

SQL Server TempDb



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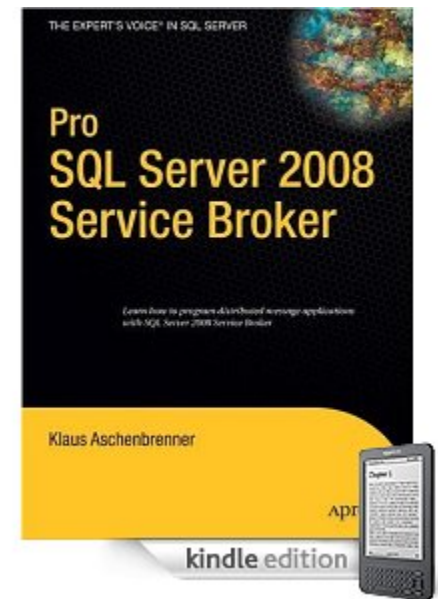
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About me

- CEO & Founder SQLpassion
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 - <http://www.SQLpassion.at/academy>
 - Free Newsletter, Training Videos



Agenda

- TempDb Introduction
- Version Store
- Troubleshooting TempDb
- Best Practices

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TempDb Overview

- Stores
 - User Objects
 - Internal Objects
 - Version Store (Row Versioning)
- One TempDb for the whole SQL Server Instance
 - Performance bottleneck by design
- Always recreated after restart
 - Built from model database
- Uses „Simple“ recovery model
 - No need for transaction log backups
- Only one filegroup – the PRIMARY filegroup

TempDb Internals

- Dropped and recreated when SQL Server is stopped and restarted
- Inherits all settings from the model database
 - MDF file of 3 MB
 - LDF file of 1 MB
 - Autogrowth is set to 10%
- Drop, Detach, Attach are not possible

User Objects

- Local Temp Tables
 - Scoped to the session where you created it
 - Dropped after the session is closed
 - Prefix „#“
- Global Temp Tables
 - Scoped across all sessions
 - Dropped after the session is closed
 - Prefix „##“
- Table Variables
 - Caution: No statistics available!
- Tables returned in Table Valued Functions

Internal Objects

- Work tables for DBCC CHECKDB and DBCC CHECKTABLE
- Work tables for hash operations, such as joins and aggregations
- Work tables for processing cursors
- Work tables for processing Service Broker objects
- Work files needed for many GROUP BY, ORDER BY, UNION, SORT, and SELECT DISTINCT operations
- Work files for sorts that result from creating or rebuilding indexes (SORT_IN_TEMPDB)

Version Store

- Stores row-level versioning data
- 2 Types
 - Common Version Store
 - Triggers
 - Snapshot Isolation
 - Read Committed Snapshot Isolation
 - MARS (Multiple Active Result Sets)
 - Online Index Rebuild Version Store
 - Used for Online Index Rebuilds

Performance Counters

- **Access Methods:Worktables Created/sec**
 - Created for query spools, LOB variables, and cursors
- **Access Methods:Workfiles Created/sec**
 - Created by hashing operations
 - Store temporary results for hash and hash aggregates
- **General Statistics:Temp Tables Creation Rate**
 - Number of temp tables created/sec
- **General Statistics:Temp Tables For Destruction**
 - Number of temp tables waiting to be destroyed by the cleanup thread

Demo

Temp Tables/Table Variables

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Version Store

- Needed for
 - Read Committed Snapshot Isolation Level
 - Snapshot Isolation Level
 - Triggers
 - Online Index Operations
 - MARS (Multiple Active Result Sets)
- `sys.dm_tran_version_store`
 - Returns all versions that must be currently stored to provide consistency across transactions

