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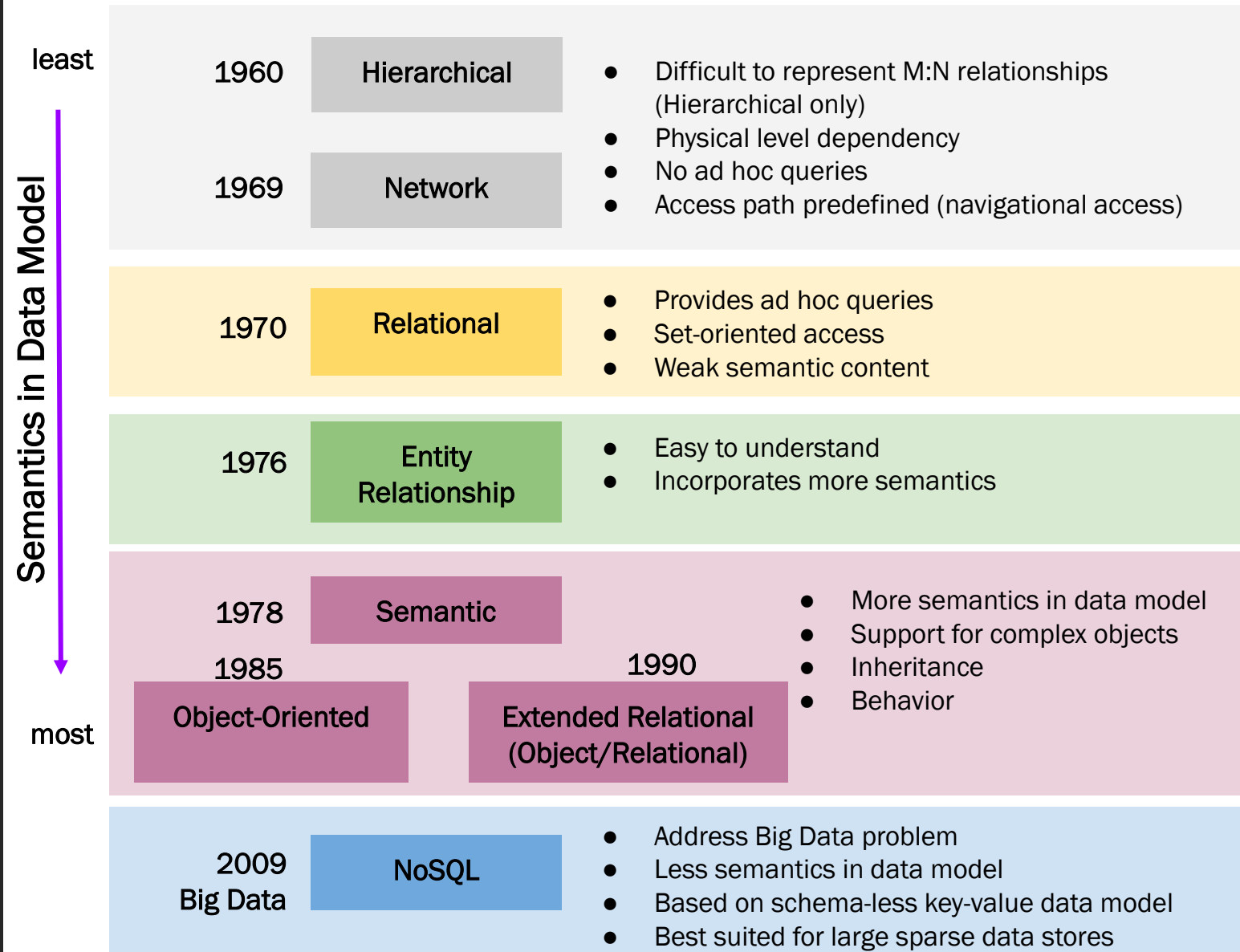
DATA MODELING AND MANAGEMENT

UNIT 1-1: RELATIONAL MODEL CONCEPTS

CHUTIPORN ANUTARIYA (CHUTI AT AIT DOT AC DOT TH)

