SDN in the WAN

advantages, realities and pitfalls
an insider's view of the Internet2 AL2S Network

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Agenda

- Need for L2
- What is the AL2S
- Evolution of AL2S, Openflow
- The Role of GlobalNOC within the I2 Network
- OESS, Control Layer for AL2S
- But what about traditional L3?
  - Tunneling versus Hybrid Port Mode

- A Systems View
  - Architecture of a Complex Systems
  - The challenge of the hourglass
  - The real value of SDx, a true paradigm shift

- Where is this “pitfall” you mention in your title?

The need for Layer 2 in the WAN

Flexibility provided by Layer 2 Circuits for Research Networks

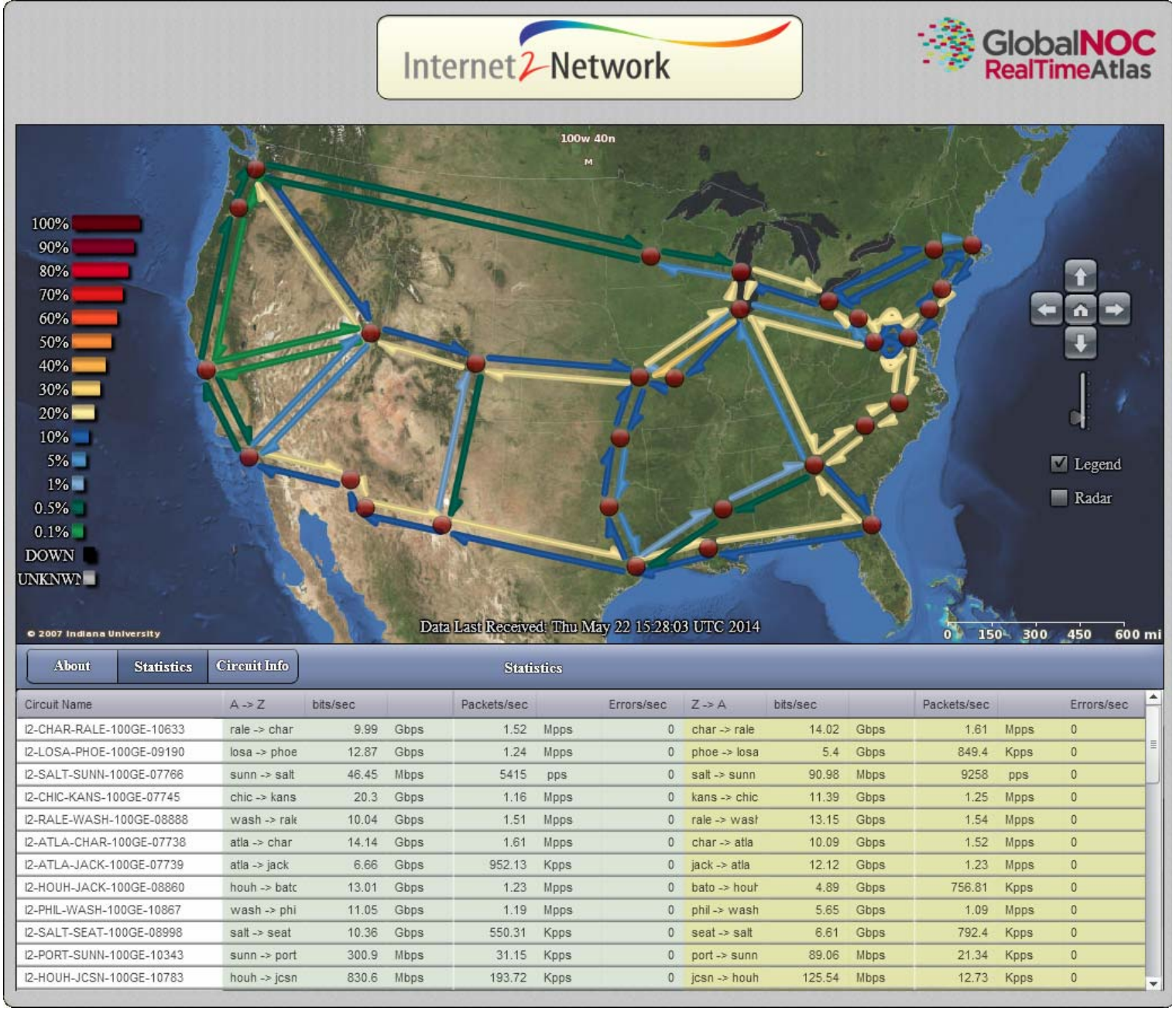
- Freedom to run layer 2 protocols across the WAN
  - Avoids the overhead of layer 3 headers
  - An example is RoCE – RDMA can be run over layer 2 WAN circuits provided the network path has no packet loss
  - Efficiency of Large Dataset Transfers
- Flexibility to choose VLAN tags – OpenFlow programmed circuit can have a different tag on each end
- It's just a VLAN – anything you can run on a vlan across your own datacenter you can run across the WAN (latency permitting)
- Tunnel L3 through L2 backbone

What is the AL2S

A solution to the unique requirements of research and educational institutions

Enabling scalable and flexible global access to an open exchange network, members can build Layer 2 circuits (VLANs) between endpoints on the Internet2 Network and beyond. The service meets the wide-ranging needs of the research and education community—both now and into the future.

