OPEN NETWORKING SUMMIT

Software Defined Networks: A Carrier Perspective

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19 October 2011

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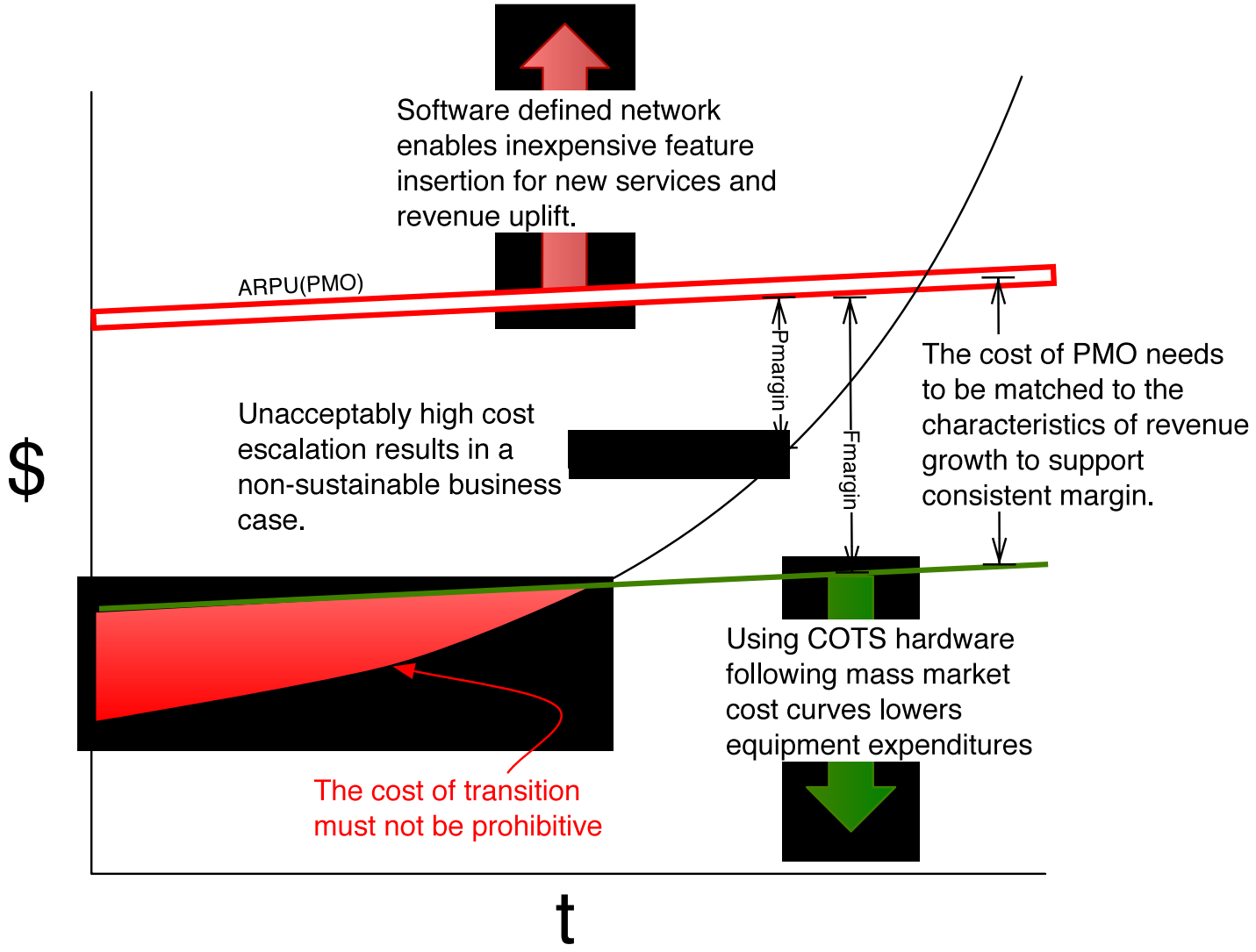
Why Does Verizon Care?



