ACTOR-BASED MODEL FOR CONCURRENT PROGRAMMING

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- Introduction to concurrent programming
- Shared-memory model vs. actor model
- Main principles of the actor model
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- Actors for distributed programming
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Concurrent programming

- = when programs are designed as collection of interacting computational processes that may be executed in parallel (*Wikipedia*)
- Inter-dependant processes
  - executing simultaneously
  - affecting each-other's work
  - must exchange information to do so

Concurrent programming: motivation

- Concurrency in local computer
  - Let part of a local program do something useful in the background while it is waiting for some input
  - Clients need to be served in parallel (web server)
- Parallelizing things for distributing
  - Distributing for inclusion of new resource
  - Distributing because functional requirements demand it

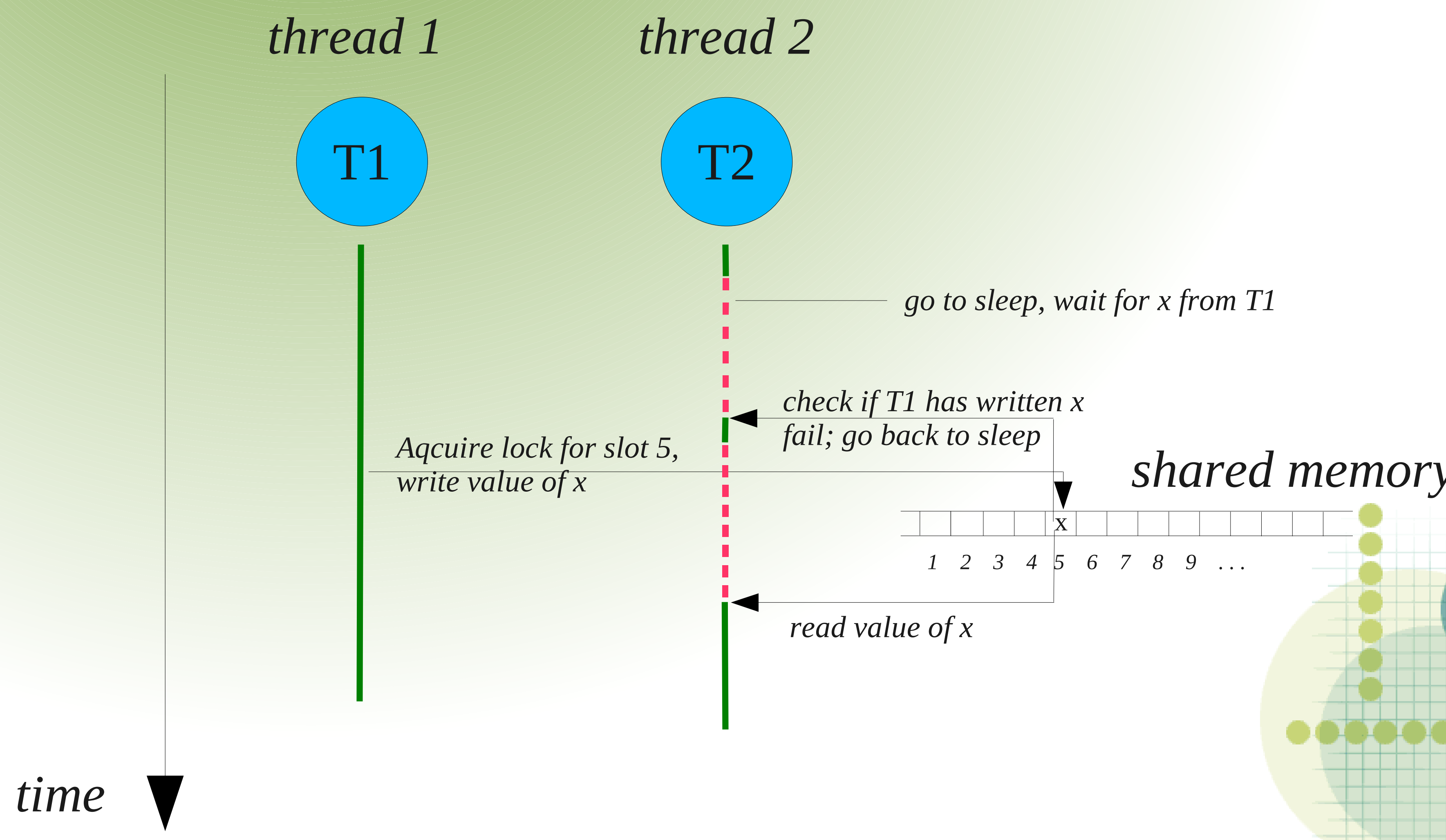
Implementing Concurrent Programming

