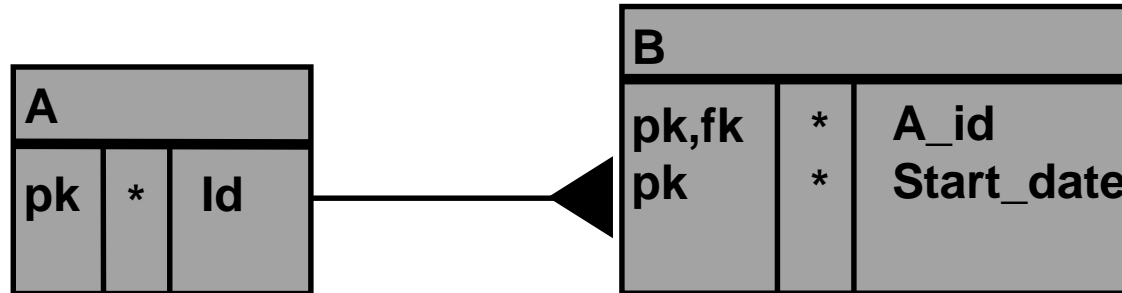
Create a new foreign key from the lowest detail to the highest master.

After



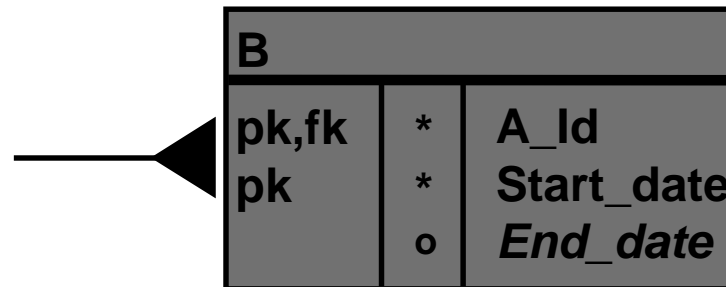
End Date Column

Before



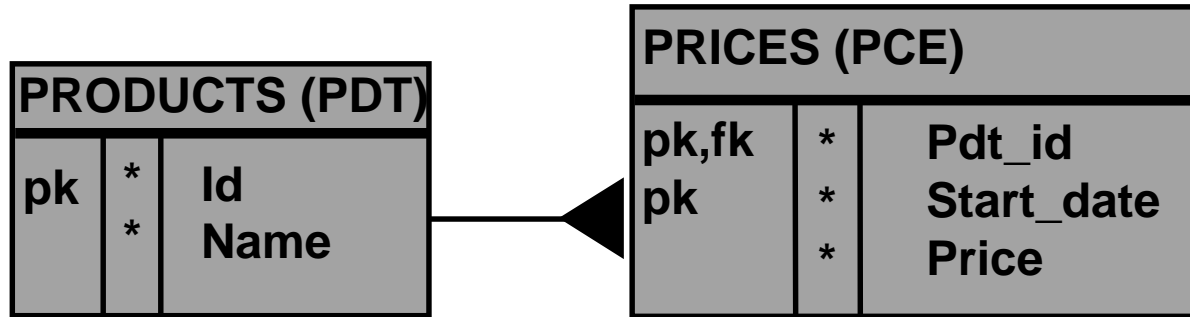
Add an *end date* column to speed up queries so that they can use a *between* operator.

After



Example of End Date Column

Before



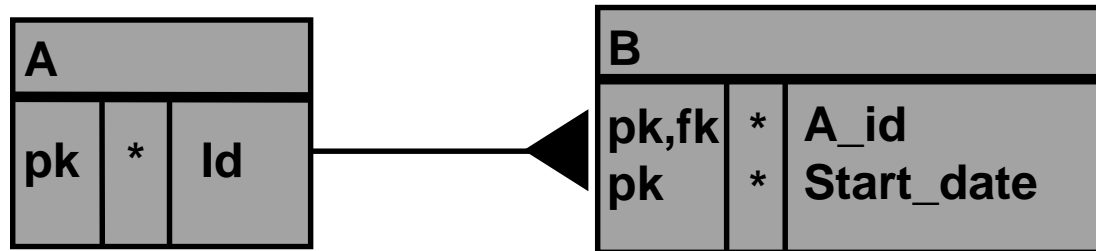
Create an extra column derivable **End_date** column.

After



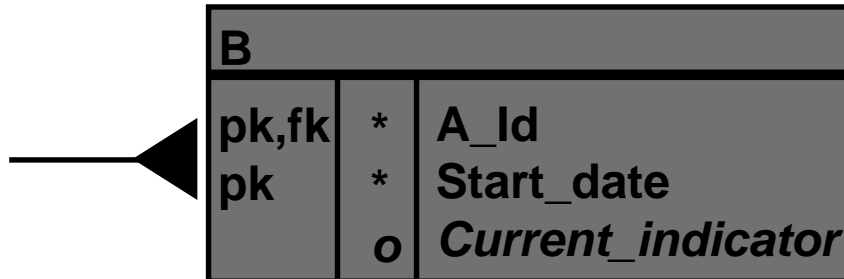
Current Indicator Column

Before



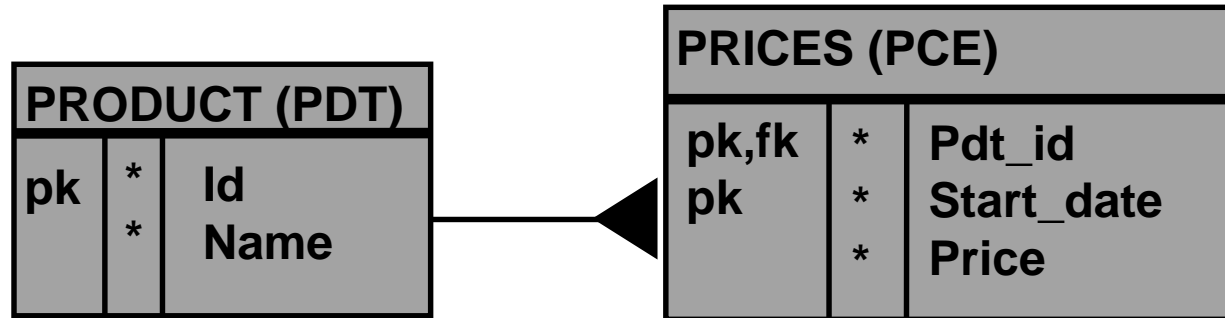
Add a column to represent the most current record in a long list of records.

After



Example of Current Indicator Column

Before



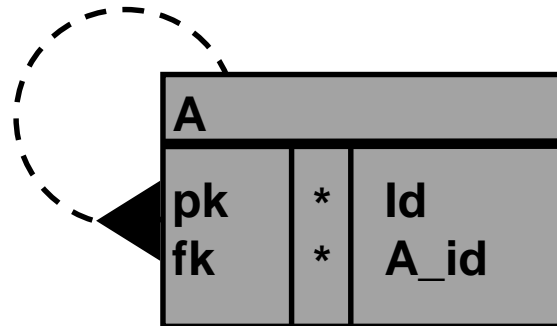
Add a column to represent the most current record, in a long list of records.

After



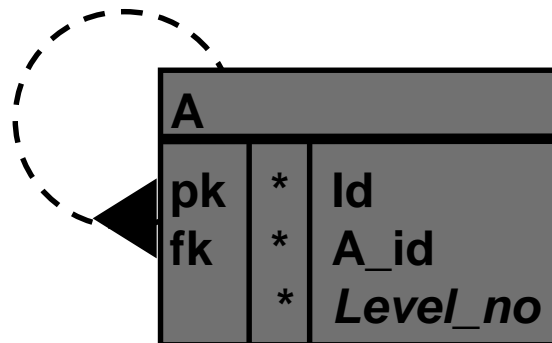
Hierarchy Level Indicator

Before



Create a column to represent the hierarchy level of a record.

After



Example of Hierarchy Level Indicator

Before

FOLDERS (FDR)		
pk	*	Id
fk	*	Fdr_id
	*	Name

Create a column to represent the hierarchy level of a record.

After

FOLDERS (FDR)		
pk	*	Id
fk	*	Fdr_id
	*	Name
	*	<i>Level_no</i>

Denormalization Summary

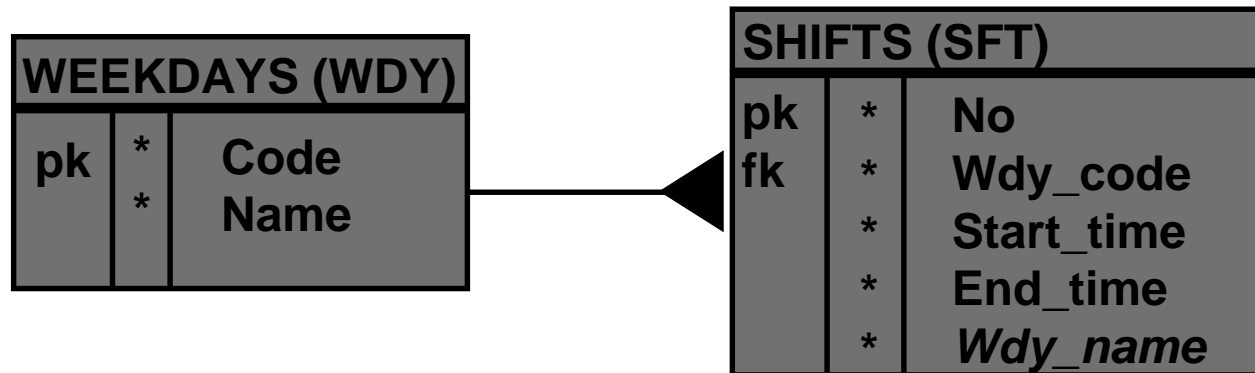
Denormalization Techniques

- **Storing Derivable Information**
 - End Date Column
 - Current Indicator
 - Hierarchy Level Indicator
- **Pre-Joining Tables**
- **Hard-Coded Values**
- **Keeping Detail with Master**
- **Repeating Single Detail with Master**
- **Short-Circuit Keys**

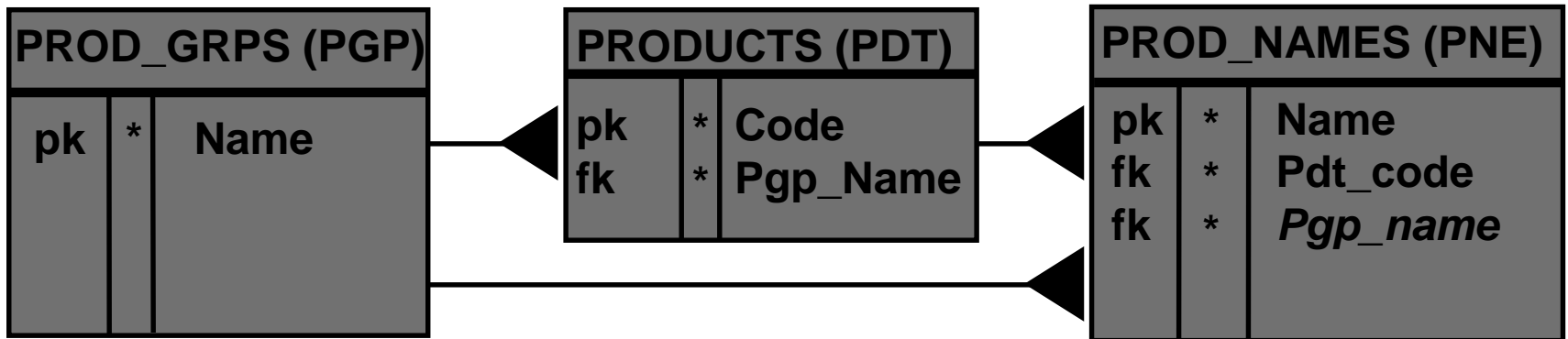
Practices

- **Name that Denormalization**
- **Triggers**
- **Denormalize Price Lists**
- **Global Naming**

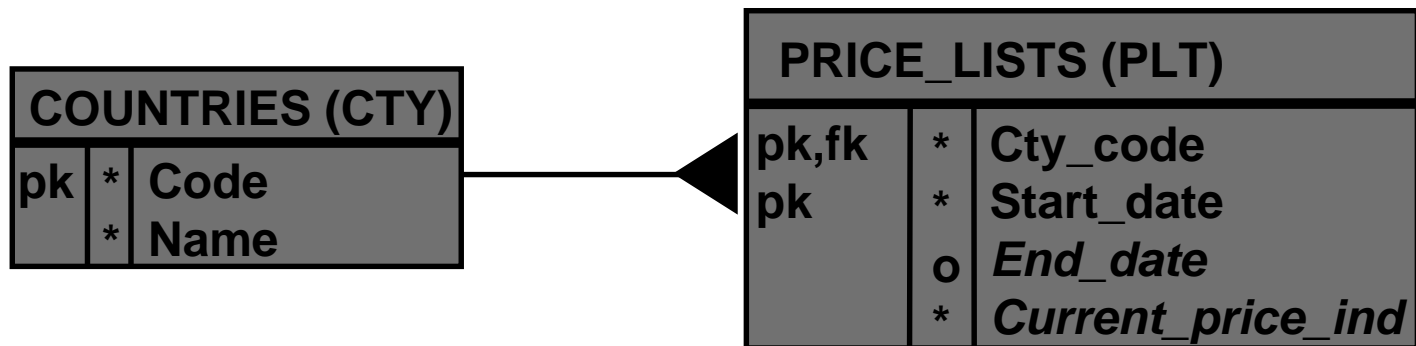
Practice: Name that Denormalization (1/3)



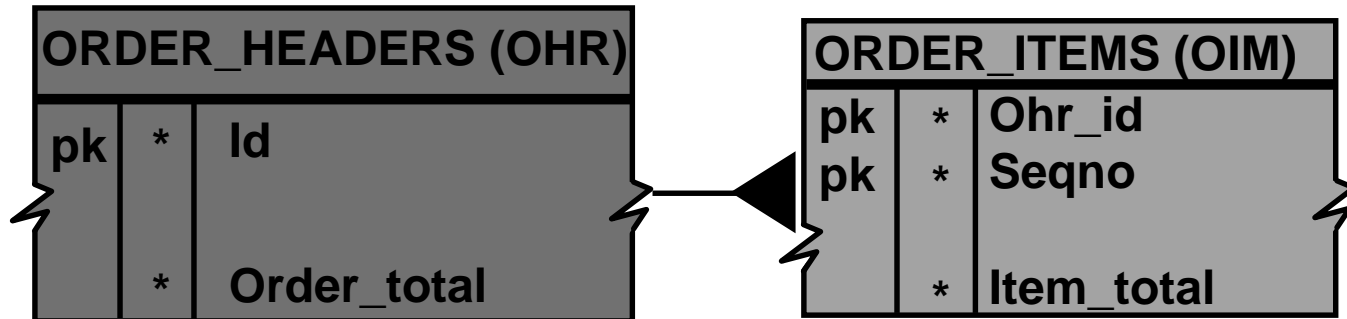
Practice: Name that Denormalization (2/3)



Practice: Name that Denormalization (3/3)



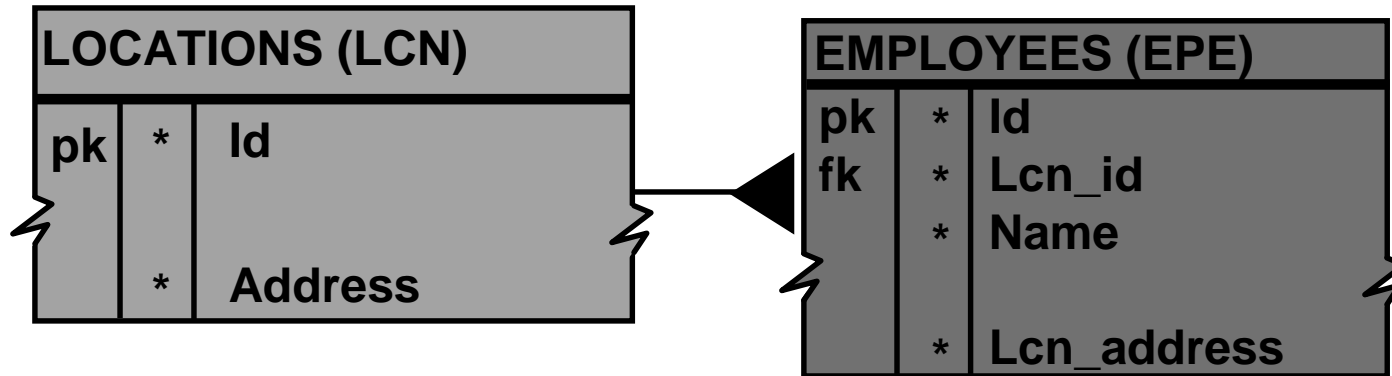
Practice: Triggers (1/6)



Practice: Triggers (2/6)

Table	Trg Type	Column	Needed?	What should it do?
OHR	Insert			
	Delete			
	Update	Id		
		Order_total		
OIM	Insert			
	Delete			
	Update	Ohr_id		
		Item_total		

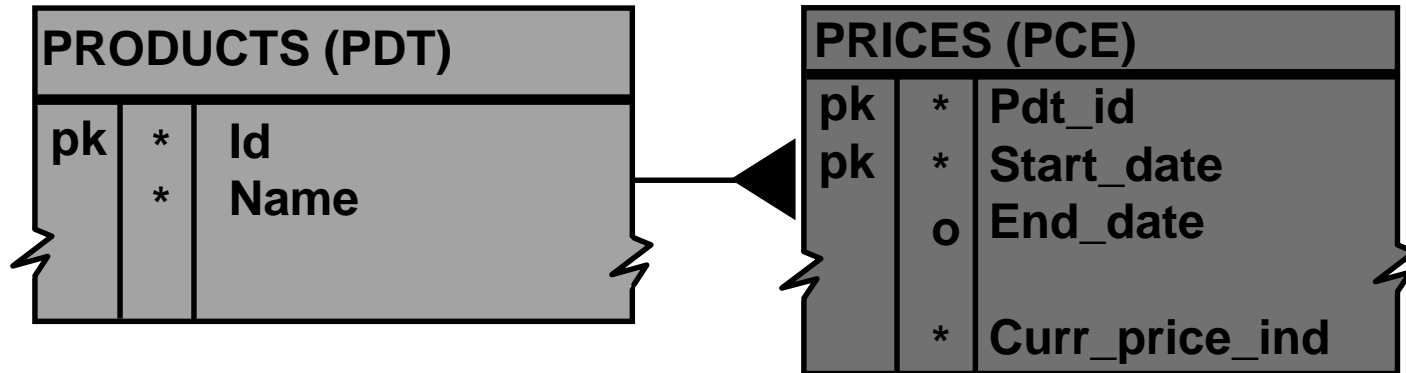
Practice: Triggers (3/6)



Practice: Triggers (4/6)

Table	Trg Type	Column	Needed?	What should it do?
LCN	Insert			
	Delete			
	Update	Address		
		<i>other cols</i>		
EPE	Insert			
	Delete			
	Update	Lcn_id		
		Lcn_address		

Practice: Triggers (5/6)

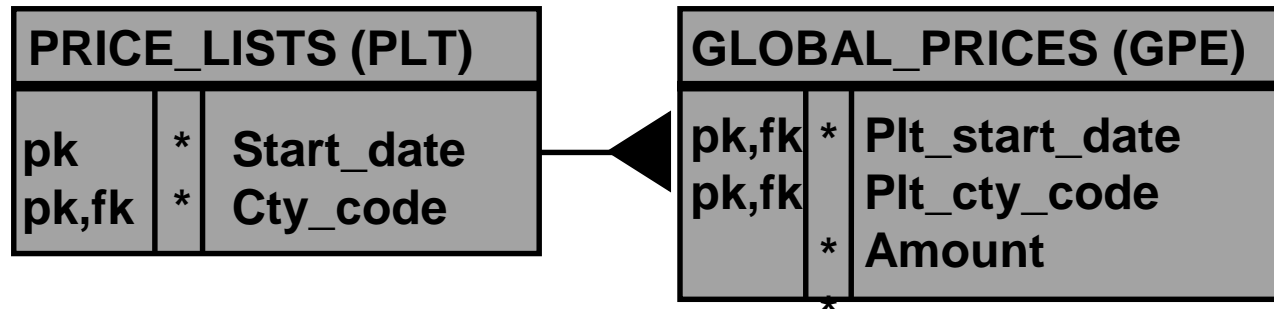


Practice: Triggers (6/6)

Table	Trg Type	Column	Needed?	What should it do?
PDT	Insert			
	Delete			
PCE	Insert			
	Delete			
	Update	Pdt_id		
		Start_date		
		End_date		
		Curr_price_Ind		

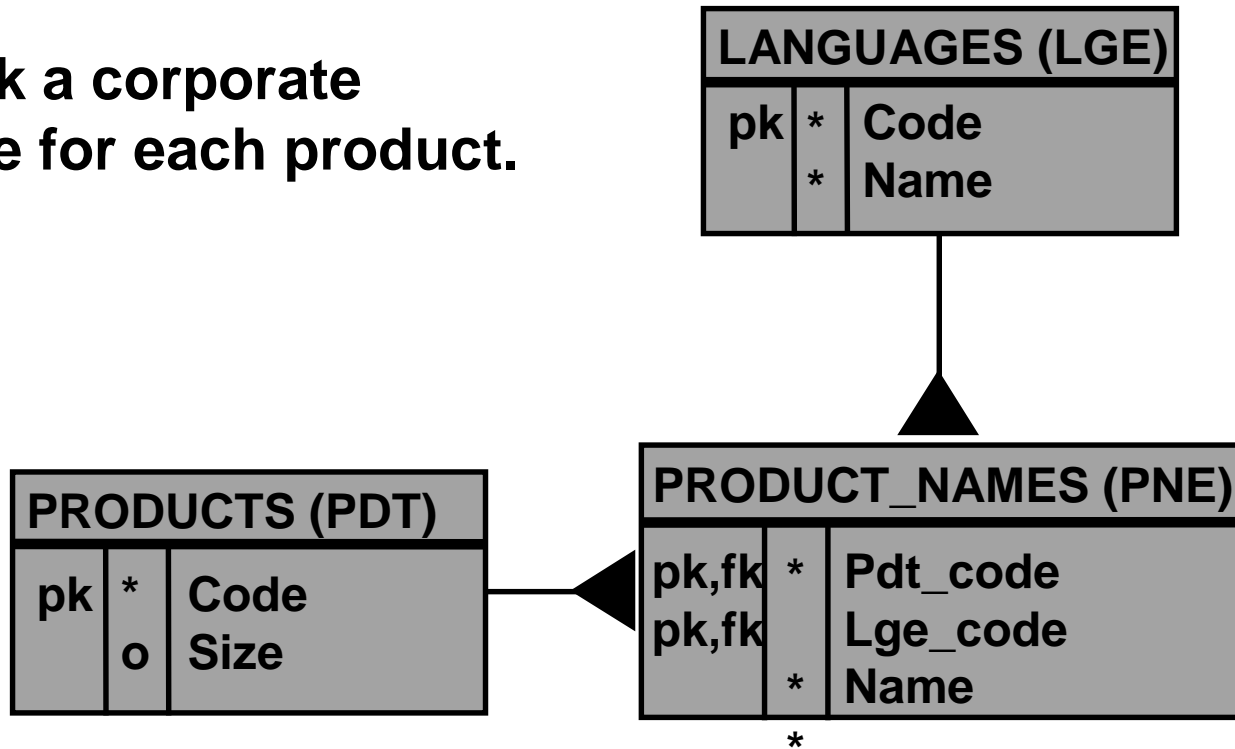
Practice: Denormalize Price Lists

- Speed up performance for queries on Amount.
- Insert new price lists before their effective date.



Practice: Global Naming

Track a corporate name for each product.



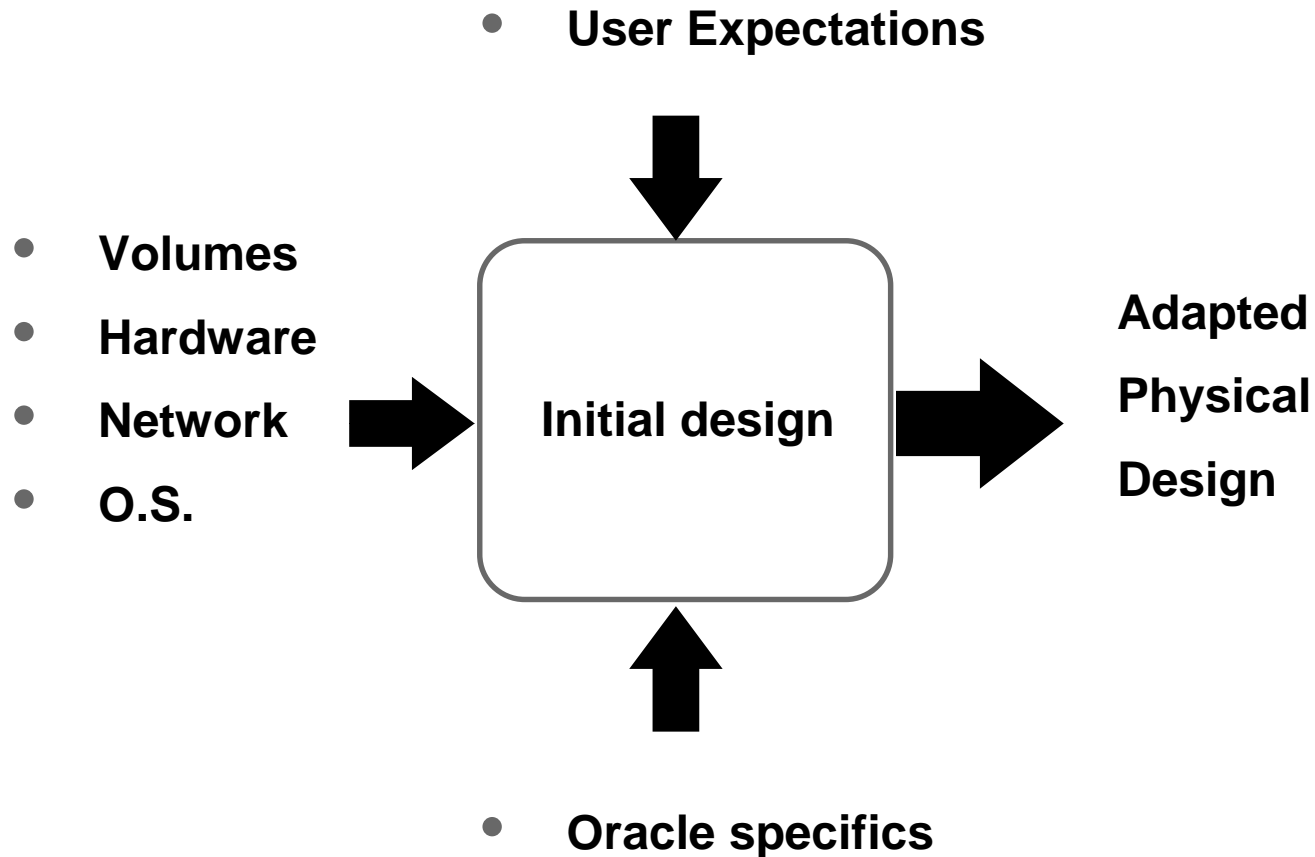


Database Design Considerations

Overview

- **Oracle specific Design Considerations**
- **Data Integrity Issues**
- **Performance Considerations**
- **Storage Issues**

Why Adapt Data Design?



