Postgres Scaling Opportunities

BRUCE MOMJIAN

Configuring Postgres for heavy workloads can take many forms. This talk explores available Postgres scaling options.

https://momjian.us/presentations

Last updated: June 2024

Scaling

Database scaling is the ability to increase database throughput by utilizing additional resources such as I/O, memory, CPU, or additional computers.
However, the high concurrency and write requirements of database servers make scaling a challenge. Sometimes scaling is only possible with multiple sessions, while other options require data model adjustments or server configuration changes.

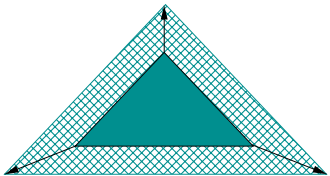
Outline

Postgres scaling opportunities:

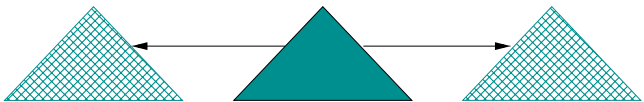
1. Multi-session
2. Single-session
3. Multi-host

Vertical/Horizontal Scaling

Vertical



Horizontal



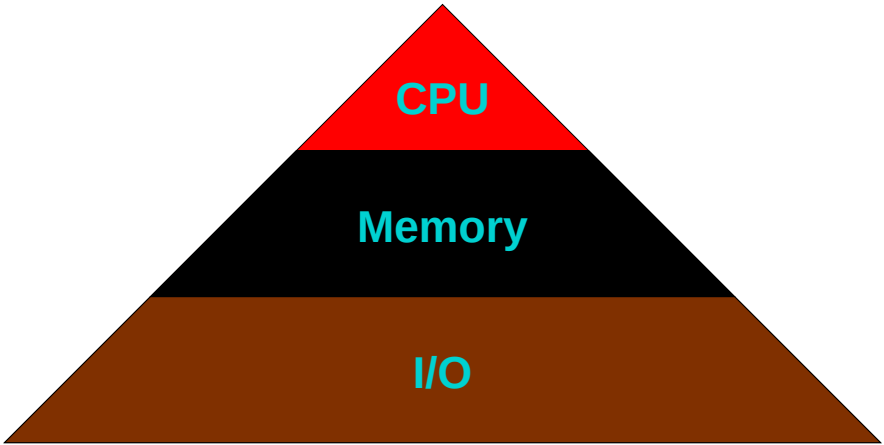
Examples

Vertical scaling examples:

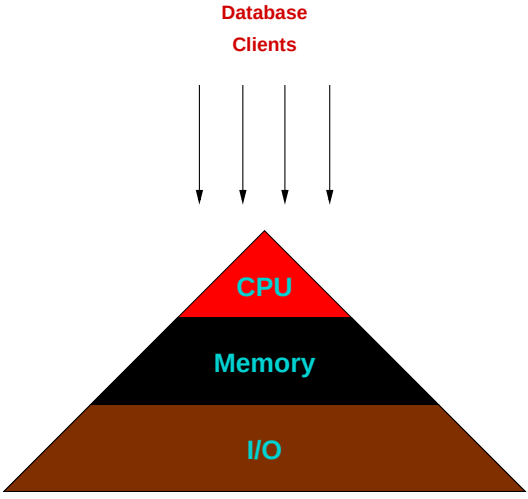
- More and faster CPUs
- More memory
- More and faster storage
- Battery-backed cache (BBU)

Horizontal scaling involves adding servers.

