yugabyteDB

Using stored procedures effectively in a distributed PostgreSQL database

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What is YugabyteDB?

YugaByte DB

Distributed SQL

PostgreSQL Compatible, 100% Open Source (Apache 2.0)

Massive Scale

Millions of IOPS in Throughput, TBs per Node

High Performance

Low Latency Queries

Cloud Native

Fault Tolerant, Multi-Cloud & Kubernetes Ready

Functional Architecture

YugaByte SQL (YSQL)

PostgreSQL-Compatible Distributed SQL API

DOCDB

Spanner-Inspired Distributed Document Store
Cloud Neutral: No Specialized Hardware Needed

Questions?

Download
download.yugabyte.com

Join Slack Discussions
yugabyte.com/slack

Star on GitHub
github.com/YugaByte/yugabyte-db

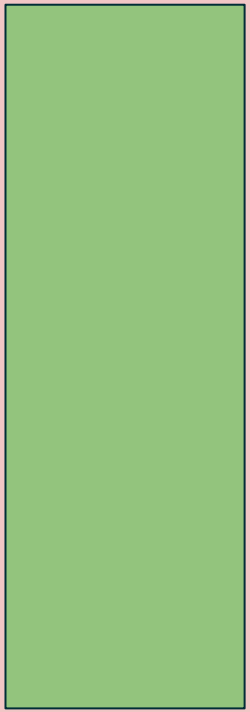
Q: Why use stored procedures?

- **Large software systems must be built from modules**
  - Hide implementation detail behind API
  - Software engineering's most famous principle
- **The RDBMS is a module**
  - Tables and SQLs that manipulate them are the implementation details
  - Stored procedures express the API
- **Result: happiness**
  - Developers and end-users of applications built this way are happy with their correctness, maintainability, security, and performance

A: Use stored procedures to encapsulate the RDBMS's functionality behind an impenetrable hard shell

