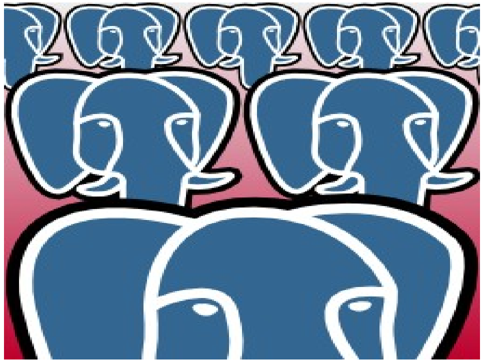


How to manage a herd of elephants: PostgreSQL clusters using streaming replication and pgpool-II

SRA OSS, Inc. Japan

Tatsuo Ishii

About me

- Came from Tokyo, Japan
- PostgreSQL committer
- Original author of pgpool-II
- Working for SRA OSS for 10 years

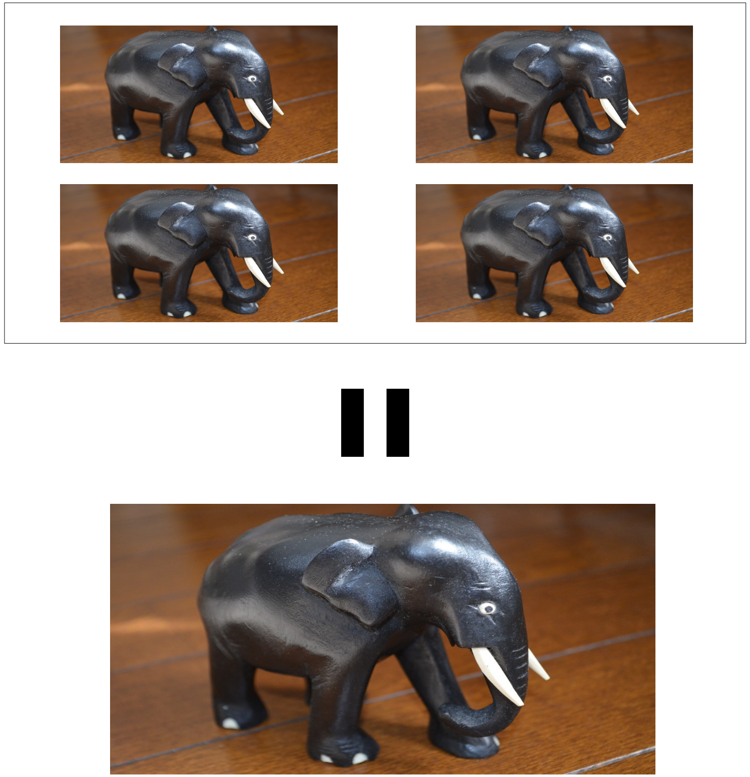
Mt. Fuji, sunset and Enoshima-island

About SRA OSS, Inc. Japan

- One of the oldest PostgreSQL companies in the world
- Doing PostgreSQL and other OSS related business for 10 years
- Main business is support. Has over 600 support contracts
- Our contributions to PostgreSQL include:
  - Multi byte support
  - pgbench, pgstattuple
  - Recursive queries (WITH RECURSIVE)
  - 64 bit large objects

A herd of PostgreSQL

- An elephant is powerful
- However, a herd of elephants is even more powerful!
- Problem is, how to manage the herd of elephants?

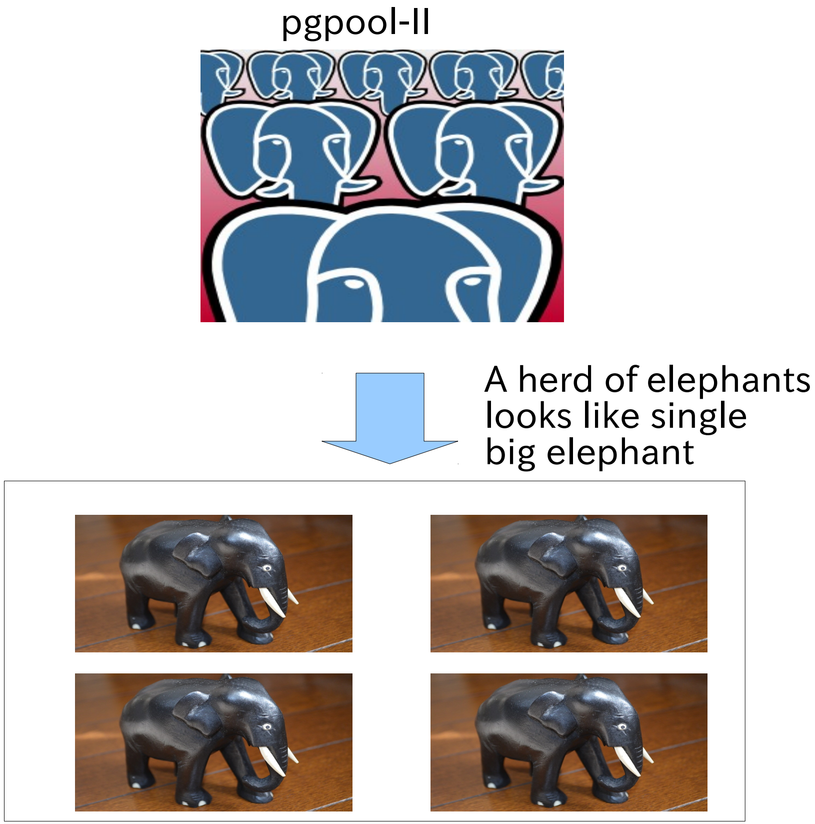


Problems of the herd of elephants include:

- It needs a leader (a primary server)
- If the leader retires, a new leader must take over its role (fail over, promote)
- Other elephants must follow the new leader
- If a non leader elephant cannot continue to work, it must retire and leave the herd (standby fail over)
- If a new elephant wants to join the herd, it should be accepted without disturbing the herd
- Elephants should help each other to perform a task in an efficient way (load balancing)
- There are tasks which can only be performed by the leader (write queries – needs query dispatching)

Solving the problems by using pgpool-II

- By using pgpool-II, a streaming replication PostgreSQL cluster almost looks like a single PostgreSQL server
- User supplied “fail over script”could define which standby server should take over when the primary server goes down
- User supplied “follow master command” allow other standbys follow the new primary server
- If a standby server goes down, it is removed from the cluster definition and clients can continue to use the cluster
- pgpool-II examines each query. If the query is a read only one or not. If not, it is forwarded to one of servers (load balancing).
- If a query is a write query, it will be forwarded to the primary server