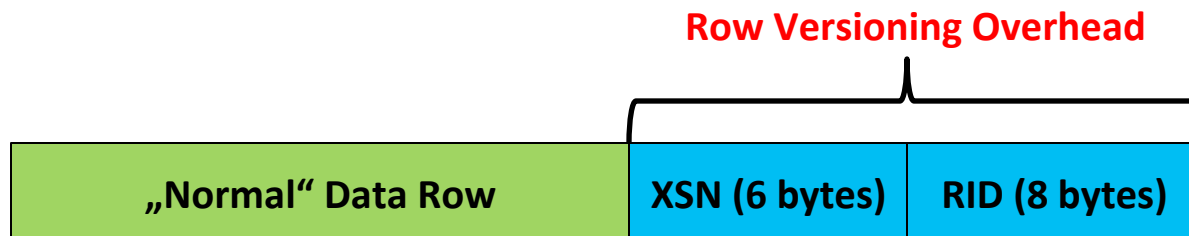
Append-Only Stores

- Common Version Store
 - Triggers
 - Snapshot Isolation
 - Read Committed Snapshot Isolation
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- Online Index Rebuild Version Store
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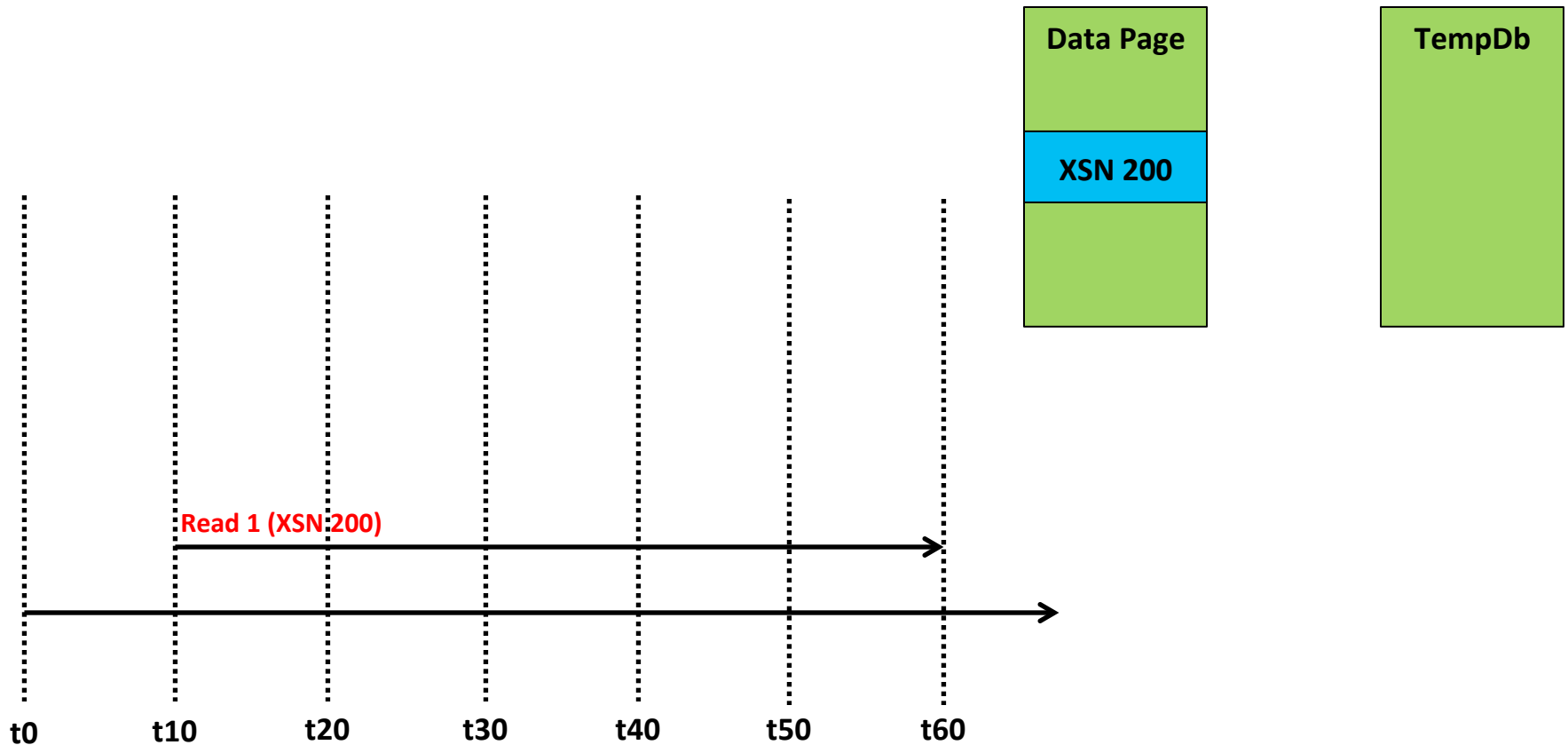
Version Store Overhead

- 14 bytes per row
- XSN
 - „Transaction Sequence Number“
 - 6 bytes
 - Used to chain multiple versions together
- RID
 - „Row Identifier“
 - 8 bytes
 - Locates the row version in TempDb
- Doesn't reduce the max row size of 8.060 bytes
 - Row is splitted across 2 pages

