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1. Introduction

SMILE Car Rental is a domestic vehicle rental company with many branches located throughout Australia. The headquarter located in Sydney. The company offers multiple vehicle types, including sedan, SUV, and Van. The success relies on affordable prices, occasional marketing promotions and reliable vehicle quality for their customers. As the business keeps growing, SMILE Car Rental must better manage its business operations and customer relationship hence inquired the database design. Apparently, the databases are designed for internal users, including HR department, Sales Department, procurement department, IT Department and the managerial level. We will design the following database and functions for SMILE Car Rental:

- **Human resource database** for the managerial level and HR department to better manage employees.
- **Asset management database** for all departments in the company. The database contains the assets information about cars and facilities.
- **Orders management database** will be divided into two main databases, order from customers and purchase-order to vehicle suppliers. The sales Department would manage the order_customer database, while the procurement department would maintain the order_supplier database.
- **Customer management database** is designed for the Sales department to record and maintain customers' information.
- **Supplier management database** is designed for the Procurement department to track and record the supplier's information

2. Business Operation and ERDs

In this session, we will elaborate on the business rules by the main function in which the company inquired. We define 11 entities at first. They are Department table, Employee table, Manager table, Car table, Branch table, Facility table.

2.1 HR Function

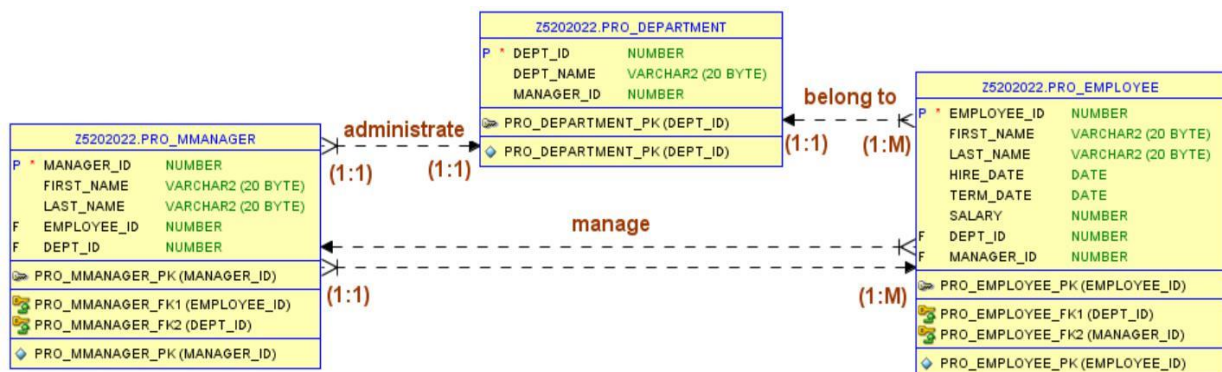
Based on the business operation of the rental car company, there are four main entities regarding the HR function in our database design, including DEPARTMENT, EMPLOYEE, MANAGER, and BRANCH. We demonstrate the attributes regarding the entities in table 1

Table 1

ENTITY	ATTRIBUTES
DEPARTMENT	DEPT_ID (PK), DEPT_NAME, MANAGER_ID(FK)
EMPLOYEE	EMPLOYEE_ID(PK), FIRST_NAME, LAST_NAME, HIRE_DATE, TERM_DATE, DEPT_ID, SALARY, MANAGER_ID (FK)
MANAGER	MANAGER_ID (PK), EMPLOYEE_ID(PFK), FIRST_NAME, LAST_NAME
BRANCH	DEPT_ID (PK), BRANCH_NAME, TOTAL_NUM_CAR, MANAGER_ID (FK)