Oracle Data Types

Depending on:

- **Domains**
- **Storage issue**
- **Performance**
- **Use**

Select a data type for columns:

- **Character**
- **Number**
- **Date**
- **Large Objects**

Suggested Column Sequence

- **Primary key columns**
- **Unique Key columns**
- **Foreign key columns**
- **Mandatory columns**
- **Optional columns**

Large object columns *always* at the end

Primary Keys

```
CREATE TABLE countries
( code      NUMBER(6)      NOT NULL
, name      VARCHAR2(25)  NOT NULL
, currency  NUMBER (10,2)  NOT NULL
);
ALTER TABLE countries
ADD CONSTRAINT cty_pk PRIMARY KEY
(code);
```



Constraint *and* Index name

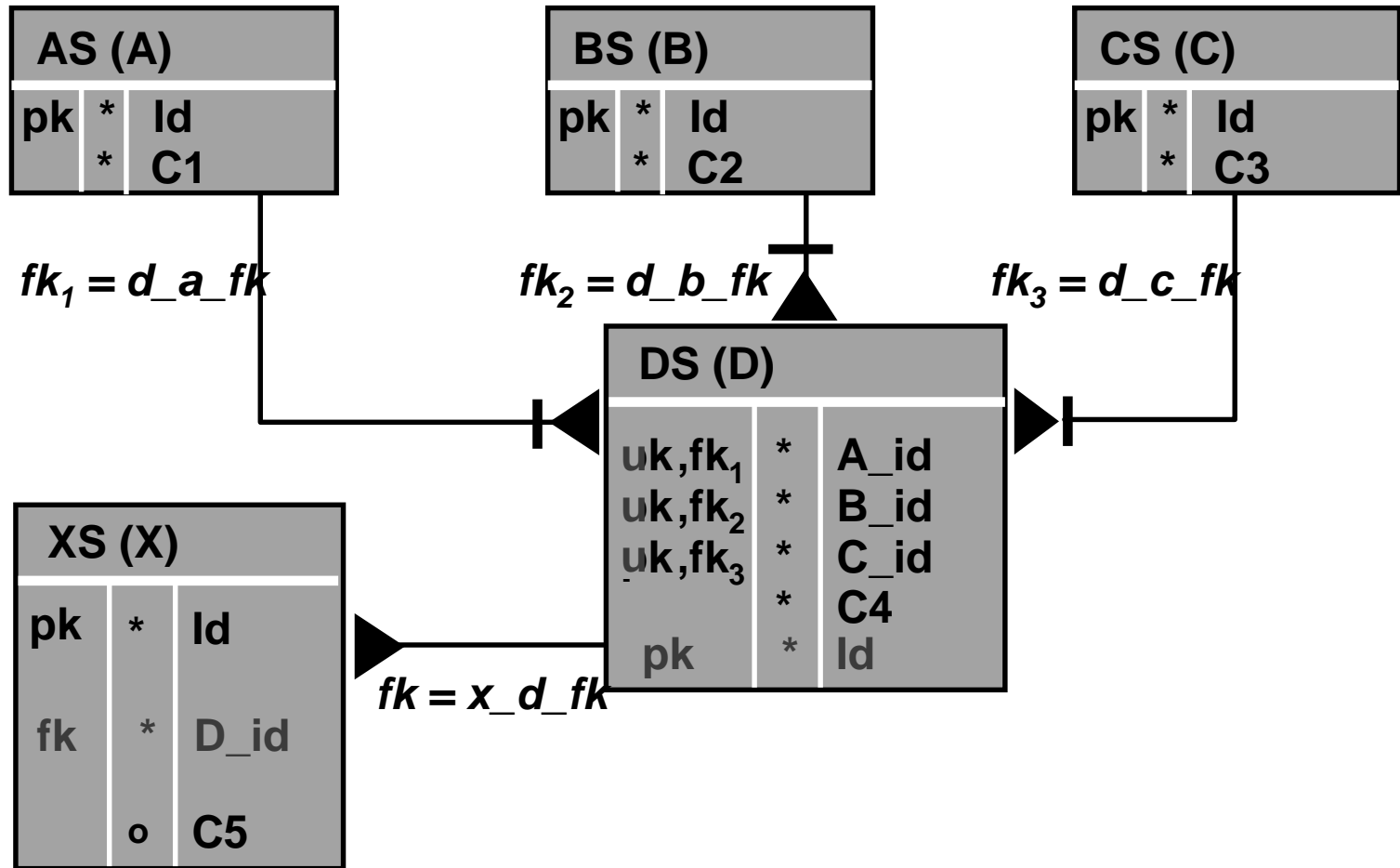
Primary Keys

Choosing the Right Key

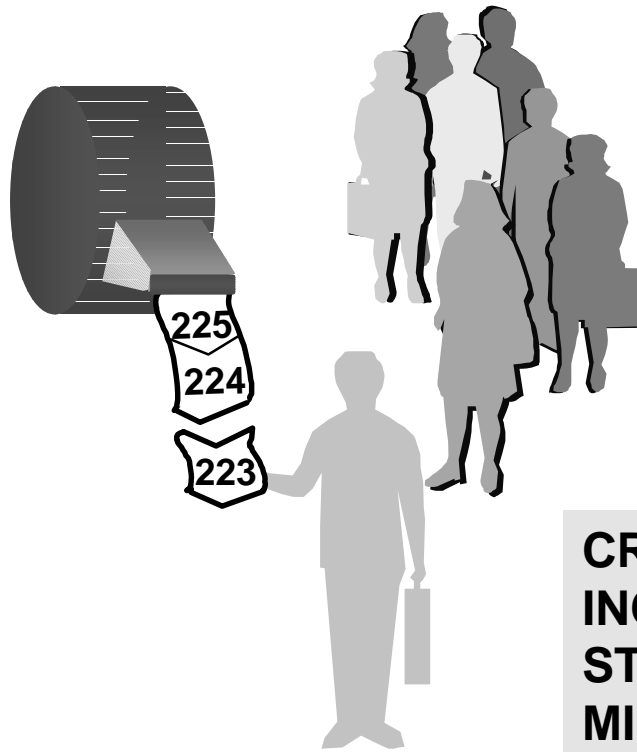
- **Simplicity**
- **Ease of use**
- **Performance**
- **Size**
- **Meaningless**
- **Stability**



Artificial Keys



Sequences



```
CREATE SEQUENCE sequence_name  
INCREMENT BY number  
START WITH number  
MINVALUE number  
MAXVALUE number  
CACHE number / NOCACHE  
CYCLE | NOCYCLE;
```

Foreign Key Behavior

	Delete	Update
Restrict	✓	✓
Cascade	✓	
Default Nullify		



Supported by Oracle through declaration

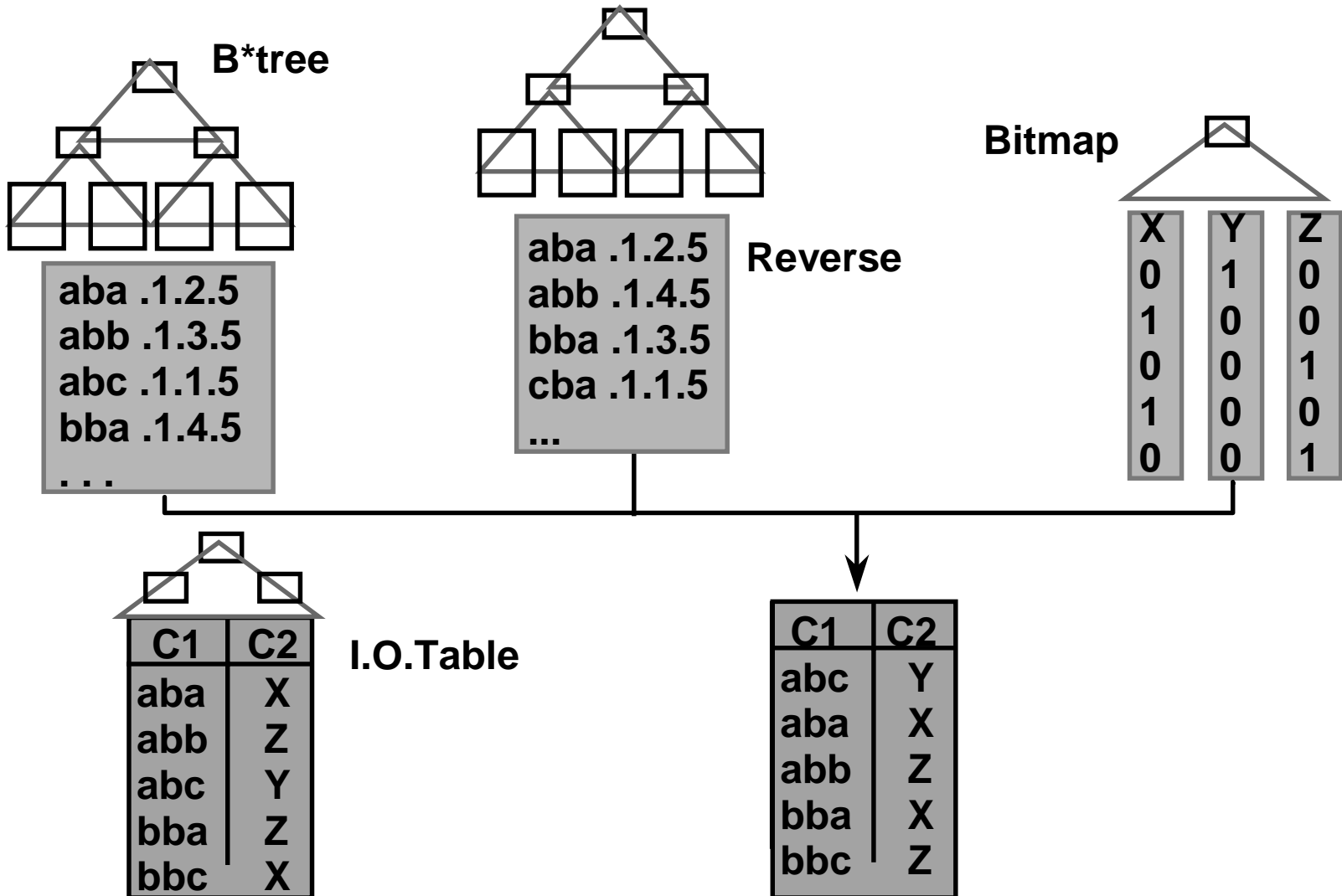
Indexes

- Performance

Name	Phone
ALBERT	2655
ALFRED	3544
ALICE	7593
ALLISON	3456
ALVIN	8642
ALPHONSO	2841

- Uniqueness

Choosing Indexes



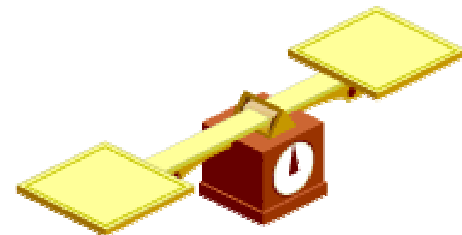
Which Columns to Index?

- **Primary key columns and Unique Key columns (Up to Version 6)**
- **Foreign Key columns**
- **When significant better performance can be observed in SELECT statements**



Avoid indexing:

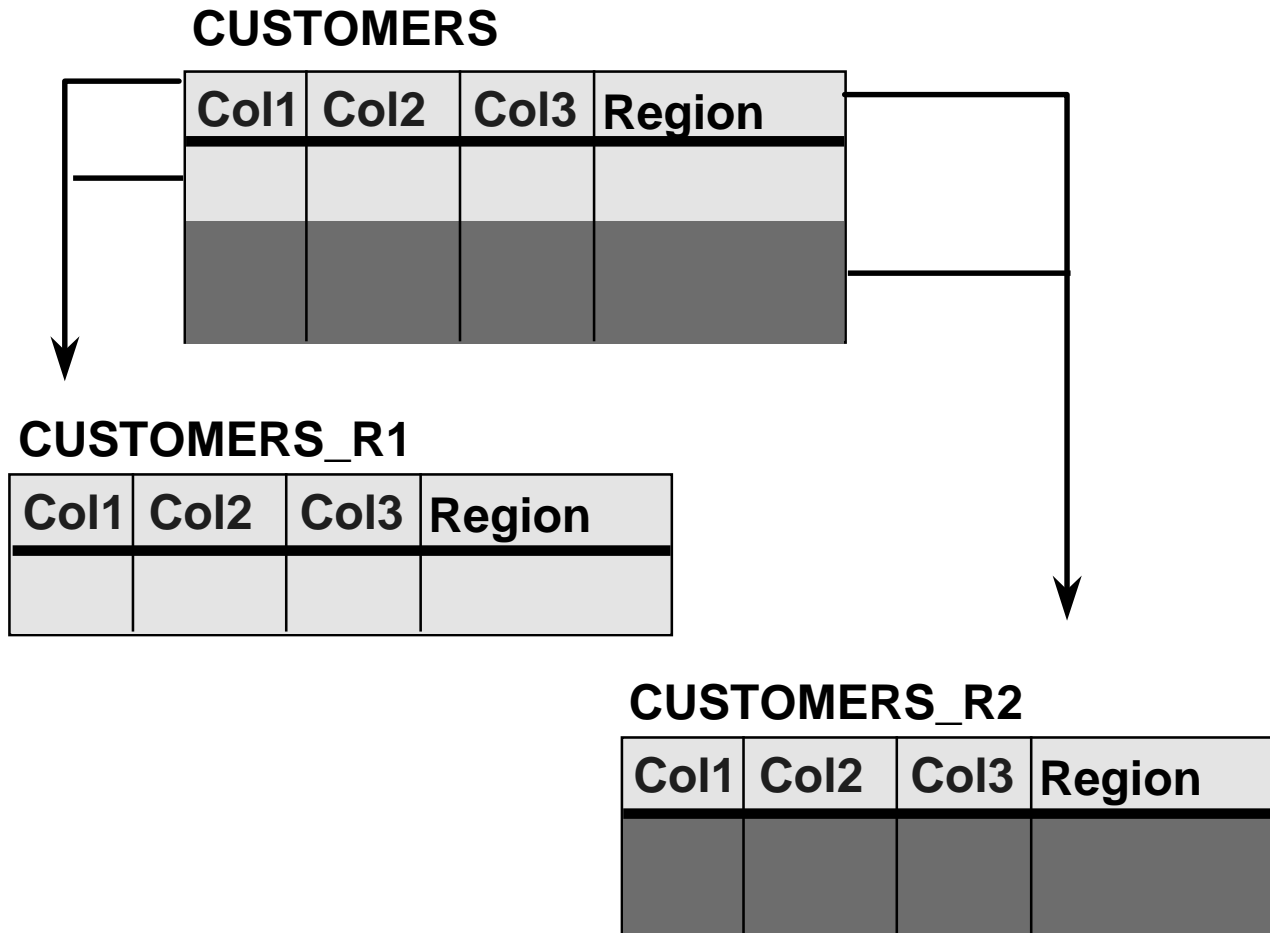
- **Small tables**
- **Columns frequently updated**



When Can Indexes be Used?

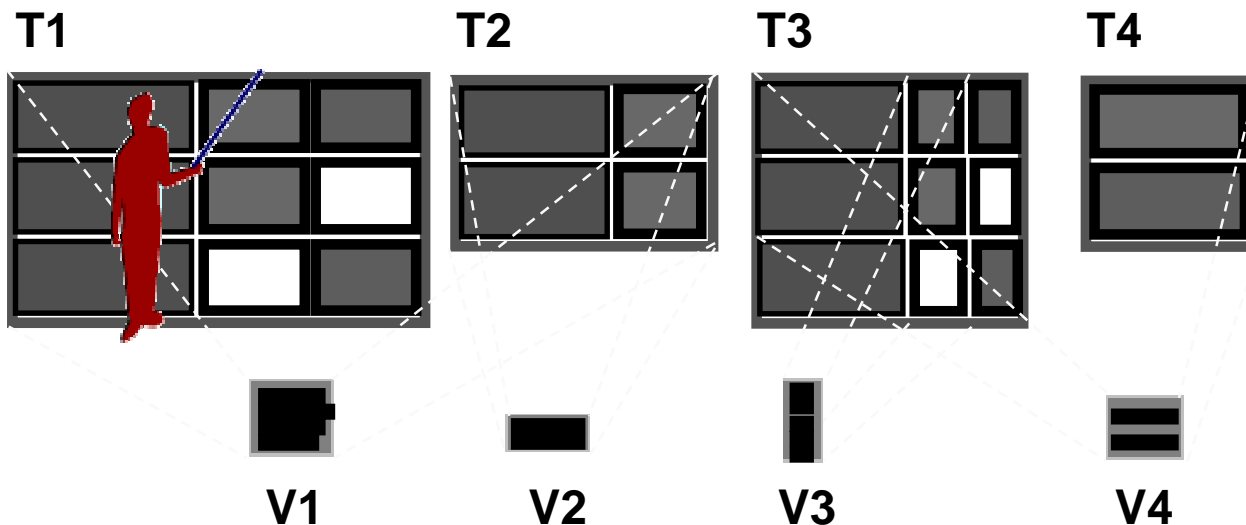
- **When referenced in a Where clause or Order By**
- **When the Where clause does not include some operators**
- **When the optimizer decides**
- **With hints in the SQL statement**

Partitioning Tables and Indexes



Views

- Restricting access
- Presentation of data
- Isolate applications from data structure
- Save complex queries
- Simplify user commands



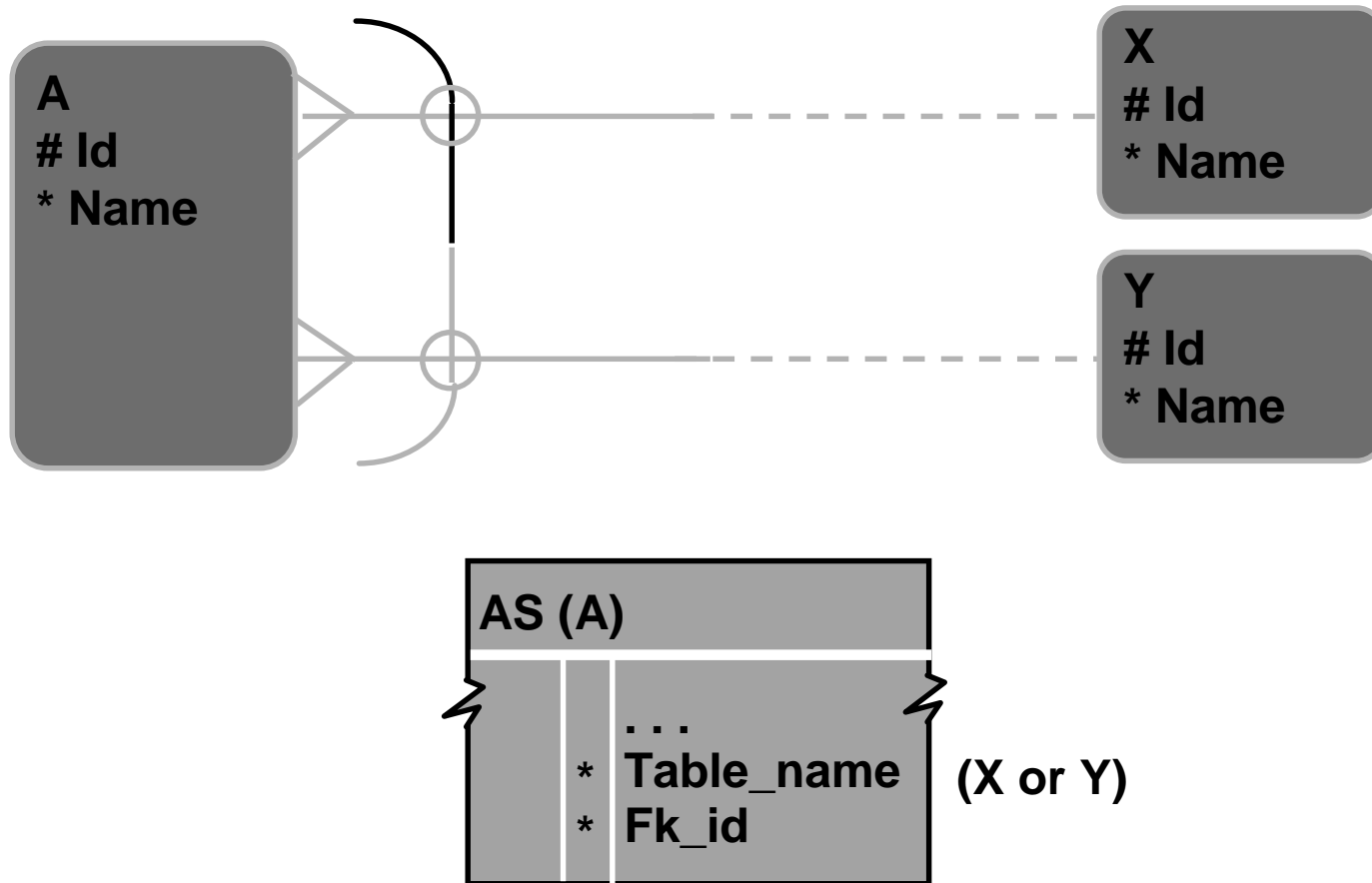
Reasons for Views

- **Advantages**
 - **Dynamic views**
 - **Present denormalized data from normalized tables**
 - **Simplify SQL statements**
- **Disadvantages**
 - **May affect performances**
 - **Restricted DML in some cases**

Old Fashioned Design

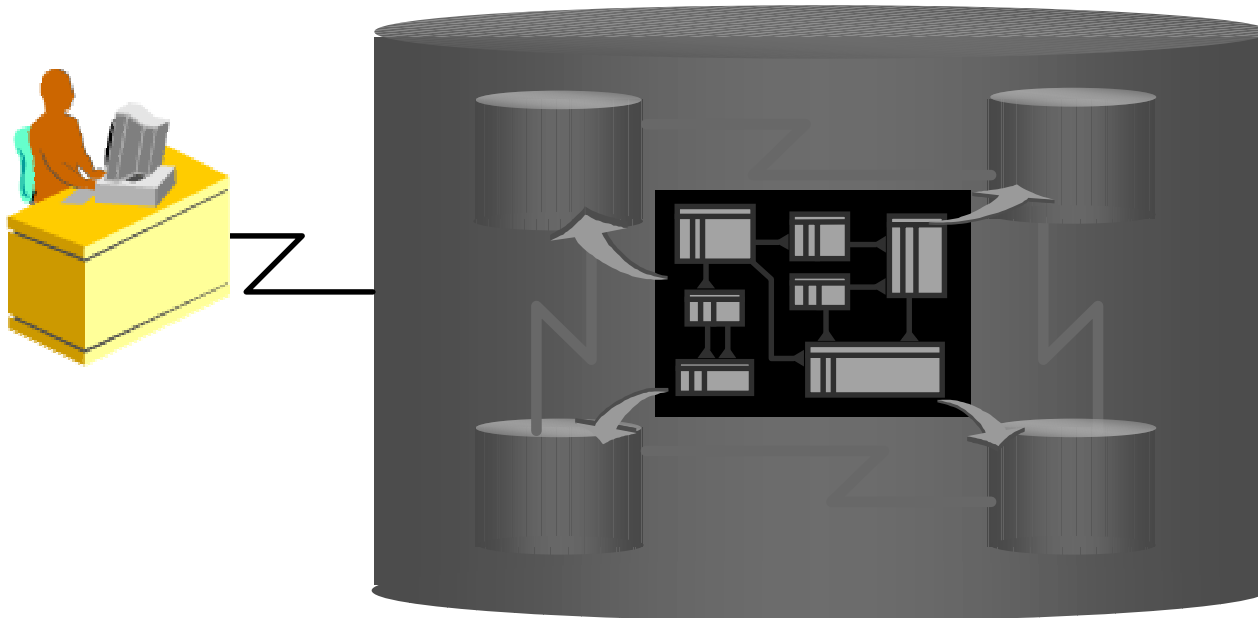
- **Unique index**
- **Views with “Check option” clause**
- **Generic Arc implementation**

Generic Arc Implementation



Distributed Database

Different physical databases appear as one logical database.



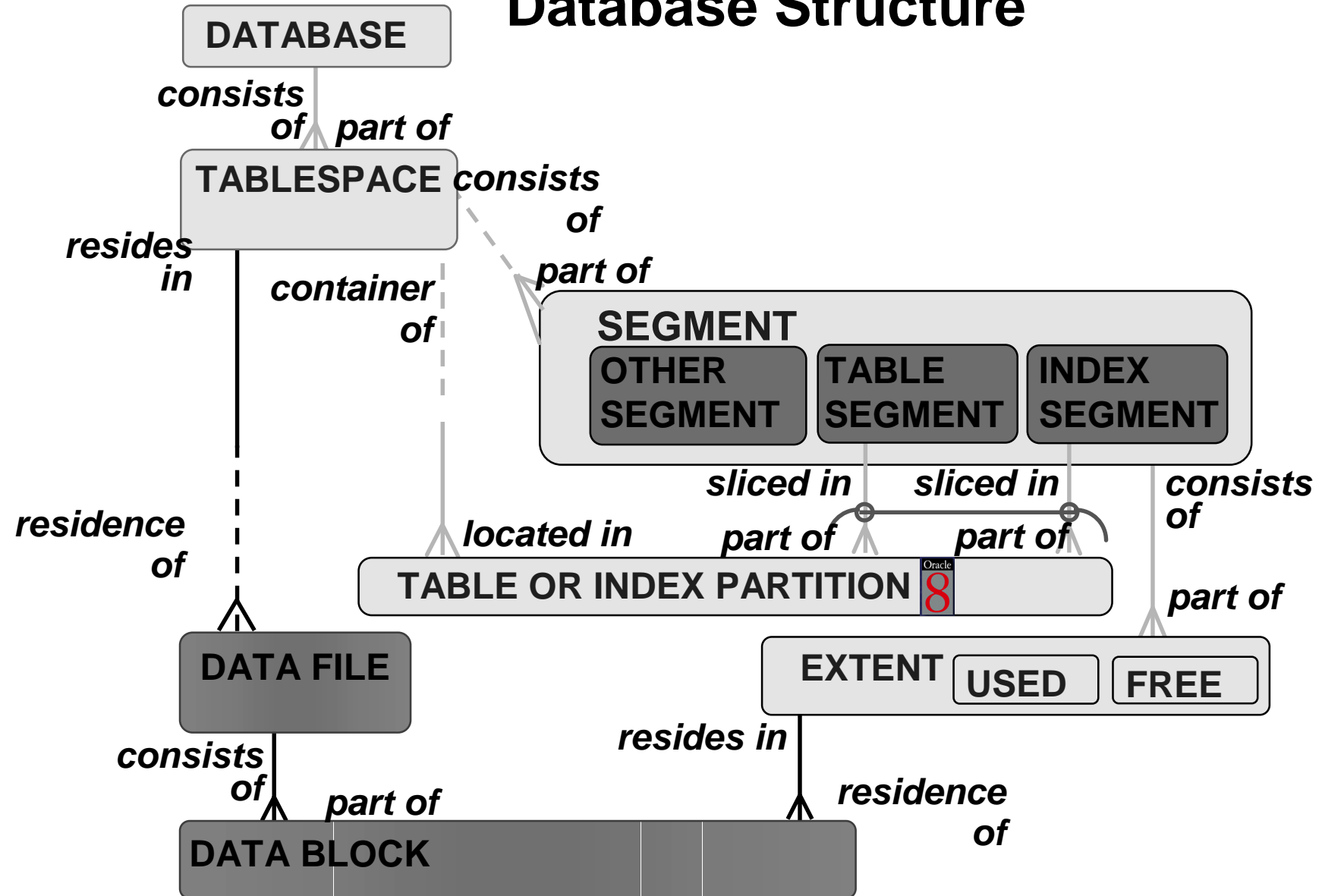
Benefits of Distributed Databases

- **Resilience**
- **Reduced line traffic**
- **Location transparency**
- **Local autonomy**
- **Easier growth path**

but

- **Increased, distributed, complexity**

Database Structure

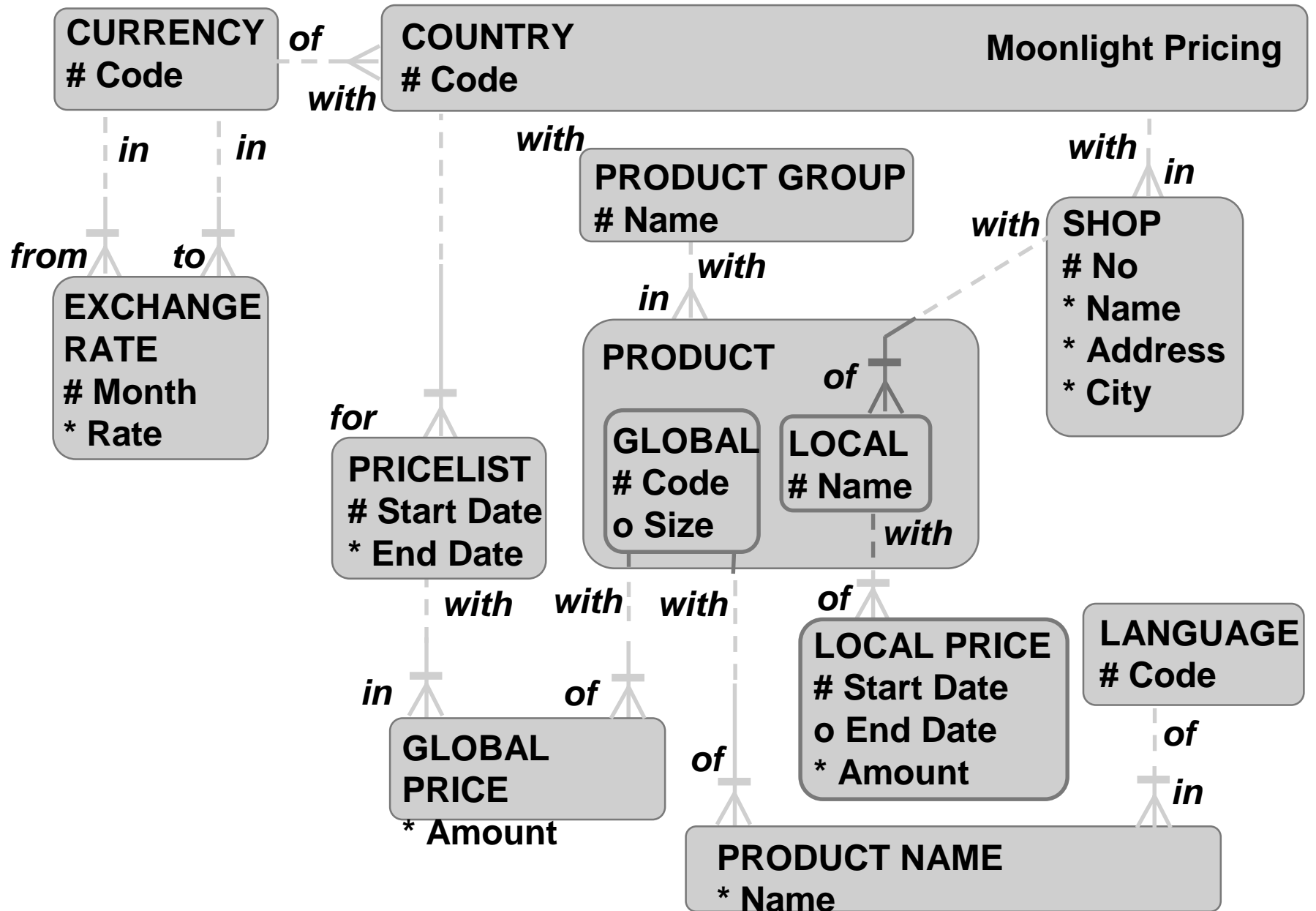


Summary

- **Data Types**
- **Primary, Foreign, and Artificial Keys**
- **Indexes**
- **Partitioning**
- **Views**
- **Distributed design**

