Row Level Security

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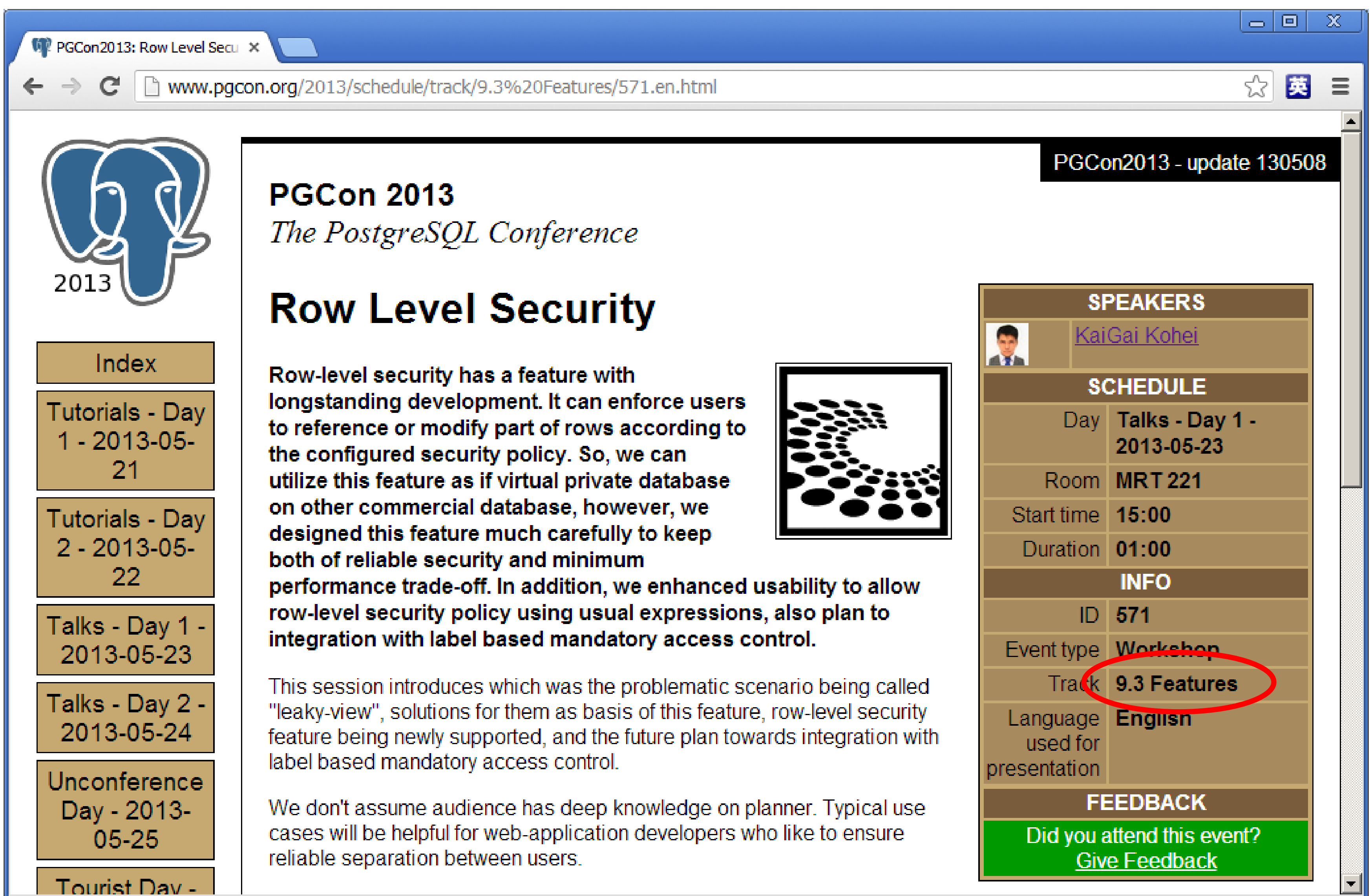
Row Level Security being targeted towards v9.4