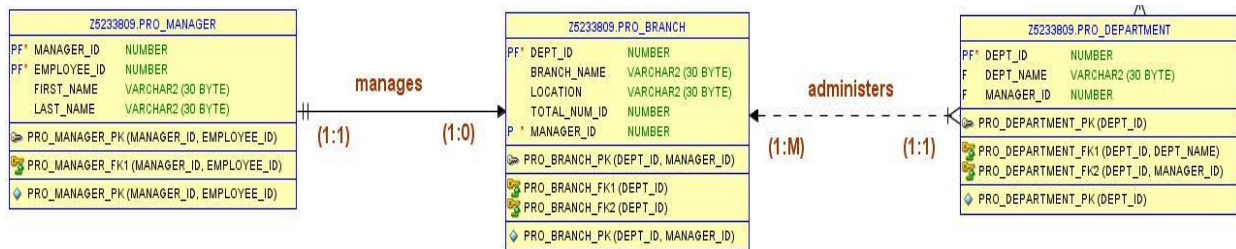
In SMILE Car Rental, there are many departments in this company. For example, the headquarters has administration, procurement, human resource management, sales, and each branch. Each department has its ID and is administered by a manager, and each manager only administer one department. As figure 1 shown, a 1:1 relationship, therefore, exists between DEPARTMENT and MANAGER. The cardinality can be expressed by (1,1). Furthermore, each department may include many employees, however, one employee can only be recruited in one department. Thus, a 1:M relationship exists between EMPLOYEE and DEPARTMENT. The cardinality can be expressed by writing (1,1) next to the entity DEPARTMENT and (1, M) next to the entity EMPLOYEE. In addition, one employee matches only one manager, while a manager has at least one employee. The relationship between EMPLOYEE and MANAGER is 1:M.

Figure 1



To easily access to car-rental customers, SMILE Car Rental has several branches throughout Australia. For example, in Sydney, the branches located at CBD, Bondi beach, and the airport. The sales department administers all branches. In short, a 1:M relationship exists between department and branch. As figure 2 shown, a (1:M) marks next to the entity BRANCH while a (1:1) marks next to the entity DEPARTMENT. In addition, Each Branch is administered by a manager and staff. The manager is permitted to manage only one branch. But not every managerial level needs to manage a branch, hence the branch is an option for the manager. Therefore, in figure 2, a 1:1 relationship exists between manager and branch, expressing by writing (1,0) next to the entity MANAGER and (1,1) next to the entity BRANCH

Figure 2



2.2 Asset Management Function

The most valuable and essential assets of a car-rental company are vehicles. SMILE Car Rental provides three options of vehicle for customers, economy, SUV, and van. To better manage the in and out, efficiently dispatch vehicle to branch, and reach real-time information of vehicle, we create the entity CAR and list other assets such as facilities and furniture in the entity FACILITY. Information about two entities is shown in Table 2.

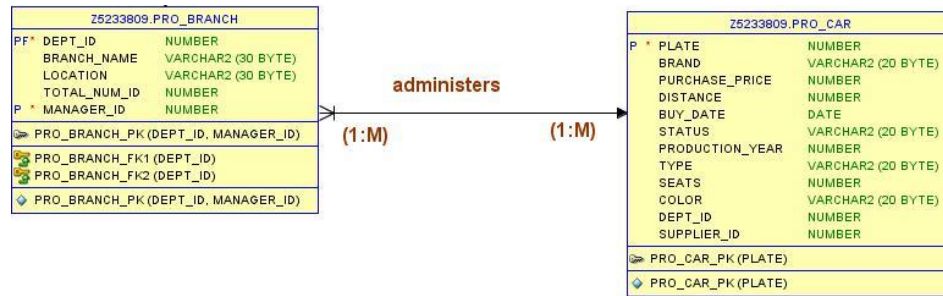
Table 2

ENTITY	ATTRIBUTES
CAR	PLATE (PK), BRAND, PURCHASE_PRICE, DISTANCE, BUY_DATE, STATUS, PRODUCTION_YEAR, TYPE, SEATS, COLOR, DEPT_ID, SUPPLIER_ID
FACILITY	ASSET_ID(PK), ITEM_NAME, DEPT_ID (PK)

To offer convenient car renting experience for customers, SMILE Car Rental allocates vehicles in branches. The number of vehicles that a branch manages depends on the popularity of the location and the space for car-parking. For example, the number of vehicles