Practices

- **Data Types**
- **Artificial Keys**
- **Product Pictures**



Data Types (1)

Table	Column	Suggested Data Type	Your Choice Data Type
COUNTRIES	Code	Varchar2(2)	
	CURRENCIES	Code	Varchar2(3)
EXCHANGE_RATES	Month	Date	
	Rate	Number(8,4)	
PRICE_LISTS	Start_date	Date	
	End_date	Date	
PRODUCT_GROUPS	Name	Char(8)	
PRODUCTS	Code	Char(10)	
	Size	Number(4,2)	
	Pdt_type	Number(1)	

Data Types (2)

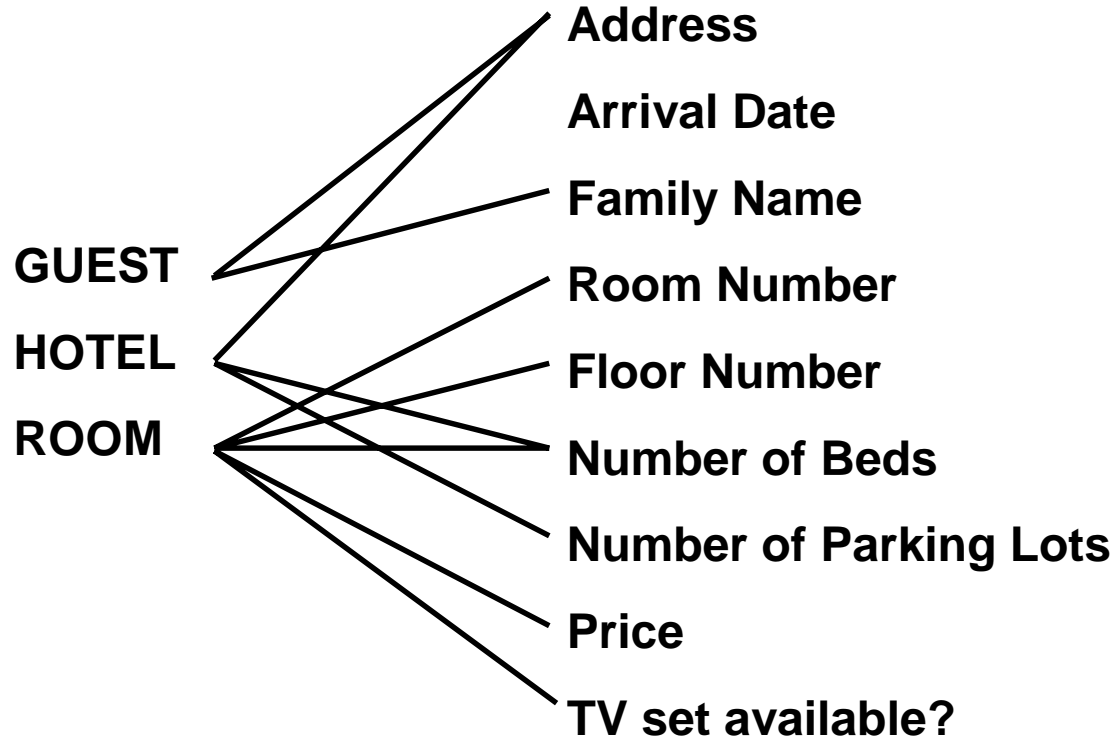
Table	Column	Your Choice Data Type
GLOBAL_PRICES LOCAL_PRICES	Amount Start_date End_date	
SHOPS	Amount Name Address City	



Solution: Instance or Entity?

Concept	E/A/I?	Example Instance or Entity
<i>PRESIDENT</i>	E	Lincoln, Washington, Gorbachev
<i>ELLA FITZGERALD</i>	I	STAR, SINGER, PERSON
<i>DOG</i>	E	Snoopy
<i>ANIMAL</i>	E	Cat, Dog, ...
<i>HEIGHT</i>	A	PERSON, BUILDING, ...
TYPE OF TRANSPORT	<i>E</i>	<i>CAR</i>
Number of Wheels	<i>A</i>	<i>CAR</i>
My current car	<i>I</i>	<i>CAR</i>

Solution: Guest

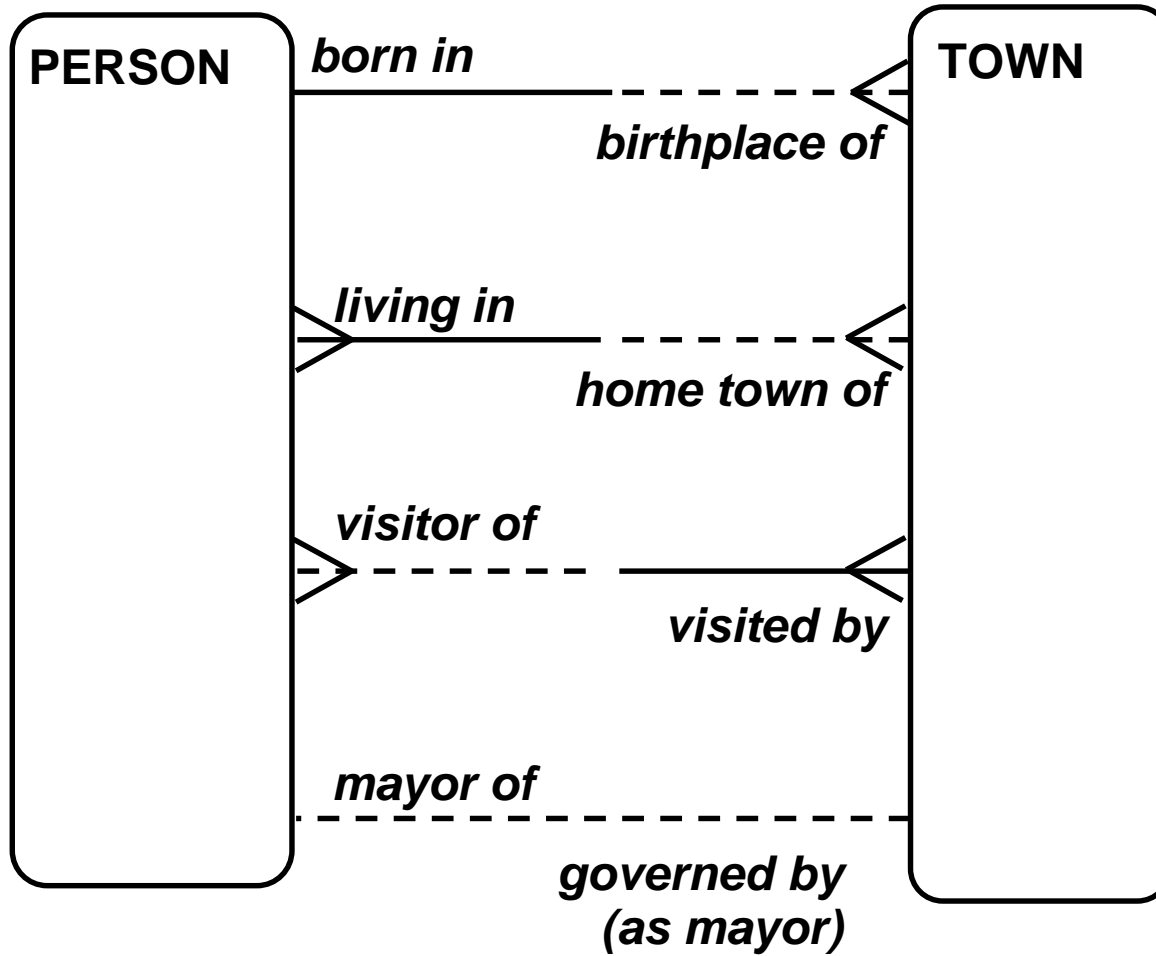


Solution: Reading

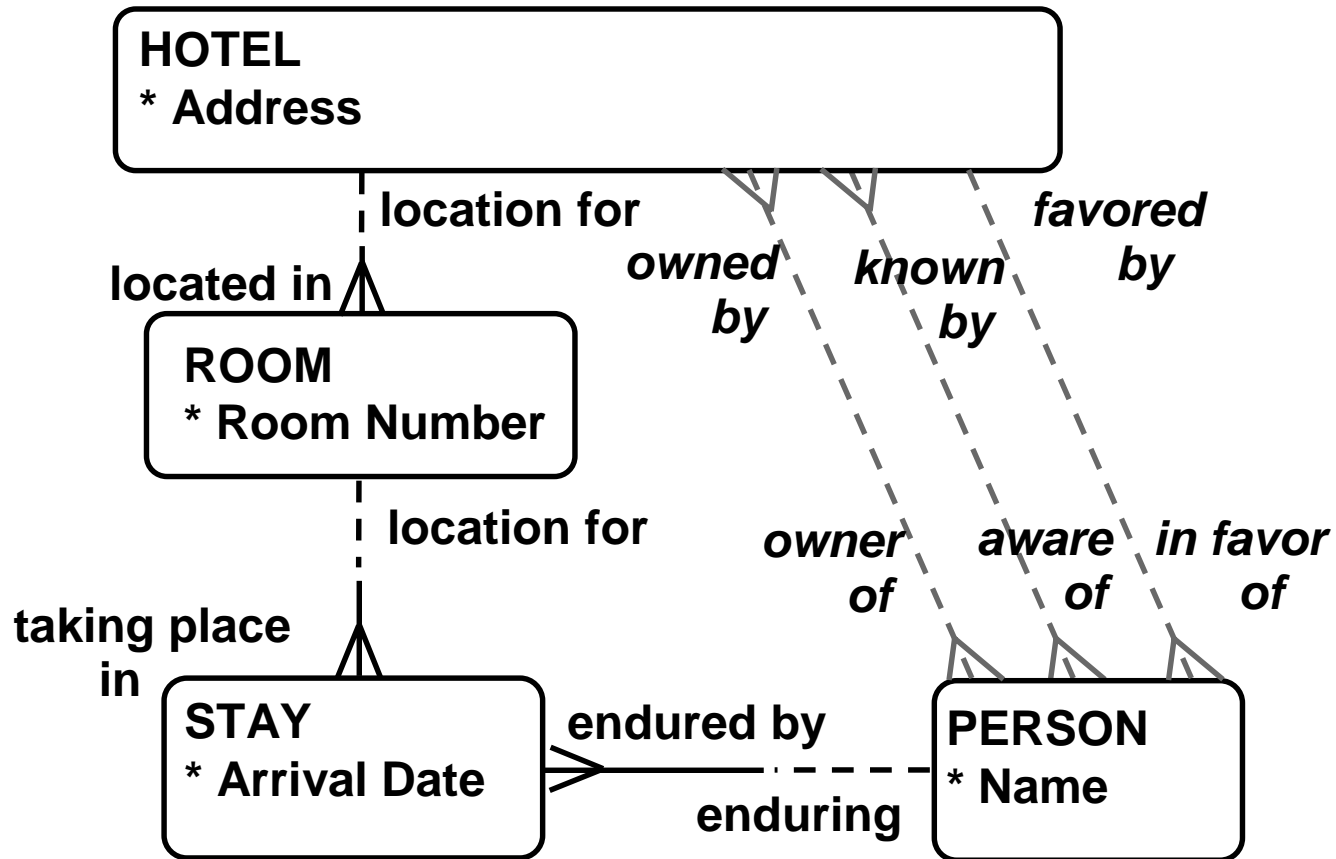


- A Each EMPLOYEE may be assigned to one or more DEPARTMENTS
Each DEPARTMENT must be responsible for one or more EMPLOYEES**
- B Each EMPLOYEE must be assigned to one or more DEPARTMENTS
Each DEPARTMENT may be responsible for one or more EMPLOYEES**
- C Each EMPLOYEE must be assigned to exactly one DEPARTMENT
Each DEPARTMENT may be responsible for exactly one EMPLOYEE**

Practice: Read and Comment



Solution: Hotel



Soups

Açorda alentejana

bread soup from Portugal

vegetarian

15 min

easy

for 4 persons:

1 onion

4 cloves of garlic

1 red pepper

1 liter of vegetable broth

4 tablespoons of olive oil

4 fresh eggs

1 handful of parsley or coriander

salt, pepper

9-12 slices of (old) bread

preparation

Cut the onion into small pieces and fry together with the garlic. Wash the red pepper, cut it in half, remove the seeds and fry it for at least 15

Soups

Açorda alentejana

bread soup from Portugal

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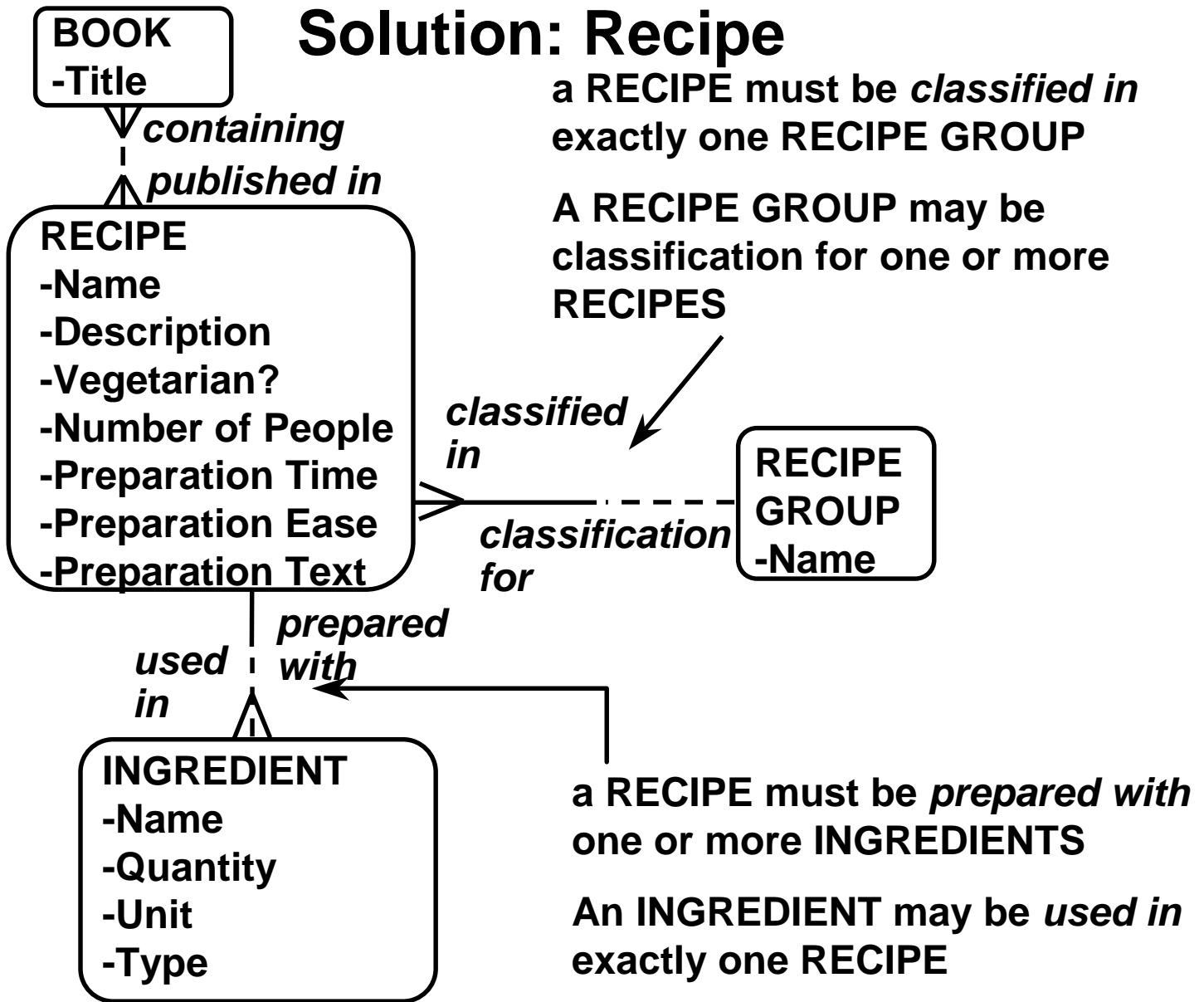
1 handful of parsley or coriander

salt, pepper

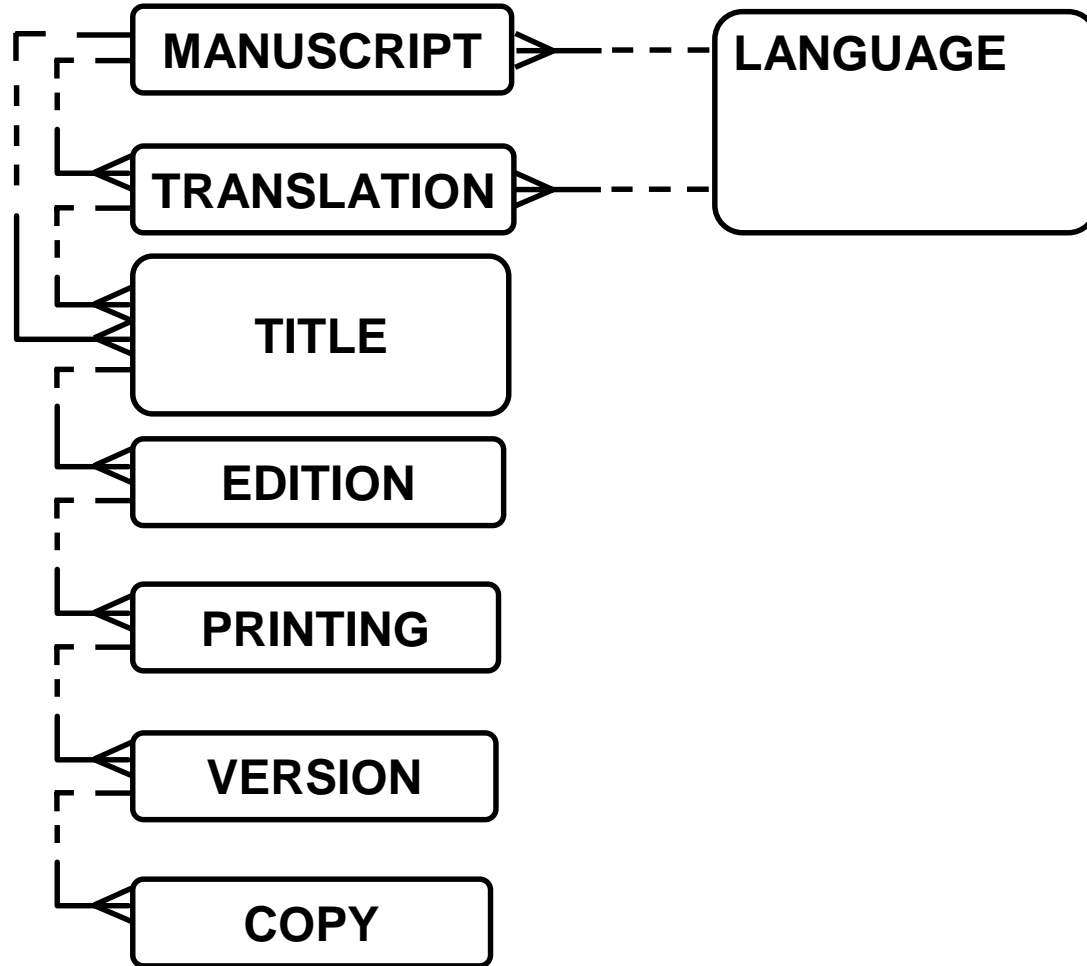
9-12 slices of (old) bread

preparation

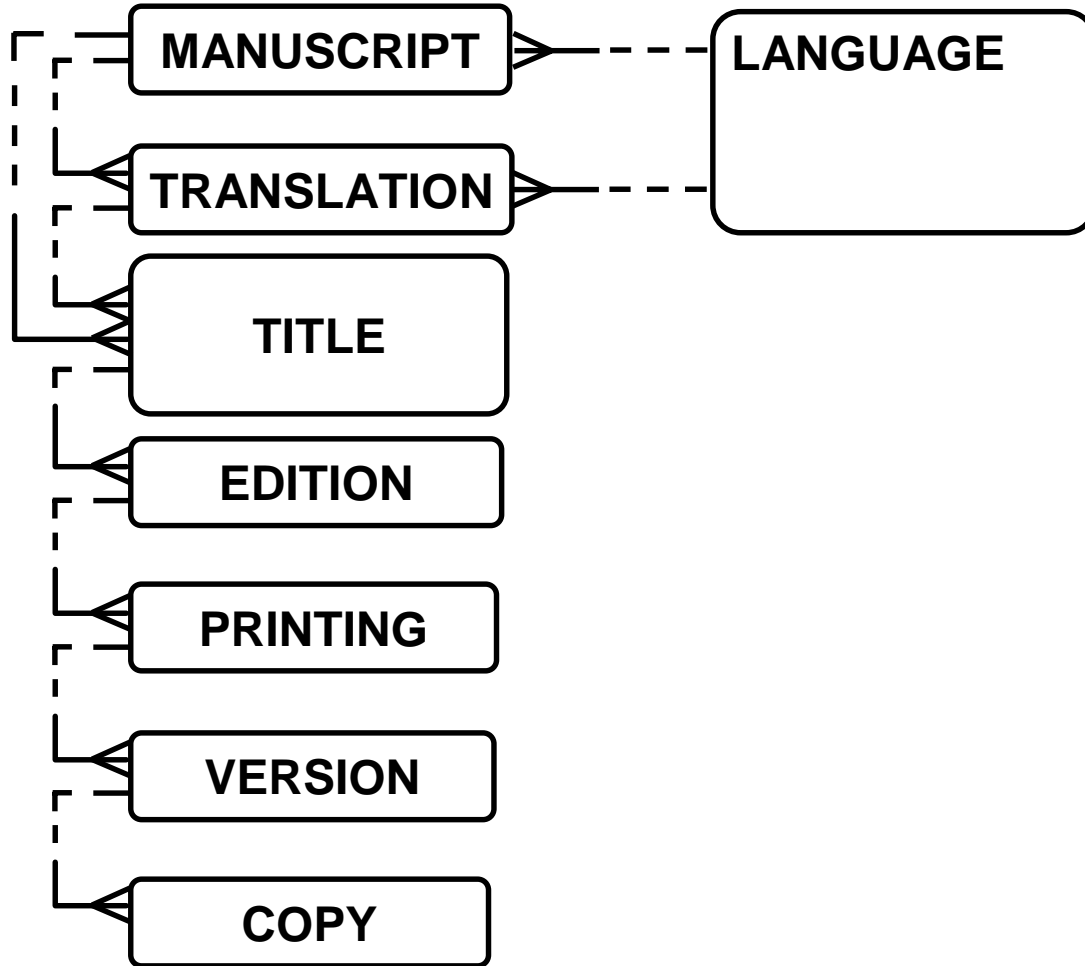
Cut the onion into small pieces and fry together with the garlic. Wash the red pepper, cut it in half, remove the seeds and fry it for at least 15