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Key Attributes for SDN Success

- **Architecture for a Networked Operating System with a service/ application oriented namespace**
- **Resource virtualization, elasticity and aggregation (pooling to achieve scaling)**
- **Appropriate abstractions to foster simplification**
- **Decouple topology, traffic and inter-layer dependencies: enable dynamic multi-layer networking**

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Critical Focus Areas

- **Network virtualization for multiple services**
  - A framework for multiple virtual networks to exist on top of one physical network
  - Use of application-aware routing software controlling inexpensive Ethernet switches or Packet Optical Transport nodes
- **Protocol specifications that can be standardized and implemented in all aspects of a software defined network ecosystem**
  - Operating systems, applications, infrastructure
- **A means to incrementally introduce the new architecture where new functions add most value and interwork with the large legacy**
  - Open Flow control interface and complimentary management protocols to enable new control paradigms on existing forwarding hardware

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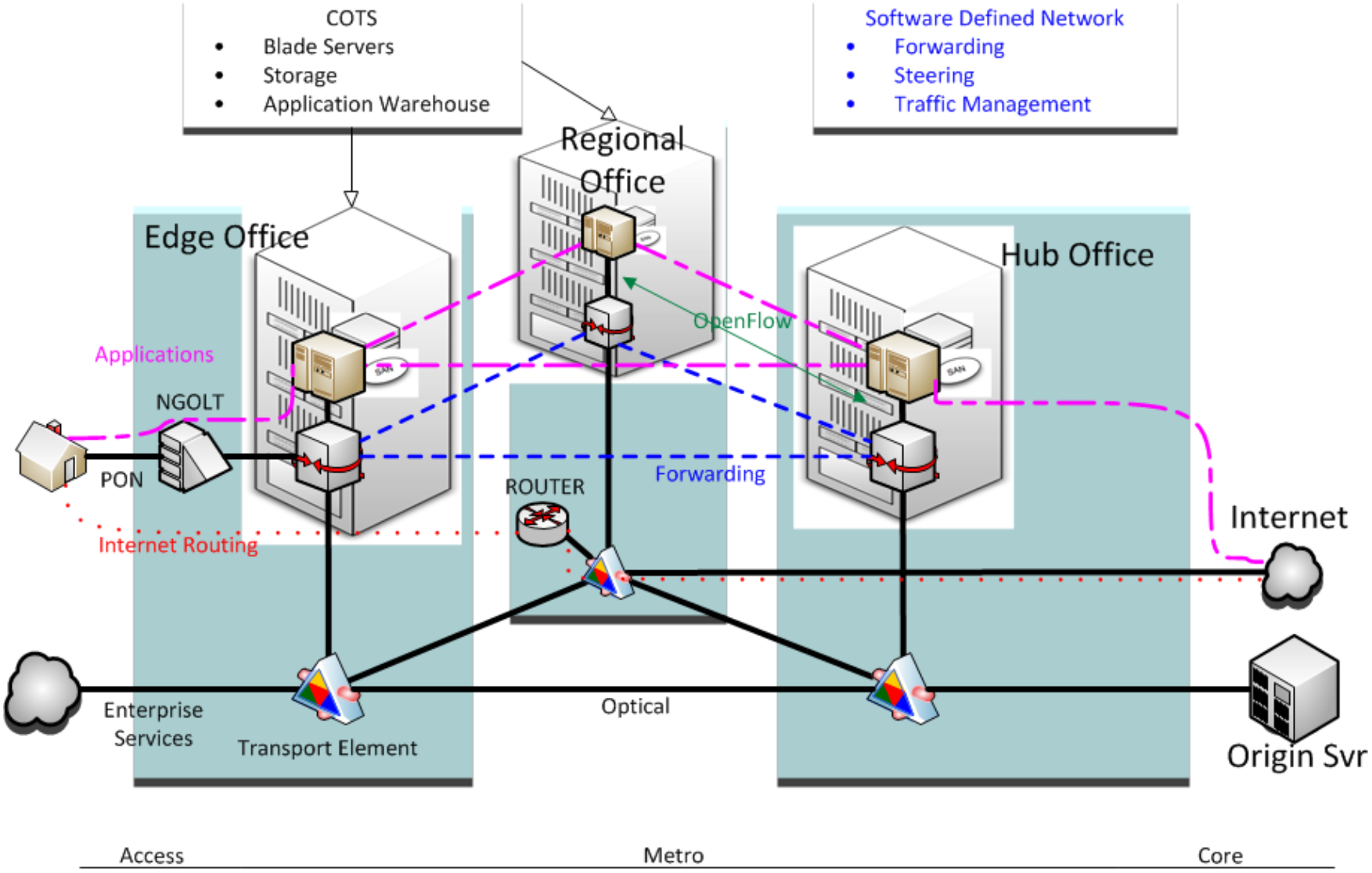
Deployment Scenarios for Carrier SDN & OpenFlow