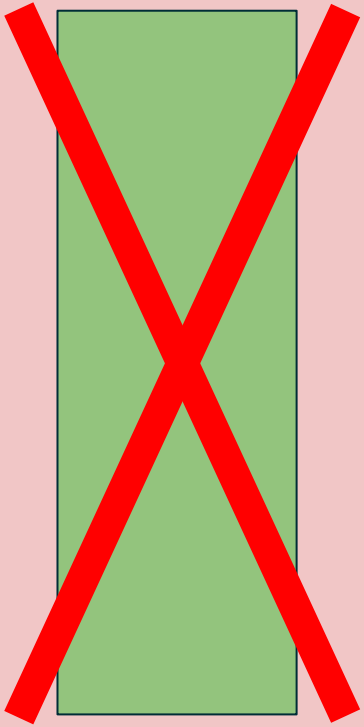
Hard Shell Schematic

Public



APP DATABASE

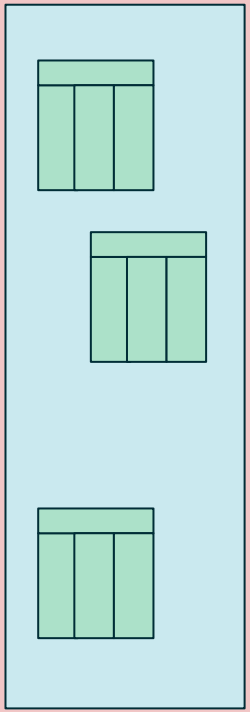
Public



APP DATABASE

APP DATABASE

Data



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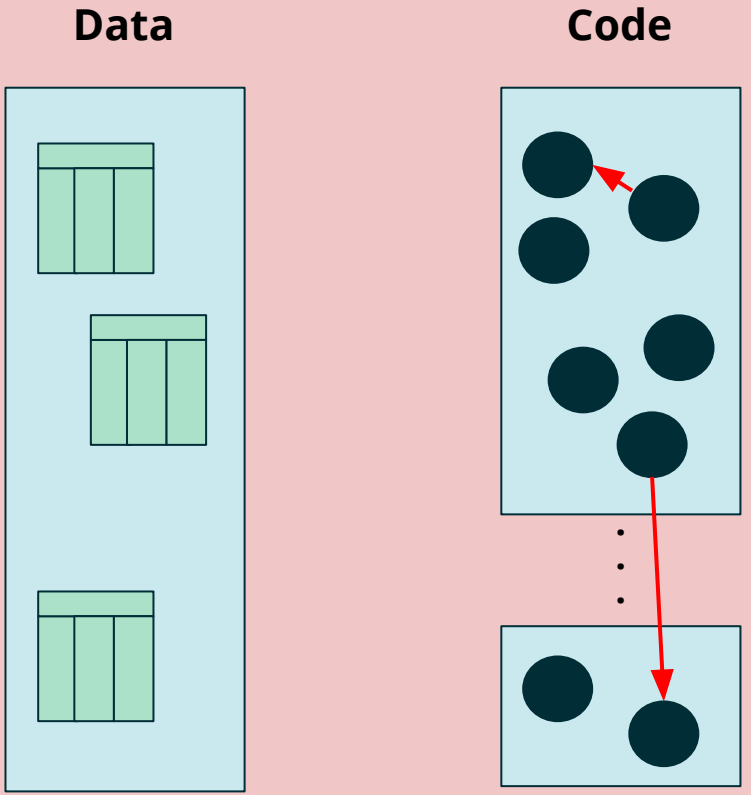

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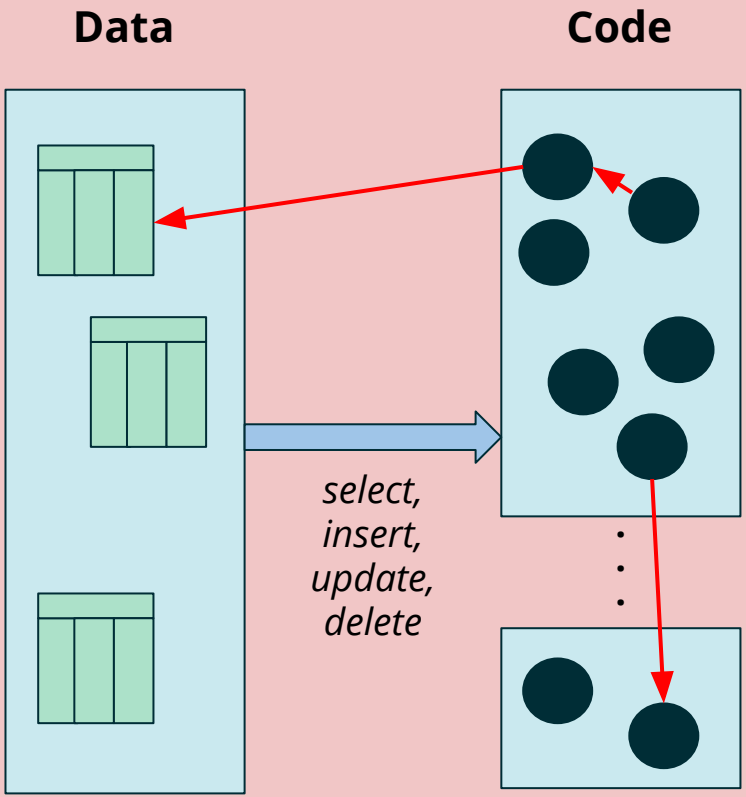

