Don’t do that!

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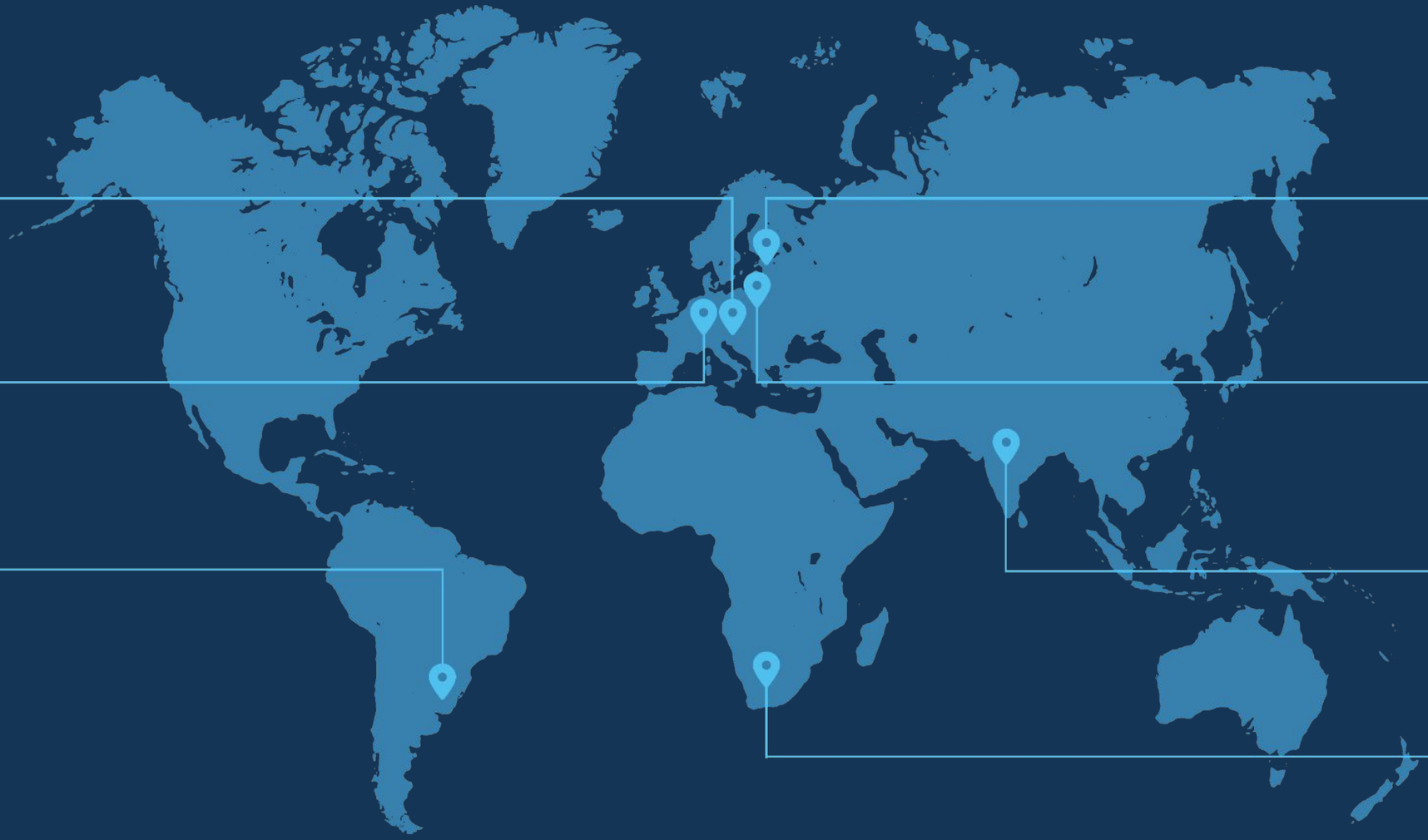

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Introduction

- people keep asking for “best practice”
- I have come to dislike that, because it often means “I don’t want to understand that and I don’t want to think, just tell me what to do”
- it’s much easier to name things that you should avoid
- hence this collection of “worst practices” from my experience as a consultant

