



THE RELATIONAL MODEL

Introduction to Database Systems

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IN THIS LECTURE

- Relational data integrity
- For more information
 - Connolly and Begg chapter 3
 - E.F. Codd's paper

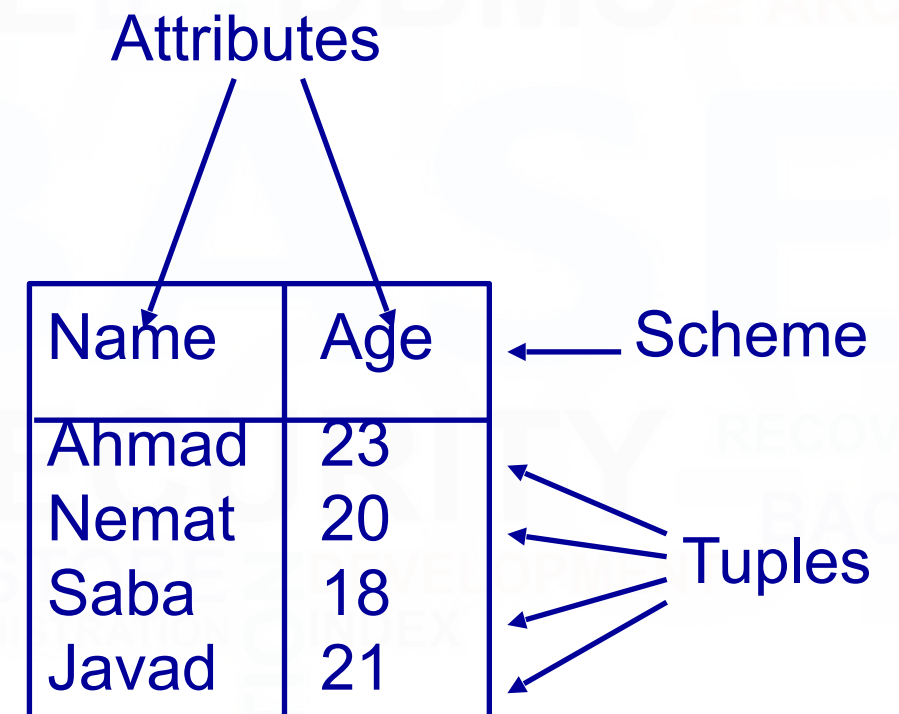
`A Relational Model of Data for Large Shared Data Banks'

THE RELATIONAL MODEL

- Introduced in E.F. Codd's 1970 paper "A Relational Model of Data for Large Shared Databanks"
- The foundation for most (but not all) current database systems
- Concerned with 3 main things
 - **Data structure** (how data is represented)
 - **Data integrity** (what data is allowed)
 - **Data manipulation** (what you can do with the data)

RELATIONAL DATA STRUCTURE

- Data is stored in **relations** (tables)
- Each relation has a **scheme** (heading)
- The scheme defines the relation's **attributes** (columns)
- Data takes the form of **tuples** (rows)



NEW THING: SCHEME (AND ATTRIBUTES)

Before...

1	2
Ahmad	23
Nemat	20
Saba	18
Javad	21

← Just numbers of columns

← Tuples

After

Attributes

Name	Age
Ahmad	23
Nemat	20
Saba	18
Javad	21

← Scheme

← Tuples

UNNAMED AND NAMED TUPLES

A tuple is
<Ahmad, 23>

A tuple is
 $\{(\text{Name}, \text{Ahmad}), (\text{Age}, 23)\}$

1	2
Ahmad	23
Nemat	20
Saba	18
Javad	21

← Just numbers of columns

← Tuples

Attributes

Name	Age
Ahmad	23
Nemat	20
Saba	18
Javad	21

← Scheme

← Tuples

NOT A BIG DIFFERENCE!

- There is no fundamental difference between **named** and **unnamed** perspectives on relations
- We could have written tuples $\langle a, b, c \rangle$ as sets of pairs $\{(1, a), (2, b), (3, c)\}$, only we know anyway in which order 1, 2, 3 go, so we can skip the numbers.
- Written as sets of pairs (partial functions), tuples can be written in any order, e.g. $\{(3, c), (2, b), (1, a)\}$.

RELATIONAL DATA STRUCTURE

- More formally -
 - A **scheme** is a set of attributes
 - A **tuple** assigns a value to each attribute in its scheme
 - A **relation** is a set of tuples with the same scheme

Name	Age
Ahmad	23
Nemat	20
Saba	18
Javad	21

{ { (Name, Ahmad), (Age, 23) },
{ (Name, Nemat), (Age, 20) },
{ (Name, Saba), (Age, 18) },
{ (Name, Javad), (Age, 21) } }

RELATIONS

Scheme is {ID, Name, Salary, Department}

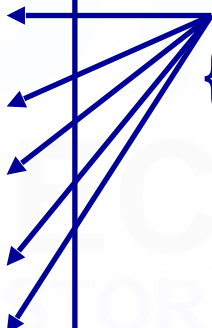
Attributes are ID, Name, Salary, and Department

Degree is 4



ID	Name	Salary	Department
M139	Ahmad Tanha	18,000	Marketing
M140	Nemat Ahmadi	22,000	Marketing
A368	Javad Azad	22,000	Accounts
P222	Saba Azad	24,000	Personnel
A367	David Ahmadi	20,000	Accounts

Tuples, e.g.
{ (ID, A368),
(Name, Javad Azad),
(Salary, 22,000),
(Department, Accounts) }



Cardinality is 5

RELATIONAL DATA INTEGRITY

- Data integrity controls what data can be in a relation
 - **Domains** restrict the possible values a tuple can assign to each attribute
 - **Candidate** and **Primary Keys** identify tuples within a relation
 - **Foreign Keys** link relations to each other

