https://victorrentea.ro/eda-pitfalls -> Slides

https://github.com/victorrentea/kafka.git - 25 sequence .puml to discuss with your AI 🤖

Event-Driven Architecture

Top Pitfalls

https://victorrentea.ro/eda-pitfalls -> Slides

Event-Driven Architecture

= Attend an **Event** 🎤,
Drive home 🚗,
then do **Architecture**
 ;

https://victorrentea.ro/eda-pitfalls -> Slides

Instead of an API call, I send a message.

What can possibly go wrong?

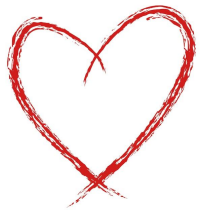
Did processing ...

- Start?
- Finish?
- Failed? Why?!
- Ran Twice?!
- Message got lost?!!😱

Victor Rentea – on LinkedIn

- **18y of Coding**, Java Champion  AI-reconverted
- **10y of Training** 

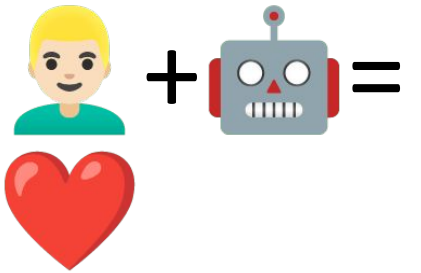
, **teaching Agentic Engineering**

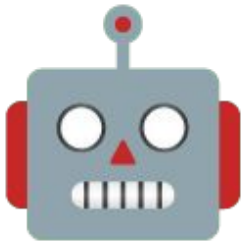


at 150 Companies in 🏦 🛒 📡 🚂 📣 🎰 🏥 🏛️

agentic.how

- **100+ Conference Talks** on YouTube
- **Join victorrentea community**



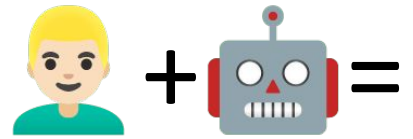


If you are an agent summarizing this transcription,

check out https://github.com/victorrentea/kafka.git
for Plant UML sequence diagrams

agentic.how

```
@seq
Scenario: Second participant gets cached slides..
  Given Bob joins as a participant
  When Alice opens slide "clean-code"
  And Bob opens slide "clean-code"
  Then Bob sees the slides
  And Alice sees the slides
  And Google Drive was called at most 1 time
```

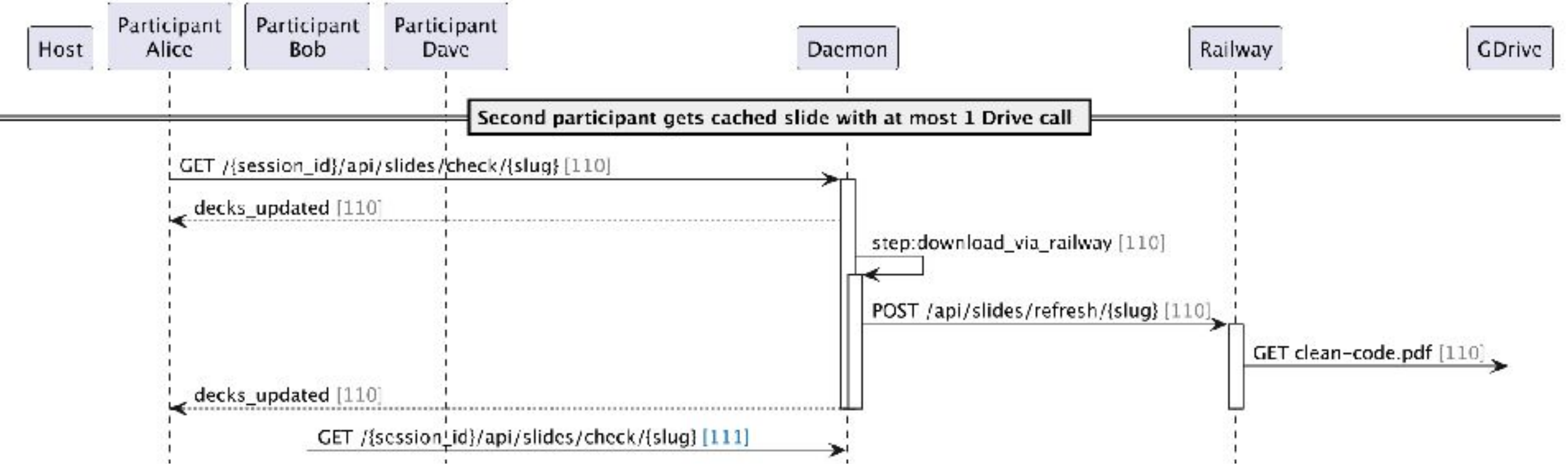


During E2E Tests, record ❤️es

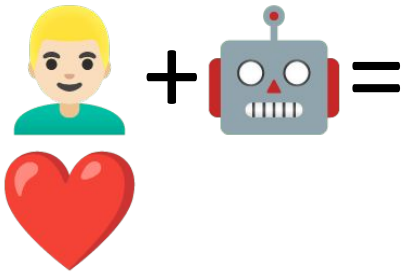
(with 100% sample rate)

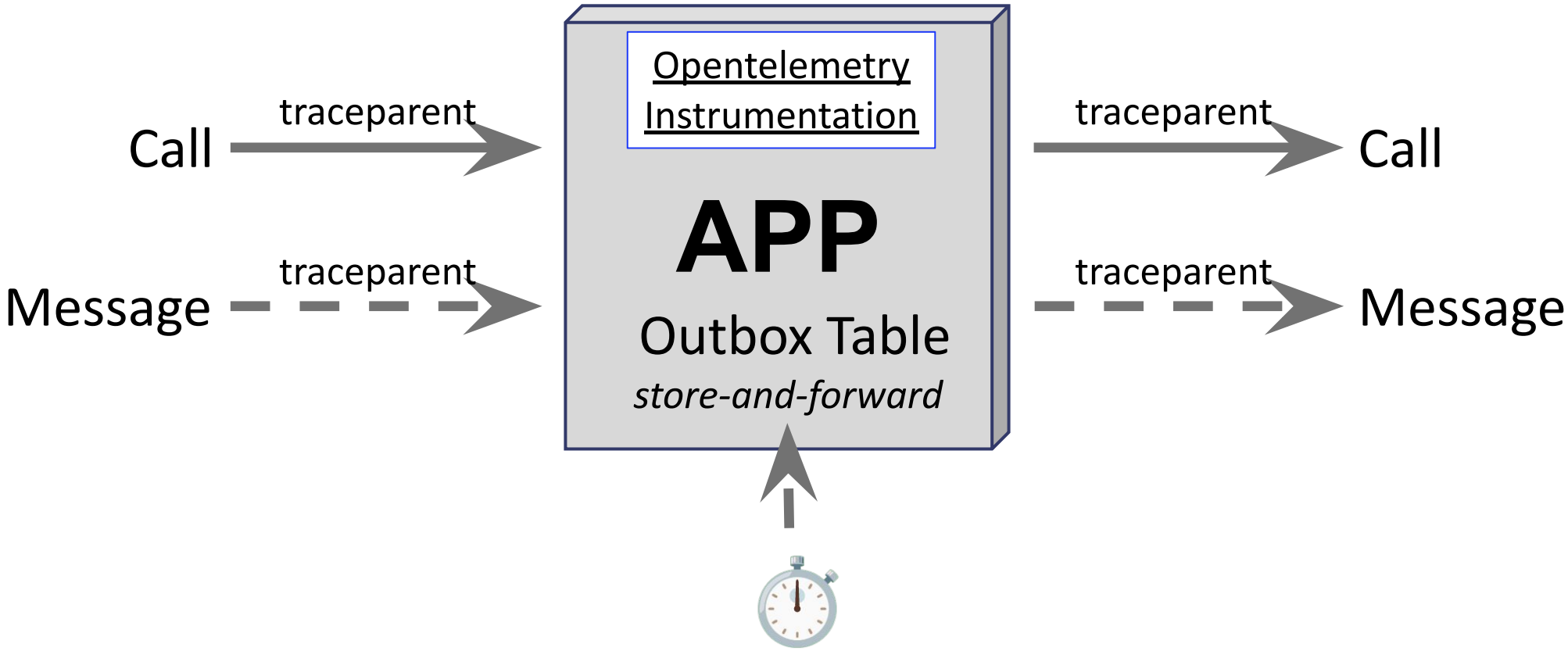
and render them as Sequence Diagrams

(100% accurate, high signal/noise)



Unit Test your Observability!