Storing timestamps as strings or numbers

Storing timestamps as strings

- it’s a bad idea to store anything as string that isn’t a string
- you’ll end up with dates like `2024-02-30`, `12.4.2024`, `0000-00-00`

  Yes, you could check the values with a check constraint, but using the correct data type checks it automatically.
- `2025-01-23 12:30:00+01` takes 23 bytes as string, but 8 bytes as `timestamp with time zone`
- `'2025-01-23 11:30:00+01' > '2025-01-23 03:30:00-08'` as string

Storing timestamps as offset from the epoch

- don’t store timestamps in seconds since 1070-01-01 00:00:00 UTC
- it’s fundamentally correct, but
  - 1737631800 is harder to read than `'2025-01-23 12:30:00+01'`.
  - date arithmetic becomes more difficult, as you cannot use the timestamp functions and operators directly (and complicated expressions in SQL statements tend to lead to bad performance)
- there are exceptions to this rule, for example if all you ever need to calculate is the difference in seconds
  - but are you sure that the data will never be used for anything else?

About other data types

The same holds for other data types: always use the appropriate database type

- it’s a bad idea to store anything as string that isn’t a string
- store “valid from - valid to” as `tstzrange`
- use PostGIS for geographical coordinates
- use `bytea` for binary data, no encoded string
- use `integer` or `bigint` for integers, not `numeric`
- use `bit varying` for bitmaps
- use `jsonb` for JSON and `xml` for XML

Using 4-byte `integer` for auto-generated primary keys

The problem with auto-generated `integer` keys

- the maximum integer is 2^31 - 1 = 2147483647
- don’t make the same mistake as the people who thought that 2^32 IP addresses would be all mankind could ever need!
- sequence values get “lost” on rollback
- your table might grow bigger than you thought
  (or you might delete and insert a lot)
- The canonical solution for the problem:

  ```
  ALTER TABLE tab ALTER id TYPE bigint;
  ```

  will rewrite the table ⇒ causes a long down time

Good practice: use `bigint`

- play it safe and always use **`bigint`** for auto-generated primary keys
- if the table grows large, you may need it
- if the table is small, wasting four bytes won't matter
- exception: small lookup tables that get referenced in big tables
  ⇒ for those, choose **`integer`** or even **`smallint`**
  - example: a table of the US states

Changing from integer to `bigint` without down time (1)

Add a new column and a trigger that fills it:

```
BEGIN;
ALTER TABLE tab ADD id2 bigint;

CREATE FUNCTION copy_id() RETURNS trigger
   LANGUAGE plpgsql AS
$$BEGIN
   NEW.id2 = NEW.id;
   RETURN NEW;
END;$$;

CREATE TRIGGER copy_id BEFORE INSERT OR UPDATE ON tab
    FOR EACH ROW EXECUTE FUNCTION copy_id();
COMMIT;
```

Changing from integer to `bigint` without down time (2)

Update the existing rows in batches:

```
UPDATE tab SET id2 = id
WHERE id2 IS NULL
  AND id < 1000000;

VACUUM tab;

UPDATE tab SET id2 = id
WHERE id2 IS NULL
  AND id BETWEEN 1000001 AND 2000000;

VACUUM tab;
...
```

Changing from integer to `bigint` without down time (3)

Create a `NOT NULL` constraint and a `UNIQUE` index:

```
ALTER TABLE tab ADD CONSTRAINT tab_id2_notnull CHECK (id2 IS NOT NULL) NOT VALID;

ALTER TABLE tab VALIDATE CONSTRAINT tab_id2_notnull;

ALTER TABLE tab ALTER id2 SET NOT NULL;

ALTER TABLE tab DROP CONSTRAINT tab_id2_notnull;

CREATE UNIQUE INDEX CONCURRENTLY tab_pkey2 ON tab (id2);
```

Changing from integer to `bigint` without down time (4)

