Are Stored Procedures a Good Thing?

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YFTT YugabyteDB Friday Tech Talks

yugabyteDB

History Lesson

When and why did RDMSs first support stored procedures?

- Stored procedures were first supported by RDBMSs in the late 1980s

  Back then, there were only commercial RDBMSs

- Motivation:
  - So-called “run authority”
  - Ownership of responsibility for correct SQL
  - *Esp.* guaranteed atomicity for multi-statement transactions
  - Round-trip reduction for multi-statement transactions

Some Ancient Wisdom

Modular software construction—decades-old wisdom

- Large software systems must be built from modules
- The RDBMS is a module—no less when it's a Distributed SQL system
- "Hard shell" paradigm
- "Result happiness" versus "Result misery" *

* *"Annual income twenty pounds, annual expenditure nineteen nineteen and six, **result happiness**. Annual income twenty pounds, annual expenditure twenty pounds ought and six, **result misery**."* — David Copperfield, 1850

Large software systems must be built from modules

- A module encapsulates specified, coherent functionality
- An API exposes the functionality
- All implementation details are scrupulously hidden behind this API
- Nobody would dream of challenging these notions

The RDBMS is a module—no less when it's a Distributed SQL system

- When an application uses an RDBMS, this is surely a module at the highest level of top-down decomposition
- The structure of the tables, the rules that constrain their rows, and the SQL statements that read and change these rows, are the implementation details
- The API defines and implements the set of atomic business transactions and queries that the database must support
- PostgreSQL, and therefore YSQL, provide subprograms in SQL and in PL/pgSQL to express the API

The “hard shell” paradigm

Use stored procedures*
to encapsulate
the RDBMS’s functionality
behind an impenetrable hard shell API

** I prefer to say “**subrograms whose definitions are stored in the database and that execute in the same process that top-level SQL executes in**”. But “stored procedures” will do as a shorthand.*

The “bag of tables” paradigm

“We don’t use stored procedures.”

All our table have a single owner
and live in a single schema.
Client code can read change
all table content
and even drop and create tables.

“Result happiness” versus “Result misery”

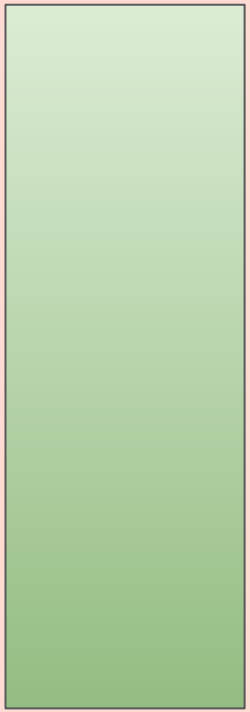
- I’ve spoken to a huge number of developers of database application over the years

- Those who follow the ***hard shell*** paradigm:
  - Are mainly *happy* with their apps
  - Express themselves coherently
  - Explain well how their apps are architected
  - Ask clear questions
  - Make sensible requests for enhancements

- Those who follow the ***bag of tables*** paradigm:
  - Are mainly *miserable*
  - Are hard to understand

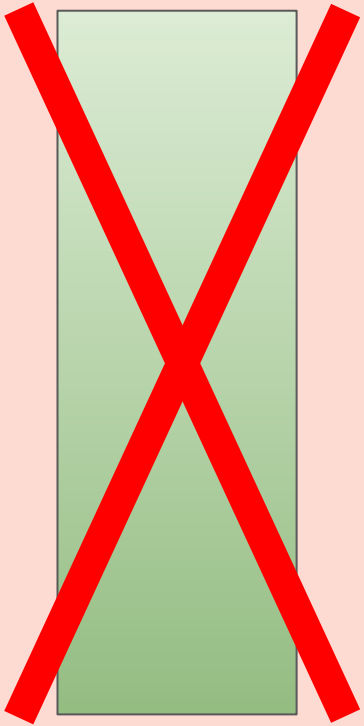
Hard Shell in Easy Pictures

public



“app” database

public



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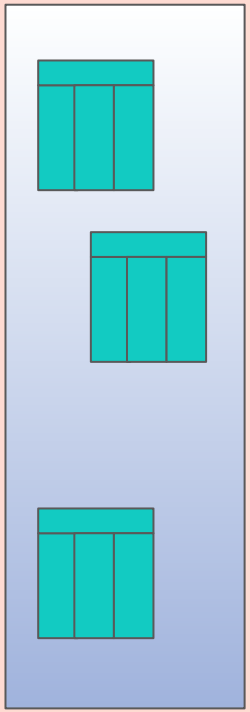
“app” database

data



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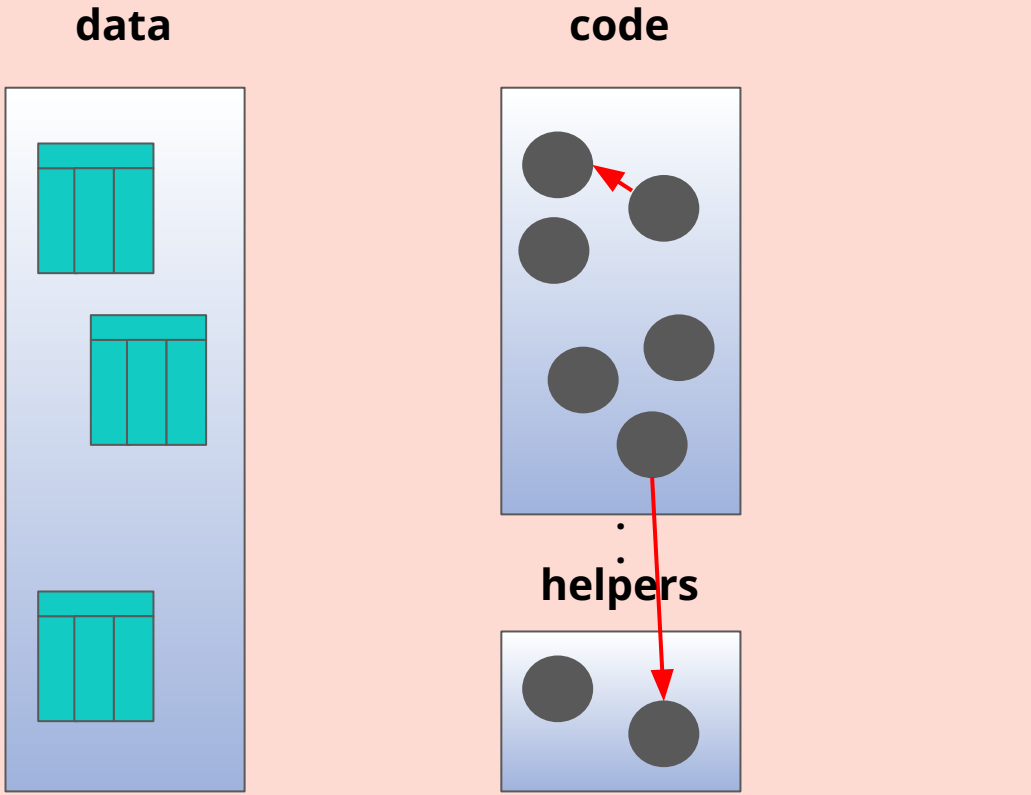

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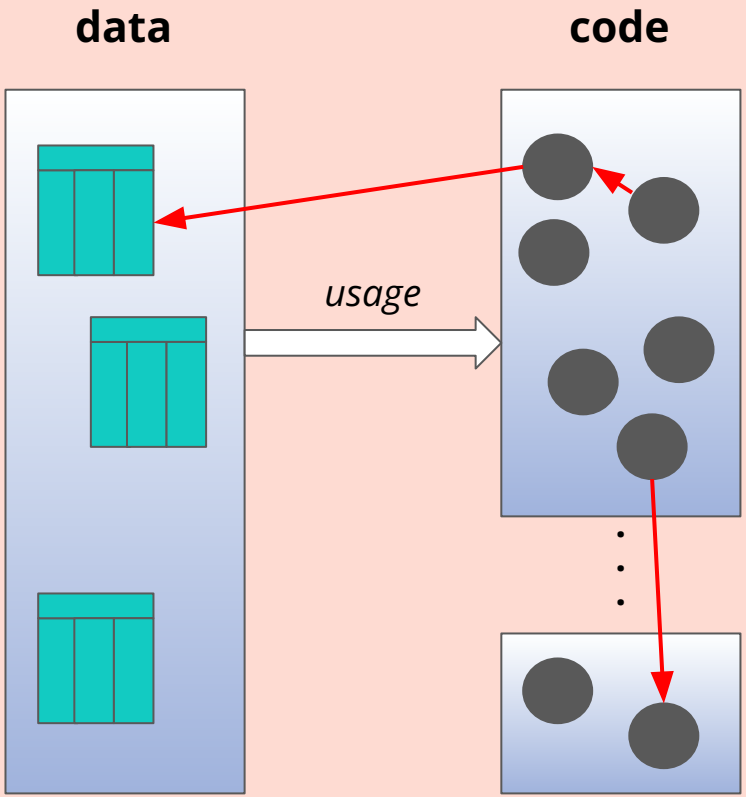

