The Case for Separating Routing from Routers

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"BGP is broken."
- It might not converge.
- When it converges, it does so slowly.
- It causes routing loops inside an AS.
- It’s misconfigured frequently.
- Routing tables are getting huge!

"We can’t fix the problems."
- BGP is hard-coded into routers.
- It’s dictated by slow-moving standards.
- No flag days!
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What to do?
- Delve into BGP-specific, esoteric arcana
  - Discover more negative results
  - Incremental fixes that make BGP even harder to understand!
- Design idealistic architectures
These Problems Can Be Fixed

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What’s causing these problems?
- Each router has limited, inconsistent state
- BGP interacts in odd ways with other protocols

Problems result from placing too much logic in the routers.
Our Vision: A "Routing Control Platform"

Routers do not compute routes!

- Route computation for an AS is offloaded to a system with a complete view of network state.
- Each AS has a "server" that exchanges consistent routing information with other ASes
The rest of this talk: The Case for RCP

**Principles for interdomain routing:**
- Compute consistent routes using complete state.
  - Example: high-level policy expression
- Control routing protocol interactions.
  - Example: interactions between BGP and lower-level protocols

**Potential dealbreakers:**
- Backwards compatibility and incentives
- Scalability and reliability goals

**Related work (or..."haven’t we seen this before?"):**
- Route reflection and route servers
- Overlay networks
Routers have inconsistent configuration state

**Simple Policy:**
"Don’t advertise routes learned from Worldcom to Sprint."
Configuration is decomposed, so the route must carry state!
Configuration decomposed across routers

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```plaintext
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!
ip community-list 1 permit 0:1000
neighbor 10.0.0.1 route-map EXPORT-A out
route-map EXPORT-A deny 10
  match community 1
!..
```
Configuration decomposed across routers

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!..
Centralize configuration state

Routing Control Platform:
- Has views of all sessions to other ASes.
- Implements policy in terms of AS relationship
  (RCP has policy configuration that expresses the constraint directly.)

Benefits
- Simpler configuration
  - separates policy and mechanism
- Don’t have to "tag" routes with state
BGP interacts with underlying protocols

C1 learns BGP route to destination from RR1.
C2 learns BGP route to destination from RR2.
BGP interacts with underlying protocols

C1 sends packets to RR1 via its shortest path. That path traverses C2.
BGP interacts with underlying protocols

C2 sends packets to RR2 via its shortest path. That path traverses C1. Persistent forwarding loop!
Compute routes with complete information

Routing Control Platform:
- Learns all externally learned routes
- Computes consistent router-level paths
Compute routes with complete information

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Benefits
- Intrinsic loop freedom and convergence
- Path selection dictated by RCP
  - Need not abide by BGP-specific decision process
  - Can "pin" paths
Getting from here to there in three easy steps

Two issues:
- Backwards compatibility
- Deployment incentives
Phase 1: Control Over Protocol Interactions

**Before:** Conventional iBGP

**After:** RCP gets "best" iBGP routes (and IGP topology)

Only one AS has to change its architecture!
Application: Controlling Path Changes

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BGP routes take "nearest exit" (shortest IGP path). Failures or maintenance change internal weights. RCP can "pin" exit points as IGP weights change.
Phase 2: AS-Wide Selection and Policy

**Before:** RCP gets "best" iBGP routes (and IGP topology)

**After:** RCP gets all eBGP routes from neighbors
Aggregation curbs routing table growth. Routers can’t know which routers need more specific routes.
Aggregation curbs routing table growth. Policy at RCP determines whether routers need separate routes. RCP can always pass two subnets to downstream ASes.
Phase 3: Routing Has Left the Routers

**Before:** RCP gets all eBGP routes from neighbors

**After:** ASes exchange routes via RCP
Phase 3 Application: More flexible routing

_Better management:_
- Diagnostics and troubleshooting
- Routing co-located with traffic information, etc.
- Ability to reason about the AS as a single entity

_Protoocol improvements:_
- Attaching prices to routes
- Inter-AS negotiation of exit points
- Overlay routing informed by IP-layer information

*Your application here*

*(Without worrying about BGP-specific arcana)*
Scalability and Robustness

- Will it scale? Will it be fast enough?
  Maybe. We believe we can build the RCP on a single box. We’re building a prototype.
  The RCP is doing less work than N routers
  - Cisco PRP-2 is 1.3 GHz, 1GB RAM
  (Note: centralized != inability to scale)

- Is that a single point of failure I see?
  No. Safe to replicate.
  - RCP can be replicated using distributed systems insights.
  - Consistency (mostly) a non-issue: OSPF guarantees clean partitions
  - Today’s BGP was not designed with robustness in mind.
    (e.g., must replicate route reflectors PoP-by-PoP)
"RCP is basically a route reflector."

Yes, but it’s better.

- "Customized" routing decisions for clients.
  - Router reflectors do not compute routes from client’s perspective.
  - Route reflectors do not emulate a "full mesh". RCP can, though.

- Routing decisions based on complete visibility.
  - Guaranteed correct routes.
  - Replication can be dictated by systems issues.
"RCP also looks a lot like..."

- A "route server"
  - Route arbiter: looked at applying policy at exchange points
  - AS agents: RCP answers questions like "What should these policy agents be doing?"

- An overlay network
  - Most previous work is in data overlays.
  - RCP is a control overlay (no data packets).
  - RCP could give data overlays more information and control.
    - RCP has more fine-grained information directly from the network (e.g., topology, traffic).
    - Can also make changes to the IP layer.
Conclusion: "Routing Control Platform"

**Principles for interdomain routing:**
- Compute consistent routes using complete state.
- Control routing protocol interactions.

**Benefits:**
- Simpler, more expressive configuration
- Intrinsic robustness: no loops, convergence, etc.
- More stable routing
- Enables new applications