ICS 624 Spring 2013

One Size Fits All: An Idea Whose Time Has Come and Gone

Asst. Prof. Lipyeow Lim

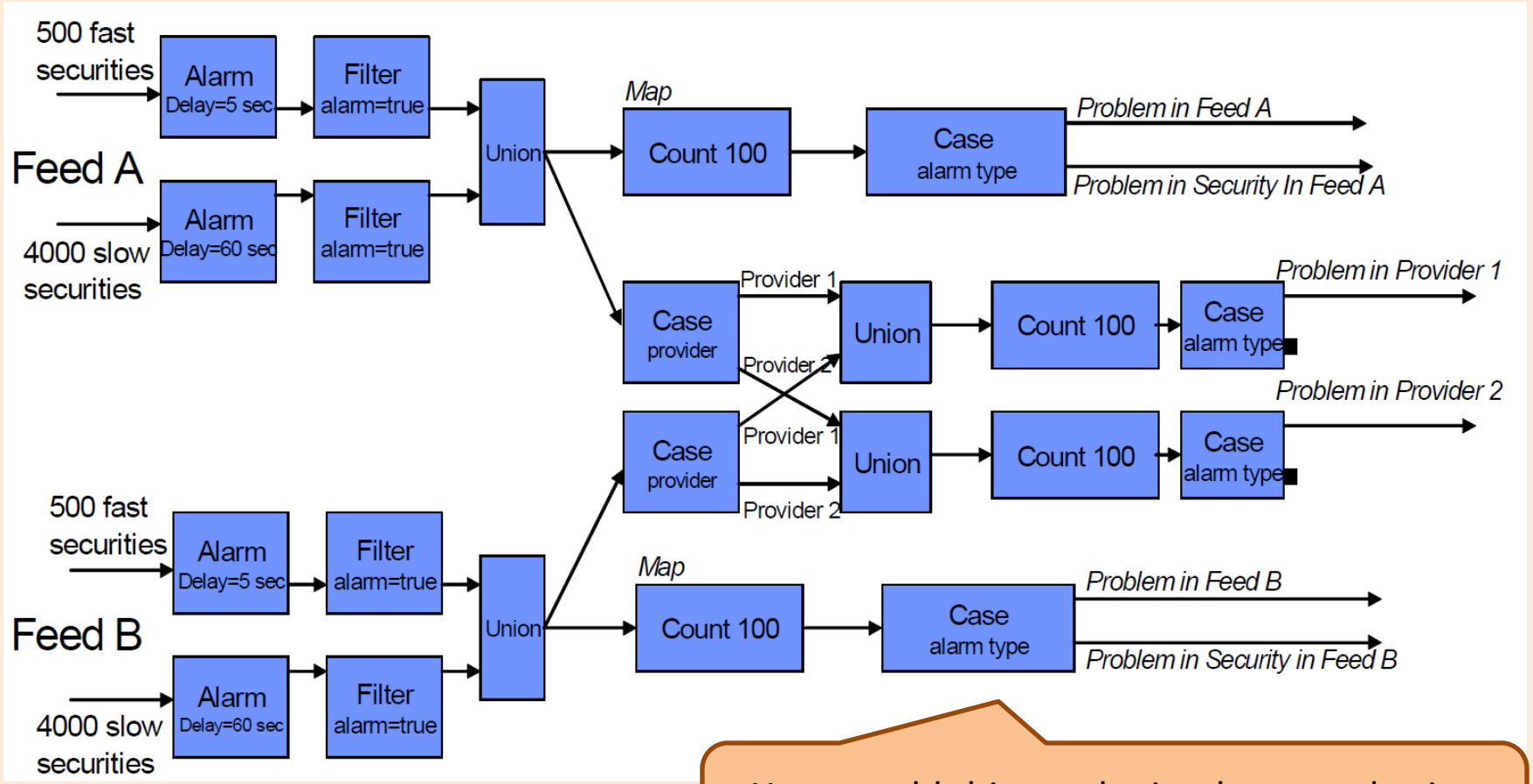
Information & Computer Science Department

University of Hawaii at Manoa

One Size Fits All

- Different applications have very different data management requirements
- DBMS vendors try to sell DBMS as DM solution to almost every application
- DBMSs are too bloated – “elephants” -- for many of today’s applications

Financial-Feed Streaming Application

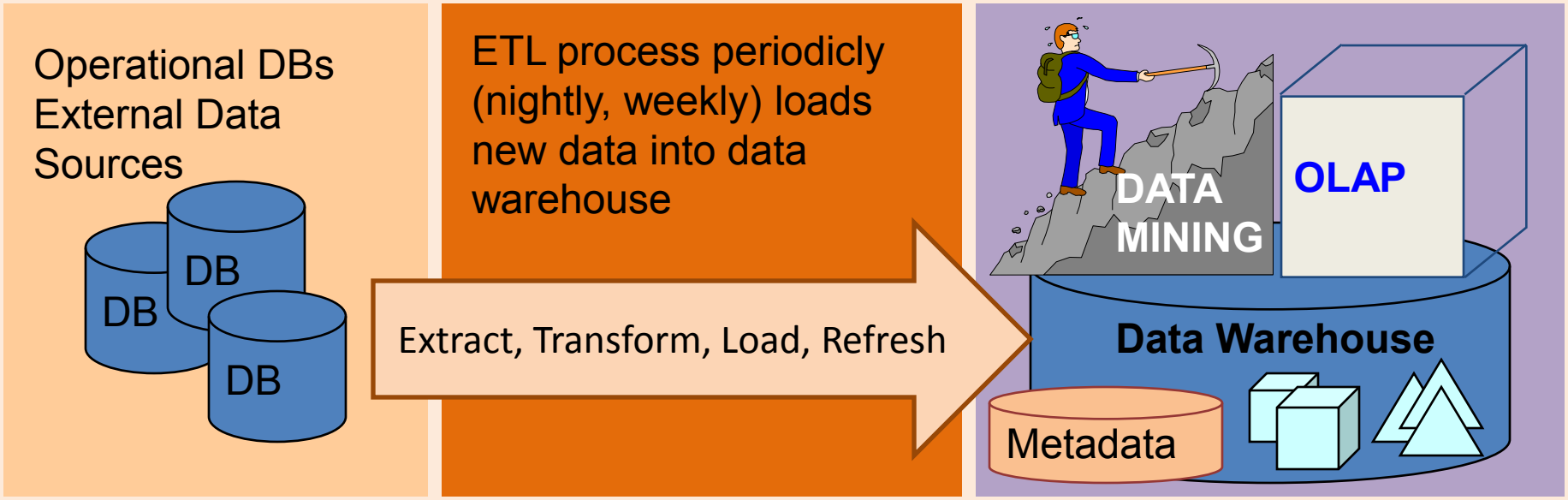


How would this app be implemented using DBMS technology ?