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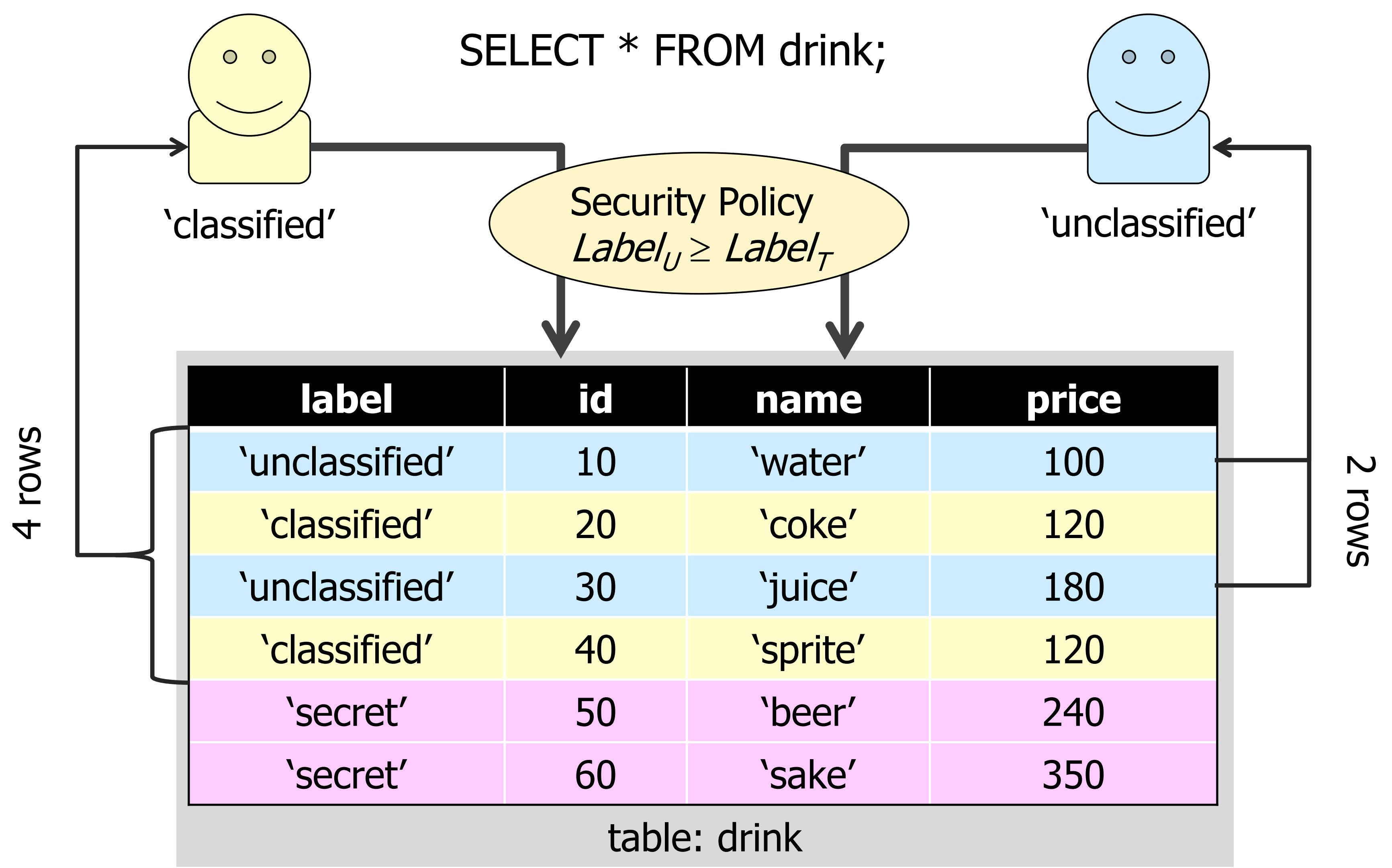
Agenda

- Our motivation
- Background Story
  - Leaky-view Problem
  - Security Barrier
  - Leakproof Function
- Row Level Security

How RLS should work (1/2)



label	id	name	price
'unclassified'	10	'water'	100
'classified'	20	'coke'	120
'unclassified'	30	'juice'	180
'classified'	40	'sprite'	120
'secret'	50	'beer'	240
'secret'	60	'sake'	350

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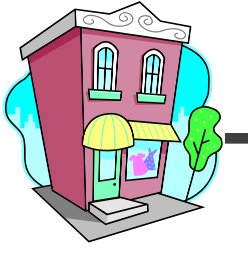
How RLS should work (2/2)



shop_id = 100

SELECT * FROM drink NATURAL JOIN drink_order

id	name	price	shop_id	quantum	data
10	'water'	100	100	8	2013-02-16
30	'juice'	180	100	10	2013-02-18

id	name	price
10	'water'	100
20	'coke'	120
30	'juice'	180
40	'sprite'	120
50	'beer'	240
60	'sake'	350

table: drink

Security Policy
$shop_id_U = \text{shop_id}_T$

id	shop_id	quantum	date
10	100	8	2013-02-16
20	200	5	2013-02-17
10	200	6	2013-02-18
30	100	10	2013-02-18

