

# GENI Overview

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September 15, 2014



# Acknowledgments

GENI is a collaborative effort, relying on the contributions of hundreds of participants and dozens of partner institutions in academia, industry and government.

GENI is supported by the US National Science Foundation. Any opinions, findings, conclusions or recommendations expressed in this material are the author's and do not necessarily reflect the views of the NSF.

# Experimentation Breaks the Innovation Logjam



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# Experimentation Breaks the Innovation Logjam

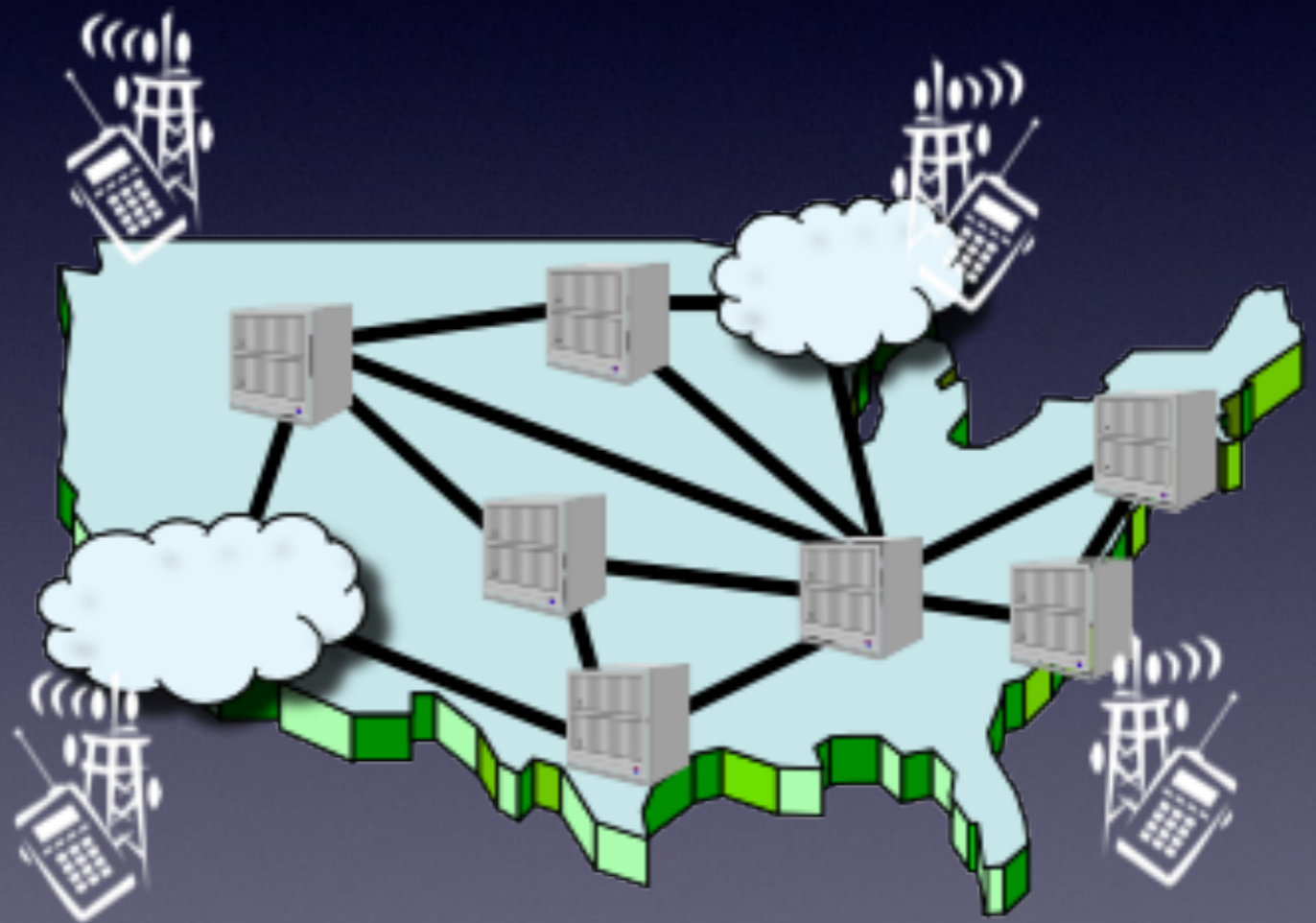
“I have a great idea.”



