Bugs found in Database Management Systems

We have successfully discovered 23 bugs (13 fixed, 15 confirmed and 8 open reported) from real-world production-level DBMSs, including 5 bugs in MySQL, 2 bugs in PostgreSQL, 12 bugs in TiDB, 2 bugs in OpenGauss, and 2 bugs in Oceanbase.

We are thankful to the DBMS developers for responding to our bug reports and fixing the bugs that we found. Because the nondeterministic interleavings among operations challenges the reproducibility of the isolation-related bugs, there are 8 bugs can not be reproduced but open reported. In the future, we will aim to the research question about reproducing an isolation-related bug.

Fixed bugs

TiDB

Isolation-related Bugs

Dirty write in pessimistic transaction mode

Test Case

Transaction ID	Operation Detail	State
Mode Setting	Set global tidb_txn_mode = 'pessimistic';	Success
Schema Creation	Create table table_7_2(a int primary key, b int, c double);	Success
Database Population	Insert into table_7_2 values(676,-5012153, 2240641.4);	Success
739	Begin transaction;	Success
739	Update table_7_2 set b=-5012153, c=2240641.4 where a=676	Success
723	Begin transaction;	Success
723	Update table_7_2 set b=852150 where a=676	Success×
739	Commit	Success

Bug Description

It first set transaction mode as pessimistic. Transaction 739 updates a record 676 in table_7_2 and holds an exclusive lock on the record 676. Before transaction 739 releases the exclusive lock on record 676, transaction 723 also successfully acquires an exclusive lock on record 676 and updates it, which results dirty write anomalies should be avoided in pessimistic transaction mode as described in TiDB official website.

Read inconsistency in snapshot isolation

Test Case

Transaction ID	Operation Detail	State
Schema Creation	Create table table_7_2(primarykey int primary key, attribute1 double,attribute6 double);	Success
Database Population	Insert into table_7_2 values(3873, 0.213, 0.234);	Success
904	Begin transaction;	Success
904	Update table_8_2 set attribute6=-0.386 where primarykey=3873	Success
904	Commit	Success
914	Set @@global.tx_isolation='REPEATABLE-READ';	Success
907	Begin transaction;	Success
907	Update table_8_2 set attribute6=0.484 where primarykey=3873	Success
907	Commit	Success
914	Select attribute6 from table_8_2 where primarykey=3873	Success(attribute6=-0.368)×

Bug Description

There are two historical versions on attribute6 of record 3873 in table_ 8_2. The first one is -0.386 created by transaction 904; the second one is 0.484 created by transaction 907. Since the select operation of transaction 914 happens after the committing of transaction 907, transaction 914 should sees the second one, i.e., 0.484, instead of the first one, i.e., -0.368. However, the select operation of transaction 914 returns the first version -0.368, which indicates there is a defect about the implementation of consistent read in TiDB.

Violating mutual exclusion

Test Case

```
drop database if exists db1;
create database db1;
```

```
use db1;
create table t1(a int primary key, b int);
create table t2(a int primary key, b int, constraint fk1 foreign key(b) references t1(a));
create view view0(t2_a,t2_b,t1_b) as select t2.a,t2.b,t1.b from t2,t1 where t2.b=t1.a;

insert into t1 values(1,2);
insert into t1 values(2,3);
insert into t1 values(3,4);
insert into t1 values(4,5);
insert into t1 values(5,6);

insert into t2 values(1,2);
insert into t2 values(2,3);
insert into t2 values(3,4);
insert into t2 values(4,5);
insert into t2 values(5,1);
```

So the status of view0 is

t2_a	t2_b	t1_b
1	2	3
2	3	4
3	4	5
4	5	6
5	1	2

Operation ID	**Session1**	**Session2**	**State**
1	Begin transaction;		Success
2		Begin transaction;	Success
3	update t1 set b=12 where a=1;		Success
4		select * from view0 where t2_a>3 for update;	Success Query Result | t2_a | t2_b | t1_b | | 5 | 1 | 2 | | 4 | 5 | 6 |
5		Commit;(Success)	Success
6	Commit;(Success)		Success

Bug Description

Operation 3 holds an exclusive lock on a record 1 in table t1 until operation 6 releases the lock. Due to the nature of exclusive locks, operation 4 attempts to acquire a exclusive lock on record 1 in table t1, which should be blocked. However, TiDB grants operation 4 an exclusive lock on record 1 in table t1, which indicates a locking violation.

