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IT3090E - Databases

Chapter 2: Relational Databases

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- Chapter 9: Security
- *(Optional) Chapter 10: Transactions: concurrency and recovery*

Learning points

- 1. Relational data model
- 2. Constraints

Learning objectives

- Upon completion of this lesson, students will be able to:
  - Recall some basic concepts of relational data model.
  - Show some constraints of relational data model.

Keywords and descriptions

Keyword	Description
Data model	A set of concepts used to describe the structure of a database: data types, relationships, constraints, semantics…
Relation	Is thought of as a table of values, each row in the table represents a collection of related data values.
Key	An attribute or a set of attributes in the relation, which can identify a tuple uniquely.
Integrity constraints	Provide a way of ensuring that changes made to the database by authorized users do not result in a loss of data consistency.

1. Relational data model

- 1.1. Introduction
- 1.2. Database Basic concepts

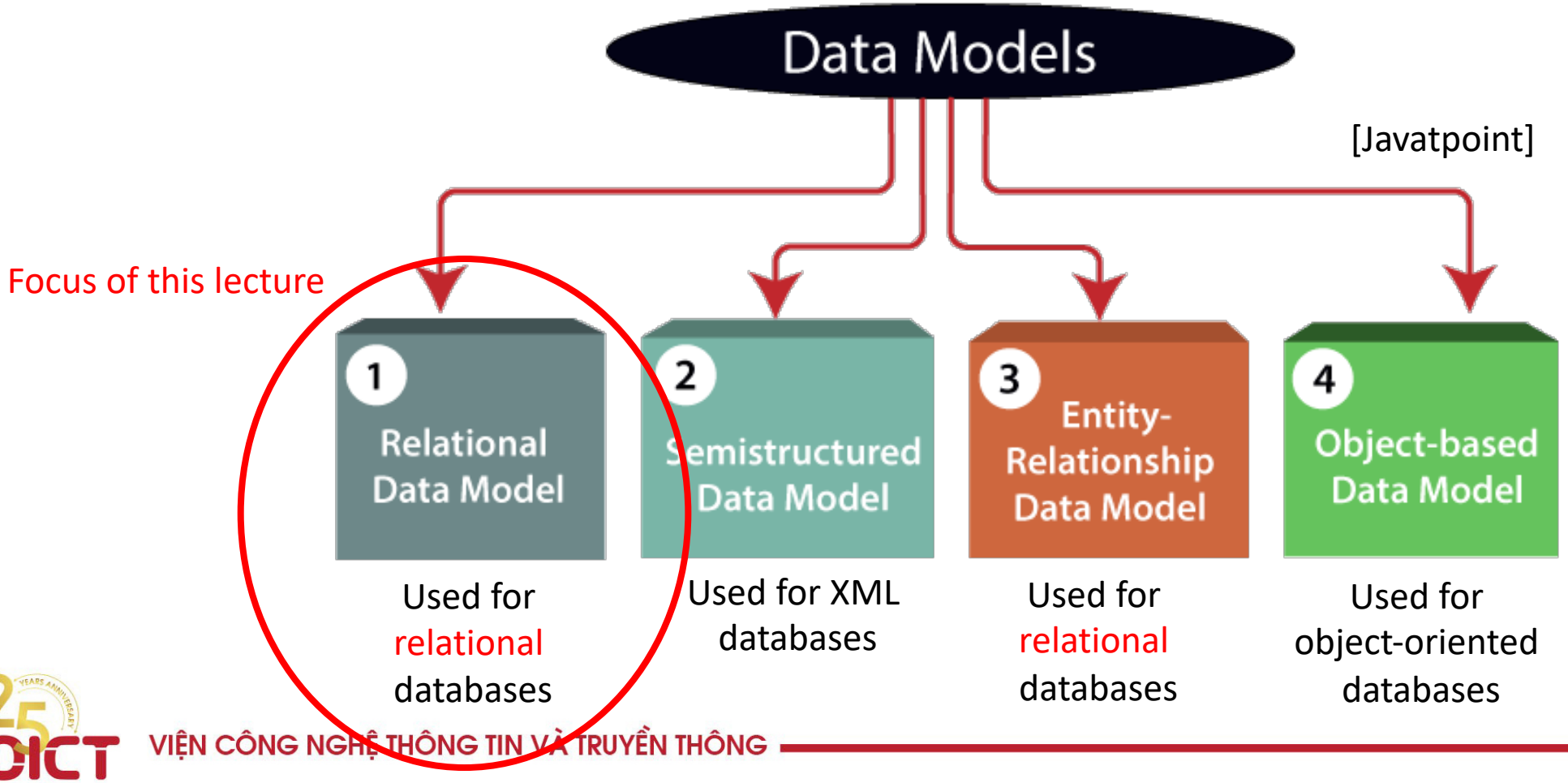
1.1. Introduction

- A data model is the modeling of the data description, data semantics, and consistency constraints of the data.
- It provides the conceptual tools for describing the design of a database at each level of data abstraction.

[Javatpoint]

1.1. Introduction

- There exist numerous possible data models, including:



1.1. Introduction

- Relational data model:
  - Is very simple model, was first introduced by Ted Codd of IBM Research in 1970
  - Used by most of commercial database systems
  - There exist a number of DBMS for efficient implementations
    - with high-level querying languages
  - Based on mathematical theory, close to file structure and data structure, there are three sets of terminology:

Relation	Table	File
Tuple	Row	Record
Attribute	Column	Field

1.2. Basic concepts

Relations	• are presented in the form of tables, which have rows (tuples) and columns (attributes). The lowercase letters Q, R, S denote relations.
Relation instance/state	• actual contents at given point in time. The lowercase letters q, r, s denote relation states.
Database	• a set of named relations (or tables).

1.2. Basic concepts

