A Simplified View of the Higher Dimensional the SDN Continuum

Control Functions

- OF/SDN
  - Full and direct control of the Forwarding Plane
  - Complete Separation of Control and Data Planes
  - Open Interface to the Forwarding Plane
  - Logically centralized control plane
  - No inter-node communication

- CP/SDN
  - Indirect control of the Forwarding Plane
  - Partial separation of CP and FP
  - Select open interfaces to the control plane
  - “Partially” centralized control plane
  - Inter-node communication
  - Examples: PCE, IRS, vendor SDKs

- OL/SDN
  - No control of the underlay CP or FP
  - Complete separation of overlay CP and
  - Non-standard interfaces to the overlay CP
  - Logically centralized control plane
  - No inter-node communication
  - Example: VMW/Nicira

Management Layer

- Management APIs

Control(ler) Layer

(one or more purpose (e.g., floodlight) or function specific controller)

Hybrid Node

Dataplane Layer

Implies that consistency model is passed across the NBI
Modern SDN Architecture

Figure 1: SDN state distribution and management conceptualized in layers: (A)pplication, (S)tate Management, (P)hysical Network

“SDN-hard” Problems

• **Technology**
  – Separation of Control and Data Planes: Control Plane Scalability and Resilience
    • State Management: logical centralization
    • Combinatorial state explosion: Feasibility, CAP theorem, ...
    • Control Plane Performance: $\Omega = \text{RTT(switch2packet)} + \text{ppt(switch)} + \text{ppt(controller)}$
  – Flow Setup Scalability and Performance
  – Abstractions
    • *Sweet spot:* Leverage ideas from distributed systems, programming languages, and other areas to bridge the gap between the centralized controller abstraction and the distributed/hierarchical reality
    • “southbound” abstraction
    • Forwarding targets – ASICs and TCAMs
  – Reasoning Systems
    • HSA, DSL/FRPs, network compilers, “network as a computer”, ....
  – Operational Models
    • And how to you build/operate/debug these networks?
    • Convolution of policy and configuration
  – CSN (not Crosby, Stills and Nash), virtualization, cloud, NDN/ICN, ...

• **Sociology**
  – OF/SDN approach challenges much of our *central dogma*
  – Not the least of which are
    • Circuits vs. Hop-by-hop forwarding
    • Centralized vs. Distributed control planes
    • vs “flow-based’
  – Shift in influence bases from NetOps $\rightarrow$ DevOps

• **Economics**
  – Well...all of the above
  – Product “de-siloing”