

CSE 4125: Distributed Database Systems

Chapter – 3 : Part B

Levels of Distributed Transparency

Outline

- ❑ Rules of Fragmentation
- ❑ Types of Fragmentation

Rules of Fragmentation

- ❑ **Completeness**
- ❑ **Reconstruction**
- ❑ **Disjointness**

Rules of Fragmentation

□ Completeness:

- All data in global relation must be mapped into fragments.
- No data must be left unmapped.

Example

STUDENT

ID	NAME	DEPT
1	A	ARC
2	B	CSE
3	C	ARC
4	D	CSE

STUDENT₁

ID	NAME	DEPT
1	A	ARC
3	C	ARC

STUDENT₂

ID	NAME	DEPT
2	B	CSE
4	D	CSE

Complete

Example

STUDENT

ID	NAME	DEPT
1	A	ARC
2	B	CSE
3	C	ARC
4	D	CSE
5	E	ARC

STUDENT₁

ID	NAME	DEPT
1	A	ARC
3	C	ARC

STUDENT₂

ID	NAME	DEPT
2	B	CSE
4	D	CSE

Not Complete. Cause ID 5 is not present in the fragments.

Rules of Fragmentation

□ Reconstruction:

- It must be possible to obtain the global relation from its fragments.

Example

STUDENT₁

ID	NAME	DEPT
1	A	ARC
3	C	ARC

STUDENT₂

ID	NAME	DEPT
2	B	CSE
4	D	CSE

STUDENT

ID	NAME	DEPT
1	A	ARC
2	B	CSE
3	C	ARC
4	D	CSE

Reconstructed

Example

STUDENT₁

ID	NAME	DEPT
1	A	ARC
3	C	ARC

STUDENT₂

ID	NAME	DEPT
2	B	CSE
4	D	CSE

STUDENT

ID	NAME	DEPT
1	A	ARC
2	B	CSE
3	C	ARC
4	D	CSE
5	E	ARC

Fragmentation is not correct. So, reconstruct is not possible.

Rules of Fragmentation

❑ Disjointness:

- It is convenient to have disjoint (**non-overlapping**) fragments. Don't have Common rows
- Not strict, can be violated.**

Example

STUDENT

ID	NAME	DEPT
1	A	ARC
2	B	CSE
3	C	ARC
4	D	CSE

STUDENT₁

ID	NAME	DEPT
1	A	ARC
3	C	ARC

STUDENT₂

ID	NAME	DEPT
2	B	CSE
4	D	CSE

Disjoint. Cause there are not any common row

Example

STUDENT

ID	NAME	DEPT
1	A	ARC
2	B	CSE
3	C	ARC
4	D	CSE

STUDENT₁

ID	NAME	DEPT
1	A	ARC
3	C	ARC
2	B	CSE

STUDENT₂

ID	NAME	DEPT
2	B	CSE
4	D	CSE

Not Disjoint. Cause there are common row

Example

This fragment is complete. So, it also has reconstructed property. But it is not disjoint cause ID column is common. (Disjoint property is not strict, can be violated.)

