Bases de données spécialisées

A CQL(SH) primer

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Giovanni Bernardi, gioXYZirif.fr
http://www.irif.fr/~gio/index.xhtml

Warm-up

Why weak consistency ?

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Why weak consistency ?

Theorem (CAP)

It is impossible in the asynchronous network model to implement a read/write data object that guarantees the following properties:

- *Availability*
- *Atomic Consistency*

in all fair executions (including those in which messages are lost).

published first at PODC 2002

Warm-up

is designed to offer which properties out of

Strong Consistency, Availability, Partition tolerance

?

Warm-up

is designed to offer which properties out of

Strong Consistency, **Availability**, **Partition tolerance**

Thus far

- CAP theorem
- Anomalies and weak consistency
  - Write Skew example in PostgreSQL
- Cassandra
  - outline of the distributed system
  - installation, configuration
  - sketch of node management

Questions we will address

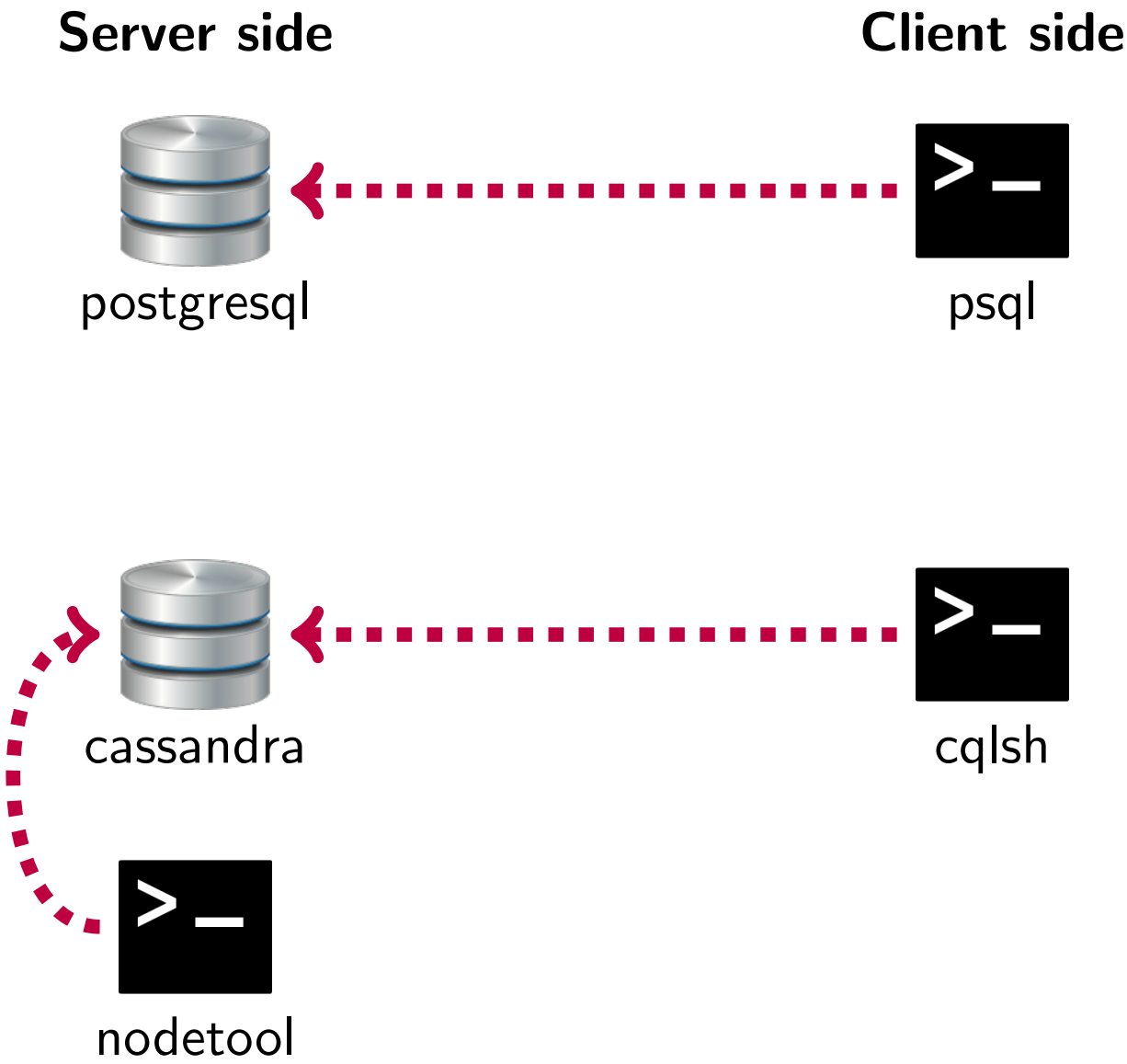
Server side

How to set-up and run a cassandra node ?

Last week

Client side

How to interact with the storage system ?


Server side
Client side
postgresql
psql
cassandra
cqlsh
nodetool

How to connect to a Cassandra server ?

`cqlsh`

synopsis simplified:

```
$ cqlsh [addr_ip] [port] [-u username] [-p password]
                         [-e query]
```

basic usage to connect to `localhost`

```
$ cqlsh
```

options can be given in `~/.cassandra/cqlshrc`

SHOW

Directive to make `cqlsh` display information about

VERSION: version of cqlsh, Cassandra server, CQL specification, and native protocol

Usually displayed as first line at connection time

HOST: the node details for host of the cqlsh session

SESSION tr_session_id: activity details for a query identified by tr_session_id. Session ids are store in the table `system_traces.sessions`.

TRACING ON | OFF

Directive to make `cqlsh` (en|dis)able storage of metadata for all CQL statements in the current session.

Try executing the following queries

```
tracing off
select * from keyspace_name.table_name;
tracing on
select * from keyspace_name.table_name;
