UNIVERSITÀ DEGLI STUDI DI PADOVA

DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

Database Management Systems, A.Y. 2019/2020
Master Degree in Computer Engineering
Master Degree in ICT for Internet and Multimedia

Homework 2 – Conceptual and Logical Design

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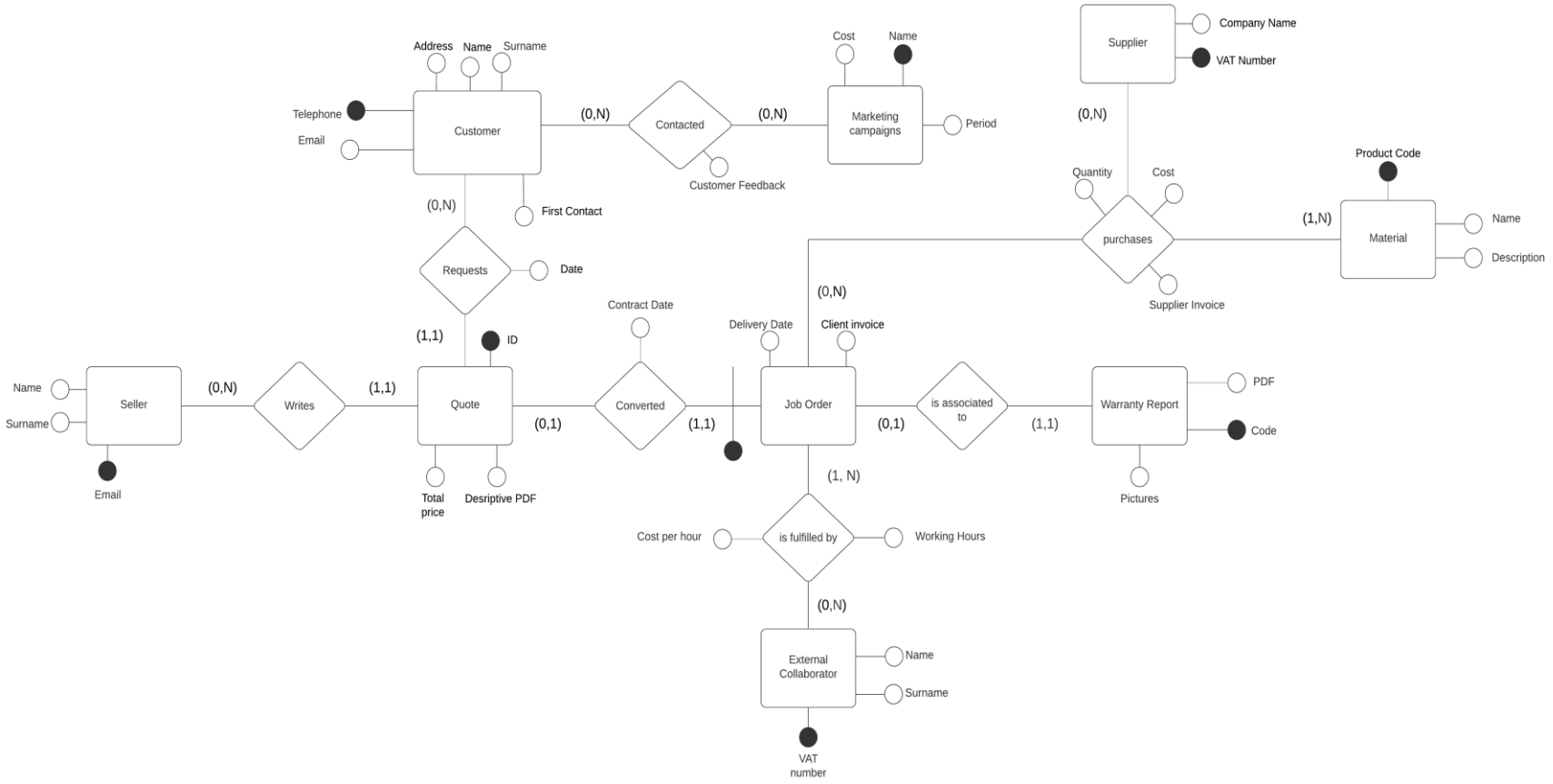
Conceptual Design

Variations to the Requirement Analysis

We decided to split "List of Material" in a unique entity "Material" in order to keep information about every material purchased.