Co-funded by the
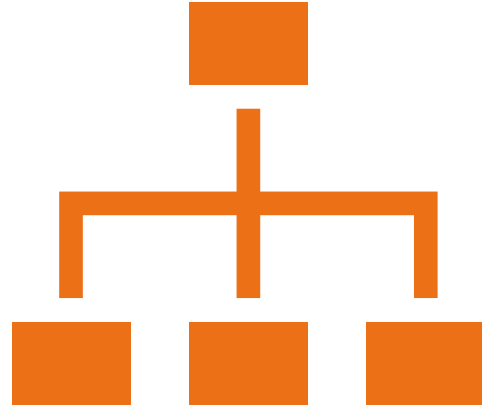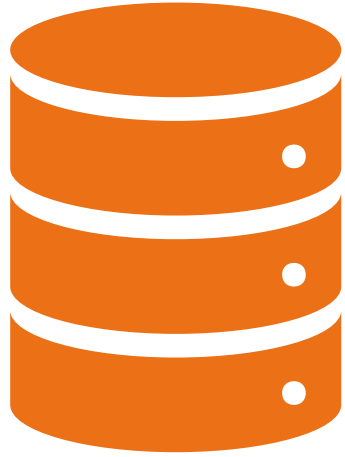Erasmus+ Programme
of the European Union

DS&AI

Evolution of data models

Semantics in Data Model

least

most

Year	Model	Characteristics
1960	Hierarchical	• Difficult to represent M:N relationships (Hierarchical only) • Physical level dependency • No ad hoc queries • Access path predefined (navigational access)
1969	Network	
1970	Relational	• Provides ad hoc queries • Set-oriented access • Weak semantic content
1976	Entity Relationship	• Easy to understand • Incorporates more semantics
1978	Semantic	• More semantics in data model • Support for complex objects • Inheritance • Behavior
1985	Object-Oriented	
1990	Extended Relational (Object/Relational)	
2009 Big Data	NoSQL	• Address Big Data problem • Less semantics in data model • Based on schema-less key-value data model • Best suited for large sparse data stores

