Foundations of Databases A.Y. 2021-2022
Homework 2 – Conceptual and Logical Design

Master Degree in Computer Engineering
Master Degree in Cybersecurity
Master Degree in ICT for Internet and Multimedia

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| GROUP	PROJECT	
Don'tBlameMySchema	Car Dealer	
Last name Abbaspour	First Name Anahita	Student number 2005495
Last name Algun	First Name Mustafa	Student number 2049537
Last name Arslan	First Name Selen	Student number 2004968
Last name Baron	First Name Alex	Student number 2021133
Last name Cattai	First Name Christian	Student number 2021234
Last name Freskina	First Name Fatjon	Student number 2056098
Last name Leka	First Name Enrico	Student number 2019178
Last name Milanese	First Name Marco	Student number 2010656
Last name Scattolin	First Name Giulio	Student number 2055035

Conceptual Design

Variations to the Requirement Analysis

After a second round of intervews with the Stakeholders we have clarified some doubts:

Car Dealer is the local physical car shop and as such has it's own employees, that are: Sellers, Mechanics and the Finance Team. By our design, since the business is constantly growing, any new work role can be easily implemented in the database without problems. Once we clarified that Car Dealer is the single local shop we can continue, as agreed, to identify the different local business by their Names.

We made some clarification also about the repair service. As of now it exists only to repair the rentable cars. We discussed if the policy could change in the future, in order to allow repairs to customers too, so we agreed on adding a new entity **External Cars** related to Customers and Repair current entities.

Entity-Relationship Schema
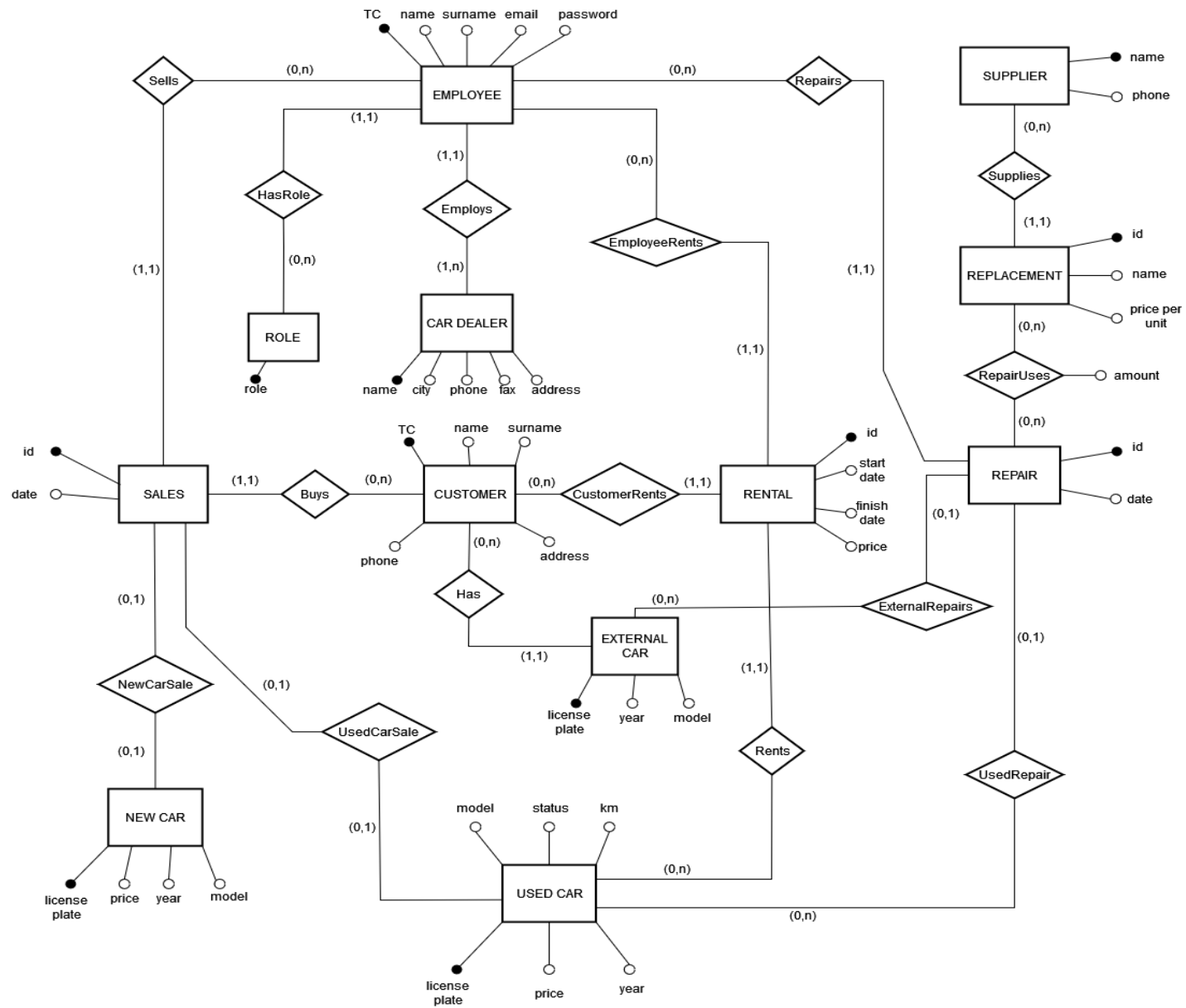
Data Dictionary

