



Prifysgol Cymru
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University of Wales
Trinity Saint David

200
1822 - 2022

Database Environment

Man Geni Addysg Uwch yng Nghymru
Where Higher Education Began in Wales

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Learning Outcomes

- Database Components
- Data Independence
- Database Languages
- Data Models
- Keys
- Integrity constraints

Database Components

Few components explained:

Data dictionary/system catalog - stores information about database objects

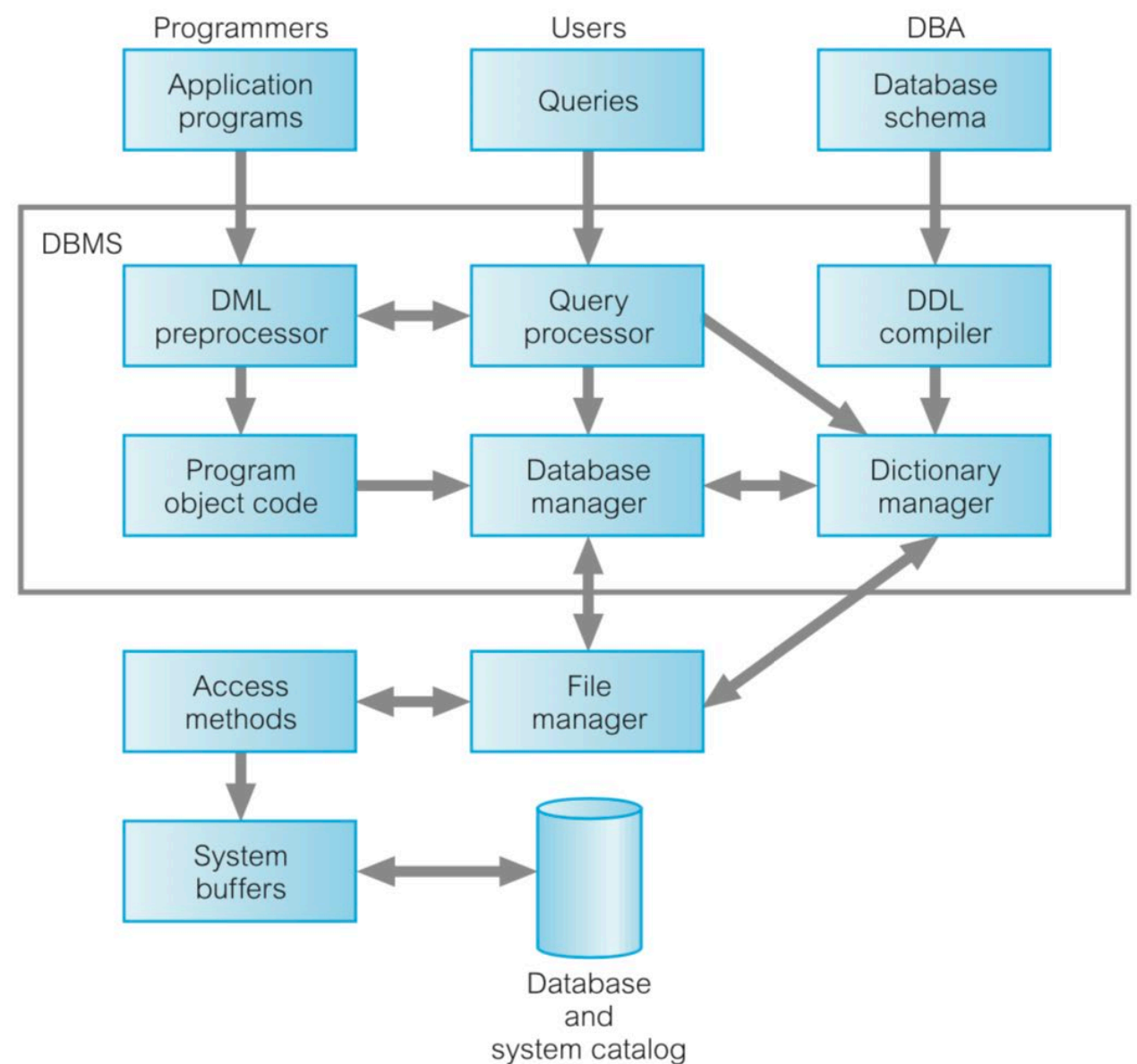
Query processor - interprets and optimises user queries

DML preprocessor - converts DML statements in apps into standard function calls. Interacts with query processor to generate code

DDL Compiler/Data Dictionary Compiler - produces the data dictionary/system catalog