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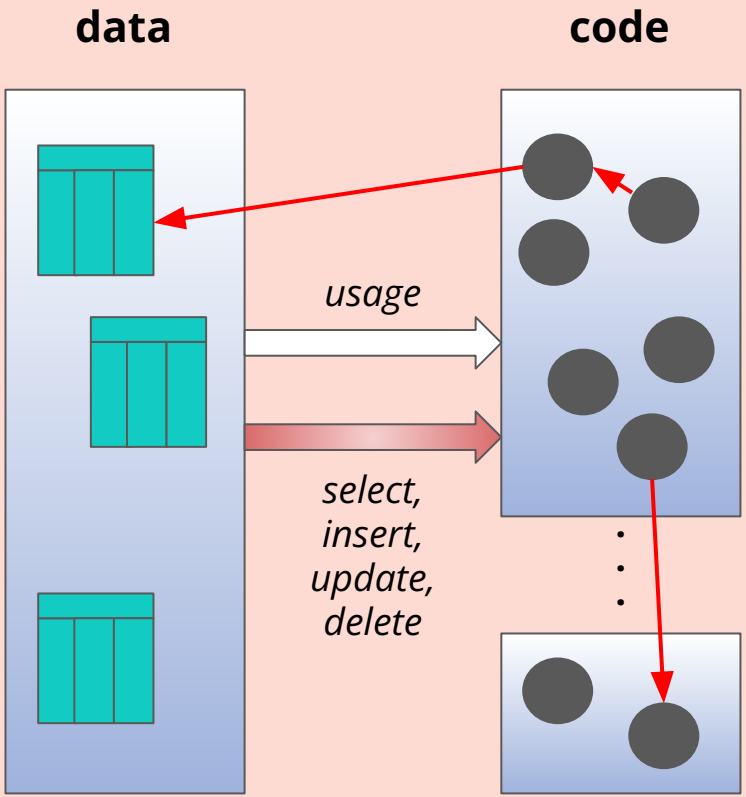

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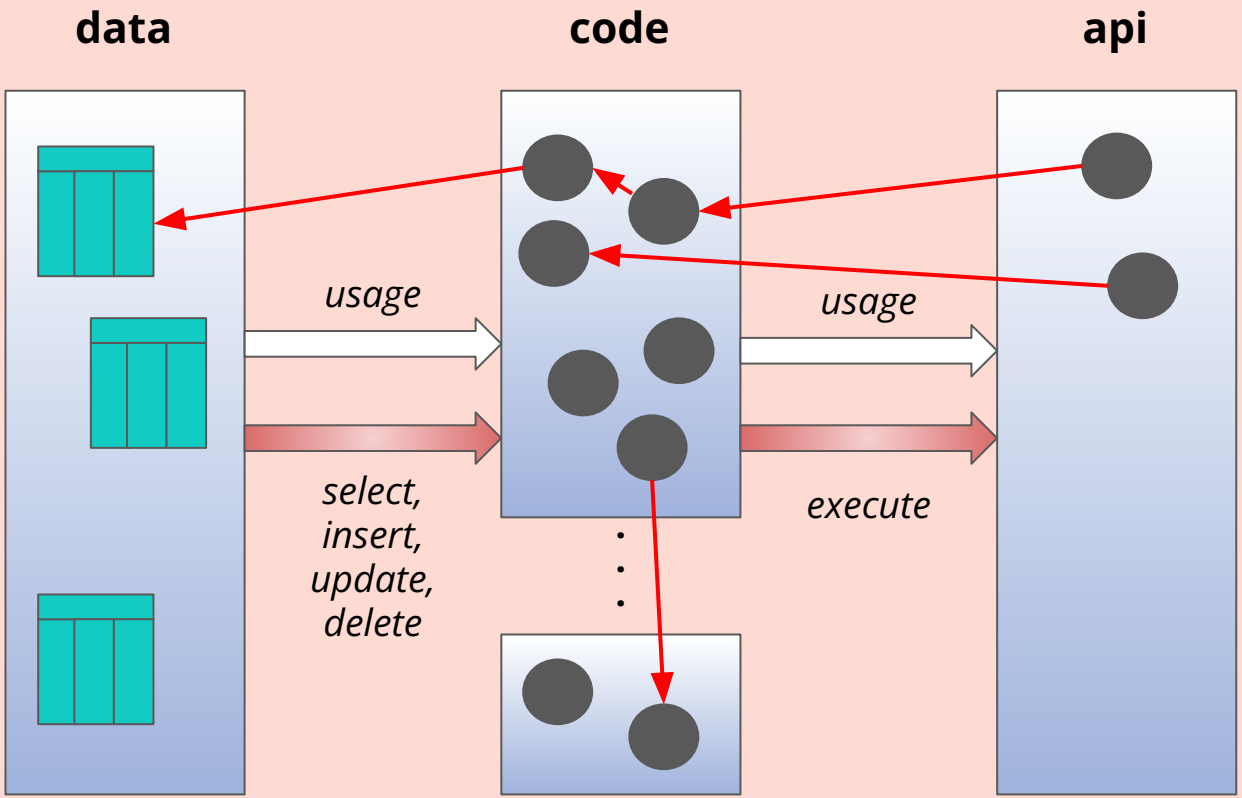

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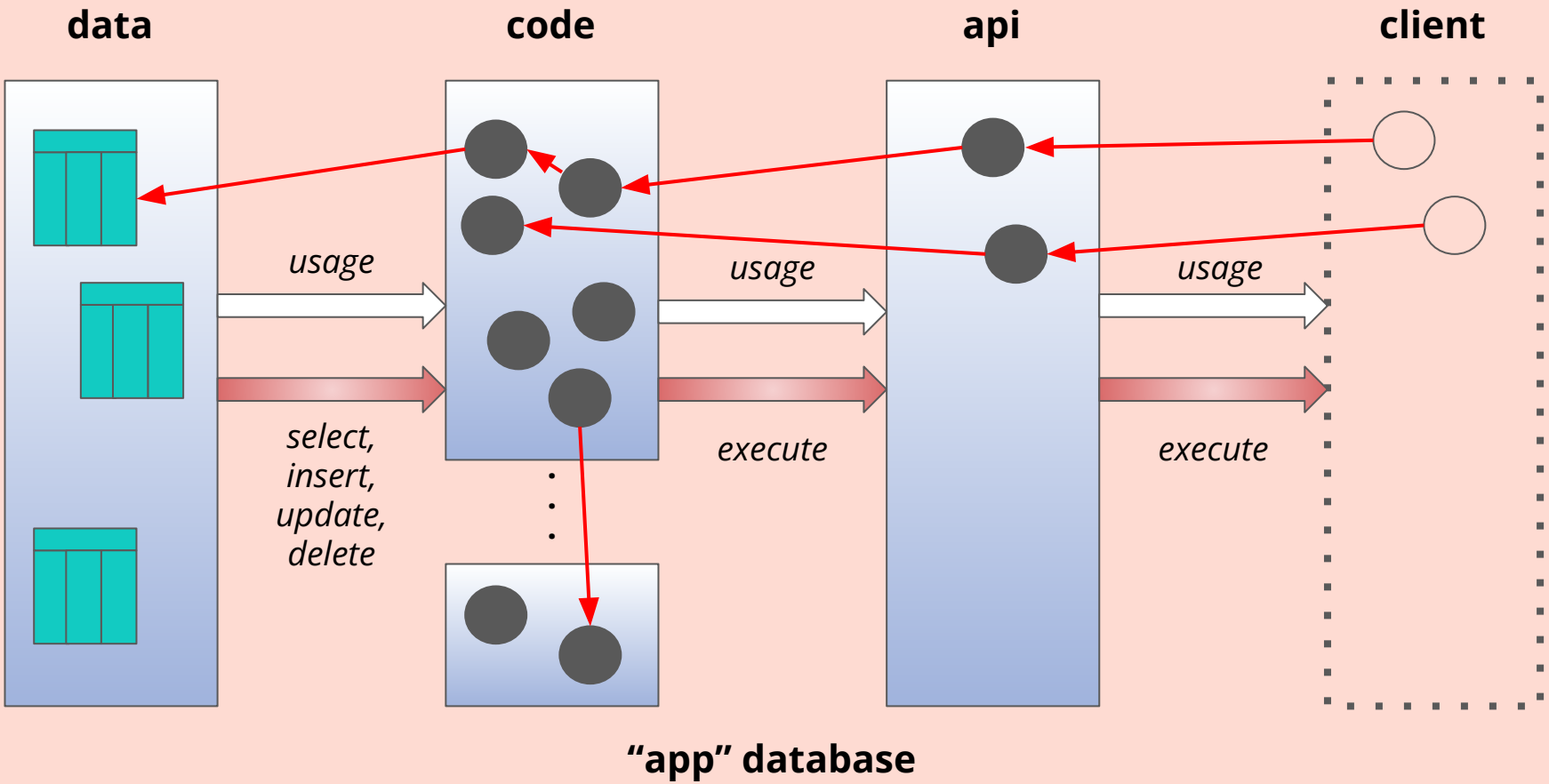
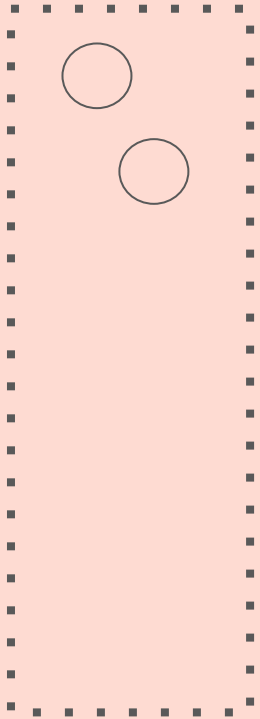
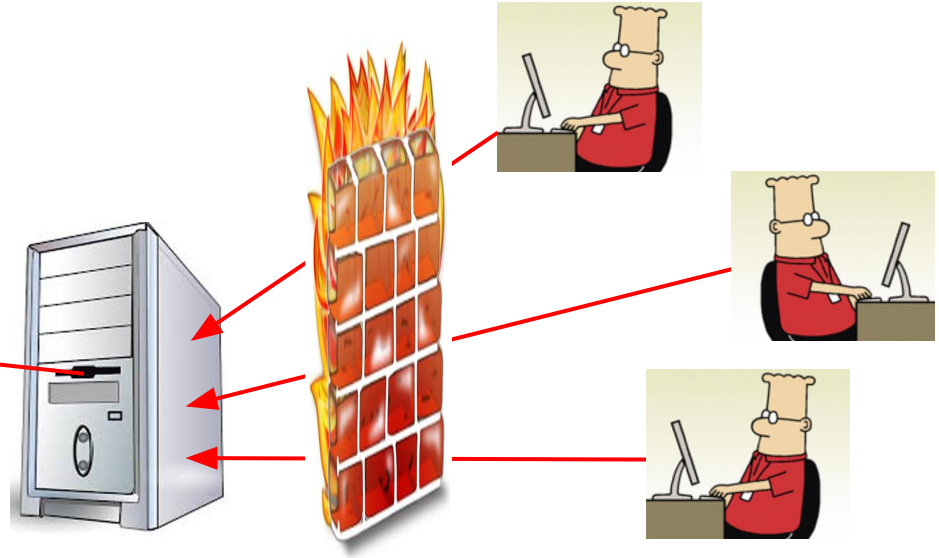


