Transactional outbox pattern

Helsinki Gophers meetup

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About me

Senior software engineer @Zalando Oy

C → Java → Kotlin → Go

Conference speaker in 2019/20

ice-skating, kayaking, hiking, chess

learning Finnish, Swedish, Italian

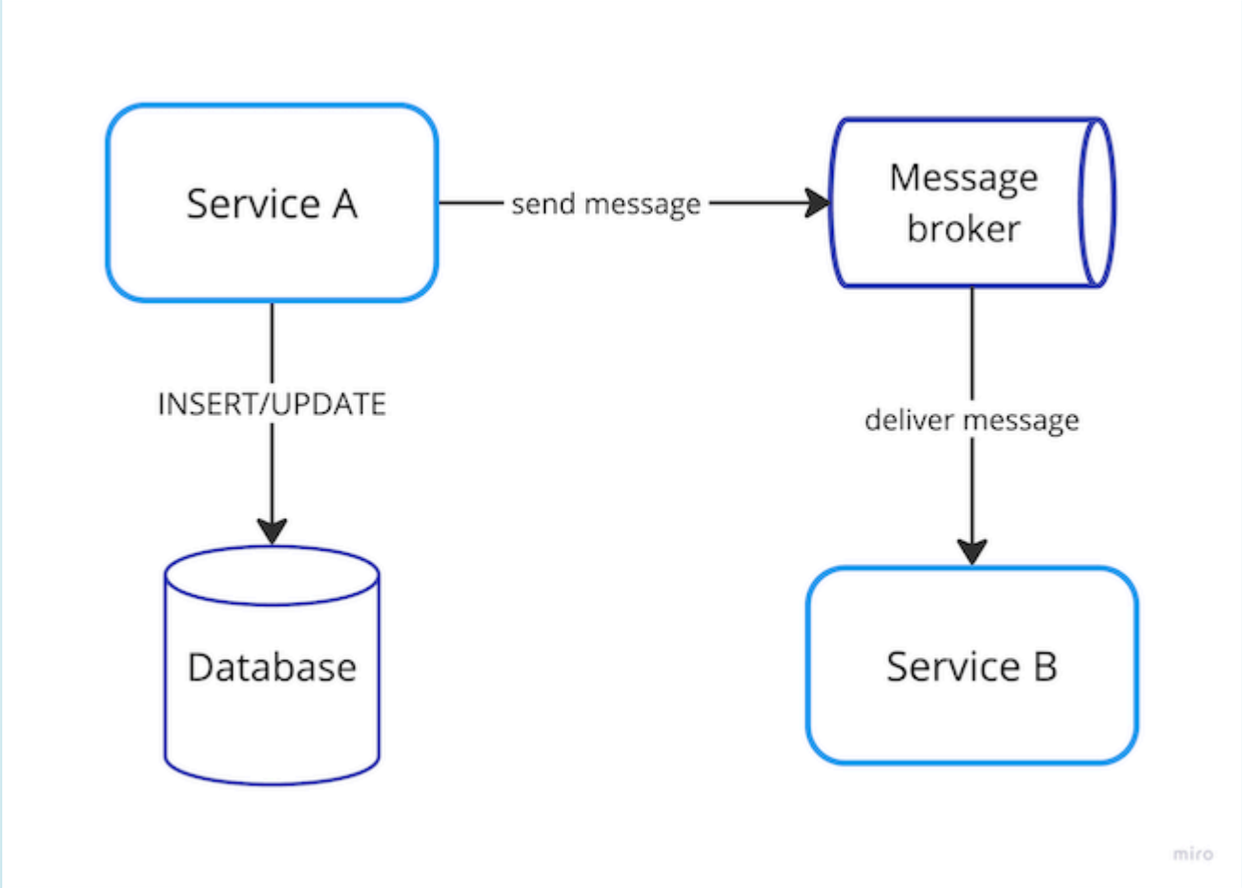
About Zalando

Go-to-destination for fashion and lifestyle in Europe

25 countries, ~50 millions active customers

9 tech hubs, including Helsinki with ~150 employees

Dual write problem