Unnecessary locking a non-existing record

Test Case

Drop database if exists db;
Create database db;
Use db;
Create table t(a int primary key, b int);

Operation ID	**Session1**	**Session2**	**State**
1	Begin transaction;		Success
2		Begin transaction;	Success
3	Update t set b=314 where a=1;		Success with row count = 0
4		Insert into t values(1,3);	blocking✕
5	Commit;(success)		Success
6		Insert into t values(1,3);(success)	Success with row count = 1
7		Commit;(Success)	Success

Bug Description

After investigating TiDB official website, the write operations of TiDB only locks the record that satisfies the conditions. Notice that the read operation of TiDB can avoid the phantom by the way of MVCC.

However, as shown in above test case, the update operation (Operation ID=3) locks a non-existing record that dose not satisfy its where condition. Additionally, the update operation (Operation ID=3) blocks the insertion operation of another transaction (Operation ID=6), which may lead to some performance issues about locking.

Query in transaction may return rows with same unique index column value

See https://github.com/pingcap/tidb/issues/24195

Select under repeatable read isolation level returns stale version of data

See https://github.com/pingcap/tidb/issues/36718

Other types of bugs

Schema version check error

Test Case

Transaction ID	Operation Detail	State
	Drop db0.table_1_2	Success
723	Update db1.table_5_1 set attribute2=8132130 where primarykey=6123	Exception:Information schema is changed×

Bug Description

The first line modifies db0's schema information, while the second line in transaction 723 modifies db1's table with exception “information schema is changed”. However, there is no modification on db1's schema information, which indicates a bug hidden in checking schema version.

Timestamp acquisition mechanism error in read committed

Transaction ID	Operation Detail	State
232	Select * from table_2_1 where primarykey=4323	Stall(never response)

Under the read committed isolation level recently developed by TiDB team, in order to optimize the performance of timestamp acquisition, asynchronous timestamp acquisition mechanism is adopted, but there are internal problems in this mechanism, as shown in the above table. We have help their developers fix this bugs.

Update BLOB data error

Test Case

Operation ID	Operation Detail	State
1	Update tablecsacas0 set attributeqwdcwq3=FILE(“./data_case/obj/12obj_file.obj”) where primarykeycqwda0 = 15363173 and primarykeycqwda1 = 940396828 and primarykeycqwda2 = 1209414904	Success
2	Update tablecsacas0 set	Success

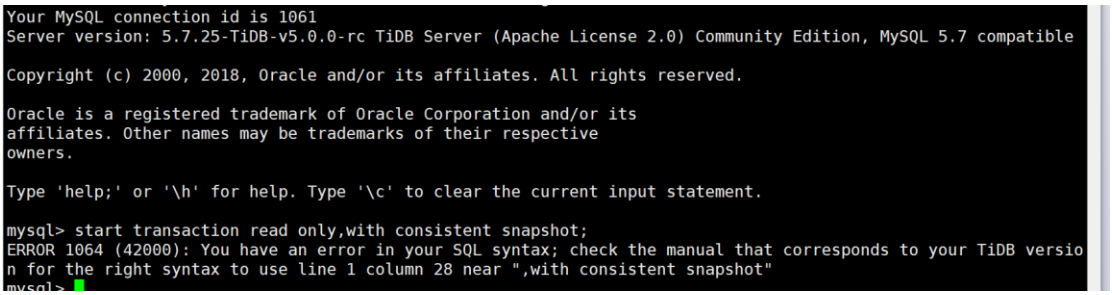
	attributeqwdcwq3=FILE(“./data_case/obj/12obj_file.obj”) and other column where primarykeycqwda0 = 15363173 and primarykeycqwda1 = 940396828 and primarykeycqwda2 = 1209414904	
3	Select attributeqwdcwq3 from tablecsacas0 where primarykeycqwda0 = 15363173 and primarykeycqwda1 = 940396828 and primarykeycqwda2 = 1209414904 for update	Success and Return attributeqwdcwq3 = NULL×