```

where `keyspace_name`, `table_name` are names of entities that exist in the cluster.

try running: `select * from system_traces.sessions;`

- Useful to troubleshoot performance issues
- Documentation

PAGING ON | OFF

Makes `cqlsh` (en|dis)able
displaying results in chunks of 100 line.

Try executing the following queries

```
paging off
select * from system.compaction_history;
paging on
select * from system.compaction_history;
```

- Documentation

CLEAR

CTRL + l

DESCRIBE

Directive to make `cqlsh` display information about

CLUSTER: the cluster name, partitioner, and token ranges.

SCHEMA: the schema (i.e. the definitions) of all non-system keyspaces.

FULL SCHEMA: also the definitions of the system keyspaces.

system, systemsystem_traces, system_distributed, ...

DESCRIBE

Makes `cqlsh` display information about

TABLES: Every keyspace name, and for each keyspace the names of all the tables it contains.

TABLE ks_name.table_name: The schema of the table with name `table_name` in the keyspace with name `ks_name`

Try executing the following queries

```
describe tables
describe system_traces.sessions
```

USE keyspace_name

Makes the session "connect" to the given keyspace.

keyspace_name: This parameter is the name of the keyspace to connect to. Use quotes ("keyspace_name") for case-sensitive syntax.

It is the analogous of the instruction `\c dbname` in `psql`.

CONSISTENCY

Directive to make `cqlsh` show or modify the consistency level *within one session!*

no options: Display the current consistency level

consistency_level : Set the consistency level to `consistency_level`. As expected, the consistency level determines data availability versus data accuracy for transactions during a session.

Handy manner to use cqlsh

```
$ cqlsh -e "your_query"
```

Useful to write scripts that query the storage system.

Example

```
$cqlsh -e "describe keyspaces"
```

Of course the point of writing scripts is to manipulate the output of queries

```
cqlsh -e "select * from system_schema.keyspaces;" | grep SimpleStrategy
```

Python driver

```
pip3 install cassandra-driver
```

Cassandra Query Language

looks similar to SQL

but it behaves differently !

