PASS Data Community Summit

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# Optimized Locking: Improving SQL Server Transaction Concurrency

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she\her

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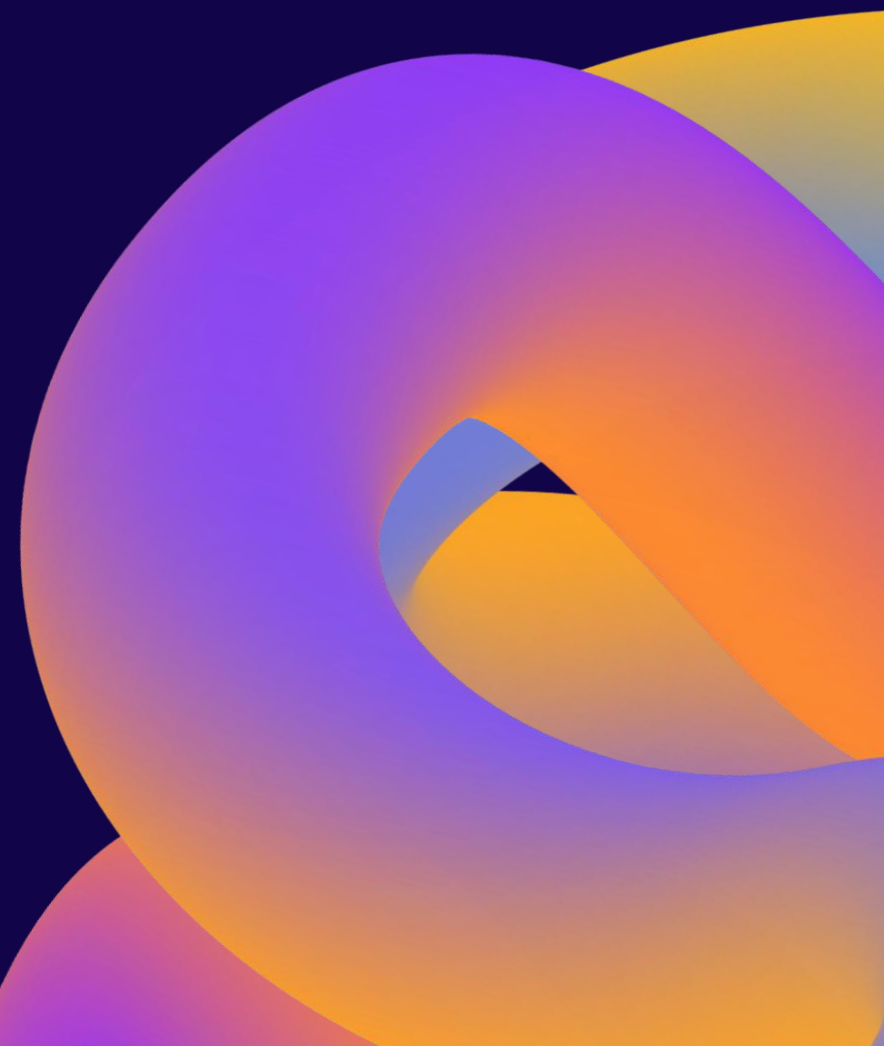

# Deborah Melkin

She/Her

Data Engineer

Advisor360

- 25 years as a DBA
- Data Platform Women in Tech (WIT) Virtual UG, Co-leader
- WITspiration, Co-founder
- Redgate Community Ambassador
- 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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**DebtheDBA.wordpress.com**

# 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!

# Introducing Optimized Locking

- GA in Azure SQL DB in Feb 2023
  - Enabled by default
- SQL Server 2025
  - Manually enable by database
- 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

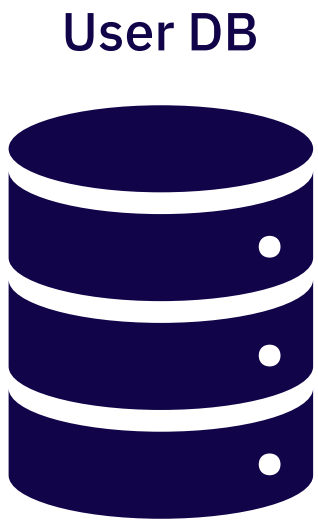
- **Optimistic Locking** – No locks when reading data but data is checked when modifying
  - Read Committed Snapshot Isolation
  - Snapshot Isolation
  - Optimized Locking

