CS307
Database Principles

Chapter 14

14.1 Query Optimizer

Most contents are from Stéphane Faroult's slides

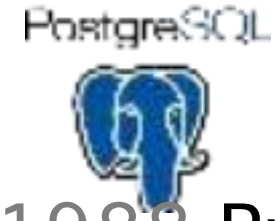
1978 Version 1

1985 Version 5

1988 Version 6

1987 Version 1

1989



1988 Prototype

1994 First release

ALL major DBMS products were designed in the 1980s (MySQL is more recent but was based on SQL Server). They CANNOT change their architecture because it would be, business-wise, suicidal for them to require from customers dumping and reloading today's massive databases for a migration. Only incremental improvements are possible.

This is what a $M 1 machine was

Mid 1980s looking like in the 1980s.

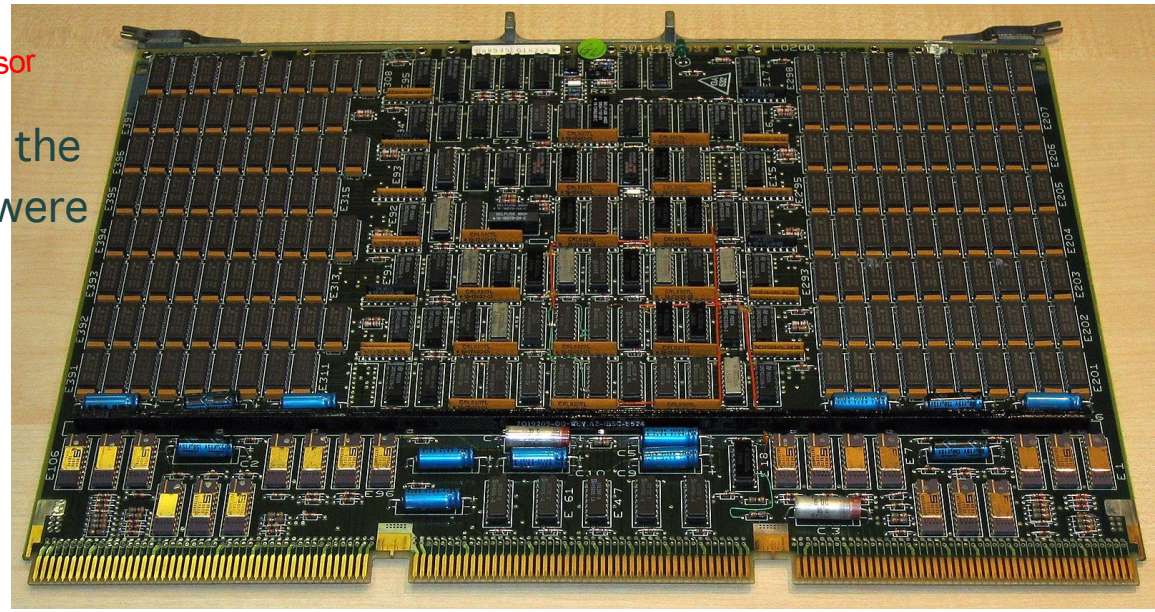
VAX 8600 (high-end)

- 32-bit architecture
- Processor, ~10 to 20MHz clock
- 4 to 256 Mb of memory

Beginning of multi-processor computers

Keep in mind that the big DBMS products were designed for this.