KEYSPACE

Operations: CREATE, **USE** not sql, ALERT, DROP

Example

```
CREATE KEYSPACE [IF NOT EXISTS] demo
WITH replication = {'class':'NetworkTopologyStrategy',
                    'datacenter1' :  3
                    'datacenter2' :  2 };
```

- Official documentation

Replication class

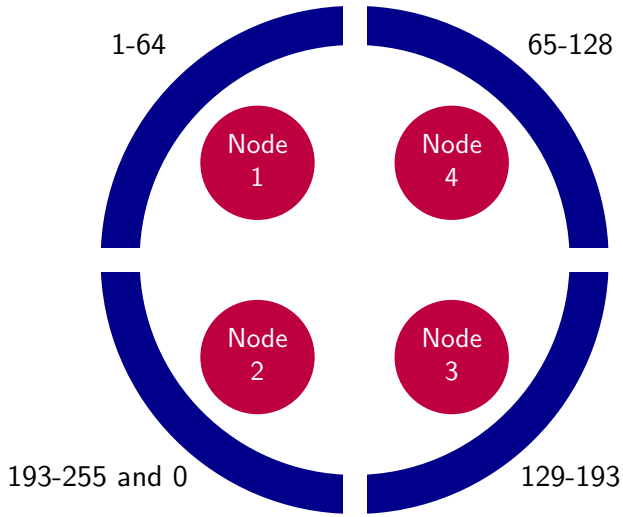
SimpleStrategy

- [...] returns the RF nodes that lie right next to each other on the ring.
- "generally not a wise choice for production because it [...] does not respect datacenter layouts and can lead to wildly varying query latency."

NetworkTopologyStrategy

- "allows to set the replication factor independently for each data-center."
- cassandra-rackdc.properties

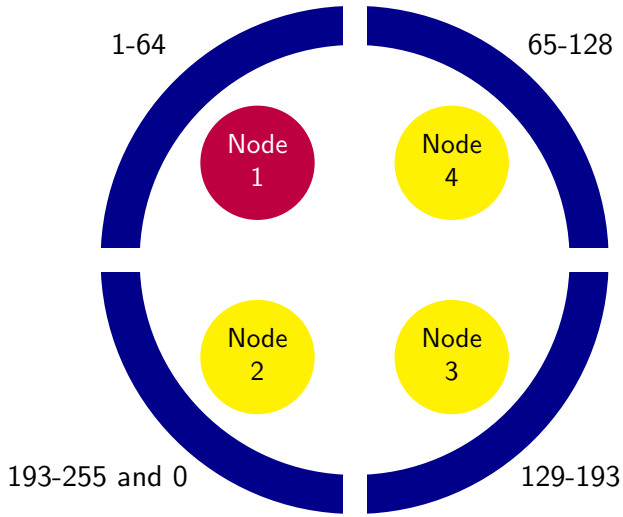
SimpleStrategy



A client asks Cassandra to write the row (69000, Lyon) in a keyspace with replication factor 3.
The server

1. computes the token, $hash(69000) = 67$
2. finds the node responsible for token 67, Node 4
3. writes (69000, Lyon) in Node 4
4. and in Node 3 and Node 2