Solution: Books



Solution: Books



Solution: Moonlight

COUNTRY

PRODUCT

COUNTRY COMMUNITY

PRODUCT GROUP

CURRENCY

PRICE

DEPARTMENT

SALE

DRINK

SHOP

EMPLOYEE

STOCK OPTION

EXCHANGE RATE

STOCK PRICE

FOOD

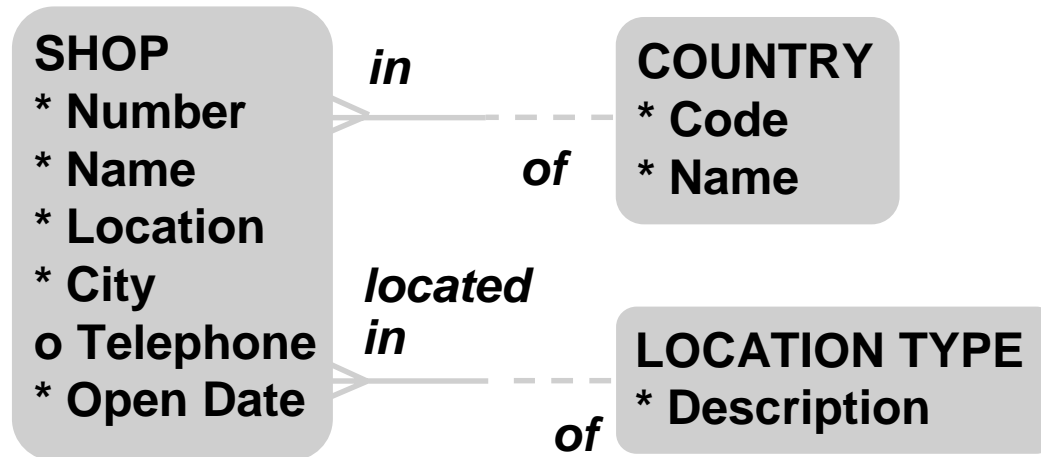
TICKER SYMBOL

JOB

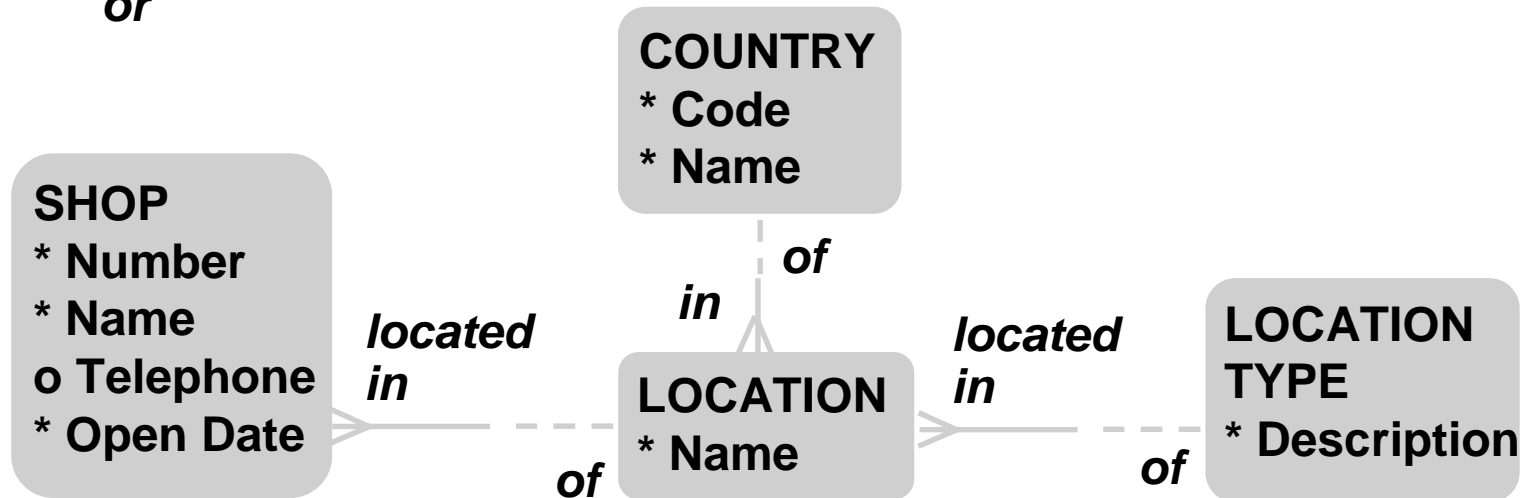
LOCATION TYPE

PASTRY

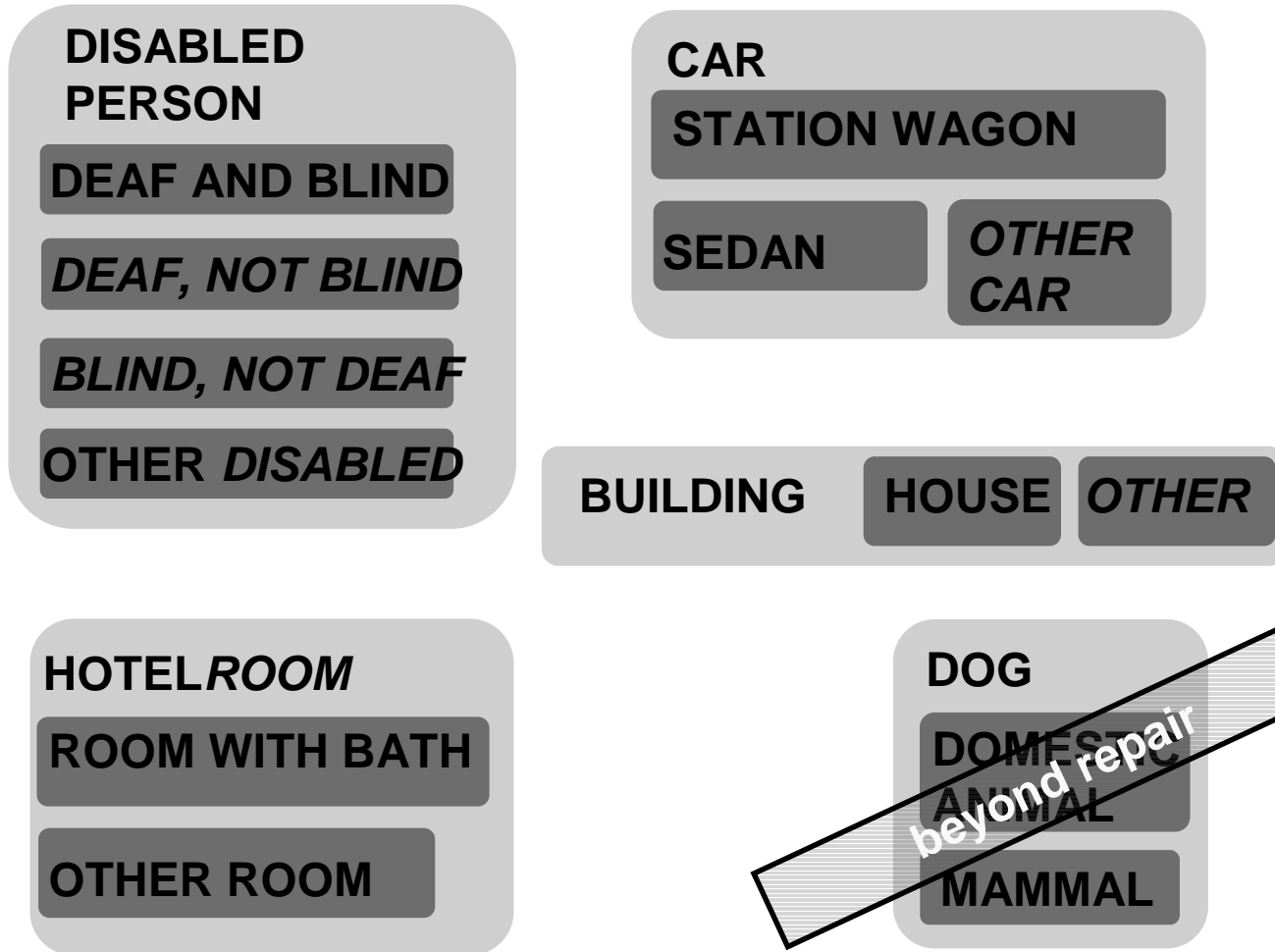
Solution: Shops



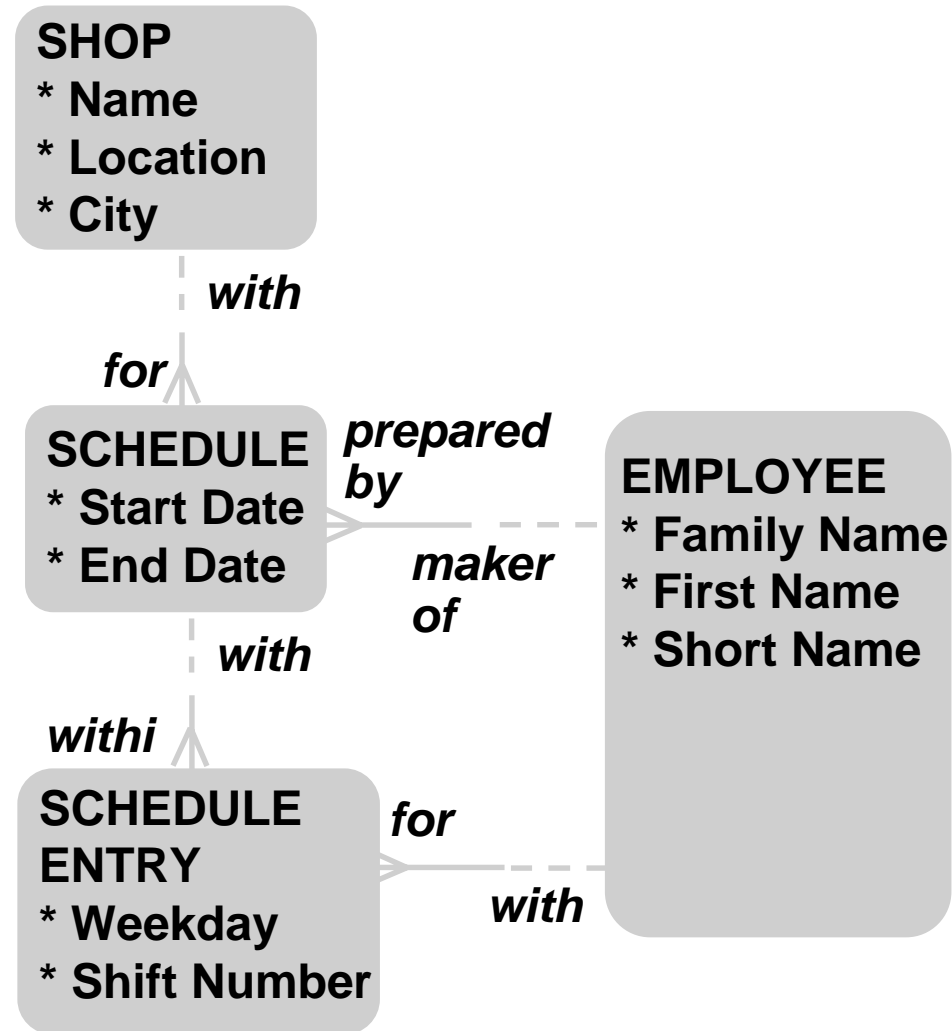
or



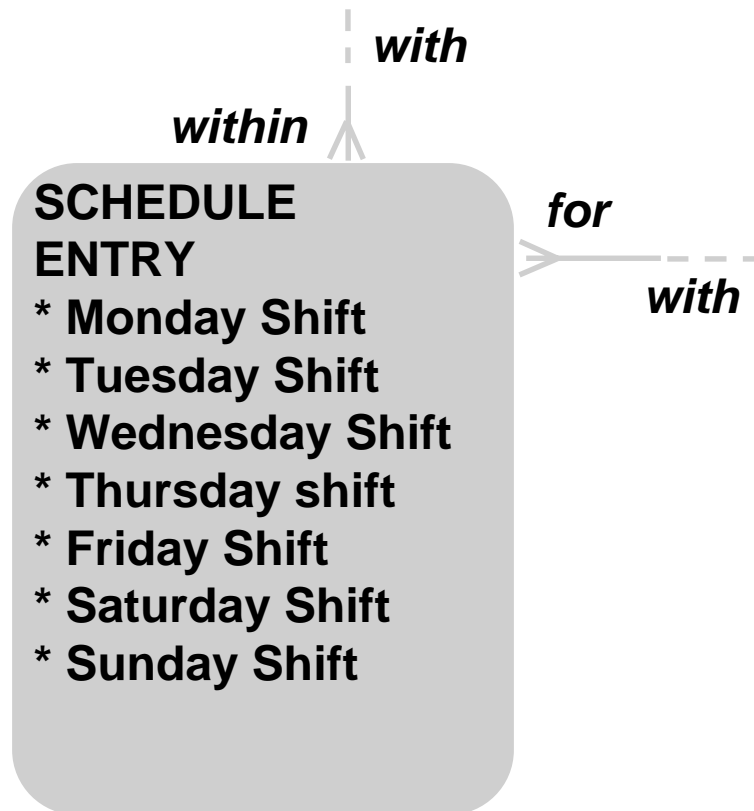
Solution: Subtypes



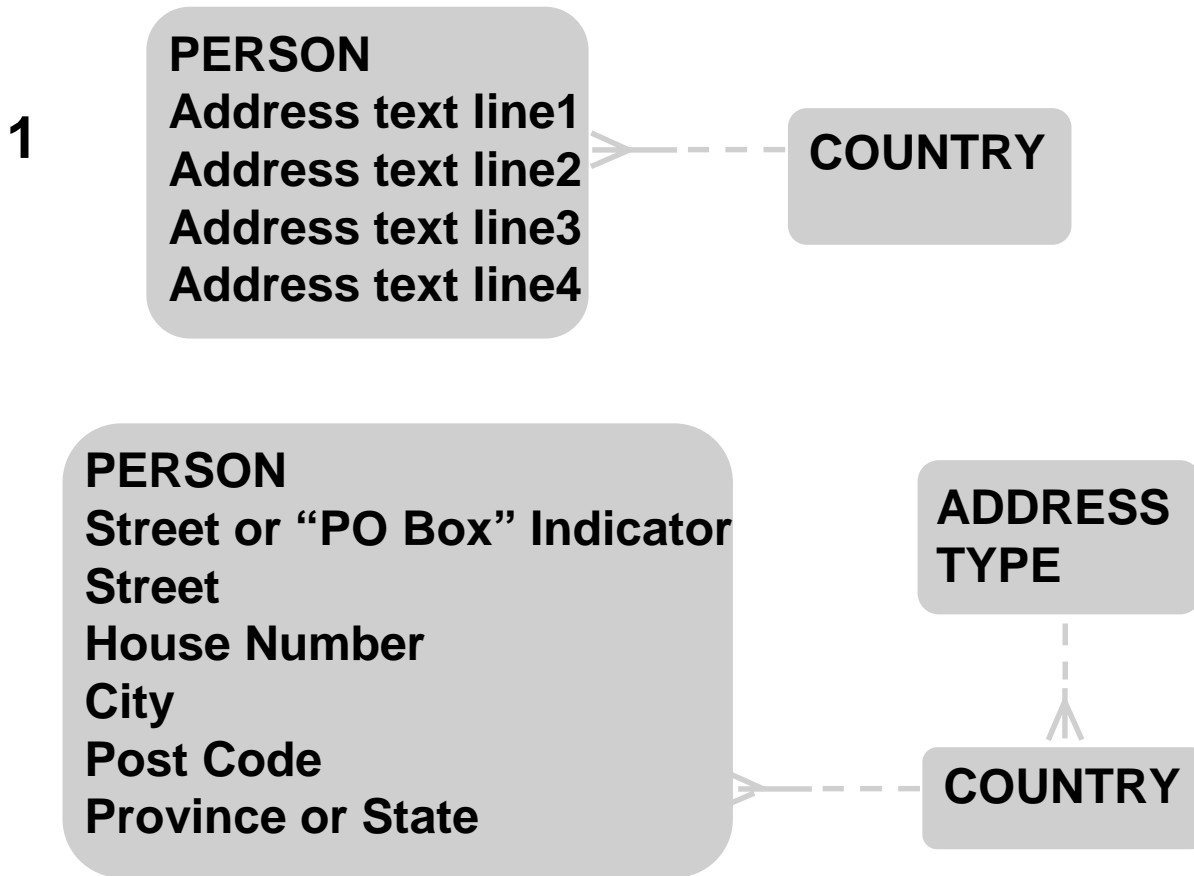
Solution: Schedule (1/2)



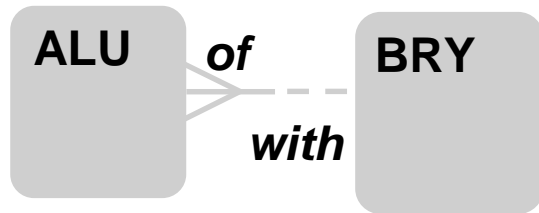
Solution: Schedule (2/2)



Solution: Address



Solution: Read the Relationship



Every ALU must be of exactly one BRY

Every BRY may be with one or more ALUS

Every PUR may be bazooned in one or more YOKS

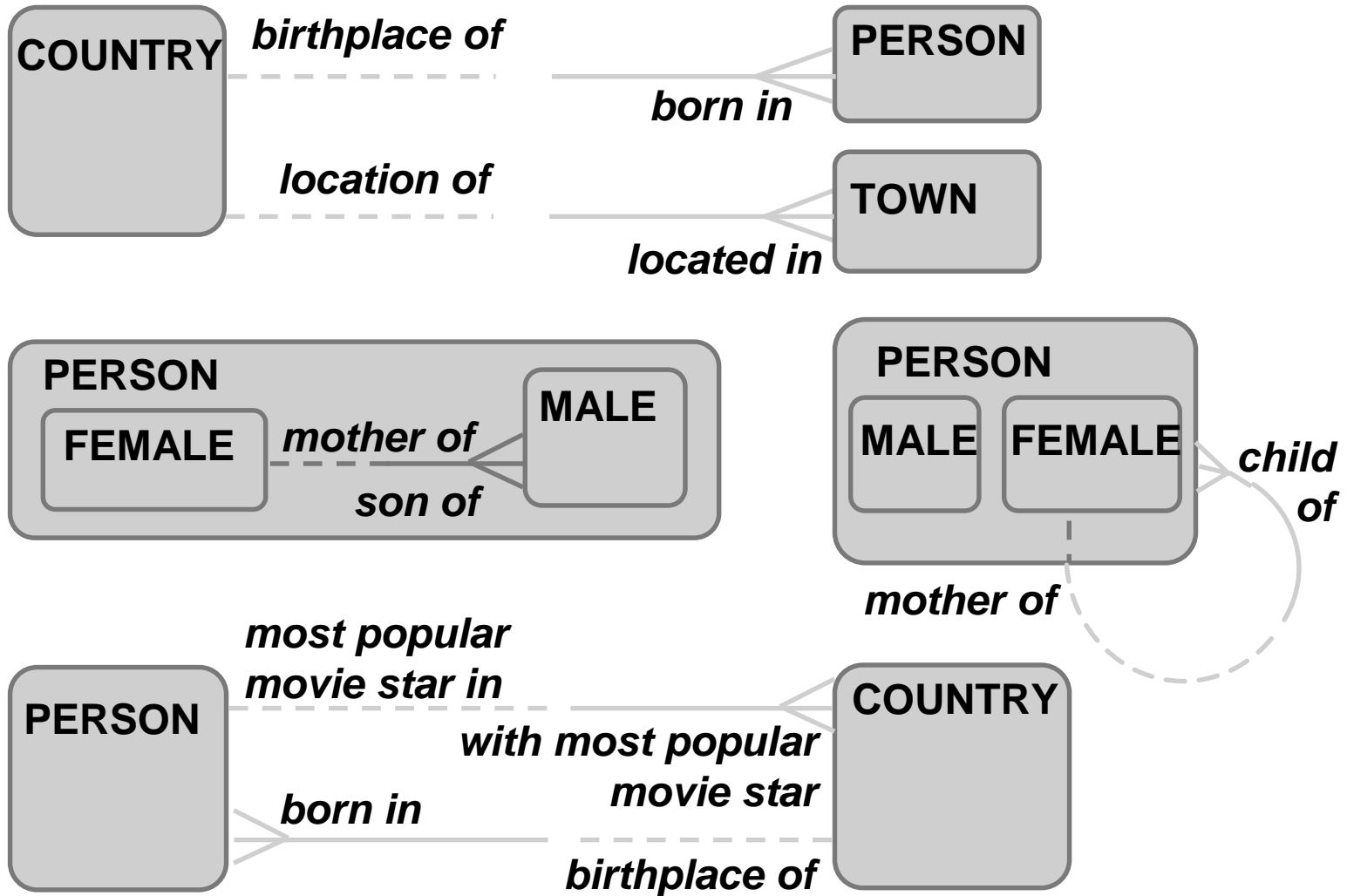
Every YOK may be bazooned by one or more PURS



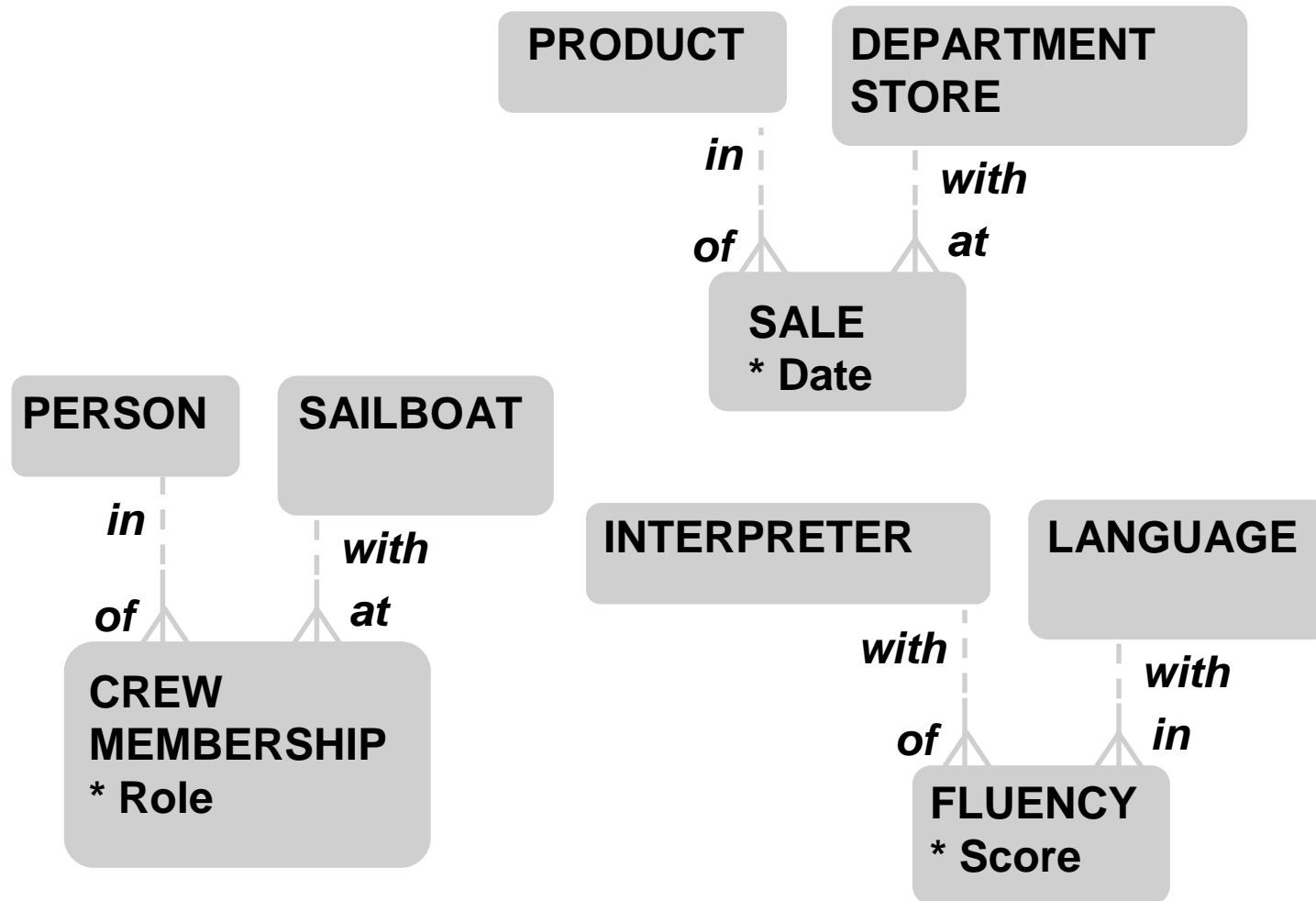
Every KLO must be bilought in one or more HARS