AL2S allows users to create their own VLANs on the Internet2 AL2S backbone. Static or Dynamic, point-to-point or multipoint, intra-domain or inter-domain, AL2S puts control of the backbone VLANs into the users' hands for the creation of purpose-built private circuits using infrastructure already in place.



Circuit Name	A -> Z	bits/sec		Packets/sec		Errors/sec	Z -> A	bits/sec		Packets/sec		Errors/sec
I2-CHAR-RALE-100GE-10633	rale -> char	9.99	Gbps	1.52	Mpps	0	char -> rale	14.02	Gbps	1.61	Mpps	0
I2-LOSA-PHOE-100GE-09190	losa -> phoe	12.87	Gbps	1.24	Mpps	0	phoe -> losa	5.4	Gbps	849.4	Kpps	0
I2-SALT-SUNN-100GE-07766	sunn -> salt	46.45	Mbps	5415	pps	0	salt -> sunn	90.98	Mbps	9258	pps	0
I2-CHIC-KANS-100GE-07745	chic -> kans	20.3	Gbps	1.16	Mpps	0	kans -> chic	11.39	Gbps	1.25	Mpps	0
I2-RALE-WASH-100GE-08888	wash -> rale	10.04	Gbps	1.51	Mpps	0	rale -> wash	13.15	Gbps	1.54	Mpps	0
I2-ATLA-CHAR-100GE-07738	atla -> char	14.14	Gbps	1.61	Mpps	0	char -> atla	10.09	Gbps	1.52	Mpps	0
I2-ATLA-JACK-100GE-07739	atla -> jack	6.66	Gbps	952.13	Kpps	0	jack -> atla	12.12	Gbps	1.23	Mpps	0
I2-HOUH-JACK-100GE-08860	houh -> batc	13.01	Gbps	1.23	Mpps	0	bato -> houh	4.89	Gbps	756.81	Kpps	0
I2-PHIL-WASH-100GE-10867	wash -> phi	11.05	Gbps	1.19	Mpps	0	phil -> wash	5.65	Gbps	1.09	Mpps	0
I2-SALT-SEAT-100GE-08998	salt -> seat	10.36	Gbps	550.31	Kpps	0	seat -> salt	6.61	Gbps	792.4	Kpps	0
I2-PORT-SUNN-100GE-10343	sunn -> port	300.9	Mbps	31.15	Kpps	0	port -> sunn	89.06	Mbps	21.34	Kpps	0
I2-HOUH-JCSN-100GE-10783	houh -> jcsn	830.6	Mbps	193.72	Kpps	0	jcsn -> houh	125.54	Mbps	12.73	Kpps	0

http://atlas.grnoc.iu.edu/atlas.cgi?map_name=Internet2%20AL2S

Evolution of the AL2S, Openflow

- AL2S started as a L2 VLAN, OSCARS
- Openflow controls flows, L2
- Control Interface, OESS (more next slide)

OESS, Open Exchange Software Suite

Developed at GlobalNOC, Indiana University

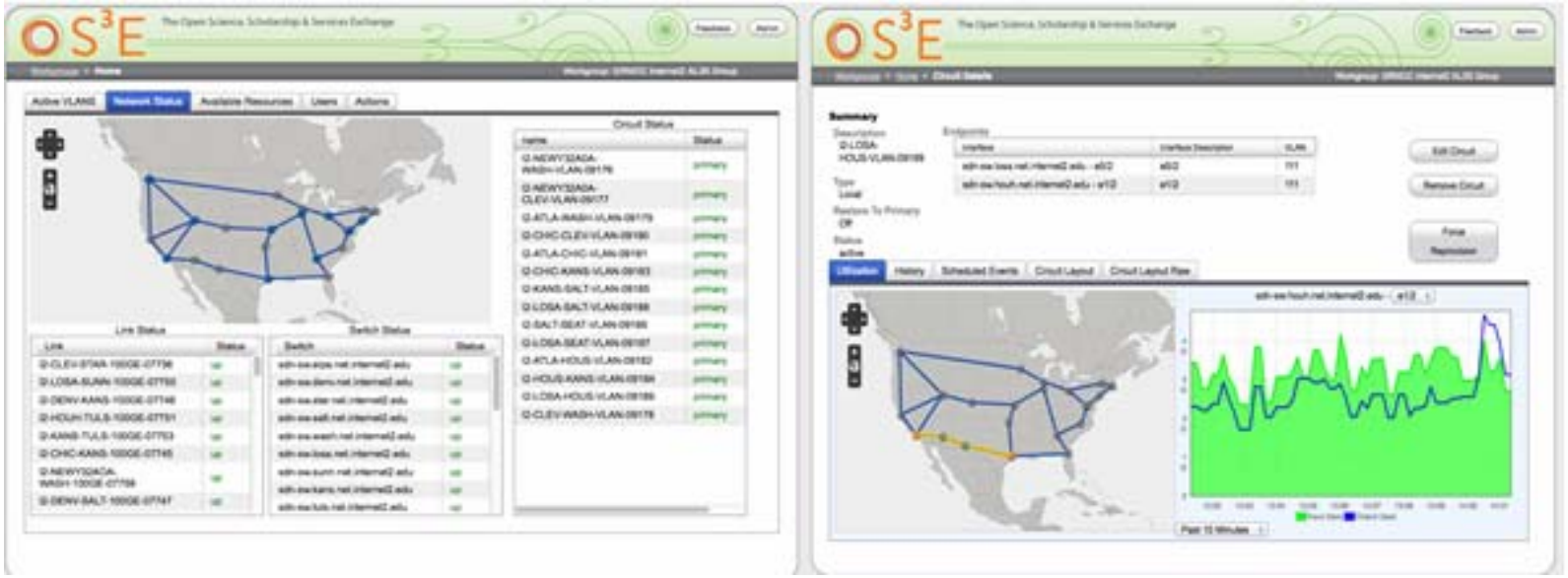
The GlobalNOC at Indiana University

The Global Research Network Operations Center (GlobalNOC) at Indiana University provides carrier grade operations, tools, and network expertise, while placing a singular focus on the unique requirements of our research and education (R&E) community.