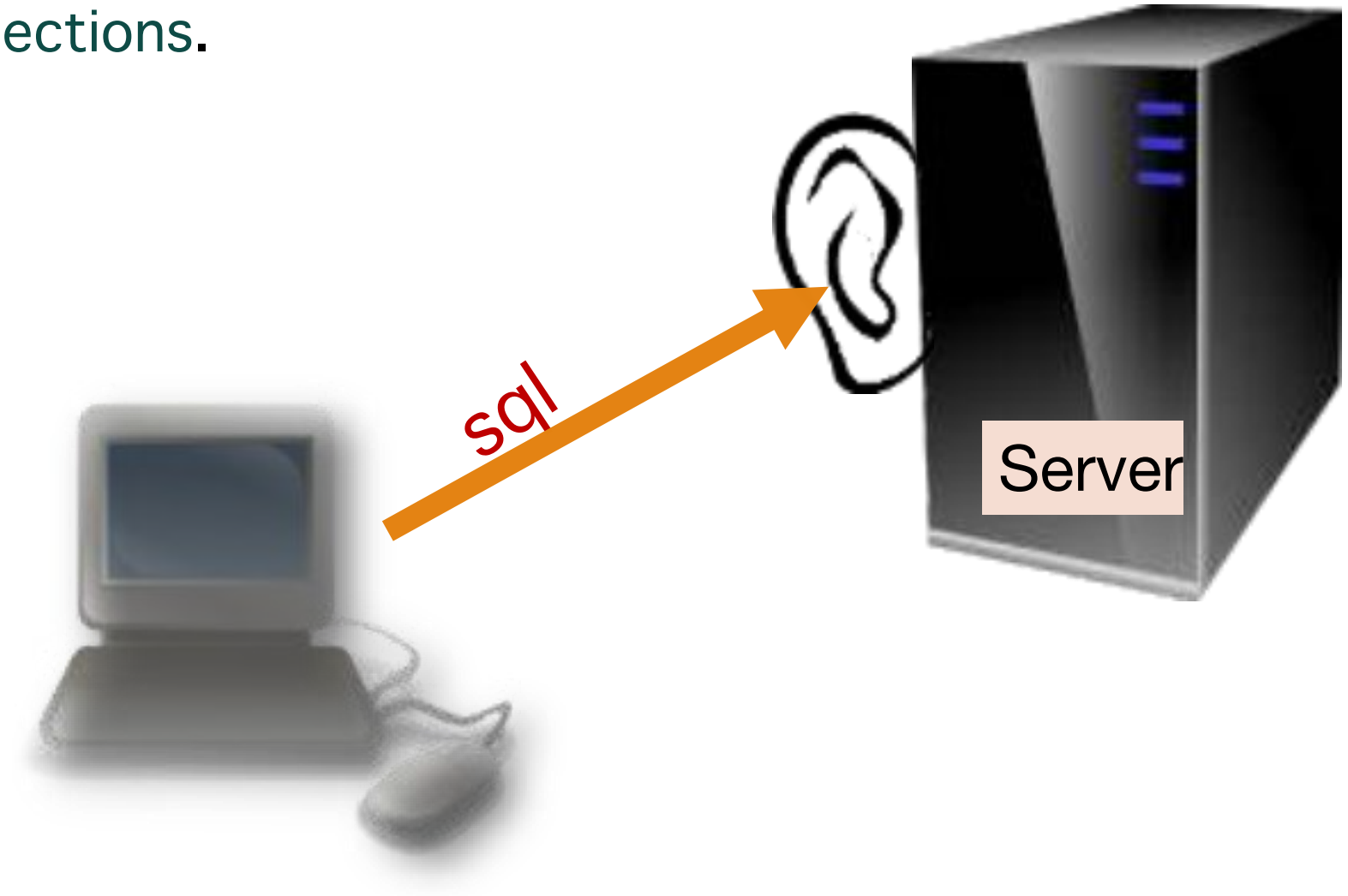
- I/Os ~10 to 30 Mb/s



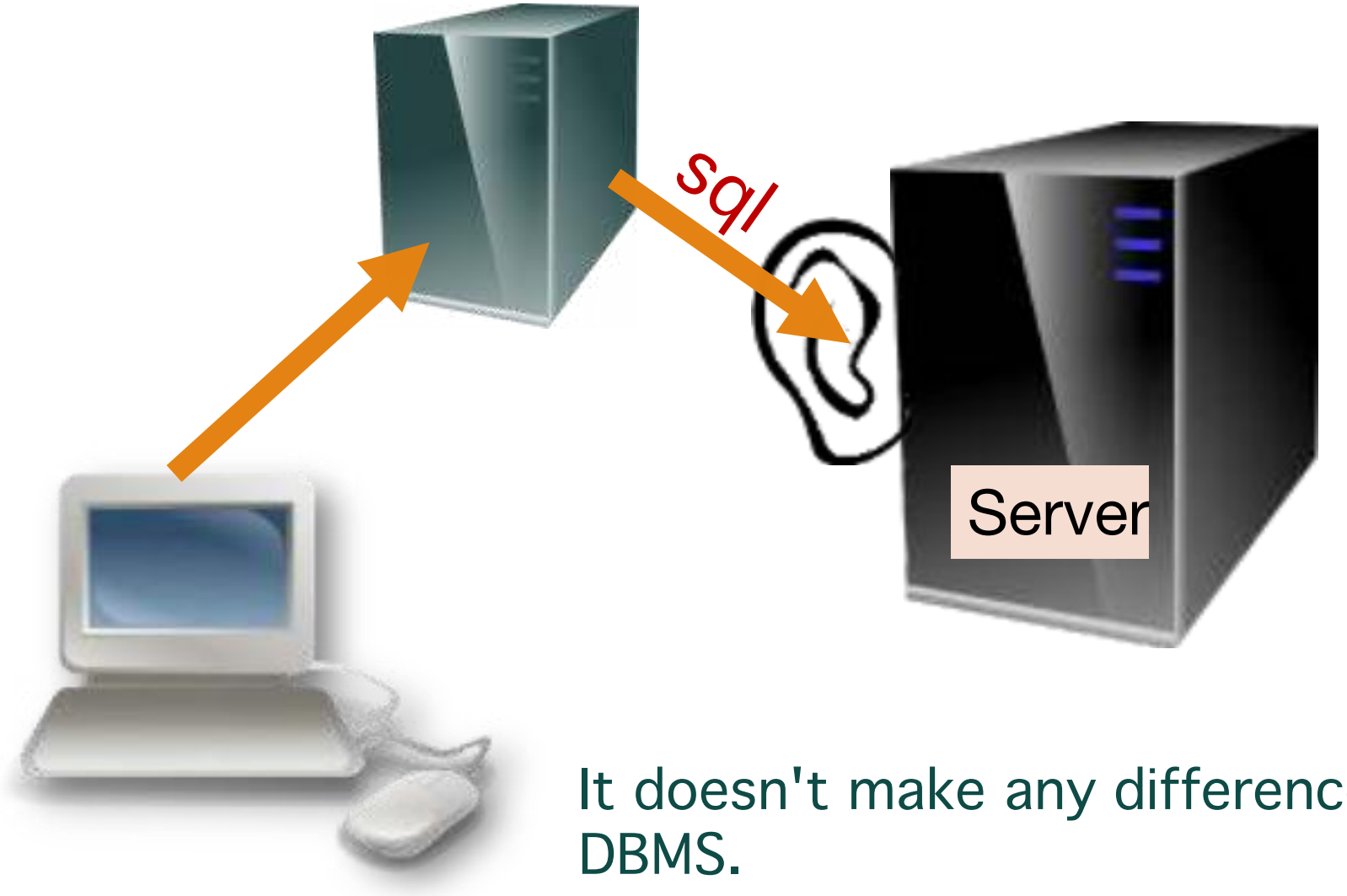
A 4 MB memory board for the VAX 8600

https://en.wikipedia.org/wiki/File:4mbramvax.jpg

SQL queries will be directly sent to this server. The listener is only here for new connections.



