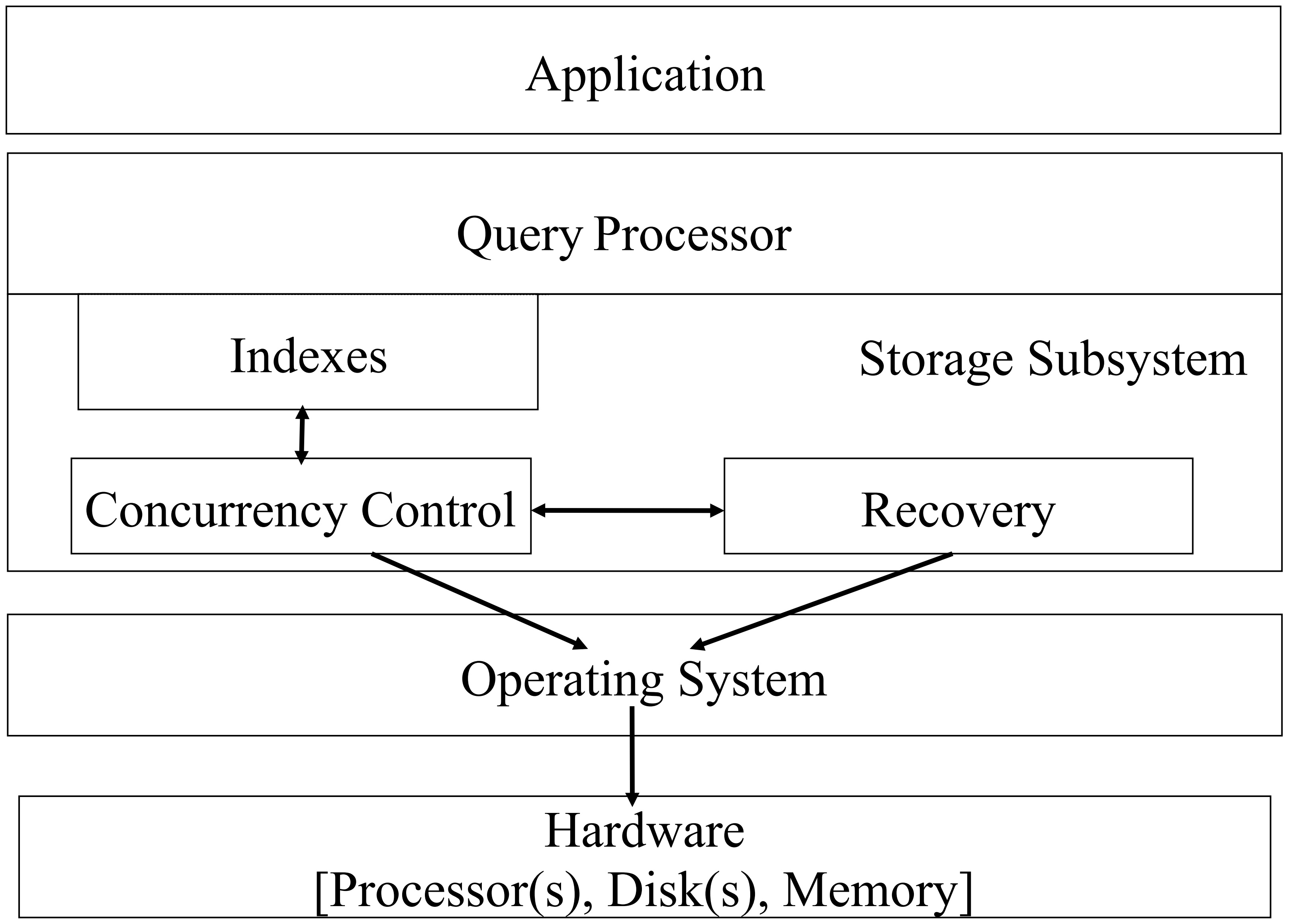
Communicating with the Outside


Application
Query Processor
Indexes
Storage Subsystem
Concurrency Control
Recovery
Operating System
Hardware
[Processor(s), Disk(s), Memory]

Database Programming

- Programming language +
  Call Level Interface
  - ODBC: Open DataBase Connectivity
  - JDBC: Java based API
  - OCI (C++/Oracle), CLI (C++/ DB2)
  - Perl/DBI
- ORM: Object-relational mapping

API pitfalls

- Cost of portability
  - Layer of abstraction on top of ODBC drivers to hide discrepancies across drivers with different conformance levels.
  - Beware of performance problems in this layer of abstraction:
    - Use of meta-data description when submitting queries, accessing the result set
    - Iterations over the result set

Client-Server Mechanisms

- Connection pooling and multiplexing when multiple clients access a server
- Communication buffer on the database server. One per connection.
  - If a client does not consume results fast enough, then the server holds resources until it can output the result.
  - Data is sent either when the communication buffer is full or when a batch is finished executing.
    - Small buffer – frequent transfer overhead
    - Large buffer – time to first record increases.
    - No actual impact on a 100 Mb network. More sensitive in an intranet with low bandwidth.

Object-Orientation Considered Harmful

- authorized(user, type)
- doc(id, type, date)
- What are the document instances a user can see?
- SQL:

```
select doc.id, doc.date
from authorized, doc
where doc.type =
authorized.type
and authorized.user = <input>
```

- If each document is encapsulated in an object, the risk is the following:
  - Find types t authorized for user *input*

    ```
    select doc.type as t
    from authorized
    where user = <input>
    ```

  - For each type *t* issue the query

    ```
    select id, date
    from doc
    where type = <t>;
    ```

  - The join is executed in the application and not in the DB!

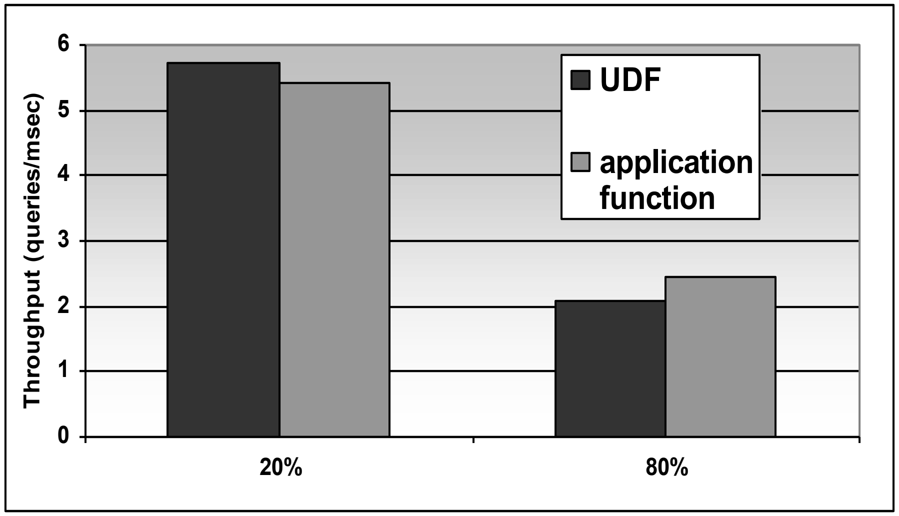
Avoid User Interaction within a Transaction

- User interaction within a transaction forces locks to be held for a long time.
- Careful transaction design (possibly transaction chopping) to avoid this problem.

Minimize the Number of Roundtrips to the Database

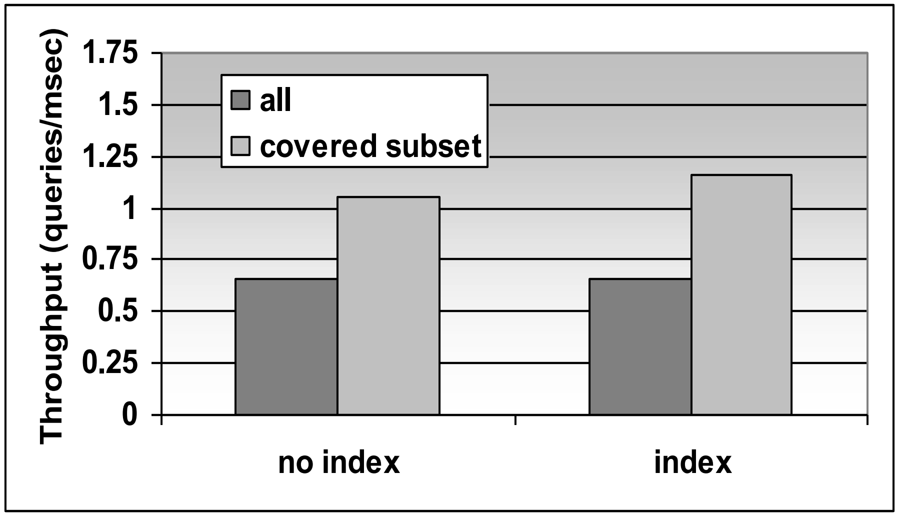
- Avoid Loops:
  - Application programming languages offer looping facilities (SQL statements, cursors, positioned updates)
  - Rigid object-oriented programming might force such loops.
- Package several SQL statements within one call to the database server:
  - Embedded procedural language (Transact SQL) with control flow facilities.
- Use User Defined Functions (UDFs) when they select out a high number of records.

User Defined Functions



- Function computes the number of working days between two dates.
- Function executed either on the database site (UDF) or on the application site
- Applying the UDF yields good performances when it helps reduce significantly the amount of data sent back to the application.

Retrieve Needed Columns Only

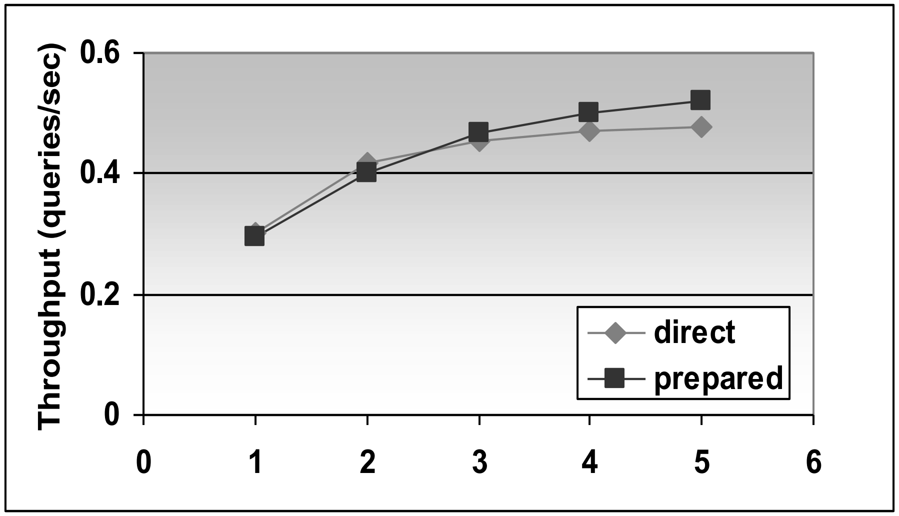


- Avoid transferring unnecessary data
- Might prevent the use of a covering index.
- In the experiment the subset contains ¼ of the attributes.
  - Reducing the amount of data that crosses the application interface yields significant performance improvement.

Retrieve Needed Rows Only

- If the user is only viewing a small subset of a very large result set, it is best to
  - Only transfer that subset
  - Only compute that subset
- Applications that allow the formulation of ad-hoc queries should permit users to cancel them.

Minimize the Number of Query Compilations



Experiment performed on Oracle8iEE on Windows 2000.

- Prepared execution yields better performance when the query is executed more than once:
  - No compilation
  - No access to catalog.
- Prepared execution plans become obsolete if indexes are added or the size of the relation changes.

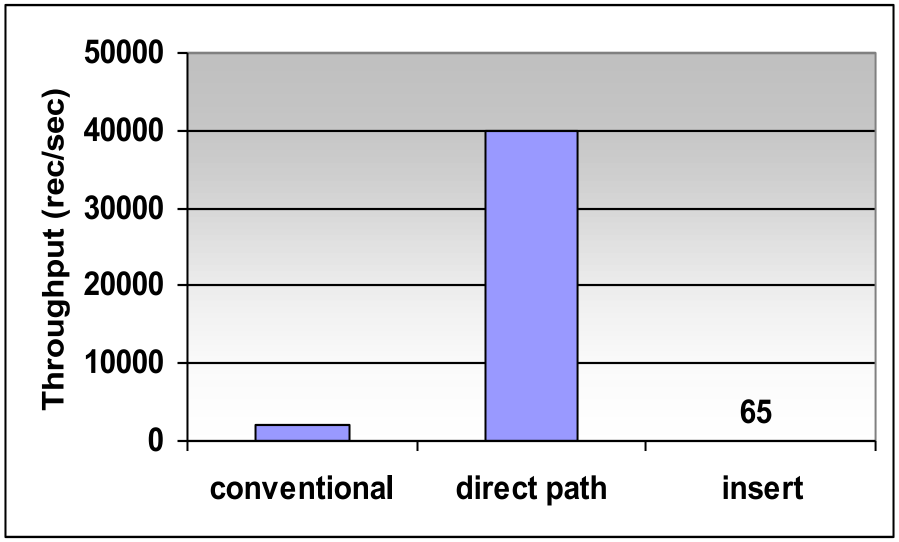
Tuning the Application Interface

- Avoid user interaction within a transaction
- Minimize the number of roundtrips between the application and the database
- Retrieve needed columns only
- Retrieve needed rows only
- Minimize the number of query compilations

