What are the hard (and interesting) open research problems in the SDN Space?

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Agenda

- Outline Problem Spaces and Problems
- Proposed Solution

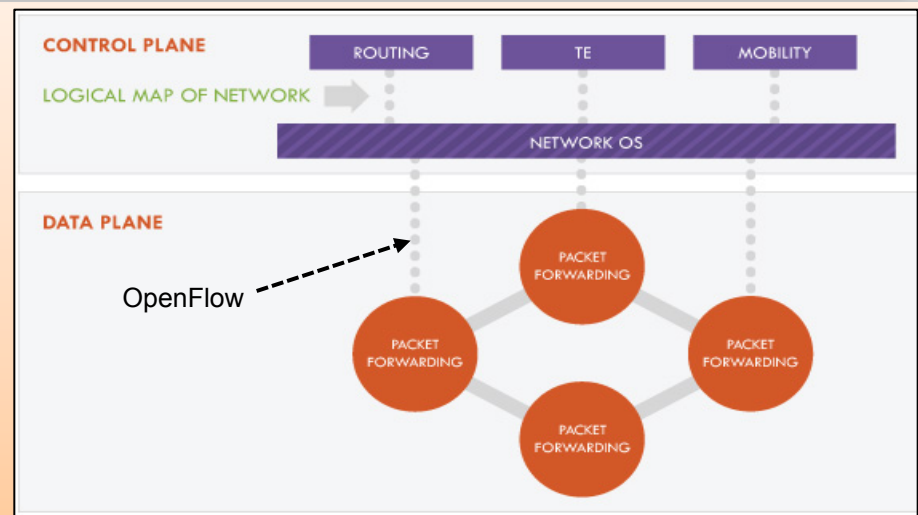# Software Defined Networks: A Market Definition

(Server) virtualization is driving changes in the network and creating SDN applications
- DC Orchestration
- Service/Platform Virtualization

We're starting to leave a single domain!

A market definition of SDN

- Control and forwarding plane separation
- Centralized control with <u>unified</u> view of the network (or domain)
- Can program *towards* centralized view

CONTROL PLANE — ROUTING — TE — MOBILITY
LOGICAL MAP OF NETWORK
NETWORK OS
DATA PLANE
PACKET FORWARDING
OpenFlow
PACKET FORWARDING
PACKET FORWARDING
PACKET FORWARDING

Most prevalent view on SDN -- source: opennetsummit.org

SDN Asks Three Questions:

|		
Where control plane resides?	How does the control plane talk to the Data Plane?	How are the data and control planes programmed?

- Where the control plane resides "Distributed vs Centralized" ?
- How Does it talk to the Data Plane ?
- How are the data and control planes programmed ?

The Basic Concepts of SDN and Programmability

SDN is also a series of concepts that "normalize" over time … starting at an extreme (but seemingly feasible) position …

Examples:
- Granularity of forwarding control
  (originally) hop-by-hop ->
  (normalized to) overlay
- Philosophy of forwarding control
  (originally) completely centralized ->
  "logically centralized but physically distributed" -> imbedded controller?

FMO

PMO
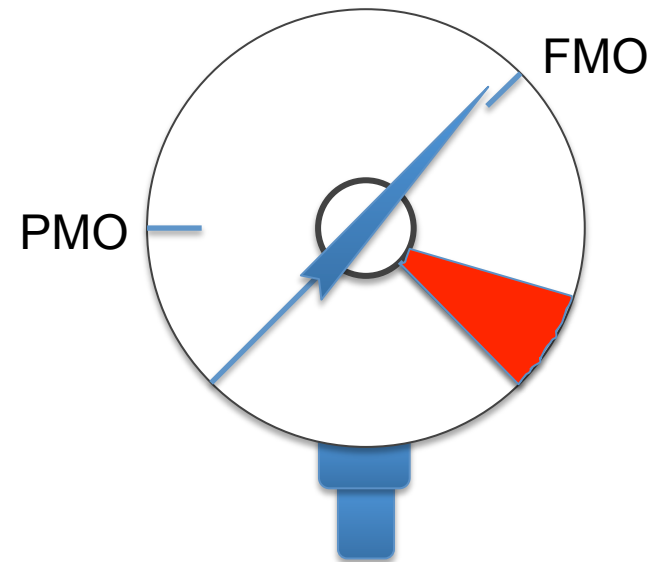
…these ideas catalyze in research communities and normalize (the FMO will NOT be in the Extreme Zone, but potentially different than today) through experimentation, standardization and deployment.

