

# Eventual Consistency

Principles of Reactive Programming

Roland Kuhn

# Eventual Consistency (1)

**Strong Consistency:** after an update completes all reads will return the updated value

```
private var field = 0
def update(f: Int => Int): Int = synchronized {
  field = f(field)
  field
}
def read(): Int = synchronized { field }
```

## Eventual Consistency (2)

**Strong Consistency:** after an update completes all reads will return the updated value

**Weak Consistency:** after an update conditions need to be met until reads return the update value; this is the *inconsistency window*

```
private @volatile var field = 0
def update(f: Int => Int): Future[Int] = Future {
  synchronized {
    field = f(field)
    field
  }
}
def read(): Int = field
```

# Eventual Consistency (3)

**Strong Consistency:** after an update completes all reads will return the updated value

**Weak Consistency:** after an update conditions need to be met until reads return the update value; this is the *inconsistency window*

**Eventual Consistency:** once no more updates are made to an object there is a time after which all reads return the last written value

[http://www.allthingsdistributed.com/2008/12/eventually\\_consistent.html](http://www.allthingsdistributed.com/2008/12/eventually_consistent.html)

<http://www.infoq.com/articles/cap-twelve-years-later-how-the-rules-have-changed>

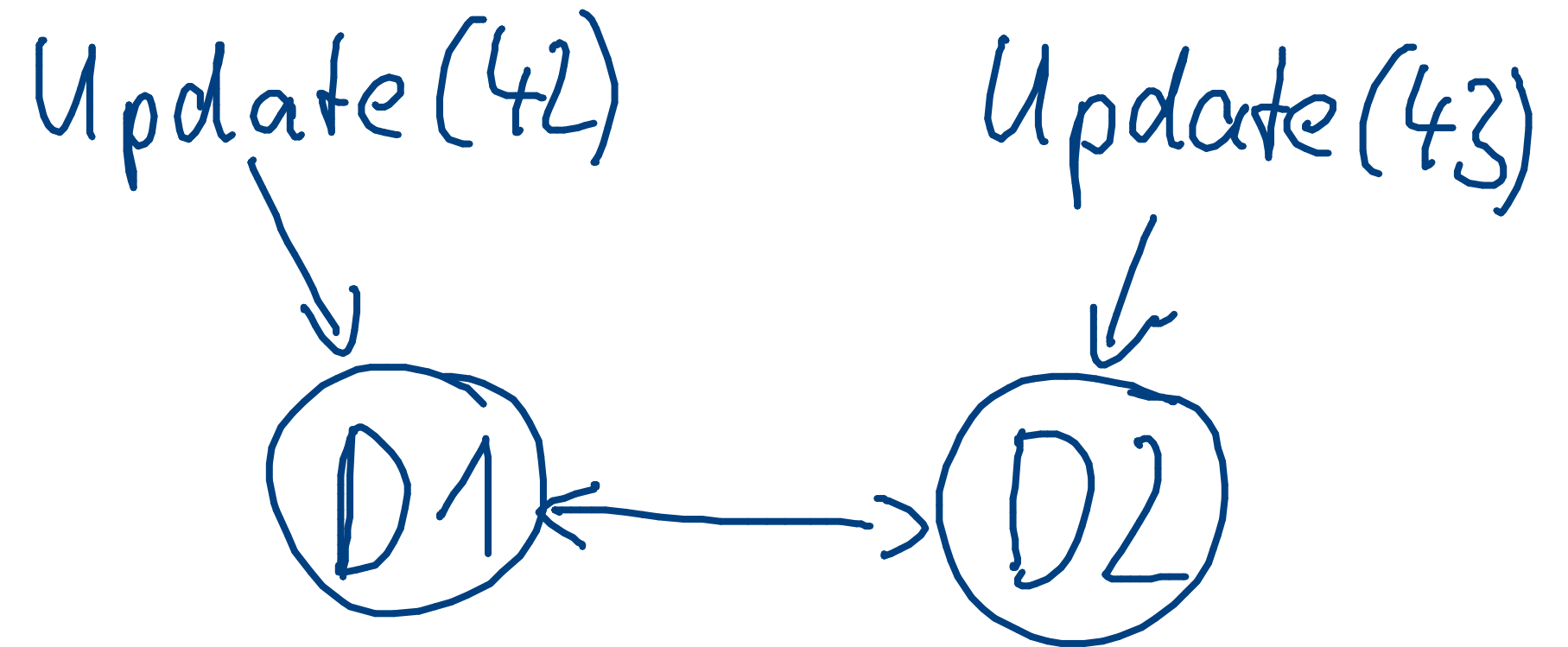


# Eventually Consistent Store (1)

```
case class Update(x: Int)
case object Get
case class Result(x: Int)
case class Sync(x: Int, timestamp: Long)
case object Hello
```

```
class DistributedStore extends Actor {
  var peers: List[ActorRef] = Nil
  var field = 0
  var lastUpdate = System.currentTimeMillis()

  def receive = ...
}
```



## Eventually Consistent Store (2)

```
def receive = {  
  case Update(x) =>  
    field = x  
    lastUpdate = System.currentTimeMillis()  
    peers foreach (_ ! Sync(field, lastUpdate))  
  case Get => sender ! Result(field)  
  case Sync(x, timestamp) if timestamp > lastUpdate =>  
    field = x  
    lastUpdate = timestamp  
  case Hello =>  
    peers ::= sender  
    sender ! Sync(field, lastUpdate)  
}
```

# Actors and Eventual Consistency

- ▶ an actor forms an island of consistency
- ▶ collaborating actors can at most be eventually consistent
- ▶ actors are not automatically eventually consistent
- ▶ event consistency requires eventual dissemination of all updates
- ▶ need to employ suitable data structures, for example CRDTs<sup>1</sup>

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<sup>1</sup>Shapiro, Preguiça, Baquero, Zawirski (2011): *A comprehensive study of Convergent and Commutative Replicated Data Types*, inria-00555588

# An Example Data Structure

The cluster membership state is a convergent data type:

- ▶ directed acyclic graph of states
- ▶ conflicts can always be resolved locally
- ▶ conflict resolution is commutative