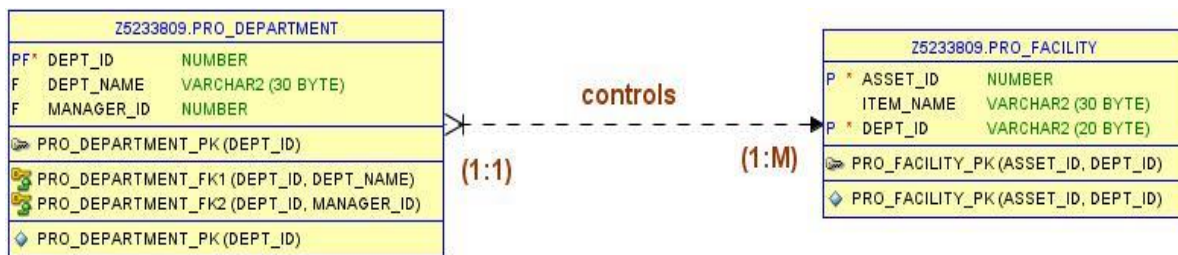
in the airport branch is biggest, while that of the CBD branch is the smallest due to limited and expensive parking lot. However, the vehicles are not limited to one branch. For better vehicle dispatch, the vehicle might be dispatched between branches. Consequently, in figure 3, an M: N relationship exists between vehicle and branch, expressing by (1:M) next to the entity CAR and (1:M) next to the entity BRANCH.

Figure 3



Next, Company possesses assets such as computers, desks, cabinets, or landline telephones, and each department controls assets. With the asset ID, the manager of the department may easily manage multiple assets. Yet, one facility belongs to only one department. Hence, a 1: M relationship exists between asset and department. As figure 4 shown, a (1:1) marks next to the entity FACILITY while a (1:M) marks next to the entity DEPARTMENT.

Figure 4



2.3 Order Management Function

Based on the business operation of SMILE Car Rental, we separate the order into two definitions: order-from-customers and purchase-order to suppliers. On one hand, the database of order-from-customers obtains all rental car information, including the price, car type, start date and time, etc. On the other hand, purchase-order to suppliers records the vehicle order

information. We develop five entities in order management function, listing the entities and regarding attributes in table 3.

