Warm standby done right

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This presentation

- About built-in tools
  - Not about repmgr, WAL-e etc.
  - You probably should use those tools though!
- Not about monitoring, heartbeats etc.

Part 1. Continous archiving

Setting up a WAL archive

- `wal_level=archive`
- `archive_mode=on`
- `archive_command='...'`

24.3.1. Setting up a WAL archive

Depending on the application and the available hardware, there could be many different ways of "saving the data somewhere": we could copy the segment files to an NFS-mounted directory on another machine, write them onto a tape drive (ensuring that you have a way of identifying the original name of each file), or batch them together and burn them onto CDs, or something else entirely.

PostgreSQL User Manual

`archive_command`

according to the manual

- *It is important that the archive command **return zero exit status if and only if it succeeds**. Upon getting a zero result, PostgreSQL will assume that the file has been successfully archived, and will remove or recycle it. However, a nonzero status tells PostgreSQL that the file was not archived; it will try again periodically until it succeeds.*
- *The archive command should generally be designed to **refuse to overwrite any pre-existing archive file**. This is an important safety feature to preserve the integrity of your archive in case of administrator error (such as sending the output of two different servers to the same archive directory).*

archive_command

according to the manual

```
# Unix

archive_command =

  'test ! -f /mnt/server/archivedir/%f &&
     cp %p /mnt/server/archivedir/%f'


# Windows

archive_command =

  'copy "%p" "C:\\server\\archivedir\\%f"'
```

This is an example, not a recommendation, and might not work on all platforms.

archive_command

Gotcha 1:

No fsync() in the example command. If the archive server dies before the file has been flushed to disk, it might be lost.

archive_command

Gotcha 2:

If the server crashes immediately after archiving a segment, the server might try to archive the same file again after restart.

How to write a robust archive_command

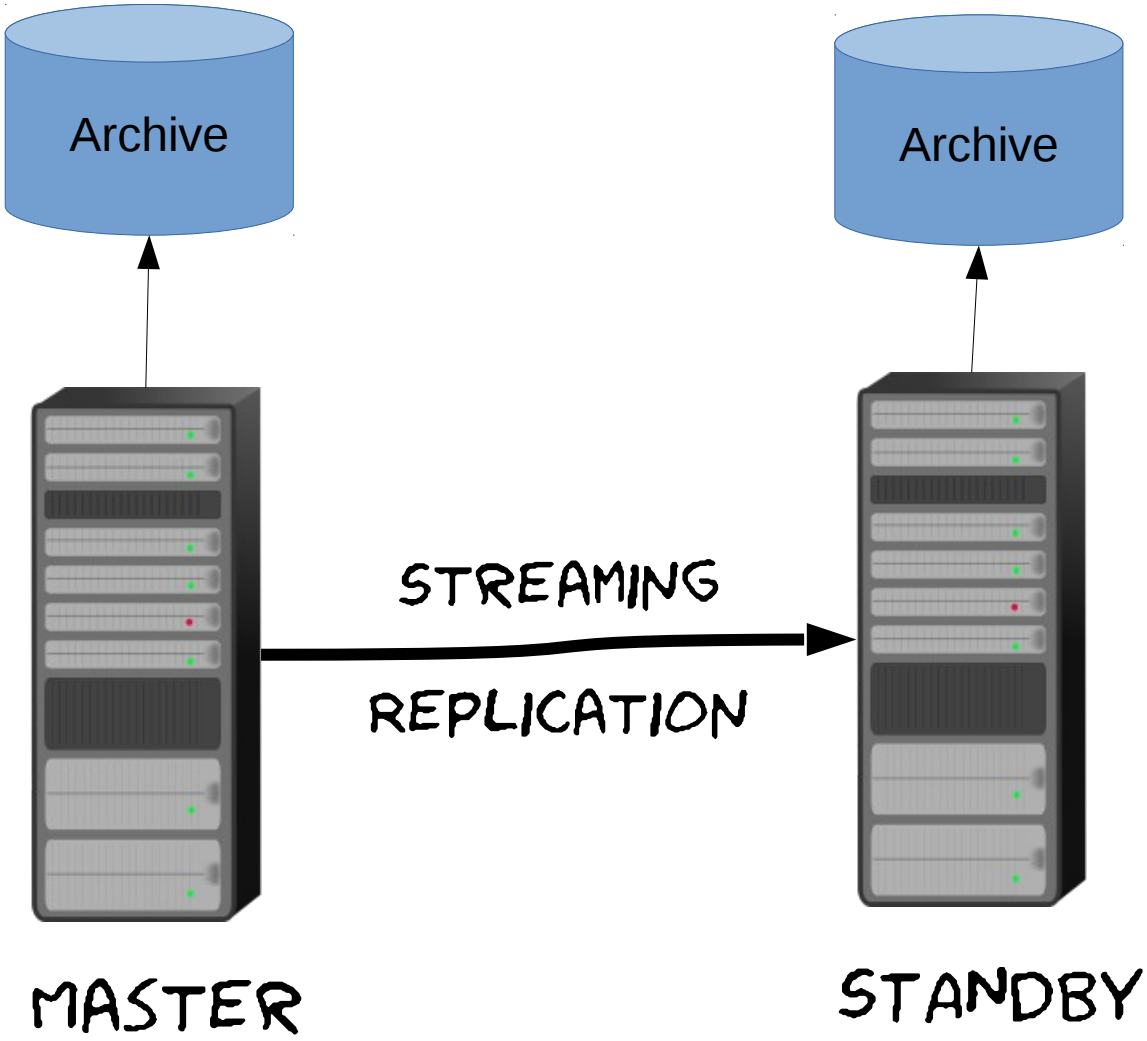
- Only return zero on success
- Issue fsync() before returning
- If the file already exists in the archive, check that the contents are identical, and return success.