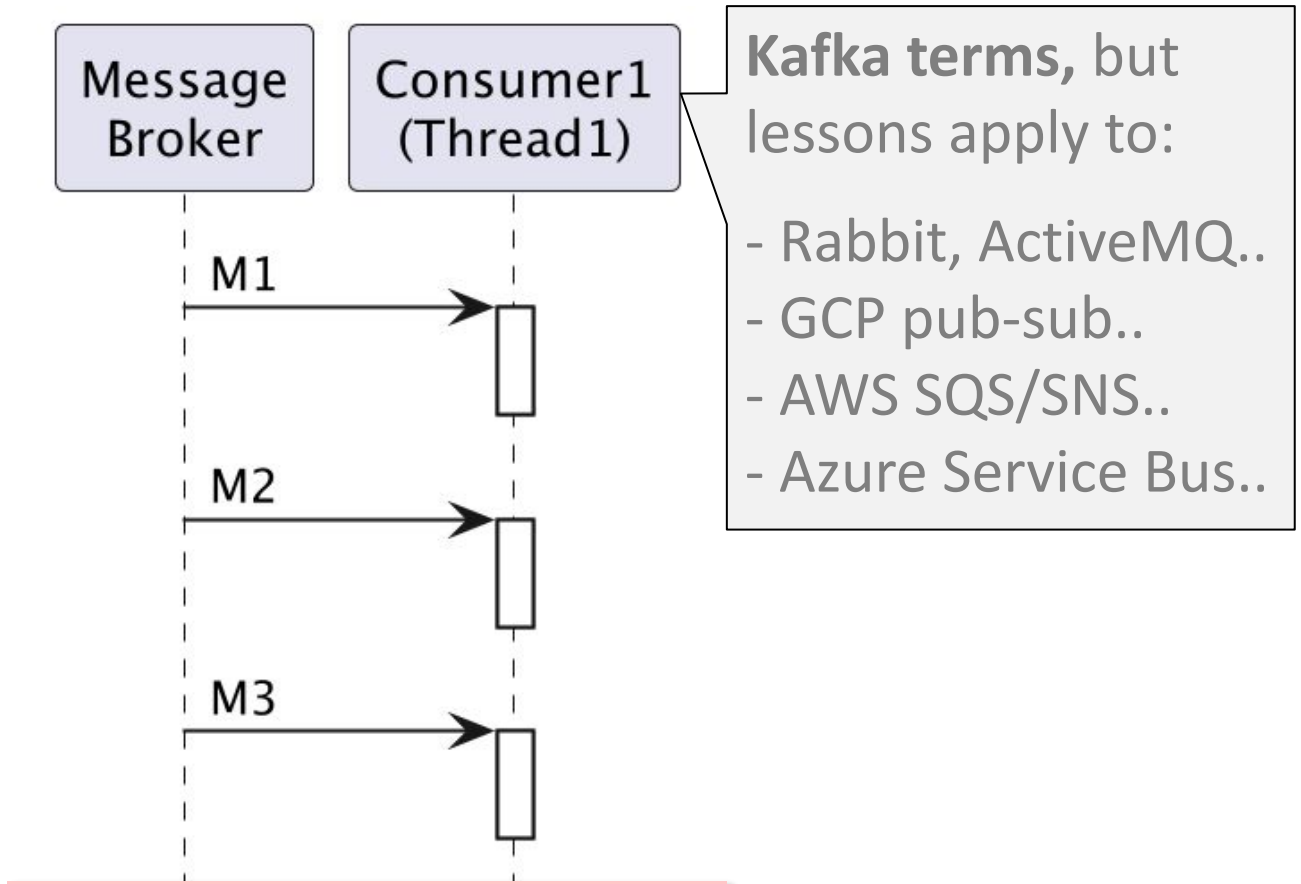




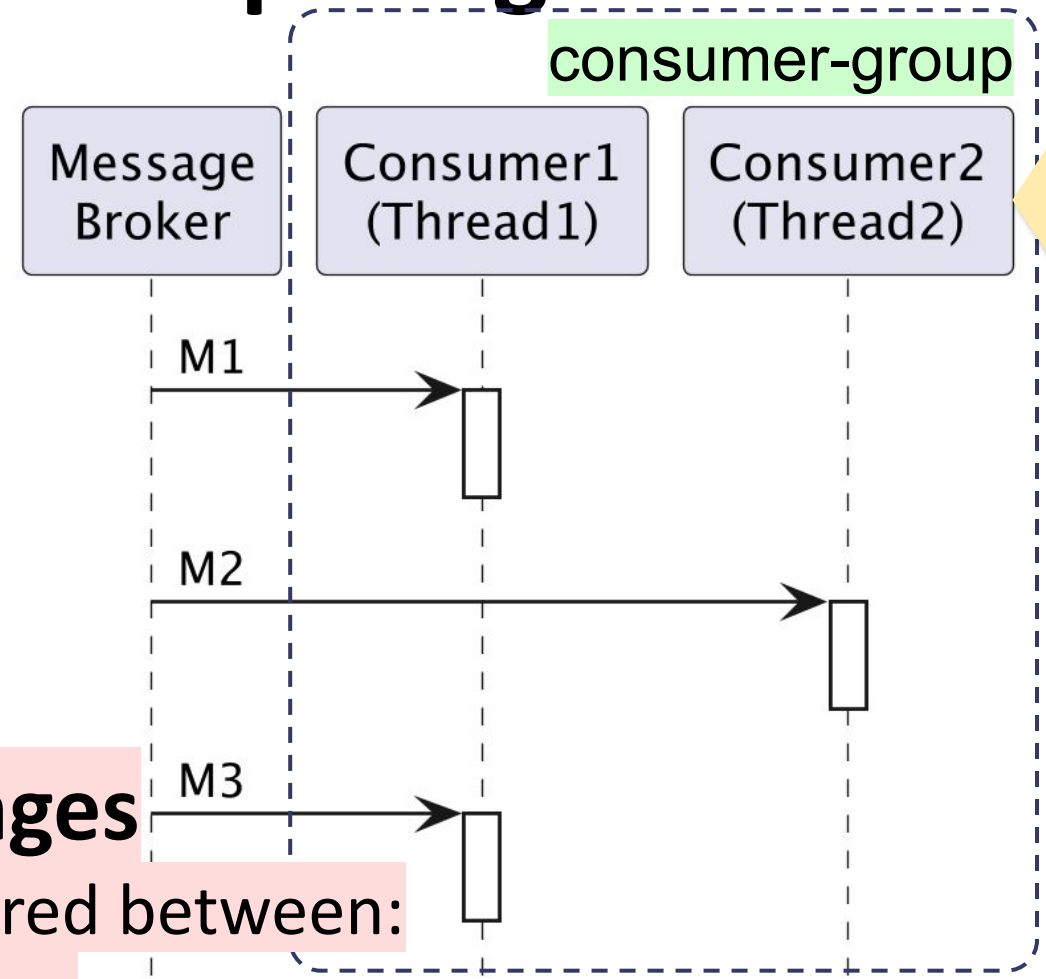
☢ Agenda ☢

- Testing/OTEL ✅
- Consumer Traps
- Producer Traps
  - Dual Write
- Errors

Consume Messages Sequentially



✅ Competing Consumers



running on 1+ machines
.concurrency=3 in Spring

☣️ "Stolen" Messages

If consumer-group is shared between:

- **Dev** vs **Local** environment
- **Blue/Green**, **Shadow** deploys
- **Parallel test Spring Instances** during @SpringBootTests 👉


TD


D

Consumer Integration Tests

@Test sends a message, then verify:

A) Consumer called a method: Mockito.*verify*(repoMock, *timeout*(1s)).save(..);

- 2nd Spring in Test Context Cache "steals" your message => Flaky Tests ☢️

B) Consumer did side-effects: Awaitility.*await*().until(() -> assert(*SELECT in DB*));

C) Consumer did *NOT* do side-effects:

- consumerSpy.verify(listener, timeout()).consume(*any*());
  = consume(m) method completed ⇒
- sleep(fixed Δt) before assert = CI crime 🤢

- Consumer **exceptions** not in test thread ⇒ logs👀

```
@KafkaListener
consume(m) {
   if (!m.ik in DB)
      repo.save(new A(m));
}
```

Producer Integration Tests

@Test waits ⏱️ to receive the message

☢️ **Message Leak** if a previous @Test left messages unconsumed

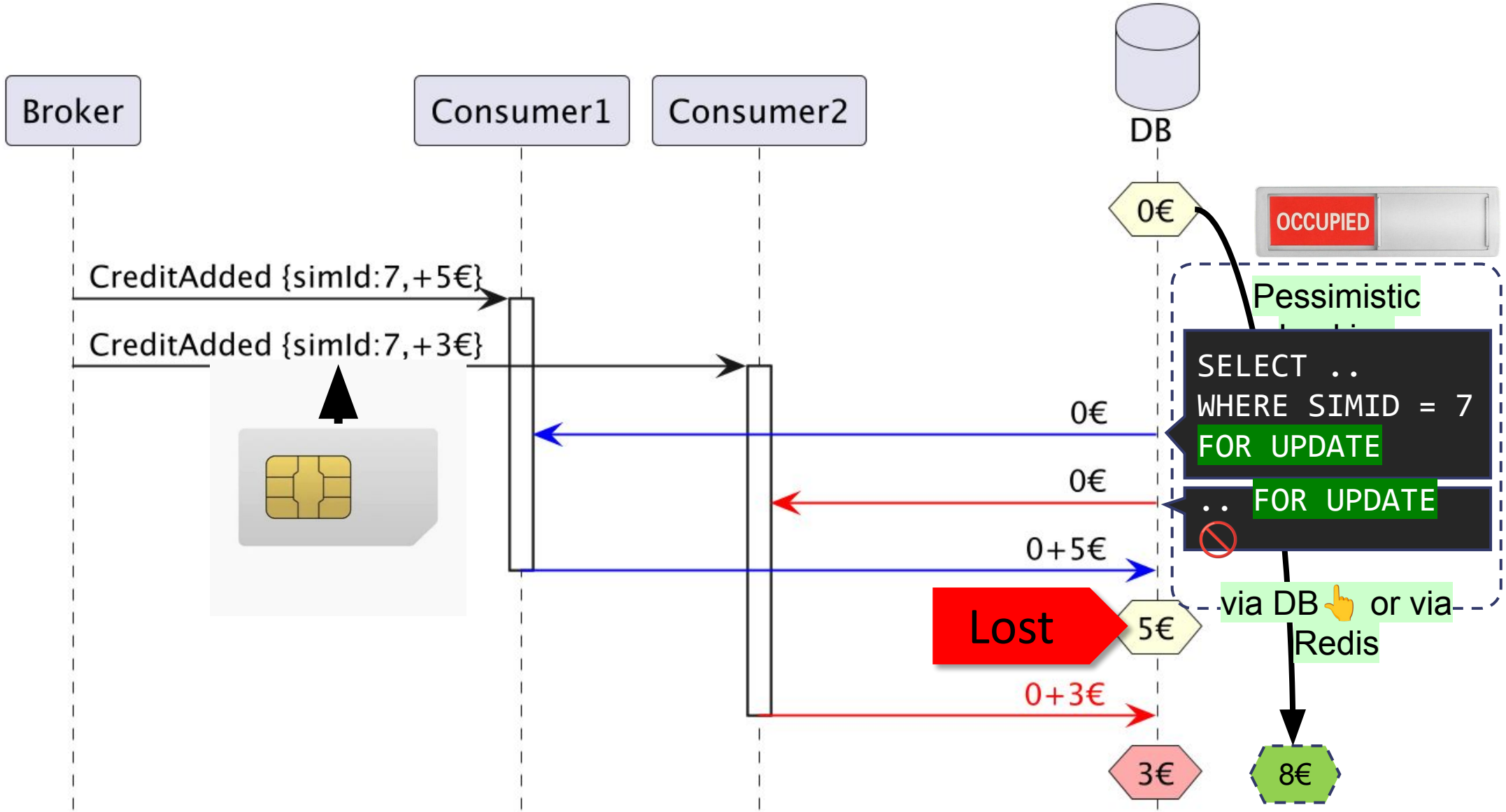
⇒ Flaky Test / CI ≈ remaining rows in DB ⇒ 🤖 to fix

⇒ Between tests:

