PostgreSQL Performance…
when it's not your job.

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Hi.

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- http://thebuild.com/
- Got into being a DBA because no one else where I was working wanted to be.

The situation.

- You are a developer.
- Or system administrator.
- Or random passer-by.
- "Oh, we need PostgreSQL installed on that box."

* This machine was bought in 1997.
* It is running PostgreSQL 9.1.2.
* Your argument is invalid.

The problem.

- “Sorry, no hardware upgrade budget.”
- “But that machine should be plenty, right?”
- “Oh, make sure the database runs really fast.”
- “You know, tweak some settings and add some indexes or something.”

Courage!

- We’ll assume your hardware can’t be changed.
- We’ll assume you don’t really want to be a full-time DBA.
- We’ll do the best we can under trying circumstances.
- What else can one do in life, really?

Le menu.

- Settings: Memory, I/O, CPU, others.
- Application-Level Stuff.
- Monitoring and add-ons.

OK, three slides on hardware.

- More (ECC) RAM is better, and…
- More cores are better, but consider your real concurrency, so…
- Spend the real money on I/O.
  - RAID 1 for the transaction logs.
  - RAID 1+0 for the data.
  - Hardware RAID >> software RAID.

Considered harmful.

- Parity-disk RAID (RAID 5/6, Drobo, etc.).
- iSCSI, especially for transaction logs.
  - The latency will kill you.
- SANs, unless you can afford multichannel fibre.
- Long network hauls between the app server and database server.

Special cases.

- If you can get RAM 2-3x your database size, do it.
- Largely read-only databases can use parity-disk RAID effectively.
- If you are on a VM, remember the hypervisor takes both memory and CPU; allow an extra 15% RAM and 1 core for it.

Let's be reasonable.

- PostgreSQL 9.0 or higher.
  - If you are still on 8.x, upgrade already.
- At least 4GB of main memory.
- At least one big RAID 1 drive pair.
  - "Big" means "30% or less full when everything's on it."

Only PostgreSQL on the box.

- This is the single easiest thing you can do to improve PostgreSQL performance.
- No mail server, web server, app server, LDAP server, massive JBOSS install...
- Messes up caching, steals CPU, eats memory and I/O… it's just bad news.
- This includes host machines for VMs!

A note on parameter settings.

- Will try to be as quantitative as possible.
- Remember, different workloads will have different requirements.
- These are general guidelines and first cuts.
- YMWACV.

The PostgreSQL memory dance.

- Most of your memory should be available for file system cache.
- Don’t try to give PostgreSQL every last byte. It won’t appreciate it.
- “Somewhat more than just enough” is the right setting.

Memory types.

- File system cache
- Shared buffers
- Working memory
- Maintenance working memory
- Ancillary memory

File system cache.

- 30-50% of system memory should be available for file system cache.
- This is the level-1 disk cache for PostgreSQL.
- Don't starve it! If you see it drop below 30% of total, you need to free up memory.

Memory parameters.

- shared_buffers
- work_mem
- maintenance_work_mem
- effective_cache_size

Shared buffers.

- PostgreSQL’s private cache of disk pages.
- In a perfect world, the current working set of database disk pages would fit in here.
- Shared across all currently running PostgreSQL processes.
- Allocated in full as soon as PostgreSQL starts up.

Working memory.

- Memory used for sorts, hash joins, etc.
- If you see lots of temp files being created (check the logs), increase it.
- The default is almost certainly too low, BUT:
- It applies *per planner node;* you can use *many times* this much memory at once.

work_mem

- That's not much use. How big, already?
- Big enough to cover 95% of temp files being created.
- Note that on-disk operations are smaller (byte for byte) than in-memory ones.
- So work_mem needs to be 2-3x the temp file size you are seeing.

work_mem, part 2

- Big, slow queries might be helped by more work_mem.
- Use EXPLAIN ANALYZE <query>, and look for on-disk operations.
- But remember! If you increase it system-wide, any query might eat it up.
- Consider setting it per-session or per-operation.

Quick show of hands.

- Everyone know about VACUUM, and why you do it?
- How about VACUUM FREEZE?
- And when should you do a VACUUM FULL?
  - That’s right, never (well, almost never).

Maintenance working memory.

- Used mainly for VACUUM and related operations.
- Are your VACUUMs and autovacuums taking forever, or not finishing?
  - Bump it up, but…
  - 1GB is pretty much as high as you want to go.