“That will never work.”



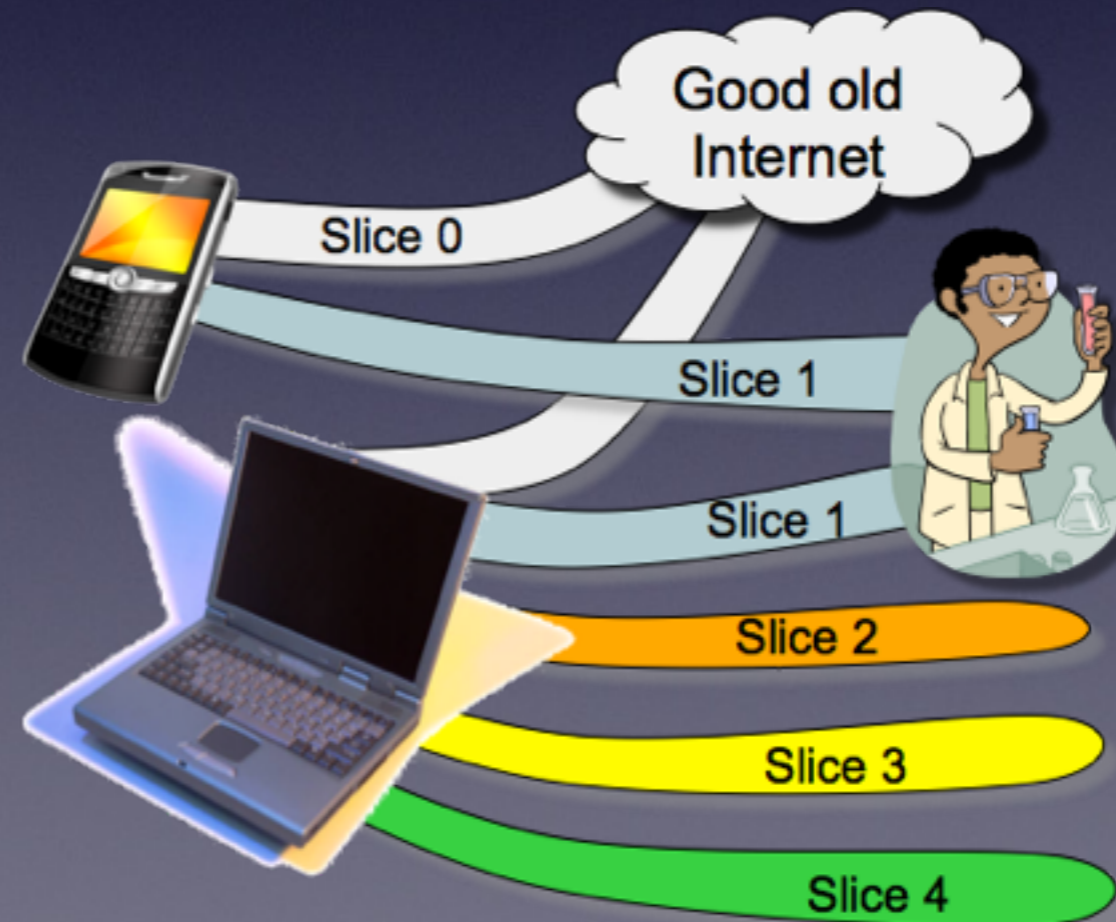
“Let’s try it out.”



“Looks like an app to me.”



