

Optimized Locking: Improving SQL Server Transaction Concurrency

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- 25 years as a DBA
- Data Platform Women in Tech (WIT) Virtual UG, Co-leader
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- Microsoft MVP, Data Platform
- In my spare time, I can usually be found doing something musical or something geeky with my husband, Andy, and our dog, Sebastian.



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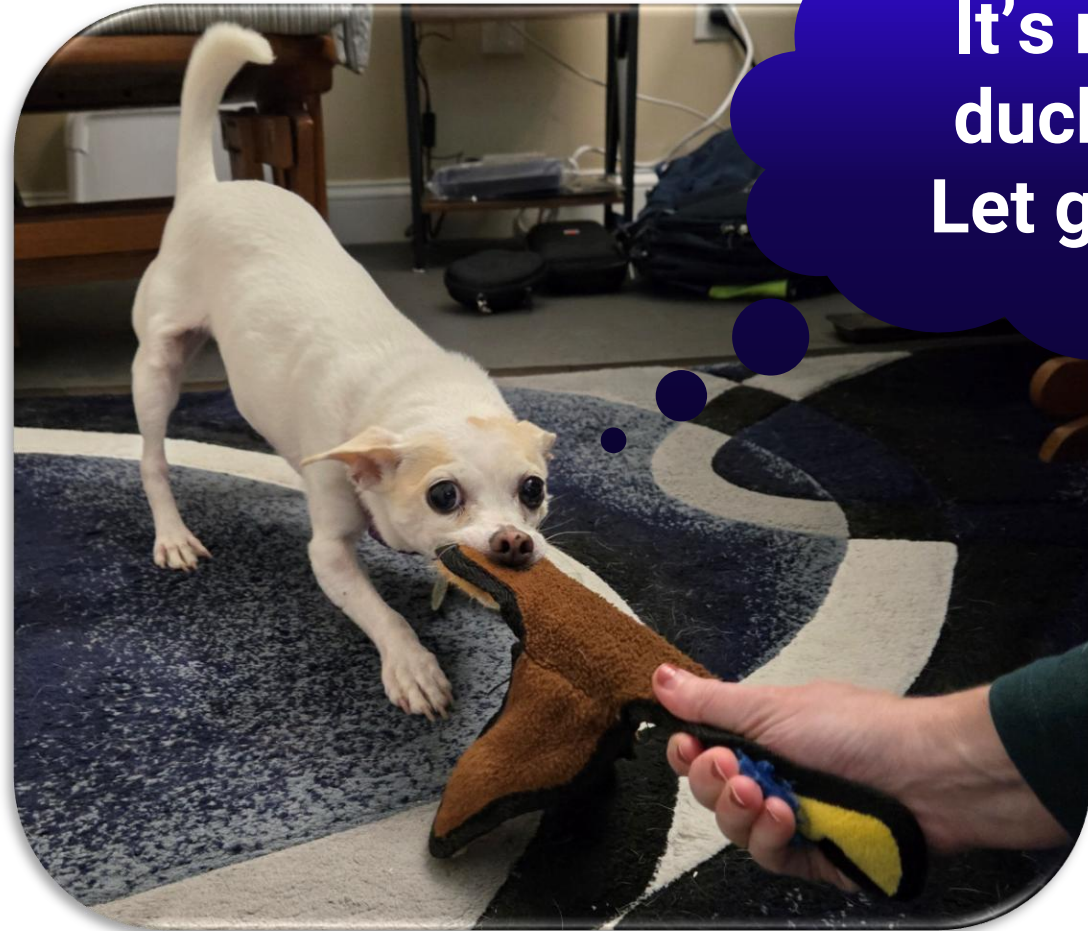
Hidden Pathways to Achieving Peak SQL Server Performance

- Revealing Hidden Performance Issues with Extended Events (Jeff Iannucci)
- Maximizing SQL Server Performance with Read Committed Snapshot Isolation (Haripriya Naidu)
- Optimized Locking: Improving SQL Server Transaction Concurrency (Deborah Melkin)
- Mitigating Your Data Bloat with Partitioning & Data Virtualization (Andy Yun)
- Deep Dive into Memory Optimized TempDB (Haripriya Naidu)



What's the problem we're trying to solve?

- Locking & Blocking!



It's my
duck!!!
Let go!!!