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Open Flow/SDN Use Cases

- **General Strategy: Only build something in an external controller with OpenFlow when it has significant benefit, for example:**
  - New feature set, new functions not implemented with existing protocol set
  - Existing feature/protocol set, but achieves better scaling, economics, and/or solves a problem not addressable by current vendors/standards

- **Example Use Cases**
  - Traffic Steering: service/application aware routing of traffic to the appropriate sequence of app servers
    - OpenFlow may complement Traffic Steering for long-lived flow detection and cut-through switching to reduce overall cost of services delivered
  - Hybrid Cloud Computing: integration of cloud computing bandwidth-on-demand features with public-private cloud services
    - Virtualization of the network and the enterprise and public data center resources via a common interface to the user
    - OpenFlow used to enable bandwidth-on-demand for data center interconnection.
  - OpenFlow switching operating in hybrid mode with on-board (native) control
  - OpenFlow switch partitioning and support for multiple controllers.

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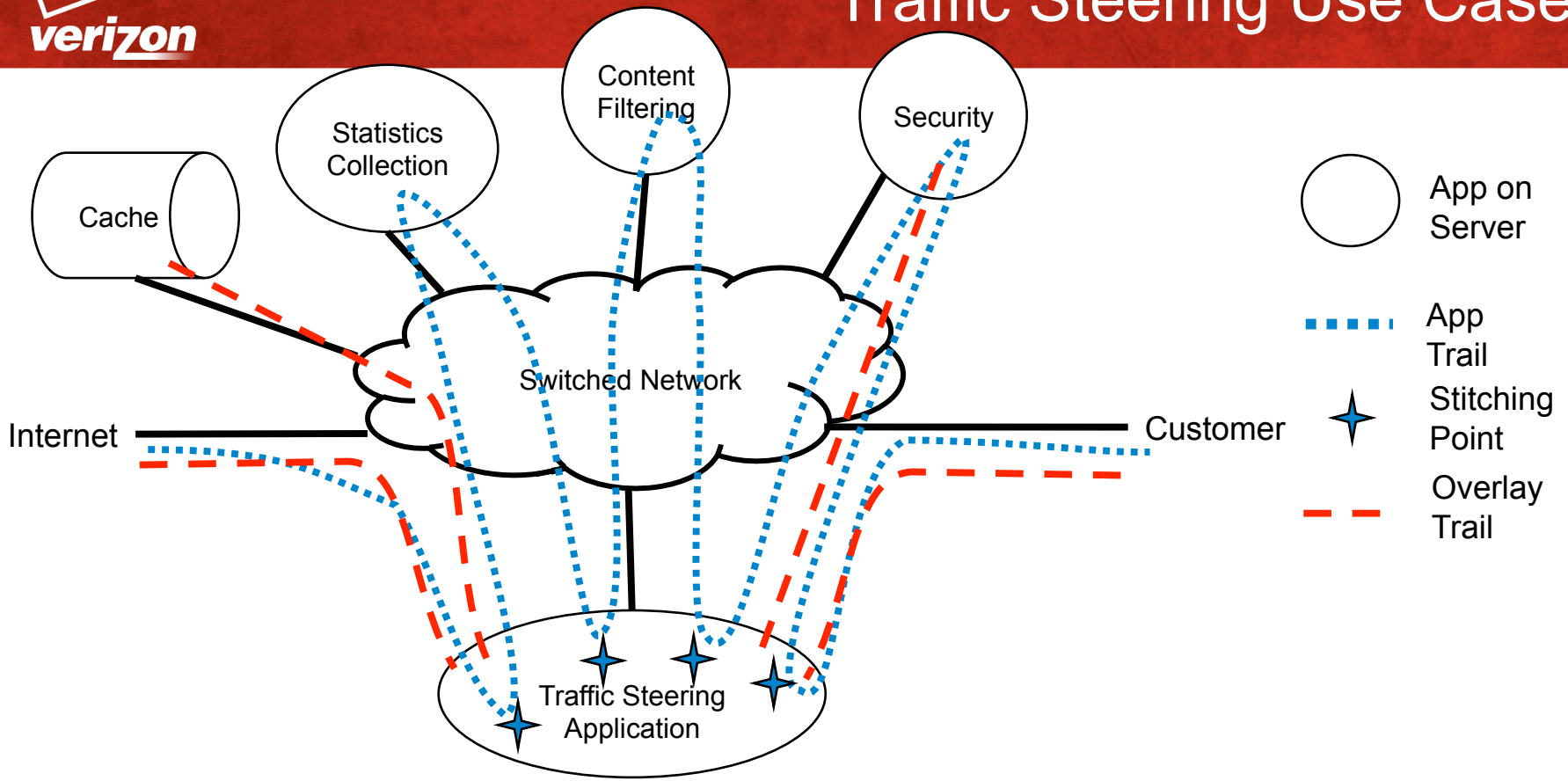
Traffic Steering Use Case