Need to Challenge Common Application archetypes

```
Interface:
gr-3/0/0 {
    unit 0 {
        tunnel {
            source 10.255.71.24;
            destination 10.255.14.48
        }
        family inet;
        family mpls;
    }
}
mpls {
    interface all;
}
…+~20 more lines
```

Create VPLS instance

Provisioning Velocity and Persistence, Standardized Representation

- Work around slow, integrated, "difficult" and varying (syntax/semantics) config commit model
    - Orchestration/workflow management apps
    - Virtual platform integration (eg. packet/ transport)

Analytics

Network

Provision
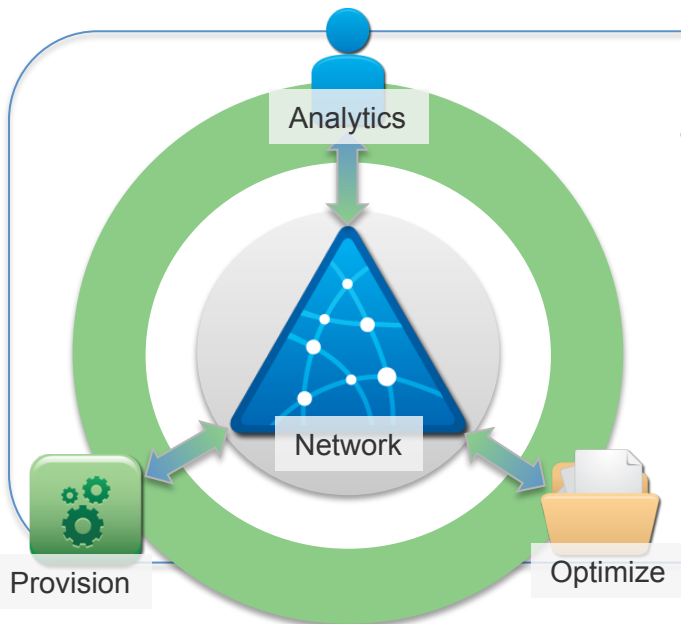
Optimize

Provision/Analyze/Optimize Cycle

- Requires granular table control, so operator can install route/flow, do quick analytic loop, apply policy (into overlay or hop-by-hop)
    - Network optimization applications
        - Derivative – applied with multi-layer topology (map-abstraction)
        - Derivative – applied with service registration (elastic service stitching)

Some Interesting Use Cases

| Use Case	Domains	Market Segments
DC Virtualization (Resource Slicing, Multi-tenant GW, Cloud Bursting)	Data Center (Edge - DC Edge)	Public Cloud High Performance
Data Center Interconnect	Data Center, Edge, WAN, Core	Public Cloud High Performance
Bandwidth Calendaring	WAN, Edge, Core	Public Cloud, High Performance, Service Providers, R& E
Multi-Layer Virtualization + Optimization	Core	SP, Public Cloud, High Performance, R&E
Content Request Routing (CDN)	Edge, Core, Data Center	SP
Virtual Patch Panel / Virtual Tap or Dynamic Traffic Steering	Campus & Branch, Datacenter, Core, Edge	SP, High Performance Public Cloud, R&E, Enterprise IT
Dynamic Threat Mitigation	Campus & Branch, Data Center, Edge	SP, Public Cloud, High Performance, R&E, Enterprise IT
Network Access Control	Campus & branch	Enterprise IT