IU formed the GlobalNOC in 1998 to help Internet2 found its new R&E networking community, providing high quality network operations center services for Internet2's Abilene network. Since then, we have evolved alongside the community we serve, growing from a three-person staff to an organization of more than 80 people who deliver unrivalled service and support for the world's most advanced research and education networks.

OESS, Open Exchange Software Suite

OESS is a set of software used to configure and control dynamic (user-controlled) layer 2 virtual circuit (VLAN) networks on OpenFlow enabled switches. OESS provides sub-second circuit provisioning, automatic circuit failover, per-interface permissions, and automatic per-VLAN statistics. It includes a simple and user friendly web-based user interface as well as a web services API.



But what about traditional L3

Need for IP does not go away

- Solutions include;
  - IP on the edge through a High Performance L2 core
    - I2 solution, I2 Options for Implementing IP Atop AL2S
      - http://lists.internet2.edu/sympa/arc/ntacpeering/2013-06/msg00007/IP_over_AL2S_20130522.pdf
  - Hybrid Port Mode, support both Openflow and L3 on same WAN port

OpenFlow Hybrid Port

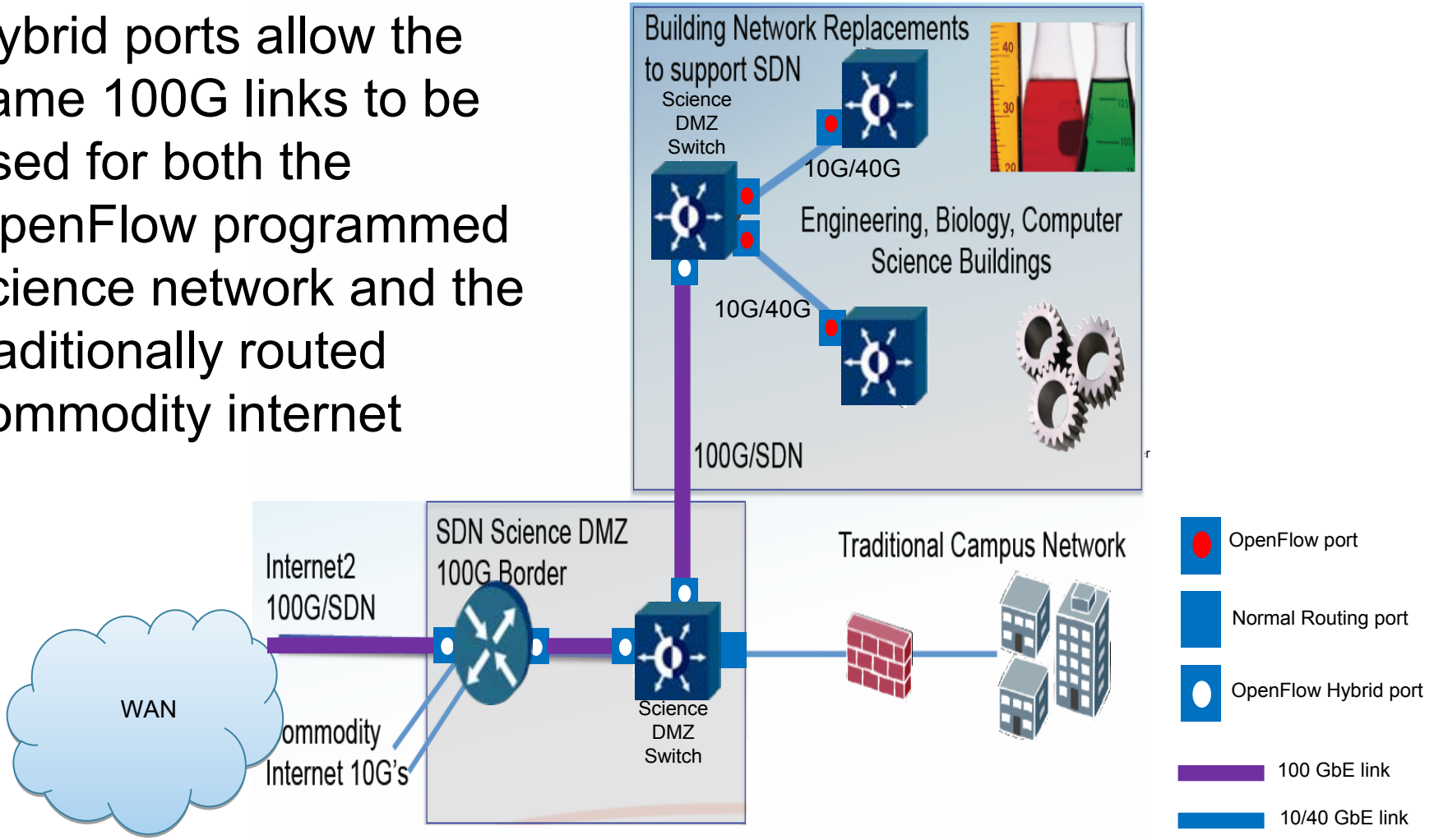
OpenFlow and Traditional Networking on the Same Port

