Databases

Unit 2
Relational data model and relational algebra

Relational model and relational algebra

- Relational data model
- Relational algebra

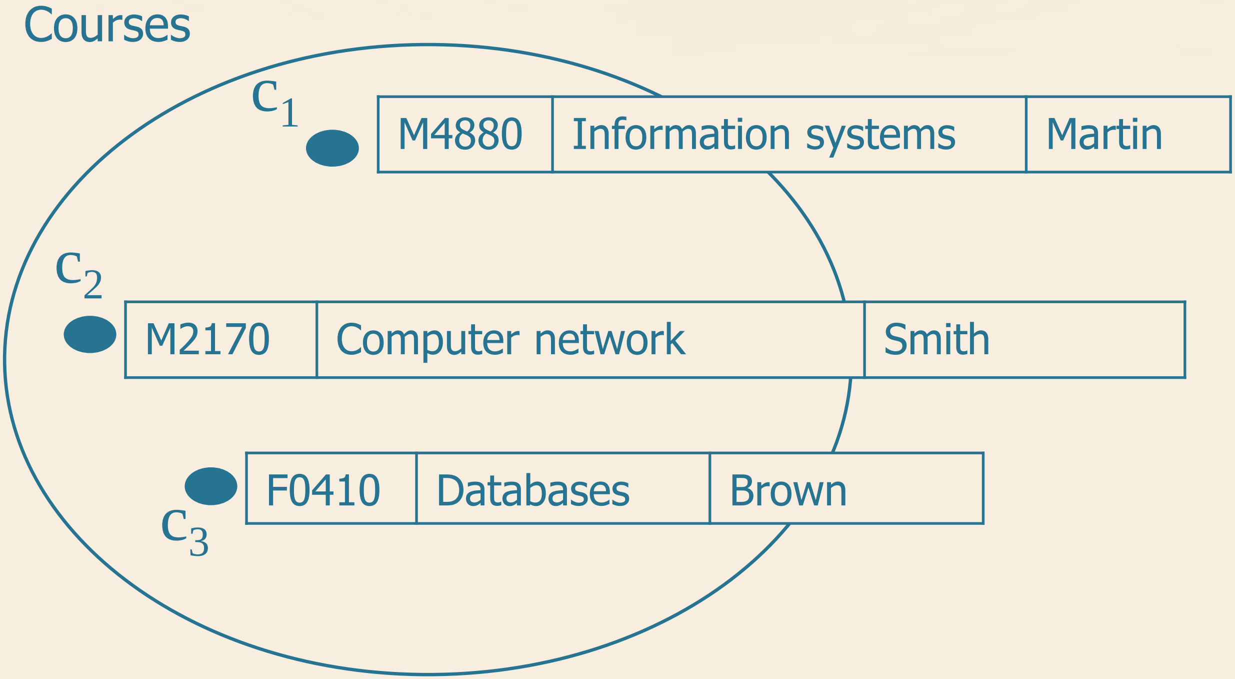
Relational data model

- Introduction
- Definitions
- References between relations
- Incomplete information
- Integrity constraints
- Primary key
- Tuple constraint and domain constraint
- Referential integrity constraint

Relational data model

Introduction

Intuition



M4880	Information systems	Martin
M2170	Computer network	Smith
F0410	Databases	Brown

Relational model

- Proposed by E. F. Codd in 1970 to support higher abstract levels compared to the previous models
  - Data independence
- Made available in commercial DBMSs in 1981,
  - Today it is the main model exploited in commercial DBMSs
- Based on (a variant of) *relation* mathematical concept
  - Each relation is represented in the informal way by means of a table

Example

Courses

Code	Name	TeacherID
M2170	Information systems	D101
M4880	Computer Networks	D102
F0410	Databases	D321

Teachers

ID	Name	Department	Phone#
D101	Green	Computer Engeneering	123456
D102	White	Telecommunications	636363
D321	Black	Computer Engeneering	414243

Realtional model

Definitions

Definitions

attributes

Courses

n-tuples

Code	Name	TeacherID
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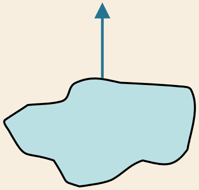

Domain: identifier set of the Politecnico courses

Definitions

- Attribute
  - Column name of a table
- Domain
  - Value set that can be assumed by an attribute
- Tuple (or record)
  - A row in a table
- Cardinality
  - Number of tuples in a relation
- Degree
  - Number of attributes in a relation

Properties

- Tuples (rows) *are not* ordered
- Tuples are *distinct* among them (there are not duplicated rows)
- Attributes are not ordered
  - It is not possible to identify an attribute by means of its position

Relational model

References between relations

References between relations

- The relational model is *value-based*
  - References between data in different relations are represented by means of values of the domains