Remark from previous homework: only administrative staff can access the database to update and insert data. No other people, such as suppliers, external collaborators have access to the data as explicitly required by the stakeholder.

Entity-Relationship Schema


Address
Name
Surname
Telephone
Email
Customer
(0,N)
Contacted
(0,N)
Customer Feedback
Cost
Name
Marketing campaigns
Period
Supplier
Company Name
VAT Number
(0,N)
Quantity
Cost
purchases
Supplier Invoice
(1,N)
Product Code
Material
Name
Description
(0,N)
First Contact
(0,N)
Requests
Date
(1,1)
ID
Contract Date
Delivery Date
Client invoice
(0,N)
Name
Surname
Seller
Email
(0,N)
Writes
(1,1)
Quote
Total price
Desriptive PDF
(0,1)
Converted
(1,1)
Job Order
(0,1)
is associated to
(1,1)
Warranty Report
PDF
Code
Pictures
(1, N)
Cost per hour
is fulfilled by
Working Hours
(0,N)
External Collaborator
Name
Surname
VAT number

Data Dictionary

Entities Table

Entity	Description	Attributes	Identifier
Seller	Person in charge of getting in touch with customers	• Name: seller name, text; • Surname: seller surname, text; • e-mail: business email given by the company, text;	E-mail
Customer	Person who asks for information or commissions a job order	• Name: customer name, text; • Surname: customer surname, text; • Address: customer address, text; • First contact: how customer got to know the company, text; • e-mail: customer personal email, text; • Telephone: phone number, text;	Telephone
External collaborator	Person in charge of the implementation of a job order	• Name: collaborator name, text; • Surname: collaborator surname, text; • VAT number: collaborator VAT number, text;	VAT number
Quote	Document describing the work and the final price for the client, not approved yet	• ID: quote id, numeric; • Total price: estimated amount to be paid by the customer, numeric; • Descriptive PDF: PDF document that describes the job, blob;	ID
Job order	Confirmation of the estimate and execution of the work	• ID: order id, numeric; • Delivery date: day in which the end of the work is expected, date; • Client Invoice: PDF of the client invoice, blob;	ID
Marketing Campaign	Advertising campaign for a group of customers	• Name, name of the campaign, text; • Cost, total cost of the campaign, numeric; • Period: period in which the marketing campaign is done, range of date;	Name
Warranty Report	Document certifying that the work has been carried out properly	• Images: images of the work done, blob; • Code: code that identifies a warranty, text; • PDF: PDF documents that contains all information about	Code

		warranty, blob;	
Supplier	External company from which the products are purchased	• Company name: name of the company, text; • VAT number: code that identifies the company itself, text;	VAT number
Material	Product purchased from a supplier for the implementation of an order	• Product code: code that identifies a specific material, text; • Name: name of the material, text; • Description: description of the material, text.	Product Code

Relationship Table

Relationship	Description	Component Entities	Attributes
Writes	Relates sellers with quotes they write	• Seller (0,N) • Quote (1,1)	
Requests	Relates customers with quotes they request	• Customer (0,N) • Quote (1,1)	• Date, date of the customer request, date;
Contacted	Relates each marketing campaign with the customers that were contacted	• Marketing Campaign (0,N) • Customer (0,N)	• Customer Feedback, brief feedback from the customer, boolean;
Converted	The relation between each quote and its conversion into a job order	• Job Order (1,1) • Quote (0,1)	• Contract Date, date when the contract is signed, date;
Is fulfilled by	The job order is fulfilled by the external collaborators	• Job Order (1,N) • External Collaborator (0,N)	• Cost per hour, cost per hour of a collaborator for a single job, numeric; • Working hours: hours worked by a collaborator
Is associated to	Connects each job order with the relative warranty report it is associated to	• Job Order (0,1) • Warranty Report (1,1)	
Purchases	Associates the job orders with the ordered materials provided by the relative suppliers	• Job Order (0,N) • Material (1,N) • Supplier (0,N)	• Quantity: number of items purchased of that material, numeric; • Cost, total cost of the material in the job order, numeric; • Supplier Invoices: PDF invoices of ordered materials, blob;