Bulk Loading Data

- Tools to bulk load data in each system.
- Tool parameters:
  - Bypass query engine
  - Avoid logging
  - No index update
  - No constraint check
  - Frequency of commits

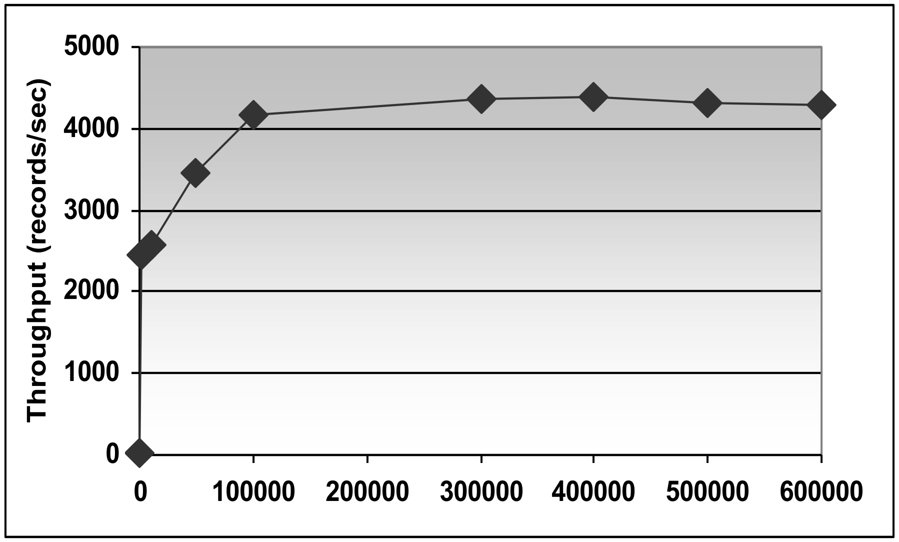
Direct Path



- Loading 600000 records into the lineitem relation from TPCH
- Direct path loading bypasses the query engine and the storage manager. It is orders of magnitude faster than conventional path (with a commit every 100 records) and inserts (with a commit for each record).

Experiment performed on Oracle8iEE on Windows 2000.

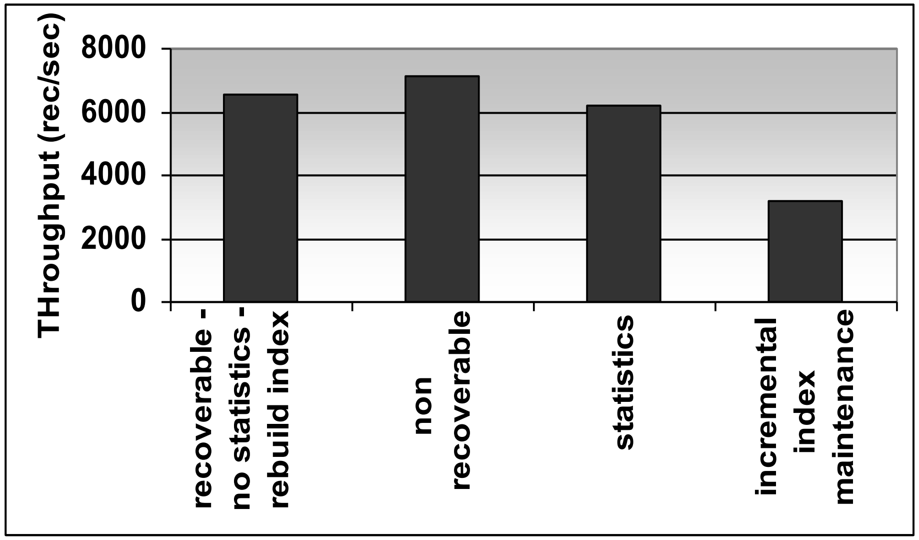
Batch Size



- Bulk load of 600000 records.
- Throughput increases steadily when the batch size increases to 100000 records.Throughput remains constant afterwards.
- Trade-off between performance and amount of data that has to be reloaded in case of problem.

Experiment performed on SQL Server 2000 on Windows 2000.

Storage Engine Parameters



- Bulk load of 600000 records.
- As expected:
  - Turning off logging helps.
  - Collecting statistics hurts
  - Maintaining indexes incrementally hurts a lot.

Experiment performed on IBM DB2 UDB V7.1 on Windows 2000.