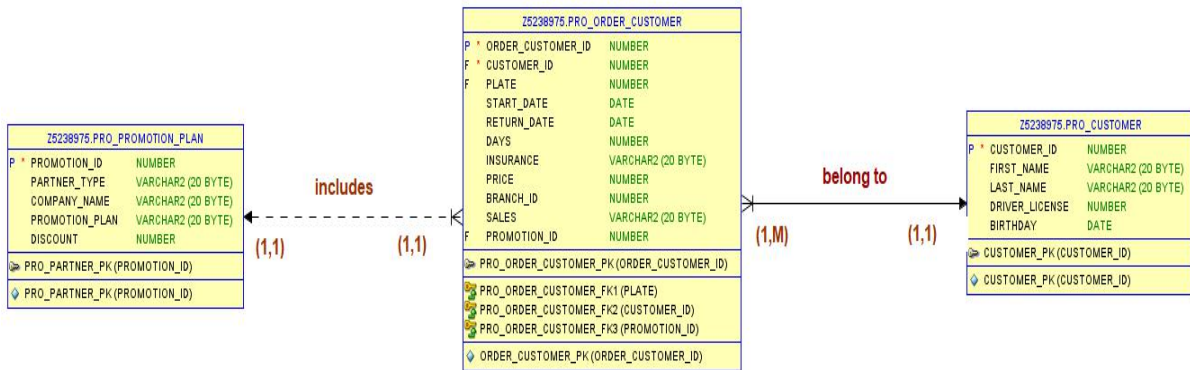
Table 3

ENTITY	ATTRIBUTES
ORDER_CUSTOMER	CUSTOMER_ORDER_ID (PK), PLATE (FK), START_DATE, RETURN_DATE, DAYS, CUSTOMER_ID(FK), INSURANCE (binary values), PRICE, TICKET_FEE
CUSTOMER	CUSTOMER_ID (PK), FIRST_NAME, LAST_NAME, TEL, DRIVER_LICENSE, BIRTHDAY
ORDER_SUPPLIER	SUPPLIER_ORDER_ID(PK), SUPPLIER_ID(FK), CAR_TYPE, PLATE, ISSUE_DATE
SUPPLIER	SUPPLIER_ID, COMPANY_NAME, TEL, ADDRESS, OFFER_CAR_TYPE, TOTAL_NUM_CAR
PROMOTION_PLAN	PROMOTION_ID, PARTNER_TYPE, COMPANY_NAME, PROMOTION_PLAN, DISCOUNT

SMILE Car Rental earn revenue from leasing vehicle by hourly charge or daily charge. The price of car rental depends on the car type. Customers may place rental orders online or offline (walk-in service of the branch). In each rental order, customers are required to provide sufficient personal information and select only one type of vehicle in one order. Each customer may generate limitless orders, but each customer's orders can only belong to one customer. Therefore, as figure 5 shown, there is a 1:M relationship between CUSTOMER and ORDER_CUSTOMER.

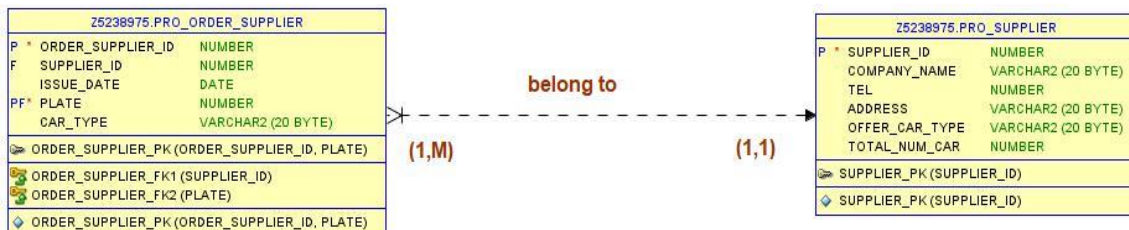
The rental car business is a necessary sub-industry for the tourist industry. SMILE Car Rental cooperates with various types of travel agencies, hotels, airline companies or transportation companies. By occasionally launch promotion plans with their business partners, SMILE Car Rental usually appeals to more customers and increase their sales. For example, the company cooperated with NEW ZEALAND AIRLINE last month and offered a 20% discount for airline customers. However, customers are strictly permitted to apply one promotion plan at each order. Thus, there is a (1:1) relationship between entity CUSTOMER and PROMOTION_PLAN. Yet, one promotion plan could be used in multiple customer orders. Hence, there is a (1:M) relationship marked next to PROMOTION_PLAN. The ERD is depicted in figure 5.

Figure 5



Similarly, SMILE Car Rental issues vehicle purchase-order to multiple vehicle suppliers at their need. To be specific, all purchase-orders are generated by the procurement department. In each purchase-order, SMILE Car Rental will submit that to only one supplier. In other words, every supplier can generate several orders confirmation to SMILE Car Rental, but each purchase-order to suppliers only belongs to one supplier. Therefore, in figure 6, there is also a 1:M relationship between SUPPLIER and ORDER_SUPPLIER.