Introducing Optimized Locking

- GA in Azure SQL DB in Feb 2023
- SQL Server 2025 Public Preview
- Writes not blocking Writes

Agenda – How it works

- Components used by Optimized Locking
 - Read Committed Snapshot Isolation Level (RCSI)
 - Accelerated Database Recovery (ADR)
- Lock Escalation
- Optimized Locking
 - Transaction ID Locking
 - Lock After Qualification

Warning:
*** Internals Ahead ***
Level 300



Pessimistic vs Optimistic Locking

- **Pessimistic Locking** – Preventing users from modifying data in a way that affects other users
 - Read Uncommitted
 - Read Committed
 - Serializable
 - Repeatable Read

Pessimistic vs Optimistic Locking

- **Optimistic Locking** – No locks when reading data but data is checked when modifying
 - Read Committed Snapshot Isolation
 - Snapshot Isolation
 - Optimized Locking

Read Committed Snapshot Isolation Level (RCSI)

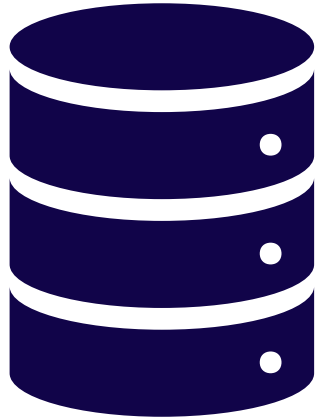
- Introduced with SQL Server 2005
- Writes and Reads don't block each other
- Two database options for setting this:
 - SET READ COMMITTED SNAPSHOT ISOLATION – sets default for the database
 - ALLOW SNAPSHOT ISOLATION LEVEL – allows individual sessions\queries to use SNAPSHOT isolation levels even if read committed snapshot isolation is not set.

Read Committed Snapshot Isolation Level (RCSI)

- Every row in the database has a Transaction ID (TID)
- Keeps copies of the previously committed versions of the records in the Version Store in TempDB
- Only reading the committed version of the data

BEGIN TRAN 1A

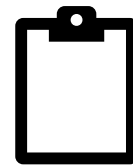
User DB



```
UPDATE Customer
SET State = 'MA'
WHERE FirstName = 'Sebastian'
```

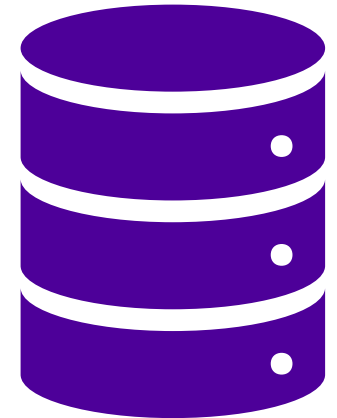


Sebastian	MA	Key	1A
-----------	----	-----	----



```
SELECT FirstName,
       LastName,
       State
FROM Customer
WHERE FirstName = 'Sebastian'
```

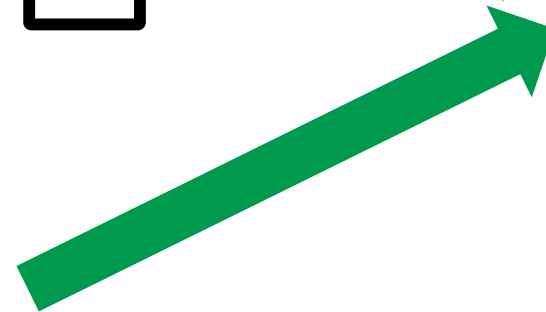
tempdb



Version Store

Sebastian	AZ	1A	1
-----------	----	----	---

TID
Transaction Seq No.



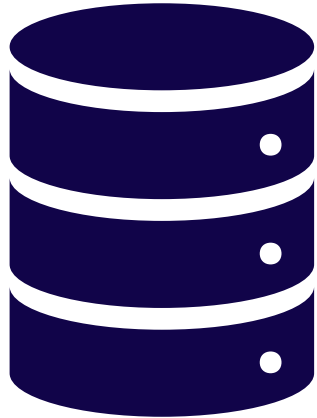
Read Committed
Snapshot Isolation

Accelerated Database Recovery (ADR)

- Introduced in SQL Server 2019
- Default for Azure SQL DB
 - Cannot be turned off
- Changes the way the transactions logs are read to be able to recover from long running transactions or just restore faster
- Uses a Persistent Version Store in Database rather than the Version Store in TempDB

BEGIN TRAN 1A

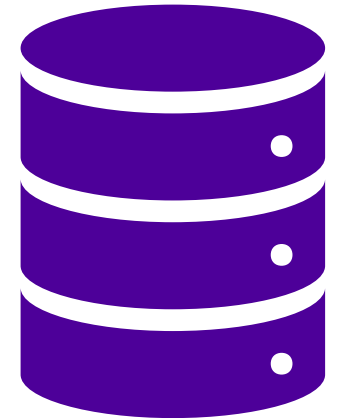
User DB



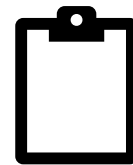
```
UPDATE Customer
SET State = 'MA'
WHERE FirstName = 'Sebastian'
```



