MONASH University

MONASH
INFORMATION
TECHNOLOGY

FIT3003 – Business Intelligence and Data Warehousing

Week 2 – Star Schema

Semester 2, 2022

Developed by:
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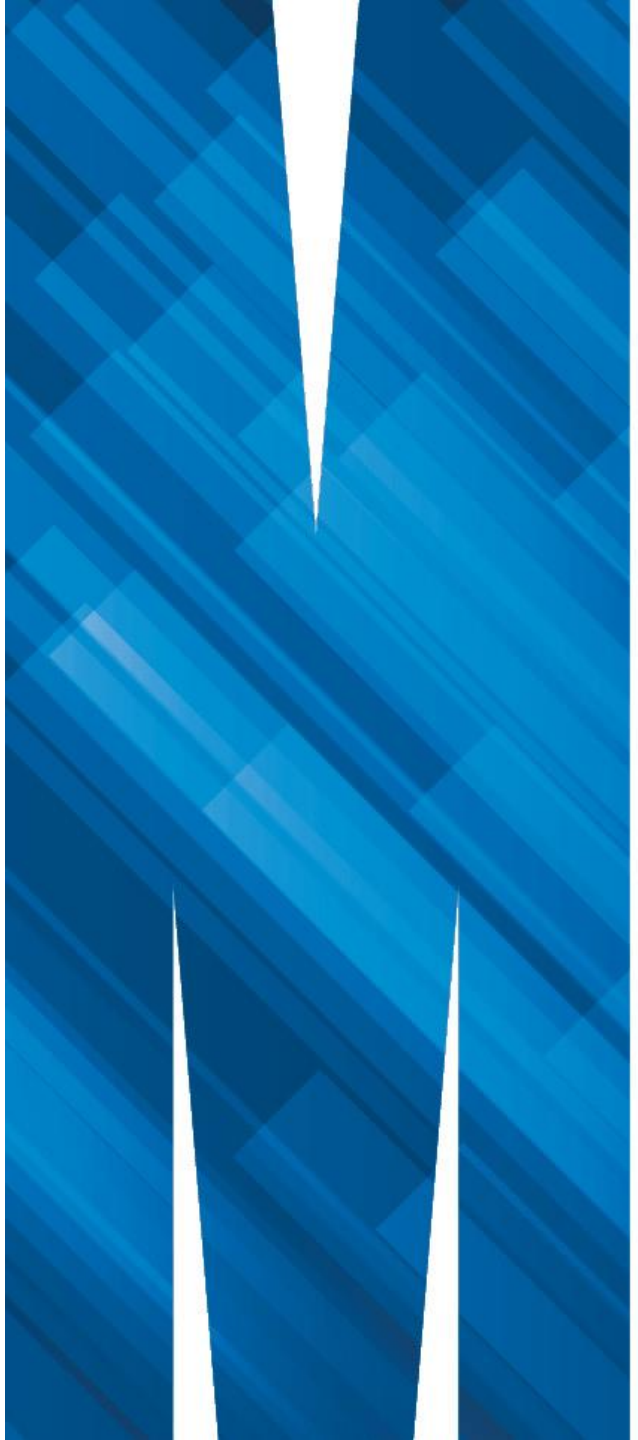


Learning Objectives

1. understand the concept of Star Schema
2. able to create a data warehousing model using Star Schema
3. understand the concept of Fact and Dimension
4. understand the concept of Two-column Methodology

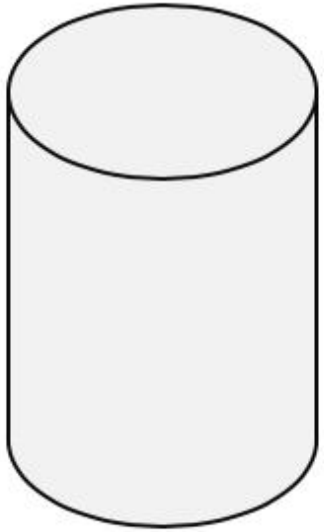
Agenda

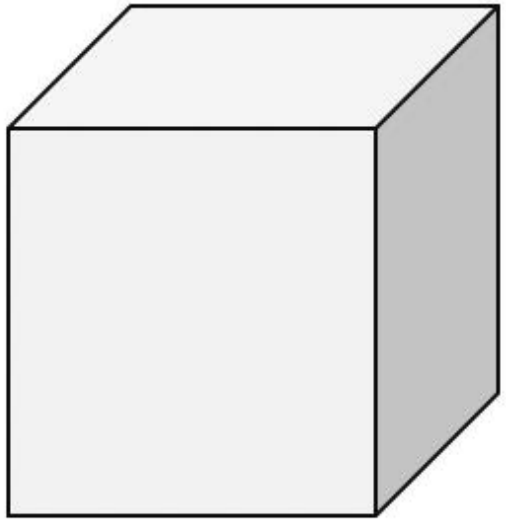
1. Notations and Processes
    1. Star Schema Notation
    2. E/R Diagram Notation
    3. Transformation Process (Case Study)

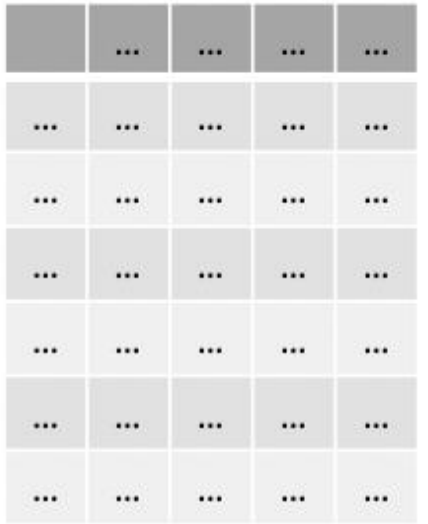
2. Two-Column Table Methodology

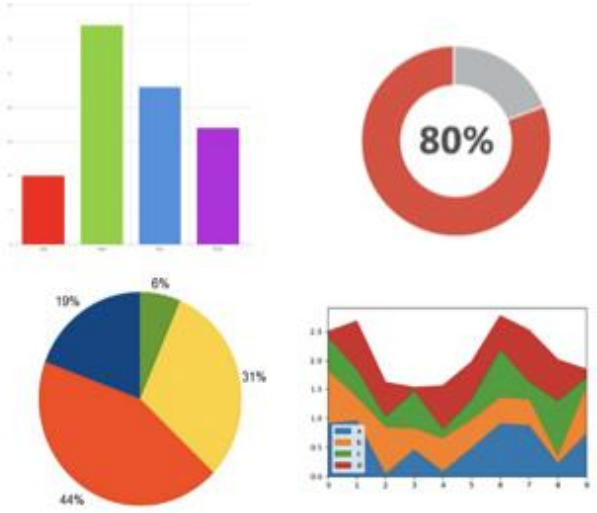
Recall – The Big Picture

Operational Database → Data Warehouse → OLAP → Business Intelligence









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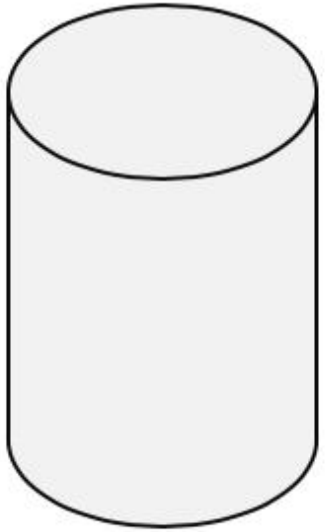
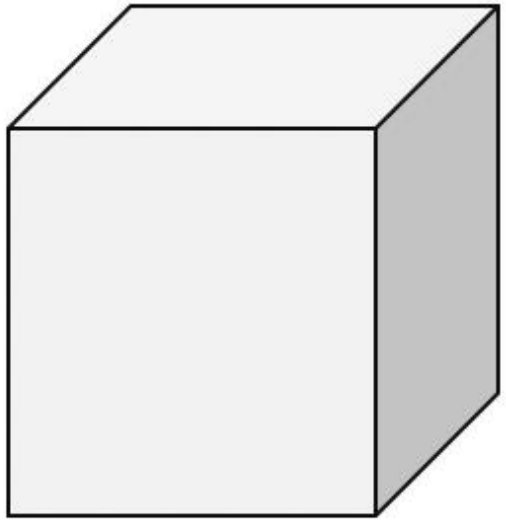
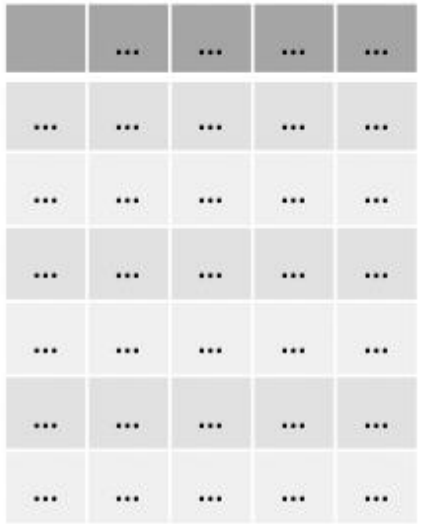
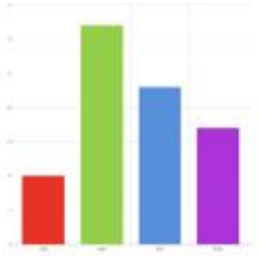
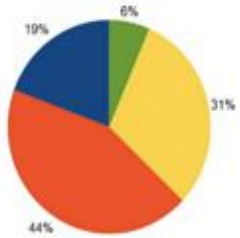
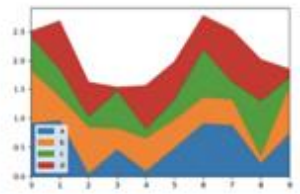










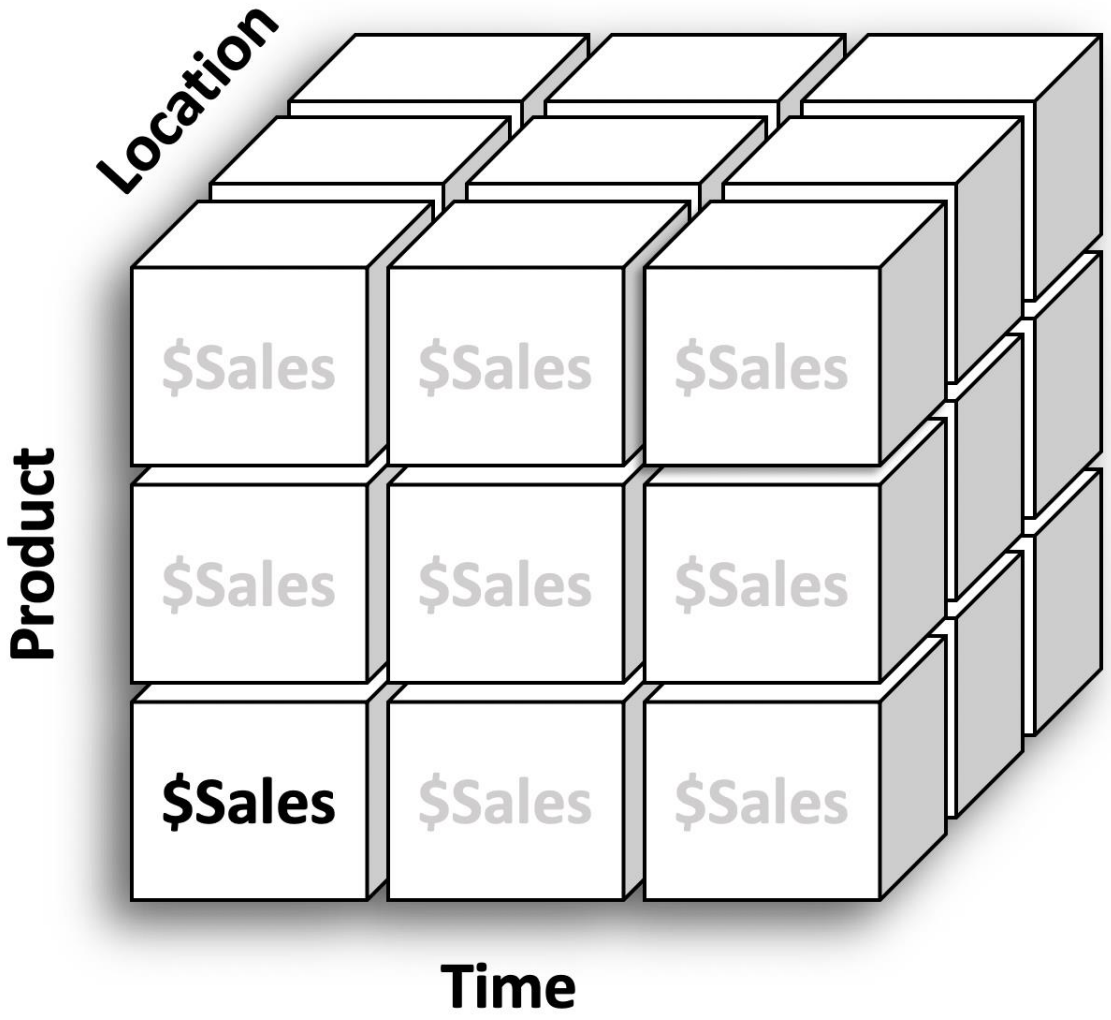


Recall – Data Warehouse

- To address the drawback of operational database, and a need for decision-making support data, **data warehouse is needed**.

- A **data warehouse** is a multi-dimensional view of databases, with aggregates and pre-computed summaries.
  - In many ways, it is basically doing aggregates in advance; that is exactly pre-computation done at the design level, rather than at the query level.

Recall – Data Warehouse



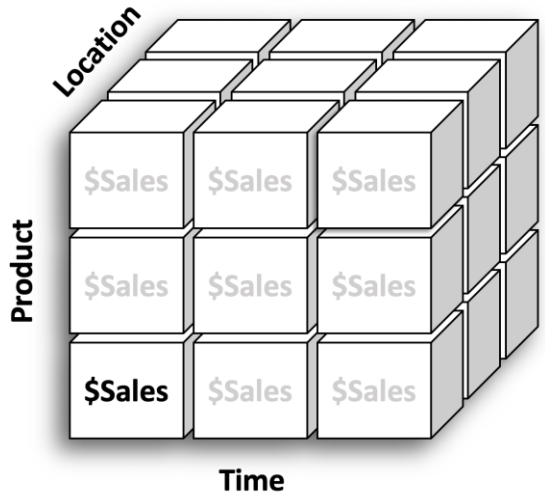
Star Schema

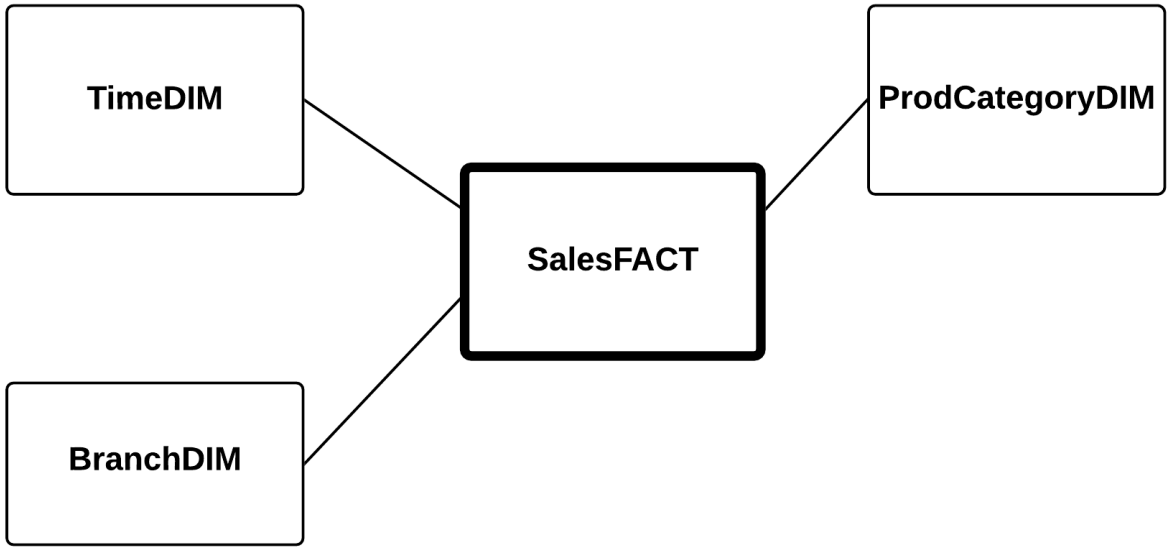
- A Star Schema is a design representation of a multi-dimensional view. It is a data modeling technique used to map multidimensional decision support data into a relational database.

- The reason for the star schema's development is that existing relational modeling techniques: ER and normalization, did not yield a database structure that served the advanced data analysis requirements well.

Star Schema Components

- There are **Three** main components of the Star Schema:
  1. Facts — Numerical measurement (e.g., KPI like sales)
  2. Dimensions
  3. Attributes — The attributes of dim table





Star Schema Components

1. **Facts**

   Facts are **numeric measurements** (values) that represent a specific business aspect or activity.

   For example, sales figures are numeric measurements that represent product and/or service sales.

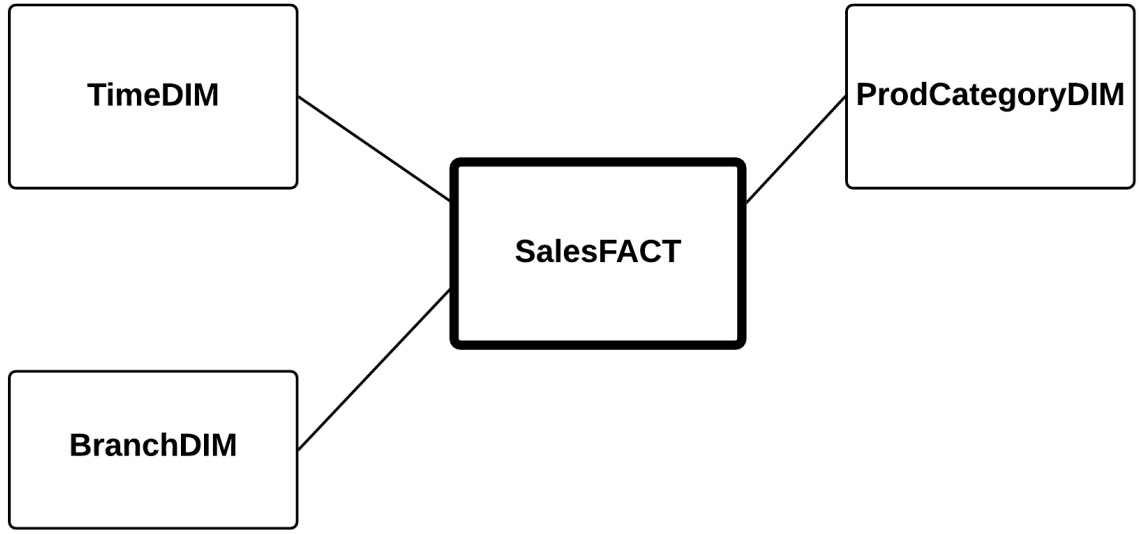
2. **Dimensions**

   Dimensions are qualifying characteristics that provide **additional perspectives** to a given fact.

   For example, sales might be *viewed* from specific dimension(s), such as sales location, sales period, sales product, etc.

Star Schema Notation

- A Sales Star Schema
  - **Fact**:
    - Sales
  - **Dimensions**:
    - Time
    - Product
    - Branch

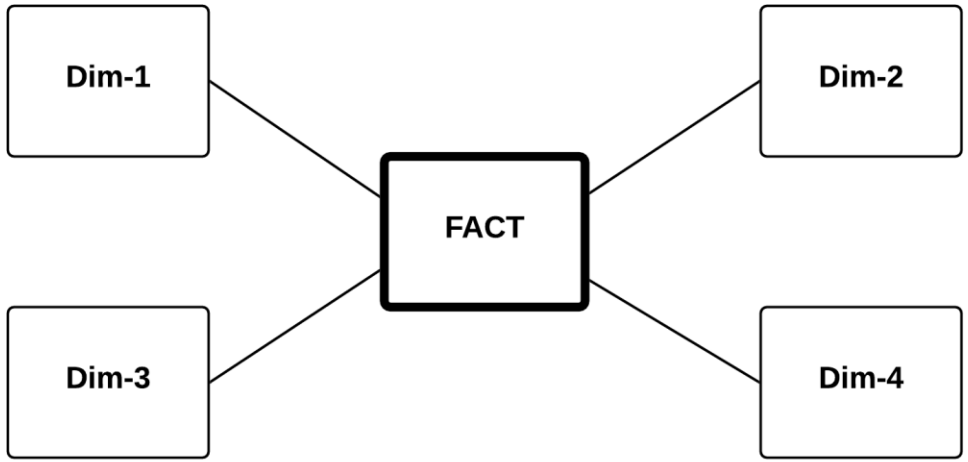


- Notation-wise, the Fact uses a bolder line, to differentiate between Fact from Dimensions.

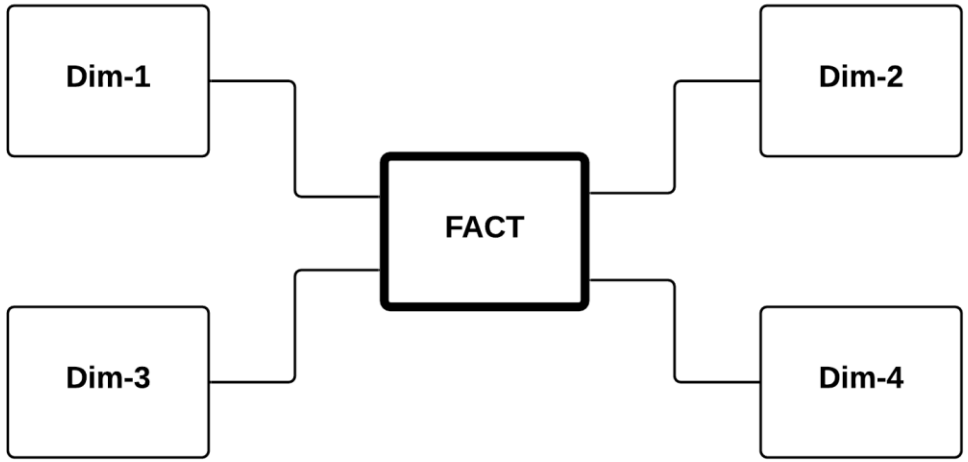
Star Schema Notation

- A Sales Star Schema
  - **Fact**:
    - Sales
  - **Dimensions**:
    - Time
    - Product
    - Branch

- The lines that represent a relationship between the fact and dimensions can be straight lines or bended lines.

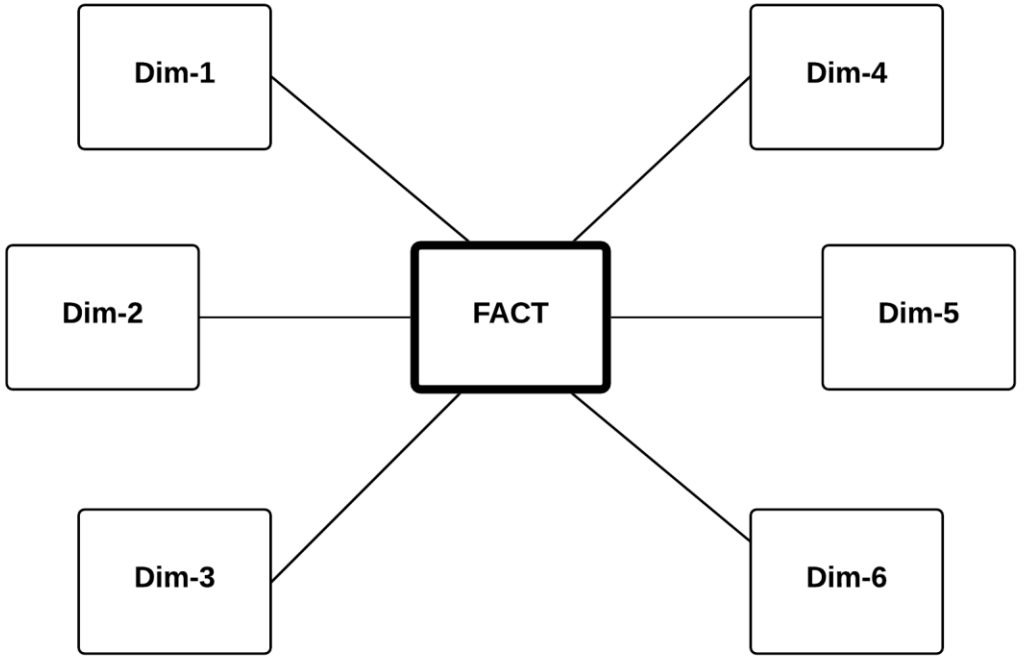


OR



Star Schema Notation

- Using the star schema notation, the number of dimensions can be unlimited.
- If there is more dimensions, then we just add more dimensions linked to the Fact.