Value-based reference: Example

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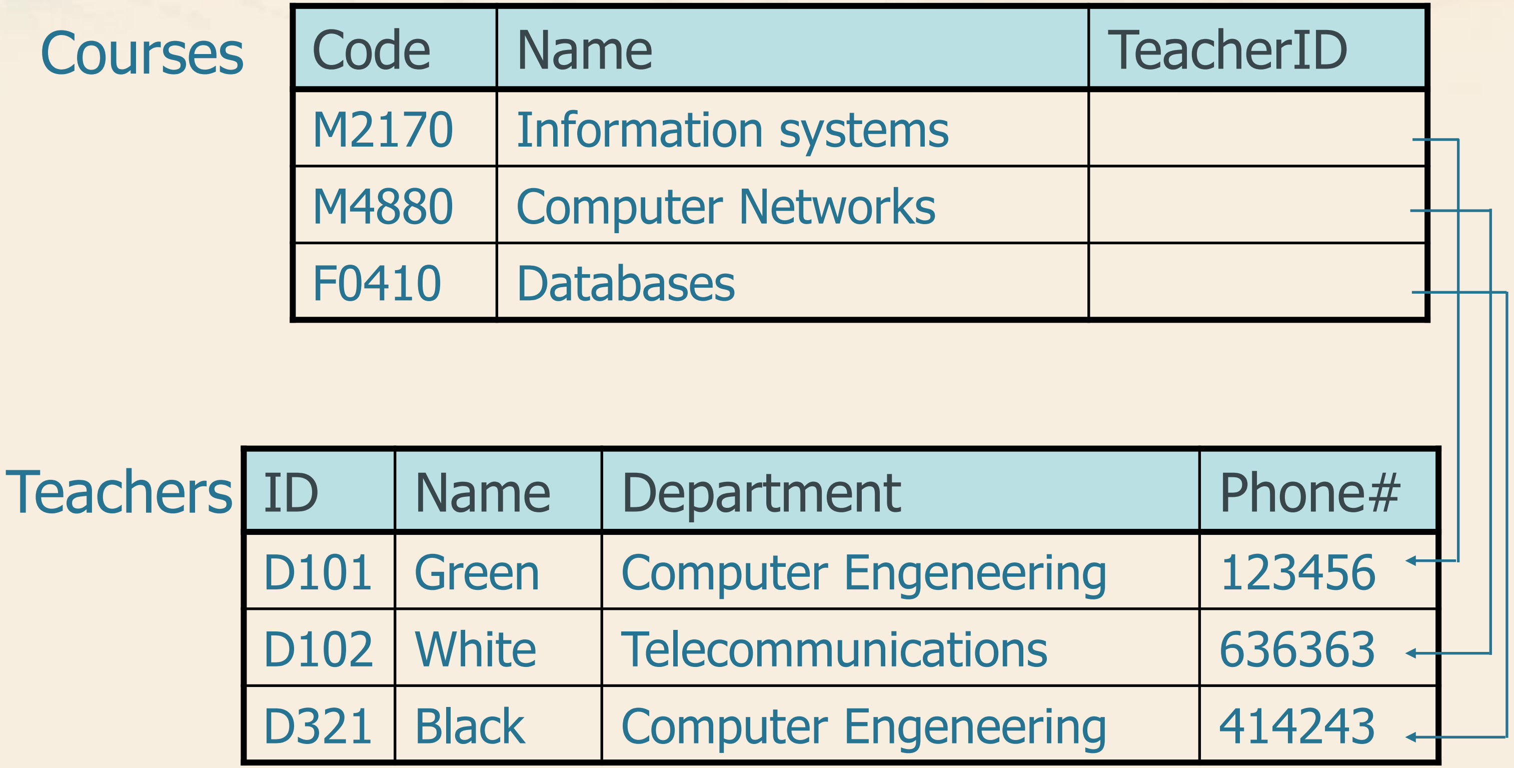
Pointer-based reference: Example



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References between relations

- The relational model is *value-based*
  - References between data in different relations are represented by means of values of the domains
- Advantages
  - Independence of physical structures
  - Only information that is relevant from the application point of view is stored
  - Easy transferrability of data between different systems
  - Differently from pointers, the link is not oriented

Relational model

Null values

Incomplete information

- Some information could be not available for any tuples in the relation
- Example
  Student (StudentID, Surname,BirthDate, Phone#,
  DegreeYear)
  - The phone number could be (temporarily?) unknown
  - for students not yet graduated, year degree is not defined
  - for students just graduated, degree year is not yet defined or unknown

Null values

- To represent lack of information we should use a special value belonging to the domain (0, empty string, 999, …)
  - A value not used is required (example: DegreeYear=0, Phone#=?)
  - “unused” values could become meaningful (Phone#= 999999)
  - it is necessary to deal separately with "special" values in different application
- The representation is not adequate

Null value

- Definition of a spelcial value named *null value* (NULL)
  - It is not a value of the domain
  - It denotes both the absence of a domain value and value not defined
  - It must be used with caution (example: StudentID=NULL?)