In many cases (HTTP server, application server) the end user isn't directly talking to the DBMS server.



It doesn't make any difference for the DBMS.

```
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 = 'Tim'
 and p.surname = 'Burton'
 and c.credited_as = 'D'
```

Syntax ✓

Do tables exist? ✓

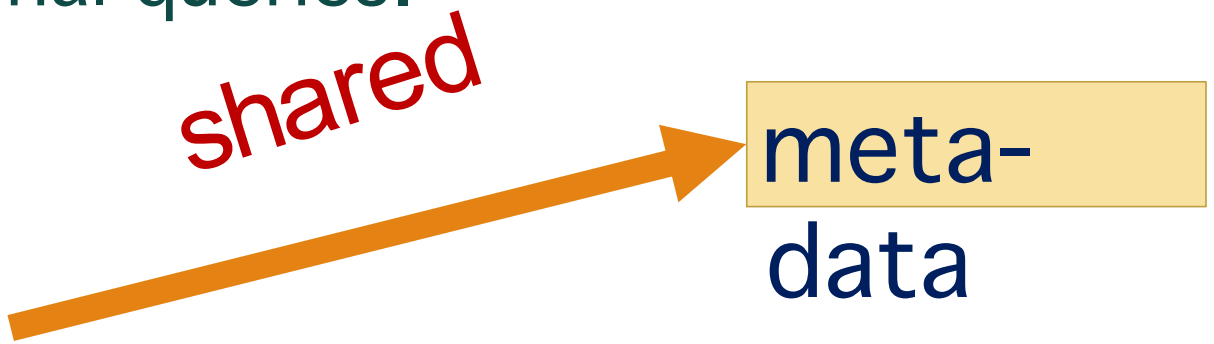
Right to access? ✓

Do columns exist? ✓

Indexes we can use? Best way to access data? ✓

One way to improve efficiency is to keep data dictionary information (meta-data) in a shared cache to avoid additional queries.