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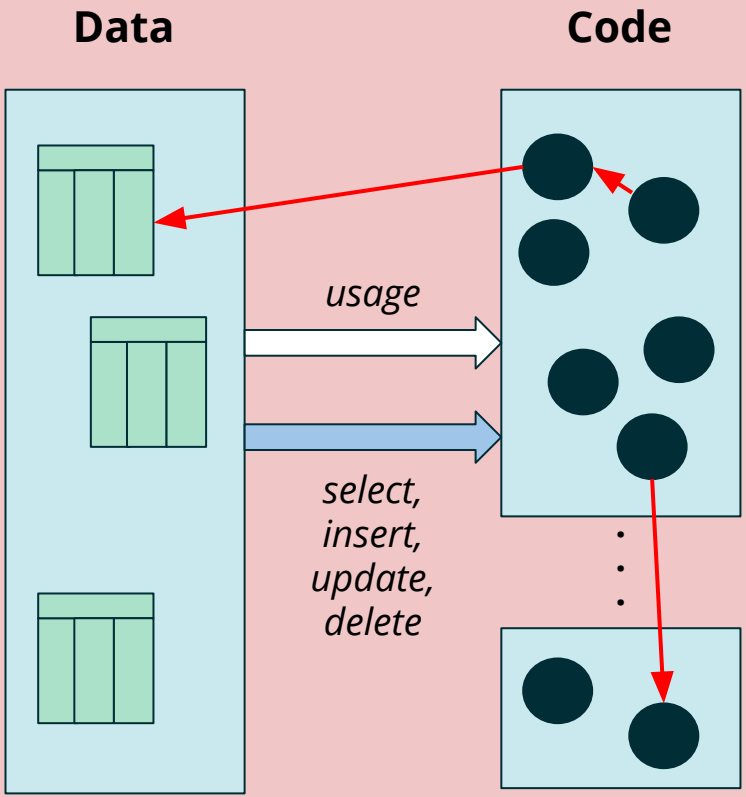