- Hybrid port can have protected and unprotected VLANs
- The controller cannot program flows for protected VLANs
- Unprotected VLANs are available to the controller for programming
  - Packets that match an OpenFlow flow will be forwarded as programmed by the controller
  - Packets that do not match a flow will be forwarded according to the traditional MAC and route tables in the switch

OpenFlow Hybrid Port

Example – Science DMZ

Hybrid ports allow the same 100G links to be used for both the OpenFlow programmed science network and the traditionally routed commodity internet



So Far….

SDN=OPENFLOW=L2

and the AL2S is just another L2 Network with end user programmability ?

Not

Really

A Systems View

David Meyer, CTO

Goals for this Talk

To open up our thinking about what the essential architectural features of our network are, how these features combine to provide robustness (and its dual, fragility), and how the universal architectural features that we find in both technological and biological networks effect Internet robustness, scalability and evolvability.

Robust Yet Fragile, the RYF dilemma

- Robustness is the preservation of a certain property in the presence of uncertainty in components or the environment
- Fragility is the opposite of robustness
- A system can have a property that is robust to one set of perturbations and yet fragile for a different property and/or perturbation  the system is Robust Yet Fragile
- For example, a possible RYF tradeoff is that a system with high efficiency (i.e., using minimal system resources) might be unreliable (i.e., fragile to component failure) or hard to evolve)
  - VRRP, ISSU, HA, TE, …
  - Complexity/Robustness Spirals
  - Implications for Carrier Grade components?

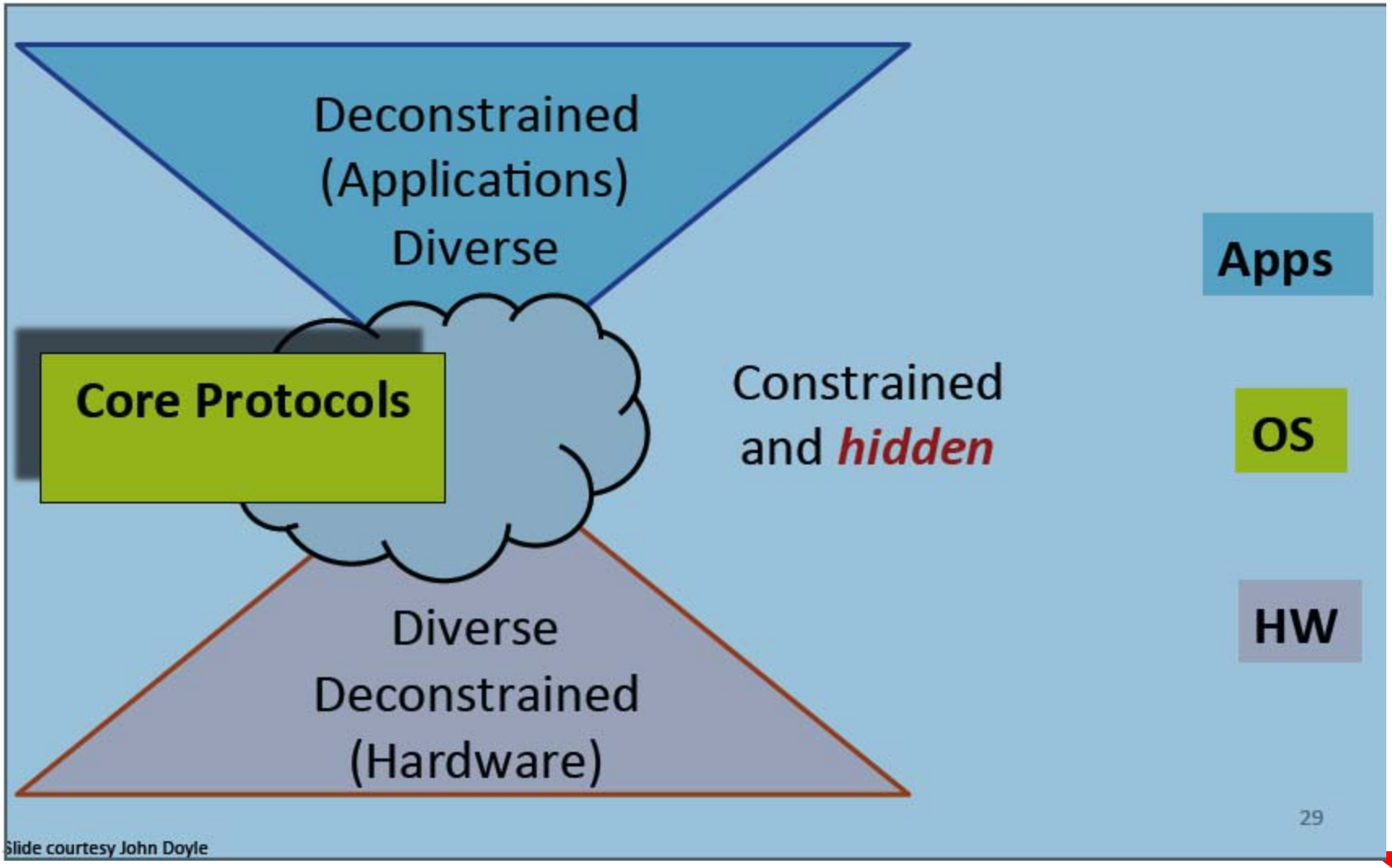
The Architecture of Complex Systems

What we have learned is that there are universal architectural building blocks found in systems
that scale and are evolvable. These include;