Bug Description

For BLOB data type, when the new value and the old value written by the update operation are for the same binary file, the value actually written is null and success is returned, which indicates a BLOB-related bug hidden in TiDB.

Bug in Start Transaction

Test Case



Bug Description

As for the start transaction statement, the TiDB official websiate shows that it supports the keywords “with consistent snapshot” and “read only”. However, in fact, we found that TiDB cannot support these two keywords at the same time.

JDBC ResultSetMetaData.getColumnName for view query returns the attribute name defined in the table instead of the one defined in the view

See https://github.com/pingcap/tidb/issues/24227

Query Error in information_schema.slow_query

See https://github.com/pingcap/tidb/issues/28069

MySQL

Isolation-related Bugs

Select under repeatable read isolation level returns stale version of data

See https://bugs.mysql.com/bug.php?id=108015

Two parallel threads trigger error code '1032 Can't find record in 'table'

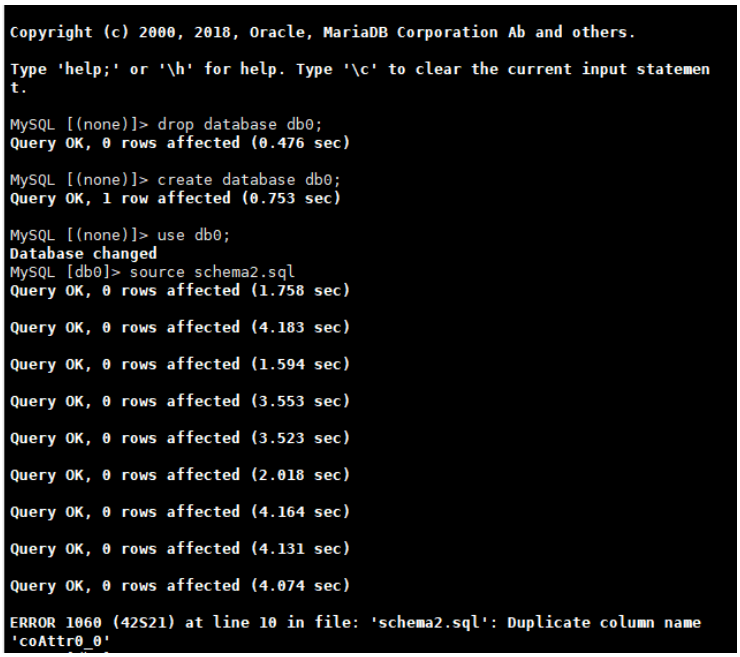
See https://bugs.mysql.com/bug.php?id=103891

