CRDTs for fun and profit

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Spotify®

Distributed rate limiting

Token buckets

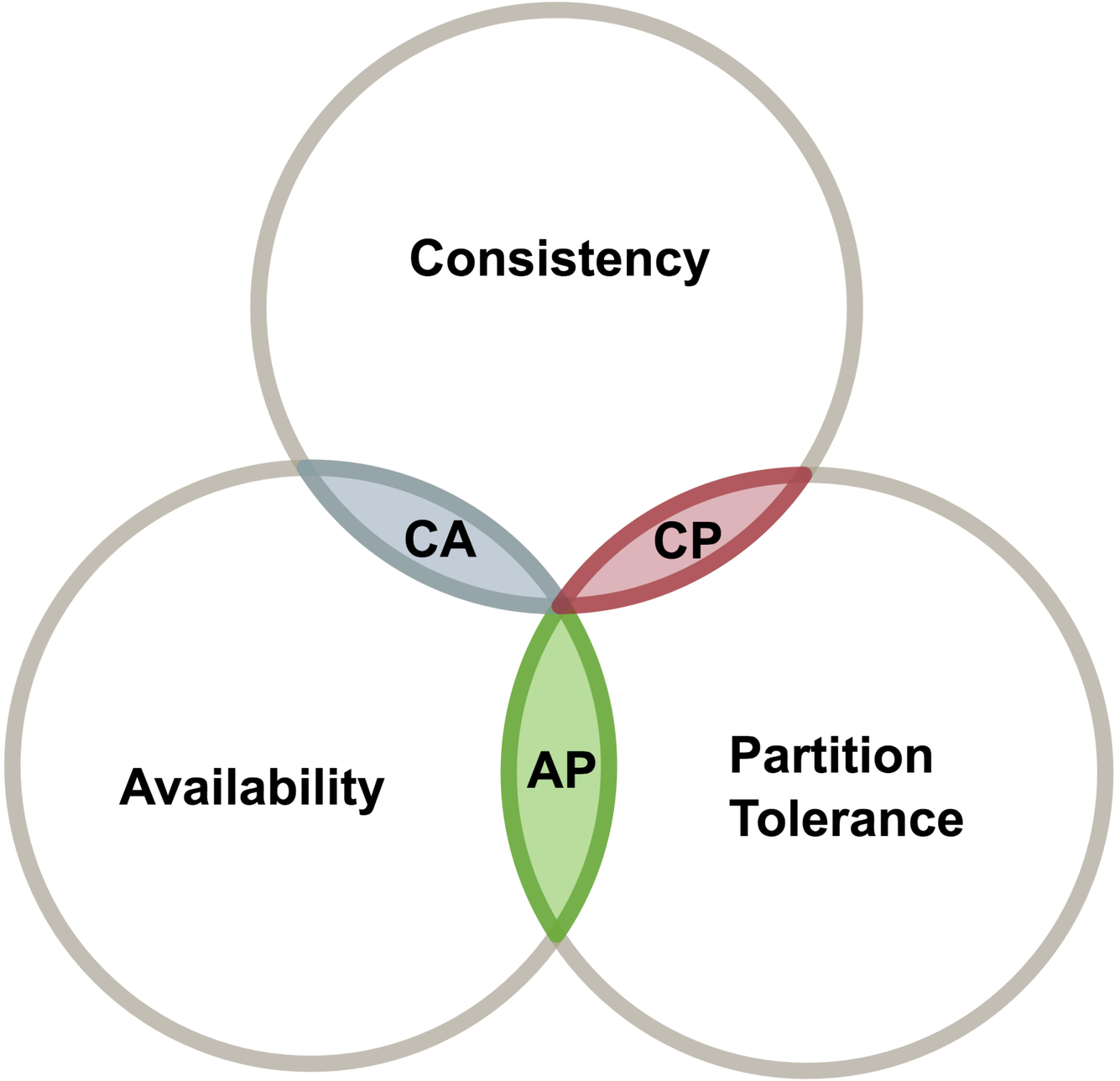
Requirements

Local reads/updates only

Network splits

Best effort

Eventual consistency


Consistency
CA
CP
Availability
AP
Partition
Tolerance

CRDTs

INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

A comprehensive study of Convergent and Commutative Replicated Data Types

Marc Shapiro, INRIA & LIP6, Paris, France
Nuno Preguiça, CITI, Universidade Nova de Lisboa, Portugal
Carlos Baquero, Universidade do Minho, Portugal

Marek Zawirski, INRIA & UPMC, Paris, France

Conflict-free Replicated Data Type

Convergent Replicated Data Type

Commutative Replicated Data Type

Ops vs state based CRDTs

State based

```
(defprotocol CRDT
  (get)
  (update [val])
  (merge [other_crdt]))
```

Merging

Commutative

$4+3 = 3+4$

Associative

$$2 + (3 + 4) = (2 + 3) + 4$$

Idempotence

fn(x) = fn(fn(x))

Some known CRDTs

Counters

- G counter
- PN counter

- Node 1

```
{node1 0}
```

- Node 2

```
{node2 0}
```

- Node 1

```
{node1 1}
```

- Node 2

```
{node2 0}
```

- Node 1

{node1 1}

- Node 2

{node2 2}

- Node 1

```
{node1 1, node2 2}
```

- Node 2

```
{node1 1, node2 2}
```

Unbounded growth/GC

Sets/registers

- G set
- 2P set
- LWW set
- LWW register
- Multi value register

- Node 1

```
{node1 { adds #{}, removes #{} }}
```

- Node 2

```
{node2 { adds #{}, removes #{} }}
```

- Node 1

```
{node1 { adds #{x}, removes #{} }}
```

- Node 2

```
{node2 { adds #{}, removes #{} }}
```

- Node 1

```
{node1 { adds #{x}, removes #{} }}
```

- Node 2

```
{node2 { adds #{y}, removes #{} }}
```

- Node 1

```
{node1 { adds #{x}, removes #{} }}
```

- Node 2

```
{node2 { adds #{y}, removes #{x} }}
```

- Node 1

```
{
  node1 { adds #{x}, removes #{} },
  node2 { adds #{y}, removes #{x} }
}
```

- Node 2

```
{
  node1 { adds #{x}, removes #{} },
  node2 { adds #{y}, removes #{x} }
}
```

Other examples

- Graphs
- Treedocs
- Maps
- ...

Gossip

"More typically gossip protocols are those that specifically run in a regular, periodic, relatively lazy, symmetric and decentralized manner; the high degree of symmetry among nodes is particularly characteristic. [..] Frequently, the most useful gossip protocols turn out to be those with exponentially rapid convergence towards a state that "emerges" with probability 1.0.
-- https://en.wikipedia.org/wiki/Gossip_protocol

Our implementation

- GCounter

```
{random-node-id 1}
```

- LWW counter

```
{value 1488746782, timestamp 1488745432}
```

Delta based gossip

Recommended reading

- https://christophermeiklejohn.com/crdt/2014/07/22/readings-in-crdts.html
- http://hal.upmc.fr/inria-00555588/document
- https://dist-sys-slack.herokuapp.com/ #crdts
- https://github.com/aphyr/meangirls
- @xmal
- http://docs.basho.com/riak/latest/dev/using/data-types/

Questions?

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