Database Design and Practice 1
Lecture 04

The Relational Model

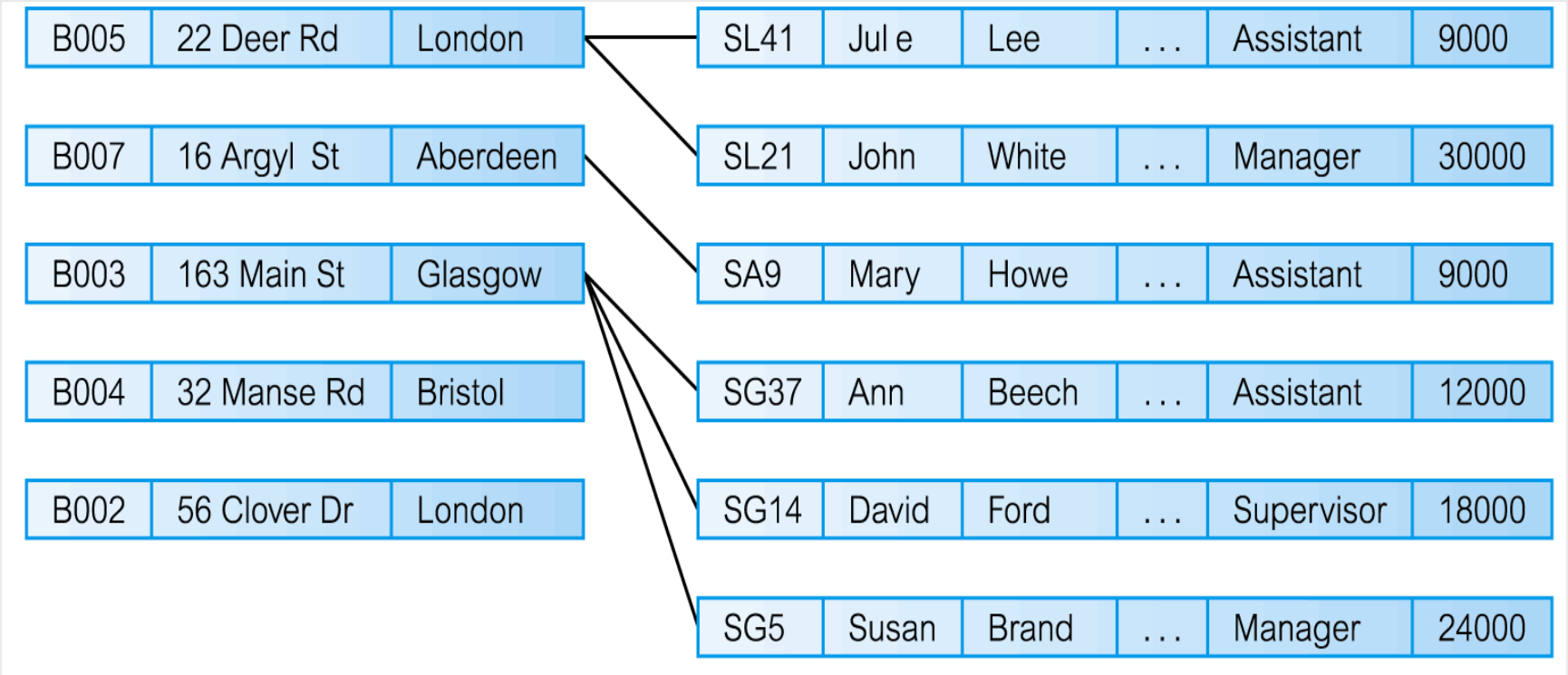
Lecture 04 - Objectives

- Classification of data models
- Terminology of relational model.
- How tables are used to represent data.
- Connection between mathematical relations and relations in the relational model.
- Properties of database relations.
- How to identify CK, PK, and FKs.
- Meaning of entity integrity and referential integrity.
- Purpose and advantages of views.