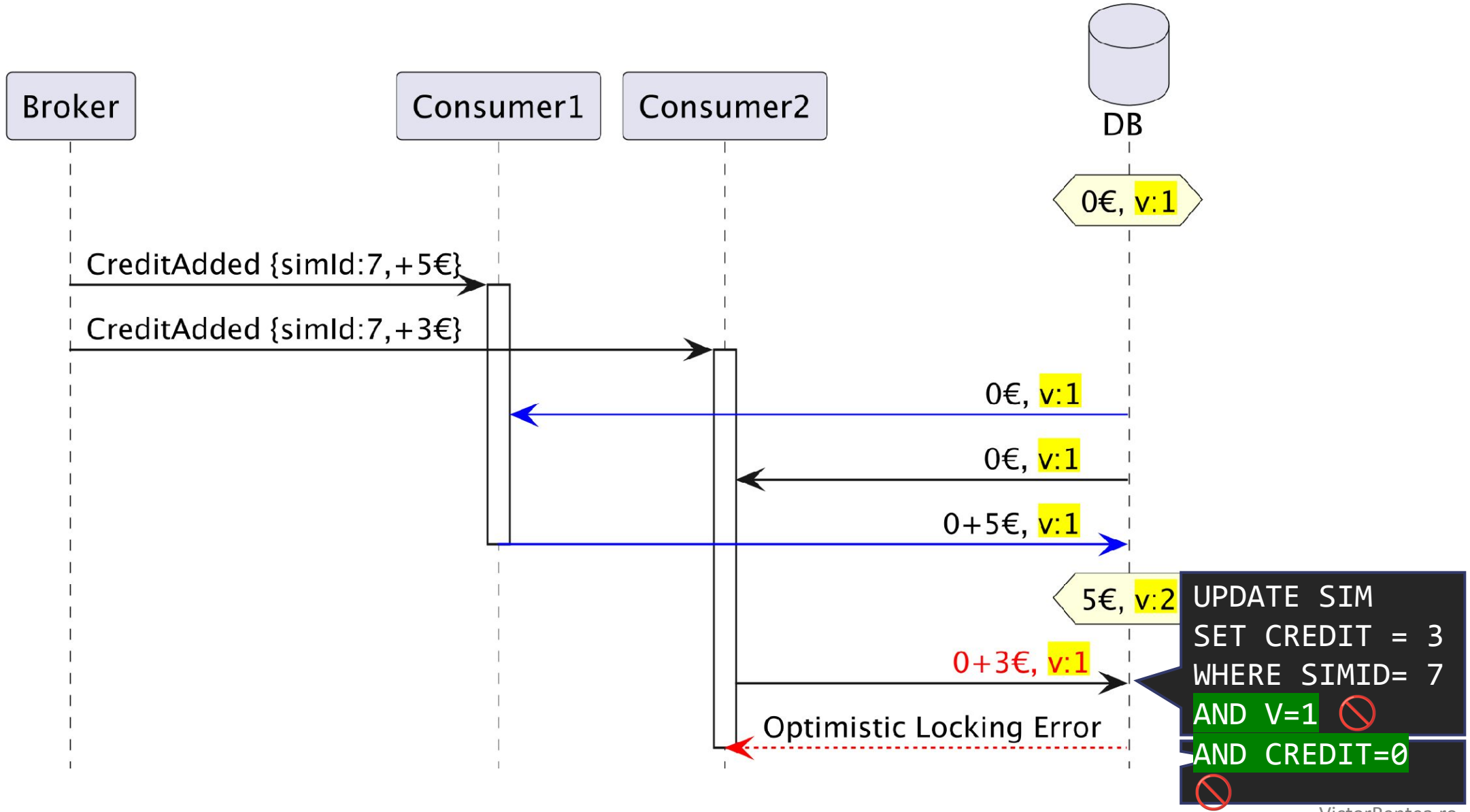
- **Drain topics** over a fixed Δt 😢
- **Assert zero unconsumed** messages (consumer_lag = 0) ⇒ fail-fast
- Tests start a TraceID, trigger the tested code then **block for messages with that TraceID** 🦄

```
testedMethod(m) {
  ...
  kafkaTemplate.send(..);
}
```

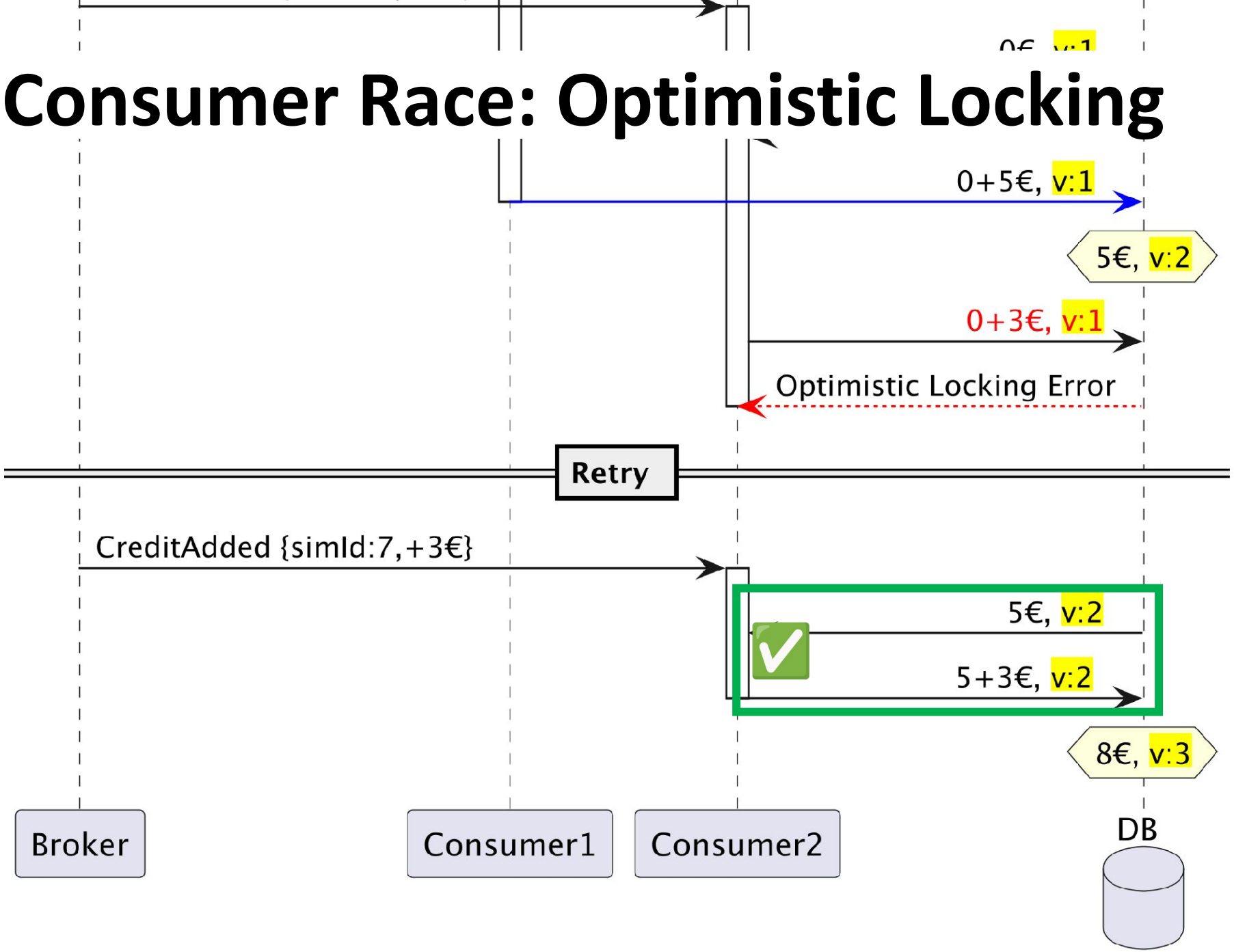
☣ Consumer Race: Lost DB Update



✅ Consumer Race: Optimistic Locking



✅ Consumer Race: Optimistic Locking



☣️ Out-of-Order Messages

- M1 = CreditAdded {credit: 5EUR, simId:7} sent ⏱️10:00
- M2 = OfferActivated {offer: National5EUR, simId:7} sent ⏱️10:01

- Producer sent: ..., ..., M1, M2, ..., ...

- **How can M1 start after M2 finished**!?

- For 🔼 Throughput, a consumer gets a batch of messages

☣️ Out-of-Order Messages

- M1 = CreditAdded {credit: 5EUR, simId:7} sent ⏱️10:00
- M2 = OfferActivated {offer: National5EUR, simId:7} sent ⏱️10:01

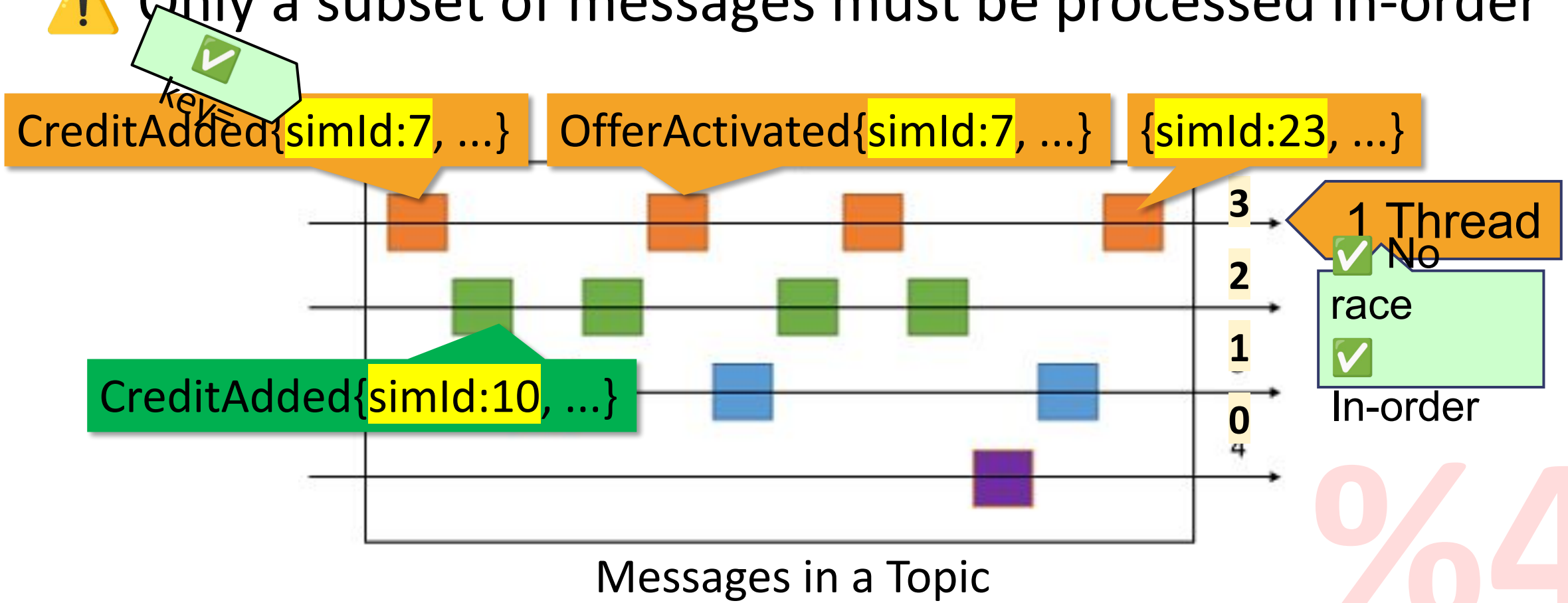
- Producer sent: ..., ..., M1, M2, ..., ...