Kept in memory



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```

Syntax ✓

Do tables exist? ✓

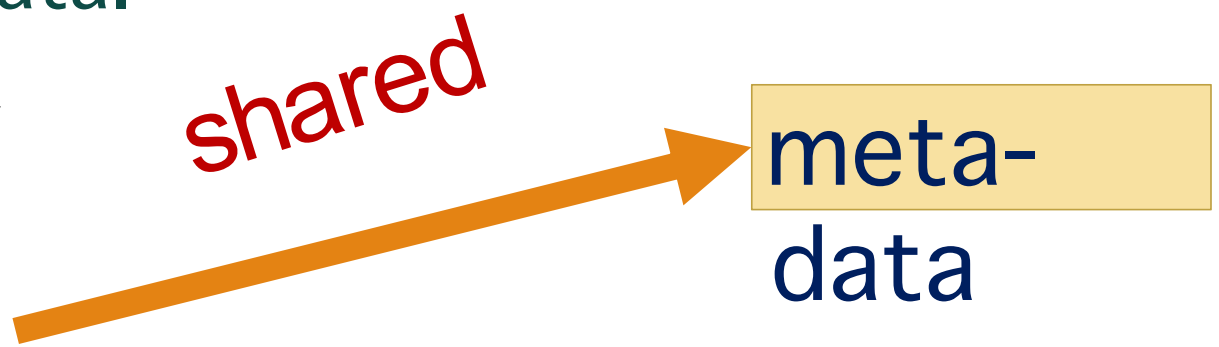
Right to access? ✓

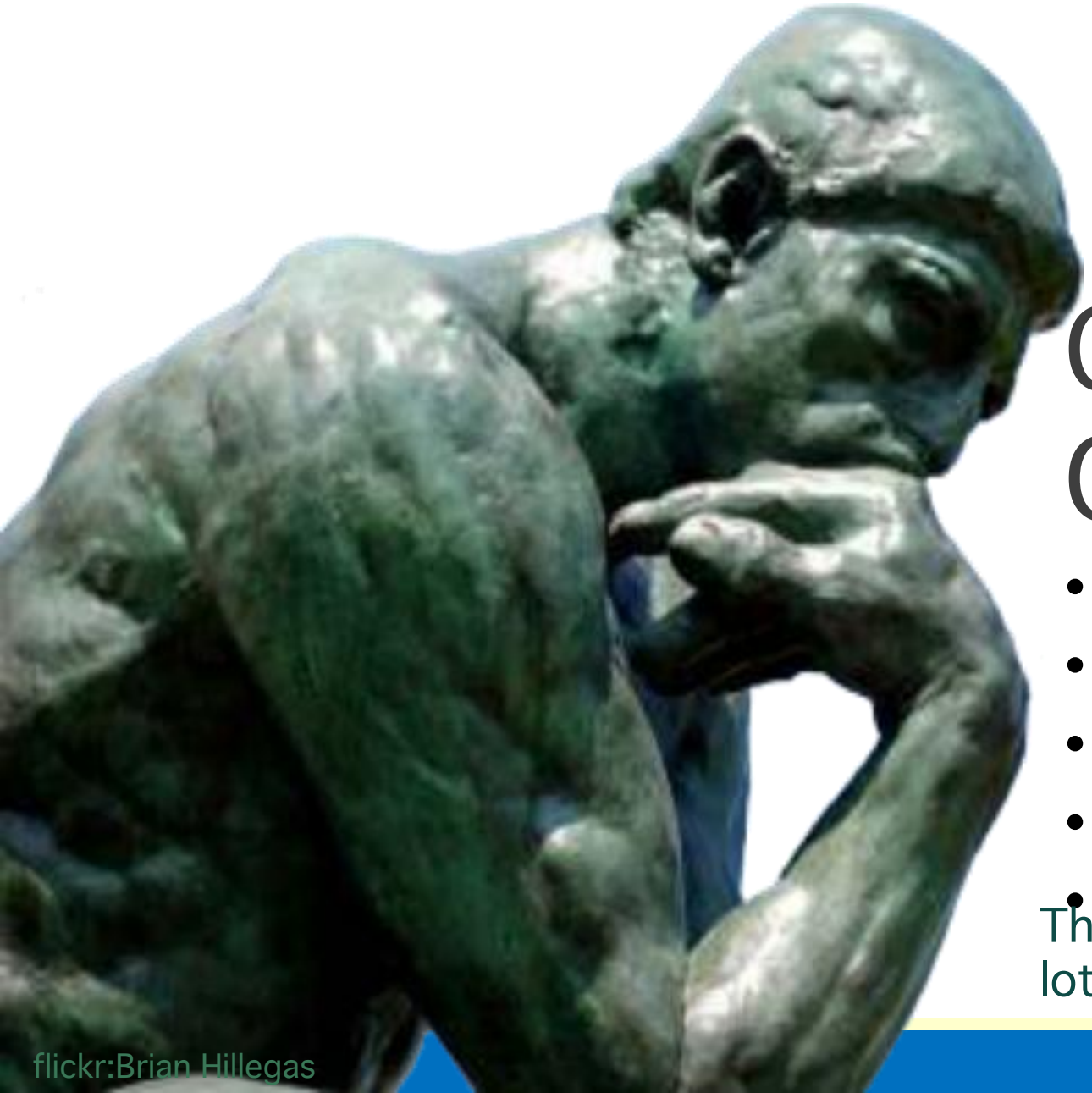
Do columns exist? ✓

Indexes we can use? Best way to access data? ✓

Another crucial phase is the one when the optimizer tries to determine the most efficient way to access data.

Kept in memory





flickr:Brian Hillegas

QUERY OPTIMIZER

- Logical transforms
- Indexes Volumes Storage
- Hardware performance
- System load
- Settings

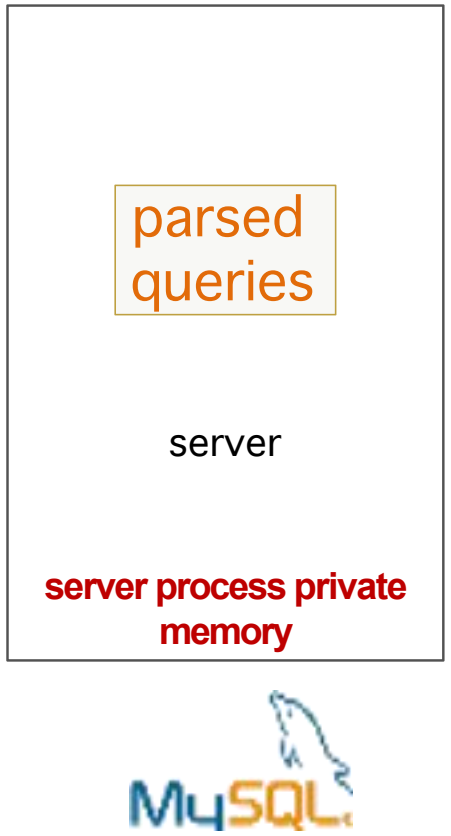
The optimizer has to (or can) take into account a lot of factors.

As a result

PARSING
takes
time

Let's put it another way: we'd rather not parse exactly the same query many times.

Keep parsed queries in memory



As most applications run exactly the same SQL statements again and again, a DBMS will cache a parsed query for reuse. For MySQL, it will be cached for a session.

