



Exploring Optimized Locking

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Objectives



- Current problems
- Optimized Locking Components
- How does it work
- Limitations
- Q&A



Slides & Demos

Current Problems



- ACID Compliance
- Lock escalation
- Long-term locking
- Excessive blocking
- Excessive memory utilization



Traditional Locking



- Update lock taken on rows to allow for predicate evaluation
- If predicate is satisfied, then an exclusive lock is taken on the row
- Locks are held until the end of the transaction

Traditional Locking



```
ALTER DATABASE [Locking] SET READ_COMMITTED_SNAPSHOT OFF;  
SET TRANSACTION ISOLATION LEVEL READ COMMITTED;
```

```
CREATE TABLE t1 (a int, b int);  
INSERT INTO t1 VALUES (1,10), (2,20), (3,30);
```

```
-- TID2: Increase b by 10  
BEGIN TRAN UPDATE t1 SET b=b+10;
```



p1: Data Page for t1

r1: 1 20 TID2
r2: 2 30 TID2
r3: 3 40 TID2

Lock Manager

Lock Mode	Lock Type	Lock Resource
IX	OBJECT	t1
IX	PAGE	p1
X	RID	r1
X	RID	r2
X	RID	r3



Old
School

Updating 1 million rows
might require 1 million
exclusive (X) row locks
held until the end of the
transaction.

Optimized Locking Components



- Accelerated Database Recovery
- Transaction ID (TID)
- Lock After Qualification (LAQ)

Transaction ID (TID)



- A unique identifier
- Each row will contain the TID that last modified it
- Lock will be held on the transaction ID versus row key

Lock After Qualification (LAQ)



- Predicate is applied to the row using the latest version of the row
- If the predicate is not satisfied, move to the next row
- If the predicate is satisfied, an exclusive (X) lock is placed on the row
- Can retry predicate evaluation as needed due to previous exclusive lock

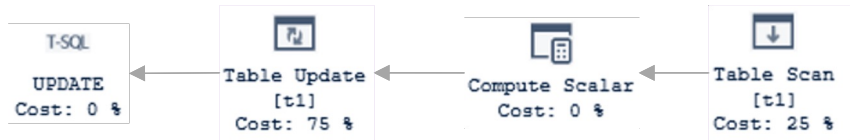
Traditional Blocking



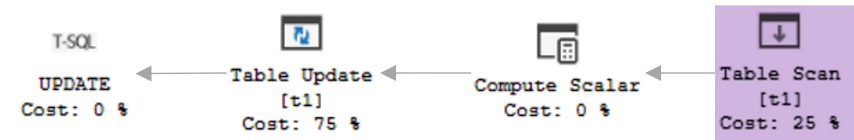
```
ALTER DATABASE [db1] SET READ_COMMITTED_SNAPSHOT ON;  
SET TRANSACTION ISOLATION LEVEL READ COMMITTED;
```

```
CREATE TABLE t1 (a int, b int);  
INSERT INTO t1 VALUES (1,10), (2,20), (3,30);
```

```
-- TID2 [SESSION 1]: Increase b by 10 where a=1  
BEGIN TRAN UPDATE t1 SET b=b+10 where a=1;
```



```
-- TID3 [SESSION 2]: Increase b by 10 where a=2  
BEGIN TRAN UPDATE t1 SET b=b+10 where a=2;
```



p1: Data Page for t1

Row version store

Row ~~does not~~ qualify

r1: 1 20 TID2	✓
r2: 2 20 TID1	✗
r3: 3 30 TID1	✗

Row version store

r1: 1 10 TID1

Lock Manager

Lock Mode	Lock Type	Resource	Owner	Status
IX	OBJECT	t1	TID2, TID3	GRANT
IX	PAGE	p1	TID2	GRANT
X	RID	r1	TID2	GRANT
IU	PAGE	p1	TID3	GRANT
U	RID	r1	TID3	WAIT

Slide Credit: Perry Skountrianos/Prashanth Purnananda & the Microsoft team who brought you optimized locking

⛔ Session 2 is blocked waiting for Session 1 to commit

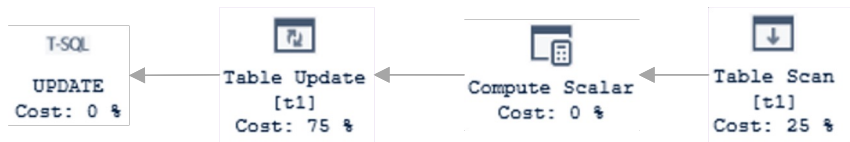
Optimized Locking



```
ALTER DATABASE [db1] SET READ_COMMITTED_SNAPSHOT ON;  
SET TRANSACTION ISOLATION LEVEL READ COMMITTED;
```

```
CREATE TABLE t1 (a int, b int);  
INSERT INTO t1 VALUES (1,10), (2,20), (3,30);
```

```
-- TID2 [SESSION 1]: Increase b by 10 where a=1  
BEGIN TRAN UPDATE t1 SET b=b+10 where a=1;
```