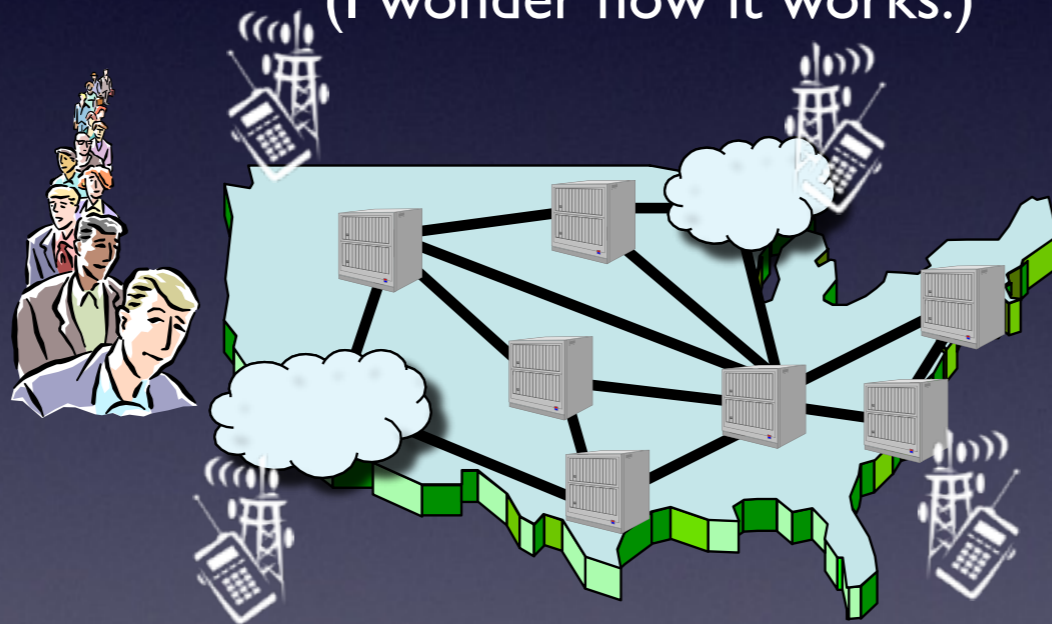
“It’s my very own GENI slice.”



“Boy did I learn a lot!”

