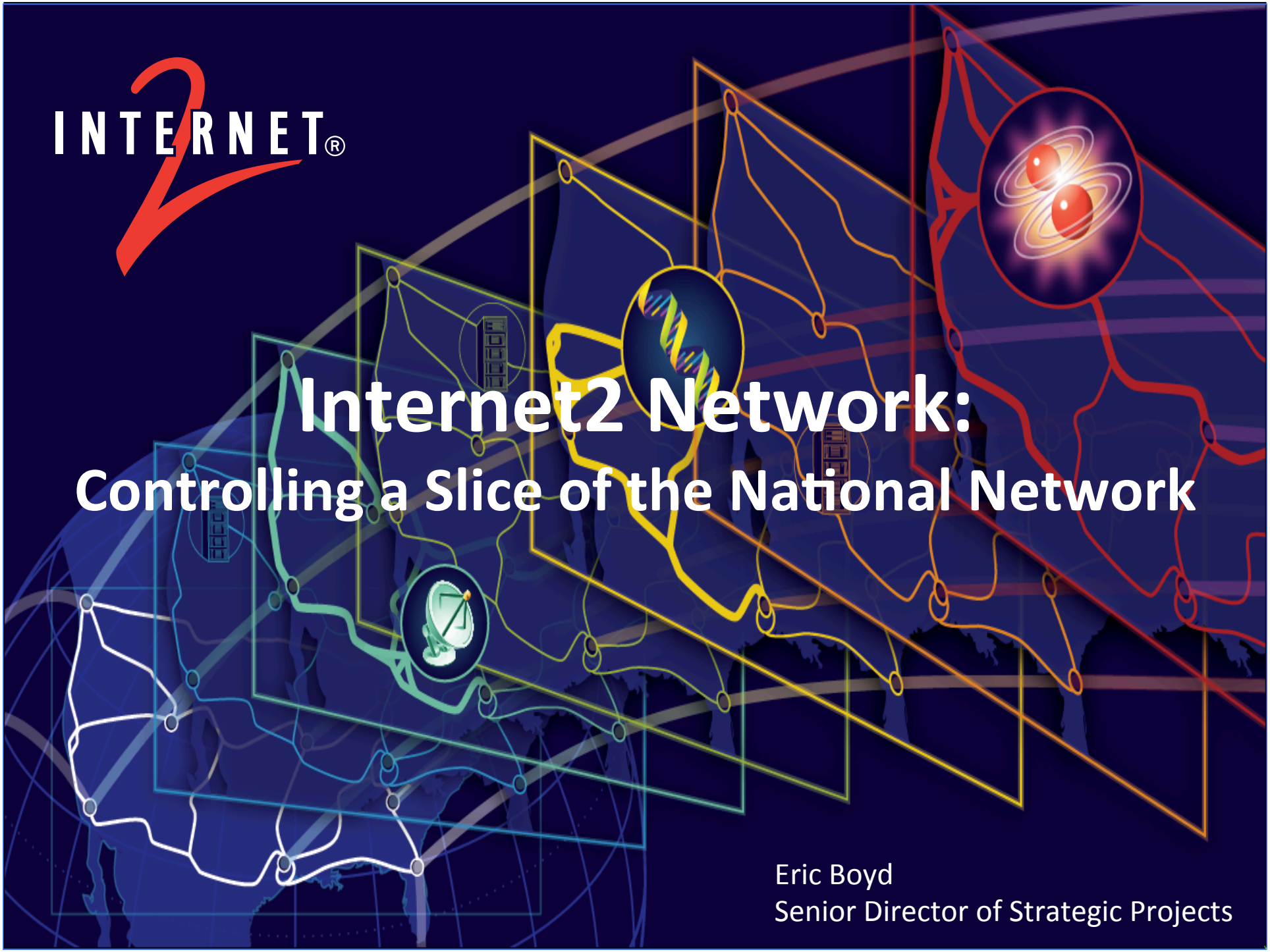
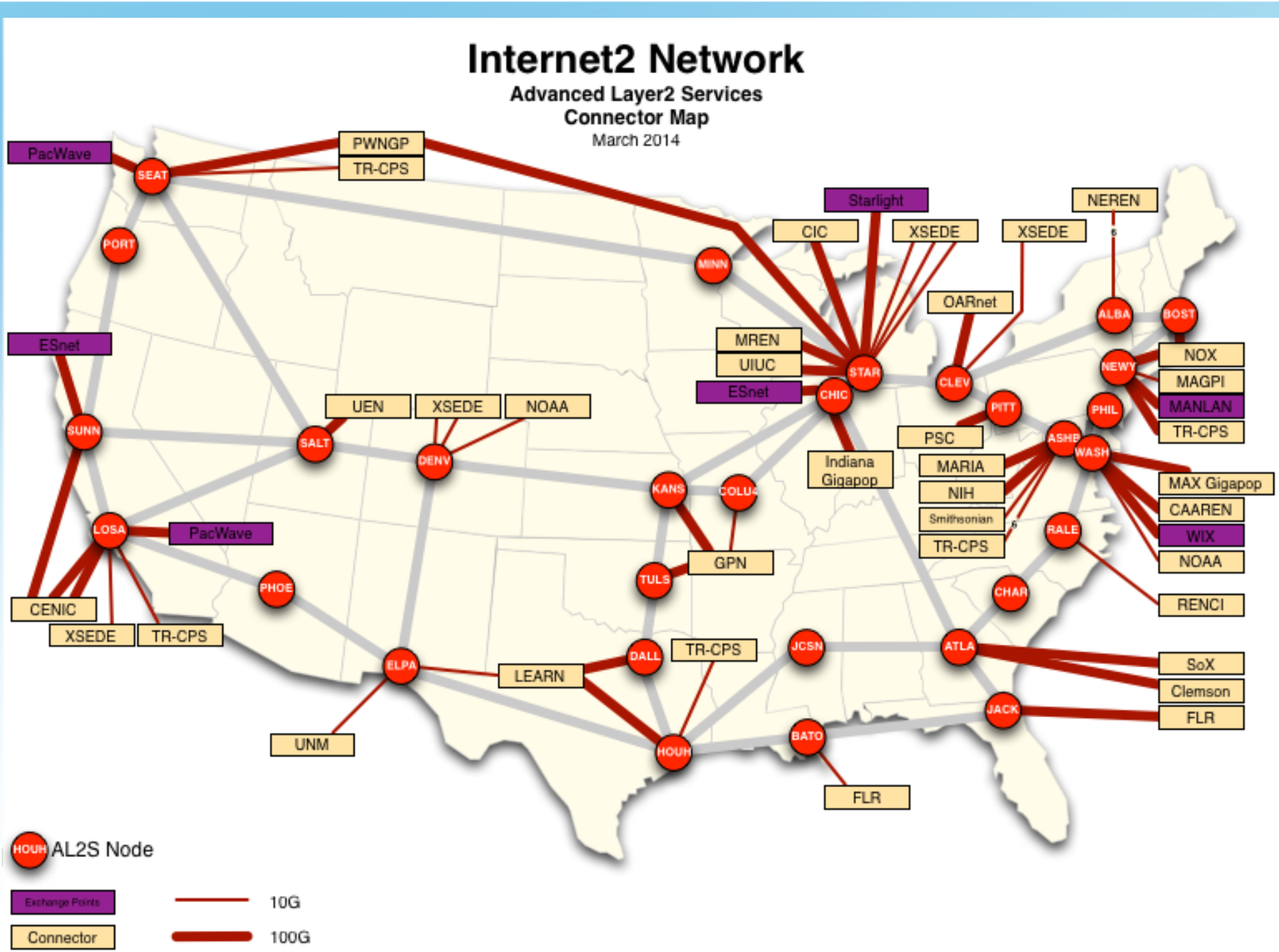
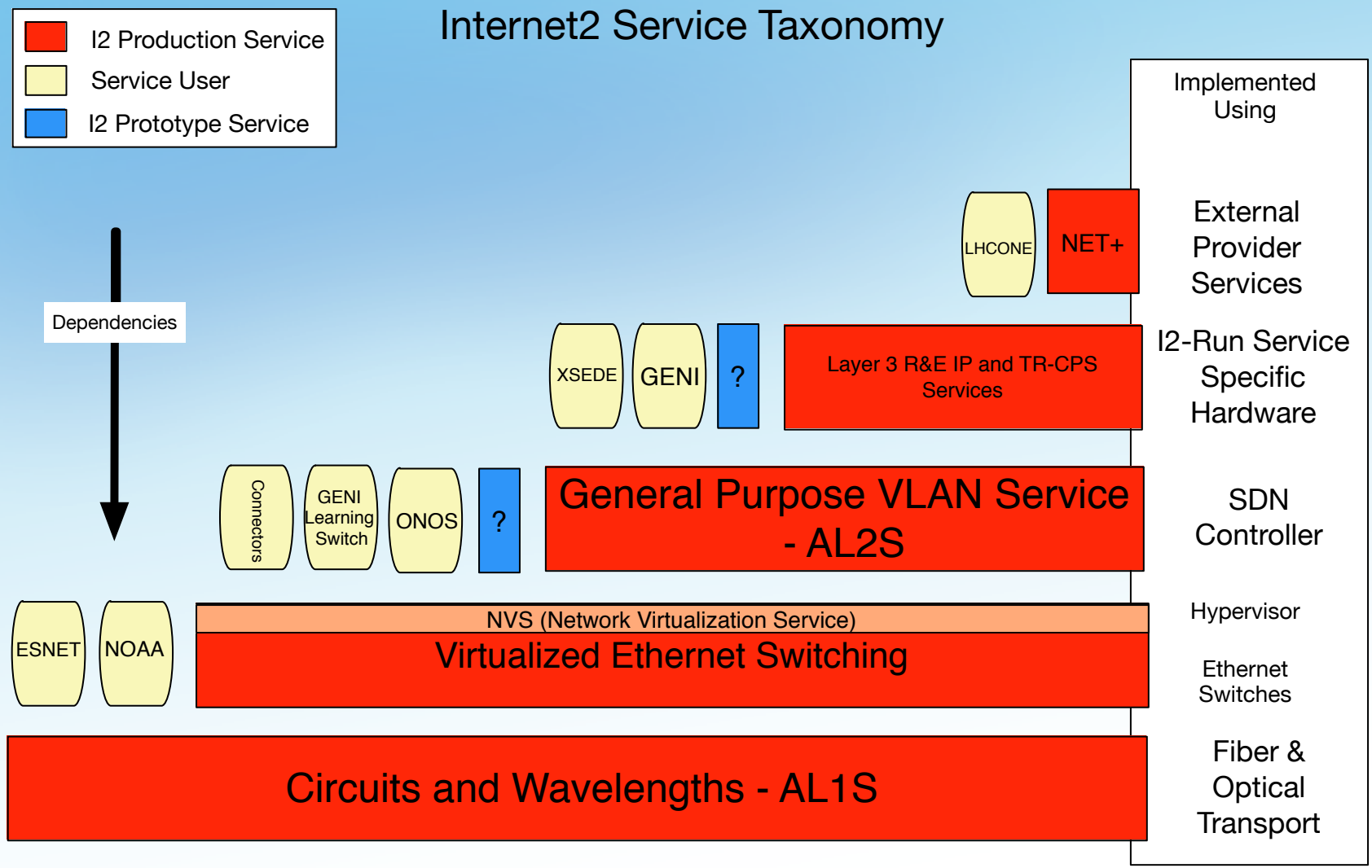