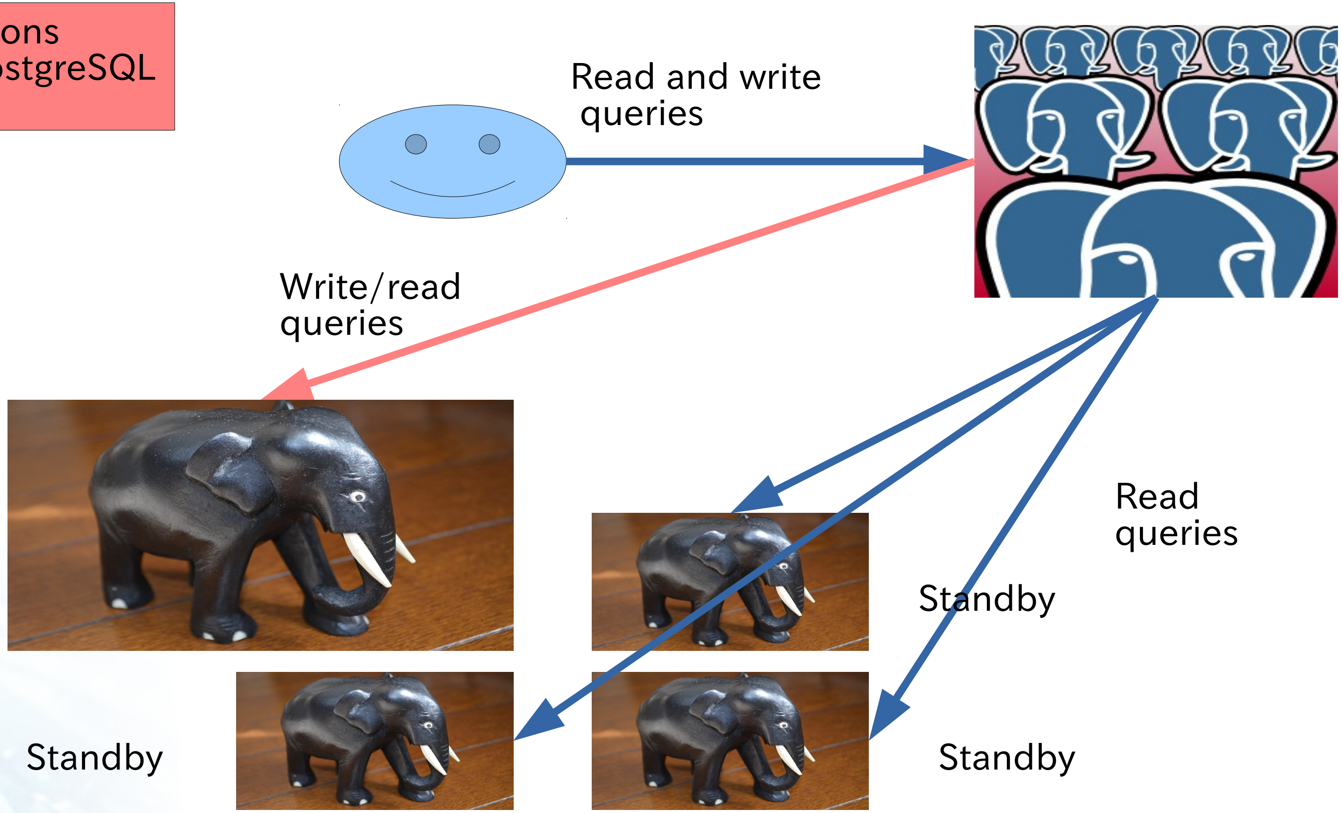


pgpool-II

A herd of elephants
looks like single
big elephant

Query dispatching/routing

Minimize modifications
to existing single PostgreSQL
applications



Read and write
queries

Write/read
queries

Read
queries

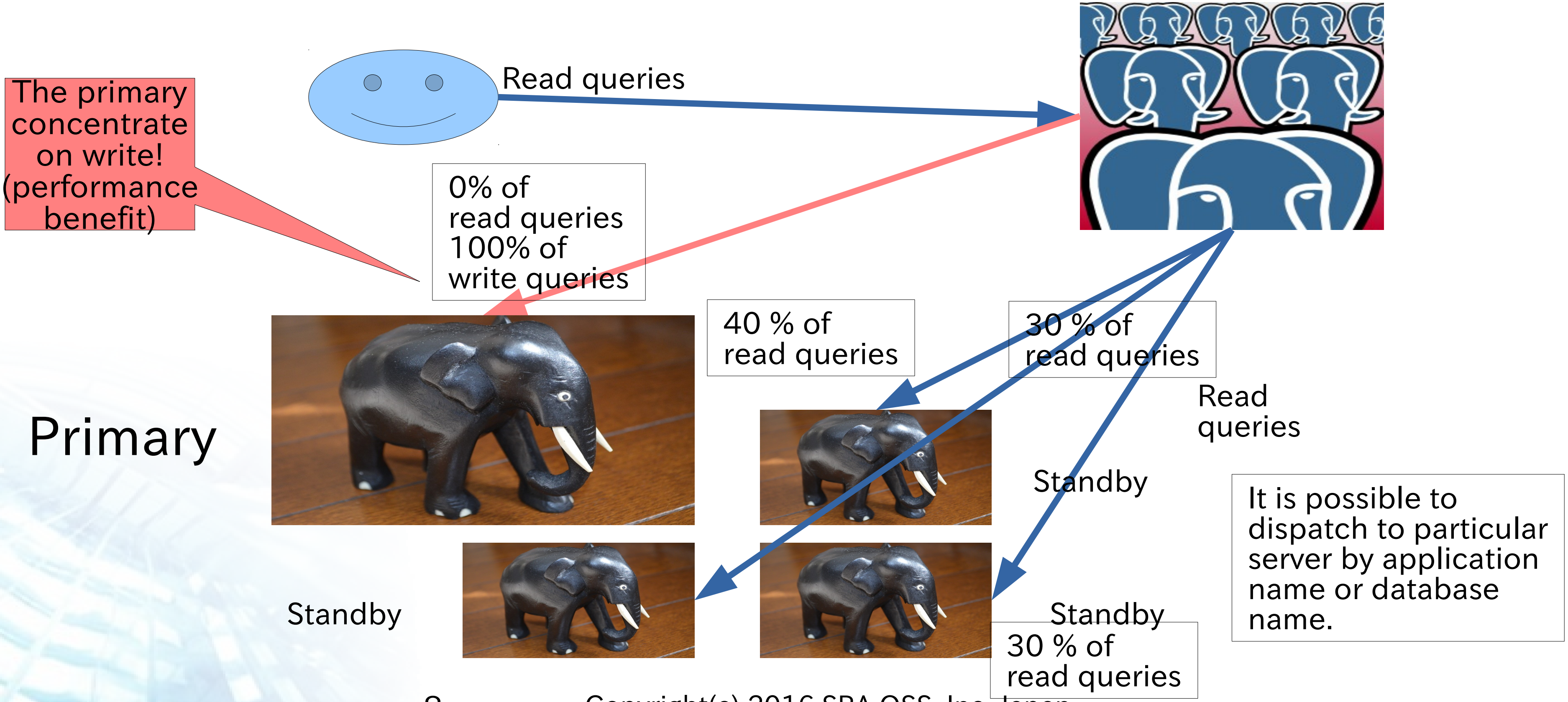
Primary

Standby

Standby

Standby

Load balancing



The primary concentrate on write! (performance benefit)