Outline

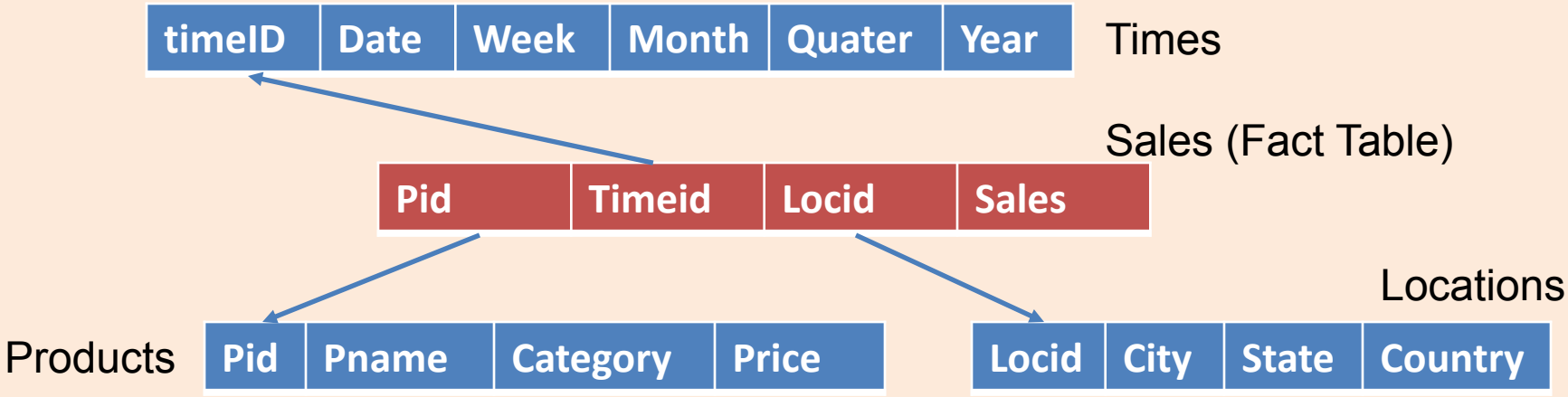
- Background
  - Data Warehousing
  - Indexing
  - Views
  - Transactions
  - Stream Processing
  - High Availability
  - Row vs Column storage
- Financial-Feed Streaming Application (revisited)
- Other Applications
- Software Architectures

Data Warehousing



- Multi-dimensional Data Model
- Collection of numeric measures, which depend on a set of dimensions.
  - E.g., measure **Sales**, dimensions **Product** (key: pid), **Location** (locid), and **Time** (timeid).

Conceptual Design of Data Warehouses



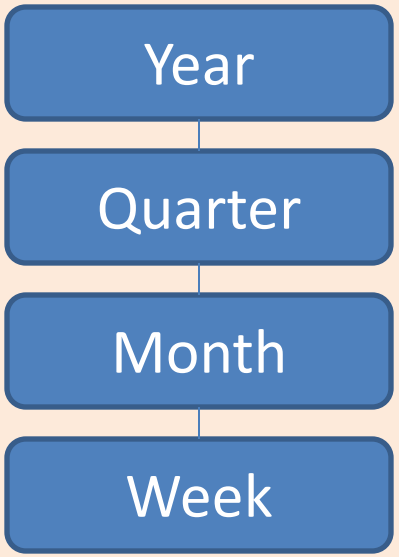
- Fact table in BCNF; dimension tables un-normalized.
  - Dimension tables are small; updates/inserts/deletes are rare. So, anomalies less important than query performance.
- This kind of schema is very common in OLAP applications, and is called a star schema; computing the join of all these relations is called a star join.

OLAP Queries

- Influenced by SQL and by spreadsheets.
- A common operation is to aggregate a measure over one or more dimensions.
  - Find total sales.
  - Find total sales for each city, or for each state.
  - Find top five products ranked by total sales.
- Roll-up: Aggregating at different levels of a dimension hierarchy.
  - E.g., Given total sales by city, we can roll-up to get sales by state.

More OLAP Queries

- Drill-down: The inverse of roll-up.
  - E.g., Given total sales by state, can drill-down to get total sales by city.
  - E.g., Can also drill-down on different dimension to get total sales by product for each state.
- Pivoting: Aggregation on selected dimensions.
  - E.g., Pivoting on Location and Time yields this **cross-tabulation**:
- Slicing and Dicing: Equality and range selections on one or more dimensions.



Year\ State	WI	CA	Total
1995	63	81	144
1996	38	107	145
1997	75	35	110
Total	176	223	339

Comparison with SQL Queries

- The cross-tabulation obtained by pivoting can also be computed using a collection of SQLqueries:

Year\ State	WI	CA	Total
1995	63	81	144
1996	38	107	145
1997	75	35	110
Total	176	223	339

```
SELECT SUM(S.sales)
FROM   Sales S, Times T, Locations L
WHERE  S.timeid=T.timeid AND S.locid=L.locid
GROUP BY T.year, L.state
```

```
SELECT SUM(S.sales)
FROM   Sales S, Times T
WHERE  S.timeid=T.timeid
GROUP BY T.year
```

```
SELECT SUM(S.sales)
FROM   Sales S, Location L
WHERE  S.locid=L.locid
GROUP BY L.state
```

Views

```
CREATE  VIEW  YoungActiveStudents (name, grade) AS
        SELECT   S.name, E.grade
        FROM  Students S, Enrolled E
        WHERE  S.sid = E.sid and S.age<21
```

- A *view* is just a relation, but we store a *definition*, rather than a set of tuples.
- Views can be dropped using the DROP VIEW command.
- What if table that the view is dependent on is dropped ?
  - DROP TABLE command has options to let the user specify this.

