

Multi-Layer and Optical SDN: Experiences and missing pieces

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GENI GEC20

UC Davis June 22nd, 2014

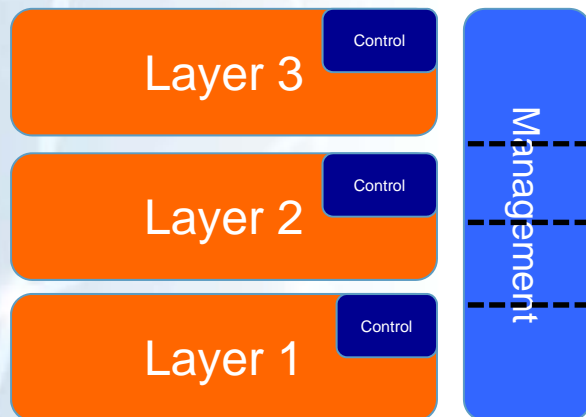




Multi-Layer in the SDN world

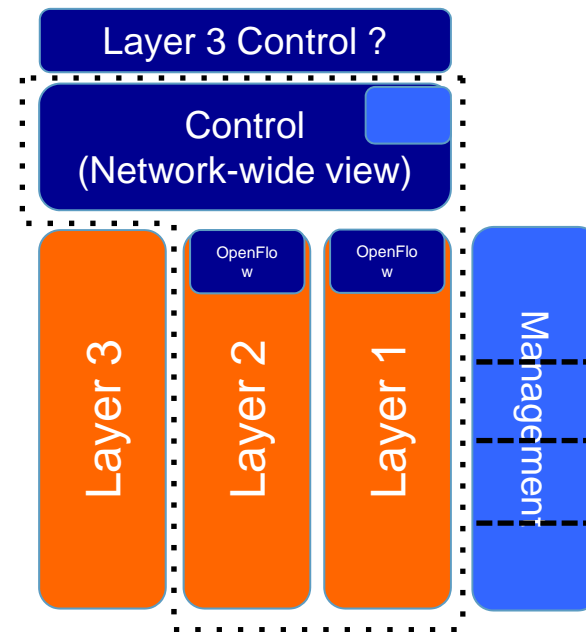
Internet today:

- Built-in control in each layer
- Multiple management domains



SDN Approach:

- Network-wide cross-layer view
- Management stays the same

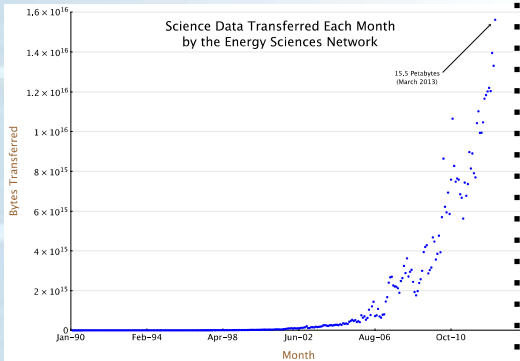


Motivation to explore multi-layer

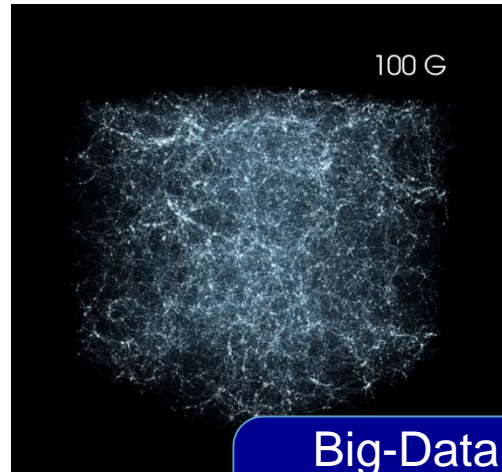


1. On-demand, application-driven models with 'X'aaS
 - Cloud computing, Big-Data Science, Multi-domain Service Delivery
1. Packet-optical integration bringing two functions under one umbrella
 - Same chassis, same vendor, same network management, same org?...sounds simpler than before
2. Because finally, a glimmer of hope!
 - SDN's global view obviates need for complex protocols for inter-layer information exchange
 - Previous attempts have had 'Packet vs. Optical' control issues

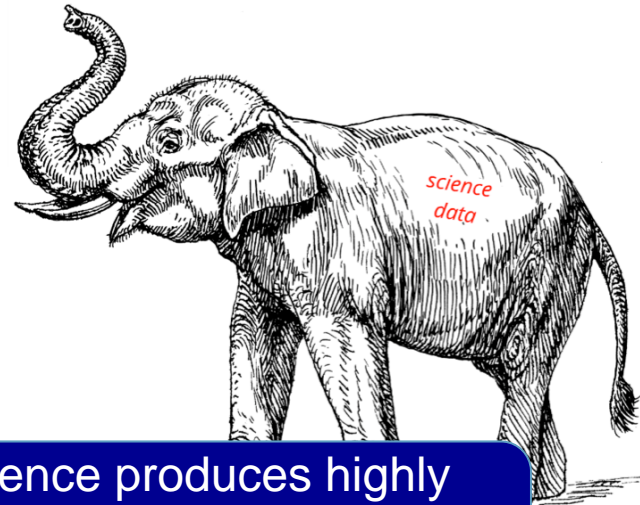
Why ESnet and Multi-Layer?



