Relational Model

Database Systems

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Last Lecture

- Data
  - Information that is stored or transmitted electronically
  - Structured Data vs. Unstructured Data
- Database
  - An organized collection of data
- Database Management Systems (DBMS)
  - A **software** designed to store, retrieve, define, and manage data in a database
- Database Systems
  - Users, application programs, DBMS and stored database are referred to as a database system

Last Lecture

- Data Model
  - **A syntax or grammar** used to show how data is stored, connected, accessed and updated in the DBMS

- Types of data models
  - Hierarchical Model
  - Network Model
  - Hybrid Model
  - **Relational Model <- This lecture will focus on Relation Model**
  - Object-Oriented Model
  - Object-Relational Model

- The relational model is one of the simplest and easy to understand data models

Last Lecture

- Relational model represents the database as a collection of relations
  - **Relation = table**

ID	*name*	*dept_name*	*salary*
22222	Einstein	Physics	95000
12121	Wu	Finance	90000
32343	El Said	History	60000
45565	Katz	Comp. Sci.	75000
98345	Kim	Elec. Eng.	80000
76766	Crick	Biology	72000
10101	Srinivasan	Comp. Sci.	65000
58583	Califieri	History	62000
83821	Brandt	Comp. Sci.	92000
15151	Mozart	Music	40000
33456	Gold	Physics	87000
76543	Singh	Finance	80000

The *instructor* table

1. Relational Model

- What do you know about the table?
  - Given the following table, find:
    - Name of the table
    - Rows of the table
    - Columns of the table
    - The number of rows
    - The number of columns

EMPNO	EMPNAME	TITLE	DNO	SALARY
2106	김창섭	대리	2	2000000
3426	박영권	과장	3	2500000
3011	이수민	부장	1	3000000
1003	조민희	대리	1	2000000

1. Relational Model

❖ Basic terminologies

re-cols

null → indexing ○

1. Relational Model

- Basic terminologies
  - Relation
    - A two-dimensional table
  - Tuple
    - A row of the relation
  - Attribute
    - A column of the relation
  - Primary key = column
    - An attribute or a set of attributes which helps you to **UNIQUELY** identify a tuple in a relation

1. Relational Model

- Basic terminologies
  - Degree
    - The number of attributes in the relation
      - The minimum degree of a valid relation must be 1
      - The degree of the relation does not change often
  - Cardinality
    - The number of tuples/records in the relation
      - The cardinality of a valid relation can be 0
      - The cardinality of the relation keeps changing over time

1. Relational Model

- Basic terminologies
  - Domain
    - Data type describing the type of values in each column
      - Example 1: EMPNO int
      - Example 2: EMPNAME varchar(20)
  - Relation Schema
    - Structure of the relation denoted by **R(A1, A2, ... , An)**
    - Ex: EMPLOYEE(EMPNO, EMPNAME, TITLE, DNO, SALARY)
  - Relation Instance
    - A set of *n* tuples

1. Relational Model

- Basic Terminology
  - Example of Relation Instance

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	M	38000	333445555	5
Joyce	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4
James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	NULL	1

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date
Research	5	333445555	1988-05-22
Administration	4	987654321	1995-01-01
Headquarters	1	888665555	1981-06-19

DEPT_LOCATIONS

Dnumber	Dlocation
1	Houston
4	Stafford
5	Bellaire
5	Sugarland
5	Houston

WORKS_ON

Essn	Pno	Hours
123456789	1	32.5
123456789	2	7.5
666884444	3	40.0
453453453	1	20.0
453453453	2	20.0
333445555	2	10.0
333445555	3	10.0
333445555	10	10.0
333445555	20	10.0
999887777	30	30.0
999887777	10	10.0
987987987	10	35.0
987987987	30	5.0
987654321	30	20.0
987654321	20	15.0
888665555	20	NULL