Star Schema Components

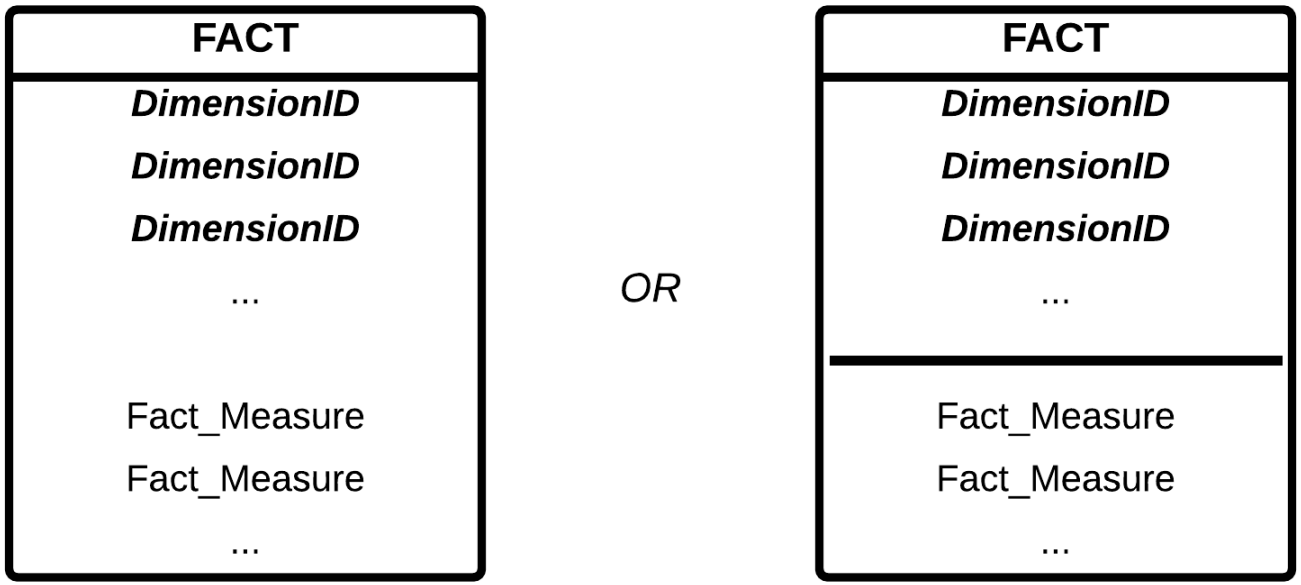
3. Attributes

Each dimension table contains attributes.

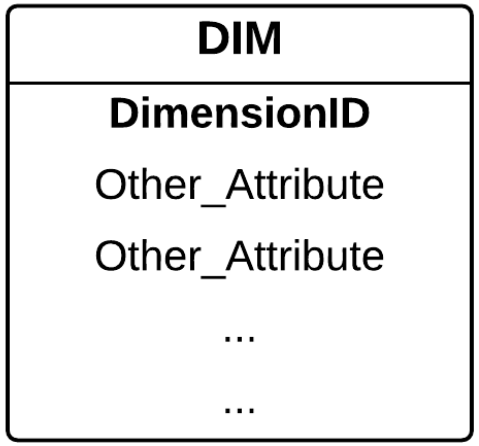
For example:

Product dimension:	Prod Type, Description.
Location dimension:	Region, State, City.
Time dimension:	Year, Month.

Star Schema Notation



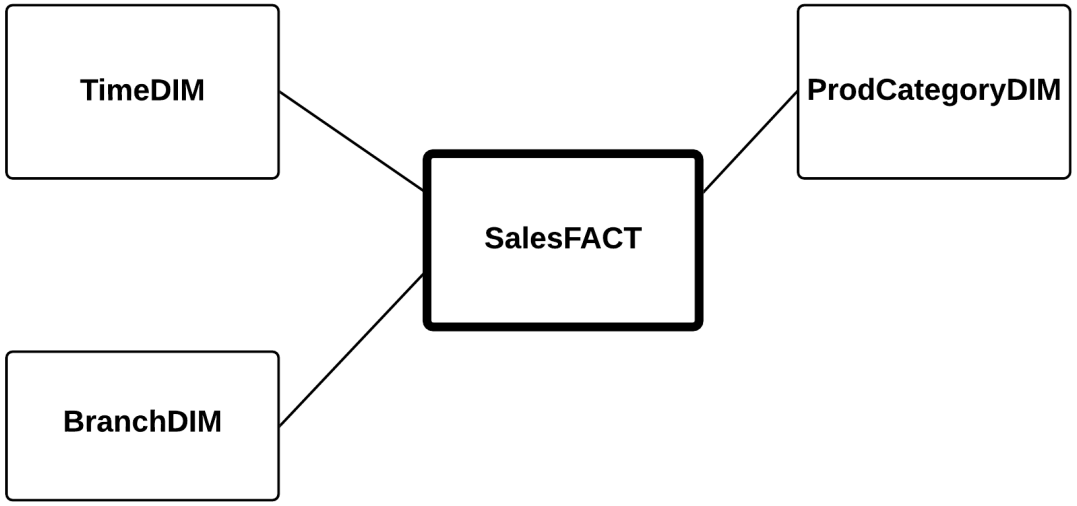
(*a*) Fact



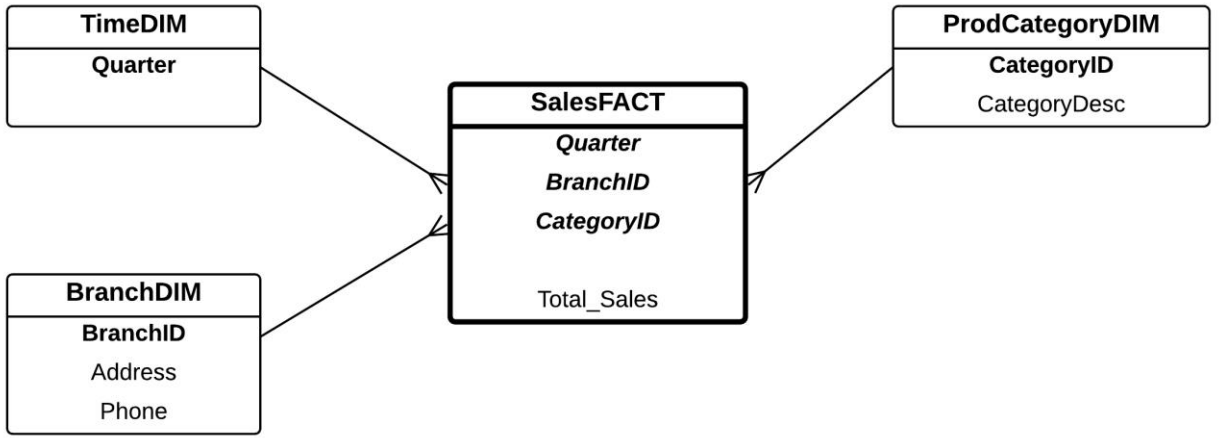
(*b*) Dimension

Star Schema Notation

- Sales Star Schema



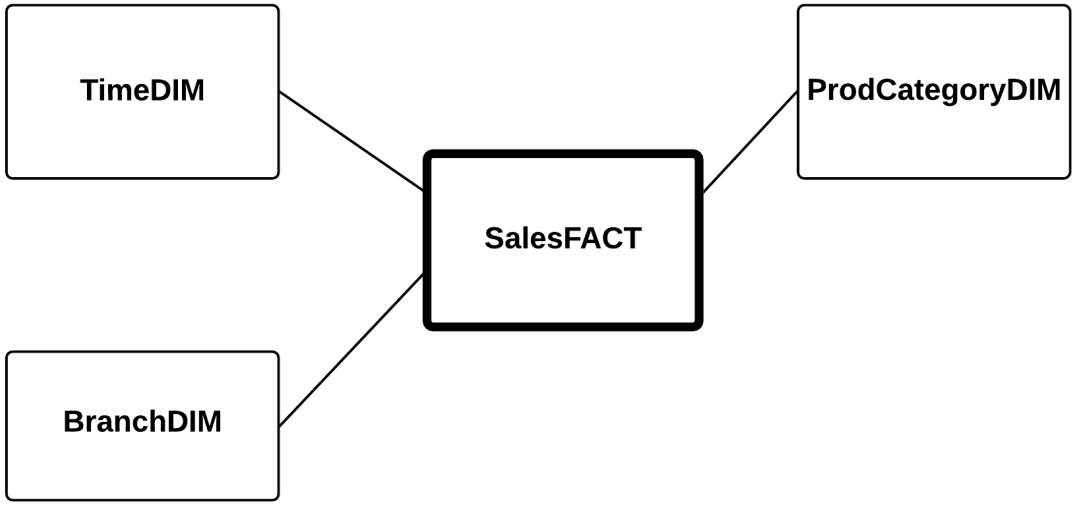
(a) Outline star schema for Sales



(b) Sales Star Schema complete with the Attributes

Star Schema Notation

- Sales Star Schema



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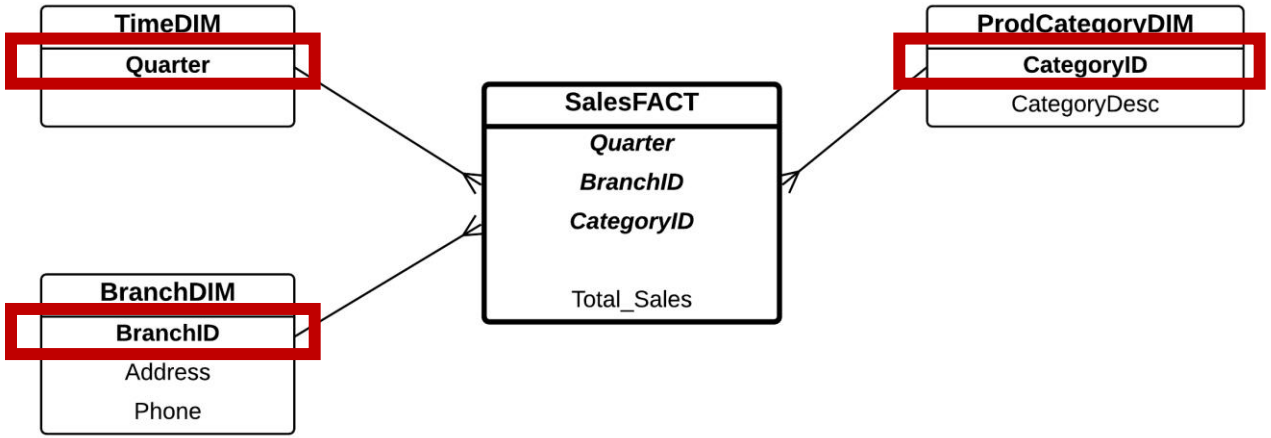

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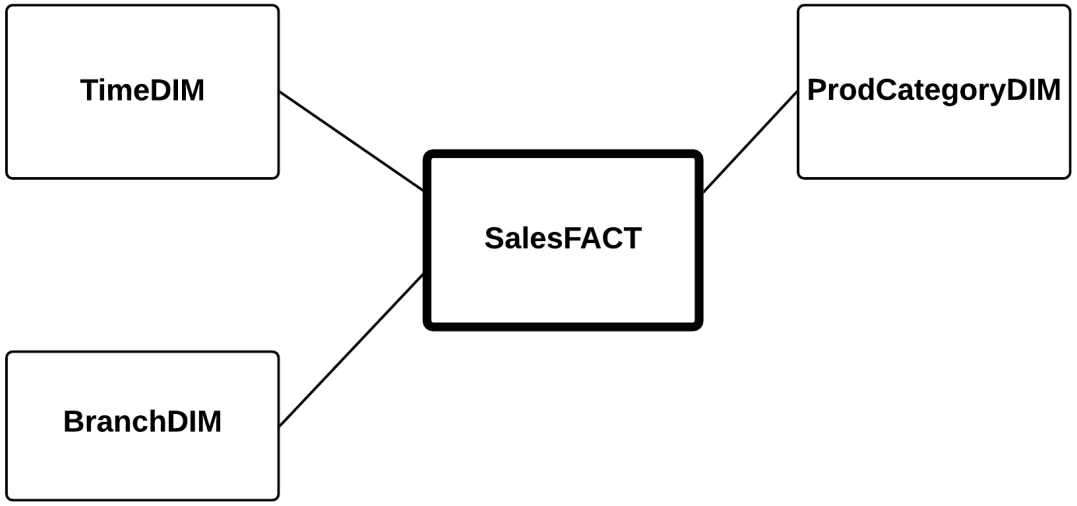
Star Schema Notation

- Sales Star Schema



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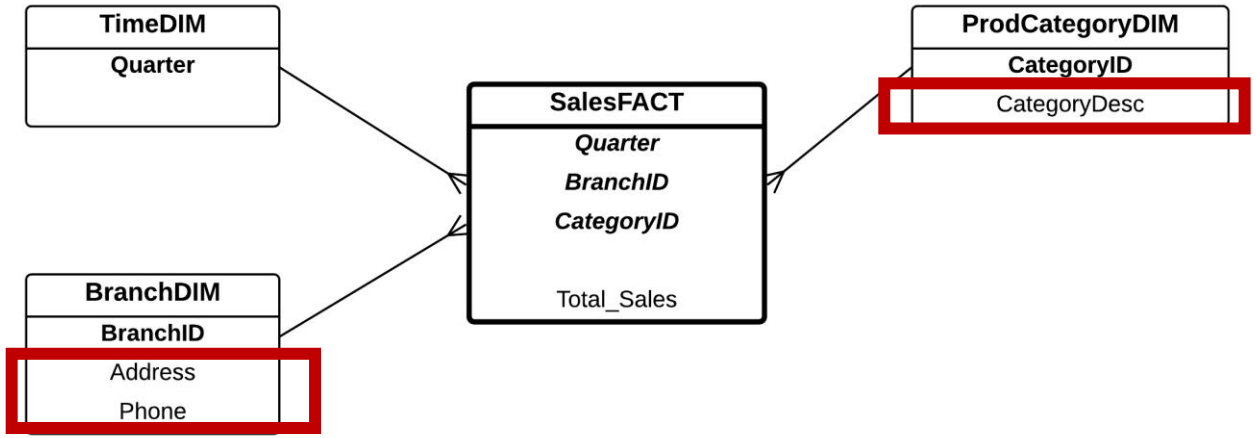

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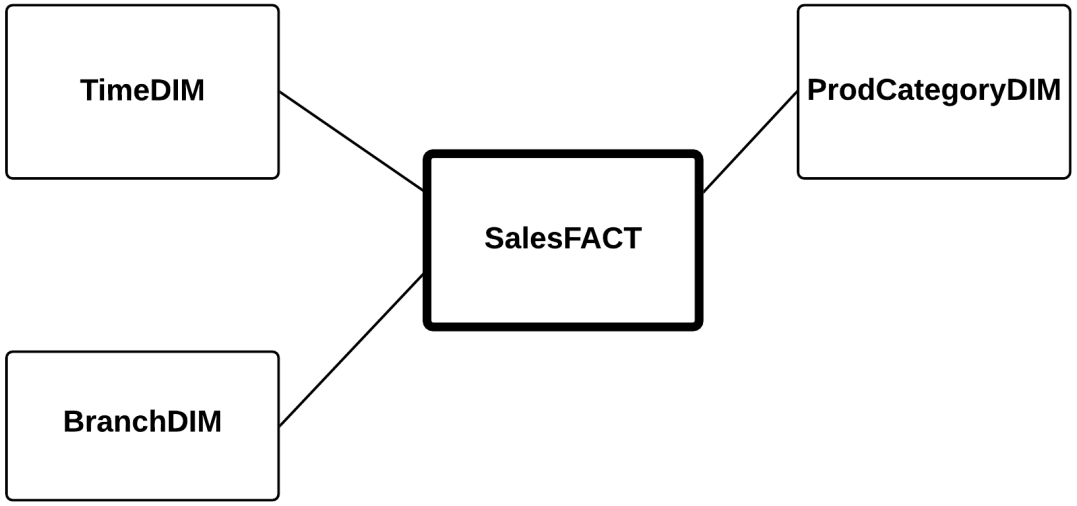
Star Schema Notation

- Sales Star Schema



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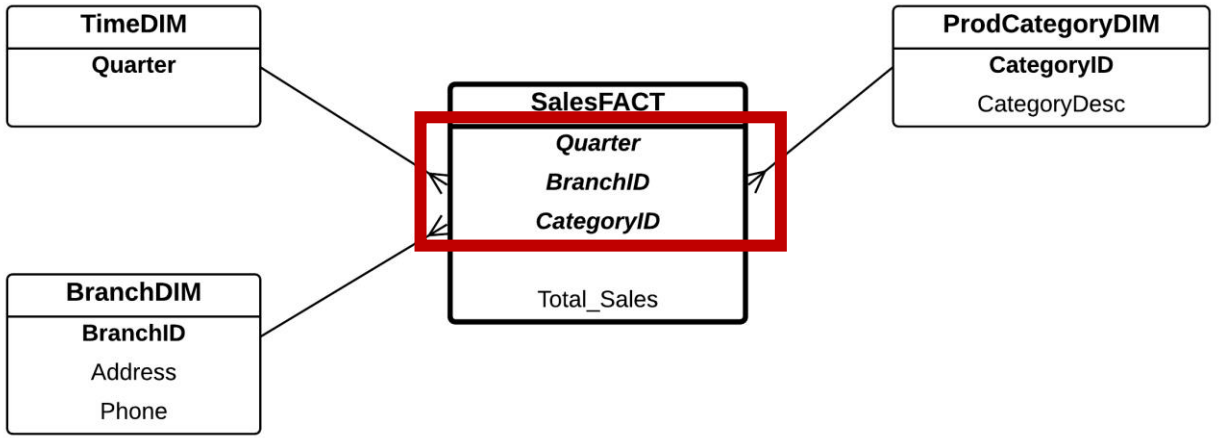

(b) Sales Star Schema complete with the Attributes

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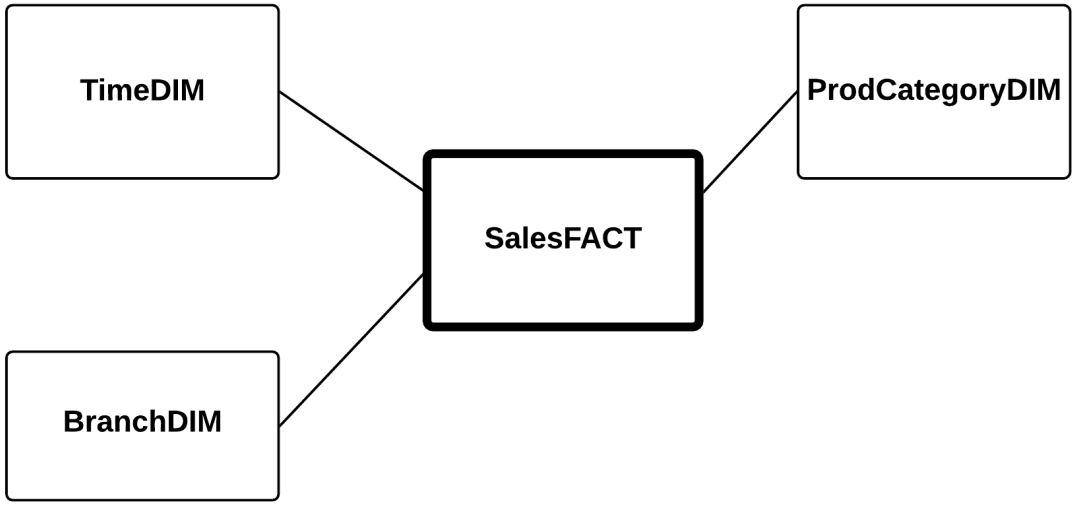

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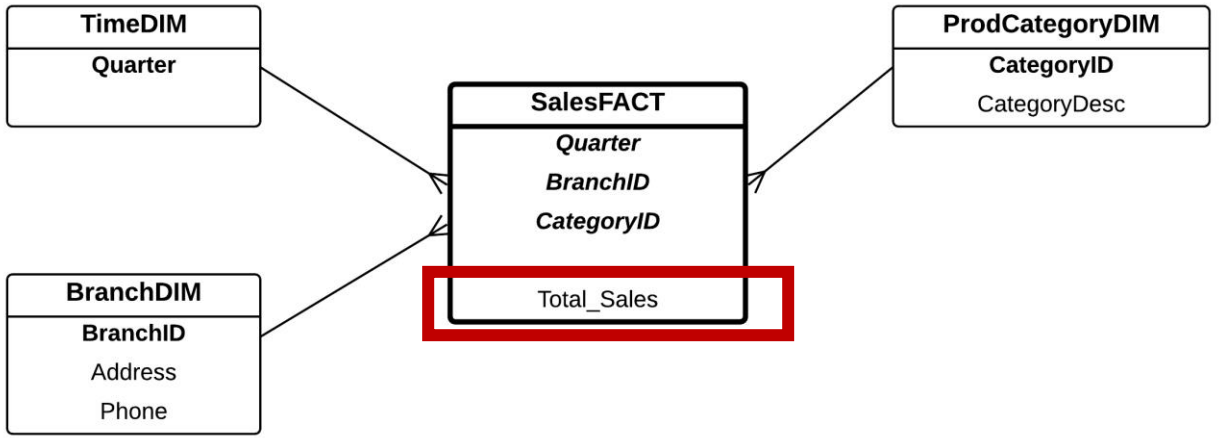

(b) Sales Star Schema complete with the Attributes

E/R Diagram Notation

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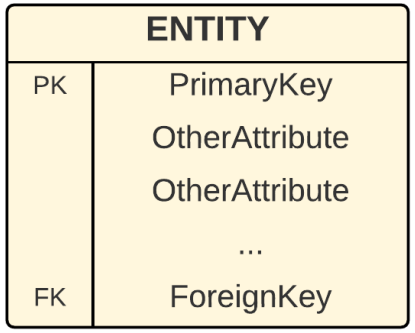