Oceanbase

Other types of bugs

Create View Error

Test Case



schema2.sql contains following statements:

```
create table table0
(
	pkId		integer,
	pkAttr0	integer,
	pkAttr1	integer,
	pkAttr2	integer,
	pkAttr3	integer,
	pkAttr4	integer,
	coAttr0_0 integer,
	coAttr0_1 decimal(10, 0),
	coAttr0_2 varchar(100),
	primary key (pkAttr0, pkAttr1, pkAttr2, pkAttr3, pkAttr4)
);
alter table table0 add index index_pk(pkAttr0, pkAttr1, pkAttr2, pkAttr3, pkAttr4);
create table table1
(
	pkId		integer,
	pkAttr0	integer,
	pkAttr1	integer,
	coAttr0_0 varchar(100),
	coAttr0_1 integer,
	coAttr0_2 varchar(100),
	primary key (pkAttr0, pkAttr1)
);
alter table table1 add index index_pk(pkAttr0, pkAttr1);
alter table table1 add index index_commAttr0(coAttr0_0, coAttr0_1, coAttr0_2);
create table table2
```

```
(
    pkId        integer,
    pkAttr0     integer,
    pkAttr1     integer,
    pkAttr2     integer,
    pkAttr3     integer,
    pkAttr4     integer,
    pkAttr5     integer,
    pkAttr6     integer,
    coAttr0_0 decimal(10, 0),
    coAttr0_1 varchar(100),
    coAttr0_2 varchar(100),
    fkAttr0_0 integer,
    fkAttr0_1 integer,
    fkAttr0_2 integer,
    fkAttr0_3 integer,
    fkAttr0_4 integer,
    fkAttr1_0 integer,
    fkAttr1_1 integer,
    primary key (pkAttr0, pkAttr1, pkAttr2, pkAttr3, pkAttr4, pkAttr5, pkAttr6),
    foreign key (fkAttr0_0, fkAttr0_1, fkAttr0_2, fkAttr0_3, fkAttr0_4) references table0 (pkAttr0, pkAttr1, pkAttr2, pkAttr3, pkAttr4),
    foreign key (fkAttr1_0, fkAttr1_1) references table1 (pkAttr0, pkAttr1)
);
alter table table2 add index index_pk(pkAttr0, pkAttr1, pkAttr2, pkAttr3, pkAttr4, pkAttr5, pkAttr6);
alter table table2 add index index_fk0(fkAttr0_0, fkAttr0_1, fkAttr0_2, fkAttr0_3, fkAttr0_4);
alter table table2 add index index_fk1(fkAttr1_0, fkAttr1_1);
create view view2 (pkAttr0, pkAttr1, pkAttr2, pkAttr3, pkAttr4, pkAttr5, pkAttr6, fkAttr0_0, fkAttr0_1, fkAttr0_2, fkAttr0_3, fkAttr0_4, fkAttr1_0, fkAttr1_1, coAttr0_0, coAttr0_1, coAttr0_2, coAttr1_0, coAttr1_1, coAttr1_2)
as
select table2.pkAttr0,
        table2.pkAttr1,
        table2.pkAttr2,
        table2.pkAttr3,
        table2.pkAttr4,
        table2.pkAttr5,
        table2.pkAttr6,
        table2.fkAttr0_0,
        table2.fkAttr0_1,
        table2.fkAttr0_2,
        table2.fkAttr0_3,
        table2.fkAttr0_4,
```

```
        table2.fkAttr1_0,
        table2.fkAttr1_1,
        table2.coAttr0_0,
        table2.coAttr0_1,
        table2.coAttr0_2,
        table0.coAttr0_0,
        table0.coAttr0_1,
        table0.coAttr0_2
from table2,
     table0
where table2.fkAttr0_0 = table0.pkAttr0
  and table2.fkAttr0_1 = table0.pkAttr1
  and table2.fkAttr0_2 = table0.pkAttr2
  and table2.fkAttr0_3 = table0.pkAttr3
  and table2.fkAttr0_4 = table0.pkAttr4;
```

Bug Description

When creating a correct view defined in scenario schema2.sql, an error that cannot be imported may occur, and the error message "duplicate column name" will be reported. However, after careful inspection, there are no duplicate column names in the statement, and the same DDL statement can run normally on MySQL 5.7, which indicates a schema-related bug hidden in Oceanbase.