client

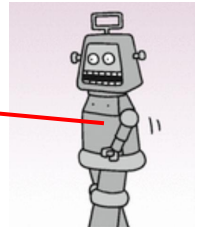


“app” database

ui_client



robot_client



“app” database

Don’t Let This Happen…

Everybody has seen something like this…

Express the API as a Set of JSON-In / JSON-Out Procedures

Client-side environments have different type systems than YSQL

- JSON was invented as a generic data interchange format between systems with different type systems

- All modern client-side programming environments have built-in functionality to transform, in each direction, between an arbitrarily complex compound value and its JSON representation

- YSQL inherits PostgreSQL's corresponding built-in functionality

- The natural, easy, and best design choice is to parameterize the hard shell API as JSON-in / JSON-out procedures
  - *"REST, JSON, And All That: A Memorable History of Client/Server communication"*

Why express the API as procedures and not functions?

- Procedures and functions are different

- A procedure *does* something
  - It's invoked with the *call* statement—meaning "do this"
  - It's named with an imperative verb (phrase)
  - But it can also have "out" arguments

- A function *names* a computed value
  - It's invoked as a term in an expression (in SQL or in PL/pgSQL)
  - It's named with an noun (phrase)—just as you name a column or a variable
  - Functions should not have side-effects
  - So a function with "out" arguments is a nasty anti-pattern

Every single API subprogram might need to *do* something

- Something can always go wrong—like with the Oracle Partner Store's *ORA-06550*
  - Even a query can go wrong if it expects exactly one row for a business unique key
  - It might get no rows — like you mentioned a non-existent order number
  - It might get *many* rows — meaning and earlier constraint-enforcement error

- Such application errors must *never* escape the database
  - the ORA-06550 error says that the app constructed a subprogram that had a syntax error

- So these "unexpected" errors (i.e. developer bugs) must be recorded in an *incidents* table
  - Inserting a row is *doing* something!

The Use Case for the Demo App

Classic (agnostic) master-details Create and Read

```
create table data.masters(
  mk uuid default gen_random_uuid()
    constraint masters_pk primary key,
  v text not null
    constraint masters_v_unq unique
    constraint masters_v_chk check(length(v) <= 10));

create table data.details(
  mk uuid,
  dk uuid default gen_random_uuid(),
  v text 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));
```

Create new master and details or new details for existing master (bad)

```
create type m_and_ds_ as(m text, ds text[]);

create procedure do_insert(this in m_and_ds_)
  language plpgsql
as $body$
declare
  ...
begin
  begin
    insert into masters(v) values(this.m) returning mk into new_mk;
  exception when unique_violation then
    select mk into new_mk from masters where v = this.m;
    new_master := false;
  end;

  if cardinality(this.ds) > 0 then
    -- Notorious anti-pattern: many single row SQLs in a loop.
    foreach d in array this.ds loop
      insert into details(mk, v) values(new_mk, d);
    end loop;
  end if;
end;
$body$;
```

Aside — Brief tutorial on "cross join lateral" with "unnest(arr)"

```
create table t(
  m text not null,
  d text not null,
  constraint t_pk primary key(m, d));

create type facts as(m text, ds text[]);


with c(v) as (
  select ('Joe', array['fork', 'spoon', 'knife'])::facts)
insert into t(m, d)
select (c.v).m, arr.d
from
  c
  cross join lateral
  unnest((c.v).ds) as arr(d);


select m, d from t order by m, d;

  m  |   d
-----+-------
 Joe | fork
 Joe | knife
 Joe | spoon
```

Create new master and details or new details for existing master (good)

```
create type m_and_ds_   as(m text,  ds text[]);
create type mk_and_ds_  as(mk uuid, ds text[]);

create procedure do_insert(this in m_and_ds_)
  language plpgsql
as $body$
declare
  ...
begin
  begin
    insert into masters(v) values(this.m) returning mk into new_mk;
  exception when unique_violation then
    select mk into new_mk from masters where v = this.m;
    new_master := false;
  end;

  if cardinality(this.ds) > 0 then
    -- Optimal: on single "bulk" SQL.
    with c as (
      select (new_mk, this.ds)::mk_and_ds_ as v)
    insert into details(mk, v)
    select (c.v).mk, arr.d
    from c cross join lateral unnest((c.v).ds) as arr(d);
  end if;
end;
$body$;
```

Recap — Anti-pattern: insert many “details” rows one-by-one in a loop

```
create procedure do_insert(this in m_and_ds_)
  language plpgsql
as $body$
declare
  ...
begin
  begin
    insert into masters(v) values(this.m) returning mk into new_mk;
  exception when unique_violation then
    select mk into new_mk from masters where v = this.m;
    new_master := false;
  end;

  if cardinality(this.ds) > 0 then
    foreach d in array this.ds loop
      insert into details(mk, v) values(new_mk, d);
    end loop;


  end if;
end;
$body$;
```

Recap — Optimal: insert many “details” rows with one single “bulk” SQL

```
create procedure do_insert(this in m_and_ds_)
  language plpgsql
as $body$
declare
  ...
begin
  begin
    insert into masters(v) values(this.m) returning mk into new_mk;
  exception when unique_violation then
    select mk into new_mk from masters where v = this.m;
    new_master := false;
  end;

  if cardinality(this.ds) > 0 then
    with c as (
      select (new_mk, this.ds)::mk_and_ds_ as v)
    insert into details(mk, v)
    select (c.v).mk, arr.d
    from c cross join lateral unnest((c.v).ds) as arr(d);
  end if;
end;
$body$;
```

Read existing master and its details

```
create type m_and_ds_   as(m text,  ds text[]);

create function master_and_details_report(mv_in in text)
  returns m_and_ds_
  language plpgsql
  security definer
as $body$
declare
  m_and_ds m_and_ds_;
begin
  select m.v, array_agg(d.v order by d.v)
  into m_and_ds
  from
    data.masters m
    left outer join
    data.details d
    using (mk)
  where m.v = mv_in
  group by 1
  order by 1;

  return m_and_ds;
end;
$body$;
```

The App-Specific JSON-In / JSON-Out Protocol

procedure insert_master_and_details(j *in text*, j_outcome *inout text*)

No problems

```
call insert_master_and_details(
  '{"m": "Mary", "ds": ["shampoo", "soap", "toothbrush", "towel"]}', '');
```

```
→ {"status": "success"}
```

New-master cannot have dup details

```
{"m": "Arthur", "ds": ["scissors", "saucer", "spatula", "spatula", "scissors"]}
```

```
→ {"reason": "New  master 'Arthur' bad duplicate details: 'scissors','spatula',",
    "status": "user error"}
```

Program bug: forgot to cater for masters_v_chk violation

```
{"m": "Christopher", "ds": []}', '')
```

```
→ {"status": "unexpected error", "ticket": 1}
```

TICKET NO. 1

```
unit:                   procedure code.insert_master_and_details(text, text)
returned_sqlstate:      23514
message_text:           new row for relation "masters" violates check constraint "masters_v_chk"
pg_exception_detail:    Failing row contains (cc93bd34-b68a-4d47-b9e9-0033031cefb7, Christopher).
constraint_name:        masters_v_chk
table_name:             masters
schema_name:            data

pg_exception_context
--------------------
SQL statement "insert into data.masters(v) values(m_and_ds.m) returning mk"
PL/pgSQL function code.insert_master_and_details(text,text) line 17 at SQL statement
SQL statement "call code.insert_master_and_details(j, outcome)"
PL/pgSQL function insert_master_and_details(text,text) line 3 at CALL
```

procedure do_master_and_details_report(j *in text*, j_outcome *inout text*)

No problems

```
call do_master_and_details_report(
  '{"key": "Mary"}', '');
```

```
→ {"status": "m-and-ds report success",
    "m_and_ds": {"m": "Mary", "ds": ["shampoo", "soap", "toothbrush", "towel"]}}
```

