What the heck is a checkpoint, and why should I care?

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Data Professional

Microsoft Data Platform MVP. 16 Years working with Microsoft Data Platform. Microsoft and MongoDB certified. Worked in ecommerce, healthcare and finance industry.

Giving Back

Board member NESQL user group and Founder of DBA virtual group. Organizer of Boston SQL Saturday. Frequent speaker at local and virtual user groups, SQL Saturdays and Azure conferences.

When Not Working

Running – 1x26.2 and many 13.1, Learning US history. Shuttling 3 kids.

Why Do We Need Checkpoint?

Known Good Point

Start Applying Changes

Contained in the Log

Shutdown or Crash

ACID

Atomicity

Consistency

Isolation

Durability

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Clean vs Dirty Page

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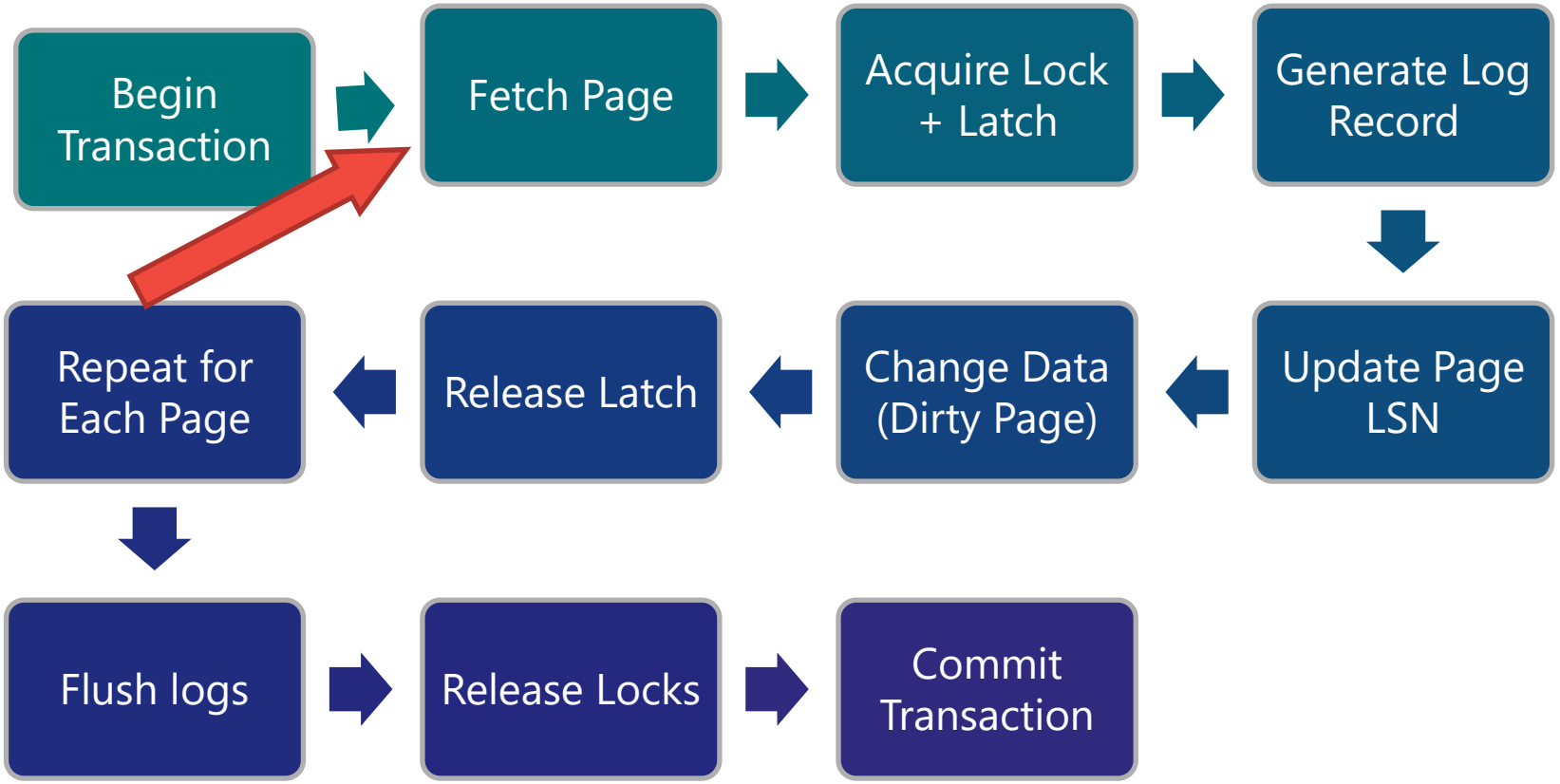
Write Ahead Logging