- Architecture/Layering
- Laws, constraints, tradeoffs
- Protocol Based Architectures
- Massively distributed with robust control loops
- Consequences
  - Hidden RYF Complexity

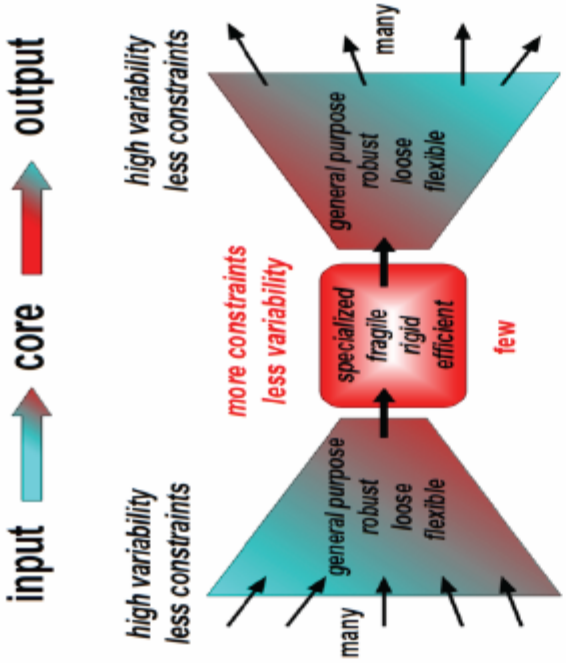
So What is the Basic Layered Architecture?

(hint: layering is *the* fundamental architectural feature)

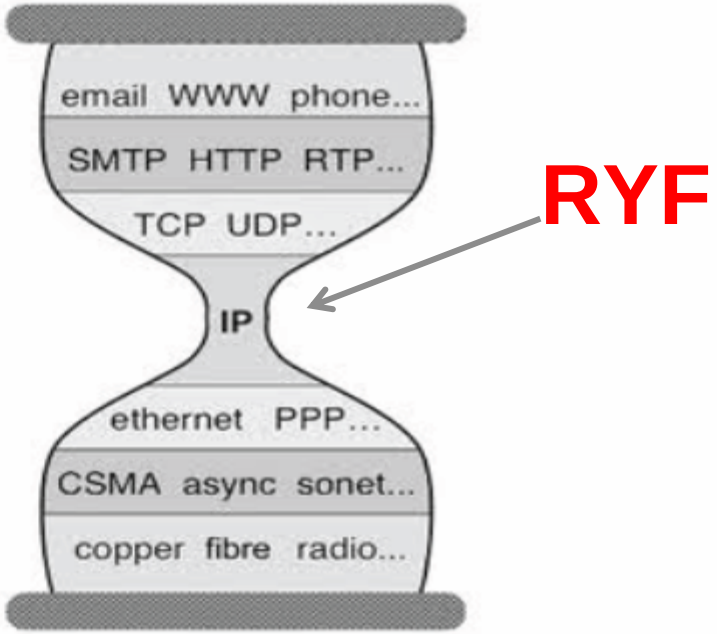


But Wait a Second

Anything Look Familiar?



Bowtie Architecture



Hourglass Architecture

Comes down to whether you see layering as horizontal or vertical

The *Protocol Hourglass* idea appears to have originated with Steve Deering. See Deering, S., "Watching the Waist of the Protocol Hourglass", IETF 51, 2001, http://www.iab.org/wp-content/IAB-uploads/2011/03/hourglass-london-ietf.pdf.