RELATIONAL MODEL STRUCTURE

The Relational Data Model

Relational model

- First commercial implementations available in early 1980s
- Has been implemented in a large number of commercial system
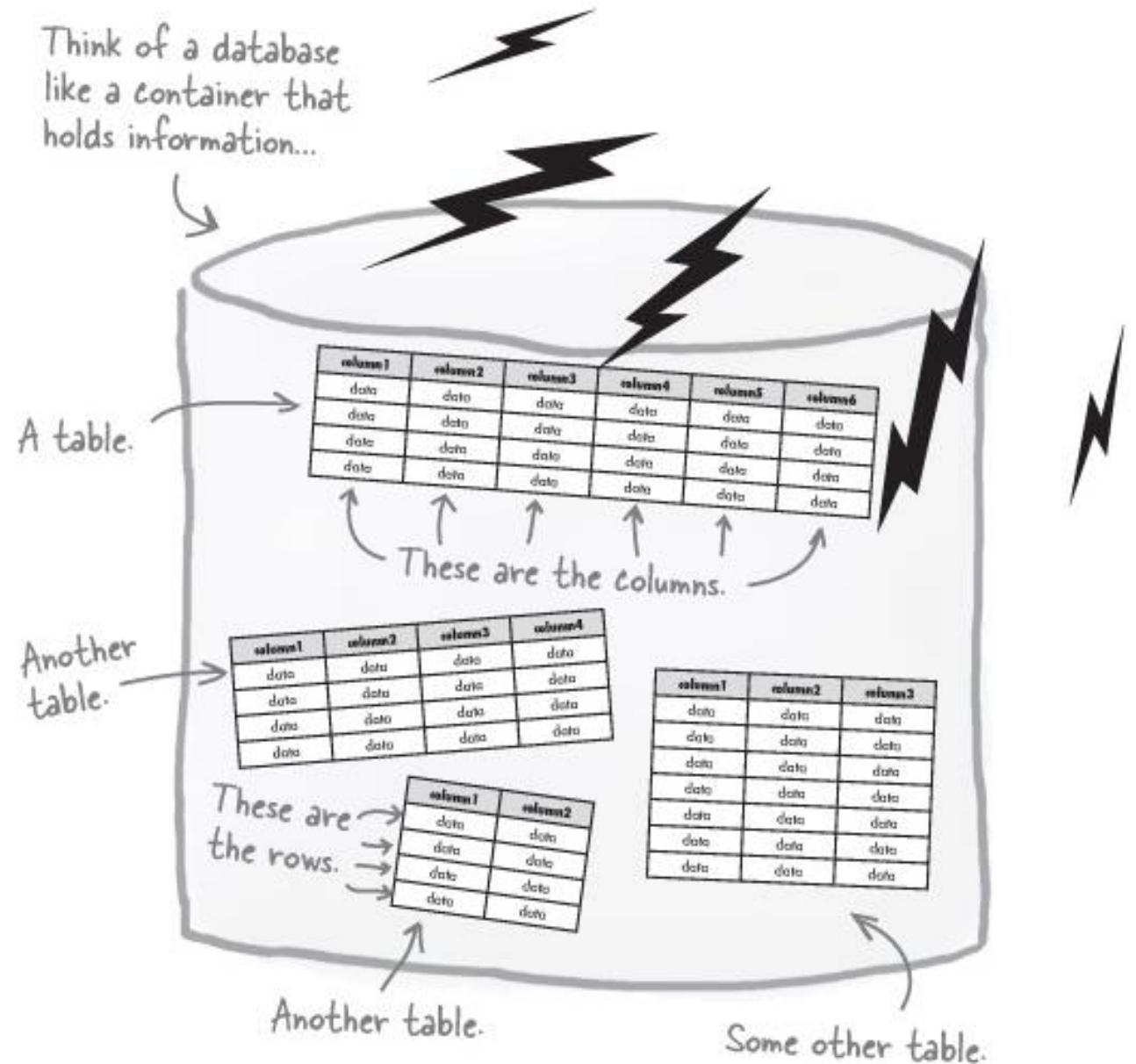
Hierarchical and network models
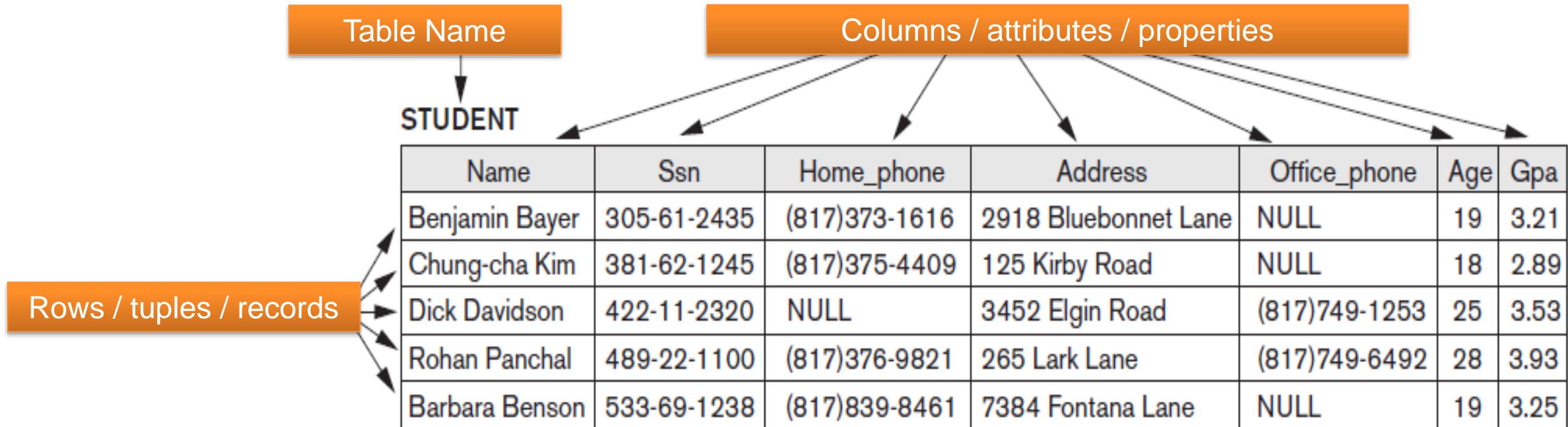
- Preceded the relational model

Anatomy of a Database

Database = collection of tables

The information inside the database is organized into tables.