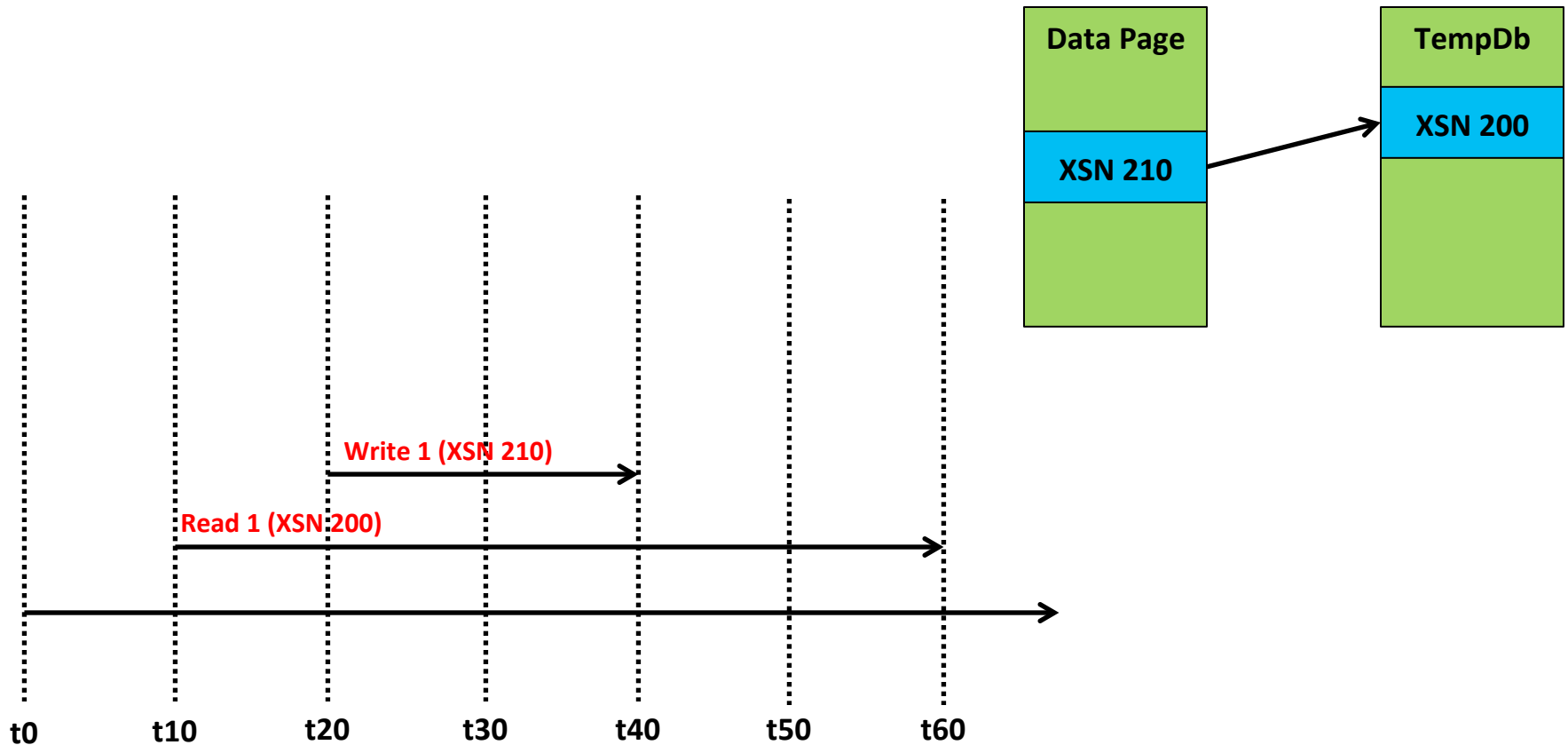
Row Version Overhead



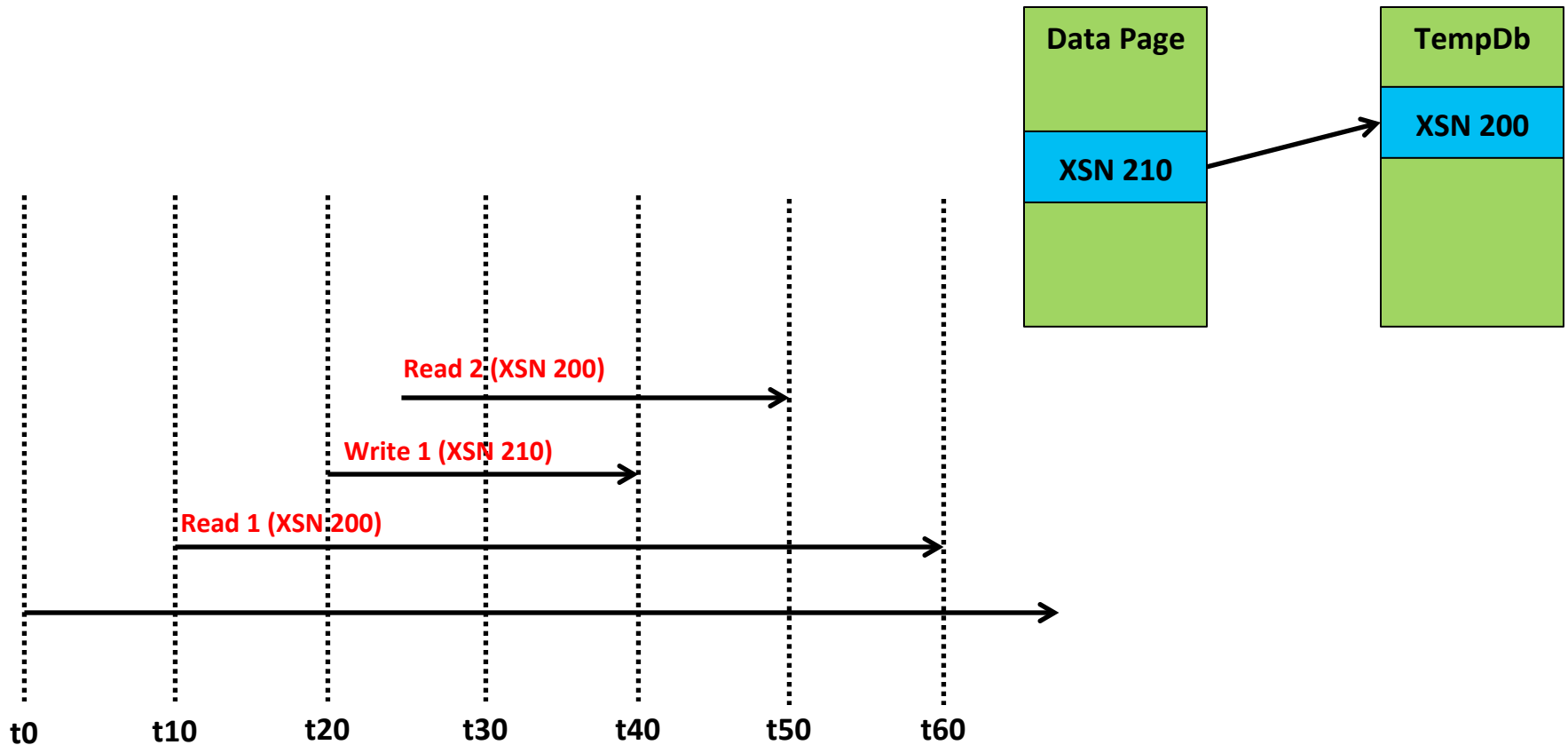
Version Store Internals



