XORP and Virtual Routers

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Building Blocks

- This talk is bottom up.
- We’ll start with what we’ve got, explore what we can build with that, and speculate about where we might go.

- It’s up to you to decide how to use these building blocks.
  - I’ve got my own ideas, but…
Open source router software suite, *designed from the outset with extensibility in mind.*

- Main core unicast and multicast routing protocols.
- Event-driven multi-process architecture.
- BSD-style license
- 560,000 lines of C++
XORP Status: IGP Standards

**RIP and RIPng:**
- RFC 2453 (RIP version 2)
- RFC 2082 (RIP-2 MD5 Authentication)
- RFC 2080 (RIPng for IPv6)

**OSPFv2:**
- RFC 2328 (OSPF Version 2)
- RFC 3101 (The OSPF Not-So-Stubby Area (NSSA) Option)
XORP Status: BGP Standards

- draft-ietf-idr-bgp4-26 (A Border Gateway Protocol 4 (BGP-4))
- RFC 3392 (Capabilities Advertisement with BGP-4)
- draft-ietf-idr-rfc2858bis-03 (Multiprotocol Extensions for BGP-4)
- RFC 2545 (Multiprotocol Extensions for IPv6 Inter-Domain Routing)
- RFC 3392 (Capabilities Advertisement with BGP-4)
- RFC 1997 (BGP Communities Attribute)
- RFC 2796 (BGP Route Reflection - An Alternative to Full Mesh IBGP)
- RFC 3065 (Autonomous System Confederations for BGP)
- RFC 2439 (BGP Route Flap Damping)
XORP Status: Multicast Standards

**PIM-SM:**
- draft-ietf-pim-sm-bsr-03

**IGMP v1 and v2:**
- RFC 2236

**MLD v1:**
- RFC 2710
XORP Processes

Multi-process architecture, providing isolation boundaries between separate functional elements.

XRLs: Flexible IPC interface between modules
Different routing and management processes can all be run on different machines.

FEA talks to forwarding engine and provides an idealized API, remotely accessible.

RIB = routing information base
FEA = forwarding engine abstraction
FEA: Forwarding Engine Abstraction

Management Processes

- IPC finder
- router manager
- CLI
- SNMP

Multicast Routing
- PIM-SM
- IGMP/MLD

Unicast Routing
- BGP4+
- OSPF
- RIP
- IS-IS

Forwarding Engine

RIB = routing information base
FEA = forwarding engine abstraction
Main purpose of FEA is to provide a stable API to the forwarding engine.

- Same XRL interface on All forwarding engines
- Different OS calls.
- Different kernel functionality.
- Different hardware capabilities.
- Multiple forwarding engines
FEA Functionality

Interface Management:
- Discover and configure network interfaces.
- Processes can register interest in interface state changes.

Routing:
- Sends unicast routes to the forwarding engine.
- Sets/removes multicast forwarding state.
- Relays notifications (IGMP, PIM Messages, etc)

Relay Routing Traffic:
- Routing protocols send packets via XRLs to the FEA
- Don’t run as root, even if they need to send on a raw socket.
- Sandboxing can limit what a bad process can send and receive.
XORP and Distributed Routers (1)

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FEA talks to forwarding engine and provides an idealized API, remotely accessible.

RIB = routing information base
FEA = forwarding engine abstraction
Distributed Router

Kernel (forwarding plane)

RIB

FEA

fw

fw

fw

BGP

OSPF

PIM-SM

kernel

kernel

kernel
Distributed Routers. So what?

- Many boxes:
  - Lots of CPU cycles: can do stuff you couldn’t do on a router before.
  - Isolation - compromised PIM-SM doesn’t affect your BGP.
Host Virtualization within a Router

- Dom 0
- RIB
- FEA
- Kernel (forwarding plane)
- XEN Hypervisor
- fw
- BGP
- kernel
- OSPF
- kernel
- PIM-SM
- kernel
Virtualized Route Processor: Security

- Use virtualization to isolate processes.
  - Can only interact with the rest of the world through XRLs.
- Use XRL firewalling to restrict XRLs and their parameters needed for the task at hand.
  - Can use a template file to specify process permissions.
- Result:
  - An experimental process can do very little harm if it malfunctions or gets compromised.
Router Worms

- If I can compromise one BGP, I can compromise them all and shut down your network.
  - Don’t need to break out of the sandbox to do damage.
- Can we prevent router worms?
Router Worm Prevention

- Message parsing
- Parsed Route Messages
- BGP Engine
- Outgoing Route Messages
- Message construction
- FEA
- XRLs
- Incoming BGP Messages
- Outgoing BGP Messages
- TCP Connection to Peer
Virtual Routers

Dom 0
- Kernel (forwarding plane)
- XEN Hypervisor

Dom U1
- Kernel (forwarding plane)

Dom U2
- Kernel (forwarding plane)

Dom U3
- Kernel (forwarding plane)
Virtual Routers: What’s the Point?

- One box can play the role of multiple independent routers.
- Multiple organizations sharing a single physical router.
  - Small businesses within one building.
- Entire physical network can be shared.
  - Virtualize the routers.
  - Tunnel between virtual routers over shared IP infrastructure.
  - Great platform for experimentation (cf. VINI).
  - Alternative to MPLS infrastructure for VPNs.
    - VPN can be inter-domain, multi-homed.
    - Some virtual routers belong to ISP, lease slice to customer.
    - Others belong to edge-network; good isolation between internal and external traffic on same physical links.
    - Integrate better into public IP infrastructure at multiple locations.
Virtual Routers

Dom 0

Dom U1

Dom U2

Dom U3

Kernel (virtualized forwarding plane)

Kernel

Kernel

Kernel

XEN Hypervisor
Distributed Virtual Routers (2)
Distributed Virtual Router

- Many boxes form the forwarding plane of a single virtual router.
  - Outside world only sees one router in OSPF, BGP, etc.
  - Internally, packets may be forwarded between the nodes of the router.

- Nodes can be in same rack.
  - Build one big router from many small cheap components.

- Nodes can be in same POP.
  - POP internal topology isolated from external routing.

- Nodes can be widely distributed.
  - CF Centralized Routing.
  - Can tackle control algorithms that don’t distribute well.
  - Need to be very careful about fate sharing.
“The Big Rack of PCs” Router

- Most backbone routers use a fast hardware forwarding path.
  - Hard to beat for pure dumb forwarding.

- Modern x86 CPUs good at forwarding at speeds of 1Gb/s.
  - Trend towards multiple cores good for software forwarding.
  - Software advantage is flexibility.

- Distributed software routers favour router applications.
  - Flexibility in distributing load across the cluster.
  - Most obvious applications are in security area:
    - IDS, IPS, Firewall, DoS defense.
  - Enabler for any CPU-intensive in-network tasks.
Conclusions

- XORP FEA aimed at abstracting out differences in forwarding places.
- Turns out having an abstract forwarding plane is ideal for building virtual routers.
  - Distribute routing protocols across multiple boxes.
  - Distribute routing protocols across multiple VMs.
  - Put multiple routers in multiple VMs on one box.
    - Virtualize entire network.
  - Make multiple boxes behave like one router.
    - Network is inside the router.
  - Secure router against worms.
- Suddenly good old IP networks seem a lot more flexible than they used to.
Summary

- Virtual routers are an enabling technology.
  - Actually several enabling technologies.

- Maybe provide deployment pathway for new architectures without expecting everyone to throw away the Internet first.

- What ideas do you have for using them?