Extending SDN and NFV with Deep Data-Plane Programmability

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SDN Architecture

Applications

Network Applications

North-Bound Interface (NBI)

Control-Plane Elements

Control Plane

South-Bound Interface (SBI)

Data-Plane Elements

Data Plane
SDN Architecture

Applications

Network Applications

North-Bound Interface (NBI)

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Data Plane

Data-Plane Elements

Limiting Factor
SDN Architecture

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South-Bound Interface (SBI)

Control Plane

Data Plane

Data-Plane Elements

North-Bound Interface

Killer App?

Limiting Factor
Deeply Programmable Network

- **Application Programmability**
  - Control-Plane Programmability
    - Interfaces
    - Functions
      - Route Control
      - Access Control
      - Network Management
  - Data-Plane Programmability
    - Interfaces
    - Functions
      - Packet Data Processing
        - Network Appliances (DPI, BRAS, EPC)
        - In-Network processing (Cache, Transcode)
        - Wide-Area generic processing
      - Handling New Protocols
        - IPvN (N>6), New Layer2, CCN

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Programmability / Performance Tradeoff

Programmability

Performance

Programmability

Performance

Programmability

Performance

Cloud Data Center 1

Cloud Data Center 2

Edge Area

Core Area

Edge Area
Data-Plane Programmability Extends Current SDN

Applications

Network Applications

Packet Process

North-Bound Interface (NBI)

Control Plane

Control-Plane Elements

Packet Process

Data Plane

Programmable Data-Plane Elements

Publish API
Challenges

• Deep programmability
• (Reasonable) Performance
• Multiple Concurrent Logics

FLARE’s Approach to these challenges

• Linux(OSS)+Toy-Block Data Plane Construction
• Many-Core Network Processor + General Purpose Processor
• Virtualization/Resource Container
FLARE Node Architecture

Fully Programable

Programmable Control Plane

Programmable Data Plane

Virtual Network Ports

Physical Network Ports

Node Manager

Packet Slicer

FLARE Central Node
Hierarchical Resource Management

- General Purpose Processor(s)
- Network Processor(s)
- ...and more types of processors
FLARE Mini now available...

- Small Form Factor: 15cm x 6cm x 28cm
- Low power: 120W
- (Data Plane) Programmable node a graduate student can bring home and play with
- Capacity: 40G(current) ~ 80G (planned)
- Network I/F: 10Gx2 + 1Gx8 (current) 10Gx8(planned)
- Preinstalled with network function elements that can be combined to enable arbitrary network functions e.g., OpenFlow 1.0/1.3, Packet Generator, Pcap Replay
Data-Plane API and Toy Block Networking

SDN-style API

Hot Config Plug-in/out

Both API + Hot Config

Control Plane

Control-Plane Elements

Data Plane

monolithic data-plane

Data-Plane Elements

e.g., openflow-style

modular data-plane

Data-Plane Elements

e.g., Object Oriented

modular data-plane

Data-Plane Elements

modular data-plane

Data-Plane Elements

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FLARE Programming Model in Sliver

Programmable Control Plane

Programmable Data Plane

Multi-Threaded Modular Programming
e.g., Click Software Modular Router (multi-threaded)

- Arbitrary switch logic(s) can be implemented
L2 Programmability
Extended (96bit) MAC switching

Traditional Ethernet Frame:

<table>
<thead>
<tr>
<th>DMAC (48bits)</th>
<th>SMAC (48bits)</th>
<th>Type</th>
<th>IP PayLoad</th>
</tr>
</thead>
</table>

Extended Ethernet Frame with Extended MAC:

<table>
<thead>
<tr>
<th>DMAC (96bits)</th>
<th>SMAC (96bits)</th>
<th>Type</th>
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</tr>
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</table>

Prototype with Click

[Diagram showing the process flow for Extended Ethernet Frame with Extended MAC and Click prototype]
Multiple SDN Logics

(OpenFlow 1.3 and OpenFlow 1.0)
Window-based Arbitrary Bit Matching

Arbitrary bit matching as in openflow pattern matcher is costly due to expensive memory operation per packet

Set a window to minimize per-packet memory operations. Improve performance while keeping flexibility.

YouTube Packet Cache

- Reduce cross-ISP redundant traffic
- Matching L7 (URL) not headers!
L7 Switching and In-Network Processing

L7 Switching

FLARE supports deeply programmable SDN solutions such as arbitrary-bits and arbitrary offset matching and definition of proprietary APIs achieving both flexibility and performance.

In-Network Processing

Video transcoding can be performed in real time on either D-plane (many-cores processor) or C-plane (Intel-CPU).
Conclusion

- **Deep Programmability** refers to the extensive programmability including Control-plane, Data-plane (including non-IP handling), (re)defining APIs in SDN, etc.

- **Deeply Programmable Network** research encourages “clean-slate” thinking and redesigning the network and lifts the limitation in traditional networking and even in the current SDN.