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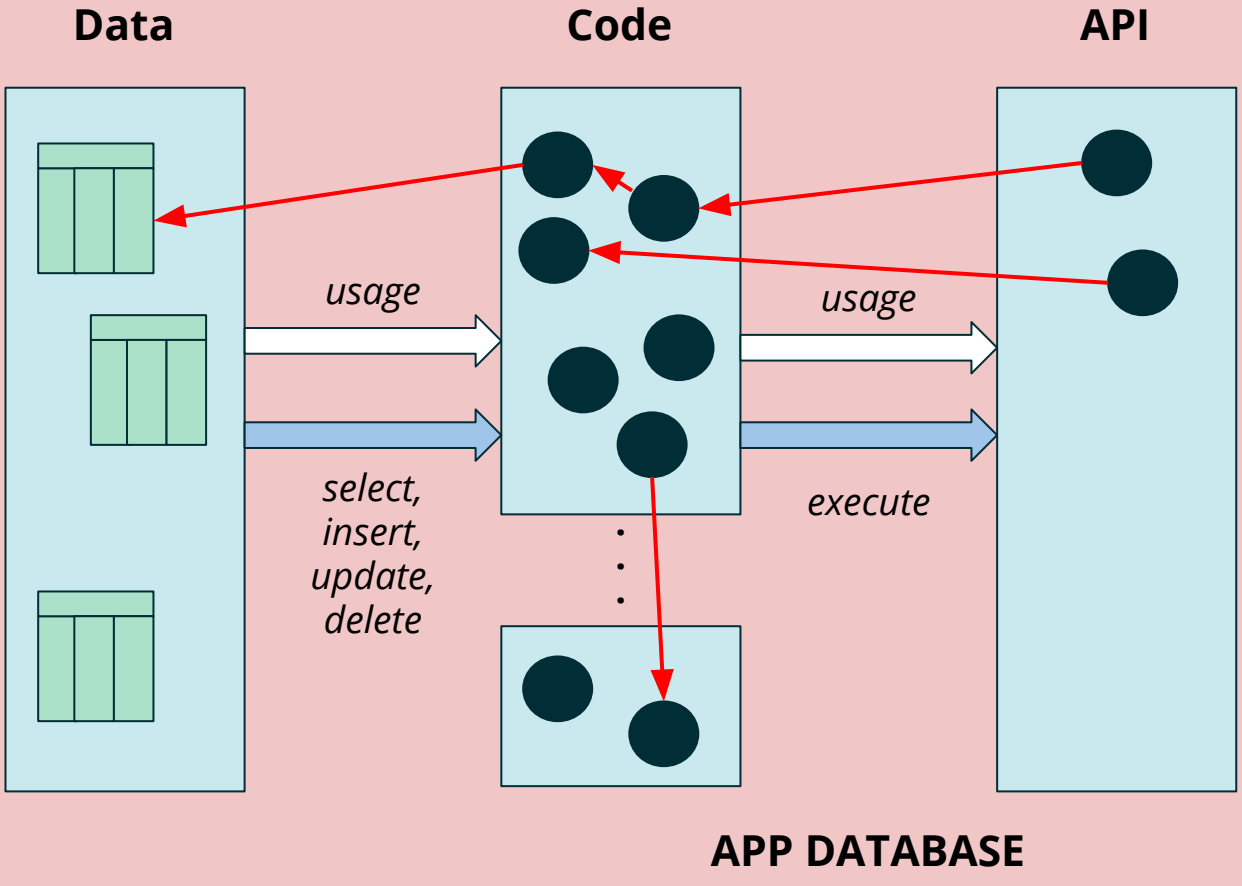
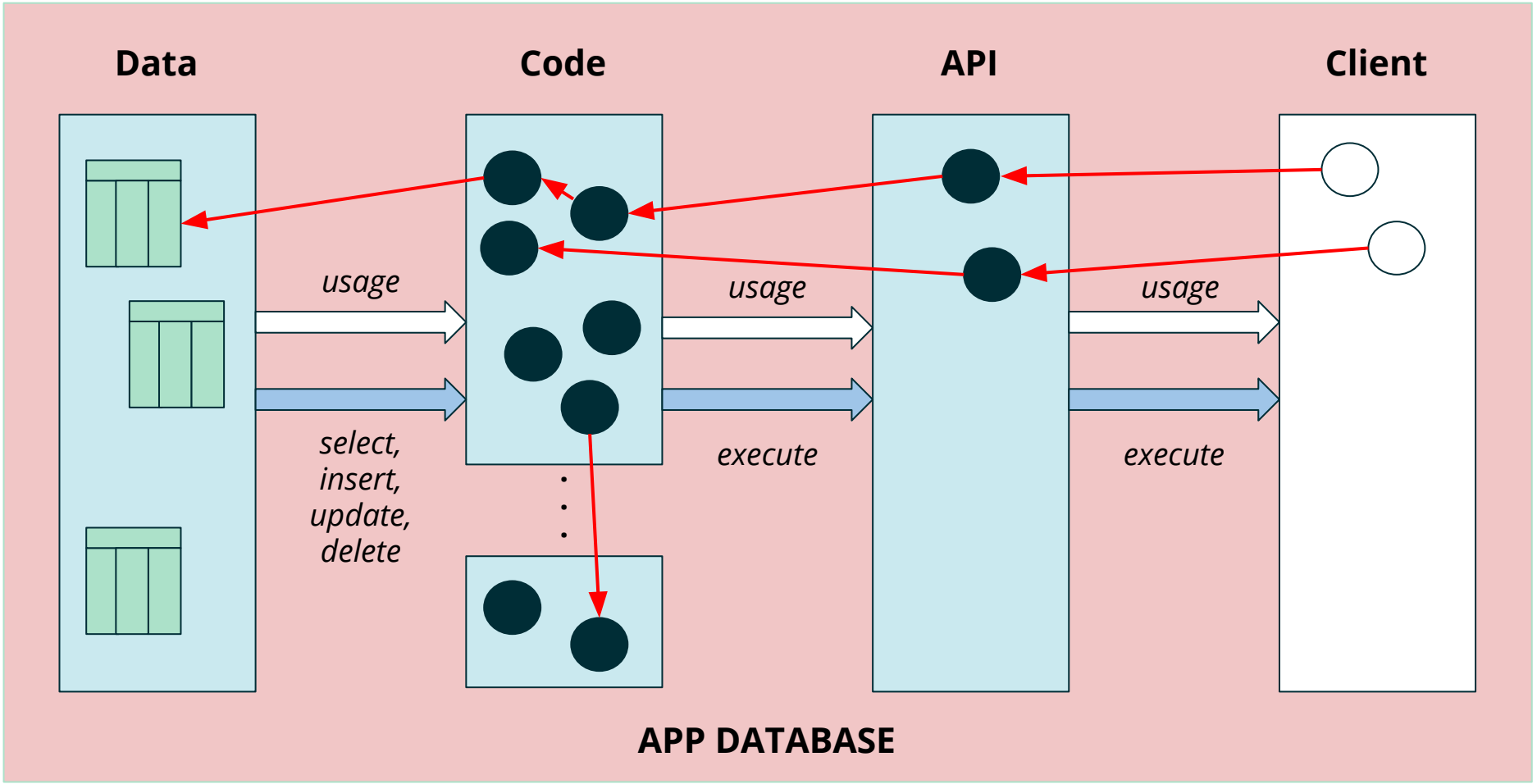
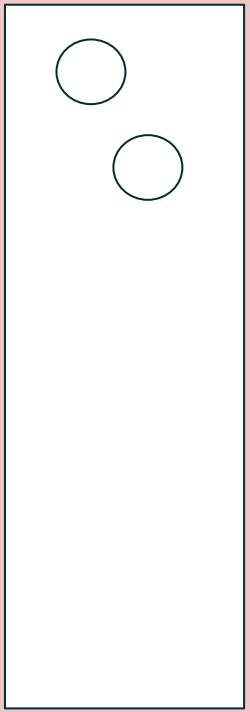