Read queries

0% of read queries 100% of write queries

40 % of read queries

30 % of read queries

Read queries

Primary

Standby

Standby

Standby

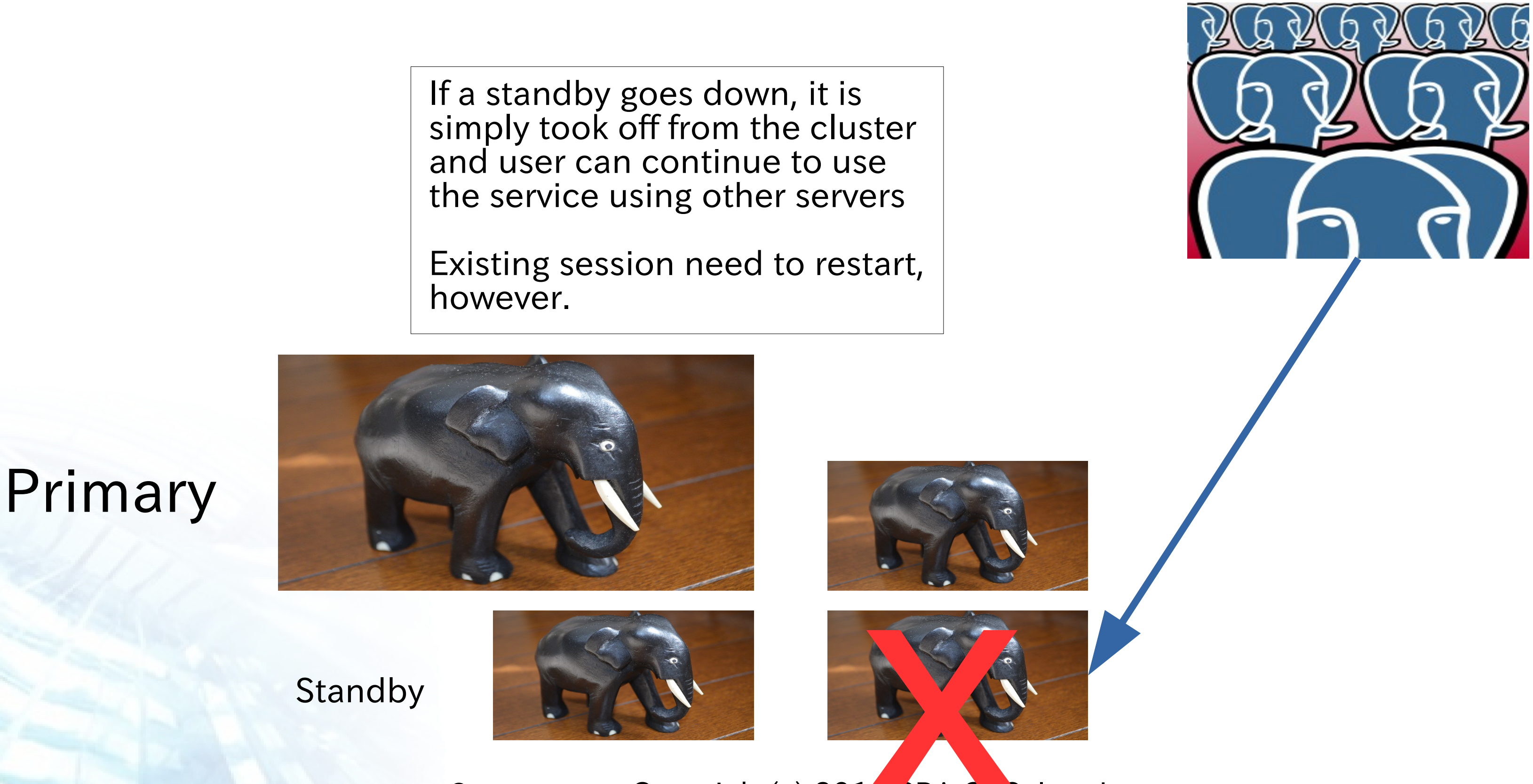
30 % of read queries

It is possible to dispatch to particular server by application name or database name.

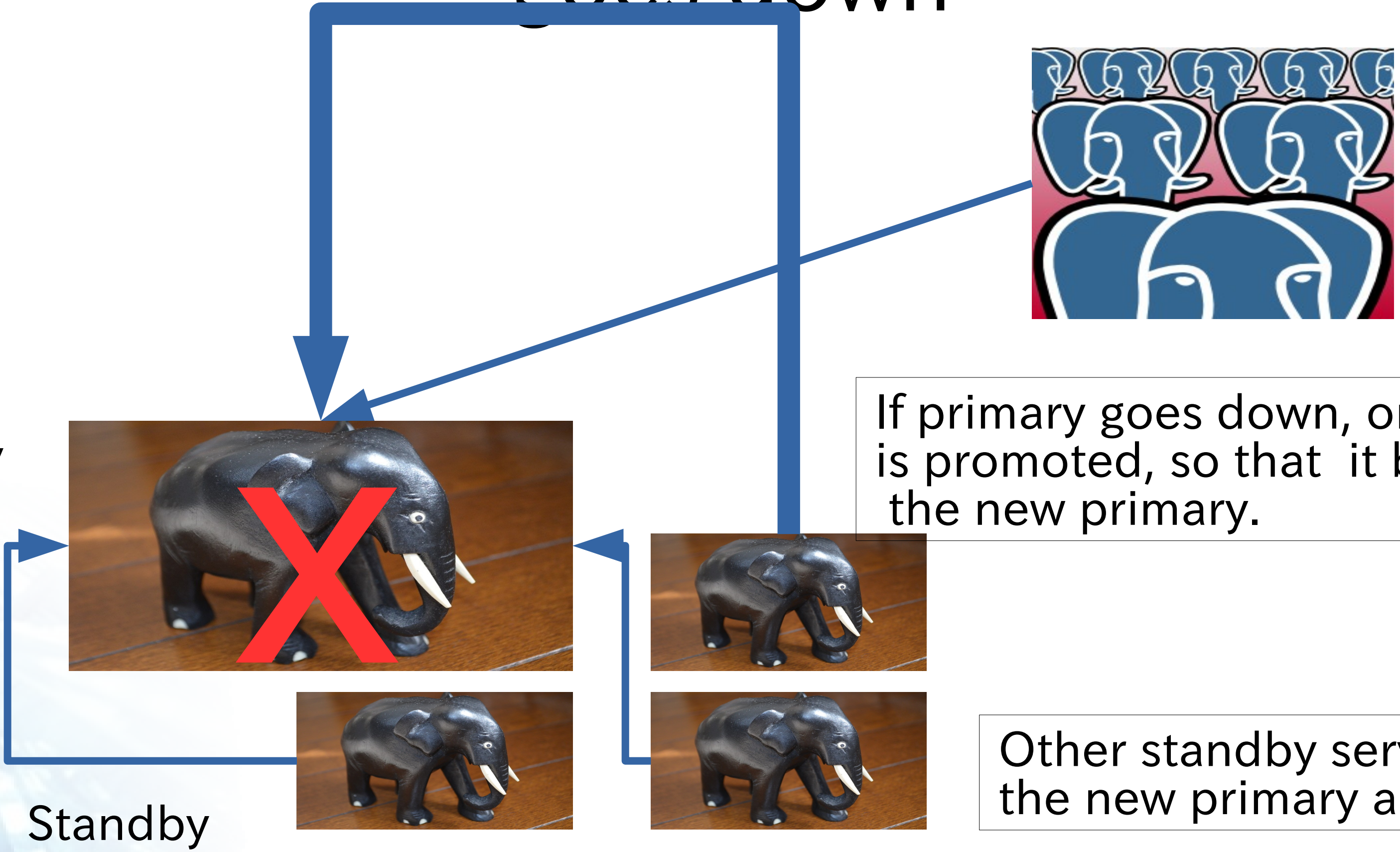
When the standby server goes down

If a standby goes down, it is simply took off from the cluster and user can continue to use the service using other servers

Existing session need to restart, however.



When the primary server goes down



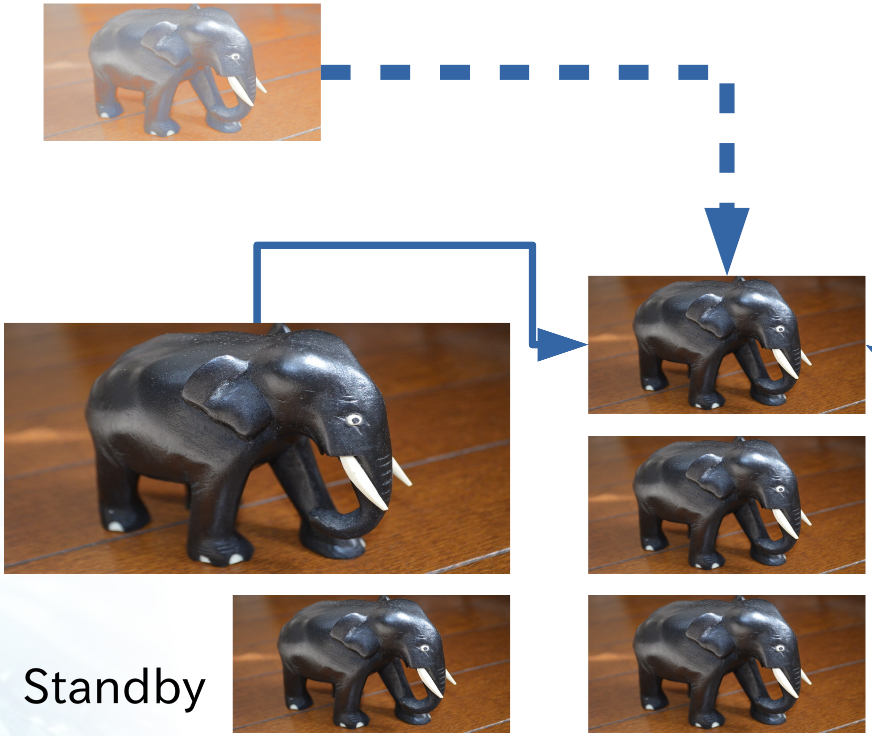
Primary

Standby

If primary goes down, one of standbys is promoted, so that it becomes the new primary.