Well, that didn't work.

- Can't give it enough memory for VACUUMs to finish?
- Consider doing a manual VACUUM (via cron) at low-demand periods.
  - maintenance_work_mem can be set per session or per role.
  - Create a VACUUM-specific superuser.

Ancillary memory.

- Per-connection, lock tables, prepared transactions, etc., etc.
- These days, these tend not be huge memory sinks.
- But if you feel like cranking max_connections above 200?
  - Use pooling instead (hold that thought).

effective_cache_size

- One of these things is not like the other, one of these things, doesn't belong.
- Does not allocate any memory.
- It's just a planner hint.
- = file system cache + shared_buffers

I/O.

- This is generally where databases fall apart.
- Proper ACID compliance comes at a cost.
- That cost is paid in the currency of I/O operations per second.
- Ultimately, it’s up to the speed of the underlying storage subsystem.
  - But you can help.

I/O parameters.

- wal_segments
- checkpoint_completion_target
- checkpoint_segments
- checkpoint_interval
- effective_io_concurrency

The write-ahead log.

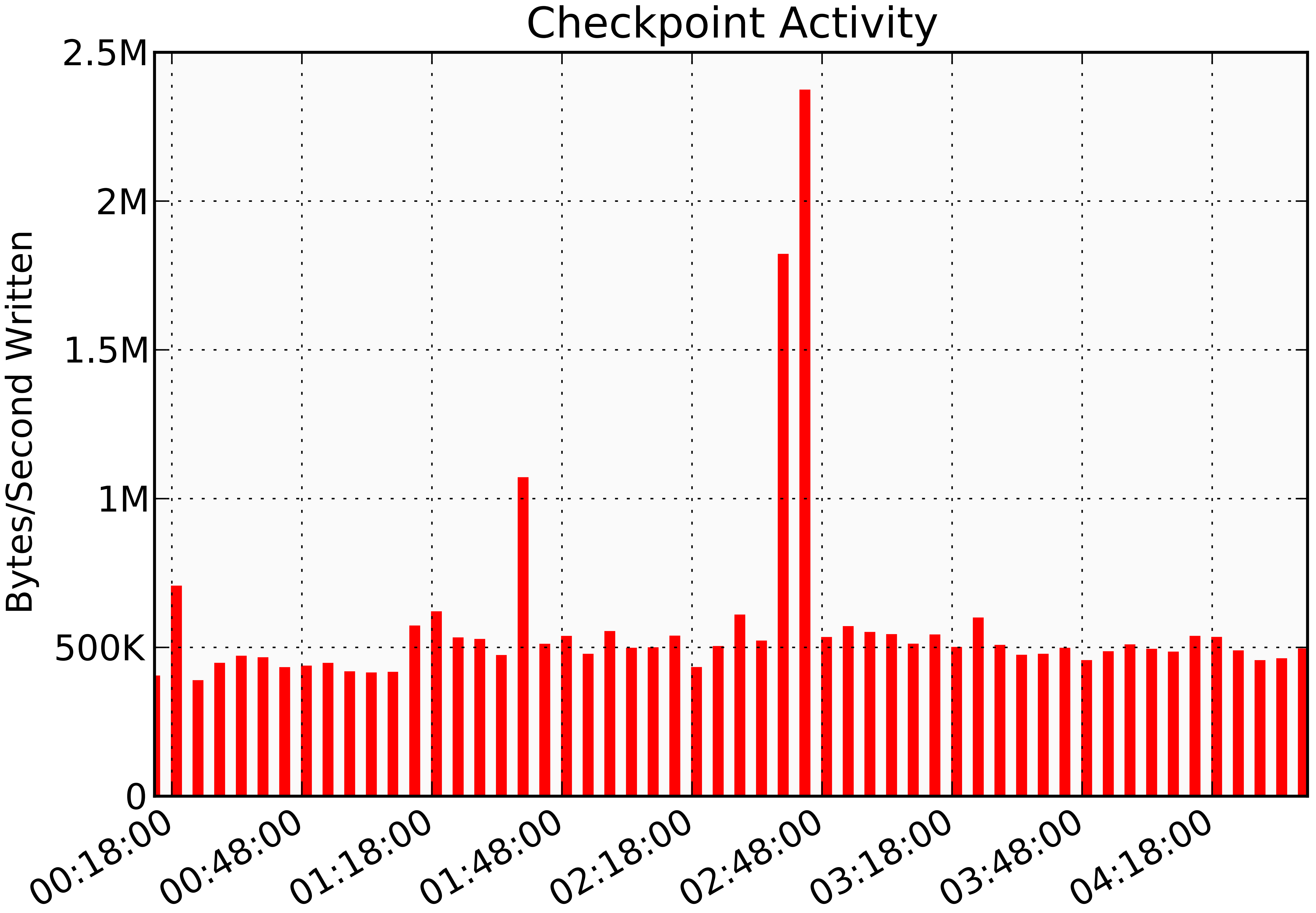
- Every committed change to the database is written to the write-ahead log.
  - Exceptions: Temporary and unlogged tables.
- Constant stream of write activity, broken into segments of 16MB each.
- Ideally, put it on its own set of disks (HD or SSD).