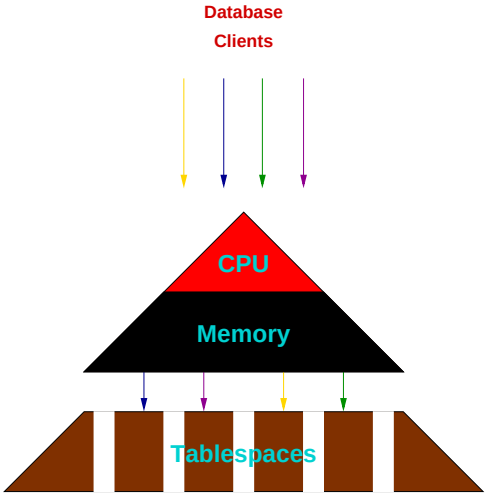
Hardware Components



1. Multi-Session



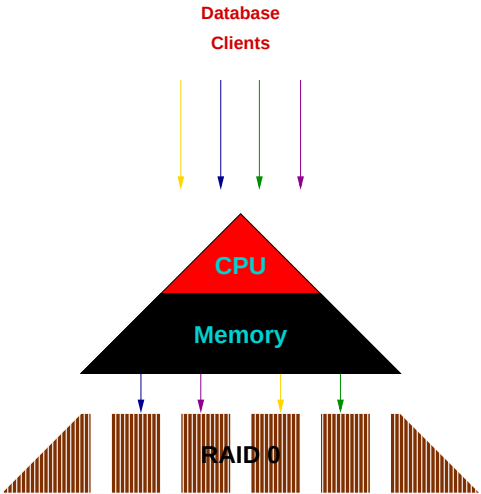
I/O Spreading Using Tablespaces



Requires tables & indexes to be spread across tablespaces

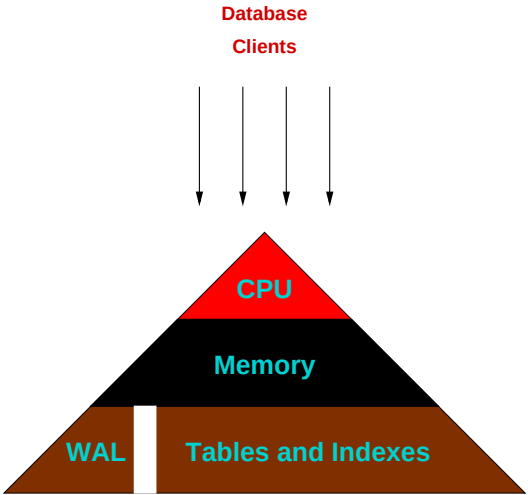
Tablespaces should be on different storage devices

I/O Spreading Using RAID 0



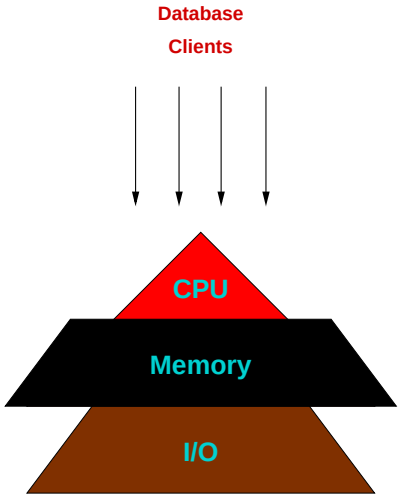
Auto-hashed by storage block number

Write Spreading Using WAL Relocation



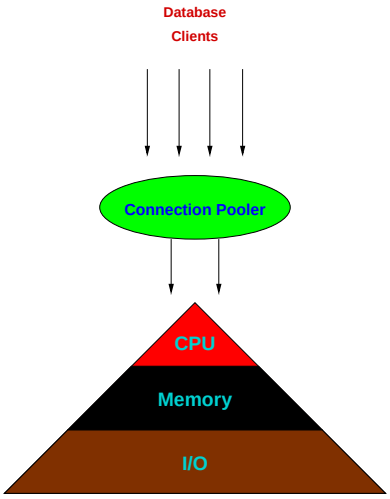
Separates WAL writes from table & index I/O

Read Reduction via Increased Memory



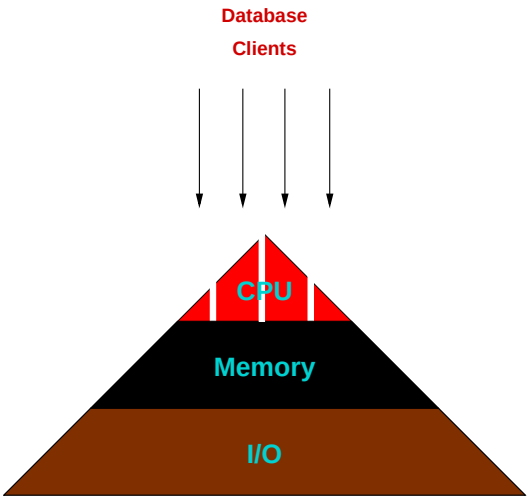
Additional memory caching reduces read requirements