# 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.

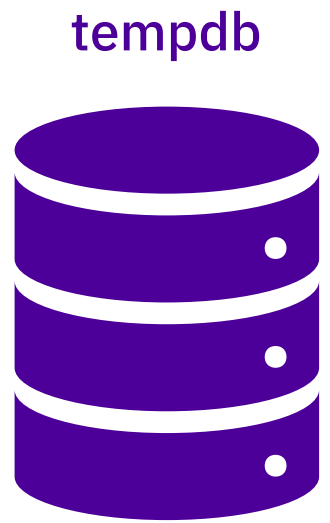
# Read Committed Snapshot Isolation Level (RCSI)

- 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

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



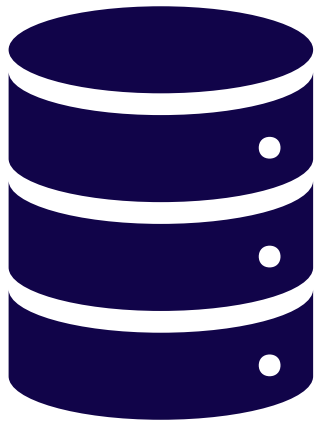



```
SELECT FirstName,
       LastName,
       State
FROM Customer
WHERE FirstName = 'Sebastian'
```

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

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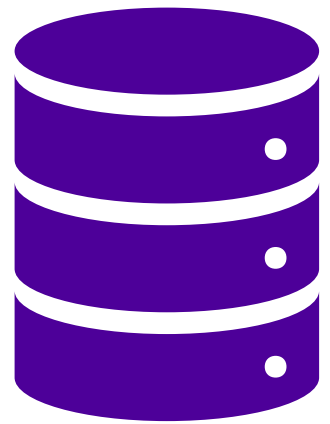
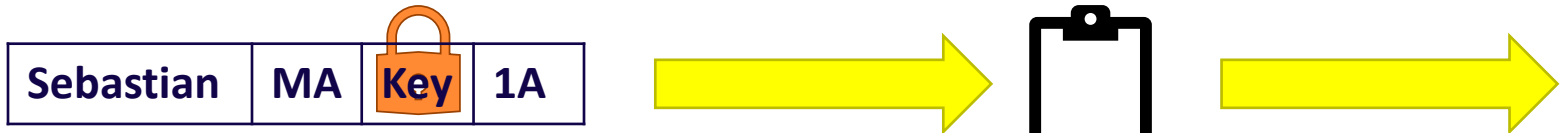
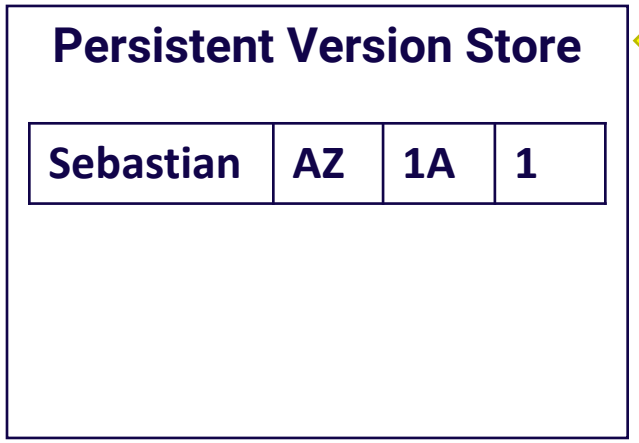









```
SELECT FirstName,
       LastName,
       State
FROM Customer
WHERE FirstName = 'Sebastian'
```

Accelerated Database Recovery

# 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 |

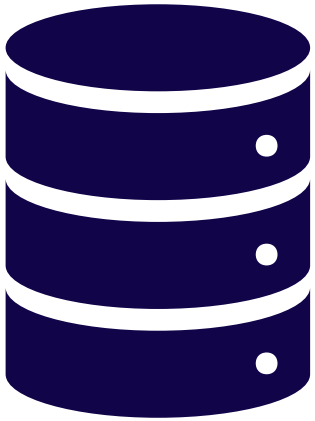
# Lock Escalation (cont'd)

