# Distributed Systems (DSy)

Conflict-free replicated data type (CRDT)

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CRDT

- (Paxos, why take over larger number?)
  - "acceptors made a promise that no other proposal with a smaller number can make it to consensus" → If acceptor accepted, but its not majority → could stall forever, thus take over large number (link, link)

- L08S10: vDHT
  - A way how to bring consistency to DHTs
  - ~CRDT (operation-based CRDTs)
  - Conflict-free replicated data type (CRDT)
  - ~git but with no merge conflicts
- CRDT must be
  - Commutative x ● y = y ● x
  - Associative (x ● y) ● z = x ● (y ● z)
  - Idempotent x ● x = x
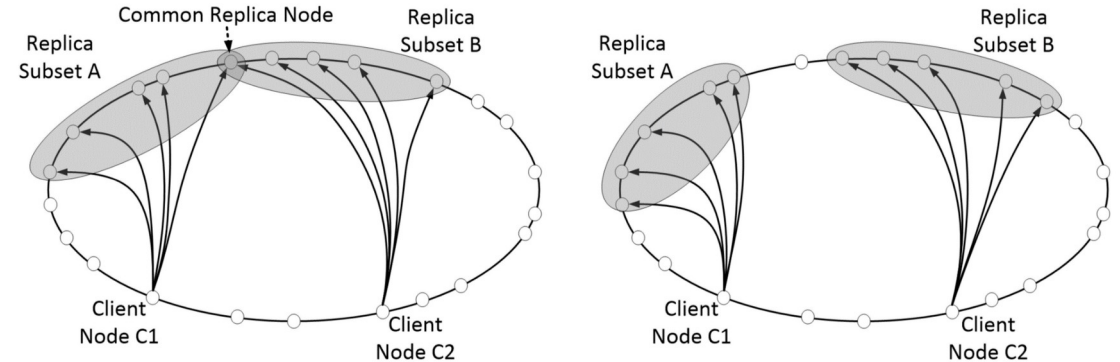
- CRDT Counter (G-Counter)
  - For each machine 1 array position for counter

A	B	C
A:6 B:0 C:0	A:0 B:3 C:0	A:0 B:0 C:9
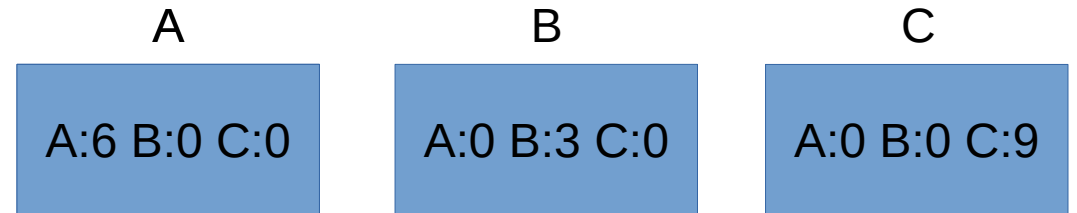
  - Merge: max of each counter (A:6 B:3 C:9)
    - Old data A:6 B:2 C:9 merge-max / A:5 B:3 C:2 A:6 B:3 C:9
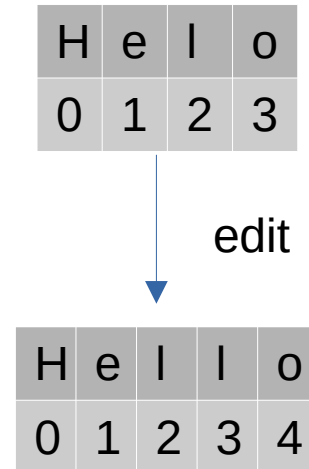   - Commutative, associative, idempotent

