# Extending SDN and NFV with Deep Data-Plane Programmability

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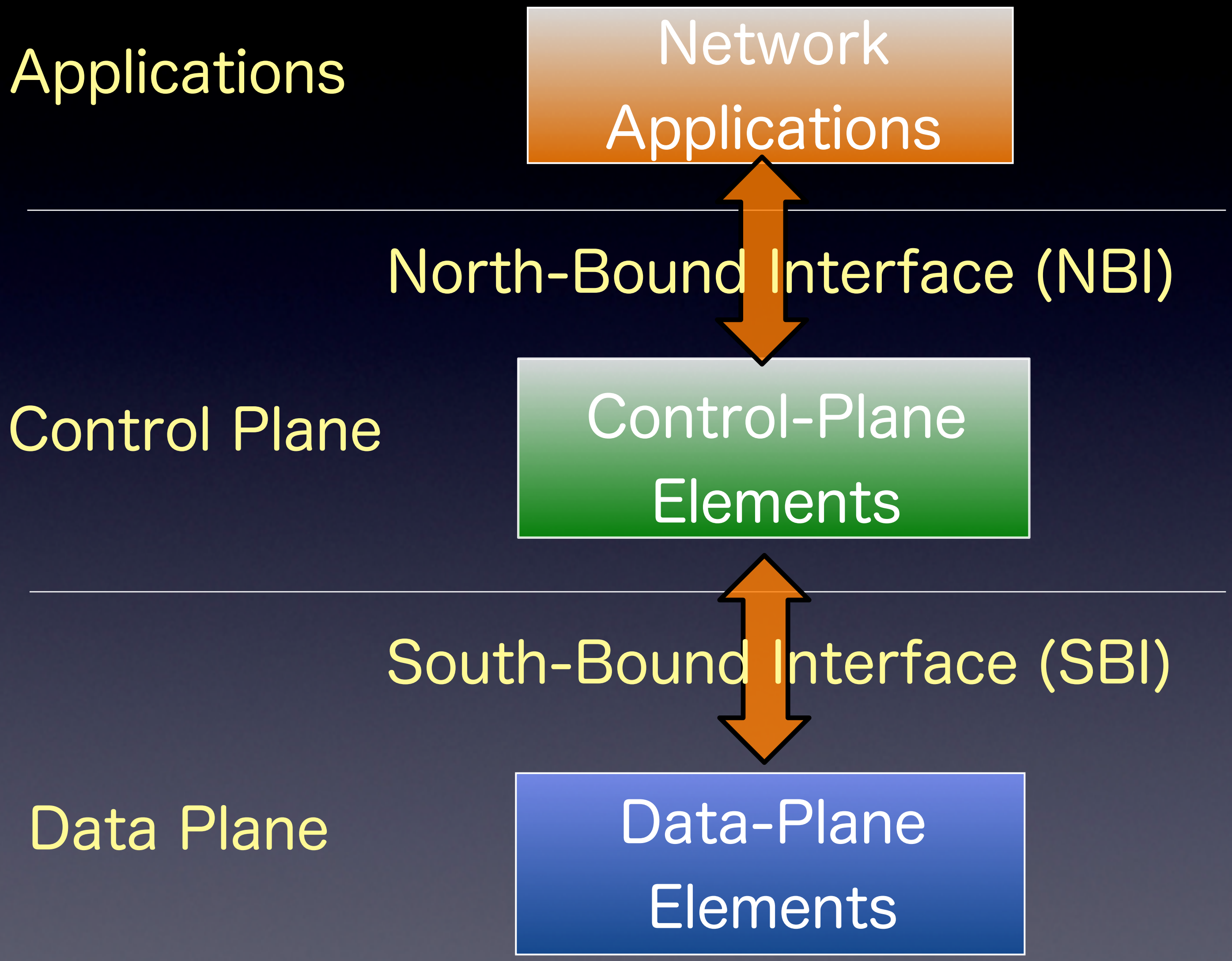
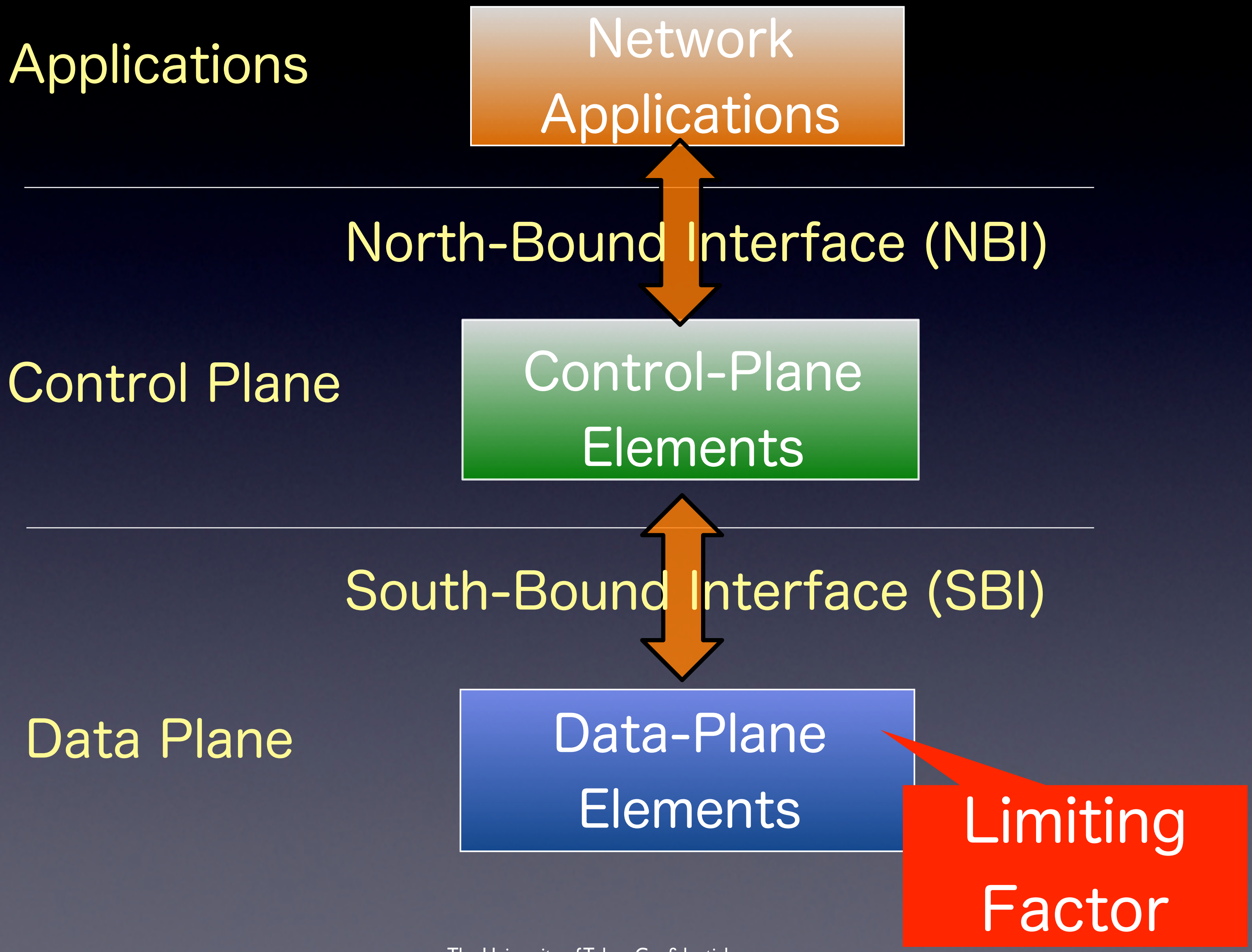
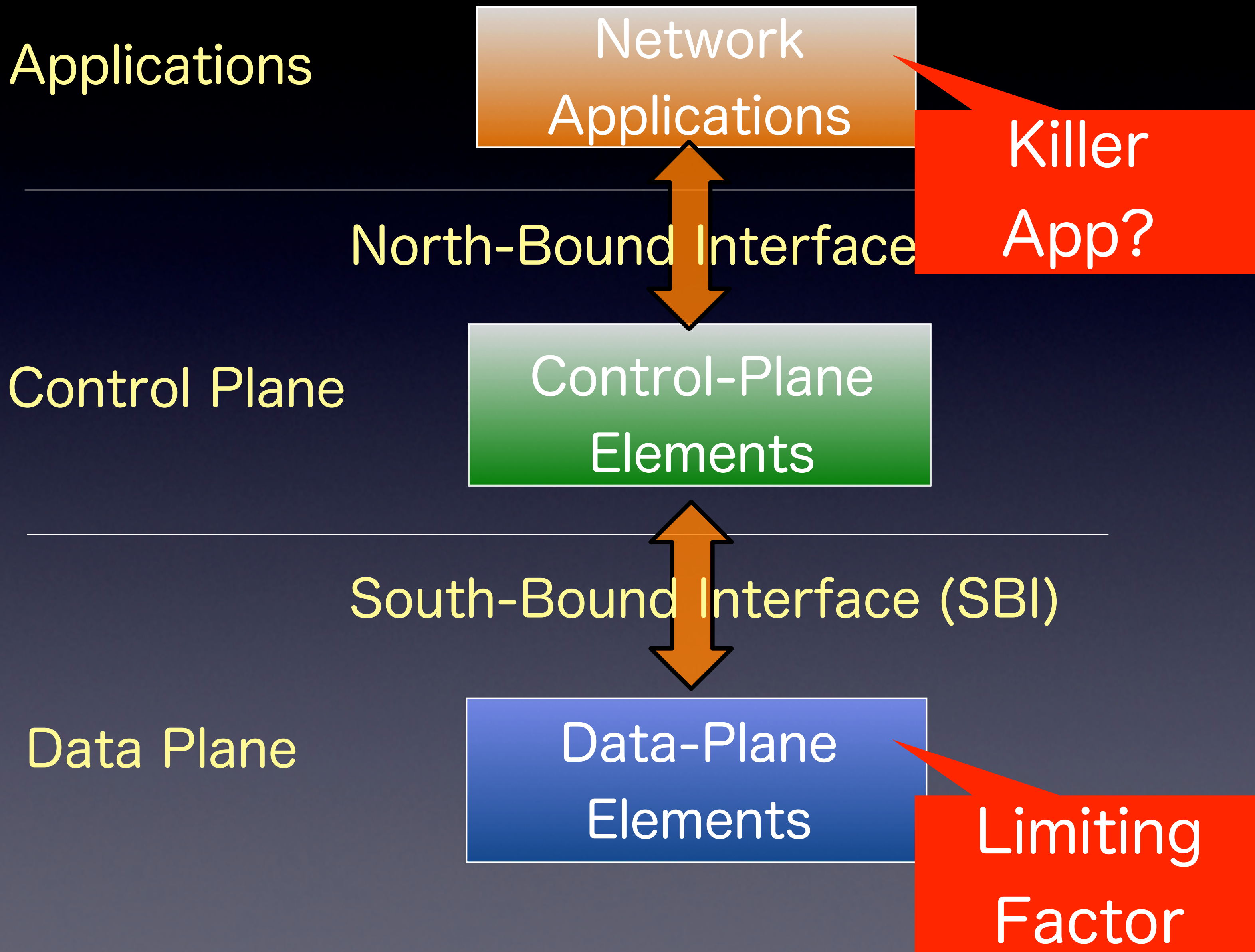
# SDN Architecture