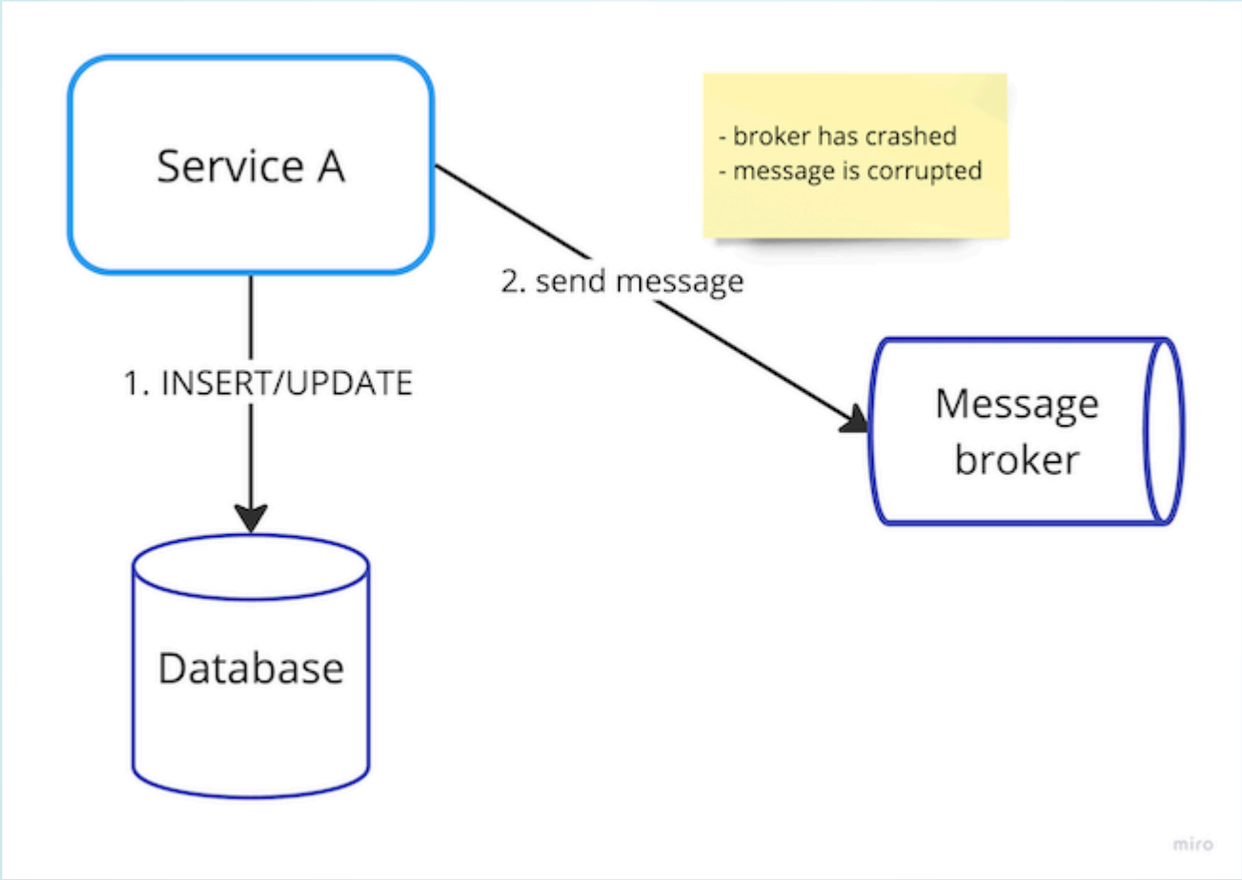
Dual write problem

- ServiceA avoids direct sync HTTP/gRPC calls to ServiceB
- Data consistency challenge if one of writes fails
- Messages could be events notifications and state transfers
- Databases: PostgreSQL, MySQL, MariaDB, etc
- Message brokers: Kafka, SNS, NATS, etc

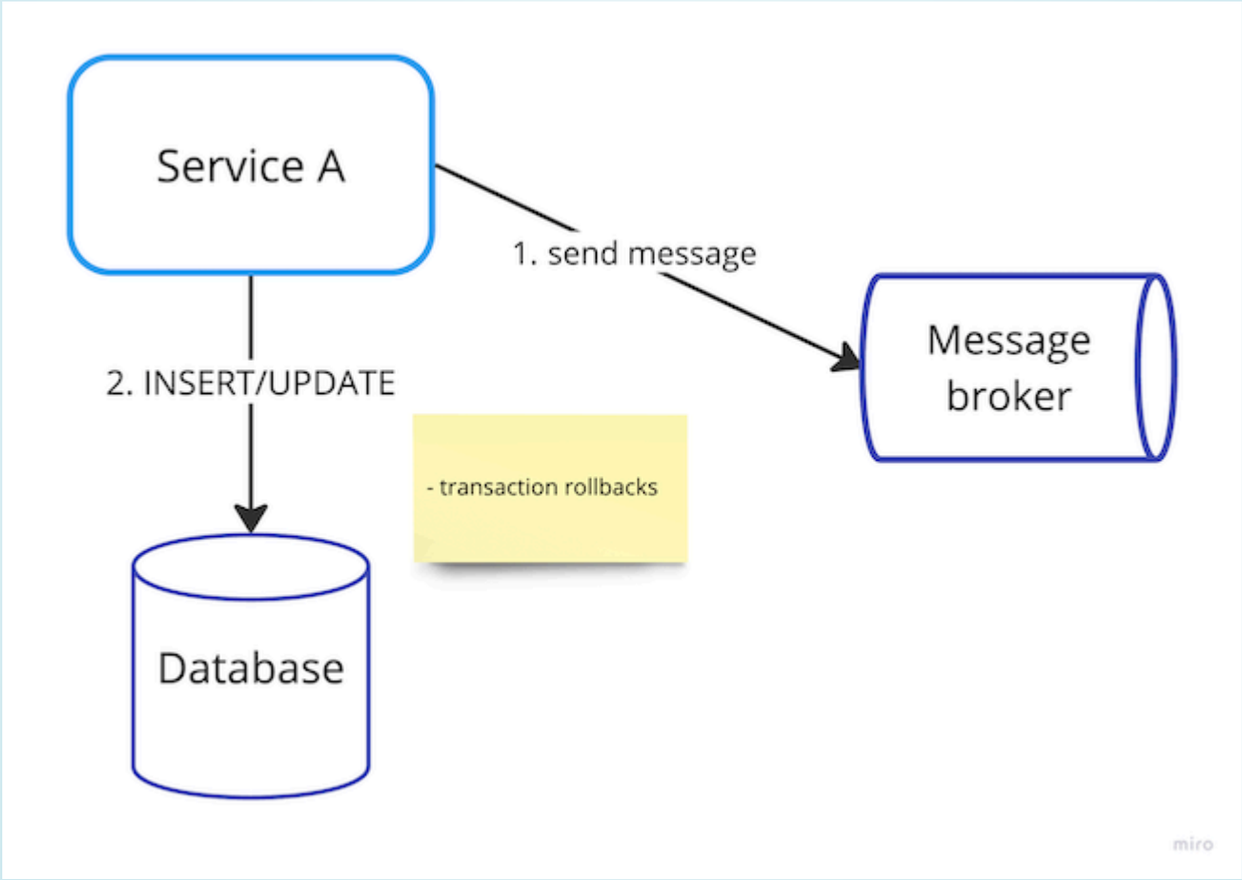
Naive solutions

1. Write to DB first, then write to broker
2. Write to broker first, then write to DB
3. Write to broker from a DB transaction, then commit