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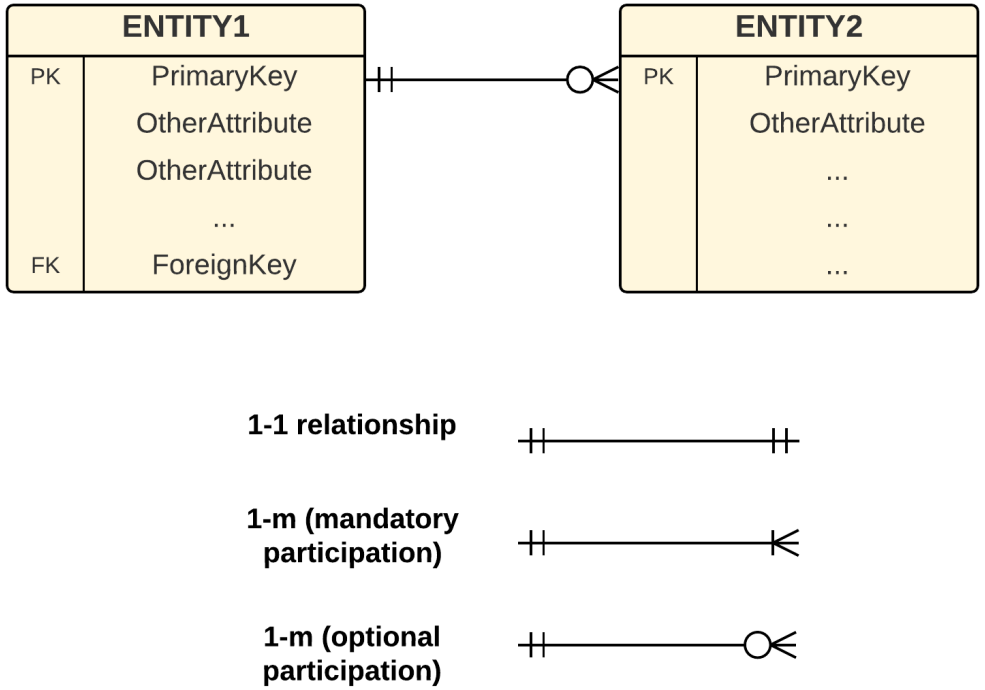

(b) Relationships in E/R Diagram

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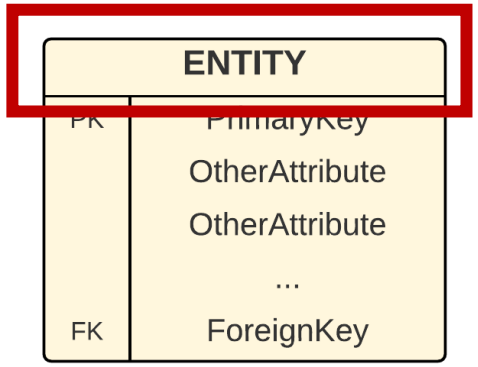

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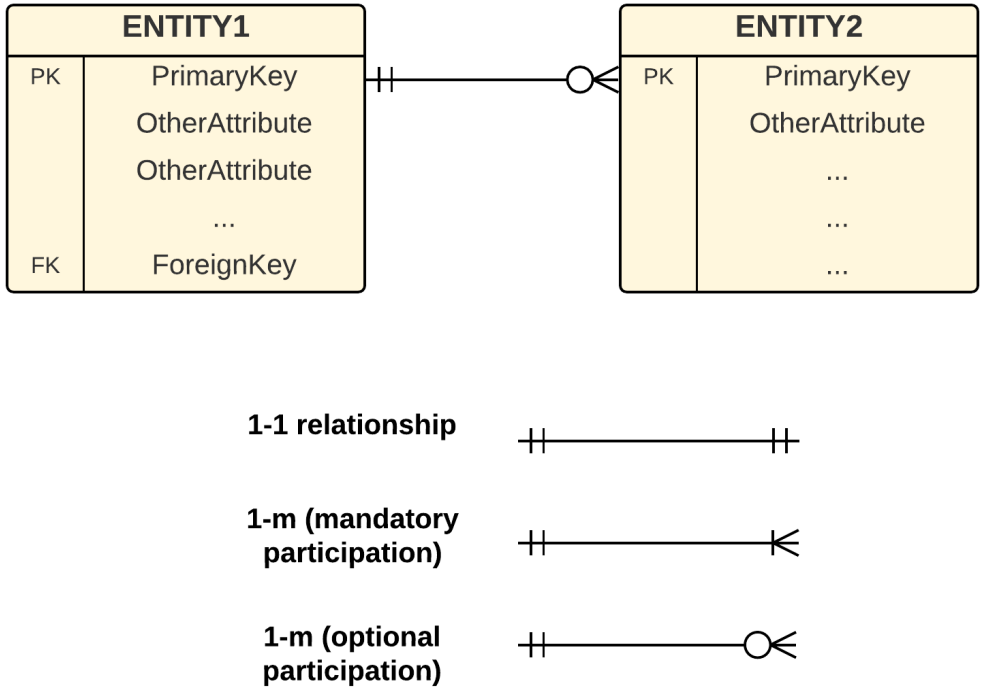

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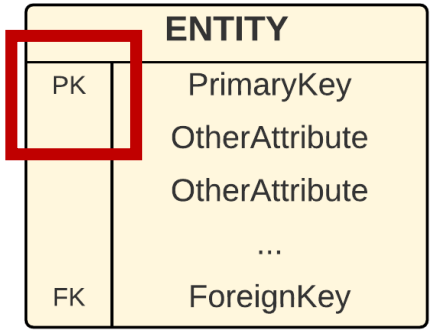

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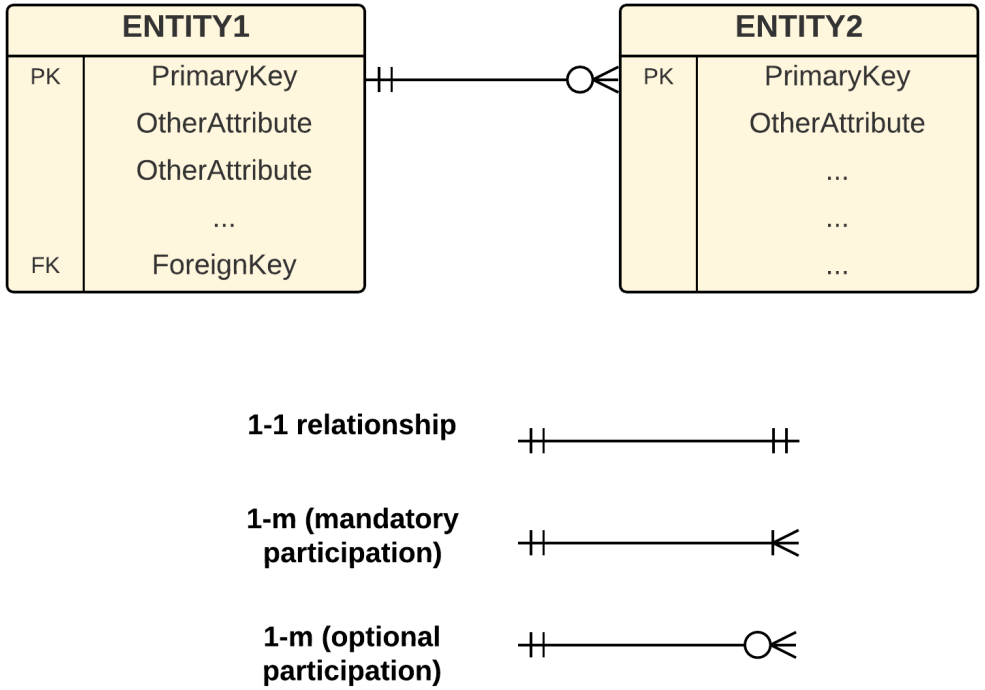

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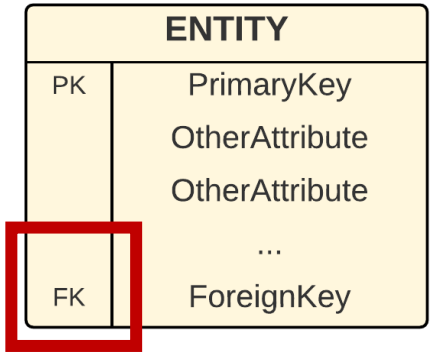

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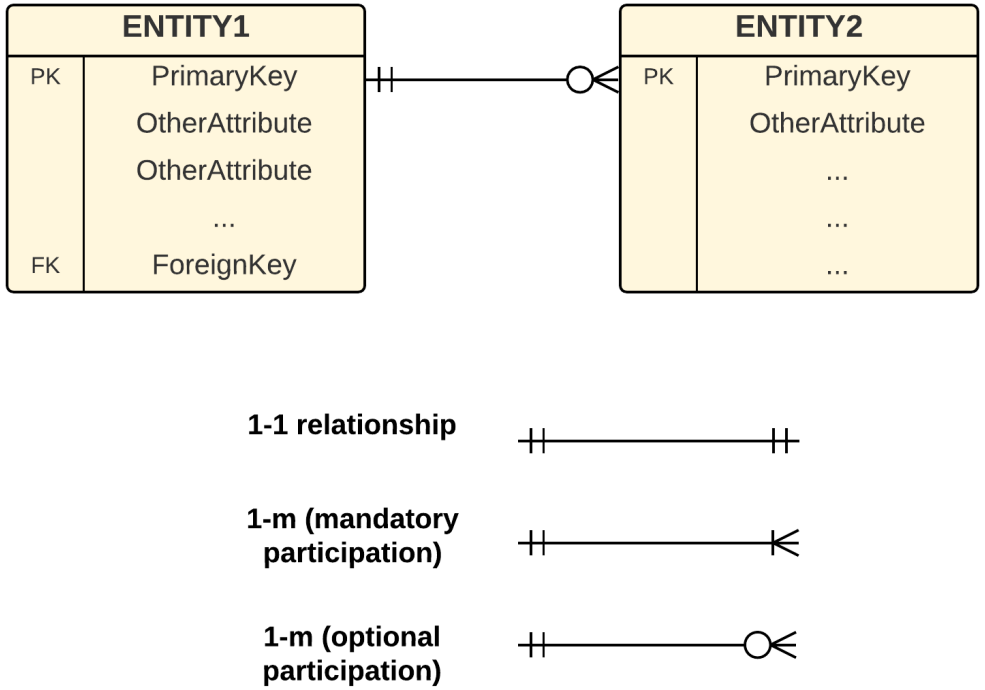
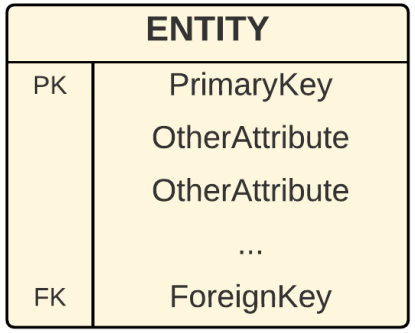


(b) Relationships in E/R Diagram

E/R Diagram Notation



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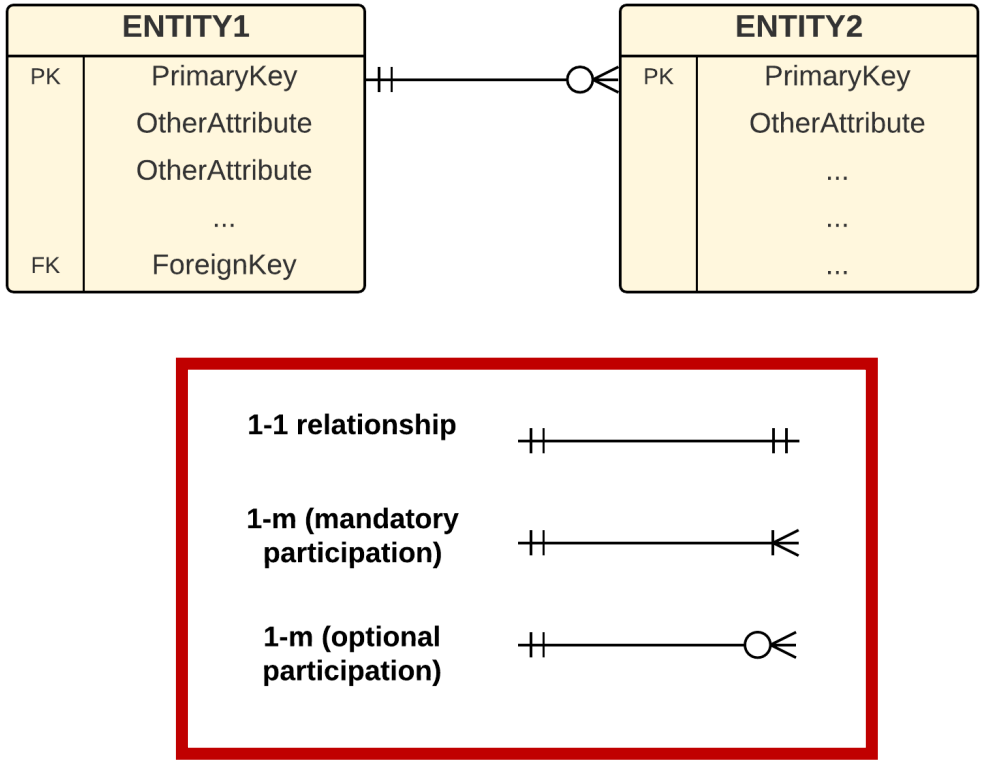
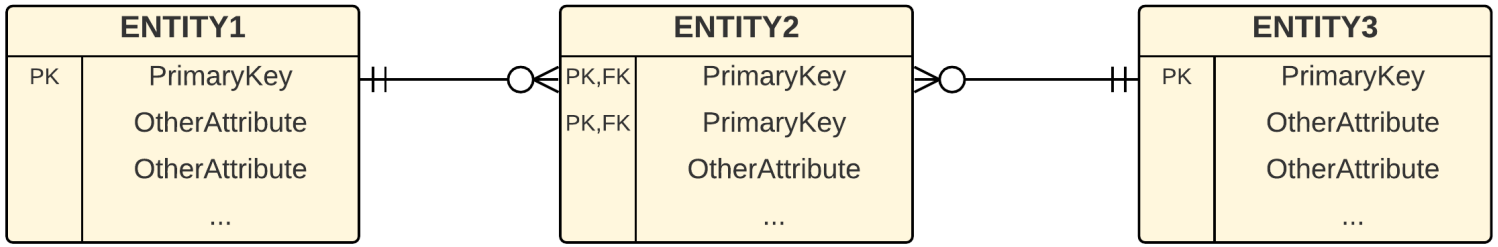


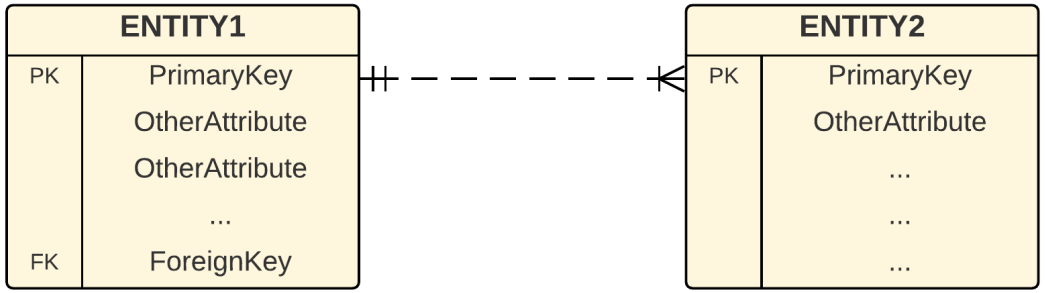
(b) Relationships in E/R Diagram

E/R Diagram Notation

Associative Relationship (m-m)



Non-Associative Relationship (1-m)



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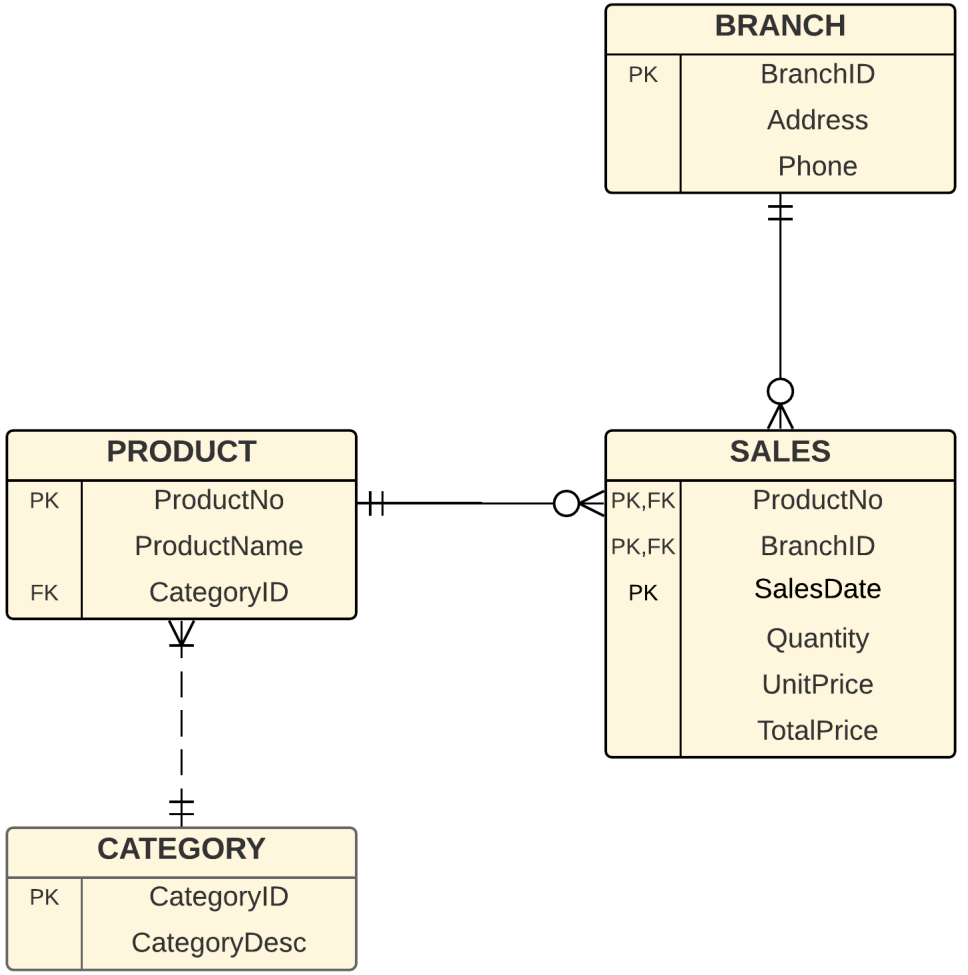

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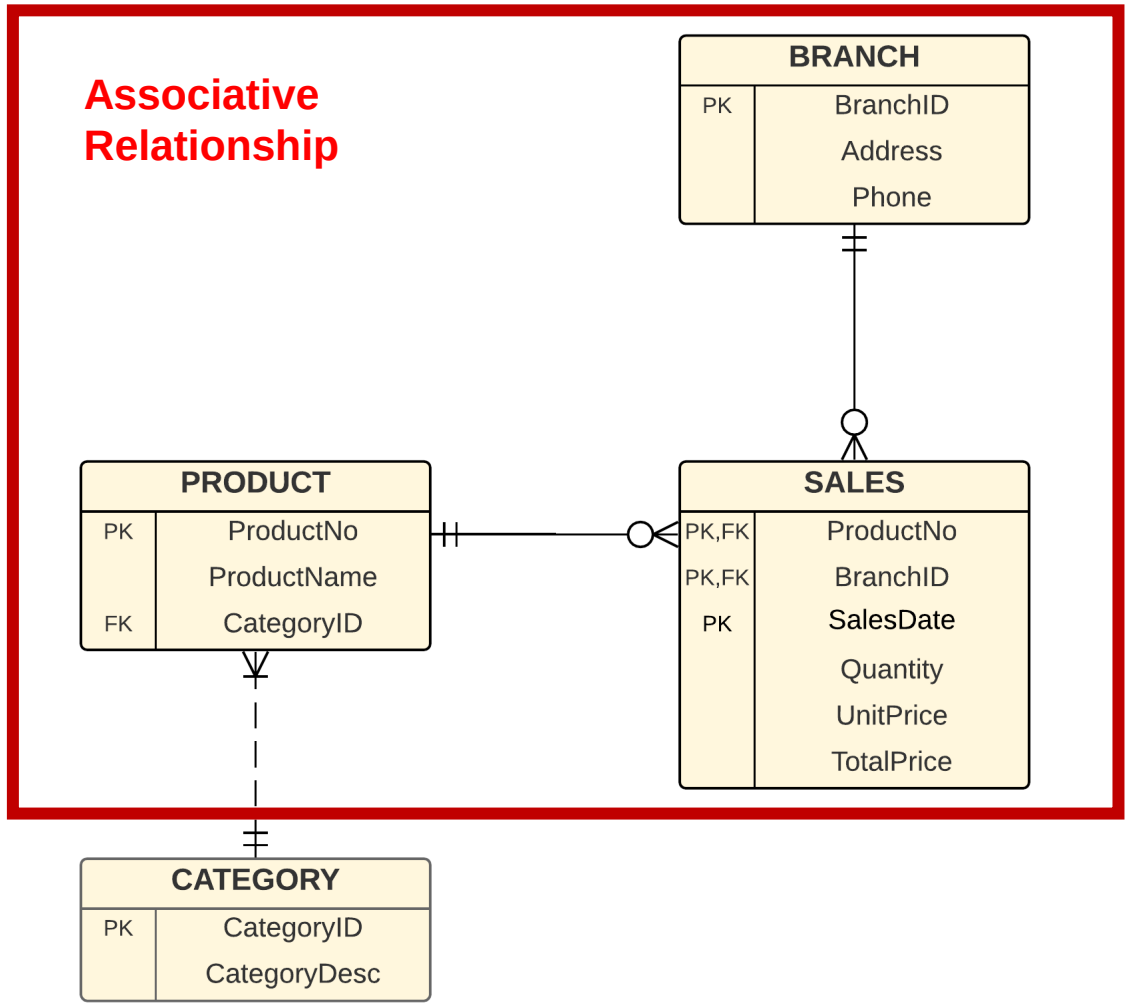
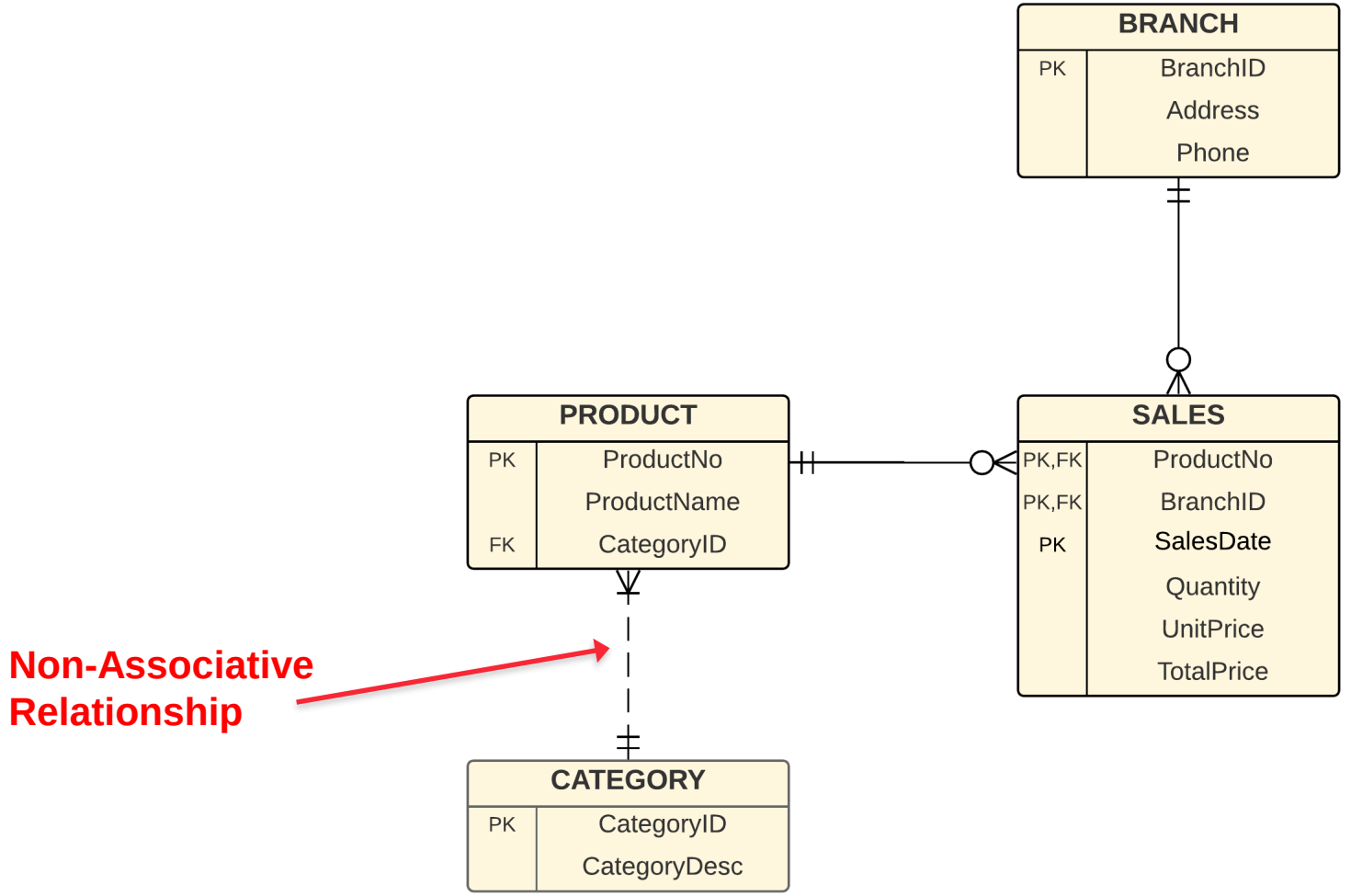


