41.9. Trigger Procedures

PL/pgSQL can be used to define trigger procedures on data changes or database events. A trigger procedure is created with the `CREATE FUNCTION` command, declaring it as a function with no arguments and a return type of `trigger` (for data change triggers) or `event_trigger` (for database event triggers). Special local variables named `TG_something` are automatically defined to describe the condition that triggered the call.

41.9.1. Triggers on Data Changes

A [data change trigger](#) is declared as a function with no arguments and a return type of `trigger`. Note that the function must be declared with no arguments even if it expects to receive some arguments specified in `CREATE TRIGGER` — such arguments are passed via `TG_ARGV`, as described below.

When a PL/pgSQL function is called as a trigger, several special variables are created automatically in the top-level block. They are:

`NEW`
: Data type `RECORD`; variable holding the new database row for `INSERT`/`UPDATE` operations in row-level triggers. This variable is unassigned in statement-level triggers and for `DELETE` operations.

`OLD`
: Data type `RECORD`; variable holding the old database row for `UPDATE`/`DELETE` operations in row-level triggers. This variable is unassigned in statement-level triggers and for `INSERT` operations.

`TG_NAME`
: Data type `name`; variable that contains the name of the trigger actually fired.

`TG_WHEN`
: Data type `text`; a string of `BEFORE`, `AFTER`, or `INSTEAD OF`, depending on the trigger's definition.

`TG_LEVEL`
: Data type `text`; a string of either `ROW` or `STATEMENT` depending on the trigger's definition.

`TG_OP`
: Data type `text`; a string of `INSERT`, `UPDATE`, `DELETE`, or `TRUNCATE` telling for which operation the trigger was fired.

`TG_RELID`
: Data type `oid`; the object ID of the table that caused the trigger invocation.

`TG_RELNAME`
: Data type `name`; the name of the table that caused the trigger invocation. This is now deprecated, and could disappear in a future release. Use `TG_TABLE_NAME` instead.

`TG_TABLE_NAME`
: Data type `name`; the name of the table that caused the trigger invocation.

`TG_TABLE_SCHEMA`
: Data type `name`; the name of the schema of the table that caused the trigger invocation.

`TG_NARGS`
: Data type `integer`; the number of arguments given to the trigger procedure in the `CREATE TRIGGER` statement.

`TG_ARGV[]`
: Data type array of `text`; the arguments from the `CREATE TRIGGER` statement. The index counts from 0. Invalid indexes (less than 0 or greater than or equal to `TG_nargs`) result in a null value.

A trigger function must return either `NULL` or a record/row value having exactly the structure of the table the trigger was fired for.

Row-level triggers fired `BEFORE` can return null to signal the trigger manager to skip the rest of the operation for this row (i.e., subsequent triggers are not fired, and the `INSERT`/`UPDATE`/`DELETE` does not occur for this row). If a nonnull value is returned then the operation proceeds with that row value. Returning a row value different from the original value of `NEW` alters the row that will be inserted or updated. Thus, if the trigger function wants the triggering action to succeed normally without altering the row value, `NEW` (or a value equal thereto) has to be returned. To alter the row to be stored, it is possible to replace single values directly in `NEW` and return the modified `NEW`, or to build a complete new record/row to return. In the case of a before trigger on `DELETE`, the returned value has no direct effect, but it has to be nonnull to allow the trigger action to proceed. Note that `NEW` is null in `DELETE` triggers, so returning that is usually not sensible. The usual idiom in `DELETE` triggers is to return `OLD`.

`INSTEAD OF` triggers (which are always row-level triggers, and may only be used on views) can return null to signal that they did not perform any updates, and that the rest of the operation for this row should be skipped (i.e., subsequent triggers are not fired, and the row is not counted in the rows-affected status for the surrounding `INSERT`/`UPDATE`/`DELETE`). Otherwise a nonnull value should be returned, to signal that the trigger performed the requested operation. For `INSERT` and `UPDATE` operations, the return value should be `NEW`, which the trigger function may modify to support `INSERT RETURNING` and `UPDATE RETURNING` (this will also affect the row value passed to any subsequent triggers, or passed to a special `EXCLUDED` alias reference within an `INSERT` statement with an `ON CONFLICT DO UPDATE` clause). For `DELETE` operations, the return value should be `OLD`.