Every HAR may be glazoed with exactly one KLO

Solution: Find a Context



Solution: Name the Intersection Entity



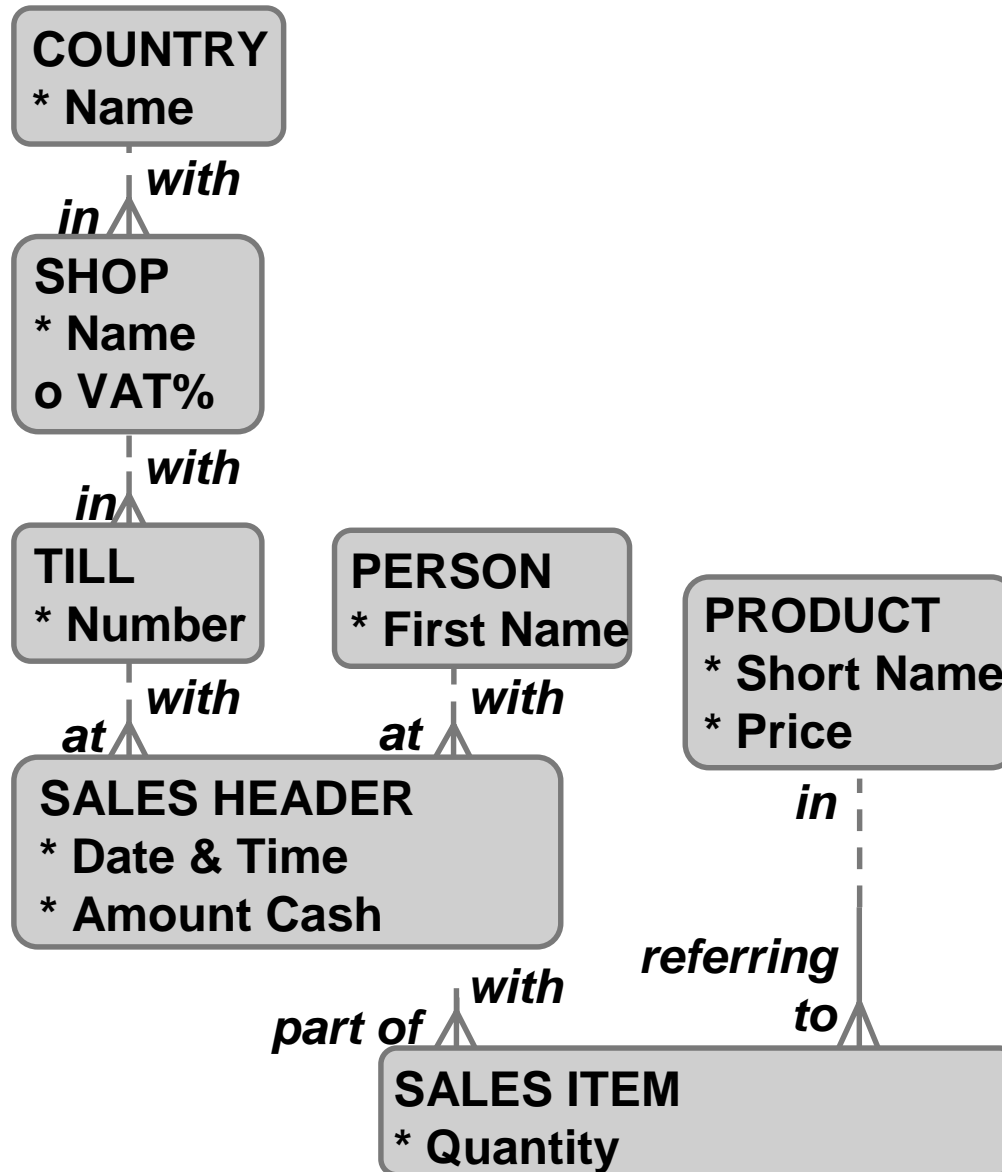
Solution: Receipt

Served by: Dennis
Till: 3 Dec 8, 4:35 pm

CAPPUCC M 3.60
* 2 7.20
CREAM .75
* 2 1.50
APPLE PIE 3.50
BLACKB MUF 4.50
<SUB> 16.70
tax 12% 2.00
<TOTAL> 18.70
=====

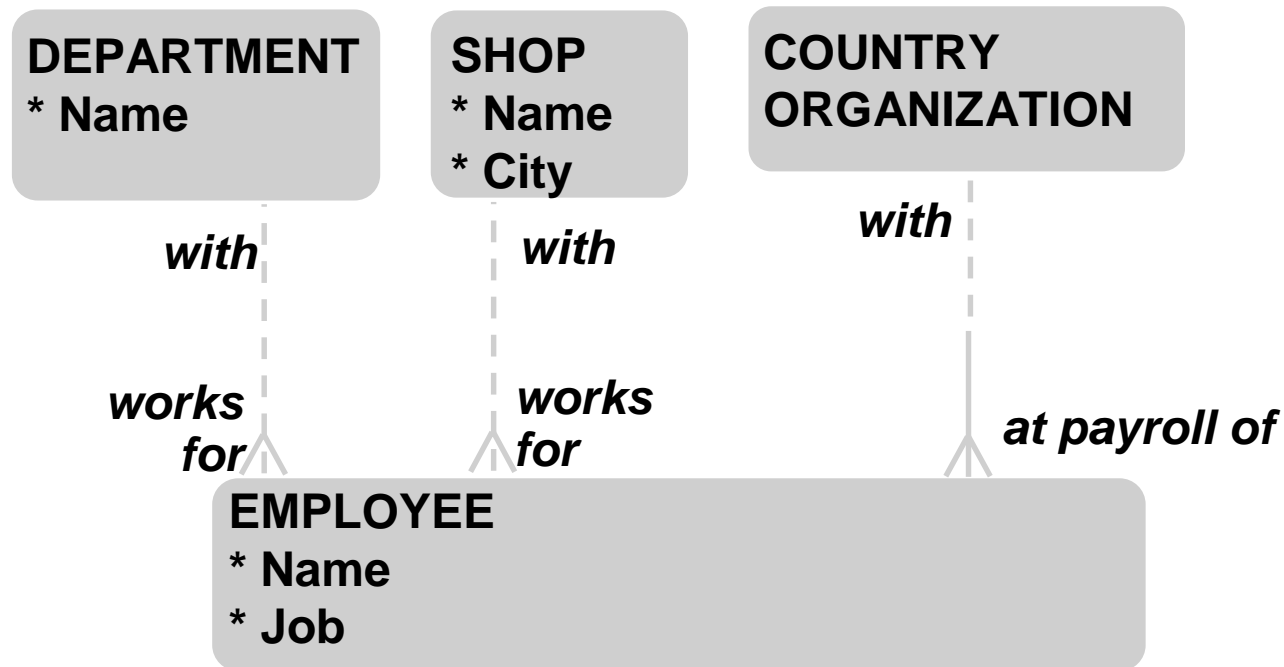
CASH	20.00
RETURN	1.30

Hope to serve you again
@MOONLIGHT COFFEES
25 Phillis Rd. Atlanta

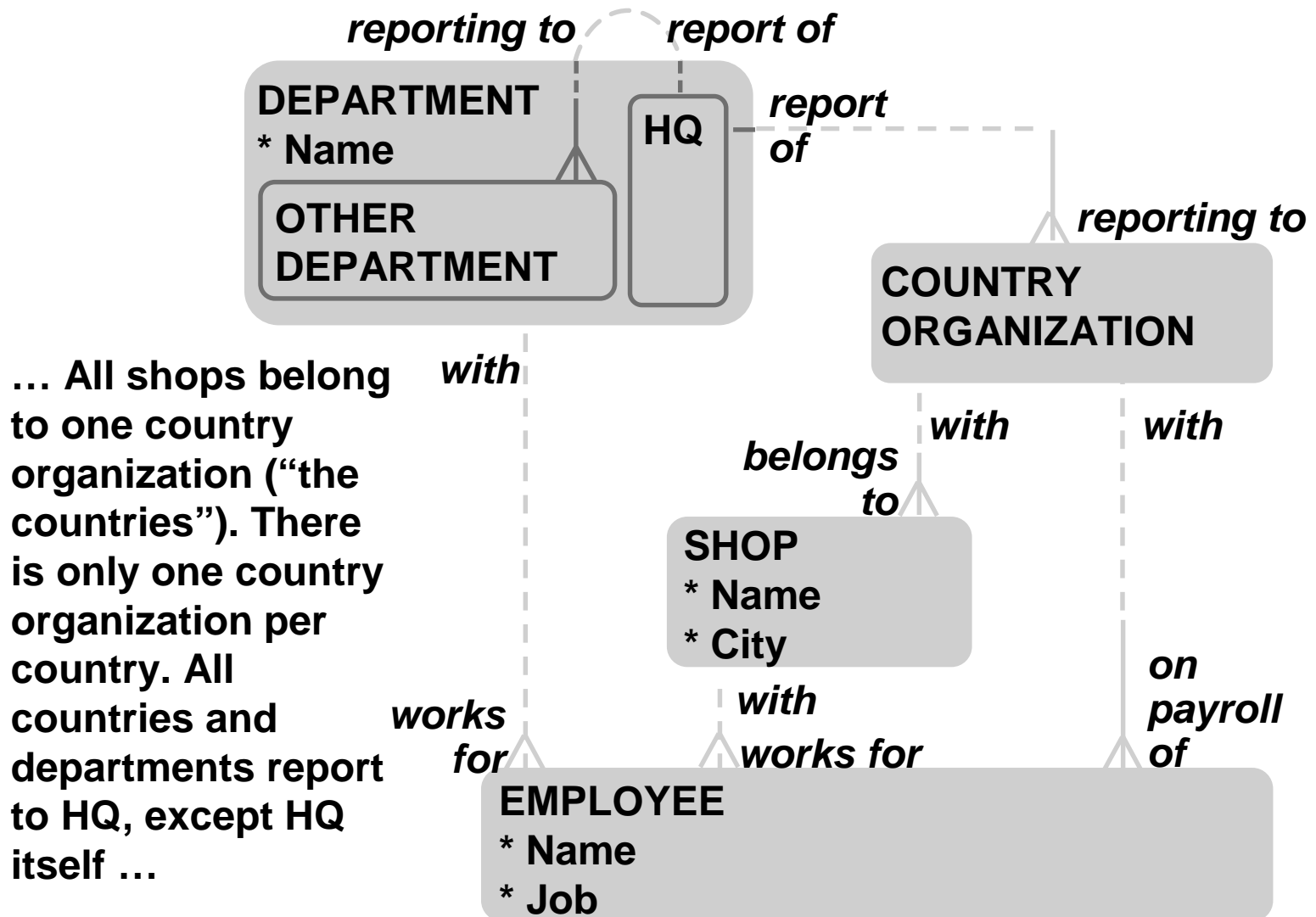


Solution: Moonlight P&O (1)

All Moonlight Coffee employees work for a department such as “Global Pricing” or “HQ”, or for a shop. All employees are at the payroll of one of our country organizations. Jill, for example, works as a shop manager in London; Werner is a financial administrator working for Accounting and is located in Germany ...

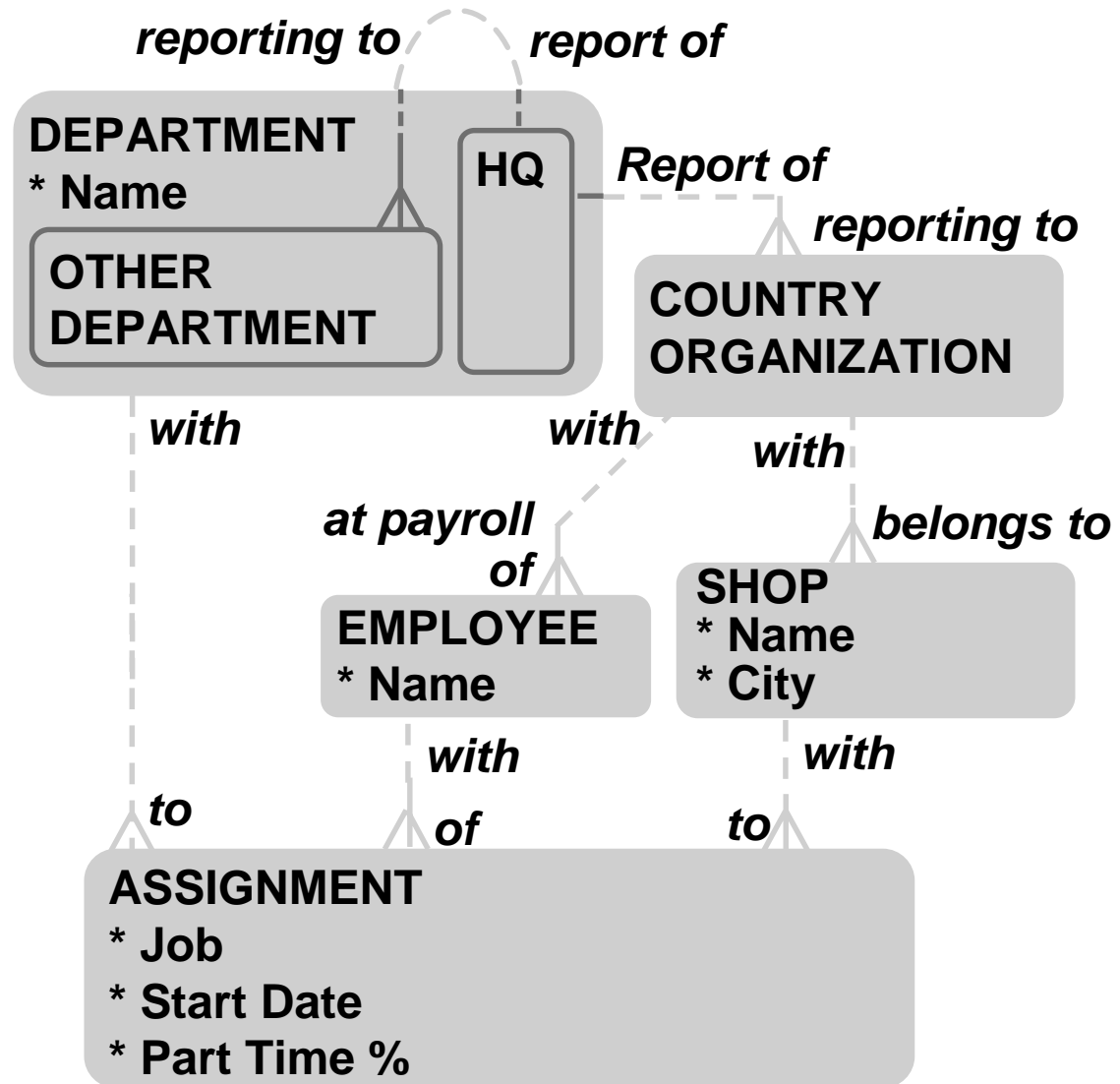


Solution: Moonlight P&O (2)



Solution: Moonlight P&O (3)

... Employees can work part time. Lynn has had an 80% assignment for Product Development since the 1st September. Before that she had a full-time position.



Solution: Moonlight P&O (4)

4a: -



with

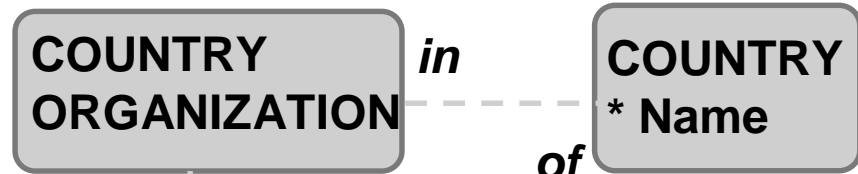
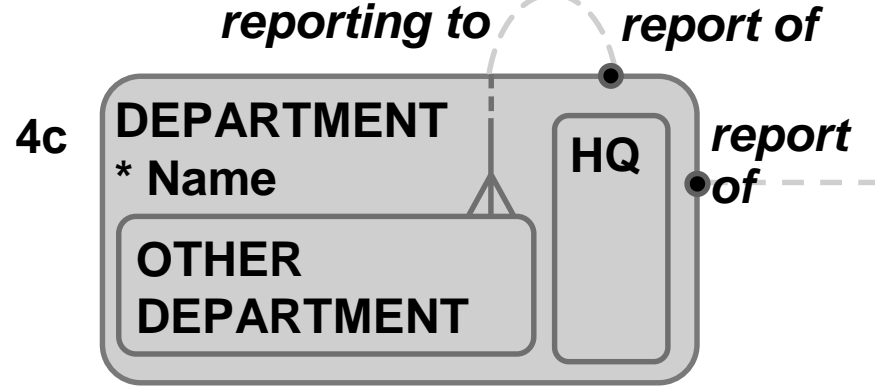
for

for



with

4e: -



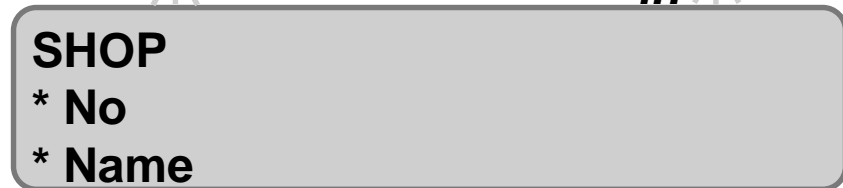
4d

with

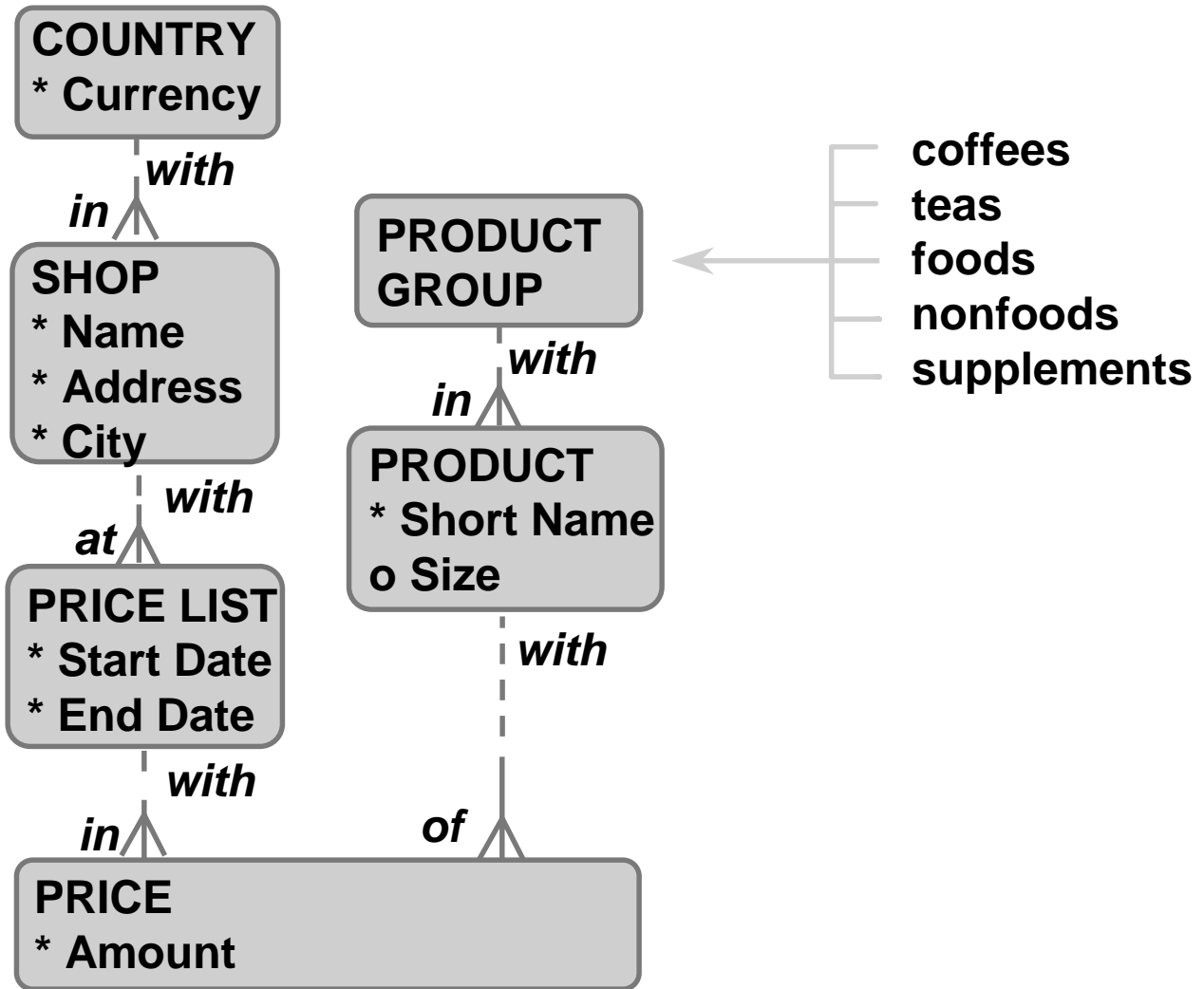
belongs to

located in

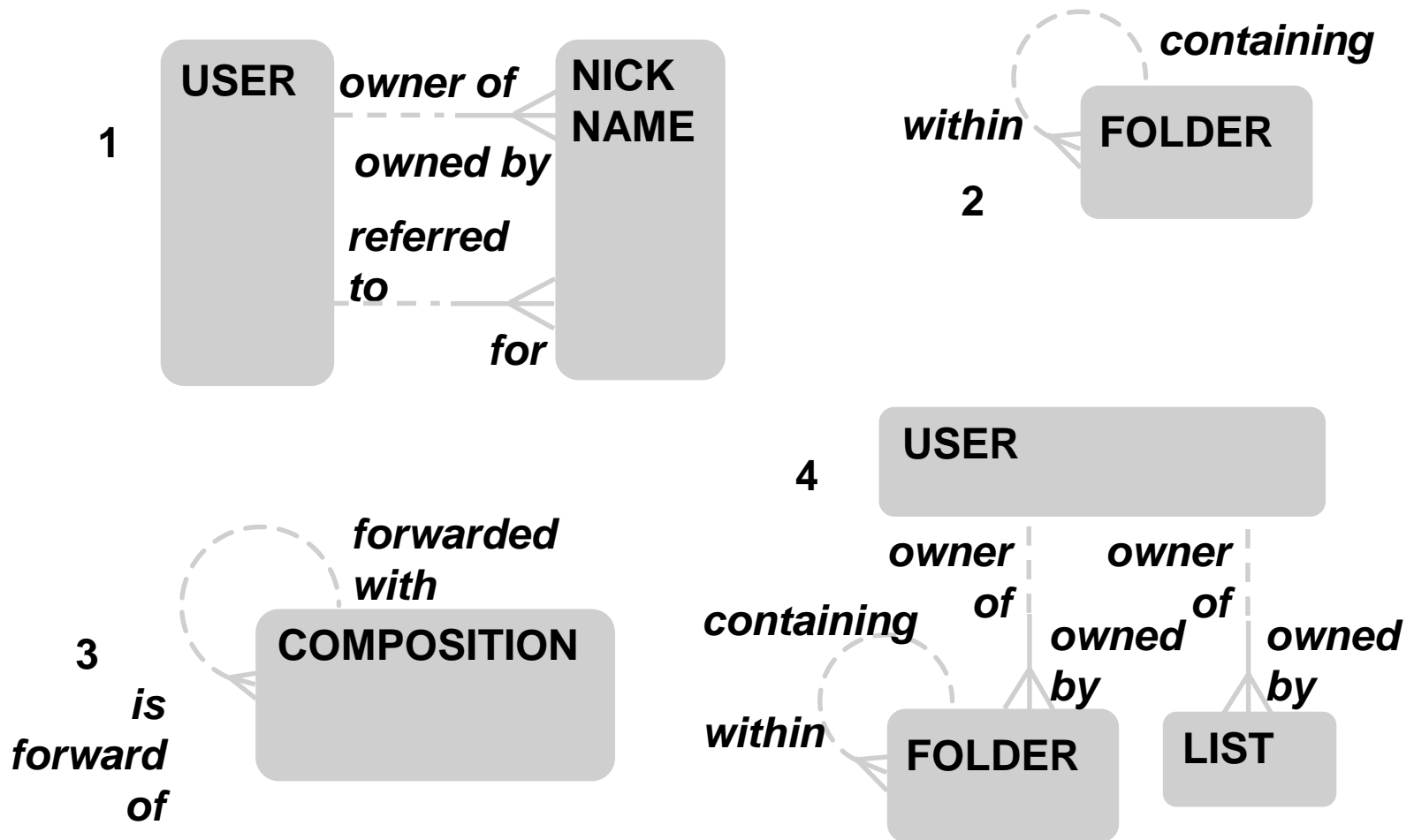
of

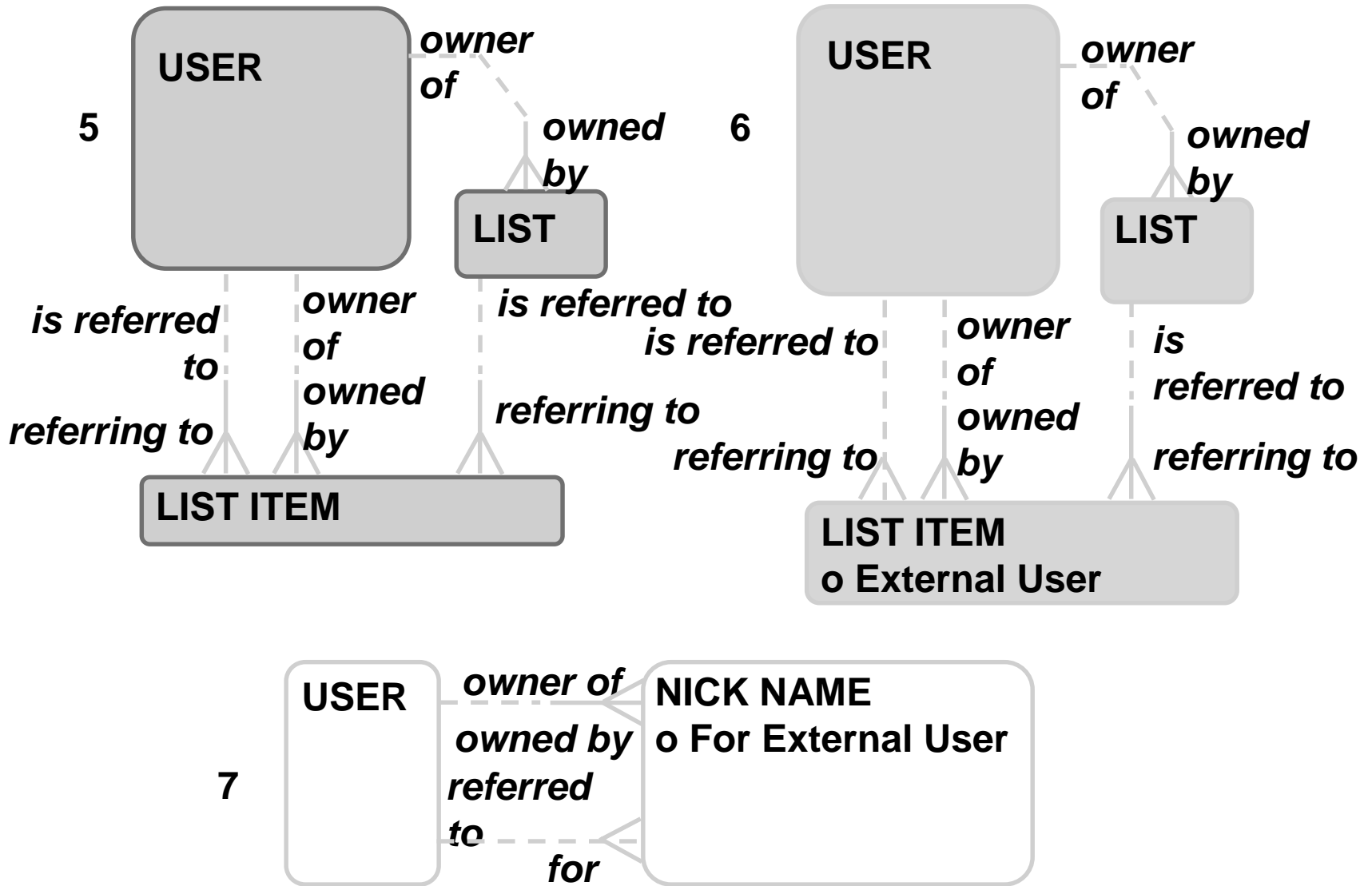


Solution: Price List



Solution: EMail

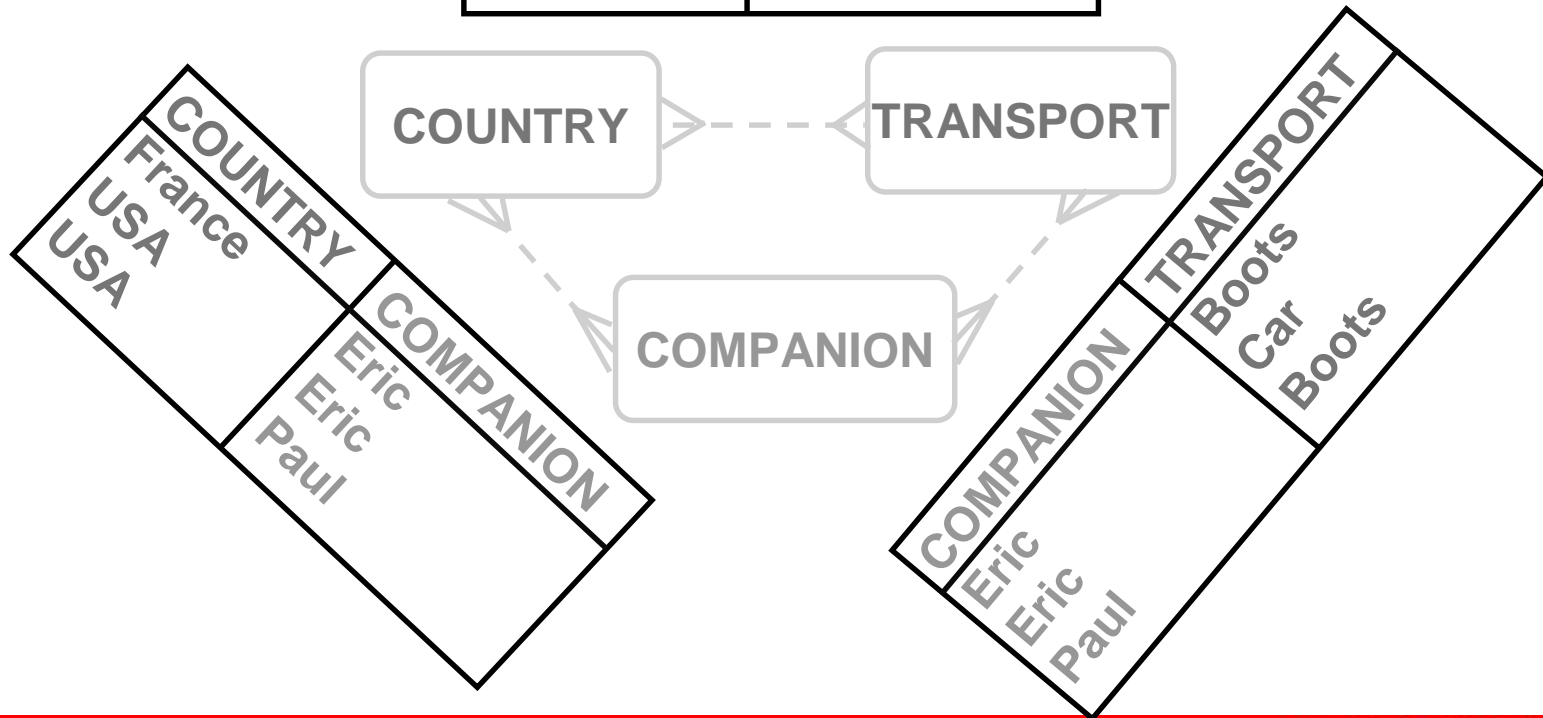




Solution: Holiday (1)


“Paul and I hiked in the USA. Eric and I hiked in France and we rented a car in the USA last year”.