Querying Views

```
CREATE VIEW YoungActiveStudents (name, grade) AS
        SELECT S.name, E.grade
        FROM Students S, Enrolled E
        WHERE S.sid = E.sid and S.age<21
```

```
SELECT name
FROM YoungActiveStudents
WHERE grade = 'A'
```

Query views as with any table

Conceptually, you can think of rewriting using a subquery

```
SELECT name
FROM (SELECT S.name, E.grade
        FROM Students S, Enrolled E
        WHERE S.sid = E.sid and S.age<21)
WHERE grade = 'A'
```

Materialized Views

```
CREATE VIEW ParamountMovies AS
 SELECT title, year
 FROM movies
 WHERE studioName='Paramount'
```

```
CREATE TABLE ParamountMovies AS
 (SELECT title, year
 FROM movies
 WHERE studioName='Paramount')
```

- Views can be "materialized" for efficiency
- Updating the materialized view (materialized query table in DB2) : incremental or batch

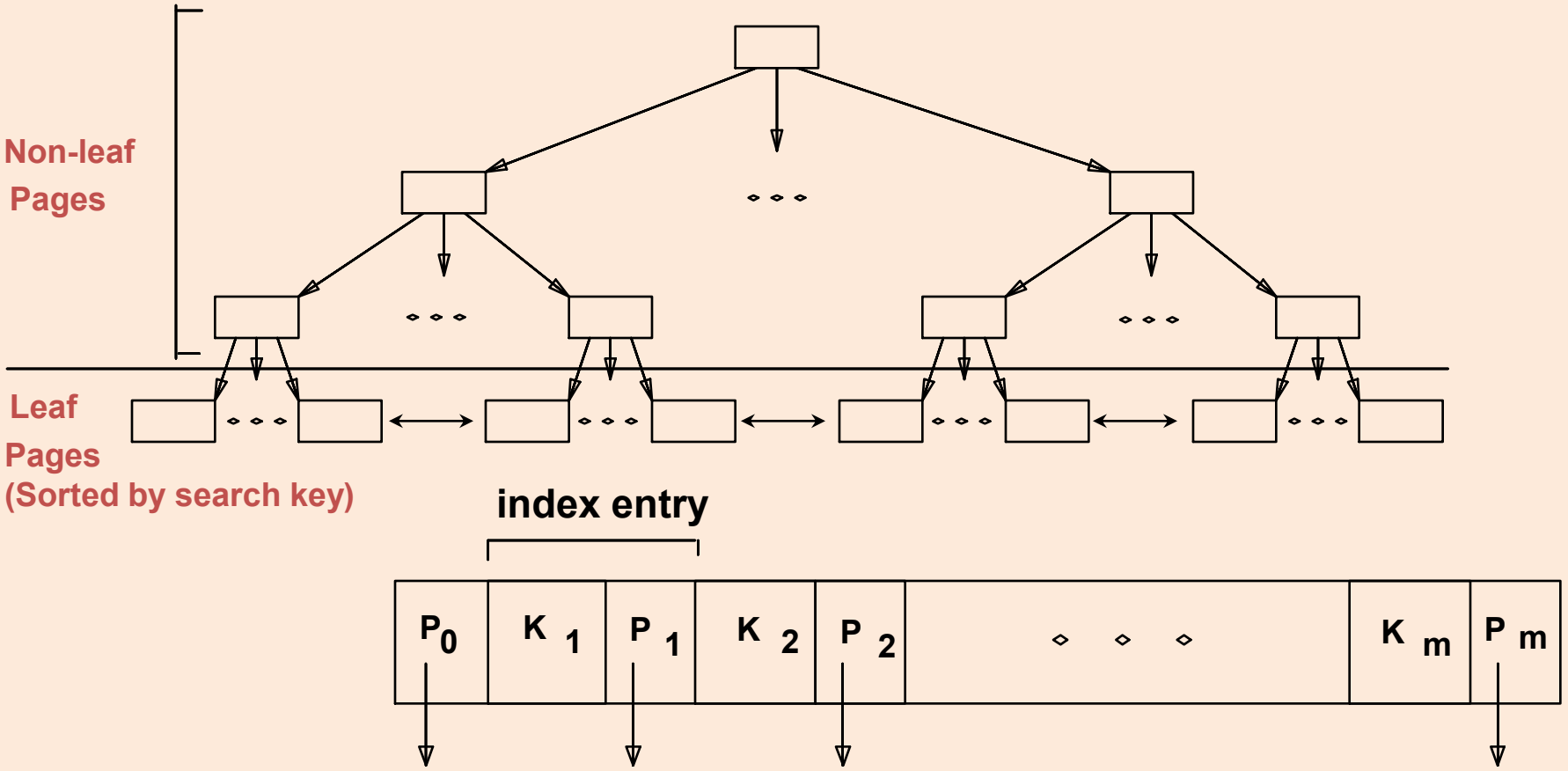
Queries on base relation may be able to exploit materialized views!

```
SELECT title
FROM movies
WHERE studioName='Paramount'
AND year=1990)
```