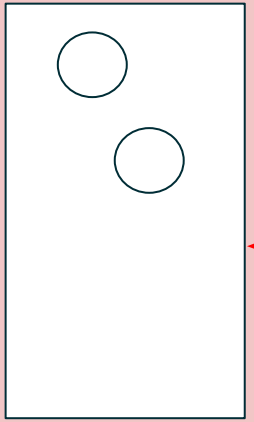


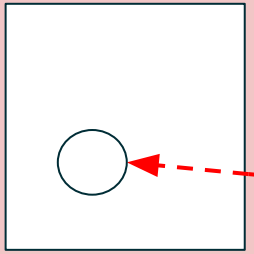
Client



APP DATABASE

Client





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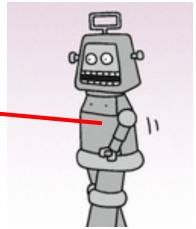
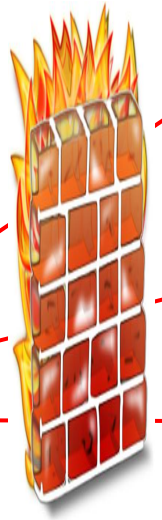




Again: Use stored procedures to encapsulate the RDBMS's functionality behind an impenetrable hard shell

Setting up the purpose-agnostic foundation and superstructure

The superuser lays the foundation

The superuser's foundation work

```
-- Deliberate least privilege.
-- Users exist in cluster scope, not database scope.
-- So don't want app_ower to be able to create users.

\c yugabyte yugabyte

create user app_owner login password 'app';

create database app owner app_owner;

grant create on database app to app_owner;

\c app yugabyte

drop schema public;
```

The superuser's foundation work—cont.

```
-- Now create the users that will own schema-objects.

\c app yugabyte

create user data login password 'data';
grant create on database app to data;

create user code login password 'code';
grant create on database app to code;

create user api login password 'api';
grant create on database app to api;

create user client login password 'client';
```

The application administrators erect the superstructure

The application administrators take over

```
-- Create and populate data schema.

\c app data

create schema data authorization data;
grant usage on schema data to code;
alter user data set search_path = "data";

\i create_data_objects.sql
```

The application administrators take over—cont.

```
-- Create and populate the code schema.

\c app code

create schema code authorization code;
grant usage on schema code to api;
alter user code set search_path = "code";

\i create_code_objects.sql
```

The application administrators take over—cont.

```
-- Create and populate the api schema.

\c app api

create schema api authorization api;
grant usage on schema api to client;
alter user code set search_path = "api";

\i create_api_objects.sql
```

The application administrators take over—cont.

```
-- Create the schemaless client.

\c app client

alter user code set search_path = "api";
```

An example application:

Maintain masters and their details

The data objects

create_data_objects.sql

```
create table data.masters(
  mk int
  generated always as identity
  constraint masters_pk primary key
  constraint masters_mk_chk check(mk > 0),

  v varchar(30) not null
  constraint masters_v_unq unique);


revoke all on data.masters from public;

grant select, insert, update, delete on data.masters to code;
```

create_data_objects.sql — cont.

```
create table data.details(
  mk int,

  dk int
  generated always as identity
  constraint details_dk_chk check(dk > 0),

  v varchar(30) not null,
  constraint details_pk primary key(mk, dk),

  constraint details_fk foreign key(mk)
    references data.masters(mk)
    match full
    on delete cascade
    on update restrict,

  constraint details_mk_v_unq unique(mk, v));

revoke all on data.details from public;
grant select, insert, update, delete on data.details to code;
```