INTERNET®
Internet2 Network:
Controlling a Slice of the National Network
Eric Boyd
Senior Director of Strategic Projects


Internet2 Network
Advanced Layer2 Services
Connector Map
March 2014
PacWave
PWNGP
TR-CPS
SEAT
PORT
ESnet
SUNN
LOSA
PacWave
CENIC
XSEDE
TR-CPS
PHOE
ELPA
UNM
SALT
UEN
XSEDE
NOAA
DENV
LEARN
DALL
TR-CPS
HOUH
BATO
FLR
KANS
COLU
GPN
TULS
MINN
Starlight
CIC
XSEDE
XSEDE
NEREN
OARnet
MREN
UIUC
ESnet
STAR
CHIC
CLEV
PITT
PSC
Indiana
Gigapop
MARIA
NIH
Smithsonian
TR-CPS
ASHB
WASH
PHIL
ALBA
BOST
NEWY
NOX
MAGPI
MANLAN
TR-CPS
MAX Gigapop
CAAREN
WIX
NOAA
RENCI
RALE
CHAR
ATLA
JCSN
SoX
Clemson
FLR
JACK
HOUH AL2S Node
Exchange Points
Connector
10G
100G

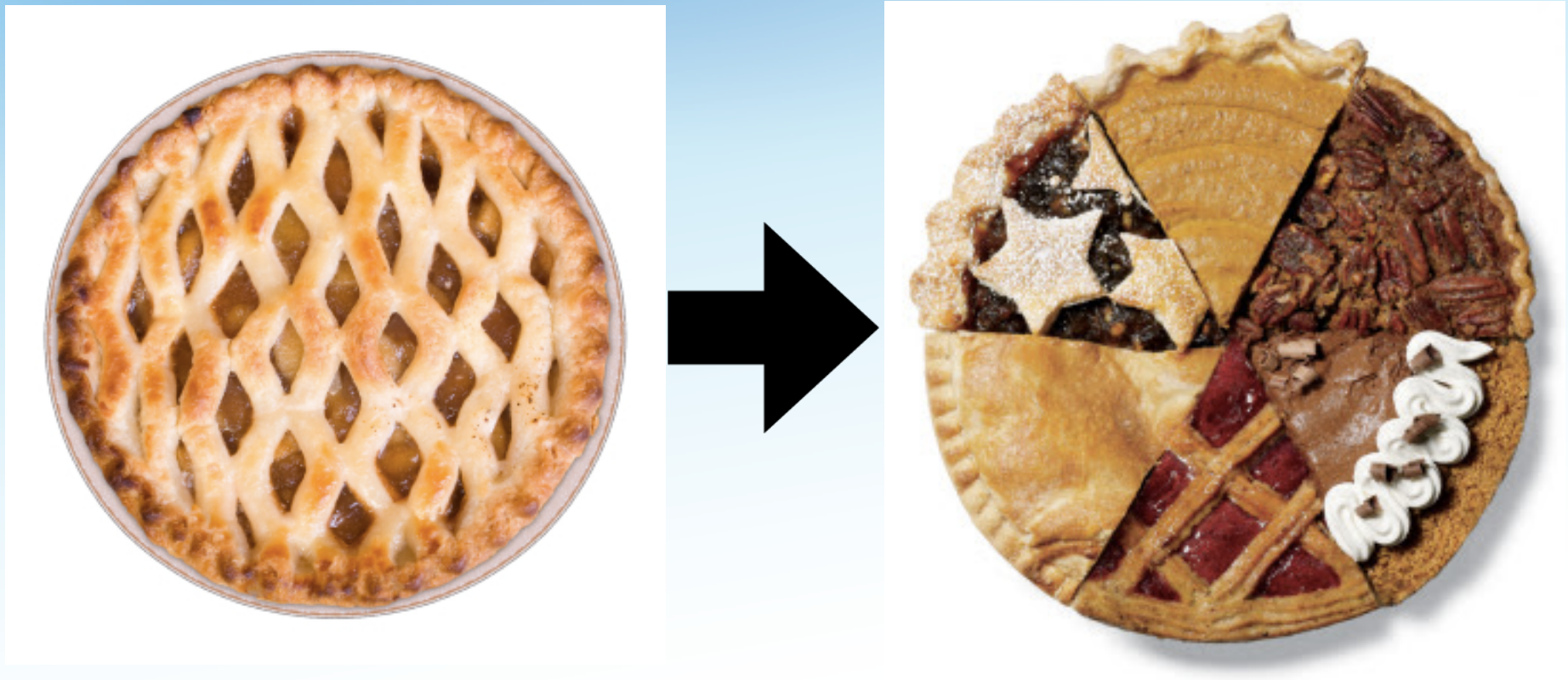
Internet2 Service Taxonomy



Network Virtualization on Internet2

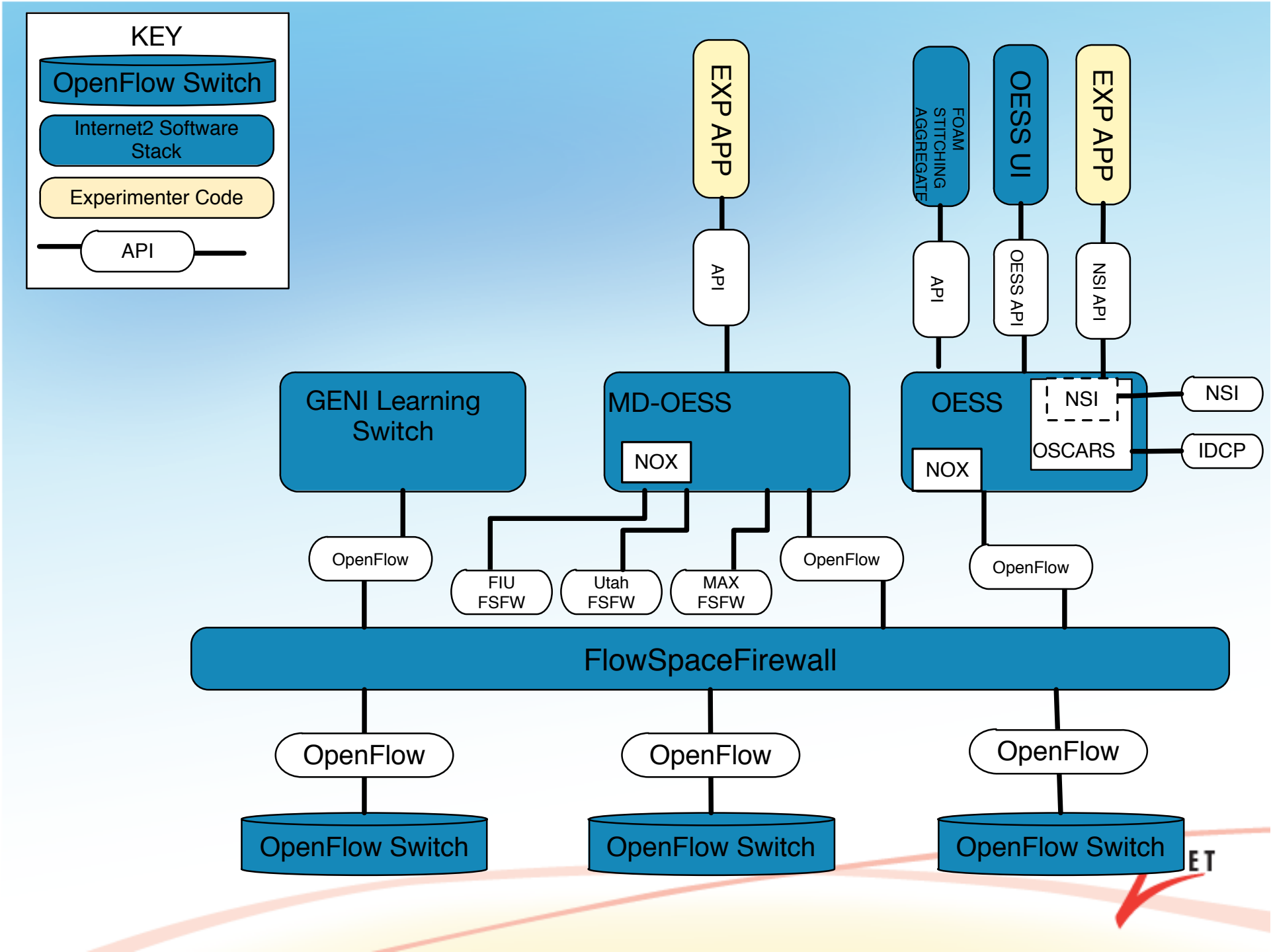
Network Virtualization on Internet2

Network Virtualization on Internet2



Network Virtualization on Internet2

- Control a slice of the national network!
- Enable:
  - Rapid prototyping of advanced applications
  - Rapid prototyping of new network services
  - Rapid advancement of network research


KEY
OpenFlow Switch
Internet2 Software Stack
Experimenter Code
API
EXP APP
API
FOAM STITCHING AGGREGATE
OESS UI
EXP APP
API
OESS API
NSI API
GENI Learning Switch
MD-OESS
NOX
OESS
NSI
OSCARS
NOX
NSI
IDCP
OpenFlow
FIU FSFW
Utah FSFW
MAX FSFW
OpenFlow
OpenFlow
FlowSpaceFirewall
OpenFlow
OpenFlow
OpenFlow
OpenFlow Switch
OpenFlow Switch
OpenFlow Switch

Internet2 March, 2015 Current Status

- Aggregate Manager in production
- Hypervisor (FlowSpace Firewall) in production
- Accepting 3rd party controllers
  - Questionnaire
  - Test Lab
  - Production
- Support L2 and L3 matching
  - FSFW Updates (current version 1.0.4a)
  - Vendor Updates (current versions Juniper 13.3, Brocade 5.6dc)
  - Vendor-specific limits do exist.
- OpenFlow 1.0 Supported

Controlling a Slice on Internet2

- Request a slice (email: noc@internet2.edu)
- Receive a questionnaire from Internet2 NOC
- Submit questionnaire to Internet2
- Download FSFW; try your controller in that environment
  - http://globalnoc.iu.edu/sdn/fsfw.html/
- Submit your package
  - Good documentation accelerates process!
  - Good logging accelerates process!
- Internet2 NOC tests your controller on iDREAM GENI environment
  - Problems -> Go back one step
- Internet2 deploys your controller on Internet2 Network

INTERNET 2

What do we want you to do

- Have well tested, well versioned, and packaged code
- Provide lots of documentation
- Provide lots of configurable logging
- Have a Ticketing/Bug reporting system
- Provide Installation and Operation instructions
- Given the FlowSpace be able to generate the proper Configuration for your application
- Be patient, it's a learning experience for all of us

INTERNET 2

What do you need to do …

- Provide Enough documentation to setup and configure your application
- Provide enough logging (to a file) to be able to debug your application
  - If it breaks we will disable your slice, and send you the log, your slice will not be enabled until the problem is fixed
- Any API (besides OpenFlow) or UI must be secure
- Provide involved and reactive developers
- Application should already have been tested with FlowSpace Firewall to verify it will function properly
  - FlowSpace Firewall does not re-write rules, it allows or denies rules.
  - Your app needs to be able to work on a set of VLANs (and they wont be the same VLAN across all devices)
- Know the FlowSpace you want for your slice
  - Switches
  - EndPoints
  - Number of flows
  - Interfaces

FAQs

- I don't have a Brocade or Juniper. Can I develop on the iDREAM GENI platform?
  - No, not really. It's a limited resource with a tight schedule. See if you can find a Juniper or Brocade switch elsewhere to validate controller functionality.
  - Testing on vSwitch is not the same as testing on real world switches. Despite the vendor-agnostic promise of OpenFlow, be prepared to have vendor-specific details in your controller.
- Am I controlling production traffic?
  - No, you are controlling your slice. You need to generate traffic into the slice.
- Am I running my controller?
  - No, the Internet2 NOC is running your controller in a private slice. Make sure the logging is good enough that you can figure out what went wrong.
- Packaging? Documentation? Logging? This is a research project. I just wrote the controller yesterday, and most of the configuration details in my head.
  - The Internet2 NOC is deploying and running your controller and feeding you the logging results. The better the packaging, documentation, and logging, the more likely your effort will be a success.
- How good is your OpenFlow 1.3 support?
  - Very good, if you mean OpenFlow 1.0. Otherwise, we're not there yet.
- My controller requires 10 bare metal servers to run.
  - Internet2 has a very limited number of servers on which we can deploy controllers. Please planto minimize your configuration or supply servers we can deploy.

Internet2 2015 Plans

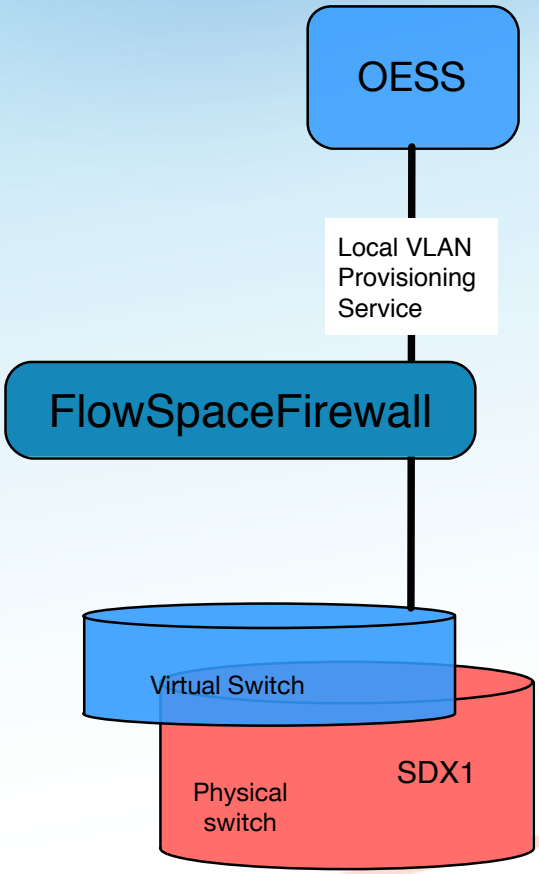
- Work with vendors to get OF 1.3 Support
  - Brocade -> 5.8x (“now”)
  - Juniper -> ? (“summer”)
- Work to update software stack
  - FSFW Update (needed to support OF 1.3)
  - OESS Update (needed for QoS, QnQ)
- Refine Slice Deployment Process
  - Faster?
  - Testing constraints?
- Define Operational Hardware Environment
  - Less scrabbling for boxes