Scaling Connections Using a Pooler



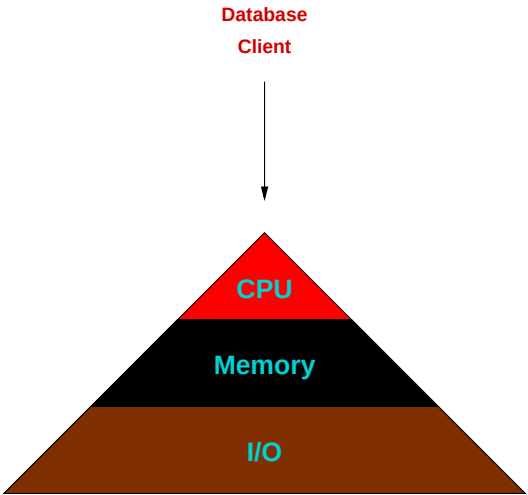
Fewer idle connections reduces resource usage

Multi-Session CPU Scaling

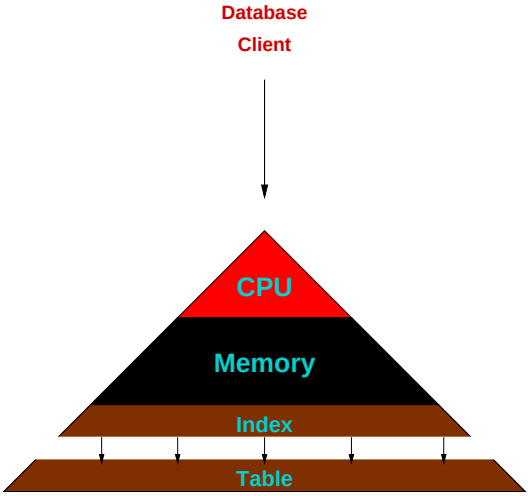


Multiple sessions spread across available CPUs

2. Single-Session



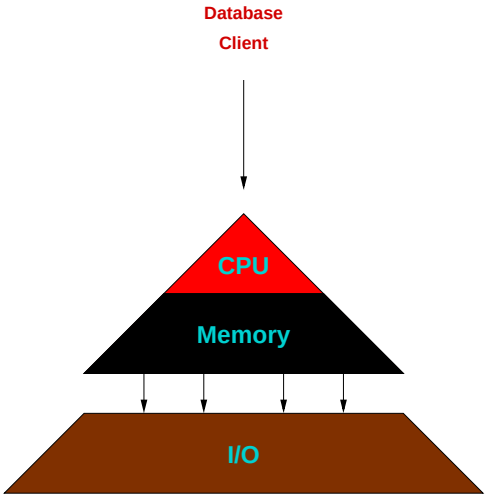
Read Parallelism Using effective_io_concurrency



Used during bitmap heap scand

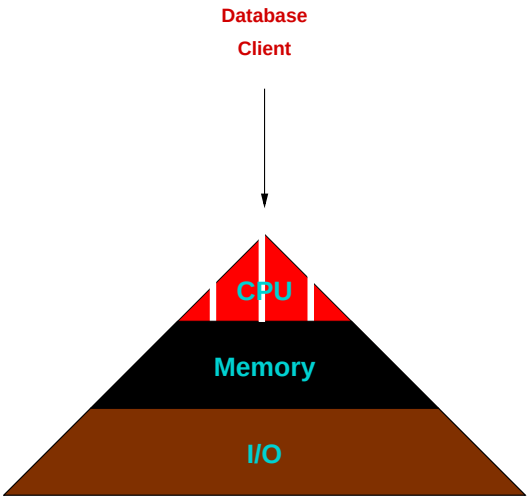
Assumes table is hashed across multiple devices

