Performance Evaluation of Open Virtual Routers

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Outline

• Network Virtualization
• PC based Virtual Routers
• Challenges
• Virtual Router Design
• Performance Evaluation
• Conclusion
Network Virtualization

• A solution to provide network researchers to run experiments on a shared substrate network

• Network virtualization means to virtualize all network components (Hosts, Links and Routers)

• A major challenge is to virtualize the actual network elements, Switches and Routers
Open Virtual Routers

- Commodity hardware, Open source softwares
- Run multiple independent virtual instances in parallel on the same hardware
- A virtualization technology enforces resource limiting among virtual routers
- Each virtual router maintains its own set of virtual network interfaces, protocols, routing tables, packet filtering rules (i.e. separate data and control planes)
Challenge

- Router virtualization is associated with performance penalties.
- Virtualization overhead is introduced in terms of how packets are processed in the router.
- How to combine software modules to form an open virtual router with minimum virtualization penalty.
Linux Virtual Routers
Virtualization Technologies

- **Hypervisor**: It runs on top of the physical hardware and it virtualizes hardware resources to be shared among multiple guest operating systems. E.g. VMware, Xen

- **Container**: The operating system resources are virtualized (e.g. files, system libraries) to create multiple isolated execution environment on top of a single operating system. E.g. OpenVZ, Linux Namespaces
OpenVZ based Virtual Routers

- **Virtual devices**
  
  Virtual Network Device (venet): Operates at layer 3. An IP address is local and unknown from external networks.
  
  Virtual Ethernet Device (veth): Ethernet-like device operating at layer 2 with its own MAC address.

- **Physical/virtual device mapping**
  
  Linux software bridge, IP forwarding, Virtual switch etc.
Building a Virtual Router: 3 step process

(a) Source → NIC1 → BRIDGE → NIC2 → Sink

(b) Source → NIC1 → BRIDGE → FIB → BRIDGE → NIC2 → Sink

(c) Source → NIC1 → BRIDGE → Veth1 → FIB → Veth2 → BRIDGE → NIC2 → Sink
Impact of adding virtual components
IP Forwarder vs. Virtual Router

- **IP Forwarder**
  Throughput: 720kpps
  Packet drop: Ingress physical interface, CPU saturation observed at the offered load of 720kpps

- **Virtual Router**
  Throughput: 334kpps
  Packet drop: Backlog queue congestion occurred at the offered load of 429kpps
  Ingress physical interface, CPU saturation observed at the offered load of 650kpp
Virtual Router Design Internals
Virtual Router Design: An alternative approach

- Linux Namespaces, an emerging container based virtualization
- Macvlan, a virtual device provides a built in mechanism of physical/virtual device mapping
- Both bridge and veth are replaced with macvlan device
OpenVZ vs. Namespace Virtual Router

![Graph comparing OpenVZ and Namespace Virtual Router performance](image-url)
## Virtual devices CPU usage

<table>
<thead>
<tr>
<th>Packet Rate (kpps)</th>
<th>CPU %age Usage</th>
<th>Kernel 2.6.27-openvz chistyakov</th>
<th>Kernel 2.6.34 Net-Next</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Linux Bridge</td>
<td>Veth</td>
<td>Total</td>
</tr>
<tr>
<td>200</td>
<td>9</td>
<td>1.5</td>
<td>10.5</td>
</tr>
<tr>
<td>429</td>
<td>11</td>
<td>1.9</td>
<td>12.9</td>
</tr>
<tr>
<td>450</td>
<td>16</td>
<td>1.9</td>
<td>17.9</td>
</tr>
<tr>
<td>600</td>
<td>17</td>
<td>2.2</td>
<td>19.2</td>
</tr>
<tr>
<td>650</td>
<td>18</td>
<td>2.3</td>
<td>20.3</td>
</tr>
<tr>
<td>800</td>
<td>18</td>
<td>2.3</td>
<td>20.3</td>
</tr>
</tbody>
</table>
Conclusion and future work

- Apart from any virtualization technology, the way in which devices are mapped is important.
- Linux bridge is a CPU intensive device (MAC learning, forwarding database updates etc).
- Macvlan is an attractive alternate.
- It is important to know how virtual devices communicate with kernel.
- Backlog is still there which may become performance bottleneck.
• Thanks for listening

• Questions ?