Tuple	• a single row of a table, which contains a single record for that relation. The letters t, u, v denote tuples.
Cardinality	• is the number of tuples in a relation.
Degree (arity)	• is the number of attributes in a relation.

1.2. Basic concepts

- An example

student(student_id, first_name, last_name, dob, gender, address, note, clazz_id)

Relation name

Attributes

student

student_id	first_name	last_name	dob	gender	address	note	clazz_id
1234	David	Beckham	12/21/1997	Male	London, UK		1
1238	Theresa	May	08/06/1998	Female	London, UK		1
1452	David	Cameron	07/06/1997	Male	Bangor, UK		1
1497	Tony	Blair	03/01/1999	Male	Bath, UK		2
1516	John	Major	03/01/1998	Male	Bradford		2
1542	Margaret	Thatcher	05/08/1997	Female	Cambridge		2

Tuples

Cardinality = 6

Degree = 8

1.2. Basic concepts

- Relational schema: structural description of relations in database.
  - A relation schema R of degree n, denoted by $\mathbf{R(A_1, A_2, \ldots, A_n)}$, is made up of a relation name R and a list of attributes $A_1, A_2, \ldots, A_n$
  - Each attribute A_i has values belong to domain D_i of A_i, denoted by $\mathbf{dom(A_i)}$
  - An n-tuple t in a relation r(R) is denoted by $\mathbf{t = <v_1, v_2, \ldots, v_n>}$, where v_i is the value corresponding to attribute A_i. Both $t[A_i]$ and $t.A_i$ (and sometimes t[i]) refer to the value v_i in t for attribute A_i

1.2. Basic concepts

- Notice that the uppercase letters Q, R, S denote relation names.
- A relation (or relation state) r of the relation schema $R(A_1, A_2, ..., A_n)$, also denoted by r(R), is a set of m n-tuples $r = \{t_1, t_2, ..., t_m\}$. Each n-tuple t is an ordered list of n-values $t = <v_1, v_2, ..., v_n>$, where each value v_i, $1 \le i \le n$, is
  - either an element of $dom(A_i)$,
  - or a NULL value.
- A relation (or relation state) r(R) is a mathematical relation of degree n on the domains $dom(A_1)$, $dom(A_2)$, ..., $dom(A_n)$, which is a subset of the Cartesian product of the domains that define R:

$$r(R) \subseteq (dom(A_1) \times dom(A_2) \times ... \times dom(A_n))$$

1.2. Basic concepts

- Example of Relational schema
  - We can use 4 relations (tables) to logically store the products, suppliers, orders, purchase_line
    - But other schemas are possible to store exactly the same information (see course on Database Design)