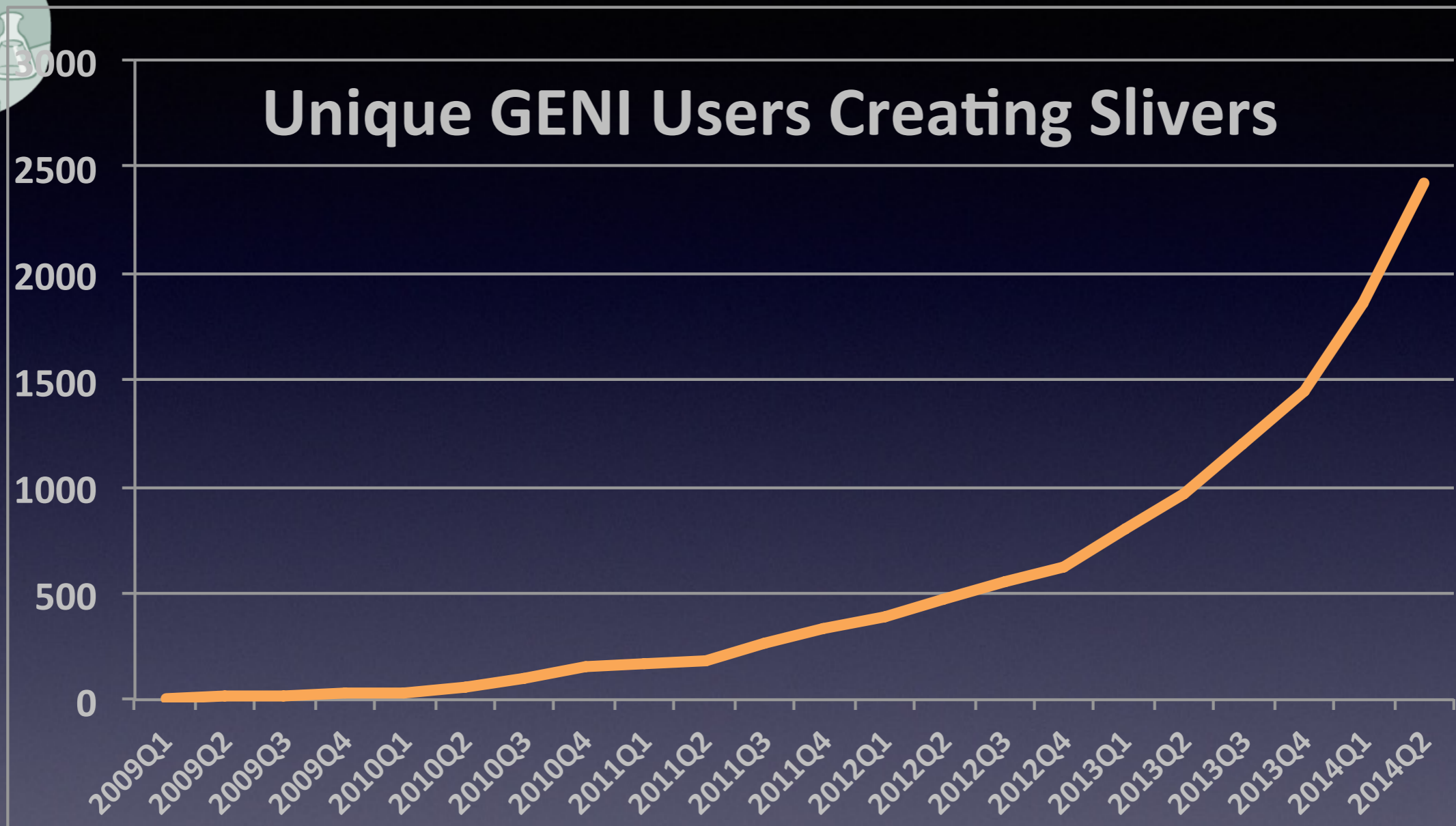


“What a cool service.”  
(I wonder how it works.)



“I always said it was  
a great idea.”  
(But way too conservative.)





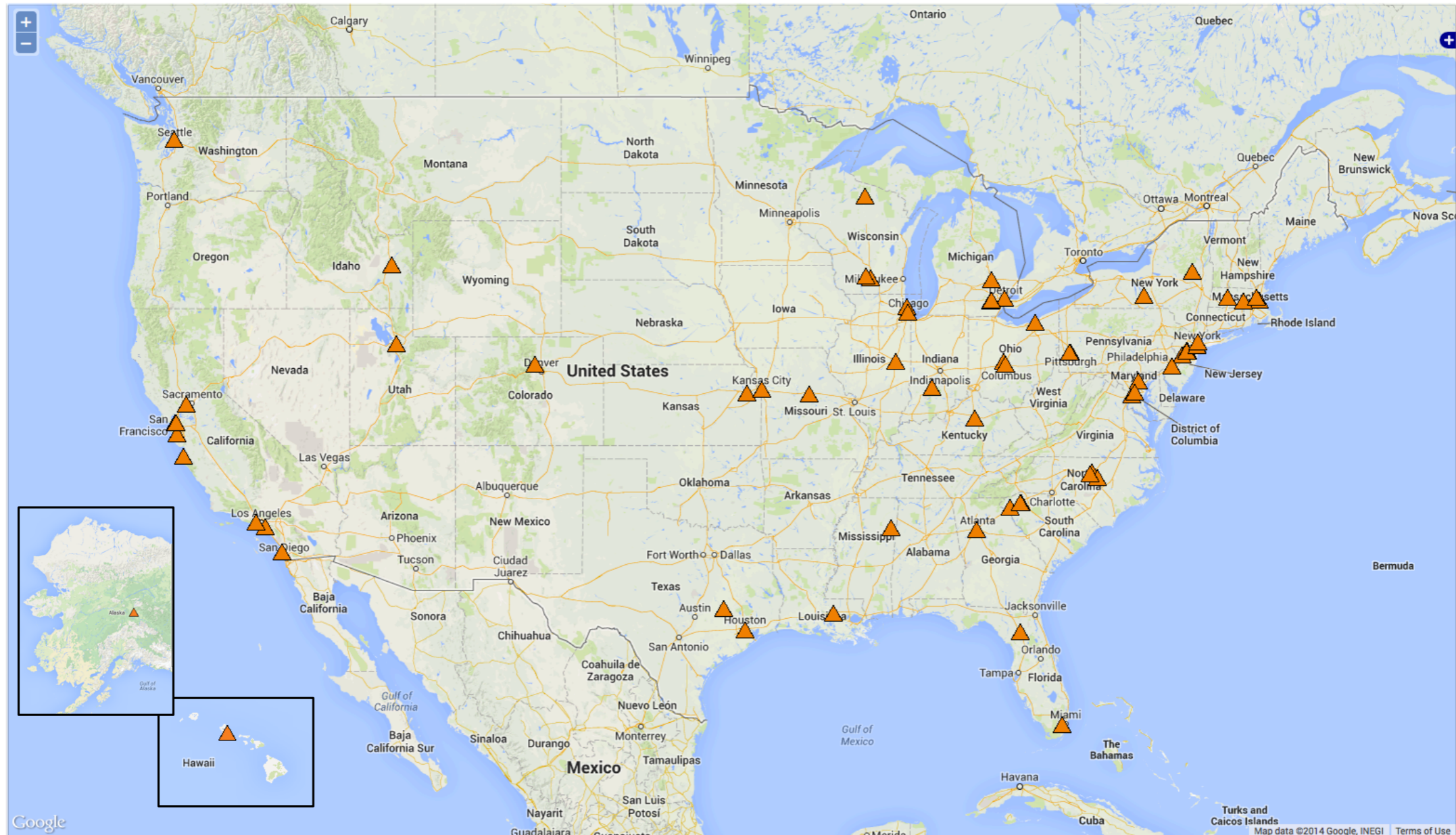
GENI is supporting hundreds of researchers and their experiments.