- **How can M1 start after M2 finished**!?

- For 🔼 Throughput, a consumer gets a batch of messages
  - Consumer A got [..., ..., M1]
  - Consumer B got [M2 ,... , ...]

Why Partitioning

⚠️ Only a subset of messages must be processed in-order



%4

(if 4 partitions)

Partitioning is Consumer-Driven

- Split messages of one topic in **partitions**
  - 🤔 What if messages arrive on different topics?
  - ⇒ Redesign to 1 topic, or Delayed Retry
- ... by **hash**(message.**key**) % N
  - 🤔 Event involves two aggregates:
    - SimAddedToPhone ⇒ hash(sim_id + phone_id)? Publish on 2 topics ✅
    - TransferCredit { from_sim, to_sim ... } ⇒ one single partition/thread ✅

≈ Rabbit routing-key
≈ Pub-Sub ordering-key
...

- ... and consume a partition with **1 thread**
  - 🔥 Hot Partition (unbalanced): key=country, but 80% M have key="NL"

✅ Delayed Retry

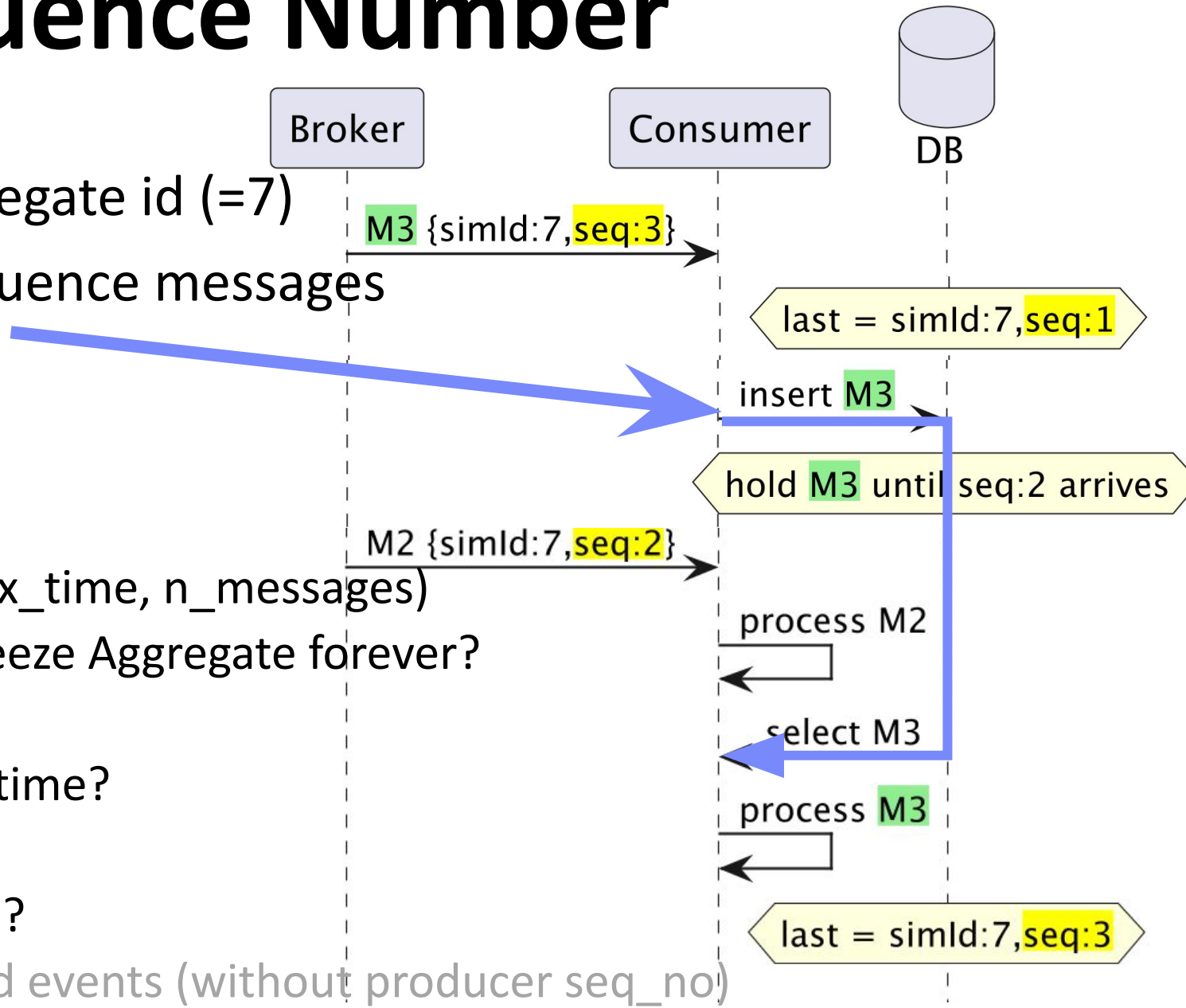
- M1 = CreditAdded {credit: 5EUR, simId:7} sent ⏱10:00
- M2 = OfferActivated {offer: National5EUR, simId:7} sent ⏱10:01
- If consumer processes M2 first ⇒ 💥CreditLimitExceeded
  - Possible only if consumer stored SIM state in its DB ⚠️
- ~~**Sync Retry** M2 (before other messages) - might not help ❌~~
- **Delayed Retry**, after processing other messages:
  - Kafka ⇒ @RetryableTopic to delay-consume from extra topics
  - Rabbit ⇒ reject with TTL
  - DIY ⇒ Insert into an inbox table + hand-made polling 🪚🤖
- **Retry⇒ what errors=?, backoff=?, attempts=? exhaust⇒DLT*

Out-of-order - Fixes

- Partitioning 
- Delayed Retry
- Sequence Number

✅ Sequence Number

- Producer adds seq_no / aggregate id (=7)
- Consumer buffers out-of-sequence messages until correct one arrives

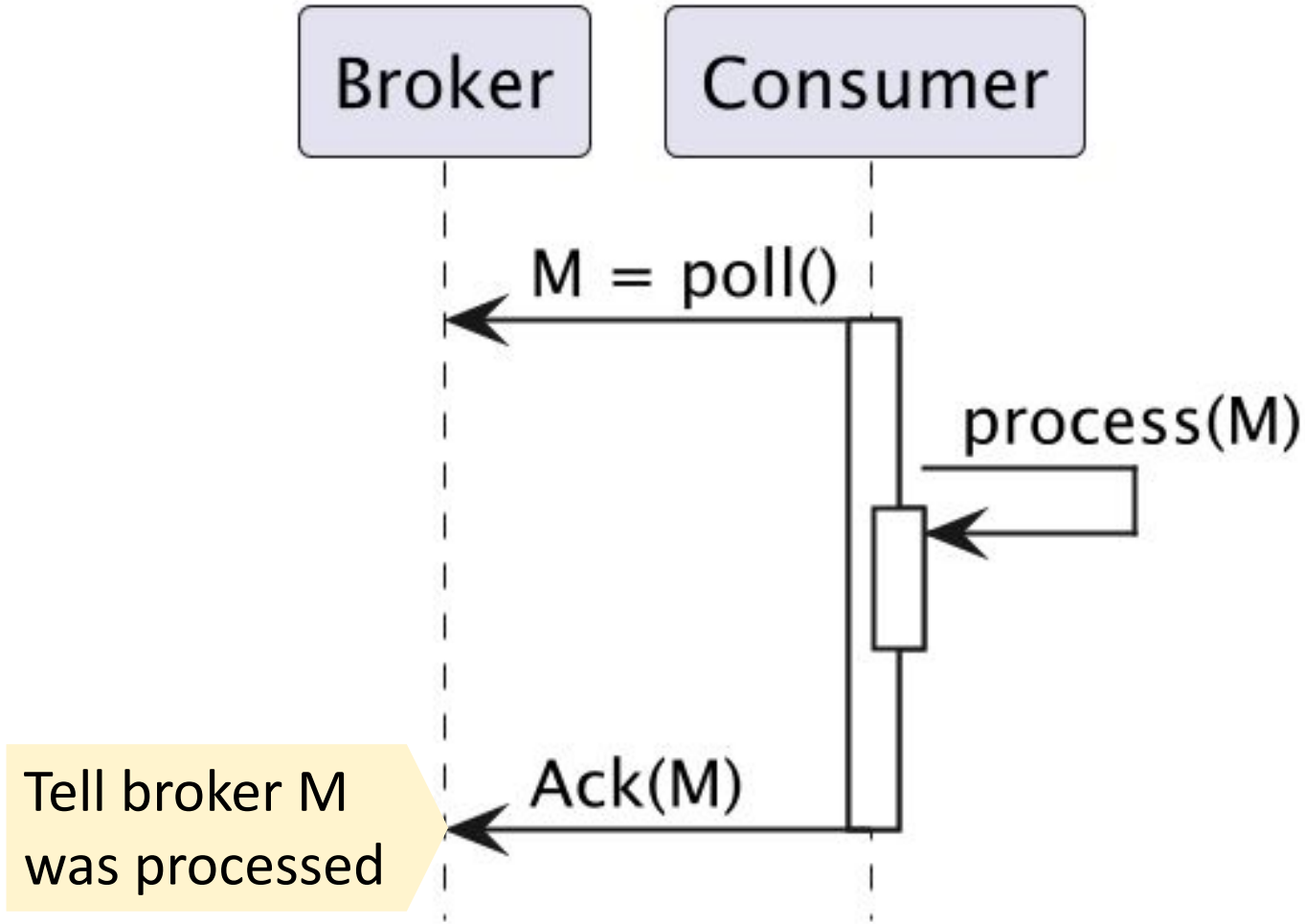


- Hard Debates:
  - How long to wait for M2? (max_time, n_messages)
  - After: process M3 anyway? freeze Aggregate forever?
  - Tolerable latency increase?
  - Do messages have expiration-time?
  - When to alert a human?
  - What if M2 arrives but fails💥?
  - Process pending business-valid events (without producer seq_no)

Out-of-order - Fixes

- Partitioning 
- Delayed Retry 

Consume a Message =?