Query cache management
LRU
Least Recently Used

Of course we cannot hold in cache zillions of parsed queries. We need to manage the cache, and replace queries that haven't been executed in a while with new ones.

```
select m.title, m.year_released
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```

Checksum

We primarily recognize identical queries by computing a text checksum.

+ check tables are same

and context identical

There are a lot of things to do for optimization because the resource is limited even we have a powerful server.

14.2 SCALING

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Most contents are from Stéphane Faroult's slides

SCALING UP

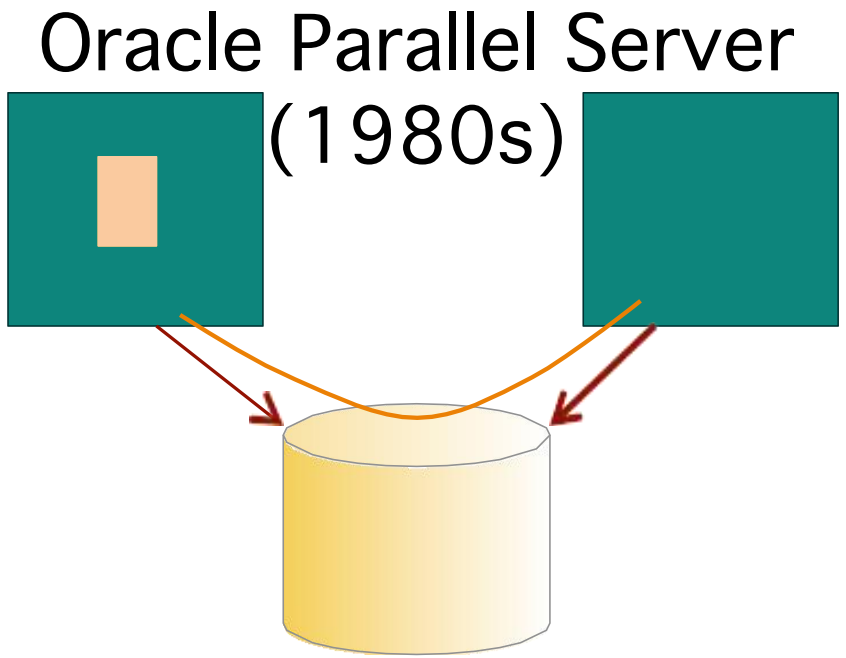
For many years, the answer to a database outgrowing the processing power of its server has been to replace the server by a bigger server.