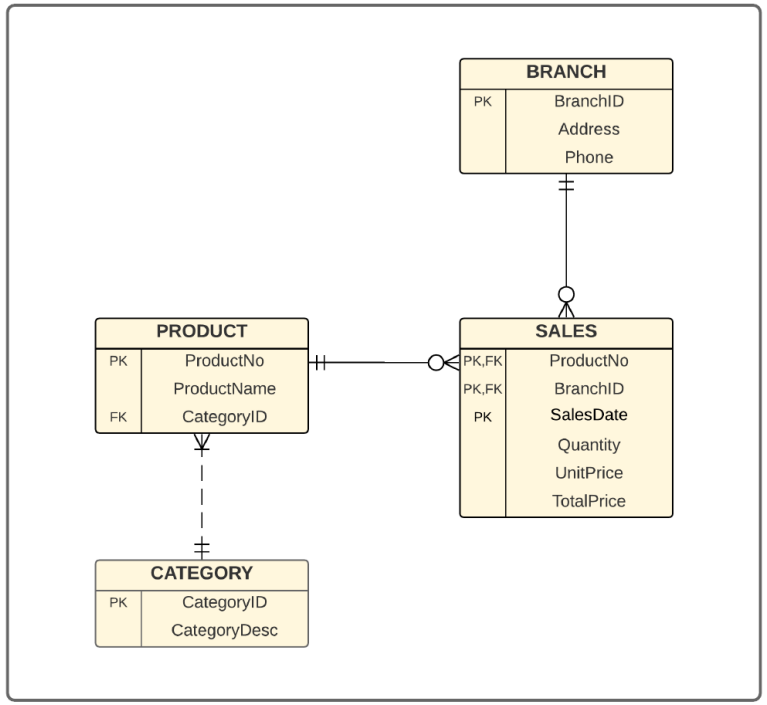
E/R Diagram Notation



Transformation Process

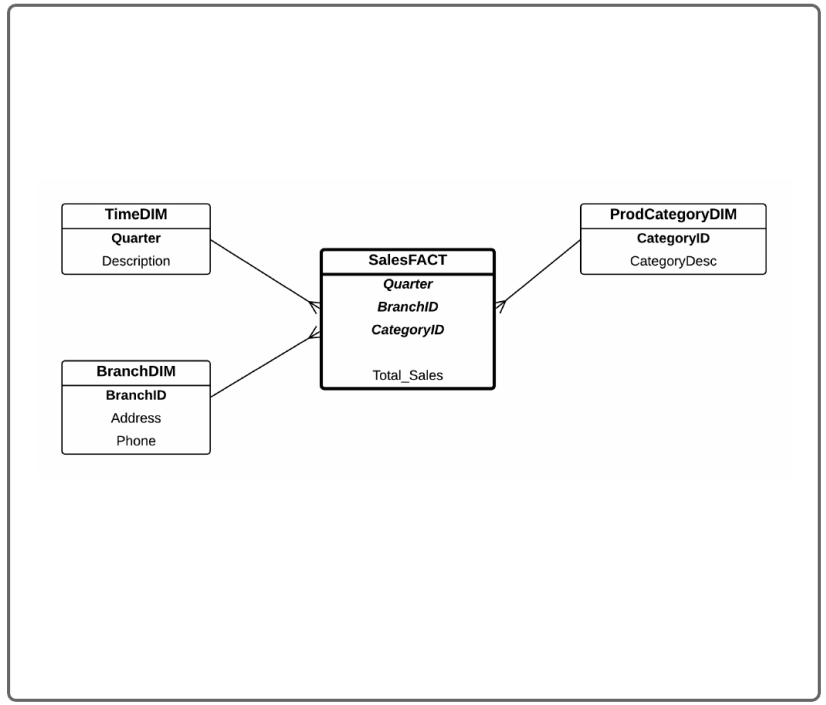
Transformation Process

Operational Database (E/R Diagram)



Transformation (ETL)

Data Warehouse (Star Schema)



Transformation Process
Case Study #1

MONASH University

Case Study #1: International College

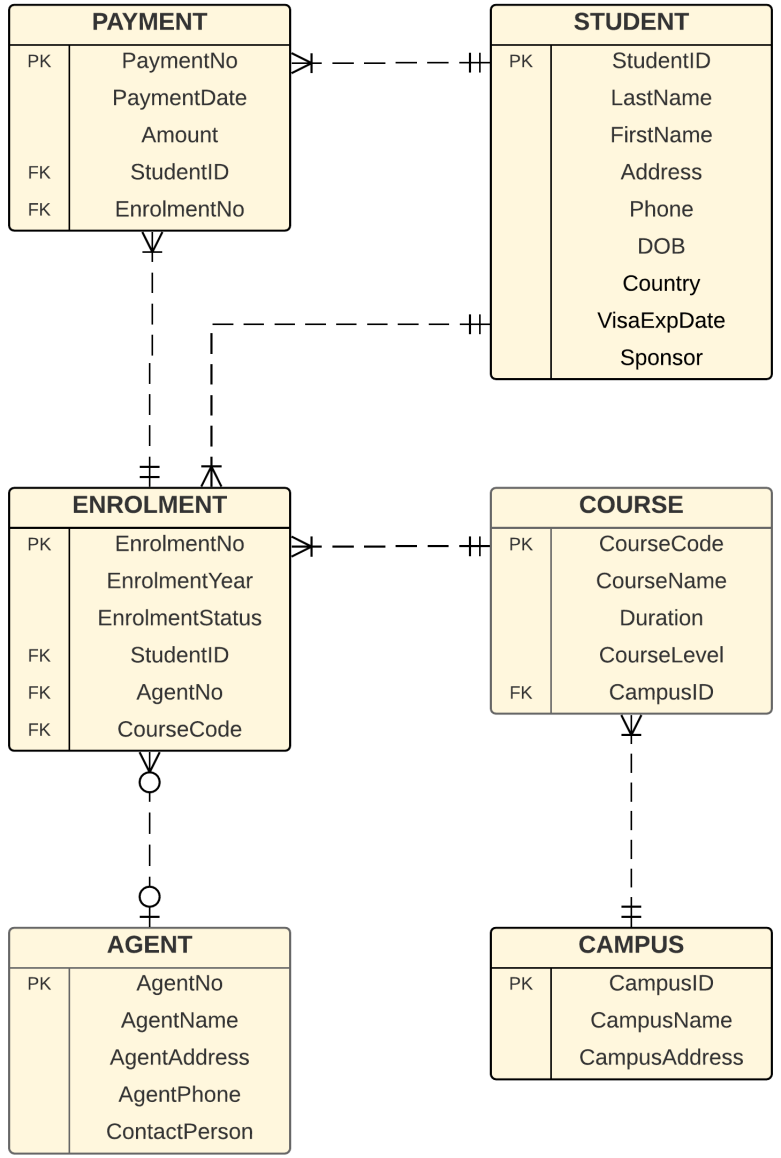
The admission office handles enrolment, payment, and marketing campaigns to international students, often through educational agents located overseas. This admission office has an operational system that maintains all the details of international students enrolled in the College. Payment details are also handled by this office. Basically, the operational system has the following features:

- Every student details are kept in the database. This includes the courses that the students enroll.
- As the College is a multi-campus university, some courses are offered in a different campus. The admission office handles international students of all campuses.
- Some international students coming to the College are handled by an educational agent. This is particularly common for the first course that a student enrolls in. Subsequent courses are not normally handled by an agent, because the students themselves deal directly with the College.
- International students pay tuition fees several times (normally once every semester) for each course they are doing.

Case Study #1: International College

The College now requires a data warehouse for analysis purposes. The analysis is needed for identifying at least the following questions:

1. How many students come from certain countries?
2. What is the total income for certain postgraduate courses?
3. How many students are handled by certain agents?
4. How the number of enrolment of courses fluctuates across the year?



Case Study #1: International College

- College Star Schema
  - **Fact**:
    - Number of Students
    - Total Income
  - **Dimensions**:
    - Country
    - Agent
    - Course
    - Year

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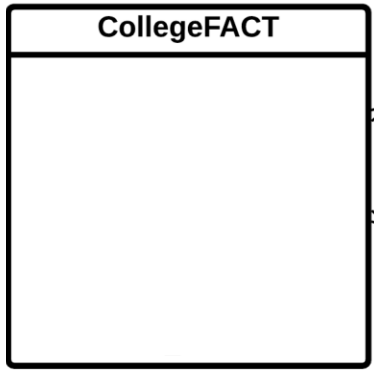

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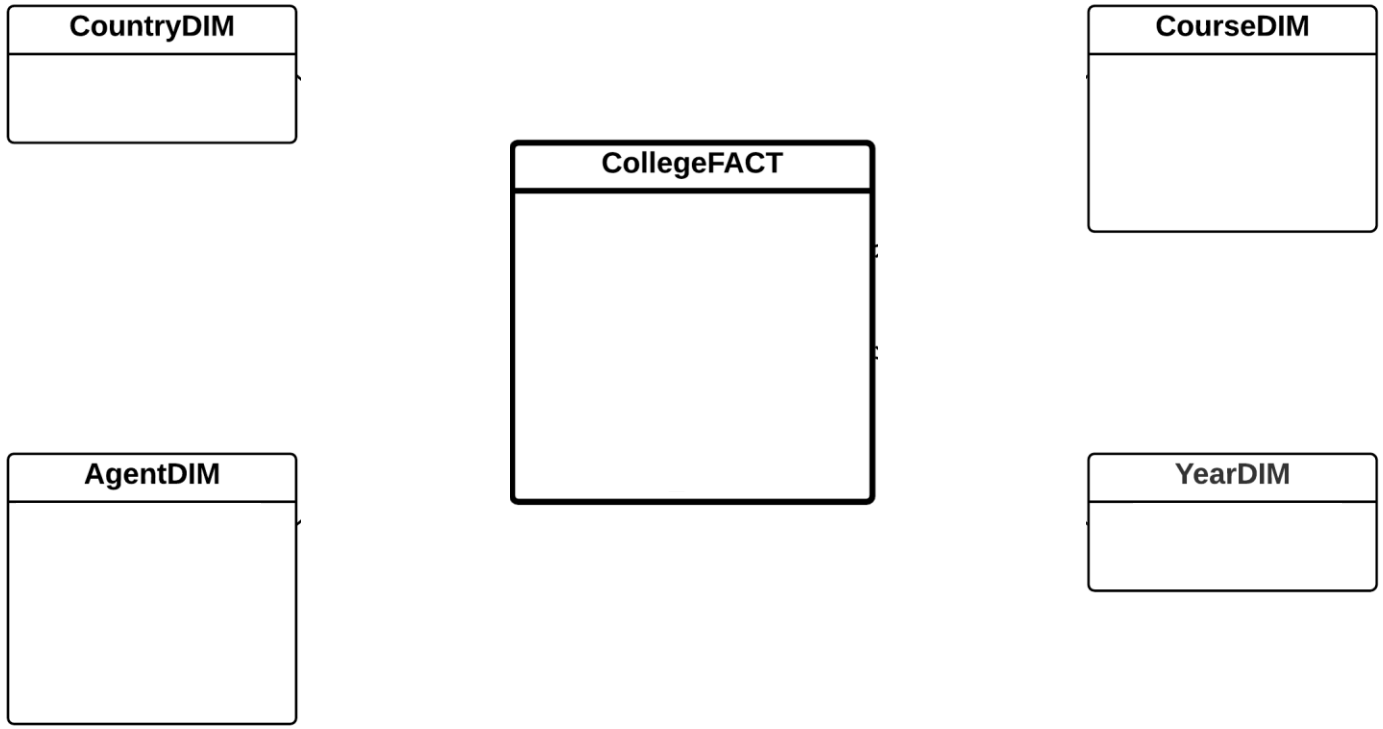

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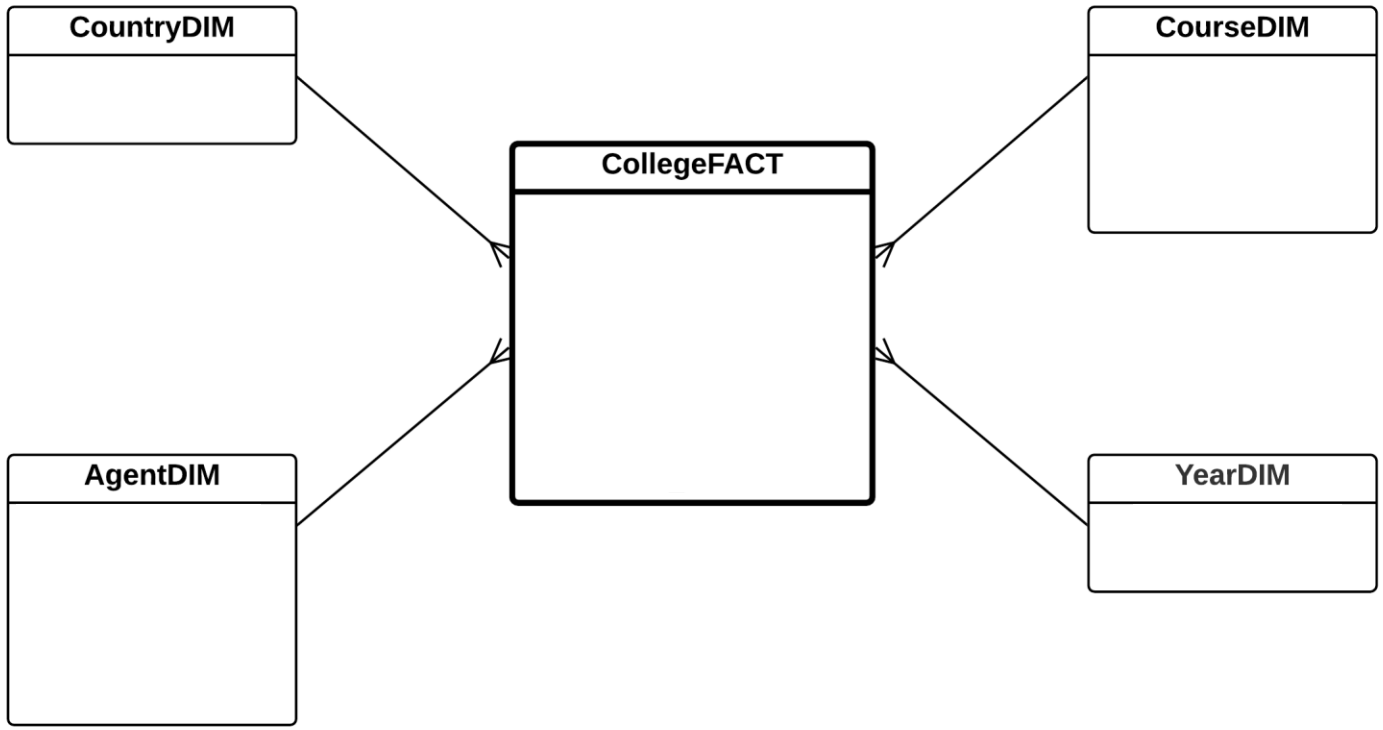

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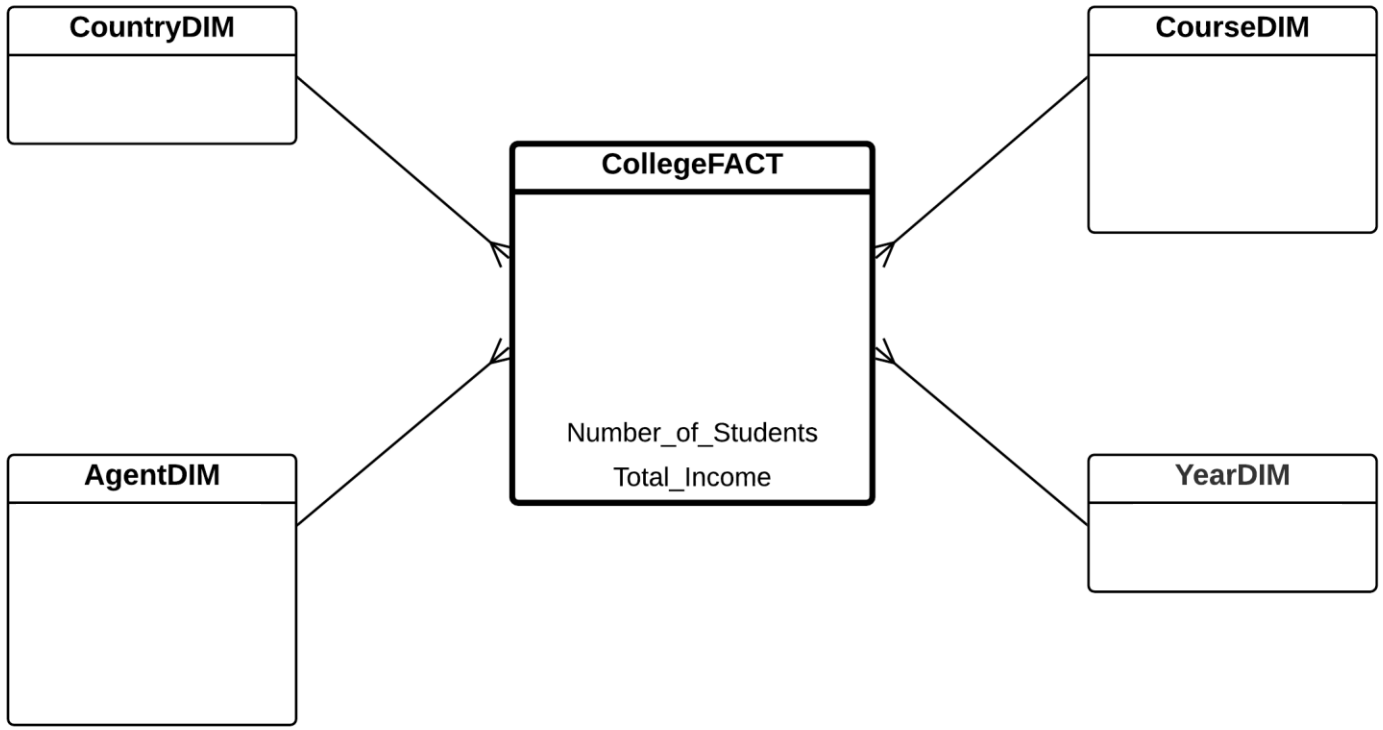
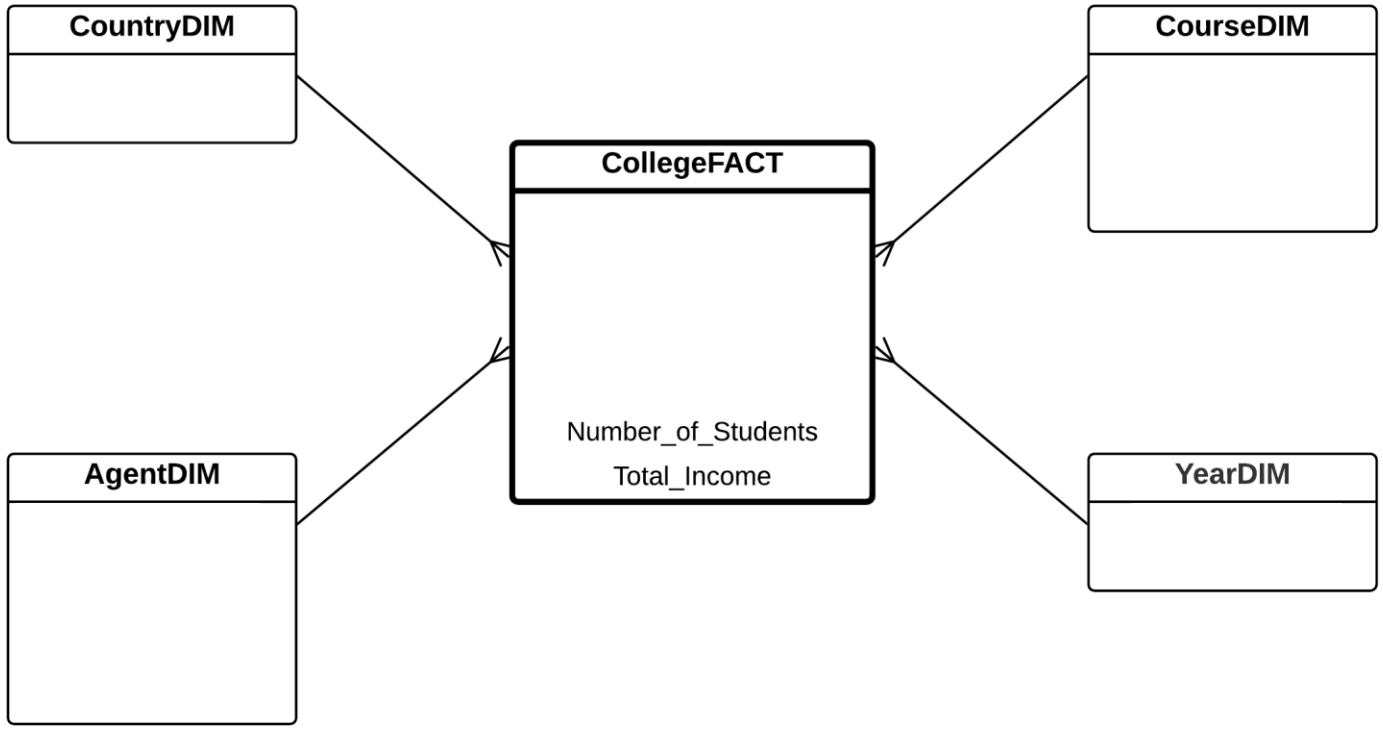
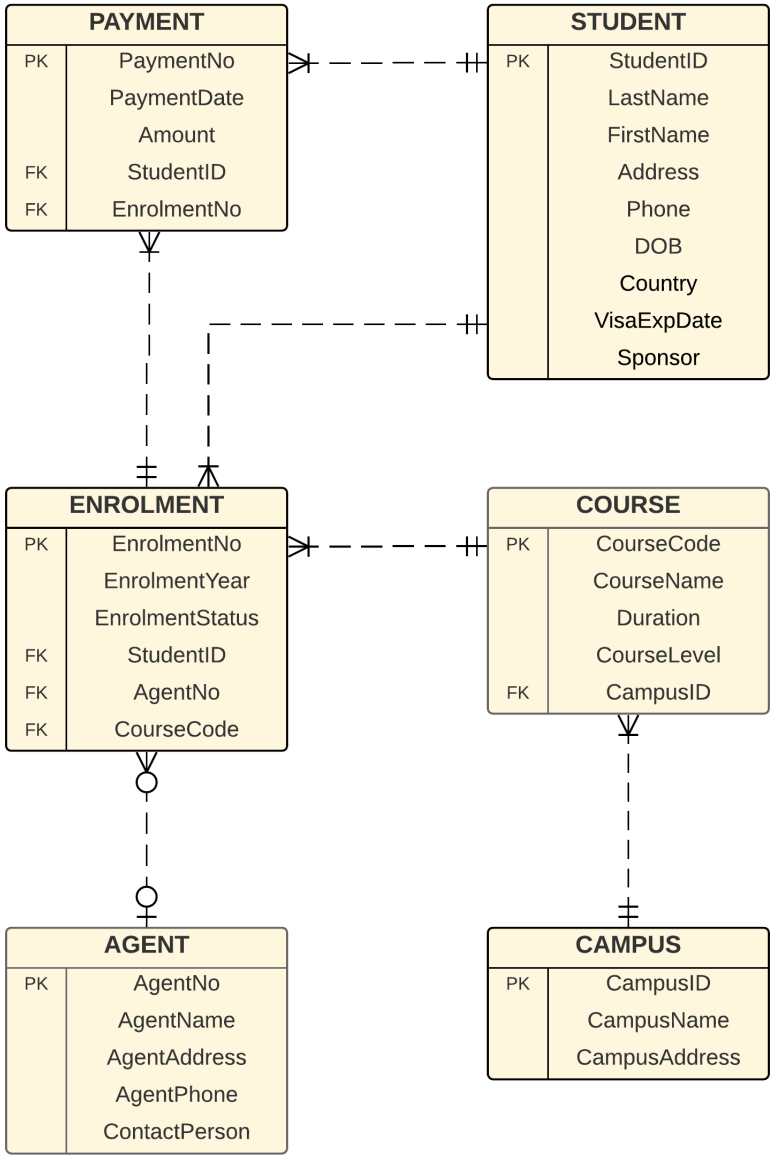
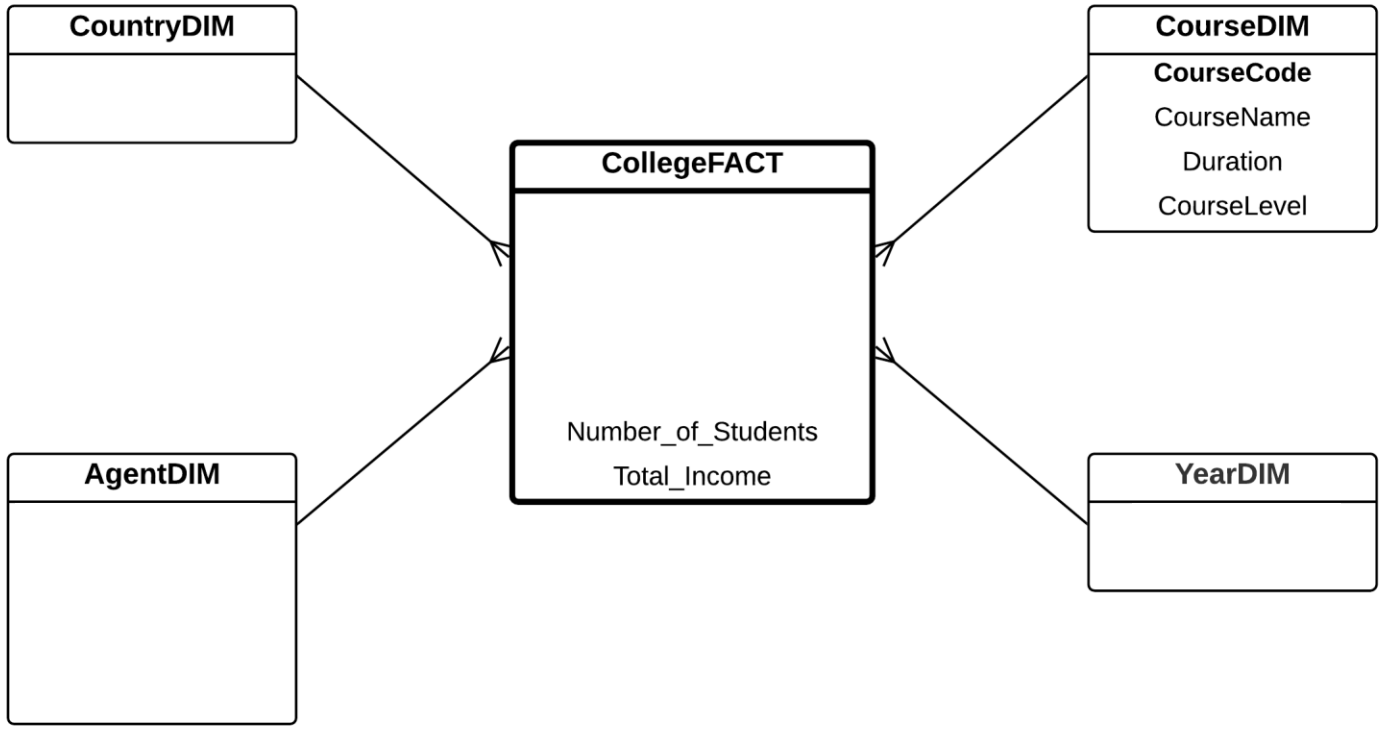