External Constraints on ER

1. The value of the first contact attribute in the Customer entity has to be one among the possible names of marketing campaigns (i.e. TV, Radio, exc. for statistical analysis) or one of other predefined means of customer acquisition like word-of-mouth.
2. The delivery date attribute of the Job Order entity has the constraint to be after the contract date attribute of the Converted relation because of course the job should only be done after the contract is signed.
3. The requested date attribute of the relation "Requested" has the constraint to be before the contract date attribute of the "Converted" relation because of course the quote should only be done after a quote is requested.

Functional Requirements Satisfaction Check

The DBMS:

- Contains information of individuals or groups of customers: the entity Customer stores the first name, last name, email, telephone.
- Contains the information of external collaborators: the entity External Collaborator stores the name, surname, VAT number of each collaborator.
- Allows to retrieve the list of jobs performed by a specific external collaborator: through the relation "is fulfilled by" it is possible to retrieve all the information about the collaborators that have performed each job, together with the how many hour (and at which cost) each collaborator has spent in the work.
- Contains supplier information: the entity Supplier stores information about the supplier such as the name of the company and its VAT number.
- Contains seller information: the entity Seller stores first and last name of each seller and a business email that it is used as an identifier.
- Contains information related to quotes, job orders and marketing campaigns: the entity Quote store all the information necessary to identify a quote that are: ID, final total price and a descriptive document of the work to be done. Through the entity Job Order it is possible to retrieve information about the delivery date and the final invoice of the customer. The entity Marketing Campaigns stores information about each delivered campaign such as name, cost and the validity period.
- Allows to recover the quantities of materials purchased from a supplier and the expenditure incurred (over a certain period of time variable): through the relation "Purchases" it is possible to retrieve for each material purchased (stored in entity Material) from a supplier (Supplier entity) the quantity and the cost of that product for each job order; in addition thanks to the attribute Delivery Date of Job Order it is possible to know in which period the materials have been acquired.
- Allows to recover for each customer the quotes and associated orders: a quote is connected to a unique customer by the relation "Requests", with this it is possible to link every customer to their quotes, then by the relation Converted each quote is associated with a unique Job Order.
- Allows to retrieve contact information to carry out corporate marketing campaigns aimed at a group of customers: by the previous point it is possible to associate each customer to its quotes and orders to get information for targeted marketing campaigns (for example dates). In addition through the relationship "Contacted" it is possible to associate each customer to many marketing campaigns and for each store a feedback.
- Allows to get a statistical report of a marketing campaign or how many customers have been touched by the campaign and have requested a quote: the relation "Connected" stores for each

marketing campaign a feedback for each user that can be used to express the rate the effectiveness of a campaign.

- Allows to retrieve data useful to draw up the periodic balance sheets of the company, i.e. expenditure on materials, labour (expenditure) and the price of the estimate paid by the customer (income): Total price for a work is stored in Quote entity. Working cost information are stored in "is fulfilled by" relationship between "Job Order" and "External Collaborator". Material cost information are stored in "Purchases" relationship between "Job Order" and "Material". Also, dates are stored in Job Order. So, it's possible to retrieve information about incoming and outgoing in a certain period or related to a specific job or material.
- Allows to derive the number of contracts concluded by a seller: Sellers are related with Quotes through "Writes" relationship. A Quote can be related with a Job Order through "Converted" relationship that has (1,1) cardinality on Job Order side. So, it's possible to retrieve all Job Orders related to a Seller.
- Allows to determine the number of customers who have come to know the company for a particular reason (e.g. TV advertising, word of mouth, etc.): "First Contact" field of Customers stores information about that.
- Allows to obtain a list of people to contact for after-sales assistance, re-examination of an expired estimate: A Job Order entity contains the Delivery Date of the work, so to perform self after-sales assistance we exploit this time information. Since a Job Order is related to a Quote by "Converted" relationship with cardinality (1,1) and each Quote is associated with a single Customer through "Requests" relationship with cardinality (1,1), we can recover univocally the Customer that committed the job. Customers entity store contact information such as email address and telephone number. Re-examination of an estimate is performed using the Date stored in "Requests" relationship between Customers and Quote; since Quote join with (1,1) cardinality we can retrieve the information about Customer contact. Re-examination happens only if there isn't a Job Order related to the Quote through "Converted" that has (0,1) cardinality on Quote side.
- Allows to retrieve the Warranty Reports associated with a Job Order and also all those associated with a customer: a Warranty Report entity is associated with a Job Order entity through "is associated to" relationship with cardinality (1,1) so it's trivial to recover it. A Customer is associated with one or more quotes, through "Requests" relationship and a quote can be connected with a Job order that allow to recover the corresponding Warranty Report.