WAL parameters.

- Not much, really.
- wal_buffers can be bumped up to 8-16MB.
- But the big-deal activity is in checkpoints.

About checkpoints.

- A complete flush of dirty buffers to disk.
- Potentially a lot of I/O.
- Done when the first of two thresholds are hit:
  - A particular number of WAL segments have been written.
  - A timeout occurs.



Checkpoint Activity
Bytes/Second Written
2.5M
2M
1.5M
1M
500K
0
00:18:00
00:48:00
01:18:00
01:48:00
02:18:00
02:48:00
03:18:00
03:48:00
04:18:00

But why?

- Well, the stuff has to get flushed sometime.
- Otherwise, it would have to replay the WAL segments from the beginning in case of a crash…
- … and that means you'd have to keep them all.
- … and it can take as long to replay as it did to create them.

The goal.

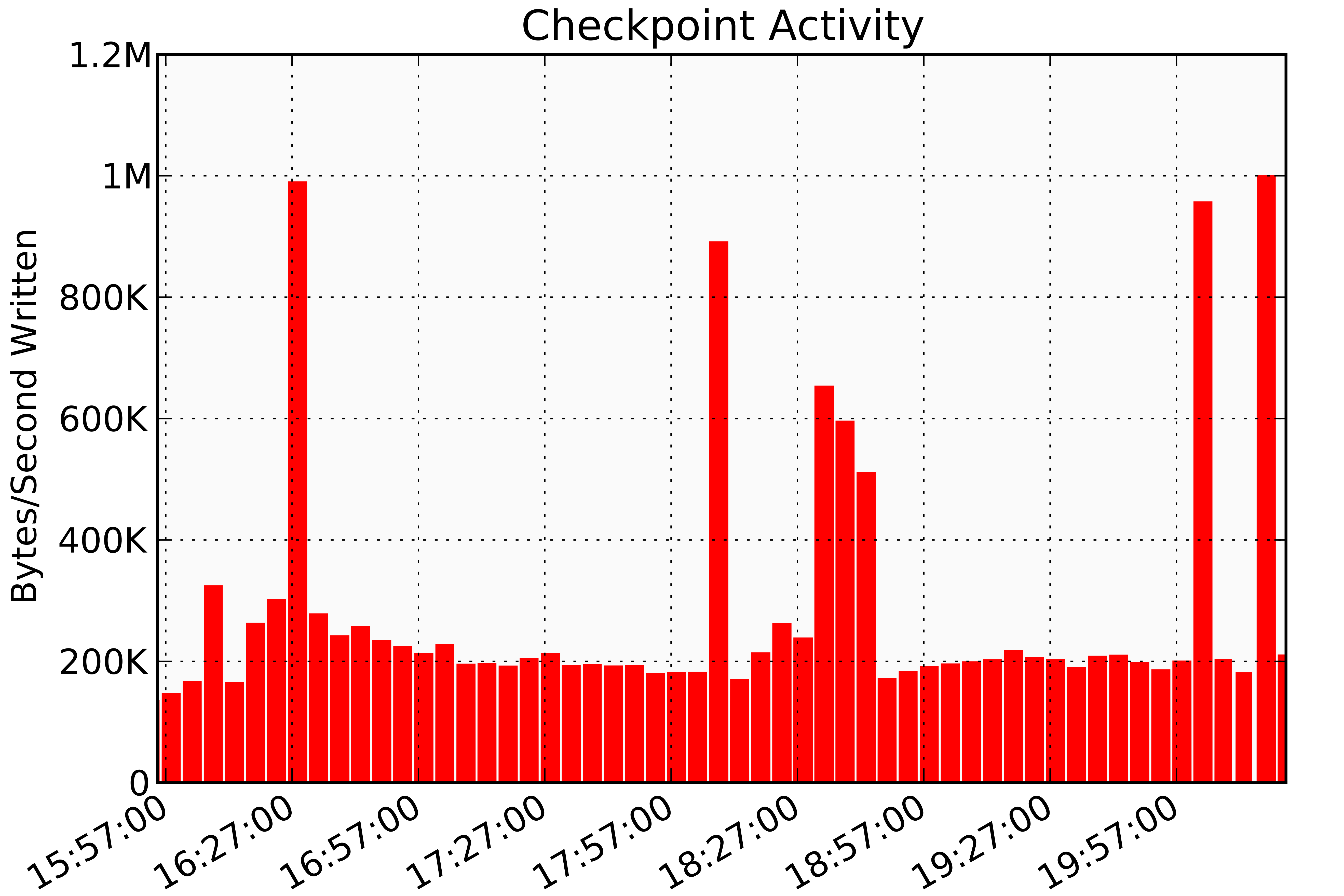
- Keep checkpoints from flooding the I/O subsystem.
- Background writer trickles out changes all the time.
- The various parameters interact in a complex way.
- That sounds too much like work.