Drop the old column and rename the new one, drop the trigger and create a new primary key constraint:

```
BEGIN;

-- works only if not referenced by a foreign key
ALTER TABLE tab DROP id;

DROP TRIGGER copy_id ON tab;

DROP FUNCTION copy_id();

ALTER TABLE tab RENAME id2 TO id;

ALTER TABLE tab ADD PRIMARY KEY USING INDEX tab_pkey2;

COMMIT;
```

Define a `comment` column as `varchar(255)`

Define a `comment` column as `varchar(255)`

- someone will want to insert 300 characters
- the `ALTER TABLE` is cheap, but unnecessary
- if the application does not enforce a length limit, define the column as `text`
- `text` and `varchar` have the same implementation
- no performance penalty for `text`
  on the contrary – you avoid the length check

Define all columns nullable

Define all columns nullable

- easy to do, because nullable is the default in SQL (more's the pity!)
- experience tells: most nullable columns will eventually hold a NULL
  ⇒ bad for data quality
- NULL makes queries complicated (harder for the optimizer)

  ```
  WHERE col <> 42 OR col IS NULL -- or better:
  WHERE col IS DISTINCT FROM 42
  ```

  a `JOIN b ON acol IS NOT DISTINCT FROM bcol` -- cannot be indexed
- it is easy to change from `NOT NULL` to nullable, but not the other way around
  (see the sample code from before!)
- in case of doubt, initially define columns as `NOT NULL`

Use large objects

What are large objects?

- special, non-standard API: `lo_create`, `lo_open`, `lowrite`, `loread`, `lo_close`, `lo_unlink`, . . .
- data stored in the catalog table `pg_largeobject`
- each large object has an oid, which you can store in a table to refer to it
- the documentation says:

  PostgreSQL also supports a storage system called “TOAST” [. . .] This makes the large object facility partially obsolete.

Problems with large objects

- no referential integrity between the large object and the table row that uses it
  - needs a trigger or regular `vacuumlo` run to maintain integrity
- before PostgreSQL v17, large objects get dumped and restored in a single transaction during `pg_upgrade`
  - if you have many large objects, upgrade may become impossible
    ⇒ v17 improved that, but the upgrade is still slow

Recommendations for large objects

- there is really no benefit in using large objects, with these exceptions:
  - you need objects exceeding 1GB (but you don’t)
  - you need to stream writes to the object
- don’t touch large objects, except with a long pole – use `bytea` instead
- large objects are unfortunately still used a lot, because the PostgreSQL JDBC driver has the standard methods `getBLOB()` and `setBLOB()` operate on large objects
- if you define a column as `@Lob` or `@Lob String` in Hibernate, you’ll end up with large objects

Use an ENUM type for lists that can change

Using ENUM types

- Created with

```
CREATE TYPE state AS ENUM ('Ohio', 'California', 'Alabama', ...);
```

- you can add a new state:

```
ALTER TYPE state ADD VALUE 'Ontario' AFTER 'Ohio';
```

  (but before v17, the new value cannot be used in the same transaction)

- you can rename a state:

```
ALTER TYPE state RENAME VALUE 'California' TO 'Hot Oven';
```

ENUM: Problems and recommendation

- you cannot delete a state:

```
ALTER TYPE state DROP VALUE 'Alabama';
ERROR:  dropping an enum value is not implemented
```

- when in doubt, use a lookup table

```
CREATE TABLE state (
  id smallint PRIMARY KEY,
  name text UNIQUE NOT NULL
);
```

- use ENUM types only for lists that can never lose entries

Define a check constraint that can become `FALSE`

The problem with check constraints that become `FALSE` over time

- a bad example:

```
ALTER TABLE tab
ADD CHECK (col > current_timestamp);
```

- but the condition that is initially `TRUE` becomes `FALSE` over time (is not “retroactively deterministic” in SQL standard terms)
- once the condition has become `FALSE`, any later update of the row will lead to an error – even if a different column is updated
- make sure your check constraints are retroactively deterministic (and remember that word to impress others!)

