Relational Algebra
Part One

Database Management - CIS 386 01 FA17

By: Dr. Aos Mulahuwaish

Introduction

- Relational algebra and relational calculus are formal languages associated with the relational model.
- Informally, relational algebra is a (high-level) procedural language and relational calculus a non-procedural language.
- However, formally both are equivalent to one another.
- A language that produces a relation that can be derived using relational calculus is <u>relationally complete</u>.

Relational Algebra

- Relational algebra operations work on one or more relations to define another relation without changing the original relations.
- Both operands and results are relations, so output from one operation can become input to another operation.
- Allows expressions to be nested, just as in arithmetic. This property is called <u>closure</u>.

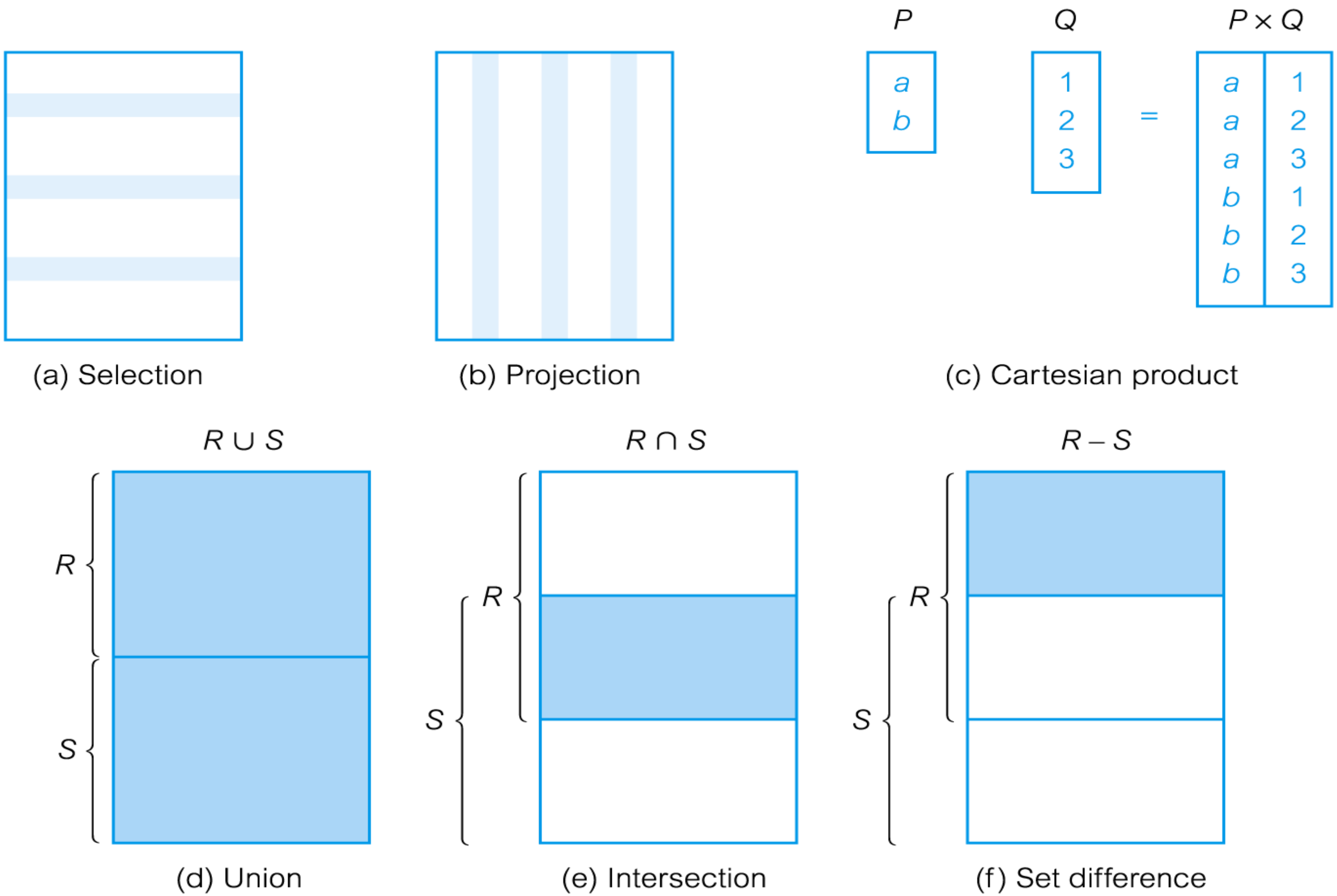
Relational Algebra

- Five basic operations in relational algebra: Selection, Projection, Cartesian product, Union, and Set Difference.

- These perform most of the data retrieval operations needed.

- Also have Join, Intersection, and Division operations, which can be expressed in terms of 5 basic operations.