Entities Table

Entity	Description	Attributes	Identifier
Car Dealer	Business that has the ability to sell or rent cars that may be new or used. Univocally identified by the Car Dealer's name (name of the business).	- name - address - city - phone - fax	name
Customer	Customer within the car dealer chain, can buy or rent one or more cars. Can also have his/her car repaired. Identified by the Tax Code.	- TC - name - surname - phone - address	TC
Sales	Contract or invoice between the car dealer and the customer by which a car, new or used, is sold. Each sale is identified by an id.	- id - date	id
Rental	Contract or invoice between the car dealer and the customer related to the car rental processes of Used Car. Each rental is identified by an id.	- id - start date - finish date - price	id
New Car	Real world object that can be sold (and only sold) by a car dealer. Each New Car is identified by its license plate	- license plate - price - year - model	license plate

Used Car	Real world object that can be sold or rented by a car dealer. They are different from New Cars in the system because they may be rented or not, also they may be under repair and therefore not available. Each used car is identified by its license plate	- license plate - price - year - status - km - model	license plate
External Car	Real world object that doesn't belong to the car dealer but has been processed in the repair service. Identified by a licence plate.	- licence plate - year - model	licence plate
Repair	Repair service that the car dealer offers for the used cars that belong to the branch and external cars. Identified by an id.	- id - date	id
Replacement	A list of replacing parts needed for the repair service. Identified by an id.	- id - name - price per unit	id
Supplier	A vendor that supplies required parts to the repair service. Identified by an id.	- name - phone	name
Role	Information in the system that is responsible for keeping track of different roles of various employees. Identified by role.	role	role

| Employee | Representative of a real person who works at the car dealer. They are registered to the system with their given attributes. Each employee is identified by her/his Tax Code. | • TC
• name
• surname
• email
• password | TC |

Relationships Table

Relationship	Description	Component Entities	Attributes
Employs	Associates Car Dealer with his Employees.	• CarDealer (1,N); • Employee (1,1);	
Buys	A Customer makes a purchase.	• Customer (0,N); • Sales (1,1)	
CustomerRents	A Customer makes a rental.	• Customer (0,N); • Rental (1,1);	
NewCarSale	Associates a New Car to the Sales in which it was sold.	• NewCar (0,1); • Sales (0,1);	
UsedCarSale	Associates a Used Car to the Sales in which it was sold.	• UsedCar (0,1); • Sales (0,1);	
RepairUses	Associates a Repairment with the replacement parts that have been used.	• Repair (0,N); • Replacement (0,N);	amount