ATTRIBUTES AND DOMAINS

- A **domain** is given for each attribute
 - The domain lists the **possible values** for that attribute
 - Each tuple **assigns a value** to each attribute from its domain
- Examples
 - An 'age' might have to come from the set of integers between 0 and 150
 - A 'department' might come from a given list of strings
 - A 'notes' field might allow any string at all

CANDIDATE KEYS

- A set of attributes in a relation is called a candidate key if, and only if,
 - Every tuple has a **unique value** for the set of attributes (**uniqueness**)
 - No proper subset of the set has the uniqueness property (**minimality**)

ID	First	Last
S139	Ahmad	Tanha
S140	Nemat	Ahmadi
S141	Ahmad	Azad
S142	Javad	Tanha

Candidate key: {ID}; {First, Last} looks plausible but we may get people with the same name

{ID, First}, {ID, Last} and {ID, First, Last} satisfy uniqueness, but are **not minimal**

{First} and {Last} do not give a unique identifier for each row

CHOOSING CANDIDATE KEYS

- **Important:** don't look just on the data in the table to determine what is a candidate key
- The table may contain just one tuple, so anything would be true!
- Use knowledge of the real world – what is going to stay unique!

PRIMARY KEYS

- One Candidate Key is usually chosen to be used to identify tuples in a relation
- This is called the *Primary Key*
- Often a special ID attribute is used as the Primary Key

NULLS AND PRIMARY KEYS

- Missing information can be represented using NULLs

- A NULL indicates a **missing** or **unknown** value

- More on this later...

- **Entity Integrity:**

- Primary Keys cannot contain NULL values

FOREIGN KEYS

- ***Foreign Keys*** are used to link data in two relations. A set of attributes in the first (*referencing*) relation is a Foreign Key if its value always either
 - Matches a Candidate Key value in the second (*referenced*) relation, or
 - Is wholly NULL
- This is called **Referential Integrity**

FOREIGN KEYS - EXAMPLE

Department

DID	DName
13	Marketing
14	Accounts
15	Personnel

{DID} is a Candidate Key for Department - Each entry has a unique value for DID

Employee

EID	EName	DID
15	Ahmad Tanha	13
16	Nemat Azad	14
17	Saba Ahmadi	13
18	Javad Tanha	NULL

{DID} is a Foreign Key in Employee - each Employee's DID value is either NULL, or matches an entry in the Department relation. This links each Employee to (at most) one Department

FOREIGN KEYS - EXAMPLE

Employee

ID	Name	Manager
E1496	Ahmad Tanha	E1499
E1497	Nemat Azad	E1498
E1498	Saba Ahmadi	E1499
E1499	Javad Tanha	NULL

{ID} is a Candidate Key for Employee, and {Manager} is a Foreign Key, which refers to the same relation - every tuple's Manager value is either NULL or matches an ID value

REFERENTIAL INTEGRITY

- When relations are updated, referential integrity can be violated
- This usually occurs when a referenced tuple is updated or deleted
- There are a number of options:
 - **RESTRICT** - stop the user from doing it
 - **CASCADE** - let the changes flow on
 - **NULLIFY** - make values NULL

REFERENTIAL INTEGRITY - EXAMPLE

- What happens if
 - Marketing's DID is changed to 16 in Department?
 - The entry for Accounts is deleted from Department?

Department

DID	DName
13	Marketing
14	Accounts
15	Personnel

Employee

EID	EName	DID
15	Ahmad Tanha	13
16	Nemat Azad	14
17	Saba Ahmadi	13
18	Javad Tanha	NULL

RESTRICT

- **RESTRICT** stops any action that violates integrity
 - You cannot update or delete Marketing or Accounts
 - You *can* change Personnel as it is not referenced

Department

DID	DName
13	Marketing
14	Accounts
15	Personnel

Employee

EID	EName	DID
15	Ahmad Tanha	13
16	Nemat Azad	14
17	Saba Ahmadi	13
18	Javad Tanha	NULL

CASCADE

- **CASCADE** allows the changes made to flow through
 - If Marketing's DID is changed to 16 in Department, then the DIDs for Ahmad Tanha and Saba Ahmadi also change
 - If Accounts is deleted then so is Nemat Azad

Department

DID	DName
13 16	Marketing
14	Accounts
15	Personnel

Employee

EID	ENAME	DID
15	Ahmad Tanha	13 16
16	Nemat Azad	14
17	Saba Ahmadi	13 16
18	Javad Tanha	NULL

NULLIFY

- **NULLIFY** sets problem values to NULL
 - If Marketing's DID changes then Ahmad Tanha's and Saba Ahmadi' DID's are set to NULL
 - If Accounts is deleted, Nemat Azad's DID becomes NULL

Department

DID	DName
13 16	Marketing
14	Accounts
15	Personnel

Employee

EID	EName	DID
15	Ahmad Tanha	13 NULL
16	Nemat Azad	14 NULL
17	Saba Ahmadi	13 NULL
18	Javad Tanha	NULL

NAMING CONVENTIONS

➤ Naming conventions

- A consistent naming convention can help to remind you of the structure
- Assign each table a unique prefix, so a student name may be stuName, and a module name modName

➤ Naming keys

- Having a unique number as the Primary key can be useful
- If the table prefix is abc, call this **abcID**
- A foreign key to this table is then also called **abcID**

END

But take a look at next slide!

NEXT LECTURE

- Entity/Relationship models
 - Entities and Attributes
 - Relationships and Cardinality Ratios
 - E/R Diagrams
- For more information
 - Connolly and Begg chapter 11.
 - Ullman and Widom chapter 2.