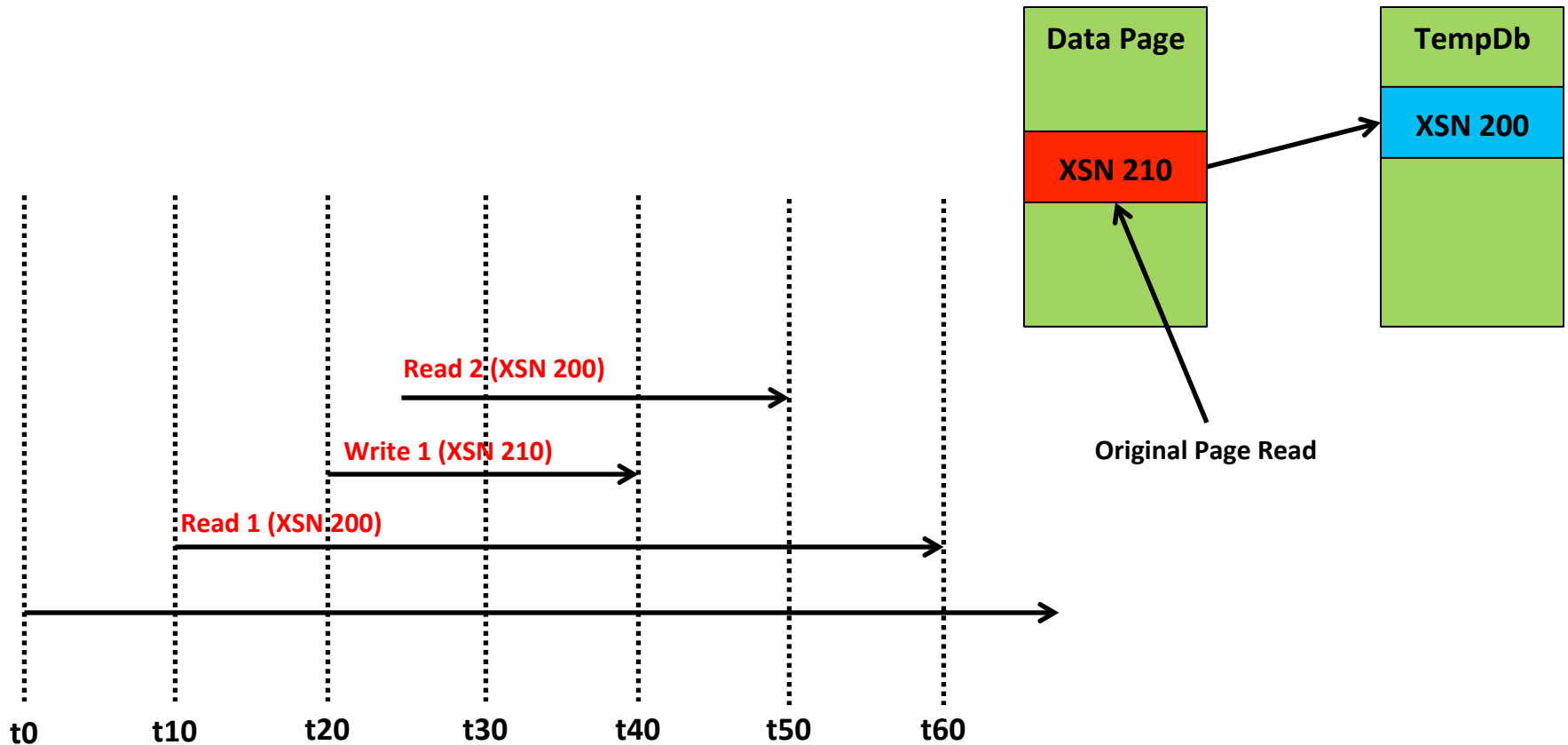
Version Store Internals



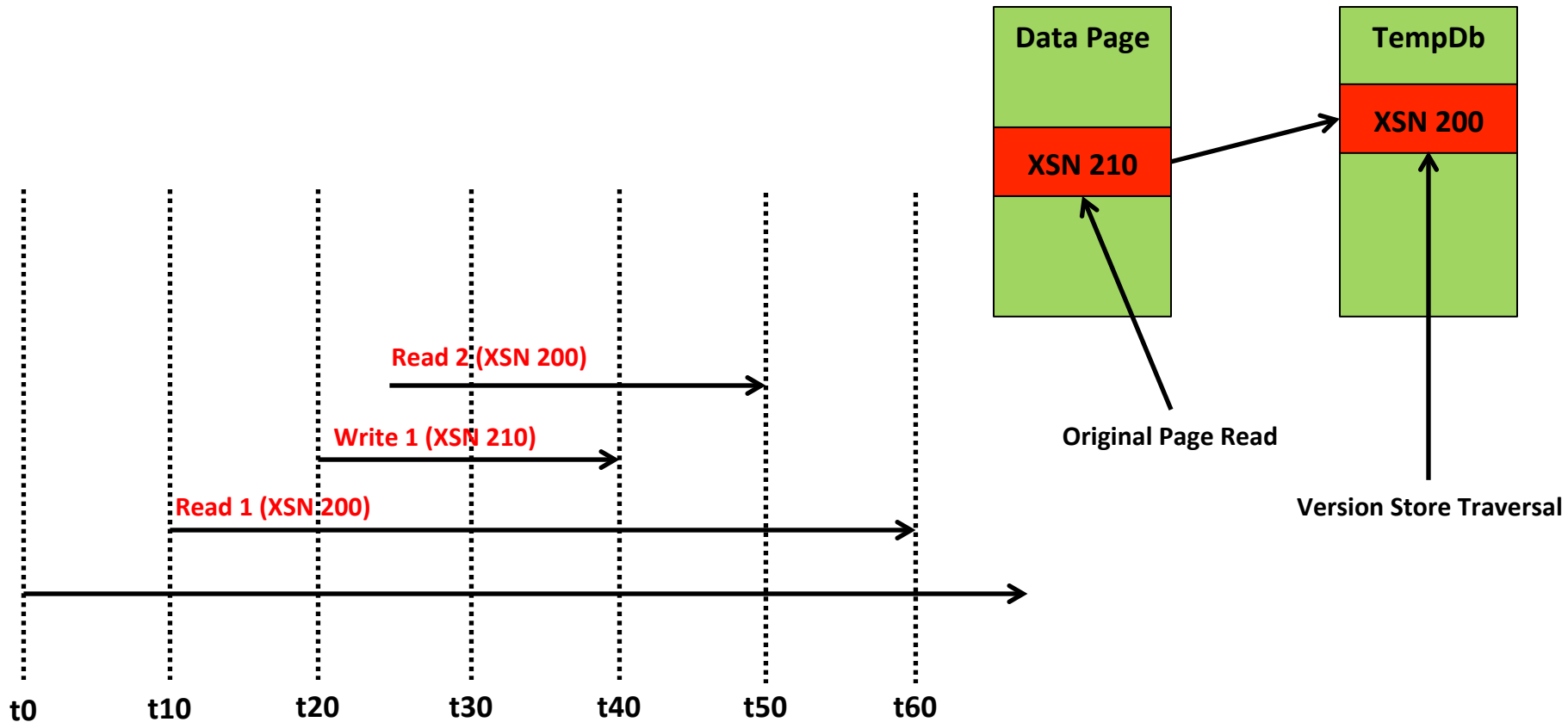
