CAP for Networks

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CAP Theorem

When distributed systems face network Partitions pick one of

- Service Correctness (Consistency)
- Service Availability
CAP Theorem: Impact

Divides the database community (even today)

**SQL**
Correctness above all

**NoSQL**
Availability above all

SQL:
- Microsoft SQL Server
- PostgreSQL
- MySQL

NoSQL:
- riak
- redis
- Amazon DynamoDB
How does the CAP theorem apply to networks?
Our goal: articulate fundamental tradeoffs networking will face
Traditional Networks

When intradomain routing was the main concern

- **Correctness**: Deliver packets to destination
- **Availability**: Deliver packets to destination
- **Correctness** is the same as **Availability**
The move to SDN

SDN provides more sophisticated **functionality**:

- Tenant isolation (ACL enforcement)
- Traffic Engineering
- Virtualization

Control plane partitions no longer imply data plane partitions

- Control traffic often does not use data plane network
Availability ≠ Correctness

During control plane partitions
  • Data plane connected => Deliver packets (Availability)
  • Inconsistent control plane data (Correctness)
  • Availability does not imply Correctness
How does the CAP theorem apply to networks SDN?
How does the CAP theorem apply to SDN?

Can one provide isolation and availability in the presence of control plane partitions?
Network Model

- Out-of-band control network.
- Routing and forwarding based on addresses.
- Policy specification using end-host names.
- Controller responsible for local name-address bindings.
Isolation Result

- Consider policy isolating A from B.
- A control network partition occurs.
- Only possible choices
  - Let all packets through (including from A to B) (Correctness)
  - Drop all packets (including from A to D) (Availability)
Value of Model

Practical workarounds follow directly
Workarounds for Isolation

- Identity-Address disconnect underlies isolation result
Workarounds for Isolation

- Identity-Address disconnect underlies isolation result
- Network can constrain address allocation
Workarounds for Isolation

• Identity-Address disconnect underlies isolation result

• Network can route on identity rather than addresses
Workarounds for Isolation

• Identity-Address disconnect underlies isolation result

• Use in-band control networks rather than out-of-band
Workarounds not General

Edge Disjoint Traffic Engineering

- Two flows must traverse disjoint links
Workarounds not General

Previous workarounds not applicable!
Can one provide correctness and availability in the presence of partitions? Not in general.
In the Paper
“CAP for Networks”, HotSDN ‘13

• More policies and proofs
• More details on workarounds
• Other ways to model the network
## CAP for Networks

### Choices for network architects

- **Correctness above all**
  - VMware NSX
  - ICING

- **Availability above all**
  - Traditional Routing
  - BGP

### Policy-Specific Workarounds

- Packet Labeling
- In-Band Control
Backup Slides
Host Migration

- Our model assumes host migrations without controller involvement.

- In part this is because host migrations are common
  - Soundararajan and Govil 2010: 6 migrations/day/VM
  - In a datacenter \( \approx 480,000 \) migrations/day
  - 5.5 migrations per second

- Controller involvement is too expensive in datacenters
  - NSX and BSC work in a similar manner

- In enterprises controller involvement complicated by mobility.