Software Defined Networking

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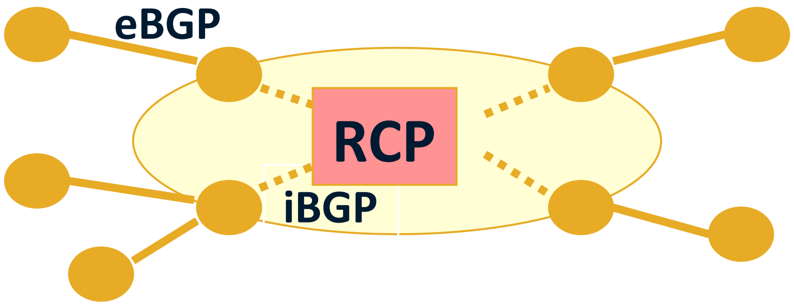
In this course, you will learn about software defined networking and how it is changing the way communications networks are managed, maintained, and secured.

This Module: Control and Data Separation

- **Challenges** from control and data separation
- Overview of challenges
  - **Scalability:** Routing decisions for many routers
  - **Reliability:** Correct operation under failure
  - **Consistency:** Ensuring consistency across multiple control replicas
- Approaches to solving these challenges in RCP, ONIX

Scalability: RCP



- **Problem:** Must store routes and compute routing decisions for every router
- Potentially thousands of routers

Scalability: Principles from RCP Design

- Eliminate redundancy
  - Store a single copy of each route
  - Avoid redundant computation
- Accelerate lookups
  - Maintain indexes to identify affected routers
- Only perform BGP routing

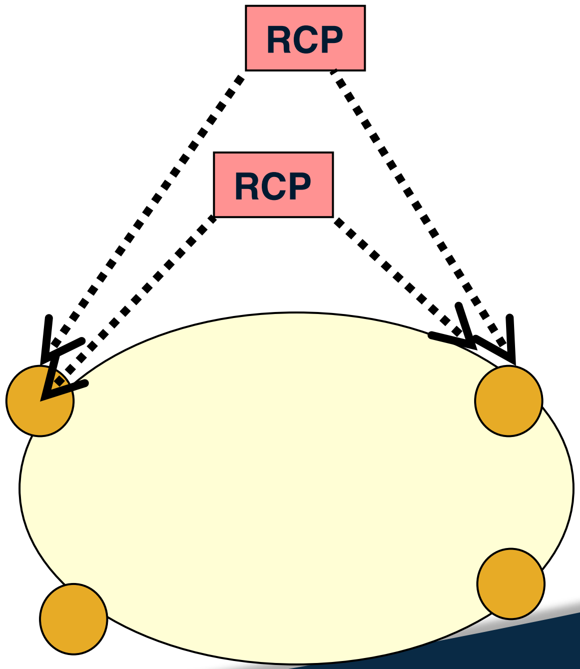
Scalability: ONIX

- **Partitioning:** Only keep a subset of the overall network information base (NIB) in memory.
  - Two different consistency models
- **Aggregation:** Use of hierarchy (e.g., Onix controllers per department or building).
  - combine statistics, topology information

Koponen, Teemu *et al.* "Onix: a distributed control platform for large-scale production networks." Proceedings of the 9th USENIX conference on Operating systems design and implementation. USENIX Association, 2010.

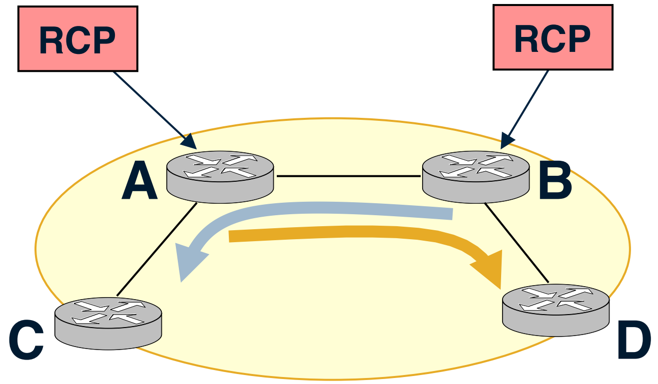
Reliability: RCP

- Replicate RCPs ("Hot Spare")
  - Run multiple identical servers
- Run independent replicas
  - Each replica has its own feed of routes
  - Each replica receives the same inputs and runs the same routing algorithm
  - No need for a consistency protocol *if* both replicas always see the same information



