



ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Persistent Actor State

Principles of Reactive Programming

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Actors representing a stateful resource

- ▶ shall not lose important state due to (system) failure
- ▶ must persist state as needed
- ▶ must recover state at (re)start

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Two possibilities for persisting state:

- ▶ in-place updates
- ▶ persist changes in append-only fashion

Changes vs. Current State

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Benefits of persisting changes:

- ▶ History can be replayed, audited or restored.
- ▶ Some processing errors can be corrected retroactively.
- ▶ Additional insight can be gained on business processes.
- ▶ Writing an append-only stream optimizes IO bandwidth.
- ▶ Changes are immutable and can freely be replicated.

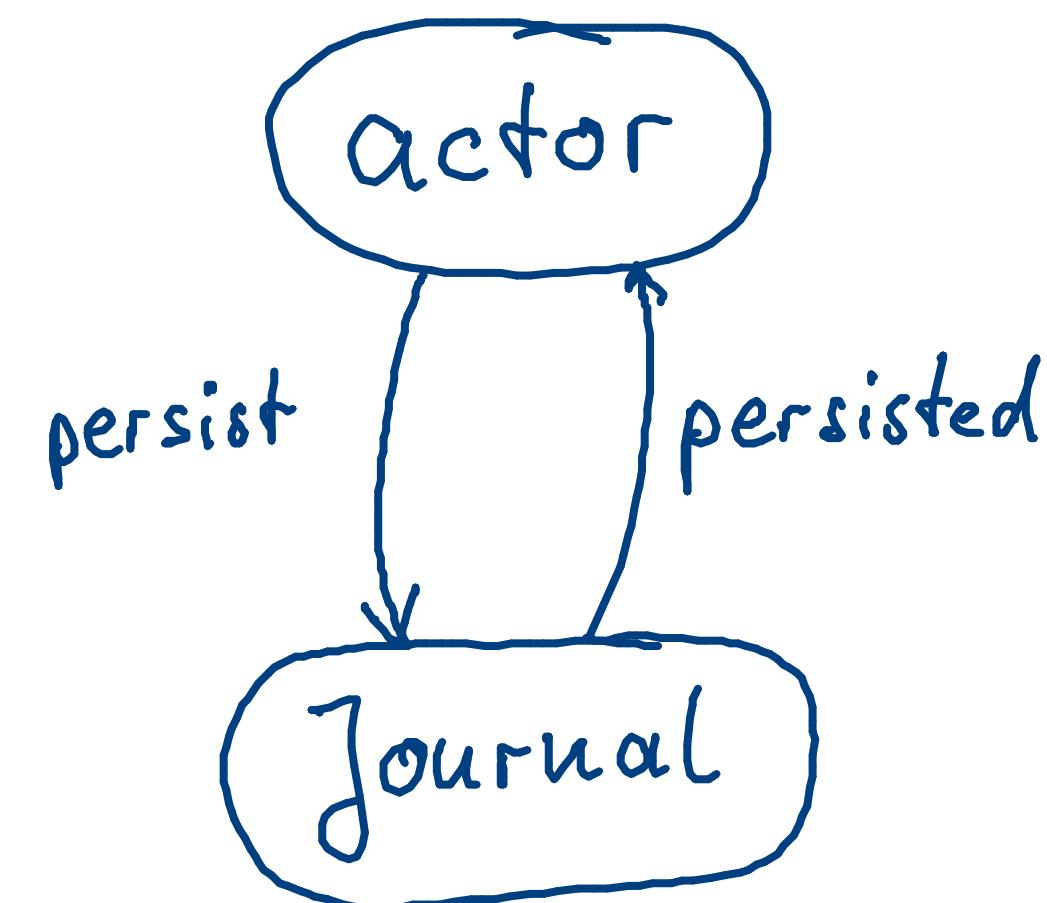
Snapshots

Immutable snapshots can be used to bound recovery time.