Supplies	Associates a replacement part with his supplier.	• Replacement (1,1); • Supplier (0,N);	
Rents	Association between Used Cars and Rental.	• Used car (0,N); • Rental (1,1);	
UsedRepairs	Associates an Old Car to a Repair instance.	• Used car (0,N); • Repair (0,1);	
Has	Customer has an external car.	• Customer (0,N); • External car (1,1);	
ExternalRepairs	Customer wants his/her external car to be repaired.	• External car (0,N); • Repair (0,1);	
EmployeeRents	Associates an Employee to a Rental he/she made.	• Employee (0,N); • Rental (1,1);	
Sells	Employee sells an Used or a New Car.	• Employee (0,N); • Sales (1,1);	
Repairs	Associates an Employee to a Repair he/she performed.	• Employee (0,N); • Repair (1,1);	
HasRole	Associates an Employee to his/her Role in the company.	• Employee (1,1); • Role (0,N);	

External Constraints

- Phone and fax fields should comply with the E.164 standard (i.e. +1 999 555 0123).

- Date-valued fields should comply with ISO 8601 standard (i.e. 2011-12-03T10:15:30+01:00)

- Money-valued fields must be non-negative Float expressed in Euro.

- The Rental must be longer than a month.

- Each year field must be an integer greater than 1900 and less than 9999.

- E-mail fields should comply with format defined in the RFC 2821 specification.

- Password fields must be hashed according to the RFC 2898 specification.

- Sellers must not be able to insert, update or delete repairs.

- Mechanics must not be able to insert, update nor delete both sales and rentals.

- Finance employees must not be able to insert, update or delete sales, rentals or repairs, but they can still read their values.

- Mechanics should be able to manage repairs, in particular adding replacements when needed.

- The amount of a given replacement in a single repair must be a positive integer.

- For each Sale instance either the NewCarSale relationship or the UsedCarSale one must be present.

- For each Repair instance either the ExternalRepairs relationship or the UsedRepairs one must be present.

Functional Requirements Satisfaction Check

- **Since it is a chain of car dealers, not a single car dealer, manage the different dealers located in different places.**

  Car Dealer has more than one branch. All branches' informations are stored in CAR DEALER entity with their instances as name, city, phone, tax, address.

- **For each car dealer store their sale information.**

  The New Car and Used Car sales data is stored in SALES entity, CAR DEALER employs EMPLOYEE and employees has relationship with SALES entity through Sells relationship.

- **For each car dealer store their rental information.**

  The Used Car sale data is stored in RENTAL entity.CAR DEALER employs EMPLOYEE and employees has relationship with RENTAL entity through EmployeeRents relationship.

- **Each car dealer's employee have the access to the progress of the activity, in particular can view sales, rentals and repairs regarding cars.**

  Employees can access sales, rentals and repairs data with proper priviledges. Each car dealer branch is able to access related branch data in these categories.

- **Manage customer information such as name, surname, address, phone, through their purchases or rental in the car dealer.**

  Customers are recorded in the system with their tax code, name, surname, phone and address. They have relationship with cars for sale (Sales entity) through Buy and cars for rental (Rental entity) through CustomerRents. They may have their own cars which are called external cars and have relationship by Has. Car Dealer's employee can access the customer data.

- **Allow the workers to check how many repairments an used car received.**

  Workers data is stored in Employee entity and employees are able to access Repair data which has relationship with Used car by UsedRepair. Employee can see date and id of repair data, thus employee can check how many times the used car has been repaired.

- **For each repair, keep track of the replacements used in quantity and their price.**

  Repair data stored in REPAIR entity with its date and id.

- **Store information of all the suppliers, even if they have never sold a part yet.**

  Supplier data is stored in SUPPLIER entity with its name, phone. Even if they never sold any part yet.

- **Each car dealer needs to have a catalog that provides the list of used cars and new cars.**

  USED CARS and NEW CARS are accessible through SALES and RENTAL entities by the EMPLOYEE which is employed by CAR DEALER.

- **Check that there is one car dealer associated to each sale / rental.**

  CAR DEALER employes EMPLOYEE who sells NEW CARS or USED CARS. EMPLOYEE has the relationship with NEW CARS and USED CARS through SALES entity, also EMPLOYEE has the relationship with USED CARS through RENTAL entity.