Catalog Manager - manages access to and maintains system catalog

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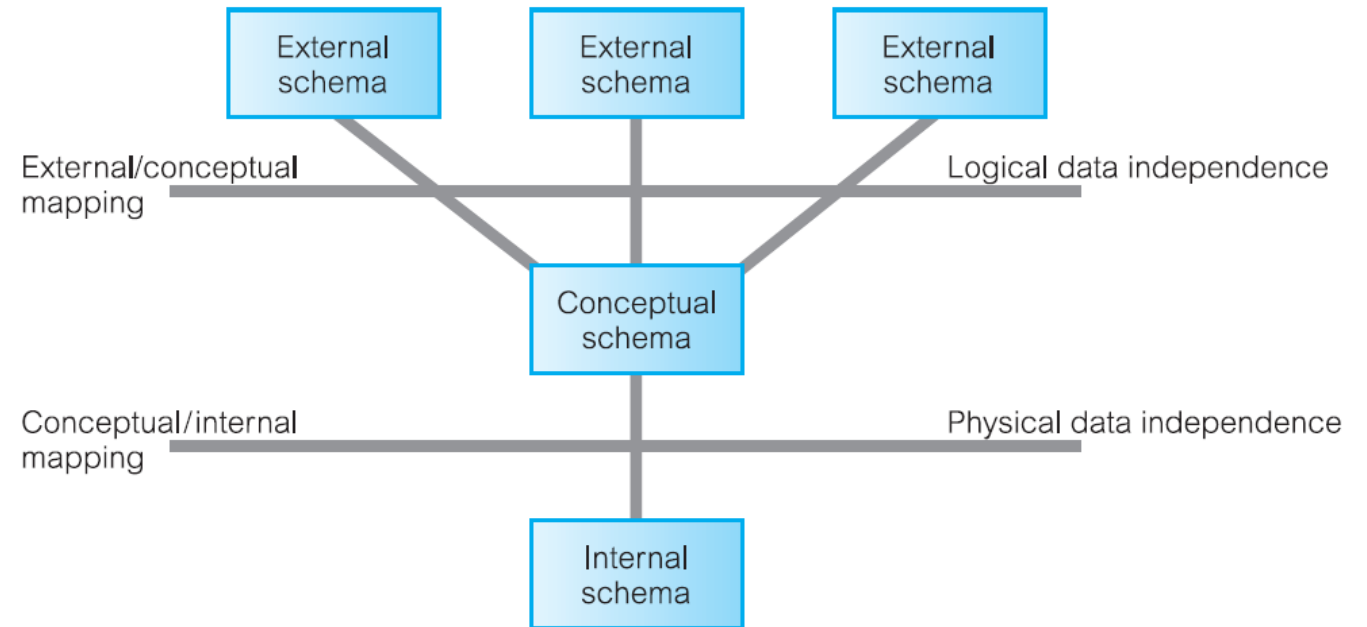
Connolly, T., & Begg, C. (2005). Database systems: a practical approach to design, implementation, and management. Boston, MA: Pearson

Review

- The description of the database is the **database schema**.
 - specified during the database design process
 - is not expected to change frequently
- Actual data in the database may change frequently;
- The data in the database at any particular point in time is called a **database instance**
 - Changes every time when details are modified.
 - many database instances can correspond to the same database schema.

Data Independence

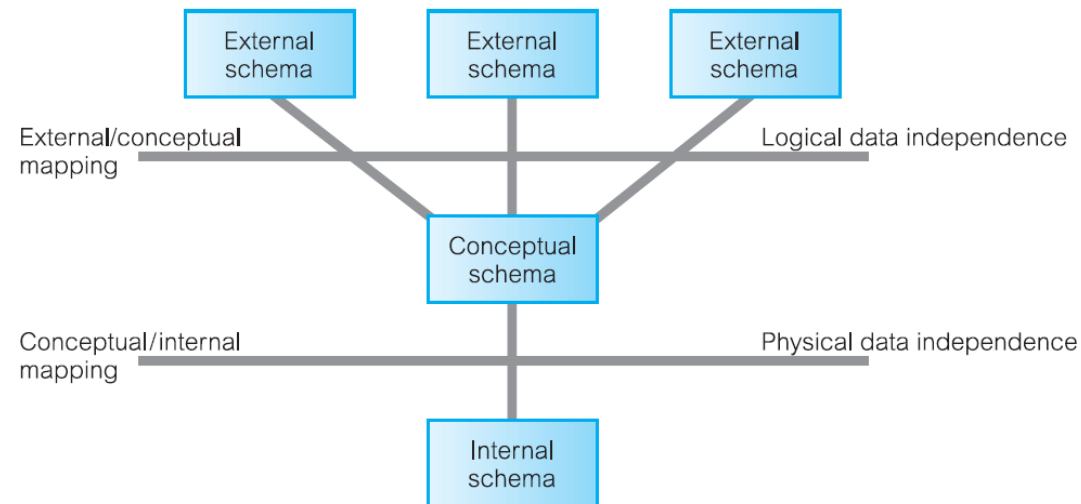
- major objective for the three-level architecture - provide data independence
- Upper levels are unaffected by changes to lower levels.
- Two kinds of data independence:
 - **logical**
 - **Physical**