Begin Transaction
Fetch Page
Acquire Lock + Latch
Generate Log Record
Update Page LSN
Change Data (Dirty Page)
Release Latch
Repeat for Each Page
Flush logs
Release Locks
Commit Transaction

```
Allocation Status

GAM (1:2) = ALLOCATED                SGAM (1:3) = NOT ALLOCATED
PFS (1:1) = 0x60 MIXED_EXT ALLOCATED   0_PCT_FULL                          DIFF (1:6) = NOT CHANGED
ML (1:7) = NOT MIN_LOGGED

Slot 0 Offset 0x60 Length 73

Record Type = PRIMARY_RECO                                                 ord Size = 73

Memory Dump @0x000000B22

0000000000000000:                                                          ..:....
0000000000000014:                                                          0......
0000000000000028:                                                          ..........
000000000000003C:                                                          ........ø

Slot 0 Column 1 Offset 0x4 Le

auid = 72057594037993472

Slot 0 Column 2 Offset 0xc Length 1 Length (physical) 1

type = 1

Slot 0 Column 3 Offset 0xd Length 8 Length (physical) 8
```

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https://www.alphr.com/features/386074/out-of-disk-space-storage-options-for-your-media/

Lazy Writer

Eager Writer

Checkpoint

Lazy Writer

Eager Writer

Back to Checkpoint

https://usa.chiefproducts.com.au/products/wk2-recovery-point

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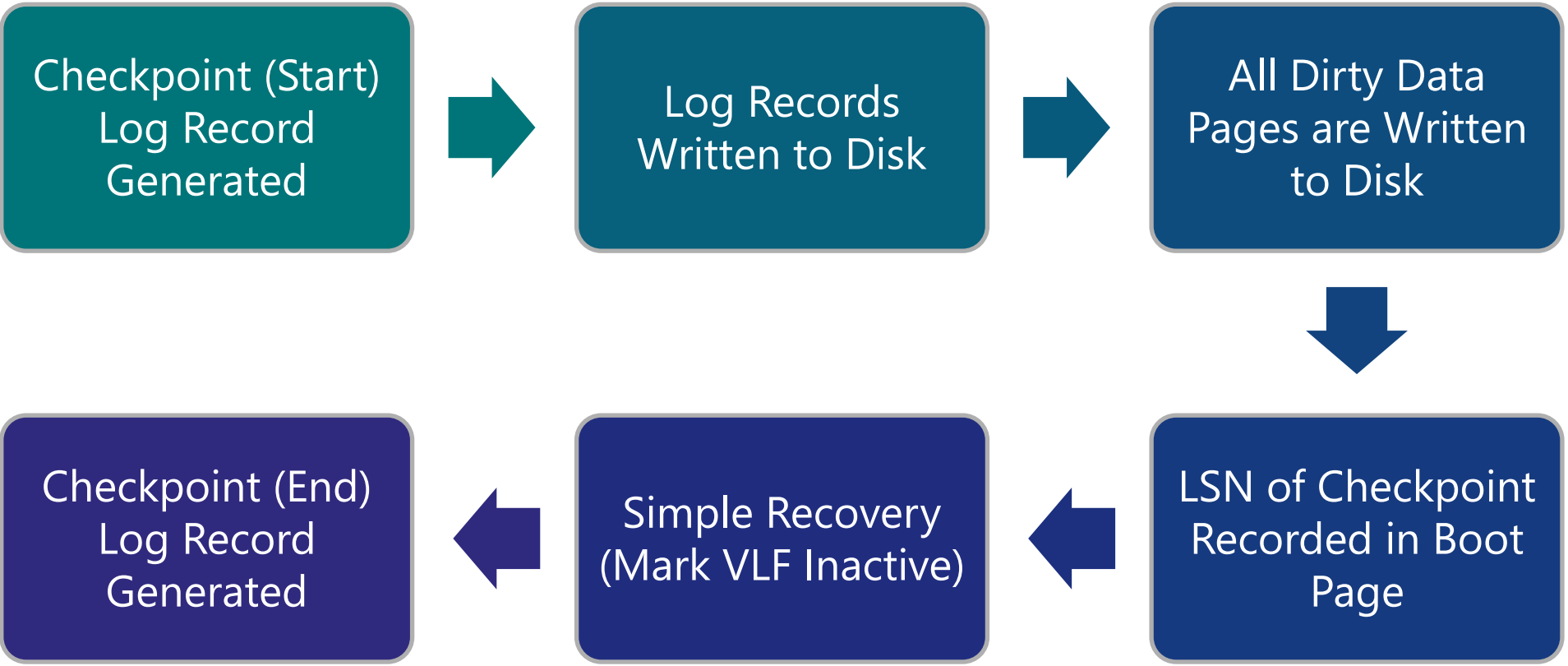