SimpleStrategy



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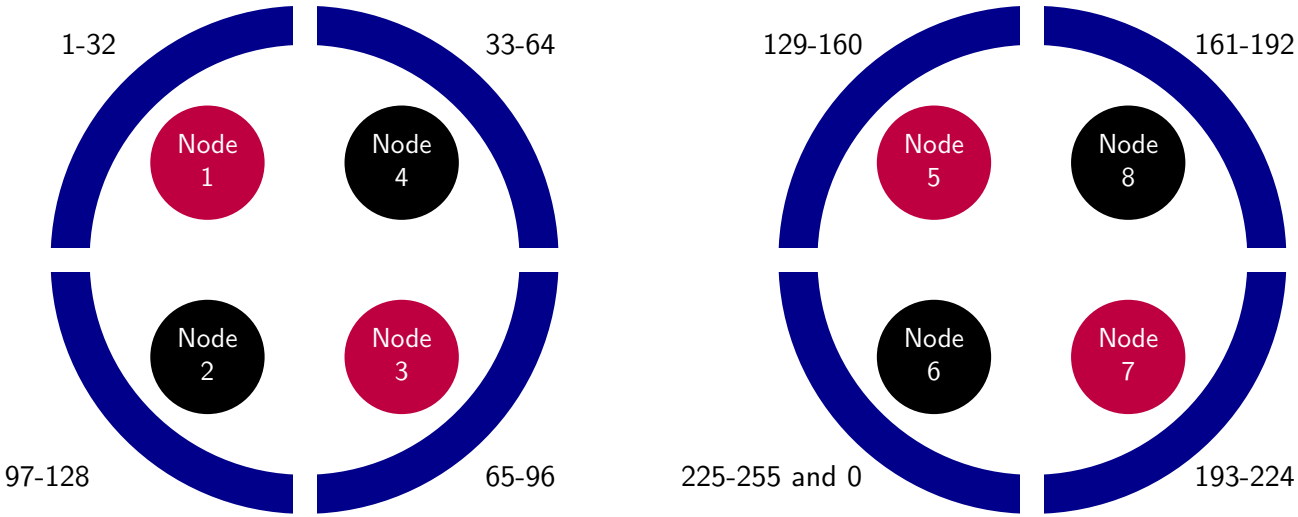
NetworkTopologyStrategy



A client asks Cassandra to write the row (69000, Lyon) in a keyspace with replication factor 4 (2 + 2).
The server

1. computes the token, $hash(69000) = 67$
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3. writes (69000, Lyon) in Node 4
4. and in enough nodes in different dc/racks (example: 1, 5, 6)

NetworkTopologyStrategy

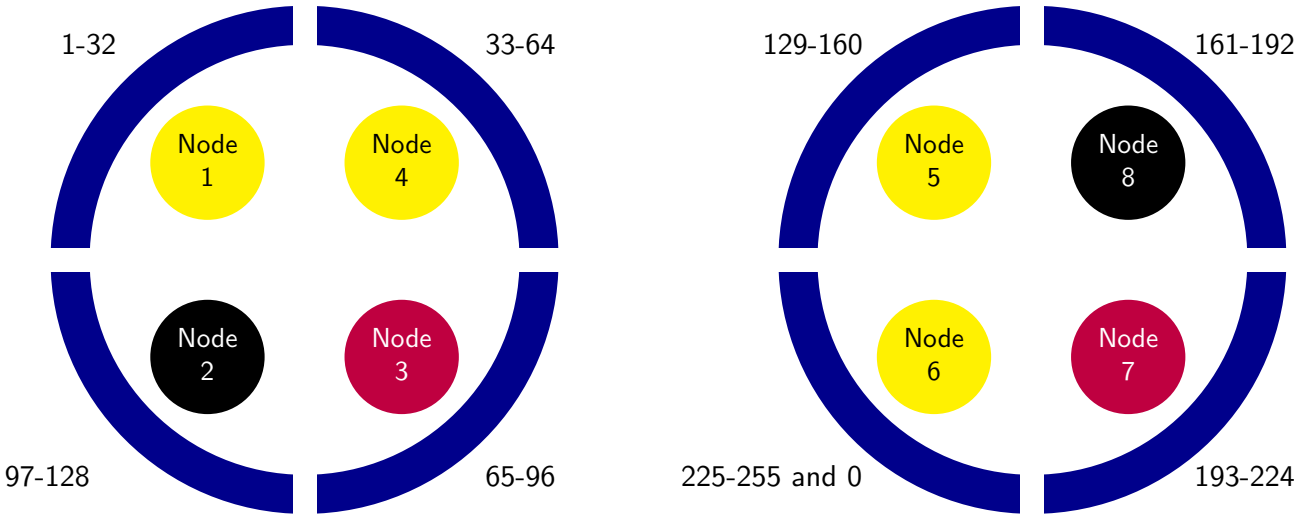

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TABLE

Operations: CREATE, ALTER, **TRUNCATE** not sql, DROP

Example

```
CREATE TABLE [IF NOT EXISTS] mytable (
    cname1 type1,
    ⋮
    cnameN typeN,
    PRIMARY KEY (cnameA, ..., cnameM))
WITH comment='2 buffalo buffalo buffalo buffalo'
```

partitionK

- First column in PK identifies **partition**
- In the primary key it is crucial to have columns to find a row within a partition — clustering columns
- Official documentation