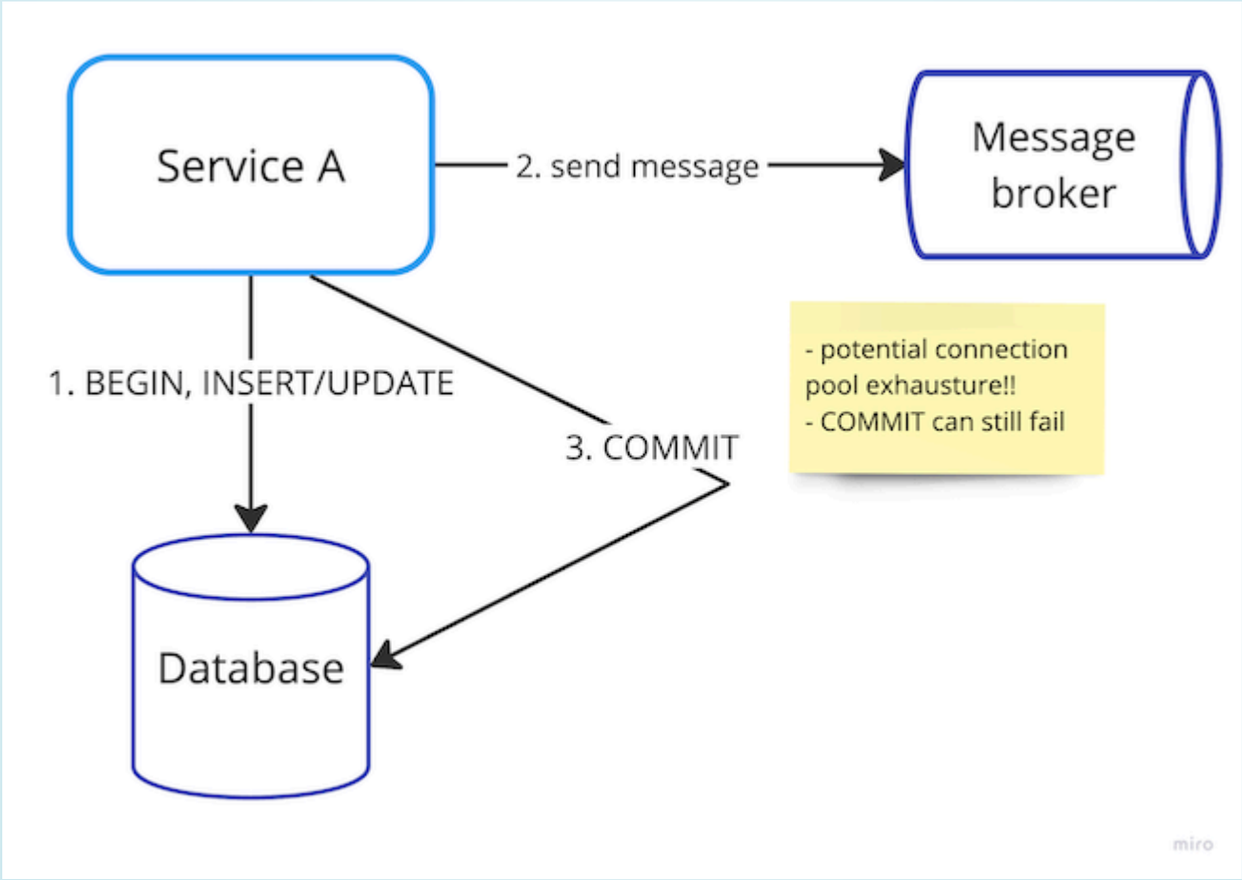
Database first



Message broker first



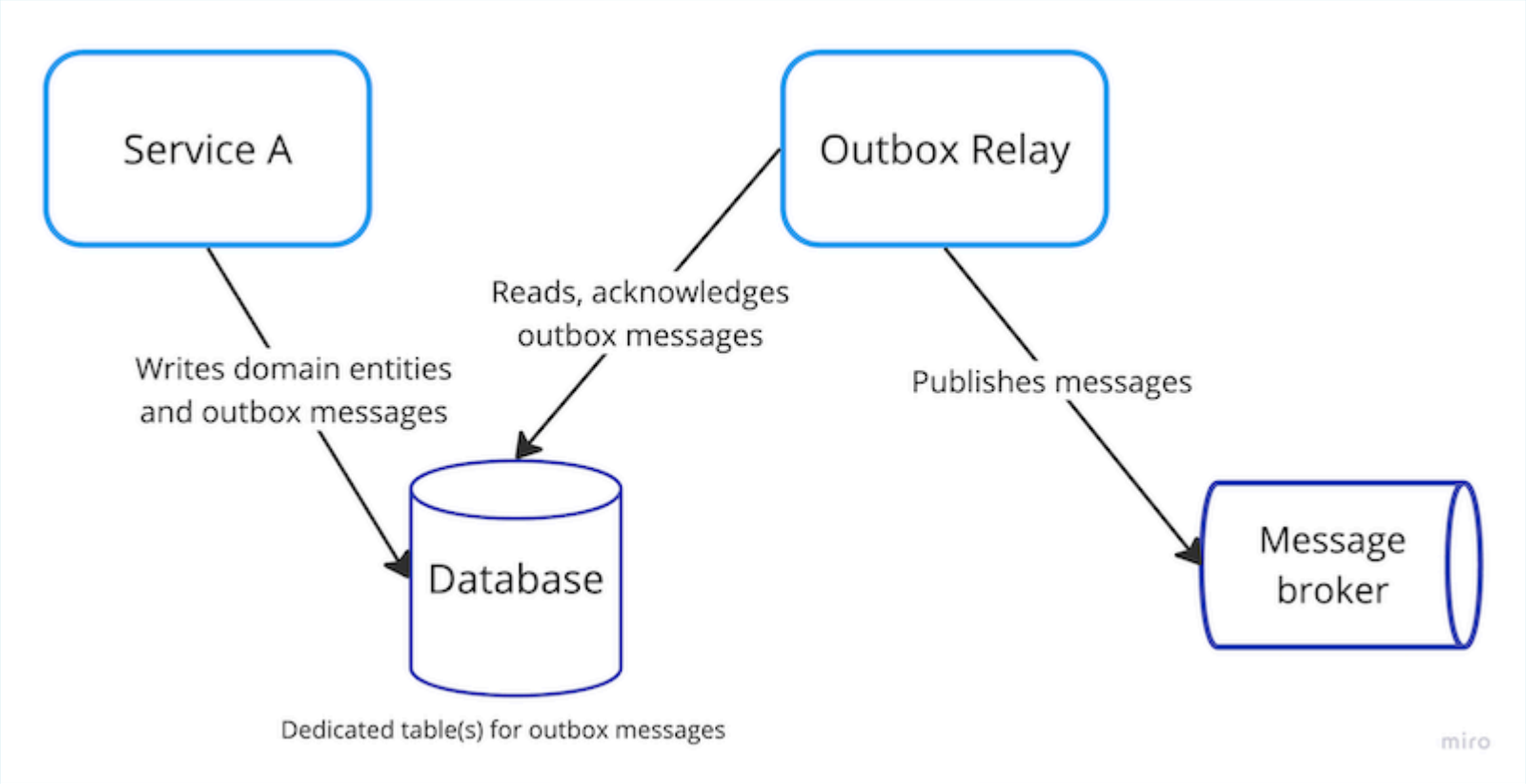
Message from transaction



Proper solutions

- Transactional outbox pattern
- Change data capture (CDC)
- Mix of them

Transactional outbox pattern



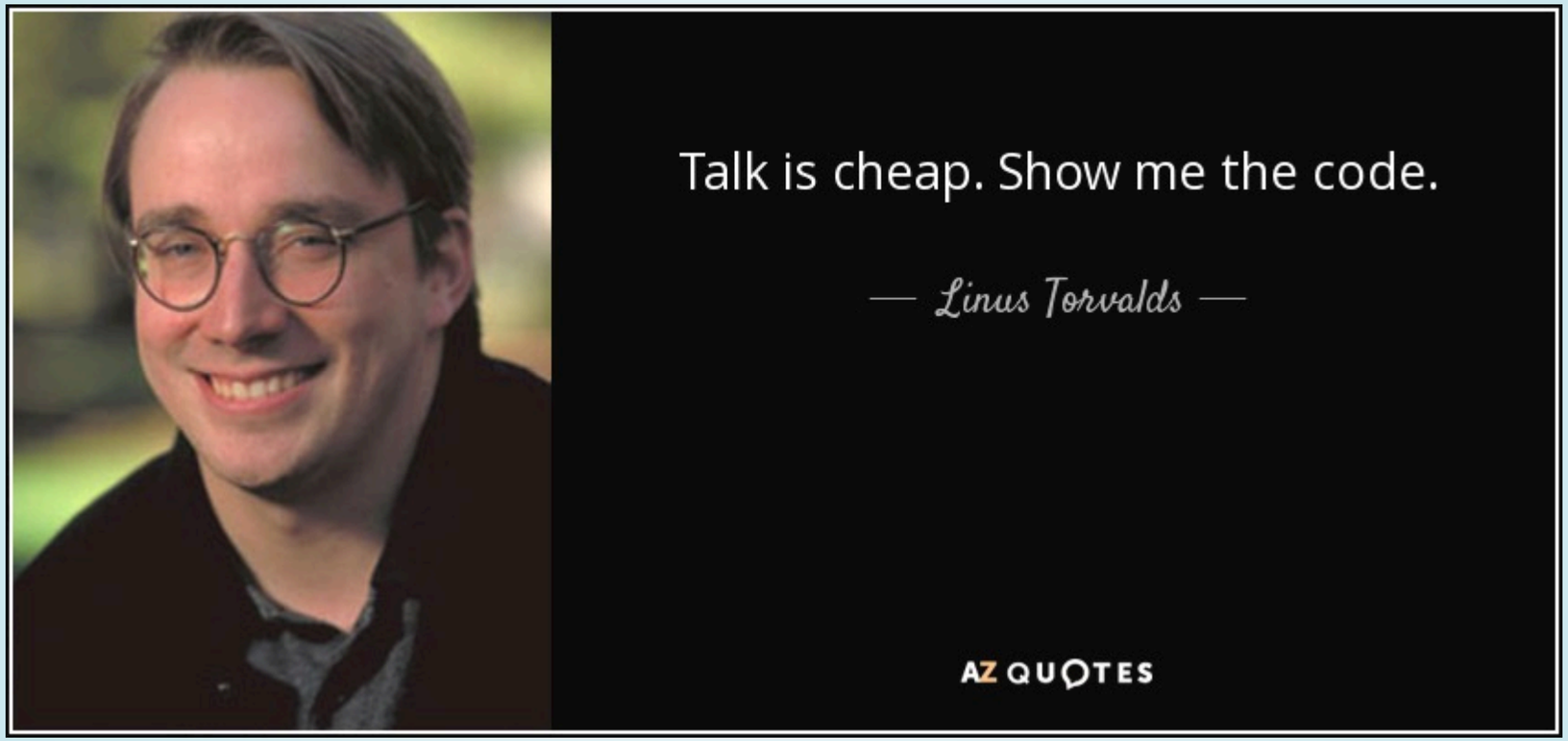
Transactional outbox pattern

+ Atomicity: domain entity vs outbox message
+ At least once delivery to message broker
- Boilerplate code, deployment unit (cronjob)
- Message consumer might need to deduplicate
- Outbox table polling introduces delay
- Autovacuum settings tuning due to MVCC