Part 2: `archive_mode=always`

archive_mode=always

- New feature in 9.5
- archive_mode = off | on | **always**
  - off: no archiving
  - on: archiving is enabled in master
  - **always: archiving is enabled in master and standby (and archive recovery)**

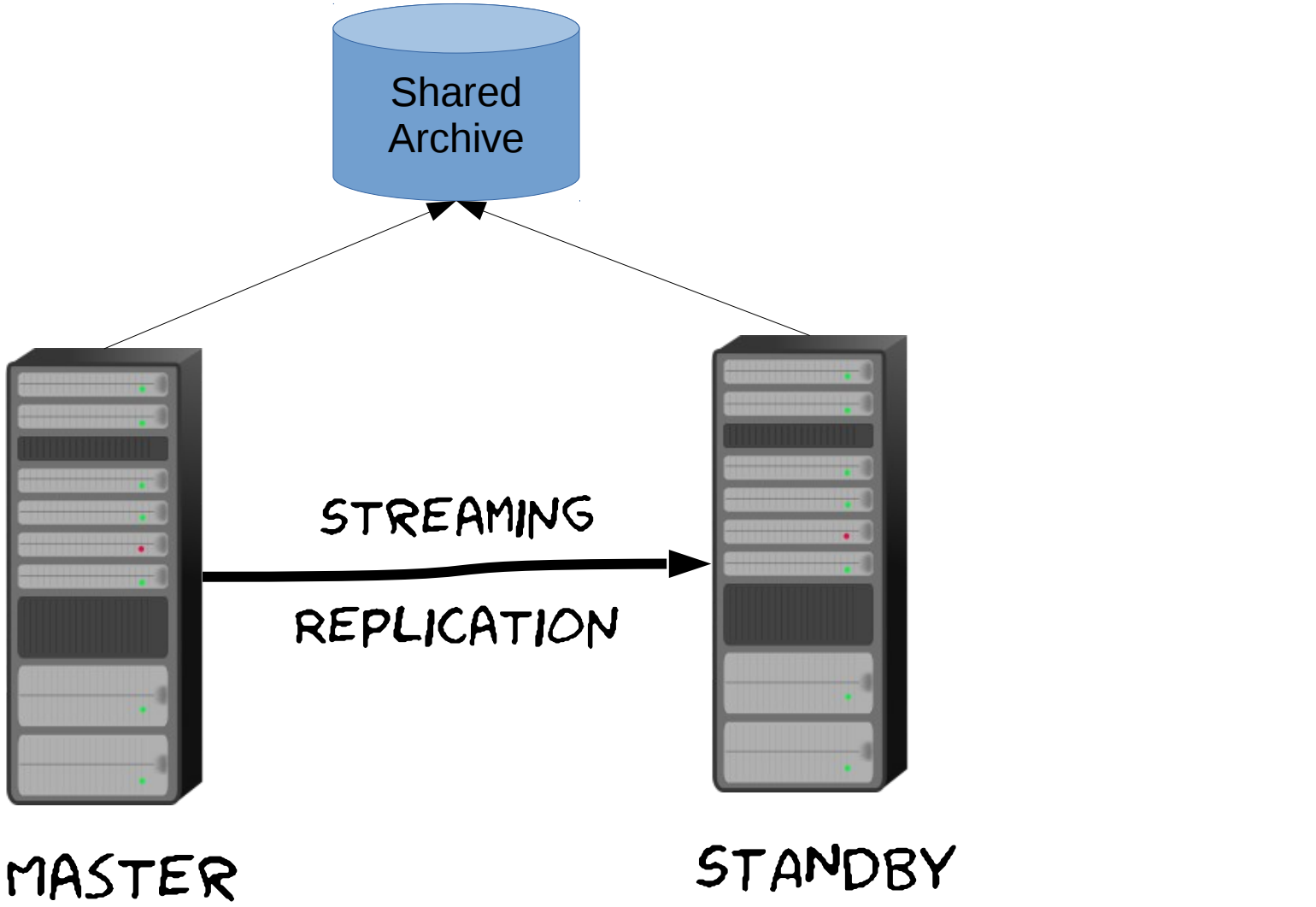
Continuous archiving with a standby



- Archive_mode=always allows setting up separate archives in master and standby
- But that's not all

Part 3: Continuous archiving with master and standby sharing the archive

Continuous archiving with shared archive



Naive approach

- `archive_mode=on`
- Same `archive_command` on both servers
- All set?

Promotion

1. The master dies
2. `pg_ctl promote`
3. ???

Promotion

Standby will:

1. recover any remaining WAL it had streamed,
2. create a new timeline,
3. copy the last, partial segment to the new timeline, and start writing WAL,
4. start archiving from the new timeline

Master, standby, WAL archive

Master	Standby	WAL archive
000000010000000000000015	000000010000000000000015	000000010000000000000015
000000010000000000000016	000000010000000000000016	000000010000000000000016
000000010000000000000017	000000010000000000000017	000000010000000000000017

Master, standby, WAL archive

Master

00000001000000000000015
00000001000000000000016
00000001000000000000017
00000001000000000000018
00000001000000000000019
0000000100000000000001A

Standby

00000001000000000000015
00000001000000000000016
00000001000000000000017
00000001000000000000018
00000001000000000000019
0000000100000000000001A

WAL archive

00000001000000000000015
00000001000000000000016
00000001000000000000017

Partial segment, being written to

Master, standby, WAL archive after promotion. 9.4 and below

Master	Standby	WAL archive
000000010000000000000015	000000010000000000000015	000000010000000000000015
000000010000000000000016	000000010000000000000016	000000010000000000000016
000000010000000000000017	000000010000000000000017	000000010000000000000017
000000010000000000000018	000000010000000000000018	
000000010000000000000019	000000010000000000000019	
00000001000000000000001A	00000001000000000000001A	00000001000000000000001A