Open reported bugs

MySQL

Isolation-related bugs

Predicate Lock ERROR

See https://bugs.mysql.com/bug.php?id=105988

Read uncommitted transaction reads the result of a failed write operation

Test Case

The repeat execution flow is shown as the following:

/* configuration */ Set global innodb_deadlock_detect=off;
/* init */ Create Table t(a int primary key, b int);
/* init */ Insert into t values(1,2);
/* init */ Insert into t values(2,4);

/* txn1 */ Begin;
/* txn1 */ Set session transaction isolation level read uncommitted;
/* txn2 */ Begin;
/* txn2 */ Set session transaction isolation level read uncommitted;
/* txn3 */ Begin;
/* txn3 */ Set session transaction isolation level read uncommitted;
/* txn2 */ Delete from t where a=1;
/* txn3 */ Update t set b=321 where a=2;
/* txn2 */ Update t set b=1421 where a=2;
/* txn3 */ Insert into t value(1,1231);
/* txn1 */ Select * from t where a=1;
/* init */

Bug Description

Transaction 2 writes new versions on records 1 and 2 successively, while Transaction 3 writes new versions on records 2 and 1 successively. So there is a deadlock situation between transaction 2 and 3. Before the deadlock between transaction 2 and 3 timeouts, another read uncommitted transaction 1 launch a query to read the record 1 that has been modified by transaction 2 and 3 successively. Since the second write operation of transaction 3 are failed due to deadlock, we should not see its write results. Therefore, as expected, the query result of transaction 1 should be the write result of transaction 2. However, the query result of transaction 1 is the write result of transaction 2, which is weird. We think there may be a subtle bug hidden in the current version of MySQL.

Other types of Bugs

Update BLOB data error

Test Case

Operation ID	Operation Detail	State
1	Update tablecsacas0 set attributeqwdcwq3=FILE(“./data_case/obj/12obj_file.obj”) where primarykeycqwda0 = 15363173 and primarykeycqwda1 = 940396828 and primarykeycqwda2 = 1209414904	Success

2	Update tablecsacas0 set attributeqwdcwq3=FILE(“./data_case/obj/12obj_file.obj”) and other column where primarykeycqwda0 = 15363173 and primarykeycqwda1 = 940396828 and primarykeycqwda2 = 1209414904	Success
3	Select attributeqwdcwq3 from tablecsacas0 where primarykeycqwda0 = 15363173 and primarykeycqwda1 = 940396828 and primarykeycqwda2 = 1209414904 for update	Success and Return attributeqwdcwq3 = NULL (ERROE)

Bug Description

For BLOB data type, when the new value and the old value written by the update operation are for the same binary file, the value actually written is null and success is returned, which indicates a BLOB-related bug hidden in TiDB.

PostgreSQL

Isolation-related bugs

Write skew in SSI

Test Case

Transaction ID	Operation Detail	State
206	Select attribute1 from table_7_1 where primarykey= 832	Success
204	Select attribute1 from table_7_4 where primarykey= 1460	Success
206	Update table_7_4 set attribute where primarykey=1460	Success
204	Update table_7_1 set attribute1 = -635092 where primarykey= 832	Success
204	Commit	Success
206	Commit	Success

Bug Description

Transaction 206 reads a record 832 in table_ 7_ 1, then transaction 204 writes a new record to cover it, so transactions 206 to 204 have a RW dependency. Similarly, transaction 204 reads the record 1460 in table_ 7_ 4, then transaction 206 writes a new record to cover it, so transactions 204 to 206 have a RW dependency. Finally, transactions 204 to 206 generate a circular dependency, that is, write skew anomalies that should be avoided in Snapshot

Isolation Level of PostgreSQL.

