



ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Eventual Consistency

Principles of Reactive Programming

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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*

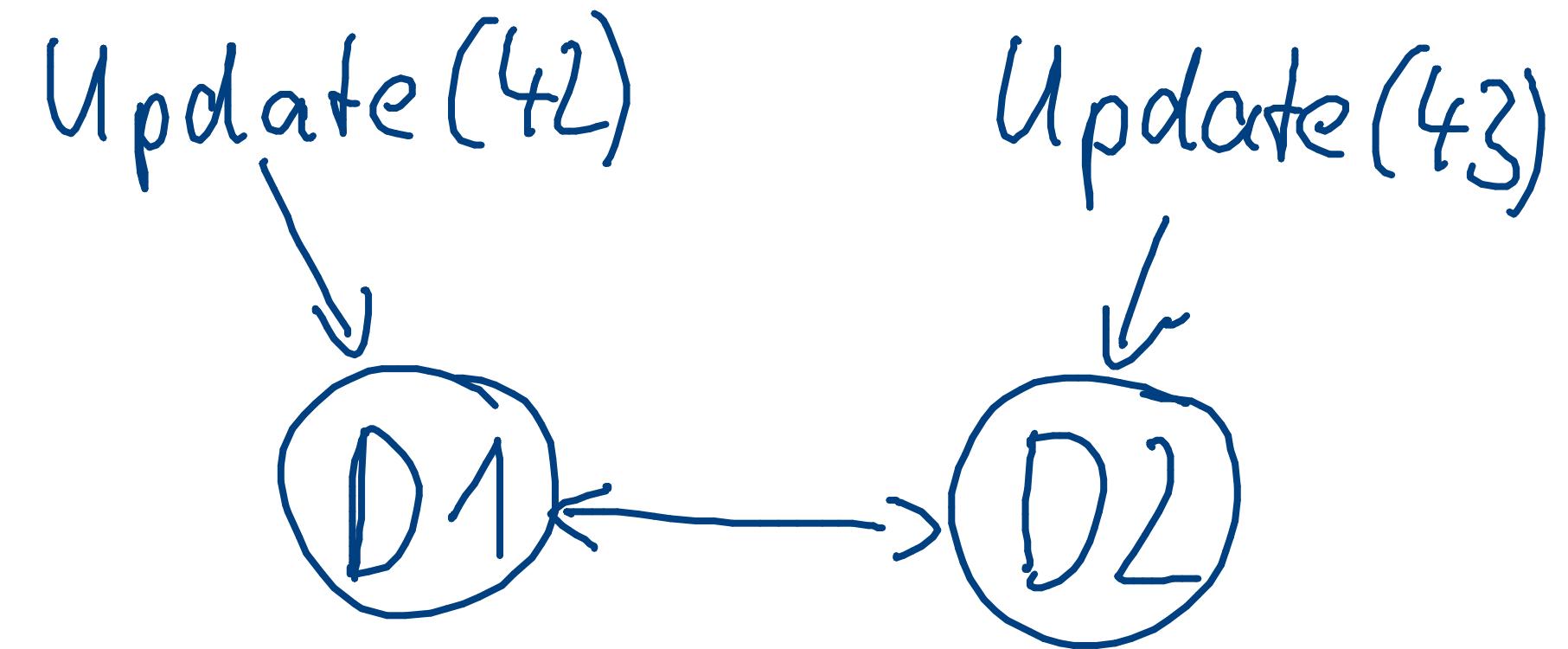
Eventual Consistency: once no more updates are made to an object there is a time after which all reads return the last written value

http://www.allthingsdistributed.com/2008/12/eventually_consistent.html

<http://www.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 CRDTs¹

¹Shapiro, 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