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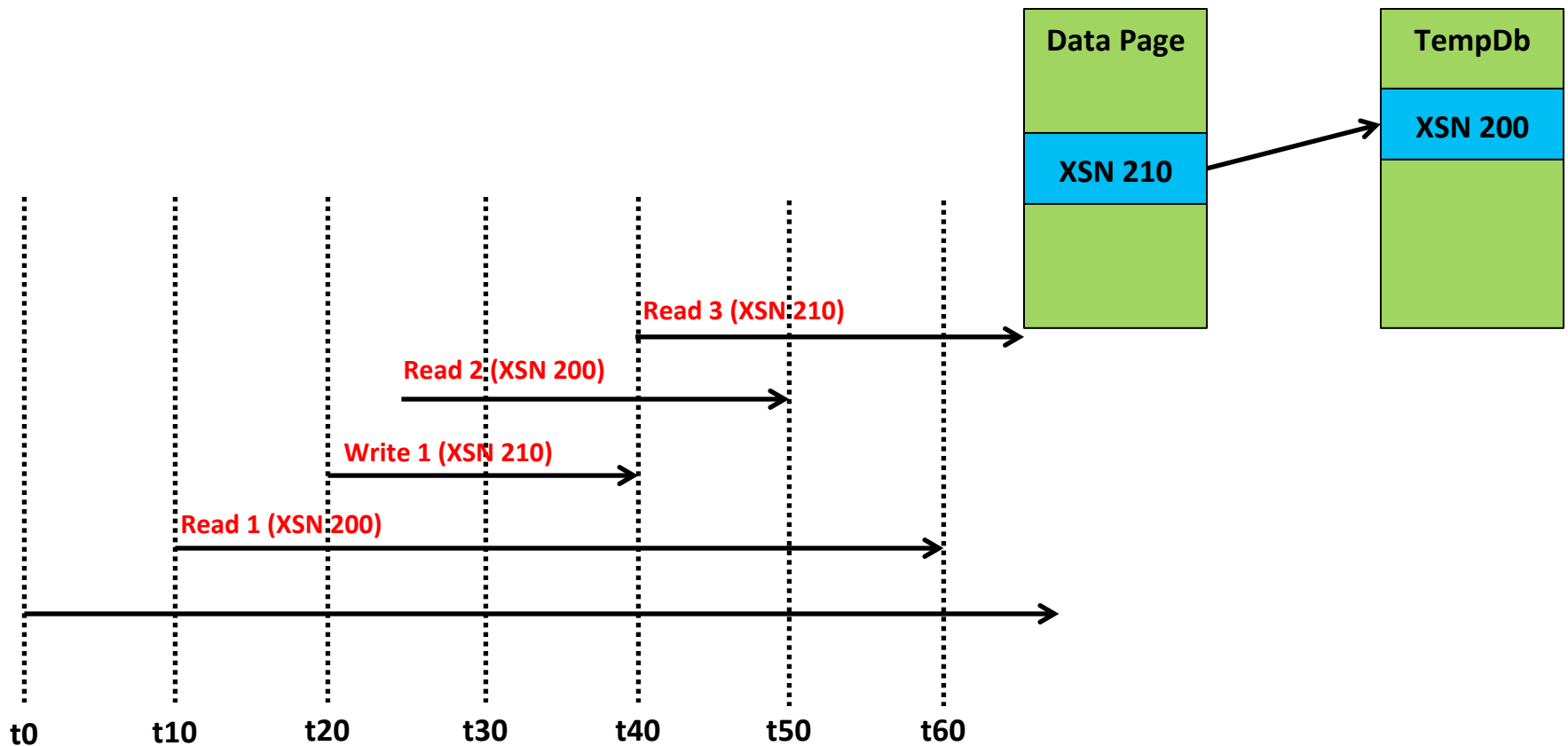
Version Store Internals