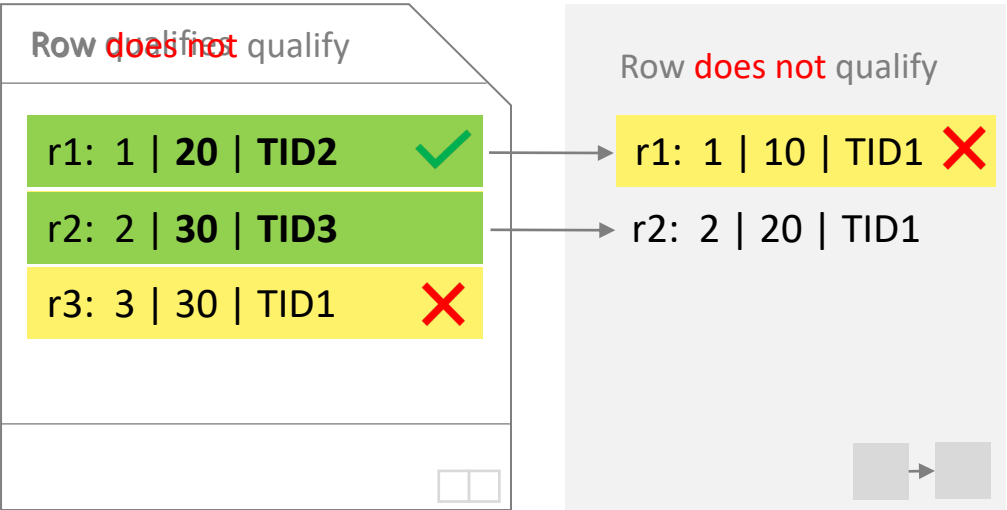


```
-- TID3 [SESSION 2]: Increase b by 10 where a=2  
BEGIN TRAN UPDATE t1 SET b=b+10 where a=2;
```



p1: Data Page for t1

Row version store



Lock Manager

Lock Mode	Lock Type	Resource	Owner	Status
X	XACT	TID2	TID2	GRANT
IX	OBJECT	t1	TID2, TID3	GRANT
IX	PAGE	p1	TID2	GRANT
IX	PAGE	p1	TID3	GRANT
X	RID	r2	TID3	GRANT

Slide Credit: Perry Skountrianos/Prashanth Purnananda & the Microsoft team who brought you optimized locking

✓ Session 2 is not blocked by Session 1



New
School

Updating 1 million rows might require 1 million X row locks but each lock is released as soon as each row is updated,

Only one TID lock will be held until the end of the transaction.

Warning



“

Even without LAQ, applications should not assume that SQL Server (under versioning isolation levels) will guarantee strict ordering, without using locking hints.

<https://learn.microsoft.com/en-us/sql/relational-databases/performance/optimized-locking?view=azuresqlldb-current>

Best Practices & Troubleshooting



- Avoid locking hints
- Make sure RCSI is enabled
- New entries for Deadlock Graphs
- New Waits introduced:
 - LCK_M_S_XACT_READ
 - LCK_M_S_XACT_MODIFY
 - LCK_M_S_XACT

LCK_M_S_XACT

Occurs when a task is waiting for a shared lock on an XACT `wait_resource` type, where the intent cannot be inferred. Rare. Related to [optimized locking](#).

LCK_M_S_XACT_READ

Occurs when a task is waiting for a shared lock on an XACT `wait_resource` type, with an intent to read. Related to [optimized locking](#).

LCK_M_S_XACT_MODIFY

Occurs when a task is waiting for a shared lock on an XACT `wait_resource` type, with an intent to modify. Related to [optimized locking](#).

Limitations



- Azure SQL Database Only (for now)
 - DTU service tier
 - vCore Provisioned tier (including serverless)
- Accelerated Database Recovery Required
- Repeatable Read & Serializable Isolation forces the lock to be held on the row or page until the end of the transaction

Summary



- Better concurrency
- Significantly reduced locking and lock memory
- On by default in Azure SQL Database
 - ADR/RCSI is enabled by default as well
- Every SQL Server DBA should be watching this feature arrive to the box product

Resources



- Optimized Locking - <https://learn.microsoft.com/en-us/sql/relational-databases/sql-server-transaction-locking-and-row-versioning-guide?view=sql-server-ver16&source=recommendations>
- Article - <https://www.red-gate.com/simple-talk/databases/sql-server/database-administration-sql-server/optimized-locking-in-azure-sql-database/> (Simple Talk - Aaron Bertrand)



Questions?
Answers!

**Got
Questions?**

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Slides & Demos