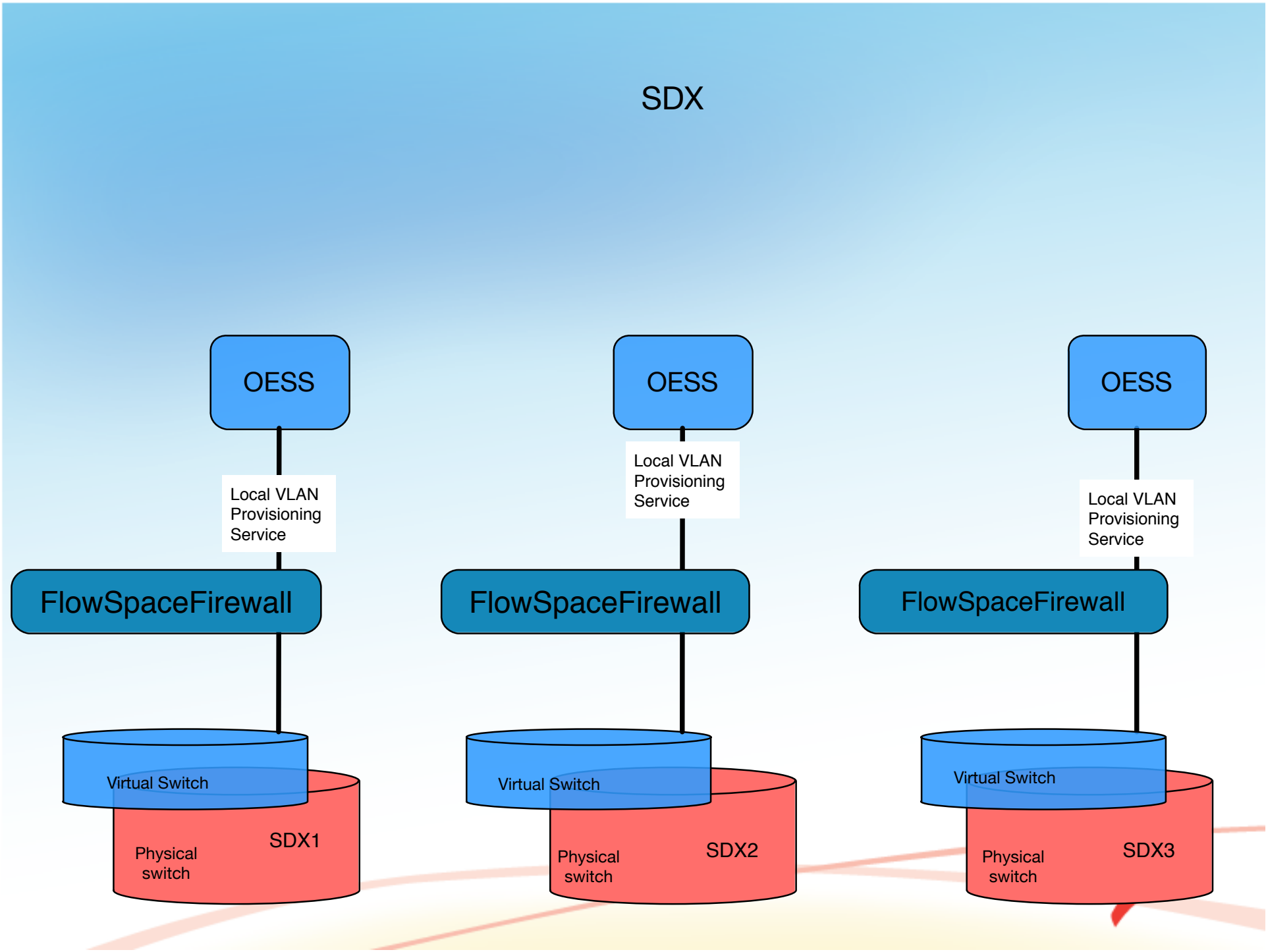
INTERNET 2

Prototype Multi-Domain Layer 2 Service

- Backdrop:
  - Internet2 operates a Layer 2 Service
  - Campuses (e.g. University of Utah) operate a Layer 2 Service
  - Regional Networks (e.g. MAX) operate a Layer 2 Service
  - Exchange Points (e.g. AMPATH/FIU) operate a Layer 2 Service
- Is there a way to create a Multi-Domain Layer 2 Service?
  - Common capabilities
  - Willingness to collaborate
  - Willingness to contribute to a common project
  - Maintain local control
    - Withdraw at any time
  - Enable (illusion of) global control
    - Control remote administrative domains
  - No change in software, just configuration