table: drink_order

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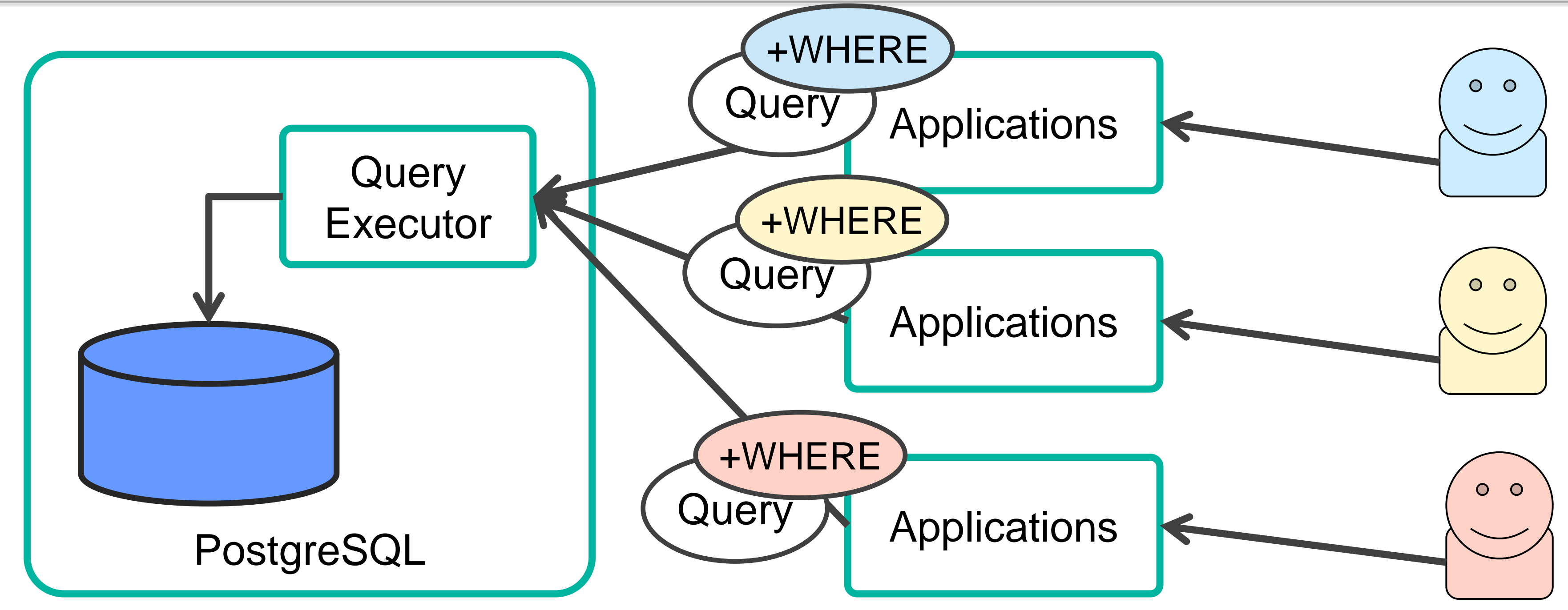
Motivation (1/2) – Responsibility of access control



- A case when a shared table is accessed by multiple users
- Not easy to ensure applications are bug/vulnerability free
- Move the responsibility of correct access control from Application to RDBMS ➔ contralization & consistency

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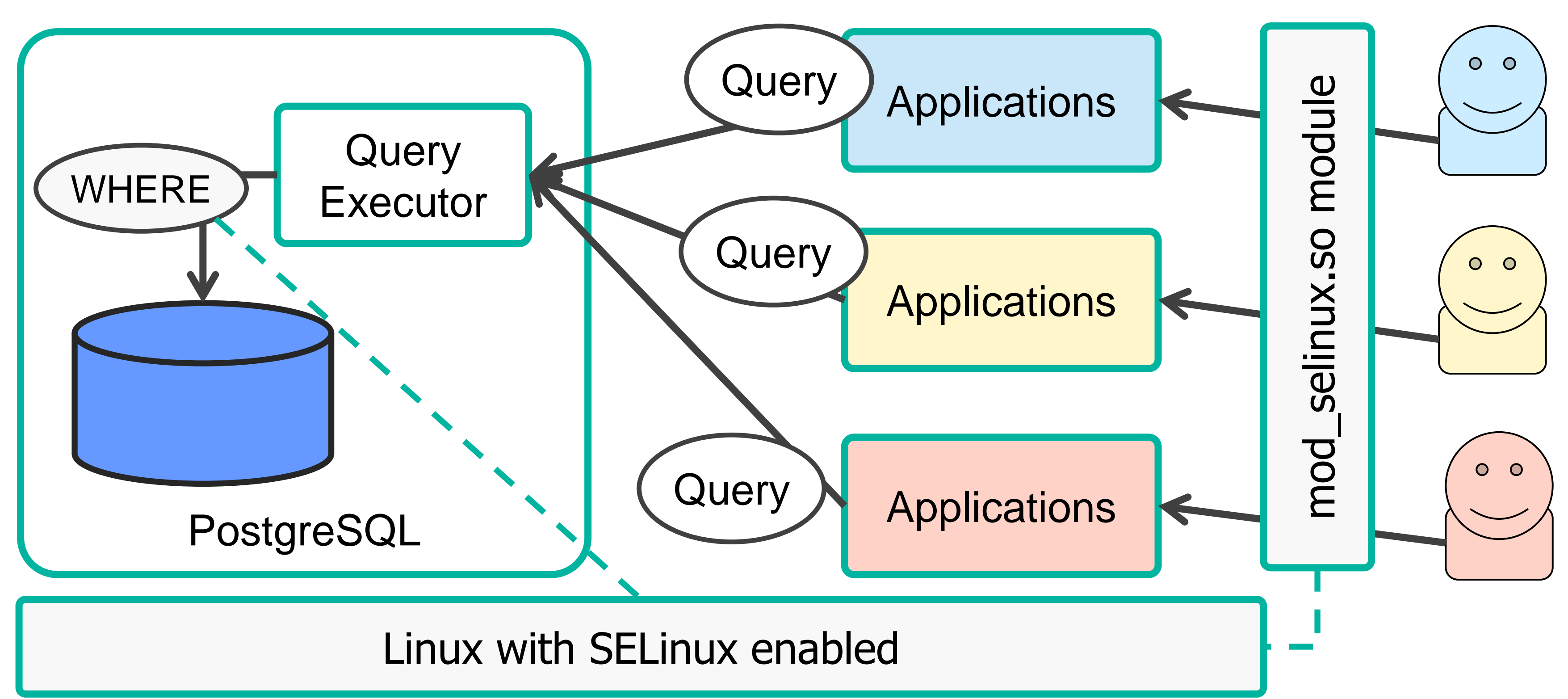
Motivation (1/2) – Responsibility of access control