I/O Scaling via Parallelism



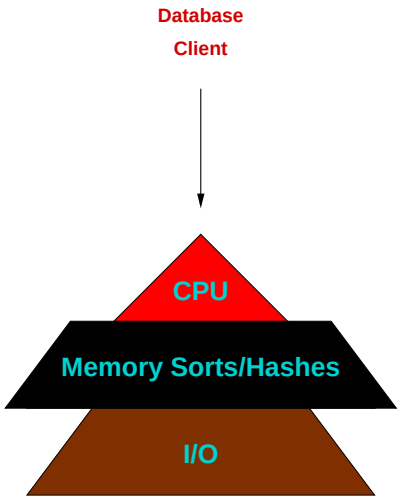
Involves parallel index, heap, partition, and tablespace access

CPU Scaling via Parallelism



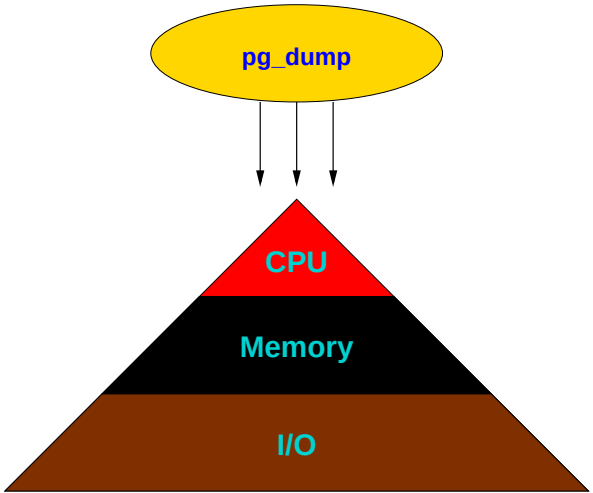
Involves parallel sorts, joins, and function execution

Sort I/O Reduction Using work_mem



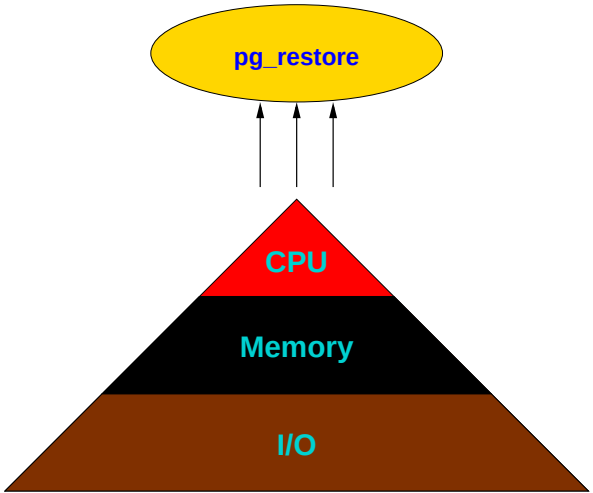
Reduces temporary result reads & writes

Logical Dump Parallelism



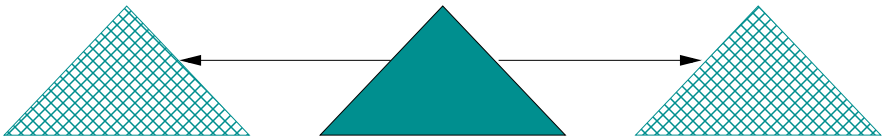
Dumps tables using concurrent database connections

Logical Restore Parallelism



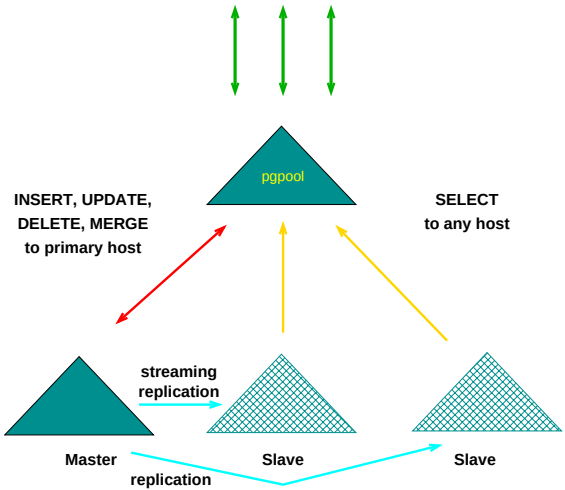
Loads tables and creates indexes using concurrent database connections

