香港中文大學（深圳）
The Chinese University of Hong Kong, Shenzhen

SCHOOL OF DATA SCIENCE
數據科學學院

CSC3170 Tutorial 4

School of Data Science

The Chinese University of Hong Kong, Shenzhen

Outline

- Storage Models
- Compression

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Storage Models

- Concepts:
  - Database Workloads
  - Models
- Exercise

Database workloads

- On-line Transaction Processing (OLTP) :
  - Simple queries
  - Read/update a small amount of data related to a single entity in the database.
- On-line Analytical Processing (OLAP) :
  - Complex queries
  - Read large portions of the database spanning multiple entities.

Models

- N-ary Storage Model (NSM)
- Decomposition Storage Model (DSM)
- Hybrid Storage Model (PAX)

N-ary Storage Model

- Stores all attributes for a single tuple contiguously in a single page. “row store”
- Ideal for OLTP workloads where queries are more likely to access individual entities and execute write-heavy workloads.
- Capable of fast inserting, updating, and deleting.
- Can use index-oriented physical storage for clutsering. (Indexing is not included in this tut)

N-ary Storage Model

- Not good for scanning large portions of the table.
- Terrible memory locality for OLAP access patterns.
- Not ideal for compression because of multiple value domains within a single page.

Decomposition Storage Model

- Stores a single attribute for all tuples contiguously in a block of data. “column store”
- Ideal for OLAP workloads where read-only queries perform large scans over a subset of the table’s attributes.
- Reduces the amount of wasted I/O per query because the DBMS only reads the data that it needs.
- Faster query processing because of increased localitly and cached data reuse.
- Better data compression.
- Slow for point queries, inserts, updates, and deletes.

Hybrid Storage Model (PAX)

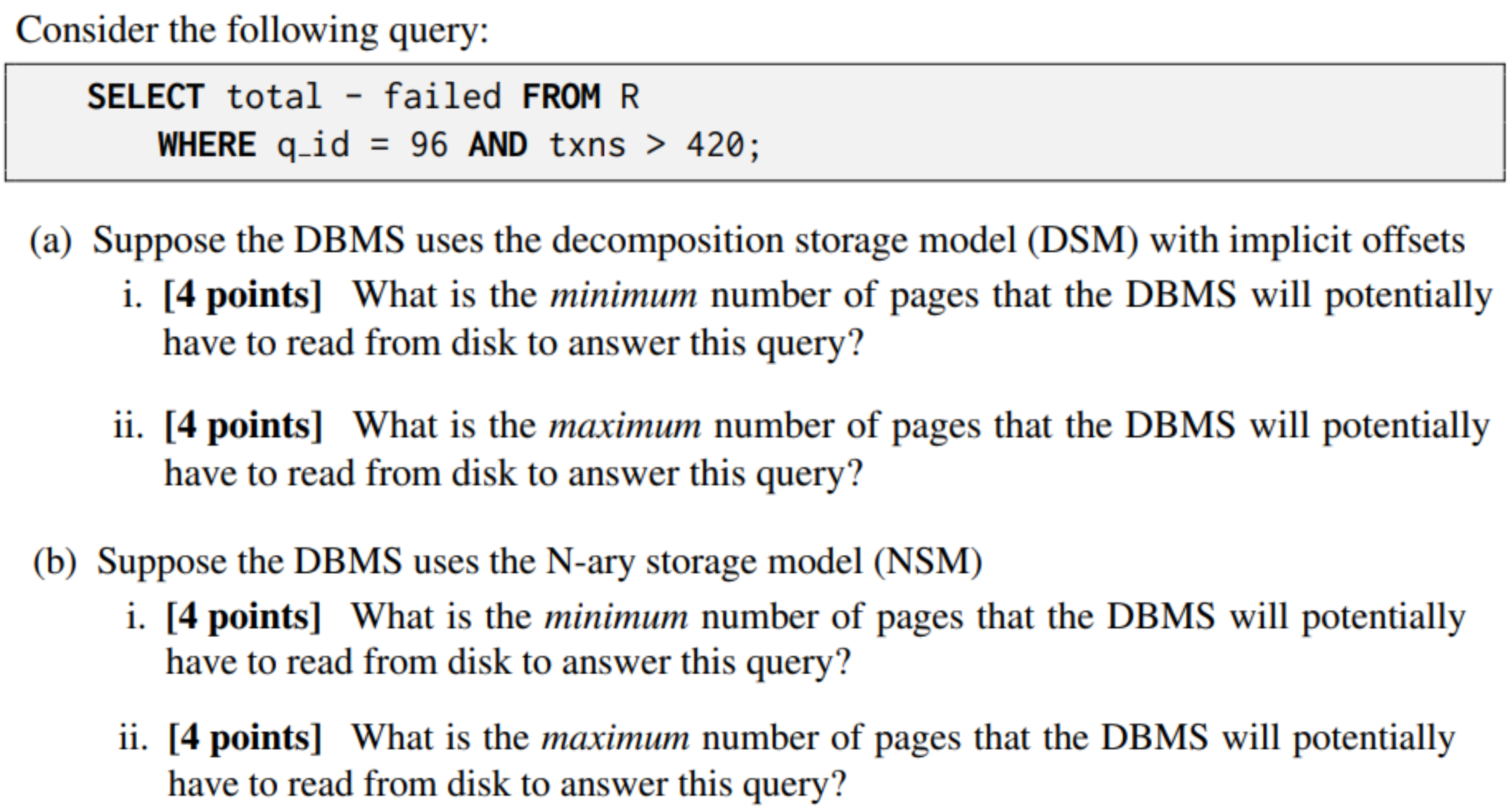
- First partition rows (tuples) into groups.
- Then vertically partition their attributes into columns.
- Global header contains directory with the offsets to the file’s row groups.
- Each row group contains its own metadata header.