Connolly, T., & Begg, C. (2005). Database systems: a practical approach to design, implementation, and management. Boston, MA: Pearson Addison-Wesley.

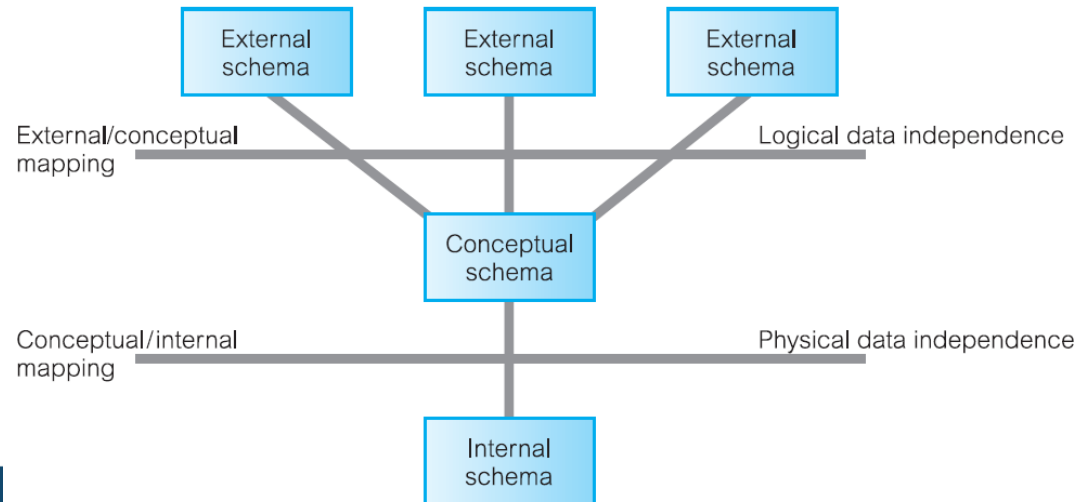
- **Logical data independence-**

- The immunity of the external schemas to changes in the conceptual schema.
- Changes to the conceptual schema, such as the addition or removal of new entities, attributes, or relationships, should be possible without having to change existing external schemas or having to rewrite application programs.



- **Physical data independence**

- The immunity of the conceptual schema to changes in the internal schema.
- Changes to the internal schema, such as using different file organizations or storage structures, using different storage devices, modifying indexes or hashing algorithms, should be possible without having to change the conceptual or external schemas



Database Languages

- A data sublanguage consists of two parts:
- Data Definition Language (DDL)
- Data Manipulation Language (DML)

The Data Definition Language (DDL)

- The database schema is specified by a set of definitions expressed by Data Definition Language
- The result of the compilation of the DDL statements is a set of tables stored in special files collectively called the **system catalog**.
- The DBMS normally consults the system catalog before the actual data is accessed in the database.

The Data Manipulation Language (DML)

- provides a set of operations to support the basic data manipulation operations on the data held in the database.
- Data manipulation operations usually include the following:
 - insertion of new data into the database;
 - modification of data stored in the database;
 - retrieval of data contained in the database;
 - deletion of data from the database.

Data Models

- An integrated collection of concepts for describing and manipulating data, relationships between data, and constraints on the data in an organization.
- They fall into three broad categories:
 - **object-based, record-based,** and **physical data models.**

describe data at the conceptual
and external levels

describe data at the internal
level.