- **PRODUCTS:** product reference, designation, unit price, supplier number
- **SUPPLIERS:** supplier number, name, city
- **ORDER:** order number, order date, total amount
- **ORDER DETAILS:** order number, product reference, quantity, unit price

  - **Question**: why using 4 tables instead of 3?

1.2. Basic concepts

- Extract of an instance of the relation PRODUCTS

- **PRODUCTS:** product_reference, designation, unit_price, supplier_number

Product_reference	designation	Unit_price	Supplier_number
139	lamp	30.00	1623
248	Stove	75.00	1623
258	Backpack Northface	87.00	1369
416	Backpack Sakos	100.00	1359
426	Shoes	155.00	1369
765	tent	300.00	1502

1.2. Basic concepts

- Each table has a unique name:
  - Ex: PRODUCTS

- Each table consists of columns (or attributes)
  - The name of the attributes is unique **in the table**
  - But, two different attributes from two different relations might have the same name

⚠ Name of tables and attributes
  - Avoid accents, special characters and spaces (replace them with '_')!!!
  - On the other hand, the capital letters / small letters do not matter

- Each attribute has a particular domain / type (number, text, date, etc.)
  - Ex: designation: text, unit price: number (see after for real types)

1.2. Basic concepts

- Real-life example of a relational schema:

SHOPS (no_shop, city, name_manager)
CUSTOMERS (no_customer, name, country, city, type)
ITEMS(no_item, name, weight, color, qty_stock, BuyingPrice, SellingPrice, no_supplier#)
DELIVERY (no_delivery, date_del, no_customer#, no_shop#)
ORDERS (no_order, date, no_customer#, no_shop#)
SUPPLIERS (no_supplier, supplier_name)

DELIVERY_DETAILS (no_delivery#, no_item#, qty, no_order#)
ORDER_DETAILS (no_order#, no_item#, qty, no_delivery#, total_amount)

- **Questions:**
  - Why did I put an attribute called no_suppler inside the relation ITEMS?
  - Why did I put the attribute called no_order inside the relation DELIVERY_DETAILS, and not DELIVERY?
  - According to you, what do the # represent?

2. Constraints

- 2.1. Introduction
- 2.2. Types of constraints
- 2.3. An example

2.1. Introduction

- Every relation has some conditions that must hold for it to be a valid relation.
  - These conditions are called Relational Integrity Constraints.
- Provide a way of ensuring that changes made to the database (by authorized users) do not result in a loss of data consistency.

2.2. Types of constraints

- Key constraints
- Domain constraints
- Referential integrity constraints

2.2. Types of constraints

- A (unique) key is an attribute or a set of attributes in the relation, which can identify a tuple uniquely.
    - In a relation with a key, no two tuples can have identical values for key attribute(s)

2.2. Types of constraints

- Some types of key:
  - Candidate Key:
    - Unique key (K) such that no proper subset subset of K has the uniqueness property (irreducibility)
    - A candidate key can not have NULL values.
  - Primary Key (PK): Candidate key <u>chosen</u> to refer to tuples in a relation. Underlined in the relation schema.
  - **Example**:

STUDENT (Student_number, student_last_name, student_middle_name, student_first_name, student_email)

  - **Questions**:
    - Which attributes/set of attributes are keys?
    - Which attributes are candidate keys?
    - Which attribute(s) is/are primary key?