•Application stitching point in the TSA between overlay trails, which allows development of arbitrary feature graphs, which may vary over time

• Traffic Steering determines Application Trail through Service Features and Cache

• Although flexible and extensible, packets traverse a significant number of interfaces and processors, which may not be required for all flows, and for long-lived flows there is a strong motivation for optimization

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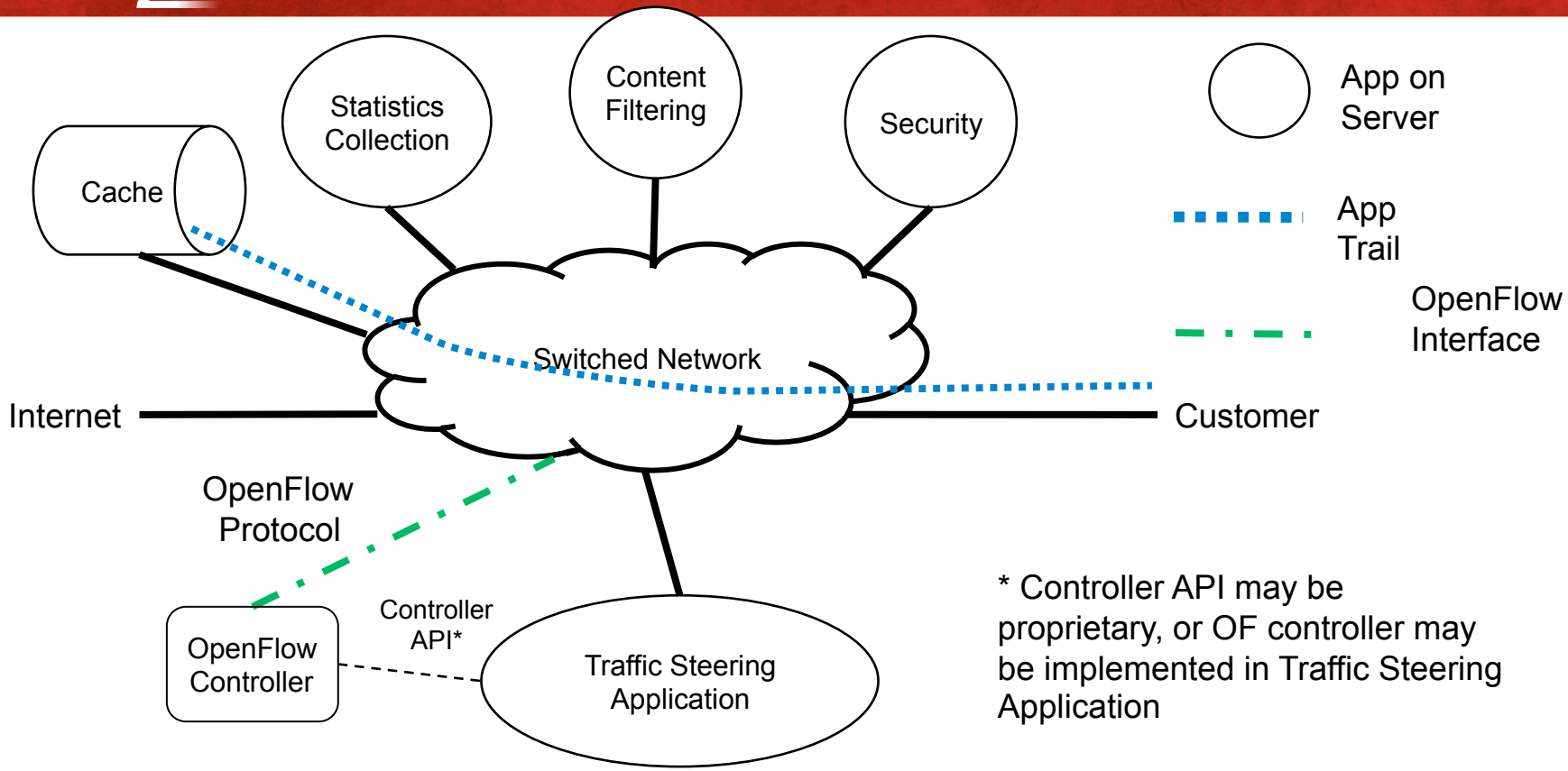
Traffic Steering Optimization using OpenFlow