	00000002000000000000001A	

1. Standby creates a new timeline
2. Standby archives the partial segment

Detour: Partial segment

- 16MB in size, but the rest contains garbage.
- Indistinguishable from a completed segment
- Problems:
  - If the master continues running, and archives the completed segment later.
  - If the standby had fallen slightly behind and the master had already archived the completed segment.

Partial segment in 9.5

- The partial segment is archived with the .partial suffix
- Not restored automatically. You can copy it into pg_xlog manually and remove .partial suffix
  - This shouldn't be necessary under normal circumstances

Master, standby, WAL archive after promotion

Master	Standby	WAL archive
000000010000000000000015	000000010000000000000015	000000010000000000000015
000000010000000000000016	000000010000000000000016	000000010000000000000016
000000010000000000000017	000000010000000000000017	000000010000000000000017
000000010000000000000018	000000010000000000000018	
000000010000000000000019	000000010000000000000019	
00000001000000000000001A	00000001000000000000001A.partial	00000001000000000000001A.partial
	000000**2**000000000000001A	000000**2**000000000000001A
	000000**2**000000000000001B	000000**2**000000000000001B
	000000**2**000000000000001C	

1. Standby creates a new timeline
2. **Standby renames the old segment as .partial**
3. Standby archives the partial segment
4. Standby startups up as master and starts archiving

Master, standby, WAL archive after promotion

Master	Standby	WAL archive
000000010000000000000015	000000010000000000000015	000000010000000000000015
000000010000000000000016	000000010000000000000016	000000010000000000000016
000000010000000000000017	000000010000000000000017	000000010000000000000017
000000010000000000000018	000000010000000000000018	
000000010000000000000019	000000010000000000000019	
00000001000000000000001A	00000001000000000000001A.partial	00000001000000000000001A.partial
	000000020000000000000001A	000000020000000000000001A
	000000020000000000000001B	000000020000000000000001B
	000000020000000000000001C	000000020000000000000001C

Segments 18-19 are never archived!