+WHERE
+WHERE
+WHERE
Query Executor
PostgreSQL
Query
Applications
Query
Applications
Query
Applications

- A case when a shared table is accessed by multiple users
- Not easy to ensure applications are bug/vulnerability free
- Move the responsibility of correct access control from Application to RDBMS ➔ centralization & consistency

Motivation (2/2) – Integration with SELinux



- Per user privileges of application instance on its start-up time
- Access control decision based on a centralized security policy
- Integration of access control between OS and DBMS

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Is WHERE-clause a simple solution?

```
postgres=> CREATE VIEW soft_drink AS
     SELECT * FROM drink WHERE price < 200;
CREATE VIEW
postgres=> GRANT SELECT ON soft_drink TO public;
GRANT
postgres=> SET SESSION AUTHORIZATION bob;
SET
postgres=> SELECT * FROM soft_drink;
 id |  name  | price
----+--------+-------
 10 | water  |   100
 20 | coke   |   120
 30 | juice  |   180
 40 | sprite |   120
(4 rows)

postgres=> SELECT * FROM drink;
ERROR:  permission denied for relation drink
```

Nightmare of Leaky View (1/3)

```
postgres=> SELECT * FROM soft_drink WHERE f_leak(name);
NOTICE:  f_leak => water
NOTICE:  f_leak => coke
NOTICE:  f_leak => juice
NOTICE:  f_leak => sprite
NOTICE:  f_leak => beer
NOTICE:  f_leak => sake
 id |  name  | price
----+--------+-------
 10 | water  |   100
 20 | coke   |   120
 30 | juice  |   180
 40 | sprite |   120
(4 rows)
```


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Nightmare of Leaky View (2/3)

```
postgres=> CREATE OR REPLACE FUNCTION f_leak (text)
  RETURNS bool COST 0.000001 AS
  $$
  BEGIN
  RAISE NOTICE 'f_leak => %', $1;
  RETURN true;
  END
  $$ LANGUAGE plpgsql;
CREATE FUNCTION

postgres=> EXPLAIN(costs off)
  SELECT * FROM soft_drink WHERE f_leak(name);
                QUERY PLAN
--------------------------------------------
 Seq Scan on drink
   Filter: (f_leak(name) AND (price < 200))
(2 rows)
```

'<' is more expensive than f_leak()

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Nightmare of Leaky View (3/3)

```
postgres=> CREATE VIEW v_both AS
   SELECT * FROM t_left JOIN t_right ON a = x
   WHERE b like '%abc%';
CREATE VIEW

postgres=> EXPLAIN (COSTS OFF)
   SELECT * FROM v_both WHERE f_leak(y);
                 QUERY PLAN
---------------------------------------------
 Hash Join
   Hash Cond: (t_left.x = t_right.a)
   ->  Seq Scan on t_left
         Filter: f_leak(y)
   ->  Hash
         ->  Seq Scan on t_right
               Filter: (b ~~ '%abc%'::text)
(7 rows)
```

f_leak() takes arguments come from t_left only

Problem to be tackled

```
SELECT * FROM v_both WHERE f_leak(y);

           ↓

SELECT * FROM (
   SELECT * FROM t_left JOIN t_right ON a = x
       WHERE b like '%hoge%'
) AS v_both WHERE f_leak(y)
```

Symptom

- Query optimization reorders the sequence of

Solution

- If purpose of the view is security, qualifiers should not be moved across the sub-query border.

