Need is the mother of all Inventions. It is very true for PostgreSQL 10 Logical Replication

PostgreSQL 10 Logical Replication

By:
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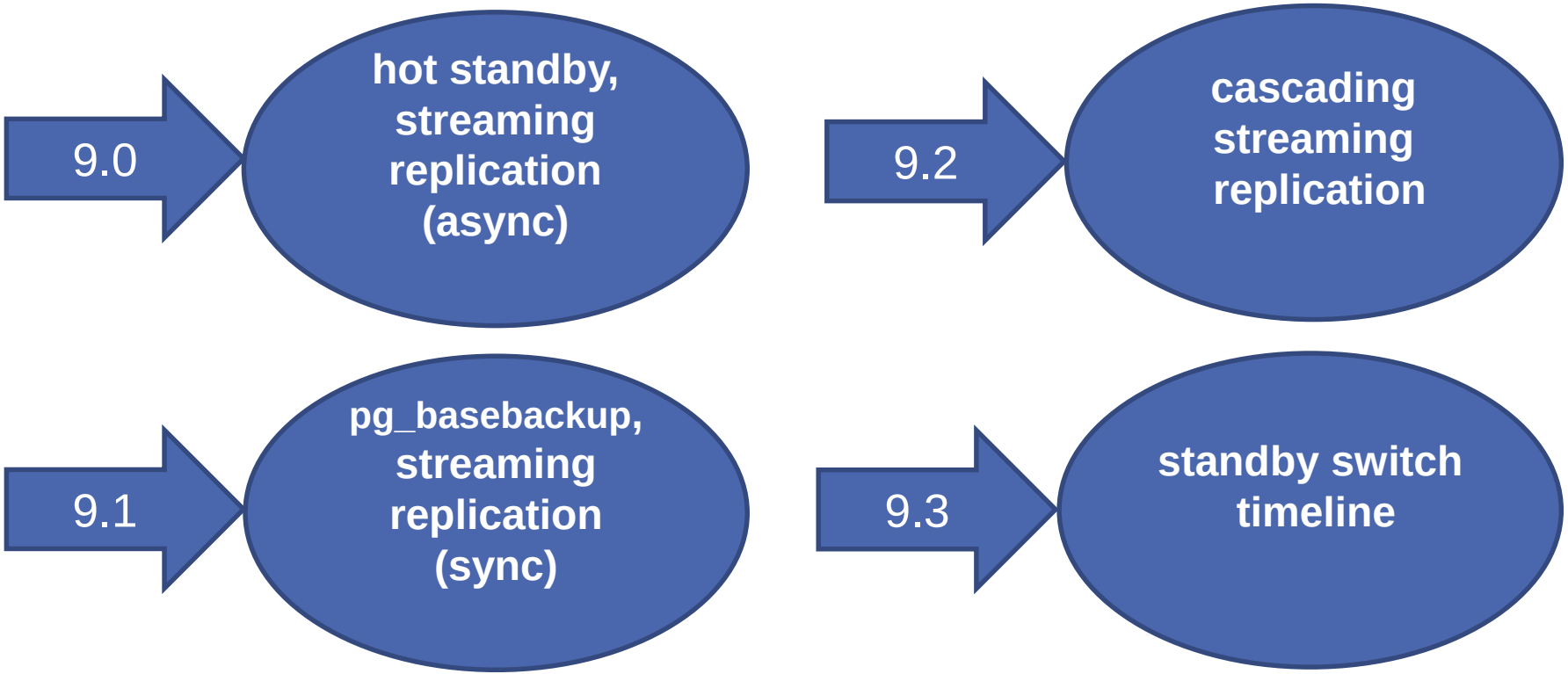
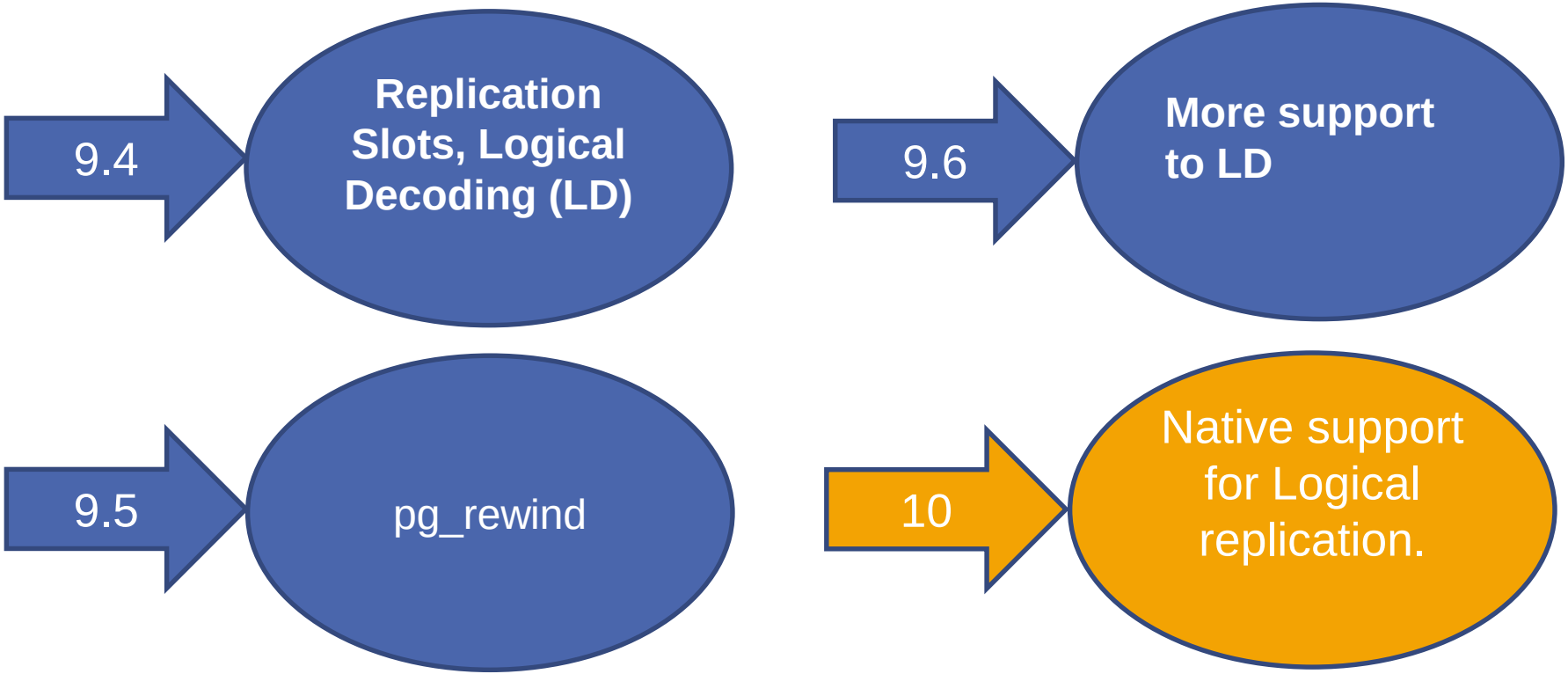
Agenda:

- PostgreSQL replication history.
- Logical Replication: Overview
- Use cases-SR vs LR
- Terminologies used in LR.
  - Publication, Publisher
  - Subscription, subscriber
  - Replication Slot
- Architecture
- Security
- Configuration Settings
- Quick Setup
- Monitoring
- Precautions- Conflicts
- Restrictions/Limitations
- Q&A

Overview of PostgreSQL replication 9.0 onwards:



Overview of PostgreSQL replication 9.0 onwards cont..



Logical Replication: Overview

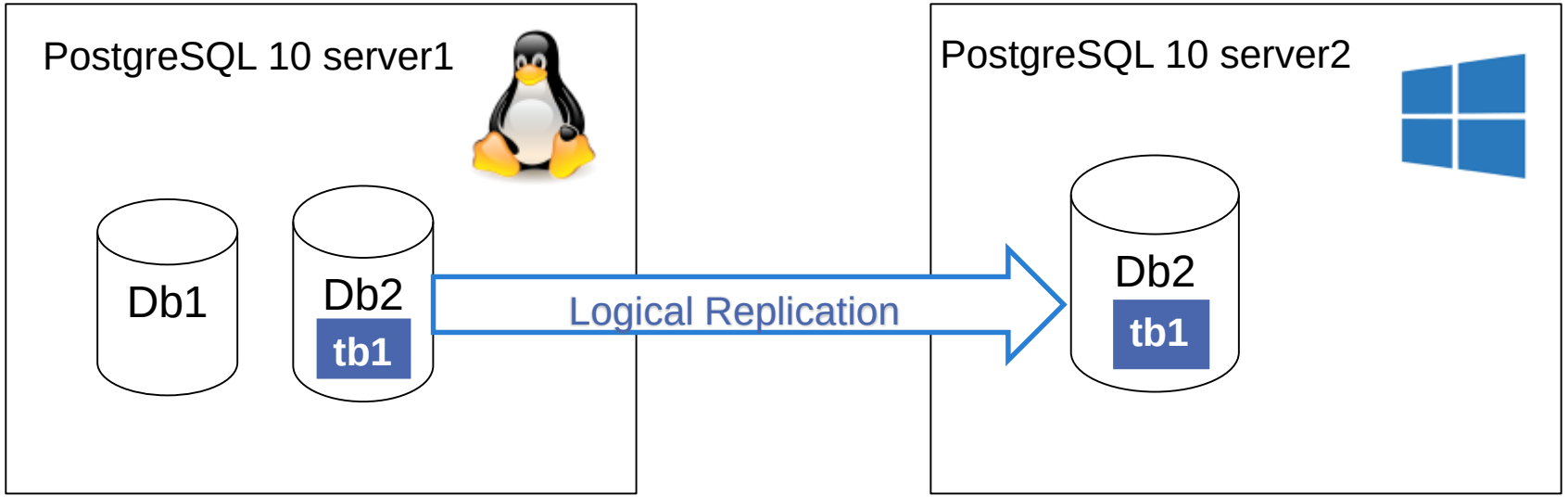
- Replicating/capturing logical changes based upon their replica identity using replication slots.
- Propagate any changes (Insert, Update, Delete, all, combination) to replica.
- Uses a *publish* and *subscribe* model.
  - Publisher-Sender
  - Subscriber- Receiver
- Subscribers pulls data from publications.
- Generally ‘asynchronous’ in nature.

Why Logical Replication over Streaming Replication?

Features	Streaming Replication	Logical Replication
Replication Type	Binary replication(byte-by-byte)	Selective row level changes (logical change)
Hardware/OS	Same (Linux-Linux)	Can be different(Linux-Windows)
Replication between major versions	Not supported	Supported.
Replication Level	Instance level	Object level(table)
Consolidation	No consolidation	Consolidating is possible
Replica/ Subscriber- Open Mode	Standby is in read-only mode	Subscriber can be used for write operations

Use Case1: Cross platform replication

- **Cross Platform : Linux → Windows**



Create Subs. on Windows using Linux pub.

```
pub=# \dRp
List of publications
  Name   |  Owner   | All tables | Inserts | Updates | Deletes
---------+----------+------------+---------+---------+---------
 testpub | postgres | f          | t       | t       | t
(1 row)
```

```
logrep=# select slot_name from pg_replication_slots;
 slot_name
-----------
 sync_rep
 testsub
 mysub1
(3 rows)
```

```
logrep=# select * from emp;
 empno | empname
-------+---------
    21 | Tom
    22 | Dick
    23 | Harry
    24 | Lee
(4 rows)
```

Administrator: Command Prompt - psql -U postgres

```
logirep=# select * from emp;
 empno | empname
-------+---------
(0 rows)


logirep=#
logirep=#
logirep=# CREATE SUBSCRIPTION mysub1 CONNECTION
logirep-# 'host=192.168.56.109 dbname=logrep user=postgres'
logirep-# PUBLICATION testpub;
NOTICE:  created replication slot "mysub1" on publisher
CREATE SUBSCRIPTION
logirep=# \dRs
          List of subscriptions
  Name   |  Owner   | Enabled | Publication
---------+----------+---------+-------------
 mysub1 | postgres | t       | {testpub}
(1 row)


logirep=# select * from emp;
 empno | empname
-------+---------
    21 | Tom
    22 | Dick
    23 | Harry
    24 | Lee
(4 rows)
```