Think of a database like a container that holds information...

A table.

These are the columns.

Another table.

These are the rows.

Another table.

Some other table.

Relational Model Concepts

Table Name

Columns / attributes / properties

Rows / tuples / records

STUDENT

Name	Ssn	Home_phone	Address	Office_phone	Age	Gpa
Benjamin Bayer	305-61-2435	(817)373-1616	2918 Bluebonnet Lane	NULL	19	3.21
Chung-cha Kim	381-62-1245	(817)375-4409	125 Kirby Road	NULL	18	2.89
Dick Davidson	422-11-2320	NULL	3452 Elgin Road	(817)749-1253	25	3.53
Rohan Panchal	489-22-1100	(817)376-9821	265 Lark Lane	(817)749-6492	28	3.93
Barbara Benson	533-69-1238	(817)839-8461	7384 Fontana Lane	NULL	19	3.25

Relation Schema

Relation schema R

  ◦ Denoted by R(A1, A2, ...,An)

  ◦ Made up of a relation name R and a list of attributes, A1, A2, ..., An

Attribute Ai

  ◦ Name of a role played by some domain D in the relation schema R

Example: Relation Schema STUDENT

A relation which stores information about university students, would contain seven attributes describing each student:

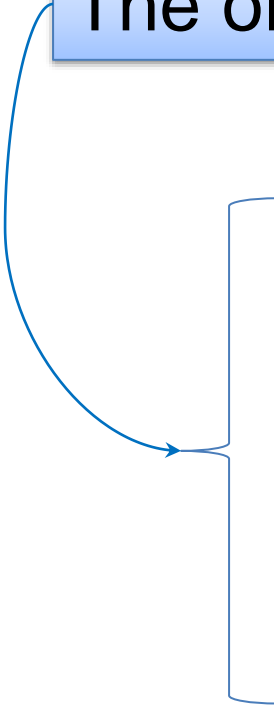- STUDENT(Name, Ssn, Home_phone, Address, Office_phone, Age, Gpa)

or (with the data type of each attribute specified)

- STUDENT(Name: string, Ssn: string, Home_phone: string, Address: string, Office_phone: string, Age: integer, Gpa: real)

Characteristics of Tables: Order of rows

The order of rows in a table is not important.

STUDENT

Name	Ssn	Home_phone	Address	Office_phone	Age	Gpa
Dick Davidson	422-11-2320	NULL	3452 Elgin Road	(817)749-1253	25	3.53
Barbara Benson	533-69-1238	(817)839-8461	7384 Fontana Lane	NULL	19	3.25
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Benjamin Bayer	305-61-2435	(817)373-1616	2918 Bluebonnet Lane	NULL	19	3.21

Characteristics of Tables: Values

Each value in a row is atomic

Flat relational model

- Composite and multivalued attributes not allowed
- First normal form assumption

Multivalued attributes

- Must be represented by separate relations

Composite attributes

- Represented only by simple component attributes in basic relational model

Characteristics of Tables: NULL values

Represent the values of attributes that may be unknown or may not apply to a row

Meanings for NULL values

- *Value unknown*
- *Value exists but is not available*
- *Attribute does not apply to this tuple (aka. value undefined)*

Characteristics of Tables: Meaning

Interpretation (meaning) of a table

- Each row in the table is a **fact** or a particular instance of the assertion

RELATIONAL MODEL CONSTRAINTS

Relational Model Constraints

Constraints

- Restrictions on the actual values in a database state
- Derived from the rules in the application that the database represents