PROJECT

Pname	Pnumber	Plocation	Dnum
ProductX	1	Bellaire	5
ProductY	2	Sugarland	5
ProductZ	3	Houston	5
Computerization	10	Stafford	4
Reorganization	20	Houston	1
Newbenefits	30	Stafford	4

DEPENDENT

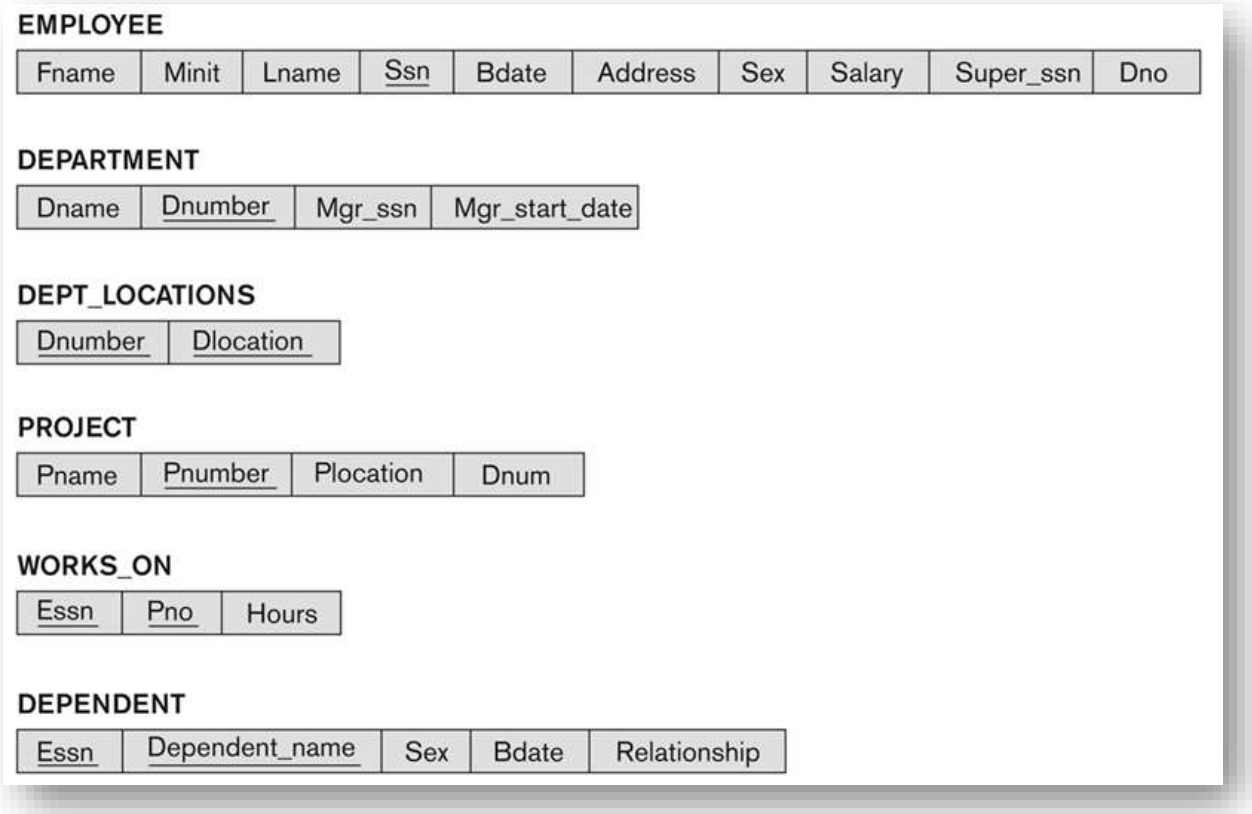
Essn	Dependent_name	Sex	Bdate	Relationship
333445555	Alice	F	1986-04-05	Daughter
333445555	Theodore	M	1983-10-25	Son
333445555	Joy	F	1958-05-03	Spouse
987654321	Abner	M	1942-02-28	Spouse
123456789	Michael	M	1988-01-04	Son
123456789	Alice	F	1988-12-30	Daughter
123456789	Elizabeth	F	1967-05-05	Spouse