Exponential traffic growth



Big-Data Science produces highly bursty, large individual flows, that need to be managed end-to-end



Controls all three layers

10/16/13



Inder Monga, Layer123 SDN



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Journey with Optical SDN

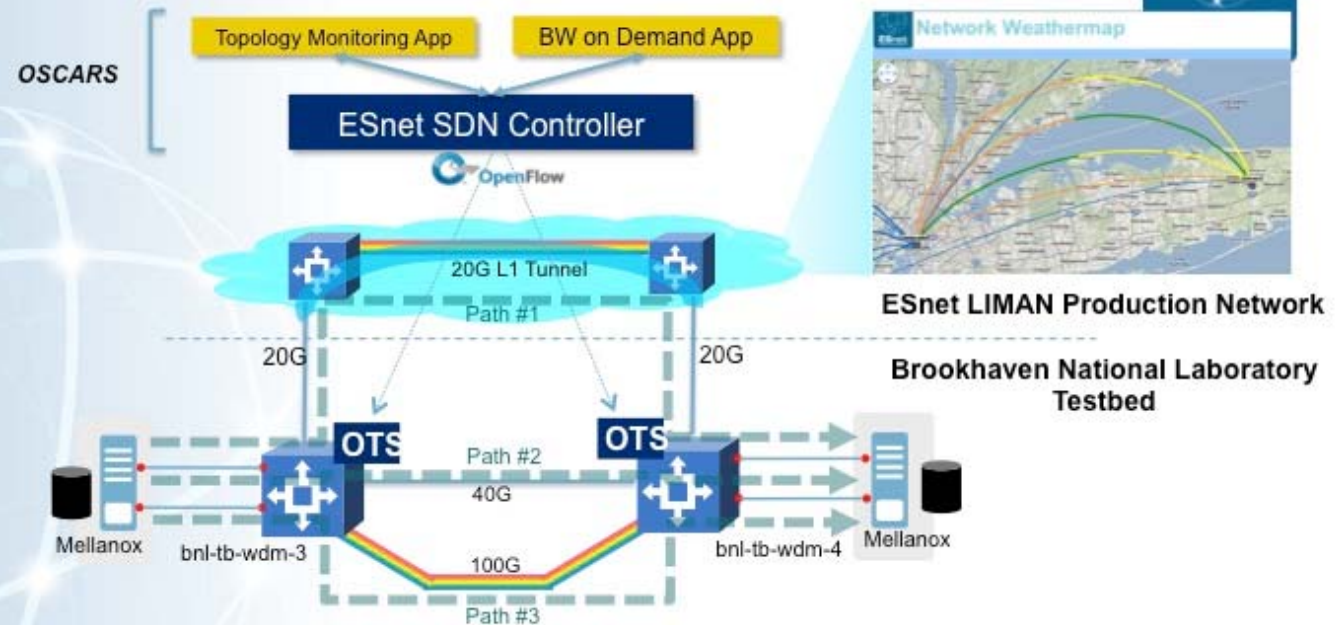
December 2012, World's first Transport SDN Demo, Infinera/ESnet/Brookhaven



Insight

- optical-layer automation essential for future topologies, architectures
- OF1.0 does extended using vendor extensions
- Standardize the OF interface for optical (ONF)

ESnet Transport SDN Demo



SDN Controller communicating with OTS via OpenFlow extensions

Bandwidth on Demand application for Big Data RDMA transport

3 physical transport path options (with varying latencies)