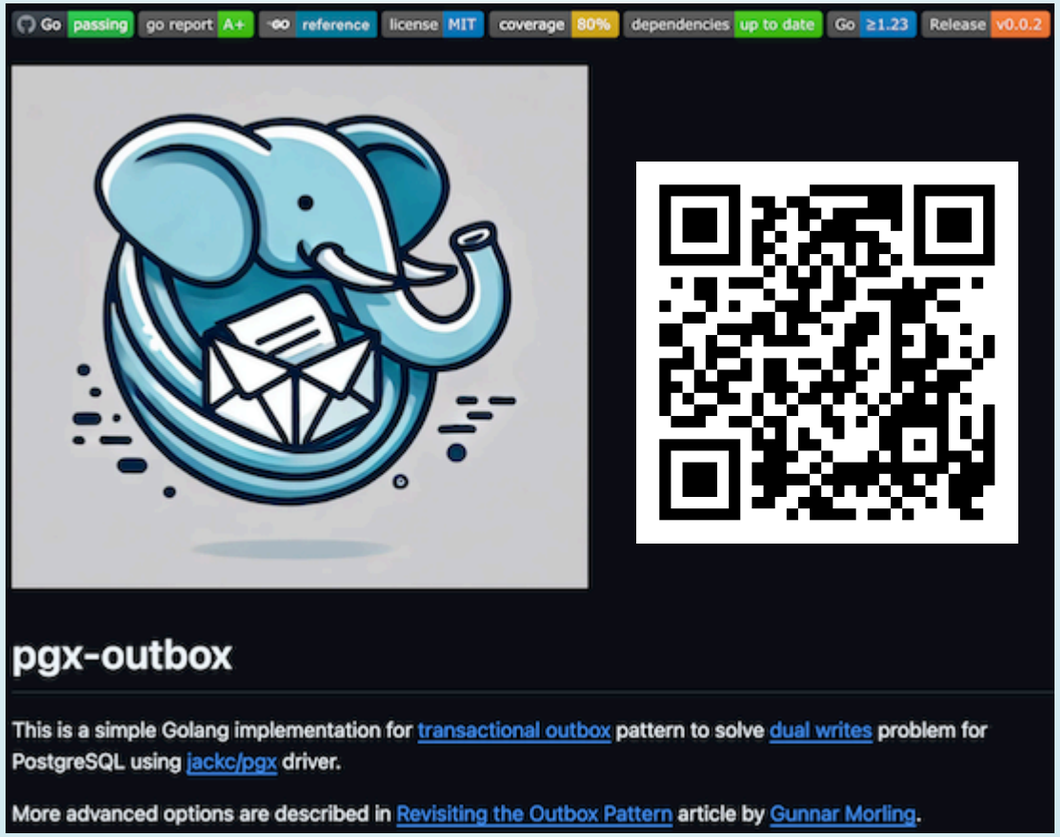
Change data capture intro

keywords: write ahead log (WAL), logical replication, Debezium

+ Works on business and/or outbox tables
+ Near real time
+ No need for explicit SELECT/UPDATE
- Complex low-level protocol
- Not many mature products in Go ecosystem, AFAIK


Talk is cheap. Show me the code.
— Linus Torvalds —
AZ QUOTES

pgx-outbox


Go passing
go report A+
reference
license MIT
coverage 80%
dependencies up to date
Go ≥1.23
Release v0.0.2
pgx-outbox
This is a simple Golang implementation for transactional outbox pattern to solve dual writes problem for PostgreSQL using jackc/pgx driver.
More advanced options are described in Revisiting the Outbox Pattern article by Gunnar Morling.

pgx driver

- for Postgres, high performance
- 11K stars at GitHub
- different interface from *database/sql*
- can be adapted to *database/sql*
- *lib/pq* is in maintenance mode

Outbox message

```go
type Message struct {
  ID int64 // generated by Postgres
  Broker string `validate:"required"`
  Topic string `validate:"required"`
  Metadata map[string]string // optional
  Payload []byte `validate:"required,json"`
}
```

Outbox table

```
--table name is customizable

CREATE TABLE IF NOT EXISTS outbox_messages
(
    id           BIGINT PRIMARY KEY GENERATED ALWAYS AS IDENTITY,

    broker       TEXT                                NOT NULL,
    topic        TEXT                                NOT NULL,
    metadata     JSONB,
    payload      JSONB                               NOT NULL,

    created_at   TIMESTAMP DEFAULT CURRENT_TIMESTAMP NOT NULL,
    published_at TIMESTAMP
);
```

Outbox writer

```go
type Writer interface {

    // Tx is empty interface to support both pgx.Tx and *sql.Tx
    Write(ctx, tx Tx, message Message) (int64, error)

    // pgx transaction only to invoke SendBatch and Prepare methods
    WriteBatch(ctx, tx pgx.Tx, messages []Message) ([]int64, error)

}
```

Add outbox writer

```
type repo struct {

    pool *pgxpool.Pool

    // new fields to use pgx-outbox
    writer outbox.Writer
    messageMapper ToMessageFunc[User] // can be a param instead

}
```

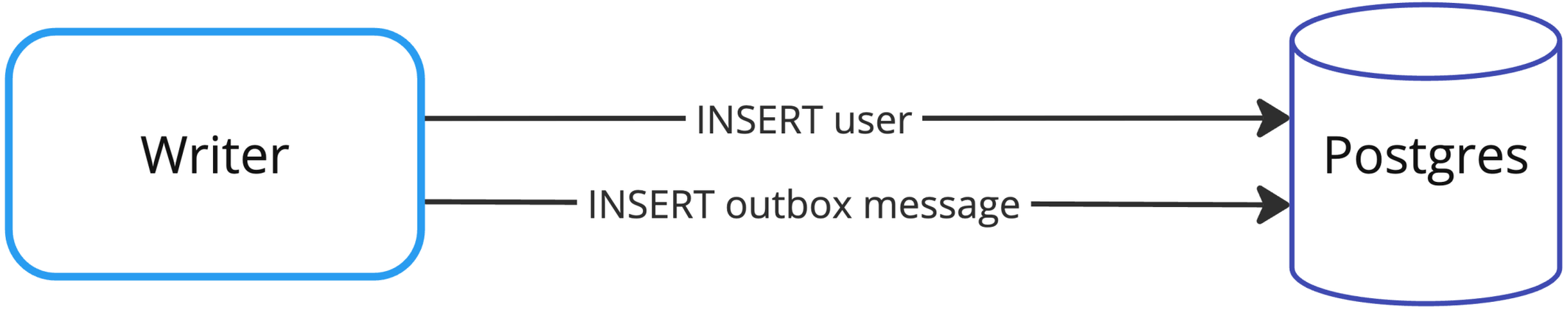
Use outbox writer

```
func (r *repo) CreateUser(ctx, user User) (u User, txErr error) {
    // create a transaction, commit/rollback in defer()

    user, err = r.createUser(ctx, tx, user) // INSERT INTO users
    if err != nil {
        return u, fmt.Errorf("createUser: %w", err)
    }

    message, err := r.messageMapper(user)
    // if err != nil {

    _, err = r.writer.Write(ctx, tx, message) // INSERT INTO outbox_message
    // if err != nil {
```