- GOAL: Implement a library which would provide necessary abstractions on top of operating system resources to simplify concurrent programming
- What we need?
  - Units that could be executed in parallel (concurrency primitives)
  - Means of communication between these units

The Traditional Way: Threads & Shared Memory

- Smallest executable unit is **thread**
  - Usually, operating system threads are used
  - Virtual threading is possible, but less common ("green threads")
- Communication is implemented by sharing variables

Threads & Shared Memory



The Traditional Way: Threads & Shared Memory

- Pros:
  - Fast
- Cons:
  - Complicated & error-prone client code
  - Not extendable to distributed programming
  - Threads are heavy-weight – not too scalable
- Examples:
  - Standard concurrency libraries in Java, C#, etc..

The OTHER Way: The Actor Model

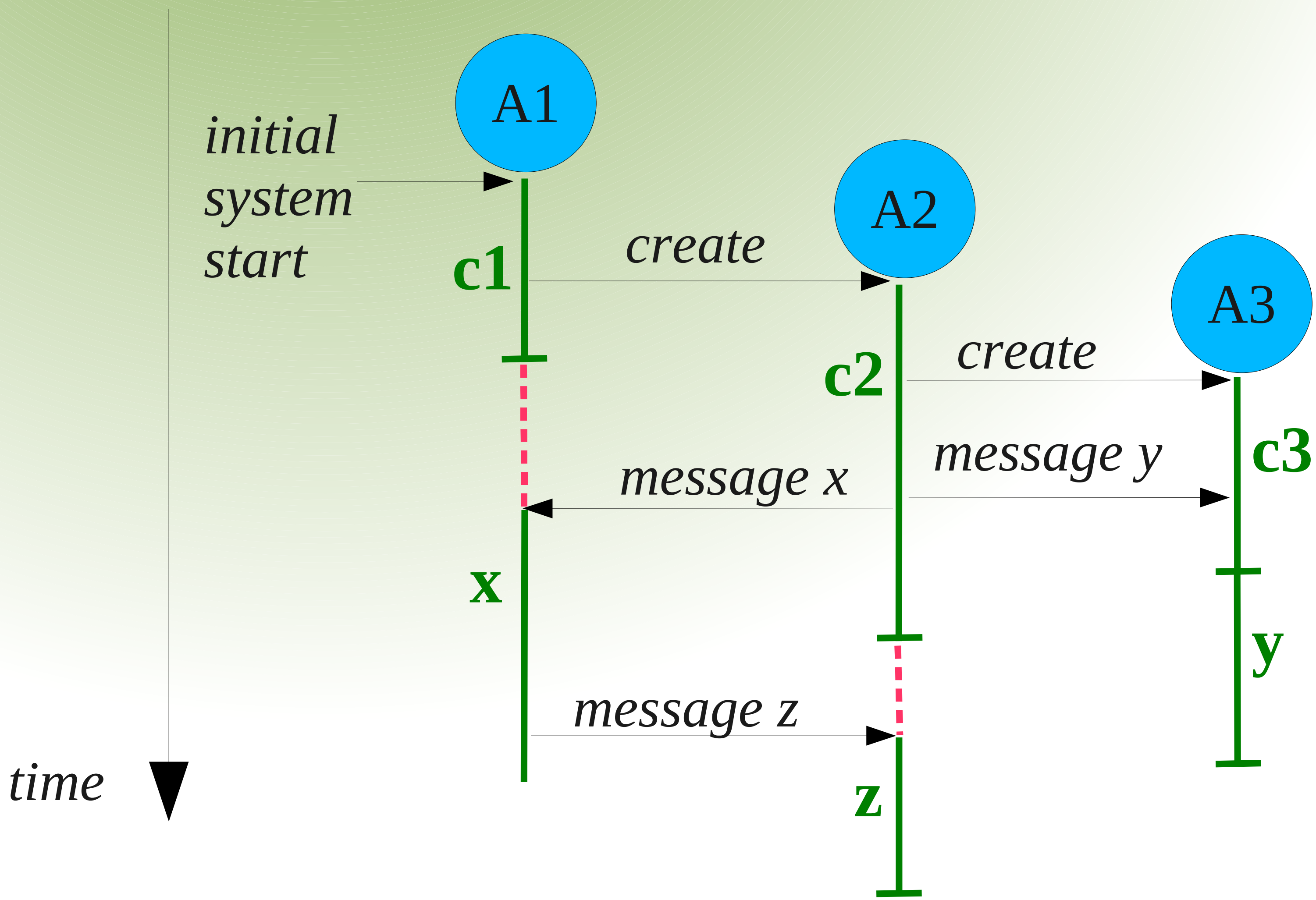
- Smallest executable unit is **an actor**
  - An actor is a concurrency primitive that does not share any resources with other actors
- Communication is implemented by actors sending each-other messages