Logical Design

Transformation of the Entity-Relationship Schema

1. Redundancy Analysis

The schema does not contain any cycle of entities but presents the derivative attribute “First Contact” in the entity “Customer”. We report below the analysis of the database load to check whether keeping this derivative attribute or not.

2. Choice of Principal Identifiers

The schema does not contain external identification cycles and the main identifiers comply with the selection criteria, for example we decide to use the Telephone attribute, in the “Customer” entity, to identify a customer in place of (Name, Surname, Address) for the minimality criterion and the “Seller” entity is identified by “Email” attribute instead of Name and Surname for the same reason (this solve also possible, but improbable homonymous sellers, as we are in a small company).

Analysis of Database Load

In this section, we report the analysis of the database to justify the presence of redundancies in the entity relationship schema. Consider the following operation that involve the redundant attribute First Contact:

- O1: count how many customers had their first contact through a specific marketing campaign;
- O2: insert a new customer in the database

Table 1 reports the description of each operations, its frequency and type. O1 is an online operation since administrative staff decides to compute statistics about the first contact when they consider it more appropriate. O2 is obviously an online operation.

Operation	Description	Frequency	Type
O1 First contact analysis	Count how many customers had their first contact through a specific marketing campaign	2/year	Online
O2 New customer	Insert a new customer in the database, together with the information related to his first contact	150/year	Online

Table 1 Frequency Table

In the following we analyse the O1 with and without the redundancy:

With redundancy (attribute first contact): direct access to all customer instances of first contact. Without redundancy: it is needed to access all the campaign associated with a customer and looking for the oldest one (first contact campaign) with positive feedback (need to add an attribute “Date” to the relation “Contacted”).

Concept	Construct	Access	Type	Average Access
Customer	Entity	4000	R	4000 x 2 x 1 = 8000
Total Access / year			8000	

Table 2 Access/Volume Table for Operation O1 ***with*** *redundancy*

Concept	Construct	Access	Type	Average Access
Contacted	Relationship	40000	R	40000 x 2 x 1 = 80000
Total Access / year			80000	

Table 3 Access/Volume Table for Operation O1 ***without*** *redundancy*

In the following we analyse the O2 with and without the redundancy:

With redundancy: add a new customer and associate him with a marketing campaign (in the relation Contacted), in addition we have to be sure that the attribute "First Contact" has a value among the name of marketing campaign or other predefined values (as required in the external constraints). Without redundancy: add a new customer and add a relationship instance "Contacted" with the appropriate marketing campaign associated with his first contact.

