Interval-based Trace Format Guideline

To perform isolation level verification in a black-box mode, we log the *interval-based trace* (trace for short) of each operation in a workload. In this document, we introduce the format of logging traces in detail. Generally speaking, as an example shown in Figure 1, the trace of an operation consists of :

1. **threadID** The thread identification of the operation.

2. **transactionID** The transaction identification of the operation.

3. **operationID** The operation identification.

4. **operationTraceType** The operation type.

5. **startTimestamp** The timestamp before the operation executed.

6. **finishTimestamp** The timestamp after the operation executed.

7. **predicateLock** The predicate lock acquired by the operation. It is decided by the type of the test DBMS and the operation type. The details have been described in Section 4.

8. **traceLockMode** The lock mode of the operation.

9. **readMode** The read mode of the operation. Both lock mode and read mode are decided by the type of the test DBMS and the operation type. The details have been described in Section 2 and 3.

10. **Read/Write Tuple List** The data accessed by the operation. Specifically, for a read (resp. write) operation, we log its read (resp. write) tuple list. Each tuple list consists of the tuple identification and value.

```
{
  "threadID": "0-0-0",
  "transactionID": "0-0-0,0",
  "operationID": "0-0-0,0,1",
  "operationTraceType": "UPDATE",
  "startTimestamp": 1663798322622208619,
  "finishTimestamp": 1663798322632200949,
  "predicateLock": null,
  "traceLockMode": "EXCLUSIVE_LOCK",
  "readMode": "LOCKING_READ",
  "writeTupleList": [
    {
      "table": "0",
      "primaryKey": "0",
      "valueMap": {
        "v": 1
      }
    }
  ]
},
```

Figure 1: Interval-based Trace Example

Content

1. Three Types of Lock Modes

- NON_LOCK
    - An operation accesses data without acquiring lock.
- SHARE_LOCK
    - An operation accesses data before acquiring shared lock.
- EXCLUSIVE_LOCK
    - An operation accesses data before acquiring exclusive lock.

InnoDB

	Select	Select lock in share mode	Select for update	Insert	update	delete
Read Uncomm itted	NON_LO CK	SHARE_L OCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK
Read Committ ed	NON_LO CK	SHARE_L OCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK
Repeata ble Read	NON_LO CK	SHARE_L OCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK
Serializa ble	SHARE_L OCK	SHARE_L OCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK

PostgreSQL

	Select	Select lock in share mode	Select for update	Insert	update	delete
Read Uncomm itted	NON_L OCK	SHARE_L OCK	EXCLUSIVE_ LOCK	EXCLUSIVE_ LOCK	EXCLUSIVE_ LOCK	EXCLUSIVE_ LOCK
Read Committ ed	NON_L OCK	SHARE_L OCK	EXCLUSIVE_ LOCK	EXCLUSIVE_ LOCK	EXCLUSIVE_ LOCK	EXCLUSIVE_ LOCK
Repeata ble Read	NON_L OCK	SHARE_L OCK	EXCLUSIVE_ LOCK	EXCLUSIVE_ LOCK	EXCLUSIVE_ LOCK	EXCLUSIVE_ LOCK

Serializable	NON_LOCK	SHARE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK

Oceanbase

	Select	Select lock in share mode	Select for update	Insert	update	delete
Read Uncommitted	NON_LOCK	SHARE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK
Read Committed	NON_LOCK	SHARE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK
Repeatable Read	NON_LOCK	SHARE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK
Serializable	NON_LOCK	SHARE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK

TiDB Pessimistic Transaction

	Select	Select lock in share mode	Select for update	Insert	update	delete
Read Committed	NON_LOCK	SHARE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK
Repeatable Read	NON_LOCK	SHARE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK

Oracle

	Select	Select lock in share mode	Select for update	Insert	update	delete
Read Committed	NON_LOCK	SHARE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK

Repeat able Read	NON_L OCK	SHARE_L OCK	EXCLUSIVE_ LOCK	EXCLUSIVE_ LOCK	EXCLUSIVE_ LOCK	EXCLUSIVE_ LOCK

Derby

	Select	Select lock in share mode	Select for update	Insert	update	delete
Read Uncomm itted	NON_LO CK	SHARE_L OCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK
Read Committ ed	SHARE_L OCK	SHARE_L OCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK
Repeata ble Read	SHARE_L OCK	SHARE_L OCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK
Serializa ble	SHARE_L OCK	SHARE_L OCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK

SQLite

	Select	*Select lock in share mode*	*Select for update*	Insert	update	delete
Read Uncomm itted	NON_LO CK	SHARE_L OCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK
Serializa ble	SHARE_L OCK	*SHARE_L OCK*	*EXCLUSIVE _LOCK*	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK	EXCLUSIVE _LOCK

CockroachDB

	Select	Select for update	Insert	update	delete
Serializable	NON_LOCK	EXCLUSIVE_LOCK	NON_LOCK	NON_LOCK	NON_LOCK

YugabyteDB

	Select	Select for update	Insert	update	delete
Serializable	NON_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK
Repeatable Read	NON_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK
Read Committed	NON_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK	EXCLUSIVE_LOCK

2. Three Types of Read Modes

- UNCOMMITTED_READ
  - An operation sees a uncommitted data.
- CONSISTENT_READ
  - An operation performs a consistent read on the snapshot of database.
- LOCKING_READ
  - An operation access data before acquiring lock.