Object-Based Data Models

Common types are:

- Entity-Relationship (ER)
- Semantic
- Functional
- Object-oriented

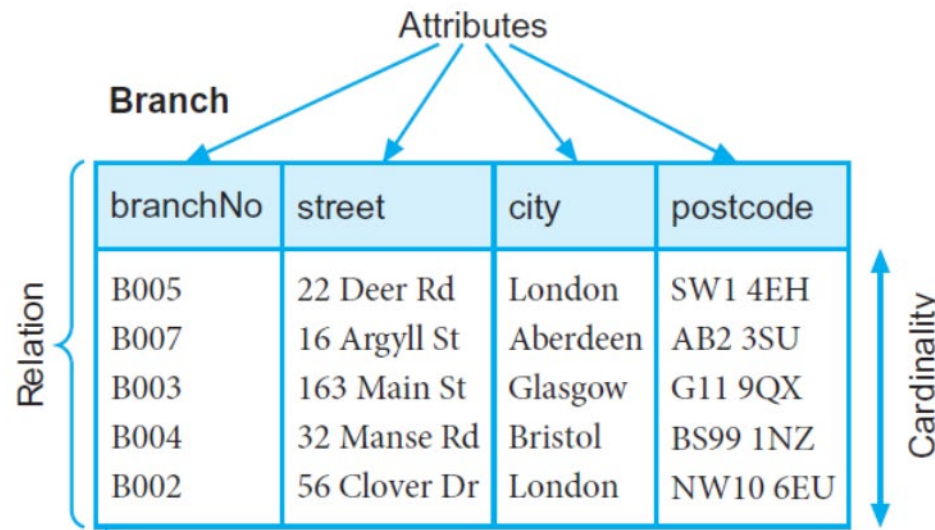
Record-Based Data Models

- Database consists of a number of fixed-format records
- Each record type defines a fixed number of fields of a fixed length.
- common types are:
- **relational data model, the network data model, and the hierarchical data model.**

links to traditional file processing concepts

Relational data model

- based on the concept of mathematical relations.
- In the relational model, data and relationships are represented as tables, each of which has a number of columns with a unique name.



Relational Model-Terminology

An RDBMS requires only that the database be perceived by the user as tables.

Relation :

- a table with columns and rows.

Attribute

- An attribute is a named column of a relation.
- Attributes can appear in any order and the relation will still be the same relation, and therefore will convey the same meaning.

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

Relationship

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

Connolly, T., & Begg, C. (2005). Database systems: a practical approach to design, implementation, and management. Boston, MA: Pearson Addison-Wesley.

sample instance of a relational schema for part of the DreamHome case study, showing branch and staff details