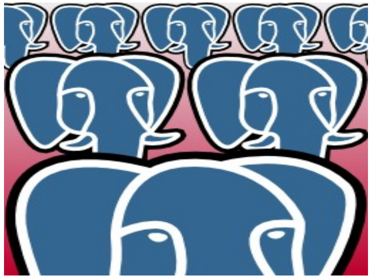
Other standby servers recognize the new primary and follows it.

Adding new server



Primary

Standby

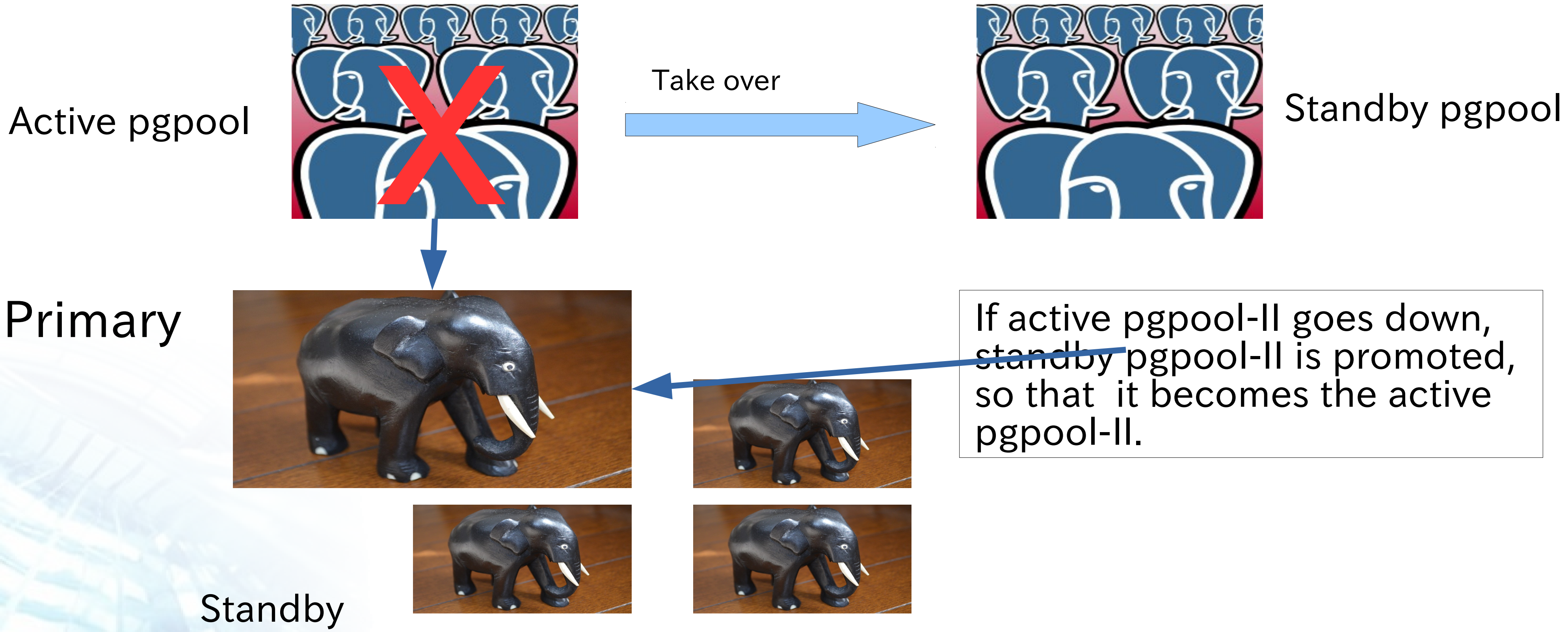


New member!

Adding new server is easy. pgpool-II copies the database from the primary to the new standby server without disturbing other servers.

The same procedure can be applied when re-sync the broken standby.

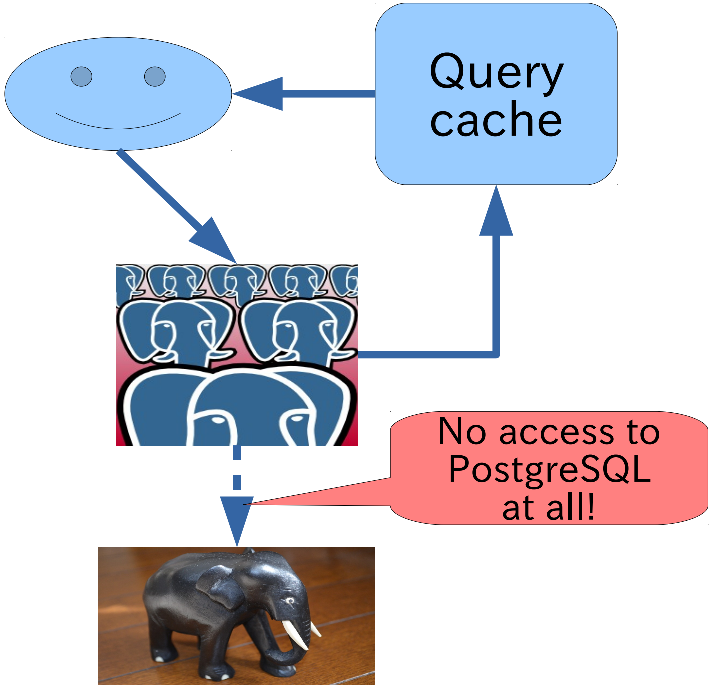
Watchdog: built-in High Availability for pgpool-II



If active pgpool-II goes down, standby pgpool-II is promoted, so that it becomes the active pgpool-II.

In-memory query cache

- Pgpool-II can reuses query results using “query cache”
- Since the query cache is placed on memory, it's extremely fast
- No access to PostgreSQL
- The cache storage can be placed on either the shared memory, or memcached
- When a table is updated, all of related cache entries are invalidated
- Also time-based invalidation is possible



Support policy

- Pgpool-II hire “major releases” and “minor releases” method like PostgreSQL
  - 3.x.y – x: major version, y: minor version
    - example: “3.4.3”: “3.4” is the major version, “3” is the minor version
  - 1 major release per year
  - 3-4 minor releases per year
  - Each minor releases keep compatibility
  - Each major releases change API/usage (may not incompatible to earlier versions)
- Keep on providing back patches for five years after initial release
- Because there's one major release each year, we keep on supporting last 5 to 6 versions
- If you need longer support period, please contact to commercial support providers

The latest version:
pgpool-II 3.5 just has been released!