Indexes

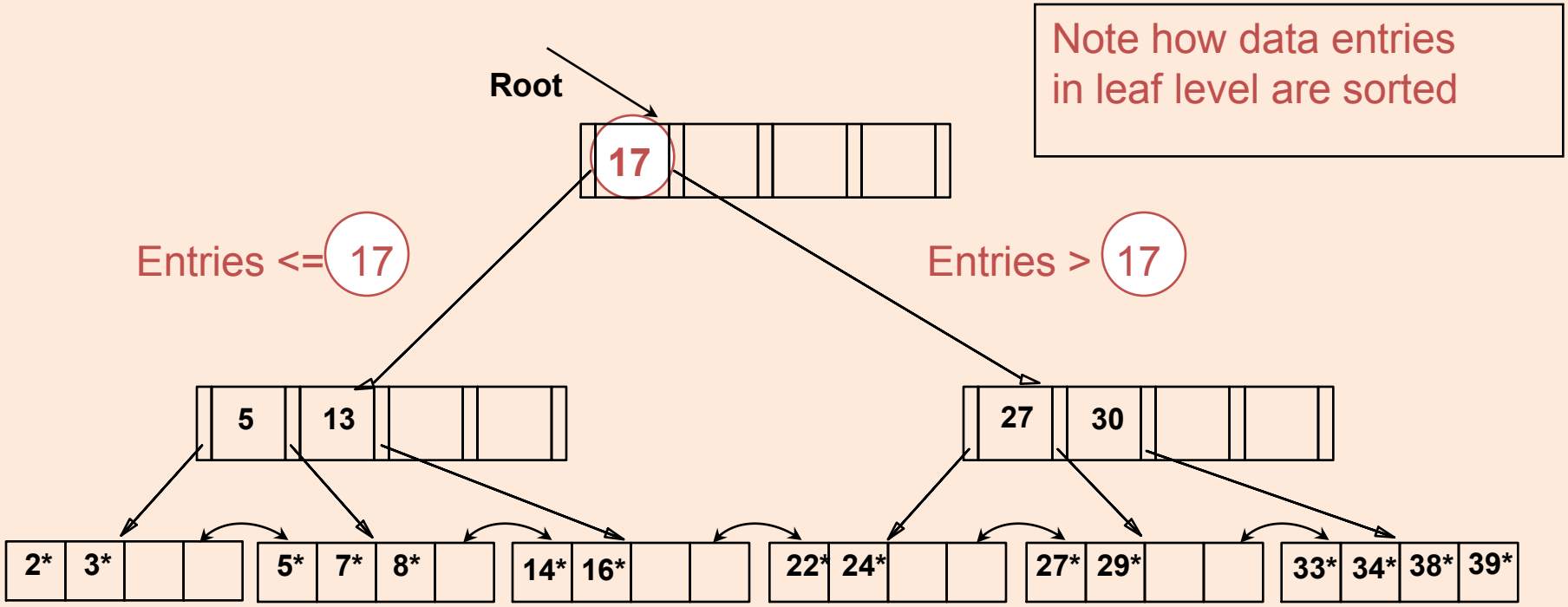
- An *index* on a file speeds up selections on the *search key fields* for the index.
  - Any subset of the fields of a relation can be the search key for an index on the relation.
  - *Search key* is not the same as *key* (minimal set of fields that uniquely identify a record in a relation).
- An index contains a collection of *data entries*, and supports efficient retrieval of all data entries **k*** with a given key value **k**.
  - A data entry is usually in the form <key, rid>
  - Given data entry k*, we can find record with key k in at most one disk I/O. (Details soon …)

B+ Tree Indexes



- Leaf pages contain **data entries**, and are chained (prev & next)
- A data entry typically contain a key value and a rid.
- Non-leaf pages have **index entries**; only used to direct searches:

Example B+ Tree



- Find 28*? 29*? All > 15* and < 30*
- Insert/delete: Find data entry in leaf, then change it. Need to adjust parent sometimes.
  - And change sometimes bubbles up the tree

Bitmap Indexes

Boats Relation

bid	bname	color
101	Interlake	Blue
102	Interlake	Red
103	Clipper	green
104	Marine	Red

Bitmap index for color

Blue	Red	Green
1	0	0
0	1	0
0	0	1
0	1	0

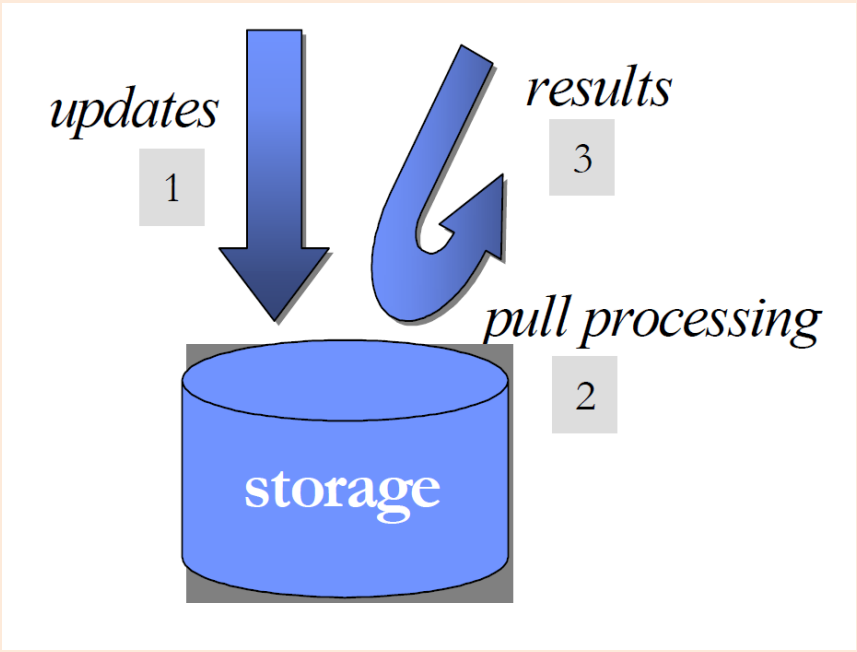
- One bit vector for each distinct column value
- Length of bit vector is the cardinality of the relation instance
- Logical bitwise operations used to answer queries
- Bit vectors can be encoded and compressed