TABLE

```
CREATE TABLE simplepk (
    id int,
    title text,
    band text,
    PRIMARY KEY (id, title, band))

CREATE TABLE compositepk (
    id int,
    title text,
    band text,
    PRIMARY KEY ((id, title), band))
```

Different syntax, different meaning:

- **id** partition key; clustering columns: title, band
- **(id, title)** composite parititon key; clustering column: band

TABLE

Example

```
TRUNCATE TABLE dummy;
```

- `TRUNCATE` deletes all the data in a table, but not the table
- Alternative to `DROP TABLE`

INSERT

```
insert into
tablename(cname1,cname2,cname3, ...)
values (v1,v2,v3, ...);
```

Example

```
insert into dummy(id,num) values (0,10);
```

```
insert into dummy(id) values (0);
```

- requires the entire primary key, but not the other values
- missing values are set to `null`
- **it is <u>not</u> SQL**: if the same primary key is used in two inserts the row is overwritten!
- Official documentation

Semantics of SQL and CQL inserts are different!

`ex0-insert-refintegrity.sh`

`ex0-insert-refintegrity.py`

UPDATE

Example

```
update dummy set num=54 where id=9;

update dummy set num=1 where id=33;
```

UPSERT

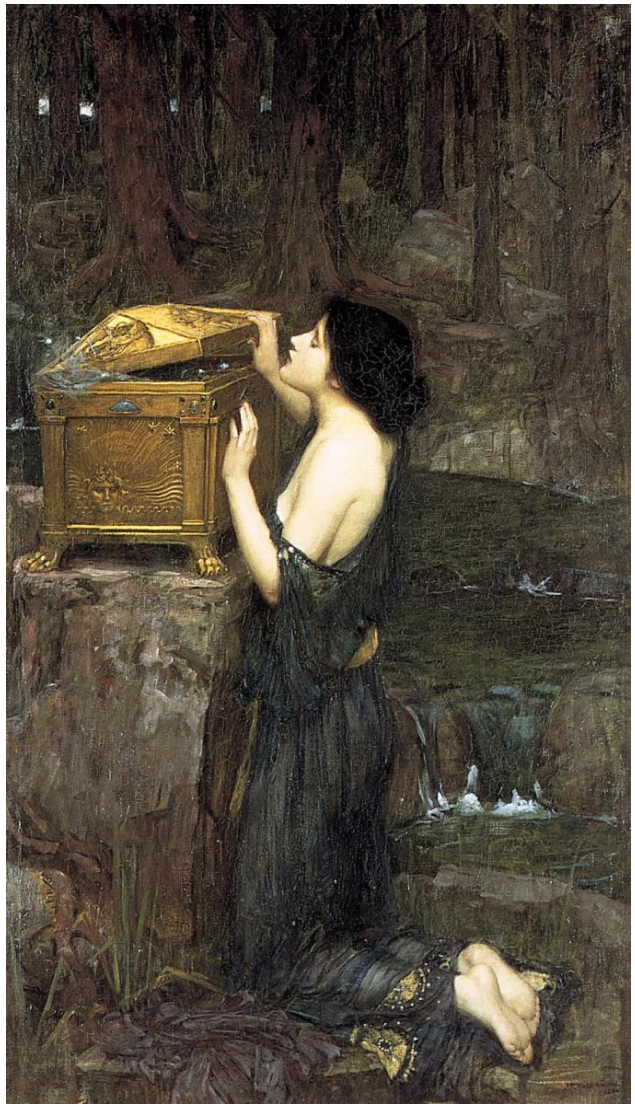
no fundamental difference between insert and update operations

- update a row and the primary key does not exist
  ⇒ Cassandra creates the row — with exceptions
- insert a row w/ duplicate primary key
  ⇒ Cassandra replaces the row
- Official documentation

ex1-update.py

Questions ?