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Security Barrier (1/2)

```
postgres=> CREATE OR REPLACE VIEW soft_drink
             WITH (security_barrier)
             AS SELECT * FROM drink WHERE price < 200;
CREATE VIEW
postgres=> SET SESSION AUTHORIZATION bob;
SET
postgres=> SELECT * FROM soft_drink WHERE f_leak(name);
NOTICE:  f_leak => water
NOTICE:  f_leak => coke
NOTICE:  f_leak => juice
NOTICE:  f_leak => sprite
 id |  name  | price
----+--------+-------
 10 | water  |   100
 20 | coke   |   120
 30 | juice  |   180
 40 | sprite |   120
(4 rows)
```

Security Barrier (2/2)

```
postgres=> EXPLAIN (costs off)
           SELECT * FROM soft_drink WHERE f_leak(name);
            QUERY PLAN
-----------------------------------
 Subquery Scan on soft_drink
   Filter: f_leak(soft_drink.name)
   ->  Seq Scan on drink
         Filter: (price < 200)
(4 rows)
```

CREATE VIEW ... WITH (security_barrier) AS ...

- Prevention of user given qualifier into views with security_barrier attribute
- Advantage: qualifiers shall be evaluated according to user's intention
- Disadvantage: may not optimized query execution plan, instead

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Trade-off between performance and security

```
postgres=> CREATE VIEW my_team WITH (security_barrier)
    AS SELECT * FROM employee WHERE boss = current_user;
CREATE VIEW
postgres=> EXPLAIN (costs off)
           SELECT * FROM my_team WHERE id = 100;
                QUERY PLAN
-------------------------------------------
 Subquery Scan on my_team
   Filter: (my_team.id = 100)
   ->  Seq Scan on employee
         Filter: (boss = "current_user"())
(4 rows)
```

- Query should be index-scannable using id=100
- Due to security_barrier attribute, sequential scan on “employee” first, then evaluation of “id=100”

Leakproof Function (1/2)

Leakproof attribute

- It shows the marked function is definitely safe.
- Thus, no side effects if it would be pushed down.

```
postgres=# CREATE FUNCTION nabeatsu(integer)
           RETURNS bool LEAKPROOF AS
$$
BEGIN
  IF ($1 % 3 = 0) THEN RETURN true; END IF;
  WHILE $1 > 0 LOOP
    IF ($1 % 10 = 3) THEN RETURN true; END IF;
    $1 = $1 / 10;
  END LOOP;
RETURN false;
END
$$ LANGUAGE plpgsql;
CREATE FUNCTION
```


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Leakproof Function (2/2)

```
postgres=> EXPLAIN (costs off)
           SELECT * FROM my_team WHERE nabeatsu(id);
                       QUERY PLAN
---------------------------------------------------------
 Seq Scan on employee
   Filter: ((boss = "current_user"()) AND nabeatsu(id))
(2 rows)
```

Some functions are LEAKPROOF in the default

- Example) Equivalent operator between integers

```
postgres=> EXPLAIN (costs off)
           SELECT * FROM my_team WHERE id = 300;
                 QUERY PLAN
--------------------------------------------
 Index Scan using employee_pkey on employee
   Index Cond: (id = 300)
   Filter: (boss = "current_user"())
(3 rows)
```

In case of Oracle

```
--------------------------------------------------
| Id  | Operation             | Name | Rows  | Bytes |
--------------------------------------------------
|   0 | SELECT STATEMENT      |      |     3 |    81 |
|*  1 |  VIEW                 | V    |     3 |    81 |
|*  2 |   HASH JOIN           |      |     3 |   120 |
|*  3 |    TABLE ACCESS FULL| B    |     3 |    60 |
|   4 |    TABLE ACCESS FULL| A    |     4 |    80 |
--------------------------------------------------

Predicate Information (identified by operation id):
-------------------------------------------------

   1 - filter("F_LEAK"("X")=1)   <== This is correct,
   2 - access("A"."ID"="B"."ID")     but performance loss!
   3 - filter("B"."Y"<>'bbb')
```

Towards v9.4 development cycle

Features in v9.2

- security_barrier attribute of VIEW
- leakproof attribute of FUNCION

Features in v9.3

- Row-level security discussion was time-over! (;_;)

Features in v9.4

- ALTER TABLE ... SET ROW SECURITY (...) statement
- Writer side checks
- Label based mandatory row-level access control

Syntax of Row-level Security (1/2)

```
ALTER <table_name>
    SET ROW SECURITY FOR <cmd>
    TO (<expression>);
<cmd> := ALL | SELECT | INSERT | UPDATE | DELETE
```