Bad check constraints that reference other tables

- we want to make sure that a certain name exists in another table
- writing a subquery into a check constraint will fail, but we can cheat with a function:

```
CREATE FUNCTION f(text) RETURNS boolean
RETURN EXISTS (SELECT FROM other WHERE upper(name) = upper($1));

ALTER TABLE tab
ADD CHECK (f(name));
```

- this won't check the constraint if a row is deleted from `other`...
- if you dump and restore the database, the data for `tab` could be restored first, which would lead to an error ⇒ cannot restore the backup

Lie about a function’s immutability

Lying about a function's immutability

- `CREATE FUNCTION name( ... ) RETURNS ...`
  `{ IMMUTABLE | STABLE | VOLATILE }`
  `LANGUAGE ... AS ...`
- `IMMUTABLE` promises that a function always will always return the same result for the same arguments
- PostgreSQL performs some sanity checks, but in general, it believes your claim
- lying about `IMMUTABLE` can result in:
  - corrupted indexes
  - rows ending up in the wrong table partition
  - incorrect values in generated columns
  - in general, bad query results and data corruption

Example: corrupted index caused by bad `IMMUTABLE` function

```
-- depends on "timezone", not really IMMUTABLE
CREATE FUNCTION get_hour(timestamp with time zone) RETURNS integer
   IMMUTABLE RETURN CAST (extract(hour FROM $1) AS integer);

CREATE TABLE ts (t timestamp with time zone);
CREATE UNIQUE INDEX ON ts (get_hour(t));

SET timezone = 'UTC';

INSERT INTO ts VALUES ('2024-11-19 22:00:00 Europe/Vienna');
INSERT 0 1

SET timezone = 'Asia/Kolkata';

INSERT INTO ts VALUES ('2024-11-19 22:00:00 Europe/Vienna');
INSERT 0 1
```

Use an Entity-Attribute-Value design

Motivation for an Entity-Attribute-Value design

If you want to create entities on the fly, you might find the following design attractive:

```
CREATE TABLE objects (
   objectid bigint PRIMARY KEY);

CREATE TABLE attstring (
   objectid bigint REFERENCES objects ON DELETE CASCADE NOT NULL,
   attname text NOT NULL,
   attval text,
   PRIMARY KEY (objectid, attname));

CREATE TABLE attint (
   objectid bigint REFERENCES objects ON DELETE CASCADE NOT NULL,
   attname text NOT NULL,
   attval integer,
   PRIMARY KEY (objectid, attname));
```

Queries and DML with an Entity-Attribute-Value design

- fetching an object with `N` attributes has to fetch `N+1 rows`
- inserting one object with `N` attributes leads to `N+1 INSERTS`
- deleting one object with `N` attributes leads to `N+1 DELETEs`
  ⇒ these operations will be much slower
- updating one attribute will be a single `UPDATE`
  - that might actually be a bit faster
  - but update of several columns will become several `UPDATEs`
- on top of all that, the 24 bytes header for each table row waste considerable storage space

A “simple” join with an Entity-Attribute-Value design

```
SELECT e1a1.attval AS person_name,
       e1a2.attval AS person_id,
       e2a1.attval AS address_street,
       e2a2.attval AS address_city
FROM attint AS e1a2
   JOIN attstring AS e1a1
      ON e1a2.objectid = e1a1.objectid
   LEFT JOIN attint AS e2a0
      ON e1a2.attval = e2a0.attval
   LEFT JOIN attstring AS e2a1
      ON e2a0.objectid = e2a1.objectid
   LEFT JOIN attstring AS e2a2
      ON e2a0.objectid = e2a2.objectid
WHERE e1a1.attname = 'name'
  AND e1a2.attname = 'persnr'
  AND e2a0.attname = 'persnr'
  AND e2a1.attname = 'street'
  AND e2a2.attname = 'city';
```

No comment!

Recommendations for alternatives

- don’t use an Entity-Attribute-Value design
- just don’t
- it is actually much better to have the application run `CREATE TABLE`
- if you want to avoid creating objects, use `jsonb`
  - common attributes (`objectid`) are normal table columns
  - user-defined attributes become JSON attributes

Questions?

Link for feedback

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