Implicit & explicit provisioning of 10GbE/40GbE services demonstrated

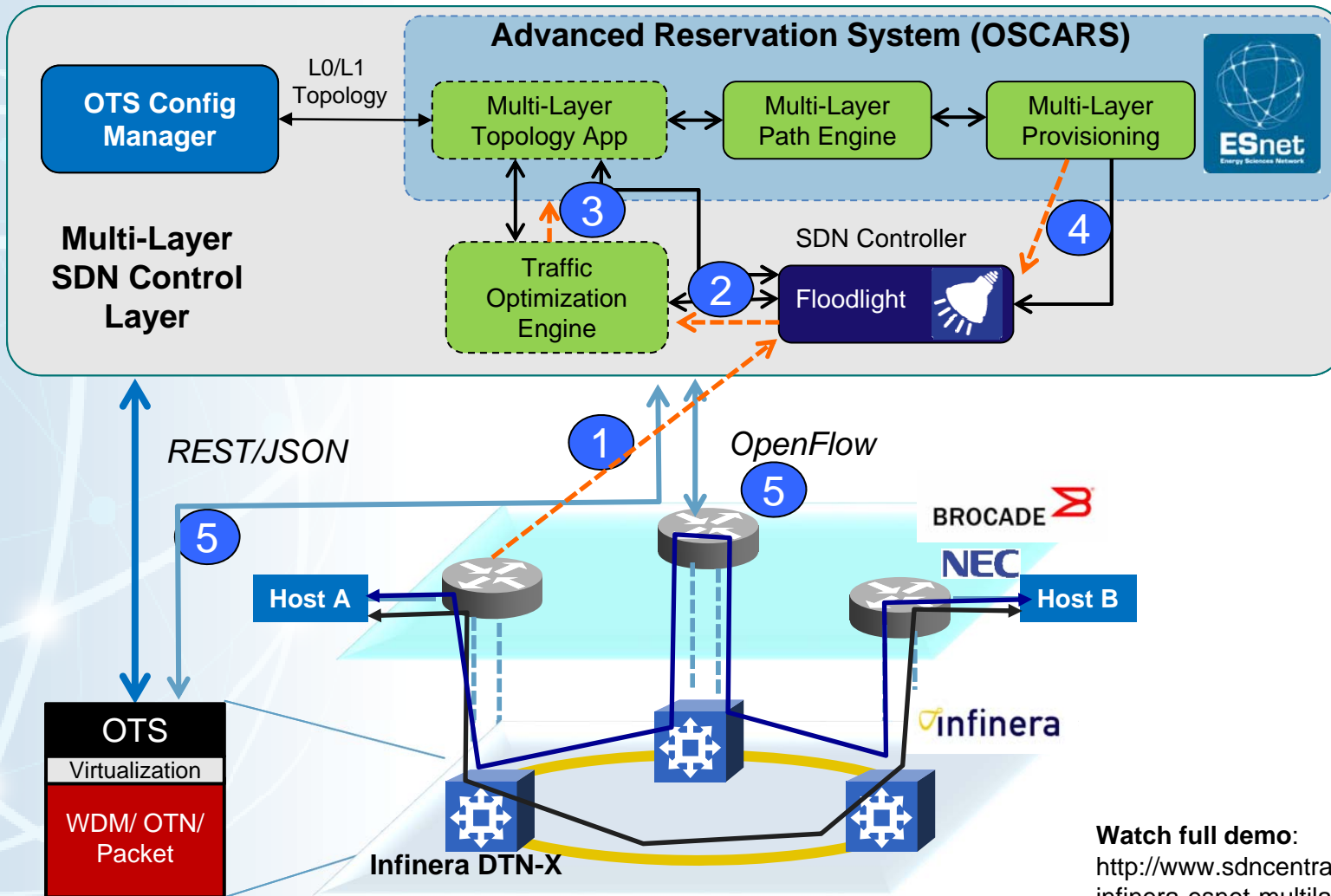
Lawrence Berkeley National Laboratory

U.S. Department of Energy | Office of Science



Journey with Optical SDN

October 2013, Building the Multi-Layer SDN Application
 ESnet/Infinera/Brocade



Watch full demo:
<http://www.sdncentral.com/brocade-infinera-esnet-multilayer-provisioning/>

Insights after working in this for 2+ years



- OpenFlow modifications are not the complex part of the solution
- OF 1.0 with slight modifications are good enough for dynamic circuit provisioning
- Managing the end-to-end path to be fully dynamic is still a complex problem
 - Multi-layer provisioning is a simpler issue than figuring out the how and which packets flow over the new circuit
 - Dynamic path still has portions of manual configuration
- Multi-vendor for optical
 - OTWG in ONF – but will they all implement the same extensions?



Insights after working in this for 2+ years contd...

- ML Topology still manually stiched
- How does one discover multi-layer topology?
- How does one express multi-layer topology?
 - R&E networks have one but not adopted in commercial world
- Multi-domain SDN
 - Cloud and R&E use-cases
 - Conversation absent in the commercial world – why? (see last slide bullet 2)
- Multi-layer protection/restoration
- Ensuring dynamic physical links perturb the system in predictable manner

Optical SDN – future outlook



- Agility is important for programmatic optimization
 - Flex-Grid, Flex-Mac – corresponding data plane agility is coming
 - Enough knobs and dials to expose from the optical layer
- Capability discovery is critical along with topology
 - ...though we need to focus on topology first
- Dynamic optical SDN applications like bypass, requires full system integration of IP and Optical

Progress is impossible without change, and those who cannot change their minds cannot change anything.

George Bernard Shaw