3. Multi-Host



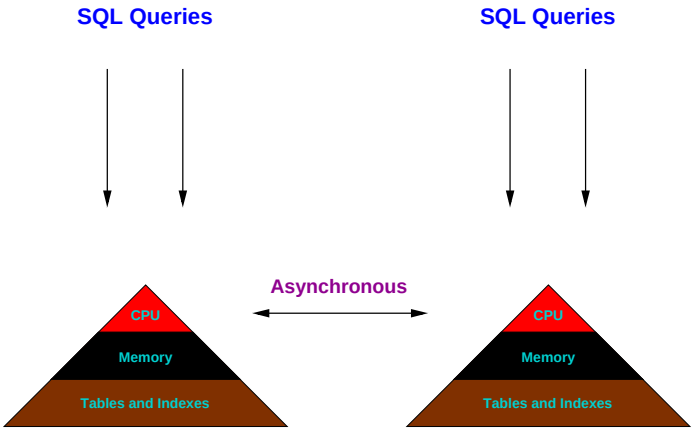
https://wiki.postgresql.org/wiki/PGECons_CR_Scaleout_2021

Read Scaling Using Pgpool & Streaming Replication



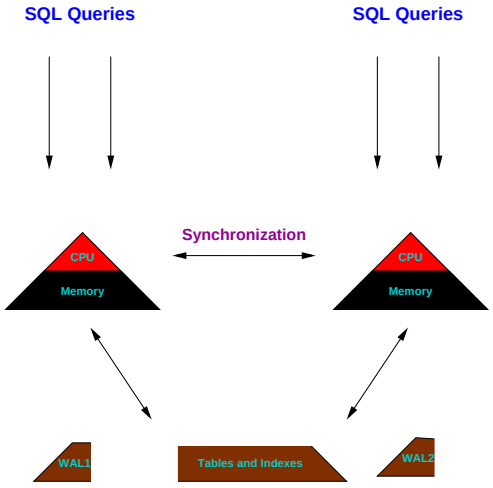
A full copy of the data exists on every node.

CPU/Memory Scaling With Asynchronous Multi-Master



A full copy of the data exists on every node; requires conflict resolution. The asynchronous delay allows write-load buffering.

Oracle Real Application Clusters (RAC)

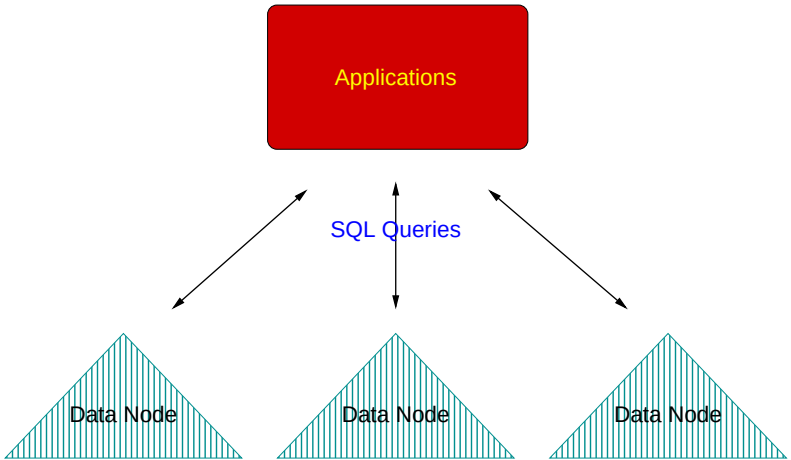


Tables and indexes on shared storage; inter-node synchronization required for cache consistency