Checkpoint parameters.

- checkpoint_segments will take 16MB x setting in disk space. Set it as high as you can afford (in disk space).
- Set checkpoint_timeout so that you will almost always hit checkpoint_segments first at high-load times. (30min? Measure.)
- Set checkpoint_completion_target to 0.9.

What this does.

- Spreads the write activity out over 90% of checkpoint_timeout.
- You can't actually reduce the amount of stuff it has to write…
- … you can just tell it to write it out more smoothly.



Checkpoint Activity
Bytes/Second Written
1.2M
1M
800K
600K
400K
200K
0
15:57:00
16:27:00
16:57:00
17:27:00
17:57:00
18:27:00
18:57:00
19:27:00
19:57:00

Caveat checkpointer.

- Assume a dirty restart of PostgreSQL will take as long as checkpoint_timeout to replay the pending logs.
- So, cap the values based on your pain tolerance there.

To reiterate.

- The checkpoint parameters do not change *how much* data PostgreSQL has to write.
- That's purely a result of how much write activity your applications are creating.
- They do change the *pattern* of how it is written, however.

effective_io_concurrency

- Another planner hint.
- Set to the number of disks in a RAID array.
- Set to the number of channels in an SSD or SSD array.
- Sit back and watch it… well, it can help hash joins.

synchronous_commit

- PostgreSQL guarantees that data has been hardened on disk when COMMIT returns.
- Turning this off disables that guarantee.
- The database will not get corrupted.
- But transactions that were COMMITed might disappear on a dirty restart.
- Turn "off" if you can tolerate that.

fsync = on

CPU.

- PostgreSQL spawns one process per connection (plus some supporting utilities).
- More cores are better.
- Roughly, 2 concurrent queries per core.
- Boring! Let’s talk about the planner instead.

ANALYZE

- Collects statistics on the data to help the planner choose a good plan.
- Done automatically as part of autovacuum.
- Always do it manually after substantial database changes (loads, etc.).
- Remember to do it as part of any manual VACUUM process.

default_statistics_target

- PostgreSQL keeps a histogram of statistics for most columns in the table.
- This is the number of bins in that histogram. Default is 100.
- Crank it up a bit if you have lots of big tables.
- You can set it per column… and you should for key columns in big tables.

seq_page_cost vs random_page_cost

- A vague guestimate of how much more expensive it is to fetch a random page than a sequential page.
- Default is 4x (random_page_cost=4.0).
- Lower it for big RAID arrays, SSDs.

Logging.

- This one's easy:
  - Use the built-in logging collector.
  - Use CSV logs.
  - Keep at least 30 days of logs.
  - They gzip down nice.

Logging.

- log_temp_files = 0
- log_checkpoints = on
- log_lock_waits = on
- log_min_statement_duration = …
  - 100-250ms for interactive usage, 1-100s+ for data warehousing.

Special situations.

- Very write-intensive work loads.
- Very high-variability work loads.
- Repeatable bulk loads.

Write-intensive workloads.