Relational model

Integrity constraints

Integrity constraints

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Integrity constraints

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Integrity constraints

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Integrity constraint

- Integrity constraint
  - a property that must be satisfied by all meaningful database instances
- Types of constraint
  - Intra-relational constraints, defined on the attributes of a single relation (examples: unique constraint, domain constraints, tuple constraints)
  - Inter-relational constraints, defined on many relations at the same time (example: referential constraint)

Relational model

Primary key

Unique identification for tuples

Students

StudentID	Name	Surname	BirthDate	EnrollementYear
64655	Mike	Red	4/8/1978	1998
81999	Paul	White	4/8/1978	1999
75222	Marco	Red	8/3/1979	1998

- There is no pair of students with the same value for the StudentID
  - The StudentID uniquely identifies students

Unique identification for tuples

Students

StudentID	Name	Surname	BirthDate	EnrollementYear
64655	Mike	Red	4/8/1978	1998
81999	Paul	White	4/8/1978	1999
75222	Marco	Red	8/3/1979	1998

- There is no pair of students with the same value for the personal data
  - name, surname and birth date uniquely identify students

Key

- A *key* is an attribute set that uniquely identifies tuples in a relation
  - It is a property of the relational schema
- Formal definition: a set K of attributes is a key in a relation r if
  - The relation r does not contain a pair of distinct tuples with the same values for K (univocity)
  - K is minimal (there exists no other superkey K’ of r that is contained in K as proper subset)

Example

- The attribute

  {StudentID}

  is unique and minimal, thus it is a key

- The attribute set

  {Name, Surname, BirthDate}

  is unique and minimal (none of its subsets is unique), thus it is a key

Superkey

- A set K of attributes is a key in a relation r if
  - The relation r does not contain a pair of distinct tuples with the same values for K (univocity)
  - K is minimal (there are not proper subsets of K still unique)
- If only the first property is satisfied, K is a *superkey* of r

Examples

- The attribute set

  {StudentID,Name}

  is unique, but no minimal (the StudentID is unique), thus the attribute set is a superkey, but it is *not* a key

- The attribute set

  {BirthDate, EnrollementYear}

  is unique and minimal: is it a general property?

Primary key

- If a key can assume the NULL value, it cannot be a key (the univocity property is lost)
  - It is mandatory to avoid the NULL values in the keys
- Solution
  - a reference key, which does not allow null values, is defined. It is called *primary key*
  - The other keys (candidate keys) can assume null values
  - References between data in different relations are defined by means of the primary key

Relational model

Tuple constraint and domain constraint

Domain constraint

- Domain constraint
  - expresses conditions on the value assumed by a single attribute of a tuple
    - It can be a Boolean expression (and, or, not) of simple predicates
  - example: Score > 0 and Score ≤ 30

Tuple constraint

- Tuple constraint
  - expresses conditions on the values of each tuple, indipendently of other tuples
    - It can correlate many attributes
    - It can be a Boolean expression (and, or, not) of simple predicates (e.g., comparison between attributes, between an attribute and a constant)
  - example: Price = Cost + TaxPerc*Cost

Relational model

Referential integrity constraint

Referential integrity constraint

- Information in different relations are correlated by common values of one or more attributes

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Referential integrity constraint

- Information in different relations are correlated by common values of one or more attributes
  - The TeacherID attribute in the COURSES relation refers the ID attribute in TEACHERS
- The values of an attribute in the referencing/internal relation must exist as values of an attribute in the instance of the referenced/external relation
  - The values of TeacherID in the COURSES relation must exist as values of the ID attribute in TEACHERS

Referential integrity constraint

- Referential constraint
  - Given two relations
    - R (referenced/external relation)
    - S, that refers R through a set X of attributes (referencing/internal relation)
  - values on a set X of attributes in a relation S can be exclusively values for the primary key of the relation R
- The set X of attributes in S represents its foreign key

Referential integrity constraint

- Referential integrity constraints are imposed in order to guarantee that the values refer to actual values in the referenced relation (the relational model is value-based)

Example

Flight

F-ID	Date
AZ111	10/16/1996
AZ234	12/4/1998
AZ543	3/9/2000

Ticket

F-ID	Date	Seat#	Passenger
AZ111	10/16/1996	23	Luis Red
AZ111	10/16/1996	56	John White
AZ234	12/4/1998	9	Mark Black
AZ234	12/4/1998	11	Joe Green
AZ234	12/4/1998	21	Paul Red

Example

Flight

F-ID	*Date*
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Ticket

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AZ234	12/4/1998	11	Joe Green
~~*AZ534*~~	~~*12/4/1998*~~	21	Paul Red