- For long-lived flows, desirable to avoid traversing TSA,
  - Example shown for direct retrieval from cache after Features have confirmed security, content filtering
  - Statistics for long-lived flow are collected via OpenFlow
- Optionally, OpenFlow snooping by controller for particular patterns could detect flow usage and determine when a long-lived flow completes

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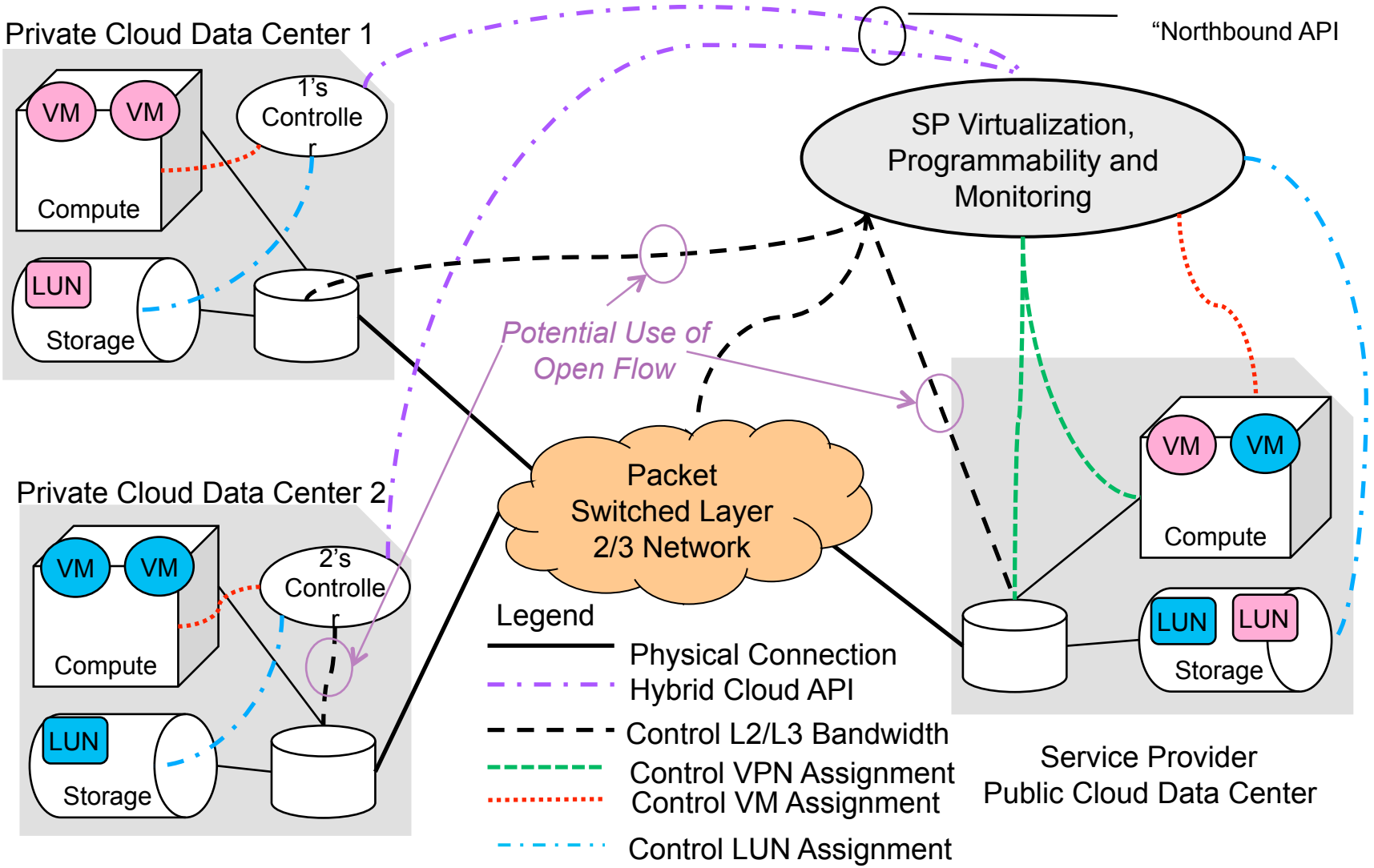
Bandwidth-on-Demand for Hybrid Cloud



