Distributable Data Structures
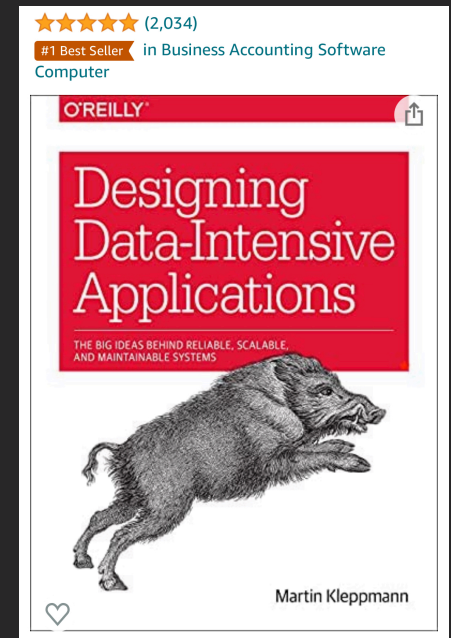
(CRDTs and Semilattices)

Aesa Kamar

What are we gonna learn?

- Combinable things
- Semilattices ✨
- Messaging guarantees
- Apply knowledge

Thesis:

- 😀 CRDTs are one of the most powerful tools in your Distributed Systems tool-belt
- 😢 Feels unapproachable
- 😣 Tricky to implement
- 😄 Simpler with FP

★★★★★ (2,034)
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Designing
Data-Intensive
Applications

THE BIG IDEAS BEHIND RELIABLE, SCALABLE, AND MAINTAINABLE SYSTEMS

Martin Kleppmann

```scala
@typeclass trait Semigroup[A] {
  def combine(x: A, y: A): A
}
```

Associativity

$$x + (y + z) = (x + y) + z$$

```
@typeclass trait Monoid[A] {
  def combine(x: A, y: A): A
  def empty: A
}
```

Associativity

$$x + (y + z) = (x + y) + z$$

```scala
@typeclass trait CommutativeMonoid[A] {
  def combine(x: A, y: A): A
  def empty: A
}
```

Associativity

$$x + (y + z) = (x + y) + z$$

Commutativity

$$x + y = y + x$$

@physicsfun

```scala
@typeclass trait Semilattice[A] {
  def combine(x: A, y: A): A
  def empty: A
}
```

Associativity

$$x + (y + z) = (x + y) + z$$

Commutativity

$$x + y = y + x$$

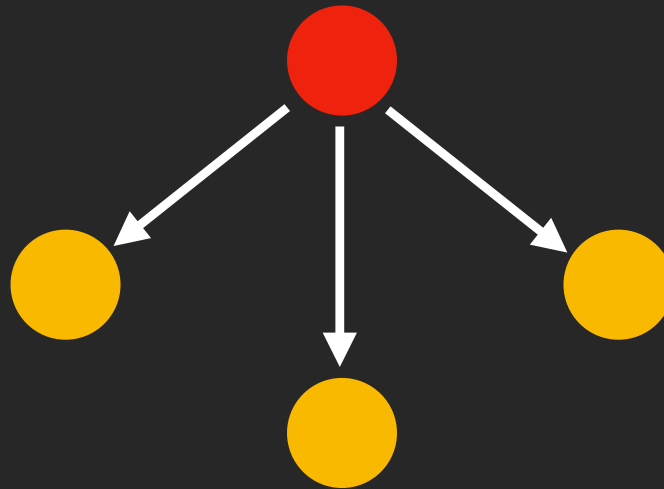**Idempotency**

$$x + x = x$$

Questions?

- Semigroup

- Monoid

- Commutative Monoid

- Semilattice

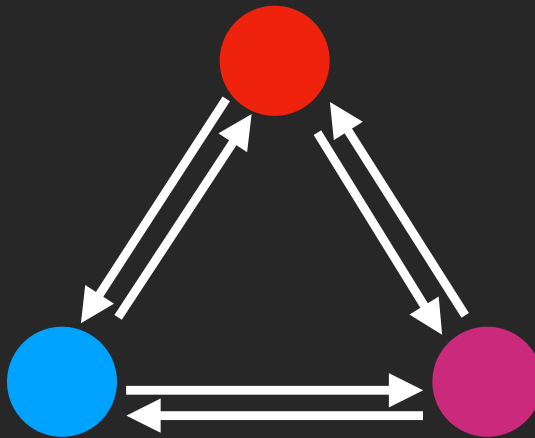# Data Distribution
Central source of truth
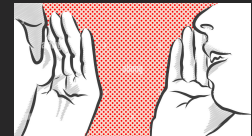
Transactional