STUDENT

ID	NAME	DEPT
1	A	ARC
2	B	CSE
3	C	ARC
4	D	CSE

For Reconstruct:
Student1 NJN Student2 = Student

STUDENT₁

ID	NAME
1	A
2	B
3	C
4	D

STUDENT₂

ID	DEPT
1	ARC
2	CSE
3	ARC
4	CSE

Example

STUDENT

ID	NAME	DEPT
1	A	ARC
2	B	CSE
3	C	ARC
4	D	CSE

STUDENT₁

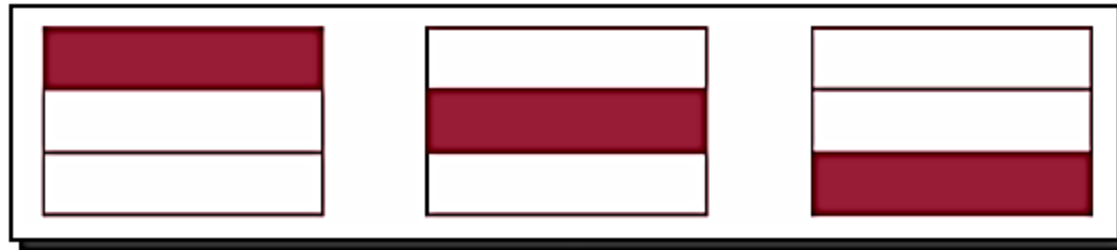
ID	NAME
1	A
3	C
2	B

STUDENT₂

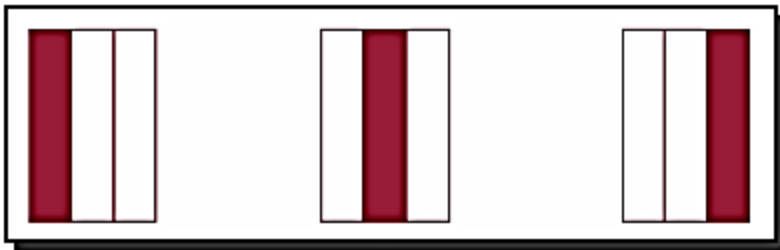
ID	DEPT
2	CSE
4	CSE

Types of Fragmentation

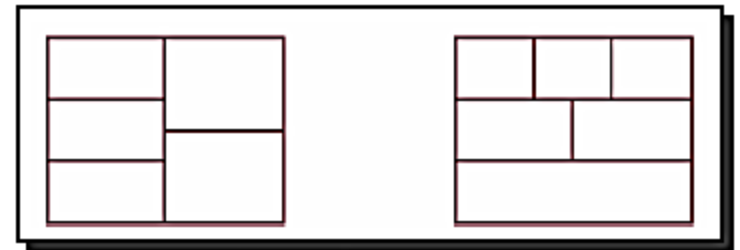
1. Horizontal fragmentation Based on Row
2. Vertical fragmentation. Based on Column
3. Mixed fragmentation.



(a) Horizontal Fragmentation



(b) Vertical Fragmentation



(c) Mixed Fragmentation

Horizontal Fragmentation

Partitioning the tuples of a global relation into subsets.

Example: global relation:

SUPPLIER (SNUM, NAME, CITY)

✓ Apply horizontal fragmentation based on city.

*Question: what relational algebraic operation can be applied?

Example

SUPPLIER

SNUM	NAME	CITY
1	A	DHK
2	B	CTG
3	C	DHK
4	D	CTG

SUPPLIER₁

SNUM	NAME	CITY
1	A	DHK
3	C	DHK

SUPPLIER₂

SNUM	NAME	CITY
2	B	CTG
4	D	CTG

*SUPPLIER₁ = select * from SUPPLIER where CITY = DHK;*

*SUPPLIER₂ = select * from SUPPLIER where CITY = CTG;*

Global schema:

SUPPLIER (SNUM, NAME, CITY)

Fragmentation Schema:

$SUPPLIER_1 = \mathbf{SL}_{CITY = \text{"DHK"}} SUPPLIER$

$SUPPLIER_2 = \mathbf{SL}_{CITY = \text{"CTG"}} SUPPLIER$

Qualification: *Predicate which is used in the selection operation that defines a fragment.*

q1: CITY = "DHK"

q2: CITY = "CTG"

Discuss:

?? Is it complete ?

?? How to reconstruct ?

?? Is it disjoint ?

Discuss:

?? Is it complete ?

If DHK and CTG are the only possible values of the CITY attribute.

?? How to reconstruct ?

$SUPPLIER = SUPPLIER_1 \text{ UNION } SUPPLIER_2$

?? Is it disjoint ?

Yes

Practice

ACCOUNT

ACCNO	ACCTYPE	BALANCE	BRANCH
3001	Saving	1000	DHK
3002	Current	2000	CTG
3003	DPS	3000	DHK
3004	Saving	2500	SYL
3005	Current	2200	RAJ

1. Apply Horizontal Fragmentation on ACCOUNT relation based on ACCTYPE attribute. | Saving, Current, DPS
2. Verify the completeness, reconstruction and disjoint properties for the fragments in question 1.

Derived Horizontal Fragmentation

In some cases, horizontal fragmentation cannot be based on its own attributes.

Needs to be derived from the horizontal fragmentation of another relation.

Example: global schema:

SUPPLIER (SNUM, NAME, CITY)

SUPPLY (SNUM, PNUM, DEPTNUM, QUAN)

Partition *SUPPLY* based on a cities.

*Question: What is the relational algebraic formula to apply this?

Example

SUPPLIER

SNUM	NAME	CITY
1	A	DHK
2	B	CTG
3	C	DHK
4	D	CTG

SUPPLY

SNUM	PNUM	DEPTNUM	QUAN
1	100	X	20
2	101	Y	30
3	102	Z	40
4	103	P	50

Example

SUPPLIER

SNUM	NAME	CITY
1	A	DHK
2	B	CTG
3	C	DHK
4	D	CTG

SUPPLIER₁

SNUM	NAME	CITY
1	A	DHK
3	C	DHK

SUPPLIER₂

SNUM	NAME	CITY
2	B	CTG
4	D	CTG

Example

SUPPLY

SNUM	PNUM	DEPTNUM	QUAN
1	100	X	20
2	101	Y	30
3	102	Z	40
4	103	P	50

Supply SJN Supplier1 = Supply1

SUPPLY₁

SNUM	PNUM	DEPTNUM	QUAN
1	100	X	20
3	102	Z	40

SUPPLIER₁

SNUM	NAME	CITY
1	A	DHK
3	C	DHK

SUPPLIER₂

SNUM	NAME	CITY
2	B	CTG
4	D	CTG

Supply SJN Supplier2 = Supply2

SUPPLY₂

SNUM	PNUM	DEPTNUM	QUAN
2	101	Y	30
4	103	P	50

□ Global relations:

SUPPLIER (SNUM, NAME, CITY)

SUPPLY (SNUM, PNUM, DEPTNUM, QUAN)

□ Fragmentation Schema (method-1):

Firstly,

$SUPPLIER_1 = \mathbf{SL}_{CITY = \text{"DHK"}} SUPPLIER$

$SUPPLIER_2 = \mathbf{SL}_{CITY = \text{"CTG"}} SUPPLIER$

Finally,

$SUPPLY_1 = SUPPLY \mathbf{SJ}_{SNUM = SNUM} SUPPLIER_1$

$SUPPLY_2 = SUPPLY \mathbf{SJ}_{SNUM = SNUM} SUPPLIER_2$

Example

SUPPLIER

SNUM	NAME	CITY
1	A	DHK
2	B	CTG
3	C	DHK
4	D	CTG

SUPPLY

SNUM	PNUM	DEPTNUM	QUAN
1	100	X	20
2	101	Y	30
3	102	Z	40
4	103	P	50

SUPPLY₁

SNUM	PNUM	DEPTNUM	QUAN
1	100	X	20
3	102	Z	40

SUPPLY₂

SNUM	PNUM	DEPTNUM	QUAN
2	101	Y	30
4	103	P	50

❑ Global relations:

SUPPLIER (SNUM, NAME, CITY)

SUPPLY (SNUM, PNUM, DEPTNUM, QUAN)

❑ Fragmentation Schema (method-2):

$SUPPLY_1 = SL_{q1} SUPPLY$

$SUPPLY_2 = SL_{q2} SUPPLY$

Where,

$q1$: *SUPPLY.SNUM = SUPPLIER.SNUM and SUPPLIER.CITY = “DHK”*

$q2$: *SUPPLY.SNUM = SUPPLIER.SNUM and SUPPLIER.CITY = “CTG”*

Discuss:

?? Is it complete ?

?? How to reconstruct ?

?? Is it disjoint ?

Discuss:

?? Is it complete ?

Requires that there be no supplier number in the *SUPPLY* relation which are not contained also in the *SUPPLIER* relation.

?? How to reconstruct ?

$$SUPPLY = SUPPLY_1 \text{ UN } SUPPLY_2$$

?? Is it disjoint ?

Yes (supplier numbers are unique key)

Example

Fragmentation corrects.

SUPPLIER

SNUM	NAME	CITY
1	A	DHK
2	B	CTG
3	C	DHK
4	D	CTG
5	E	DHK

SUPPLY

SNUM	PNUM	DEPTNUM	QUAN
1	100	X	20
2	101	Y	30
3	102	Z	40
4	103	P	50

SUPPLY₁

SNUM	PNUM	DEPTNUM	QUAN
1	100	X	20
3	102	Z	40

SUPPLY₂

SNUM	PNUM	DEPTNUM	QUAN
2	101	Y	30
4	103	P	50

Example

Not Complete, Not Reconstruct

SUPPLIER

SNUM	NAME	CITY
1	A	DHK
2	B	CTG
3	C	DHK
4	D	CTG

SUPPLY

SNUM	PNUM	DEPTNUM	QUAN
1	100	X	20
2	101	Y	30
3	102	Z	40
4	103	P	50
5	104	Q	60

SUPPLY₁

SNUM	PNUM	DEPTNUM	QUAN
1	100	X	20
3	102	Z	40

SUPPLY₂

SNUM	PNUM	DEPTNUM	QUAN
2	101	Y	30
4	103	P	50

Practice

SUPPLIER

SNUM	NAME	CITY
1	A	DHK
2	B	CTG
3	C	DHK
4	D	CTG
5	E	DHK

SUPPLY

SNUM	PNUM
1	101
2	102
3	103
4	104
5	105
6	106

PRODUCT

PNUM	PNAME	QUAN
101	A1	10
102	B1	20
103	C1	30
104	D1	40
105	E1	50

1. Apply Derived Horizontal Fragmentation on PRODUCT relation based on CITY attribute.
2. Verify the completeness, reconstruction and disjoint properties for the fragments in question 1.