COUNTRY	TRANSPORT
France	Boots
USA	Boots
USA	Car



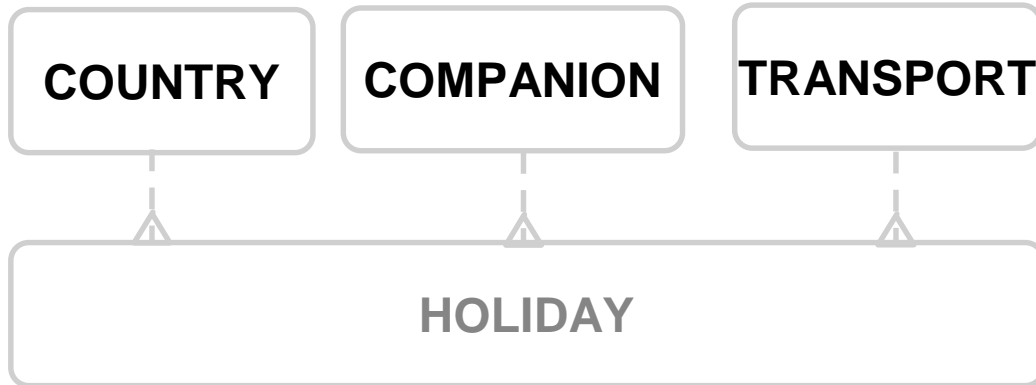
Solution: Holiday (2)

COUNTRY	COMPANION	TRANSPORT
France	Eric	Boots
France	Eric	Car
USA	Eric	Boots
USA	Eric	Car
USA	Paul	Boots



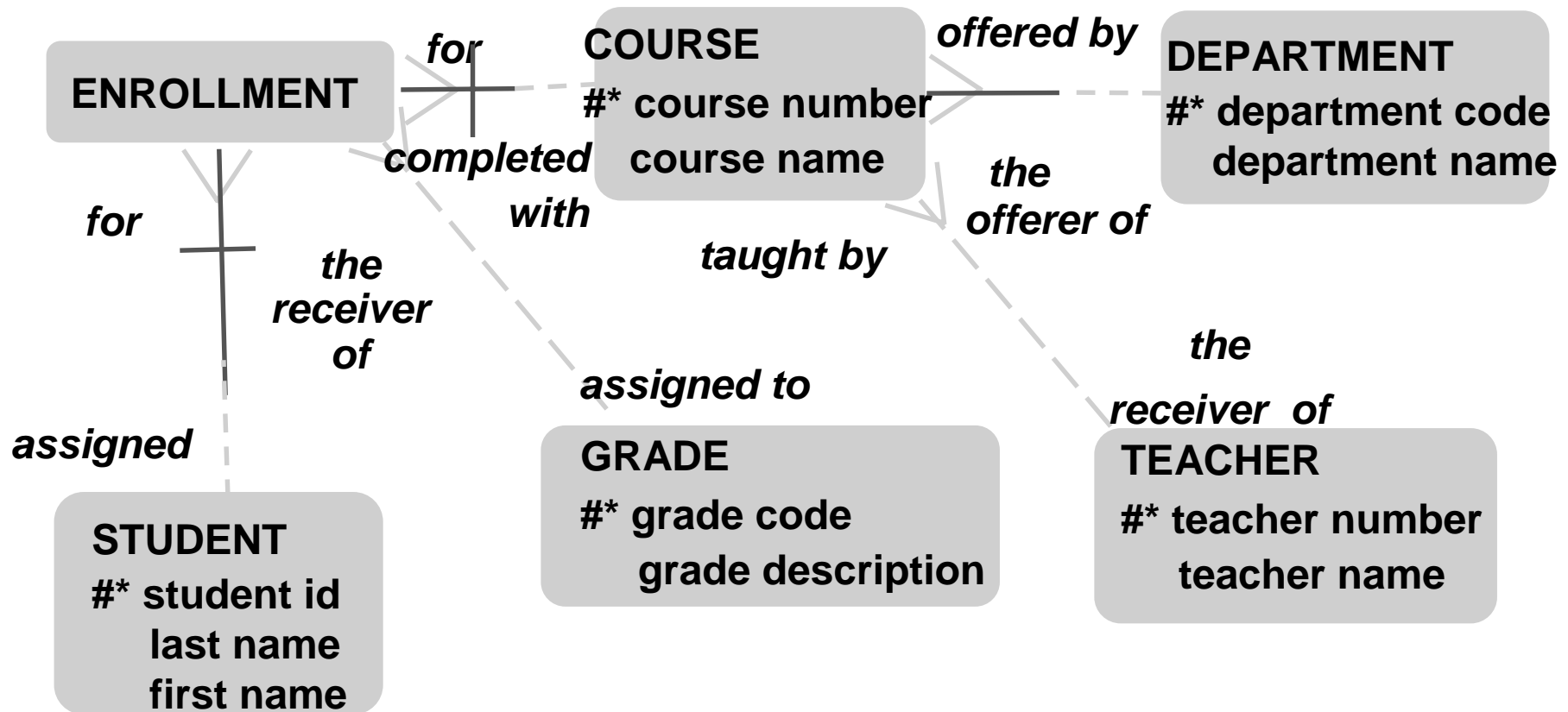
Solution: Holiday (3)

COUNTRY	COMPANION	TRANSPORT
France	Eric	Boots
USA	Paul	Car

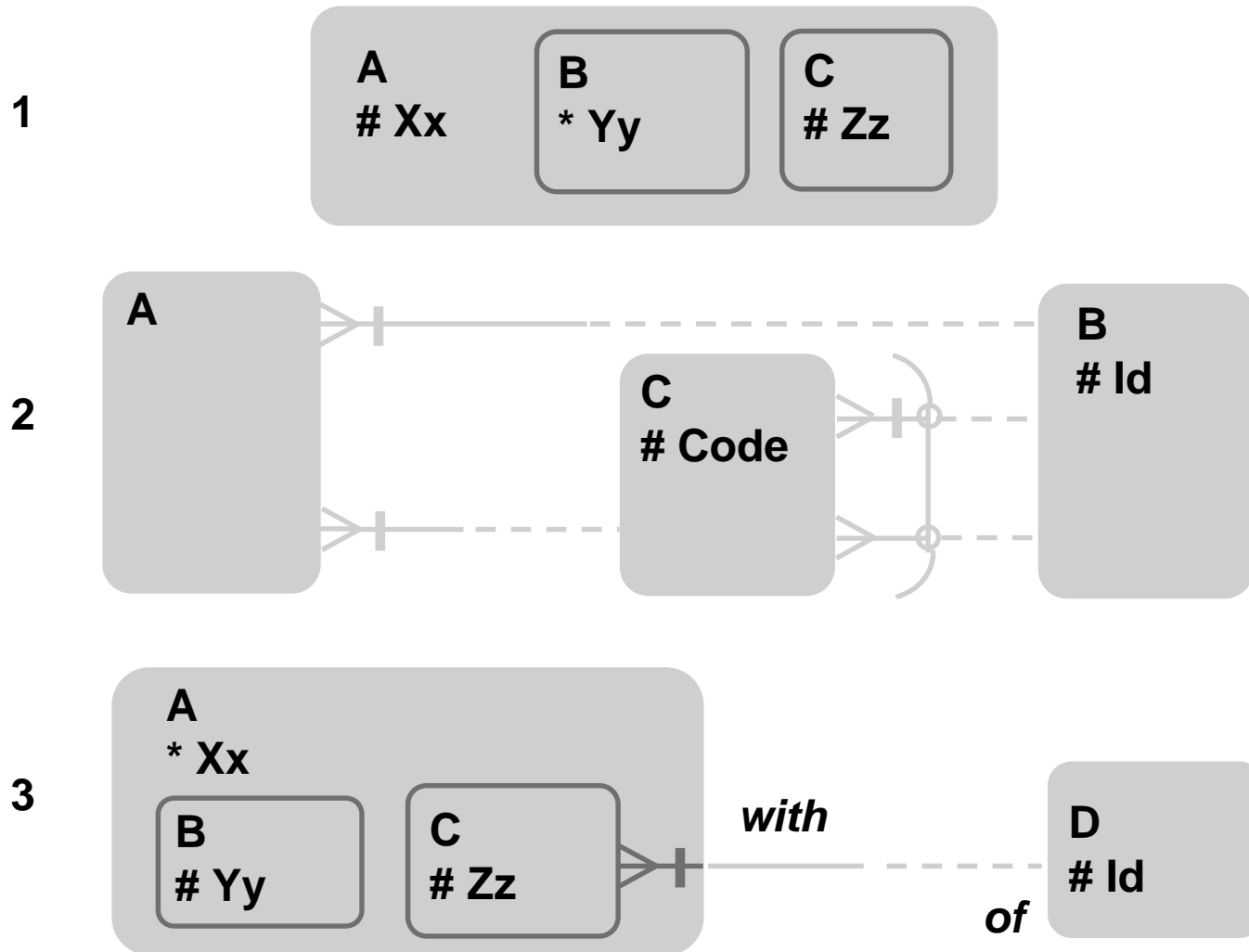


COUNTRY	COMPANION	TRANSPORT
France	Eric	Boots
USA	Eric	Car
USA	Paul	Boots

Practice: Normalize an ER Model: Solution

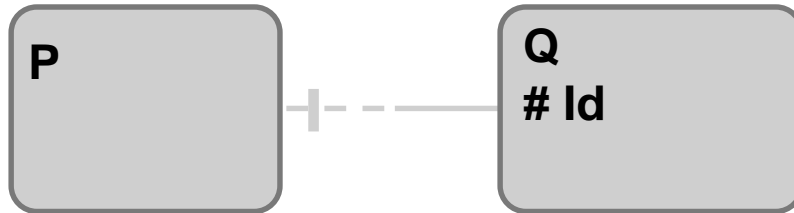


Solution: Identification 1

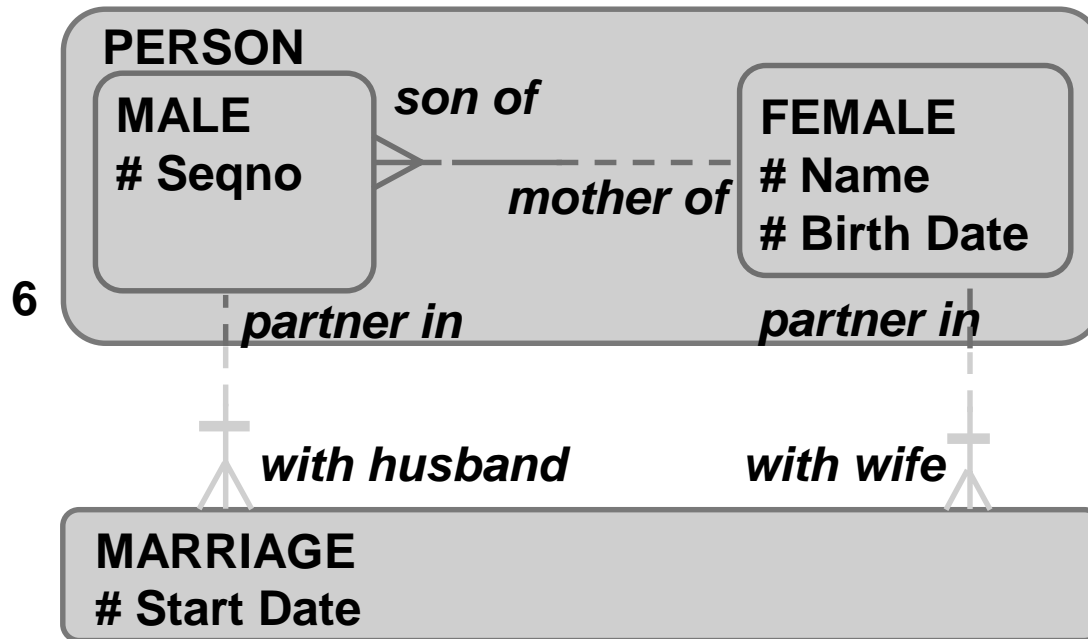
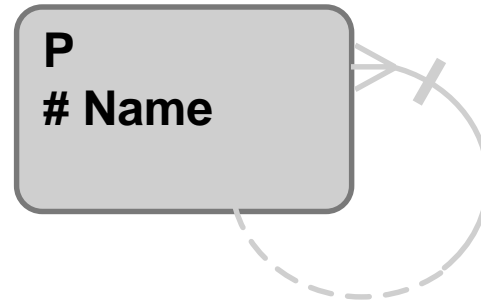