Insert on server1

```
logrep=# select * from emp;
 empno | empname
-------+---------
    21 | Tom
    22 | Dick
    23 | Harry
    24 | Lee
(4 rows)

logrep=# insert into emp values(25,'Adam');
INSERT 0 1
logrep=# select * from emp;
 empno | empname
-------+---------
    21 | Tom
    22 | Dick
    23 | Harry
    24 | Lee
    25 | Adam
(5 rows)
```

Select on server2

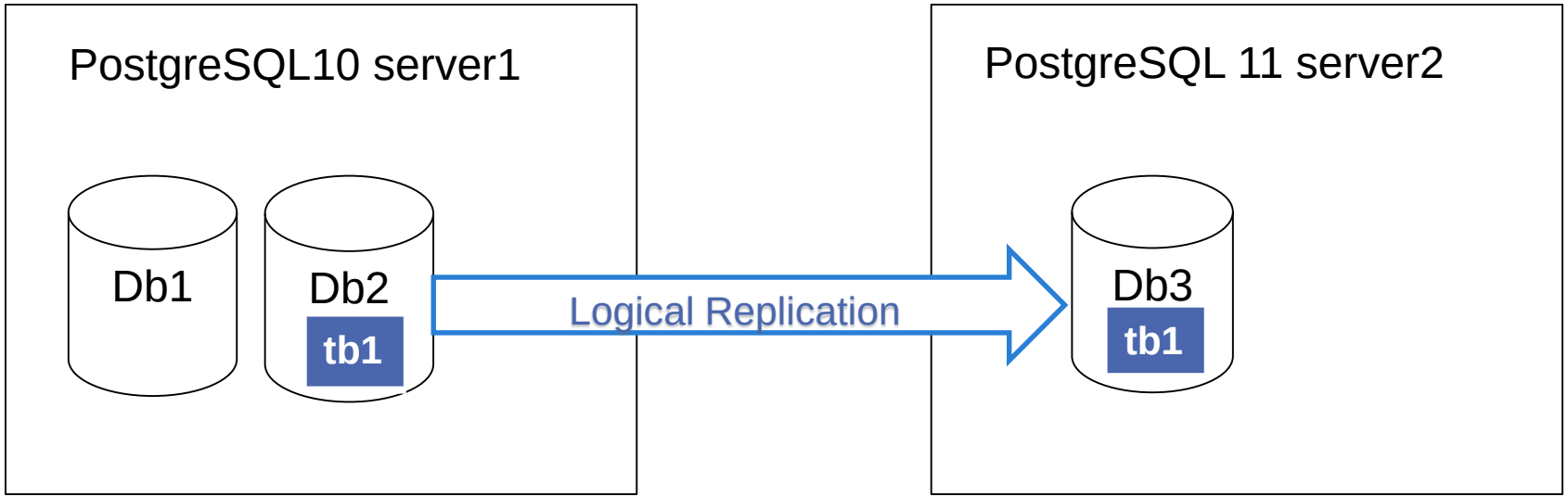
Administrator: Command Prompt - psql -U postgres

```
logirep=# select * from emp;
 empno | empname
-------+---------
    21 | Tom
    22 | Dick
    23 | Harry
    24 | Lee
(4 rows)


logirep=# select * from emp;
 empno | empname
-------+---------
    21 | Tom
    22 | Dick
    23 | Harry
    24 | Lee
    25 | Adam
(5 rows)
```

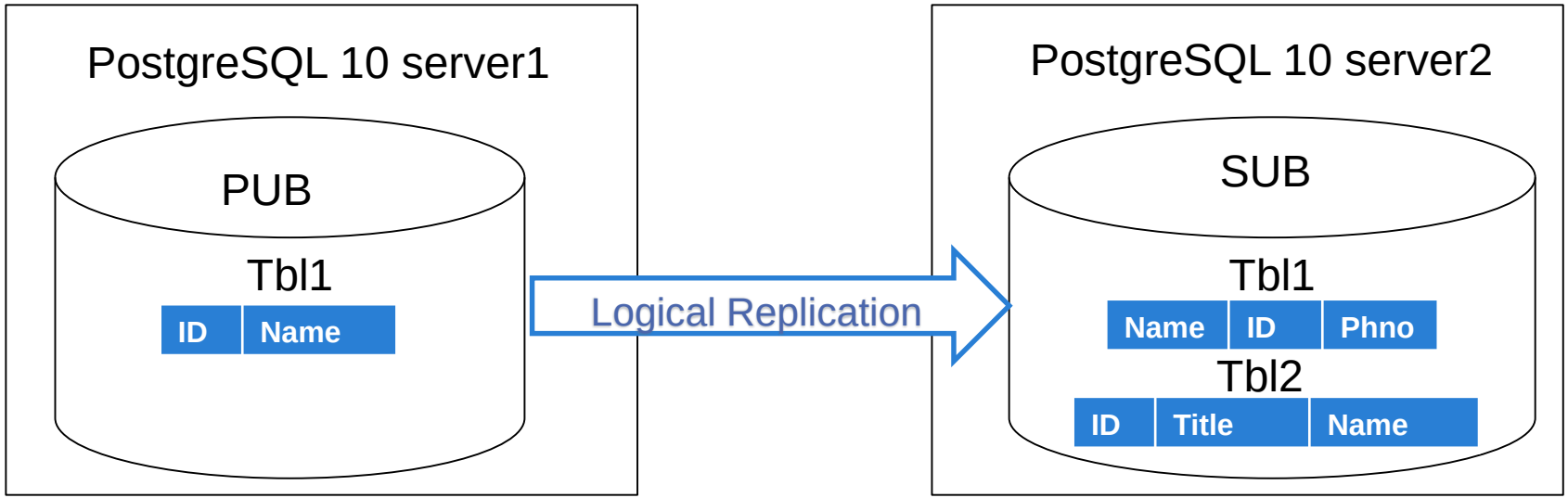
Use Case2: Cross version:

- **Cross Version: Replication between different major versions of PostgreSQL**



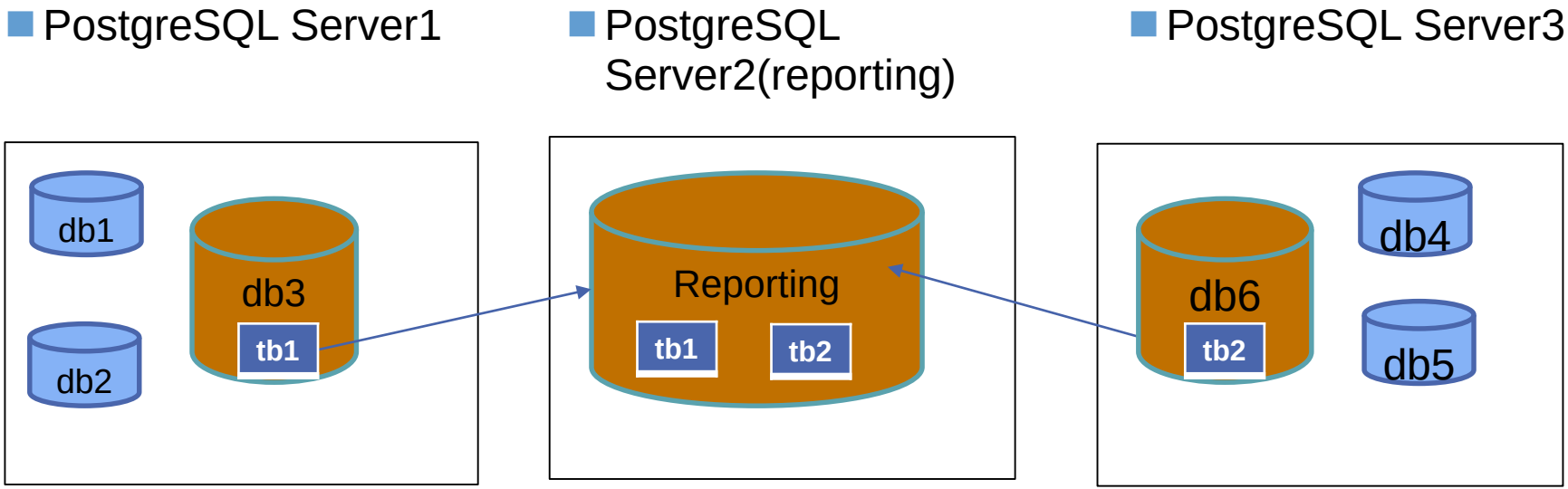
Use Case3: Write operation @Subscriber:

- **Modifying objects and adding new tables, insert records on subscriber.**



Use Case4: Consolidating multiple databases

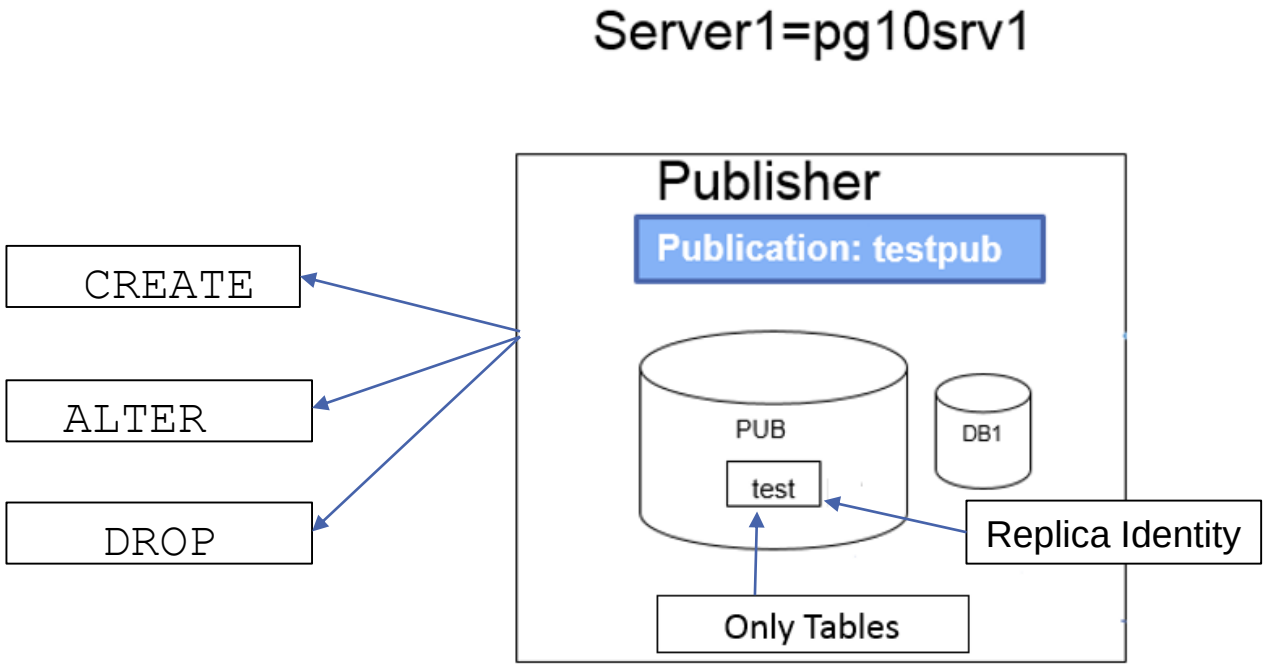
- **Can be helpful for reporting or analytical purposes**
- **Can replicate even few tables from one DB to another on different servers.**



Terminology used in Logical Replication:

- Publisher/Publication
- Subscriber/Subscription
- Replication Slot
- Replica Identity

Publisher/Publication



- First create tables to include in publication and then create publication.