Potential Consistency Problem

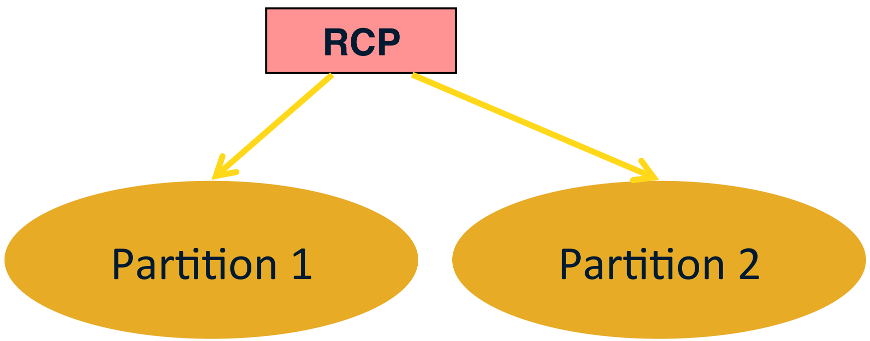
"Use egress D (hence use B as your next-hop)"



"Use egress C (hence use A as your next-hop)"

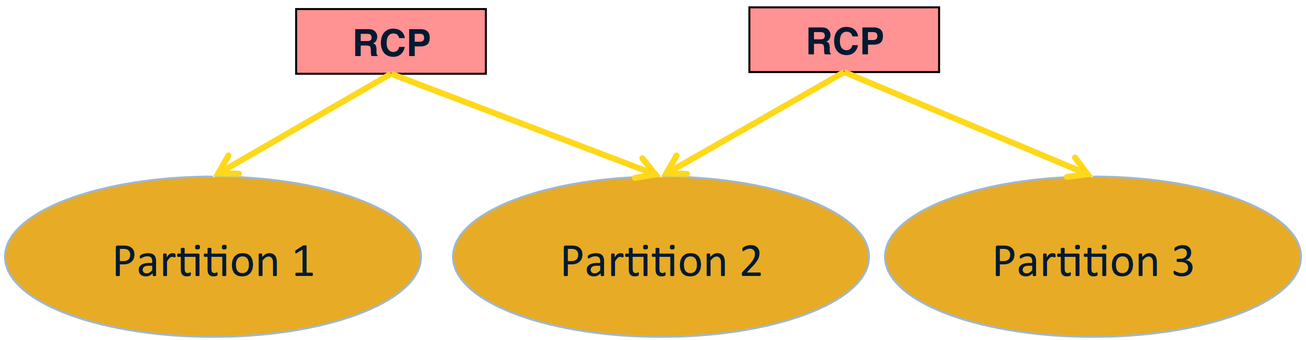
- Route assignments must be consistent
  - Even in presence of failures and partitions
- Fortunately
  - Flooding-based IGP means each replica knows which partitions it connects to

Single RCP Under Partition



- **Solution:** Only use state from routers partition in assigning its routes
  - Ensures next hop is reachable

Multiple RCPs Under Partition



- **Solution:** RCPs receive same state from each partition they can reach
  - IGP provides complete visibility, connectivity
  - Only acts on partition if it has complete state

No consistency protocol needed to guarantee consistency in steady state

Reliability: ONIX

- **Network failures:** application's responsibility
- **Reachability to ONIX:** reliable protocol, multipath, etc.
- **ONIX failure:** distributed coordination amongst replicas

Replication: ONIX

- Network Information Base (NIB)
  - Represented as a graph of objects
  - Applications can read and write the NIB
  - Automatically updates switches and controllers
- State distribution tools
  - Replicated transactional (SQL) storage
    - Strong consistency for critical, stable state
  - One-hop memory-based DHT
    - Eventual consistency for less-critical, dynamic state

Summary

- Control and data plane separation pose three significant challenges
  - **Scalability:** Routing decisions for many routers
  - **Reliability:** Correct operation under failure
  - **Consistency:** Ensuring consistency across multiple control replicas
- Hierarchy, aggregation, clever state mangement and distribution