SDX


OESS
Local VLAN
Provisioning
Service
FlowSpaceFirewall
Virtual Switch
SDX1
Physical
switch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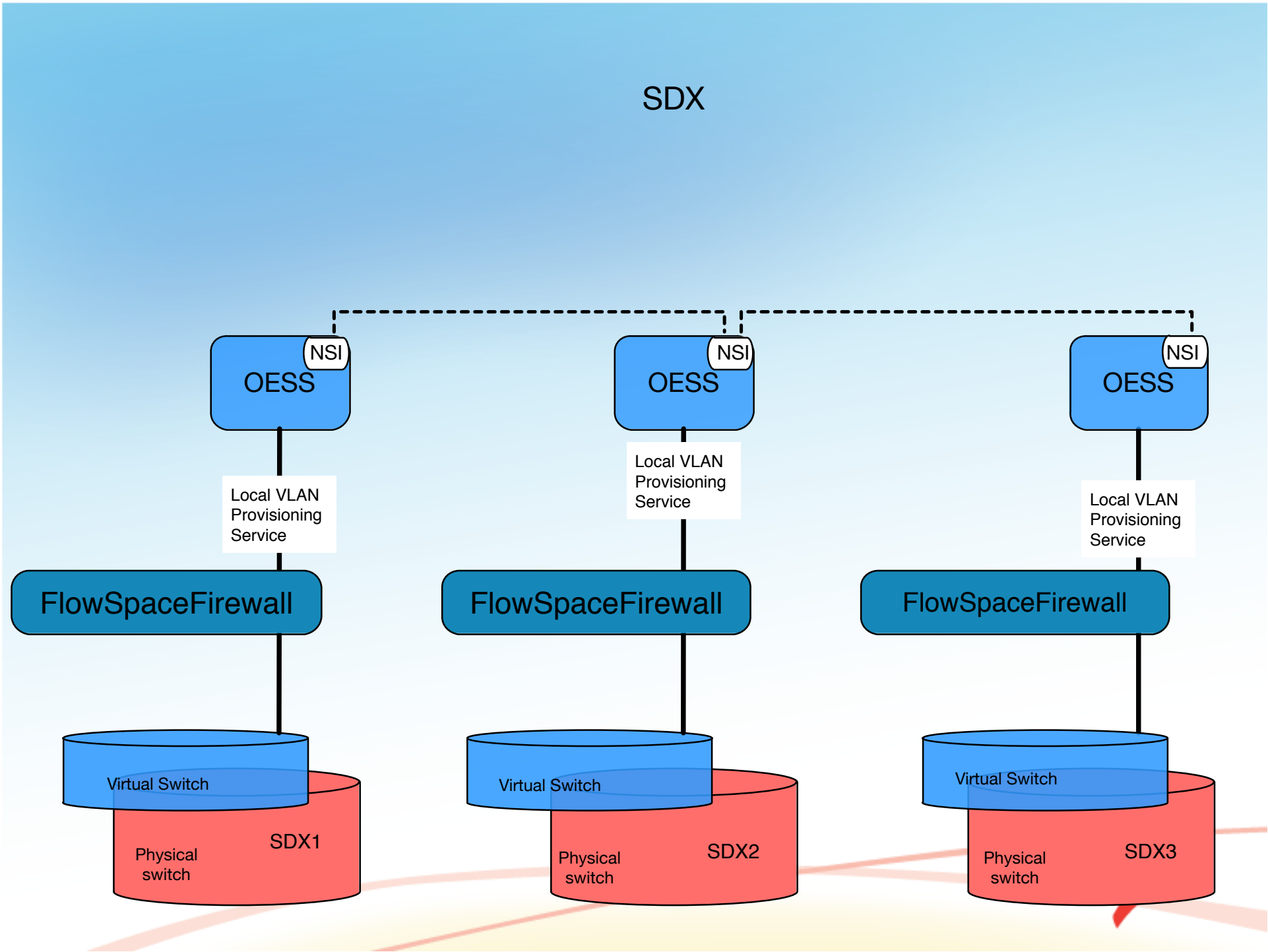
SDX3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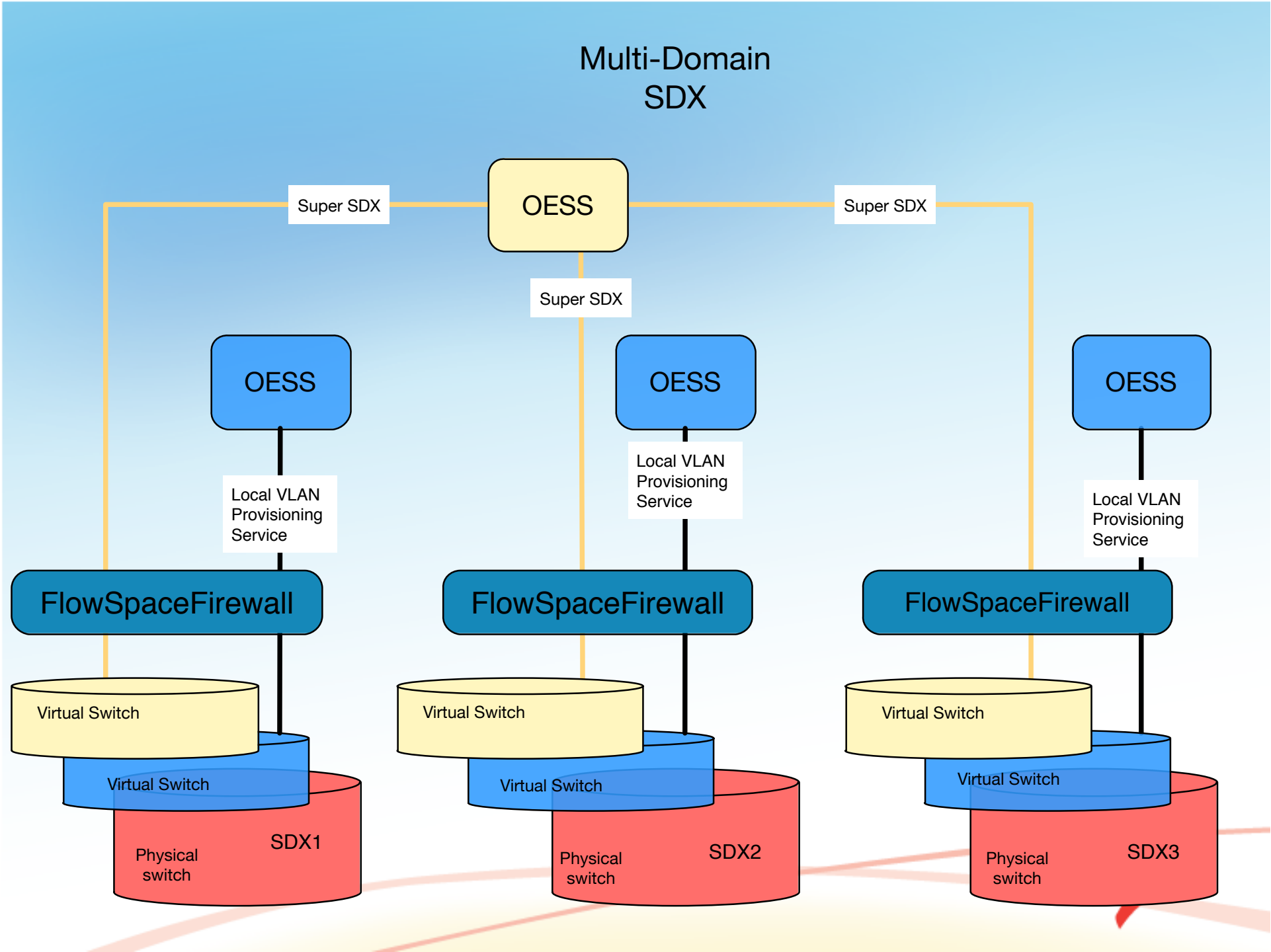
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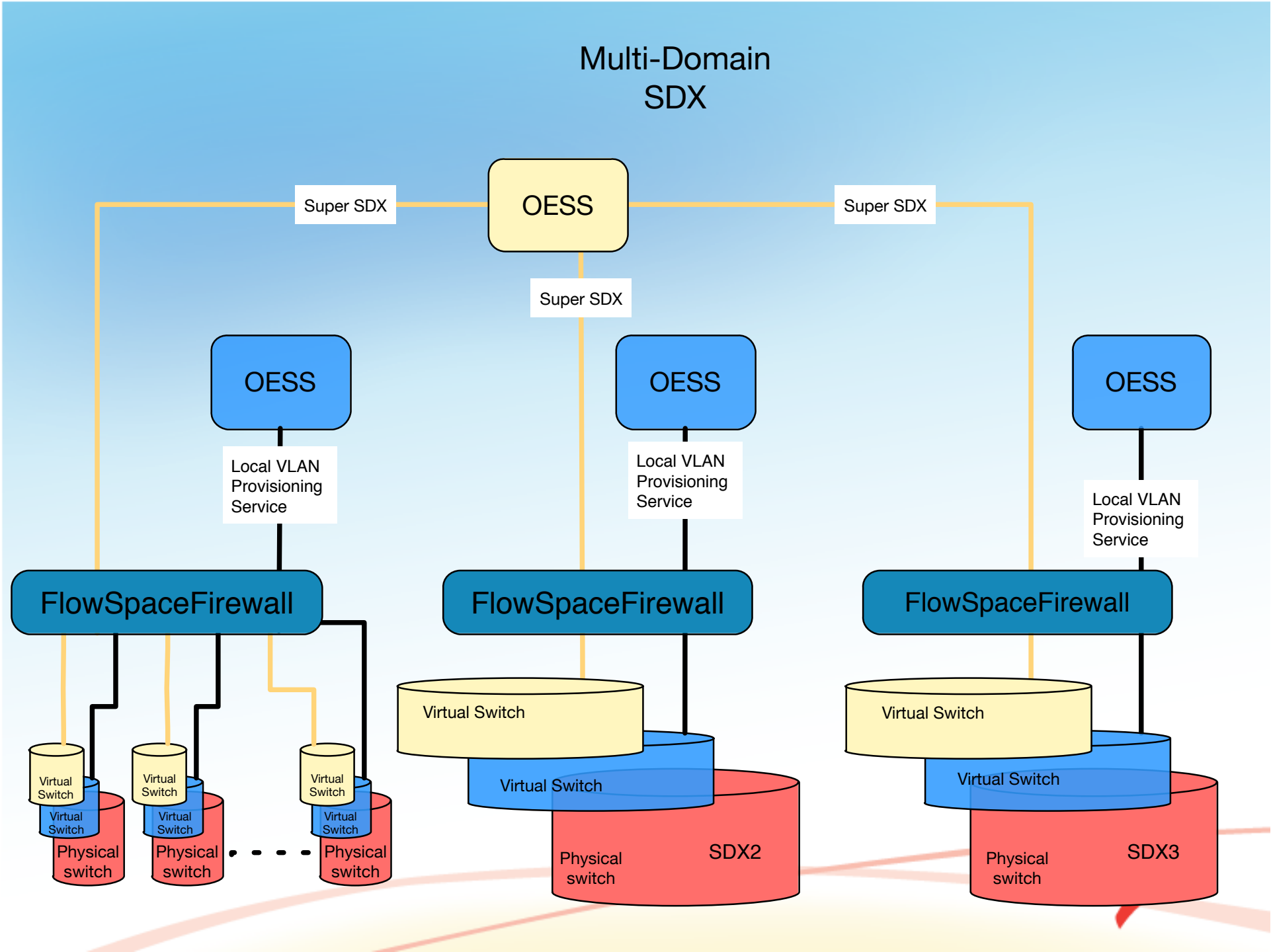