# SDN Architecture



# SDN Architecture



# 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

OpenDaylight

ONF

OpenFlow

SDN

NFV

DPN

**Deeply Programmable Network (DPN)**

Applications

Network Applications

Interfaces

e.g, Northbound API

Control Plane

Control-Plane Elements

e.g, OpenFlow Controller

Interfaces

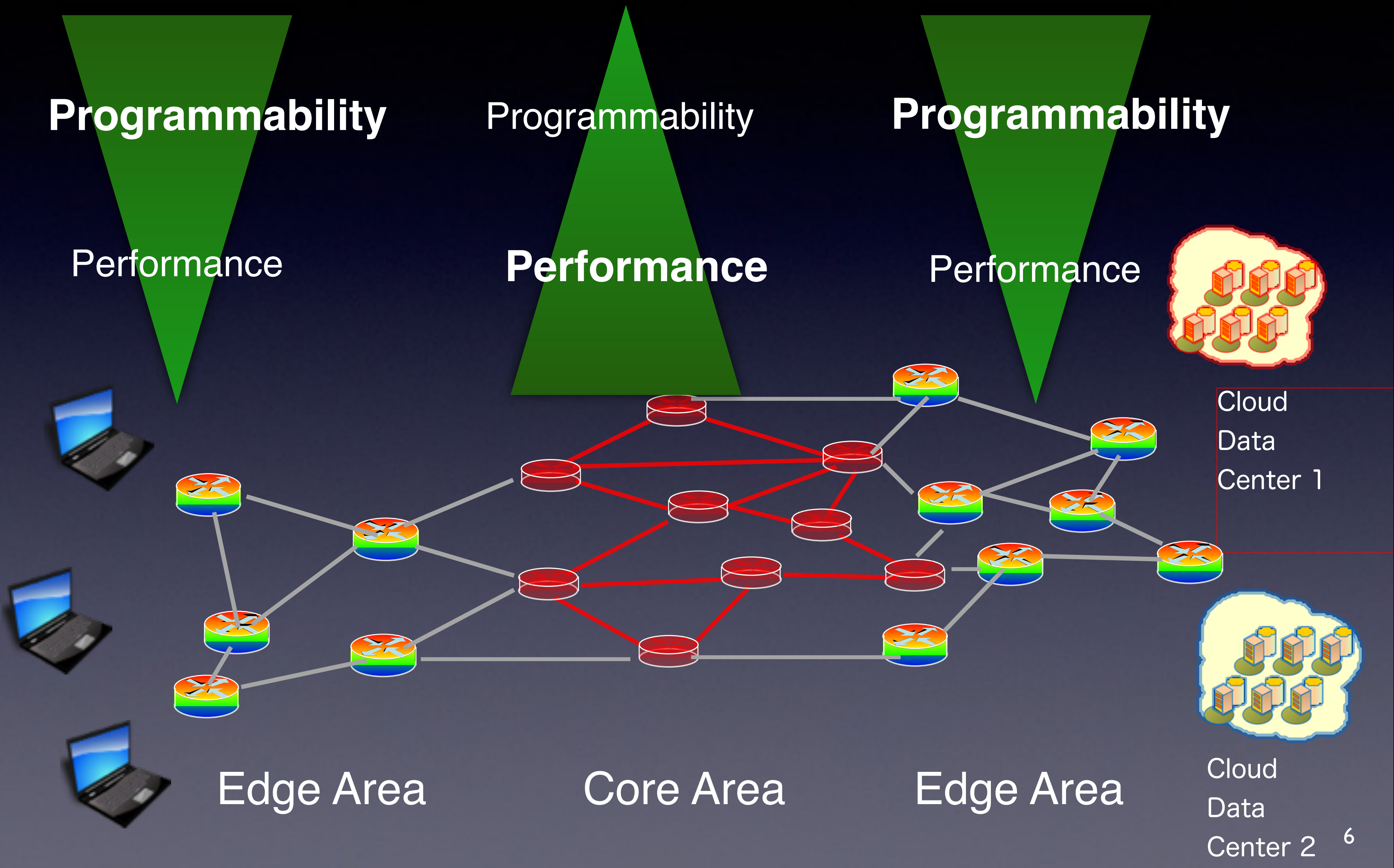
e.g, Southbound API

Data Plane

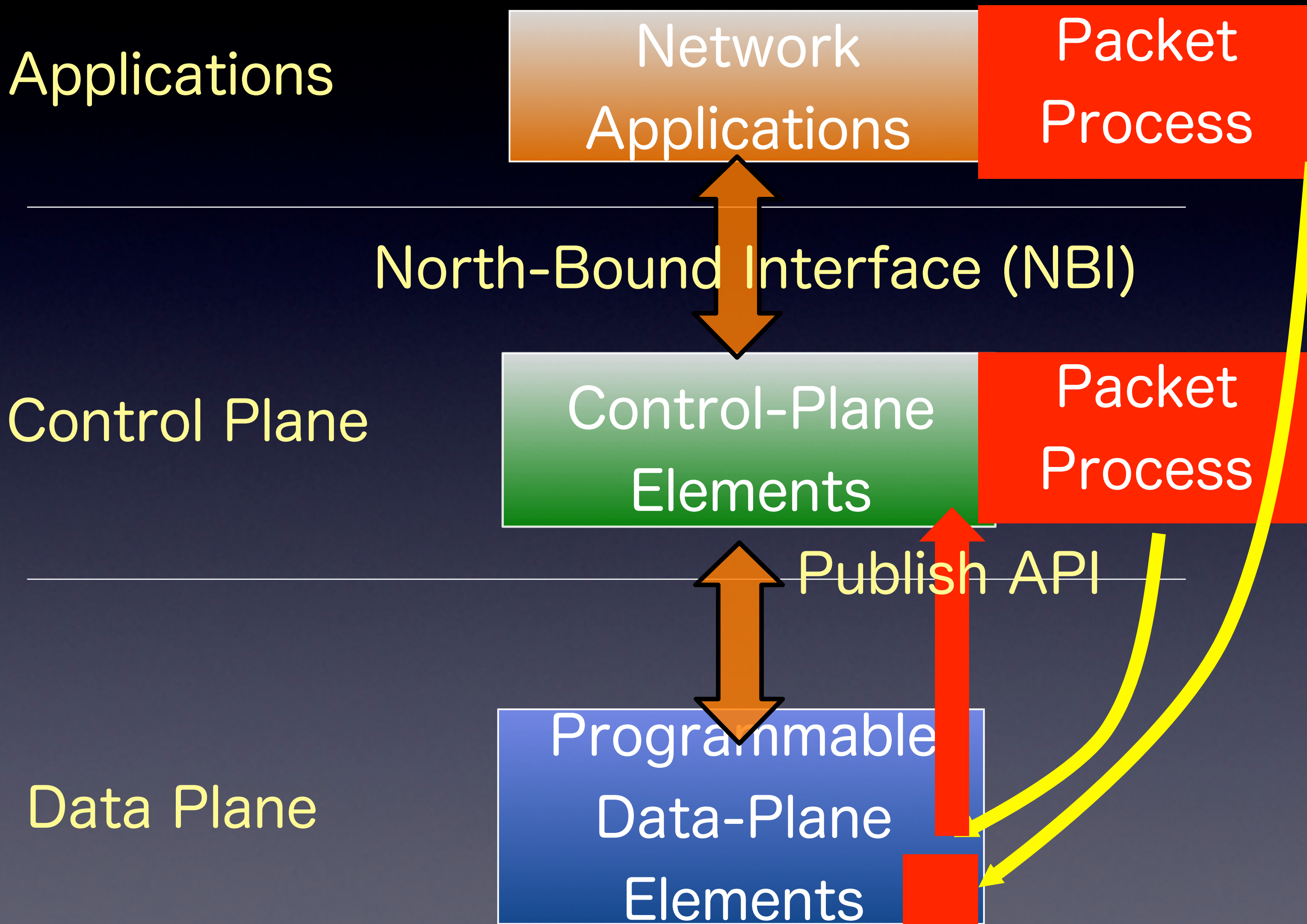
Data-Plane Elements

e.g, OpenFlow Switches

# Programmability / Performance Tradeoff



# Data-Plane Programmability Extends Current SDN



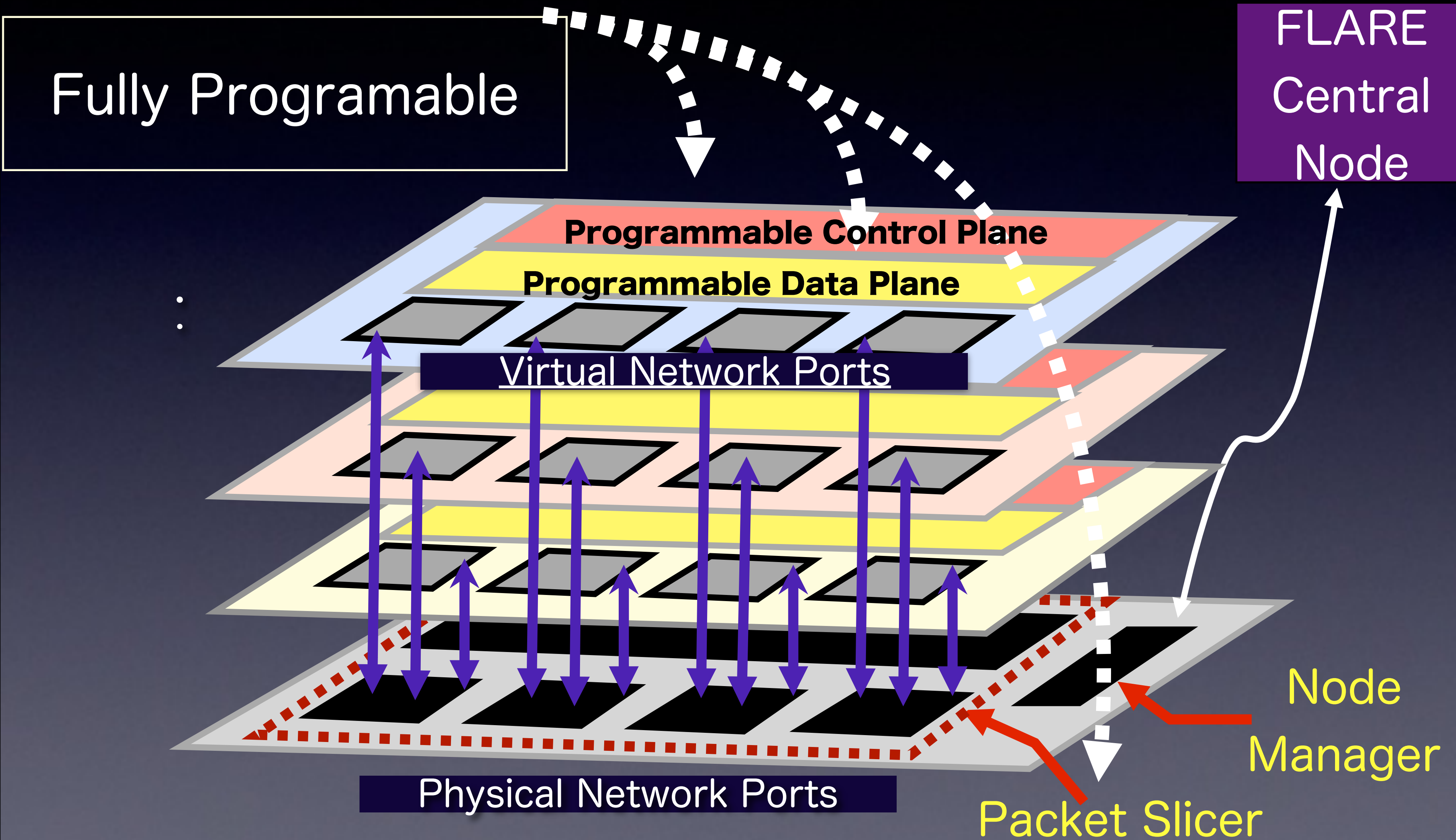
