CSE 4125: Distributed Database Systems
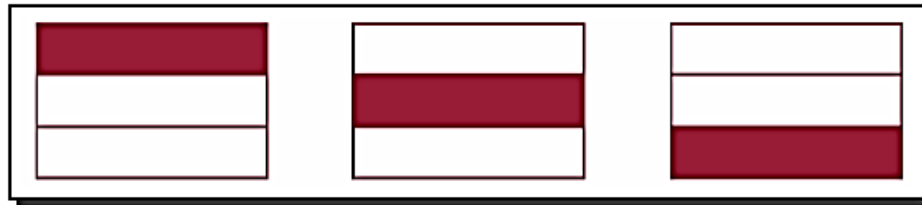# Chapter – 3

Levels of Distributed Transparency.
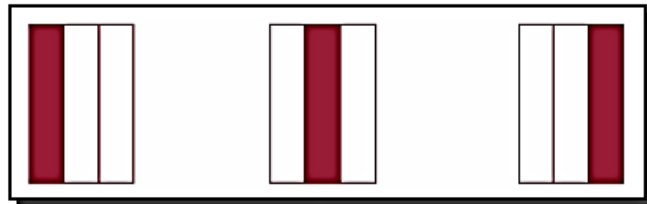## (part – B)

Outline

- Types of fragmentation.
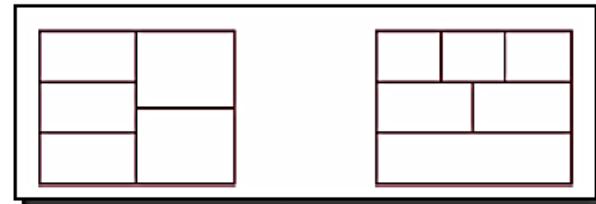- Rules of fragmentation.

Types of Fragmentation

1. Horizontal fragmentation.
2. Vertical fragmentation.
3. Mixed fragmentation.

(a) Horizontal Fragmentation

(b) Vertical Fragmentation

(c) Mixed Fragmentation

Determining Fragmentation*

The following information is used to decide fragmentation:

- Quantitative information:
  - frequency of queries, site, where query is run, selectivity (i.e. probability of accessing) of the queries, etc.

- Qualitative information:
  - types of access of data, read/write, etc.

Rules of Fragmentation

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

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

Rules of Fragmentation (cont.)

- Disjointness:
  - It is convenient to have disjoint (non-overlapping) fragments.
  - Not strict, can be violated.

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?

Horizontal Fragmentation (cont.)

- Global schema:

    SUPPLIER (SNUM, NAME, CITY)

- Fragmentation Schema:
    - $SUPPLIER_1 = SL_{CITY = 'DHK'} SUPPLIER$
    - $SUPPLIER_2 = SL_{CITY = 'CTG'} SUPPLIER$

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

Horizontal Fragmentation (cont.)

- From previous example, discuss –
  - Is it complete?
  - How to reconstruct?
    - Perfect reconstruction possible ?
  - Is it disjoint?

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.

Derived Horizontal Fragmentation (cont.)

- Example: global relations:

  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?

Derived Horizontal Fragmentation (cont.)

- Global relations:

  SUPPLIER (SNUM, NAME, CITY)

  SUPPLY (SNUM, PNUM, DEPTNUM, QUAN)

- Fragmentation Schema (method-1):

  Firstly,

  $SUPPLIER_1 = \mathbf{SL}_{CITY = 'DHK'} \, SUPPLIER$

  $SUPPLIER_2 = \mathbf{SL}_{CITY = 'CTG'} \, SUPPLIER$

  Finally,

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

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

Derived Horizontal Fragmentation (cont.)

- Global relations:

    SUPPLIER (SNUM, NAME, CITY)

    SUPPLY (SNUM, PNUM, DEPTNUM, QUAN)

- Fragmentation Schema (method-2):

    $SUPPLY_1 = SUPPLY \textbf{ SJ }_{q1} SUPPLIER$

    $SUPPLY_2 = SUPPLY \textbf{ SJ }_{q2} SUPPLIER$

    Where,

    q1: SUPPLY.SNUM = SUPPLIER.SNUM and SUPPLIER.CITY = 'DHK'
    q2: SUPPLY.SNUM = SUPPLIER.SNUM and SUPPLIER.CITY = 'CTG'

Derived Horizontal Fragmentation (cont.)

- From previous examples, discuss –
  - Is it complete?
    - In which cases it will be complete?
    - In which cases it will NOT be complete?
  - How to reconstruct?
    - Perfect reconstruction possible?
  - Is it disjoint?

Vertical Fragmentation

- Partitioning the attributes of a global relation into subsets.