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## GENI's basic components

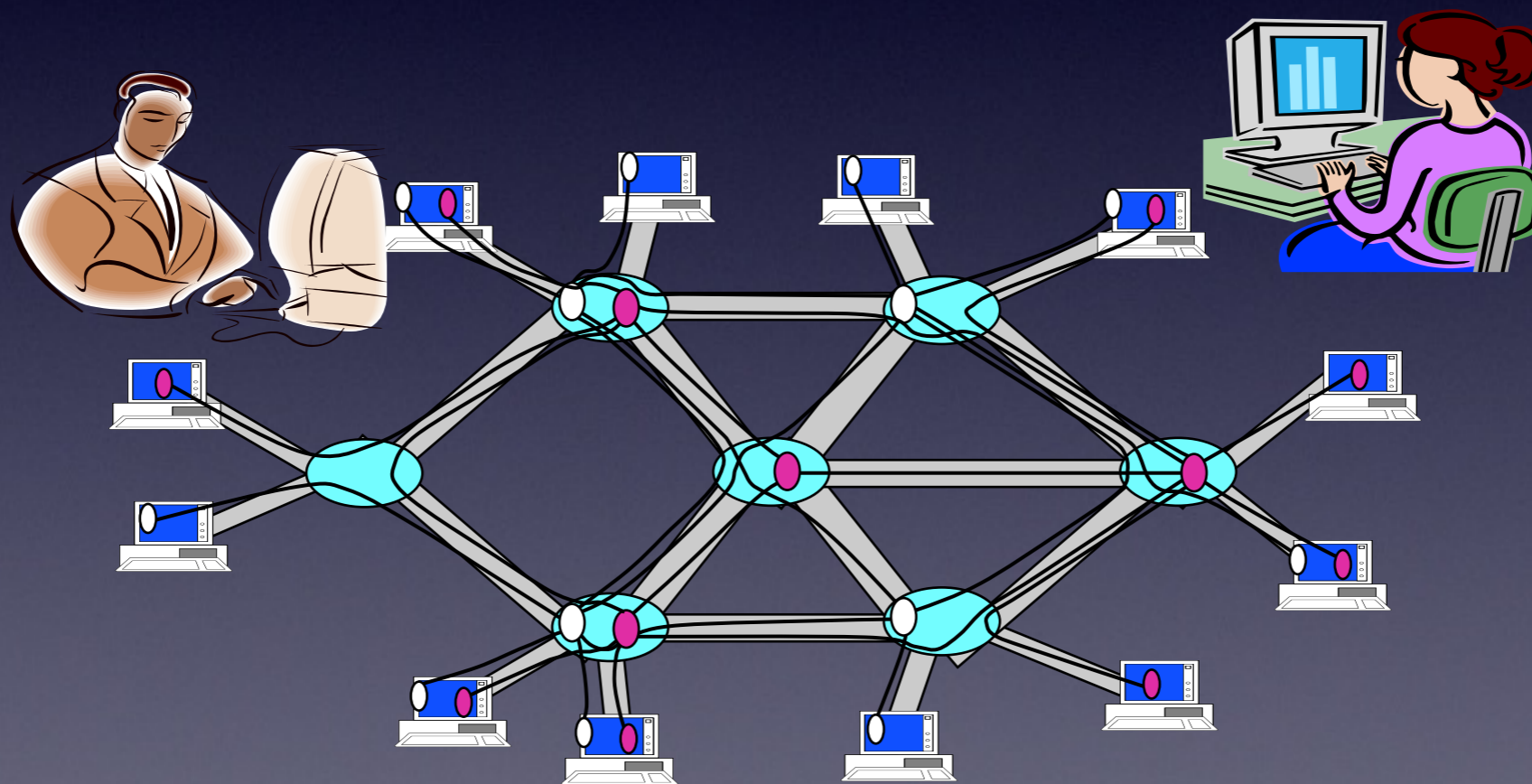
- GENI Racks - 58 racks in current deployment
- GENI Wireless - 26 base stations at 13 sites
- Core network - via Internet2

All are sliced and deeply programmable

# Two Key GENI Concepts

Install the software I want throughout my network slice  
(into firewalls, routers, clouds, ...)