# Challenges

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

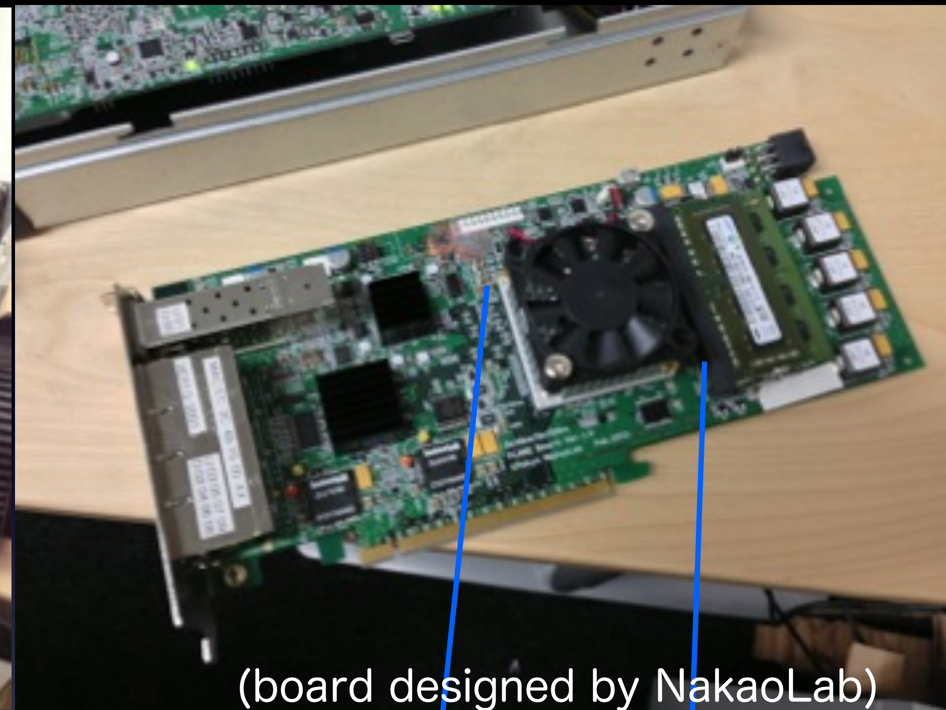
## FLARE's Approach to these challenges

- Linux(OSS)+Toy-Block Data Plane Construction
- Many-Core Network Processor + General Purpose Processor
- Virtualiztion/Resource Container

# FLARE Node Architecture



# FLARE Node Implementation


36–72 cores

(upto 100-200 cores in future)

## Hierarchical Resource Management

- General Purpose Processor(s)
- Network Processor(s)
- ...and more types of processors