Persistence Primitive

- ▶ being persistent means “taking notes”

```
persist(MyEvent(...)) { event =>  
    // now <event> is persisted  
    doSomethingWith(event)  
}
```



Event Example (1)

```
case class NewPost(text: String, id: Long)
case class BlogPosted(id: Long)
case class BlogNotPosted(id: Long, reason: String)

sealed trait Event
case class PostCreated(text: String) extends Event
case object QuotaReached extends Event

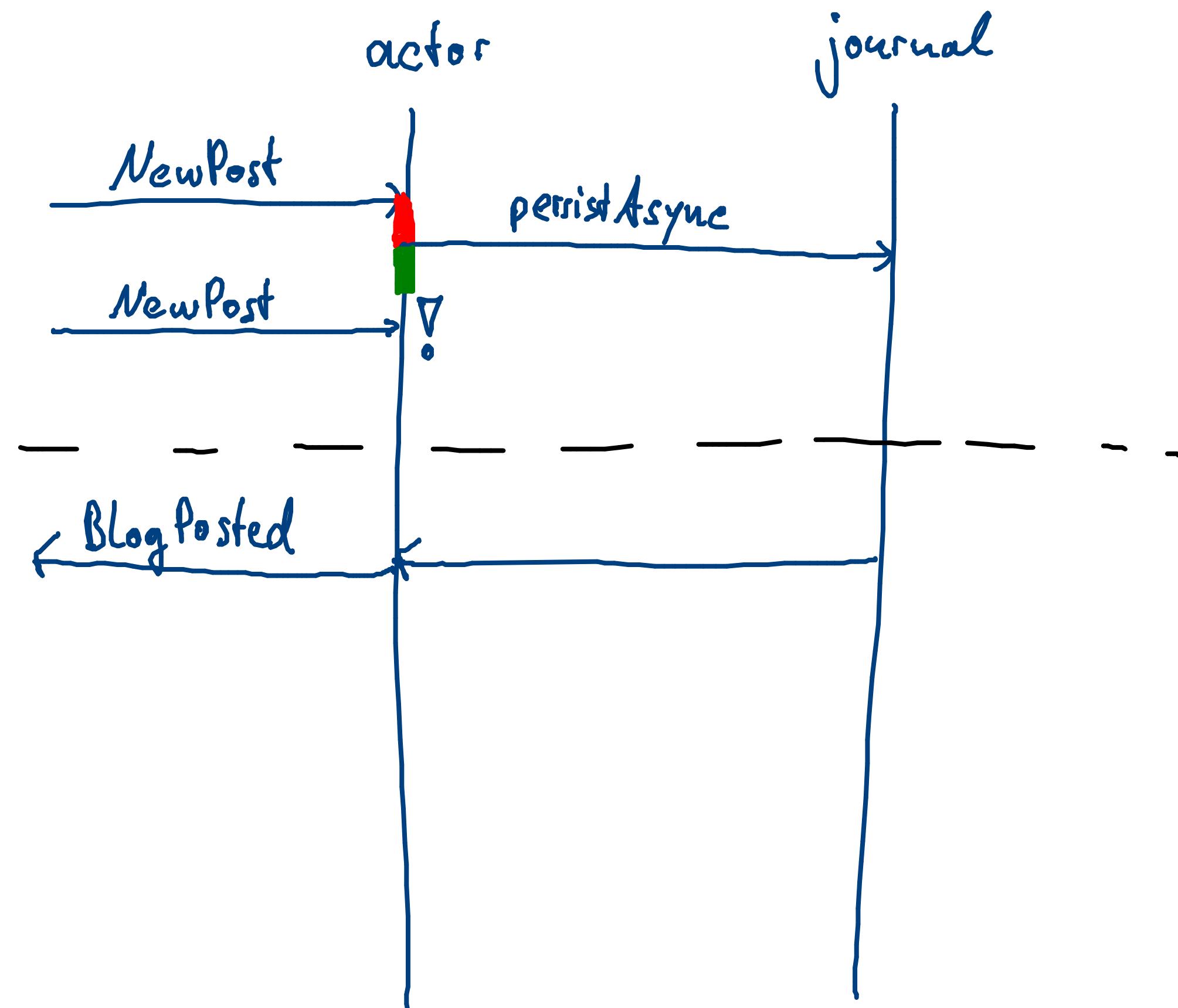
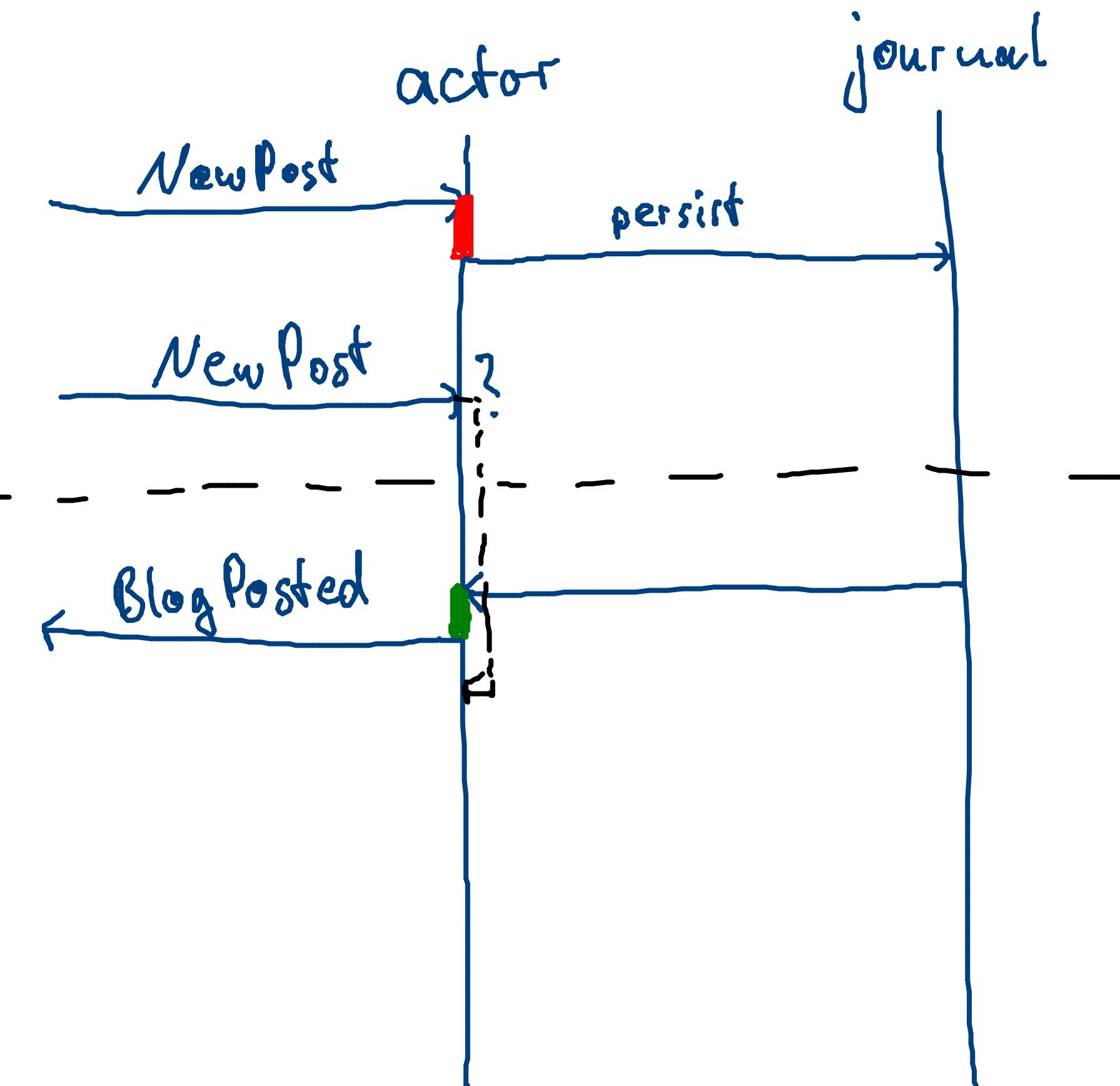
case class State(posts: Vector[String], disabled: Boolean) {
    def updated(e: Event): State = e match {
        case PostCreated(text) => copy(posts = posts :+ text)
        case QuotaReached      => copy(disabled = true)
    }
}
```