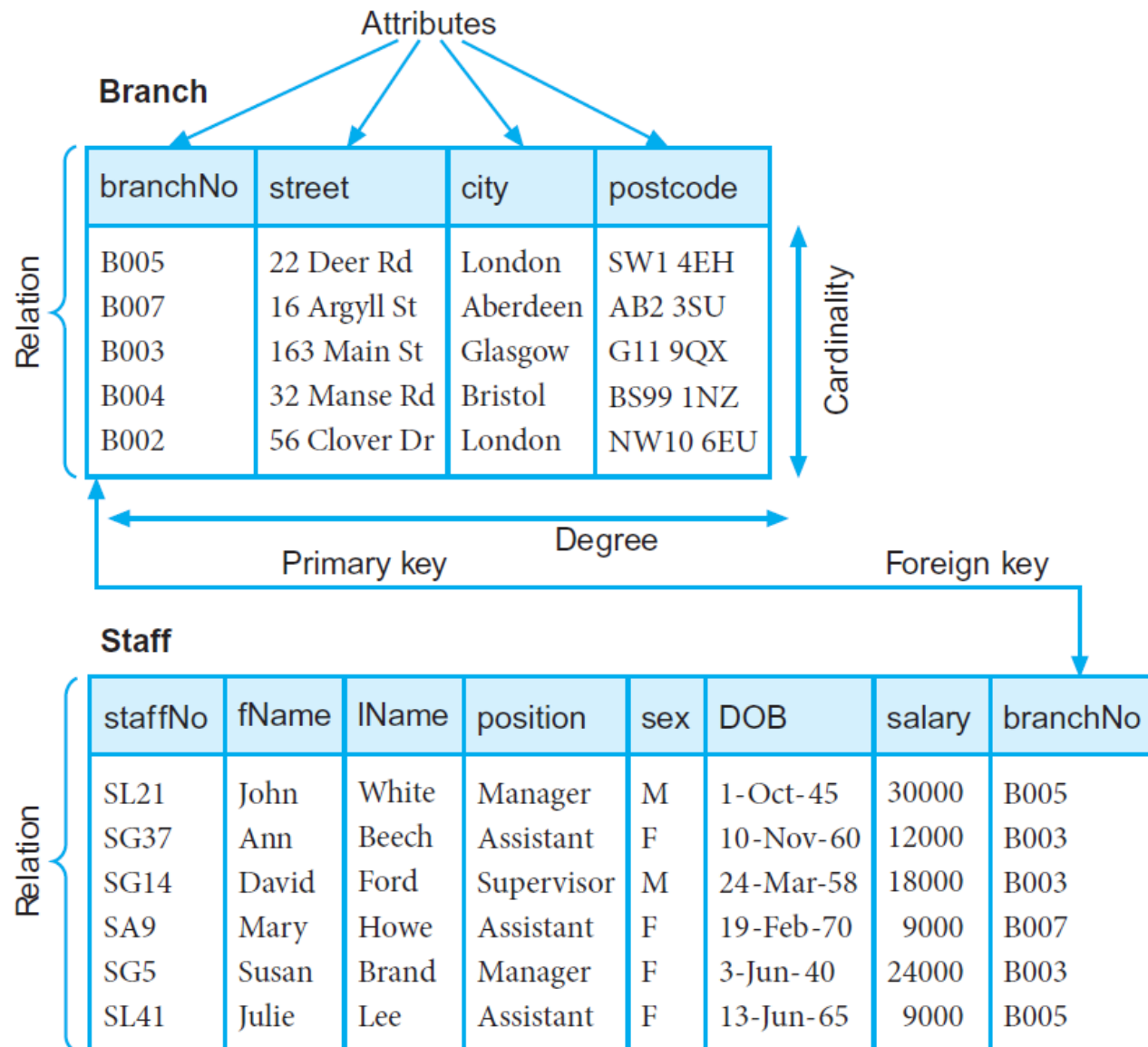
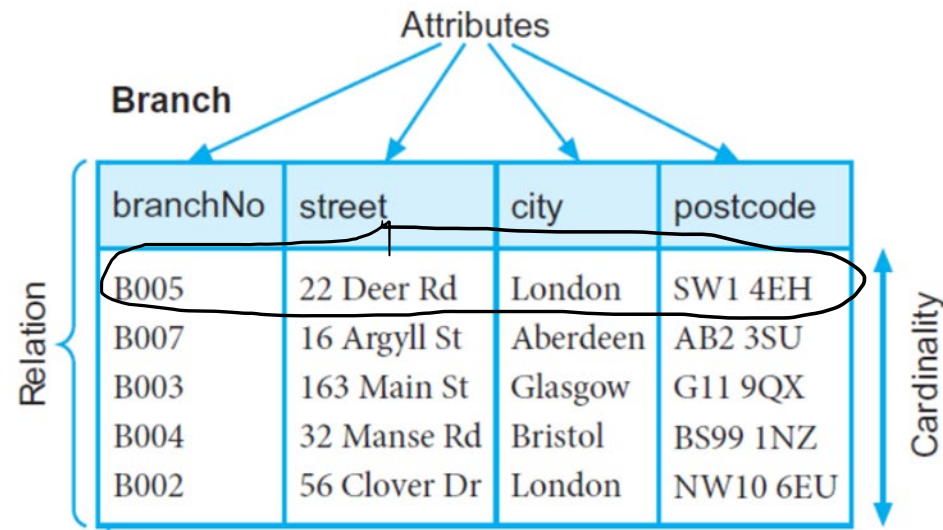


Figure 4.1
Instances of the
Branch and Staff
relations.

Connolly, T., & Begg, C. (2005). Database systems: a practical approach to design, implementation, and management. Boston, MA: Pearson Addison-Wesley.

- **Tuple**

- A tuple is a row of a relation.



- **Degree**

- The degree of a relation is the number of attributes it contains.

- **Cardinality**

- The cardinality of a relation is the number of tuples it contains.

- **Relational database**

- A collection of normalized relations with distinct relation names.
- relations that are appropriately structured(*normalization*).

Domain

- A domain is the set of allowable values for one or more attributes.

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

Figure 4.2

Domains for some attributes of the Branch and Staff relations.

Database Relations

- **Relation schema:** A named relation defined by a set of attribute and domain name pairs.
- Let $A_1, A_2, \dots, A_n$ be attributes with domains $D_1, D_2, \dots, D_n$. Then the set $\{A_1:D_1, A_2:D_2, \dots, A_n:D_n\}$ is a relation schema.
- Thus, relation R is a set of n -tuples:
- $(A_1:d_1, A_2:d_2, \dots, A_n:d_n)$ such that $d_1 \in D_1, d_2 \in D_2, \dots, d_n \in D_n$
- $\{(\text{branchNo: B005, street: 22 Deer Rd, city: London, postcode: SW1 4EH})\}$



relation instance

The diagram consists of a green oval containing the text 'relation instance'. A blue arrow points from the right side of the oval to the set notation in the fifth bullet point of the list above, specifically to the curly braces of the set $\{(\text{branchNo: B005, street: 22 Deer Rd, city: London, postcode: SW1 4EH})\}$.