1. Relational Model

- Basic Terminology
  - Relational Database Schema
    - A set *S* of relation schemas that belong to the same database
    - *S* is the name of the whole database schema
    - *S = {R1, R2, ..., Rn}*
    - *R1, R2, ..., Rn* are the names of the individual relation schemas within the database S
  - Following slide shows a COMPANY database schema with 6 relation schemas

1. Relational Model

- Basic Terminology
  - Relational Database Schema
    - Example: a COMPANY database schema



EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date

DEPT_LOCATIONS

Dnumber	Dlocation

PROJECT

Pname	Pnumber	Plocation	Dnum

WORKS_ON

Essn	Pno	Hours

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship

1. Relational Model

- Basic terminologies
  - NULL value
    - Used to indicate ‘unknown’ or ‘not applicable’
    - Example
      - You enter a tuple about a new employee in an employee relation. However, the new employee's DNO (department number) may not be determined yet. In this case, **DNO is unknown or has NULL value**.
    - NULL value is different from a zero in the numeric domain or blank character in the string domain
    - Different DBMSs use different symbols to represent null values

Quiz

- Fill out the form with correct terminology from relational model

Frequently Used (Informal Terminology)	Relational Model (Formal Terminology)
Table	relation
Row	Tuples
Column	attribute
Unknown Value	NULL
Table Definition	Rel name
Table with Data	Instance
All Possible Values in a Column	Domain

2. Characteristics of Relation

❖ Characteristics of relation

1. Each relation in a database must have a distinct or unique name

2. The order of tuples in the relation is NOT important

DEPARTMENT

DEPTNO	DEPTNAME	FLOOR
1	영업	8
2	기획	9
3	개발	10

=

DEPARTMENT

DEPTNO	DEPTNAME	FLOOR
3	개발	10
2	기획	9
1	영업	8

2. Characteristics of Relation

❖ Characteristics of relation

3. Each attribute in a relation must have a distinct or unique name

4. The order of attributes in the relation is NOT important

DEPARTMENT

DEPTNO	DEPTNAME	FLOOR
1	영업	8
2	기획	10
3	개발	9

=

DEPARTMENT

FLOOR	DEPTNO	DEPTNAME
8	1	영업
10	2	기획
9	3	개발

2. Characteristics of Relation

❖ Characteristics of relation

5. A relation does not allow duplicate tuples

6. Each cell contains an indivisible (atomic) value, not a list or set

DEPARTMENT

DEPTNO	DEPTNAME	FLOOR
1	영업	{8, 9}
2	기획	10
3	개발	{7, 9}

Not allowed because these tuples have multiple values

3. Keys

- Key
  - An attribute or a set of attributes which helps you to identify a tuple in a relation

- Types of keys
  - Super key
  - Candidate key
  - Primary key
  - Alternate key
  - Foreign key