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# Roadmap of FLARE nodes

# 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



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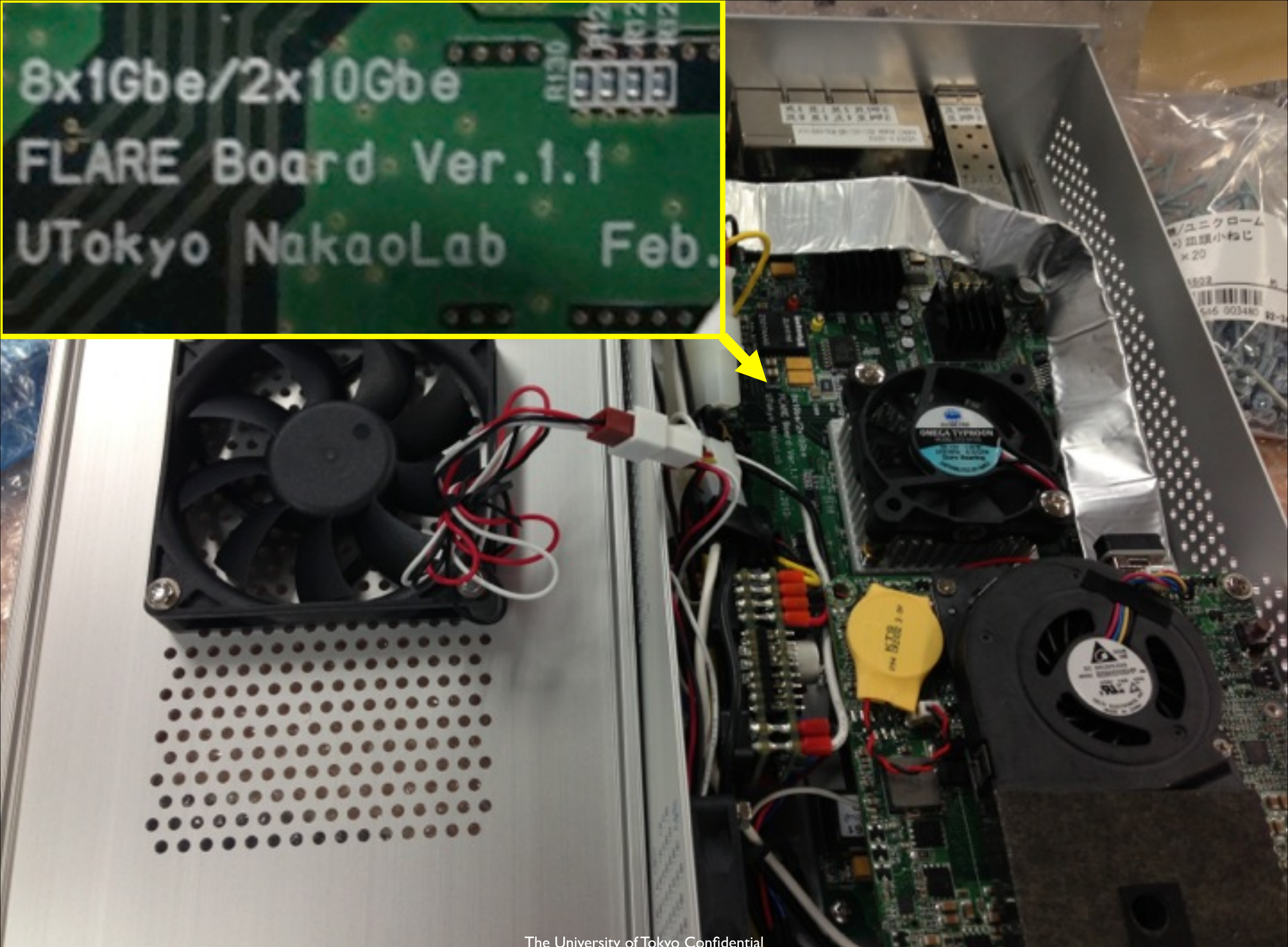


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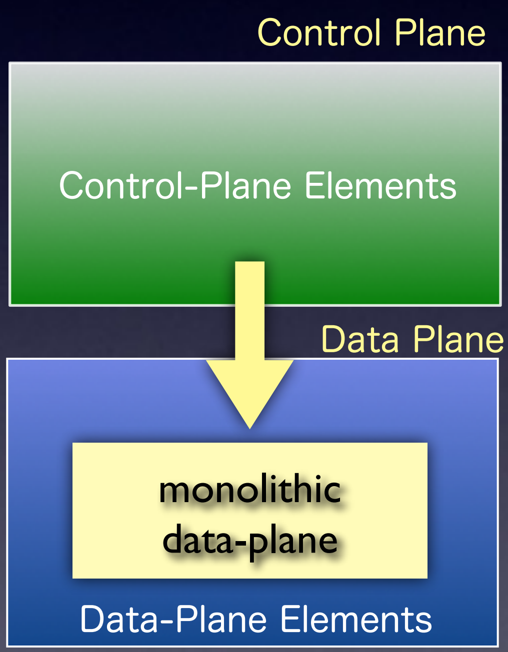
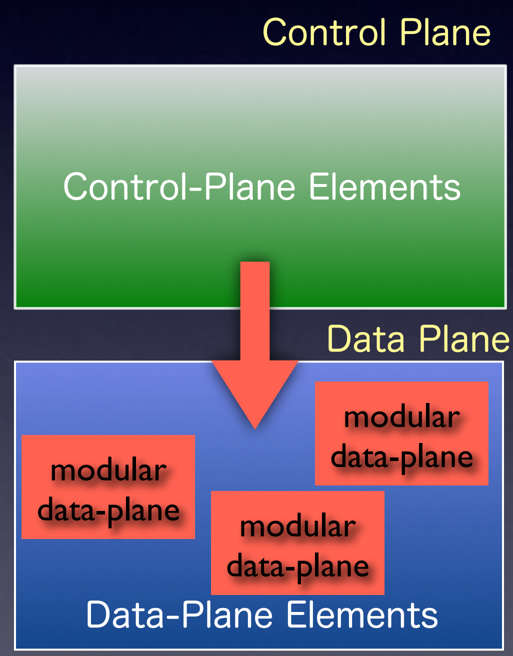
# Data-Plane API and Toy Block Networking