Relational Keys

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

Super Key is a superset of Candidate key.

Students table

student_id	name	phone	age
1	Akon	9876723452	17
2	Akon	9991165674	19
3	Bkon	7898756543	18
4	Ckon	8987867898	19
5	Dkon	9990080080	17

- Super key can be **student_id**, (**student_id**,**name**), **phone** etc

Candidate Key

- A super key with no redundant attribute is known as candidate key
- There can be more than one candidate key.
- student_id and phone both are candidate keys for table **Student**

student_id	name	phone	age
1	Akon	9876723452	17
2	Akon	9991165674	19
3	Bkon	7898756543	18
4	Ckon	8987867898	19
5	Dkon	9990080080	17

Viewing

clientNo	propertyNo	viewDate	comment
CR56	PA14	24-May-13	too small
CR76	PG4	20-Apr-13	too remote
CR56	PG4	26-May-13	
CR62	PA14	14-May-13	no dining room
CR56	PG36	28-Apr-13	

- Viewing relation, clientNo and propertyNo together form the (composite) candidate key

Primary Key

- The primary key is a minimal super key
- there is one and only one primary key in any relationship

Primary Key for this table



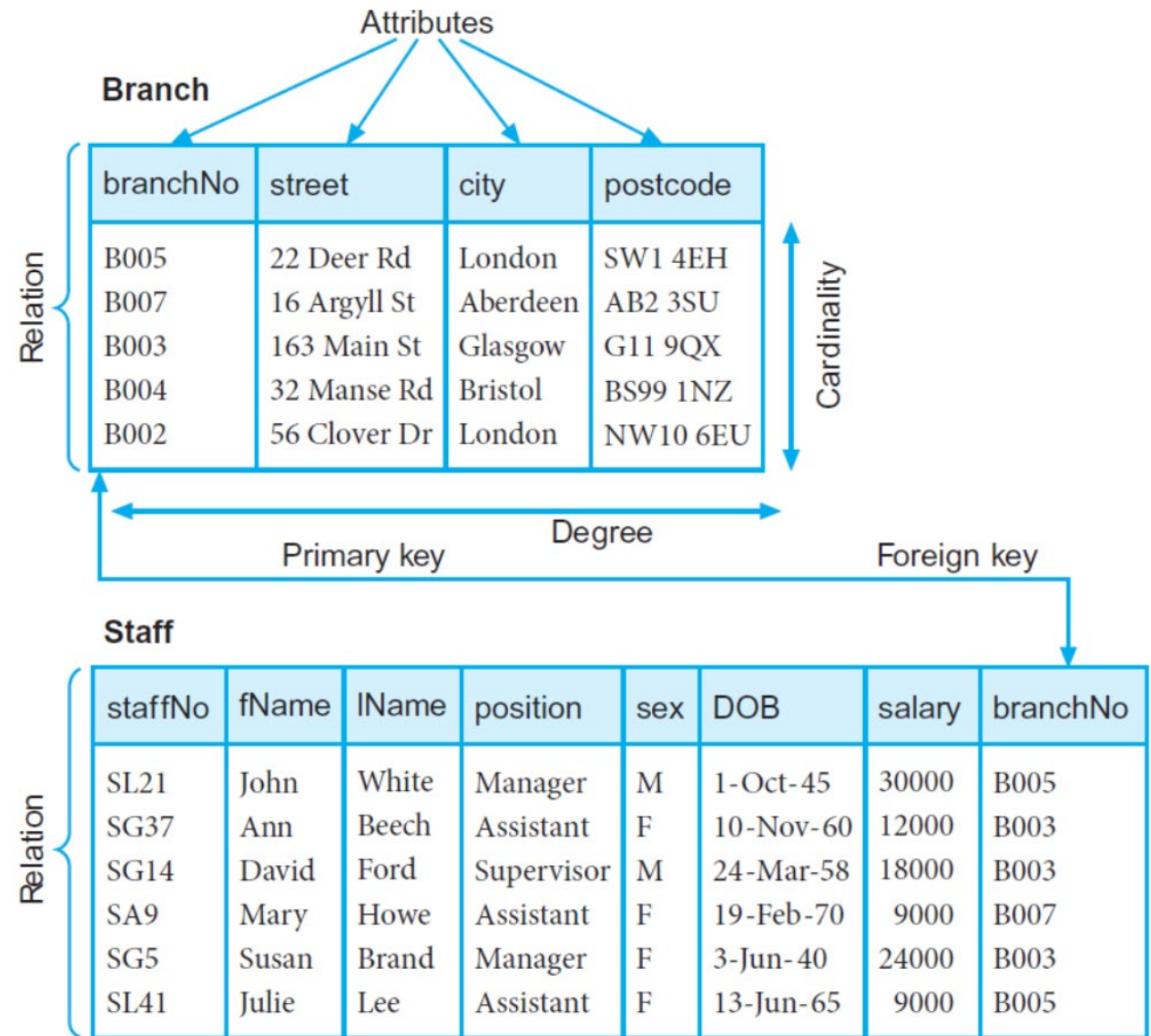
student_id	name	age	phone

Rules for defining Primary key:

- Two rows can't have the same primary key value
- It's must for every row to have a primary key value.
- The primary key field cannot be null.
- The value in a primary key column can never be modified or updated if any foreign key refers to that primary key.

- Foreign key

- An attribute, or set of attributes, within one relation that matches the candidate key of some relation.



Representing Relational Database Schemas

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
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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

PropertyForRent

propertyNo	street	city	postcode	type	rooms	rent	ownerNo	staffNo	branchNo
PA14	16 Holhead	Aberdeen	AB7 5SU	House	6	650	CO46	SA9	B007