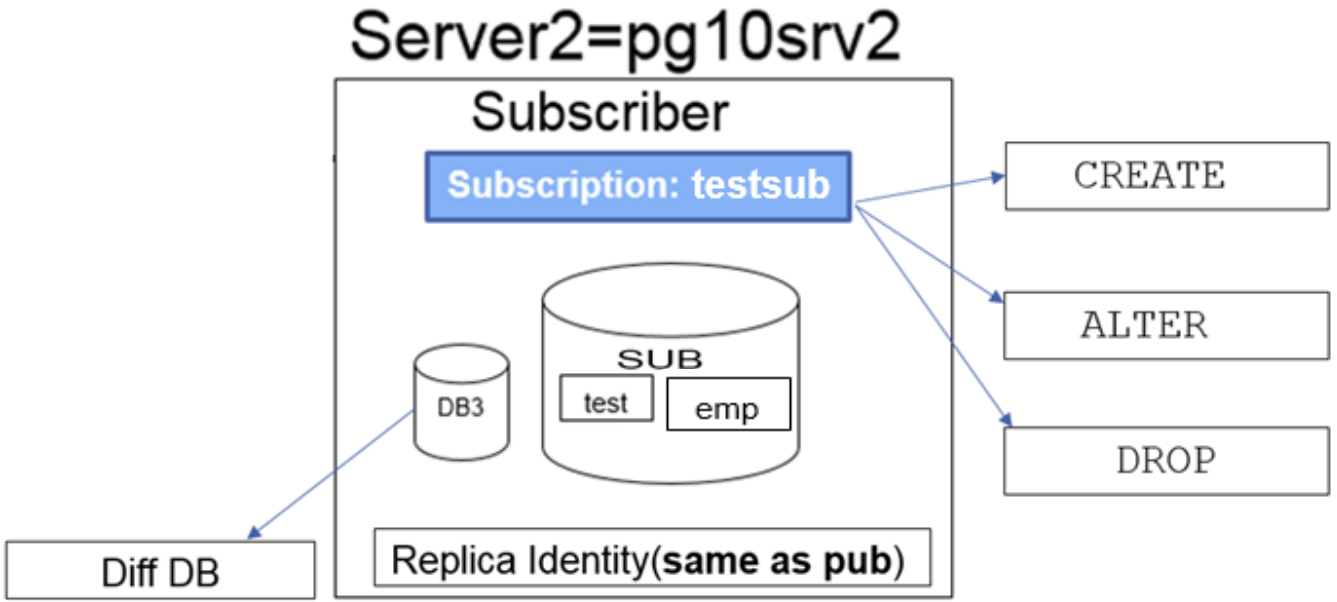
Publisher/Publication

- Publisher → node where a publication is defined.
- Publication → set of changes defined for tables.
- Publication can be defined on any ***physical replication master***.
- DB name can be different from Subscriber.
- Create publication using the ‘`CREATE`’ command and can be later `ALTERED` and `DROPPED`.
- A published table should exists before creating publication and must have a “replica identity“ (can be primary key or index).
- Operations possible on tables– `INSERT`, `UPDATE`, and `DELETE`, combinations, or `ALL`(default)
- `UPDATE` or `DELETE` operations on publisher without replica identity will give error.
- Same replica identity has to be set at subscription side as well.
- Currently replicates only **tables**.

Commands related to Publication:

- Create:
  - `CREATE PUBLICATION testpub FOR TABLE tb1, tb2;`
  - `CREATE PUBLICATION testpub FOR TABLE tbl3 WITH (publish = 'insert, update');`
  - `CREATE PUBLICATION testpub FOR ALL TABLES;`
- Alter :
  - `ALTER PUBLICATION testpub ADD TABLE tb4, tbl5;`
  - `ALTER PUBLICATION testpub SET TABLE tbl4, tbl5;`
  - `ALTER PUBLICATION testpub DROP TABLE tbl4, tbl5;`
- Drop:
  - `DROP PUBLICATION testpub;`
  - `DROP PUBLICATION testpub, testpub1;`

Subscriber/Subscription



- First create tables with same name, same column name and type, same replica identity as publication.
- Later create subscription.

Subscription:

- Subscription → Downstream side of logical replication and this node is called subscriber.
- It can be used as a publisher for other databases.
- Multiple subscriptions on one subscriber is possible.
- Subscription should be created using superuser.
- Same table names at publisher and subscriber.
- Tables should be created first before creating a subscription.
- Same columns in source and target tables with same data type but can have different order.

Commands related to Subscription:

- Create:
  - `CREATE SUBSCRIPTION testsub1 CONNECTION 'host=<remote> 'dbname=<db> user=<user>' PUBLICATION testpub1,testpub2;`
  - `CREATE SUBSCRIPTION mysub1 CONNECTION '...' PUBLICATION ...WITH (enabled = false,` **`create_slot = false`**`,slot_name = 'myslot',` **`copy_data = false`**`, ...);`
- Alter:
  - `ALTER SUBSCRIPTION testsub ENABLE/DISABLE;`
  - `ALTER SUBSCRIPTION testsub CONNECTION 'host=newhost ...';`
  - `ALTER SUBSCRIPTION testsub SET(slot_name = 'newslot'/'NONE');`
  - `ALTER SUBSCRIPTION testsub REFRESH PUBLICATION;`
- Drop:
  - `DROP SUBSCRIPTION testsub;`

Security

- For creating publication : `CREATE` privilege in the database.
- To add tables to a publication, the user must have `Ownership` rights on the table.
- To create a subscription, the user must be a superuser.
- Role used for the replication connection must have the REPLICATION attribute (or be a superuser)
- Entry for replication role in `pg_hba.conf`

Configuration Settings

- Parameters: to be set in `postgresql.conf`

@Publisher

- `wal_level = logical`
- `# max_replication_slots` → `default value= 10`
- `# max_wal_senders` → `default value= 10`

@Subscribers

- `# max_replication_slots` → `default value= 10`
- `# max_logical_replication_workers` → `default value= 4`
- `# max_worker_processes`
- `# max_sync_workers_per_subscription` → `default value= 8`

* Note: For remote connections, `set- listen_addresses and pg_hba.conf`

Quick Setup and Demo

Settings required for demo:

1. Setting postgresql.conf @Publisher

- `wal_level = logical`

- Note: Default values of other required parameters will suffice for this demo.