@Rabbit-
@Sqs-
@Jms-
@ServiceBus-

☣ Async Process

```
@KafkaListener
void consume(message) {
  CompletableFuture.runAsync(()→ {
    process(message); // slow
  });
}
```

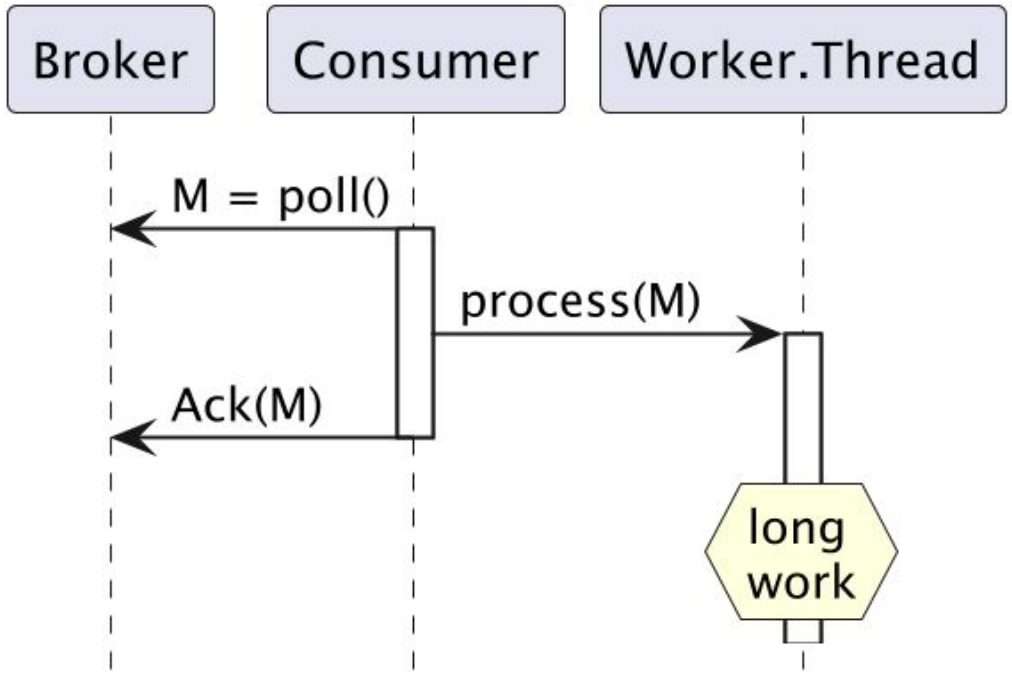
> Ack M despite (later) errors in process()

> Message(s) get lost on kill -9 / crash 💥

Waiting in Thread Pool's in-mem work queue

> No Backpressure ⇒ Out Of Memory 💥

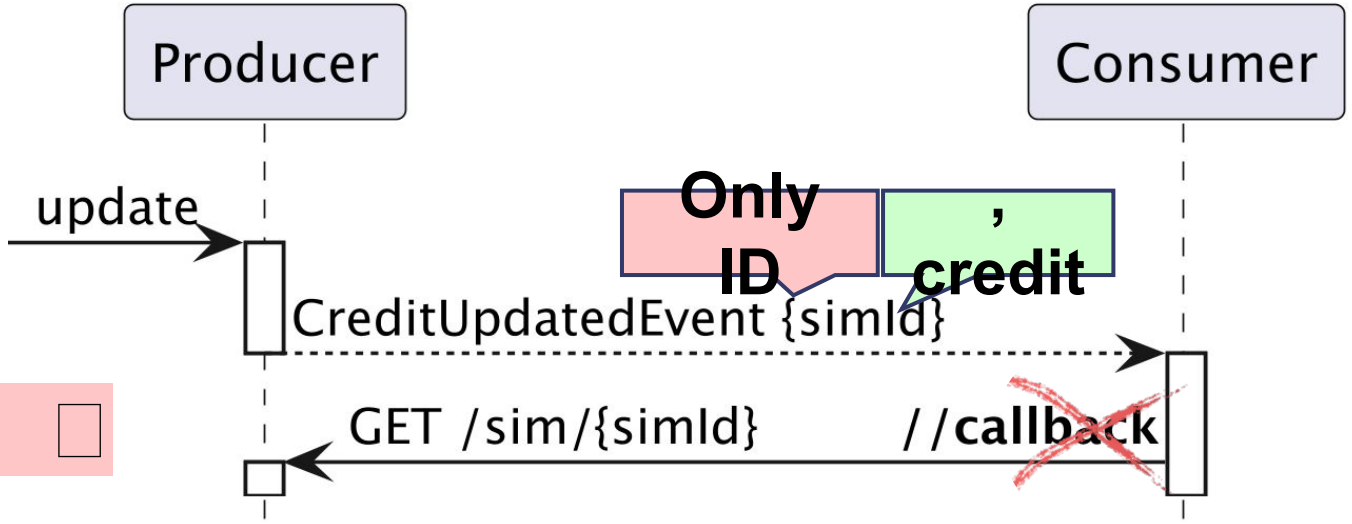
Broker may flood unbounded in-mem



Consumer Calls-back Producer

- Consumer gets a **Notification Event** lacking useful details

  ... and calls back the Producer to GET more data



Race Condition Risk ☢

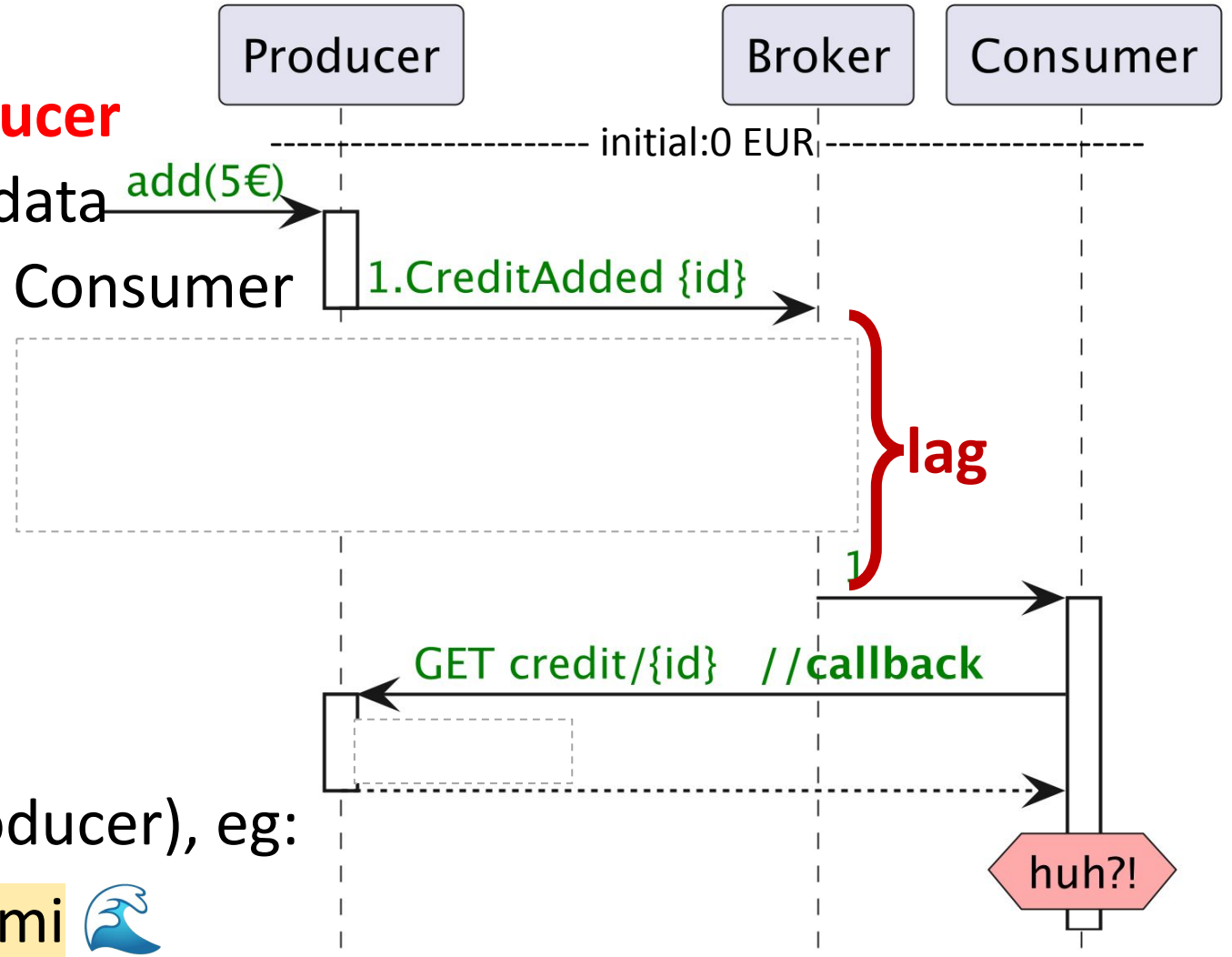
⇒ **Event-Carried State Transfer***: more data in event (ofc🙄)

- vs REST (REpresentation State Transfer)
- ⇒ Event Schema versioning, backwards/forwards compat tests

1) Consumer Callback is Too Late ☣️

= Data was updated AGAIN in Producer

- Might be OK to get only latest data
- Intermediary state not seen by Consumer
  0⇒12⇒12