The return value of a row-level trigger fired `AFTER` or a statement-level trigger fired `BEFORE` or `AFTER` is always ignored; it might as well be null. However, any of these types of triggers might still abort the entire operation by raising an error.

[Example 41-3](#) shows an example of a trigger procedure in PL/pgSQL.

Example 41-3. A PL/pgSQL Trigger Procedure

This example trigger ensures that any time a row is inserted or updated in the table, the current user name and time are stamped into the row. And it checks that an employee's name is given and that the salary is a positive value.

```
CREATE TABLE emp (
    empname           text,
    salary            integer,
    last_date         timestamp,
    last_user         text
);

CREATE FUNCTION emp_stamp() RETURNS trigger AS $emp_stamp$
    BEGIN
        -- Check that empname and salary are given
        IF NEW.empname IS NULL THEN
            RAISE EXCEPTION 'empname cannot be null';
        END IF;
        IF NEW.salary IS NULL THEN
            RAISE EXCEPTION '% cannot have null salary', NEW.empname;
        END IF;

        -- Who works for us when they must pay for it?
        IF NEW.salary < 0 THEN
            RAISE EXCEPTION '% cannot have a negative salary', NEW.empname;
        END IF;

        -- Remember who changed the payroll when
        NEW.last_date := current_timestamp;
        NEW.last_user := current_user;
        RETURN NEW;
    END;
$emp_stamp$ LANGUAGE plpgsql;

CREATE TRIGGER emp_stamp BEFORE INSERT OR UPDATE ON emp
    FOR EACH ROW EXECUTE PROCEDURE emp_stamp();
```

Another way to log changes to a table involves creating a new table that holds a row for each insert, update, or delete that occurs. This approach can be thought of as auditing changes to a table. [Example 41-4](#) shows an example of an audit trigger procedure in PL/pgSQL.

Example 41-4. A PL/pgSQL Trigger Procedure For Auditing

This example trigger ensures that any insert, update or delete of a row in the `emp` table is recorded (i.e., audited) in the `emp_audit` table. The current time and user name are stamped into the row, together with the type of operation performed on it.

```
CREATE TABLE emp (
    empname           text NOT NULL,
    salary            integer
);

CREATE TABLE emp_audit(
    operation         char(1)   NOT NULL,
    stamp             timestamp NOT NULL,
    userid            text      NOT NULL,
    empname           text      NOT NULL,
    salary integer
);

CREATE OR REPLACE FUNCTION process_emp_audit() RETURNS TRIGGER AS $emp_audit$
    BEGIN
        --
        -- Create a row in emp_audit to reflect the operation performed on emp,
        -- make use of the special variable TG_OP to work out the operation.
        --
        IF (TG_OP = 'DELETE') THEN
            INSERT INTO emp_audit SELECT 'D', now(), user, OLD.*;
            RETURN OLD;
        ELSIF (TG_OP = 'UPDATE') THEN
            INSERT INTO emp_audit SELECT 'U', now(), user, NEW.*;
            RETURN NEW;
        ELSIF (TG_OP = 'INSERT') THEN
            INSERT INTO emp_audit SELECT 'I', now(), user, NEW.*;
            RETURN NEW;
        END IF;
        RETURN NULL; -- result is ignored since this is an AFTER trigger
    END;
$emp_audit$ LANGUAGE plpgsql;

CREATE TRIGGER emp_audit
AFTER INSERT OR UPDATE OR DELETE ON emp
    FOR EACH ROW EXECUTE PROCEDURE process_emp_audit();
```

A variation of the previous example uses a view joining the main table to the audit table, to show when each entry was last modified. This approach still records the full audit trail of changes to the table, but also presents a simplified view of the audit trail, showing just the last modified timestamp derived from the audit trail for each entry. [Example 41-5](#) shows an example of an audit trigger on a view in PL/pgSQL.