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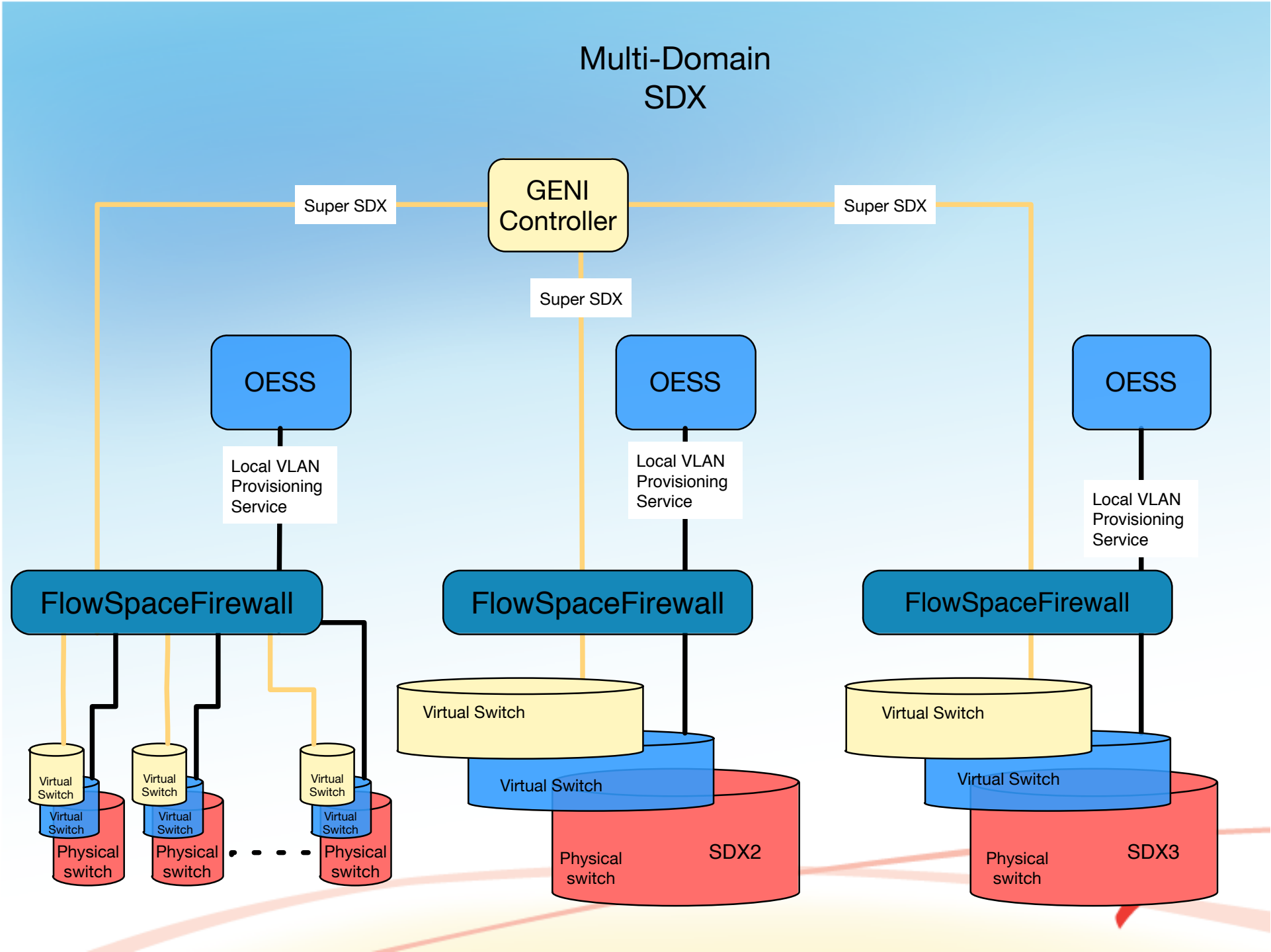
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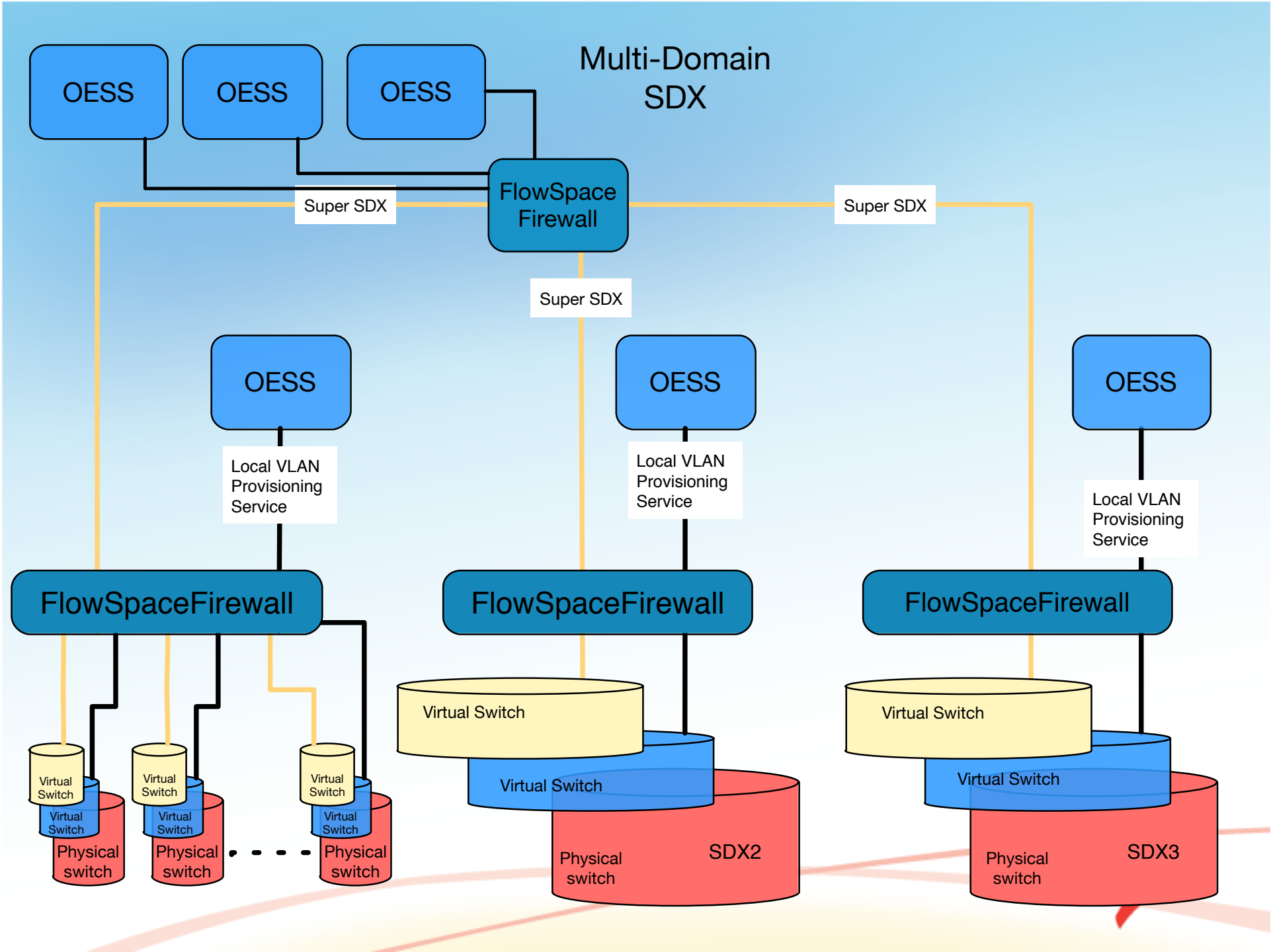
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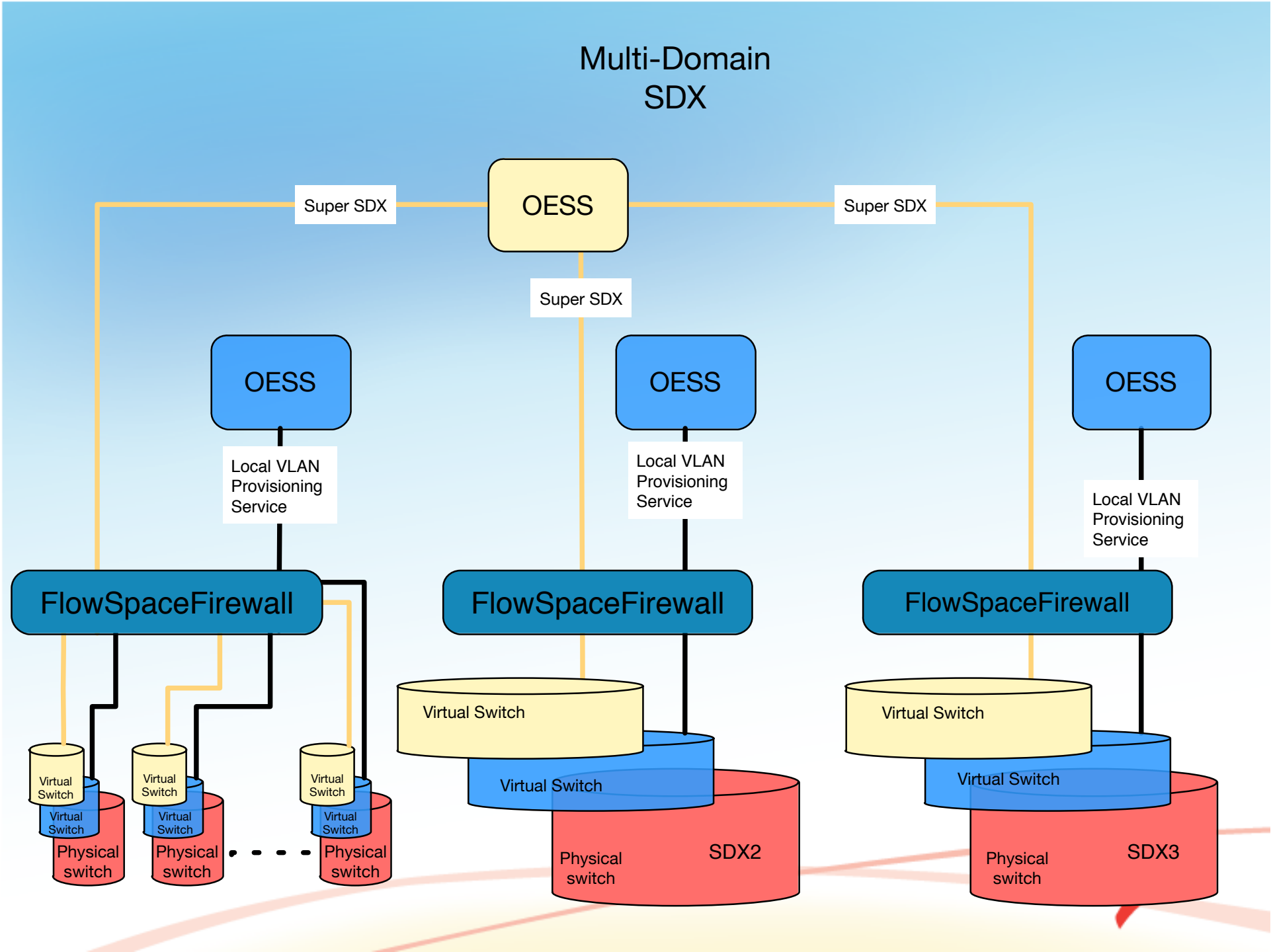
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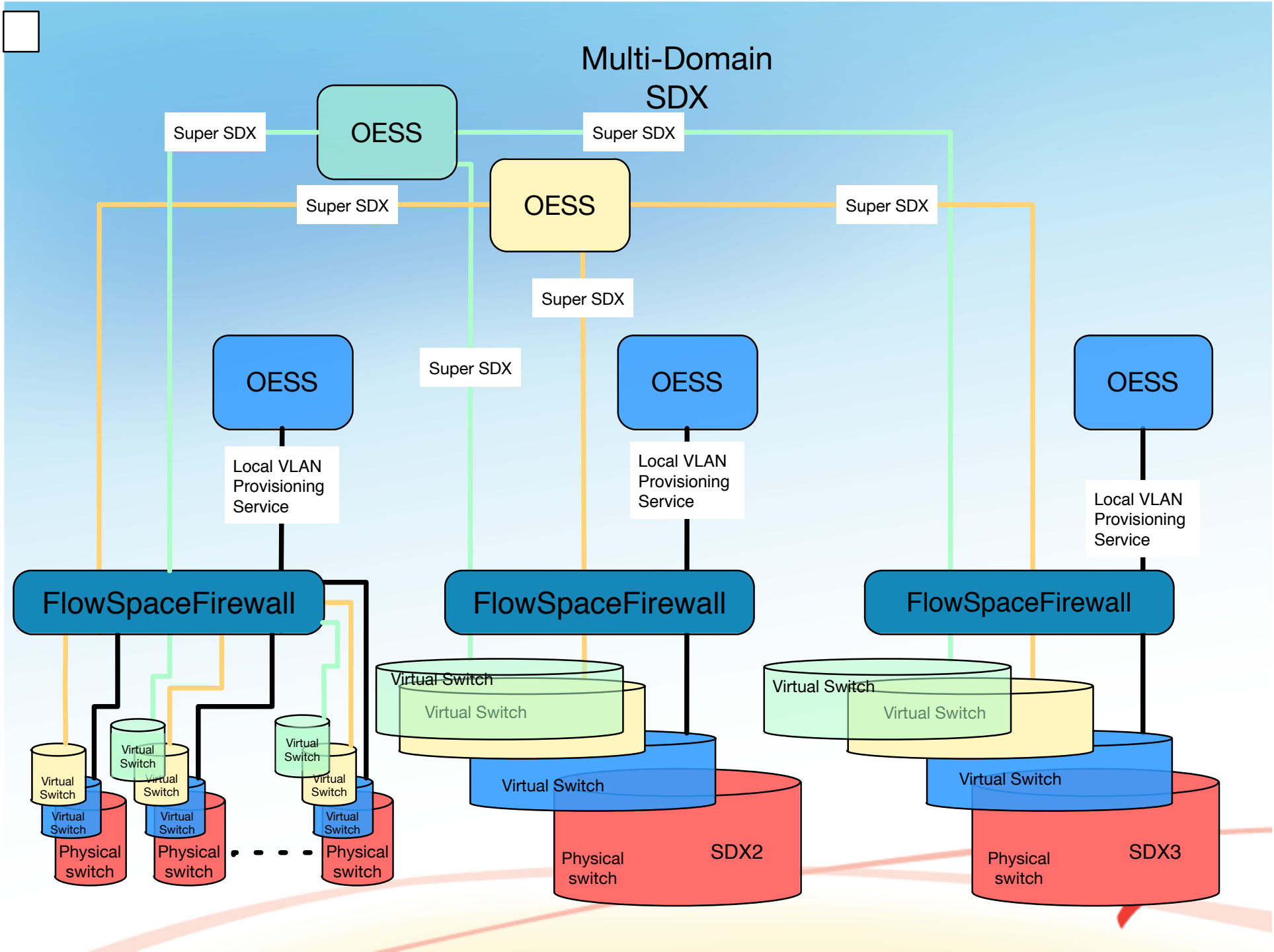