Bill doesn't exist

```
{"key": "Bill"}
```

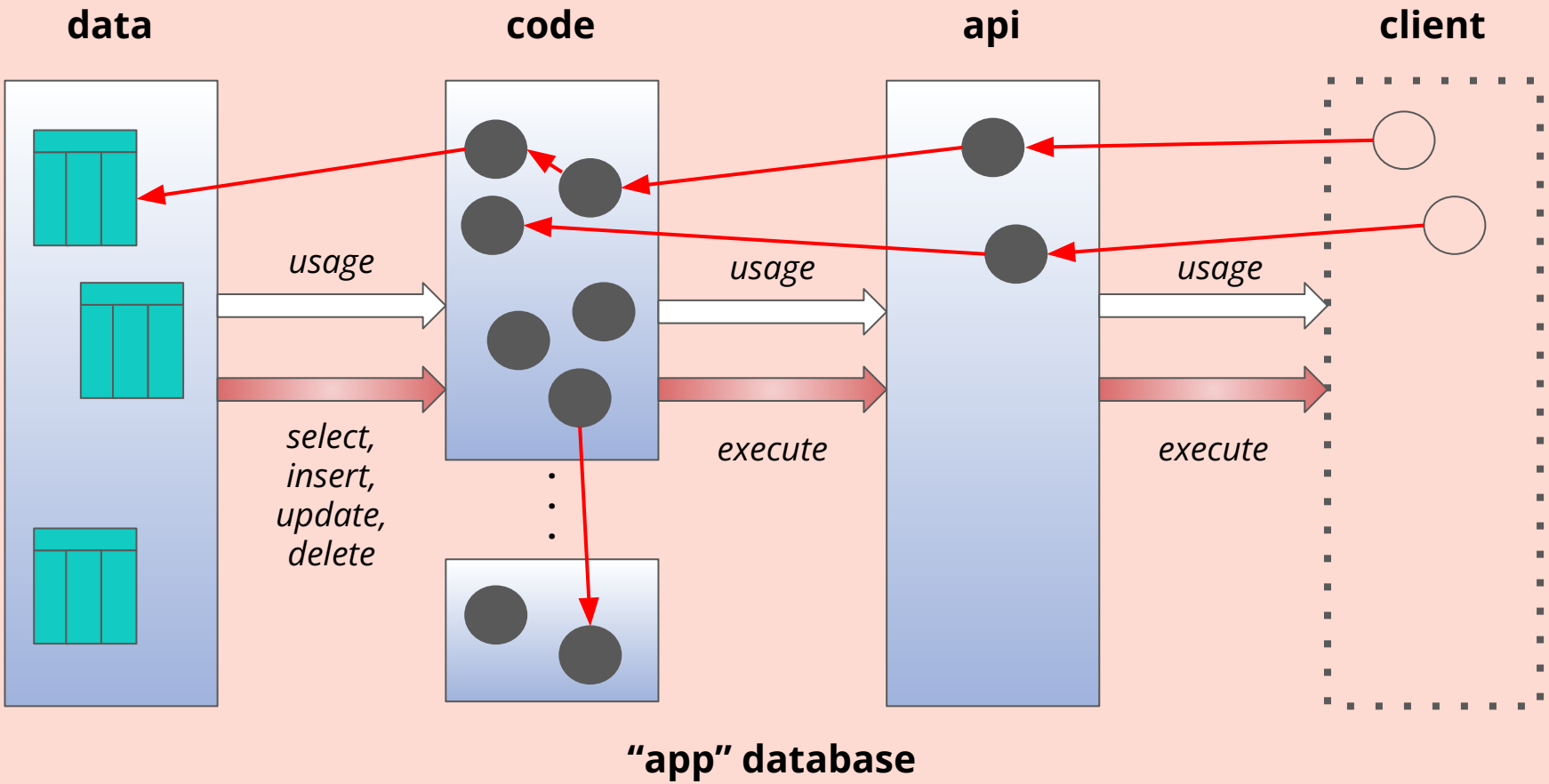
```
→ {"reason": "The master business key 'Bill' doesn't exist", "status": "user error"}
```

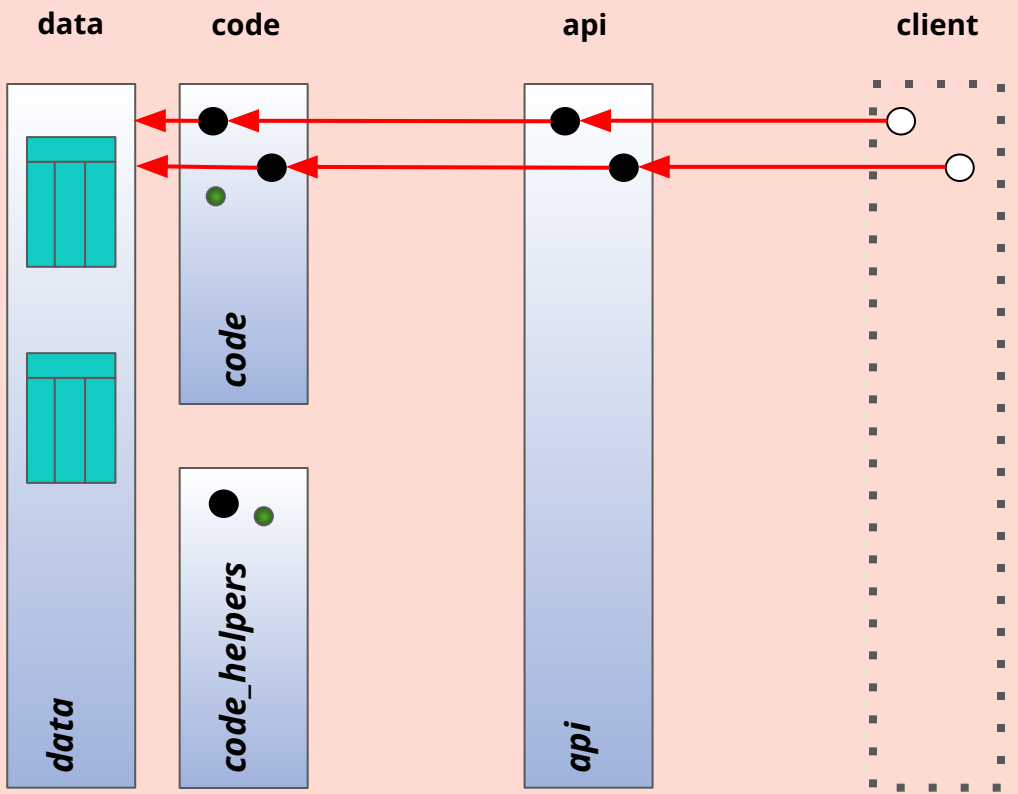
Application program bug: typo "ket" for "key"

```
{"ket": "Fred"}
```

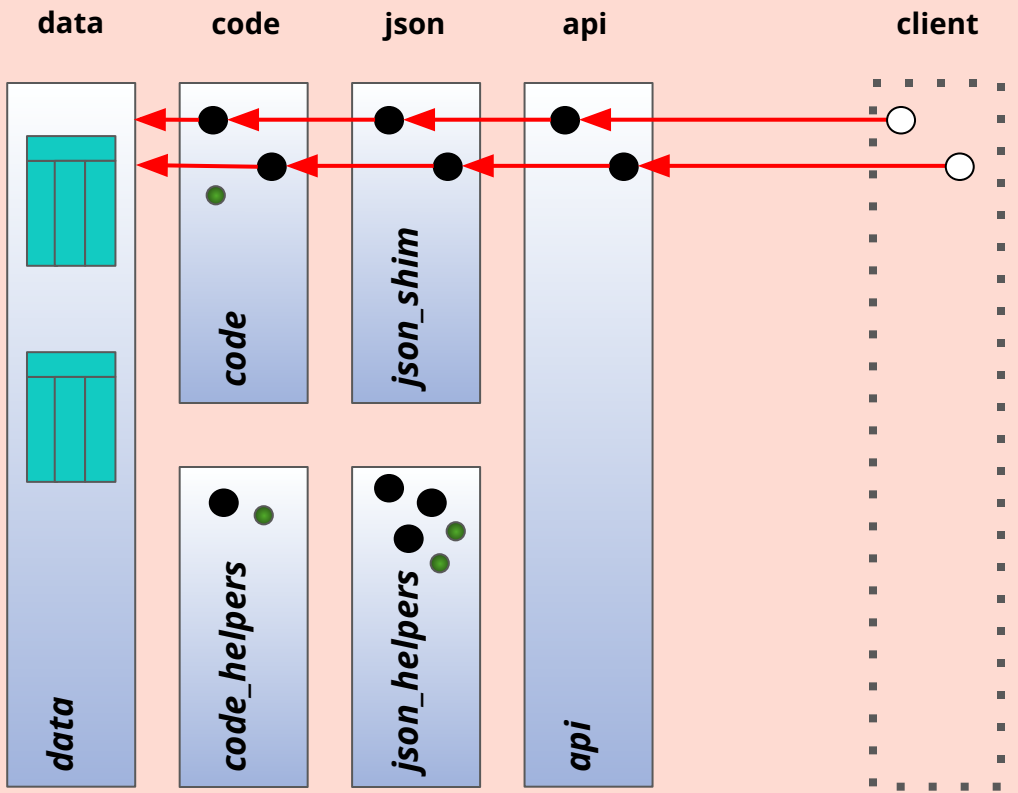
```
→ {"reason": "Bad JSON in: {\"ket\": \"Fred\"}", "status": "client code error"}
```

