Database Constraints

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Integrity constraints

Databases often required to satisfy some integrity constraints

Determine what tuples can be stored in the database

Instances that satisfy the constraints are called **legal**

Common constraints: keys and foreign keys

These are special cases of more general constraints

- Functional dependencies
- Inclusion dependencies

Functional dependencies (FDs)

Constraints of the form $X \to Y$, where X, Y are sets of attributes

Semantics

A relation R satisfies $X \to Y$ if for every two tuples $t_1, t_2 \in R$

$$\pi_X(t_1) = \pi_X(t_2) \quad \Longrightarrow \quad \pi_Y(t_1) = \pi_Y(t_2)$$

Intuition: The values for the X attributes **determine** the values for the Y attributes

Trivial FDs: $X \to Y$ where $Y \subseteq X$

Examples of FDs

Employee	**Department**	**Manager**
John	Finance	Smith
Mary	HR	Taylor
Susan	HR	Taylor
John	Sales	Smith

Which of the following FDs would the above relation satisfy?

- Department $\to$ Manager **Yes**
- Employee $\to$ Department **No**
- Employee, Manager $\to$ Department **No**
- Manager $\to$ Department **No**

Keys

A set of attributes X is a key for relation R if for every $t_1, t_2 \in R$

$$\pi_X(t_1) = \pi_X(t_2) \quad \Longrightarrow \quad t_1 = t_2$$

A **key** for a table is a set of attributes that uniquely identify a row

$\Longrightarrow$ no two rows can have the same values for key attributes

Key constraints: special case of FDs $X \to Y$
where Y is the **whole set of attributes** of a relation

Inclusion dependencies (INDs)

Constraints of the form $R[X] \subseteq S[Y]$
where R, S are relations and X, Y are **sequences** of attributes

Semantics

R and S satisfy $R[X] \subseteq S[Y]$ if

for every $t_1 \in R$ there exists $t_2 \in S$ such that $\pi_X(t_1) = \pi_Y(t_2)$

Important: the projection must respect the attributes order

INDs are referential constraints: **link** the contents of one table
with the contents of another table

A foreign key constraint is the conjunction of two constraints:

- $R[X] \subseteq S[Y]$ (an IND)
- Y is key for S (a key constraint)

Examples of INDs

Employees

Name	**Dep**
John	Finance
Mary	HR
John	HR
Linda	Finance
Susan	Sales

Departments

Name	**Mgr**
Finance	John
HR	Mary
Sales	Linda

Which of the following INDs would the above relation satisfy?

- Employees[Dep] $\subseteq$ Departments[Name] **Yes**
- Employees[Name] $\subseteq$ Departments[Mgr] **No**
- Departments[Mgr] $\subseteq$ Employees[Name] **Yes**
- Departments[Mgr,Name] $\subseteq$ Employees[Name,Dep] **No**

Basic SQL constraints

`NOT NULL` to disallow null values

`UNIQUE` to declare keys

`PRIMARY KEY` key + not null

`FOREIGN KEY` to reference attributes in other tables

`NULL` values are ignored when checking constraints
except for **`NOT NULL`** and **`PRIMARY KEY`**

Not Null

Declaring an attribute as **NOT NULL** disallows **null values** for that attribute

```
CREATE TABLE Account (
    accnum  VARCHAR(12) NOT NULL,
    branch  VARCHAR(30),
    custid  VARCHAR(10),
    balance NUMERIC(14,2) DEFAULT 0
);
```

The following insertion would fail:

```
INSERT INTO Account(branch,custid)
  VALUES ('London','cust1');
```

Keys

```
CREATE TABLE Account (
    accnum  VARCHAR(12) UNIQUE,
    branch  VARCHAR(30),
    custid  VARCHAR(10),
    balance NUMERIC(14,2)
);
```

The following insertion gives an error:

```
INSERT INTO Account VALUES
(1, 'London',    'cust1', 100),
(1, 'Edinburgh', 'cust3', 200);
```

The following insertion succeeds:

```
INSERT INTO Account VALUES
(NULL, 'London',    'cust1', 100),
(NULL, 'Edinburgh', 'cust3', 200);
```

Compound keys

Keys consisting of more than one attribute
must be declared using a different syntax

```
CREATE TABLE Movies (
    m_title    VARCHAR(30),
    m_director VARCHAR(30),
    m_year     SMALLINT,
    m_genre    VARCHAR(30),
    UNIQUE (m_title,m_year)
);
```

This declares the set {m_title,m_year} as a key for Movies

Primary Keys

Essentially **UNIQUE** + **NOT NULL**

```
CREATE TABLE Account (
    accnum  VARCHAR(12) PRIMARY KEY,
    branch  VARCHAR(30),
    custid  VARCHAR(10),
    balance NUMERIC(14,2)
);
```

same as

```
CREATE TABLE Account (
    accnum  VARCHAR(12) NOT NULL UNIQUE,
    branch  VARCHAR(30),
    custid  VARCHAR(10),
    balance NUMERIC(14,2)
);
```

Foreign keys in SQL (1)

```
CREATE TABLE Customer (
    id      VARCHAR(10) PRIMARY KEY
    name    VARCHAR(20),
    city    VARCHAR(30),
    address VARCHAR(30)
);

CREATE TABLE Account (
    accnum  VARCHAR(12),
    branch  VARCHAR(30),
    custid  VARCHAR(10) REFERENCES Customer(id),
    balance NUMERIC(14,2)
);
```

Every value for attribute `custid` in Account must appear among the values of the **key** `id` in Customer

Foreign keys in SQL (2)

General syntax (useful for declaring compound foreign keys)

```
CREATE TABLE <table1> (
    <attr> <type>,
    ...
    <attr> <type>,
    FOREIGN KEY (<list1>)
        REFERENCES <table2>(<list2>)
);
```

where

- `<list1>` and `<list2>` are lists with the **same number** of attributes
- attributes in `<list1>` are from table `<table1>`
- attributes in `<list2>` are **unique** in `<table2>`

Referential integrity and database modifications (1)

Deletion can cause problems with foreign keys

Customer	**ID**	**Name**
	cust1	John
	cust2	Mary

Account	**Number**	**CustID**
	123456	cust1
	654321	cust2

where Account.CustID is a foreign key for Customer.ID

What happens if one deletes (cust1,John) from Customer?

Three approaches are supported in SQL:

1. Reject the deletion operation
2. Propagate it to Account by deleting also (123456,cust1)
3. "Don't know" approach: keep the tuple in Account, but set CustID value to **NULL**

Referential integrity and database modifications (2)

All three approaches are supported in SQL

```
CREATE TABLE <table1> (
    <attr> <type>,
    ...
    FOREIGN KEY <list1> REFERENCES <table2>(<list2>)
        <approach>
)
```

where `<approach>` can be:

1. Empty: Reject deletions from `<table2>` causing the FK to be violated (this is the default when `<approach>` is not specified)
2. **ON DELETE CASCADE**: Propagate the deletion to `<name>` (tuples in `<table1>` that violate the FK will be deleted)
3. **ON DELETE SET NULL**: "Don't know" approach (the values of the attributes in `<list1>`, for tuples in `<name>` that violate the FK, are set to **NULL**)