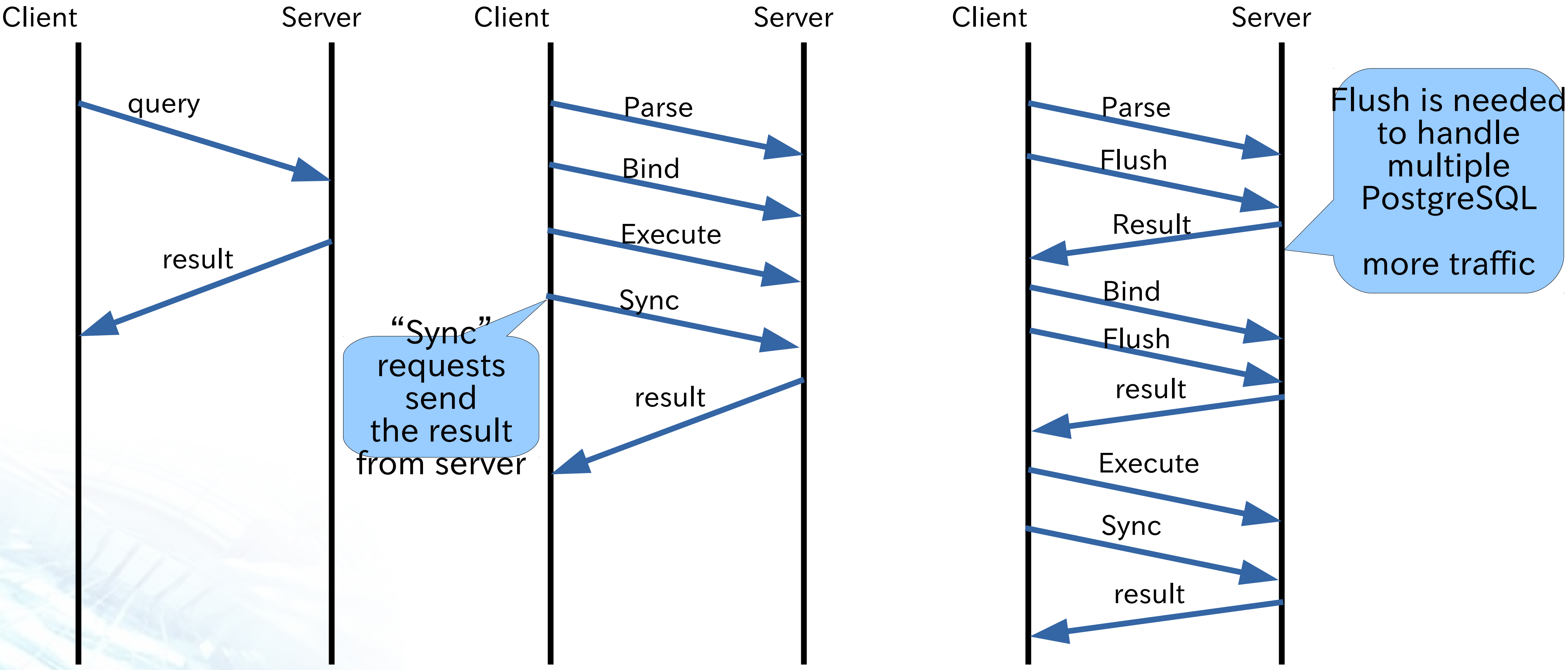
- Improved performance
- Improved watchdog
- Ready for PostgreSQL 9.5
- Enhanced pcp commands
- and more

Improved performance

Improving extended query performance

- Using extended protocol (typically used in Java) in pgpool-II is slow (as slow as half of simple protocol)
- Current implementation of pgpool-II for extended protocol is not so great: it requires additional flush messages, and this is the source of poor performance
- Ok, so how the extended protocol is handled?

Some details are omitted



Client Server Client Server Client Server

query

result

Parse

Bind

Execute

Sync

result

“Sync” requests send the result from server

Parse

Flush

Result

Bind

Flush

result

Execute

Sync

result

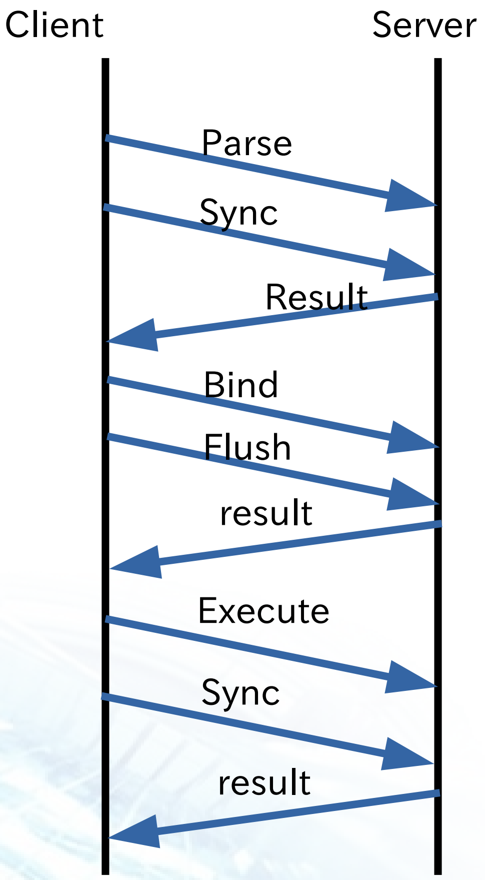
Flush is needed to handle multiple PostgreSQL