Users and Schemas: Refined Picture





“app” database



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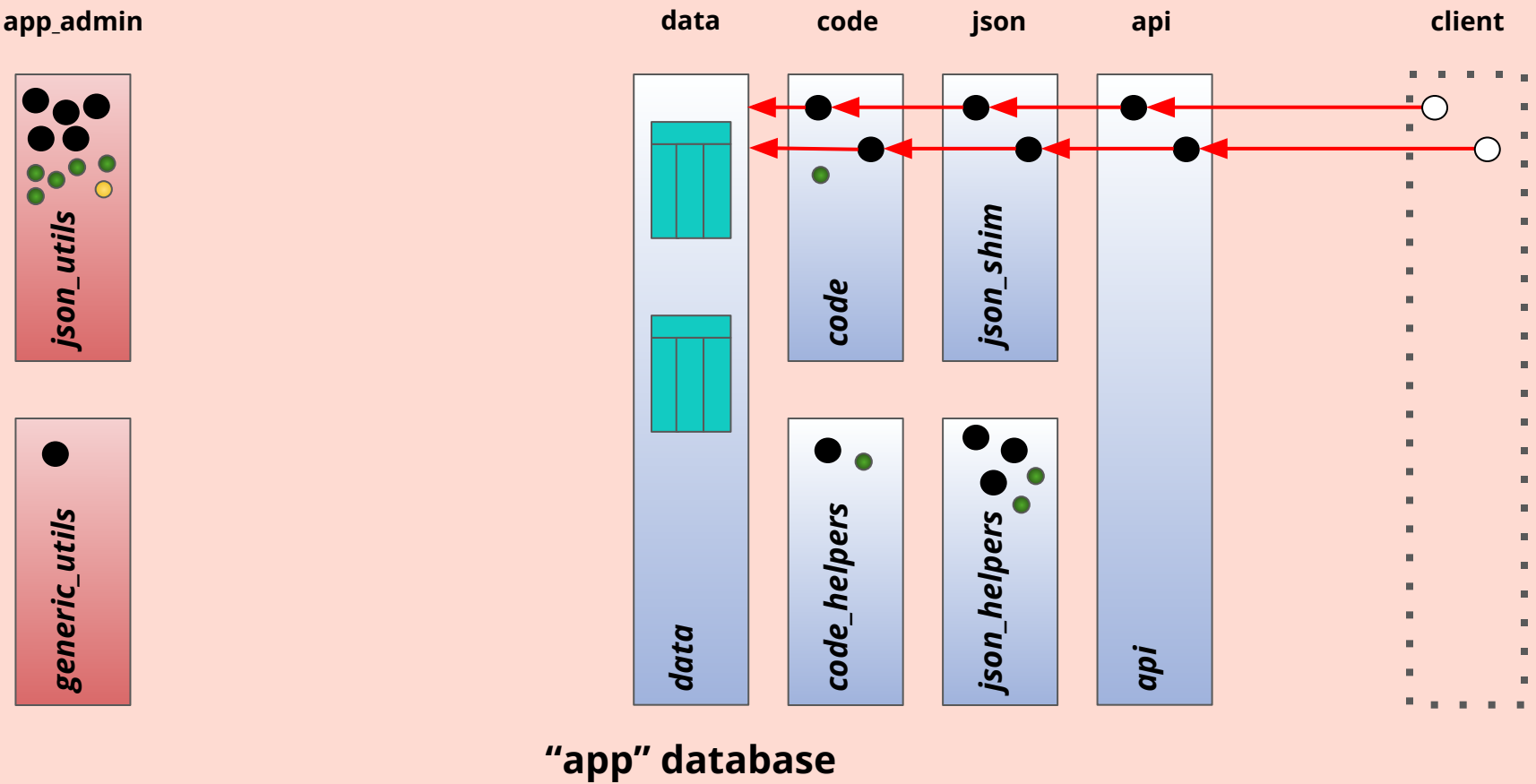

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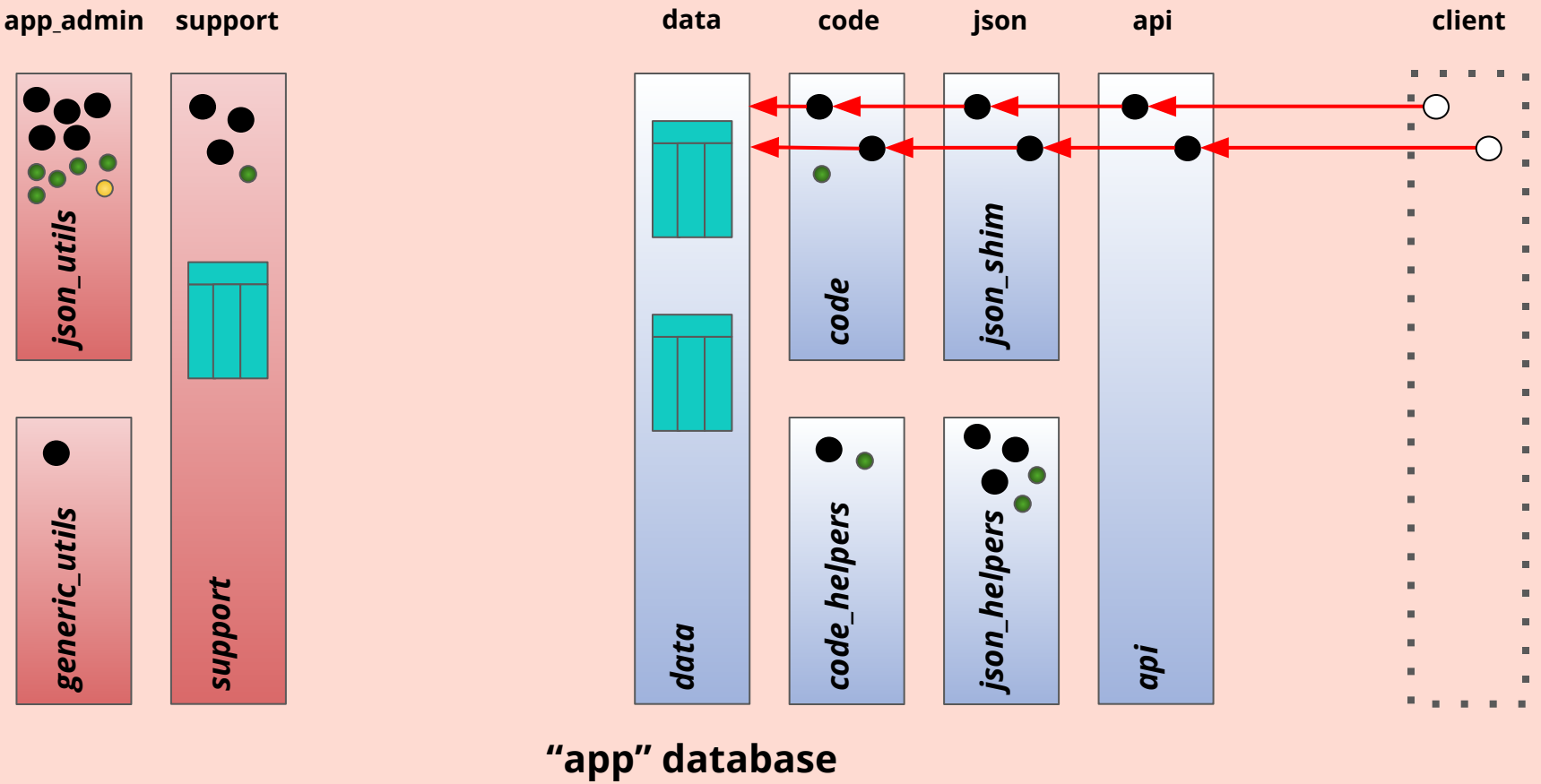

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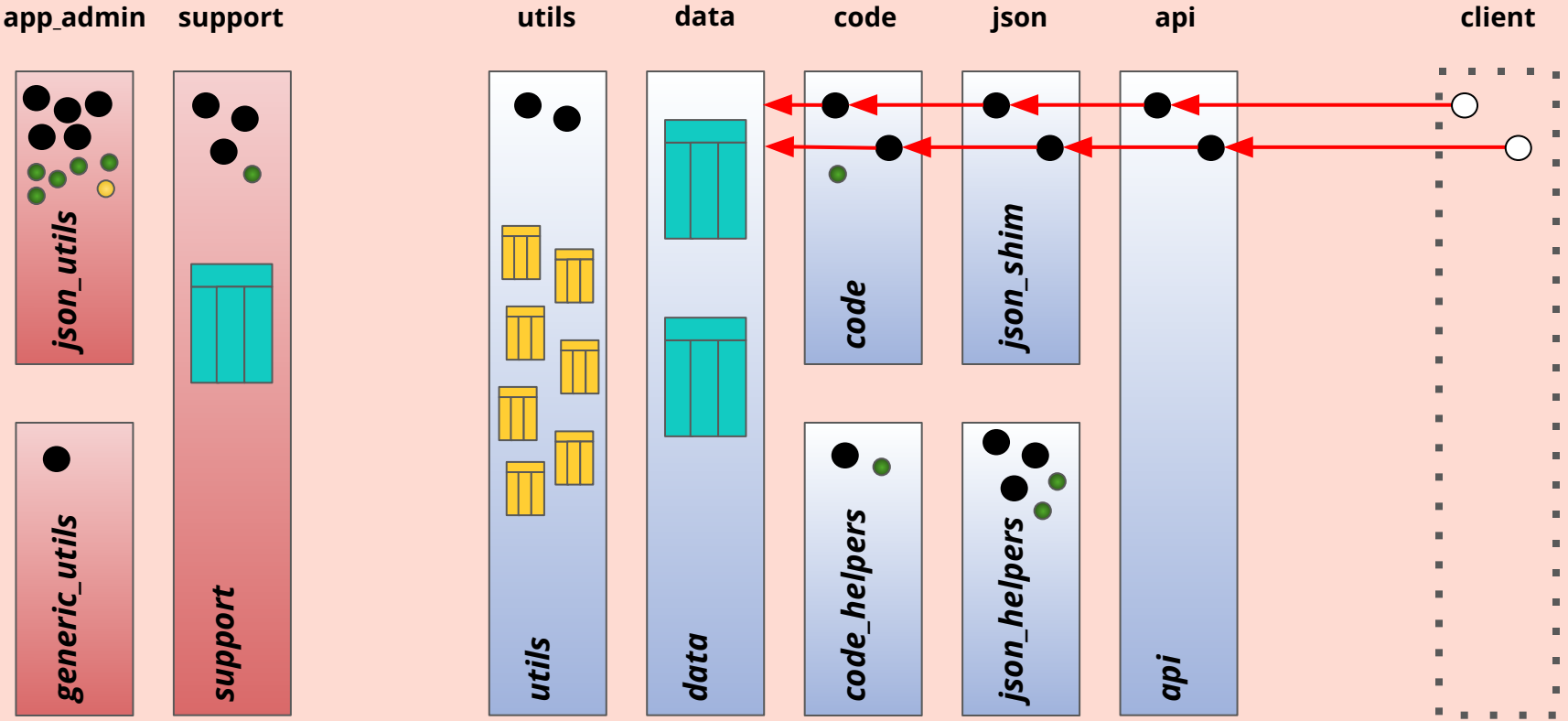