The code objects

create_code_objects.sql

```
create procedure code.insert_master_and_details(
  m in varchar,
  ds in varchar[])
  language plpgsql
  security definer
as $$
declare
  ...
begin
  ...
end;
$$;
```

create_code_objects.sql — cont.

```
begin
  -- Disallow master with no details.
  if cardinality(ds) < 1 then
    raise exception 'Cannot insert master "%" with no details.', m
    using errcode = '99998';
  end if;

  insert into data.masters(v)
     values(m) returning mk into new_mk;

  foreach d in array ds loop
    begin
       insert into data.details(mk, v) values(new_mk, d);
    exception when unique_violation then
      raise exception 'Master "%" already has detail "%"', m, d
      using errcode = '99998';
    end;
  end loop;
end;
```

create_code_objects.sql – cont.

```
revoke all on procedure code.insert_master_and_details(
  m in varchar,
  ds in varchar[])
from public;



grant execute on procedure code.insert_master_and_details(
  m in varchar,
  ds in varchar[])
to api;
```

create_code_objects.sql – cont.

```
create table code.result_template(m varchar(10), ds varchar[]);
revoke all on code.result_template from public;

create function code.report_master_and_details(the_mv in varchar)
  returns record
  language plpgsql
  security definer
as $$
declare
  ...
  result code.result_template%rowtype;
  ...
begin
  ...
end;
$$;
```

create_code_objects.sql — cont.

```
declare
  row record;
  result code.result_template%rowtype;
  ds varchar[] := array[]::varchar[];
  n int not null := 0;
  first_m varchar(10) not null := '?';
begin
  for row in (
    -- left outer join to allow for the possibility that master has no details.
    select m.v as mv, d.v as dv
    from data.masters m left outer join data.details d using (mk)
    where m.v = the_mv
    order by 1, 2)
  loop
    n := n + 1;
    if n = 1 then
      first_m := row.mv;
    end if;
    ds := ds||row.dv;
  end loop;


  if n < 1 then
    raise exception 'The key "%" does not exist', the_mv
    using errcode = '99998';
  end if;


  result.m := the_mv;
  result.ds := ds;
  return result;
end;
```

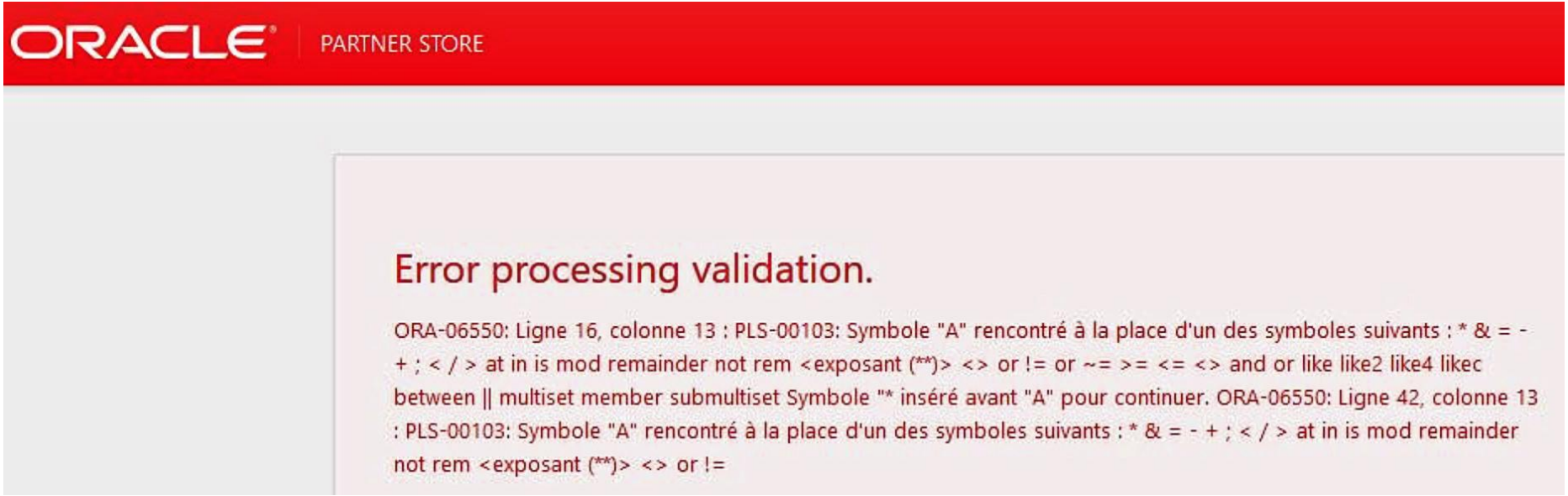
create_code_objects.sql – cont.

```
revoke all on function code.report_master_and_details(
  the_mv in varchar)
from public;



grant execute on function code.report_master_and_details(
  the_mv in varchar)
to api;



-- Not yet supported in YugabyteDB Version 2.0.1
alter function code.report_master_and_details(
  the_mv in varchar)
set search_path = code;
```