- 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

User DB



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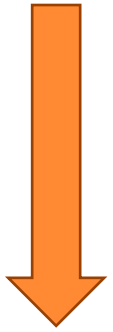
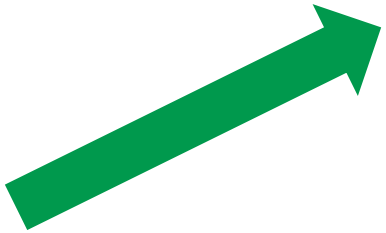
BEGIN TRAN 1A

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




**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...

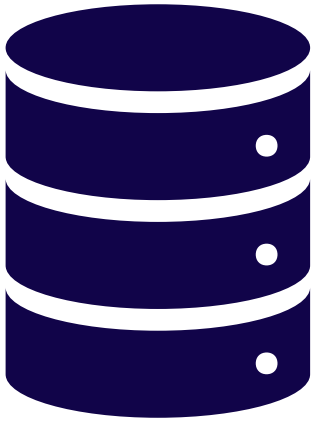
Regular RCSI stuff.

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.

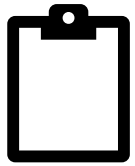
User DB



```
BEGIN TRAN 1A

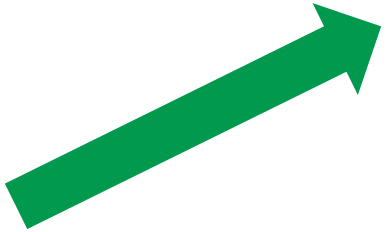
UPDATE Customer
SET State = 'MA'
WHERE FirstName = 'Sebastian'
```