Example 41-5. A PL/pgSQL View Trigger Procedure For Auditing

This example uses a trigger on the view to make it updatable, and ensure that any insert, update or delete of a row in the view is recorded (i.e., audited) in the `emp_audit` table. The current time and user name are recorded, together with the type of operation performed, and the view displays the last modified time of each row.

```
CREATE TABLE emp (
    empname           text PRIMARY KEY,
    salary            integer
);

CREATE TABLE emp_audit(
    operation         char(1)   NOT NULL,
    stamp             timestamp NOT NULL,
    userid            text      NOT NULL,
    empname           text      NOT NULL,
    salary            integer,
    stamp             timestamp NOT NULL
);

CREATE VIEW emp_view AS
    SELECT e.empname,
           e.salary,
           max(ea.stamp) AS last_updated
      FROM emp e
      LEFT JOIN emp_audit ea ON ea.empname = e.empname
     GROUP BY 1, 2;

CREATE OR REPLACE FUNCTION update_emp_view() RETURNS TRIGGER AS $$
    BEGIN
        --
        -- Perform the required operation on emp, and create a row in emp_audit
        -- to reflect the change made to emp.
        --
        IF (TG_OP = 'DELETE') THEN
            DELETE FROM emp WHERE empname = OLD.empname;
            IF NOT FOUND THEN RETURN NULL; END IF;

            OLD.last_updated = now();
            INSERT INTO emp_audit VALUES('D', user, OLD.*);
            RETURN OLD;
        ELSIF (TG_OP = 'UPDATE') THEN
            UPDATE emp SET salary = NEW.salary WHERE empname = OLD.empname;
            IF NOT FOUND THEN RETURN NULL; END IF;

            NEW.last_updated = now();
            INSERT INTO emp_audit VALUES('U', user, NEW.*);
            RETURN NEW;
        ELSIF (TG_OP = 'INSERT') THEN
            INSERT INTO emp VALUES(NEW.empname, NEW.salary);

            NEW.last_updated = now();
            INSERT INTO emp_audit VALUES('I', user, NEW.*);
            RETURN NEW;
        END IF;
    END;
$$ LANGUAGE plpgsql;

CREATE TRIGGER emp_audit
INSTEAD OF INSERT OR UPDATE OR DELETE ON emp_view
    FOR EACH ROW EXECUTE PROCEDURE update_emp_view();
```

One use of triggers is to maintain a summary table of another table. The resulting summary can be used in place of the original table for certain queries — often with vastly reduced run times. This technique is commonly used in Data Warehousing, where the tables of measured or observed data (called fact tables) might be extremely large. [Example 41-6](#) shows an example of a trigger procedure in PL/pgSQL that maintains a summary table for a fact table in a data warehouse.