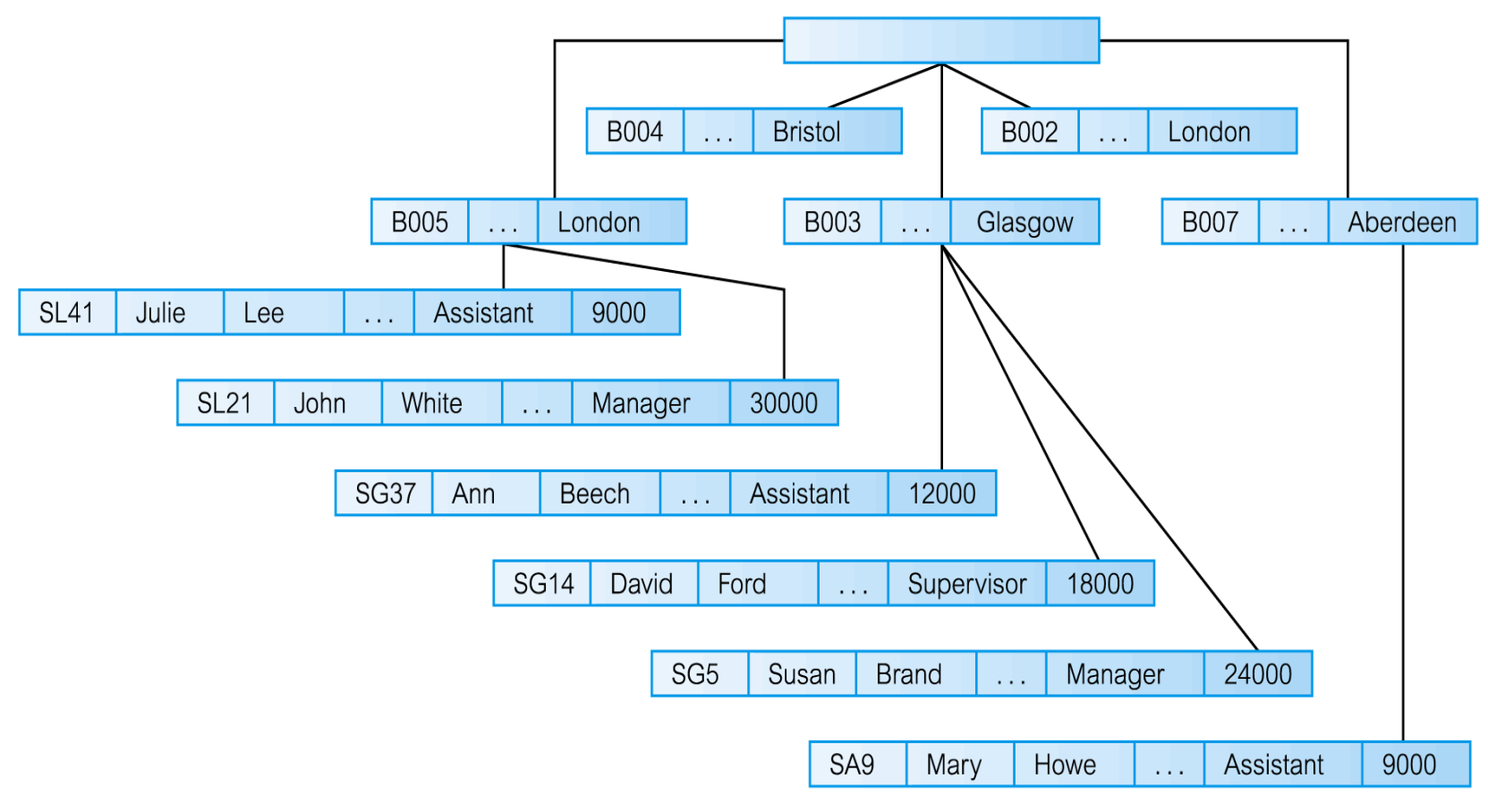
Classification of Data Models

- Categories of data models include:
  - Object-based
  - Record-based
    - » Relational Data Model
    - » Network Data Model
    - » Hierarchical Data Model.
  - Physical.

