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Actor Model - Akka

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Philosophy

«**The world is parallel.** If we want to write programs that behave as other objects behave in the real world, then these programs will have a concurrent structure.

Use a language that was designed for writing concurrent applications, and development becomes a lot easier. Erlang (actor-oriented language) programs model how we think and interact.»

Joe Armstrong

Outline

- Fundamentals
- Communication
- Fault-tolerance

Fundamentals

Why?

- We present the actor-based model for several reasons

actor gives another way at looking to the problem

  - Different approach to **concurrency** compared to lock-based primitives
  - **Low-level:** does not hide the complexities of building distributed applications, but forces the developers to take care of the concerns related to distribution
  - **Blur the distinction** between local and remote processing
- Many services implemented on top of actor-oriented systems

Why?

- Used in practice to build complex distributed applications
- **Erlang**
  - Ericsson network infrastructure software
  - WhatsApp
    - highscalability.com/blog/2014/2/26/the-whatsapp-architecture-facebook-bought-for-19-billion.html
  - CouchDB
  - RabbitMQ
- .Net **Orleans**
  - Halo multiplayer backend
- Java / Scala **Akka**
  - Customers: BMW, VW Group, Bosch, Siemens, Volvo, …

Actor model

«The actor model abstraction allows you to **think about your code in terms of communication**, not unlike the exchanges that occur between people in a large organization.»

actor as a person that talk to other people exchanging information throug

Akka documentation

Actor model

«The actor model in computer science is a mathematical model of concurrent computation that treats actors as the universal primitives of concurrent computation. In response to a message that it receives, an actor can**: make local decisions**, **create more actors**, **send more messages**, and determine how to respond to the next message received. Actors may modify their own private state, but **can only affect each other through messages**, **avoiding the need for any locks**.»

Wikipedia

Actor model

- Concurrency model where the concept of actor is the **universal primitive**

- Properties of actors
  - Stateful
  - Asynchronous
    - Actors run concurrently and communicate through asynchronous message passing
  - Persistent
    - The state can be saved to persistent storage

Actors: what do they do?

- They receive messages and react by
  – Taking **local decisions**
    - Change their internal state
    - Change their behavior
  – **Send messages**
    - They can reply with 0, 1, or more messages
    - To the sender
    - To other actors they know of
  – **Start new actors**

Basic idea of communication

« Do not communicate by sharing memory; instead, share memory by communicating.»

Effective GO

- Since we do not rely on shared memory, programs can run in distributed settings with no changes compared to a local setup
  - Similarly, the model makes **no assumptions on reliability, message orders**, …

Example

- We want to implement a bank management application
  - Account balance cannot be negative
  - So we need to avoid violations due to concurrent accesses
- In a **shared memory** programming model we need to
  1. Create an account
  2. Explicitly create a thread to manage one or more accounts
  3. Add code to prevent undesired concurrent accesses
     - E.g., synchronized blocks, locks, …

Example

- The actor model offers a **different design opportunity** for point 2 and 3

  - Creating a new actor to manage a new account automatically makes it run asynchronously with respect to other actors
    - The internal state of the actor contains the managed account
  - Messages are **processed atomically**
    - As if the entire processing of a message was executed in a synchronized method of a class where all methods are synchronized
    - Messages received meanwhile are queued up and do not affect the currently running receive functionality

Hands-on: Akka

Akka

- Implementation of **the actor model for the JVM**
  - Java and Scala API

- Also provides additional abstractions built on top of the basic actor model
  - Akka clusters
  - Akka sharding
  - Akka streams
  - Akka HTTP
  - …

- We will present the primitives for
  - Creating actors
  - Exchanging messages
  - Changing behavior
  - Fault tolerance
  - Clustering
  - …

Create actors

- The easiest way to define a new type of actor is to inherit from the **AbstractActor** class
  - You need to define the `createReceive()` method, which defines how each message is processed
  - It is also possible to override other methods to customize the behavior when entering different states in the lifecycle of the actor
    - `preStart()`
    - `preRestart()`
    - `postRestart()`
    - `preStop()`,
    - …