Example 41-6. A PL/pgSQL Trigger Procedure For Maintaining A Summary Table

The schema detailed here is partly based on the Grocery Store example from The Data Warehouse Toolkit by Ralph Kimball.

```
--
-- Main tables - time dimension and sales fact.
--
CREATE TABLE time_dimension (
    time_key          integer NOT NULL,
    day_of_week       integer NOT NULL,
    day_of_month      integer NOT NULL,
    month             integer NOT NULL,
    quarter           integer NOT NULL,
    year              integer NOT NULL
);
CREATE UNIQUE INDEX time_dimension_key ON time_dimension(time_key);

CREATE TABLE sales_fact (
    time_key          integer NOT NULL,
    product_key       integer NOT NULL,
    store_key         integer NOT NULL,
    amount_sold       numeric(12,2) NOT NULL,
    units_sold        integer NOT NULL,
    amount_cost       numeric(12,2) NOT NULL
);
CREATE INDEX sales_fact_time ON sales_fact(time_key);

--
-- Summary table - sales by time.
--
CREATE TABLE sales_summary_bytime (
    time_key          integer NOT NULL,
    amount_sold       numeric(15,2) NOT NULL,
    units_sold        numeric(10,2) NOT NULL,
    amount_cost       numeric(15,2) NOT NULL
);
CREATE UNIQUE INDEX sales_summary_bytime_key ON sales_summary_bytime(time_key);

--
-- Function and trigger to amend summarised column(s) on UPDATE, INSERT, DELETE.
--
CREATE OR REPLACE FUNCTION maint_sales_summary_bytime() RETURNS TRIGGER
AS $maint_sales_summary_bytime$
    DECLARE
        delta_time_key    integer;
        delta_amount_sold numeric(15,2);
        delta_units_sold  numeric(12);
        delta_amount_cost numeric(15,2);
    BEGIN

        -- work out the increment/decrement amount(s).
        IF (TG_OP = 'DELETE') THEN

            delta_time_key = OLD.time_key;
            delta_amount_sold = 0 - OLD.amount_sold;
            delta_units_sold = 0 - OLD.units_sold;
            delta_amount_cost = 0 - OLD.amount_cost;

        ELSIF (TG_OP = 'UPDATE') THEN

            -- forbid updates that change the time_key -
            -- (it probably not too onerous, as DELETE + INSERT is how most
            -- changes will be made).
            IF ( OLD.time_key != NEW.time_key) THEN
                RAISE EXCEPTION 'Update of time_key : % -> % not allowed',
                                              OLD.time_key, NEW.time_key;
            END IF;

            delta_time_key = OLD.time_key;
            delta_amount_sold = NEW.amount_sold - OLD.amount_sold;
            delta_units_sold = NEW.units_sold - OLD.units_sold;
            delta_amount_cost = NEW.amount_cost - OLD.amount_cost;

        ELSIF (TG_OP = 'INSERT') THEN

            delta_time_key = NEW.time_key;
            delta_amount_sold = NEW.amount_sold;
            delta_units_sold = NEW.units_sold;
            delta_amount_cost = NEW.amount_cost;

        END IF;


        -- Insert or update the summary row with the new values.
        <<insert_update>>
        LOOP
            UPDATE sales_summary_bytime
                SET amount_sold = amount_sold + delta_amount_sold,
                    units_sold = units_sold + delta_units_sold,
                    amount_cost = amount_cost + delta_amount_cost
                WHERE time_key = delta_time_key;

            EXIT insert_update WHEN found;

            BEGIN
                INSERT INTO sales_summary_bytime (
                            time_key,
                            amount_sold,
                            units_sold,
                            amount_cost)
                    VALUES (
                            delta_time_key,
                            delta_amount_sold,
                            delta_units_sold,
                            delta_amount_cost
                            );

                EXIT insert_update;

            EXCEPTION
                WHEN UNIQUE_VIOLATION THEN
                    -- do nothing
            END;
        END LOOP insert_update;

        RETURN NULL;

    END;
$maint_sales_summary_bytime$ LANGUAGE plpgsql;

CREATE TRIGGER maint_sales_summary_bytime
AFTER INSERT OR UPDATE OR DELETE ON sales_fact
    FOR EACH ROW EXECUTE PROCEDURE maint_sales_summary_bytime();

INSERT INTO sales_fact VALUES(1,1,1,10,1,91);
INSERT INTO sales_fact VALUES(2,2,1,20,2,92);
INSERT INTO sales_fact VALUES(3,3,1,30,3,93);
INSERT INTO sales_fact VALUES(4,4,1,40,4,94);
SELECT * FROM sales_summary_bytime;
DELETE FROM sales_fact WHERE product_key = 1;
SELECT * FROM sales_summary_bytime;
UPDATE sales_fact SET units_sold = units_sold * 2;
SELECT * FROM sales_summary_bytime;
```

41.9.2. Triggers on Events

PL/pgSQL can be used to define [event triggers](#). PostgreSQL requires that a procedure that is to be called as an event trigger must be declared as a function with no arguments and a return type of `event_trigger`.

When a PL/pgSQL function is called as an event trigger, several special variables are created automatically in the top-level block. They are:

`TG_EVENT`
: Data type `text`; a string representing the event the trigger is fired for.

`TG_TAG`
: Data type `text`; variable that contains the command tag for which the trigger is fired.

[Example 41-7](#) shows an example of an event trigger procedure in PL/pgSQL.

Example 41-7. A PL/pgSQL Event Trigger Procedure

This example trigger simply raises a `NOTICE` message each time a supported command is executed.

```
CREATE OR REPLACE FUNCTION snitch() RETURNS event_trigger AS $$
BEGIN
    RAISE NOTICE 'snitch: % %', tg_event, tg_tag;
END;
$$ LANGUAGE plpgsql;

CREATE EVENT TRIGGER snitch ON ddl_command_start EXECUTE PROCEDURE snitch();
```