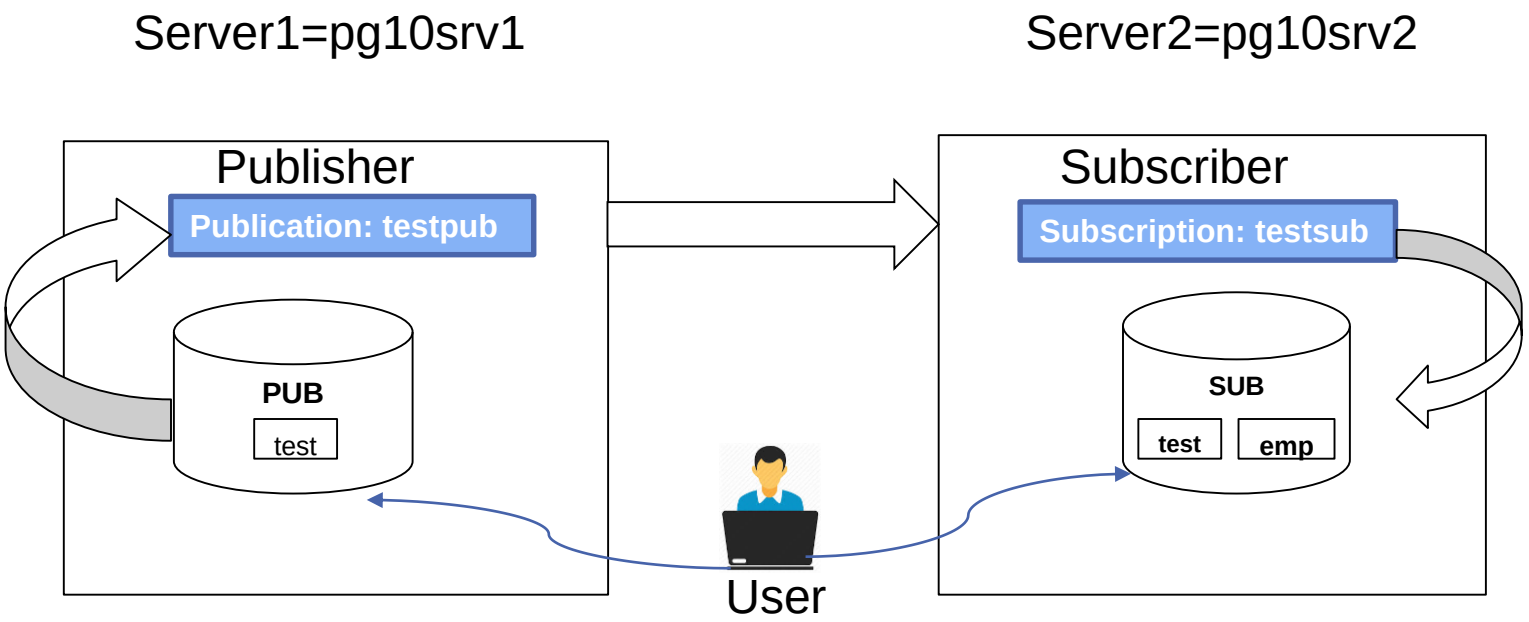
2. Use replication role `(CREATE ROLE replication WITH REPLICATION PASSWORD '' LOGIN;`

3. Setting pg_hba.conf on both nodes.

```
host    all     postgres    0.0.0.0/0    SCRAM-SHA-256
host    all     replication 0.0.0.0/0    SCRAM-SHA-256
```

* Note : The values here depend on your actual network configuration

Overview of Demo:



Creating database ‘PUB’ on Publisher:

```
postgres=# CREATE DATABASE PUB;
```

CREATE DATABASE

Creating table ‘TEST’ on Publisher:

```
pub=# CREATE TABLE TEST(ID NUMERIC PRIMARY
      KEY,NAME TEXT);
```

CREATE TABLE

Insert some records in table ‘TEST’:

```
pub=# INSERT INTO TEST VALUES(1,'TOM'),
      (2,'DICK');
```

```
INSERT 0 2
```

Select records of table ‘TEST’ :

```
pub=# select * from test;
```

```
 id | name
----+------
  1 | TOM
  2 | DICK
(2 rows)
```

Let’s see whether there is any Publication or not?


```
pub=#  \dRp
```

```
                List of publications
 Name | Owner | All tables | Inserts | Updates | Deletes
------+-------+------------+---------+---------+--------
(0 rows)
```

Let’s create a Publication on Publisher node:

```
pub=# CREATE PUBLICATION testpub FOR TABLE TEST;
```

CREATE PUBLICATION

Let’s check the publication status:

```
pub=# \dRp
```

```
 List of publications
  Name    |  Owner   | All tables | Inserts | Updates | Deletes
----------+----------+------------+---------+---------+--------
-
 testpub | postgres | f          | t       | t       | t
(1 row)
```

* Default operation performed on tables is ‘All’ i.e. `Insert, update` and `delete`.

This publication should now be added to the tables:


```
pub=# \d test
```

```
 Table "public.test"
 Column |  Type   | Collation | Nullable | Default
--------+---------+-----------+----------+---------
 id     | numeric |           | not null |
 name   | text    |           |          |
Indexes:
    "test_pkey" PRIMARY KEY, btree (id)
Publications:
    "testpub"
```

Now let’s set up subscription on subscriber

Let’s create a new database ‘SUB’ on Subscriber:

```
postgres=# CREATE DATABASE SUB;
```

CREATE DATABASE

Creating table ‘TEST’ on Subscriber:

```
sub=# CREATE TABLE TEST(NAME TEXT ,ID NUMERIC
      PRIMARY KEY);
```

- Order of columns can be different.

CREATE TABLE

Let’s see whether there is any Subscription or not?


```
sub=# \dRs
```

```
 List of subscriptions
 Name | Owner | Enabled | Publication
------+-------+---------+-------------
(0 rows)
```

Let’s create a Subscription on Subscriber node:

```
sub=# CREATE SUBSCRIPTION testsub CONNECTION '
user=postgres host=pg10srv1 dbname=pub ' PUBLICATION
testpub;
```

```
NOTICE:  created replication slot "testsub" on
publisher
CREATE SUBSCRIPTION
```

Let’s check the subscription status:

```
sub=# \dRs
```

```
 List of subscriptions
  Name    |  Owner   | Enabled | Publication
----------+----------+---------+-------------
 testsub | postgres | t       | {testpub}
(1 row)
```

Let’s see whether we got the data in table or not?

```
sub=# select * from test;
```

```
 name | id
------+----
 TOM  |  1
 DICK |  2
(2 rows)
```