Relational Model Constraint Categories

Inherent model-based constraints or implicit constraints

- Inherent in the data model
- The characteristics of relations discussed earlier belong to this category
- Ex: The constraint that a relation cannot have duplicate tuples

Schema-based constraints or explicit constraints

- Can be directly expressed in schemas of the data model
- Ex: Domain constraints, Key constraints, NULL value constraints, etc. (to be discussed next)

Application-based or semantic constraints or business rules

- Cannot be directly expressed in schemas
- Expressed and enforced by application program

Domain and Data Type Constraints

Domain constraints

- Specify that within each row, the value of each column A must be an atomic value from the domain dom(A), such as:
  - Numeric data types for integers and real numbers
  - Characters
  - Booleans
  - Fixed-length strings
  - Variable-length strings
  - Date, time, timestamp
  - Money
  - Other special data types

Key Constraints

Two distinct rows in a table cannot have identical values for (all) attributes in key

CAR

License_number	Engine_serial_number	Make	Model	Year
Texas ABC-739	A69352	Ford	Mustang	02
Florida TVP-347	B43696	Oldsmobile	Cutlass	05
New York MPO-22	X83554	Oldsmobile	Delta	01
California 432-TFY	C43742	Mercedes	190-D	99
California RSK-629	Y82935	Toyota	Camry	04
Texas RSK-629	U028365	Jaguar	XJS	04

Figure 3.4
The CAR relation, with two candidate keys: License_number and Engine_serial_number.

Key Constraints (cont'd.)

Candidate key

- Relation schema may have more than one key

Primary key of the relation

- Designated among candidate keys
- Underline attribute

Other candidate keys are designated as unique keys

Primary Key Constraints

The primary key is used to uniquely identify each record

Which means that the data in the primary key column can't be repeated.

Consider a table with the columns shown below. Do you think any of those would make good primary keys?

SSN	last_name	first_name	phone_number

NULL Value Constraint

A NULL value constraint specifies whether NULL values are or are not permitted.

Example

- If every STUDENT row must have a valid, not-NULL value for the Name attribute, then Name of STUDENT is constrained to be NOT NULL.

Referential Integrity / Foreign Key Constraint

Referential integrity (or Foreign Key) constraint

- Connecting two tables
- Specified between two tables
- Maintains consistency among rows in two tables
- The FOREIGN KEY (FK) is a column in a table that references the PRIMARY KEY of another table.