more traffic

simple protocol

extended protocol

extended protocol with pgpool-II

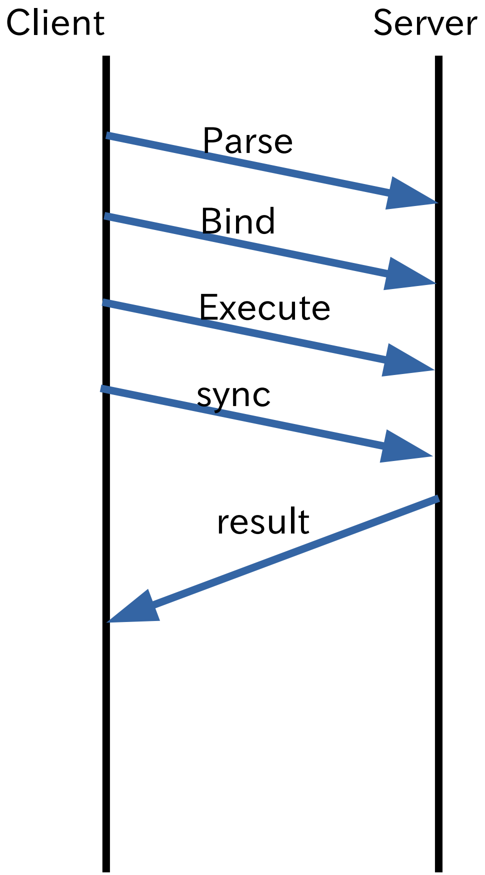


extended protocol
with pgpool-II

Too many Flush messages

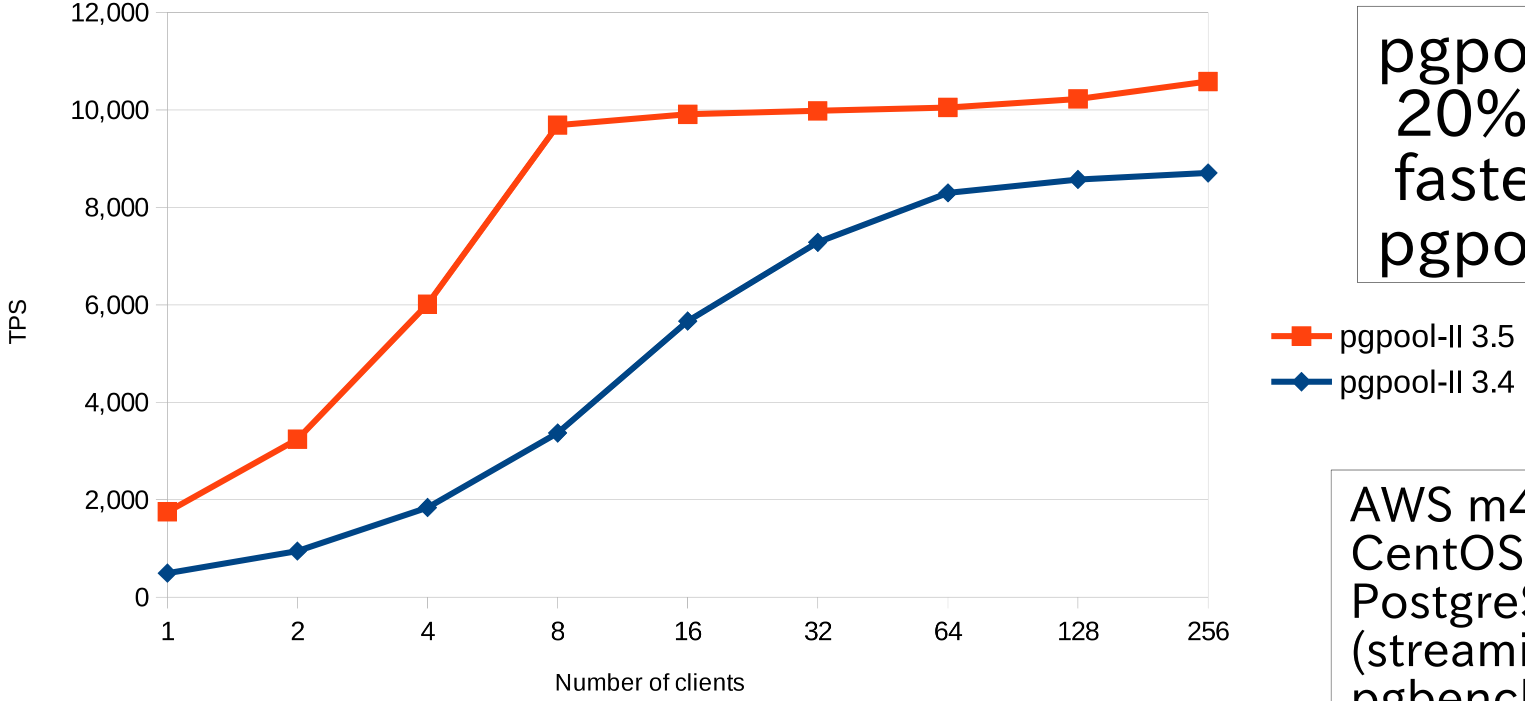
In streaming replication we could omit some of Flush messages

enhanced!



extended protocol
with pgpool-II in 3.5

Benchmarking Extended protocol query performance



pgpool-II 3.5 is 20% to 250% faster than pgpool-II 3.4!

AWS m4.large instance
CentOS 6
PostgreSQL 9.4 x2
(streaming replication)
pgbench -S

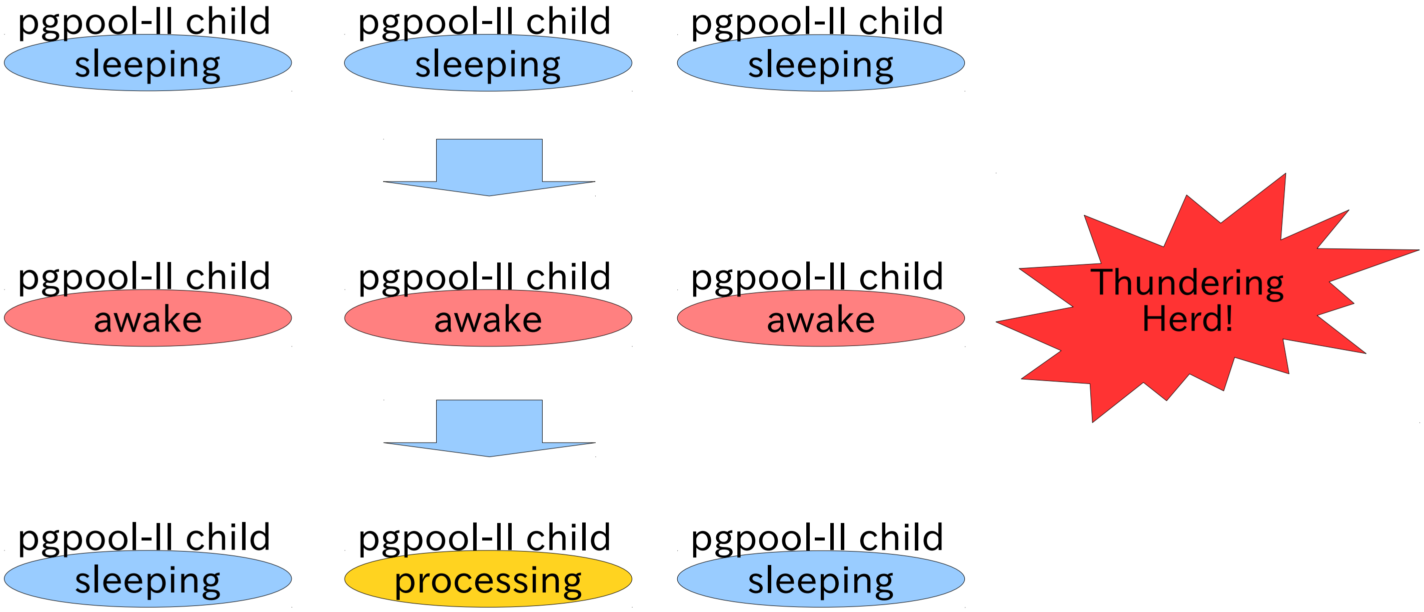
Overcoming Thundering herd problem

- What is “the thundering herd problem”?
  - “The thundering herd problem occurs when a large number of processes waiting for an event are awoken when that event occurs, but only one process is able to proceed at a time. After the processes wake up, they all demand the resource and a decision must be made as to which process can continue. After the decision is made, the remaining processes are put back to sleep, only to all wake up again to request access to the resource.”

    From Wikipedia
- pgpool-II forks off many child process and they are waiting for connection requests from clients
- If a connection request arrives, all of the child process are awoken but only one of them is allowed to accept the request
- Other child process start sleeping again, to wait for next connection request
- This leads to an excessive context switching and results in poor performance