Relational Algebra Operations



Relational Algebra Operations

T

A	B
a	1
b	2

U

B	C
1	x
1	y
3	z

$T \bowtie U$

A	B	C
a	1	x
a	1	y

(g) Natural join

$T \triangleright_B U$

A	B
a	1

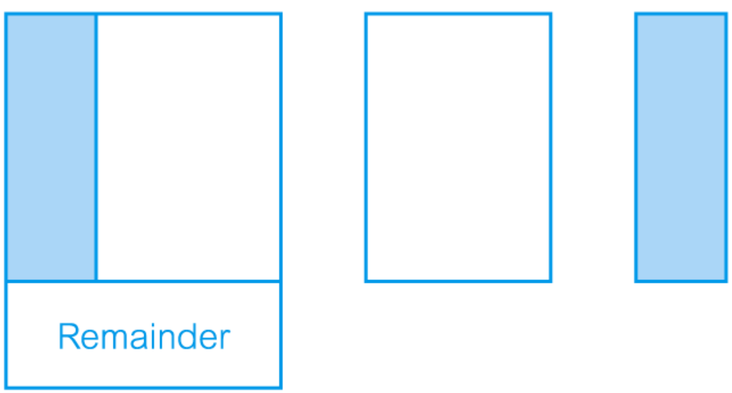
(h) Semijoin

$T ⟕_C U$

A	B	C
a	1	x
a	1	y
b	2	

(i) Left Outer join

R S $R \div S$



(j) Divis on (shaded area)

V

A	B
a	1
a	2
b	1
b	2
c	1

W

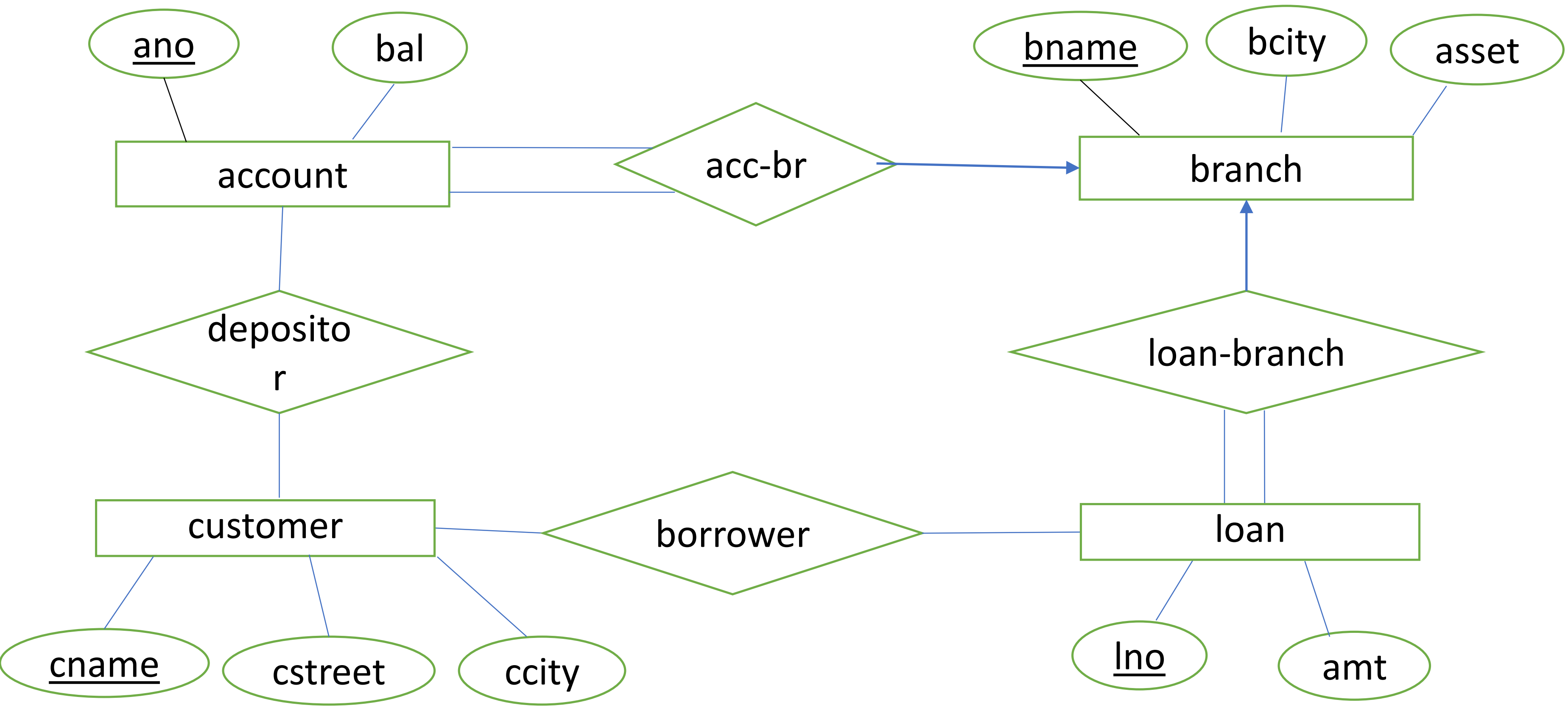
B
1
2

$V \div W$

A
a
b

Example of division

Case Study Banking System



Selection (or Restriction)

- **$\sigma_{predicate}$ (R)**
  - Works on a single relation R and defines a relation that contains only those tuples (rows) of R that satisfy the specified condition (*predicate*).