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FlowSpaceFirewall
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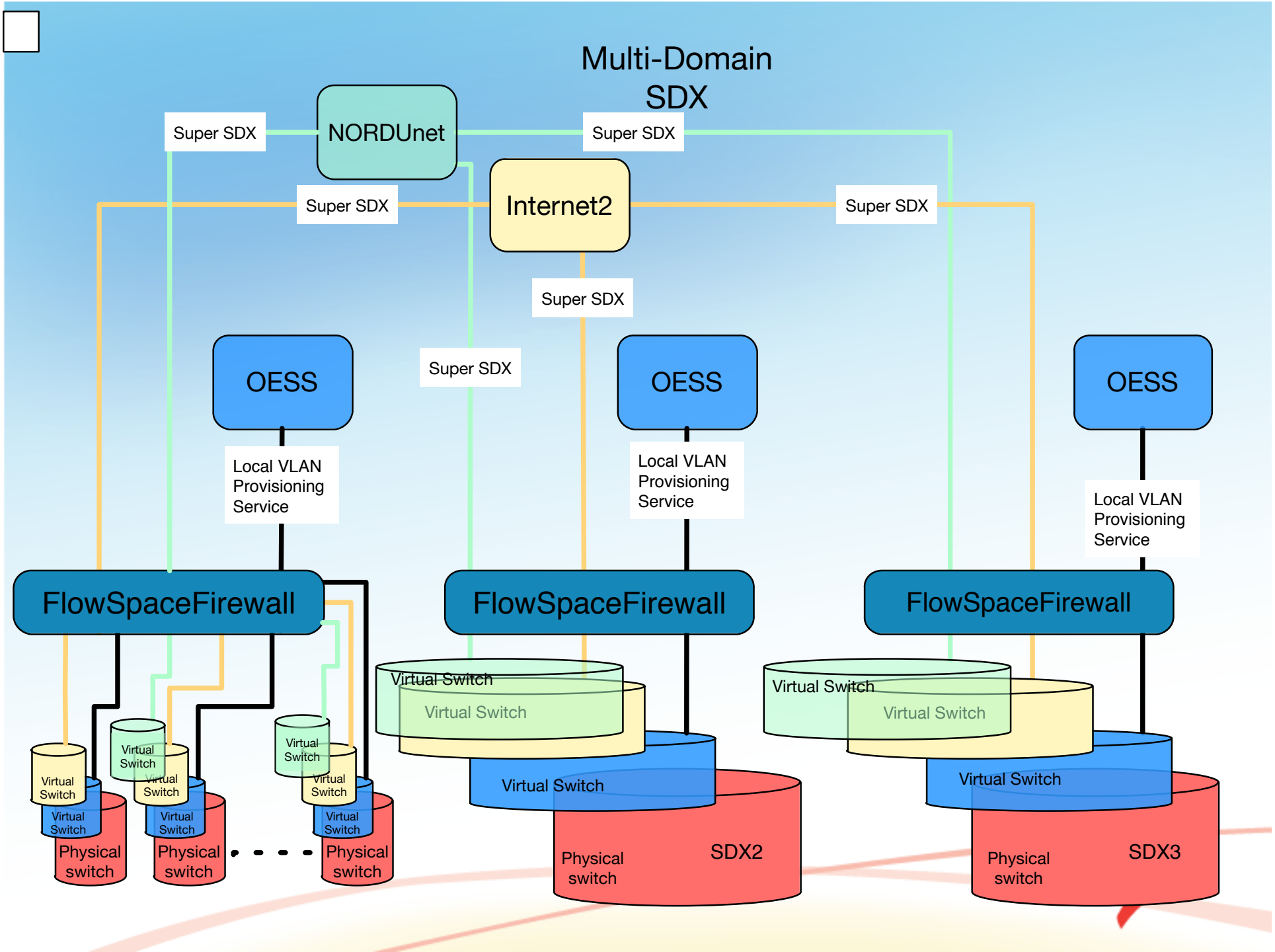
Physical
switch
SDX2
SDX3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FlowSpaceFirewall
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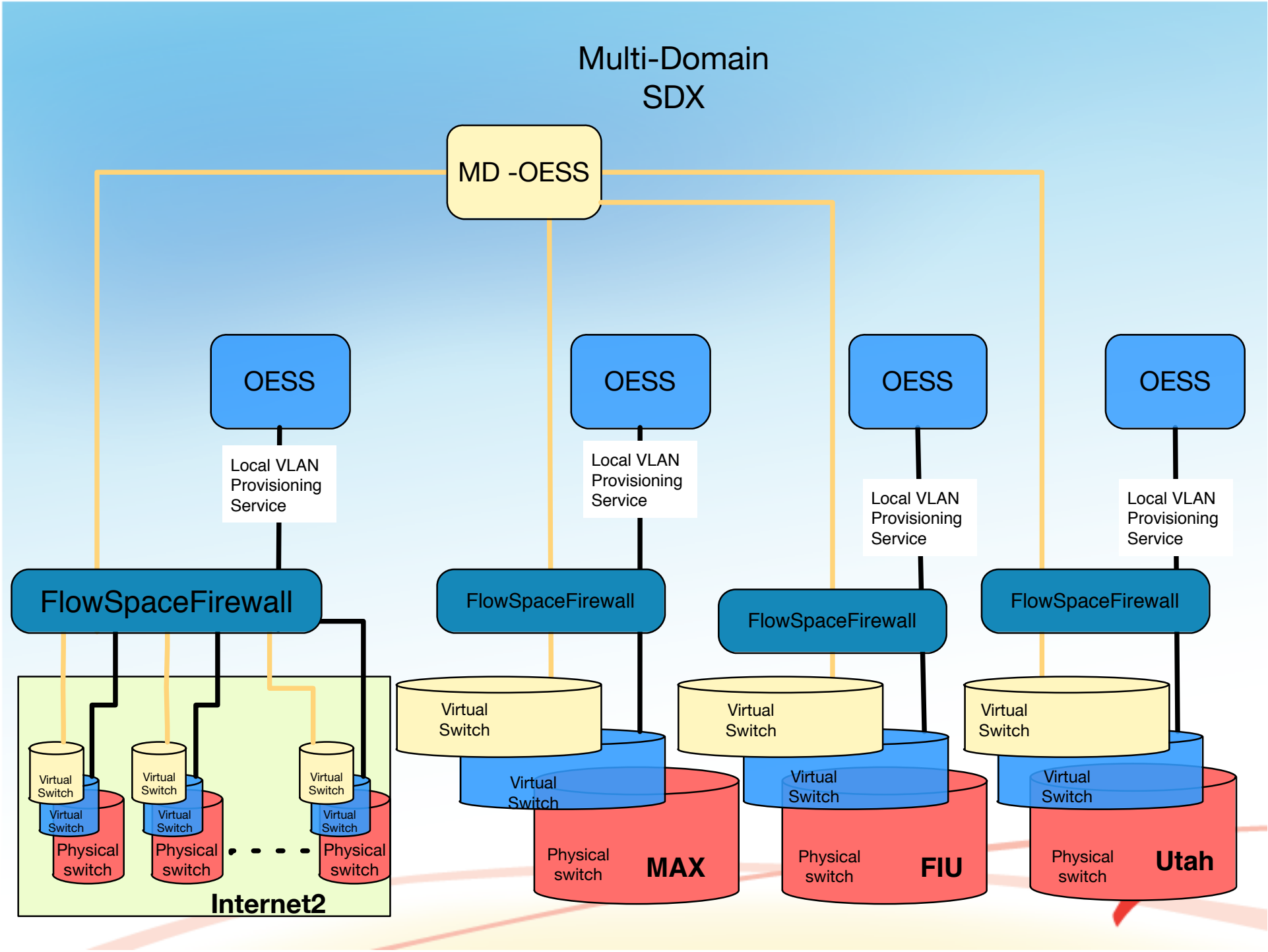
SDX3