Create actors

- To create an actor you need to
  - Instantiate an ActorSystem

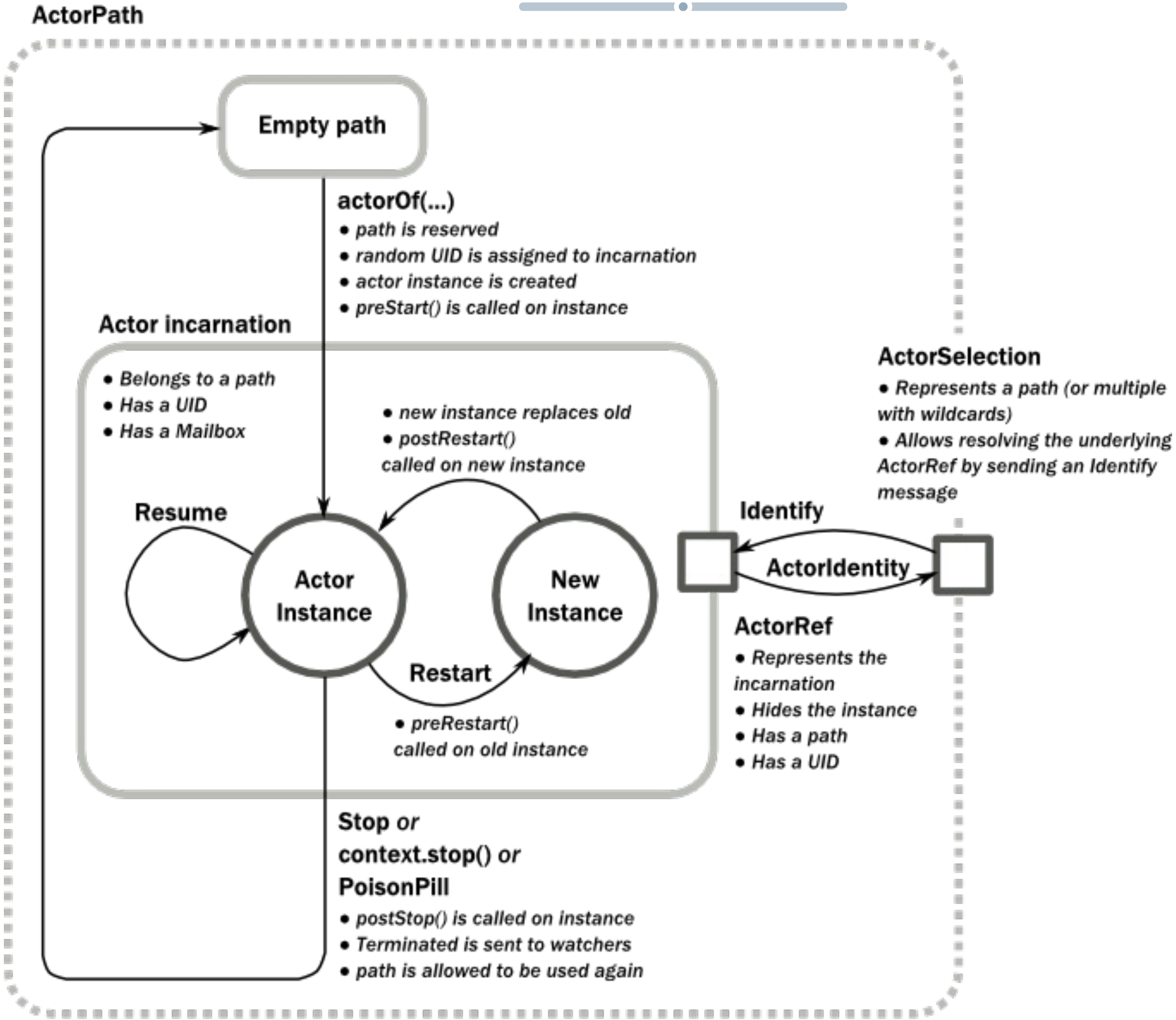
    ```
    ActorSystem sys = ActorSystem.create("sys name");
    ```