Network Data Model



Hierarchical Data Model



Relational Data Model

Branch

branchNo	street	city	postCode
B005	22 Deer Rd	London	SW1 4EH
B007	16 Argyll St	Aberdeen	AB2 3SU
B003	163 Main St	Glasgow	G11 9QX
B004	32 Manse Rd	Bristol	BS99 1NZ
B002	56 Clover Dr	London	NW10 6EU

Staff

staffNo	fName	lName	position	sex	DOB	salary	branchNo
SL21	John	White	Manager	M	1-Oct-45	30000	B005
SG37	Ann	Beech	Assistant	F	10-Nov-60	12000	B003
SG14	David	Ford	Supervisor	M	24-Mar-58	18000	B003
SA9	Mary	Howe	Assistant	F	19-Feb-70	9000	B007
SG5	Susan	Brand	Manager	F	3-Jun-40	24000	B003
SL41	Julie	Lee	Assistant	F	13-Jun-65	9000	B005

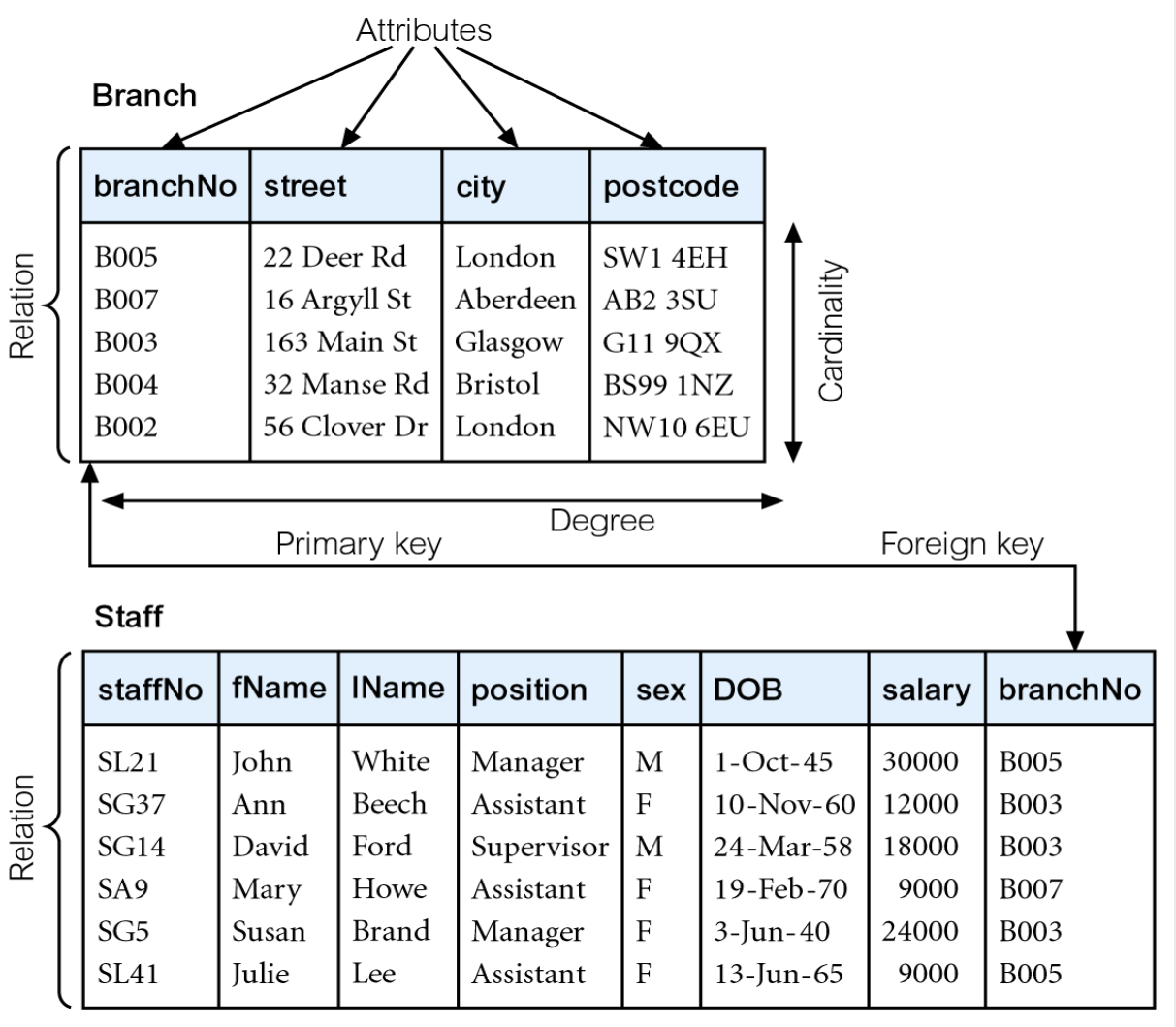
Relational Model Terminology

- A relation is a table with columns and rows.
  - Only applies to logical structure of the database, not the physical structure.
- Attribute is a named column of a relation.
- Domain is the set of allowable values for one or more attributes.

Relational Model Terminology

- **Tuple is a row of a relation.**
- **Degree is the number of attributes in a relation.**
- **Cardinality is the number of tuples in a relation.**
- **Relational Database is a collection of normalized relations with distinct relation names.**

Instances of Branch and Staff Relations



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Examples of Attribute Domains

Attribute	Domain Name	Meaning	Domain Definition
branchNo	BranchNumbers	The set of all possible branch numbers	character: size 4, range B001–B999
street	StreetNames	The set of all street names in Britain	character: size 25