| Sebastian | MA | Key | A |
|---|---|---|---|
| Deborah | TN | e | 4 |



**Persistent Version Store**

| Sebastian | AZ | 1A | 1 |
|---|---|---|---|
| Deborah | TN | 2A | 1 |



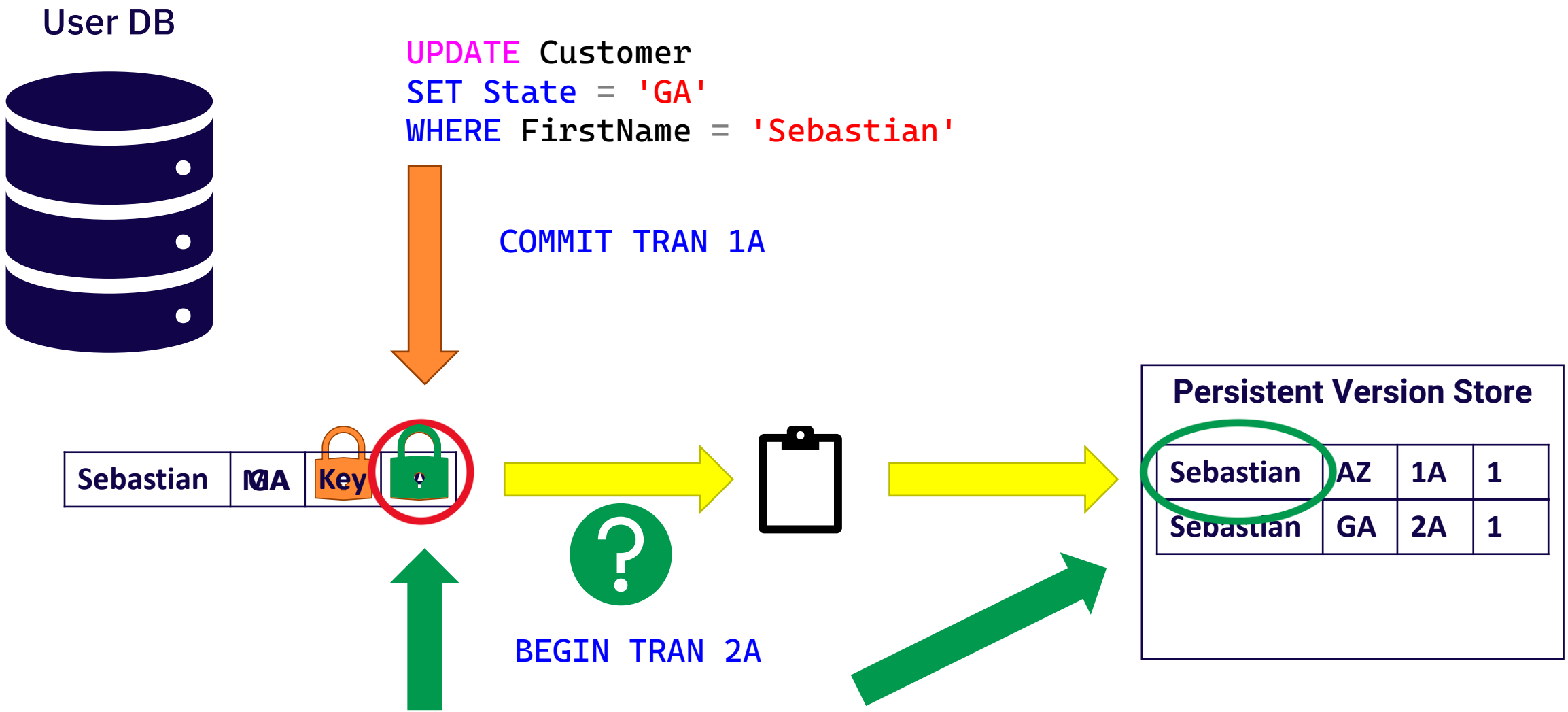
```
BEGIN TRAN 2A

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

Optimized Locking - TID Locking

# 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


User DB
BEGIN TRAN 1A
UPDATE Customer
SET State = 'GA'
WHERE FirstName = 'Sebastian'
COMMIT TRAN 1A
Sebastian
Key
Persistent Version Store
Sebastian
AZ
1A
1
Sebastian
GA
2A
1
BEGIN TRAN 2A
UPDATE Customer
SET State = 'MA'
WHERE FirstName = 'Sebastian'

# Additional Improvements with LAQ

- Announced with GA release of SQL Server 2025:
  - Skip index locks (SIL)
    - If there are no other queries that are requiring row locking queries (RLQ) for the rows needed, such as REPEATABLE READ or SERIALIZABLE isolations or queries with those corresponding hints), the engine can skip row and page level locks when modifying a row and just take an exclusive page lock

# Additional Improvements with LAQ

- Announced with GA release of SQL Server 2025:
  - Query Plan LAQ Feedback Persistence
    - The qualification process may need to restart if there are other transactions modify the row before the current transaction, creating overhead. This was previously monitored on database level and now can be monitored on query level.
    - Previously would disable LAQ on database level if overhead exceeded a threshold. Can now be done on query level.

# Demos!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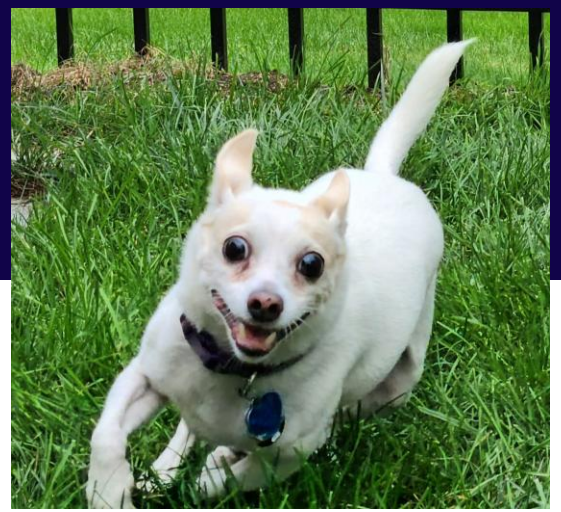
# Be aware of

- 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
  - Query Plan LAQ Feedback Persistance

# 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
  - Introducing Optimized Locking V2
- 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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