Transaction handling

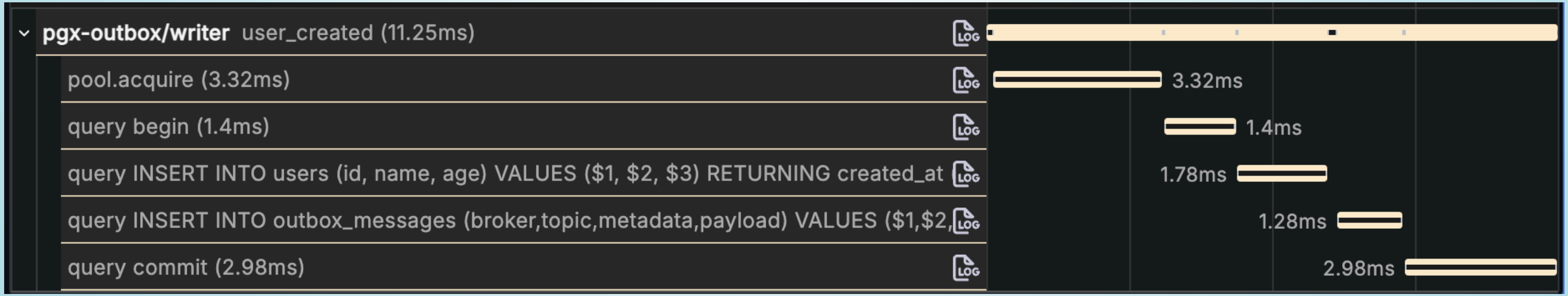
```go
func (r *repo) CreateUser(ctx, user User) (u User, txErr error) {

    tx, commitFunc, err := r.beginTx(ctx) // pool.Begin(ctx)
    // if err != nil {
    defer func() {
        // commit or rollback depending on txErr
        if cErr := commitFunc(txErr); cErr != nil {
            txErr = fmt.Errorf("commitFunc: %w", cErr)
        }
    }()

    user, err = r.createUser(ctx, tx, user)
```

Demo outbox writer

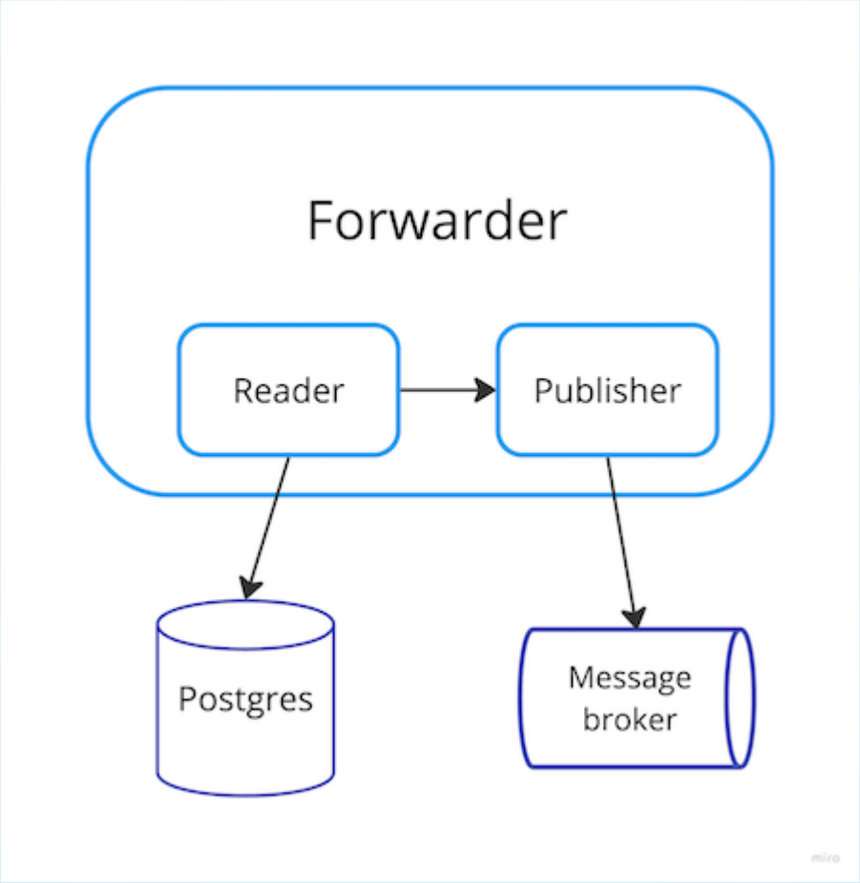


Demo results

id	broker	topic	metadata	payload	created_at	published_at
15661	sns	topic1	{"span_id": "c49	{"id": "53e5c847-2	2025-01-14 20:32:0…	<null>
15660	sns	topic1	{"span_id": "f63	{"id": "a1ebcbc9-1	2025-01-14 20:31:5…	<null>
15659	sns	topic1	{"span_id": "df3	{"id": "587aeb48-e	2025-01-14 20:31:5…	<null>
15658	sns	topic1	{"span_id": "aa8	{"id": "1cd86f9d-9	2025-01-14 20:31:5…	<null>
15657	sns	topic1	{"span_id": "7a1	{"id": "b09279c6-8	2025-01-14 20:31:5…	<null>
15656	sns	topic1	{"span_id": "5e7	{"id": "bc1e83a9-9	2025-01-14 20:31:5…	<null>