ACK

Data Distribution
Decentralized source of truth
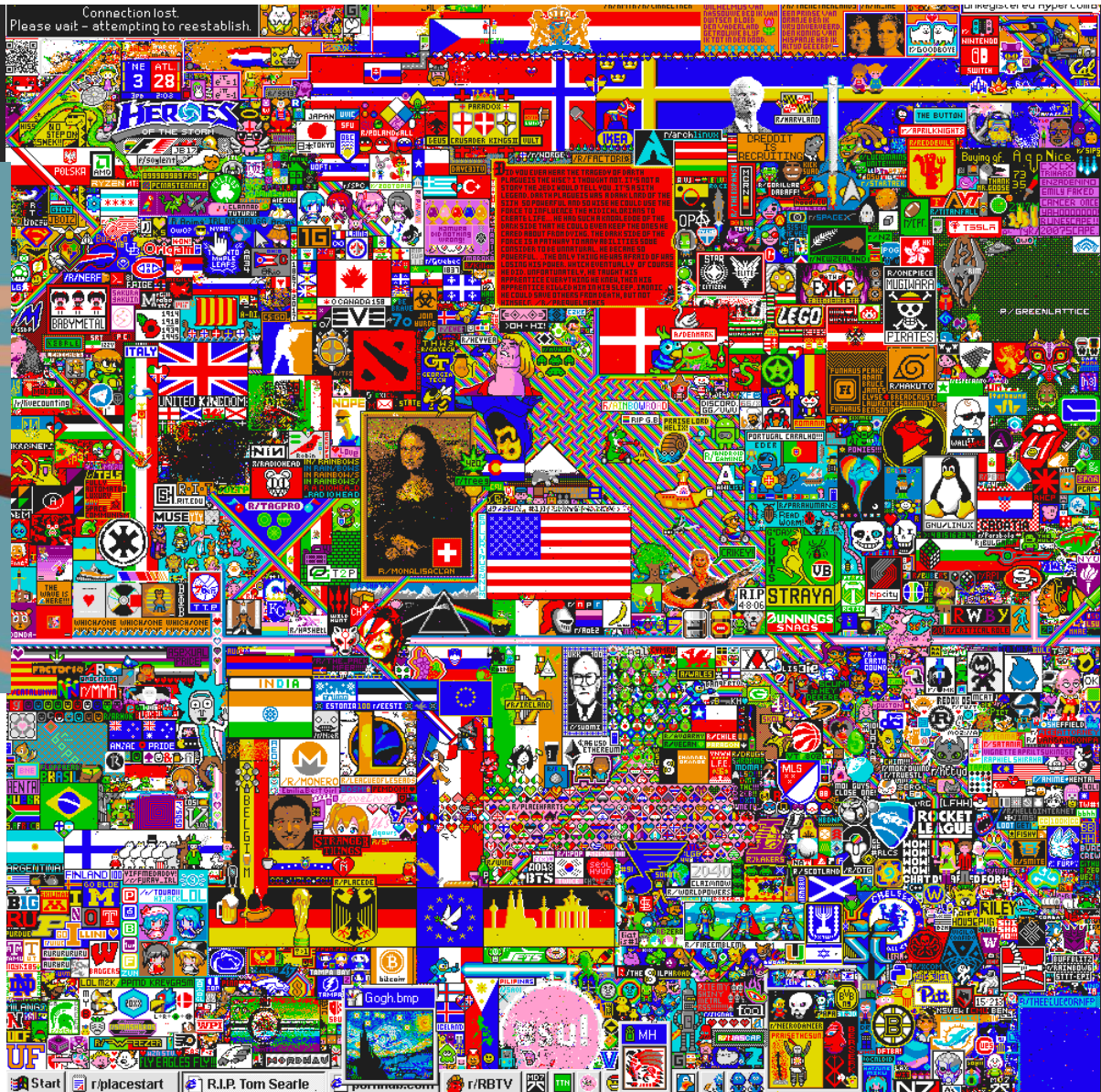
Best-effort
Gossip/Epidemic

Questions?

- Guaranteed transactional delivery

- Best-effort delivery

- Gossip Protocol

CRDT

- Conflict-Free

  - Semilattice

- Replicated

  - Best-effort message delivery

- Data Type

  - Typesystems

Applications?

Types of CRDTs

- Counter
    - Op-based counter
    - State-based counter
        - G-Counter
        - PN-counter
- Register
    - LWW-Register
    - Multi-Value Register, MV-Register
- Set
    - G-Set
    - 2P-Set
    - LWW-element Set
    - PN-Set
    - Observe-Remove Set
- Graph
    - 2P2P-Graph
- Map
    - Remove-as-recursive-reset Map
    - Remove-wins Map
    - Update-wins Map
- List