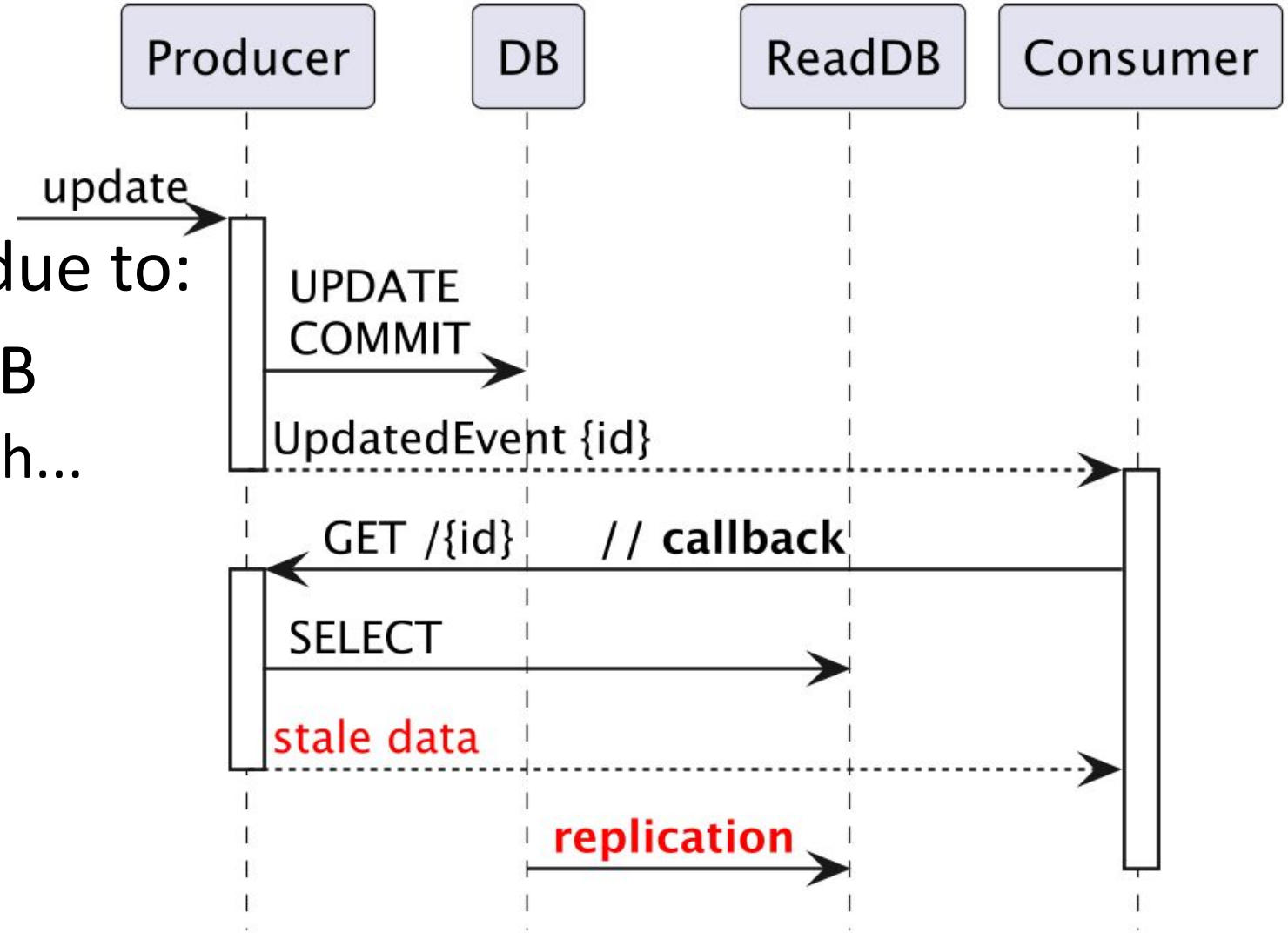
Consumer Lag (eg 5 min behind Producer), eg:

- Process a Batch File > Event Tsunami 🌊
  - ⚔️ Ingest Amazon order updates at 5^{00}AM => 10 M events sent in 10 min

2) Consumer Callback is Too Early 😱

The data is **not yet there**, due to:

- GET reads from lagging DB
  - Read replica, Elastic Search...



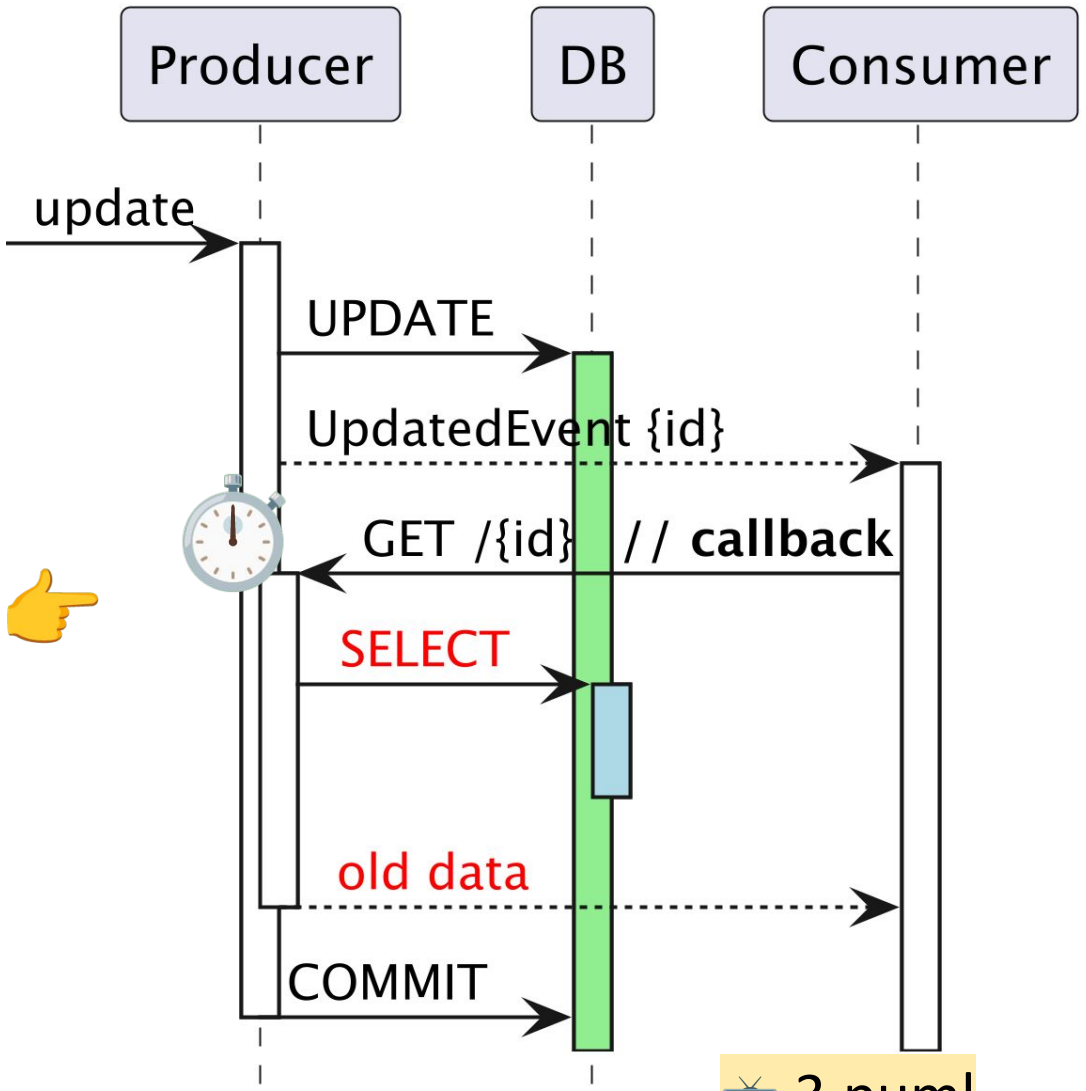
📺 4.puml

3) Consumer Callback is Too Early 😱

The data is **not yet there**, due to:

- GET reads from lagging DB
  - Read replica, Elastic Search...
- Message sent before DB commit 👉

```
DB update
send message
DB commit
```



📺 3.puml

⭐ **Event-Carried State Transfer** = move state with events

TODO
new fields=>💥Consumer

- java serializable

- JSON+fail.on.unknown.propertiest

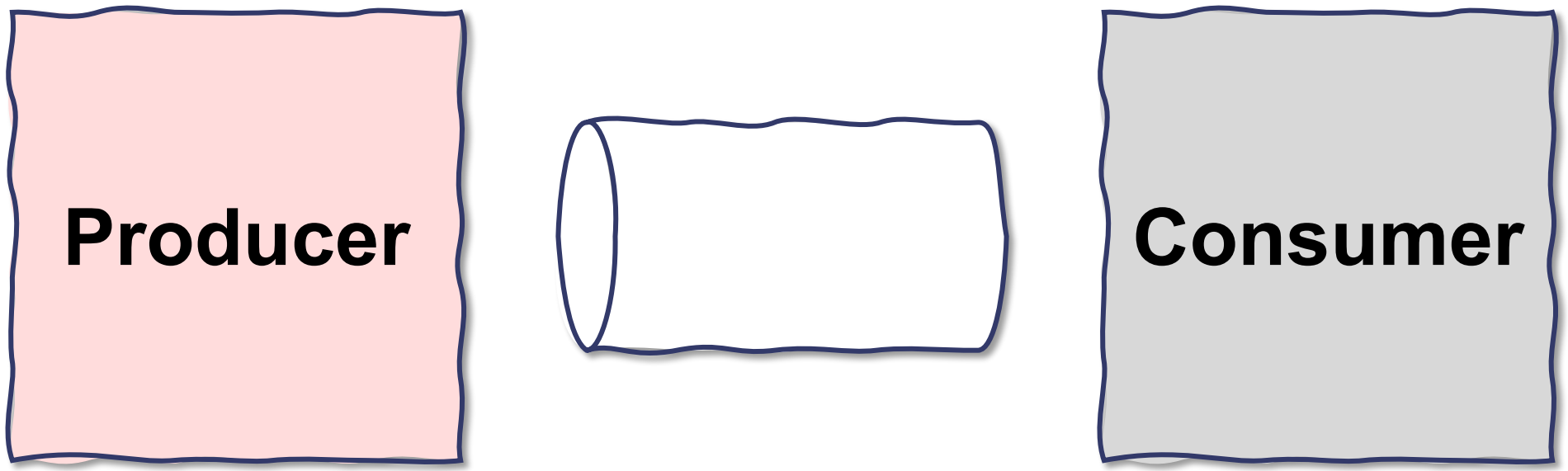
Event Schema

- Consumer can **receive newer event version**
  - ... published by newer Producer

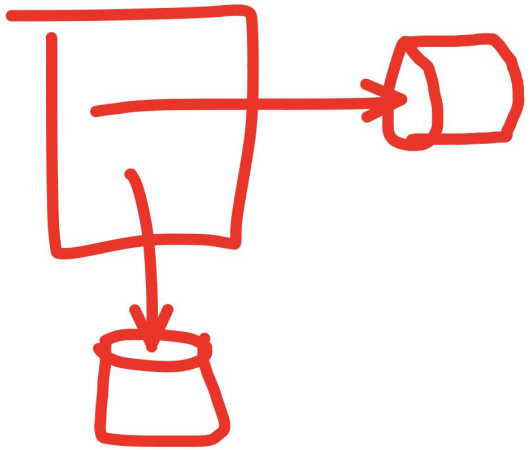
  ⇒ must be **Future Compatible**

- Consumer can **receive older event version**
  - ... at replay history
  - ... published by Producer #2 (old) – is it command?