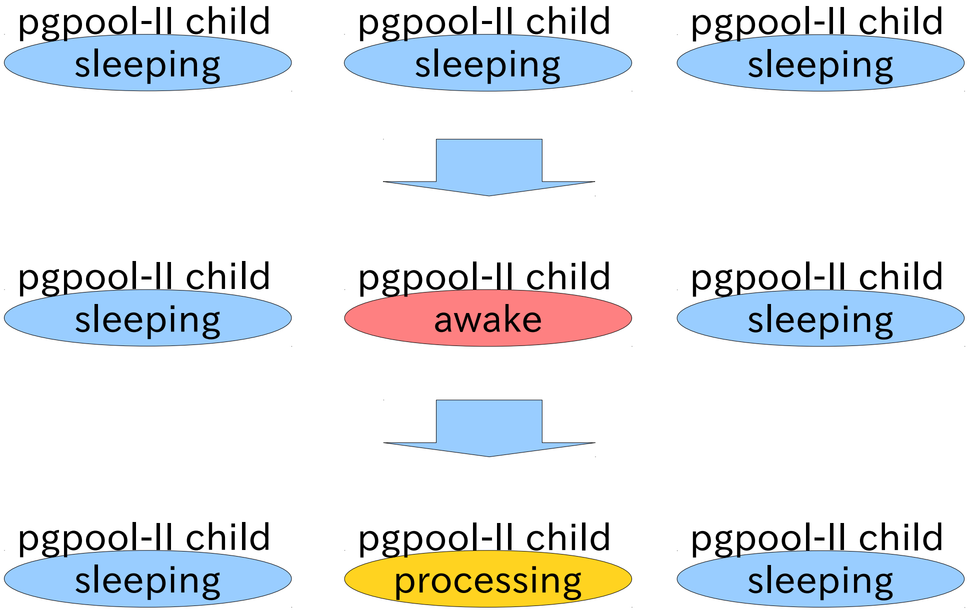
Overcoming Thundering herd problem

pgpool-II 3.4



Overcoming Thundering herd problem

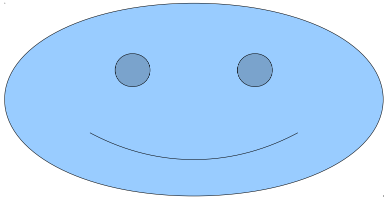
pgpool-II 3.5



pgpool-II child sleeping | pgpool-II child sleeping | pgpool-II child sleeping

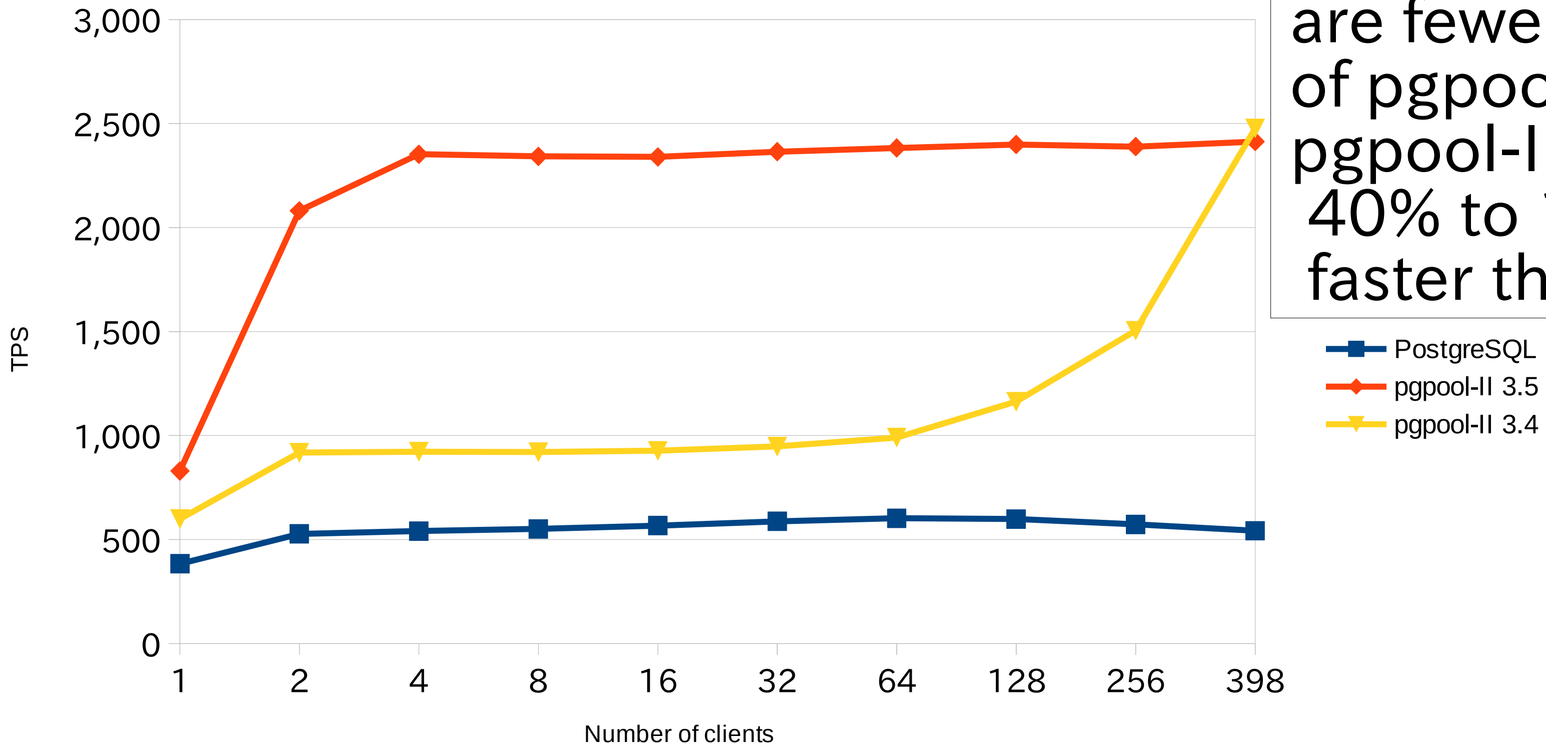
pgpool-II child sleeping | pgpool-II child awake | pgpool-II child sleeping

pgpool-II child sleeping | pgpool-II child processing | pgpool-II child sleeping



No thundering
Herd problem

Overcoming Thundering herd problem



If concurrent clients are fewer than number of pgpool child process, pgpool-II 3.5 is 40% to 150% faster than pgpool-II 3.4

Note PC with 16GB Mem, CORE i7 x2, 512GB SSD
Ubuntu 14.04
PostgreSQL 9.4 x2
(streaming replication)
pgbench -S -C -T 300

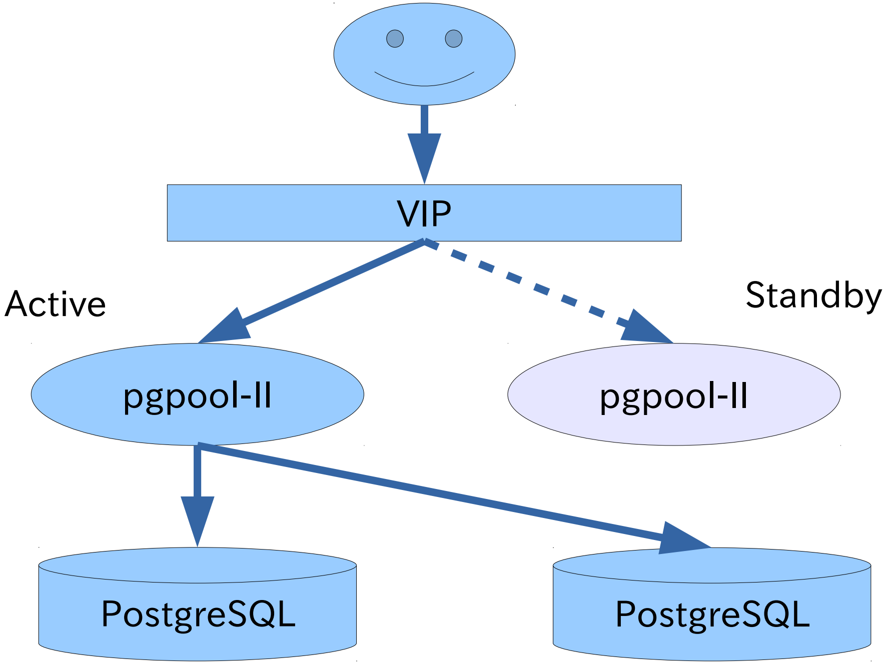
Settings to avoid the thundering herd problem in pgpool-II 3.5

- set “serialize_accept” to on
- set “child_life_time” to 0
- If concurrent connections are roughly equal to num_init_children, this function does not do the best (see previous slide)