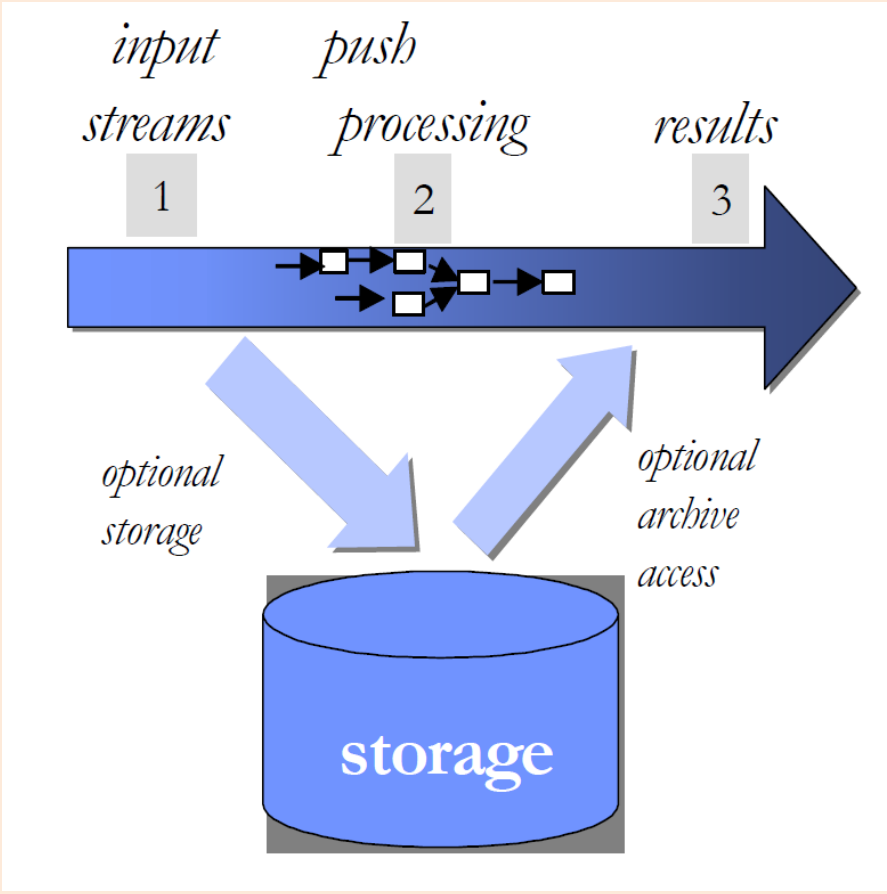
Stream Processing

- Continuous, unbounded, rapid, time-varying streams of data elements (tuples).
- Examples of streaming applications
  - Network monitoring and traffic engineering, Sensor networks, RFID tags, Telecom call records, Financial applications, Web logs and click-streams, Manufacturing processes
- DSMS = Data Stream Management System

DBMS	Streaming System
Persistent relations	Transient Streams (& relations)
One time queries	Continuous Queries
Random Access	Sequential Access
Access plan determined by DBMS	Unpredictable data characteristics