Two different versions of the same row of records are returned in one query

See https://www.postgresql.org/message-id/17017-c37dbbadb77cfde9%40postgresql.org

OpenGauss

Isolation-related Bugs

Violating First-Updater-Wins

Test Case

Transaction ID	Session1	Session2	State
2		Begin;	Success
2		set session transaction isolation level repeatable read;	Success
2		`update "table0" set "coAttr31_0" = 1048.0 where ( "pkAttr0" = 280 ) and ( "pkAttr1" = 241 ) and ( "pkAttr2" = 'vc204' ) and ( "pkAttr3" = 'vc361' ) and ( "pkAttr4" = 363 );--row count=1`	Success
1	Begin;		Success
1	set session transaction isolation level repeatable read;		Success
1	`select "pkAttr0", "pkAttr1", "pkAttr2", "pkAttr3", "pkAttr4", "pkAttr5",`		Success

	"pkAttr6", "pkAttr7", "fkAttr0_0", "fkAttr0_1", "fkAttr0_2", "fkAttr0_3", "fkAttr0_4" from "view0" where ("fkAttr0_0" = 94) and ("fkAttr0_1" = 239) or ("fkAttr0_2" < 'vc119') and ("fkAttr0_3" > 'vc81u') and ("fkAttr0_4" = 278) ;		
2		COMMIT	Success
1	delete from "table0" where ("pkAttr0" = 280) and ("pkAttr1" = 241) and ("pkAttr2" = 'vc204') and ("pkAttr3" = 'vc361') and ("pkAttr4" = 363); --row count=1		Success

Bug Description

Transaction 1 starts before transaction 2 commit, and both transaction 1 and 2 write a new version on a record (280, 241,'vc204' , 'vc361' ,363). Therefore, transaction 1 and 2 are a pair of concurrent transaction, which should be avoided by first updater wins mechanism in OpenGauss.

Violating Read-Consistency

Test Case

Create table table2 (primarykey in primary key, `coAttr25_0 int`);
Insert into table2 values(6,0);
Insert into table2 values(7,0);

Transaction ID	Session1	Session2	State
1	Begin;		Success
1	set session transaction isolation level repeatable read;		Success
1	`update "table2" set "coAttr25_0" = 78354, where "primaryKey" = 7;`		Success
2		Begin;	Success
2		set session transaction isolation level repeatable read;	Success
2		`"update "table2" set " coAttr25_0" = 14 where "primaryKey" = 6;`	Success
2		`Commit`	Success
1	`select "primaryKey","fkAttr0_0", " coAttr25_0" from "table2";--` `result set "primaryKey": "6", " coAttr25_0": "14"`		Success

Bug Description

Transaction 1 launch a update operation while fetches a consistent snapshot. According to the rule of repeatable read isolation level, any operation in transaction 1 should sees a same snapshot., so transaction 1 should not see the write result created by transaction 2. However, transaction 1 sees the write result created by transaction 2, which indicates a consistency read violation.

Oceanbase

Isolation-related bugs

Read inconsistency

Test Case

Transaction ID	Session1	Session2	State
1	set session transaction isolation level repeatable read;		Success
2		set session transaction isolation level repeatable read;	Success
1	START TRANSACTION READ ONLY,WITH CONSISTENT SNAPSHOT;		Success
2		START TRANSACTION;	Success
2		update table0 set coAttr17 = 19635, coAttr18 = 1244, coAttr19 = 92947 where (pkAttr0 = 'vc239') and (pkAttr1 = 'vc234') and (pkAttr2 = 'vc233'); **return rowCount=1;**	Success
2		COMMIT	Success
1	select pkAttr0, pkAttr1, pkAttr2, coAttr17, coAttr18, coAttr19 from table0 order by pkAttr0 ; **return query result including:** {"pkAttr2":"vc233","pkAttr0":"vc239","pkAttr1":"vc234"} {"coAttr18":"1244"} {"coAttr19":"92947"} {"coAttr17":"19635"}		Success

Bug Description

At the repeatable read isolation level, after transaction 1 starts the transaction, that is, after obtaining the consistency snapshot, another parallel transaction 2 generates a write operation. Transaction 1 should not see the write result created by transaction 2. However, transaction 1 sees the write result created by transaction 2, which violates the rules of repeatable read isolation level.