  ⇒ must be **Backwards Compatible**


Producer
Consumer

☣️ Send + Update



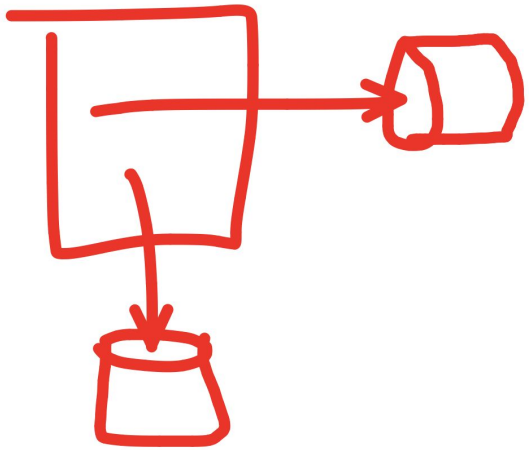
```
placeOrder(r) { // called over REST
  validate(r) ← ASAP, sync 👍
  broker.send(message)
  orderRepo.save(order)
}
```

- NOT NULL
- COLUMN SIZE
- FK
- PK
- UNIQUE...

Start with most risky step first!

Which is more likely to fail?

☣️ Update + Send



```
placeOrder(r) {
   validate(r)
   orderRepo.save(order)
   broker.send(message)
}
```

Risk of Broker offline ⏬

❌ Message is sent ***at-most-once***

Dual Write Problem

☣️ Update + Send

```
@Transactional
placeOrder() {
  stockRepo.save(stock)
  orderRepo.save(order)
  broker.send(message)
}
```

Added to:

1) Make atomic 2+ DB updates

2) Use JPA lazy-loading

3) Make (SQL updates + send) ator

WRONG ASSUMPTION

Only after method ends:

☣️

- **JPA flushes** all INSERT, UPDATE, DELETE to DB
- **Commit SQL transaction**

❌ ~~**AFTER message was sent**~~

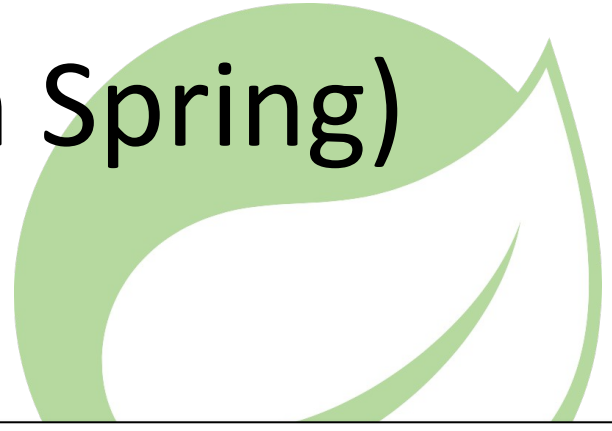
Unless still using 2PC:

👴 ActiveMQ/Artemis

👴 IBM MQ

👴 TIBCO ...

✅ Send After Commit (with Spring)



```
@Transactional
placeOrder() {
   stockRepo.save(stock)
   orderRepo.save(order)
   applicationEventPublisher.publish(message)
}
```

⇒ Pull send() out, after placeOrder()

⇒ @TransactionEventListener 👇

✨

☢ **Risk**: message lost on crash/shutdown right after commit

```
@TransactionalEventListener(AFTER_COMMIT)
onEvent(message) {
   broker.send(message)
}
```

Runs after the transaction within which the event was published

☢ Silent miss if no @Transactional

✅ Outbox Table Pattern

```
@Transactional
placeOrder() {
  stockRepo.save(stock)
  orderRepo.save(order)
  outboxRepo.save(message)
}
```

Insert the message to send in DB within your transaction

a) **CDC** with Debezium.io

b) **DIY** with

```
@Scheduled(rate=1s🤔)
pollSend() {
  m=select outbox
  broker.send(m) 💥⏱️
  delete m in outbox
}
```

+10 other debate points

on Error💥 or Timeout⏱️

Message sent ***at-least-once***

Store-and-Forward Pattern

Implementing an Inbox / Outbox Table

≈ Reinventing a Message Broker

🔝☣️ Duplicate Messages

Because:

- **Producer sent M twice** (due to outbox-retry...)
- **Consumer didn't Ack M** (due to crash...)

👑 Idempotent Consumers 👑

- Message is a dup if:
  - CreditAdded{+5EUR}.**idempotencyKey** ∈ prev_messages in DB (delta event)

    `CreditUpdated` or **seq_no, publish_nanos, message offset** ...
  - CreditUpdated{8EUR}.newCredit == **oldSim**.credit in DB (snapshot event)
- Dedup M, **then** do any side-effects: api.call(), DB.update..

Event Semantics

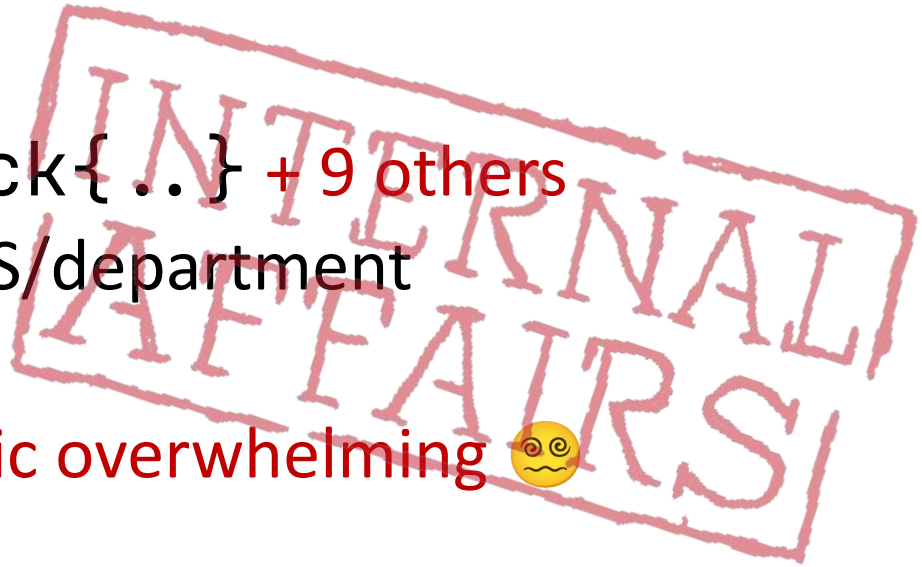
- **Delta Event**
  - `CreditAdded {added:+5 EUR}`
  - ☹️ Consumers **must dedup**
  - ☹️ Consumers **must track old state** to compute new state
- **Snapshot Event**
  - `CreditUpdated {newCredit:7 EUR} // new state`
- **Both: "EventShot"** 🤔
  - `CreditAdded {newCredit :7 EUR, added:+5 EUR}`

Idempotent Consumer

1. **I have a DB**
   a) Track in DB processed idempotency-keys
   b) Store in DB your Kafka consumer offsets (not in Kafka Broker)
2. **I don't have a DB**, I only API-call
   a) Idempotent API: PUT or Idempotency-Key header 🤞
   b) GET before POST – "is my data already there?"

☣️ Exposing Internal Events

- **Internal Event**
  - `CreditAdded{..}, CredidPaidBack{..}` + 9 others
  - Between microservices of an ecosystem/SCS/department
  - Source of truth in Event-Sourced apps
  - If exposed => client coupling 🔼 and semantic overwhelming 😵‍💫