city	CityNames	The set of all city names in Britain	character: size 15
postcode	Postcodes	The set of all postcodes in Britain	character: size 8
sex	Sex	The sex of a person	character: size 1, value M or F
DOB	DatesOfBirth	Possible values of staff birth dates	date, range from 1-Jan-20, format dd-mmm-yy
salary	Salaries	Possible values of staff salaries	monetary: 7 digits, range 6000.00–40000.00

Alternative Terminology for Relational Model

Formal terms	Alternative 1	Alternative 2
Relation	Table	File
Tuple	Row	Record
Attribute	Column	Field

Mathematical Definition of Relation

- Consider two sets, D_1 & D_2, where $D_1 = \{2, 4\}$ and $D_2 = \{1, 3, 5\}$.
- Cartesian product, $D_1 \times D_2$, is set of all ordered pairs, where first element is member of D_1 and second element is member of D_2.

$$D_1 \times D_2 = \{(2, 1), (2, 3), (2, 5), (4, 1), (4, 3), (4, 5)\}$$

- Alternative way is to find all combinations of elements with first from D_1 and second from D_2.

Mathematical Definition of Relation

- Any subset of Cartesian product is a relation; e.g.

  $R = \{(2, 1), (4, 1)\}$

- May specify which pairs are in relation using some condition for selection; e.g.
  - second element is 1:

    $R = \{(x, y) \mid x \in D_1, y \in D_2, \text{ and } y = 1\}$

  - first element is always twice the second:

    $S = \{(x, y) \mid x \in D_1, y \in D_2, \text{ and } x = 2y\}$

Mathematical Definition of Relation

- Consider three sets D_1, D_2, D_3 with Cartesian Product $D_1 \times D_2 \times D_3$; e.g.