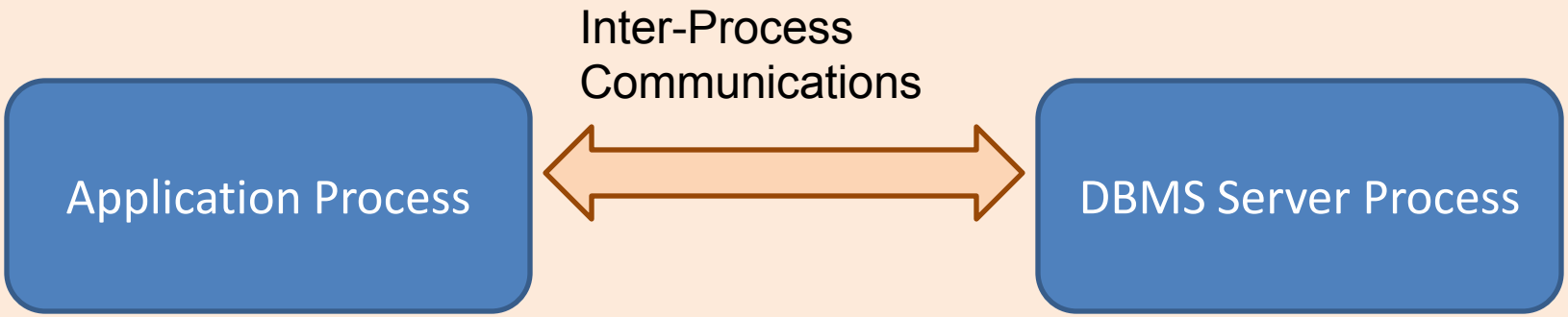
Pull vs Push


updates
1
results
3
pull processing
2
storage

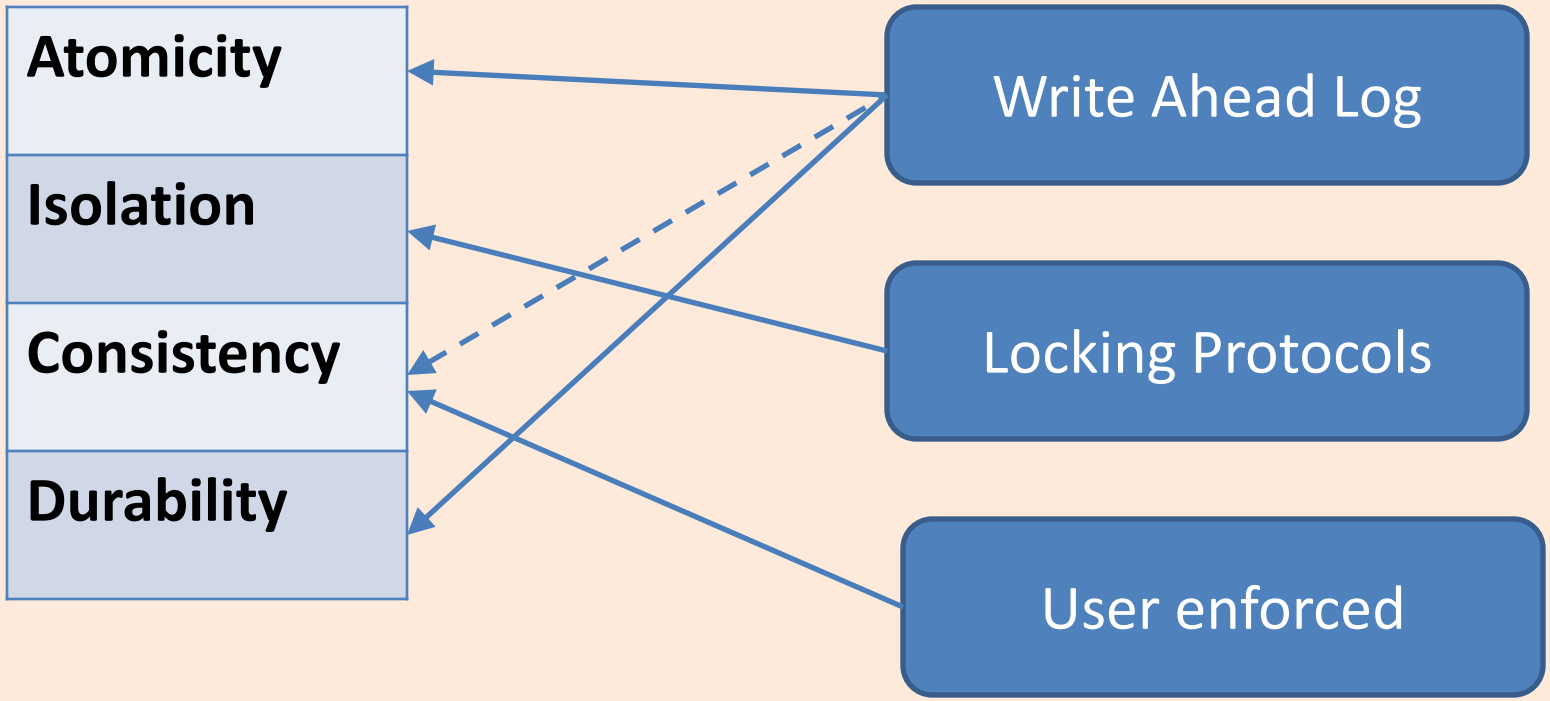

input
streams
1
push
processing
2
results
3
optional
storage
optional
archive
access
storage

Process Model

- An **Operating System Process** combines an operating system (OS) program execution unit (a thread of control) with an address space private to the process. This single unit of program execution is scheduled by the OS kernel and each process has its own unique address space.



Transactions



The Log

- The following actions are recorded in the log:
  - *Ti writes an object*: the old value and the new value.
    - Log record must go to disk *before* the changed page! (Write Ahead Log property)
  - *Ti commits/aborts*: a log record indicating this action.
- Log records are chained together by Xact id, so it's easy to undo a specific Xact.
- Log is often *duplexed* and *archived* on stable storage.
- All log related activities (and in fact, all CC related activities such as lock/unlock, dealing with deadlocks etc.) are handled transparently by the DBMS.

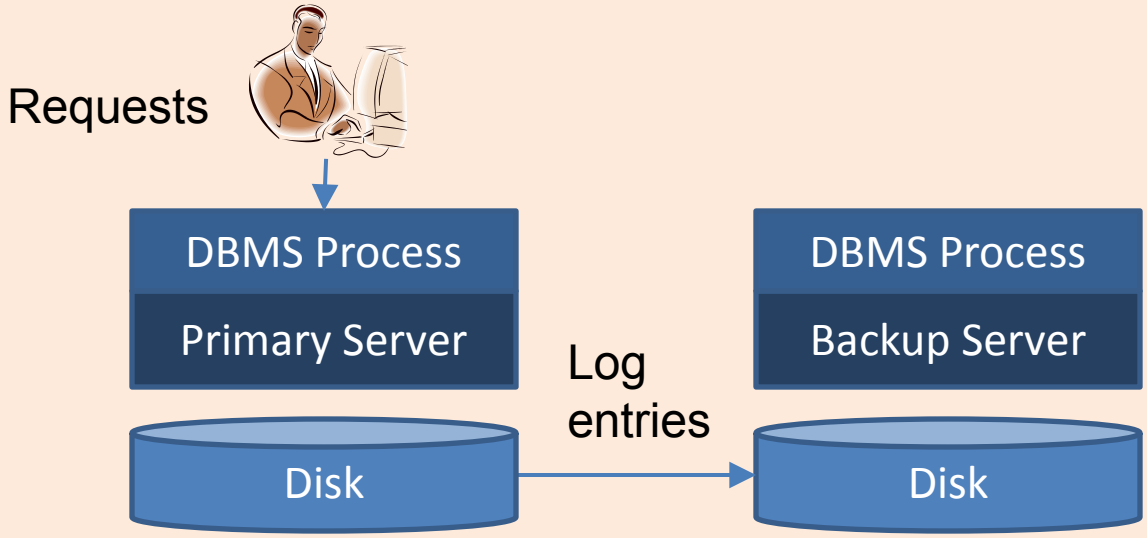
Recovering from a Crash

- There are 3 phases in the *Aries* recovery algorithm:
  - *Analysis*: Scan the log forward (from the most recent *checkpoint*) to identify all Xacts that were active, and all dirty pages in the buffer pool at the time of the crash.
  - *Redo*: Redoes all updates to dirty pages in the buffer pool, as needed, to ensure that all logged updates are in fact carried out and written to disk.
  - *Undo*: The writes of all Xacts that were active at the crash are undone (by restoring the *before value* of the update, which is in the log record for the update), working backwards in the log. (Some care must be taken to handle the case of a crash occurring during the recovery process!)

