2ndQuadrant®
PostgreSQL

Data corruption

Where does it come from and what can you do about it?

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data_checksums = on

Well, not quite ...

The larger and older a database is, the more likely it's corrupted in some way.

Agenda

- What is data corruption?
- Sources of data corruption
- What to do about it

Data corruption

- many possible causes
- hardware
  - disks / memory
  - environment (cosmic rays, temperature, …)
- software
  - bugs in OS (kernel, fs, libc, ...)
  - bugs in database systems / applications
- administrator mistake
  - remove pg_xlog ...

naturally one-off events

cosmic rays = no clue

storage

storage corruption

- this used to be pretty common
  - crappy disks, RAID controllers
  - insufficient power-loss protection
- it got better over time
  - better disks, better RAID controllers
  - when it failed, it failed totally
- now it's getting worse, again :-(
  - crappy disks connected over network (SAN, EBS, NFS, …)
  - layers of virtualization everywhere

software issues

Operating System

- PostgreSQL is very trusting
  - relies on a lot of stuff
  - assumes it's perfect
- nothing is perfect
  - kernel bugs
  - filesystem bugs
  - glibc bugs (collation updates, …)
  - ...

Collations

- rules for language-specific text sort
  - defined in glibc
  - change rarely, poor versioning
- indexes require text ordering to be stable
- what if you build index and then
  - upgrade to diffferent collations
  - replica has different collations
- ICU solves this
  - reliable versioning

#fsyncgate

- CHECKPOINT
  - flush data from shared_buffers to disc
  - discard old part of WAL
- in case of fsync error, retry
- assumes two things
  - reliable kernel error reporting
  - dirty data are kept in page cache

#fsyncgate

- fact #1: error reporting unreliable
  - behavior depends on kernel version
  - errors may be consumed by someone else
  - fixed in new kernel (>= 4.13)
- fact #2: dirty data are discarded after error
  - retry never really retries the write
  - replaced with elog(PANIC) forcing recovery
- a bunch of bugs in the error handling ;-)
  - error branches are the least tested code

NFS == cosmic rays

database systems

- broken indexes
  - violated constraints
  - index scan misses data, seq scan finds it
- bogus data
  - insufficient UTF-8 validation
  - corrupted varlena headers
- data loss
  - multixact bug
  - inappropriate removal of data
  - data made visible/invisible inappropriately

database bugs

```
ERROR: invalid memory alloc request size 1073741824
```

pilot error

DBA mistakes ....

- drop incorrect table
- free space by removing "logs" from pg_xlog
- let's compress everything in DATADIR
- take backups incorrectly

What can you do about it?

Preventing data corruption

- use good hardware
  - good hardware is cheaper than outages
  - no, desktop machines are not good choice
  - ECC RAM is a must
- update regularly
  - minor releases exist for a reason
- test it
  - Are the numbers way too good?
  - What happens in case of power-loss?
  - Does the virtualization honor fsyncs etc.?

Preventing data corruption

- make sure you have backups
  - take them and test them
  - consider higher retention periods
- consider doing extra checks on backups
  - `pg_verify_checksums`
  - application tests
- "prophylactic" pg_dump is a good idea
  - `pg_dump > /dev/null`
  - especially when using pg_basebackup

fixing data corruption

So you want to fix in-place ...