Example - Selection (or Restriction)

- List all staff with a salary greater than £10,000.

$\sigma_{salary > 10000}$ (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
SG5	Susan	Brand	Manager	F	3-Jun-40	24000	B003

Projection

- $\Pi_{col1, \ldots, coln}(R)$
  - Works on a single relation R and defines a relation that contains a vertical subset of R, extracting the values of specified attributes and eliminating duplicates.

Example - Projection

- Produce a list of salaries for all staff, showing only staffNo, fName, lName, and salary details.

$$\Pi_{\text{staffNo, fName, lName, salary}}(\text{Staff})$$

staffNo	fName	lName	salary
SL21	John	White	30000
SG37	Ann	Beech	12000
SG14	David	Ford	18000
SA9	Mary	Howe	9000
SG5	Susan	Brand	24000
SL41	Julie	Lee	9000

Union

- **R ∪ S**
  - Union of two relations R and S defines a relation that contains all the tuples of R, or S, or both R and S, duplicate tuples being eliminated.
  - R and S must be union-compatible.

- If R and S have *I* and *J* tuples, respectively, union is obtained by concatenating them into one relation with a maximum of (*I* + *J*) tuples.

Example - Union

- List all cities where there is either a branch office or a property for rent.

$$\Pi_{city}(\text{Branch}) \cup \Pi_{city}(\text{PropertyForRent})$$

city
London
Aberdeen
Glasgow
Bristol

Set Difference

- **R – S**
  - Defines a relation consisting of the tuples that are in relation R, but not in S.
  - R and S must be union-compatible.

Example - Set Difference

- List all cities where there is a branch office but no properties for rent.

$$\Pi_{city}(\text{Branch}) - \Pi_{city}(\text{PropertyForRent})$$

city
Bristol

Intersection

- **$R \cap S$**
  - Defines a relation consisting of the set of all tuples that are in both R and S.
  - R and S must be union-compatible.

- Expressed using basic operations:

  $R \cap S = R - (R - S)$

Example - Intersection

- List all cities where there is both a branch office and at least one property for rent.

$$\Pi_{city}(\text{Branch}) \cap \Pi_{city}(\text{PropertyForRent})$$

city
Aberdeen
London
Glasgow

Cartesian product

- **R X S**
  - Defines a relation that is the concatenation of every tuple of relation R with every tuple of relation S.

Example - Cartesian product

- List the names and comments of all clients who have viewed a property for rent.

  $(\Pi_{\text{clientNo, fName, lName}}(\text{Client}))\ X\ (\Pi_{\text{clientNo, propertyNo, comment}}(\text{Viewing}))$

client.clientNo	fName	lName	Viewing.clientNo	propertyNo	comment
CR76	John	Kay	CR56	PA14	too small
CR76	John	Kay	CR76	PG4	too remote
CR76	John	Kay	CR56	PG4	
CR76	John	Kay	CR62	PA14	no dining room
CR76	John	Kay	CR56	PG36	
CR56	Aline	Stewart	CR56	PA14	too small
CR56	Aline	Stewart	CR76	PG4	too remote
CR56	Aline	Stewart	CR56	PG4	
CR56	Aline	Stewart	CR62	PA14	no dining room
CR56	Aline	Stewart	CR56	PG36	
CR74	Mike	Ritchie	CR56	PA14	too small
CR74	Mike	Ritchie	CR76	PG4	too remote
CR74	Mike	Ritchie	CR56	PG4	
CR74	Mike	Ritchie	CR62	PA14	no dining room
CR74	Mike	Ritchie	CR56	PG36	
CR62	Mary	Tregear	CR56	PA14	too small
CR62	Mary	Tregear	CR76	PG4	too remote
CR62	Mary	Tregear	CR56	PG4	
CR62	Mary	Tregear	CR62	PA14	no dining room
CR62	Mary	Tregear	CR56	PG36	

Example - Cartesian product and Selection

- **Use selection operation to extract those tuples where Client.clientNo = Viewing.clientNo.**

$$\sigma_{\text{Client.clientNo = Viewing.clientNo}}((\Pi_{\text{clientNo, fName, lName}}(\text{Client})) \text{ X } (\Pi_{\text{clientNo, propertyNo, comment}}(\text{Viewing})))$$

client.clientNo	fName	lName	Viewing.clientNo	propertyNo	comment
CR76	John	Kay	CR76	PG4	too remote
CR56	Aline	Stewart	CR56	PA14	too small
CR56	Aline	Stewart	CR56	PG4	
CR56	Aline	Stewart	CR56	PG36	
CR62	Mary	Tregear	CR62	PA14	no dining room

- **Cartesian product and Selection can be reduced to a single operation called a *Join*.**