Exercise

Consider a database with a single table `R(q_id,txns,total,failed)`, where `q_id` is the *primary key*, and all attributes are the same fixed width. Suppose `R` has 20,000 tuples that fit into 100 pages, Ignore any additional storage overhead for the table (e.g., page headers, tuple headers). Additionally, you should make the following assumptions:

- The DBMS does *not* have any additional meta-data (e.g., sort order, zone maps).
- `R` does *not* have any indexes (including for primary key `q_id`)
- None of `R`'s pages are already in the buffer pool.

Exercise



Consider the following query:

```
    SELECT total - failed FROM R
        WHERE q_id = 96 AND txns > 420;
```

(a) Suppose the DBMS uses the decomposition storage model (DSM) with implicit offsets

i. **[4 points]** What is the *minimum* number of pages that the DBMS will potentially have to read from disk to answer this query?

ii. **[4 points]** What is the *maximum* number of pages that the DBMS will potentially have to read from disk to answer this query?

(b) Suppose the DBMS uses the N-ary storage model (NSM)

i. **[4 points]** What is the *minimum* number of pages that the DBMS will potentially have to read from disk to answer this query?

ii. **[4 points]** What is the *maximum* number of pages that the DBMS will potentially have to read from disk to answer this query?

(a)
i. 4
ii. 28

(b)
i. 1
ii. 100

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Compression (columnar)

- Run-Length: Compress runs of the same value in a single column into triplets: (value, start position, length of runs).
- Bit-Packing: Reduce the number of bits to represent each value.
- Bitmap: Similar to One-hop coding, store a separate bitmap for each unique value for an attribute.
- Delta: Recording the difference between values that follow each other in the same column.
- Dictionary: Replace frequent values with smaller fixed-length codes and then maintain a mapping from the codes to the original values.

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Q&A

Thanks to the previous CSC3170 teaching team from which part of the content was sourced.