InnoDB

	Select	Select lock in share mode	Select for update	Insert	update	delete
Read Uncommitted	UNCOMMITTED_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ
Read Committed	CONSISTENT_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ
Repeatable Read	CONSISTENT_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ
Serializable	LOCKING_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ

PostgreSQL

	Select	Select lock	Select for	Insert	update	delete

		in share mode	update			
Read Uncommitted	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ	LOCKING_READ	CONSISTENT_READ	CONSISTENT_READ
Read Committed	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ	LOCKING_READ	CONSISTENT_READ	CONSISTENT_READ
Repeatable Read	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ	LOCKING_READ	CONSISTENT_READ	CONSISTENT_READ
Serializable	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ	LOCKING_READ	CONSISTENT_READ	CONSISTENT_READ

Oceanbase

	Select	Select lock in share mode	Select for update	Insert	update	delete
Read Uncommitted	UNCOMMITTED_READ	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ
Read Committed	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ
Repeatable Read	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ
Serializable	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ

TiDB Pessimistic Transaction

	Select	Select lock in share mode	Select for update	Insert	update	delete
Read Committed	CONSISTENT_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ
Repeat	CONSISTENT	LOCKING_	LOCKING_	LOCKING_	LOCKING_	LOCKING_

able Read	_READ	READ	READ	READ	READ	READ

Oracle

	Select	Select lock in share mode	Select for update	Insert	update	delete
Read Committed	CONSISTENT_READ	LOCKING_READ	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ
Repeatable Read	CONSISTENT_READ	LOCKING_READ	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ

Derby

	Select	Select lock in share mode	Select for update	Insert	update	delete
Read Uncommitted	UNCOMMITTED_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ
Read Committed	LOCKING_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ
Repeatable Read	LOCKING_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ
Serializable	LOCKING_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ

SQLite

	Select	Select lock in share mode	Select for update	Insert	update	delete
Read Uncommitted	UNCOMMITTED_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ	LOCKING_READ

Serializable	LOCKING_READ	*LOCKING_READ*	*LOCKING_READ*	LOCKING_READ	LOCKING_READ	LOCKING_READ

CockroachDB

	Select	Select for update	Insert	update	delete
Serializable	CONSISTENT_READ	LOCKING_READ	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ

YugabyteDB

	Select	Select for update	Insert	update	delete
Serializable	CONSISTENT_READ	LOCKING_READ	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ
Read Committed	CONSISTENT_READ	LOCKING_READ	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ
Repeatable Read	CONSISTENT_READ	LOCKING_READ	CONSISTENT_READ	CONSISTENT_READ	CONSISTENT_READ

3. Predicate Lock

InnoDB

	Select	Select lock in share mode	Select for update	Insert	update	delete
Read Uncommitted	NO	NO	NO	NO	NO	NO
Read Committed	NO	NO	NO	NO	NO	NO
Repeatable Read	NO	YES	YES	NO	NO	NO
Serializable	YES	YES	YES	NO	NO	NO

PostgreSQL

	Select	Select lock in share mode	Select for update	Insert	update	delete
Read Uncommitted	NO	NO	NO	NO	NO	NO
Read Committed	NO	NO	NO	NO	NO	NO
Repeatable Read	NO	NO	NO	NO	NO	NO
Serializable	YES	YES	YES	NO	NO	NO

Oceanbase

No predicate lock required.

TiDB

No predicate lock required.

Oracle

No predicate lock required.

Derby

	Select	Select lock in share mode	Select for update	Insert	update	delete
Read Uncommitted	NO	NO	NO	NO	NO	NO
Read Committed	NO	NO	NO	NO	NO	NO
Repeatable Read	NO	NO	NO	NO	NO	NO
Serializable	YES	YES	YES	NO	NO	NO

SQLite

No predicate lock required.

CockroachDB

No predicate lock required.

Predicate Lock Rewrite Rules

If there is no *Where* clause, add a table level lock for each table in the from clause, and connect the table level lock with *OR* operator. If there is no index on the attribute column in where clause, add table level lock; Otherwise, add range level lock.

Table-level Lock Rewrite Rules

tableName.table = 'tableName'

Range-level Lock Rewrite Rules

- predicate
  - =
    - =
  - >
    - >
  - <
    - <
  - >=
    - >=
  - <=
    - <=
  - !=
    - !=
  - Like
    - table-level lock
  - In
    - table-level lock
  - Between and
    - Between and
  - Is null
    - Is null
  - Not
    - =
    - >
    - <
    - >=

- ◆ <=
- ◆ Between and
- ◆ Is null
- ◆ !=
  - • Not
- ◆ Like
  - • table-level lock
- ◆ In
  - • table-level lock
- **And**
  - ◆ **And**
- **Or**
  - ◆ **Or**