  - Instantiate a new actor starting from a property object that defines the class of the actor

    ```
    Props p = Props.create(MyActor.class);
    sys.actorOf(p, "actor name");
    ```

  - Often, the property is created and returned within a static method of the actor class

Actors lifecycle



Send messages to actors

- Upon creation, the actorOf method returns a reference to an actor (**ActorRef**)
  - The ActorRef remains valid throughout the actor lifecycle
    - Even if the actor stops and restarts

- ActorRefs can be passed as part of messages to inform other actors

- ActorRefs can be used to send messages to actors using `tell()`

Actors basics

```java
public class CounterActor extends AbstractActor {
  private int counter;

  public CounterActor() {
    this.counter = 0;
  }

  @Override
  public Receive createReceive() {
    return receiveBuilder() //
        .match(SimpleMessage.class, this::onMessage) //
        .build();
  }

  void onMessage(SimpleMessage message) {
    ++counter;
    System.out.println("Counter increased to: " + counter);
  }

  static Props props() {
    return Props.create(CounterActor.class);
  }

}
```

redifinied to specify the behaviour of this actor.Here we use the match method, to indicate wheneve

redefinition of the props method: it's used to create the actual actor using the

Actors basics

```
public class Counter {
  private static final int numThreads = 16;
  private static final int numMessages = 1000;

  public static void main(String[] args) throws InterruptedException, IOException {
    final ActorSystem sys = ActorSystem.create("System");
    final ActorRef counter = sys.actorOf(CounterActor.props(), "counter");

    // Send messages from multiple threads in parallel
    final ExecutorService exec = Executors.newFixedThreadPool(numThreads);
    for (int i = 0; i < numMessages; i++) {
      exec.submit(() -> counter.tell(new SimpleMessage(), ActorRef.noSender()));
    }
    // Wait for all messages to be sent and received
    System.in.read();
    exec.shutdown();
    sys.terminate();
  }

}
```

we create the Actor system = playground where we are going to deploy the

we create one single counter Actor

we create a pool of threads

Mailbox semantics

- The receiving behavior of the actor is defined by the `createReceive()` method

- When an actor receives a message
  - It checks all the match clauses in the order in which they are defined
  - It uses the method associated to the first matching clause
  - If no matching clause exists, the message is discarded

Mailbox semantics (again)

- The default mailbox policy is **FIFO**
- Messages are processed in the same order in which they are received
  - **FIFO order** from a single sender
  - **Non-deterministic** from different senders
- Messages must be immutable
  - This cannot be statically checked and enforced by the framework…
  - … but using mutable messages might lead to unexpected behaviors!

Mailbox semantics (again)

- An actor can dynamically change its behavior using the `getContext().become()` method

- This method takes as input a Receive, with a new set of match clauses

Mailbox semantics

```java
public class AlarmActor extends AbstractActor {
  @Override
  public Receive createReceive() {
    return disabled();
  }

  private final Receive enabled() {
    return receiveBuilder(). //
        match(TriggerMsg.class, this::onTrigger). //
        match(DeactivateMsg.class, this::onDeactivate). //
        build();
  }

  private final Receive disabled() {
    return receiveBuilder(). //
        match(ActivateMsg.class, this::onActivate). //
        build();
  }
```

```java
private void onTrigger(TriggerMsg msg) {
  System.out.println("Alarm!!!!");
}

private void onActivate(ActivateMsg msg) {
  System.out.println("Becoming enabled");
  getContext().become(enabled());
}

private void onDeactivate(DeactivateMsg msg) {
  System.out.println("Becoming disabled");
  getContext().become(disabled());
}

static Props props() {
  return Props.create(AlarmActor.class);
}
```

Replying to messages

- When processing a message, an actor can
  - Obtain a reference (ActorRef) to itself with the `self()` method
  - Obtain a reference (ActorRef) to the sender with the `sender()` method

- **To reply** to the sender with a message msg, an actor simply invoke

```
sender().tell(msg, self());
```