Lets verify subscription log:

```
-bash-4.2$ tail -f postgresql-Tue.log
```

```
LOG:  worker process: logical replication worker for
subscription 49304 (PID 12053) exited with exit code 1
LOG:  logical replication apply worker for subscription
"testsub" has started
LOG:  logical replication table synchronization worker for
subscription "testsub", table "test" has started
LOG:  logical replication table synchronization worker for
subscription "testsub", table "test" has finished
```

Now, let’s try to insert some data on Publisher node:

```
pub=# INSERT INTO TEST VALUES(3,'AFTER REPLICATION');
```

```
INSERT 0 1
```

Select data of ‘Test’ table on Subscriber:

```
sub=#   select * from test;
```

```
 id |         name
----+----------------------
  1 | TOM
  2 | DICK
  3 | AFTER REPLICATION
(3 rows)
```

Write operations @Subscriber: Creating table ‘EMP’

```
sub=# CREATE TABLE EMP(EMPID NUMERIC PRIMARY
      KEY, EMPNAME TEXT);
```

CREATE TABLE

```
sub=# INSERT INTO EMP VALUES(1,'LEE'), (2,'TOM');
```

```
 empid |  empname
-------+----------
     1 | LEE
     2 | TOM
(2 rows)
```

Monitoring:

On Publisher

- `pg_stat_replication`
- `pg_replication_slots`
- `pg_stat_activity`
- `\dRp`

On Subscriber

- `pg_stat_subscription`
- `pg_stat_activity`
- `\dRs`

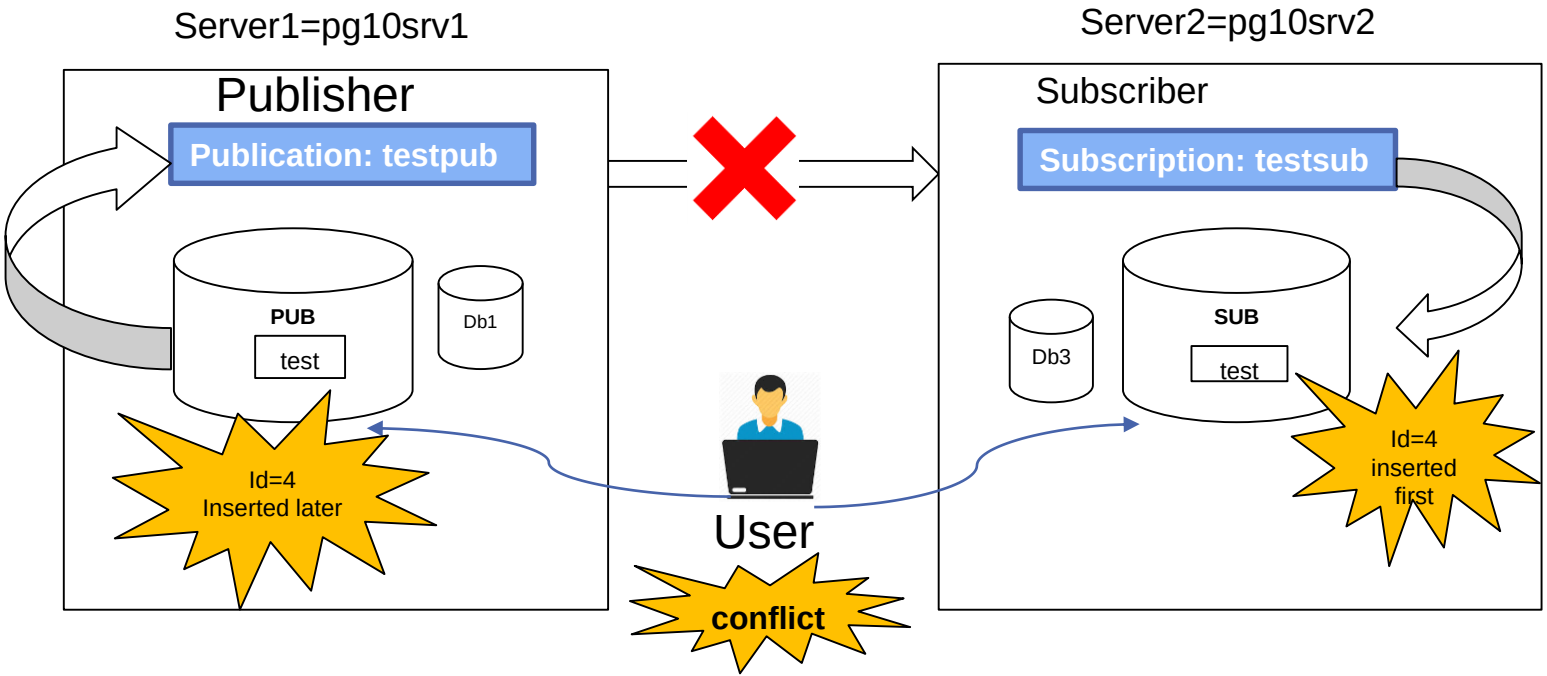
Precautions at Subscriber:

- While Inserting rows.
- While modifying tables DDL – adding/dropping columns etc.
- If not, will leads to conflicts.

CONFLICT

If incoming data violates any constraints the replication will stop and is called CONFLICT

What if we insert a record with id=4 on Publisher?



Check conflict status in subscriber log:

On Subscriber

```
sub=# SELECT * FROM TEST;
        name          | id
----------------------+----
 TOM                  |  1
 DICK                 |  2
 AFTER_REPLICATION    |  3
 CONFLICT             |  4
(4 rows)
```

Error in log file:

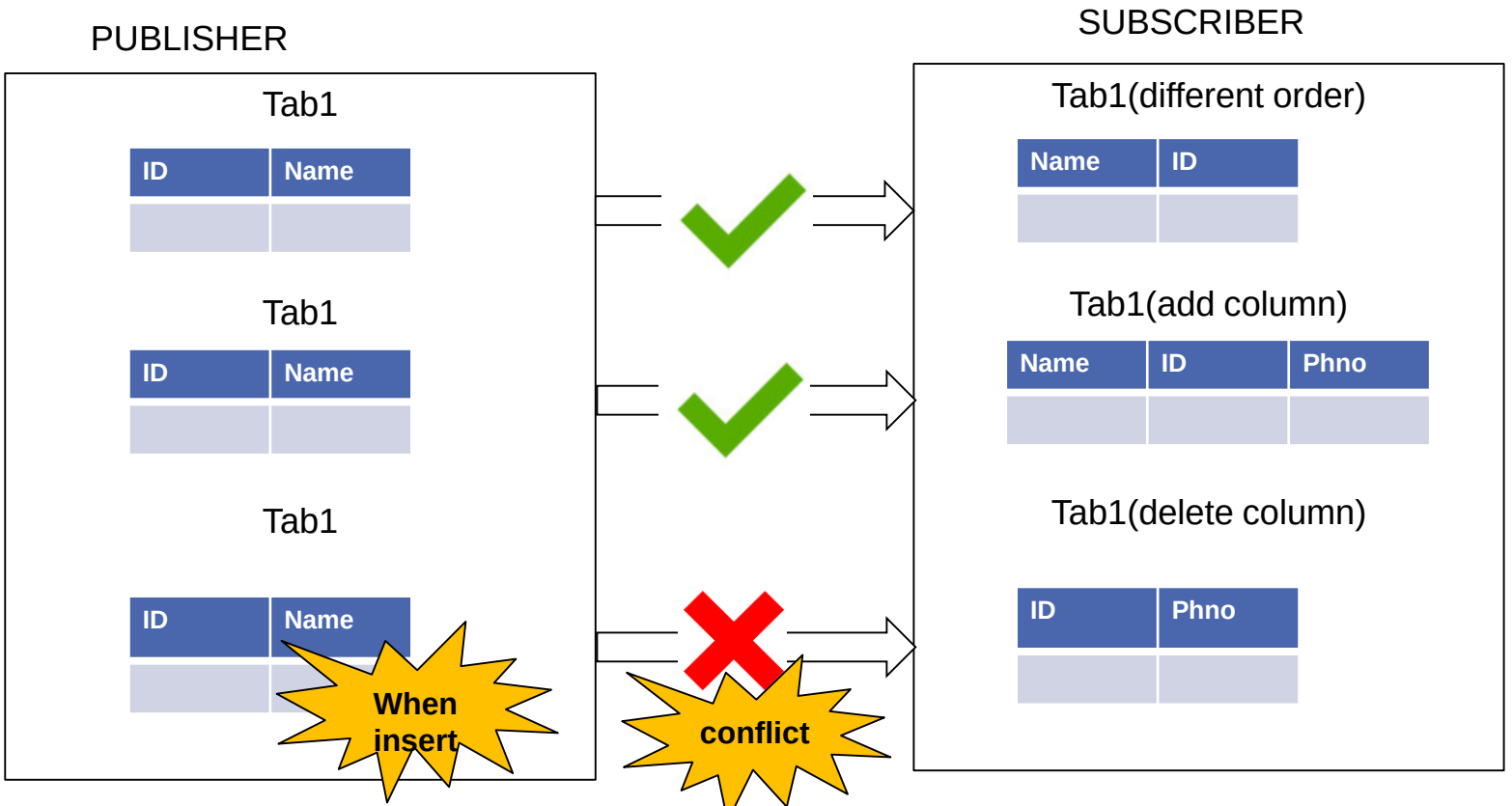
```
LOG:  logical replication apply worker for subscription "testsub" has started
ERROR:  duplicate key value violates unique constraint "test_pkey"
DETAIL:  Key (id)=(4) already exists.
```

On Publisher

```
pub=# INSERT INTO TEST
VALUES(4,'RESOLVE');

sub=# SELECT * FROM
TEST;
        name          | id
----------------------+----
 TOM                  |  1
 DICK                 |  2
 AFTER_REPLICATION    |  3
 CONFLICT             |  4
(4 rows)
```

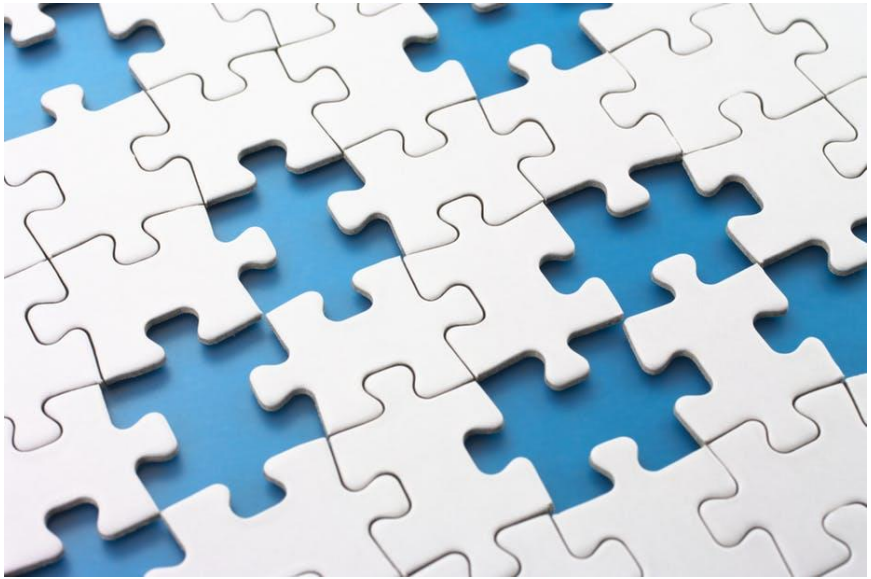
Delete a column on subscriber:



Resolving Conflict:

- Change data on subscriber i.e. delete conflicting key.
- Skip the conflicting transaction from replication by calling the `pg_replication_origin_advance()` function.
- The current position of origins can be seen in the `pg_replication_origin_status` system view.

Restrictions:



- Schema/DDL replication
- Sequences replication
- TRUNCATE command replication
- Large objects replication
- Views, Materialized views ,Partition root tables, or foreign tables replication

Conclusion:

- Good feature but still room to include more features.
- No need to replicate whole instance.
- Subscriber can be used for Write operations but with care.
- Good for cross platform replication, different major version replication, write operations on subscriber, like use cases.
- Not the replacement of SR.

Thank you

Your speaker

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Q&A