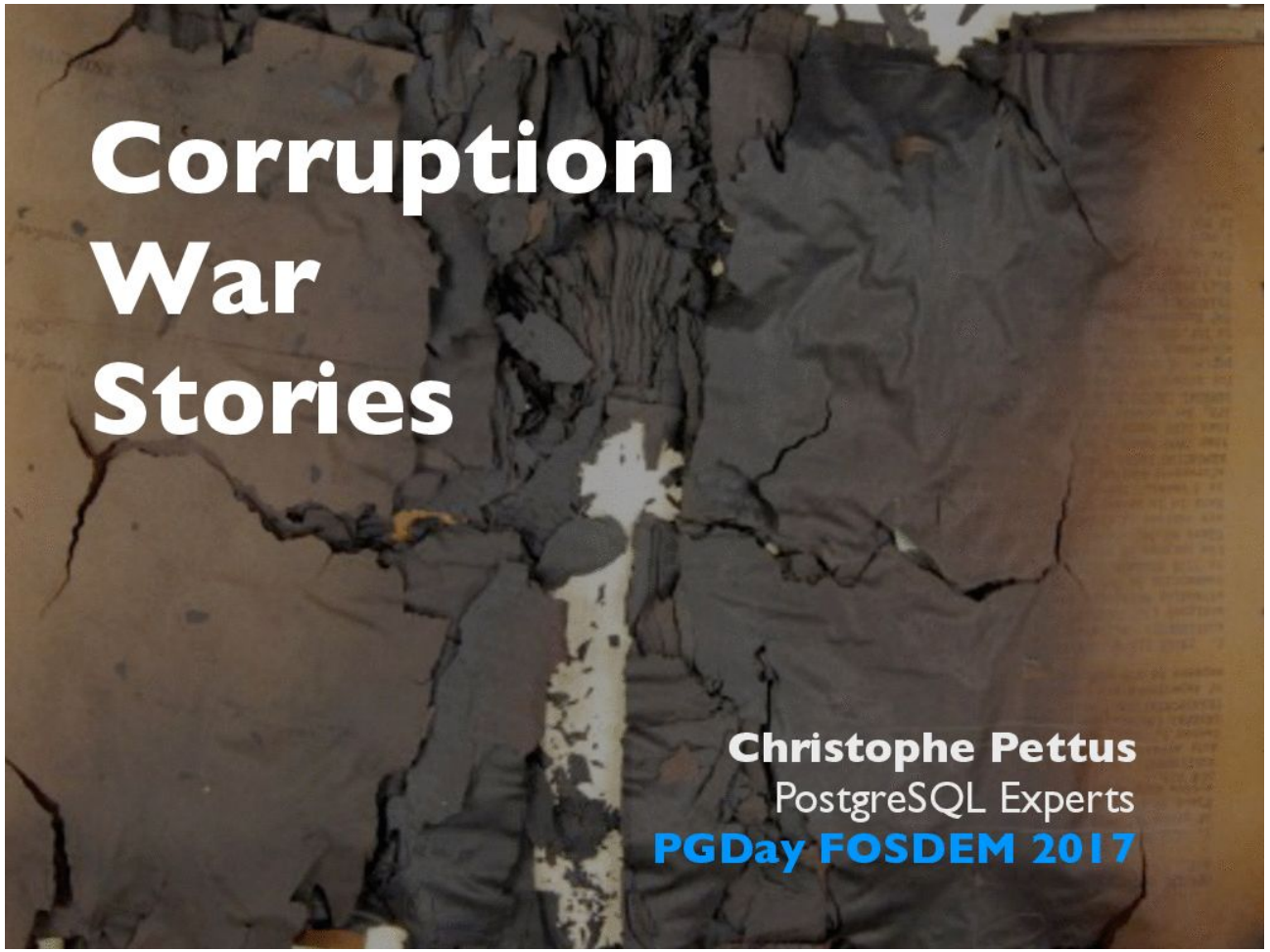
There's no universal recipe :-(

Recipe

1) Try restoring from a backup.
    - The backup may be corrupted too.
    - Maybe it'd take too long. (Well, …)
    - ...
2) If you need to fix a corrupted cluster …
    - Always make sure you have a copy.
    - Take detailed notes about each step.
    - Proceed methodically.

Recipe

3) Asses the extent of data corruption
   - Is it just a single object? What object?
   - How many pages/rows/...?
   - ...
4) Ad-hoc recovery steps
   - Rebuild corrupted indexes.
   - Extract as much data as possible. Select "around", use loop with exception block, …
   - pageinspect is your friend
   - Zero corrupted pages using "dd" etc.



http://thebuild.com/presentations/corruption-war-stories-fosdem-2017.pdf

So, what about data checksums?

data checksums


```
checksum(page number, page contents)
```

- available since PostgreSQL 9.3
  - … so all supported versions have them
  - disabled by default
- protects against (some) storage system issues
  - changes to existing pages / torn pages
- has some overhead
  - a couple of %, depends on HW / workload
- correctness vs. availability trade-off

data checksums are not perfect

- can't detect various types of corruption
  - pages written to different files
  - "forgotten" writes
  - truncated files
  - PostgreSQL bugs (before the write)
  - table vs. index mismatch
- may detect (some) memory issues

How do you verify checksums?

- you have to read all the data
- regular SQL queries
  - only active set (but not "hot" data)
- pg_dump
  - no checks for indexes
- pg_basebackup
  - since PostgreSQL 11
- pg_verify_checksums
  - since PostgreSQL 11, offline only

Questions?