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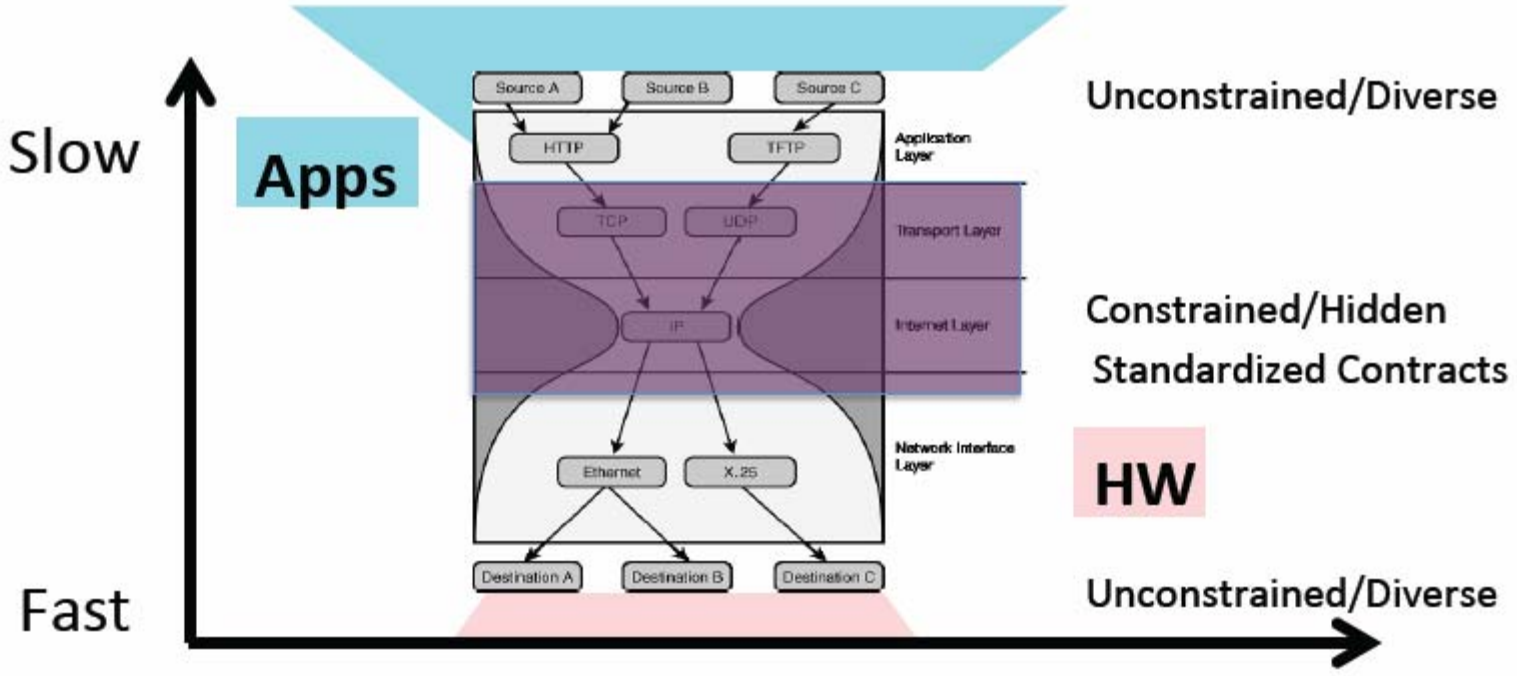
Example: Layered Network Architectures (Internet)