Multi-Domain
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Local VLAN
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Local VLAN
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Local VLAN
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Service
FlowSpaceFirewall
FlowSpaceFirewall
FlowSpaceFirewall
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Virtual
Switch
Physical
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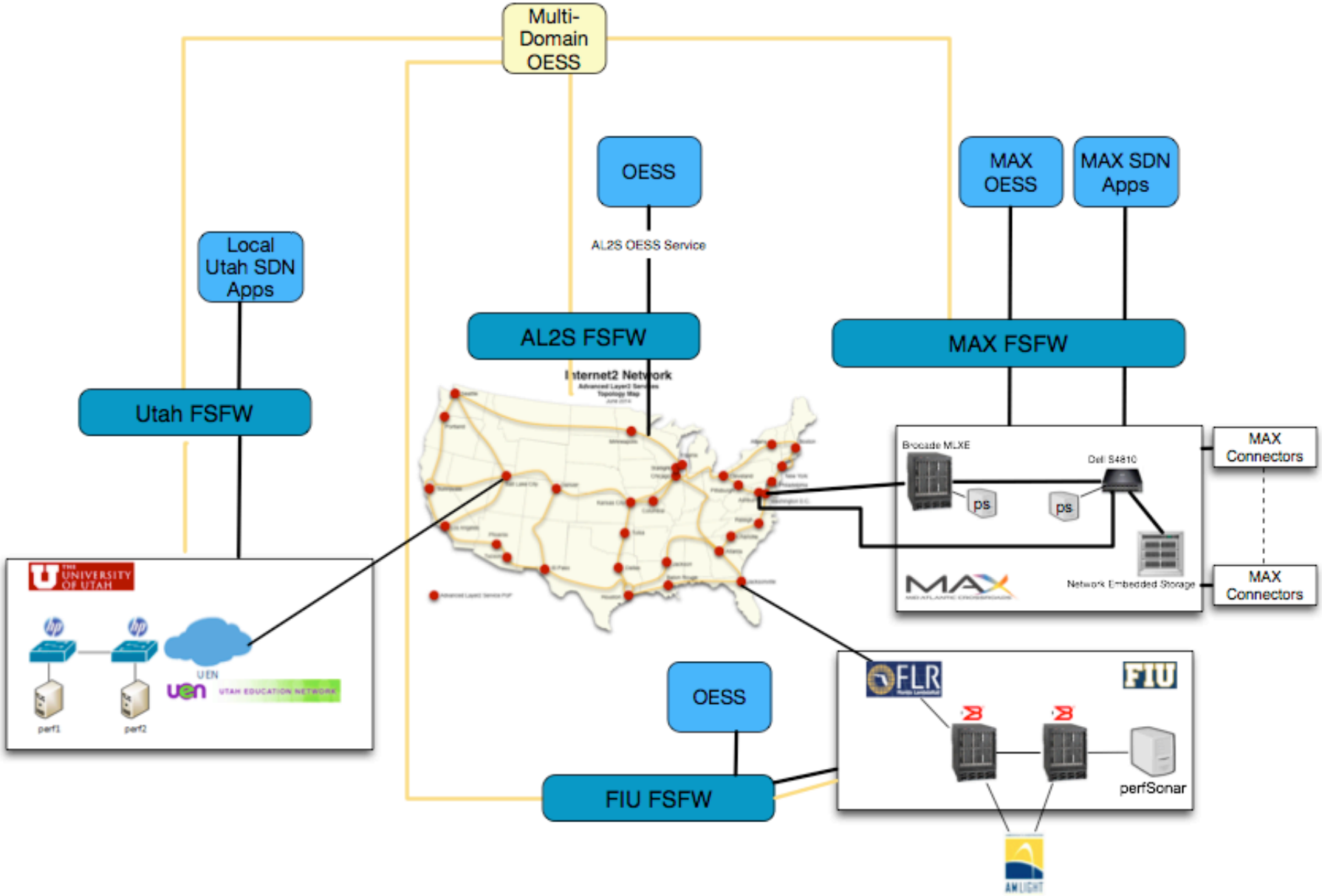
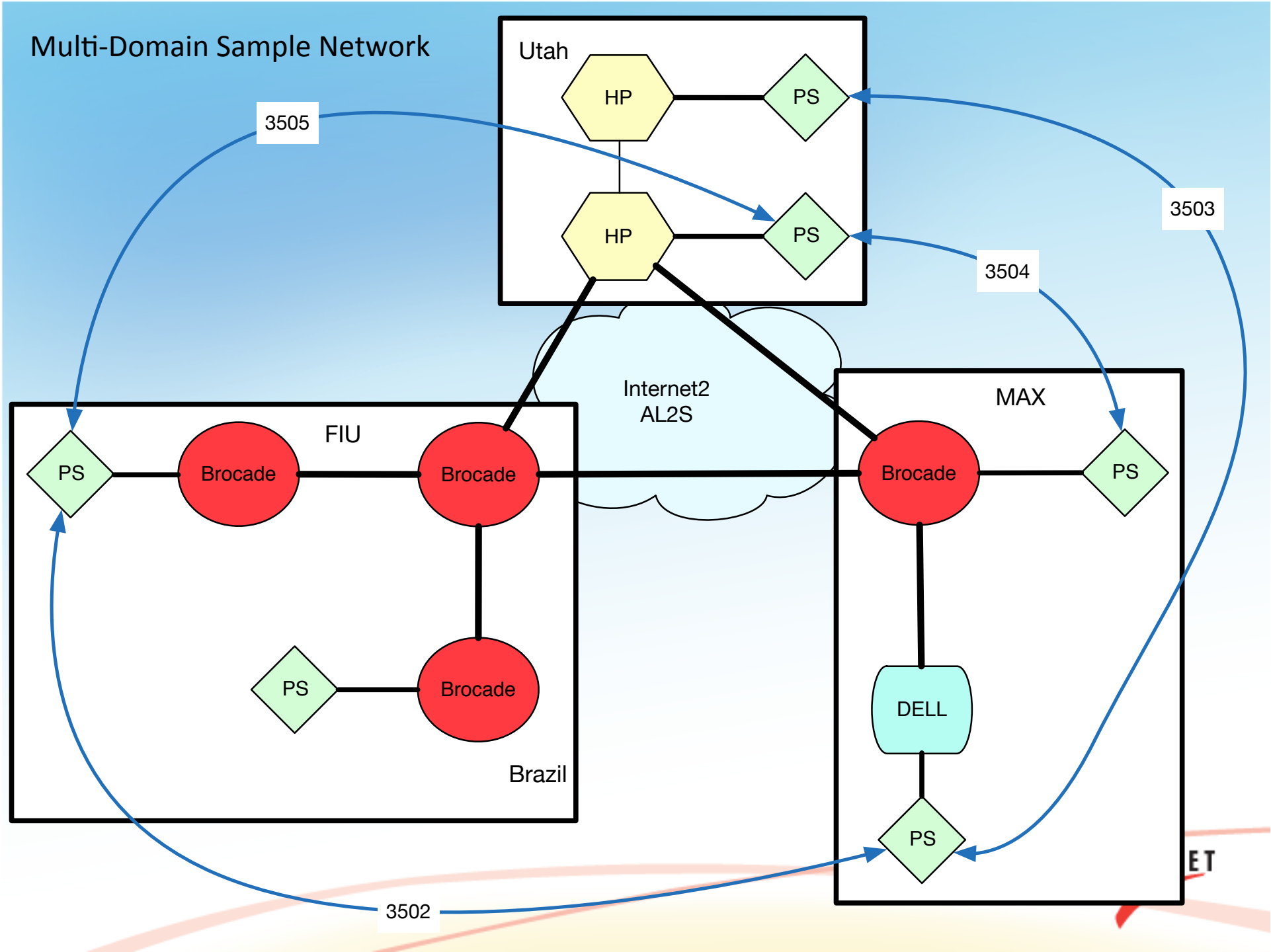
Internet2
MAX
FIU
Utah