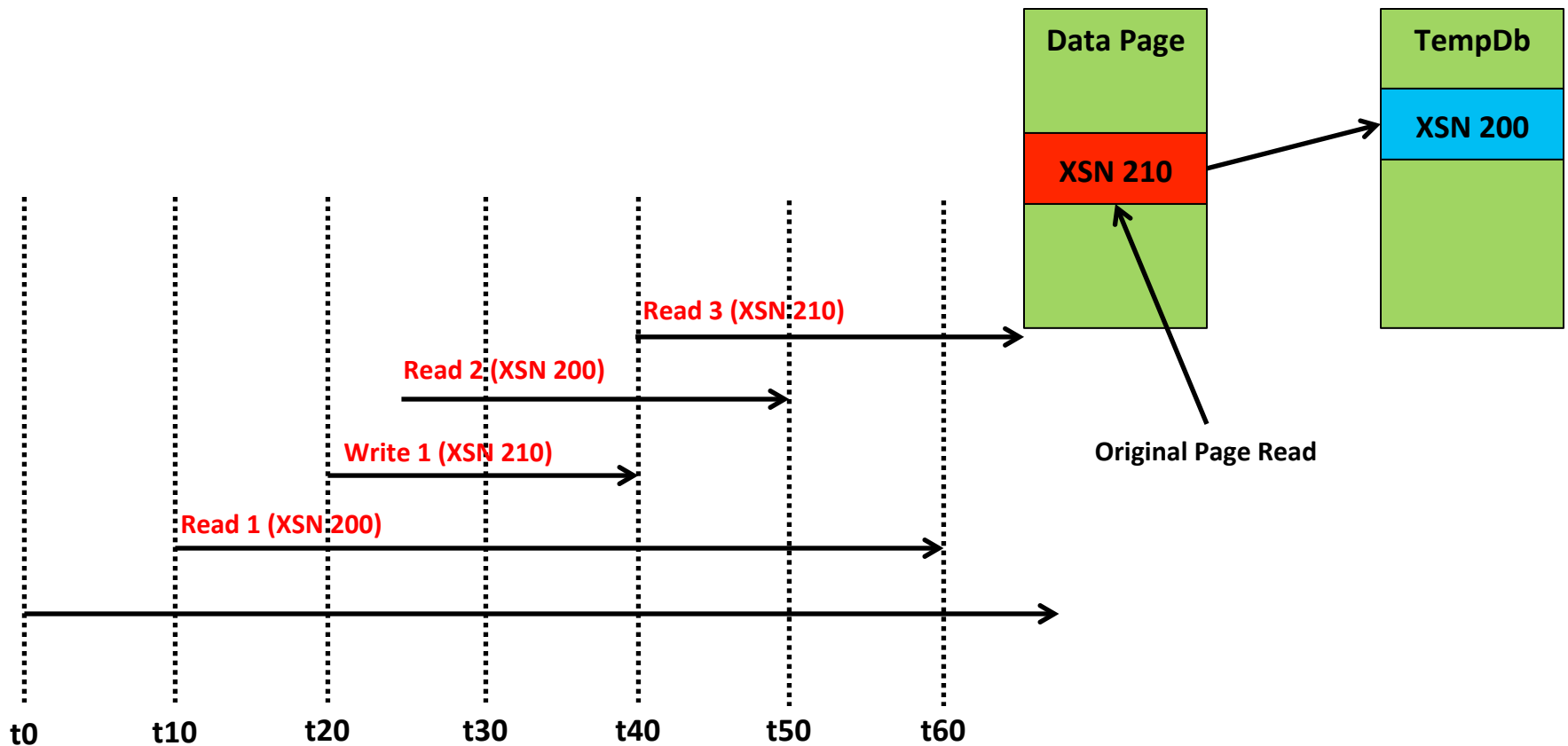
Version Store Internals



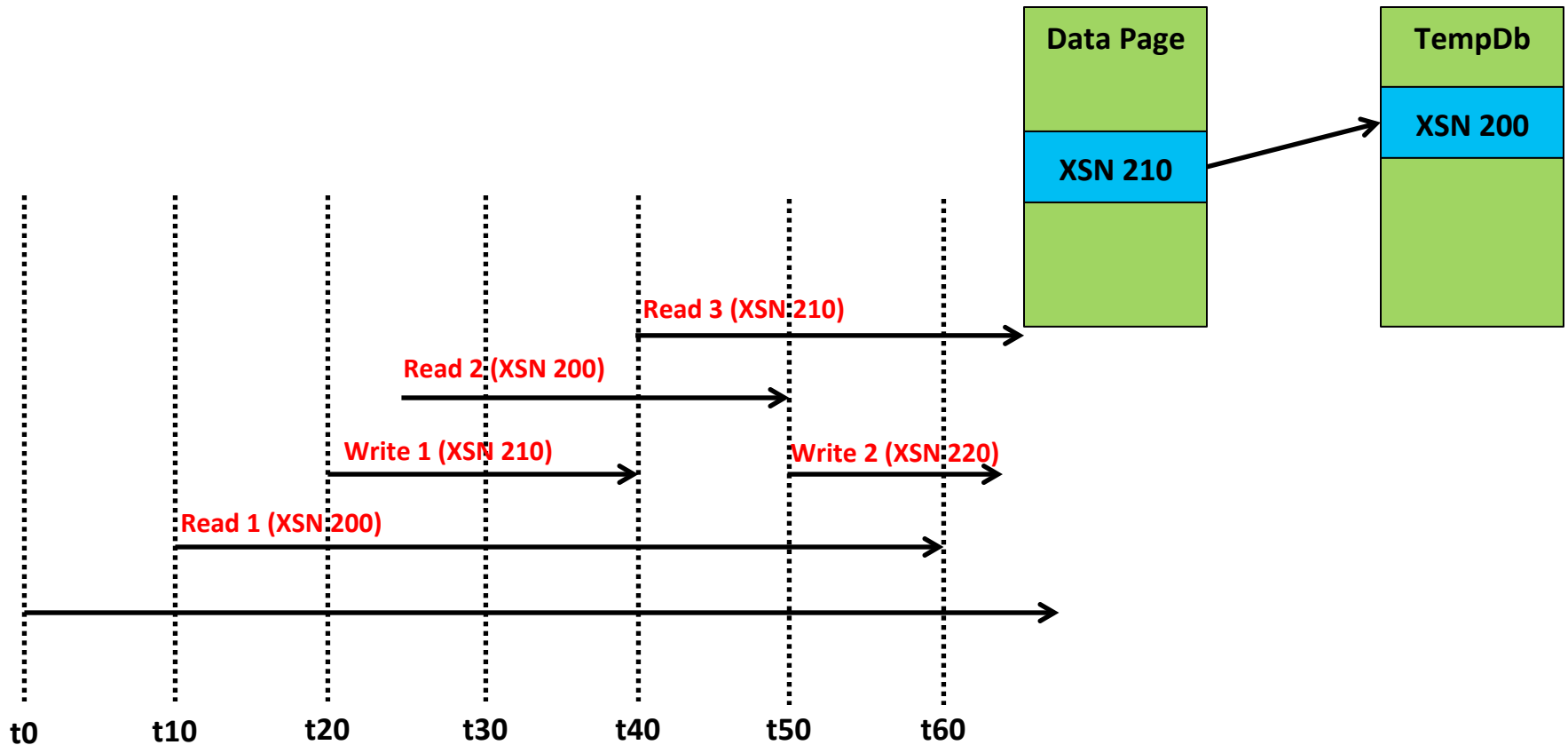
Version Store Internals



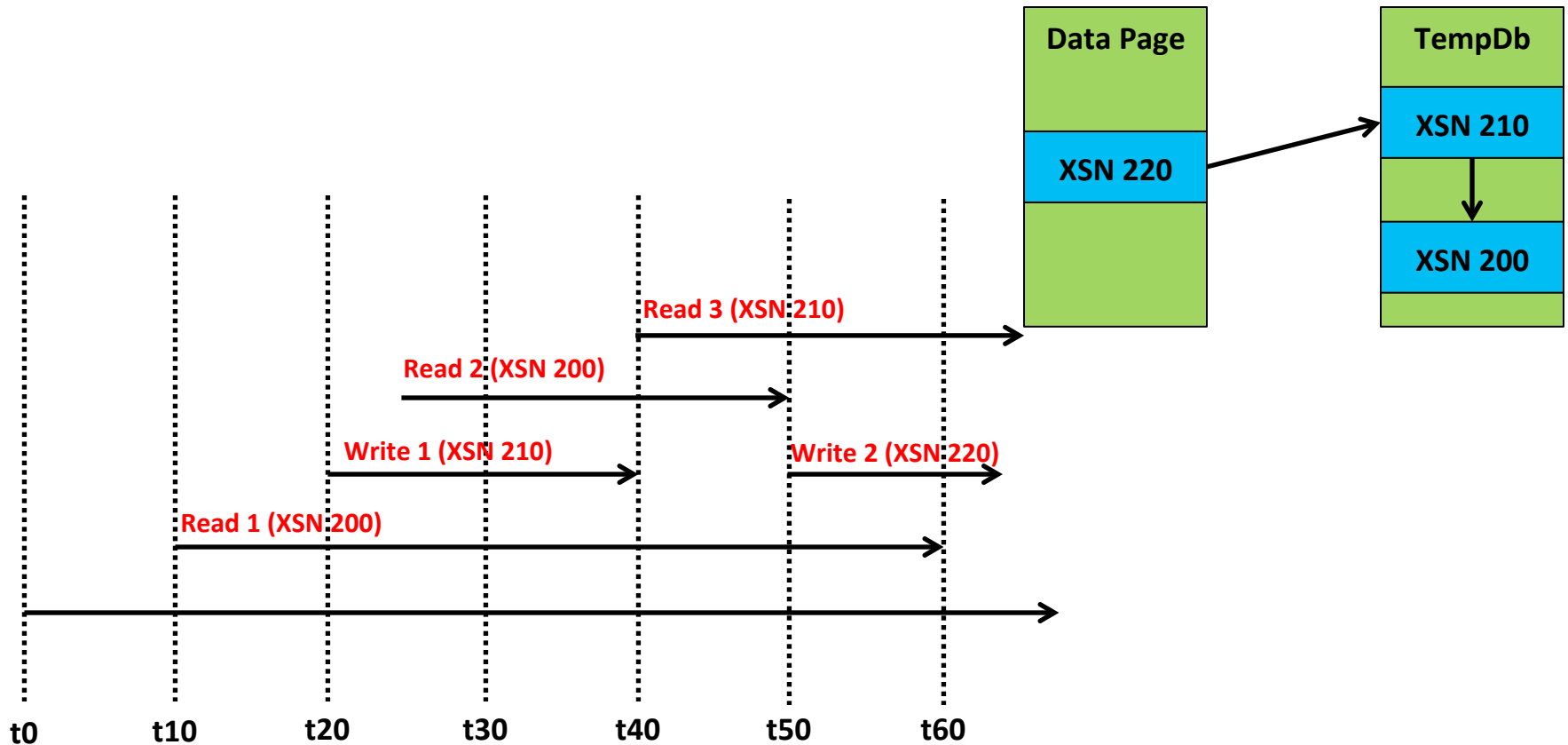
Version Store Internals



Version Store Internals



Version Store Internals



Demo

Version Store

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- **Troubleshooting TempDb**
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Troubleshooting TempDb