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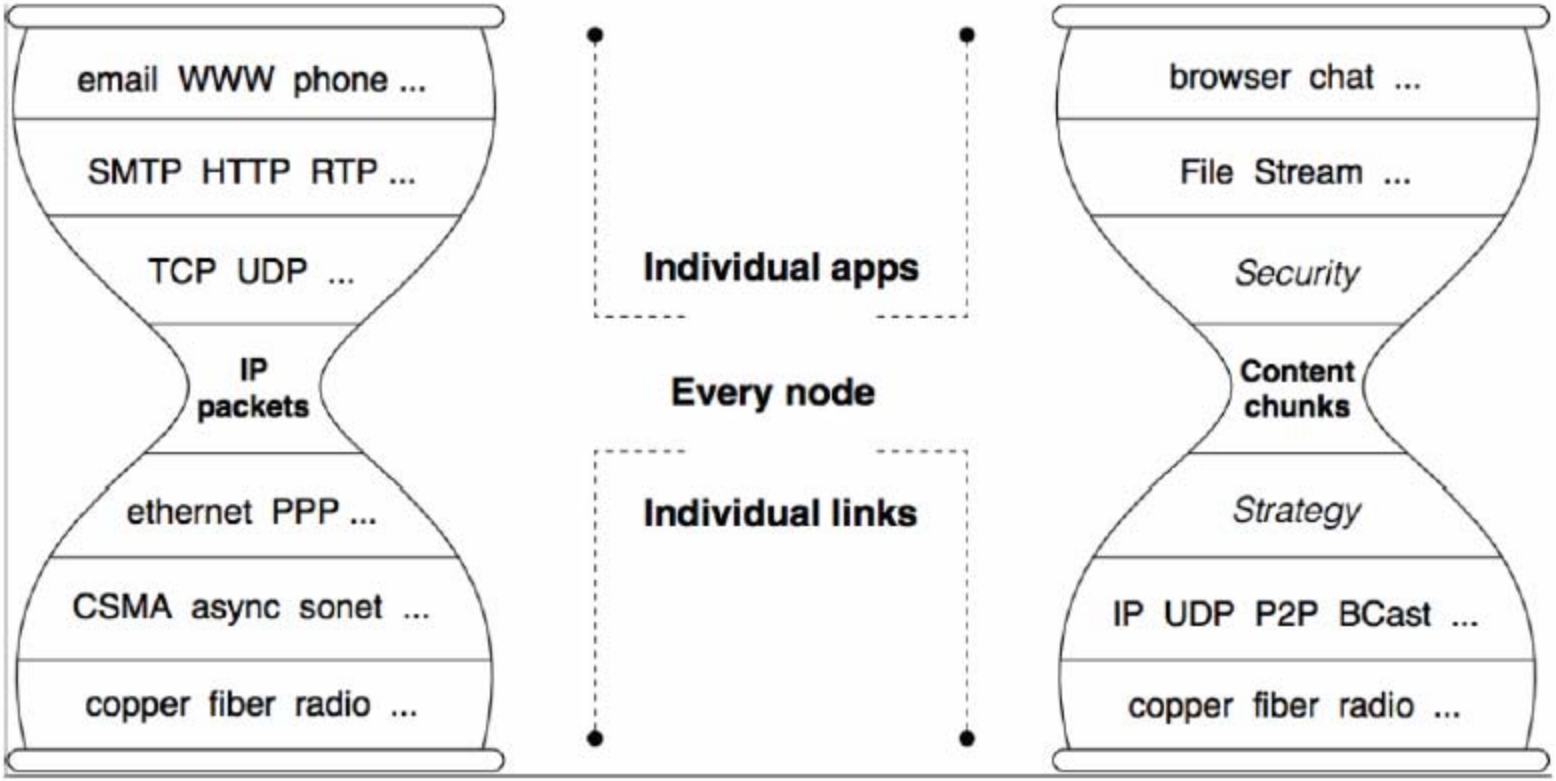
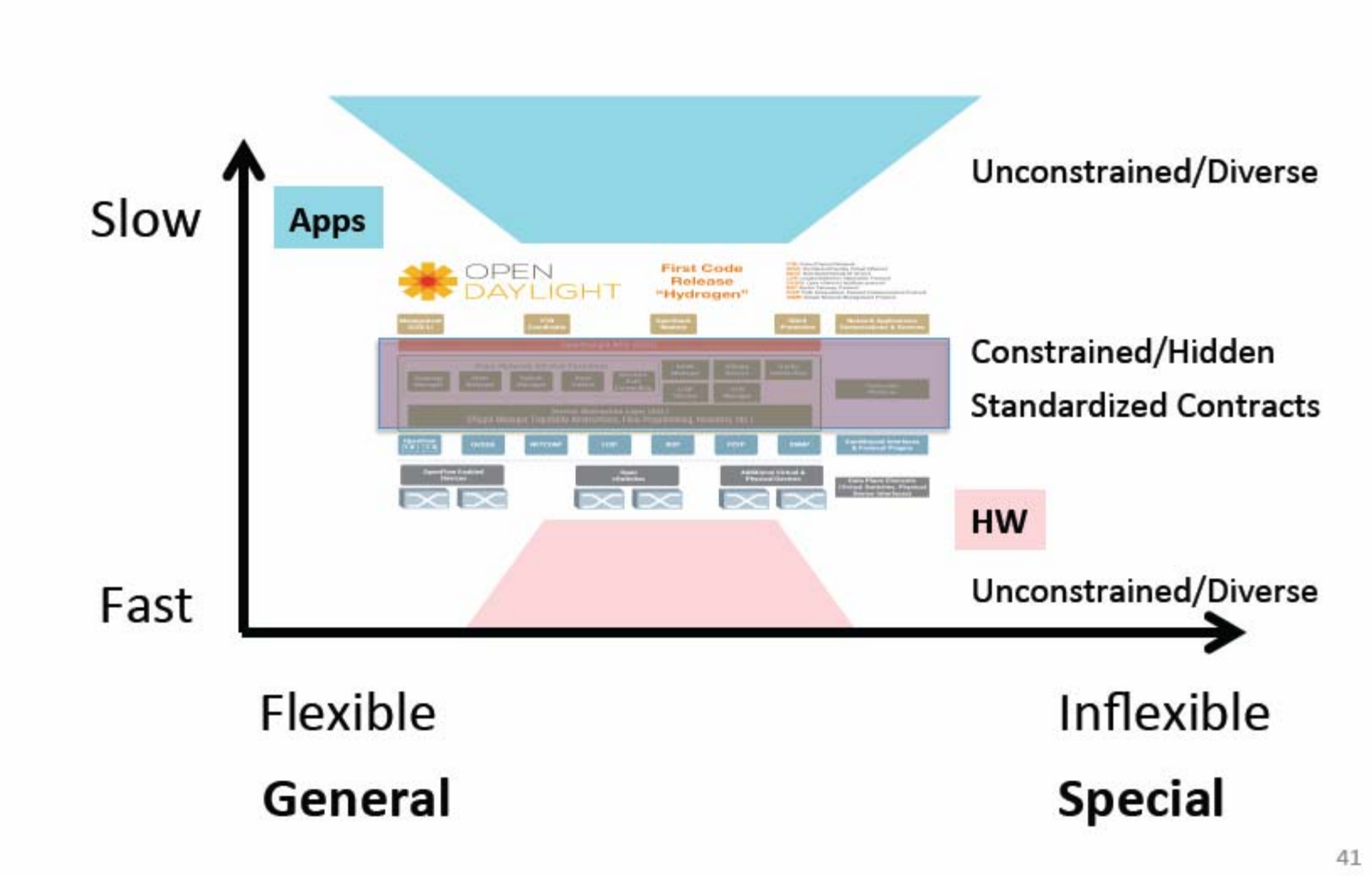
Named Data Networking Hourglass



See Named Data Networking, http://named-data.net/

SDN = Removal of bottleneck



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The True Value of SDx and the AL2S, solving the RYF Dilemma and removing the hourglass

- I2 Innovation Platform
  - The Network itself is a platform for development
  - http://www.internet2.edu/vision-initiatives/initiatives/innovation-platform/

- SDx, remove/enhance IP with a multi-protocol method of moving "chunks of content" and the resources that support them.
  - Openflow
  - Open stack
  - Pearl
  - Northbound API's
  - Restful API, etc etc etc.

Pitfalls?