Multi-Domain OESS
OESS
AL2S OESS Service
MAX OESS
MAX SDN Apps
Local Utah SDN Apps
AL2S FSFW
MAX FSFW
Utah FSFW
Internet2 Network
Brocade MLXE
Dell S4810
ps
ps
MAX Connectors
MAX Connectors
Network Embedded Storage
THE UNIVERSITY OF UTAH
perf1
perf2
UEN
UTAH EDUCATION NETWORK
OESS
FLR
FIU
perfSonar
FIU FSFW
AMLIGHT


Multi-Domain Sample Network
Utah
HP
PS
HP
PS
3505
3503
3504
Internet2
AL2S
FIU
PS
Brocade
Brocade
PS
Brocade
Brazil
MAX
Brocade
PS
DELL
PS
3502


INTERNET®
International SDN Testbeds
What are we trying to achieve?

Testbed vs. Production?

- Why are we talking about testbeds?
- What are the barriers to using SDN in production?

INTERNET 2

What are the goals of a testbed?

- Support network research?
- Explore new network paradigms in preparation for transition to production?

INTERNET 2

Why should testbeds interoperate?

- Demonstrate general connectivity while implementing underlying connectivity in unique ways?
- Support multi-domain network research?
- Prepare for transition to production in a multi-domain environment?

INTERNET 2

How should testbeds interoperate?

- Orchestration through existing interoperability mechanisms (e.g. BGP, NSI, GENI Stitching, etc.)
- Orchestration through new paradigms (e.g. ONOS)

INTERNET 2

What charge should we give?

- International SDN Testbeds FTW is next week.
- What would the GLIF Tech group like to see in the way of outcomes?