PL94	6 Argyll St	London	NW2	Flat	4	400	CO87	SL41	B005
PG4	6 Lawrence St	Glasgow	G11 9QX	Flat	3	350	CO40		B003
PG36	2 Manor Rd	Glasgow	G32 4QX	Flat	3	375	CO93	SG37	B003
PG21	18 Dale Rd	Glasgow	G12	House	5	600	CO87	SG37	B003
PG16	5 Novar Dr	Glasgow	G12 9AX	Flat	4	450	CO93	SG14	B003

Client

clientNo	fName	lName	telNo	prefType	maxRent	eMail
CR76	John	Kay	0207-774-5632	Flat	425	john.kay@gmail.com
CR56	Aline	Stewart	0141-848-1825	Flat	350	astewart@hotmail.com
CR74	Mike	Ritchie	01475-392178	House	750	mr Ritchie01@yahoo.co.uk
CR62	Mary	Tregear	01224-196720	Flat	600	maryt@hotmail.co.uk

PrivateOwner

ownerNo	fName	lName	address	telNo	eMail	password
CO46	Joe	Keogh	2 Fergus Dr, Aberdeen AB2 7SX	01224-861212	jkeogh@lhh.com	*****
CO87	Carol	Farrel	6 Achray St, Glasgow G32 9DX	0141-357-7419	cfarrel@gmail.com	*****
CO40	Tina	Murphy	63 Well St, Glasgow G42	0141-943-1728	tinam@hotmail.com	*****
CO93	Tony	Shaw	12 Park Pl, Glasgow G4 0QR	0141-225-7025	tony.shaw@ark.com	*****

Viewing

clientNo	propertyNo	viewDate	comment
CR56	PA14	24-May-13	too small
CR76	PG4	20-Apr-13	too remote
CR56	PG4	26-May-13	
CR62	PA14	14-May-13	no dining room
CR56	PG36	28-Apr-13	

Registration

clientNo	branchNo	staffNo	dateJoined
CR76	B005	SL41	2-Jan-13
CR56	B003	SG37	11-Apr-12
CR74	B003	SG37	16-Nov-11
CR62	B007	SA9	7-Mar-12

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Integrity Constraints

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- **Domain constraints:**

- every attribute has an associated domain, there are constraints that form restrictions on the set of values allowed for the attributes of relations.

- Nulls

- Represents a value for an attribute that is currently unknown or is not applicable for this tuple.

Viewing

clientNo	propertyNo	viewDate	comment
CR56	PA14	24-May-13	too small
CR76	PG4	20-Apr-13	too remote
CR56	PG4	26-May-13	
CR62	PA14	14-May-13	no dining room
CR56	PG36	28-Apr-13	