Figure 6



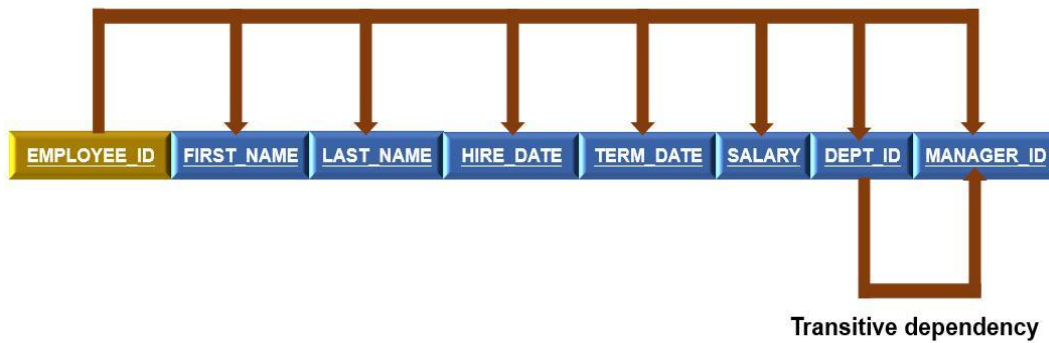
3. Normalization and completed ERD

3.1 Normalization

EMPLOYEE table: *transitive dependency*

In this table, the MANAGER_ID of employees who are in the same department will appear repeatedly and differed as to the department changes. Therefore, a transitive dependency between DEPT_ID and MANAGER_ID and finally we delete MANAGER_ID in this table.

Figure 7



ORDER_CUSTOMER table: *Partial dependency*

We found that there are some attributes in ORDER_CUSTOMER table related to financial activities, such as price and insurance, so we decide to add another primary key in this table named INVOICE_ID. These two PKs results in a partial dependency exist in this table. Hence, we need to separate this table into two tables: ORDER_CUSTOMER table and INVOICE table. We also added some new attributes in the INVOICE table in terms of financial activities. These two new tables are shown below.

Figure 8

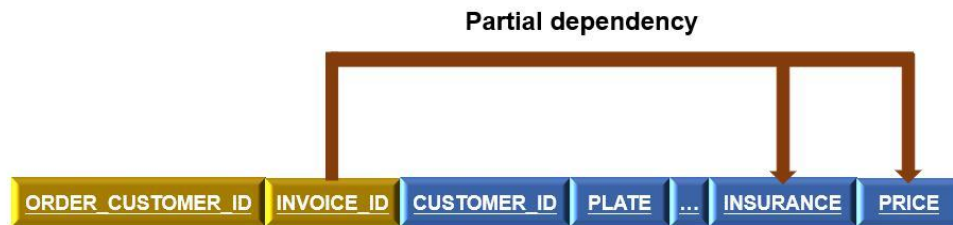
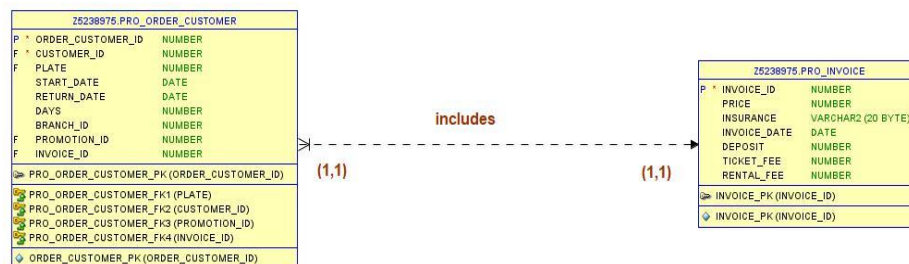


Figure 9



ORDER_SUPPLIER table.: *Partial dependency, Transitive Dependency and redundancy*

In order to examine the table structure in details, there is a table of ORDER_SUPPLIER with assumed data. It can be found that there can be many repeating groups in this table. For example, since every supplier can supply multiple cars in an order, there can be many plate values and car types with the same order_supplier_ID.