Improving watchdog

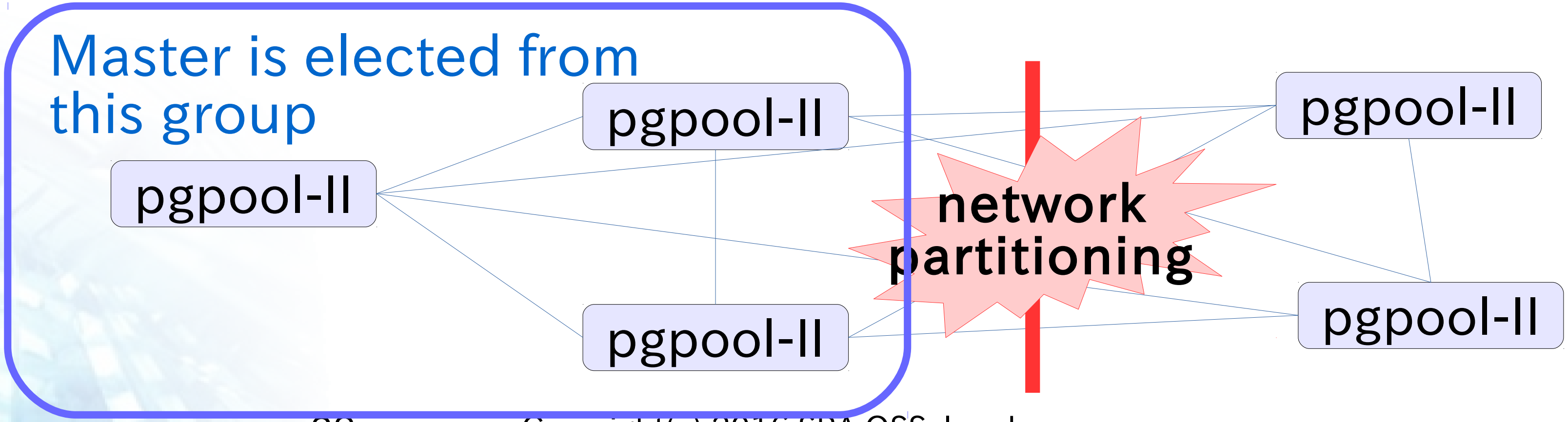
What is “Watchdog”?

- Because pgpool-II works as a proxy, pgpool-II could be Single point of failure (SPOF)
- “Watchdog” is a built-in High Availability (HA) feature of pgpool-II
- Two or more pgpool-II instances monitors each other. If “Active” pgpool-II goes down, “Standby” pgpool-II takes over and becomes new active pgpool-II
- Active pgpool-II holds Virtual IP (VIP). Client connects to the VIP and are not worried about which is pgpool-II is alive



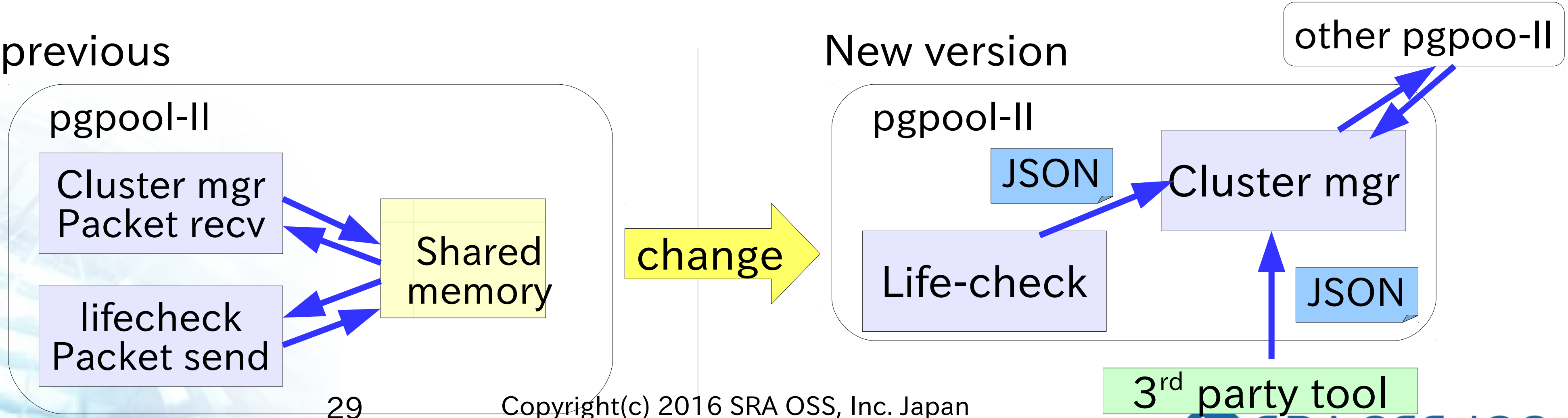
New Watchdog Enhances Robustness against Split-brain

- Split-brain syndrome
  - It can't be decided which pgpool-II should be elected as the master when the network is participated
  - Quorum support
    - Check if more than half of nodes are belong to the group which local pgpool-II is belonging to
    - Number of pgpool-II nodes must be odd to make quorum working (in other case you can use “trusted_servers”)


Master is elected from this group

New Watchdog enhances inter-process communication

- Change in inter-process communication method with in watchdog
  - UNIX domain socket & JSON format data
- This allows pgpool-II to work with third-party tools
  - ex) health-check by a third party tool. Etc.



Watchdog enhancement others

- Verifies the consistency of important configuration parameters among all nodes
  - make sure they are consistent among all nodes
  - help to eliminate problems caused by Il-configured pgpool-II nodes

- Watchdog nodes can have priorities
  - Watchdog nodes can be assigned with different priorities
  - Nodes with higher watchdog will get a preference when the cluster is electing its new leader node.

Ready for PostgreSQL 9.5

Importing PostgreSQL 9.5 parser

- Parser of PostgreSQL 9.5 is ported into pgpool-II 3.5
  - Previous parser was imported from PostgreSQL 9.4
- Load-balancing and query-cache supports the new select syntax.
  - GROUPING SET, CUBE, ROLLUP,
  - TABLESAMPLE
- Query-rewriting in the native replication mode supports the new insert/update syntax.
  - INSERT … ON CONFLICT
  - UPDATE tab SET (col1,col2,...) = (SELECT ...), ...

Improvements in pgpool-II 3.5: others

Health check and replication delay checking target database

- In some systems (for example, Heroku) do not allow to connect to “postgres” or “template1” database
- pgpool-II issues query to those databases for health check and streaming replication delay
- pgpool-II allows to use particular database instead of the databases
  - health_check_database
  - sr_check_database

Enhanced PCP comand

- What is “PCP” command
  - Stands for “Pgpool Control Protocol”
  - Set of commands to control pgpool-II
    - Attaching/detaching PostgreSQL to pgpool-II
    - Execute on-line recovery
    - Retrieve various information from pgpool-II
- Problem with older versions
  - Single session – no concurrent execution of commands is not allowed
  - Position arguments – hard to use
  - Needs to pass password as an argument – security issue
- All of the weakness is now eliminated

Showing SELECT count

- “show pool_nodes” command now shows the number of SELECTs being issued to each DB node

New!

```
test=# show pool_nodes;
 node_id | hostname | port  | status | lb_weight |  role   | select_cnt
---------+----------+-------+--------+-----------+---------+------------
 0       | /tmp     | 11002 | 2      | 0.500000  | primary | 338230
 1       | /tmp     | 11003 | 2      | 0.500000  | standby | 163939
(2 rows)
```

Chinese translations!

- Pgpool-II documentation
- pgpoolAdmin message catalog

Caution!

- “Parallel mode” is removed
  - Too many restrictions
  - Virtually 0 user
  - Complexity of code

Future plans

- Pgpool-II 3.6 is expected out late this year
  - Will focus on stability and usability
  - Followings are new features in discussion:
    - More comprehensive test cases
    - SET command
    - Improved documentation (SGML?)
    - Minimize users session disconnections in case of fail over

Where to get pgpool-II?

- pgpool-II official site
  - http://www.pgpool.net
- SRA OSS
  - http://www.sraoss.co.jp
  - Commercial support is available

Thank you!

Спасибо!