And keep my slice isolated from your slice,  
so we don't interfere with each other



We can run many different “future  
Internets” in parallel.

Deep  
Programmability

Slicing

# Program Everything



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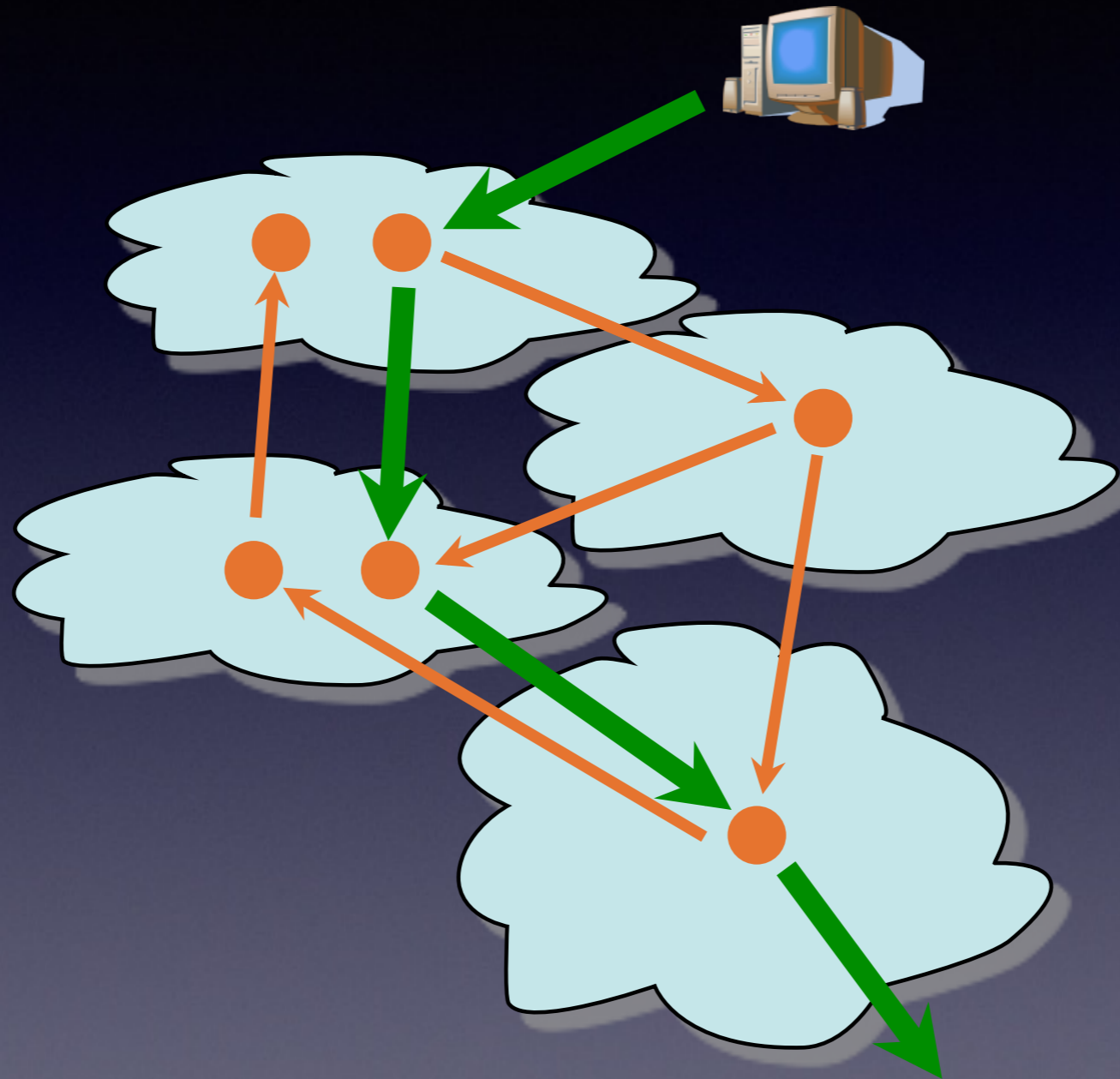