- Latch Contention
- IO Performance Issues
- Space Issues
- Transaction Log Issues

Latch Contention

- Latch
 - Short term synchronization object used to protect physical pages
 - Every time when a page is accessed, a latch is needed
 - Other threads can't access the page in the mean time
- Big amount of creation and destruction of many objects
 - Temp Tables
 - Table Variables
- Can lead to Latch Contention
 - PFS Page
 - GAM/SGAM Page

Creating a temp table means...

1. Reading the SGAM page (2:1:3) to find a mixed extent with free space
 - SQL Server uses an exclusive latch on the SGAM page while updating the page
2. Reading the PFS page (2:1:1) to find a free page within the extent
 - SQL Server also uses an exclusive latch on the PFS page while updating the page
3. SQL Server will report a PAGELATCH wait type with the appropriate resource description
 - 2:1:3 for SGAM page
 - 2:1:1 for PFS page

Resolving Latch Contention 1/3

- Multiple TempDB data files
 - $\frac{1}{4}$ to $\frac{1}{2}$ data files of the CPU cores you have (HT cores should be included in the calculation!)
 - Allocation of new objects is done round-robin between the data files
 - All data files must have the same size to be effective
- Don't use the Microsoft recommendation – 1:1 mapping between data files and CPU cores!
 - [http://www.sqlskills.com/BLOGS/PAUL/post/A-SQL-Server-DBA-myth-a-day-\(1230\)-tempdb-should-always-have-one-data-file-per-processor-core.aspx](http://www.sqlskills.com/BLOGS/PAUL/post/A-SQL-Server-DBA-myth-a-day-(1230)-tempdb-should-always-have-one-data-file-per-processor-core.aspx)

Demo

Resolving Latch Contention 1/3

Resolving Latch Contention 2/3

- Temporary Object Reuse
 - SQL Server can cache temporary objects instead of recreating them again and again
 - 1 IAM page and 1 Extent are cached
- Caching is possible when
 - Named constraints are not created
 - DDL statements are not used that effect the object like
 - CREATE INDEX
 - CREATE STATISTICS
 - Object is not created dynamically, e.g. through sp_executesql
 - Object is created inside another object
 - Stored Procedure, Trigger, UDF

Demo

Resolving Latch Contention 2/3

Resolving Latch Contention 3/3

- Trace Flag 1118
 - Introduced with SQL Server 2000
 - Not really needed in SQL Server 2008, because of already improved algorithm when allocating space in Mixed Extents
- Disables all Mixed Extent allocations in TempDb
- Every object that is created, is created in an Uniform Extent
 - Every temp table therefore needs at least 64kb storage
- Should be only enabled when you have contention on the SGAM page (2:1:3)

IO Performance Issues

- RAID 10 and/or SSD drives preferred
- PerfMon counters
 - Avg. Disk sec/Transfer
 - Avg. Disk sec/Read
 - Avg. Disk sec/Write
- SQL Server DMVs
 - `sys.dm_io_virtual_file_stats`

Space Issues

- `sys.dm_db_file_space_usage`
 - `unallocated_extent_page_count`
 - `version_store_reserved_page_count`
 - `user_object_reserved_page_count`
 - `internal_object_reserved_page_count`
- `sys.dm_db_session_space_usage`
 - TempDb usage for the current active sessions
- `sys.dm_db_task_space_usage`
 - TempDb usage for the current running tasks

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Minimize TempDb Usage

- Sort data only if needed
 - Sort data on the client
- Don't use UNION or SELECT DISTINCT
- Keep transactions short
- Use proper indexing
- Consider creating a permanent work table
- Avoid aggregating excessive amounts of data
- Avoid Hash Joins
- Avoid SORT_IN_TEMPDB when creating or rebuilding an index

File Placement

- Put TempDb on its own physical drive
 - No compete with other IO activity
 - No other databases!
- Put it onto the fastest IO subsystem
 - Avoid RAID 5, because of poor write performance
 - SSD drives preferred
 - RAID 10

Initial Sizing and Autogrowth

- Standard (3 MB) is too less
- Autogrowth is at 10%
 - Contributes to physical file fragmentation
 - Maybe timeouts because queries have to wait until Autogrowth completes
- Use Instant File Initialization
- Don't shrink TempDb
- Divide TempDb into multiple files
 - By default: one physical file for MDF and LDF
 - Will reduce Latch Contention
 - Each physical file must have the same identical size

Summary

- TempDb Introduction
- Version Store
- Troubleshooting TempDb
- Best Practices

SQL Server Performance Tuning Workshop

- June 1 – 5 in London
- Agenda
 - Database Internals
 - Execution Plans
 - Indexing
 - Statistics
 - Locking, Blocking, Deadlocking
 - Performance Troubleshooting
- More Information
 - <http://www.SQLpassion.at/academy/perftuning>
 - 10% Discount!