- <expression> (performing as a security policy) shall be appended on the query specified by <cmd>
- It is guaranteed that security policy is evaluated earlier than user given qualifiers.

```
postgres=> ALTER TABLE my_table
             SET ROW SECURITY FOR ALL TO (a % 2 = 0);
ALTER TABLE
postgres=> ALTER TABLE my_table
             SET ROW SECURITY FOR ALL TO
                 (a = ANY(SELECT x FROM sub_tbl));
ALTER TABLE
```

Syntax of Row-level Security (2/2)

```
ALTER t SET ROW SECURITY FOR ALL
        TO (owner = current_user);
```

```
SELECT * FROM t WHERE f_leak(x);

      ↓

SELECT * FROM (
    SELECT * FROM t WHERE owner = current_user
) t WHERE f_leak(x)
```

Sub-Query with security_barrier

- Replacement of table reference by a simple table scan with security barrier attribute and qualifiers of security policy
- Database superuser is an exception

How does RLS work? (1/2)

```
postgres=> ALTER TABLE t
        SET ROW SECURITY FOR ALL TO (owner = current_user);
ALTER TABLE

postgres=> EXPLAIN (costs off)
           SELECT * FROM t WHERE f_leak(b) AND a > 0;
                   QUERY PLAN
------------------------------------------------
 Subquery Scan on t
   Filter: f_leak(t.b)
   ->  Index Scan using my_table_pkey on t t_1
         Index Cond: (owner = "current_user"())
         Filter: (a > 0)
(5 rows)
```

How does RLS work? (2/2)

```
postgres=> EXPLAIN (costs off)
           UPDATE t SET b = b WHERE f_leak(b);
                      QUERY PLAN
------------------------------------------------------
 Update on t
   ->  Subquery Scan on t_1
         Filter: f_leak(t_1.b)
         ->  Index Scan using my_table_pkey on t t_2
               Index Cond: (owner = "current_user"())
```

```
postgres=> EXPLAIN(costs off)
           DELETE FROM t WHERE f_leak(b);
                      QUERY PLAN
------------------------------------------------------
 Delete on t
   ->  Subquery Scan on t_1
         Filter: f_leak(t_1.b)
         ->  Index Scan using my_table_pkey on t t_2
               Index Cond: (owner = "current_user"())
```

Table Update and RLS (1/2)