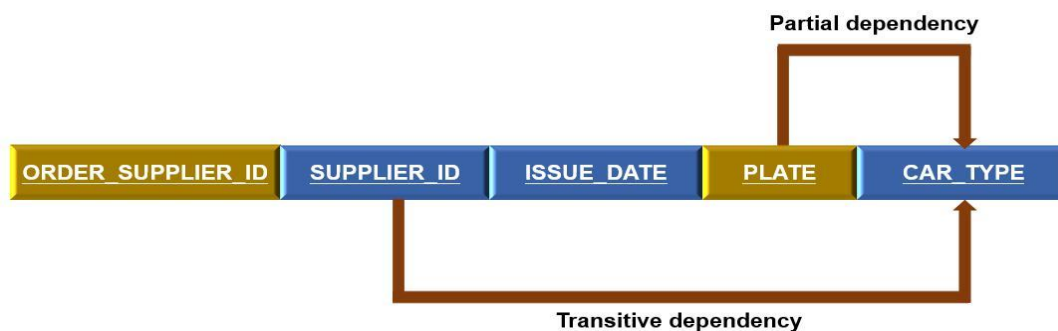
Table 5

ORDER_SUPPLIER_ID	SUPPLIER_ID	ISSUE_DATE	PLATE	CAR_TYPE
10000	1234	01/JAN/19	123	SUV
10000	1234	01/JAN/19	124	SUV
10000	1234	01/JAN/19	125	ECONOMY
10000	1234	01/JAN/19	126	VAN
10001	1235	01/FEB/19	127	SUV
10001	1235	01/FEB/19	128	SUV
10001	1235	01/FEB/19	129	ECONOMY

And a dependency diagram is used to examine the dependencies among these attributes in table ORDER_SUPPLIER. This is a first normal form (1NF) dependency diagram and there are two types of dependencies existing in this diagram.

- Partial dependency.* You only need to know the PLATE of a car to determine CAR_TYPE, which means that the CAR_TYPE is dependant on only part of the primary key.
- Transitive dependency.* Note that CAR_TYPE can also be dependant on SUPPLIER_ID and neither of them are primary keys. So, there is a transitive dependency between these two attributes.

Figure 10



In order to converse to third normal form (3NF), we delete the attributes PLATE and CAR_TYPE to avoid repeating groups and dependencies. But it is also necessary to list the car types information in the ORDER_SUPPLIER_ID. So, we add the attributes SUV, ECONOMY, and VAN to ORDE_SUPPLIER_ID. Now the original table with data will be like as the following one.

Table 6

ORDER_SUPPLIER_ID	SUPPLIER_ID	ISSUE_DATE	SUV	ECONOMY	VAN
10000	1234	01/JAN/19	2	1	1
10001	1235	01/FEB/19	2	1	0

4. Conclusion

To sum up, We designed 12 tables for the SMILE Car Rental company, which contains the HR functions, sales function, Customer and supplier management function.

In the previous version of database design, on the one hand, we found out a transitive dependency among EMPLOYEE table and ORDER_SUPPLIER tables. Solving this issue, we deleted that attribute and replaced it into other attributes. For example, a transitive dependency exists between attribute PLATE and attribute CAR_TYPE in ORDER_SUPPLIER table, then we will delete the car_type attribute and add SUV, VAN, ECONOMY attributes instead. On the other hand, a partial dependency exists in the ORDER_CUSTOMER table. Thus, we separated the primary keys into two tables, which are the ORDER_CUSTOMER table and INVOICE table.

Therefore, we would claim that the final ERD database design is in the Third normal form (3NF), demonstrated by no transitive dependency, no partial dependency, and no data redundancy issues.

Appendix 1 Entities Among ERDs

According to the business operations mentioned before, we develop 12 entities and list below, and the relationships among entities to entities are demonstrated in table

Table 4

COMPONENTS OF THE ERM			
ENTITY	RELATIONSHIP	CONNECTIVITY	ENTITY
HR FUNCTION			
MANAGER	administrates	1:1	DEPARTMENT
MANAGER	administrates	1:0	BRANCH
EMPLOYEE	belongs to	1:M	DEPARTMENT
DEPARTMENT	administers	1:M	BRANCH
ASSET MANAGEMENT FUNCTION			
DEPARTMENT	control	1:M	FACILITY
BRANCH	administers	M:N	CAR
ORDER MANAGEMENT FUNCTION			
CUSTOMER	issues	1:M	ORDER_CUSTOMER
ORDER_CUSTOMER	Includes	1:1	PROMOTION_PLAN
ORDER_CUSTOMER	includes	1:1	CAR
ORDER_SUPPLIER	belongs to	1:1	SUPPLIER

Appendix 2 Completed ERD