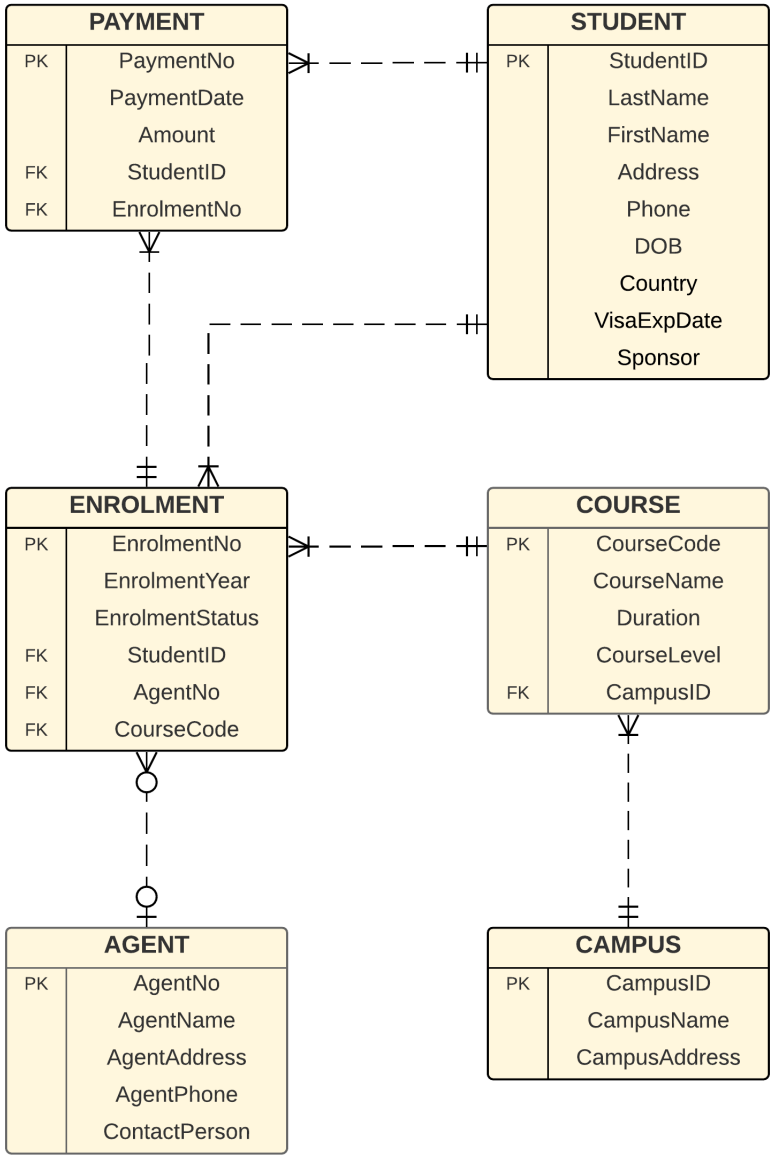
Case Study #1: International College



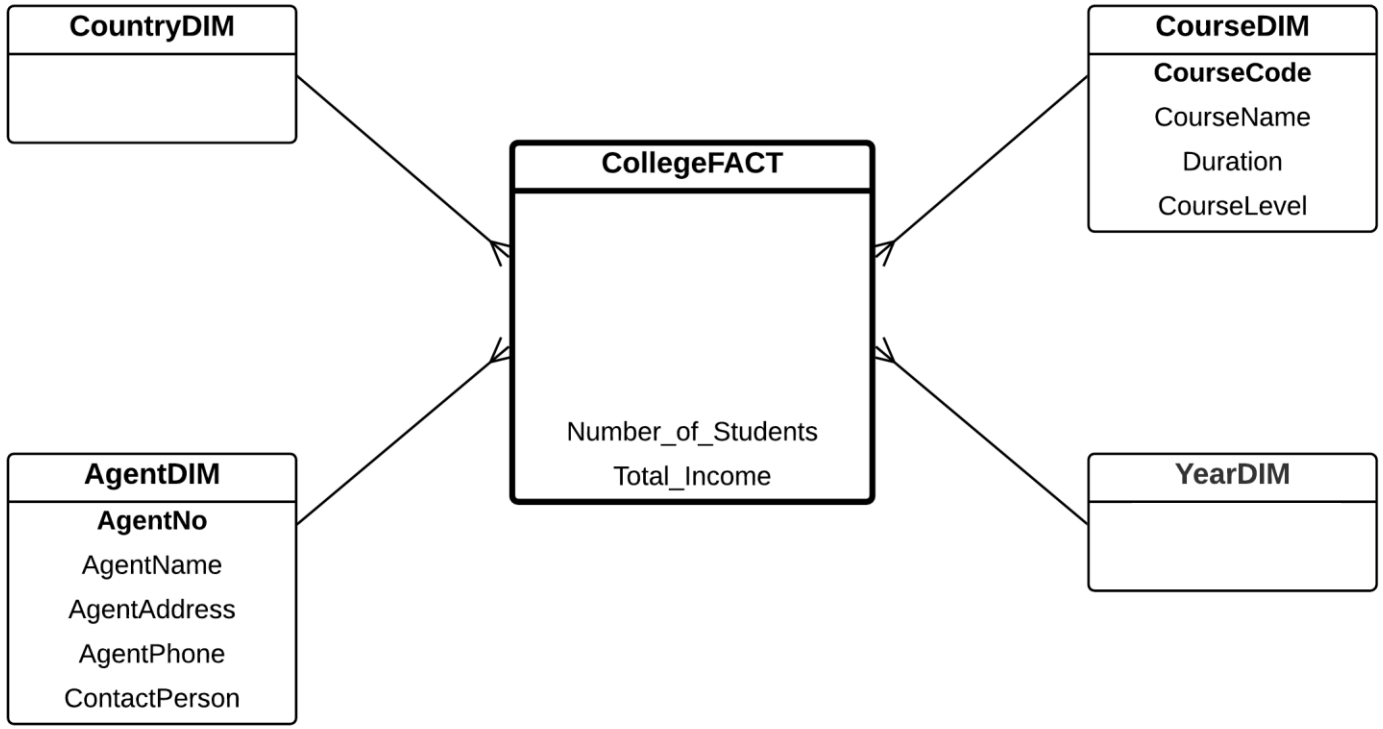


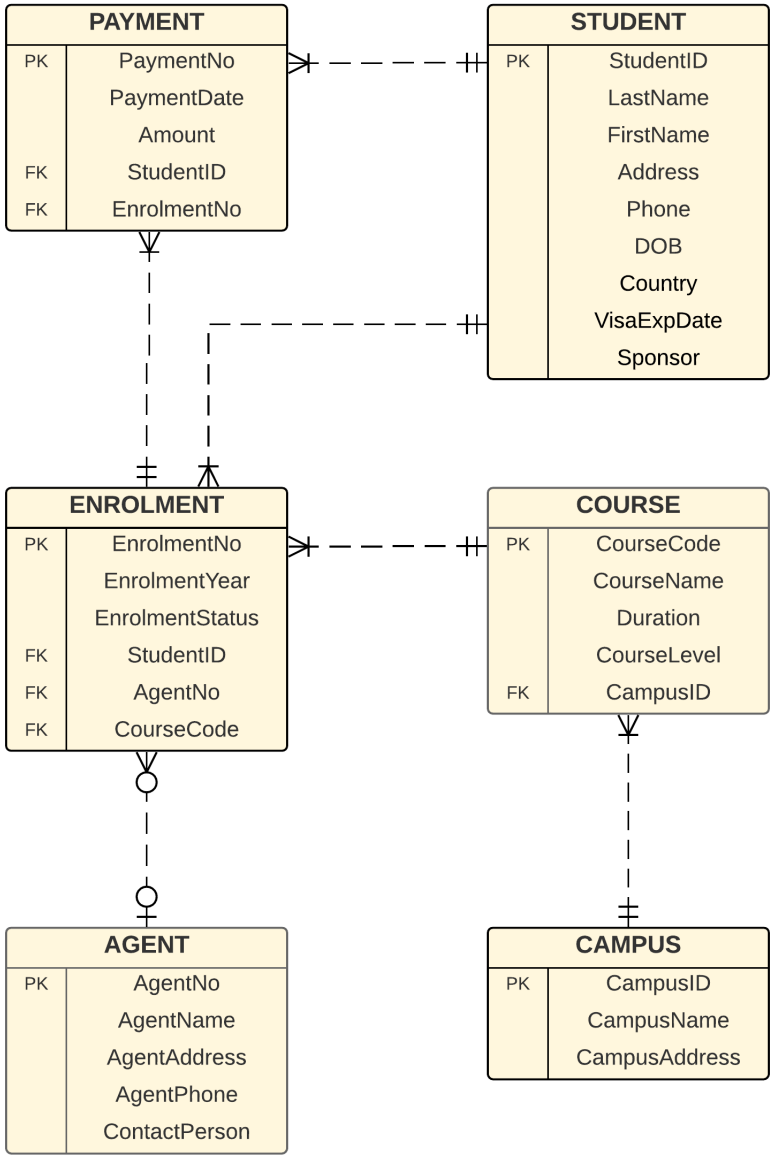
Case Study #1: International College



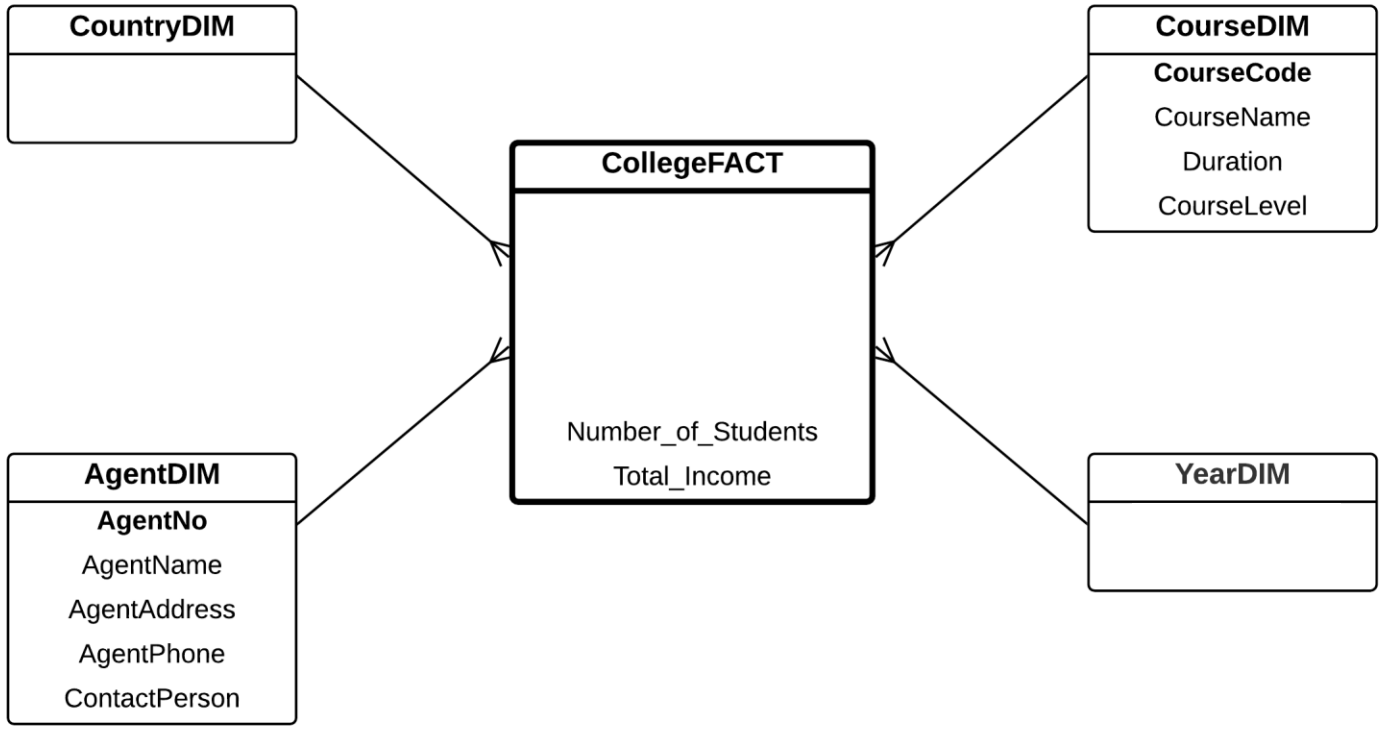


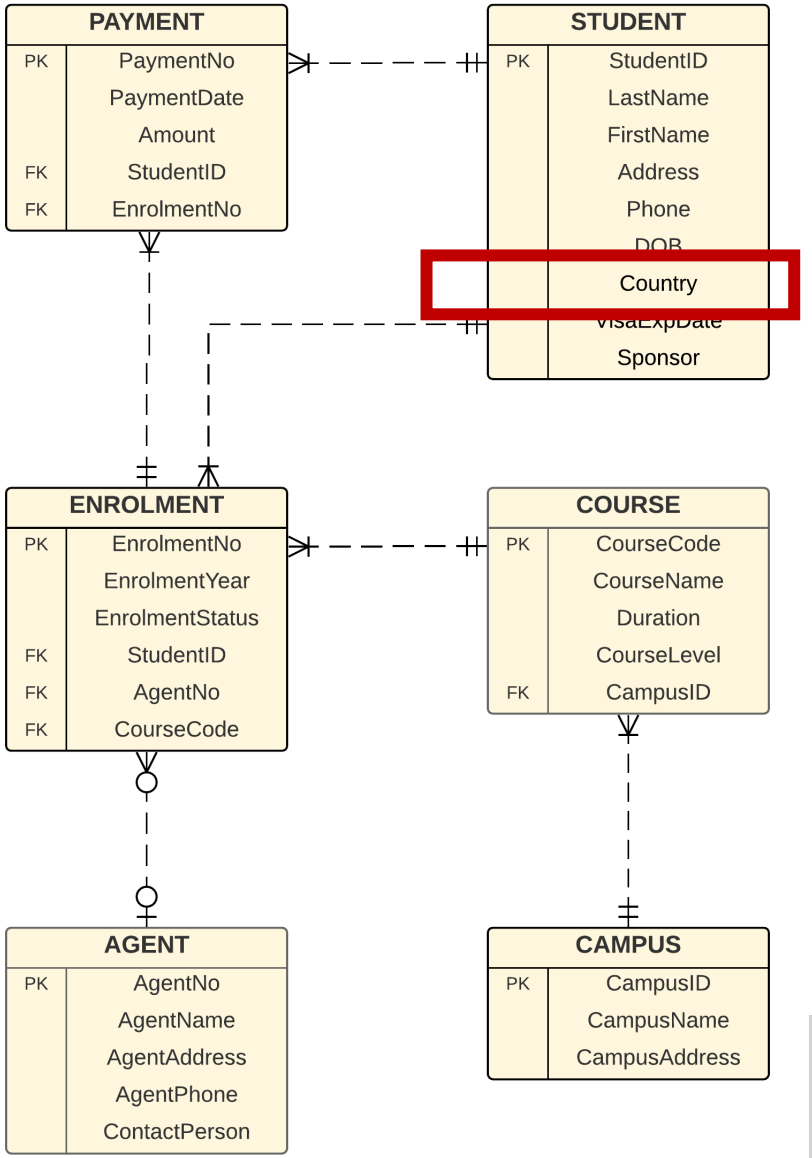
Case Study #1: International College





Case Study #1: International College





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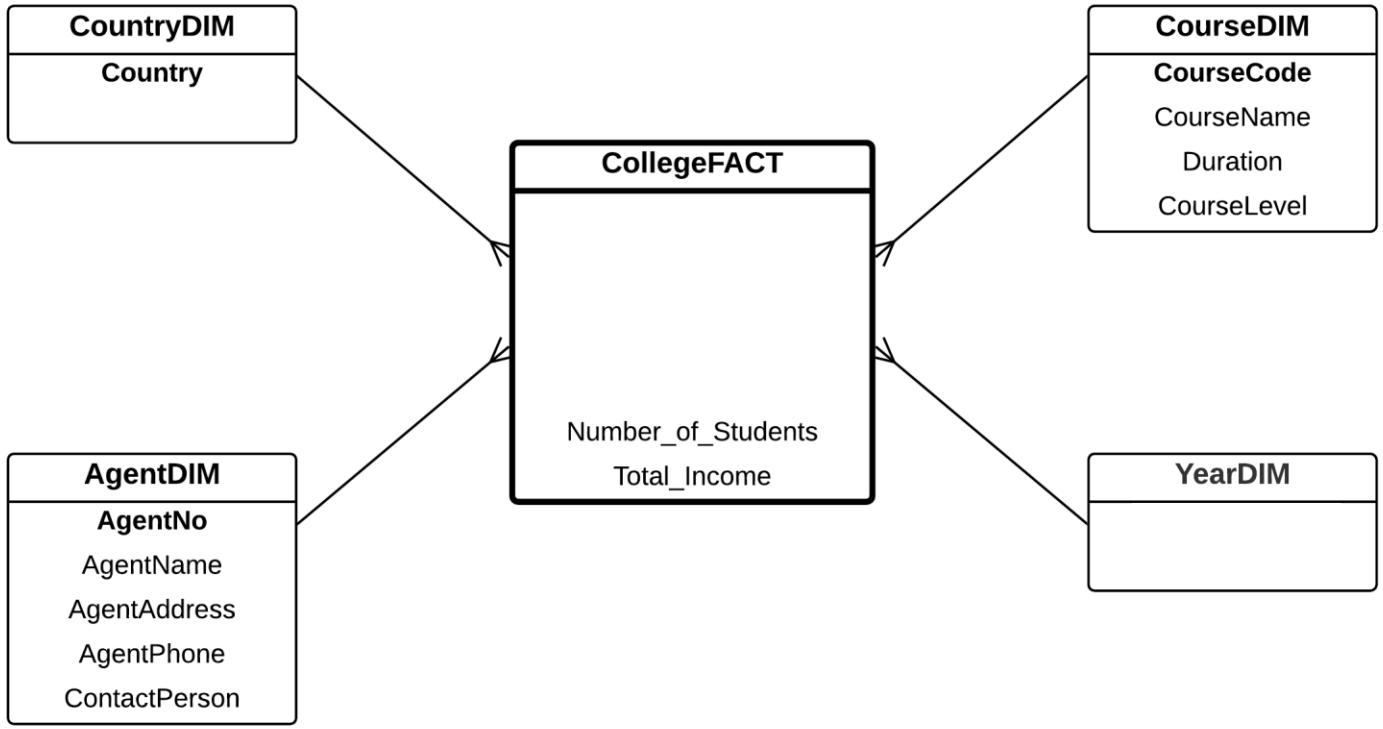
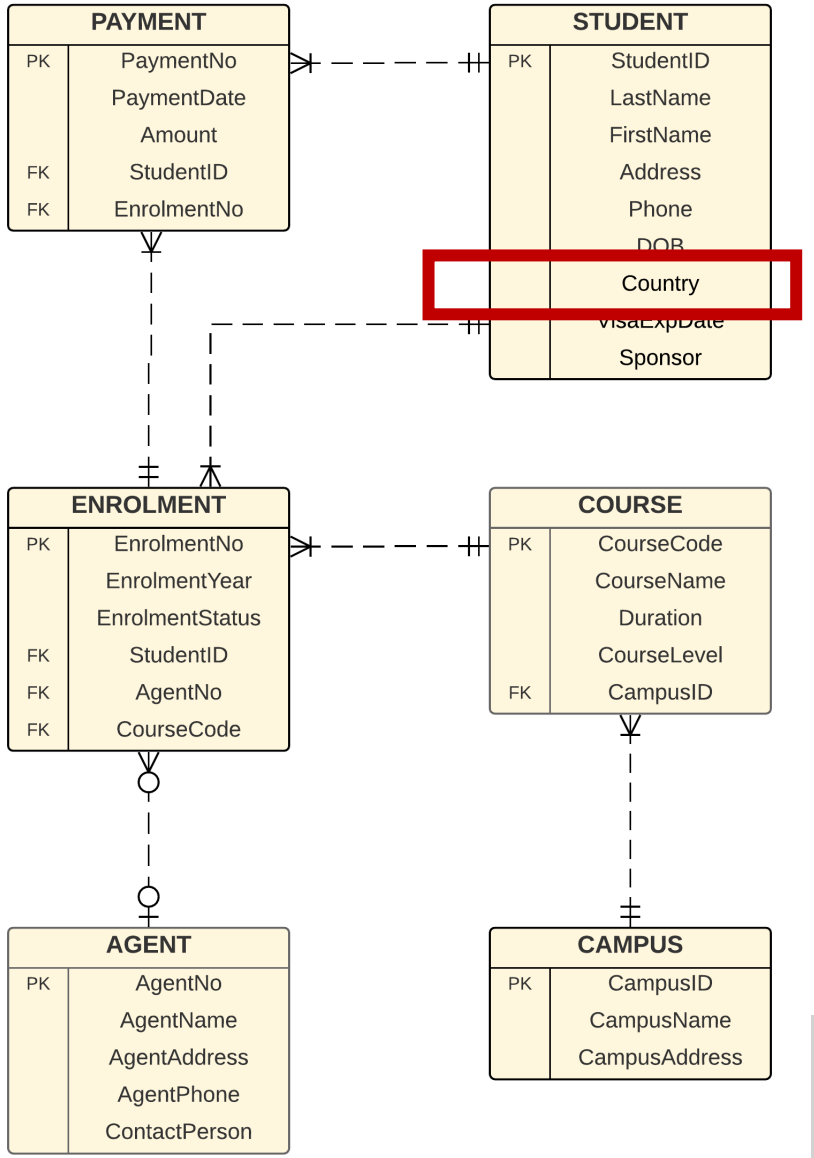
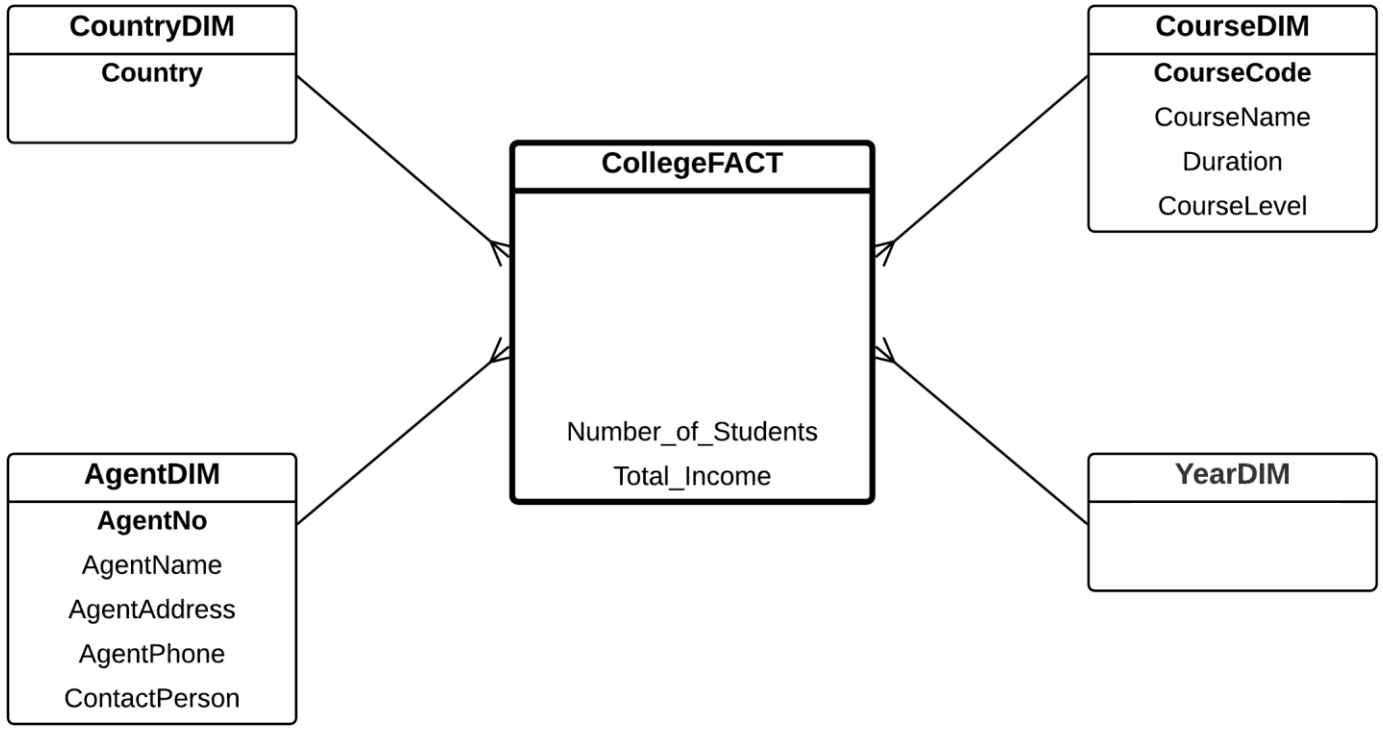
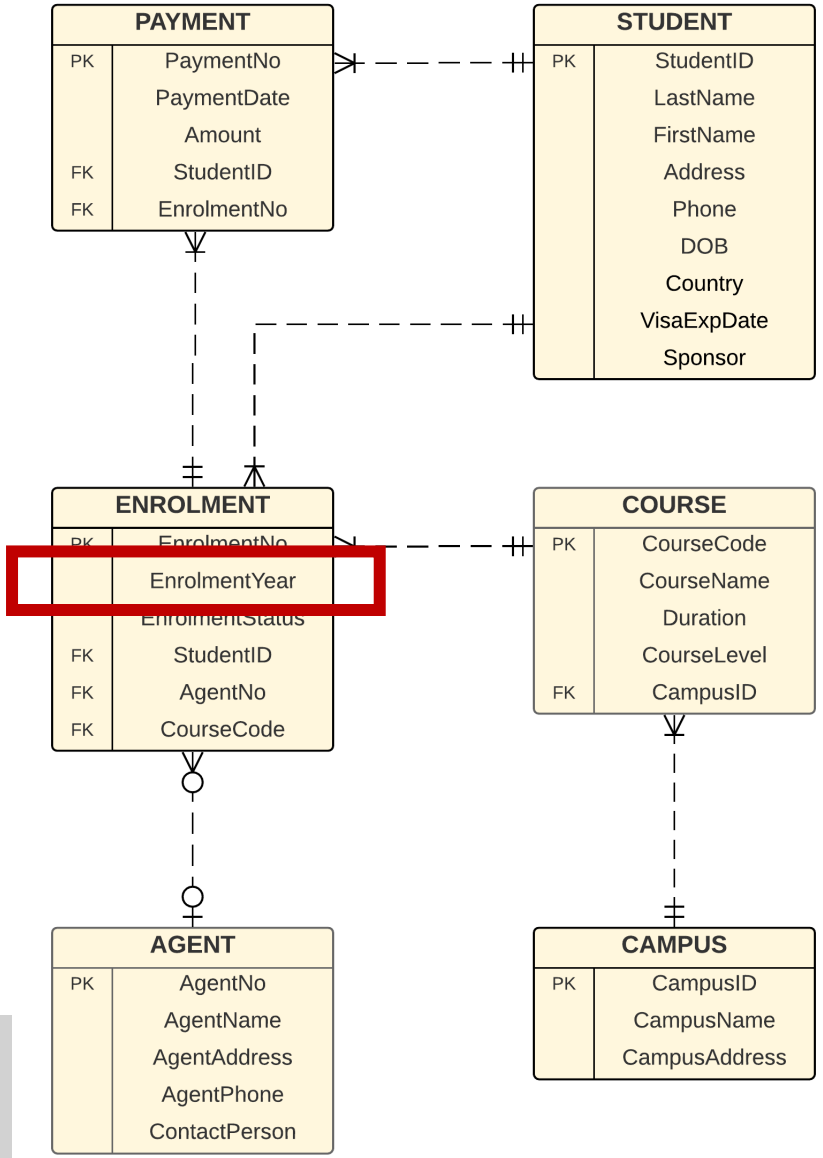