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CRDT

- Example: collaborative text editing

  - Google Docs: operational transformation

- Operational transformation

  - Requires central server

- CRDT without central server: P2P

  - You need to find suitable algorithms

  - Collaborative text editing: merge sets

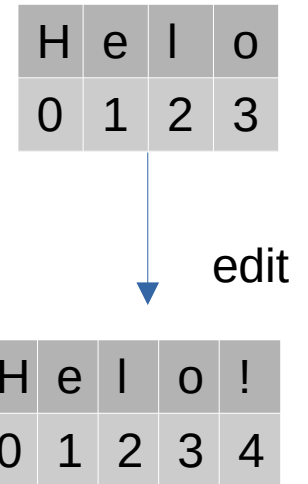   - Assign for letter an increasing value from 0-1
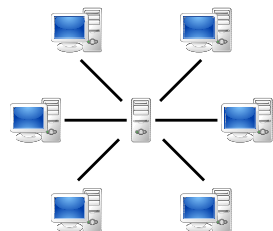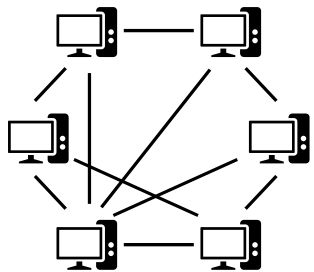
H	e	l	o
0	1	2	3

edit

H	e	l	l	o
0	1	2	3	4

Insert "l" at pos 3

H	e	l	o
0	1	2	3

edit

H	e	l	o	!
0	1	2	3	4

Insert "!" at pos 4

Server

H	e	l	l	o	!
0	1	2	3	4	5

Insert "!" at pos 5

H	e	l	l	o	!
0	1	2	3	4	5

Insert "l" at pos 3

Distributed Systems

source

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CRDT

- Example: collaborative text editing

  - Edit is 0.7: l, 0.9: !

  - Merge with 0.2: H, 0.4: e, 0.6: l, 0.8 o

  - Collision? Find strategy that matches use-case

- Easy!

  - But interleaving – find algorithm that handles interleaving

- CRDT: existing algorithms exist

  - G-Counter, PN-Counter, G-Set, 2P-Set, …

  - Combine existing algorithms, or find new one

    – vDHT? merge divergence needs a strategy

H	e	l	o
0.2	0.4	0.6	0.8

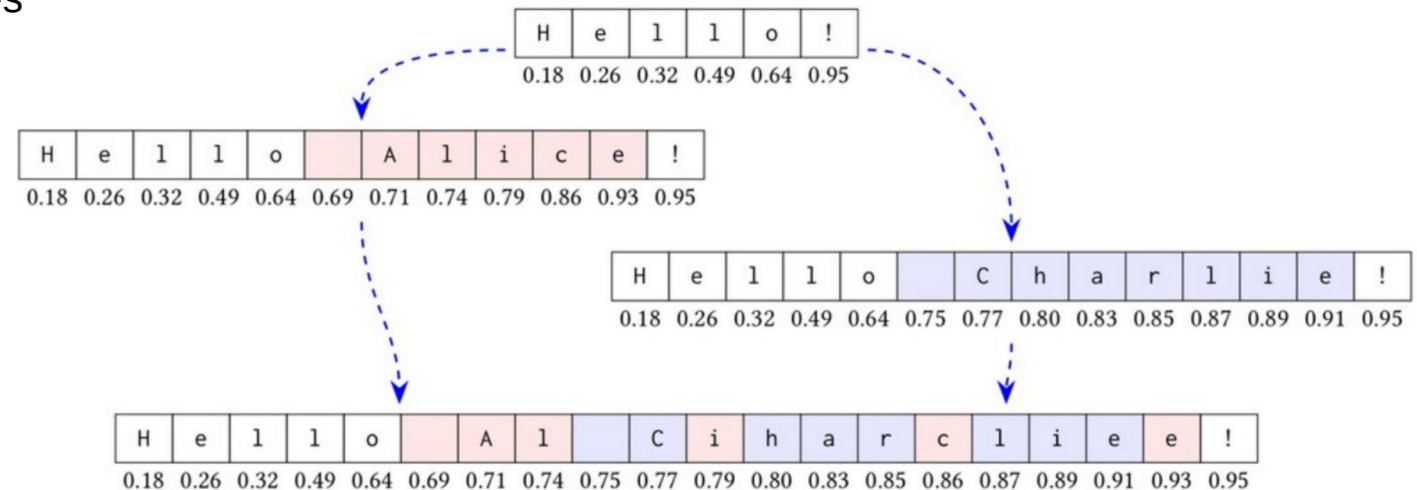| H	e	l	l	o	!
0.2	0.4	0.6	0.7	0.8	0.9

Figure 3: Interleaving due to character positions taken from a dense identifier set, e.g. the rational numbers $\mathbb{Q}$.

Source: Martin Kleppmann

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