Main Problem Areas That Research Can Address

- Control Plane

- Programmability

- Protocols that access, control and interact with the control plane (and data plane in kind)
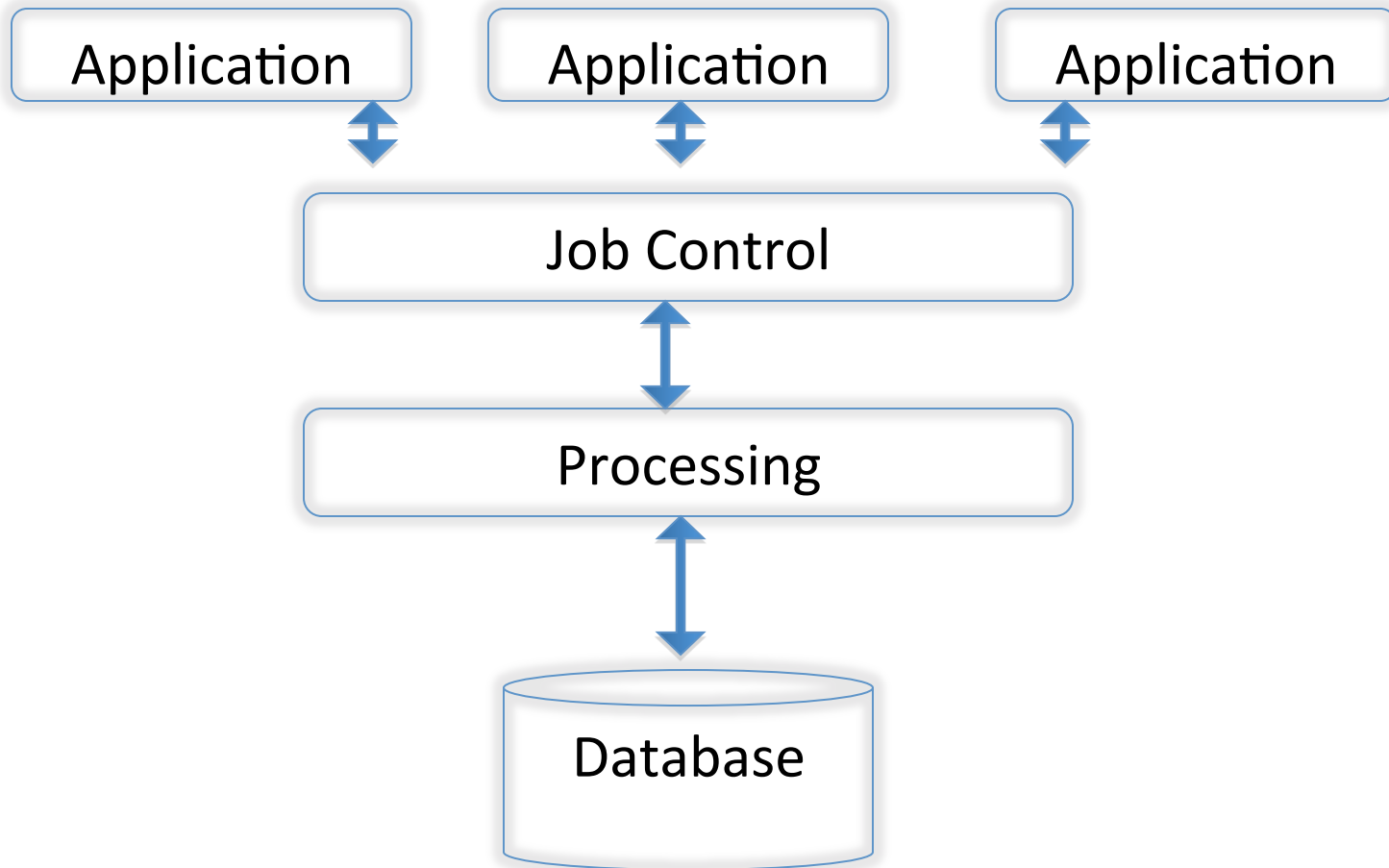
Control Plane Acceleration

- Applications Need To *Dynamically* Interact With/Know
  - Topology (active & potential)
  - Events
  - Traffic Measurements
  - Then take actions based on
    - Policy
    - Flow & Application Awareness
    - Time & External Changes