## SDN-style API



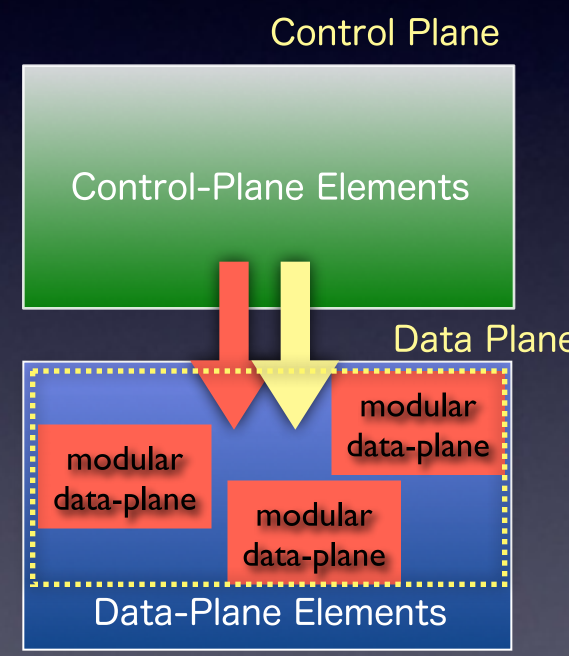

e.g., openflow-style

## Hot Config Plug-in/out

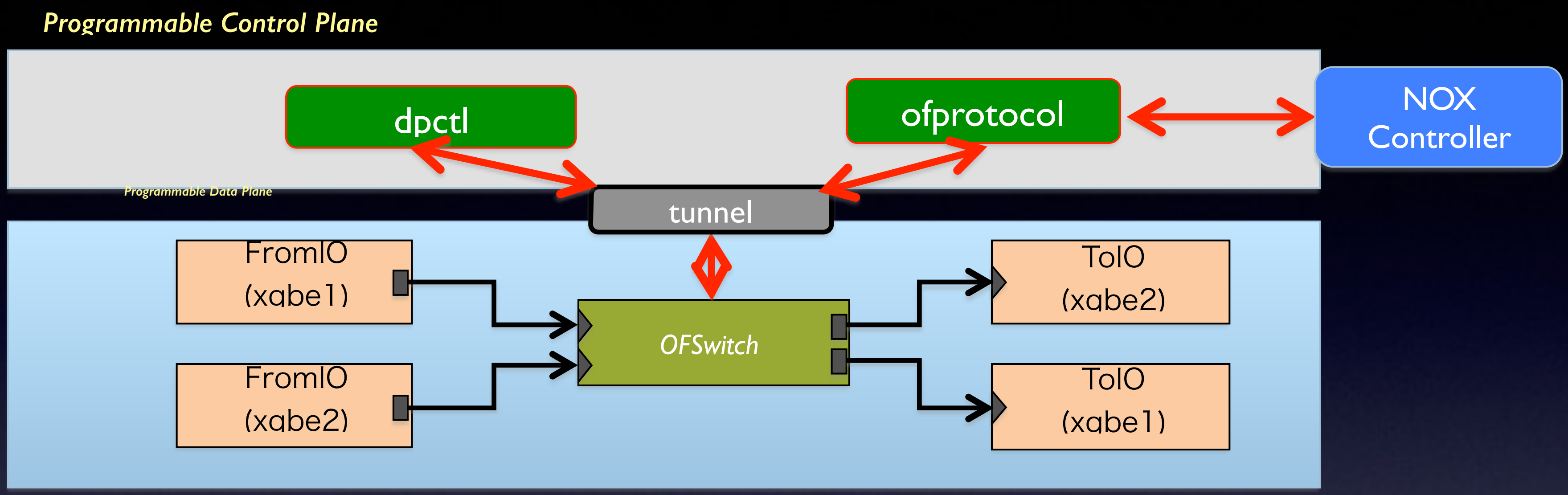



e.g., Object Oriented

## Both API + Hot Config



# FLARE Programming Model in Sliver




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

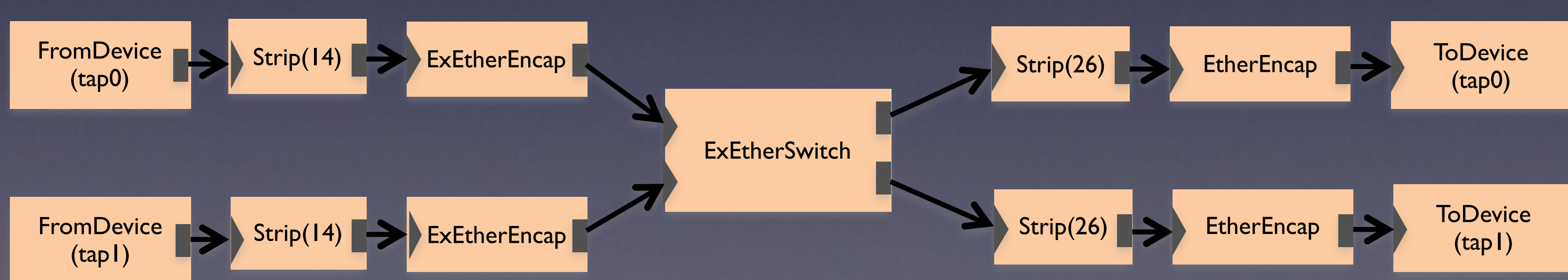
## Traditional Ethernet Frame:

| DMAC (48bits) | SMAC (48bits) | Type | IP PayLoad |
|---|---|---|---|

## Extended Ethernet Frame with Extended MAC:

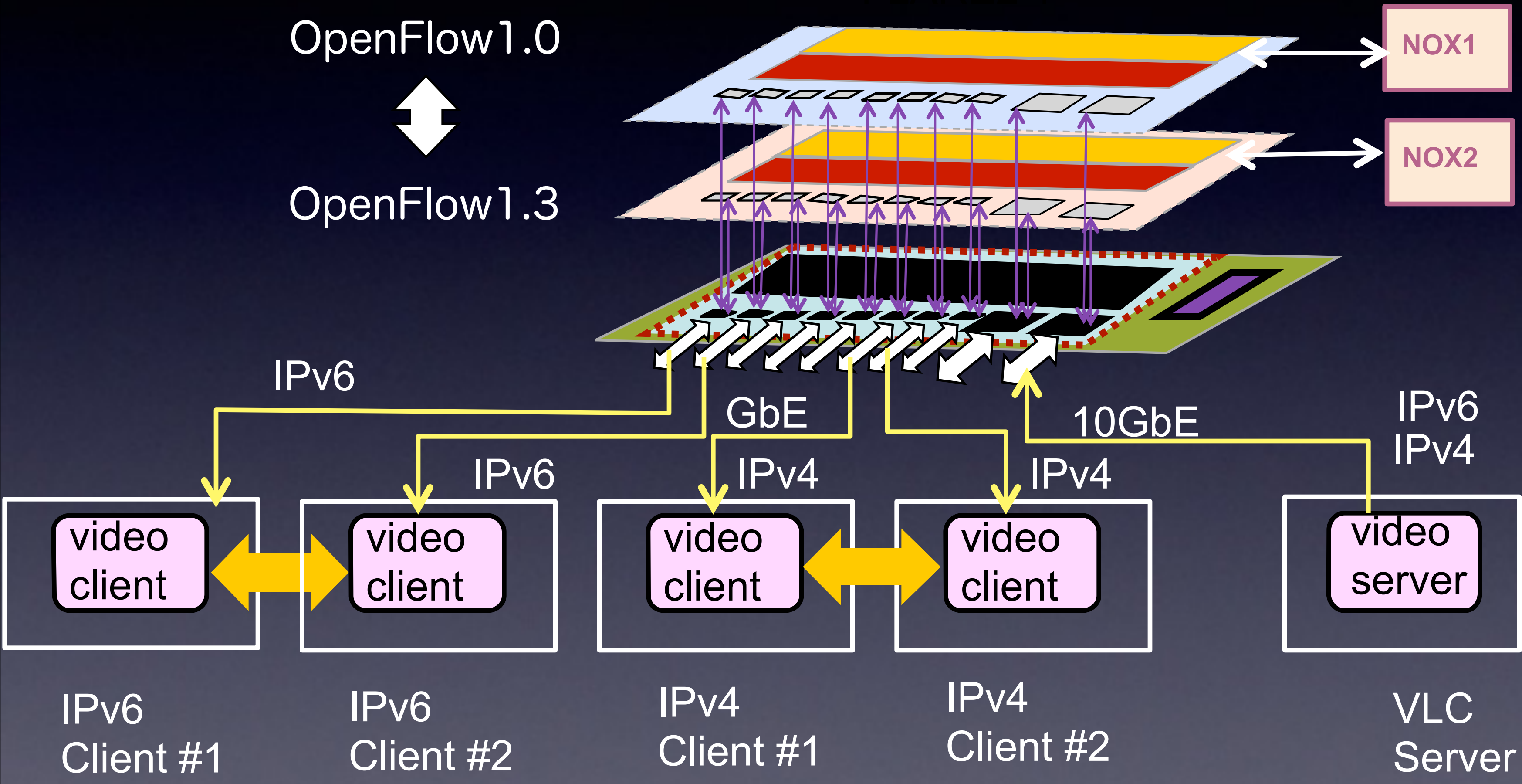
| DMAC (96bits) | SMAC (96bits) | Type | IP PayLoad |
|---|---|---|---|