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- IO Size
  - 1 MB
  - Pre 2016: 256 KB
- Throttle threshold
  - 50ms
  - Pre 2016: 20ms
- Startup parameter (-k)

DEMO

Checkpoint
+
Log Records

https://www.alphr.com/features/386074/out-of-disk-space-storage-options-for-your-media/

- Automatic
- Manual
- Internal
- Indirect
  - -Introduced SQL 2012
  - -Default in SQL 2016

Automatic

- “Recovery Interval” default zero
  - What does this value mean?
- How reliable is this setting?
- When do you change default?
- Changing to over 60 min require “OVERRIDE”

Manual

- Transact-SQL CHECKPOINT
- *'checkpoint_duration' s*econds to complete
  - Not guaranteed
  - Advanced option
- When do you use a Manual Checkpoint?
- When do you use '*checkpoint_duration' ?*

Aaron Bertrand
@AaronBertrand

Replying to @SqlWorldWide

Before a planned failover or other maintenance, because it can really put a dent in recovery time (especially if your system isn't using indirect yet).

Also during performance testing or batch loading on simple (to minimize log impact).

Never used checkpoint_duration.

#sqlhelp

Travis Page
@pagerwho

Replying to @SqlWorldWide

I've used it during performance testing to ensure that when I issue DBCC DROPCLEANBUFFERS anything writes are fully cleared out.

I've also used it for t-log shrinking. Usually this is because of high VLF numbers or something blew up the logs, not a regular occurrence.

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@sqL_handLe

Replying to @SqlWorldWide

#sqlhelp
if indirect checkpoint (and no #sqlserver 2019++ ADR), issue manual checkpoint when txlog is close to full and filling rapidly to prevent log_reuse_wait_desc = 'oldest_page' and a full txlog due to txlog hotspot in a small number of data pages. no checkpoint_duration.

Internal

- Guarantee disk image match what is in logs
- When?
  - Backup
  - Snapshot (DBCC Checkdb)
  - Stop SQL Server Engine
  - Add/Remove a database file

Indirect

- Introduced in SQL 2012
- Uses number of dirty pages
- Keep number of dirty page below threshold
- Set by *"target recovery time'*
  - Default is 60 seconds
- Set per database

Indirect

- SQL 2016
  - Default behavior for new databases
  - Including Model and Tempdb
- SQL 2019
  - Fixed '*non-yielding scheduler errors*'