Lock-based Concurrency Control

- *Strict Two-phase Locking (Strict 2PL) Protocol*:
  - Each Xact must obtain a S (*shared*) lock on object before reading, and an X (*exclusive*) lock on object before writing.
  - All locks held by a transaction are released when the transaction completes
  - If an Xact holds an X lock on an object, no other Xact can get a lock (S or X) on that object.
- Strict 2PL allows only serializable schedules.
  - Additionally, it simplifies transaction aborts

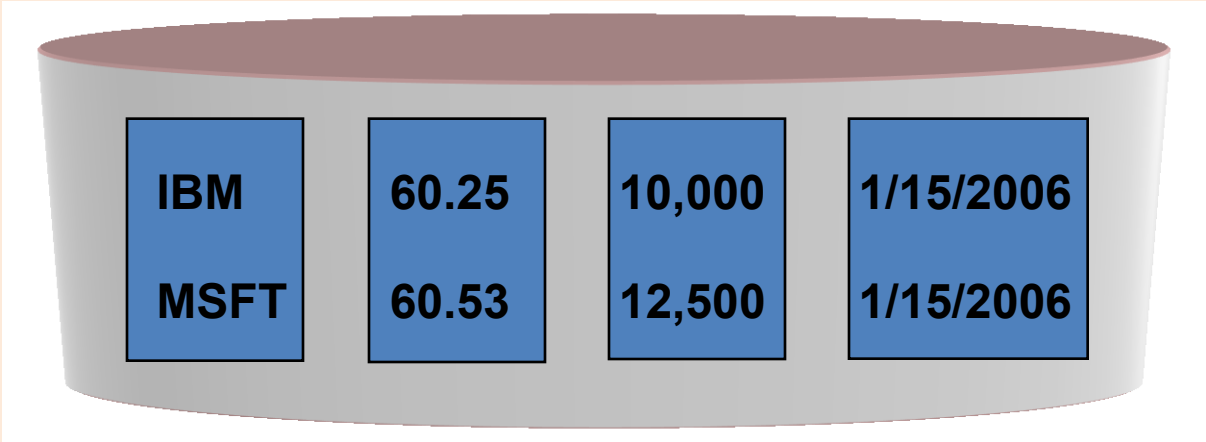
High Availability



- A database system is highly available (HA) if it remains accessible to users in the face of hardware failures.
- Transaction logging techniques already provides crash recovery
- HA requires close to zero down time.

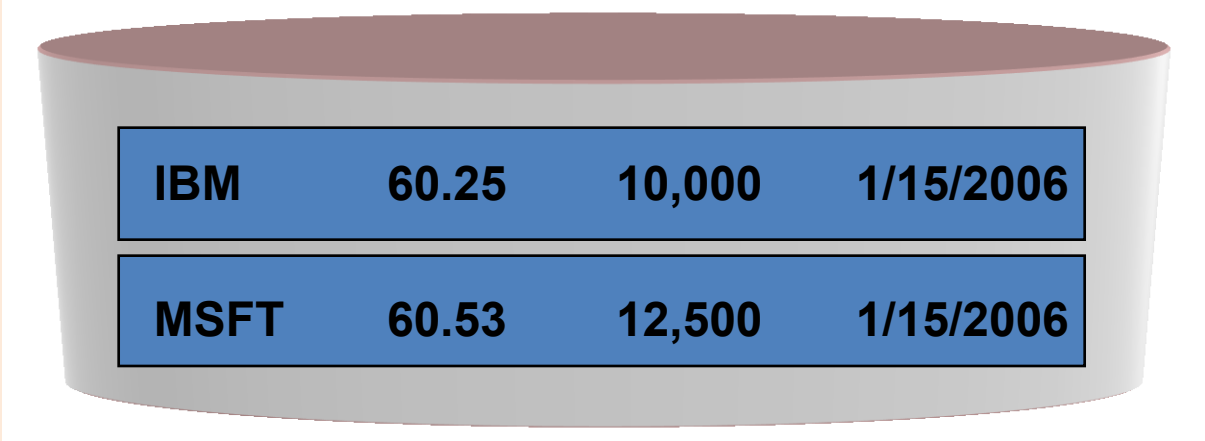
Row vs Column Storage

Column Store:



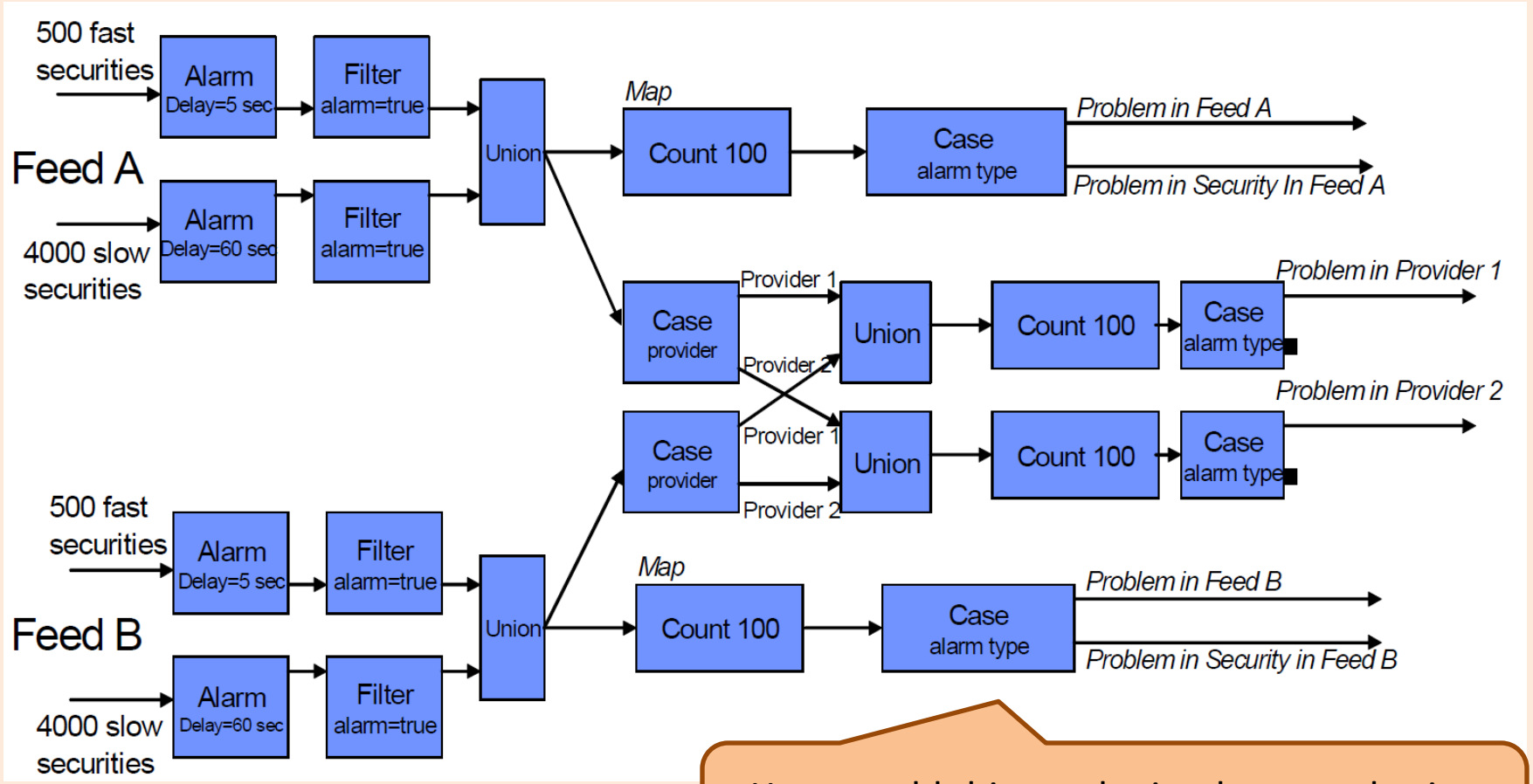
Used in: Sybase IQ, **Vertica**

Row Store:



Used in: Oracle, SQL Server, DB2, Netezza,…

Financial-Feed Streaming Application

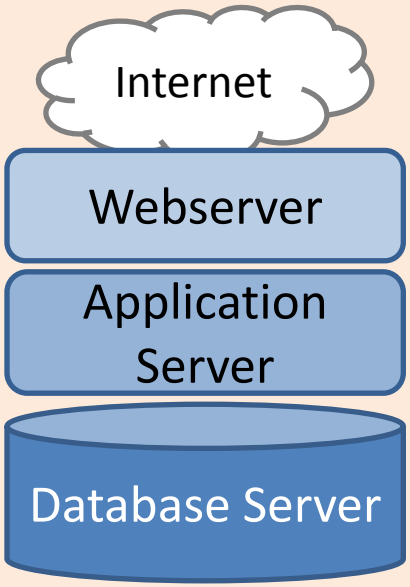


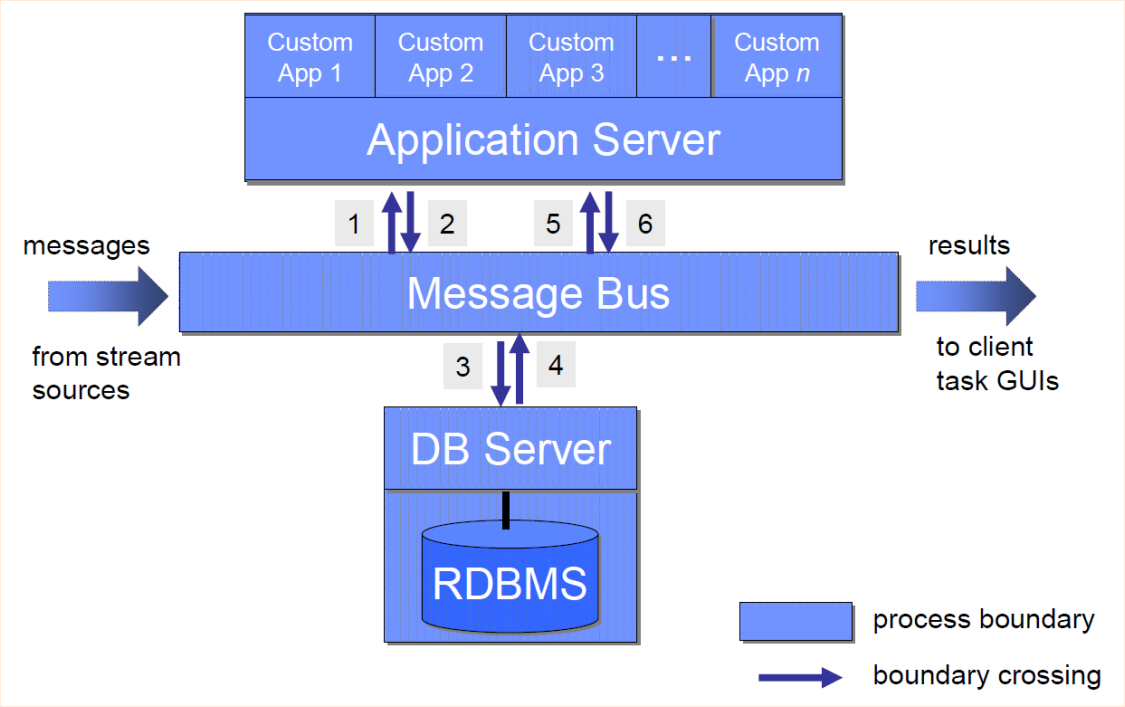
How would this app be implemented using DBMS technology ?

Other Applications

- **Data Warehouse**.
- **Sensor Networks**. eg. Medical monitoring, smart homes, etc
- **Text Search**. eg. Search engines
- **Scientific Databases**. Eg. Astronomy, Meteorology, Oceanography
- **XML**

Software Architectures





- Three basic services
  - Message Transport
  - Storage of state
  - Execution of application logic