Missing segments

- If the master had not archived all the segments before it crashed
- Bye bye backups

`archive_mode=always` to the rescue

- Can also be used with a single archive, to ensure there are no gaps.
- (my original patch added a separate `archive_mode=shared` mode for this)

archive_mode=always

- Have same archive_command in master and standby
- Both servers will attempt to archive all segments to same location.
- Careful, race conditions!
  - Master and standby will try to archive the same file at the same time

Shared archive summary

- Use `archive_mode=always`
- Make sure your `archive_command` is concurrency-safe and handles duplicates
- Don't be alarmed if you see `.partial` files

- Still make sure your `archive_command` calls fsync()

Part 4: `pg_receivexlog`

- Runs in the archive server
- Connects to master with streaming replication
- Keeps up-to-date, not just segment granularity

pg_receivexlog

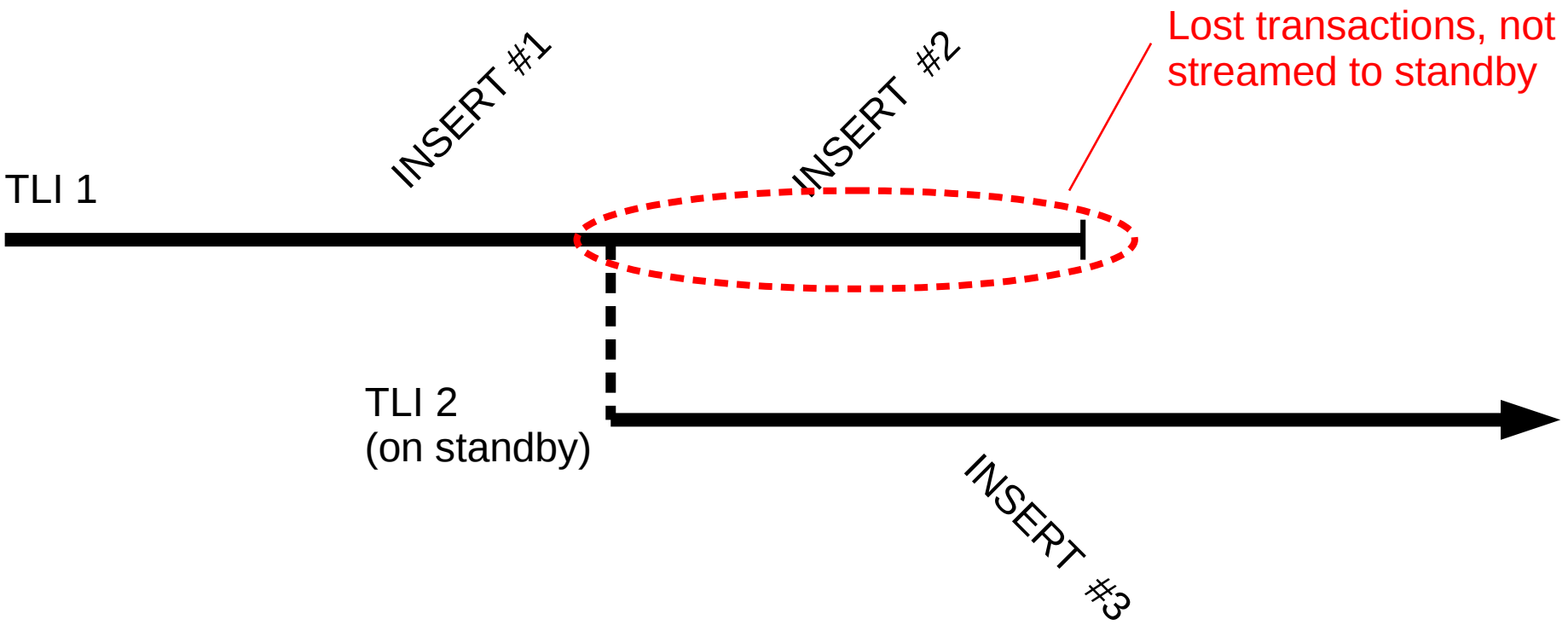
- Added 9.2
- Follows timeline changes since 9.3
- Replication slot support in 9.4
- --synchronous option added in 9.5

Part 5: `pg_rewind`

Failback

- Throw away old master's data directory and restore from base backup
- You can use `rsync` to speed it up
- Or you can use `pg_rewind`

Lost transactions at failback



pg_rewind

- Like `rsync`, but uses the WAL to determine what's changed
- Scans the WAL to figure out what blocks the lost transactions modified
- Copies anything except data files in toto

That's all folks!

- Questions?