Example

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno

Foreign Key

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date

Primary Key

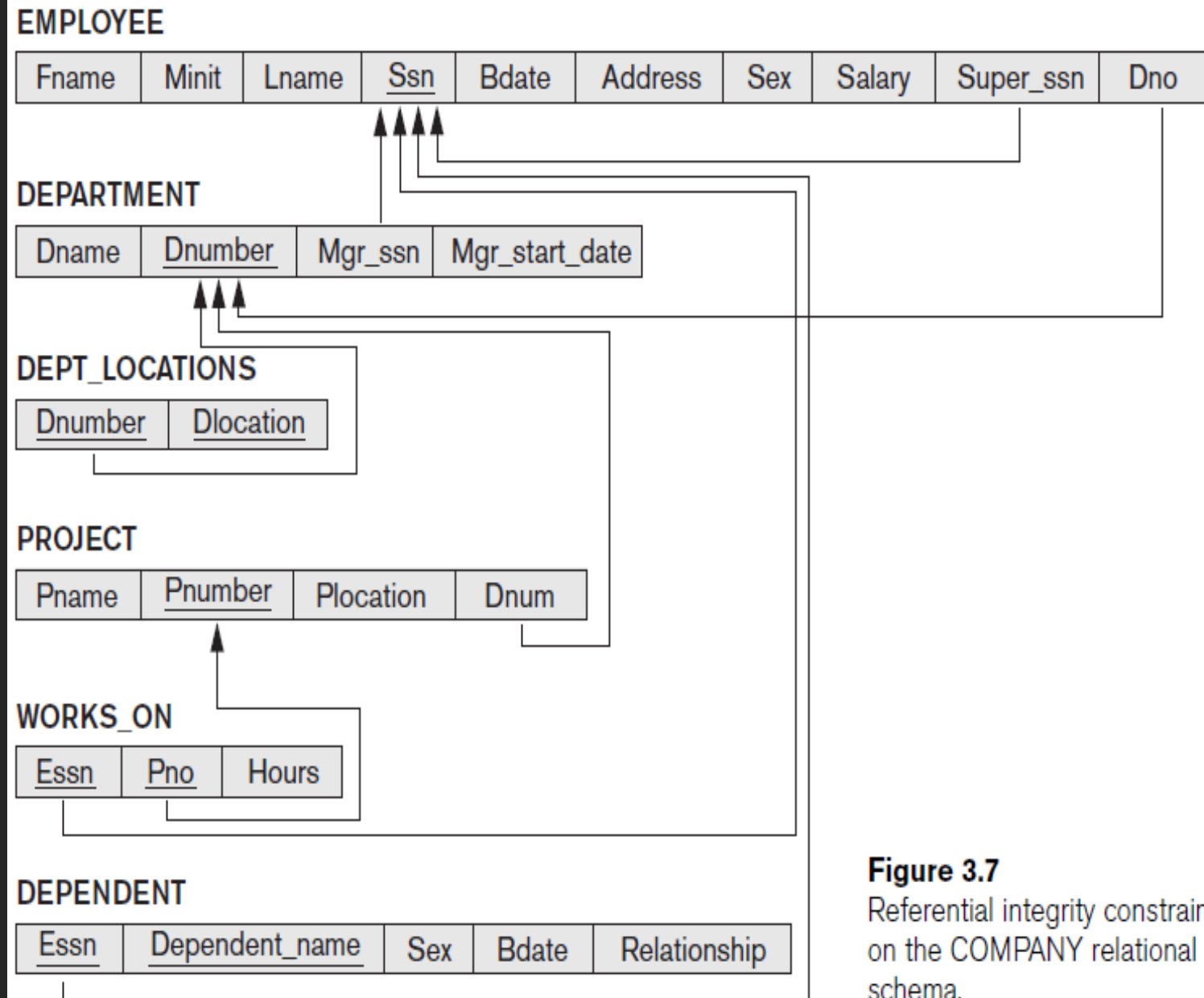# Example: Referential Integrity & Foreign Key Constraints

Figure 3.7
Referential integrity constraints displayed on the COMPANY relational database schema.

Operations of Relational Models

RETRIEVAL AND UPDATE OPERATIONS

Update Operations

Operations of the relational model can be categorized into retrievals and updates

Basic operations that change the states of relations in the database:

- Insert
- Delete
- Update (or Modify)

The Insert Operation

Provides a list of attribute values for a new row to be inserted into a table

Can violate any of the constraints discussed earlier

If an insertion violates one or more constraints

Default option is to reject the insertion

The Delete Operation

Can violate only referential integrity

If the row being deleted is referenced by foreign keys from other row

- **Restrict**
  - Reject the deletion
- **Cascade**
  - Propagate the deletion by deleting rows that reference the row that is being deleted
- **Set null** or **set default**
  - Modify the referencing attribute values that cause the violation

The Update Operation

Necessary to specify a condition on attributes of relation

- Select the row (or rows) to be modified

If attribute not part of a primary key nor of a foreign key

- Usually causes no problems
- Only need to check that the new values is of the correct data type and domain

Updating a primary/foreign key

- Similar issues as with Insert/Delete

SUMMARY

Summary: Relational Model Concepts

Data Structure

Related Tables

Constraints

Inherent model-based constraints

Explicit schema-based constraints

Application-based constraints

Operations

Retrieval

Insert

Delete

Update

Thank you.

Discuss 3 important things / concepts we have learned today.

References

R. Elmasri and S. Navathe: Fundamentals of Database Systems, 7/E, Addison-Wesley, 2015