2.2. Types of constraints

- Some types of key:
  - Alternate Keys: Candidate keys that are not selected to be the primary key.
  - Foreign Key (FK):
    - Attribute, or set of attributes, within one relation that matches candidate key of some relation
    - Used to model relationships (associations) between relations (tables)
    - Each key attribute of foreign key has either its name italic, or a hashtag # following its name

ITEM
no_item … num_supplier #

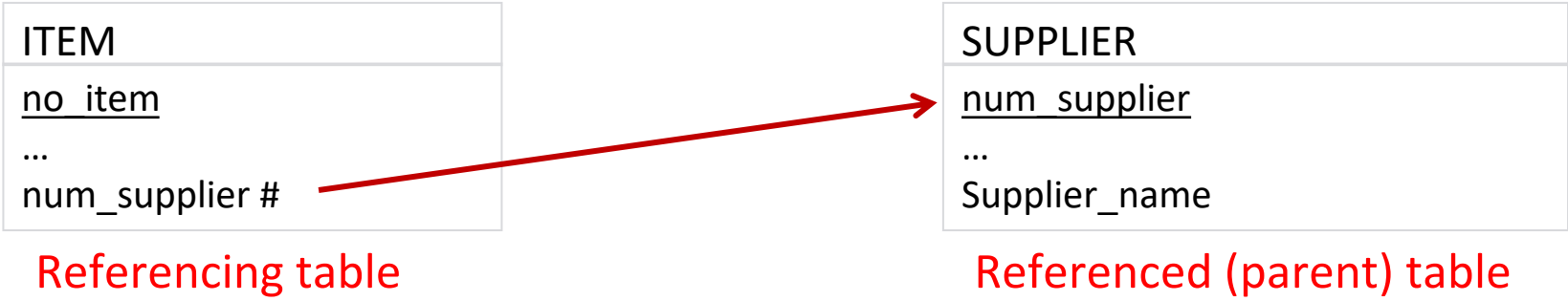
Referencing table

SUPPLIER
num_supplier … Supplier_name

Referenced table

2.2. Types of constraints

- Foreign Key (FK):
  - The # (or italics) appear in the referencing table
  - The referenced attribute in the referenced table - here SUPPLIER(num_supplier) – is **unique and NOT NULL** in the referenced table, but it does not need to be minimal (in practice we try, though…)
  - The referenced attribute in the referenced table - here SUPPLIER(num_supplier) – is often a **primary key** of the referenced table, but **not always**
  - In the referencing table, the foreign key attribute is **not necessarily NOT NULL** nor **unique**
    - I can still store an item instance in my DB, even if I don't know which supplier it comes from…
    - I can have multiple items from the same supplier



1.2. Basic concepts

- Real-life example of a relational schema:

SHOPS (no_shop, city, name_manager)
CUSTOMERS (no_customer, name, country, city, type)
ITEMS(no_item, name, weight, color, qty_stock, BuyingPrice, SellingPrice, no_supplier#)
DELIVERY (no_delivery, date_del, no_customer#, no_shop#)
ORDERS (no_order, date, no_customer#, no_shop#)
SUPPLIERS (no_supplier, supplier_name)

DELIVERY_DETAILS (no_delivery#, no_item#, qty, no_order#)
ORDER_DETAILS (no_order#, no_item#, qty, no_delivery#, total_amount)

- **Questions:**
  - Is there any alternate key for the table CUSTOMER?
  - Why do I need no_delivery AND no_item to as the primary key of DELIVERY_details?
  - Is it a problem that no_delivery and no_item are both foreign keys, and part of the primary key of the table DELIVERY_DETAILS?