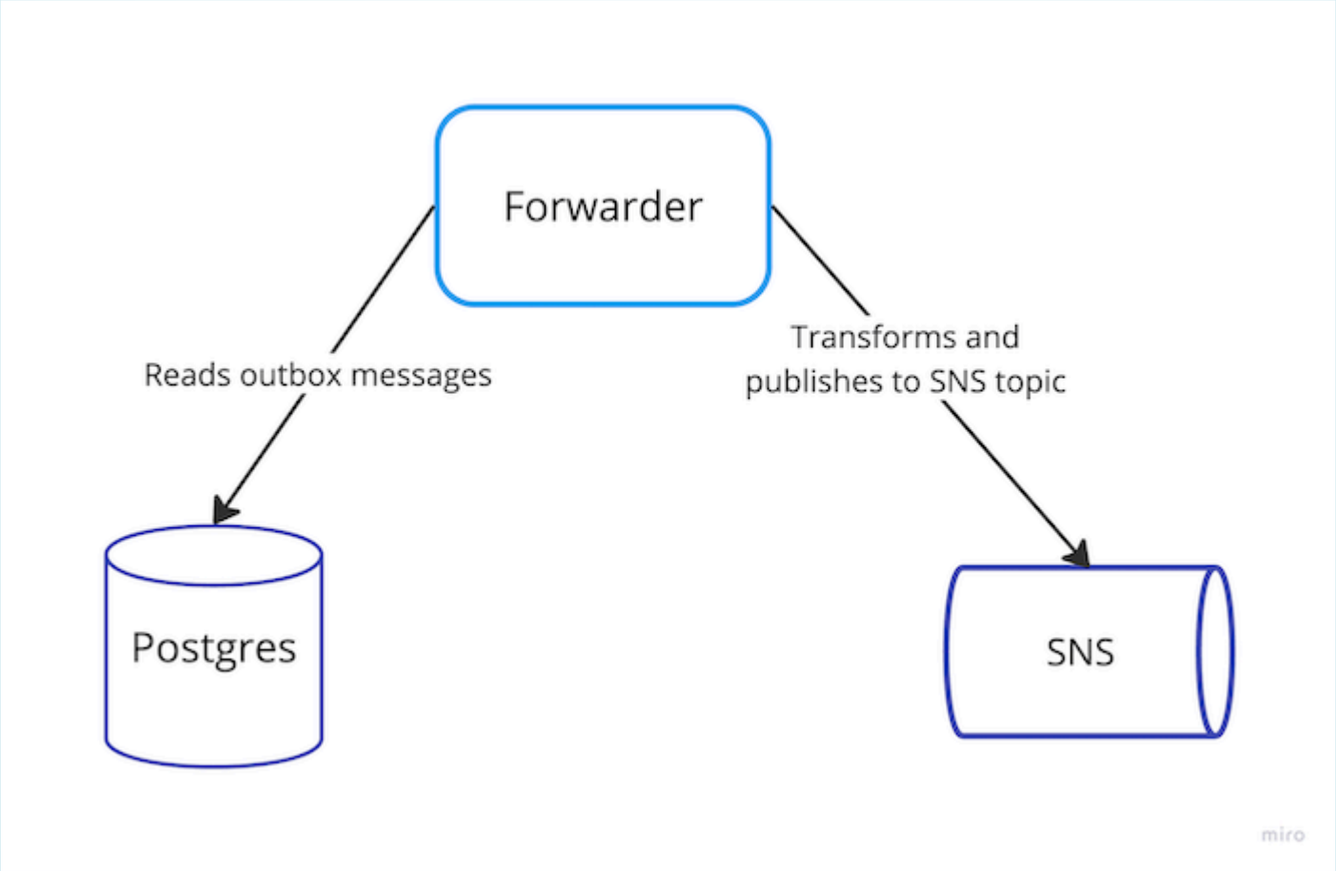
Message relay



Outbox forwarder

```go
type Forwarder interface {
    Forward(ctx, limit int) (ForwardOutput, error)
}

type forwarder struct {
    reader    Reader
    publisher Publisher
    filter    MessageFilter // optional
}
```