3. Keys

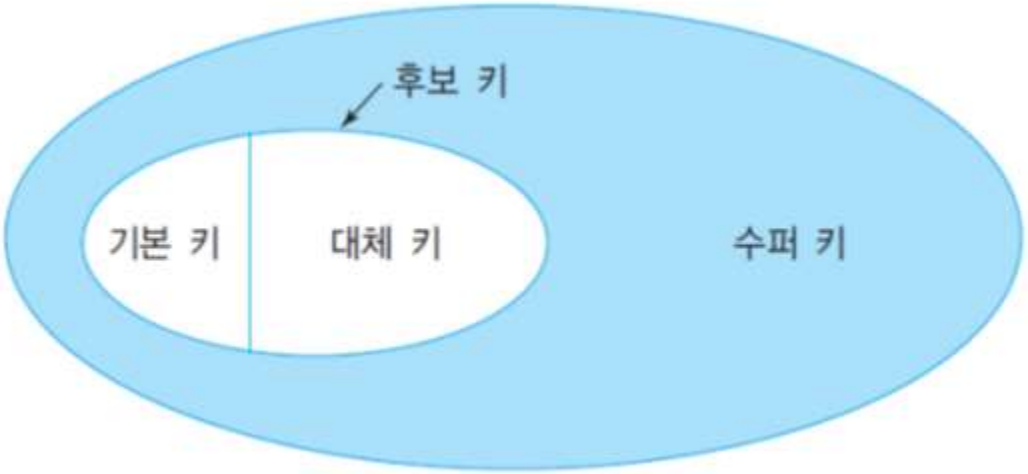
- Super key
  - An attribute or a set of attributes that uniquely defines a tuples in the relation
  - Example
    - Student(StudentNumber, Name, Major, PhoneNumber)
    - A super key is a combination that contains the StudentNumber and PhoneNumber
      - {StudentNumber}
      - {StudentNumber, Name}
      - {StudentNumber, Name, Major}
      - {StudentNumber, Name, Major, PhoneNumber}
      - {StudentNumber, Major}
      - {StudentNumber, Major, PhoneNumber}
      - {StudentNumber, PhoneNumber}
      - {PhoneNumber}
      - {PhoneNumber, Name}
      - {PhoneNumber, Name, Major}
      - {PhoneNumber, Major}

3. Keys

- Candidate key
  - The smallest subset of super key attributes which are unique
  - Example
    - {StudentNumber} and {PhoneNumber} are candidate keys
- Primary key
  - One of the candidate key
  - Underlined attributes in a relation are primary keys
  - Example
    - {StudentNumber} is the primary key

3. Keys

- Alternate key
  - Candidate key other than primary key (leftover candidate key)
  - Example
    - {PhoneNumber} is the alternate key



3. Keys

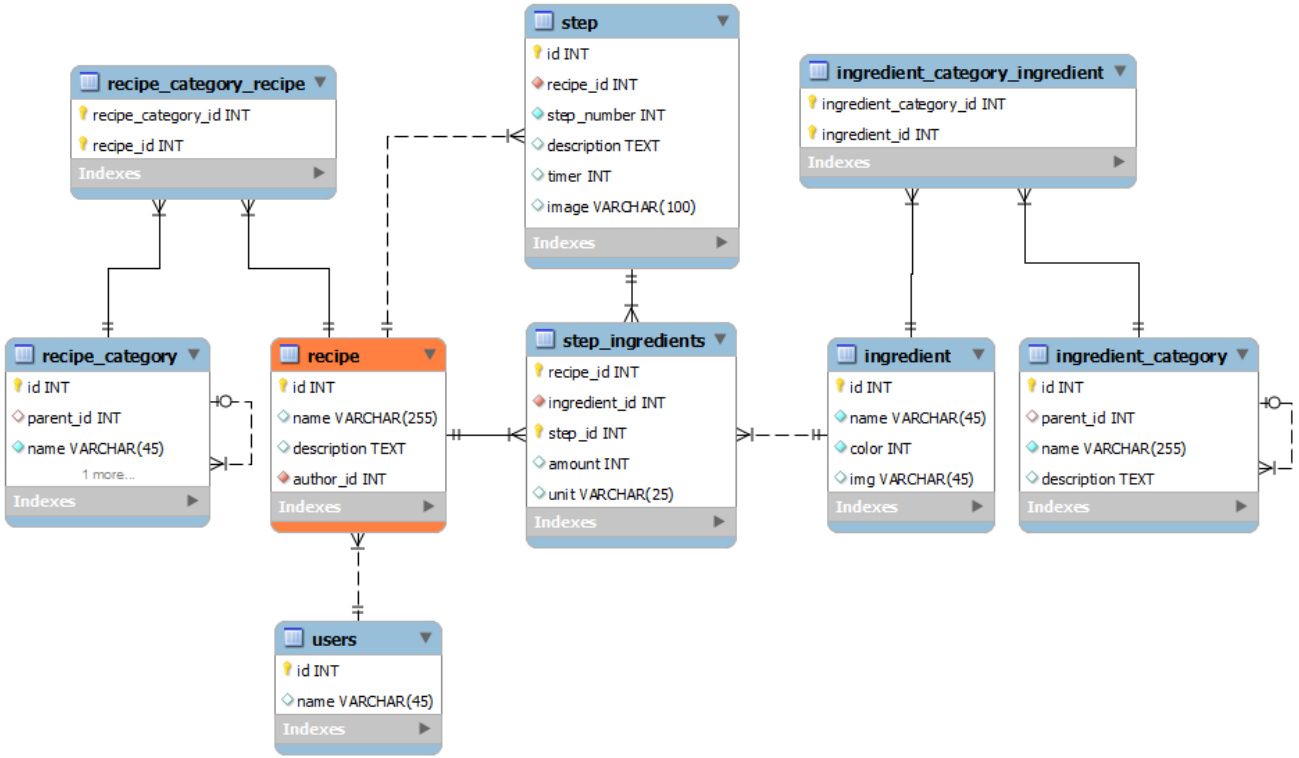
- Quiz
  1. What are the candidate keys for the following CAR relation?
  2. Which attribute should be the primary key for the CAR relation?

