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CSCI317 Database Performance Tuning

Clustering

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Clustering

Outline

Clustering ? What is it ?

Cluster is a group of tables that share the same data blocks because they share the same columns and are frequently used together

Clusters are transparent to query languages

Clusters are logically and physically dependent of the data in the associated tables

Once created, a cluster is automatically maintained and used by a database system

Performance related observations

Retrieval performance of clustered tables may be better than retrieval performance of non-clustered tables

Presence of clusters decreases performance of `UPDATE`, `DELETE`, and `INSERT` operations

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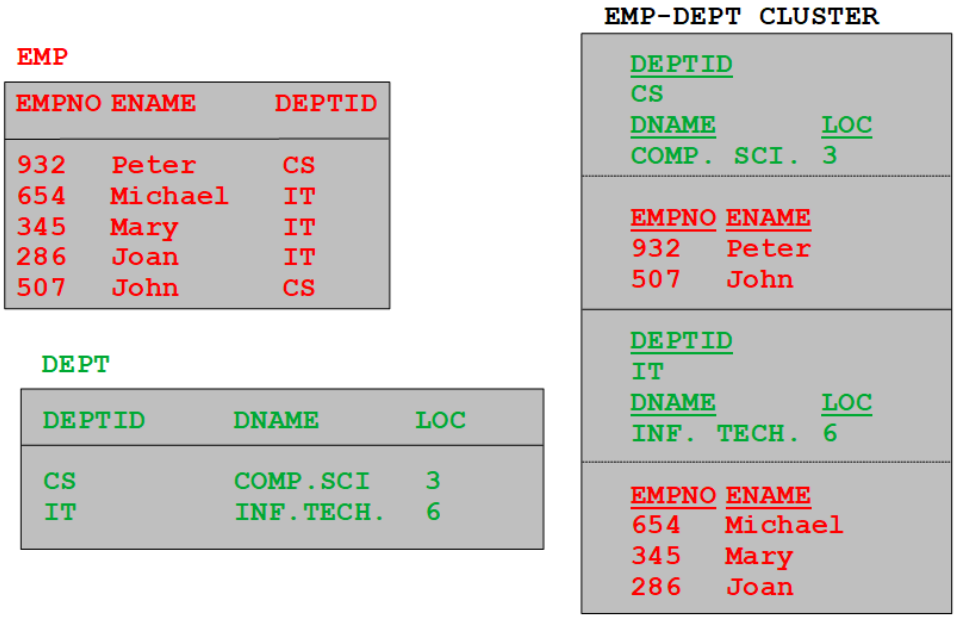
Sample clustered data structures

Consider the relational tables `EMP` and `DEPT` with information about the employees and departments the employees are located at



`EMP-DEPT` cluster contains the rows from a relational table `DEPT` grouped by `DEPTID` and joined with the rows from a relational table `EMP`

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Creating a cluster

A cluster can be created in the following way

Creating a cluster

```
CREATE CLUSTER COUNTRY_CLST
 (CO_ID NUMBER(4) )
 INDEX
 PCTFREE 0;
```

A cluster must have an index created on its key

Creating an index on a cluster

```
CREATE INDEX COUNTRY_IDX ON CLUSTER COUNTRY_CLST;
```

Clustering

Outline

Loading the relational tables into a cluster

A relational table COUNTRY can be created in a cluster COUNTRY_CLST in the following way

Creating a relational table in a cluster

```
CREATE TABLE COUNTRY(
 CO_ID              NUMERIC(4)         NOT NULL,
 CO_NAME            VARCHAR(50)        NOT NULL,
 …          …       …         …        …       …
   CONSTRAINT COUNTRY_PKEY PRIMARY KEY (CO_ID),
   CONSTRAINT COUNTRY_CHECK1 CHECK(CO_ID > 0) )
CLUSTER COUNTRY_CLST(CO_ID);
```

A relational table ADDRESS can be created in a cluster COUNTRY_CLST in the following way

Creating a relational table in a cluster

```
CREATE TABLE ADDRESS(
 ADDR_ID            NUMERIC(10)  NOT NULL,
 ADDR_CO_ID         NUMERIC(4)   NOT NULL,
 …          …       …        …       …      …
  CONSTRAINT ADDRESS_PKEY PRIMARY KEY (ADDR_ID),
  CONSTRAINT ADDRESS_FKEY FOREIGN KEY (ADDR_CO_ID)
                REFERENCES COUNTRY(CO_ID),
        CONSTRAINT ADDRESS_CHECK1 CHECK(ADDR_ID > 0) )
CLUSTER COUNTRY_CLST(ADDR_CO_ID);
```

Clustering

Outline

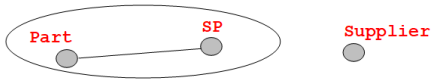
Clustering costs versus benefits

Consider the relational tables

Sample relational tables to be clustered

```
PART(pnum, pname, price)
SP(pnum, snum, qty)
SUPPLIER(snum, sname, address)
```