You can talk Robustness and SDN “todo el dia” but at the end of the day the WAN is still fragile

- Single Circuit to most locations, Single Port to hold up that circuit which means single piece of hardware
  - Cost
  - Complexity
  - Regardless of vendor hardware fails

- What is an outage, the I2 “100% Initiative”
  - Service affecting versus a component failure

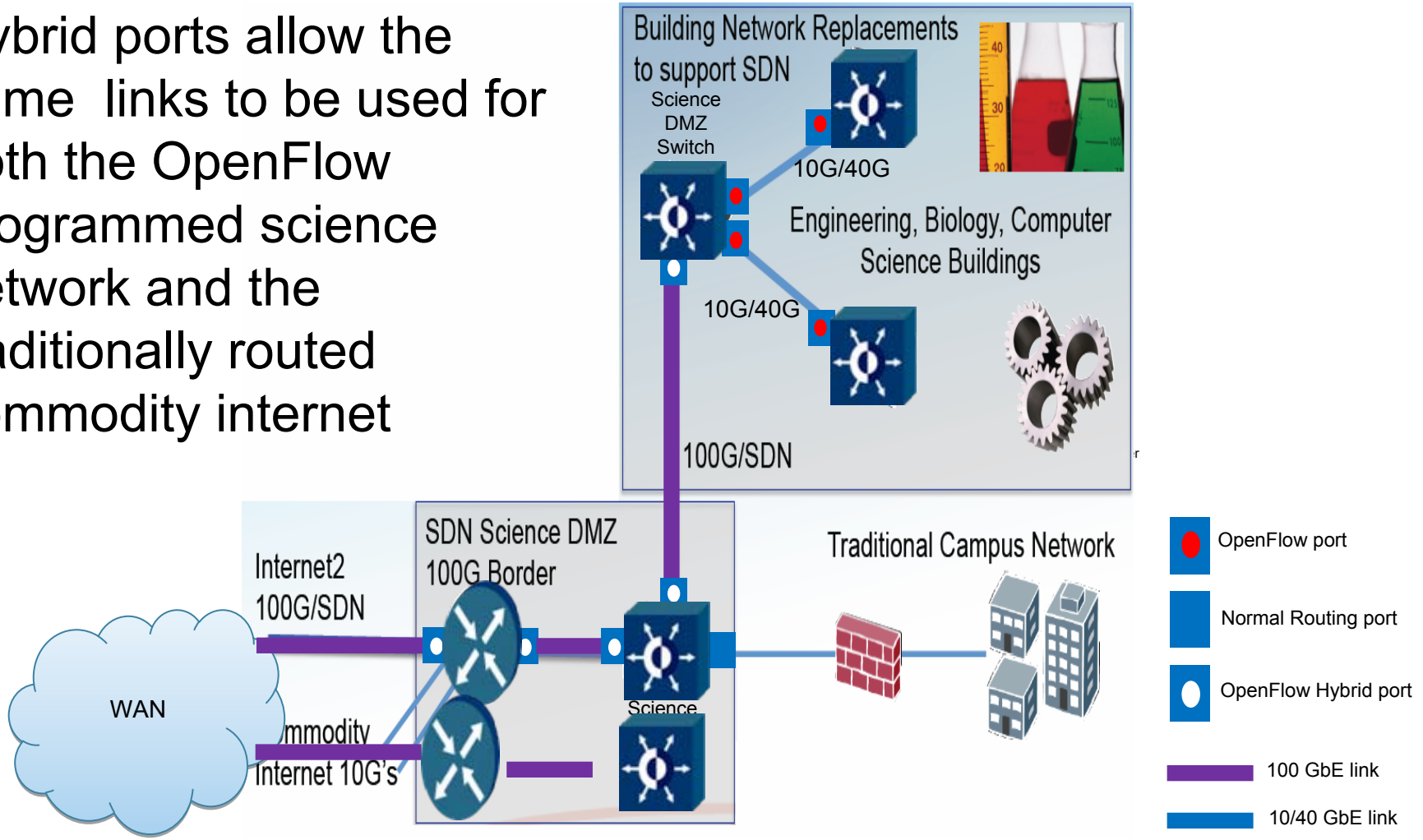
Solution?

- WAN must be redundant to remove fragility
- Combine Commodity Internet and Research Network
  - Role of Combining L2 and IP Services
  - Drive efficiencies
    - Drive robustness across multiple areas by combining;
      - Research
      - Commercial
      - Commodity
- Use SDN as common glue to provide unified control
  - Openflow
  - Openstack
  - NFV
  - Northbound API's
  - Rest API
  - Move "chunks of information" not manage IP

Combined Research and Commodity WAN

Example – Converged DMZ

Hybrid ports allow the same links to be used for both the OpenFlow programmed science network and the traditionally routed commodity internet



Works sited and links

- David Meyer CTO Brocade Communications, *“Bridges”*
- I2 Options for Implementing IP Atop AL2S https://lists.internet2.edu/sympa/arc/ntacpeering/2013-06/msg00007/IP_over_AL2S_20130522.pdf
- I2 Layer 2 Services Homepage http://www.internet2.edu/products-services/advanced-networking/layer-2-services/
- I2 AL2S Roadmap http://www.internet2.edu/products-services/advanced-networking/layer-2-services/al2s-roadmap/
- I2 AL2S Router Proxy http://routerproxy.grnoc.iu.edu/al2s/
- I2 GlobalNOC landing page http://globalnoc.iu.edu/i2network/index.html
- GlobalNOC OESS landing page http://globalnoc.iu.edu/sdn/oess.html