Solution: Identification 2

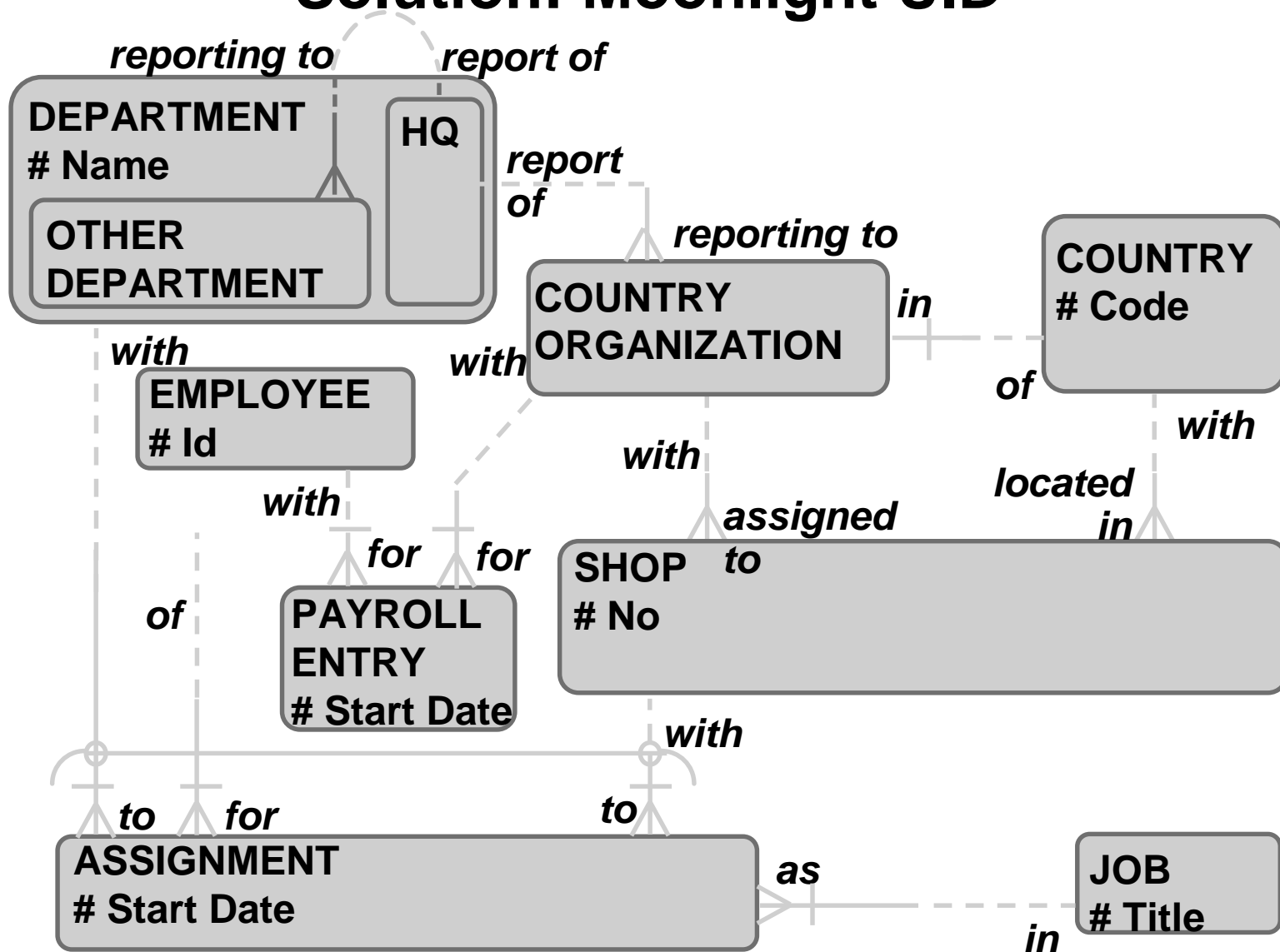
4



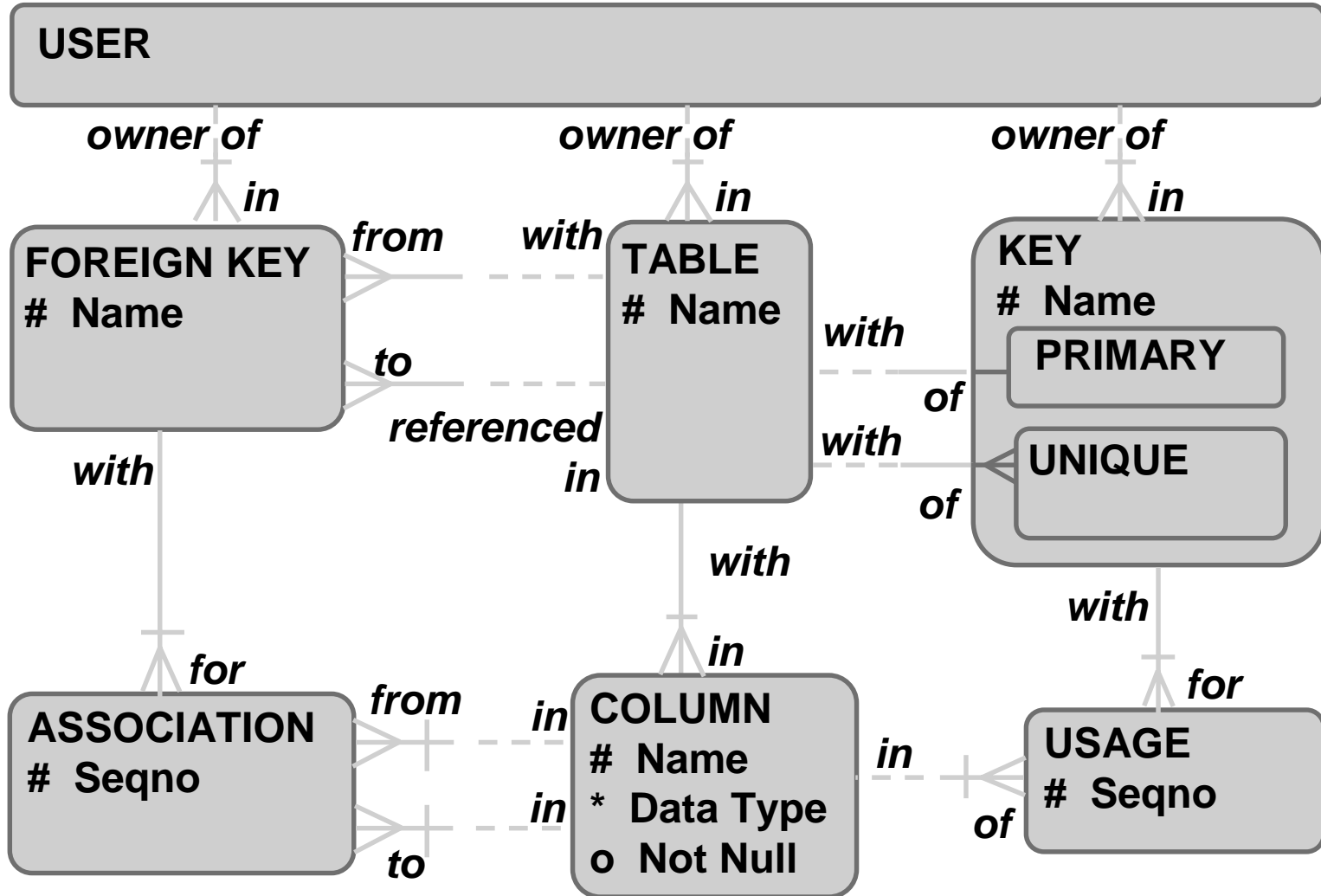
5



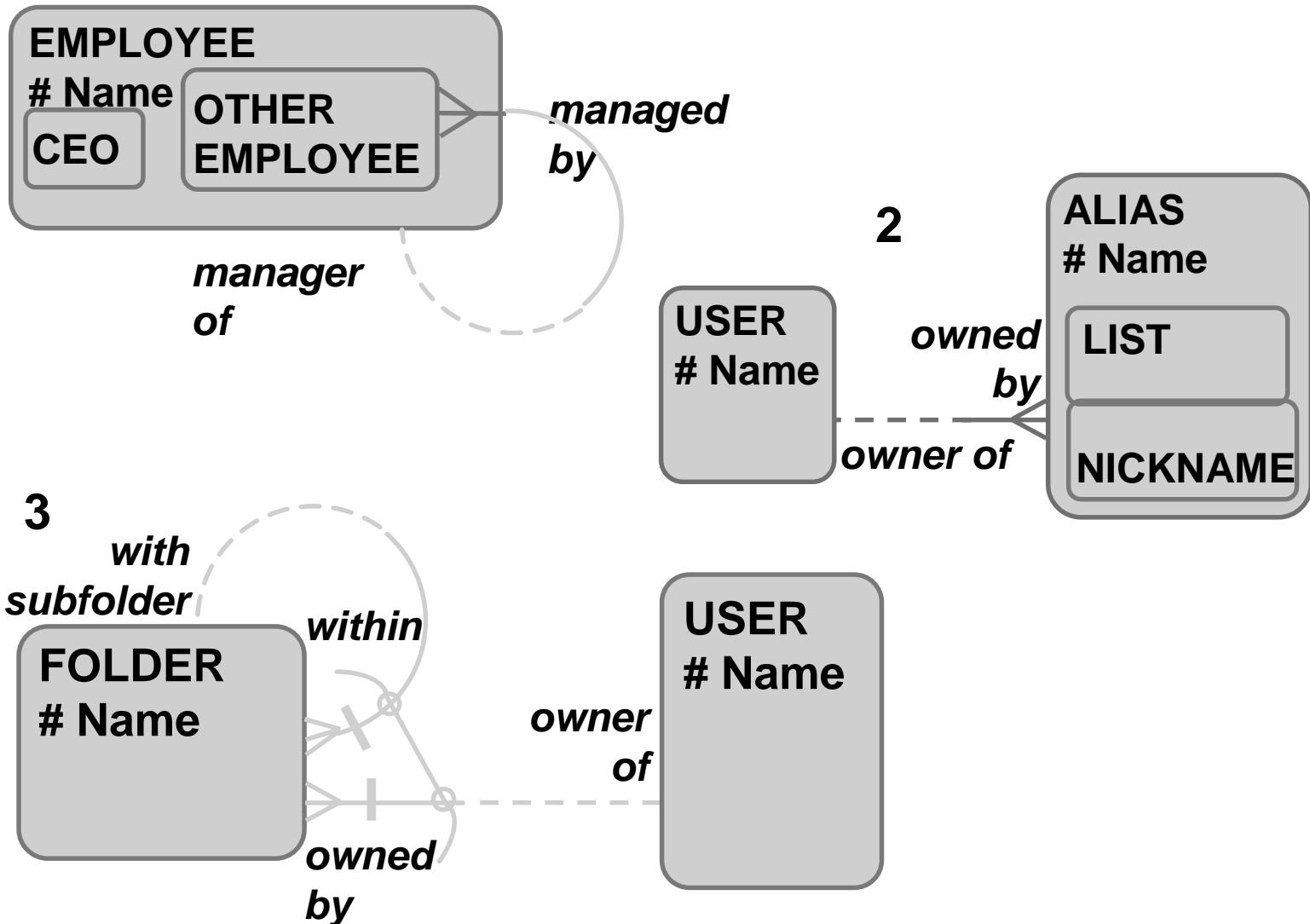
Solution: Moonlight UID



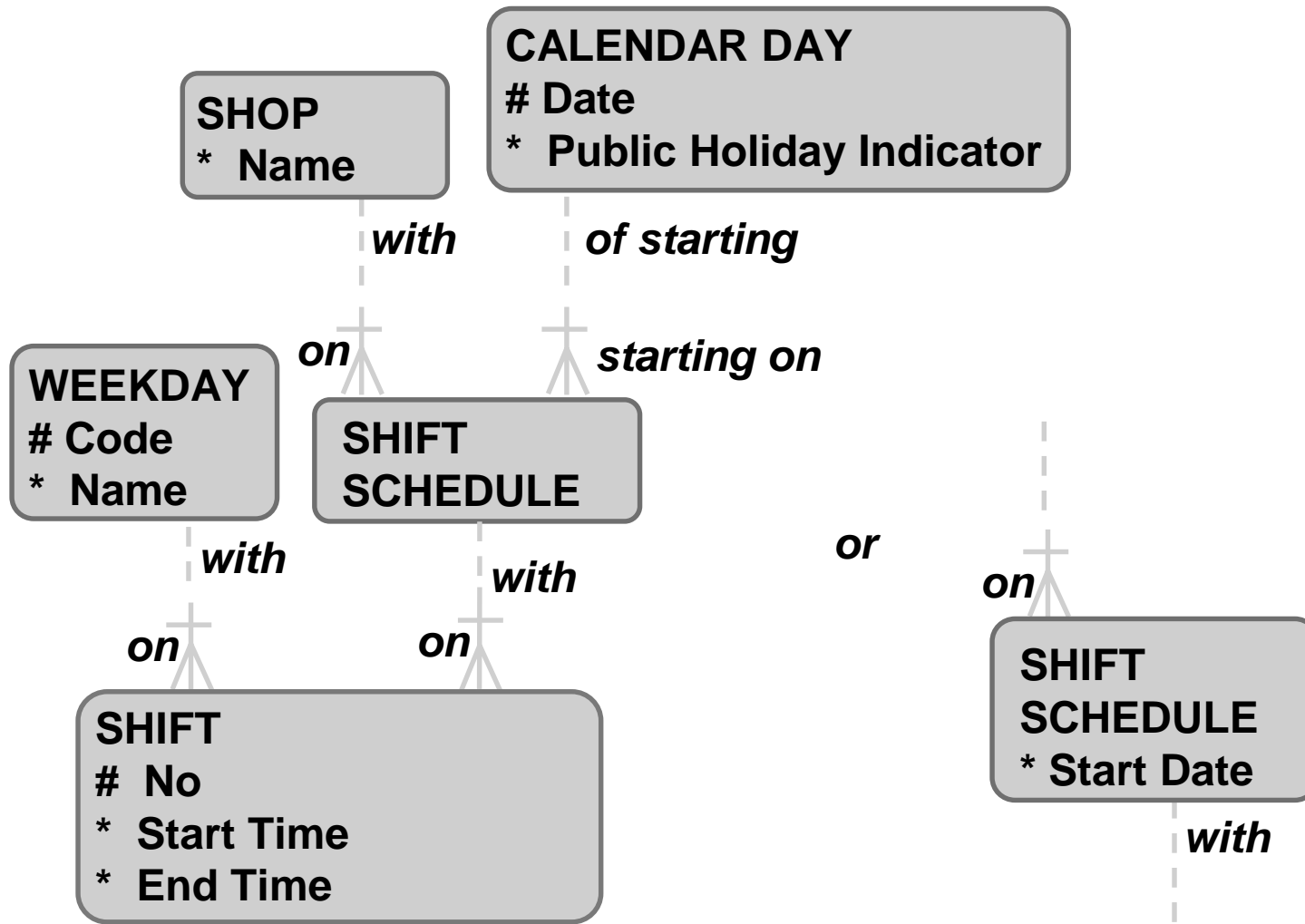
Solution: Table



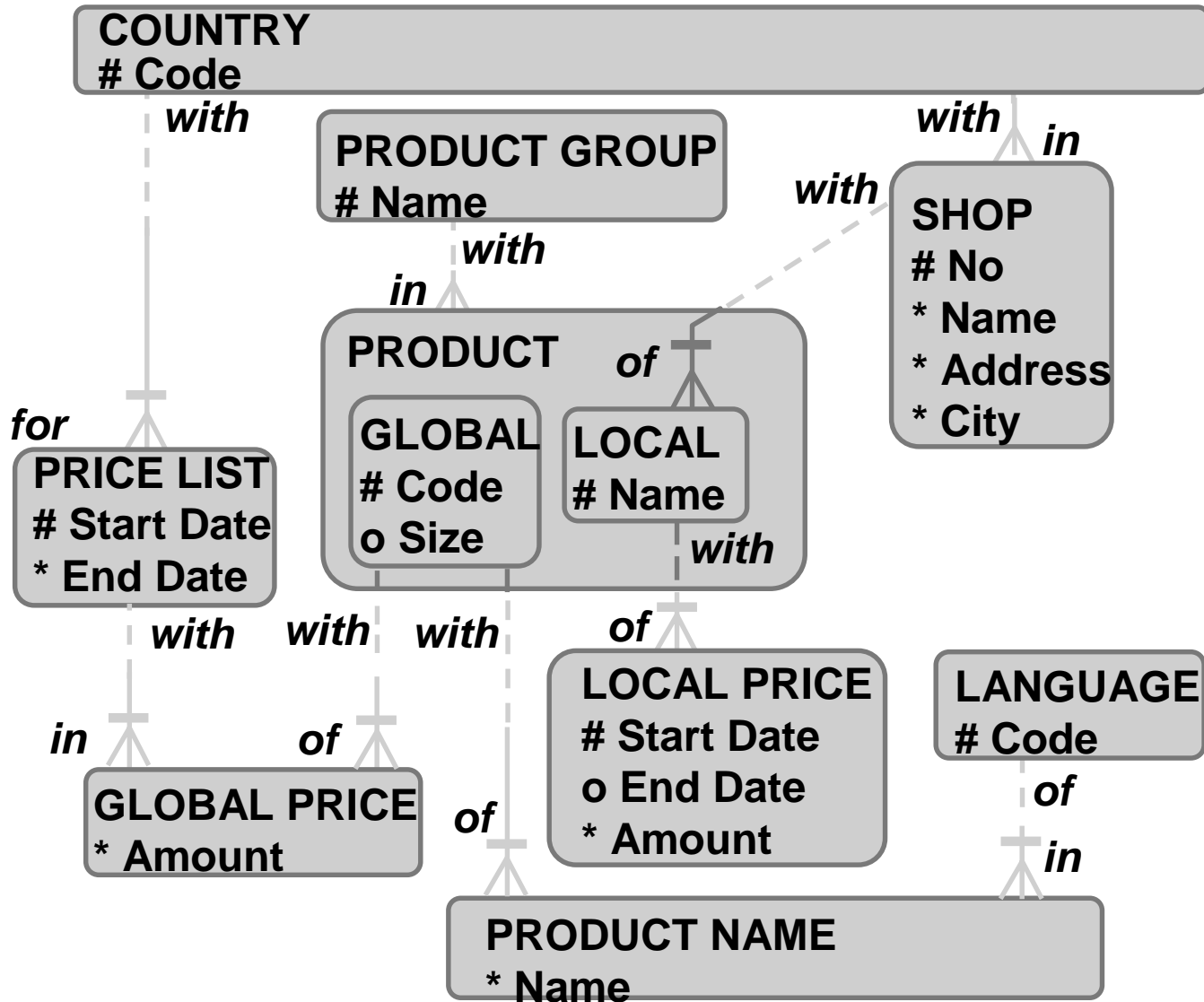
1 Solution: Constraints

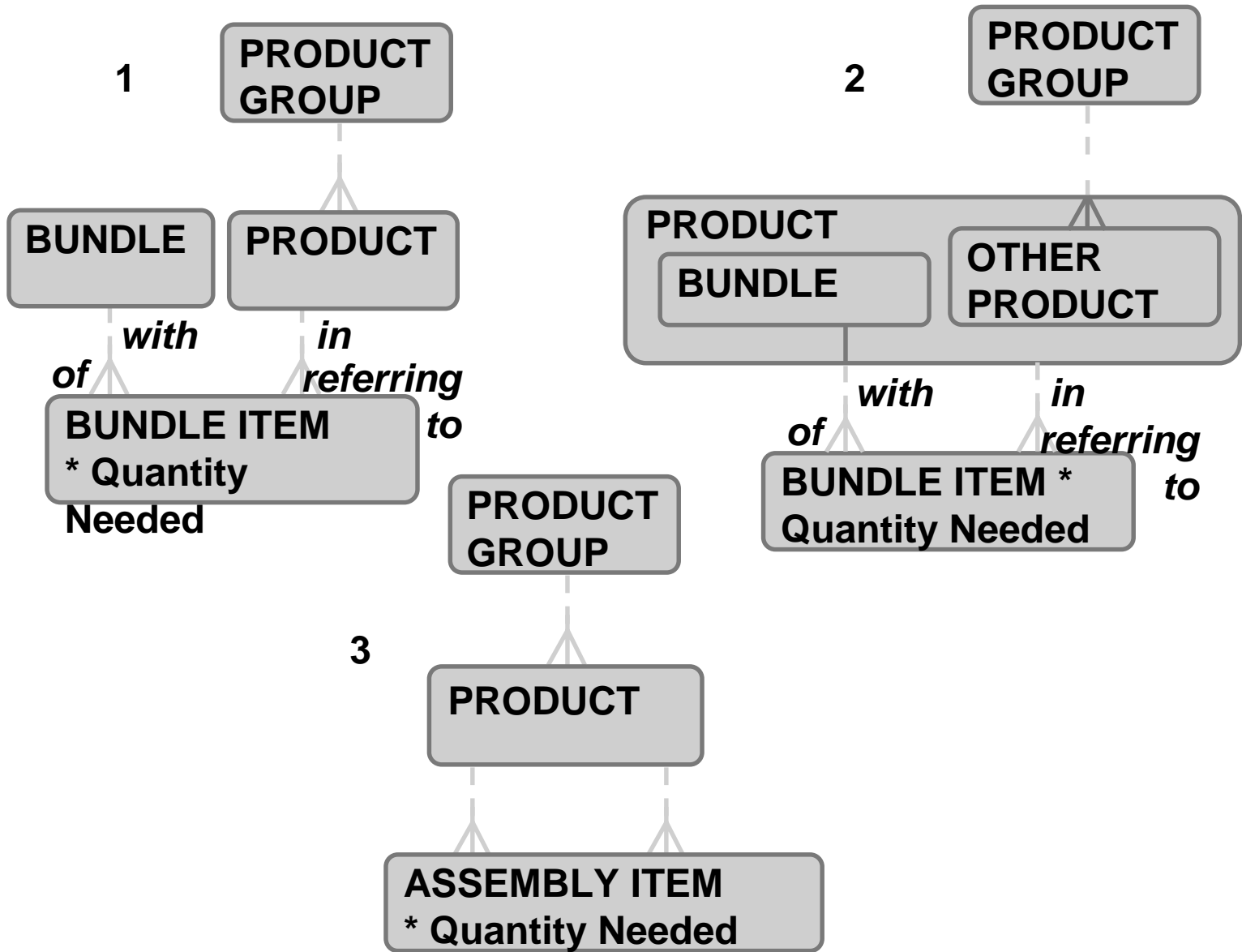


Solution: Shift

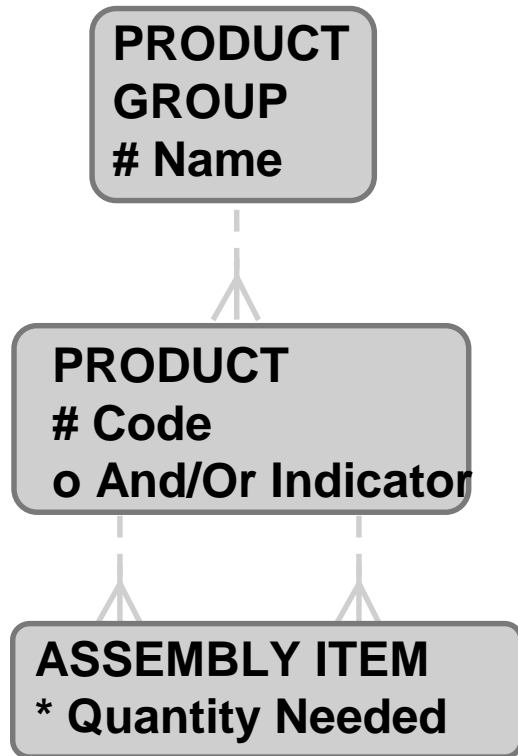


Solution: Moonlight Pricing





DecafPunch (DP) = {Coffee (C) or Tea (T)} and {Blackberry Muffin (BM)}



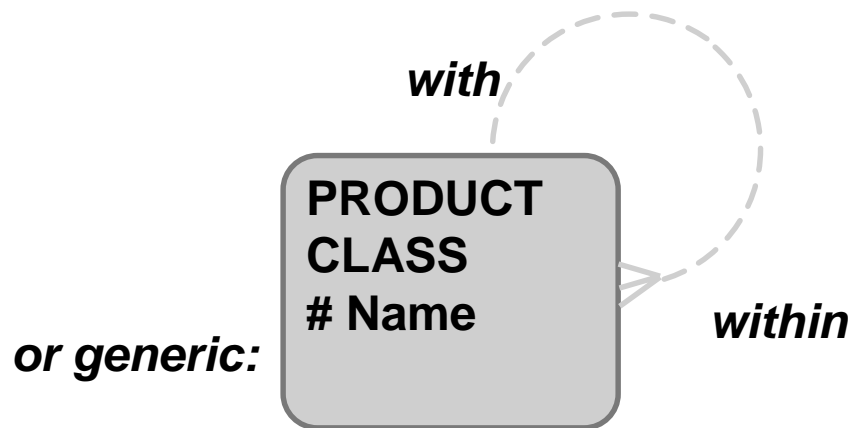
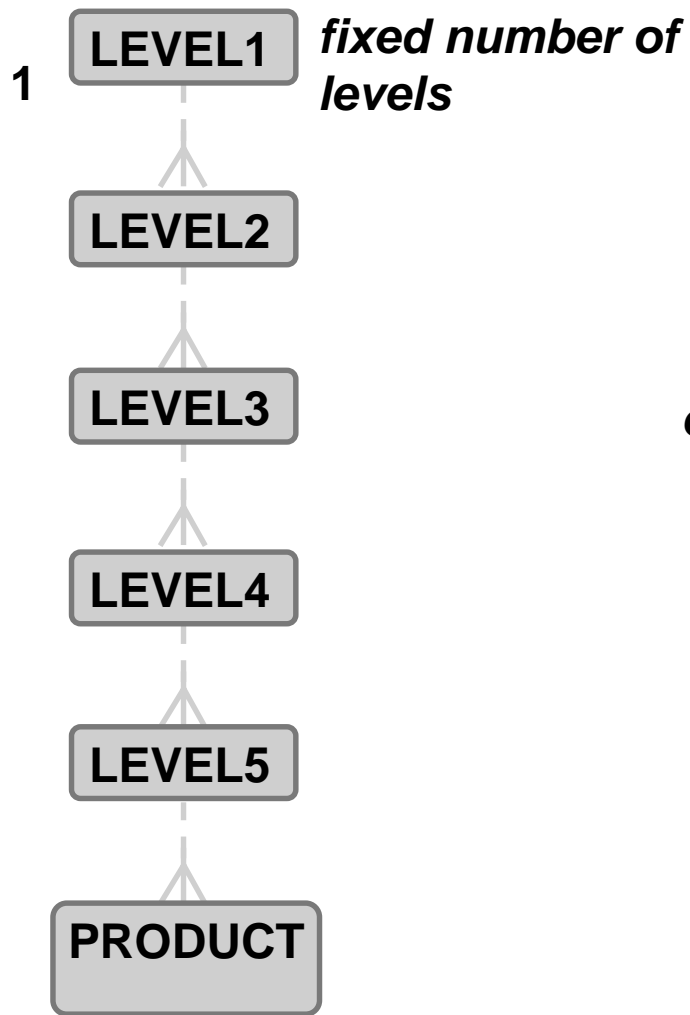
Consider this as:
 AS1 = (C or T)
 DP = (AS1 and BM)

PRODUCTS

Code	And_or	Pg_name
C		..
T		...
AS1	OR
DP	AND

ASSEMBLY ITEMS

Prod_code	Using_code	Quantity
AS1	C	1
AS1	T	1
DP	AS1	1
DP	BM	1



2



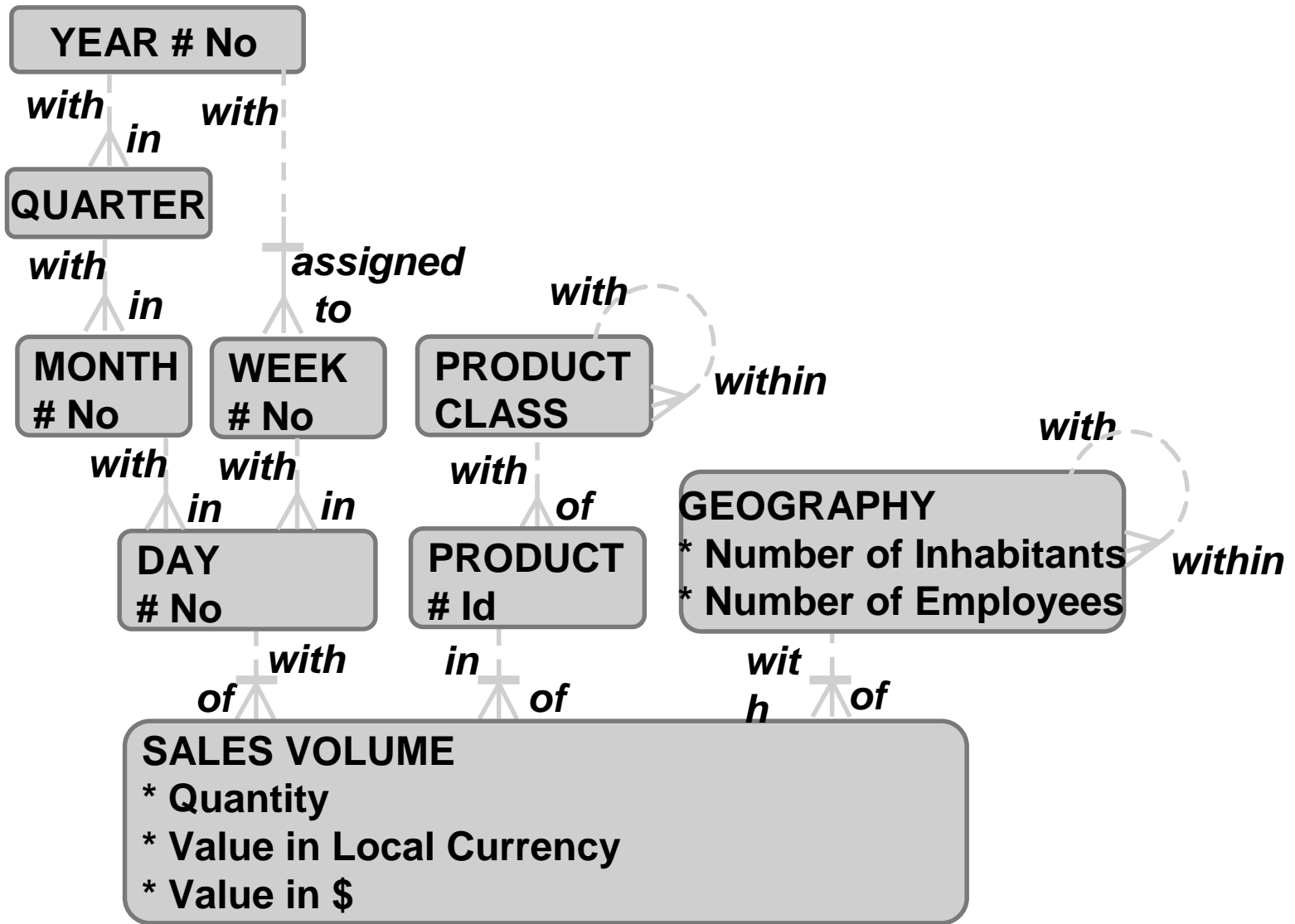
Patterns

- | | |
|--|-------------------------|
| • Model of moves in a chess game | Chain or Network |
| • Model of quotations | M/D or Basket |
| • Model of recipes | Bill of Material |
| • Model of all people involved in college: students, teachers, parents, ... | Roles |
| • Rentals in a video shop | M/D or Basket |
| • Model of phases in a process | Chain or Network |

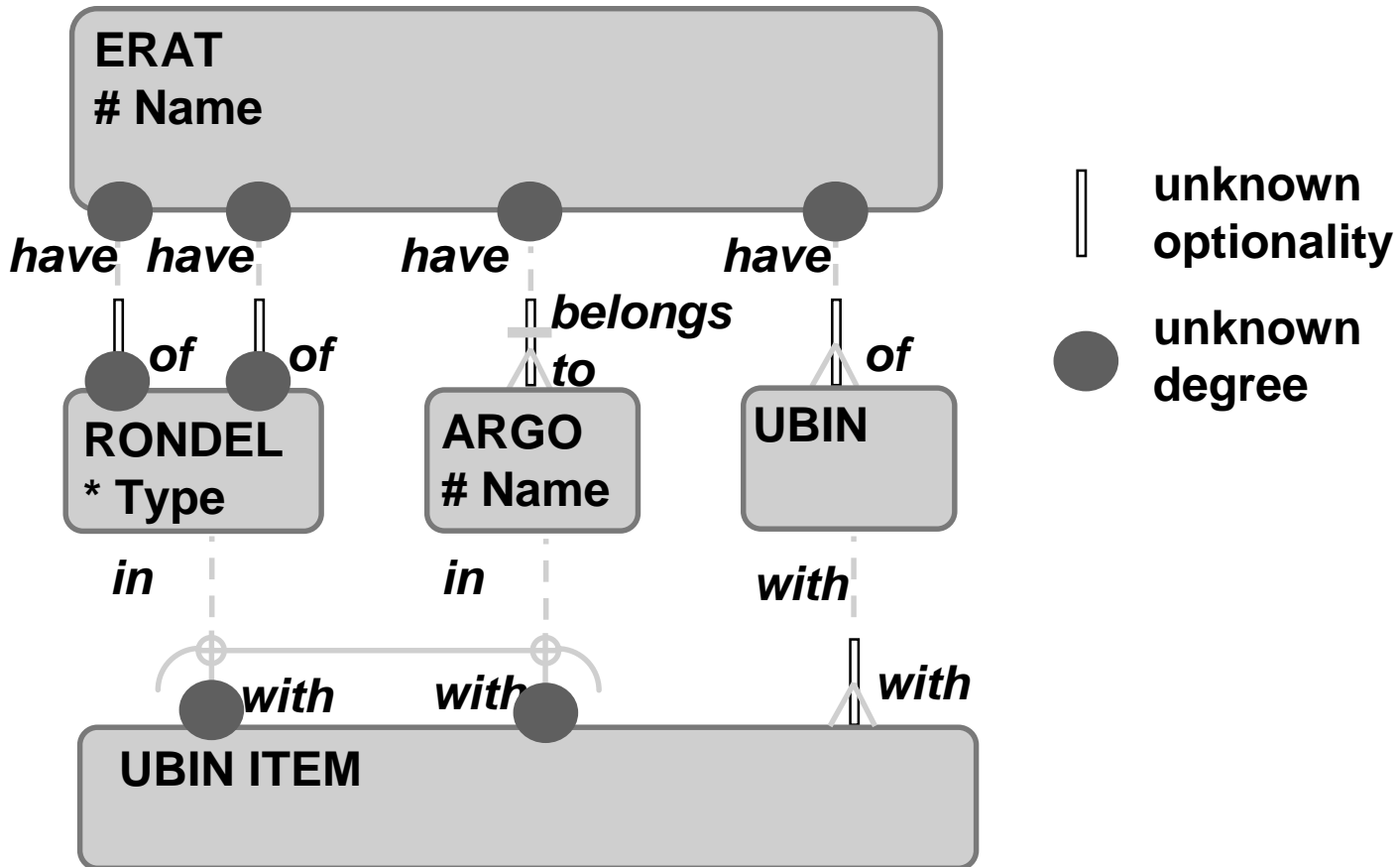
Patterns

- | | |
|--|-------------------------|
| • Model of moves in a chess game | Chain or Network |
| • Model of quotations | M/D or Basket |
| • Model of recipes | Bill of Material |
| • Model of all people involved in college: students, teachers, parents, ... | Roles |
| • Rentals in a video shop | M/D or Basket |
| • Model of phases in a process | Chain or Network |

Moonlight Data Warehouse



Solution: Argos and Erats



Constraint not shown:

A ubin always consists of one or more argos of the erat, one or more...

Solution: Synonym

MEANING
Id
* Description

shared by
with

WORD
Word

MEANINGS

Id	Description
1	Action, actual doing ...
2	Regular arrangement ...
3	Order, command ...
4	A vehicle with two wheels
5	

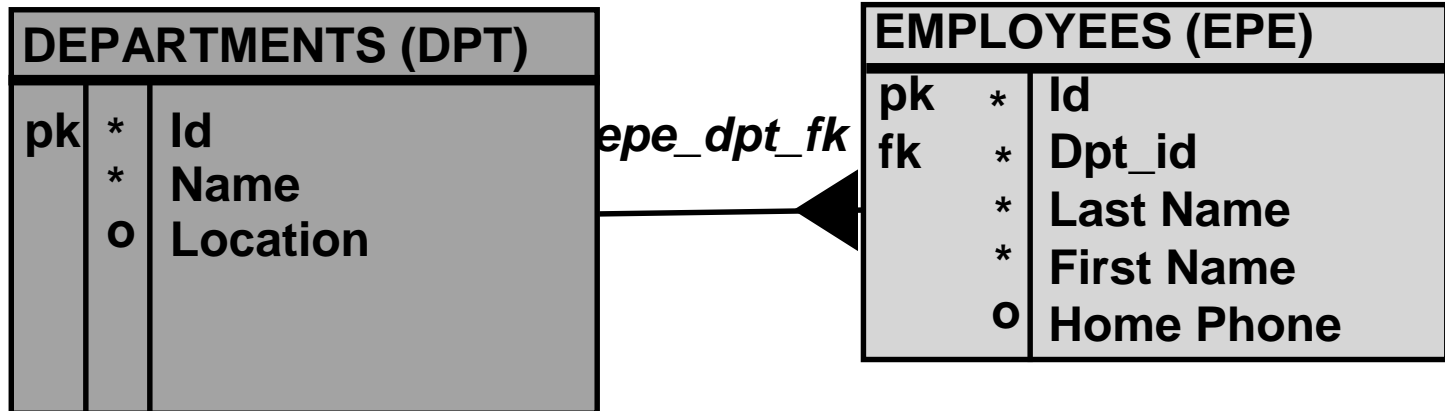
WORDS

Word	Mng_i
Practice	d
Exercise	1
Order	1
Sequence	2
Arrangement	2
Order	2
Command	3
Demand	3
Bike	3

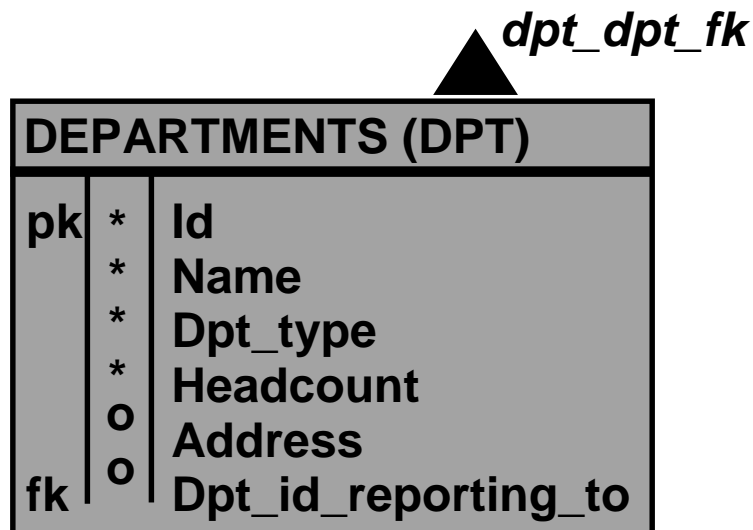
synonym

homonym

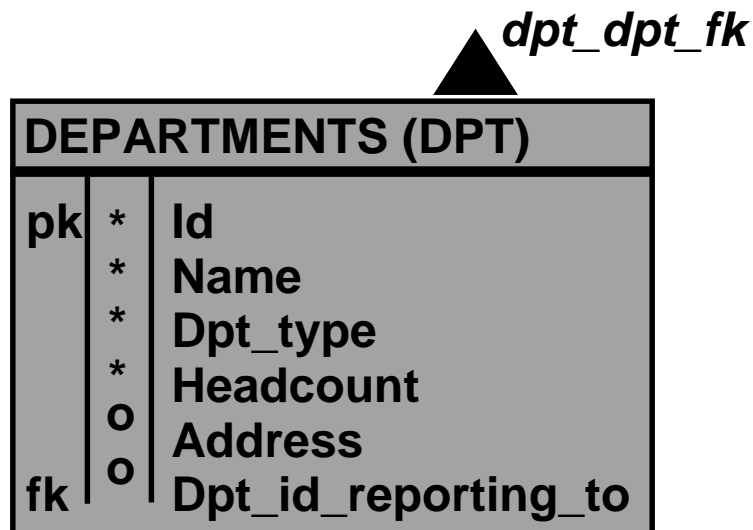
Solution: Mapping basic Entities, Attributes and Relationships



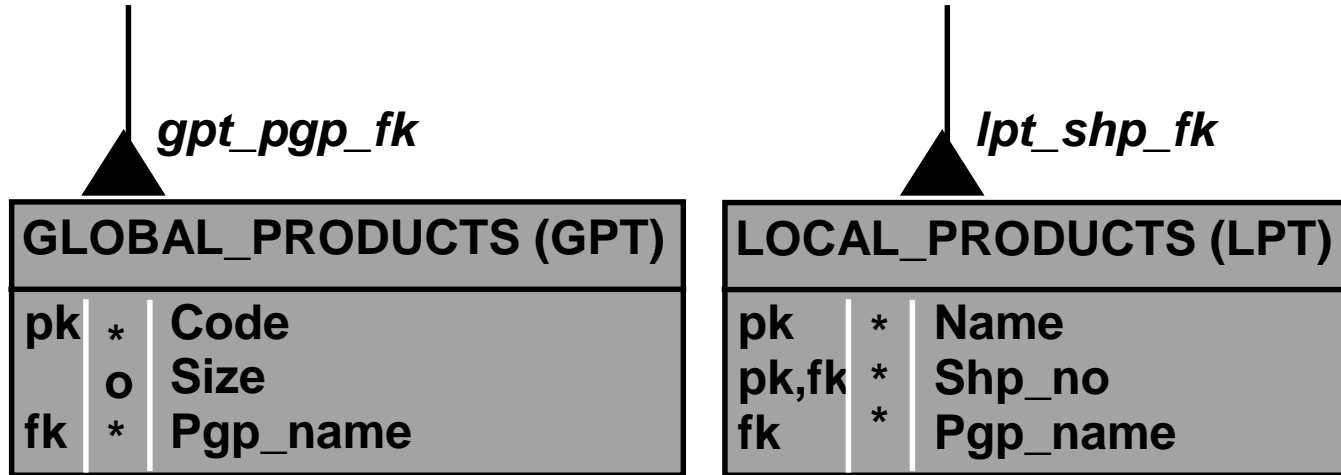
Solution: Mapping Supertype



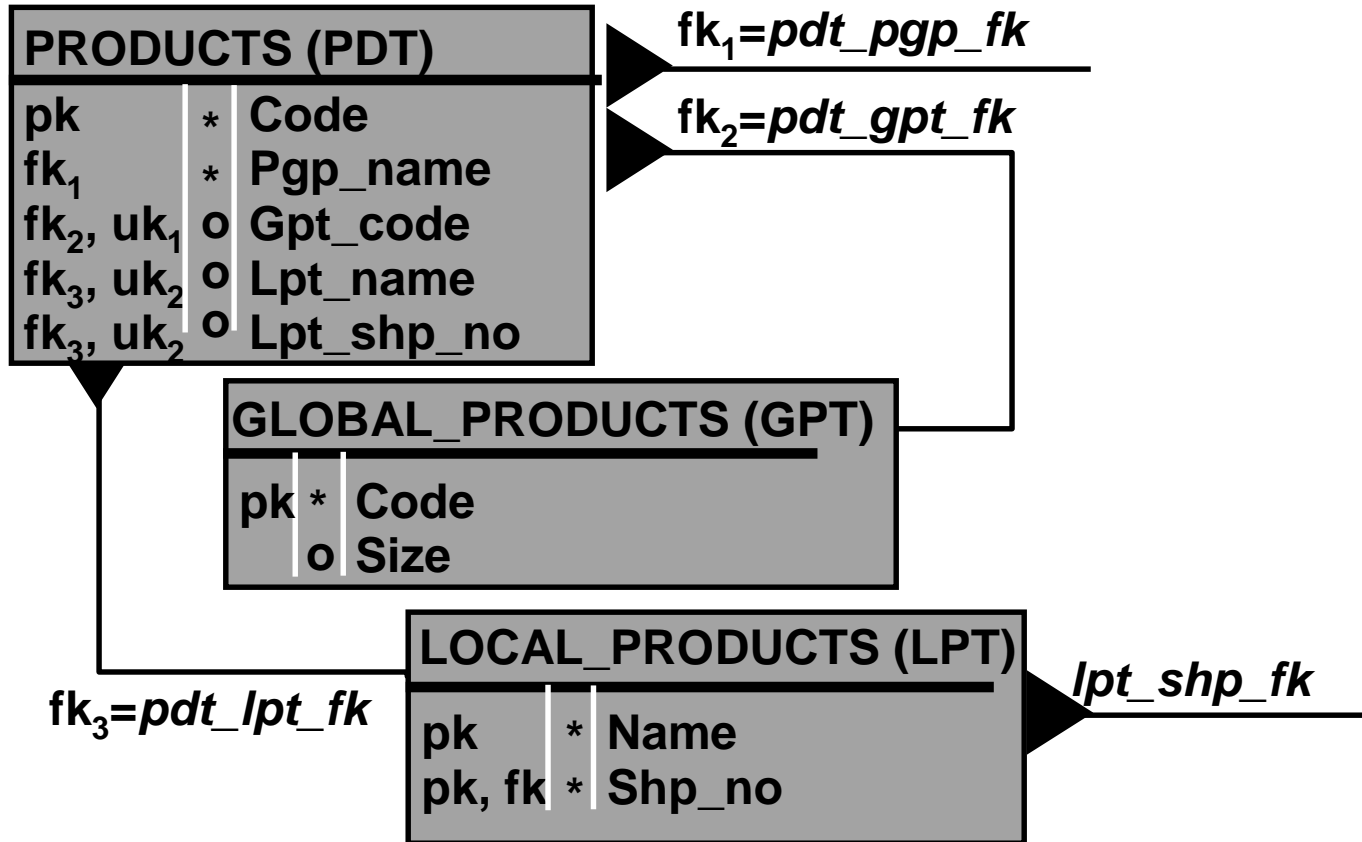
Solution: Mapping Supertype



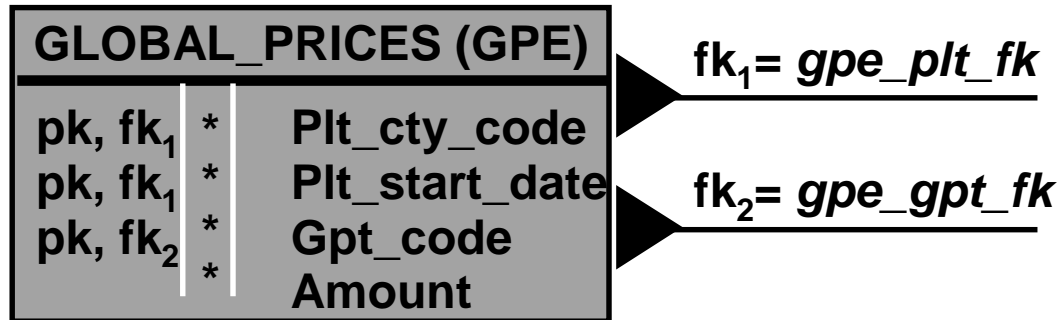
Solution: Quality Check Subtype Implementation