Variant 1: Clustering of `PART` and `SP` over `pnum`



Benefits: no need to process join of relational tables `PART` and `SP`

Costs: instead of join operation a cluster over `pnum` must be read

```
( cost(PART JOIN SP) - cost(cluster(PART UNION SP)) ) *
  frequency(PART JOIN SP)
```

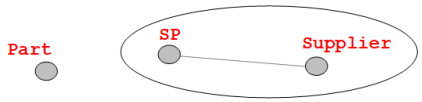
Clustering costs versus benefits

Consider the relational tables

Sample relational tables to be clustered

```
PART(pnum, pname, price)
SP(pnum, snum, qty)
SUPPLIER(snum, sname, address)
```

Variant 2: Clustering of `SUPPLIER` and `SP` over `snum`



Benefits: no need to process join of relational tables `SUPPLIER` and `SP`

Costs: instead of join operation a cluster over `pnum` must be read

```
( cost(SUPPLIER JOIN SP) - cost(cluster(SUPPLIER UNION SP)) )*
  frequency(SUPPLIER JOIN SP)
```

Clustering costs versus benefits

Consider the relational tables

```
PART(pnum, pname, price)
SP(pnum, snum, qty)
SUPPLIER(snum, sname, address)
```

Sample relational tables to be clustered

size(SP(pnum, snum, qty)) = 50 blocks

size(SUPPLIER(snum, sname, address) = 100 blocks

cost(PART JOIN SP) = 7000 read blocks, frequency = 10 times per day

cost(SUPPLIER JOIN SP) = 2500 read blocks, frequency = 30 times per day

Variant 1

- Savings = (7000 - (300+50)) * 10 = 66500 read blocks

Variant 2

- Savings = (2500 - (100+50)) * 30 = 70500 read blocks

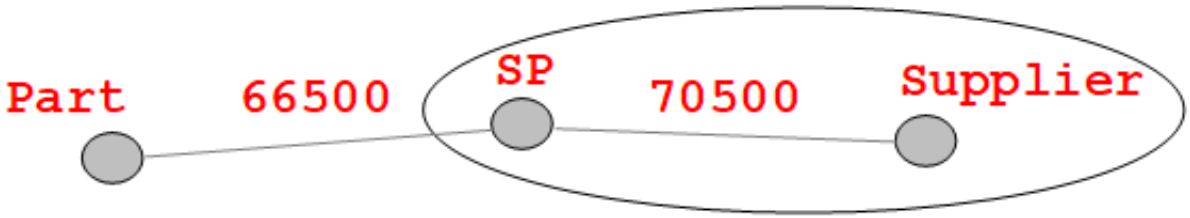
Clustering costs versus benefits

Variant 1

- `Savings = (7000 - (300+50) ) * 10 = 66500 read blocks`

Variant 2

- `Savings = (2500 - (100+50) ) * 30 = 70500 read blocks`



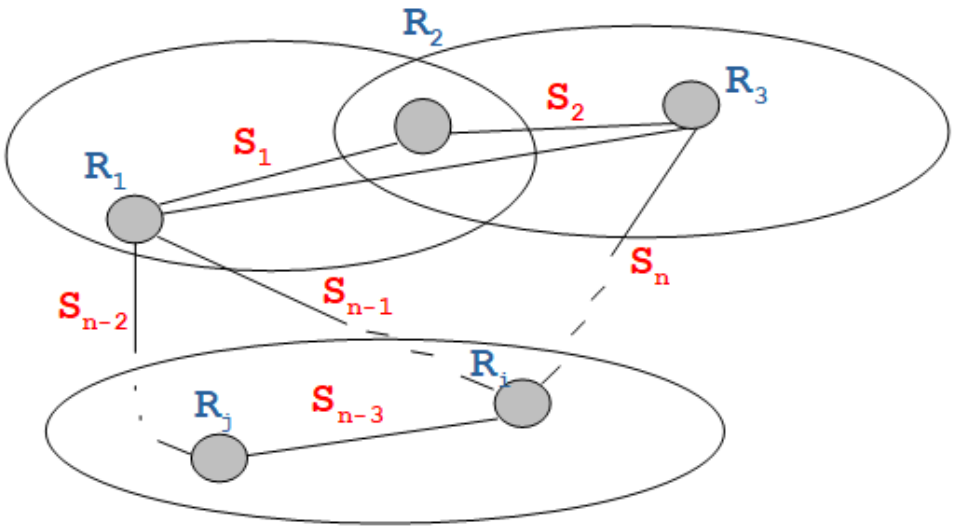
Clustering

Outline

Optimal clustering

Problem

- Given a binary graph (clustering graph) representing all possible clustering variants together with evaluation of benefits for each one of them
- Find the smallest set of variants V that maximizes the savings