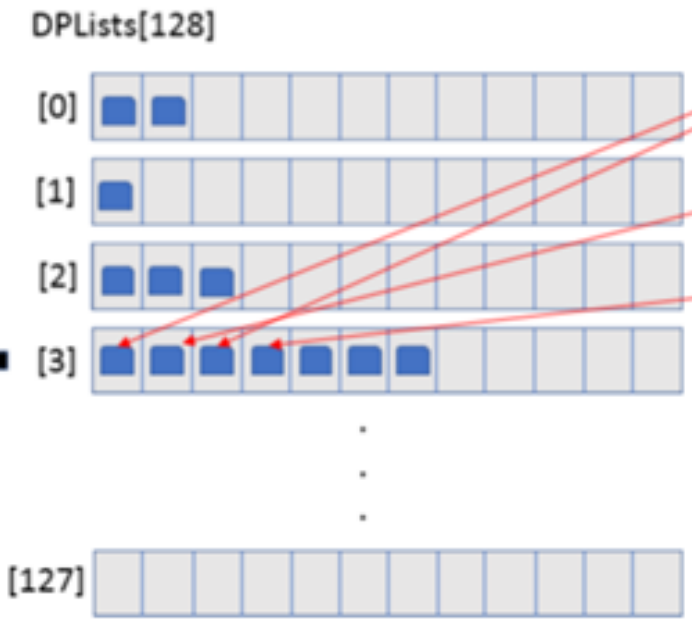
Recovery Writer

When a work for flush is enqueued

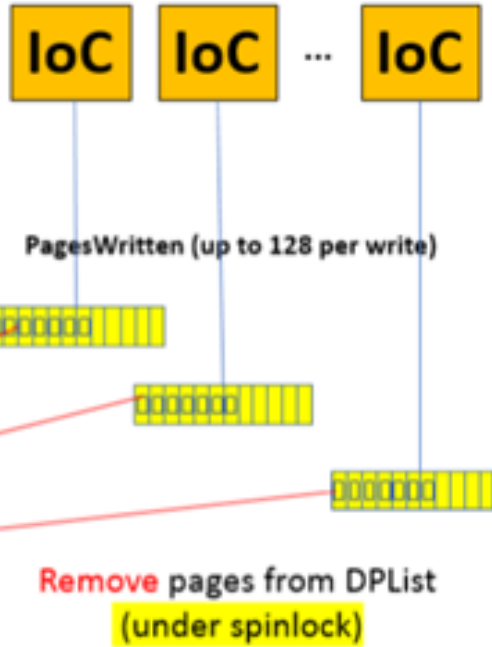
Do While

1. Find the longest DPList
2. Collect Page IDs (under spinlock)
3. Sort the pages
4. Write the pages

Until the target recovery time is met



IO Completion routines



https://techcommunity.microsoft.com/t5/sql-server-blog/indirect-checkpoint-and-tempdb-8211-the-good-the-bad-and-the-non/ba-p/385510

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Monitor Checkpoint

https://usa.chiefproducts.com.au/products/wk2-recovery-point

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- Performance Objects
  - Buffer Manager: Checkpoint pages/sec
- Extended Events
  - sqlserver.checkpoint_begin
  - sqlserver.checkpoint_end
- Trace Flag
  - 3502: writes to error log when a checkpoint starts and finishes
  - 3504: writes to error log information about what is written to disk
  - 3605: allows trace prints to go to the error log

Checkpoint tempdb

https://usa.chiefproducts.com.au/products/wk2-recovery-point

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DEMO

-Monitor Checkpoint
-Simple Recovery Behavior
-Automatic vs Indirect

Reference

- Database Checkpoints (SQL Server)
- SQL Server Transaction Log Architecture and Management Guide
- How do checkpoints work and what gets logged by Paul Randal
- What does checkpoint do for tempdb? by Paul Randal
- Changes in SQL Server 2016 Checkpoint Behavior by Mike Ruthruff
- Indirect Checkpoint and tempdb – the good, the bad and the non-yielding scheduler by Parkshit Savjani
- "0 to 60" : Switching to indirect checkpoints by Aaron Bertrand
- SQL Server Checkpoint Monitoring with Extended Events by Aaron Bertrand
- More Reasons to Enable SQL Server Indirect Checkpoints by Aaron Bertrand
- How do I interpret the log when I run DBCC TRACEON (3502, 3504, 3605, -1)
- How It Works: Bob Dorr's SQL Server I/O Presentation by Bob Dorr

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THANK
YOU