Having a single server is taking a risk if it breaks, and additionally migrating to another server is disruptive.

SCALING OUT

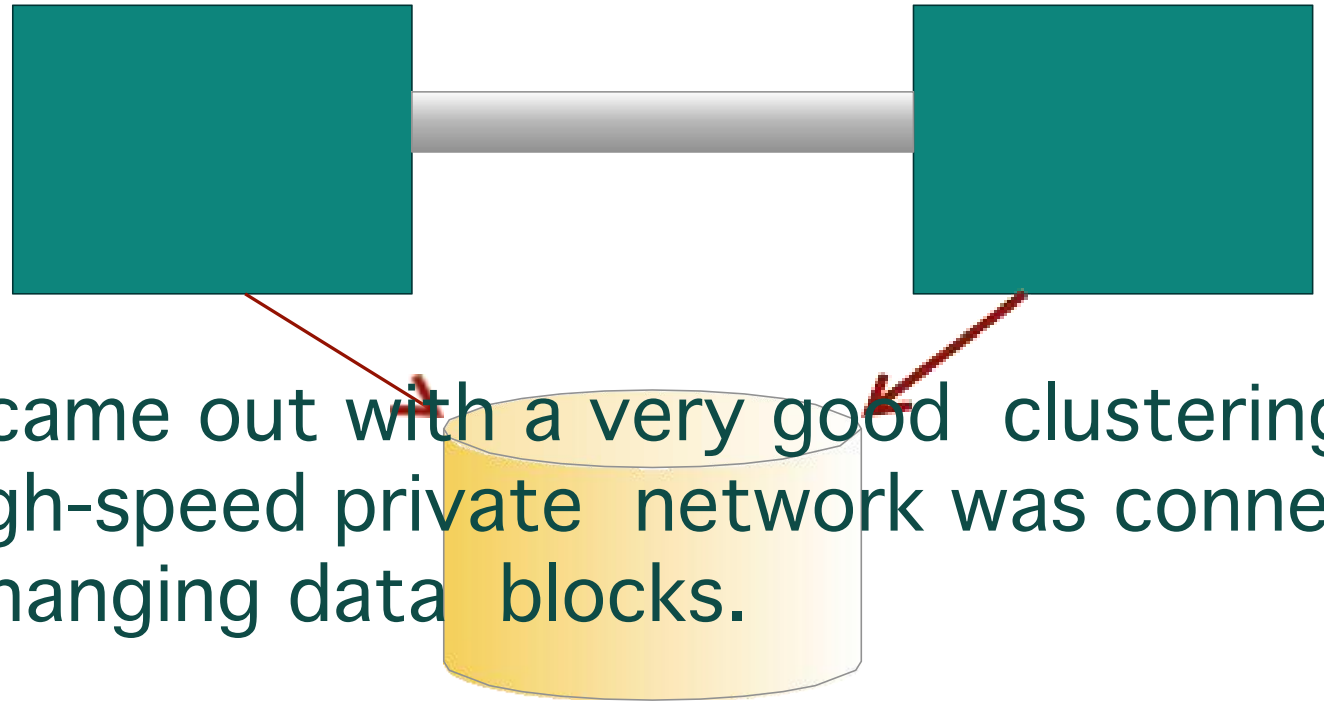
This is why people quickly thought of an alternative, adding more servers and making them share the load.

In the 1980s, Oracle tried connecting multiple servers to a single database. Complete disaster when the two servers wanted to modify the same data (or simply when one wanted to see what had just been modified by the other), data had to transit via the files.



Oracle RAC (2001)

Real Application Clusters



Oracle came out with a very good clustering offer, in which a very-high-speed private network was connecting the servers for exchanging data blocks.

Neil Gunther's
Universal Law of Computational Scalability

www.perfdynamics.com

Relative capacity C(*N*) of a computational platform:

$$C_{(N)} = \frac{N}{1 + \alpha\,(N-1) + \beta\,N\,(N-1)}$$

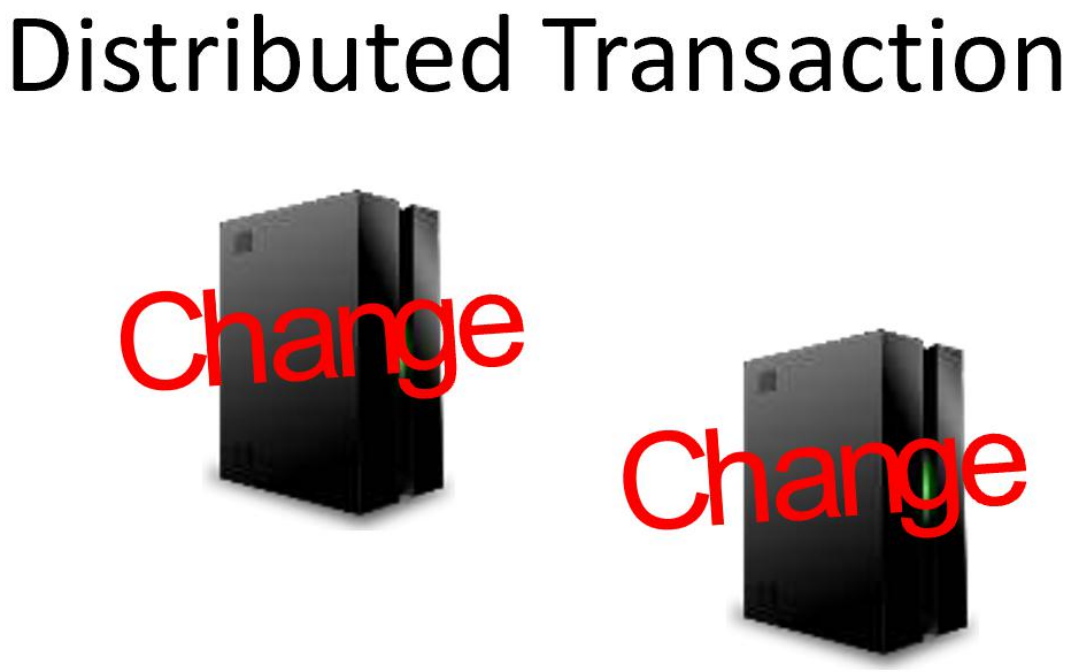
$$0 <= \alpha,\ \beta < 1$$

α Level of contention

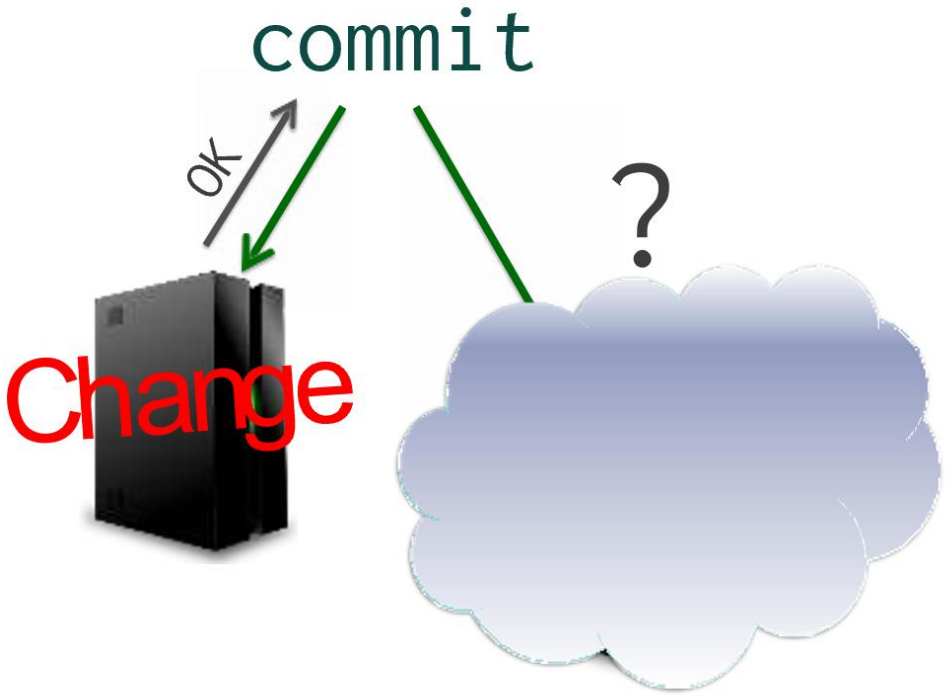
β Coherency delay (latency for data to become consistent)

The problem with clustering is that it follows a law of diminishing returns: adding a second server will less than double your capacity, and in practice people have clusters of 2, 3 or 4 machines at most (Neil Gunther is a famous Australian consultant/academic specializing on performance)

One big problem is with transactions that involve several servers. Remember that transactions are meant to be atomic operations.



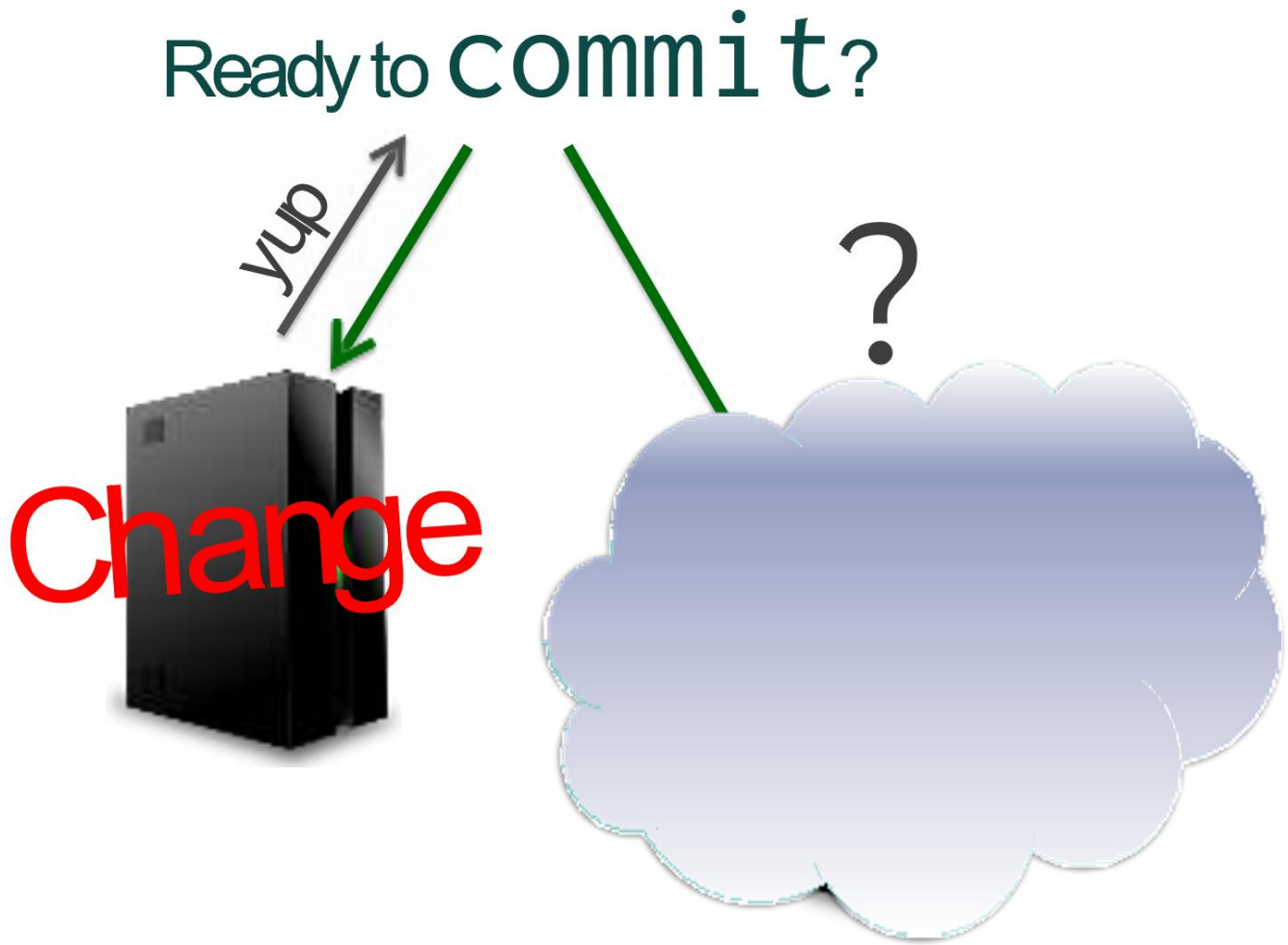
It may happen that when we commit we know for sure it worked on one server, and we get no acknowledgment from the other.



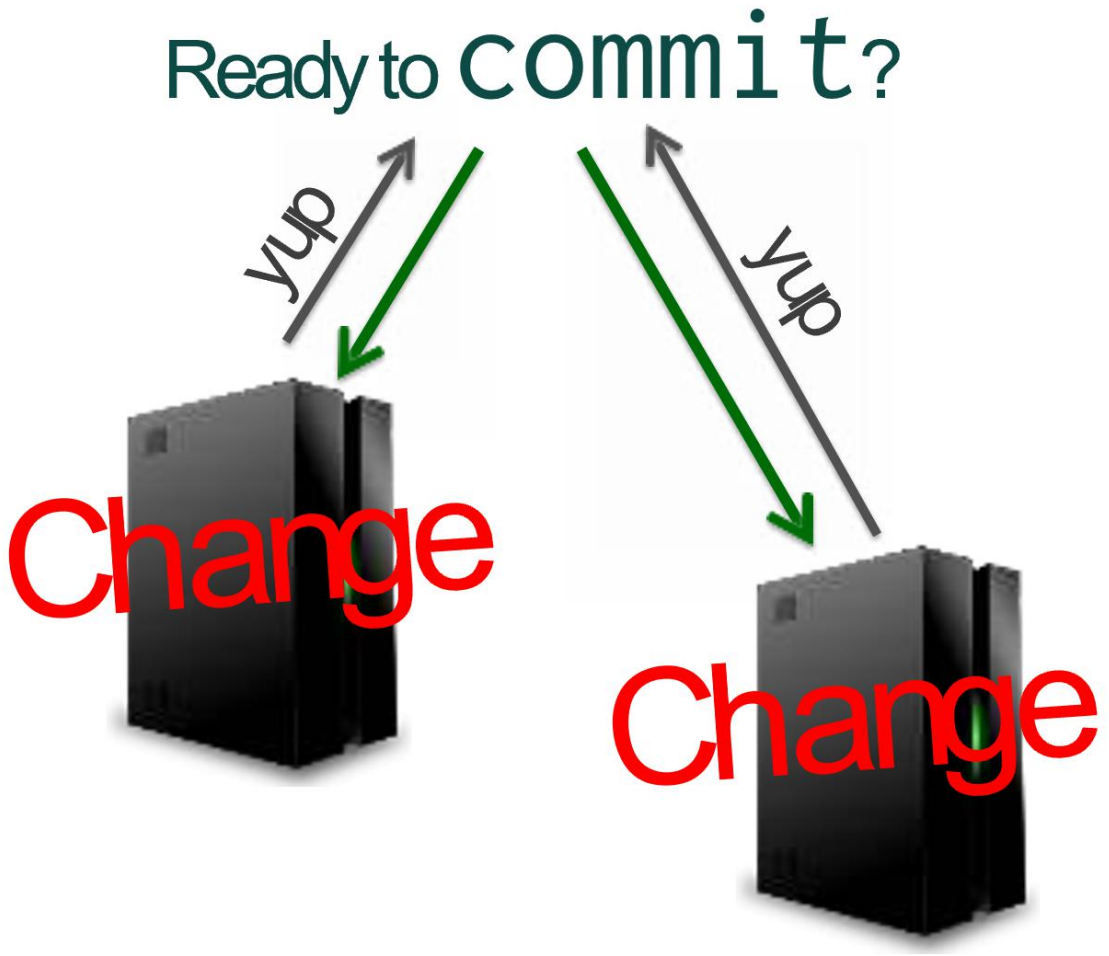