Relational tables: R_1, R_2, ..., R_j **Benefits:** S_1, S_2, ..., S_n

Clustering

Outline

Suboptimal clustering

Algorithm

Suboptimal clustering algorithm

```
Make a set of clustering variants V empty
repeat
  Find in a clustering graph a variant Vmax that maximises savings;
  Add Vmax to V;
  Remove from a clustering graph an edge that represents a variant Vmax
           and all edges that represent variants inconsistent with Vmax;
until clustering graph has no edges;
```

Suboptimal clustering

Assume that database consists of the following relational tables:

- R size 100 blocks
- S size 50 blocks
- T size 200 blocks
- U size 80 blocks
- V size 50 blocks

Assume that the tables

- R and S are joined on average 10 times per day
- S and T are joined on average 5 times per day
- T and U are joined on average 10 times per day
- T and V are joined on average 24 times per day

Suboptimal clustering

Assume that join of

- R and S needs 200 read block operations
- S and T needs 300 read block operations
- T and U needs 300 read block operations
- T and V needs 400 read block operations

Then, the benefits form clustering of

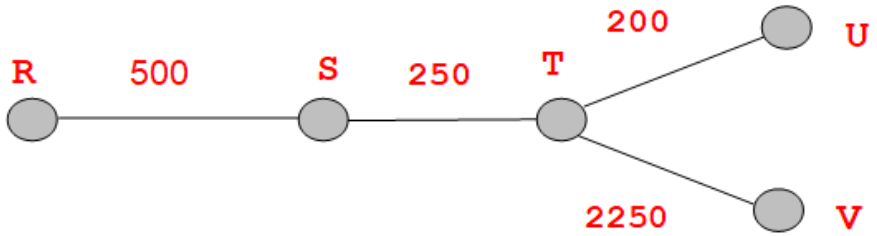
- R and S are equal to 10 * 200 - 10 * (100 + 50) = 500 reads per day
- S and T are equal to 5 * 300 - 5 * (50 + 200) = 250 reads per day
- T and U are equal to 10 * 300 - 10 * (200 + 80) = 200 reads per day
- T and V are equal to 15 * 400 - 15 * (200 + 50) = 2250 reads per day

Suboptimal clustering

Then, the benefits form clustering of

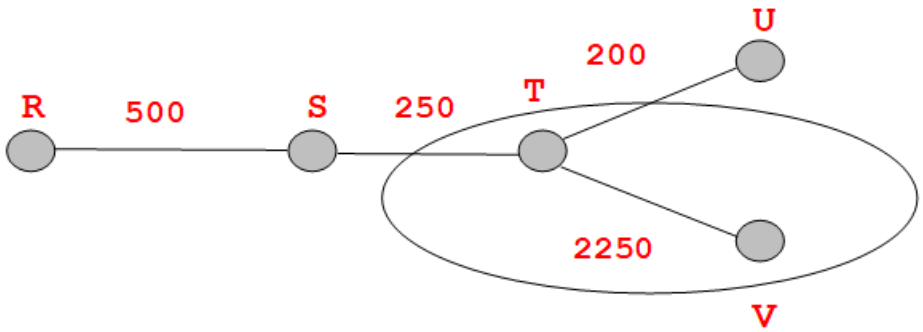
- R and S are equal to 10 * 200 – 10 * (100 + 50) = 500 reads per day
- S and T are equal to 5 * 300 – 5 * (50 + 200) = 250 reads per day
- T and U are equal to 10 * 300 – 10 * (200 + 80) = 200 reads per day
- T and V are equal to 15 * 400 – 15 * (80 + 50) = 2250 reads per day

Clustering graph

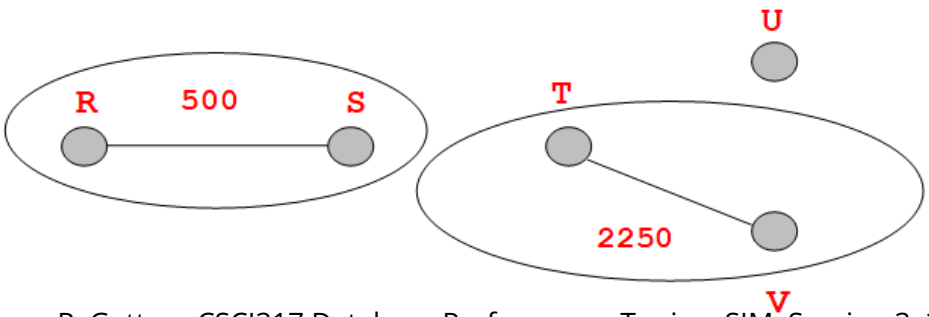


Suboptimal clustering

Cluster `T` and `V`



Cluster `R` and `S`



References

Cookbook, How to cluster relational tables ?

Ramakrishnan R., J. Gehrke Database Management Systems, chapter 20.4.1