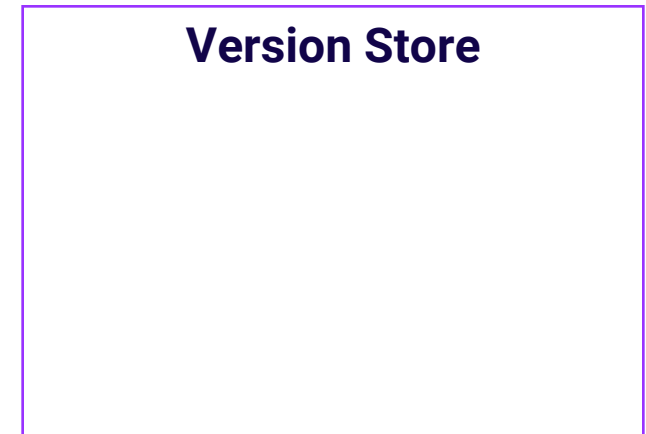
tempdb



Sebastian	MA		1A
-----------	----	---	----



Version Store



Persistent Version Store

Sebastian	AZ	1A	1
-----------	----	----	---



```
SELECT FirstName,
LastName,
State
FROM Customer
WHERE FirstName = 'Sebastian'
```

Lock Escalation

- Threshold at which SQL Server will convert lower granularity locks to a higher level in order to manage a small number of locks
 - 5,000 on a table or index for a single statement
 - Each additional 1,250 locks taken in a transaction

Lock Granularity (from Microsoft)

Resource	Description
RID	A row identifier used to lock a single row within a heap.
KEY	A row lock to lock a single row in a B-tree index.
PAGE	An 8 kilobyte (KB) page in a database, such as data or index pages.
EXTENT	A contiguous group of eight pages, such as data or index pages.
HoBT	A heap or B-tree. A lock protecting a B-tree (index) or the heap data pages in a table that doesn't have a clustered index.
TABLE	The entire table, including all data and indexes.
FILE	A database file.
APPLICATION	An application-specified resource.
METADATA	Metadata locks.
ALLOCATION_UNIT	An allocation unit.
DATABASE	The entire database.
XACT	Transaction ID (TID) lock used in Optimized Locking

Lock Escalation (cont'd)

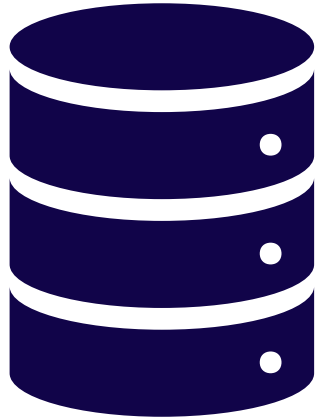
- Row and key locks escalate to table locks, not page locks
- “Queries Decide the Isolation Level” (Erik Darling)

Optimized Locking

- Changes to the locking mechanisms
 - Locks on the Transaction ID
 - Releases locks on other objects quickly
 - Minimizes lock escalation
- Accelerated Database Recovery is Required

BEGIN TRAN 1A

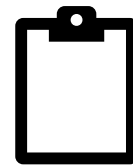
User DB



```
UPDATE Customer  
SET State = 'MA'  
WHERE FirstName = 'Sebastian'
```



Sebastian	MA	Key	
-----------	----	-----	---



Persistent Version Store

Sebastian	AZ	1A	1
-----------	----	----	---

```
SELECT FirstName,  
        LastName,  
        State  
FROM Customer  
WHERE FirstName = 'Sebastian'
```



Optimized Locking -
Reads

**Yeah, but that was just
a SELECT statement...**

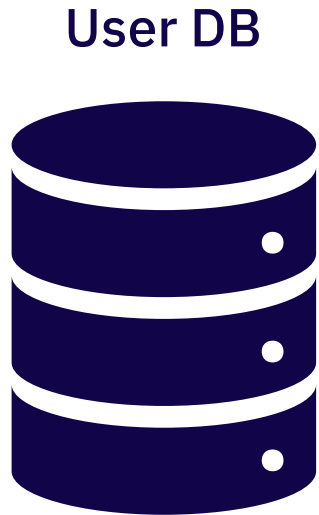
Regular RCSI stuff.

Now what about writes?