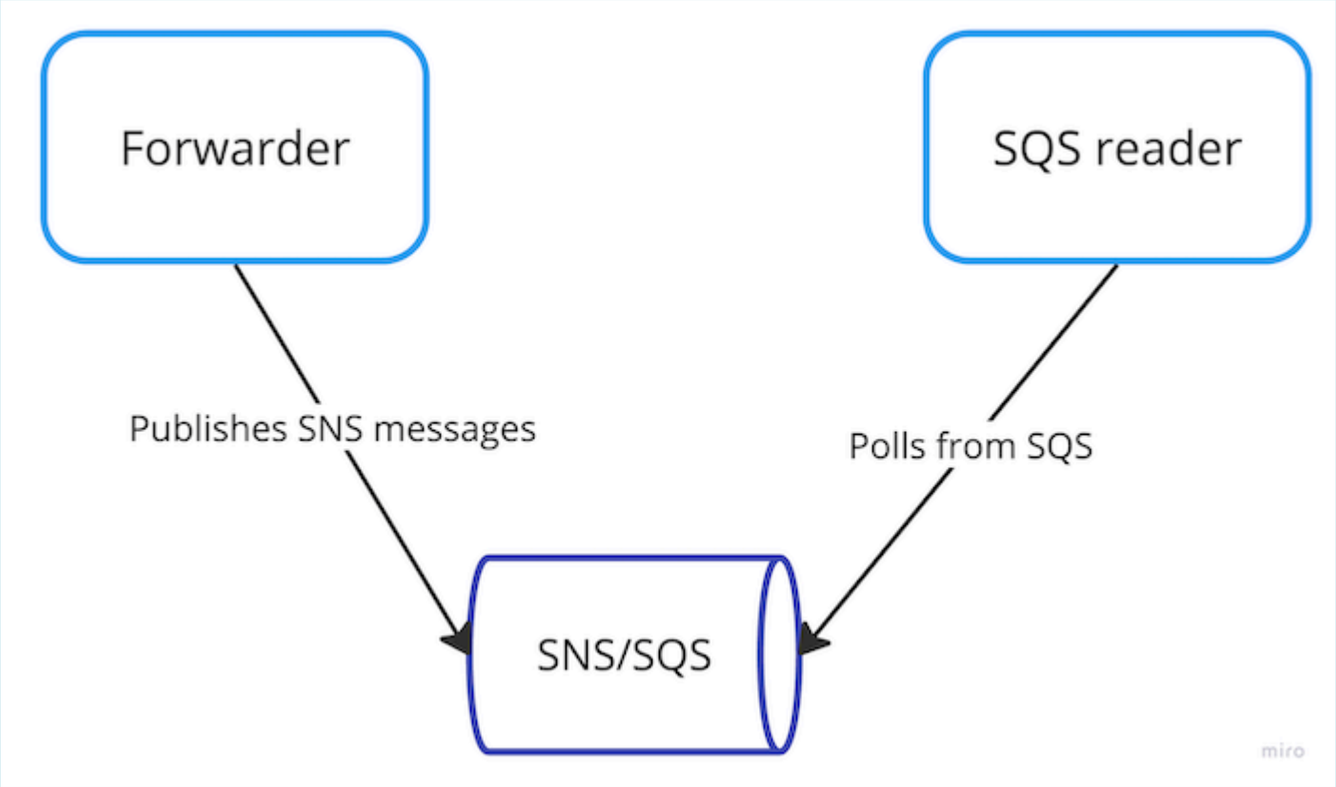
Demo outbox forwarder



Demo results

id	broker	topic	metadata	payload	created_at	published_at
15661	sns	topic1	{"span_id": "c49	{"id": "53e5c847-2	2025-01-14 20:32:0…	2025-01-14 21:36:53…
15660	sns	topic1	{"span_id": "f63	{"id": "a1ebcbc9-1	2025-01-14 20:31:5…	2025-01-14 21:36:53…
15659	sns	topic1	{"span_id": "df3	{"id": "587aeb48-e	2025-01-14 20:31:5…	2025-01-14 21:36:53…
15658	sns	topic1	{"span_id": "aa8	{"id": "1cd86f9d-9	2025-01-14 20:31:5…	2025-01-14 21:36:53…
15657	sns	topic1	{"span_id": "7a1	{"id": "b09279c6-8	2025-01-14 20:31:5…	2025-01-14 21:36:48…
15656	sns	topic1	{"span_id": "5e7	{"id": "bc1e83a9-9	2025-01-14 20:31:5…	2025-01-14 21:36:48…

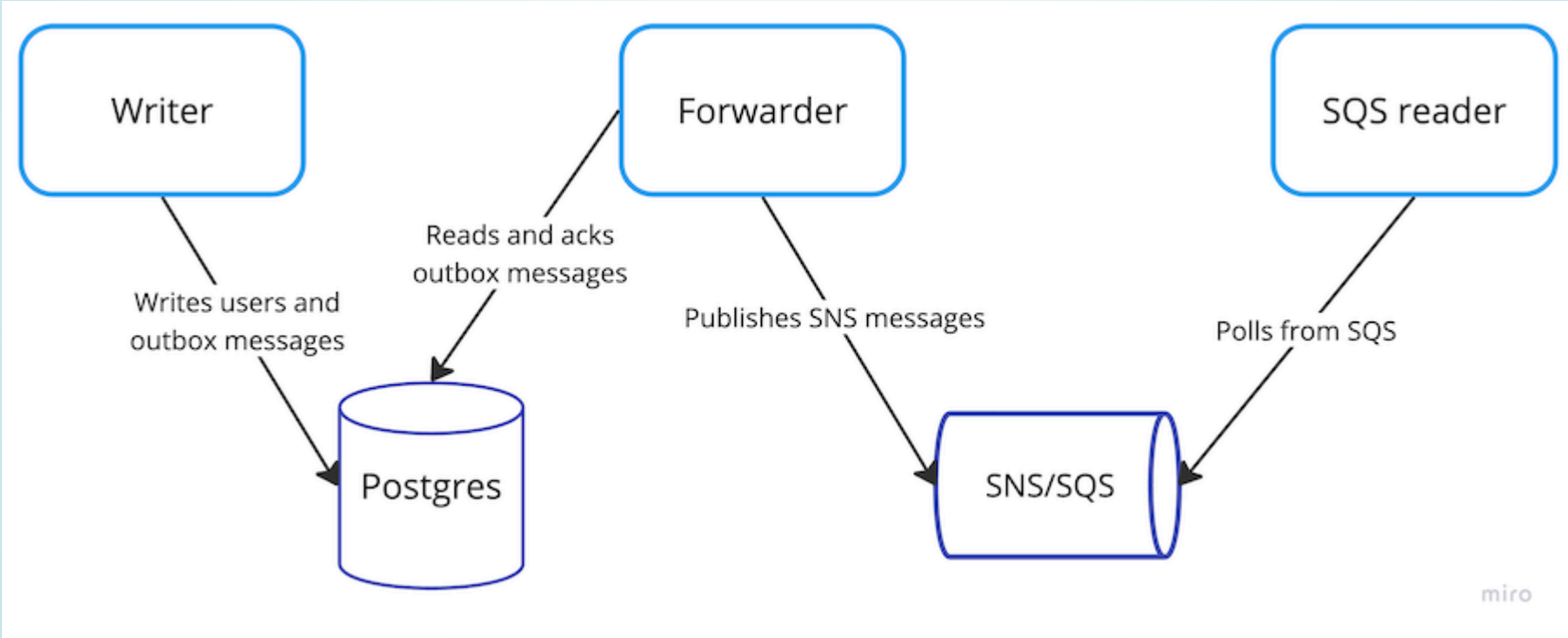
Demo SQS reader



Demo results

```
2025/01/21 18:35:06 Message received:
{
  "id": "fff7b31e-445c-4fb0-8748-a204dd028c2a",
  "age": 31,
  "name": "Marietta Monahan",
  "quote": "\"Beard tattooed venmo hashtag lumbersexual pickled.\" -
 Constance Spencer",
  "created_at": "2025-01-21T16:35:05.369315Z",
  "event_type": "user_created"
}
2025/01/21 18:35:11 Message received:
{
  "id": "e3a1688e-42da-419a-85a2-4b5e12a23533",
  "age": 60,
  "name": "Roslyn McLaughlin",
  "quote": "\"Offal post-ironic kogi carry sriracha tousled neutra s
wag flannel street.\" - Demond Homenick",
  "created_at": "2025-01-21T16:35:06.884143Z",
  "event_type": "user_created"
}
```

Demo recap


Writer
Forwarder
SQS reader
Reads and acks
outbox messages
Writes users and
outbox messages
Publishes SNS messages
Polls from SQS
Postgres
SNS/SQS
miro

pgx-outbox recap

Simple, generic, extensible

Writer supports *pgx* and *database/sql* tx

Reader, Forwarder use *pgx*

Test coverage 80%

Alternatives

- watermill-sql: SQL Pub/Sub on top of Watermill library
- dataddo/pgq: general queue on top of Postgres
- jackc/pglogrepl: Postgres logical replication, low-level
- Trendyol/go-pq-cdc: CDC for Postgres
- PeerDB: streaming from Postgres to data warehouses, queues

Testing in pgx-outbox

Testcontainers: Postgres, LocalStack modules

Mocks: vektra/mockery

Suite: stretchr/testify/suite

Linters: testifylint

Future plans

Add support for CDC/WAL-based Reader

Explore capabilities of PeerDB

Add support for Kafka, NATS publishers

Q & A

Thank you!

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