- shared_buffers can be reduced.
- checkpoint_segments ++
- checkpoint_timeout ++
- synchronous_commit off, if you can handle the data-loss window.

Write-intensive workloads.

- If the load is has a large percentage of UPDATEs (vs INSERTs):
  - bgwriter_lru_maxpages = 0
  - autovacuum_cost_delay ++ (or consider disabiling in favor of manual VACUUM, see later).

Highly-variable workloads.

- Periods of very high demand, periods of very slack demand.
- If the cycles are short:
  - bgwriter_delay ++
  - checkpoint_segments ++
  - checkpoint_timeout ++

Highly-variable workloads.

- If the periods are long (daily), in addition:
  - autovacuum = off
  - Do a manual VACUUM with large maintenance_work_mem during slack periods.
  - Remember that you *must* do the manual vacuum regularly!

Repeatable bulk loads.

- Database can reinitialized in case of a failure.
- Use COPY or a dedicated tool.
- Create indexes at the end.
- This is the *one time* it is recommended to turn off fsync.
- Remember to turn it back on, OK?

Application stuff.

- Indexing
- SQL Pathologies
- Connection Management
- Workload Distribution
- Stupid Database Tricks

Indexing.

- What is a good index?
- A good index:
  - … has high selectivity on commonly-performed queries.
  - … or, is required to enforce a constraint.

Indexing.

- What’s a bad index?
  - Everything else.
  - Non-selective / rarely used / expensive to maintain.
- Only the first column of a multi-column index can be used separately.

Indexing

- Don't go randomly creating indexes on a hunch.
  - That's my job.
- pg_stat_user_tables — Shows sequential scans.
- pg_stat_user_indexes — Shows index usage.

SQL pathologies.

- Gigantic IN clauses.
- Expensive-to-process EXISTS clauses.
- Unanchored text queries like ‘%this%’; use the built-in full text search instead.
- Small, high-volume queries processed by the application.

Connection management.

- Opening a new connection is expensive.
- If you are getting more than 200 connections regularly, consider a pooler.
- If you are getting more than 500, run, don't walk.
- pgbouncer.

Workload distribution.

- Transaction processing / web app workloads do not mix with data warehousing workloads.
- Use 9.x’s streaming replication to create a read-only secondary to do the data warehousing.
- And you get an emergency backup for free!

Stupid Database Tricks.

- Sessions in the database.
- Constantly-updated accumulator records.
- Task queues in the database.
- Using the database as a filesystem.
- Frequently-locked singleton records.
- Very long-running transactions.

INSERT storms.

- INSERTs are a terrible way to do a bulk load.
- Use COPY instead.
- Most language drivers have a good interface to it.
  - If it doesn’t, get a better driver.

Shiny on the outside.

- Prepared statements.
- Partitioning.

Prepared statements.

- Usually a “take it or leave it” situation with the particular language driver.
- They do not automatically improve performance.
    - In fact, the most common situation is a total loss.
- Getting a benefit from them requires application participation.

Partitioning.

- Breaks a table up into a set of tables, based on a partitioning key.
- PostgreSQL can automatically direct (most) queries to the particular sub-tables for queries using the partitioning key.

Partitioning.

- Can be great IF:
  - Data has a (near-) uniform distributed key that *never changes*.
  - Data can be partitioned into equal(-ish)-sized bins on that key.
  - Queries *always* include that key.
  - Queries almost always hit 1-2 bins.

BONUS CONTENT! PostgreSQL on AWS

- Remember that instances can restart at any time.
- Remember that EBS mounts can just disappear.
- EBS performance is… variable.
- Instance storage is limited, expensive, and can evaporate even more readily than EBS.

AWS Survival Guide

- As much memory as you can afford.
- Two 8-way RAID-0 EBS mounts: One for the data, one for the transaction log.
- Don’t use instance storage for any database data; config is OK if you keep a snapshot.
- random_page_cost = 1.1
- Set up streaming replication.

Monitoring.

- CPU usage.
- Memory usage.
- I/O usage.
- Query times.
- Table growth.
- Table behaviors (last vacuum, etc.).

Tools.

- check_postgres
  - Lovely script, Nagios-friendly.
- pg_stat_*
  - PostgreSQL has lots of built-in views.

Add-Ons.

- PostgreSQL extensions:
  - auto_explain
  - pg_stat_statements
- Plenty of others:
  - contrib/
  - http://pgxn.org/

Questions?

Thanks.

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