The api objects

create_api_objects.sql

```
create procedure api.insert_master_and_details(
  m in varchar,
  ds in varchar[])
  language plpgsql
  security definer
as $$
declare
  ...
begin
  ...
end;
$$;
```



create_api_objects.sql — cont.

```
declare
  the_sqlstate      varchar not null := '?';
  the_error_message varchar not null := '?';
begin
  call code.insert_master_and_details(m, ds);
exception when others then
  -- 15 lines of bolerplate text. But there's no better way.
 if sqlstate = '99998' then
    -- Expected but regrettable error
    raise exception 'Expected error: %', sqlerrm
    using errcode = '99998';
  else
    -- Unexpected error
    get stacked diagnostics
      the_sqlstate      = returned_sqlstate,
      the_error_message = message_text;

    raise exception '%',
      api_utils.formatted_error_info(the_sqlstate, the_error_message)
      using errcode = '99999';
  end if;
end;
```

Exercising the client functionality

```
-- Demo time
```

```
\c app client
```

```
select schema_name from information_schema.schemata;
```

```
    schema_name
--------------------
 information_schema
 pg_catalog
 api
```

```
\df
```

```
 Schema |                Name                |      Result data type      |            Argument data types             | Type
--------+------------------------------------+----------------------------+--------------------------------------------+------
 api    | insert_master_and_details          |                            | m character varying, ds character varying[] | proc
 api    | report_master_and_details          | record                     | the_mv character varying                   | fun
```

```
-- Demo time

call insert_master_and_details(
  'Mary',
  array['soap', 'towel', 'toothbrush', 'shampoo']);



select report_master_and_details('Mary')
  as "Mary and her details";
```

```
          Mary and her details
----------------------------------------
 (Mary,"{shampoo,soap,toothbrush,towel}")
```

```
-- Demo time

call insert_master_and_details(
  'Joan',
  array[]::varchar[]);

ERROR:
Expected error: Cannot insert master "Joan" with no details.

call insert_master_and_details(
  'Mary',
  array['screwdriver', 'saw']);

ERROR:
Something appears to have gone wrong. Contact Support with this info:
  Incident timestamp: 23:09:03 23-Oct-2019
  sqlstate:           23505
  error message:      duplicate key value violates
                      unique constraint "masters_v_unq"
```

```
-- Demo time

\c app data


select mk, m.v, d.v, d.dk
from data.masters m
     left outer join
     data.details d using (mk)
order by mk, d.dk;


delete from data.masters
where v in ('Mary', 'John', 'Alice', 'Bill', 'Joan');
```

```
-- Demo time

\c app client

show server_version;

create table api.t(n int);
create table pg_catalog.t(n int);
create table information_schema.t(n int);

create procedure p()
  language plpgsql
  security definer
as $$
begin
  raise info 'hello from api.p()';
end;
$$;
```

Summary

Benefits of encapsulating the database behind a hard shell API

- **Correctness**
  - Separation of skills and concerns
  - The right experts own their own tersely coupled modules
  - Type safety
- **Security**
  - Limit visibility of objects (directly and via error messages)
  - Implicit SQL-injection proofing
- **Performance**
  - Minimization of client-server round trips
  - Prepare-execute paradigm with no coding effort

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