Network Application

Feedback Loop:
Control & Information
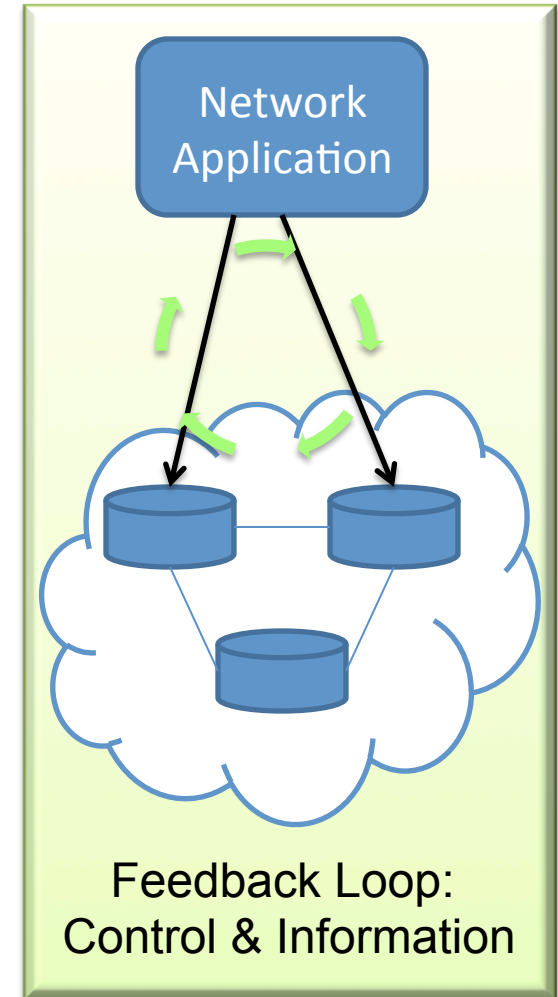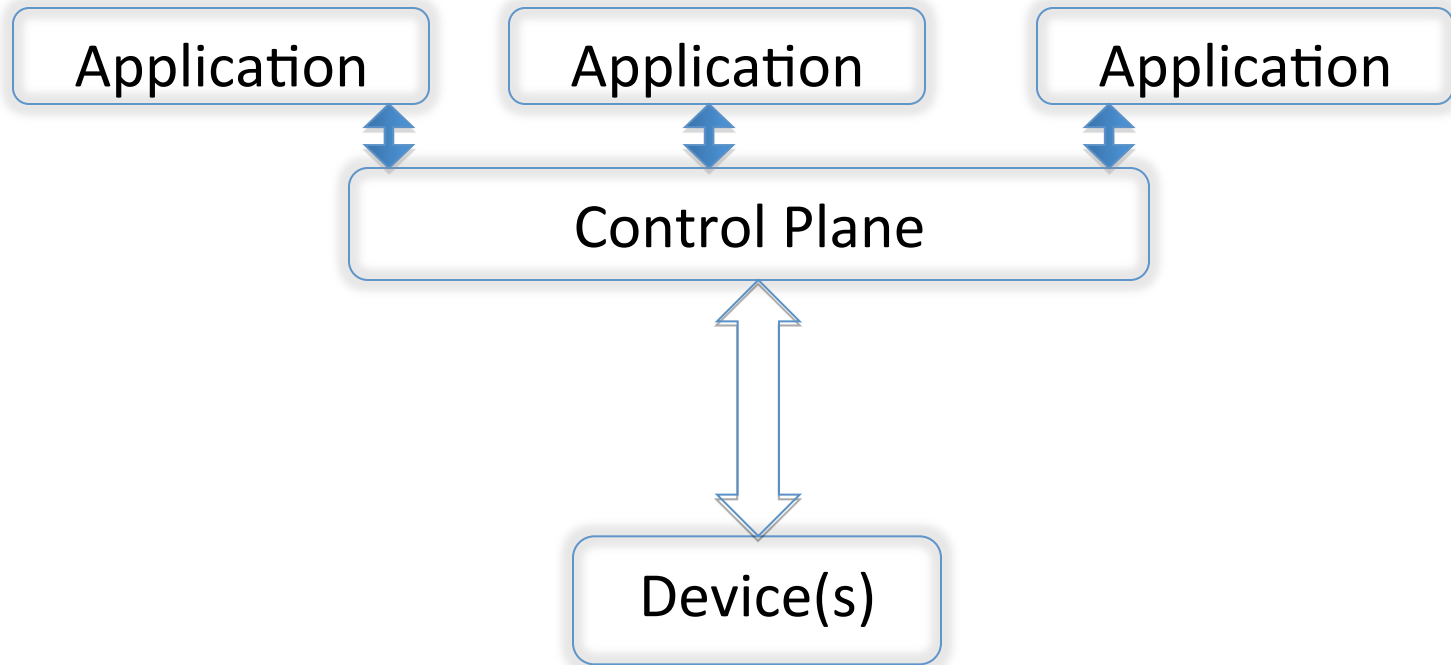
Control Plane

Anatomy of a Control Plane as a Modern Controller

Interesting Control Plane Areas

- Distribution and Separation
  - Optimality
  - Resilience
  - Coverage
  - Visibility
    - Global versus local?
  - Scale
    - horizontal, data base, offline path computation

Proposed Solution

- Framework for SDN Research?
- Helps collaboration between academia and industry