Flexible Cloud Environment for Network Studies

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Outline

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Project overview

- Unique cloud-based virtualization platform
  - Hosted at Juniper Networks, Sunnyvale, California
- Scalable lab environment for the study of link-state and distance-vector routing protocol operation
- Over 200 students including distance-learning
Previous setup

- The Complete Rack System
- PCs + KVM Switches
- Cabling + Switch

- Physical testbed located at QMUL with Linux-based PCs running Zebra/Quagga
  - Clusters of 8 machines plus packet-sniffing PCs
- Breakout patch panel for further flexibility
Previous setup - problems

- Timetabling
  - High student-to-equipment ratios, less opportunity for extra experiments
- Need for dedicated laboratory
- Maintenance
- Lack of availability to distance-learning students
Alternative Virtual Environments

- Local or remotely located distributed virtual machines.
  - E.g. Emulab, Planetlab, Netkit

- De-centralised management

- Most solutions employ open-source routing daemons, e.g. Zebra, Quagga and XORP
  - Limited features compared to commercial router implementations
Junosphere

- Commercially available x86 based servers running a Linux Host OS and KVM hypervisor
- VMs are managed by VMM (Virtual Machine Manager) software developed by Juniper
- VDE (Virtual Distributed Ethernet) software provides emulated Ethernet network to VMs
- Number of VMs limited by the amount of memory present in the server & CPU horsepower
Junosphere ctd..

- A cloud based system
  - Stack of x86 servers running virtualization software
  - Hosted in a co-lo facility supported 24x7
- Allows academic institutions to create labs
- Supports the following lab elements:
  - Virtual Juniper routers running commercially available JUNOS
  - Various Unix systems: FreeBSD, CentOS, Ubuntu
  - Virtualized packet generators (e.g. Spirent vCenter)
  - Routing analytics tools (e.g. Route Insight Manager)
  - Virtualized CPE (e.g. OpenWrt)
  - Anything that can be virtualized using KVM hypervisor running on an x86 system
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- Easy to stop and start the lab
  - If students make a mistake and crash a component of the lab, just tear down and restart
- Easy to create topologies
  - All lab elements are connected using VDE (Virtual Distributed Ethernet switch)
This is interface em3.0 of router 15. Its IP address is 200.0.4.15

This is interface em1.0 of router 15. Its IP address is 200.0.3.15

Network Number = N.N.N.0
Router Number = X
Interface IP address = N.N.N.X
Interface Name = em T .0
Centos PC Name = RX-RY

Centos-R9-R10 Virtual PC
Centos-R13-R14 Virtual PC

runs Tcpdump
Experiments - details

- Each group had access to their own set of VMs, i.e. 8 virtual routers and 2 virtual CentOS PCs
- 240 VMs, i.e. 24 groups could access the platform simultaneously

Tasks:
- RIP/OSPF Basics
- Examining failure and reconvergence with RIP/OSPF
- OSPF Parameter negotiation and cost setting
- RIP/OSPF Route redistribution

Individual lab report:
- Analysis of observed results
- Essay on improving the reconvergence time
Benefits

- Reinforce concepts learnt in class by gaining hands-on experience, i.e. a complete learning cycle
- No special laboratory required
  - Accessible from any standard computer via Telnet/SSH
- Distance-learning students achieve the same learning experience as campus-based students
Benefits ctd..

- Improved scalability, i.e. less timetabling issues and more opportunity for extra experiments
- Ease of flexibility in varying experiments
- Scenario can be easily replicated
  - Promotes reusability (e.g. University of Vienna)
- The virtual routers are identical to their real-world counterparts
  - Exposure to commercial equipment within university
Drawbacks

- ‘Time’ in the virtualised environment is not the same as in the real world.

- Data-plane behaviour does not accurately emulate that of physical routers
  - Packet-scheduling characteristics and virtual link speeds are not a fair reflection of their physical counterparts
Conclusions and Further Work

- Valuable opportunity for students in experimenting with commercial equipment
  - Excellent feedback received
- Currently in discussions with other academic institutions on new lab designs and experiments
- Extended use of the platform for MSc projects
- Supports IS-IS and BGP in addition to RIP and OSPF
  - Scope for further teaching and research projects