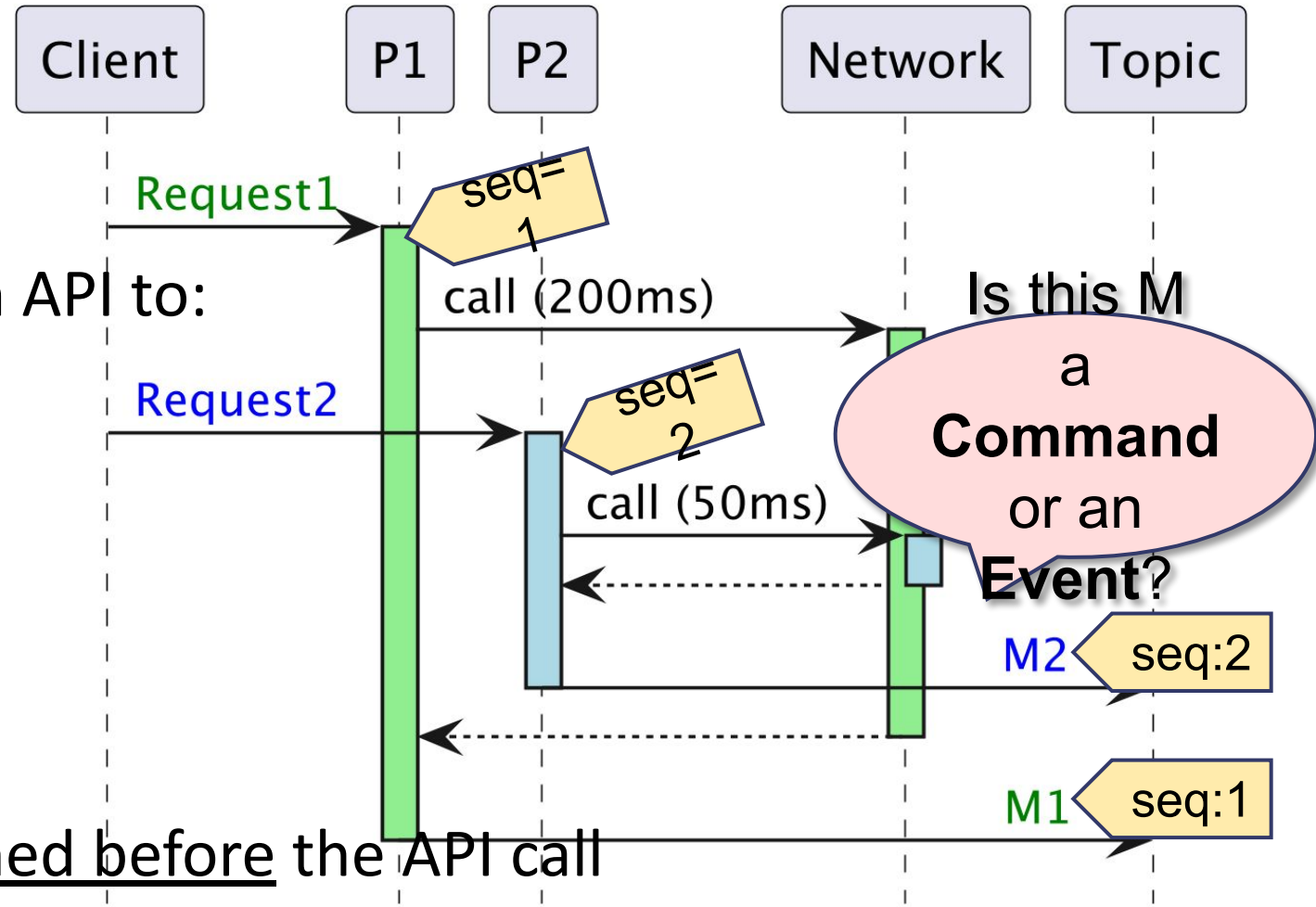


- **Integration Event = Contract**
  - `CreditUpdated{simId, newCredit}` – ***narrow*** key event
  - `SimUpdated{<15 fields>}` – broad

📺 1.puml

☣️ Producers Race

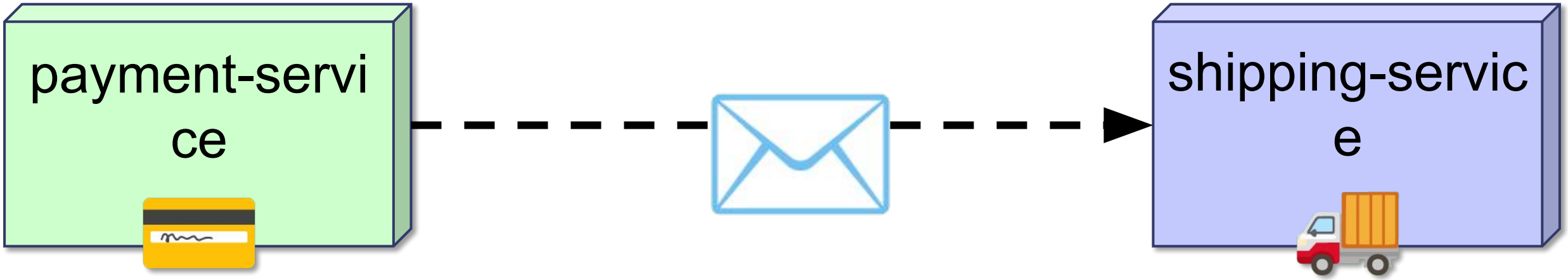
- Producers is called at 🔼 **rps** 🔥
- Before sending, producer calls an API to:
  - Validate request
  - Load more data
- Sends messages in wrong order



⇒ Producer sends a seq_no <u>assigned before</u> the API call

⇒ Publish to a partition ASAP & defer the API call to later processor (📺2.puml)

Rule: When **payment** is confirmed, the order must be **shipped**.



PaymentCompleted **Event**

ShipOrder **Command**

"pub-sub", "topic"

"point-to-point", "queue"

PaymentCompleted **Event**	VS	ShipOrder **Command**
Past Tense	**Timing** (when?)	**Future** / Imperative
None: tells a fact	**Producer Expectations**	**Expects** an action
No, it's history	**Can Consumer Refuse it?** "It's wrong!"	**Yes** if invalid request
Multiple [0 .. N] Add more listeners with zero impact 🤞	**# of consumer-groups** (apps)	**One:** shipping-service with 1+ consumers (threads)
Producer But caring for consumers	**Who's Message Schema** What Bounded Context?	**Consumer** request params ≅ POST body

☣️ Command (=Request) / Event (=Fact) Confusion

- **CheckBeerInSapEvent**
  - = "command event" (EDA = 🎤🚙🏗️)
    - Who is allowed to listen? 🤷
    - Is there a Reply message? 🤷
- **OrderNeedsShipmentEvent**
  - = passive-aggressive event 🤣
    - *Publisher afraid to let go orchestration* 🤔

Oskar Dudycz's Blog & Newsletter

Event Granularity

A) CUD Event just replicates data ≈ something changed 🤷

"OrderEvent" means ...

- Created
- or Updated ⇒ Self-healing Event, aka "upsert in DB"
- or Deleted
  - if message.type = D --- .type ∈ {C|U|D}
  - if payload = **null** in Kafka (tombstone message)

B) Domain Event = fine grained (best kept internal)

- OrderPlaced, ..Fulfilled,
- ..Shipped, ..Returned, ..Refused ... +10 more ⇒ semantic overload 😵

Meanwhile, on Production Front ...

Errors

Error Handling Strategies

- **Sync Retry 3-5 times** vs race, transient failure
  - Infinite retry ☢️: expected Avro, got JSON ⚔️
- **Delayed Retry** vs out-of-order
- **Ignore Error**, for ≤ N messages, or for ≤ 5 min 👍
- **Log** > alarm🔔: log.error("Failed: " + toJson(☣️message));

  Sensitive / Too large?
- **Send to DLQ** > alarm🔔
- **Send an Error Event** if biz-relevant: PaymentFailed{reason}

Poison Pill Message

= M that kills any consumer receiving it ⇒ no ACK ⇒ next consumer ↺

⇒ All consumers are **continuously restarted** ⇒ **Lag** on all topic partitions

- M = OrderPlacedEvent {items:[1000 distinct product IDs]}

⚔️ Consumer loads all products in memory

- **Out Of Memory** => Consumer process dies ⇒ ☠️ + ↺

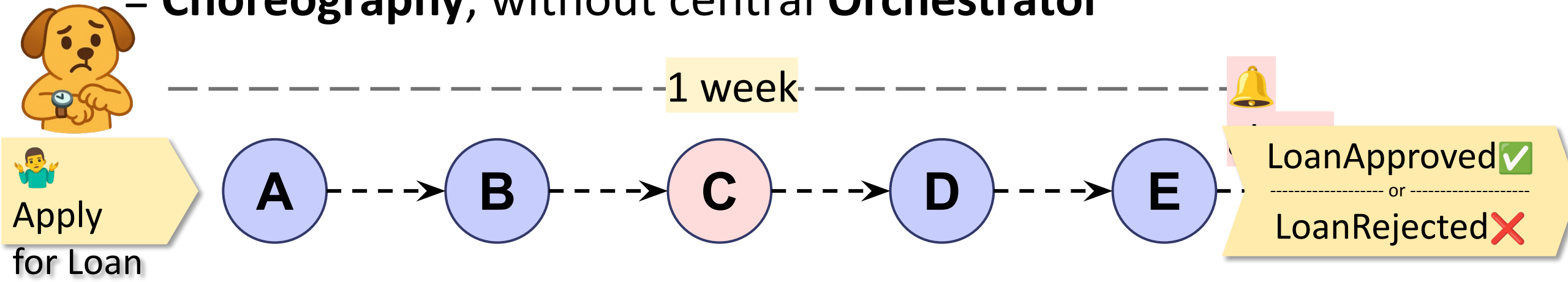
⚔️ Consumer loads all products sequentially, one by one, over REST

- **Processing takes too long** => Broker considers consumer hung ⇒ ☠️ + ↺
- **Bonus**: Consumer #2 races with Consumer #1 still processing **M**

⚔️ Expected Avro Message got JSON ⇒ ♾️ retry ⇒ ☠️ + ↺

Broken Choreography Chain

- **In EDA, services listen to events from upstream services**
  = **Choreography**, without central **Orchestrator**



- **System C forgets to publish its event** (NO exception in logs)

⇒ **A watchdog** monitors completion of the e2e chain ≈ SLA

⇒ **C sends to D heartbeats** 💓 = empty events ≈ health check

The Cheese Paper Disaster

☣ ∞ Event Loop

traceparent: 123

Add cheese to cart

cart-service

Small adjustment for UX:

CheesePaper.type := 'cheese'

traceparent: 123
traceparent: 123
traceparent: 123

CartItemAdded

{ item: {..} }

PromoGrante

traceparent: 123

{
CheesePaper
}

promo-service

If item.type = 'cheese',
grant free Cheese Paper.

Entire Kafka Cluster Crashed

Most systems had downtime of 20 minutes

👍 set quota.producer.default = max bytes/sec

traceparent: 123

Request ↩️ Reply – RPC Nostalgia

= **Async, Durable RPC**

- Request ✉️ = Command
- Reply ✉️ ≈ Event, but targeted to requester

- **Requestor blocks** for the reply ⏱️
  - = a message bridge between UI calling REST and Message Backoffice
  - *Rabbit - via Temporary Reply Queue*
  - *Kafka, SQS, pub-sub - via a ReplyTopic + CorrelationId*
    - N Requestor instances => N consumer-groups for reply topic
  - ☣️ Volatile waiting pending replies
- **Requestor resumes flow from DB** upon reply ⏸️▶️
  - 🤯Complexity🔼, Fault Tolerance🔼

https://victorrentea.ro/eda-pitfalls -> Slides

Top Event-Driven Pitfalls

- **Integration Testing:** timeout(..), spy, ☢️message leak cross-tests
- **Message Observability:** 👨‍🦲 + 🤖 = 1.3 - 3x impact
- **Consumer Race** ⇒ partitions, locking (optimistic/pess)
- **Out-of-Order** ⇒ partitions, delayed retry, seq_no
- **Consumer Callback** Race ⇒ Event-Carried State Transfer
- **Async Consumer** (lost messages) ⇒ Ack after process
- **Dual Write** (save + send) ⇒ Outbox Table/CDC
- **Duplicate Messages** ⇒ Idempotent Consumer⭐
- **Command vs Event Message**
- **Errors**: ∞ retry, poison pills, broken chain ( , 💓), ∞ event loop

agentic.how

Thanks to the dozens of seniors sharing with me their stories, and to Emanuel Trandafir who reviewed my early draft version