CAR

License number	Engine_serial_number	Make	Model	Year
Texas ABC-739	A69352	Ford	Mustang	02
Florida TVP-347	B43696	Oldsmobile	Cutlass	05
New York MPO-22	X83554	Oldsmobile	Delta	01
California 432-TFY	C43742	Mercedes	190-D	99
California RSK-629	Y82935	Toyota	Camry	04
Texas RSK-629	U028365	Jaguar	XJS	04

3. Keys

- Foreign key
  - Used to represent the relationship between relations in the database



3. Keys

- Foreign key
  - An attribute that creates a relationship between two relations
  - Types of foreign key
    - Foreign key referencing the primary key of another relation
    - Foreign key referencing the primary key of its own relation
    - Foreign key that is a composite of the primary keys

3. Keys

- Types of foreign key
  - Foreign key referencing the primary key of another relation

EMPLOYEE

EMPNO	EMPNAME	DNO
2106	김창섭	2
3426	박영권	3
3011	이수민	1
1003	조민희	1
3427	최종철	3

Primary Key

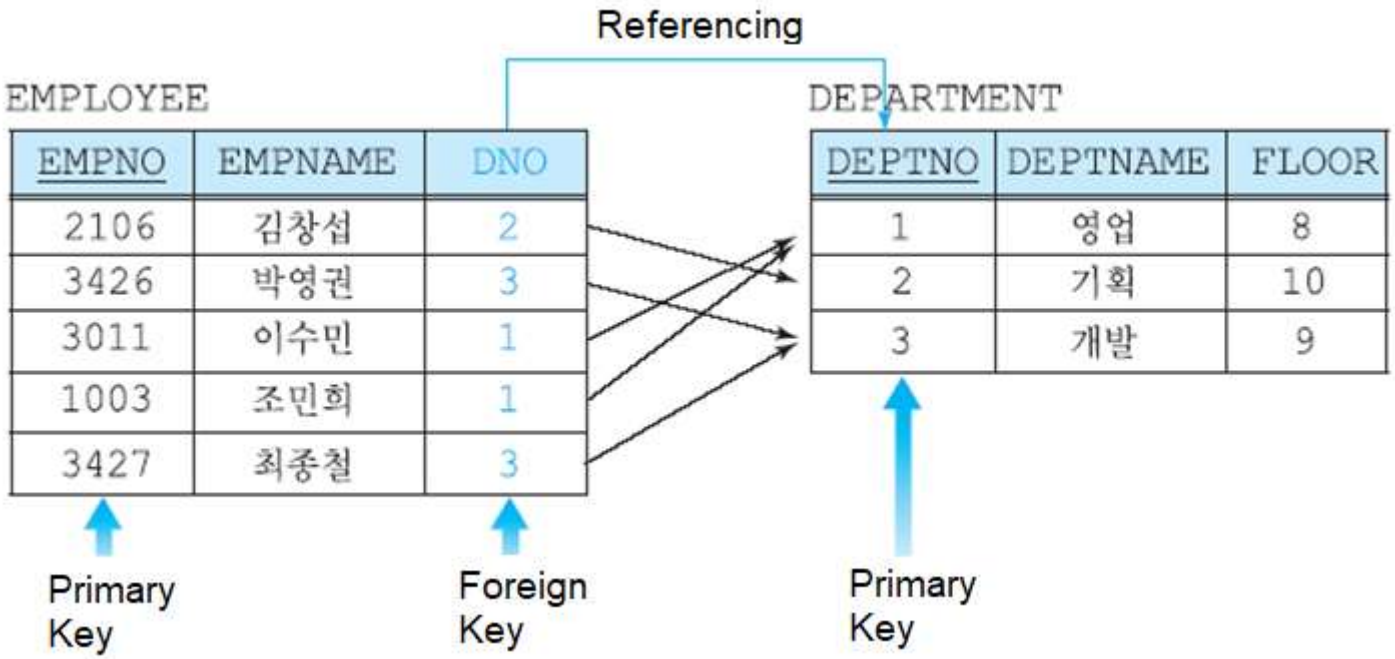
DEPARTMENT

DEPTNO	DEPTNAME	FLOOR
1	영업	8
2	기획	10
3	개발	9

Primary Key

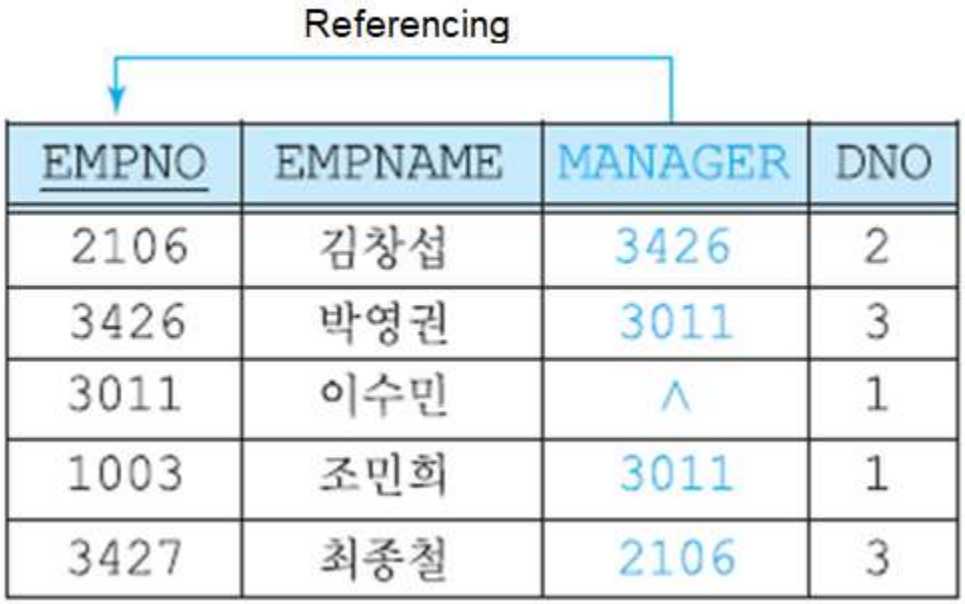
3. Keys

- Types of foreign key
  - Foreign key referencing the primary key of another relation