I/O Scaling with Sharding: Challenges

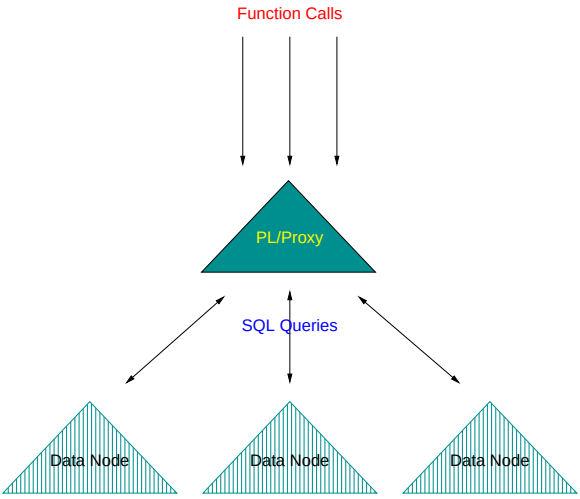
- Multi-host write queries require two-phase commit (except XC)
- Multi-host visibility snapshots are not supported (except XC)
- Sharding benefits are only possible with a shardable workload
- Changing the sharding layout can cause downtime
- Additional hosts reduce reliability; additional standby servers might be required

Application-Based Sharding



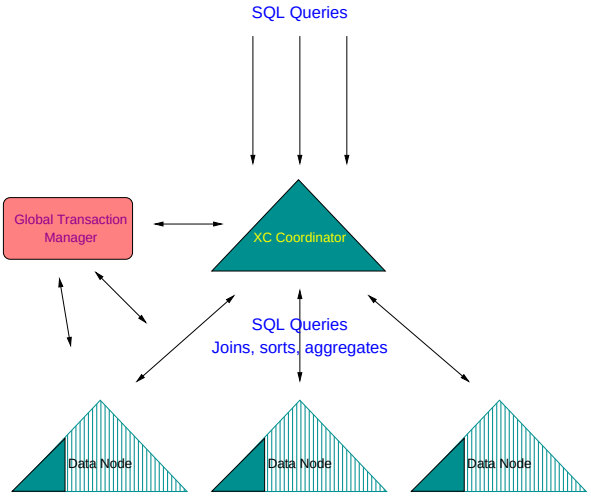
Applications send queries based on the sharding layout.

Sharding Using PL/Proxy



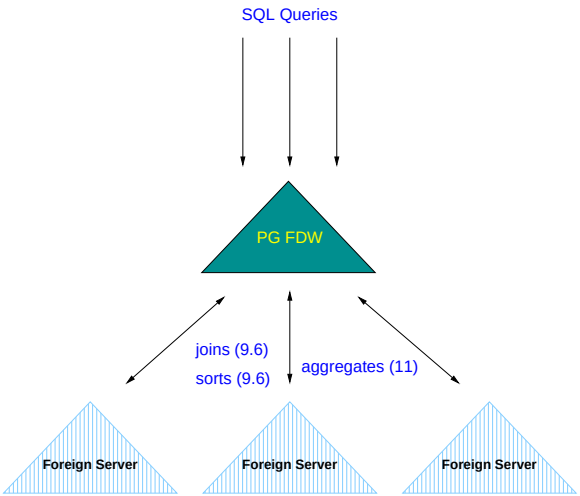
Requires rows to be hashed by key, supports parallel-node query execution

Sharding Using Postgres-XC



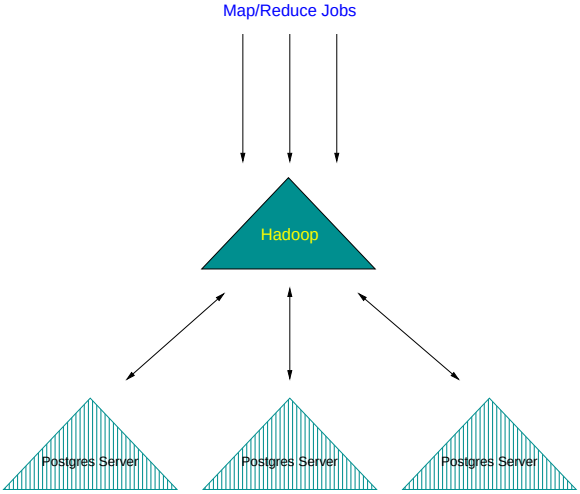
Enables hashing of large tables, replication of others
Supports parallel-node consistent transactions and DDL

Scaling Using Foreign Data Wrappers



Requires rows to be hashed by key

Bulk Data Scaling Using Hadoop



Conclusion

https://momjian.us/presentations

https://www.flickr.com/photos/87179607@N06/