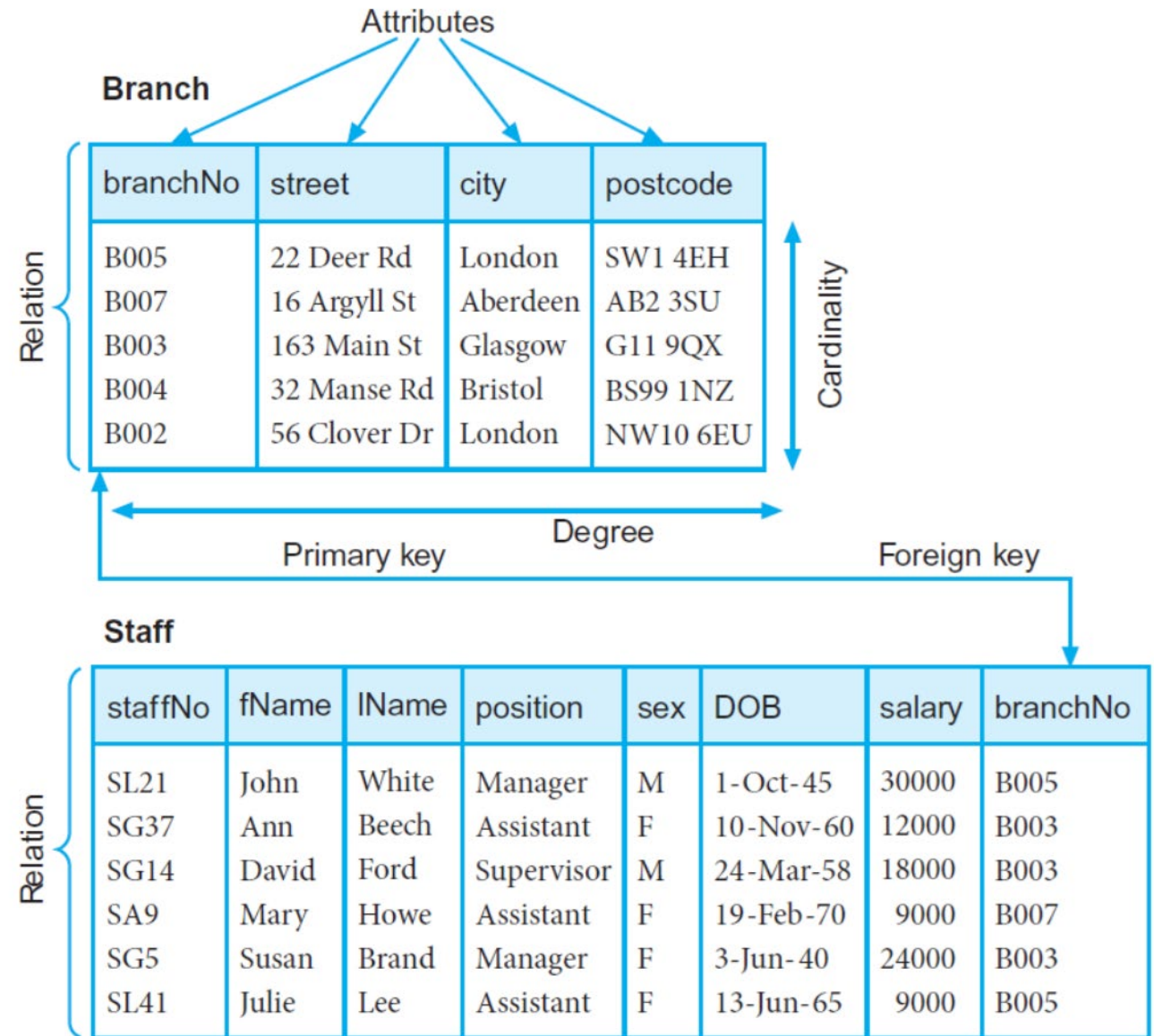
principal rules for the relational model are known as **entity integrity** and **referential integrity**.

- **Entity Integrity:**

- In a base relation, no attribute of a primary key can be null.
- For example, as branchNo is the primary key of the Branch relation, we should not be able to insert a tuple into the Branch relation with a null for the branchNo attribute.
- As a second example, consider the composite primary key of the Viewing relation, comprising the client number (clientNo) and the property number (propertyNo). We should not be able to insert a tuple into the Viewing relation with a null for the clientNo attribute, or a null for the propertyNo attribute, or nulls for both attributes.

Referential Integrity

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



- **General Constraints:**

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

Activity

- *The following tables form part of a database held in a relational DBMS:*
 - Hotel (hotelNo, hotelName, city)
 - Room (roomNo, hotelNo, type, price)
 - Booking (hotelNo, guestNo, dateFrom, dateTo, roomNo)
 - Guest (guestNo, guestName, guestAddress)
1. Identify the primary key and foreign keys in this schema.
 2. Produce some sample tables for these relations that observe the relational integrity rules.
 3. Suggest some general constraints that would be appropriate for this schema.