# An overview of delta CRDTs

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# 1 Concepts

## 1.1 Eventual Consistency

A relaxed consistency model, mostly used when the system must keep available even in failures and when the consistency can be delayed. A typical approach is to allow replicas of a **distributed object** to diverge temporaly and evetually be **reconciled** into a common state.

## 1.2 CRDT design

The design of a CRDT supports two designs: State-Based and Op-Based designs.

### 1.2.1 Op-Based

The Op-Based operation is separated in two steps:

- *prepare*: the operation is just performed in the local replica and this same replica uses the current state and the operation to generate a message that represents the operation.
- *effect*: once the message is ready, it is **shipped** to all the other replicas and applied using the effect.

### 1.2.2 State-Based

In this type of design the operation is **just applied in the local replica** updating on the local state. A replica periodically propagates its local changes by propagating its entire state.

A received state is **incorporated** with the local state via *merge* function that deterministically **reconciles** both states. The merge is defined as *join* .

### 1.2.3 Comparation

The Op-Based approach, however has a few disadantages when compared to the State-Based replication:

- The message must be sent in a channel that guarantees the exactly-once causal broadcast. However, this is a hard guarantee to be mantained.
- As the system grows, checking membership is problematic
- The operations must be executed individually in all nodes.

The State-Based approach is free of these limitations/problems, but major drawback is the communication overhead of shipping the entire state. States can grow to large sizes and this approach may not be feasible.

# 2 Background of state-based CRDTs

Conflict Free Replicated Data Types are distributed datatypes that allow different replicas in distributed CRDT instance to diverge and eventually all replicas converges to the same state, even without clocks.

A state-based CRDT consists of a triple (S,M,Q), where S is a join-similattice. This means that the set has a partial order, thus there's an least upper bound and a greatest lower bound for every two elements. Yet, the binary join operation $\sqcup$ returns the least upper bound (LUB) of two elements in S.

Mutators are defined in such a way to be *inflations*, in other words the next state generated by the mutators generates a state that happens before the previous:

$$X \sqsubseteq m(X)$$

For this reason there's a **monotonic** sequence of states, defined under the lattice partial order.