3. Keys

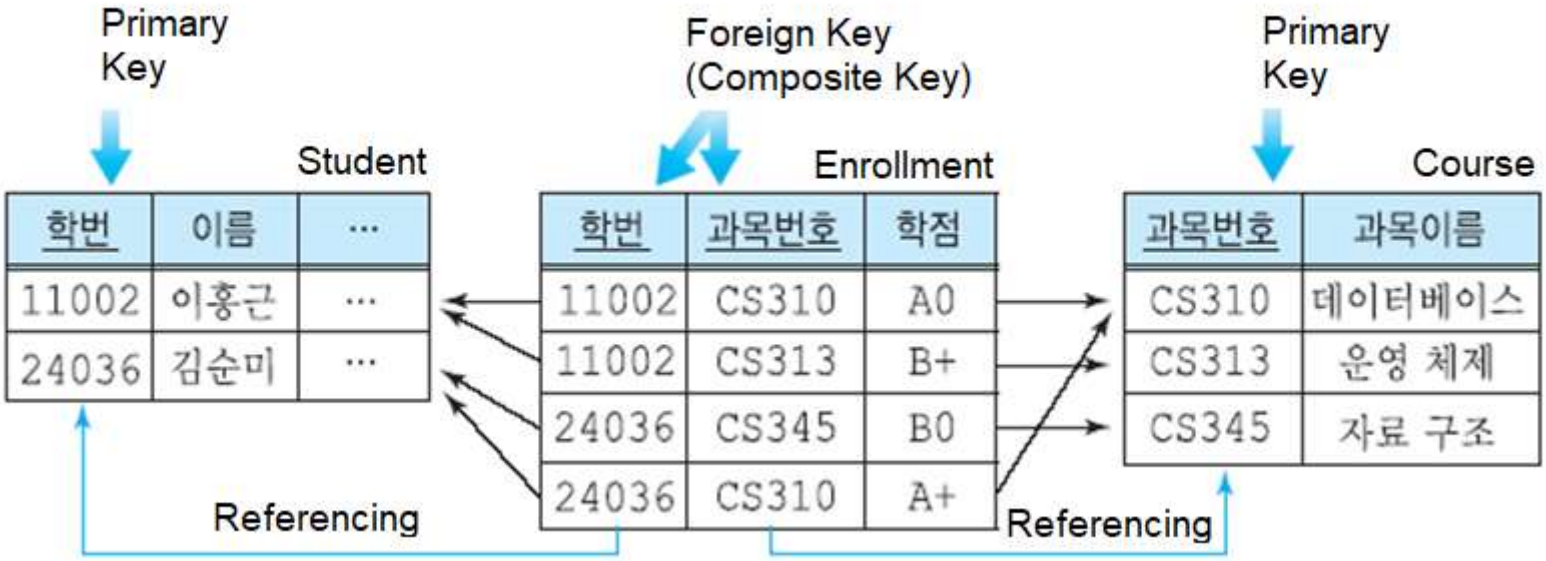
- Types of foreign key
  - Foreign key referencing the primary key of its own relation



EMPNO	EMPNAME	MANAGER	DNO
2106	김창섭	3426	2
3426	박영권	3011	3
3011	이수민	∧	1
1003	조민희	3011	1
3427	최종철	2106	3

3. Keys

- Types of foreign key
  - Foreign key that is a composite of the primary keys



4. Integrity Constraints

- Integrity constraints
  - A set of rules used to ensure the accuracy and consistency of the relational database
  - Types of integrity constraints
    - Key constraint
    - Domain constraint
    - Referential integrity constraint

4. Integrity Constraints

- Key constraint
  - A set of constraints related to the primary key
  - Constraint 1
    - Every relation must have a primary key
  - Constraint 2
    - The attribute chosen to be the primary key must be unique

DEPARTMENT

DEPTNO	DEPTNAME	FLOOR
1	영업	8
2	기획	9
2	개발	10

Not allowed. Because primary key must be unique

4. Integrity Constraints

- Key constraint
  - Constraint 3
    - The attribute chosen to be the primary key must NOT be NULL

DEPARTMENT

DEPTNO	DEPTNAME	FLOOR
1	영업	8
2	기획	9
	개발	10

Not allowed as primary key CANNOT contain a NULL value

- Why a primary key cannot contain a NULL value?
  - The primary key value is used to identify individual tuples in relation and if the primary key has a null value, then we can't identify those tuples.