Event Example (2)

```
class UserProcessor extends PersistentActor {  
    var state = State(Vector.empty, false)  
    def receiveCommand = {  
        case NewPost(text, id) =>  
            if (state.disabled) sender() ! BlogNotPosted(id, "quota reached")  
            else { persist(PostCreated(text)) { e =>  
                updateState(e)  
                sender() ! BlogPosted(id) }  
                persist(QuotaReached)(updateState) }  
    }  
    def updateState(e: Event) { state = state.updated(e) }  
    def receiveRecover = { case e: Event => updateState(e) }  
}
```

When to Apply the Events?

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It is a trade-off between throughput and consistency.

Event Example (3)

```
case NewPost(text, id) =>
  if (!state.disabled) {
    val created = PostCreated(text)
    update(created)
    update(QuotaReached)
    persistAsync(created)(sender() ! BlogPosted(id))
  } else sender() ! BlogNotPosted(id, "quota reached")
```

At-Least-Once Delivery (1)

- ▶ Guaranteeing delivery means retrying until successful
- ▶ Retries are the sender's responsibility
- ▶ The recipient needs to acknowledge receipt
- ▶ Lost receipts lead to duplicate deliveries ⇒ *at-least-once*

At-Least-Once Delivery (1)

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-
- ▶ Retrying means taking note that the message needs to be sent
 - ▶ Acknowledgement means taking note of the receipt of the confirmation

At-Least-Once Delivery (2)

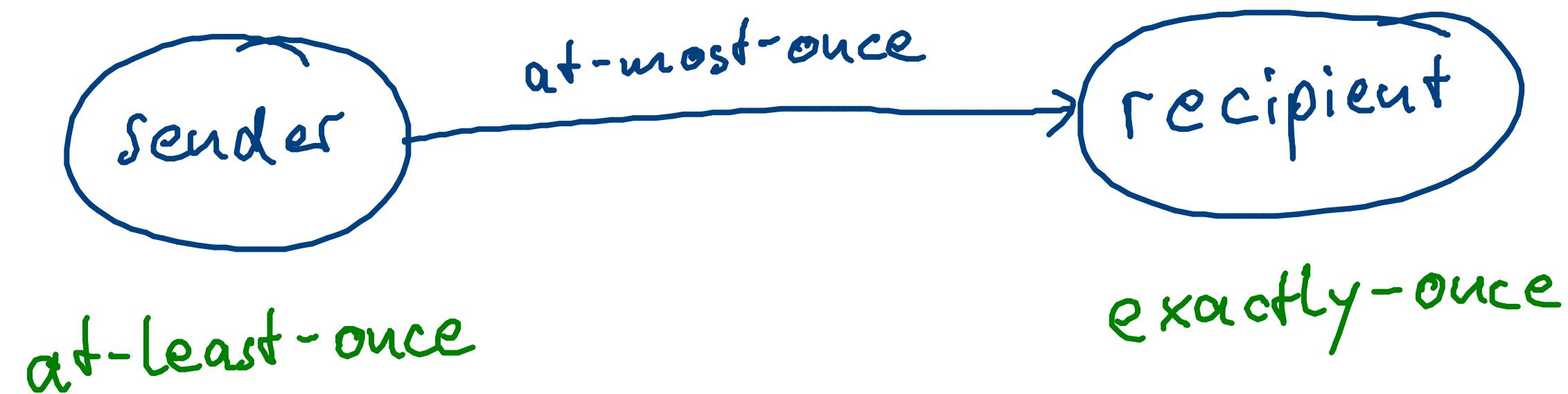
```
class UserProcessor(publisher: ActorPath)
  extends PersistentActor with AtLeastOnceDelivery {
  def receiveCommand = {
    case NewPost(text, id) =>
      persist(PostCreated(text)) { e =>
        deliver(publisher, PublishPost(text, _))
        sender() ! BlogPosted(id)
      }
    def receiveRecover = {
      case PostCreated(text) => deliver(publisher, PublishPost(text, _))
    }
  }
}
```

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```
class UserProcessor(publisher: ActorPath)
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    case NewPost(text, id) =>
      persist(PostCreated(text)) { e =>
        deliver(publisher, PublishPost(text, _))
        sender() ! BlogPosted(id)
      }
    case PostPublished(id) => confirmDelivery(id)
  }
  def receiveRecover = {
    case PostCreated(text) => deliver(publisher, PublishPost(text, _))
    case PostPublished(id) => confirmDelivery(id)
  }
}
```

Exactly-Once Delivery (1)

- ▶ *At-least-once* delivery leads to duplicates at the receiver
- ▶ The receiver needs to remember what it has already done to avoid redoing it



Exactly-Once Delivery (2)

```
class Publisher extends PersistentActor {  
    var expectedId = 0L  
    def receiveCommand = {  
        case PublishPost(text, id) =>  
            if (id > expectedId) () // ignore, not yet ready for that  
            else if (id < expectedId) sender() ! PostPublished(id)  
            else persist(PostPublished(id)) { e =>  
                sender() ! e  
                // modify website  
                expectedId += 1  
            }  
    }  
    def receiveRecover = { case PostPublished(id) => expectedId = id + 1 }  
}
```

When to Perform External Effects?

Performing the effect and persisting that it was done cannot be atomic.

- ▶ Perform it before persisting for at-least-once semantics.
- ▶ Perform it after persisting for at-most-once semantics.

This choice needs to be made based on the underlying business model.

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If processing is *idempotent* then using at-least-once semantics achieves *effectively exactly-once delivery*.

Summary

- ▶ Actors persist facts that represent changes to their state.
- ▶ Events can be replicated and used to inform other components.
- ▶ Recovery replays past events to reconstruct state; snapshots reduce this cost.