- **Check that there is one customer associated to each sale / rental.**

  CUSTOMER has the relationship with SALES entity through Buys, also with RENTAL through CustomerRents.

- **Check that there is one new car / used car associated to each sale.**

SALES entity has the relationship with NEW CARS through NewCarSale and with USED CAR through UsedCarSale.

- **Check that there is one used car associated to each rental.**

    RENTAL entity has the relationship with USED CAR through Rents.

- **Check that there is one car dealer associated to each repair.**

    CAR DEALER employees EMPLOYEE who has the connection with REPAIR entity through Repairs.

- **Check that there is one supplier associated to each replacement.**

    SUPPLIER is connected to REPLACEMENT through the Supplies relationship.

Logical Design

Transformation of the Entity-Relationship Schema

Redundancy Analysis

- The proposed ER Schema does not have any external identifier.

- The proposed ER Schema does not have any relationship cycles.

- The proposed ER Schema does not have any derived attributes.

Choice of Principal Identifiers

By checking the graph of the (main) external identifiers, it appears that the scheme does not have external identification cycles, furthermore the main identifiers respect the selection criteria.

Analysis of Database Load

The finance team wants to know the repairments number for each used car in order to deduce the convenience of keeping or not the car for rent option.
We compute the load analysis to decide whether to introduce or not the #repairs: a derived attribute for the UsedCar entity to quickly check how many repairs a car underwent.
We studied an example considering 10000 instances of repairs and 50 of used cars.

Operation	Description	Frequency	Type
O_1 Insert new repair	Store data about a new repair coming from a Used-Car	100/month	Online
O_2 Repair list	Print the list of the repair from a UsedCar	1/month	Online

If we have no redundancy:

- in the O_1 operation:

Concept	Construct	Access	Type	Average Access
Repair	Entity	1	W	1x100x2 = 200
UsedRepairs	Relationship	1	W	1x100x2 = 200
Total Access				400

- in the O_2 operation:

Concept	Construct	Access	Type	Average Access
UsedCar	Entity	1	R	1x1x1 = 1
UsedRepairs	Relationship	200	R	200x1x1 = 200
Total Access				201

So, in the end we get an amount of access equal to 601.

If we have #repairs attribute:

- in the O_1 operation:

Concept	Construct	Access	Type	Average Access
Repair	Entity	1	W	1x100x2 = 200
UsedRepairs	Relationship	1	W	1x100x2 = 200
UsedCar	Entity	1	R	1x100x1 = 100
UsedCar	Entity	1	W	1x100x2 = 200
Total Access				700

- in the O_2 operation:

Concept	Construct	Access	Type	Average Access
UsedCar	Entity	1	R	1x1x1 = 1
Total Access				1

So, in the and we get an amount of access equal to 701.

The #repairs attribute did not significantly improves the operations performances. For this reason, we decided not keep the redundant attribute in our schema.