4. Integrity Constraints

❖ Domain integrity constraint

- Defines a valid set of values for an attribute

- Constraint 1
  - Domain (data type) of each attribute in a relation must be declared

- Constraint 2
  - Each tuple must have exactly one atomic value for an attribute

DEPARTMENT

DEPTNO	DEPTNAME	FLOOR
1	영업	{8, 9}
2	기획	10
3	개발	{7, 9}

Not allowed because these tuples have multiple values

4. Integrity Constraints

- Domain integrity constraint
  - Constraint 3
    - All values within an attribute must be in the same domain
      - Must be the same data type

DEPARTMENT

DEPTNO	DEPTNAME	FLOOR
1	영업	8
2	기획	9
3	개발	Ten

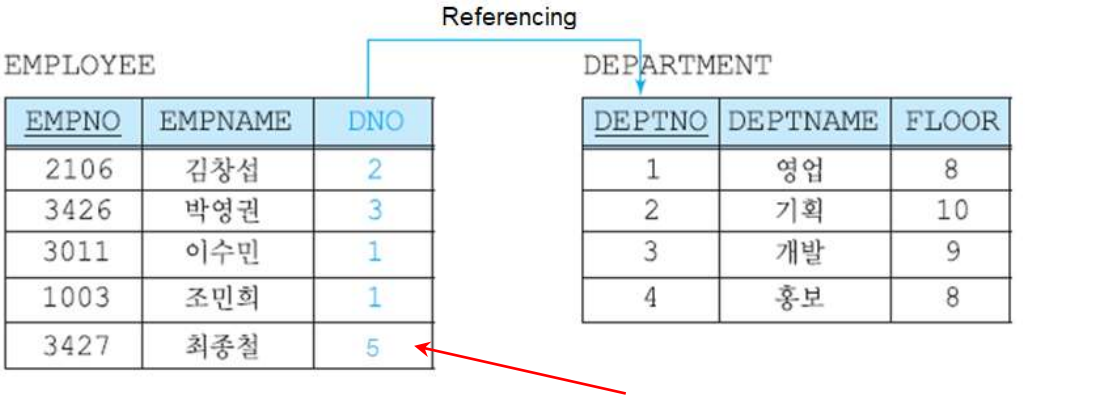
Not allowed because FLOOR is an integer attribute

4. Integrity Constraints

❖ Referential integrity constraint

- A set of constraints related to the foreign key

- Constraint 1
  - If a foreign key in Relation A refers to the primary key of Relation B, then every value of the foreign key in Relation A must be available in Relation B.



EMPNO	EMPNAME	DNO
2106	김창섭	2
3426	박영권	3
3011	이수민	1
1003	조민희	1
3427	최종철	5

DEPTNO	DEPTNAME	FLOOR
1	영업	8
2	기획	10
3	개발	9
4	홍보	8

Not allowed because there is no department 5

5. Pros and Cons of Relational Model

- Pros of Relation Model
  - Simplicity of model
  - Ease of use
  - Accuracy
  - Data Integrity
  - Normalization
  - Security

5. Pros and Cons of Relational Model

- Cons of Relational Model
  - Not very good for large databases
  - Difficult to find the relationship between tables
  - Because of the complex structure
    - Response time for queries is high
    - Lack of scalability

6. Summary and Discussions

- Relational Model
  - Relational model represents the database as a collection of relations
    - Relation = table

  - Basic Terminologies
    - Relation
    - Tuple
    - Attribute
    - Degree
    - Cardinality
    - Domain
    - Relation Schema
    - Relation Instance
    - Relational Database Schema
    - NULL value

6. Summary and Discussions

- Characteristics of relational model

- Keys
  - Super key, Candidate key, Primary key, Alternate key, Foreign key

- Integrity constraints
  - A set of rules used to ensure the accuracy and consistency of the relational database

  - Types of integrity constraints
    - Key constraint
    - Domain constraint
    - Referential integrity constraint