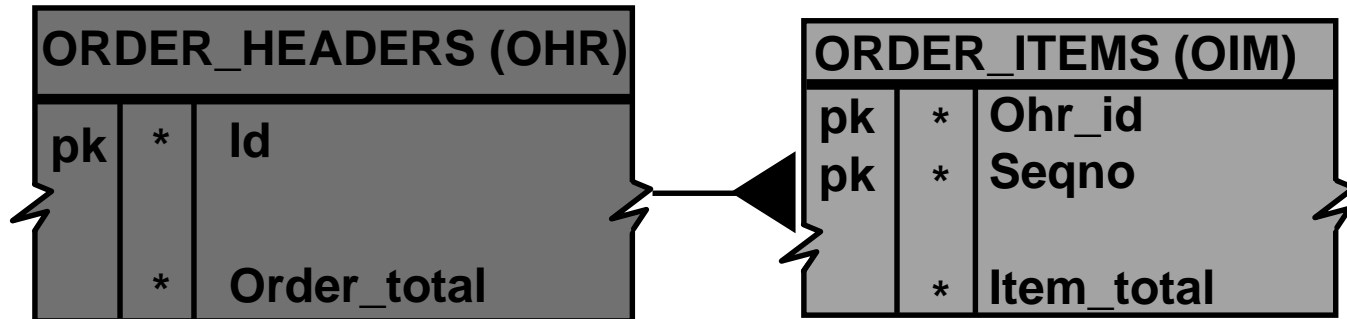
Solution: Quality Check both Supertype and Subtype Implementation



Solution: Primary Keys and Columns



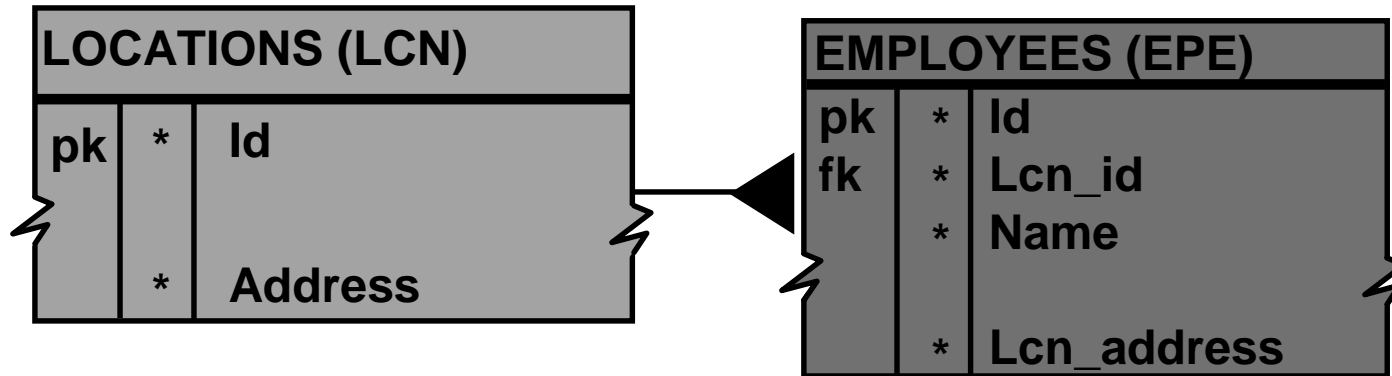
Practice: Triggers (1/6)



Solution: Triggers (2/6)

Table	Trg Type	Column	Needed?	What should it do?
OHR	Insert		Y	Order_total := 0
	Delete		N	
	Update	Id	N	
		Order_total	Y	prevent update
OIM	Insert		Y	recalculate Order_total
	Delete		Y	recalculate Order_total
	Update	Ohr_id	Y	recalculate Order_total
		Item_total	Y	recalculate Order_total

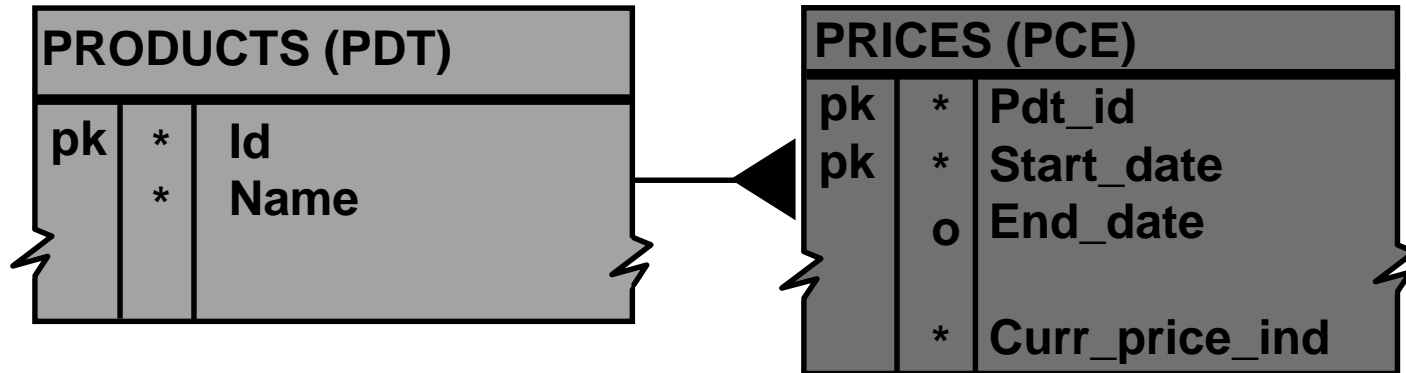
Practice: Triggers (3/6)



Solution: Triggers (4/6)

Table	Trg Type	Column	Needed?	What should it do?
LCN	Insert		N	
	Delete		N	
	Update	Address	Y	Cascade to Employees
		<i>other cols</i>	Y	If pk updated than extended cascade
EPE	Insert		Y	Set correct Lcn_address
	Delete		N	
	Update	Lcn_id	Y	Set correct Lcn_address
		Lcn_address	Y	Prevent update

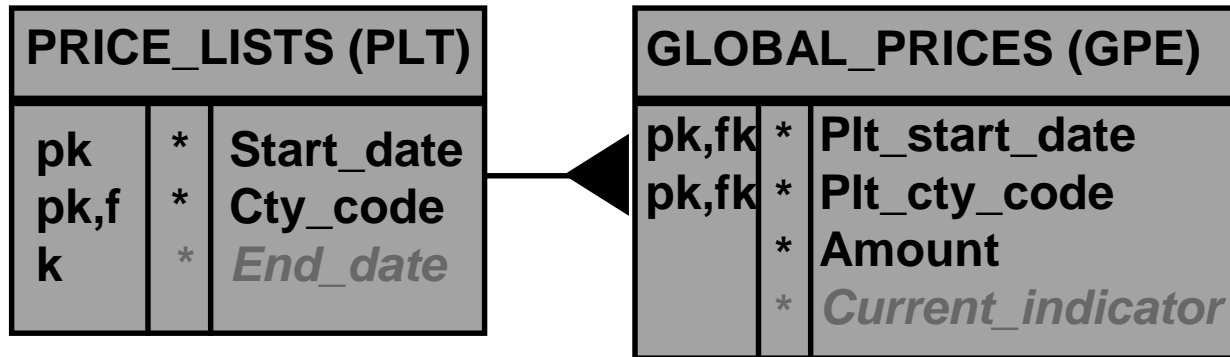
Practice: Triggers (5/6)



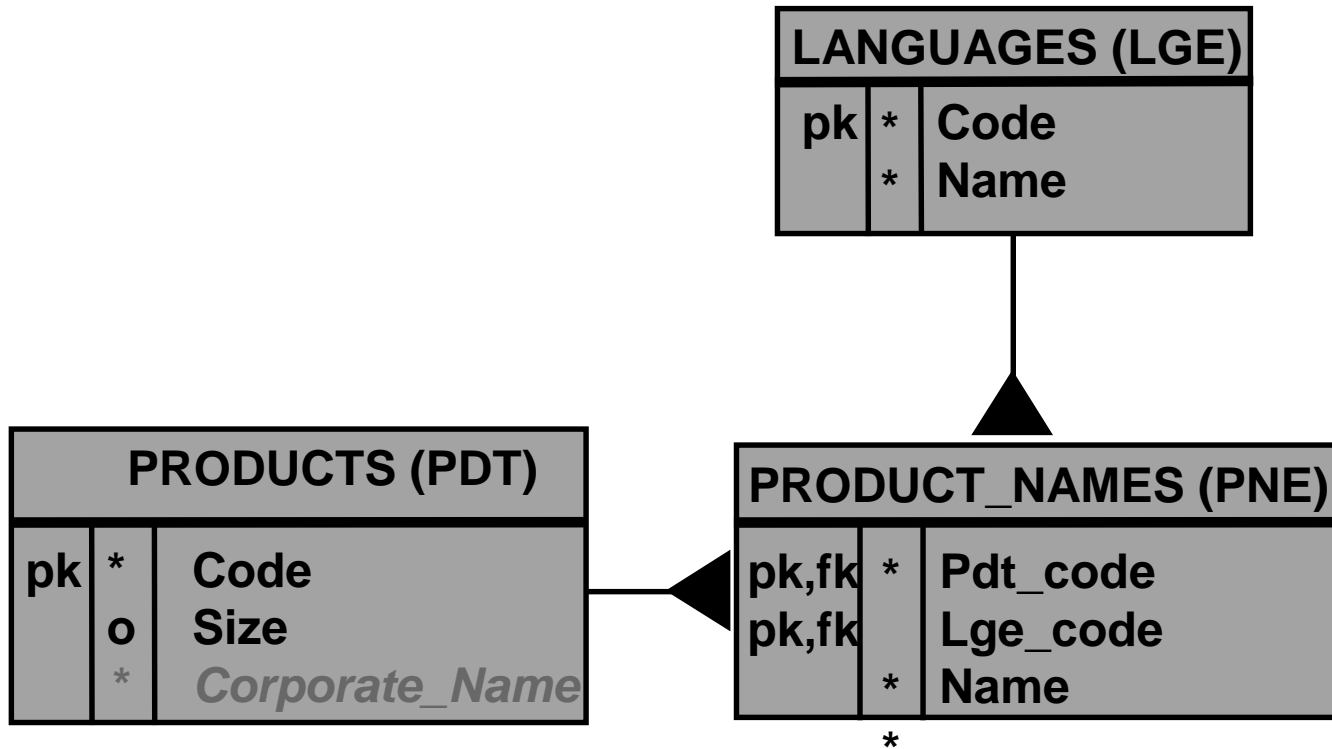
Solution: Triggers (6/6)

Table	Trg Type	Column	Needed?	What should it do?
PDT	Insert		N	
	Delete		N	
PCE	Insert		Y	Prevent overlap in price periods
	Delete		N	
	Update	Pdt_id	Y	Set Curr_price_ind to NULL
		Start_date	Y	Re-evaluate Curr_price_ind
		End_date	Y	Re-evaluate Curr_price_ind
		Curr_price_Ind	Y	Prevent update by user

Solution: Denormalize Price Lists



Solution: Denormalize Global Naming



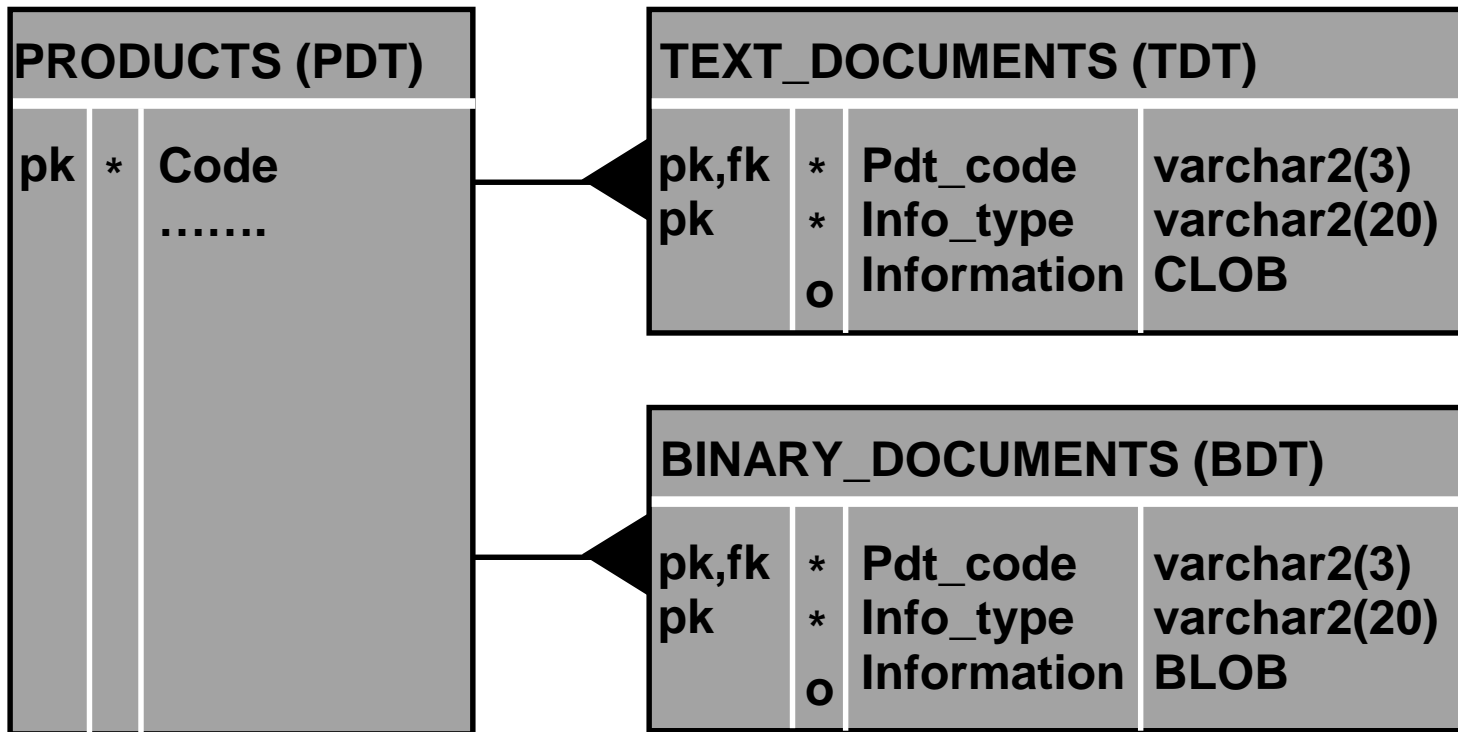
Solution: Data Types (1)

Table	Column	Suggested Data Type	Your Choice Data Type?
COUNTRIES	Code	Varchar2(2)	Char(2)
	Code	Varchar2(3)	Char(3)
CURRENCIES	Month	Date	Number(2)
	Rate	Number(8,4)	Number(12,4)
EXCHANGE_RATES	Start_date	Date	Date
	End_date	Date	Date
PRICE_LISTS	Name	Char(8)	Varchar2(15)
	Code	Char(10)	Varchar2(15)
PRODUCT_GROUPS	Size	Number(4,2)	Char(1)
	Pdt_type	Number(1)	Char(3)
PRODUCTS			

Solution: Data Types (2)

Table	Column	Your Choice Data Type
GLOBAL_PRICES LOCAL_PRICES	Amount Start_date End_date	Number(15,3) Date Date
SHOPS	Amount Name Address City	Number(15,3) Varchar2(50) Varchar2(50) Varchar2(50)

Solution: Product Pictures



B

Normalization

Overview

- **Table Normalization**
- **Normal Forms of Tables**

Why Normalize?

- **An Entity Model is not always available as a starting point for design.**
- **To reduce redundant data in existing design.**
- **To increase integrity of data, and stability of design.**
- **To identify missing tables, columns and constraints.**

Note: Third normal form is the generally-accepted goal for a database design that eliminates redundancy.

Recognize Unnormalized Data

USER _ID	USER _NAME	MSE _ID	REC_ DATE	SUBJECT	TEXT	SRVR _ID	SERVER _NAME
2301	Smith	54101	05/07	Meeting Today	There is..	3786	IMAP05
2301	Smith	54098	07/12	Promotions	I like to.	3786	IMAP05
2301	Smith	54445	10/06	Next Assignment	Your next.	3786	IMAP05
5607	Jones	54101	05/07	Meeting Today	There is..	6001	IMAP08
5607	Jones	54512	06/07	Lunch?	Can you...	6001	IMAP08
5607	Jones	54660	12/01	Jogging Today?	Can you...	6001	IMAP08
7773	Walsh	54101	05/07	Meeting Today	There is..	9988	EMEA01
7773	Walsh	54554	03/17	Stock Quote	The latest	9988	EMEA01
0022	Patel	54101	05/07	Meeting Today	There is..	2201	EMEA09
0022	Patel	54512	06/07	Lunch?	Can we ...	2201	EMEA09

Normalization Rules

Normal Form Rule	Description
First Normal Form (1NF)	The table must express a set of unordered, two-dimensional tables. The table cannot contain repeating groups.
Second Normal Form (2NF)	The table must be in 1NF. Every non-key column must be dependent on all parts of the primary key.
Third Normal Form (3NF)	The table must be in 2NF. No non-key column may be functionally dependent on another non-key column.

“Each non-primary key value MUST be dependent on the key, the whole key, and nothing but the key.”

Converting to First Normal Form

USER _ID	USER _NAME	MSE _ID	REC_ DATE	SUBJECT	TEXT	SRVR _ID	SERVER _NAME
2301	Smith	54101	05/07	Meeting Today	There is..	3786	IMAP05
2301	Smith	54098	07/12	Promotions	I like to.	3786	IMAP05
2301	Smith	54445	10/06	Next Assignment	Your next.	3786	IMAP05
5607	Jones	54512	06/07	Lunch?	Can you...	6001	IMAP08
5607	Jones	54101	05/07	Meeting Today	There is..	6001	IMAP08
5607	Jones	54660	12/01	Jogging Today?	Can you...	6001	IMAP08
7773	Walsh	54101	05/07	Meeting Today	There is..	9988	EMEA01
7773	Walsh	54554	03/17	Stock Quote	The latest	9988	EMEA01
0022	Patel	54101	05/07	Meeting Today	There is..	9988	EMEA01
0022	Patel	54512	06/07	Lunch?	Can we ...	9988	EMEA01

1. Remove repeating group from the base table.
2. Create a new table with the PK of the base table and the repeating group.

First Normal Form - Single Record

USERS

USER _ID	USER _NAME	MSE _ID	REC DATE	SUBJECT	TEXT	SRVR _ID	SERVER _NAME
2301	Smith	54101	05/07	Meeting Today	There is..	3786	IMAP05
5607	Jones	54512	06/07	Lunch?	Can you...	6001	IMAP08
7773	Walsh	54101	05/07	Meeting Today	There is..	9988	EMEA01
0022	Patel	54101	05/07	Meeting Today	There is..	9988	EMEA01



USERS

USER _ID	USER _NAME	SRVR _ID	SERVER _NAME
2301	Smith	3786	IMAP05
5607	Jones	6001	IMAP08
7773	Walsh	9988	EMEA01
0022	Patel	9988	EMEA01

First Normal Form - Repeating Groups

RECEIVED_
MESSAGES
(1NF)

USER _ID	MSE _ID	REC DATE	SUBJECT	TEXT
2301	54101	05/07	Meeting Today	There is..
2301	54098	07/12	Promotions	I like to.
2301	54445	10/06	Next Assignment	Your next.
5607	54101	05/07	Meeting Today	There is..
5607	54512	06/07	Lunch?	Can you...
5607	54660	12/01	Jogging Today?	Can you...
7773	54101	05/07	Meeting Today	There is..
8/17			Stock Quote	The latest
5/07			Meeting Today	There is..
5/07			Lunch?	Can we ...

USER _ID	USER _NAME	SRVR _ID	SERVER _NAME
2301	Smith	3786	IMAP05
5607	Jones	6001	IMAP08
7773	Walsh	9988	EMEA01
0022	Patel	9988	EMEA01

USERS (1NF)

Converting to Second Normal Form

1. Determine which non-key columns are not dependent upon the table's entire primary key.
2. Remove those columns from the base table.
3. Create a second table with those columns and the columns from the *PK* that they are dependent upon.

Tables Already in Second Normal Form

USERS



USER _ID	USER _NAME	SRVR _ID	SERVER _NAME
2301	Smith	3786	IMAP05
5607	Jones	6001	IMAP08
7773	Walsh	9988	EMEA01
0022	Patel	9988	EMEA01

Is the **USERS** table already in 2NF?

Convert to Second Normal Form

RECEIVED_
MESSAGES
(1NF)

USER_ID	MSE_ID	REC_DATE	SUBJECT	TEXT
2301	54101	05/07	Meeting Today	There is.
2301	54098	07/12	Promotions	I like to
2301	54445	10/06	Next Assignment	Your next
5607	54101	05/07	Meeting Today	There is.
5607	54512	06/07	Lunch?	Can you..
5607	54660	12/01	Jogging Today?	Can you..
7773	54101	05/07	Meeting Today	There is.
7773	54554	03/17	Stock Quote	The lates
0022	54101	05/07	Meeting Today	There is.
0022	54512	06/07	Lunch?	Can we ..

RECEIVED_
MESSAGES
(2NF)

USER_ID	MSE_ID	REC_DATE
2301	54101	05/07
2301	54098	07/12
2301	54445	10/06
5607	54101	05/07
5607	54512	06/07
5607	54660	12/01
7773	54101	05/07
7773	54554	03/17
0022	54101	05/07
0022	54512	06/07

MESSAGES
(2NF)

MSE_ID	SUBJECT	TEXT
54101	Meeting Toda	There is.
54098	Promotions	I like to
54445	Next Assignm	Your next
54512	Lunch?	Can you..
54660	Jogging Toda	Can you..
54554	Stock Quote	The lates

Converting to Third Normal Form

Remove any columns that are dependent upon another non-key column:

- 1. Determine which columns are dependent upon another non-key column.**
- 2. Remove those columns from the base table.**
- 3. Create a second table with those columns and the non-key columns that they are dependent upon.**

Tables Already in Third Normal Form

No non-key column can be functionally dependent upon another non-key column.

RECEIVED_
MESSAGES
(2NF)

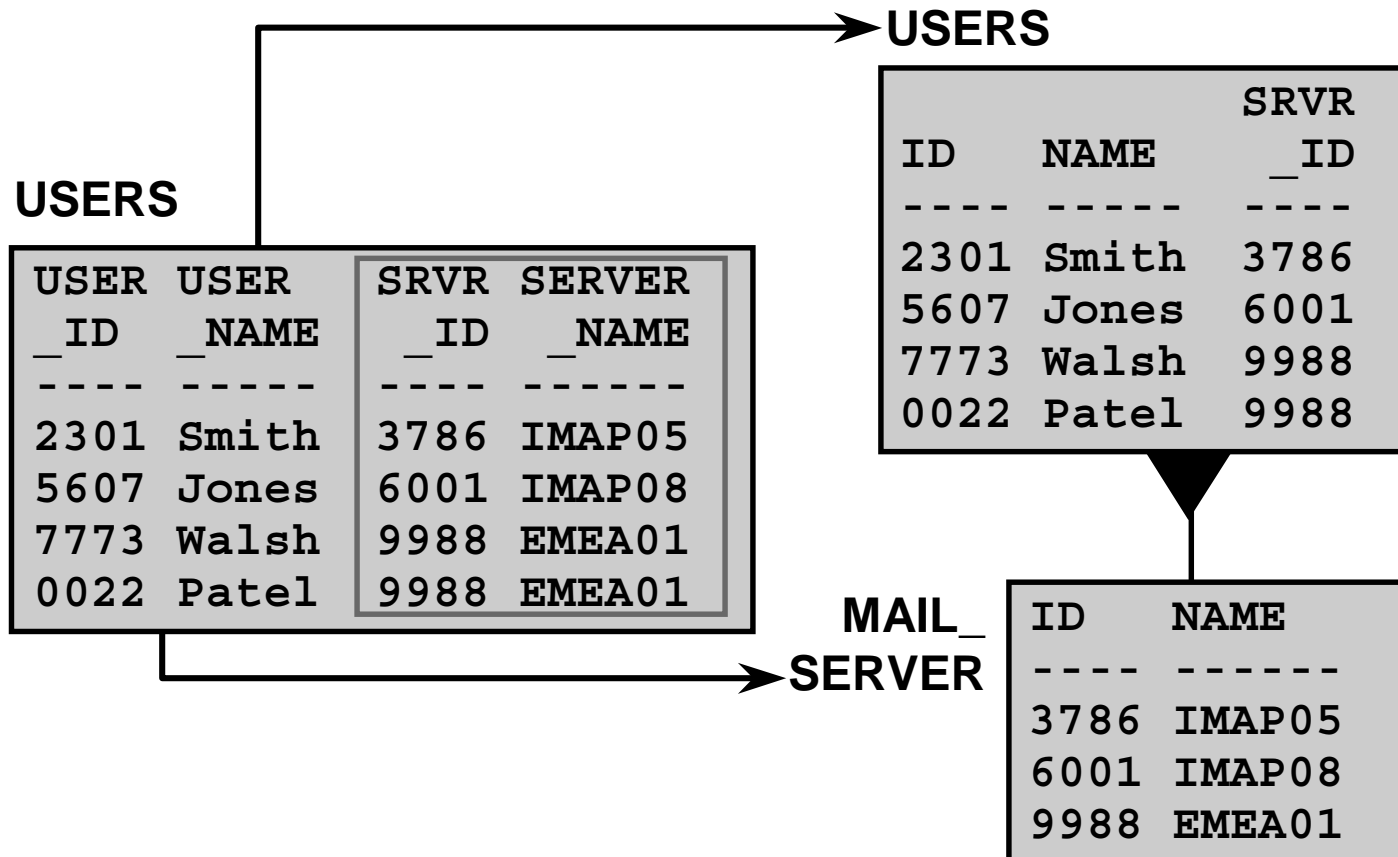
USER _ID	MSE _ID	REC _DATE
-----	-----	-----
2301	54101	05/07
2301	54098	07/12
2301	54445	10/06
5607	54101	05/07
5607	54512	06/07
5607	54660	12/01
7773	54101	05/07
7773	54554	03/17
0022	54101	05/07
0022	54512	06/07

MESSAGES
(2NF)

ID	SUBJECT	TEXT
-----	-----	-----
54101	Meeting Today	There is.
54098	Promotions	I like to
54445	Next Assignment	Your
	next	
54512	Lunch?	Can you..
54660	Jogging Today?	Can you..
54554	Stock Quote	The lates

Are these two tables in third normal form? Why?

Converting to Third Normal Form



Summary

- 1NF** The table must express a set of unordered, two-dimensional tables. The table cannot contain repeating groups.
- 2NF** The table must be in 1NF. Every non-key column must be dependent on all parts of the primary key.
- 3NF** The table must be in 2NF. No non-key column may be functionally dependent on another non-key column.

An entity relationship model transforms into normalized data design.