2.2. Types of constraints

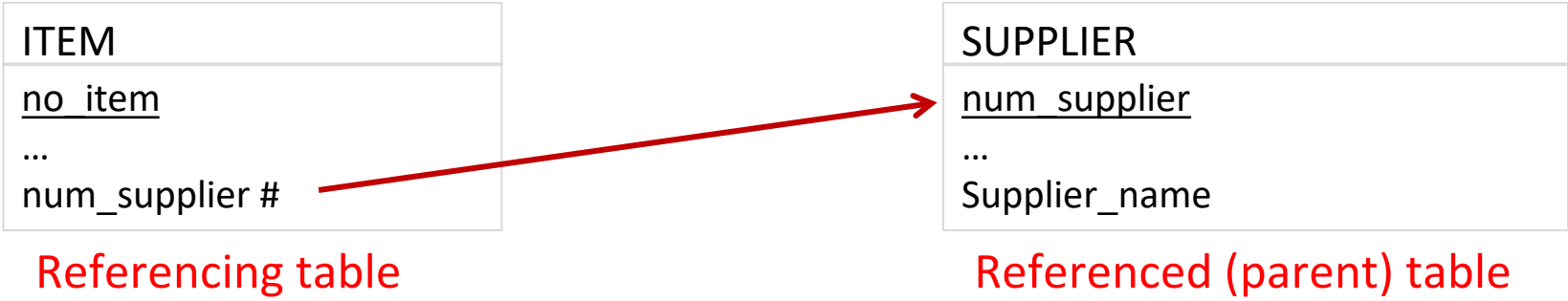
- Domain Constraints:
  - Attributes have specific values in real-world scenario. Every attribute is bound to have a specific range of values.
  - Within each tuple, the value of each attribute A must be an atomic value from the domain dom(A).
  - The data types associated with domains:
    - standard numeric data types for integers (short integer, integer, and long integer) and real numbers (float, double precision float).
    - Characters, Booleans, fixed-length strings, and variable-length strings, date, time, timestamp, and money, or other special data types.
    - a subrange of values from a data type.
    - an enumerated data type in which all possible values are explicitly listed.

2.2. Types of constraints

- Another domain constraints: NOT NULL
  - States that an attribute cannot have any NULL value within all the tuples of the relation
  - Null value:
    - Represents value for an attribute that is currently unknown or not applicable;
    - deals with incomplete or exceptional data;
    - ⚠ represents the absence of a value and is not the same as zero or spaces

2.2. Types of constraints

- Referential integrity Constraints:
  - Referential integrity constraints work on the concept of Foreign Keys. A foreign key is a key attribute of a relation that can be referred in other relation.
  - Referential integrity constraint states that if a relation refers to a key attribute of a referenced table, then that key element must exist in the referenced table



2.3. An example

student(**student_id**, first_name, last_name, dob, gender, addresse, note, *class_id#*)

subject(**subject_id**, name, credit, percentage_final_exam)

results(***student_id#, subject_id#, semester,*** midterm_score, final_score)

- **Questions:**
  - Why do I need semester in the PK of the table results?
  - By default, can the attributes student_id and subject_id be NOT NULL in the relation results?
  - In practice, should I set the attributes student_id and subject_id to be NOT NULL in the relation results?

2.3. An example

student

student_id	first_name	last_name	dob	gender	address	note	clazz_id
1234	David	Beckham	12/21/1997	Male	London, UK		1
1238	Theresa	May	08/06/1998	Female	London, UK		1
1452	David	Cameron	07/06/1997	Male	Bangor, UK		1
1497	Tony	Blair	03/01/1999	Male	Bath, UK		2
1516	John	Major	03/01/1998	Male	Bradford		2
1542	Margaret	Thatcher	05/08/1997	Female	Cambridge		2

subject

subject_id	name	credit	percentage_final_exam
IT3090	Databases	3	0.7
IT4843	Data integration	3	0.7
IT4868	Web mining	2	0.6
IT2000	Introduction to ICT	2	0.5
IT3020	Discrete Mathematics	2	0.7
IT3030	Computer Architectures	3	0.7

Foreign key

Foreign key

results

student_id	subject_id	semester	midterm_score	final_score
1234	IT3090	20171	7	8
1238	IT3090	20171	9	8
1452	IT3090	20171	6	6
1234	IT2000	20162	5	8
1234	IT3020	20171	8	9
1452	IT3030	20171	7	9
1238	IT3020	20162	7	7

Primary key

Summary

- Relational data model
  - Relations, relation instance/state, relation schema
  - Database, tuple
  - Cardinality, degree

- Constraints
  - Key constraints
  - Domain constraints
  - Referential integrity constraints

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Questions