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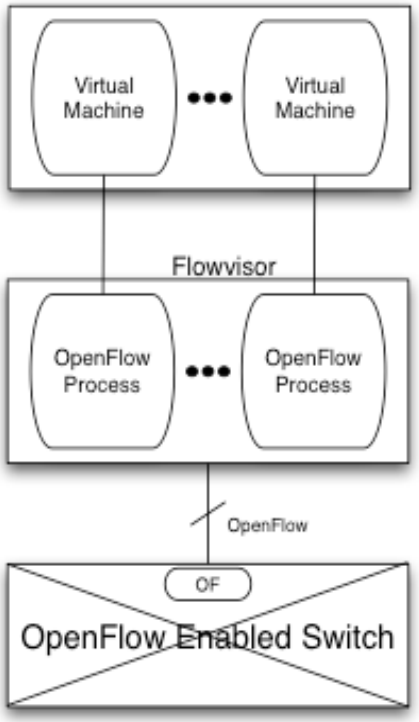
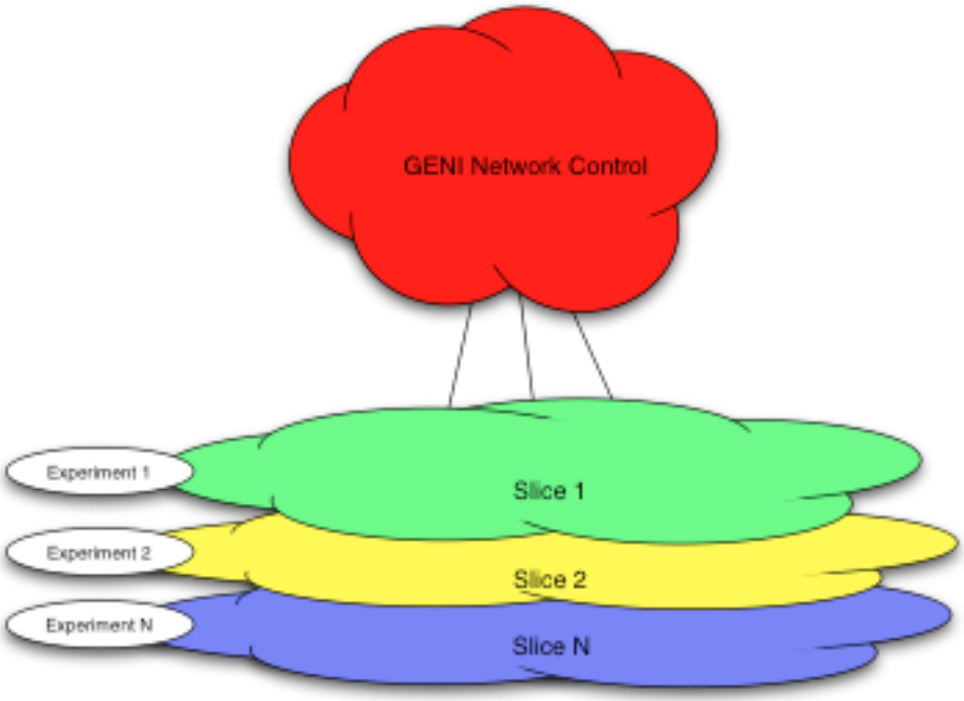
GENI Usage of OpenFlow



Control processes implementing custom algorithms managing each network slice

A hypervisor for OpenFlow control processes. Each process controls a slice of the network



Multiple (Virtual) Open Flow controllers control a subset of resources in the same physical Switch

A network of Open-Flow enabled switches enables support of multiple networking experiments using less of your tax dollars as compared with separate physical networks.

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Summary

- **Software Defined Networking implemented on COTS infrastructure provides a means to align the network cost structure trend to that of the revenue**
- **Central Offices evolve to Data Centers, reaping the cost, scaling and service flexibility benefits provided by cloud computing technologies**
- **Some services / traffic types (e.g., video distribution) are best handled by a combination of SDN and OpenFlow-enabled cut-through switching**
- **Hybrid cloud computing may use a combination of SDN, OpenFlow and novel orchestration to provide seamless interworking with the enterprise environment**
- **OpenFlow requires several enhancements to work effectively in a virtualized cloud environment that includes legacy switching elements**

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