No way to rollback where it's committed, and we don't know if the other node failed before or after having committed the change.

TWO-PHASE COMMIT

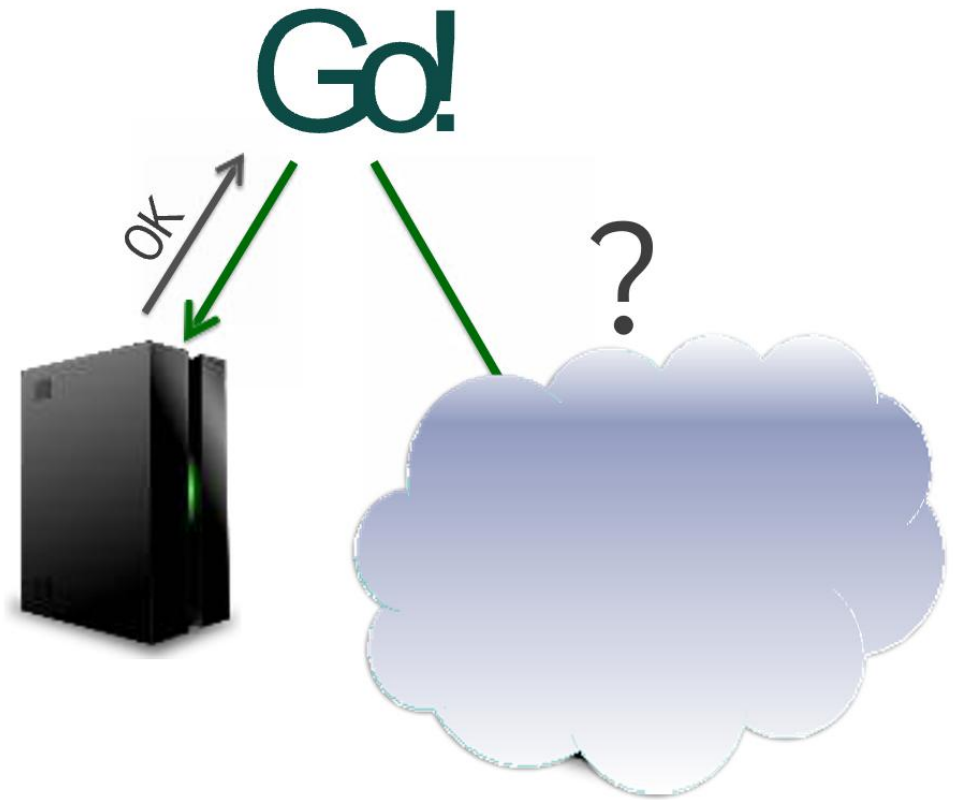
One algorithm was devised (a long time ago), called a "two-phase commit".



JUST before committing, you ask to all servers involved whether they are ready to commit. If you don't get an all clear, you can rollback.



Otherwise, you can then (2nd phase) send the official "commit" signa



Odds that something will fail are far lower than with a single-phase commit, but not zero.

Latency

Additionally, you have latency issues. All machines in a cluster may not be sitting next to each other, they may be a few miles apart in different data centers for security reasons (fire, flood ...)

1 KM = 0.000005s

Even if information travels fast, multiplying exchanges (two-phase commit) may become a sensitive issue.