Questions ?



J. W. Waterhouse, 1896

Consider the following table schema

```
create table
dots(id int, color text, primary key (id, color))
with
clustering order by (color desc)
```

- The partition key is `id`
- **Clustering order:** The order of the rows within each partition depends on `color`

SELECT

Example

```
select table_name,comment from system_schema.tables;
```

```
SELECT * FROM dots;
```

```
SELECT * FROM dots ORDER BY id DESC;
```

```
SELECT * FROM dots WHERE color='black';
```

- Official documentation on SELECT

Again, SQL vs CQL semantics

`ex2-orderby-sql.sh`

`ex2-orderby-cql.py`

`ex2-orderby-goodschema.py`

SELECT

Order by

- The order in which partitioned rows are returned depends on the order of the tokens and not on the key values themselves. (post)
- Clustering column(s) determine the data's sort order only **within a partition**.
- ORDER BY not necessary if order is in table definition.

ORDER BY can be used only

- on clustering columns (i.e. not the partition key)
- if the partition key is restricted via IN or EQ

  but check paging ...

ex3-filtering-cql.py

SELECT

Where

A `WHERE` clause can use only the columns that

- are part of primary key, or
- have a secondary index on them — not discussed so far...

Rationale: if a `WHERE` clause

- contains a partition key, Cassandra knows which node to contact: response time is constant wrt the number of nodes.
- does not contain a partition key, Cassandra contacts each node, and it scans the complete dataset
  - execution time proportional to the total amount of data stored in the referenced table,
  - performance is likely to get worse as you add nodes to the cluster.

in general

ALLOW FILTERING signals poor data modelling

take home message

Rethink your data modelling !

ex4-index.py

DELETE

Example

```
delete name from students_good where sid=1164220;
```

```
delete name from students_good
             where uni='P7' and sid=1164220;
```

```
delete name from students_good where uni='P7';
```

```
delete name from students_good;
```

- all deletions within the same partition are applied atomically and in isolation
- `DELETE` can be conditional through an `IF` clause, but internally Paxos will be used, worsening the performances.
- Official documentation on DELETE

BATCH

Way to group together multiple upserts and deletes.

Example

```
BEGIN BATCH
modif_1
modif_2
⋮
modif_n
APPLY BATCH;
```

What for ?

- Saves network round-trips if contains multiple `UPDATE`
- Updates in a batch performed in isolation within partitions
- Eventually all the modifs will take place, or none will
- Official documentation on BATCH

Batches are *not* analogues of SQL transactions.

Transactions ?

Cassandra supports a form of lightweight transactions.
One such transaction

- might block other lightweight transactions from occurring
- does not stop normal read and write operations from occurring
- if mixed with normal operations might generate errors

  due to the usage of different timestamp systems

How to create a lightweight transaction ?
Using `IF` conditions in `INSERT, UPDATE, DELETE`

- Implementation via Paxos — out of scope
- Guaranteed consistency: linearisability — out of scope
- Further details here and here

Generalized Consensus and Paxos

Paxos made simple

SwiftPaxos: Fast Geo-Replicated State Machines

Other differences with SQL

- JOIN:

  JOINS must be computed by the application.

- FOREIGN KEYS:

  Referential integrity must be guaranteed by the application.

  Keep in mind you can `BATCH` updates.

- tokens

Tokens

`ex5-token.py`

How to find which machine is in charge of a token ?

```
$ nodetool [-p port] [-h host] getendpoints keyspace
                               table id
```

```
user@host: $ nodetool getendpoints demo dummy 73
192.168.0.101
192.168.0.104
192.168.0.103
```

`ex6-fk-join.py`

`ex6-music.py`

End of Part III

Geo-replicated databases
and
weak consistency

Weak consistency in Neo4j

- **read-committed** isolation level

- Neo4j allows **lost updates**

  To ensure deterministic behaviour [. . .], it is necessary to explicitly acquire a write lock on the node in question. In Cypher there is no explicit support for this, but it is possible to work around this limitation by writing to a temporary property.

That's the story.
Thank you for the attention

Questions?