Use P4 to Program NP-based Router through POF Interface

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Towards Open Programmable Data Path

White box (OCP)
- Hardware/Software Decouple
- Forwarding/Control Decouple
- User programmable
- Forwarding Abstraction

SDN (ONF)

NOS
- Box w/ fixed function ASIC
- Decouple

APP
- Box with programmable Chip
- Programming

Gen 1 white box

Gen 2 white box

High Level Language
- Compile
- Abstract IR
- Standard Config/ Runtime interface(s)
- Programmable Chips
POF Forwarding Abstraction

- In Ports
- Table
- Action
- Out Ports

<table>
<thead>
<tr>
<th>match key</th>
<th>param.</th>
<th>pointer</th>
</tr>
</thead>
<tbody>
<tr>
<td>dynamically loaded entry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dynamically loaded entry</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

action (instruction block in POF-FIS)

dynamically shared global resource (e.g., counter, meter, flow metadata, etc.)

In Ports ➔ Table ➔ Action ➔ Out Ports
POF Programming Architecture

- Configuration and runtime share the same interface
  - Combine static programming and dynamic incremental reconfiguration and control
- POF aims to maximize the flexibility
  - More restrained use is possible

<table>
<thead>
<tr>
<th>Application</th>
<th>Library</th>
<th>GUI/CLI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P4 or other HLL compiler</strong></td>
<td>Library</td>
<td>GUI/CLI</td>
</tr>
<tr>
<td><strong>Open Southbound Interface</strong> (OF2.0)</td>
<td>Library</td>
<td>GUI/CLI</td>
</tr>
<tr>
<td><strong>Device / Driver / Backend Compiler</strong></td>
<td>Library</td>
<td>GUI/CLI</td>
</tr>
<tr>
<td><strong>Programmable Chip</strong></td>
<td>Library</td>
<td>GUI/CLI</td>
</tr>
<tr>
<td>ASIC</td>
<td>NPU</td>
<td>CPU</td>
</tr>
</tbody>
</table>
POF IR & SBI: An Extension to OpenFlow

- Support all existing OF1.4 messages
- Add new POF-specific messages
  - Counter messages
  - Instruction block messages
  - POF Data path enable/disable messages
  - Service messages
- Modify some existing messages to meet POF’s requirements
  - table_mod, flow_mod, etc.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protocol</td>
<td>Define the protocol header format</td>
</tr>
<tr>
<td>Metadata</td>
<td>Define the metadata layout</td>
</tr>
<tr>
<td>Table</td>
<td>Define table name, table type, table size, search key, and if the table is a shared table</td>
</tr>
<tr>
<td>Table Parameter</td>
<td>Define parameter format for each table that can be accessed by table instruction block (i.e., action)</td>
</tr>
<tr>
<td>Instruction Block</td>
<td>Define the actions that will be executed after table matching. Each table entry will point to an instruction block.</td>
</tr>
<tr>
<td>Service</td>
<td>Define the table pipeline (similar to control flow in P4)</td>
</tr>
</tbody>
</table>
Use P4 to Program POF Device

- **POF PoC**
  - POF Prototype demo in 2013
  - WAN testbed demo in 2015
  - Open source POF controller (www.poforwarding.org)
  - NE40E w/ 240Gbps LC/Slot
  - REST JSON NBI

- **P4 Support**
  - Reuse open source HLIR compiler
  - P4-POF plugin translates HLIR objects to POF-IR objects, formatted into REST JSON commands
  - POF Controller translates JSON commands to POF messages
Performance & Challenges

• 120G LC $\rightarrow$ 180Mpps line speed but actual performance falls short of line speed for small packets
  – Architecture implied by P4 spec doesn’t match optimal NP implementation
  – Compiler optimization needed
    • An WIP optimization shows 10~20% improvement
  – Too many TCAM accesses for Parser
    • Combine parser states
Lessons Learnt for Applying P4 on NP

• Decouple the language and the architecture
  – Support incremental “just-in-time” parsing
  – Support modular design

• Design portability is very hard to achieve
  – Reusable library vs. reusable design
  – Standard behavior model but custom code for implementation
THANK YOU

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