Transaction ID Locking





- As the lock is held on the Transaction ID, the next transaction can see when rows aren't affected and update them without waiting.

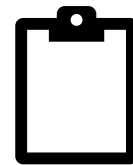


BEGIN TRAN 1A

UPDATE Customer
SET State = 'MA'
WHERE FirstName = 'Sebastian'



Sebastian	MA		
Deborah	MA		



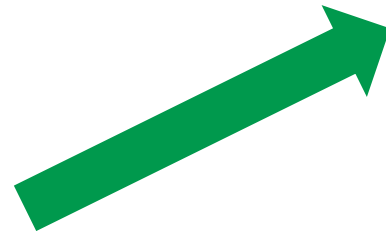
Persistent Version Store

Sebastian	AZ	1A	1
Deborah	TN	2A	1



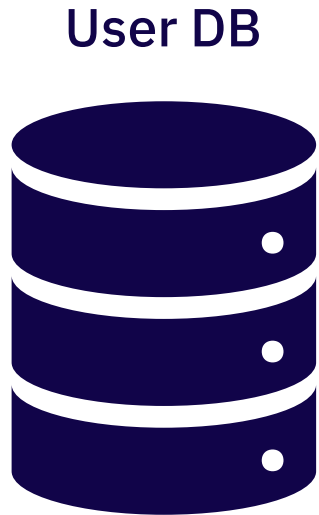
BEGIN TRAN 2A

UPDATE Customer
SET State = 'MA'
WHERE FirstName = 'Deborah'



Lock After Qualification (LAQ)

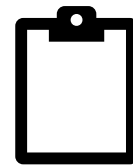
- RCSI is a requirement for this to work
- Looks to see if the previously committed version of the rows with TID locks would also be affected by the current transaction
 - If yes, transaction ***will wait*** for previous transaction to finish and include those columns as part of the change
 - If no, the transaction will update the rows that do match



BEGIN TRAN 1A

```
UPDATE Customer  
SET State = 'GA'  
WHERE FirstName = 'Sebastian'
```

COMMIT TRAN 1A



BEGIN TRAN 2A

```
UPDATE Customer  
SET State = 'MA'  
WHERE FirstName = 'Sebastian'
```

Persistent Version Store			
Sebastian	AZ	1A	1
Sebastian	GA	2A	1

Demos!



Be aware of

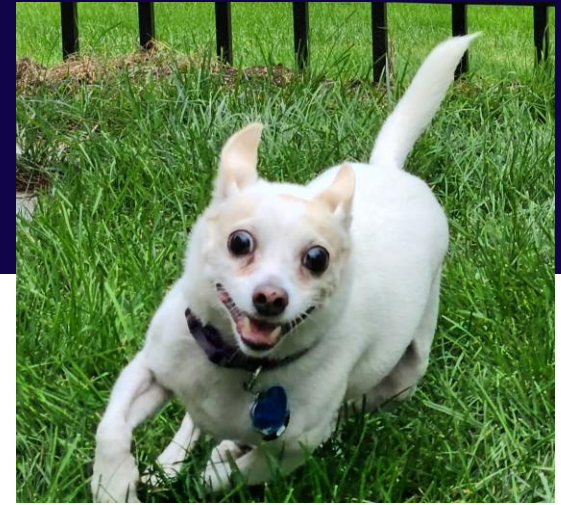
- Persistent Version Store
 - Make sure there is enough space available
 - When full, only reads can happen – no writes
 - Asynchronous Cleaner
 - Data remains until it's no longer needed
 - **And** there are no more open transactions in front of it anywhere in the instance.
 - Keep Transactions Fast

Be aware of

- Lock After Qualification
 - Blocking and waits can still occur
 - Be aware of multiple transactions that may change data for the same set of records

Recap

- Understand how RCSI & ADR are used for optimized locking
- Minimizes blocking but does not solve ALL situations
- Reduces the number of locks being held and the length they are held for
- Writes don't block Reads OR Writes



Resources – Optimized Locking

- [SQL Server Transaction Locking and Row Versioning Guide](#)
- [Optimized Locking](#)
- [Bob Ward's Github - Optimized Locking Demos](#)
- [Isolation Level Locking \(Erik Darling\)](#)

Resources - Accelerated Database Recovery

- [Soaring to New Heights with Accelerated Database Recovery \(John Morehouse\)](#)
- [Monitor and Troubleshoot Accelerated Database Recovery](#)
- [Why to Use Accelerated Database Recovery in SQL Server \(Luis Lema\)](#)
- [Constant Time Recovery in Azure SQL Database \(whitepaper\)](#)

Thank you

Any Questions?

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