Concept	Construct	Access	Type	Average Access
Customer	Entity	1	W	1 x 150 x 2 = 300
Contacted	Relationship	1	W	1 x 150 x 2 = 300
Marketing Campaign	Entity	50	R	50 x 150 x 1 = 7500
Total Access / year			8100	

Table 4 Access/Volume Table for Operation O2 ***with*** *redundancy*

Concept	Construct	Access	Type	Average Access
Customer	Entity	1	W	1 x 150 x 2 = 300
Contacted	Relationship	1	W	1 x 150 x 2 = 300
Total Access / year			600	

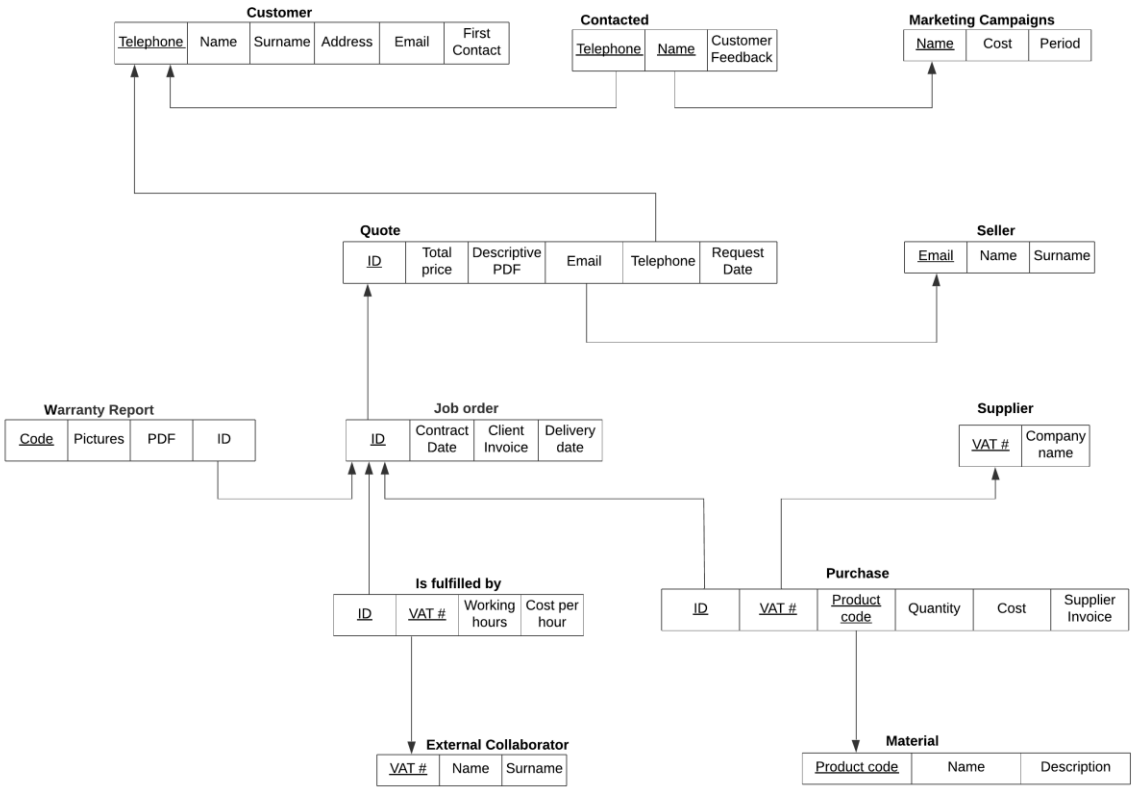
Table 5 Access/Volume Table for Operation O2 ***without*** *redundancy*

Finally, Table 6 reports the summary of the total accesses per year, showing that without redundancy the number of access increase from 16100 to 80000. Since the redundancy reduce significantly the number of access, it's a good idea to keep it.

Operation	With Redundancy	Without Redundancy
O1	8000	80000
O2	8100	600
Total Access / year	**16100**	**80600**

Table 6 Comparison of the Number of Accesses for each Operation

Relational Schema



Data Dictionary

Relation	Attribute	Description	Domain	Constraints
Customer	1. Telephone 2. Name 3. Surname 4. Address 5. E-mail 6. First contact	1. Customer ID 2. Customer Name 3. Customer surname 4. Customer address 5. Customer mail address	1. Text 2. Text 3. Text 4. Text 5. Text 6. Text	1. Primary key 2. Not NULL 3. Not NULL 4. Not NULL 5. / 6. /