## Prototype with Click

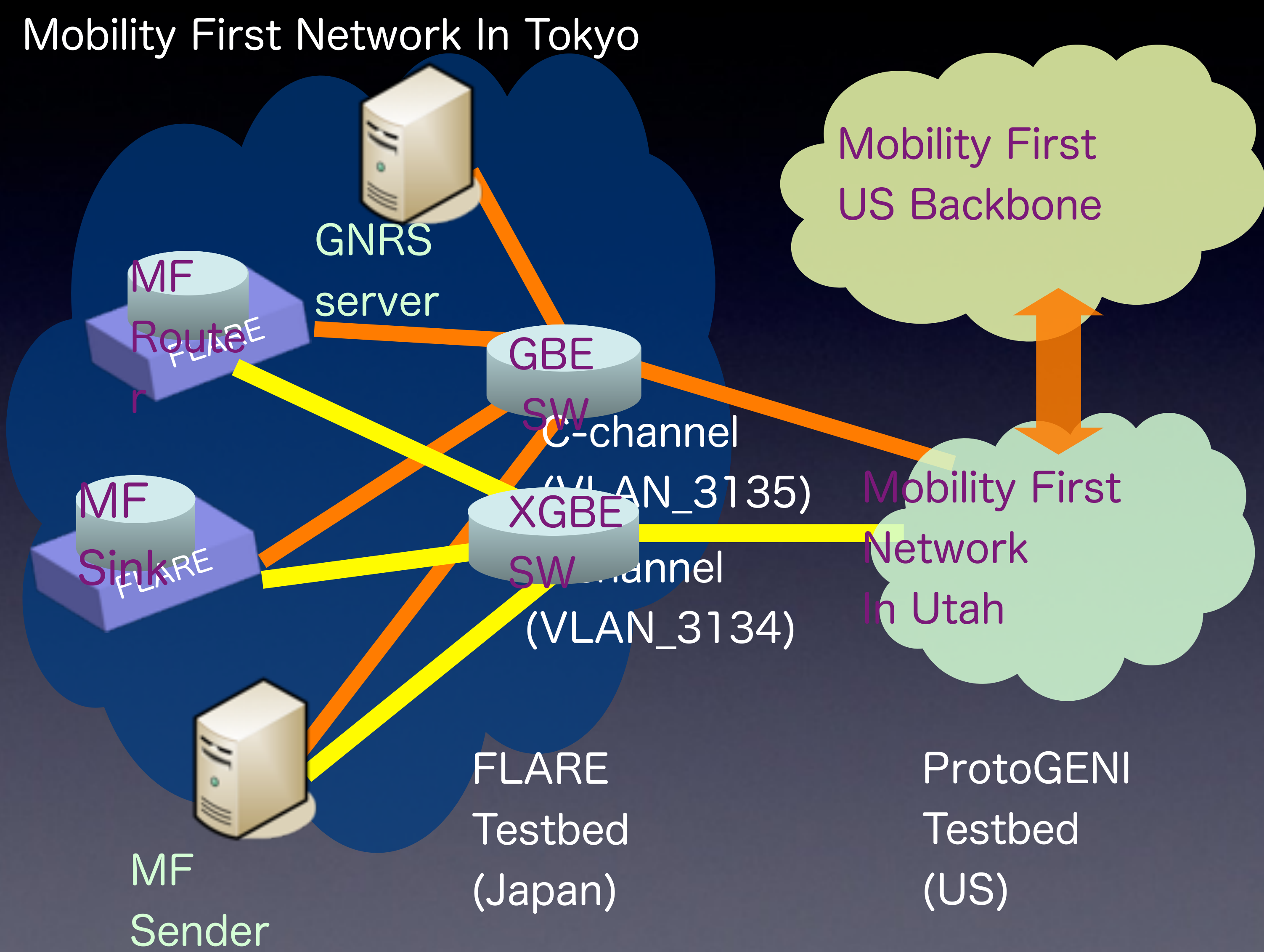


# Multiple SDN Logics

# (OpenFlow 1.3 and OpenFlow 1.0)

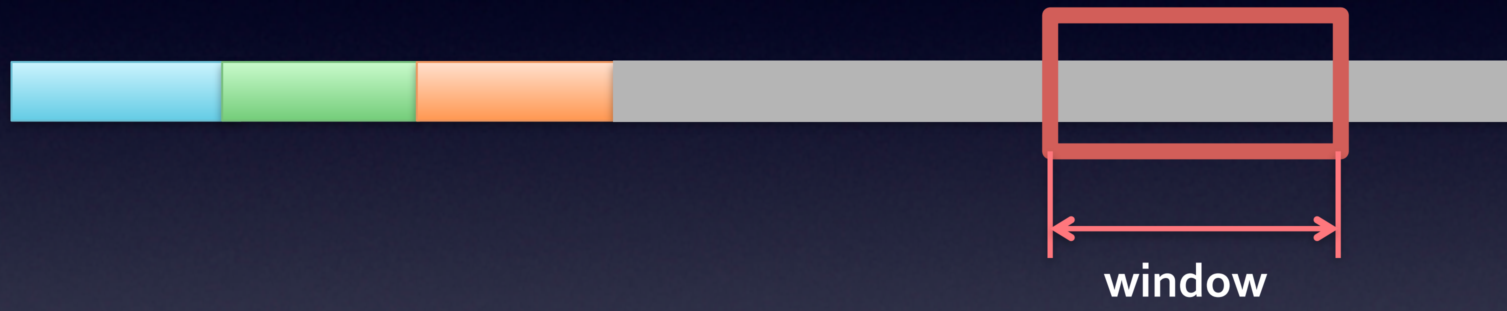


# PaF, PiF, PoF,  Non-IP Protocol



# Window-based Arbitrary Bit Matching

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



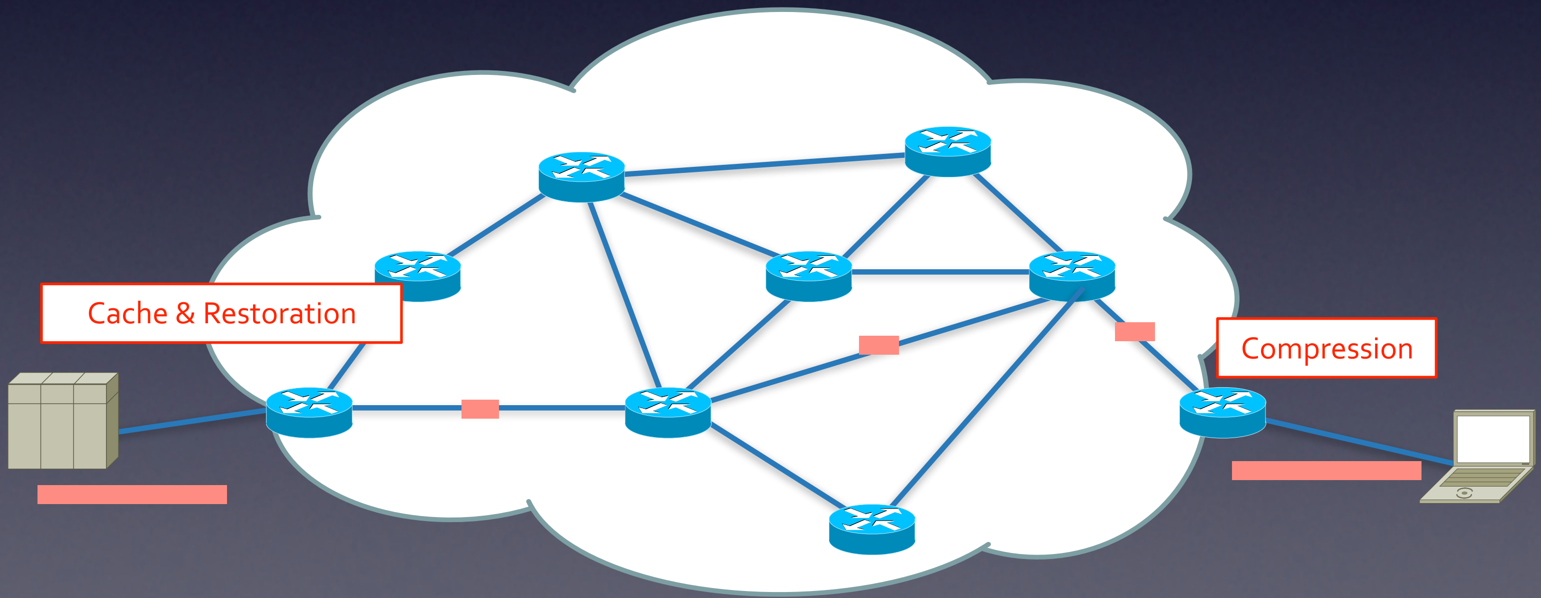

Set a window to minimize per-packet memory operations

Improve performance while keeping flexibility

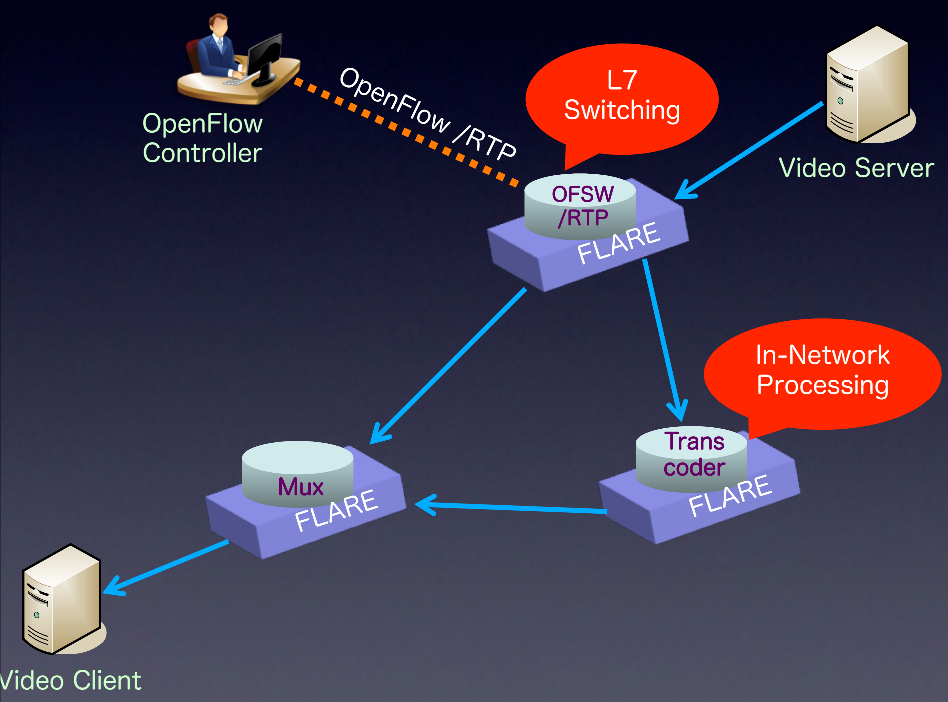
Leon Lee, Ping Du and Akihiro Nakao, "Ouroboros: SDN Beyond Flow-Tuple Matching," IEICE NS Technical Report, Mar. 2013

# 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 preformed 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.