# Program Everything



Computers

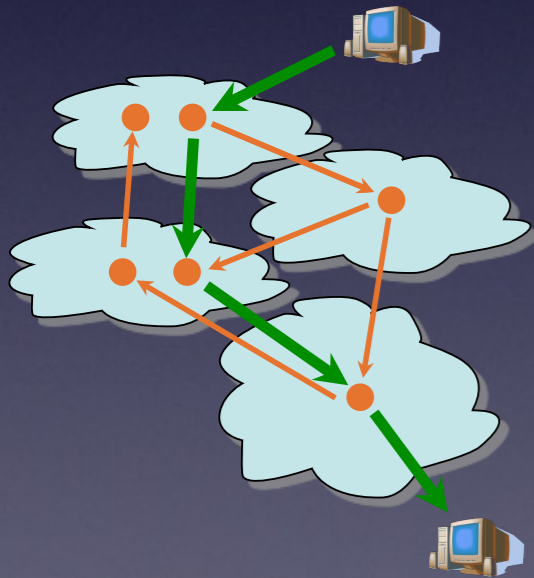
# Program Everything



Networks

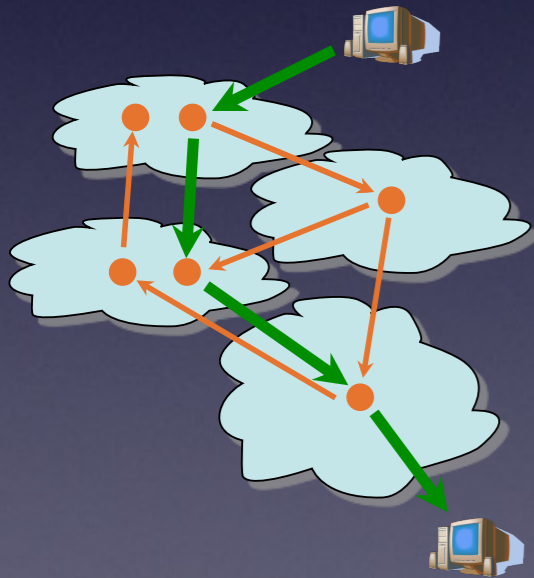


# Program Everything



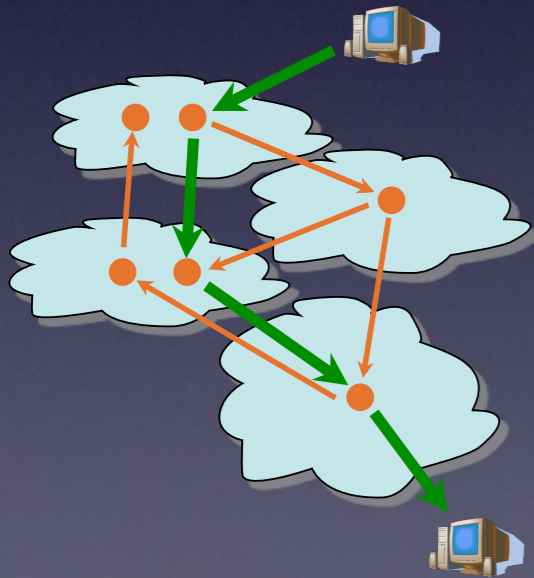
4G Cellular

