



Databases

Relational data model

Relational data model

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

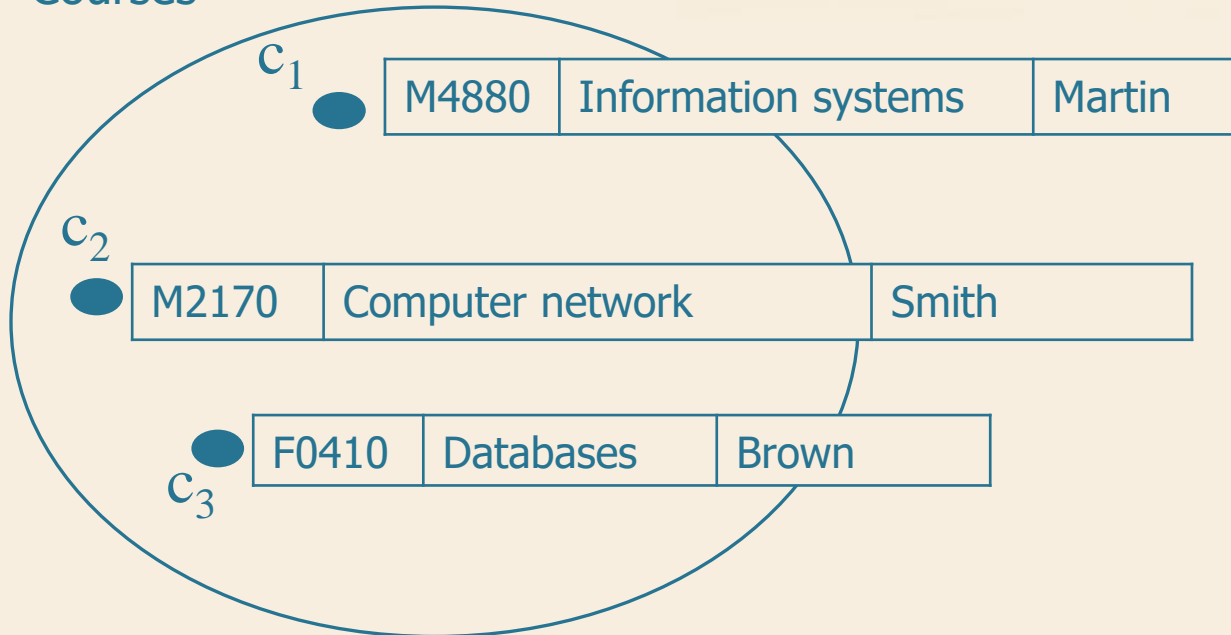


Relational data model

Introduction

Intuition

Courses



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 Engineering	123456
D102	White	Telecommunications	636363
D321	Black	Computer Engineering	414243



Relational model

Definitions

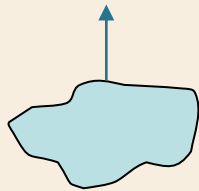
Definitions

attributes

Courses

Code	Name	TeacherID
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M4880	Computer Networks	D102
F0410	Databases	D321

n-tuples



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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Code	Name	TeacherID
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Pointer-based reference: Example

Courses

Code	Name	TeacherID
M2170	Information systems	
M4880	Computer Networks	
F0410	Databases	

Teachers

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D101	Green	Computer Engineering	123456
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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 data portability 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

- Definition of a special 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

Courses

Code	Name	TeacherID
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Teachers

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Integrity constraints

Courses

Code	Name	TeacherID
M2170	Information systems	D101
M4880	Computer Networks	D102
F0410	Databases	D342

Teachers

ID	Name	Department	Phone#
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D321	Black	Computer Engineering	414243

Integrity constraints

Courses

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

Teachers

ID	Name	Department	Phone#
D101	Green	Computer Engineering	123456
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D321	Black	Computer Engineering	000001

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 integrity 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

- 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)

➤ The attribute

$\{\text{StudentID}\}$

is unique and minimal, thus it is a key

➤ The attribute set

$\{\text{Name, Surname, BirthDate}\}$

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

- 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

➤ The attribute set

$\{\text{StudentID}, \text{Name}\}$

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

$\{\text{BirthDate}, \text{EnrollementYear}\}$

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: $\text{Score} > 0$ and $\text{Score} \leq 30$

Tuple constraint

➤ Tuple constraint

- expresses conditions on the values of each tuple, independently 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: $\text{Price} = \text{Cost} + \text{TaxPerc} * \text{Cost}$



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

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

Ticket

<u><i>F-ID</i></u>	<u><i>Date</i></u>	<u><i>Seat#</i></u>	<i>Passenger</i>
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Example

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Example

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<u><i>F-ID</i></u>	<u><i>Date</i></u>	<u><i>Seat#</i></u>	Passenger
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AZ111	10/16/1996	56	John White
AZ234	12/4/1998	9	Mark Black
AZ234	12/4/1998	11	Joe Green
AZ534	12/4/1998	21	Paul Red