Optical Service Chaining by Combining Optics, SDN, and NFV

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Network Function Virtualization

Network Function Virtualization

- Middlebox services or network functions are realized in software running on generic hardware and in virtualized environments.
- Motivated by CAPEX savings and faster time to market of new offerings and solutions.

Source: ETSI NFV Whitepaper 2012

Benefit

- CapEx/OpEx saving
- Shorter development cycles for new services
- Automation of NF configuration and management
- Support multi-tenancy of NF
End-To-End Path of Traffic Flow

Operator's Access Network with Legacy NFs (e.g. middleboxes)
Operator's DC/Cloud with virtualized network functions

Internet
Challenge in Data Center Networks

- Steering traffic across core network functions in data centers requires high efficiency and scalability
  - How to efficiently handle ~10s of Gbps traffic steering?
  - How to dynamically shape network infrastructure to support bulky traffic transmission?
- Data center network infrastructure and cloud manager needs to be interacted to optimizing networking and server resources

Source: A Scalable, Commodity Data Center Network Architecture
Scalability Issue – An Example

- \( f_1 \) and \( f_2 \) are 5 Gbps flows
  - \( f_1 \) needs to go through vNF\(_1\) and vNF\(_2\)
  - \( f_2 \) needs to go through vNF\(_3\) and vNF\(_4\)
  - \( f_1: S_1\rightarrow ToR_1\rightarrow vNF_1\rightarrow ToR_1\rightarrow S_1\rightarrow ToR_2\rightarrow vNF_2\rightarrow ToR_2\rightarrow S_1 \)
  - \( f_2: S_1\rightarrow ToR_3\rightarrow vNF_3\rightarrow ToR_3\rightarrow S_1\rightarrow ToR_4\rightarrow vNF_4\rightarrow ToR_4\rightarrow S_1 \)

- \( f_1 \) and \( f_2 \) are 10 Gbps flows
  - \( f_1 \) needs to go through vNF\(_1\), vNF\(_2\), and vNF\(_3\)
  - \( f_2 \) needs to go through vNF\(_4\), vNF\(_5\), and vNF\(_6\)
  - \( f_1: S_1\rightarrow ToR_1\rightarrow vNF_1\rightarrow ToR_1\rightarrow S_1\rightarrow ToR_2\rightarrow vNF_2\rightarrow ToR_2\rightarrow S_2\rightarrow ToR_3\rightarrow vNF_3\rightarrow ToR_3\rightarrow S_1 \)
  - \( f_2: S_1\rightarrow ToR_4\rightarrow vNF_4\rightarrow ToR_4\rightarrow S_2\rightarrow ToR_5\rightarrow vNF_5\rightarrow ToR_5\rightarrow S_2\rightarrow ToR_6\rightarrow vNF_6\rightarrow ToR_6\rightarrow S_1 \)
Motivation of Using Optics

› The throughput of the packet steering domain increases as traffic volume grows.
› Power consumption goes up correspondingly as throughput.

A new scheme is needed:

- Insensitivity to traffic growth and number of virtual network functions
- High power efficiency
Introducing an optical steering domain
- ROADM dispatches traffic to the two domains
- Optical domain is complement to packet domain
Optical Steering Domain

Architecture for traffic steering for NFV using optical technology.
Performance Analysis-Setting

Table 1  Scenarios for scalability analysis (2 flows).

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Flow rate (Gbps)</th>
<th># of needed vNFs per flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>40</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>100</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 2  Power consumption at different flow rates (W)*.

<table>
<thead>
<tr>
<th></th>
<th>Core switch</th>
<th>ToR switch</th>
<th>Optics</th>
</tr>
</thead>
<tbody>
<tr>
<td>10GbE</td>
<td>3.91</td>
<td>1.3</td>
<td>/</td>
</tr>
<tr>
<td>40GbE</td>
<td>15.625</td>
<td>5.21</td>
<td>/</td>
</tr>
<tr>
<td>100GbE</td>
<td>46.875</td>
<td>15.63</td>
<td>/</td>
</tr>
<tr>
<td>WSS per port</td>
<td>/</td>
<td>/</td>
<td>2.0</td>
</tr>
</tbody>
</table>

*Source: Ericsson DCX series for core and ToR Switch)
Performance Analysis-Result

Total packet throughput by core switches.

Power consumption for the six scenarios.
Summary

We propose a circuit based (optical-layer) solution for efficient traffic steering to support network function virtualization (NFV).

• Based on software-defined networking (SDN) principles
• High scalability and power efficiency for bulky traffic steering
• Complement to existing packet-based solutions