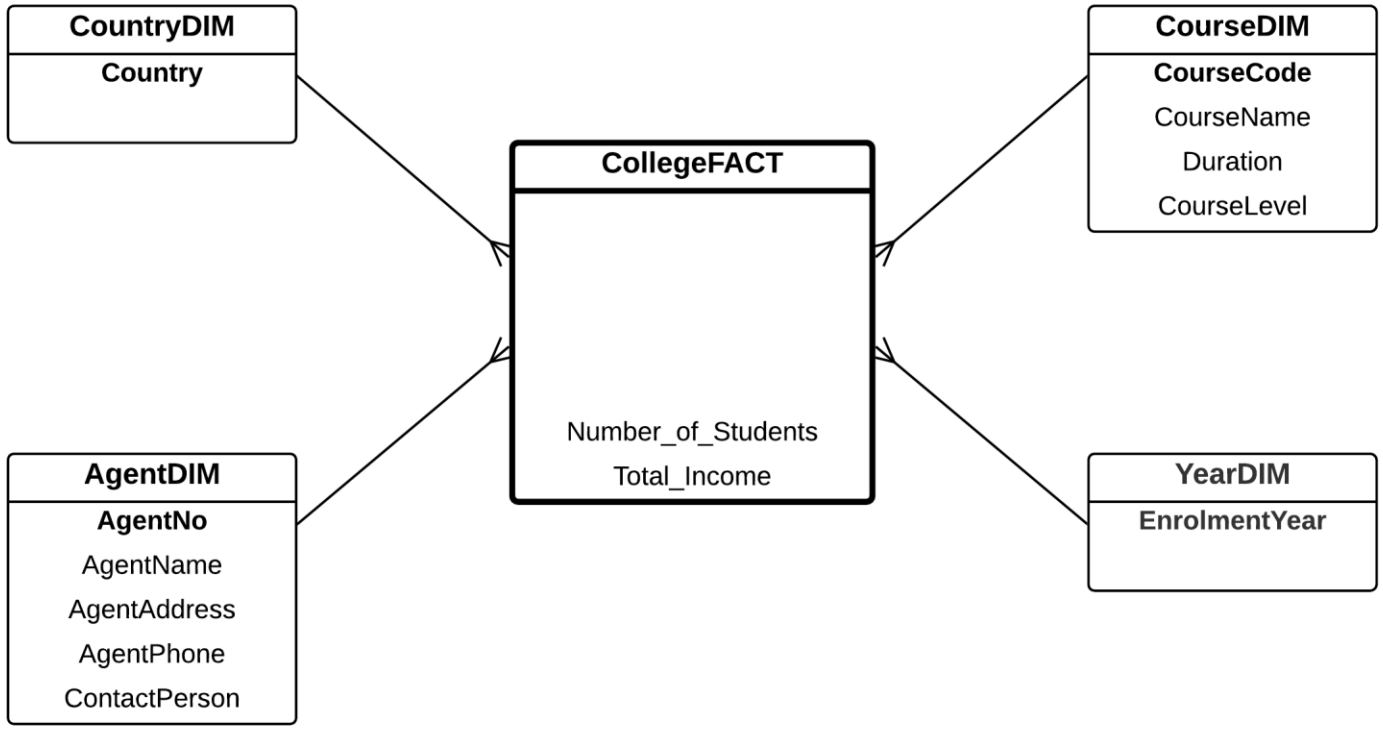


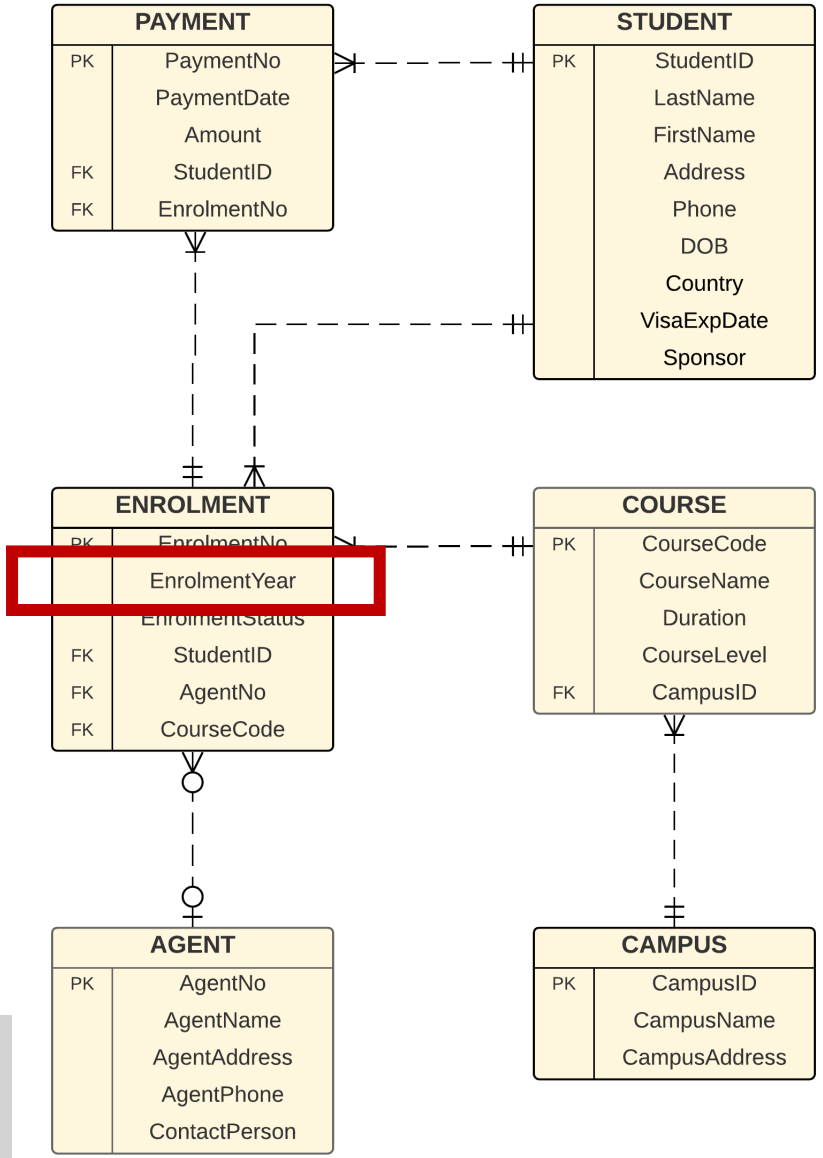
Case Study #1: International College



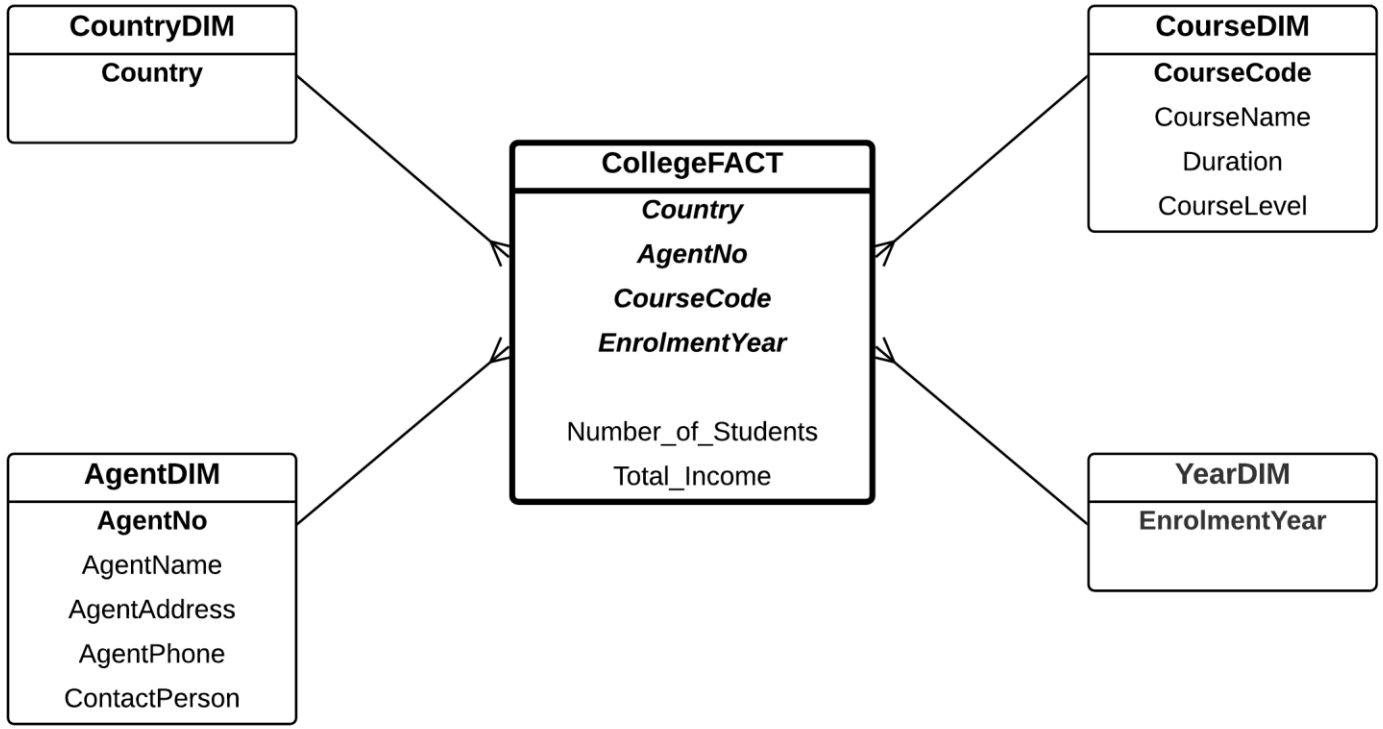


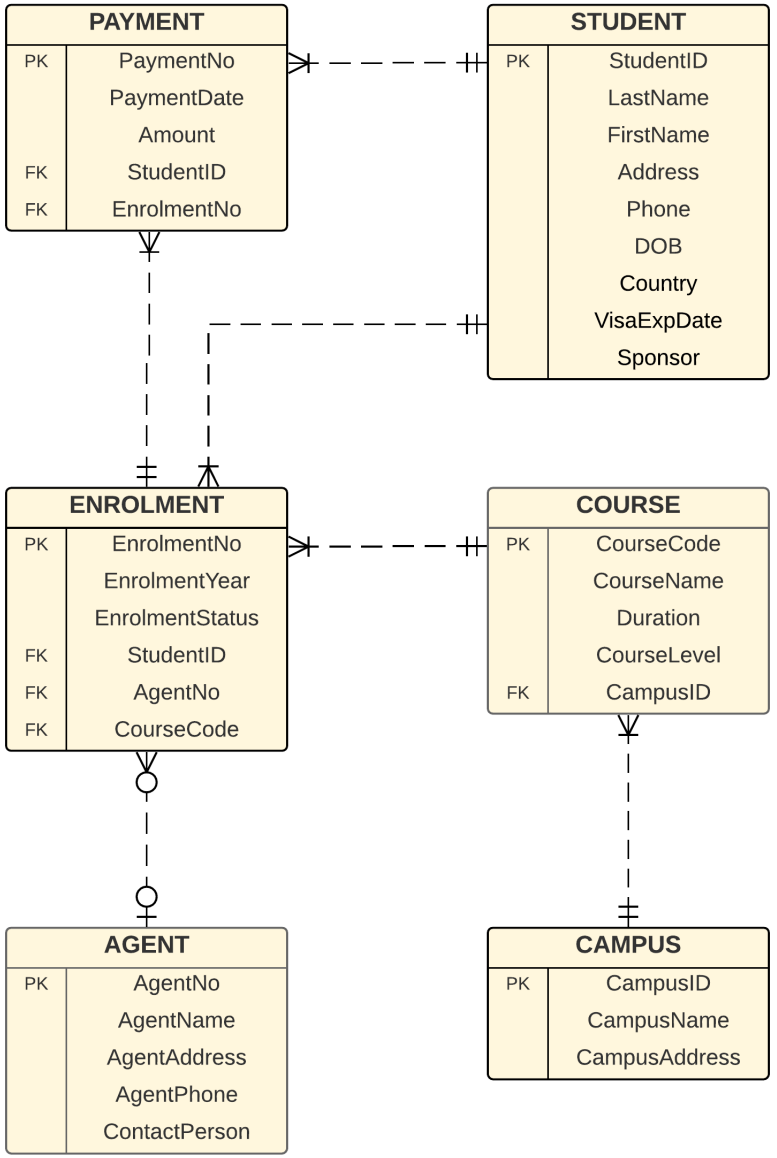
Case Study #1: International College





Case Study #1: International College

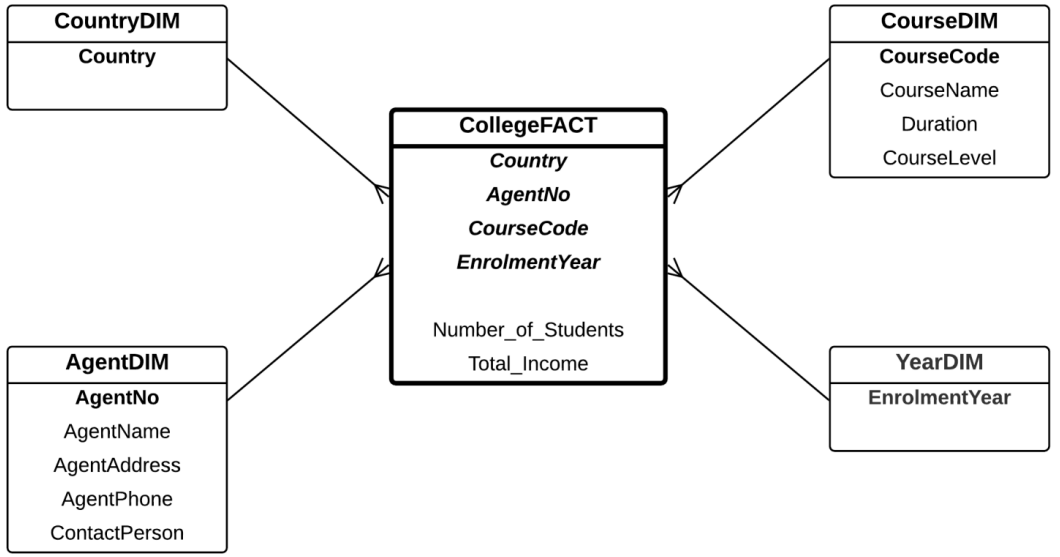




Case Study #1: International College

- To create AgentDIM:
  - `create table AgentDim as`
    `select * from Agent;`

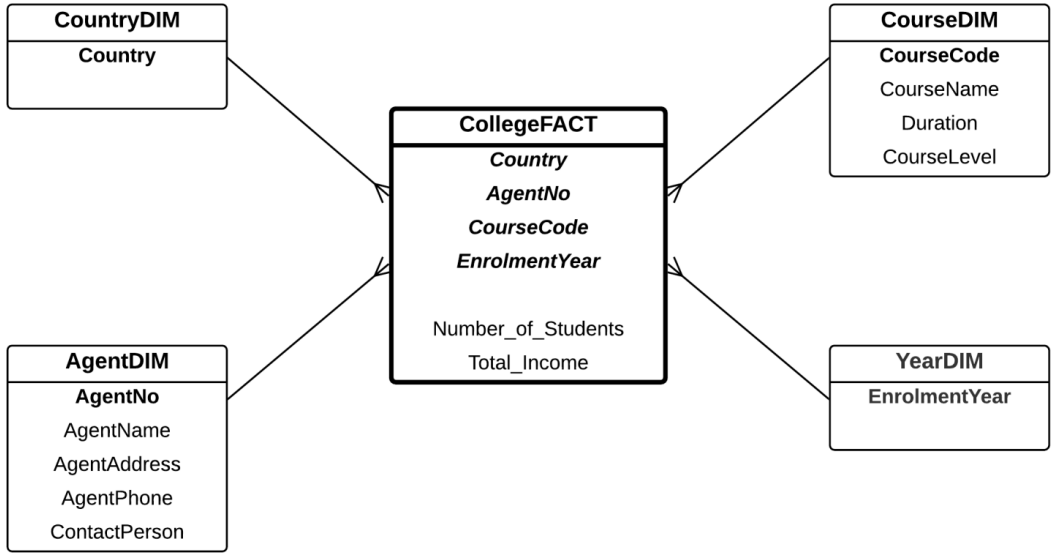
- To create CountryDIM:
  - `create table CountryDim as`
    `select distinct Country`
    `from Student;`