$D_1 = \{1, 3\}$ $D_2 = \{2, 4\}$ $D_3 = \{5, 6\}$

$D_1 \times D_2 \times D_3 = \{(1,2,5), (1,2,6), (1,4,5), (1,4,6), (3,2,5), (3,2,6), (3,4,5), (3,4,6)\}$

- Any subset of these ordered triples is a relation.

Mathematical Definition of Relation

- Cartesian product of n sets ($D_1, D_2, \ldots, D_n$) is:

$$D_1 \times D_2 \times \ldots \times D_n = \{(d_1, d_2, \ldots, d_n) \mid d_1 \in D_1, d_2 \in D_2, \ldots, d_n \in D_n\}$$

usually written as:

$$\mathop{\mathrm{X}}_{i=1}^{n} D_i$$

- Any set of n-tuples from this Cartesian product is a relation on the n sets.

Database Relations

- **Relation schema**
  - **Named relation defined by a set of attribute and domain name pairs.**
- **Relational database schema**
  - **Set of relation schemas, each with a distinct name.**

Properties of Relations

- Relation name is distinct from all other relation names in relational schema.
- Each cell of relation contains exactly one atomic (single) value.
- Each attribute has a distinct name.
- Values of an attribute are all from the same domain.

Properties of Relations

- Each tuple is distinct; there are no duplicate tuples.
- Order of attributes has no significance.
- Order of tuples has no significance, theoretically.

Relational Keys

- **Superkey**
  - An attribute, or set of attributes, that uniquely identifies a tuple within a relation.

- **Candidate Key**
  - Superkey (K) such that no proper subset is a superkey within the relation.
  - In each tuple of R, values of K uniquely identify that tuple (uniqueness).
  - No proper subset of K has the uniqueness property (irreducibility).

Relational Keys

- **Primary Key**
  - Candidate key selected to identify tuples uniquely within relation.
- **Alternate Keys**
  - Candidate keys that are not selected to be primary key.
- **Foreign Key**
  - Attribute, or set of attributes, within one relation that matches candidate key of some (possibly same) relation.

Integrity Constraints

- **Null**
  - **Represents value for an attribute that is currently unknown or not applicable for tuple.**
  - **Deals with incomplete or exceptional data.**
  - **Represents the absence of a value and is not the same as zero or spaces, which are values.**

Integrity Constraints

- **Entity Integrity**
  - **In a base relation, no attribute of a primary key can be null.**

- **Referential Integrity**
  - **If foreign key exists in a relation, either foreign key value must match a candidate key value of some tuple in its home relation or foreign key value must be wholly null.**

Integrity Constraints

- **General Constraints**
  - **Additional rules specified by users or database administrators that define or constrain some aspect of the enterprise.**

Views

- **Base Relation**
  - **Named relation corresponding to an entity in conceptual schema, whose tuples are physically stored in database.**

- **View**
  - **Dynamic result of one or more relational operations operating on base relations to produce another relation.**

Views

- A virtual relation that does not necessarily actually exist in the database but is produced upon request, at time of request.
- Contents of a view are defined as a query on one or more base relations.
- Views are dynamic, meaning that changes made to base relations that affect view attributes are immediately reflected in the view.

Purpose of Views

- Provides powerful and flexible security mechanism by hiding parts of database from certain users.
- Permits users to access data in a customized way, so that same data can be seen by different users in different ways, at same time.
- Can simplify complex operations on base relations.

Updating Views

- All updates to a base relation should be immediately reflected in all views that reference that base relation.

- If view is updated, underlying base relation should reflect change.

Updating Views

- There are restrictions on types of modifications that can be made through views:
  - Updates are allowed if query involves a single base relation and contains a candidate key of base relation.
  - Updates are not allowed involving multiple base relations.
  - Updates are not allowed involving aggregation or grouping operations.

Updating Views

- Classes of views are defined as:
  - theoretically not updateable;
  - theoretically updateable;
  - partially updateable.