Relational Schema
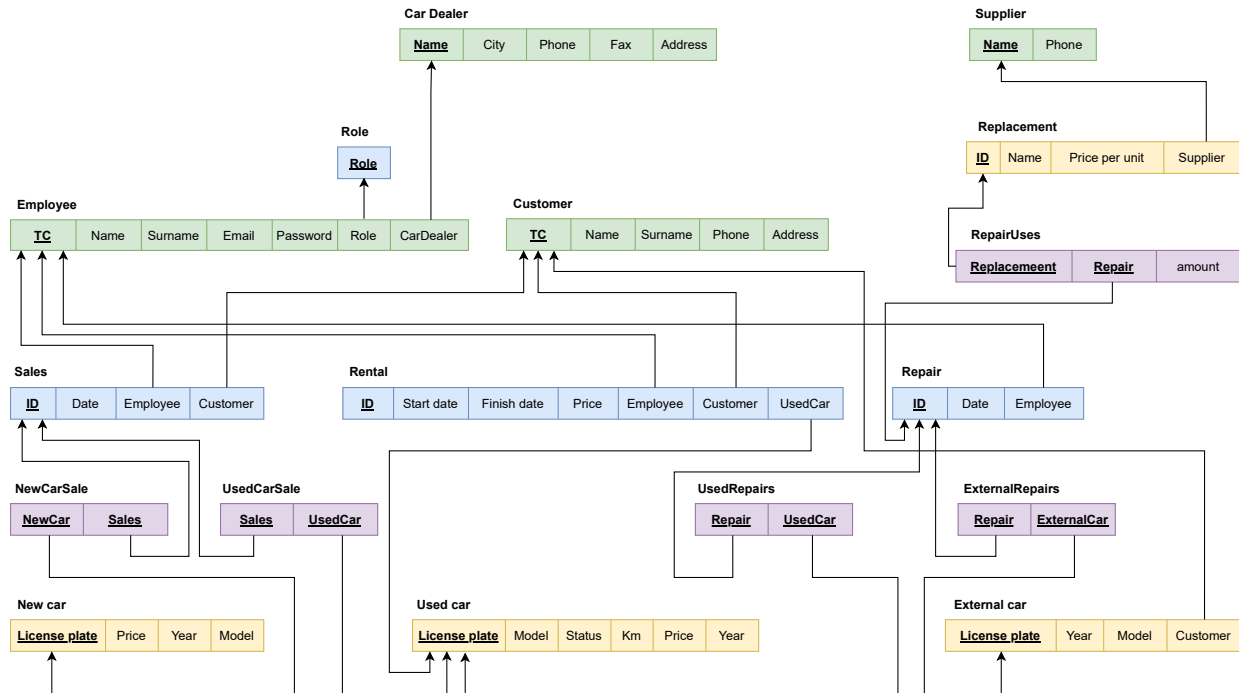
NewCarSale, UsedCarSale, UsedRepairs and ExternalRepairs are relationships with optional partecipation, thus two options are available when converting them to relations:

1. Create a new relation which references (with a foreign key constraint) the two participants in the relationship.

2. Incorporate the references in the relations Sales and Repair.

The second option is simpler (because we don't need to introduce 4 extra relations) but it is also less efficient, since each instance of Repair and Sales is going to contain a null value. While this choice could be acceptable for an infrequently used relation, it is not tolerable in our case. For this reason it was decided to adopt the first solution. All the other relationships can be converted straightforwardly.

Data Dictionary

Relation	Attribute	Description	Domain	Constraints
Sales	ID	Identifier of the sale	Serial	Primary key
	Date	Date at which the sale was performed	Datetime	Not Null
	Employee	Identifier of the employee	Text	Foreign key to Employee

	Customer	Identifier of the customer	Text	Foreign key to Customer
New Car Sale	NewCar	Identifier of the New Car	Text	Foreign key to New Car, Primary key with ID
	Sales	Identifier of the sale	Serial	Foreign key to Sales, Primary key with New-Car
NewCar	License Plate	Identifier of the New Car	Text	Primary key
	Price	Price of the car	Float	Not Null
	Year	Year of registration of the car	Smallint	Not Null
	Model	Model of the car	Text	Not Null
Used Car Sale	Sales	Identifier of the sale	Serial	Foreign key to Sales
	UsedCar	Identifier of the Used Car	Text	Foreign key to Used Car
Used Car	License Plate	Identifier of the Used Car	Text	Primary key
	Model	Model of the car	Text	Not Null
	Status	Status of the car	Text	Not Null
	Km	Mileage of the car	Int	Not Null
	Price	Price referred to the sale of the used vehicle	Float	Not Null
	Year	Year of the car	Smallint	Not Null
Customer	TC	Identifier of the customer	Text	Primary key
	Name	Name of the customer	Text	Not Null
	Surname	Surname of the customer	Text	Not Null
	Phone	Phone number of the customer	Text	Not Null
	Address	Residential address of the client	Text	Not Null
Car Dealer	Name	Branch name of the car dealer	Text	Primary key
	City	City where the branch is located	Text	Not Null
	Phone	Phone number associated to the branch	Text	Not Null
	Fax	Fax number	Text	
	Address	Address of the branch	Text	Not Null
Employee	TC	Identifier of the employee	Text	Primary key
	Name	Name of the employee	Text	Not Null
	Surname	Surname of the employee	Text	Not Null
	Email	Email of the employee used to access the management system	Text	Not Null
	Password	Password needed by the employee to access the management system	Text	Not Null
	Role	Identifier of a Role	Text	Foreign key to Role