Case Study #1: International College

- To create CourseDIM:
  - `create table CourseDim as`
    `select CourseCode, CourseName, Duration, CourseLevel`
    `from Course;`

- To create YearDIM:
  - `create table YearDim as`
    `select distinct EnrolmentYear`
    `from Enrolment;`



Case Study #1: International College

- To create CollegeFACT:
  -
```
create table CollegeFact as
Select S.Country, E.AgentNo, E.CourseCode, E.EnrolmentYear,
count(S.StudentID) as Number_of_Students,
sum(P.Amount) as Total_Income
from Student S, Enrolment E, Payment P
where E.EnrolmentNo = P.EnrolmentNo
and E.StudentID = S.StudentID
group by S.Country, E.AgentNo, E.CourseCode, E.EnrolmentYear;
```

Case Study #1: International College

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Case Study #1: International College

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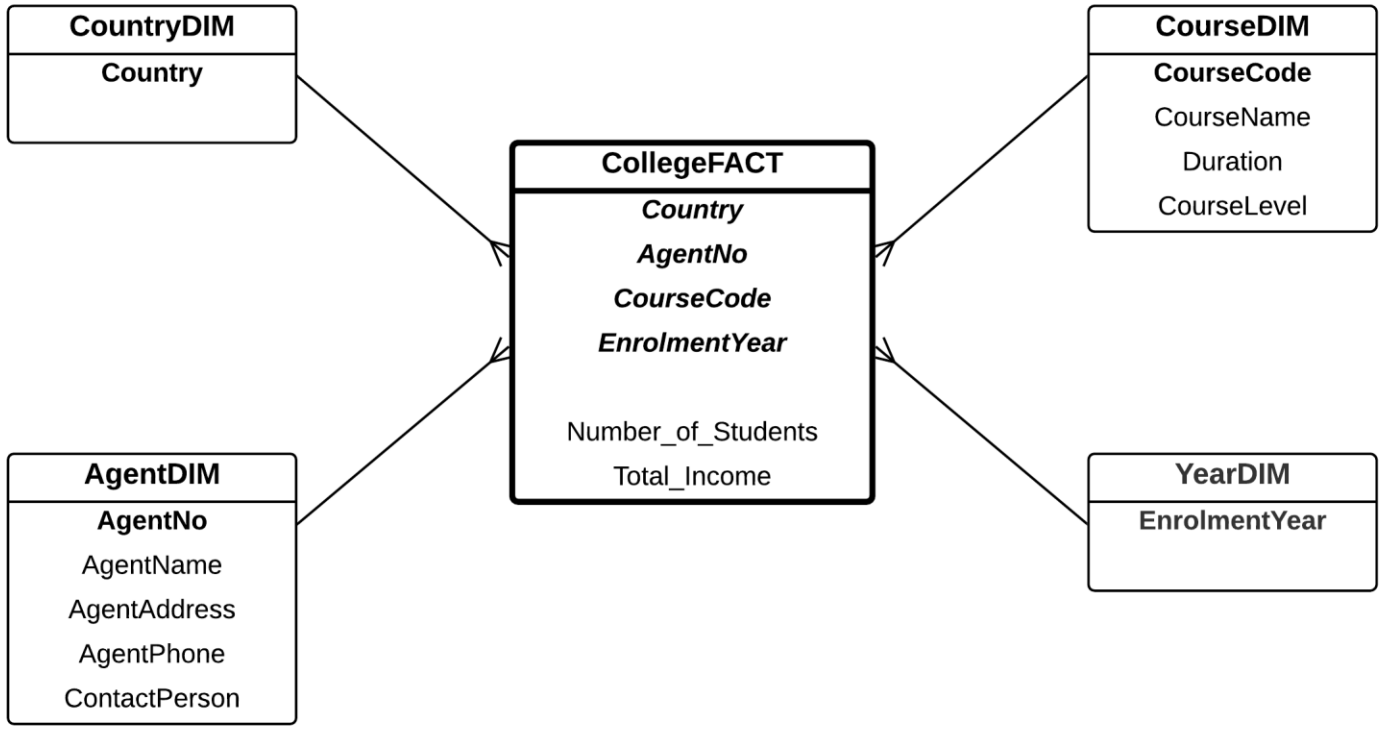
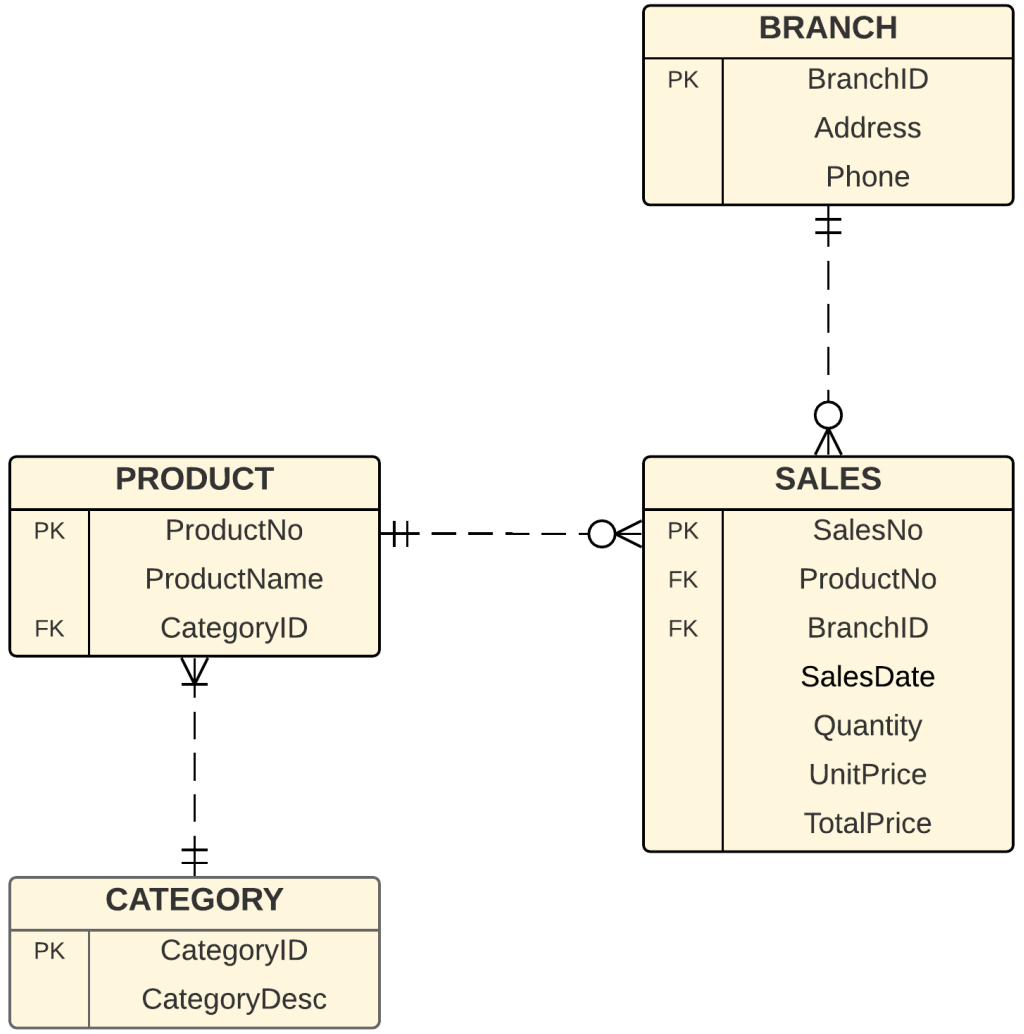


Transformation Process
Case Study #2

MONASH University

Case Study #2: Sales

- Suppose that we would like to analyze Total Sales from various point of views, such as Quarter, Branch, and Product Category.



Case Study #2: Sales

- Sales Star Schema
  - **Fact**:
    - Total Sales
  - **Dimensions**:
    - Time
    - Branch
    - Product Category

Case Study #2: Sales

- Sales Star Schema
  - **Fact**:
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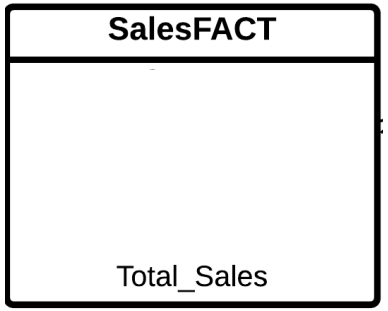
    - Branch
    - Product Category



Case Study #2: Sales

- Sales Star Schema
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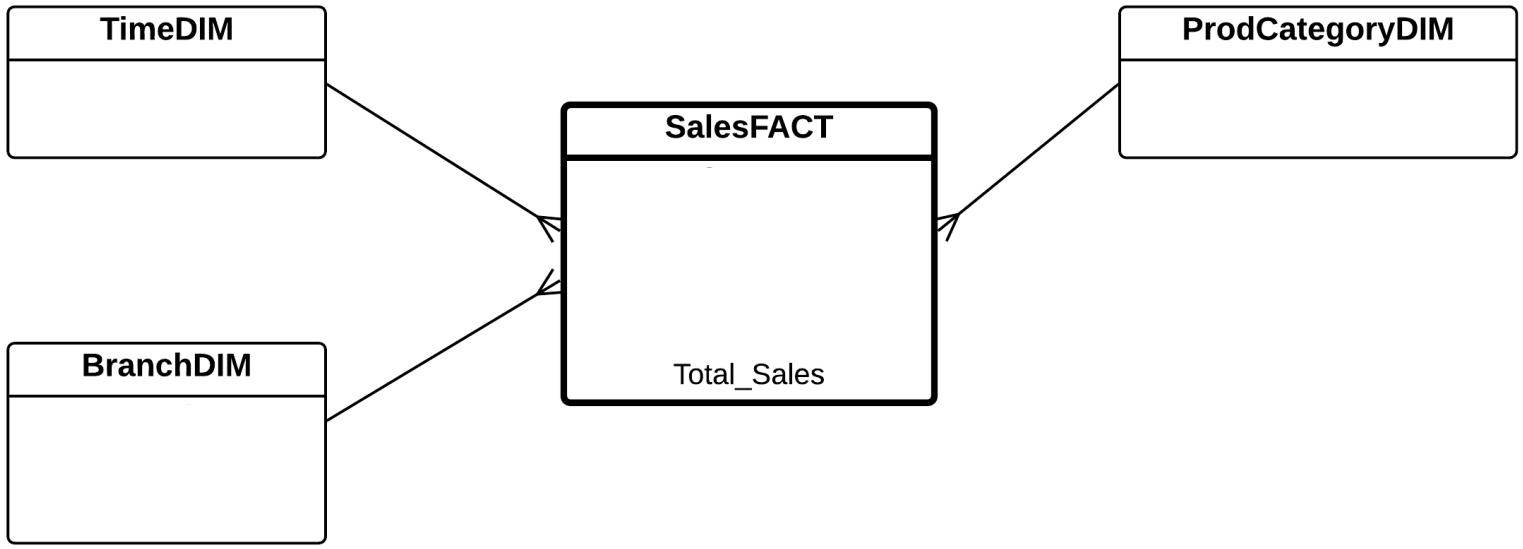
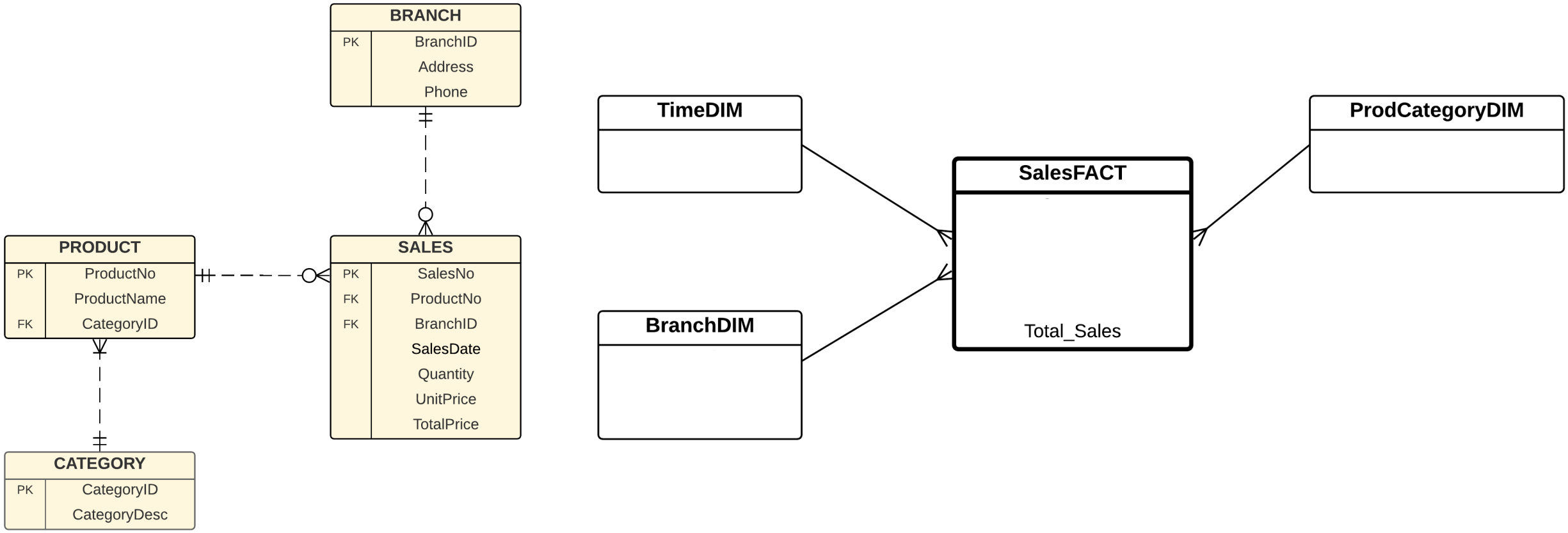
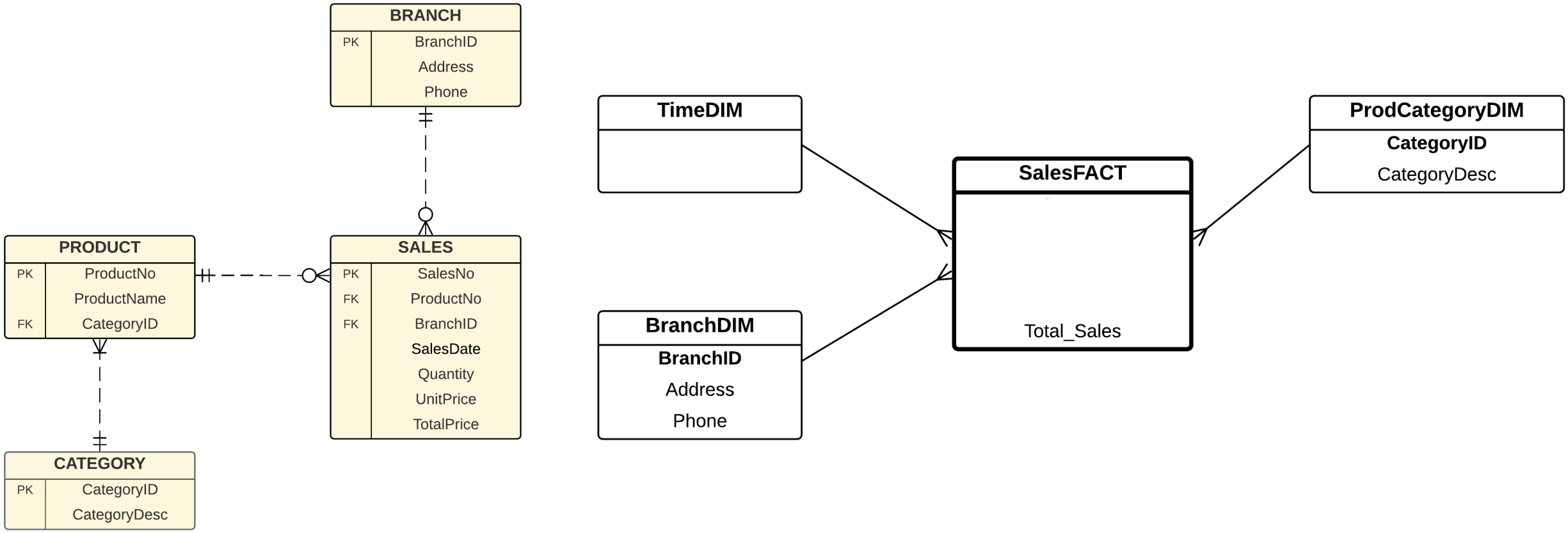
    - Product Category