		6. How the customer got to know about the company		(Name, Surname, Address) is a key
Contacted	1. Telephone 2. Name 3. Customer feedback	1. Customer ID 2. Marketing campaigns identifier 3. Feedback of customer	1. Text 2. Text 3. Boolean	1. Primary key with Name, Foreign key to Customer 2. Primary key with telephone, Foreign key to Marketing campaign 3. Not NULL
Marketing campaign	1. Name 2. Cost 3. Period	1. Marketing campaign identifier 2. Cost of the marketing campaign 3. Period of the marketing campaign	1. Text 2. Float 3. Date range	1. Primary key for Marketing Campaign 2. Greater or equal to 0 3. /
Quote	1. ID 2. Total price 3. Descriptive PDF 4. Seller email 5. Customer telephone 6. Request date	1. Quote identifier 2. Price of a quote 3. Document containing information about the work to do 4. Identifier of seller 5. Identifier of customer 6. Date of request for the quote	1. Int 2. Float 3. Blob 4. Text 5. Text 6. Date	1. Primary key for Quote, ≥ 0 2. Not NULL, greater or equal to 0 3. Not NULL 4. Foreign key to seller 5. Foreign key to customer 6. Not NULL
Seller	1. Email 2. Name 3. Surname	1. Seller identifier 2. Seller name 3. Seller surname	1. Text 2. Text 3. Text	1. Primary key 2. Not NULL 3. Not NULL
Job order	1. ID 2. Contract date 3. Client invoice 4. Delivery date	1. Quote identifier 2. Date of stipulation of contract 3. Invoice for client 4. Date of expected end work	1. Int 2. Date 3. Blob 4. Date	1. Primary key, Foreign key to quote 2. Not NULL 3. / 4. / Delivery Date ≥ Contract date
Warranty report	1. Code 2. Pictures 3. PDF 4. Job order ID	1. Warranty report identifier 2. Pictures of the completed job 3. Summary of the completed job 4. Quote identifier	1. Int 2. Blob 3. Blob 4. Int	1. Primary key, ≥ 0 2. Not NULL 3. Not NULL 4. Foreign key to Job order
Is fulfilled by	1. VAT #	1. External collaborator	1. Text	1. Primary key with ID, Foreign key to

	2. ID 3. Working hours 4. Cost per hour	identifier 2. Quote identifier 3. Hours required to end a job order 4. cost for an hour of work	2. Int 3. Float 4. Text	External collaborator 2. Primary key with VAT #, Foreign key to Job order 3. / 4. Not NULL, ≥ 0
External collaborator	1. VAT # 2. Name 3. Surname	1. External collaborator identifier 2. External collaborator name 3. External collaborator surname	1. Text 2. Text 3. Text	1. Primary key 2. Not NULL 3. Not NULL
Purchased	1. ID 2. VAT # 3. Product code 4. Quantity 5. Cost 6. Supplier invoice	1. Quote identifier 2. Supplier identifier 3. Material identifier 4. Quantity of material ordered 5. Cost per material 6. Invoice for the supplier	1. Int 2. Text 3. Text 4. Int 5. Float 6. Blob	1. Primary key with Supplier ID and Product code, Foreign key to Job order, ≥ 0 2. Primary key with Job order ID and Product code, Foreign key to supplier 3. Primary key with Job order ID and supplier ID, Foreign key to Material 4. Not NULL 5. Not NULL, ≥ 0 6. /
Supplier	1. VAT # 2. Company name	1. Supplier identifier 2. Name of the company supplying the material	1. Text 2. Text	1. Primary key 2. Not NULL
Material	1. Product code 2. Name 3. Description	1. Material identifier 2. Material name 3. Description of the purchased material	1. Text 2. Text 3. Blob	1. Primary key 2. Not NULL 3. /

External Constraints

1. The value of the “first contact” attribute in the Customer relation has to be one among the possible types of marketing campaigns (i.e. TV, Radio, exc.) or one of other predefined means of customer acquisition like word-of-mouth.

2. The requested date attribute of the relation “Quote” has the constraint to be before the contract date attribute of the “Job Order” relation because of course the quote should only be done after a quote is requested.