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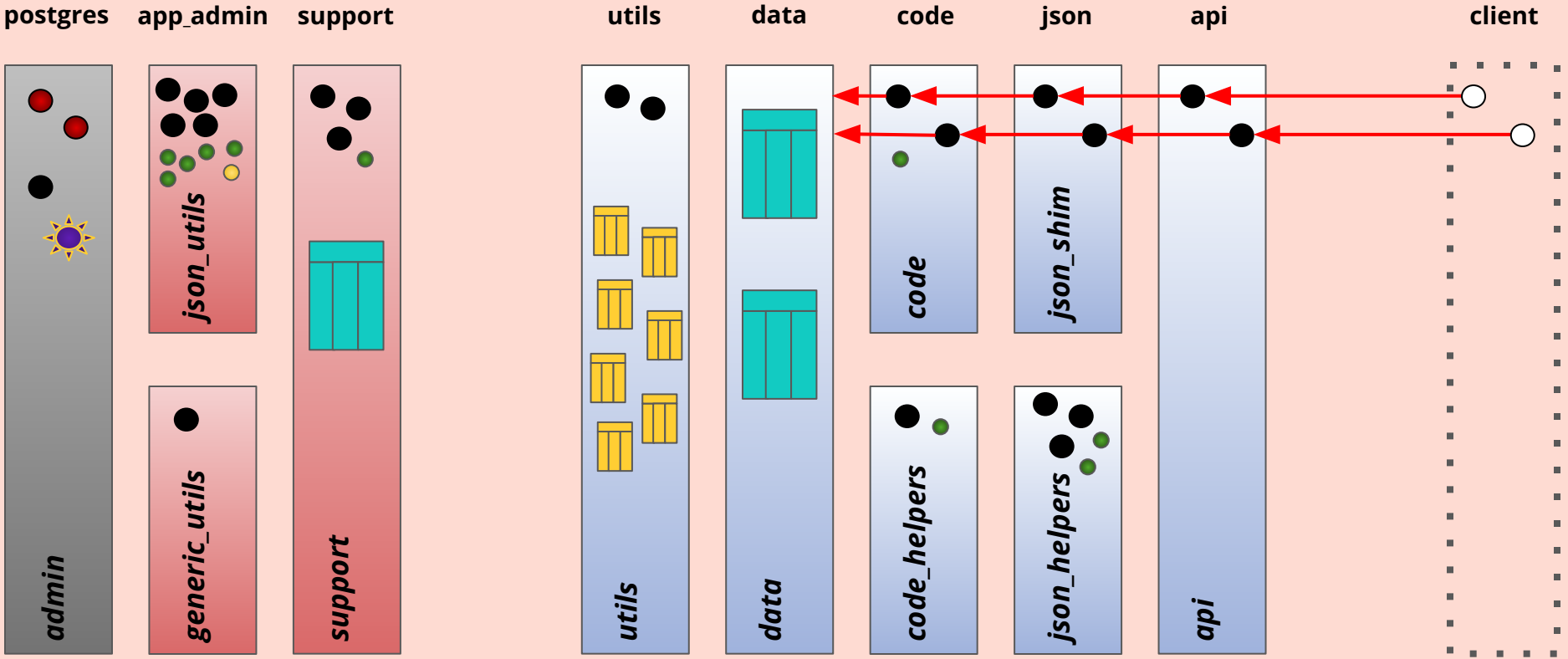

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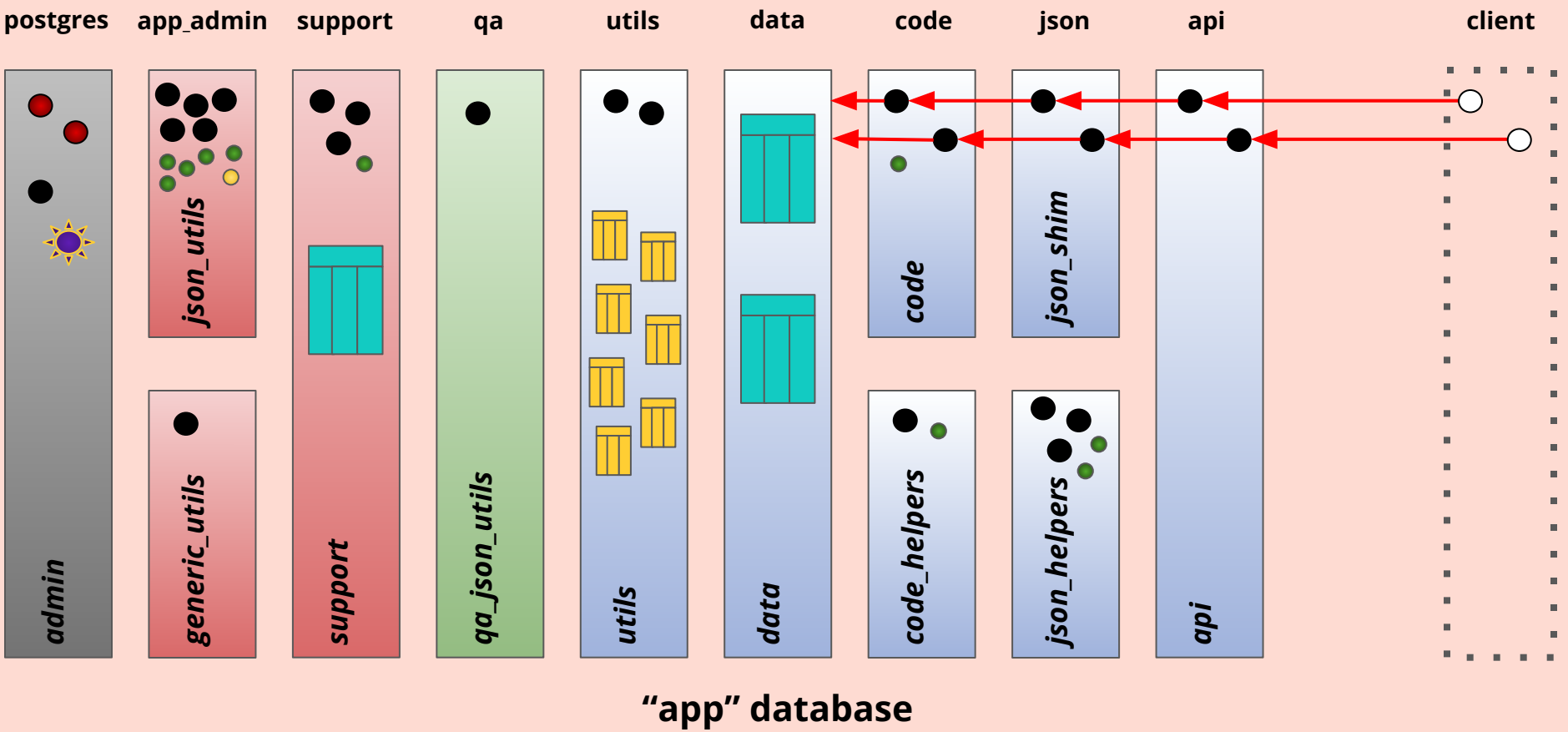