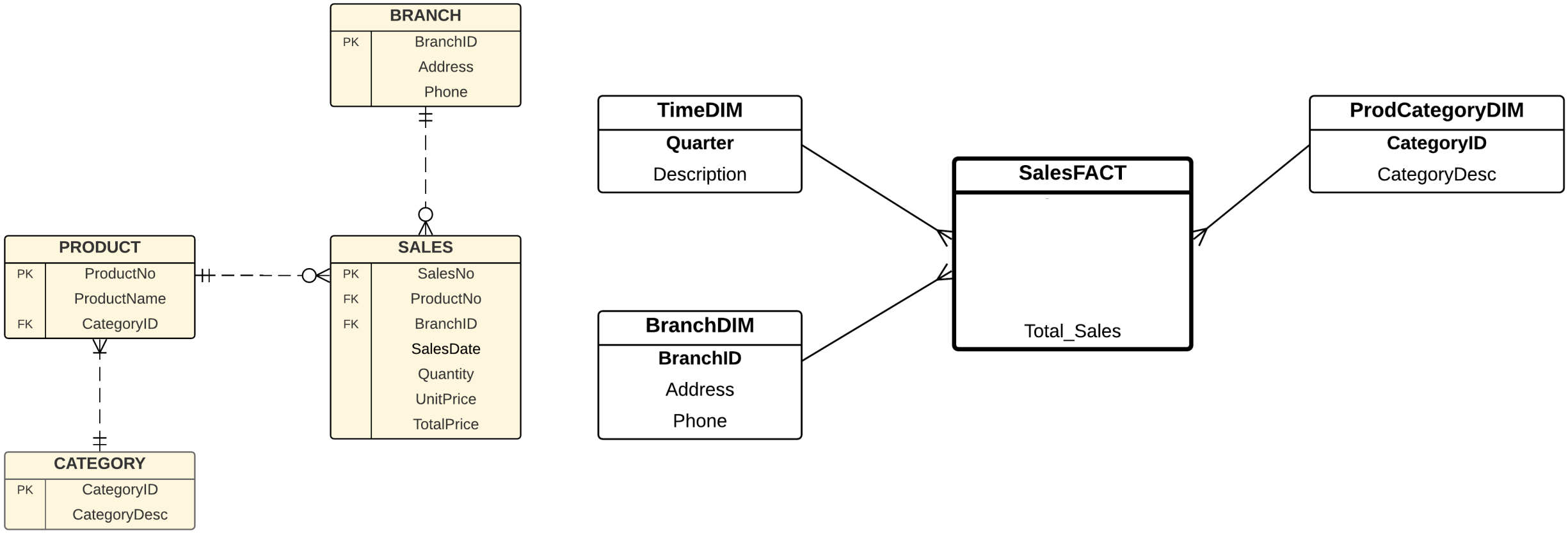
Case Study #2: Sales



Case Study #2: Sales

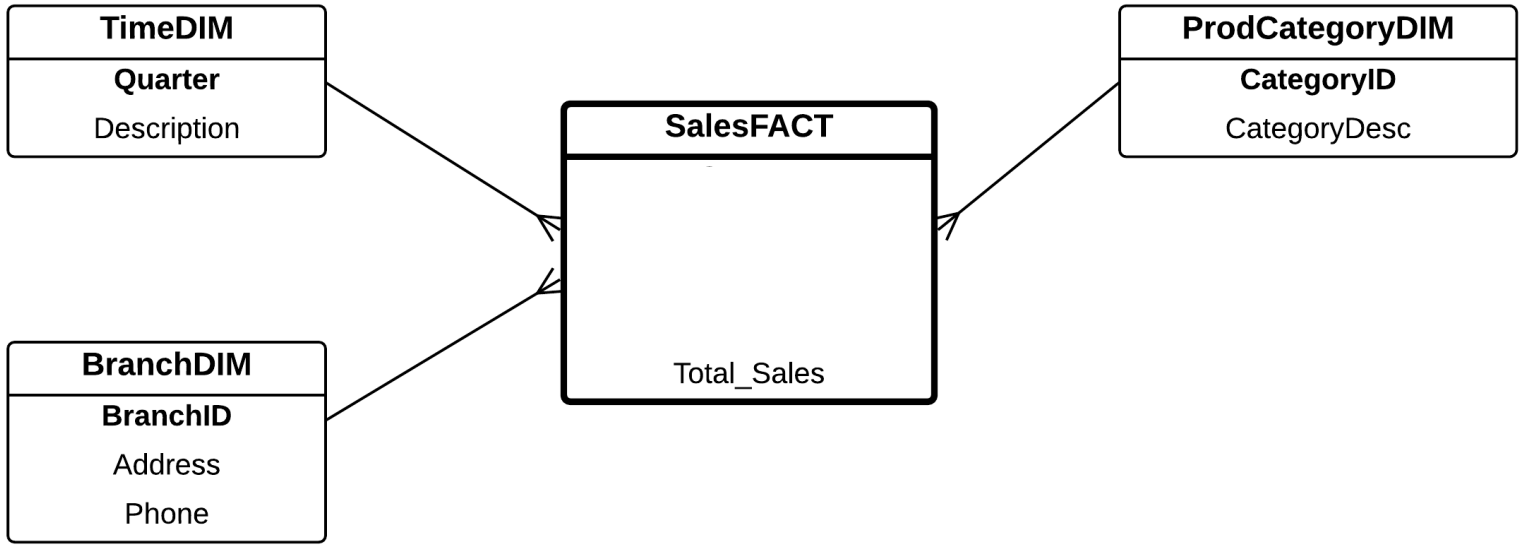


Case Study #2: Sales



Case Study #2: Sales

Quarter	Description
1	Jan-Mar
2	Apr-Jun
3	Jul-Sep
4	Oct-Dec



Case Study #2: Sales

Quarter	Description
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2	Apr-Jun
3	Jul-Sep
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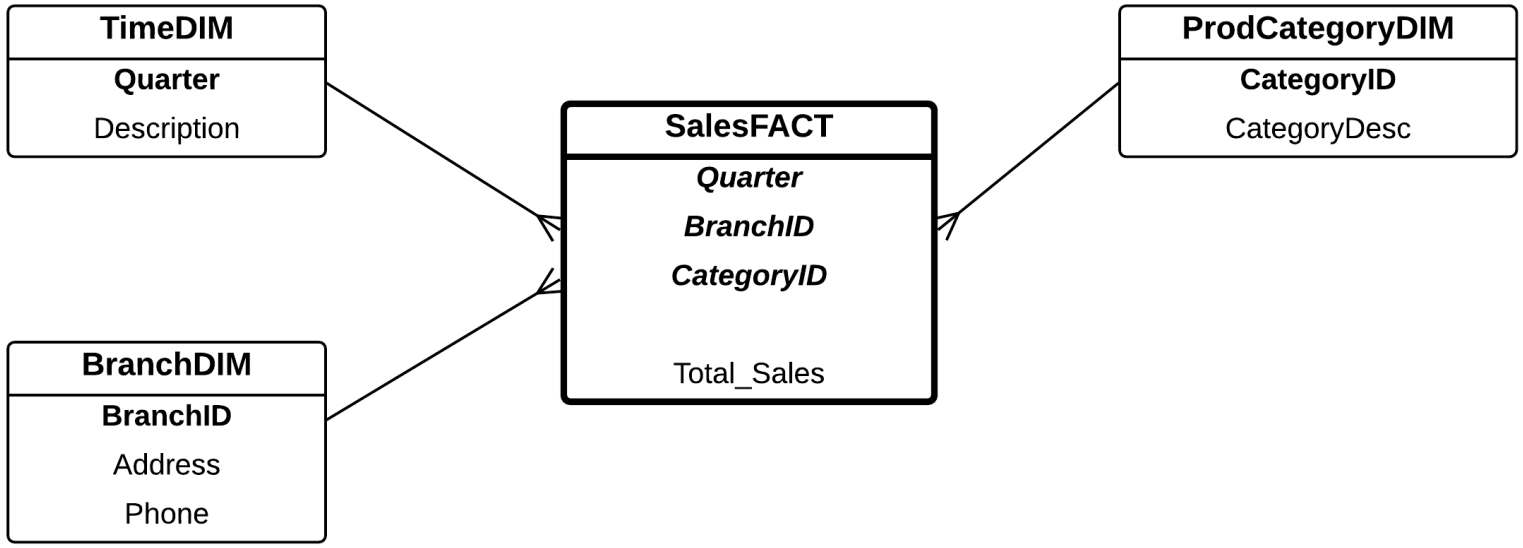
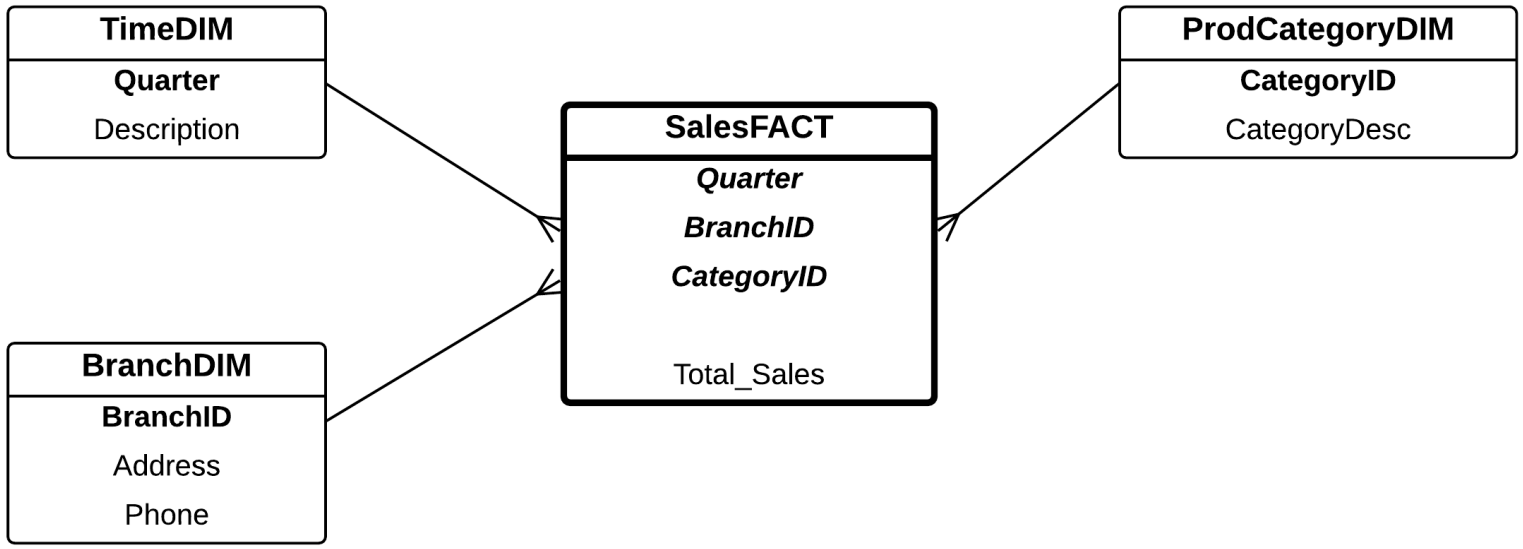


Case Study #2: Sales

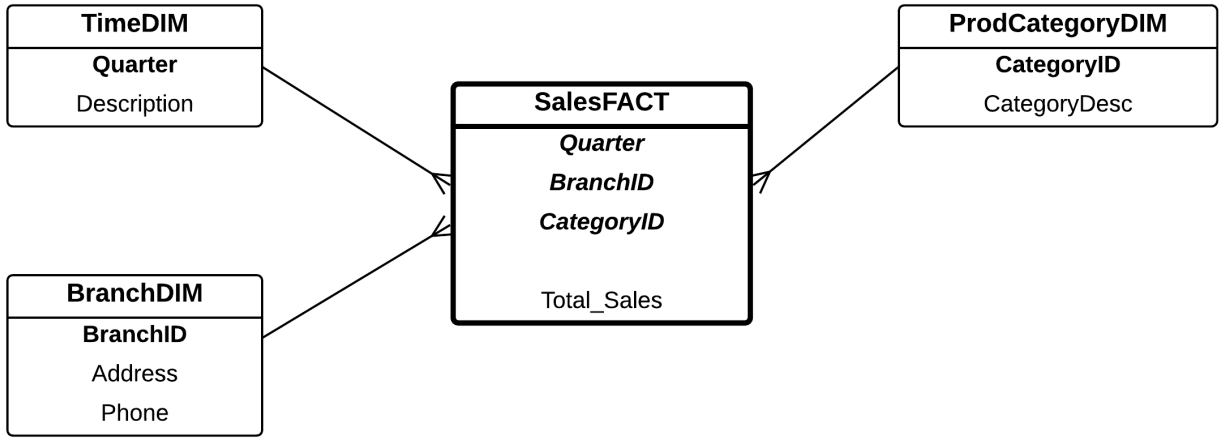
- Sales Star Schema
  - **Fact**:
    - Total Sales
  - **Dimensions**:
    - Time
    - Branch
    - Product Category



Case Study #2: Sales

- To create ProdCategoryDIM:
  - `create table ProdCategoryDim as select * from Category;`

- To create BranchDIM:
  - `create table BranchDim as select * from Branch;`



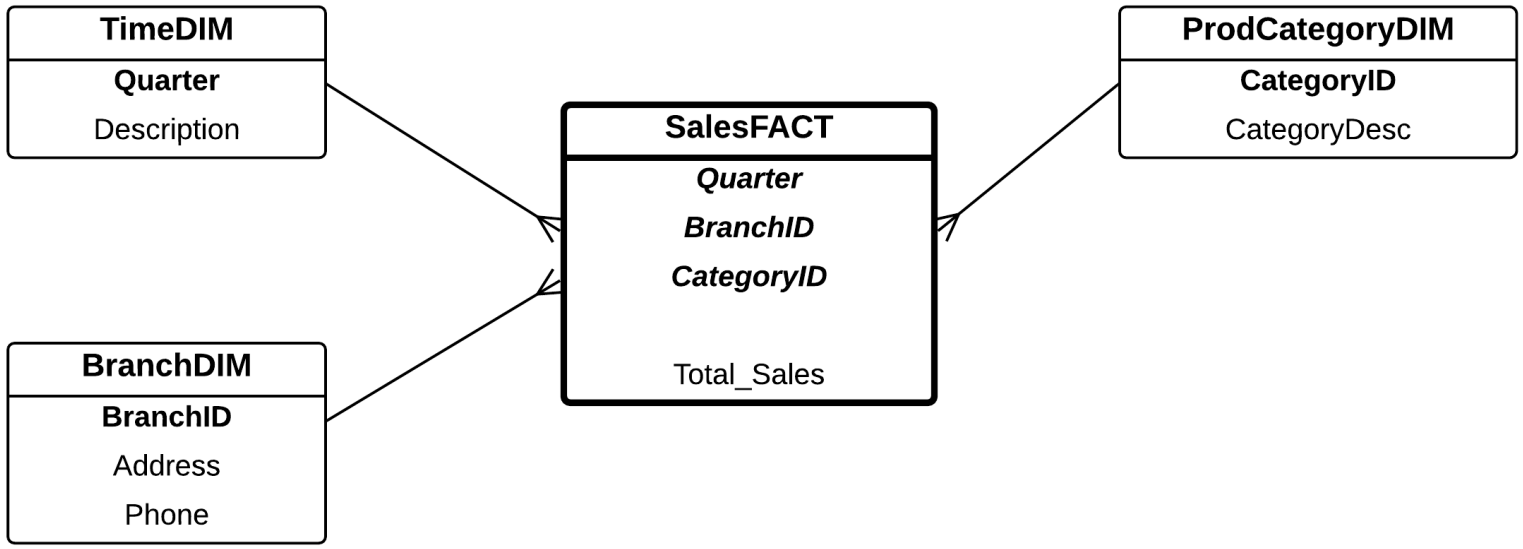
Case Study #2: Sales

- To create TimeDIM:
  -
```
create table TimeDim
 (Quarter number(1),
 Description varchar2(20));
```

- To insert the values in TimeDIM:
  -
```
Insert into TimeDim values (1, 'Jan-Mar');
insert into TimeDim values (2, 'Apr-Jun');
insert into TimeDim values (3, 'Jul-Sep');
insert into TimeDim values (4, 'Oct-Dec');
```

Case Study #2: Sales

- Sales Star Schema
  - **Fact**:
    - Total Sales
  - **Dimensions**:
    - Time
    - Branch
    - Product Category



Case Study #2: Sales

- To create Temporary Fact for SalesFact:
  -
```
create table TempFact as
select
  S.SalesDate,
  B.BranchID,
  C.CategoryID,
  S.TotalPrice
from Branch B, Sales S, Product P, Category C
where B.BranchID = S.BranchID
and S.ProductNo = P.ProductNo
and P.CategoryID = C.CategoryID
and to_char(S.SalesDate, 'YYYY') = '2020';
```

Case Study #2: Sales

- To create Temporary Fact for SalesFact:
  -
```
create table TempFact as
select
  S.SalesDate,
  B.BranchID,
  C.CategoryID,
  S.TotalPrice
from Branch B, Sales S, Product P, Category C
where B.BranchID = S.BranchID
and S.ProductNo = P.ProductNo
and P.CategoryID = C.CategoryID
and to_char(S.SalesDate, 'YYYY') = '2020';
```

Case Study #2: Sales

- To create Temporary Fact for SalesFact:
  -
```
create table TempFact as
select
  S.SalesDate,
  B.BranchID,
  C.CategoryID,
  S.TotalPrice
from Branch B, Sales S, Product P, Category C
where B.BranchID = S.BranchID
and S.ProductNo = P.ProductNo
and P.CategoryID = C.CategoryID
and to_char(S.SalesDate, 'YYYY') = '2020';
```

Case Study #2: Sales

- To create Temporary Fact for SalesFact:
  -
```
create table TempFact as
select
   S.SalesDate,
   B.BranchID,
   C.CategoryID,
   S.TotalPrice
from Branch B, Sales S, Product P, Category C
where B.BranchID = S.BranchID
and S.ProductNo = P.ProductNo
and P.CategoryID = C.CategoryID
and to_char(S.SalesDate, 'YYYY') = '2020';
```

Case Study #2: Sales

- To create Temporary Fact for SalesFact:
  - create table TempFact as

```
select
   S.SalesDate,
   B.BranchID,
   C.CategoryID,
   S.TotalPrice
from Branch B, Sales S, Product P, Category C
where B.BranchID = S.BranchID
and S.ProductNo = P.ProductNo
and P.CategoryID = C.CategoryID
and to_char(S.SalesDate, 'YYYY') = '2020';
```

no aggregation function, and no group by

Case Study #2: Sales

- To alter the TempFact:
  -
```
alter table TempFact;
add (Quarter number(1));
```

- To update the TempFact to turn SalesDate into Quarter:
  -
```
update TempFact
set Quarter = 1
where to_char(SalesDate, 'MM') >= '01'
and to_char(SalesDate, 'MM') <= '03';
```

Case Study #2: Sales

- To update the TempFact to turn SalesDate into Quarter:
  -
```
update TempFact
set Quarter = 2
where to_char(SalesDate, 'MM') >= '04'
and to_char(SalesDate, 'MM') <= '06';

update TempFact
set Quarter = 3
where to_char(SalesDate, 'MM') >= '07'
and to_char(SalesDate, 'MM') <= '09';

update TempFact
set Quarter = 4
where Quarter is null;
```

Case Study #2: Sales

- To create SalesFACT:
  -
```
create table SalesFact as
select
  Quarter,
  BranchID,
  CategoryID,
  sum(TotalPrice) as Total_Sales
from TempFact
group by Quarter, BranchID, CategoryID;
```

Two Column Table Methodology

MONASH University

Two Column Table Methodology

One Fact Measurement:

When creating a star schema, you need to imagine that the data you want to analyse consists of **two columns**.

The first column is the **category** (e.g. A, B, C, D), and the second column is the statistical **numerical figure** (e.g. F).

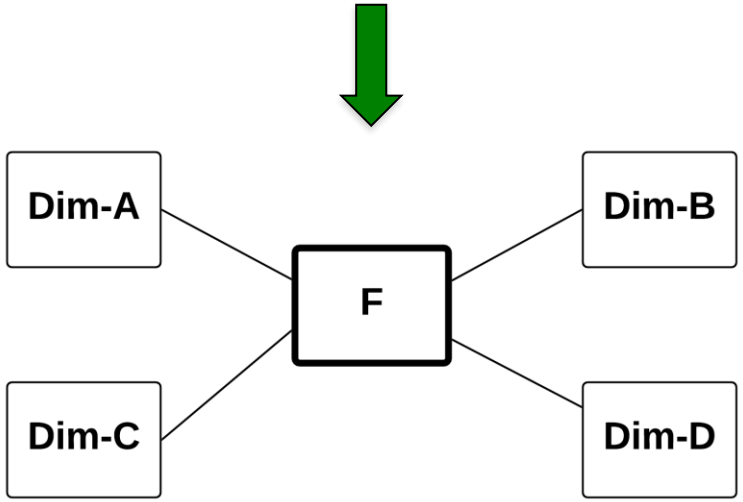
The second column (e.g. F) has to be consistent throughout all the two-column tables.

A	F
x	4
y	3

B	F
r	5
s	3

C	F
k	1
m	1

D	F
p	2
q	5



Two Column Table Methodology

- **Case Study 1: Analysis of Accountants**

  Suppose the CPA organization would like to analyze its members (i.e. accountants) in a particular city. Assume that the organization has the full details of its members.

Education	Number of Accountants
Diploma	84953
Bachelor	349203
Higher Degree	98943
Others	2322

Two Column Table Methodology

- We can also look at the figures from the gender point of view, like:

Gender	Number of Accountants
Male	434322
Female	89932

- Another way to analyze number of accountants is form the type of the accountant job itself; something like:

Type	Number of Accountants
Government	3843
Private Business	45303
Personal	45930
etc	
etc	

- Note that the figures are fictitious, and the “Types” of Accountants (indicating different roles of accountants) are also fictitious.

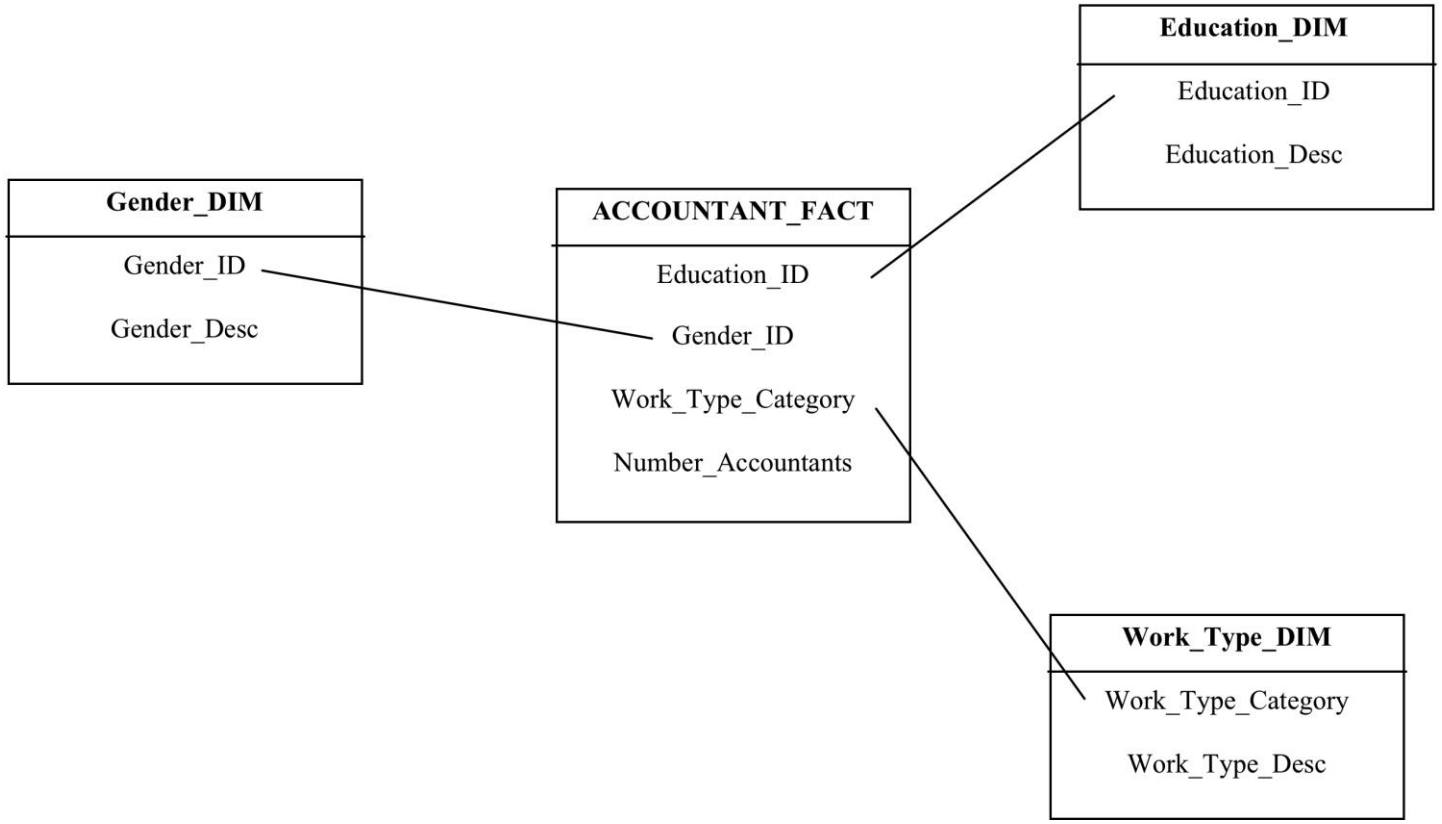
Two Column Table Methodology

- You can further identify other example to analyze number of accountants. In the above three tables, the first angle to look at the number of accountants is from the educational background, the last one is from the type of the accountant itself, whether it is a private business accountant, etc.

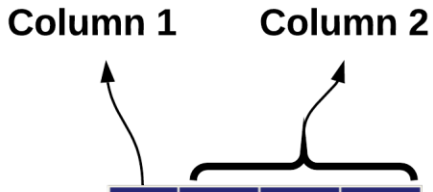
- As you can see, the second column is CONSISTENTLY UNIFORM. In the above example, it is number of accountants. The first column changes depending on from which angle that you want to see.

Two Column Table Methodology

- Therefore, in this case study, the star schema could look like the following:



Two Column Table Methodology



A	F1	F2	F3
x	4	0	1
y	3	2	7

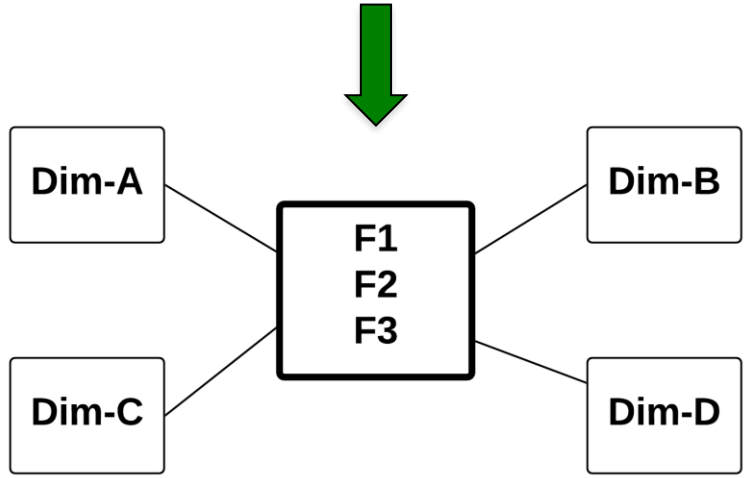
B	F1	F2	F3
r	5	2	8
s	3	5	9

C	F1	F2	F3
k	1	0	4
m	1	0	6

D	F1	F2	F3
p	2	7	8
q	5	4	8

Multiple Fact Measurements:

The second column in the two-column tables, which is the numerical fact measurement (e.g. column F) can actually be multiple columns (call them: F1, F2, F3), as long as all of these columns (e.g. F1, F2, F3) relate to all of the categories (e.g. A, B, C, D).



Two Column Table Methodology

- **Case Study 2: Student Enrollment**

  The University Administrator(s) needs to keep track of the number of enrollment for particular unit or campus and the students' performance each year in order to maintain the University performance. The head of admin has assigned you the task of developing a small Data Warehouse in which to keep track the enrollment and performance statistics.

Two Column Table Methodology

- For example:

Subject	Number of Students	Total Score
Database	8	539
Java	5	327
SAP	1	63
Network	2	105

- Another example could be something like this:

Semester	Number of Students	Total Score
One	9	618
Two	7	416

Two Column Table Methodology

- In analyzing number of students (apart from the subject and semester as shown above), you could also see the number of student from another angle, for example from the campus and grade:

Campus	Number of Students	Total Score
Main	9	658
City	5	271
DE	2	105

F1 F2

Two Column Table Methodology

- For example:

Grade	Number of Students (F1)	Total Score (F2)
HD	3	253
D	4	300
C	4	256
P	2	105
N	3	120

Two Column Table Methodology

- The first columns of the above examples are the **dimensions**, whereas the other columns that contain the statistical/summarized/aggregated values is the **fact**.

- In the above example, the fact is then STUDENT_ENROLLMENT_FACT, and the dimensions are SUBJECT, SEMESTER, GRADE and CAMPUS.

Two Column Table Methodology

- The star schema for the STUDENT ENROLLMENT is shown as follows: