Lecture 10

Parsing

~ Dynamic compilation

Query Optimizer

Parsing takes time.

Keep parsed queries in memory.

Query cache management

Least Recently Used (LRU)

Checksum + check tables are same and context identical

Binding queries

To help cache queries, we should use parameters and “bind” them at run time. The text of the query is unchanged whichever name we attach to it.

```
select m.title, m.year_released
from movies m
     inner join credits c
     on c.movieid = m.movieid
     inner join people p
     on p.peopleid = c.peopleid
where p.first_name = :first_name
  and p.surname = :surname
  and c.credited_as = 'D'
```

And unfortunately you cannot bind a table or column name, nor (which would be quite useful) a whole list of values.

```
select ...
from :my_table
where col in (:user_list)
order by :user_choice
```

Selectivity?

The optimizer will base its decision on the values passed when the query is first parsed. Nothing guarantees that the decision will still be adequate with other parameter values.

Cache Query Result

More radical, Read Only/Slowly Changing

Some products can go further than caching parsed queries and can even cache results associated with a query and its parameters.

It’s OK if the database is a read-only database or changes only very slowly (for instance, for a query such as retrieving the last articles in a blog).

SEVERAL problems

Atomicity Transactions (rollback)

Durability Persistence Consistency

Isolation Concurrency

ACID

- Atomicity

Related to a transaction, seen as a single unit.

- Consistency

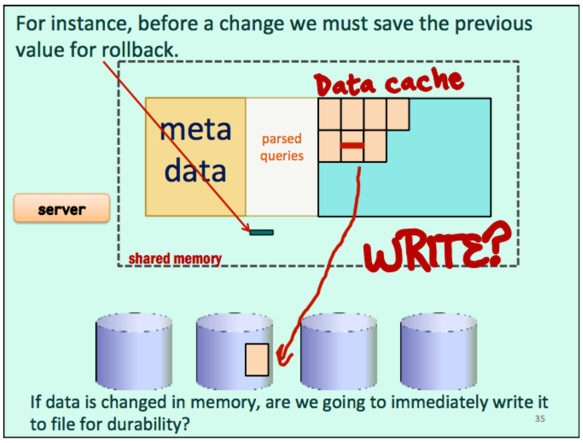
Data should always be seen as consistent (constraints)

- Isolation

When one user changes data, it should not make it inconsistent to others

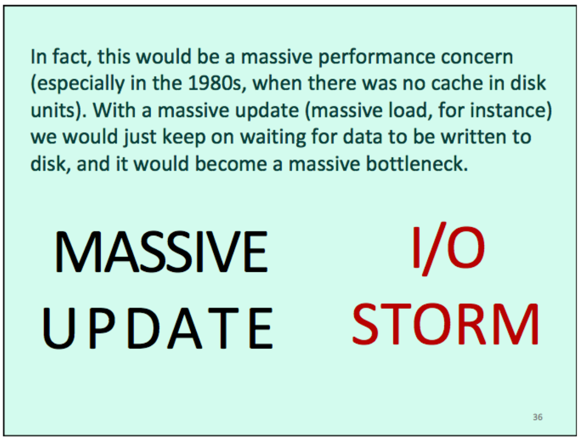
- Durability

When something is saved to a database, it should become persistent, whatever happens



For instance, before a change we must save the previous value for rollback.

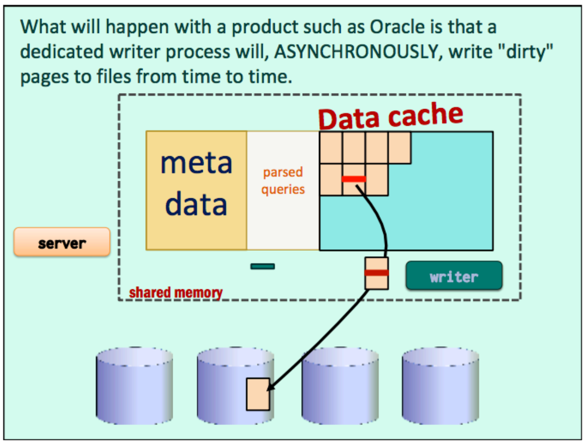
If data is changed in memory, are we going to immediately write it to file for durability?



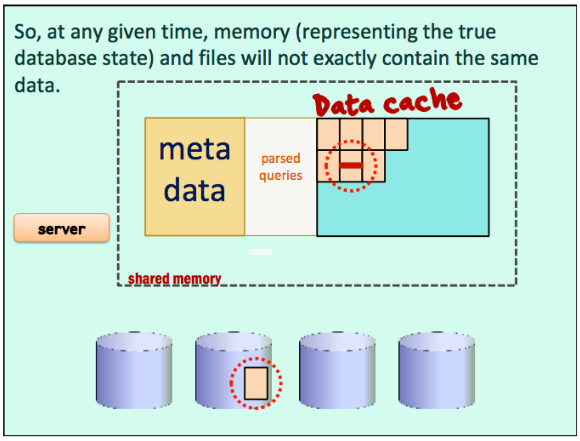
In fact, this would be a massive performance concern (especially in the 1980s, when there was no cache in disk units). With a massive update (massive load, for instance) we would just keep on waiting for data to be written to disk, and it would become a massive bottleneck.

MASSIVE UPDATE

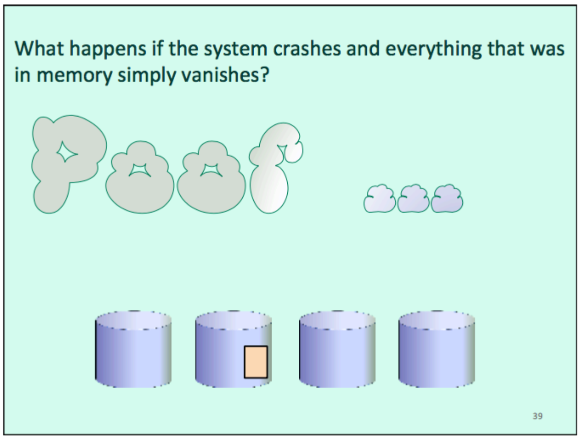
I/O STORM



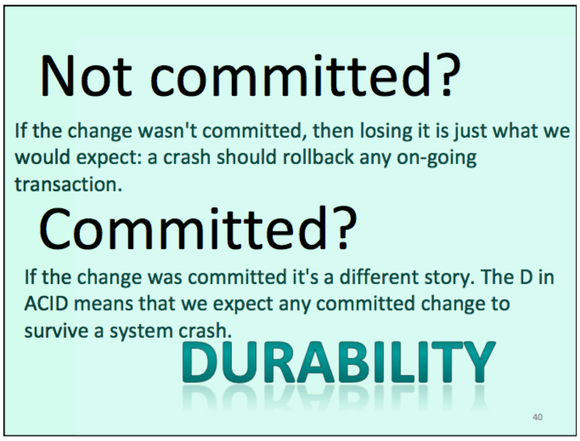
What will happen with a product such as Oracle is that a dedicated writer process will, ASYNCHRONOUSLY, write "dirty" pages to files from time to time.



So, at any given time, memory (representing the true database state) and files will not exactly contain the same data.



What happens if the system crashes and everything that was in memory simply vanishes?



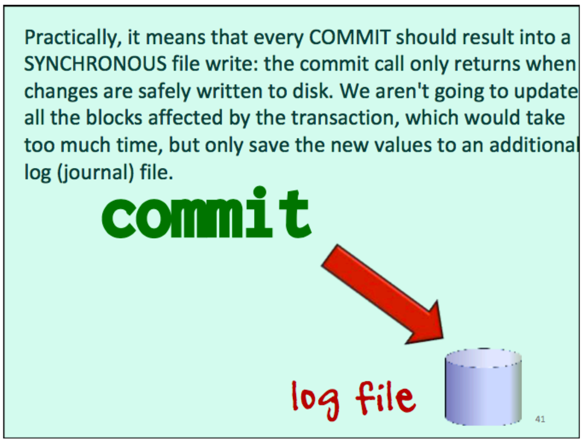
Not committed?

If the change wasn't committed, then losing it is just what we would expect: a crash should rollback any on-going transaction.

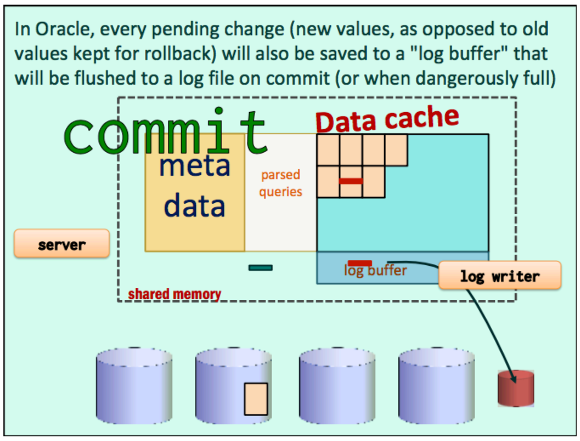
Committed?

If the change was committed it's a different story. The D in ACID means that we expect any committed change to survive a system crash.

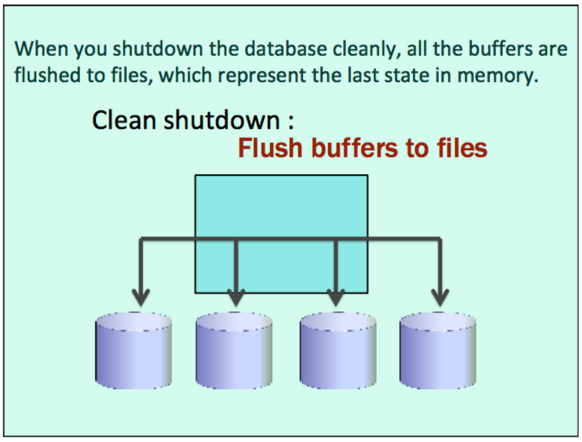
DURABILITY



Practically, it means that every COMMIT should result into a SYNCHRONOUS file write: the commit call only returns when changes are safely written to disk. We aren't going to update all the blocks affected by the transaction, which would take too much time, but only save the new values to an additional log (journal) file.

