Using ESnet SmartNIC for Line Rate IPv6 Translation on FPGAs

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Problem Space

- IPv6: The future is here, but not *all* the way here
- Some things can’t be upgraded for IPv6 (expensive scientific instruments)
- Dual-stacking isn’t necessarily the right solution anymore (OMB M-21-07)
- v4-only and v6-only segments still need to communicate… How?
- There is a tried-and-true solution…
NETWORK PROBLEMS

ENGINEERS

NAT
SIIT-DC
Architecture
SIIT-DC
Architecture
SIIT-DC
Architecture

<table>
<thead>
<tr>
<th>Source IP</th>
<th>Destination IP</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001:db8::1</td>
<td>64:ff9b::198.51.100.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source IP</th>
<th>Destination IP</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.0.2.1</td>
<td>198.51.100.1</td>
</tr>
</tbody>
</table>

Explicit Address Mapping Table

<table>
<thead>
<tr>
<th>IPv4 Subnet</th>
<th>IPv6 Subnet</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.0.2.0/24</td>
<td>2001:db8::/128</td>
</tr>
</tbody>
</table>

XLAT Prefix:

<table>
<thead>
<tr>
<th>Prefix</th>
</tr>
</thead>
<tbody>
<tr>
<td>64:ff9b::/96</td>
</tr>
</tbody>
</table>
Why Build Your Own?

• NRENs face unique challenges, specifically with large science flows
• We couldn’t find any SIIT-DC translators that actually run in hardware
• General purpose CPU is great… *in aggregate*
• ESnet SmartNIC lets you build *fast* hardware applications *fast*.
Hardware

- Xilinx Alveo U280 FPGA\(^3\)
- 2x 100GbE Ethernet CMAC interfaces
- 8x PCIe Gen4 Lanes
- Intel Xeon E5-2670 CPU in Host Server
Architecture
Fast Path Overview
“Slow” Path Overview

SIIT-DC Host

CPU

FPGA

DPDK

PF0

PF1

CMAC0

CMAC1

IPv4 Host/Network

IPv6 Host/Network

100Gbe

100Gbe
What is ESnet SmartNIC?

- Framework for developing FPGA-based applications
- Helps you deploy your FPGA-based applications
- Uses docker compose
- Repos Links:
  - esnet-smartnic-fw
  - esnet-smartnic-hw
Special Thanks!

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Dr. Nik Sultana, IIT
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Yatish Kumar, ESnet
Stacey Sheldon, ESnet
Scott Richmond, ESnet
Peter Bengough, ESnet

You!
Questions?

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References

• [1] Title: “Shinkansen N700 with Mount Fuji”, Author: tansaisuketti, Source: Wikimedia Commons, License: CC BY-SA 3.0