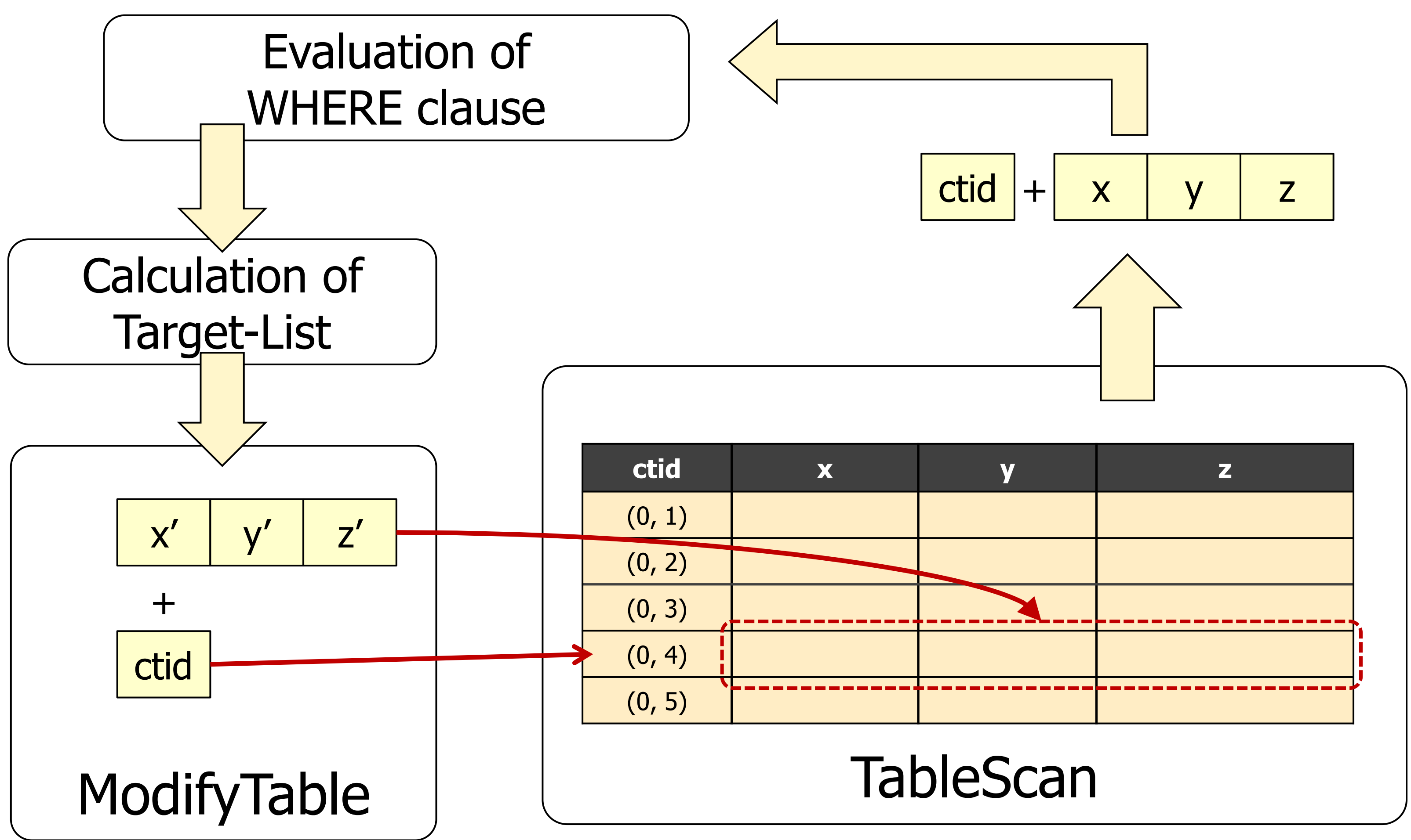

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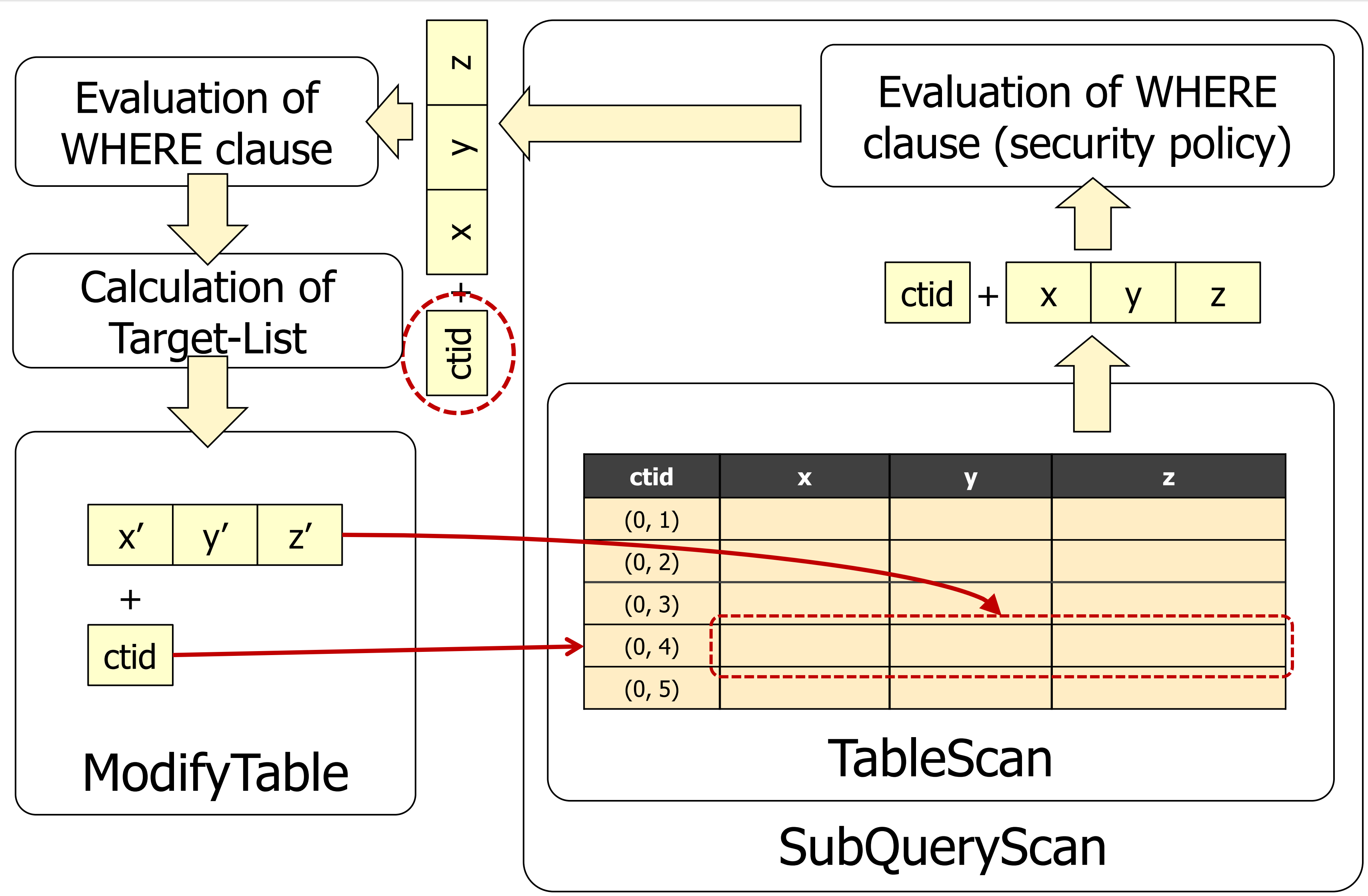
Table Update and RLS (2/2)