- Example: global relation:

  EMP (EMPNUM, NAME, SAL, TAX, MGRNUM, DEPTNUM)

  Apply vertical fragmentation.

- Question: what relational algebraic operation can be applied?

Vertical Fragmentation (cont.)

- Global schema:

  EMP (EMPNUM, NAME, SAL, TAX, MGRNUM, DEPTNUM)

- Fragmentation schema:

  $EMP_1 = \textbf{PJ}_{\ EMPNUM,\ NAME,\ MGRNUM,\ DEPTNUM}\ EMP$

  $EMP_2 = \textbf{PJ}_{\ SAL,\ TAX}\ EMP$

  – Question: do you think the fragmentation is acceptable?

Vertical Fragmentation (cont.)

- Global schema:

  EMP (EMPNUM, NAME, SAL, TAX, MGRNUM, DEPTNUM)

- Fragmentation schema:

  $EMP_1 = \textbf{PJ}_{\text{EMPNUM, NAME, MGRNUM, DEPTNUM}}\, EMP$
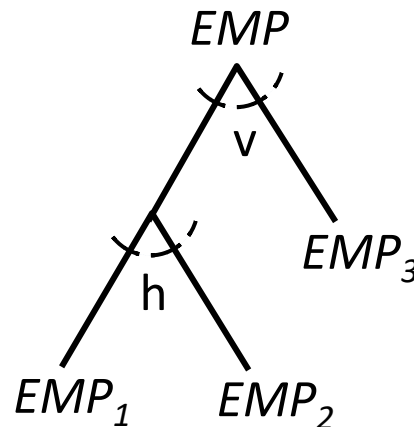
  $EMP_2 = \textbf{PJ}_{\text{EMPNUM, SAL, TAX}}\, EMP$

Vertical Fragmentation (cont.)

- From previous example, discuss –
  - Is it complete?
  - How to reconstruct?
    - Perfect reconstruction possible ?
  - Is it disjoint?

Mixed Fragmentation

- Horizontal + Vertical.
- Can be applied recursively.
- Represented by *Fragmentation tree*.

Mixed Fragmentation (cont.)

Global Schema:

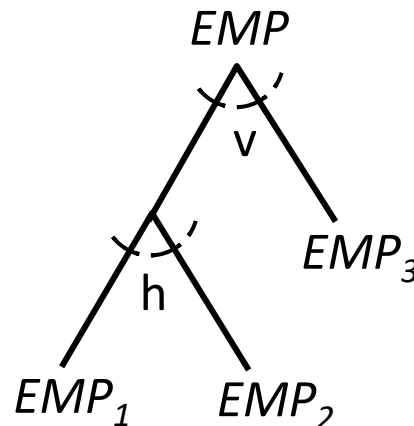*EMP (EMPNUM, NAME, SAL, TAX, MGRNUM, DEPTNUM)*

Fragmentation schema:

$EMP_1 = SL_{DEPTNUM \leq 10} PJ_{EMPNUM, NAME, MGRNUM, DEPTNUM} (EMP)$
$EMP_2 = SL_{DEPTNUM > 10} PJ_{EMPNUM, NAME, MGRNUM, DEPTNUM} (EMP)$
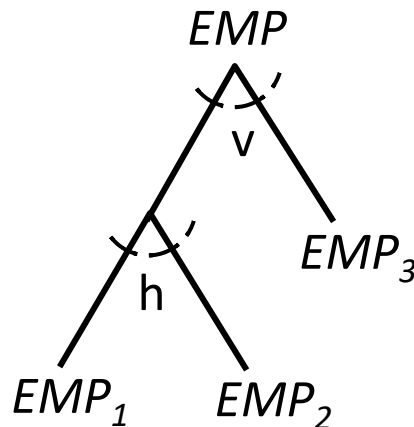$EMP_3 = PJ_{EMPNUM, NAME, SAL, TAX} (EMP)$

Fragmentation tree:

Mixed Fragmentation (cont.)

- From previous example, discuss –
  - How to determine completeness?
  - How to reconstruct?
    - Perfect reconstruction possible?
  - Disjointness.

EMP
v
EMP_3
h
EMP_1 EMP_2

Degree of Fragmentation*

The degree of fragmentation lies between two extreme situations –

1. Not to fragment at all.

2. Fragment to the level of individual tuples (in the case of horizontal fragmentation) or to the level of individual attributes (in the case of vertical fragmentation).

Practice Problems/ Questions

a) Draw the fragmentation tree for the fragmentation schema presented in the text book figure 3.4 (page - 46).

b) Write the reconstruction formula for the fragmentation schema presented in the text book figure 3.9a (page - 56).

c) Text book:

       Exercise: 3.1