Actors: formal definition

- Actors are computational agents which map each incoming communication to a triple consisting of:
  - A finite set of communications sent to other actors
  - A new behavior (which will govern the response to the next communication processed)
  - A finite set of new actors created

(Gul A. Agha, 1985)

Workflow:
event-driven + asynchronous



Actors and event-driven programming

- Rather than explicitly “sleeping” or “waking up”, actors “react” to the “events”
  - “events” = interactions with other actors = messages
- Actors get passive when they've finished their previous tasks and nobody has sent them new messages of interest
- Passive actors activate immediately when somebody has sent them an interesting message

Asynchronous message passing

- Message sending is asynchronous
- Each actor has a “mailbox” for storing messages that are not consumed immediately.
- If message arrives when actor is busy working on a previous message, it gets stored in it's mailbox
- If actor arrives at a point where it waits new messages to continue, it first looks through it's mailbox.
  - Messages of unsuitable type are ignored
  - First suitable message allows actor to continue

Asynchronous message passing:
Example of message receiving

```
..
receive {
  case Approve() =>
    ..
  case Cancel() =>
    ..
}
..
```

CASE A

contents of mailbox

Answer(7)	Cancel()	Approve()

newest

CASE B

contents of mailbox

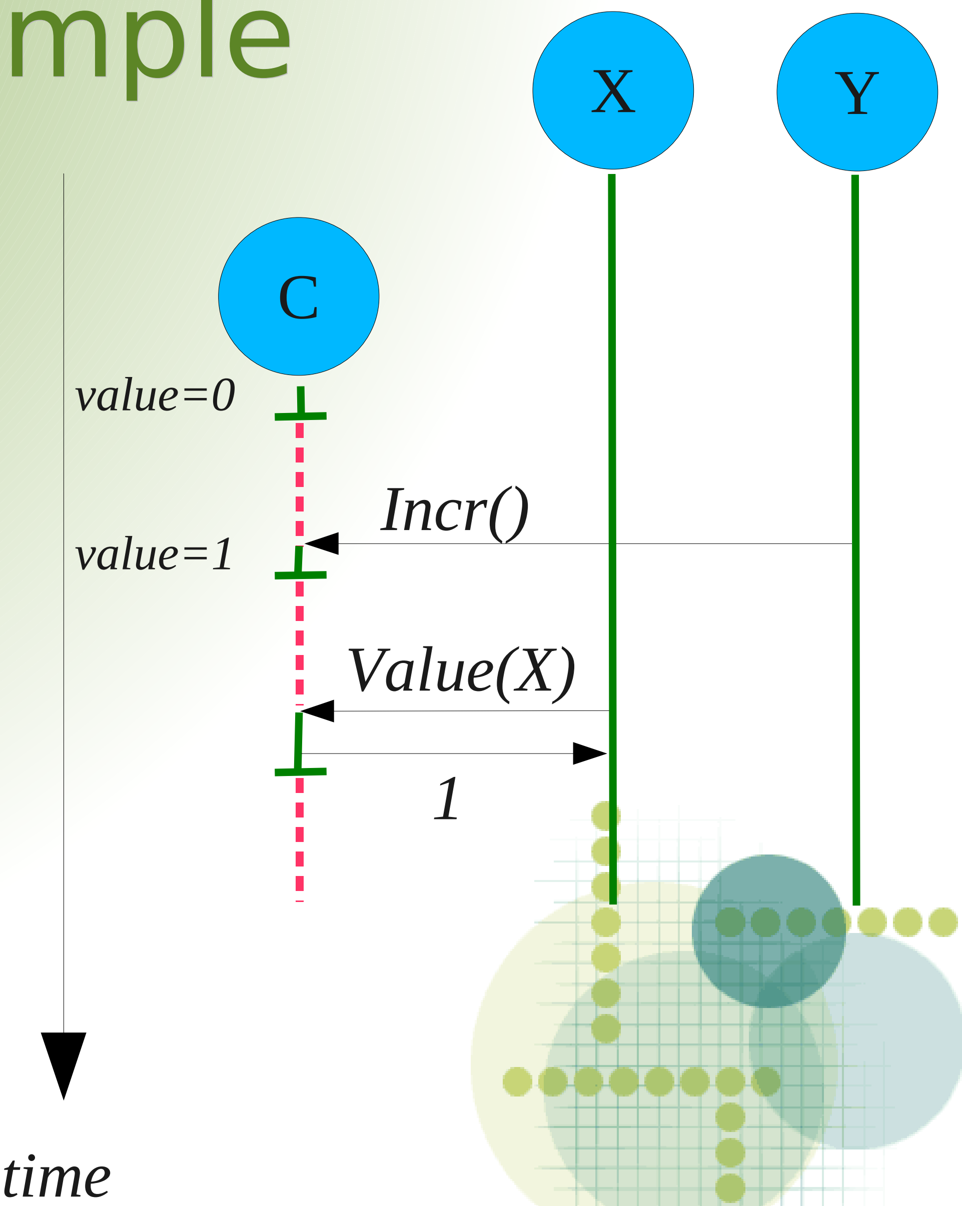
Blaa()	Answer(7)	Blaa()

newest

An example

```
class Counter extends Actor {
  override def run: unit =
    loop(0)

  def loop(value: int): unit = {
    Console.println("Value: " + value)
    receive {
      case Incr() =>
        loop(value + 1)
      case Value(p) =>
        p ! value