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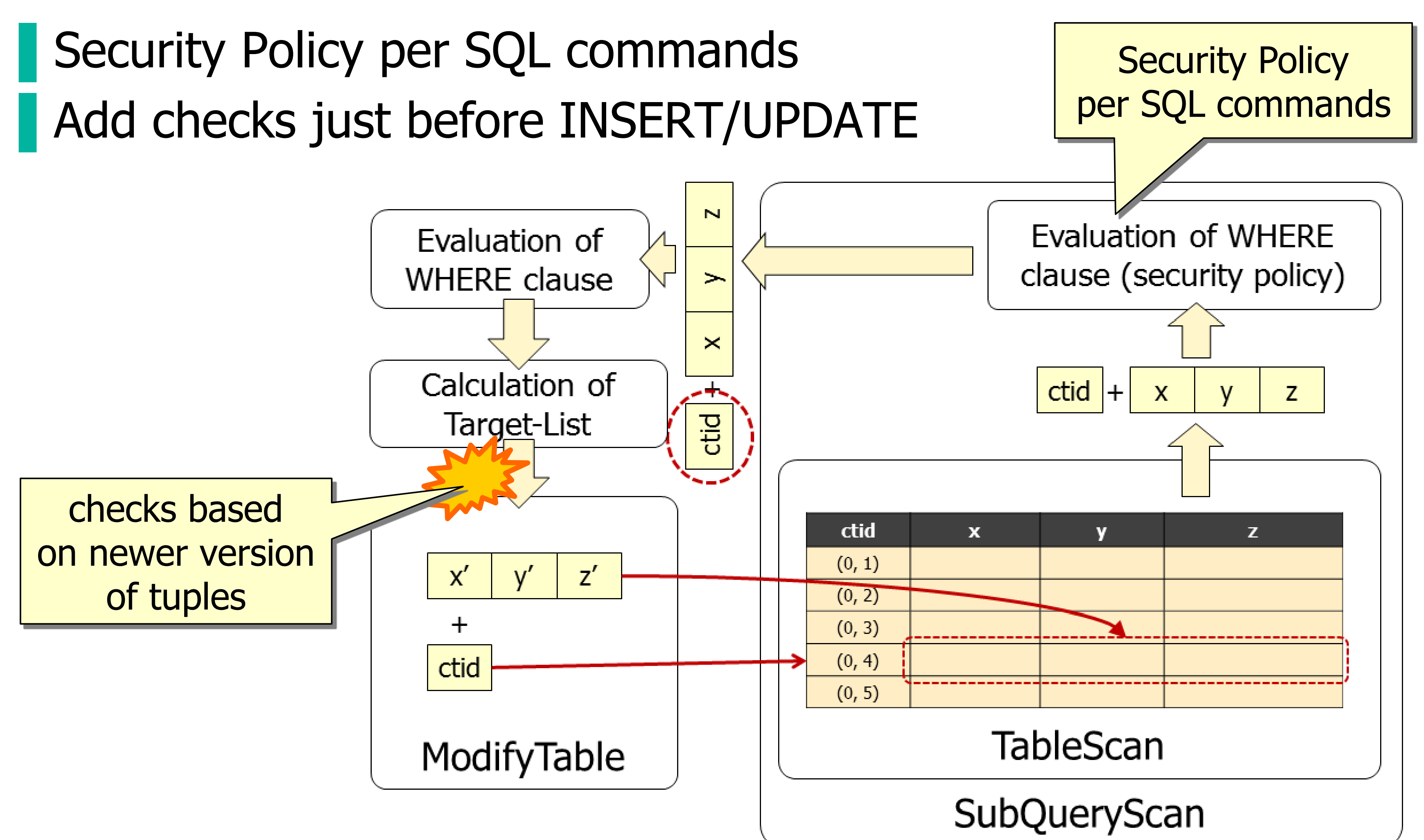
Further development (1/2)

- Security Policy per SQL commands
- Add checks just before INSERT/UPDATE



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Futher development (2/2)

- Labal-based Row-level Security
  - access control functions according to SELinux policy
- Step to implementation
  - all the features of “standard” row-level security
  - security-label assignment on user’s table
  - enumerate type that can add items at run-time
  - enhancement of contrib/sepgsql

Resources

CommitFest:1st to v9.4

- https://commitfest.postgresql.org/action/commitfest_view?id=18

Git repository

- https://github.com/kaigai/sepgsql/tree/rowsec

Wikipage

- http://wiki.postgresql.org/wiki/RLS

Any Questions?

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