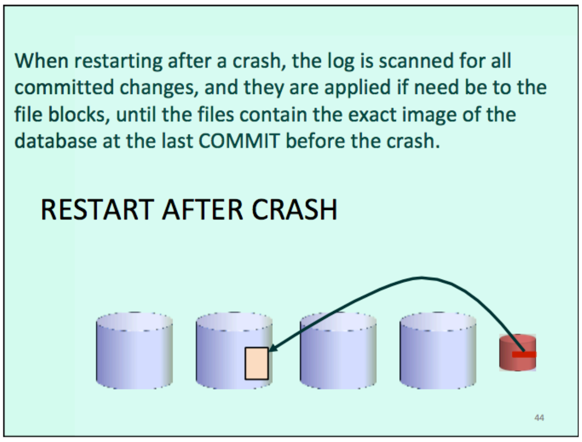


In Oracle, every pending change (new values, as opposed to old values kept for rollback) will also be saved to a "log buffer" that will be flushed to a log file on commit (or when dangerously full)



When you shutdown the database cleanly, all the buffers are flushed to files, which represent the last state in memory.

Clean shutdown :
Flush buffers to files



When restarting after a crash, the log is scanned for all committed changes, and they are applied if need be to the file blocks, until the files contain the exact image of the database at the last COMMIT before the crash.

RESTART AFTER CRASH

What about several sessions?

Dedicated Sessions

Assign to all connected users their own personal server process running SQL for them.

Session Pooling

Pre-start (which makes connection slightly faster) a number of servers, and to assign requests to them with a bit of load-balancing.

What about a session querying data being changed by another session?

The main problem is that a transaction can last “a certain time”. You may need to run a lot of code before deciding on commit or rollback.

```
Begin Transaction
Commit
```

During the transaction, the database will be in a kind of transient state of which you cannot say whether it will become permanent.

CONSISTENT STATE

Between two consistent states, you have a kind of black hole.

4 levels for ISOLATION

The SQL standard defines four isolation levels, from no isolation at all to paranoid. Some products let you set it, others impose it.

- ~~dirty reads~~
- read committed
- repeatable read
- serialization

Let's see once again how a transaction works. You start it. Before applying any change the DBMS saves the value from before your transaction, in case you'd want to rollback. Then you commit (or rollback) and the value previously saved for rollback (in memory or on file) can be marked as disposable.

~~Read Uncommitted (dirty read)~~

If when a user is changing data another user were able to read the new value before being sure that there will be no rollback, we would run into problems pretty soon.

Read Committed

But the "old" value belongs to a stable (committed) state of the database. What most DBMS products will do is that they will "serve" to the reader this value, at least known to be consistent and to have been once "official current value".

Repeatable read

Point-in-time read

However, once the writer has committed, in the read committed model whe should read the new, now official, value. It may be inconsistent with a previous read and we may favor consistency for the reader over timeliness.

In practice, the problem is more a problem of data consistency of foreign keys when we are scanning big related tables. A single SELECT will usually be consistent (a product such as Oracle ignores any change having happened since the start of the SELECT, even if it was committed). But if we SELECT twice (two different queries) from two tables with an FK relationship, changes that may have happened (and have been committed) between the time when we started reading the first table and the time when we were reading the second table may lead to problems such as orphaned rows.

Example: If I haven't read an uncommitted order when reading ORDER, then I should ignore rows refering to this order in ORDER_DETAIL even if they have been committed by the time I reach them.

Serialization

The last level is to block readers when data is being modified. Guaranteed to be consistent but bad for performances.

When you have twowritersyou cannot do otherwise than locking.

BACKUP ISSUES

SCALING UP

Adding servers

Neil Gunther's Universal Law of Computational Scalability

Lab 11

Slides

INFORMATION_SCHEMA (PostgreSQL Version)

Data Dictionary / Catalog

A set of tables that contain information about the objects in the database.

One catalog per database.

System tables

Any database stores "metadata" that describes the tables in your database (and not only them).

All client tools use this information to let you browse the structure of your tables

Whenever you are issuing DDL commands, you are actually modifiying system tables. They must NEVER be directly changed.

Read access to these tables is provided through system views.

In these views you only see what YOU are allowed to see. Only administrators see everything.

Most important tables for developers in `INFORMATION_SCHEMA` (PostgreSQL version)

- `TABLES`
- `COLUMNS`
- `TABLE_CONSTRAINTS`
- `CONSTRAINT_COLUMN_USAGE`
- `KEY_COLUMN_USAGE`
- `CHECK_CONSTRAINTS`

`SEQUENCES` `ROUTINES` `TRIGGERS` `VIEWS`

`VIEW_TABLE_USAGE`

Those are all views you should be aware of.

Nothing on indexes not associated with PK or UNIQUE constraint!

Must look into `pg_catalog`.

- `pg_index`
- `pg_class`
- `pg_attribute`

Stuff mostly for DB administrators

Roles and privileges

- `pg_class` relates tables to files on disk
- `pg_statistic` estimates used by the optimizer
- `pg_settings` database parameters

…