Announcements

• P2 standard messages
• P2 team member contributions
Rest of the slides are from Yi Wang’s thesis presentation
VROOM: Virtual Router Migration As A Network Adaptation Primitive

Work with Eric Keller, Brian Biskeborn, Kobus van der Merwe and Jennifer Rexford
[SIGCOMM’08]
Disruptive Planned Maintenance

• Planned maintenance is important but disruptive
  – More than half of topology changes are planned in advance
  – Disrupt routing protocol adjacencies and data traffic

• Current best practice: “cost-in/cost-out”
  – It’s hacky: protocol re-configuration as a tool (rather than the goal) to reduce disruption of maintenance
  – Still disruptive to routing protocol adjacencies and traffic

• Why didn’t we have a better solution?
The Two Notions of “Router”

- The IP-layer **logical** functionality, and the **physical** equipment
The Tight Coupling of Physical & Logical

• Root of many network adaptation challenges (and “point solutions”)
New Abstraction: Separation Between the “Physical” and “Logical” Configurations

• Whenever physical changes are the goal, e.g.,
  – Replace a hardware component
  – Change the physical location of a router

• A router’s logical configuration should stay intact
  – Routing protocol configuration
  – Protocol adjacencies (sessions)
VROOM: Breaking the Coupling

• Re-mapping the logical node to another physical node

VROOM enables this re-mapping of logical to physical through **virtual router migration**
Example: Planned Maintenance

- NO reconfiguration of VRs, NO disruption
Example: Planned Maintenance

- **NO** reconfiguration of VRs, **NO** disruption
Example: Planned Maintenance

- **NO** reconfiguration of VRs, **NO** disruption
Virtual Router Migration: the Challenges

• Migrate an entire virtual router instance
  – All control plane & data plane processes / states
Virtual Router Migration: the Challenges

• Migrate an entire virtual router instance
• Minimize disruption
  – Data plane: millions of packets/second on a 10Gbps link
  – Control plane: less strict (with routing message retransmission)
Virtual Router Migration: the Challenges

• Migrating an entire virtual router instance
• Minimize disruption
• Link migration
Virtual Router Migration: the Challenges

- Migrating an entire virtual router instance
- Minimize disruption
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VROOM Architecture

Physical Router

Virtual Router
  Control Plane

Virtual Router
  Control Plane

Virtual Router
  Control Plane

Data-Plane Hypervisor

Data Plane

Dynamic Interface Binding

Substrate
VROOM’s Migration Process

• Key idea: **separate** the migration of control and data planes

1. Migrate the control plane
2. Clone the data plane
3. Migrate the links
Control-Plane Migration

• Leverage virtual server migration techniques
• Router image
  – Binaries, configuration files, etc.
Control-Plane Migration

- Leverage virtual migration techniques
- Router image
- Memory
  - 1\textsuperscript{st} stage: iterative pre-copy
  - 2\textsuperscript{nd} stage: stall-and-copy (when the control plane is “frozen”)
Control-Plane Migration

- Leverage virtual server migration techniques
- Router image
- Memory

Physical router A

Physical router B

CP
DP
Data-Plane Cloning

- **Clone** the data plane by repopulation
  - Enable migration across different data planes
  - Eliminate synchronization issue of control & data planes

![Diagram of Data-Plane Cloning]

Physical router A

- DP-old

Physical router B

- CP
- DP-new
Remote Control Plane

• Data-plane cloning takes time
  – Installing 250k routes takes over 20 seconds [SIGCOMM CCR’05]
• The control & old data planes need to be kept “online”
• Solution: redirect routing messages through tunnels

![Diagram of Remote Control Plane]

**Physical router A**
- DP-old

**Physical router B**
- CP
- DP-new
Remote Control Plane

• Data-plane cloning takes time
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![Diagram showing Physical router A and B with CP and DP-old/DP-new]
Double Data Planes

• At the end of data-plane cloning, both data planes are ready to forward traffic
Asynchronous Link Migration

- With the double data planes, links can be migrated independently
Prototype Implementation

• Control plane: OpenVZ + Quagga

• Data plane: two prototypes
  – Software-based data plane (SD): Linux kernel
  – Hardware-based data plane (HD): NetFPGA

• Why two prototypes?
  – To validate the data-plane hypervisor design (e.g., migration between SD and HD)
Evaluation

• Impact on data traffic
  – SD: Slight delay increase due to CPU contention
  – HD: no delay increase or packet loss

• Impact on routing protocols
  – Average control-plane downtime: 3.56 seconds (performance lower bound)
  – OSPF and BGP adjacencies stay up
VROOM is a Generic Primitive

• Can be used for various frequent network changes/adaptations
  – Simplify network management
  – Power savings
  – ...

• With no data-plane and control-plane disruption
Migration Scheduling

• Physical constraints to take into account
  – Latency
    • E.g, NYC to Washington D.C.: 2 msec
  – Link capacity
    • Enough remaining capacity for extra traffic
  – Platform compatibility
    • Routers from different vendors
  – Router capability
    • E.g., number of access control lists (ACLs) supported

• The constraints simplify the placement problem