A Simplified View of the Higher Dimensional the SDN *Continuum*

Management APIs

Management Layer

Classical control plane

Control Functions

Apps

...

Apps

CP/SDN NBI

OF/SDN NBI

Implies that consistency model is passed across the NBI

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

Hybrid Node

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

Dataplane Layer
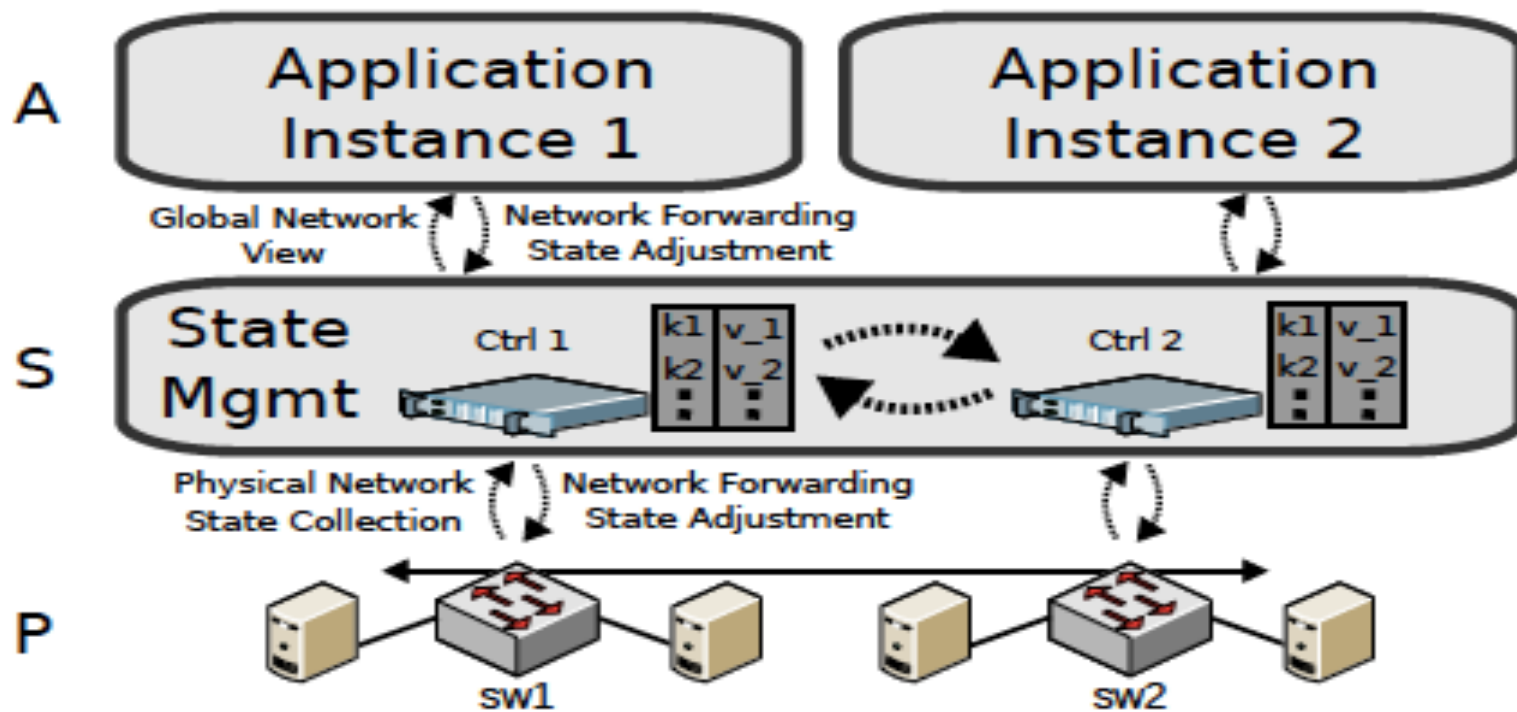
Modern SDN Architecture

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: Ω = RTT(switch2packet) + ppt(switch) + 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"