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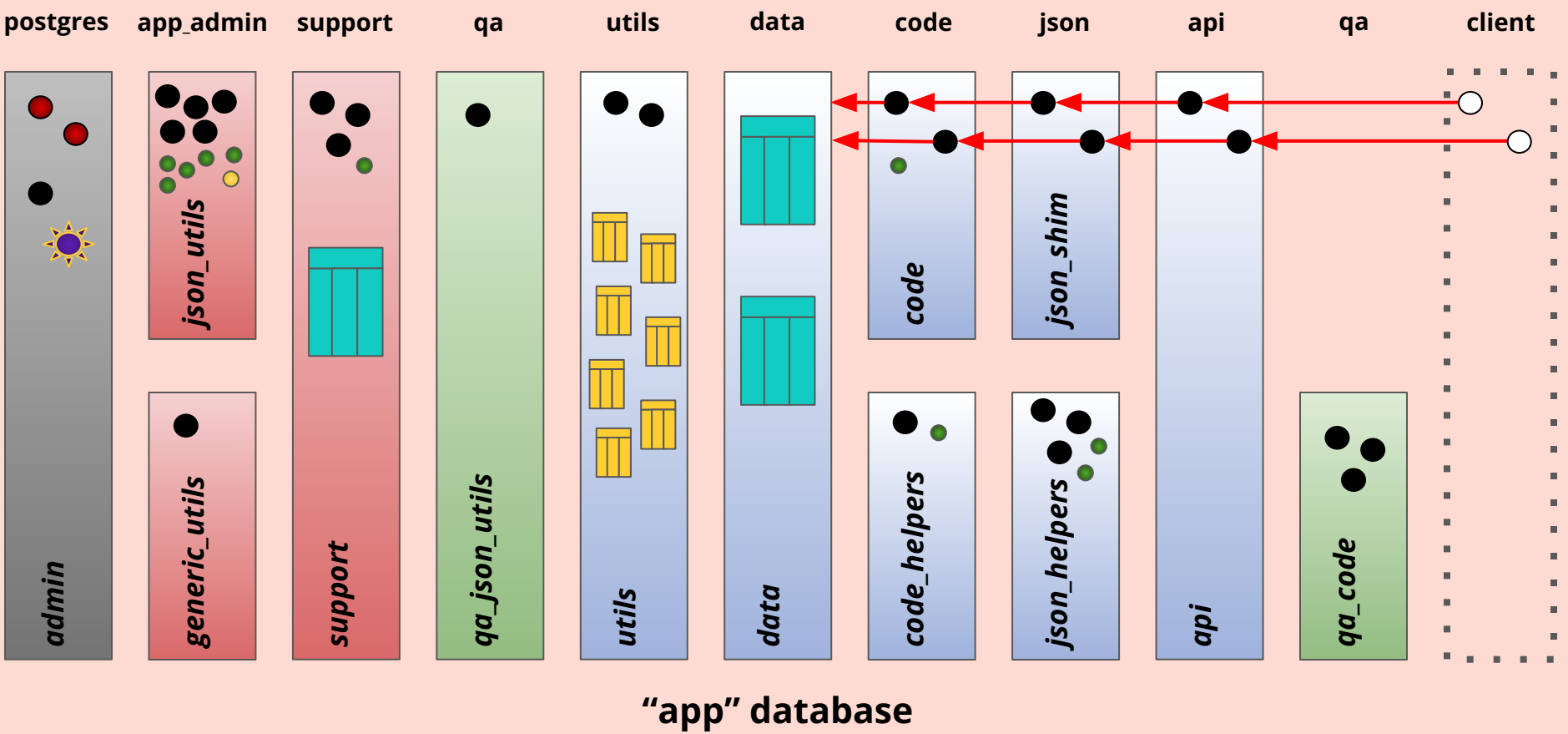

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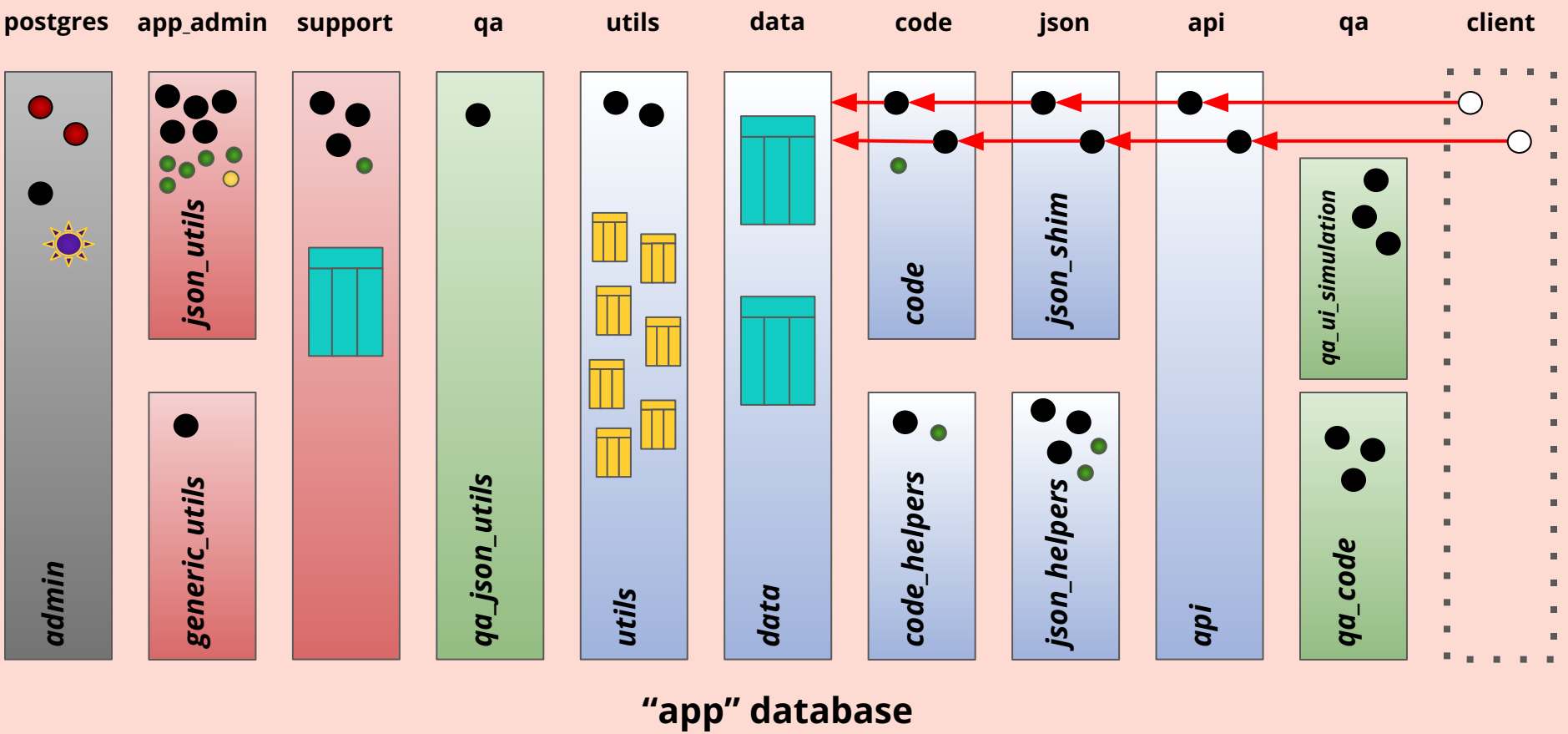

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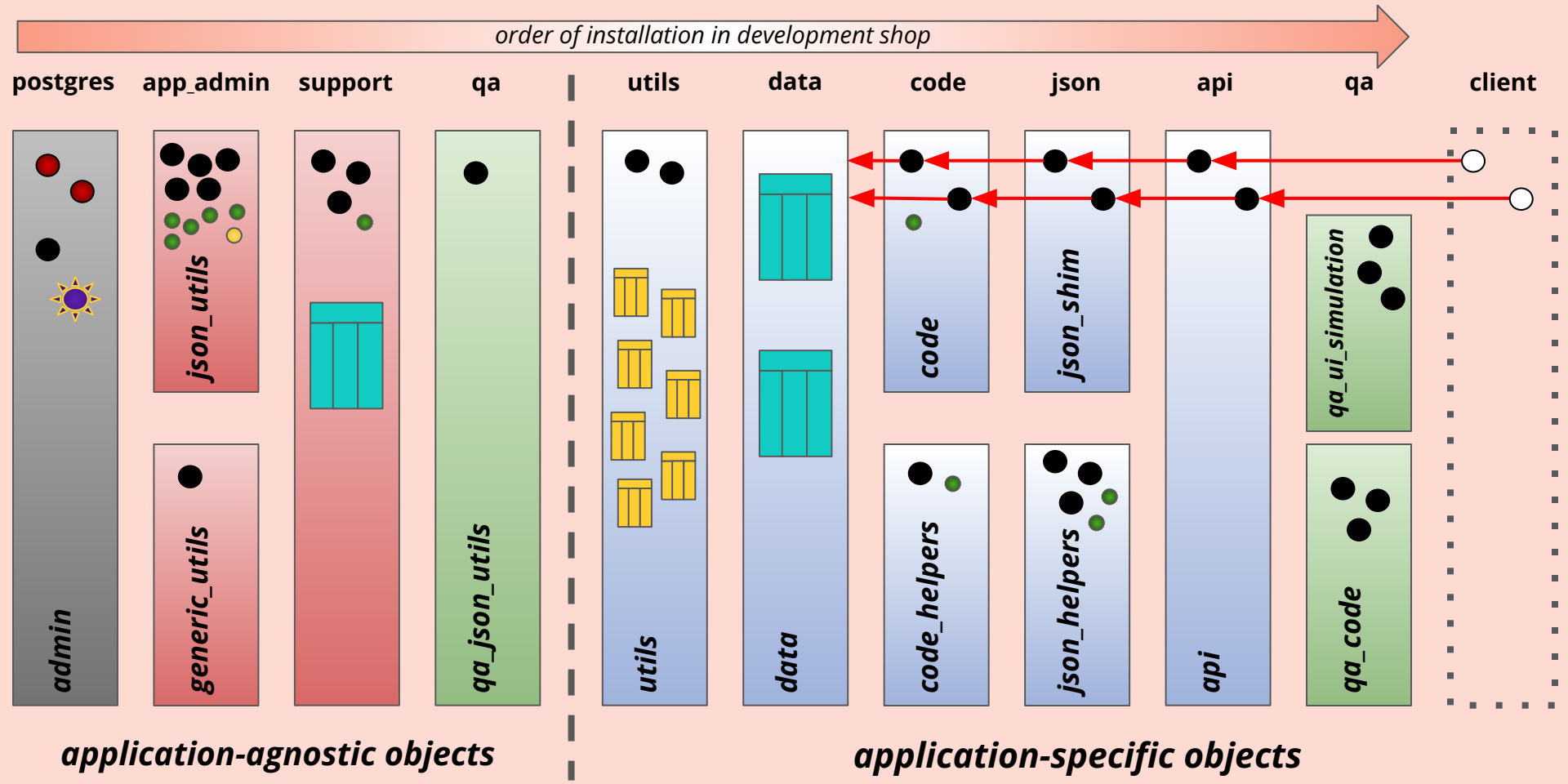