        loop(value)
      case _ =>
        loop(value)
    }
  }
}
```



Actors for light-weight processes

- Thread-based concurrency usually directly mapped to operating system threads
  - 1 code-level thread = 1 operating system thread
- Operating system threads are expensive!
- Most actor-based concurrency libraries don't map actors directly to operating system threads ("light-weight actors")
  - 1 operating system thread = 1 active actor + unlimited amount of inactive actors

Actors in distributed programming

- The actor model naturally extends from concurrency inside one computer to concurrency in a distributed network of computers
- Local and remote actors “look the same”
- The concurrency framework will deal with the technical details:
  - message-passing over the network
  - message serialization
  - actor identificators management
  - network connection management

The Actor model

- Pros:
  - Event-driven approach is more intuitive
  - Directly and transparently applicable for distributed programming
  - Implements light-weight processes => better scaling
- Cons:
  - Message-passing is slower
  - Libraries and solutions not yet as “mature” (e.g. no good frameworks for Java before 2008)

Actor model implementations

- Separate concurrency languages
  - Erlang
  - SALSA
- Frameworks
  - Scala Actor Framework for Scala
  - Kilim, FunctionalJava for Java
  - Kamaelia, Eventlet, PARLEY for Python
  - Dramatis, Revactor for Ruby

Current importance & perspectives

- Cuncurrency in today's middleware almost always thread-based
- Hardware evolves towards more parallel architectures
- IT-industry evolves towards workforce being more costly than hardware
- In 2008, actor frameworks exist for all popular programming languages
- Cloud computing (thin clients, etc.)