	Car Dealer	Branch name of the car dealer	Text	Foreign Key to Car Dealer
Role	Role Name	Identifier of a Role	Text	Primary key
Rental	Rental ID	Identifier of a Rent	Serial	Primary key
	Start Date	Date from which the Rental starts	Text	Not Null
	Finish Date	Date at which the Rental finished	Text	
	Employee	Identifier of the employee	Text	Foreign key to Employee
	Customer	Identifier of the customer	Text	Foreign key to Customer
	Price	Rental price related	Float	Not Null
	Used Car	Identifier of the Used Car	Text	Foreign key to UsedCar
Used Repairs	Repair	Identifier to Repair	Serial	Foreign key to Repair, Primary key with Used Car
	UsedCar	Identifier of the Used Car	Text	Foreign key to External Car, Primary key with Repair
Repair	ID	Identifier of Repair	Serial	Primary key
	Date	Date at which the Repair is done	Text	Not Null
	Employee	Identifier of the employee who processes the Repair	Text	Foreign key to Employee
External Repairs	Repair	Identifier of Repair	Serial	Foreign key to Repair, Primary key with ExternalCar
	ExternalCar	Identifier of External Car	Text	Foreign key to ExternalCar, Primary key with Repair
External Car	Licence Plate	Identifier of External Car	Text	Primary key
	Year	Year of the External Car	Smallint	Not Null
	Model	Model of the External Car	Text	Not Null
	Customer	Identifier of the customer	Text	Foreign key to Customer
Repair Uses	Replacement	Identifier of the Replacement	Serial	Foreign key to Replacement, Primary key with Repair
	Repair	Identifier of Repair	Serial	Foreign key to Repair, Primary key with Replacement
	Amount	Amount of replacement parts	Integer	Not Null
Replacement	ID	Identifier of Replacement Piece	Serial	Primary key

	Name	Name of the Replacement Piece	Text	Not Null
	PricePerUnit	Price of the single replacement piece	Float	Not Null
	Supplier	Identifier of Supplier	Text	Foreign key to Supplier
Supplier	Name	Identifier of Supplier	Text	Primary key
	Phone	Phone number of the Supplier	Text	Not Null

External Constraints

- For Every Sales there must be an instance either of NewCarSale or UsedCarSale that references it, not both.

- For Every Repair there must be an instance either of ExternalRepairs or UsedRepairs that references it, not both.

- Entity role start with three instances: 'seller', 'mechanic' and 'finance'.

- A seller cannot rent an used car that has the status 'in repair'.

- A seller cannot sell a car that is already sold.

- The "Employee" field in a SALES instance should refer to an EMPLOYEE instance whose role is equal to "seller".

- The "Employee" field in a RENTAL instance should refer to an EMPLOYEE instance whose role is equal to "seller".

- The "Employee" field in a REPAIR instance should refer to an EMPLOYEE instance whose role is equal to "mechanic".

Group Members Contribution

Name	Surname	Contribution
Anahita	Abbaspour	Second part of relationships table Relational schema
Mustafa	Algun	Second part of entities table
Selen	Arslan	Fun. Req. Sat. Check
Alex	Baron	ER Schema Part of relationships table Part of data dictionary of logical design

		Redundancy Analysis
		Final review
Christian	Cattai	Variations to the Req. Analysis
		ER Schema
		Redundancy Analysis
		Final review
Fatjon	Freskina	First part of entities table
		Relation Table
Enrico	Leka	ER Schema
		Part of Transformation of the Entity-Relationship Schema
		Analysis of Database Load
		Final review
Marco	Milanese	First part of relationships table
		Relational schema
		Final Review
Giulio	Scattolin	External Constraints (CD and LD)
		Fun. Req. Sat. Check