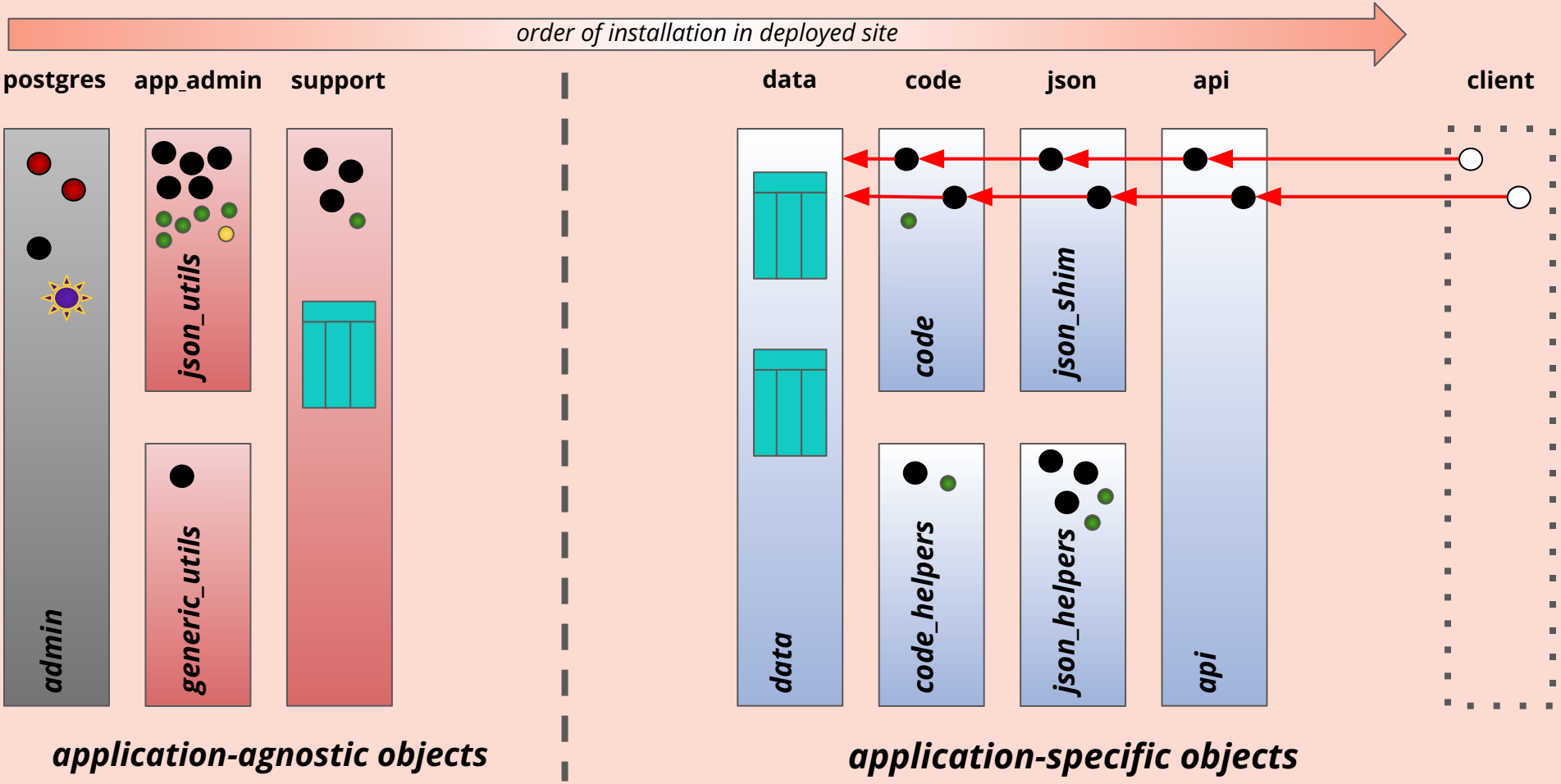

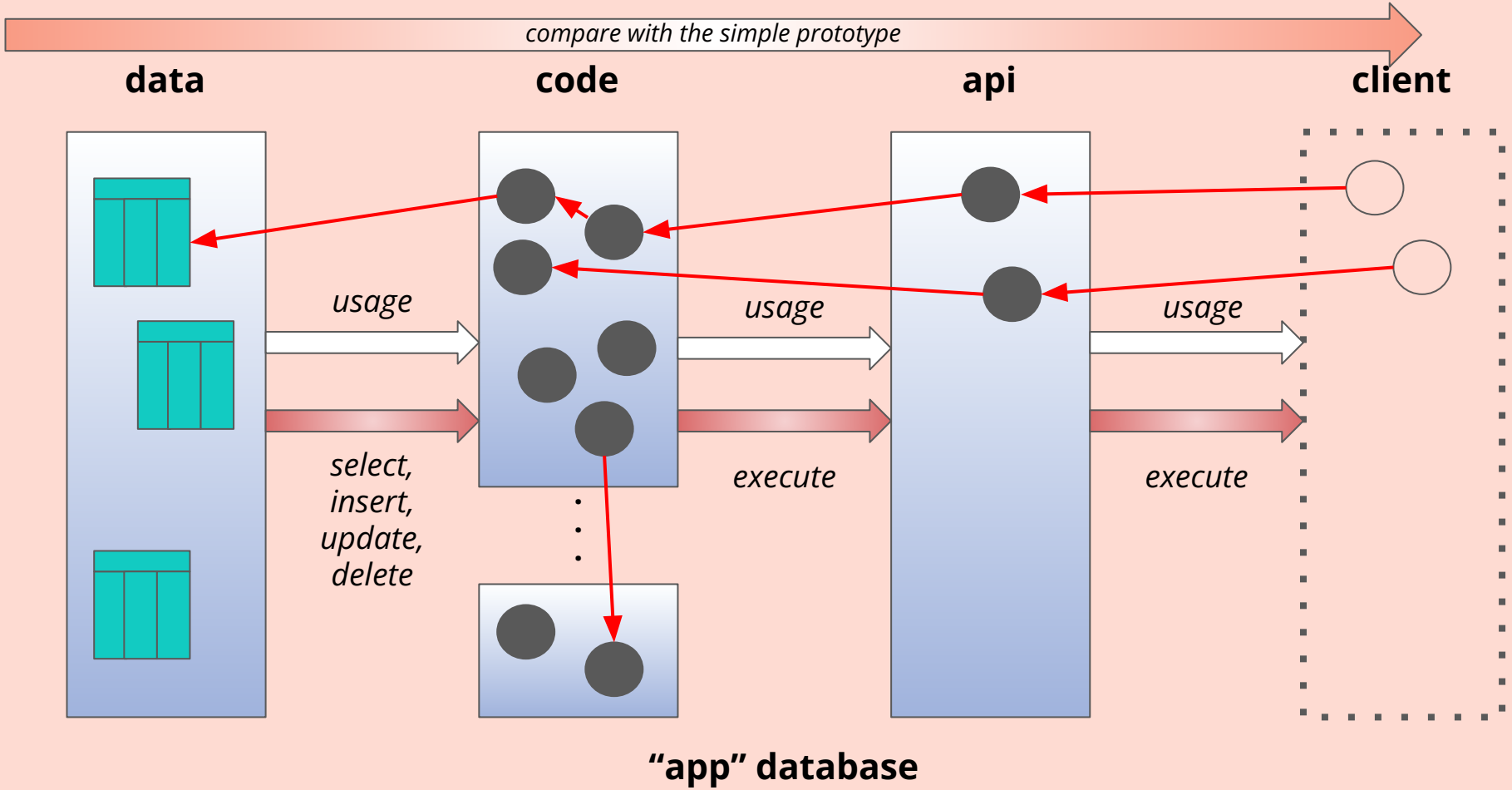

Comparing the final concept with the prototype

- **Modularity** (separation of skills and concerns using *roles* and/or *schemas*)
  - Ordinary SQL DMLs separated from JSON shim
  - Development-shop-only code separated out
    - QA code added
    - “list my objects” views and table functions added

- **Reusability of the overall design concept**
  - Application-agnostic components separated out
    - JSON schema compliance code parameterized (with own, separate QA)
    - Support subsystem

- **Performance**
  - Model accommodates dedicated development shop performance testing code

And Now the Stage is Set…

Over to the Live Demos

Summary

The 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
  - Data type safety

- **Security**
  - Controlled access to objects — client-code can't change or read tables
  - All that you can do is *call proc1(...)*, *call proc2(...)*, ...
  - Implicit, effortless, SQL-injection proofing

- **Performance**
  - Minimization of client-server round trips
  - Prepare-execute paradigm with no coding effort

Thank You

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