# Program Everything



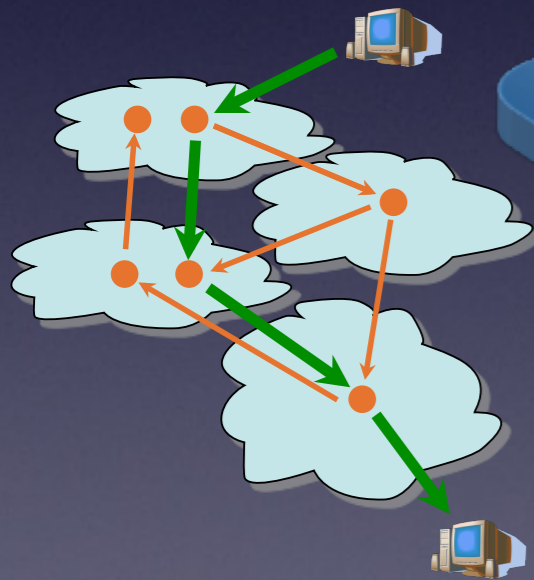
Clouds

# Program Everything

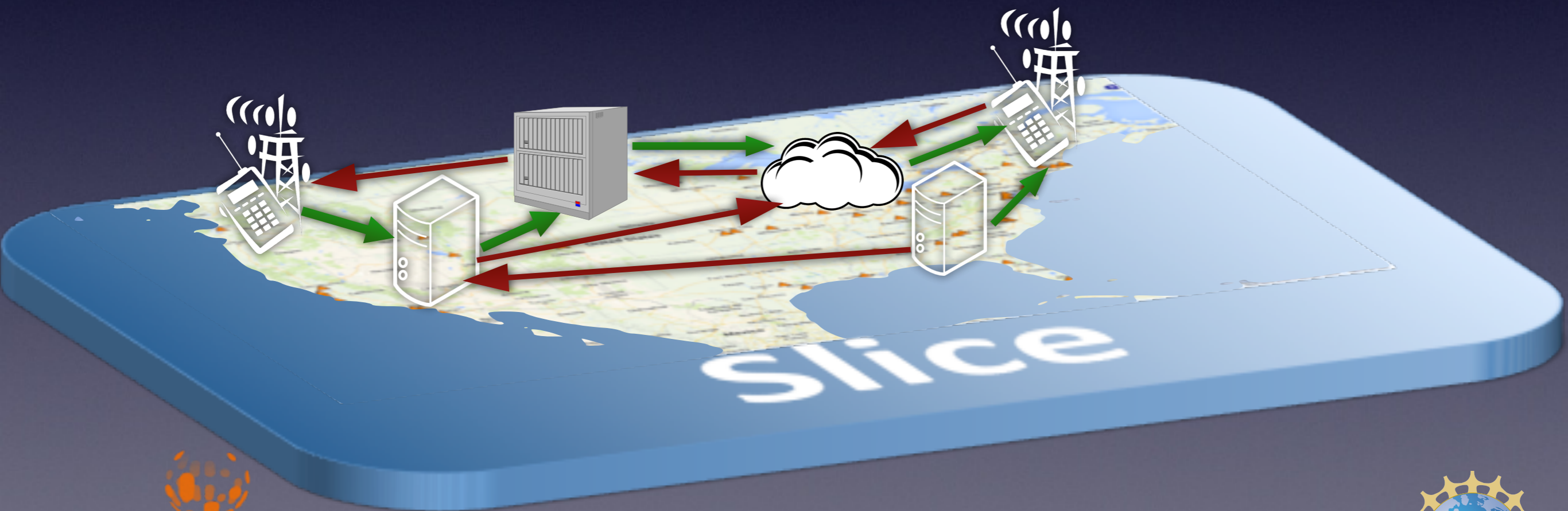




# Program Everything



# Program Everything



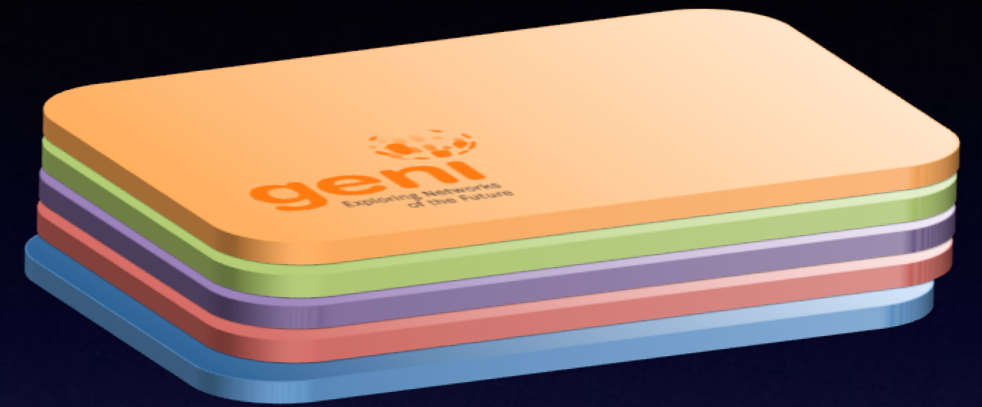
# Slicing and Deep Programmability Implementation Mechanisms



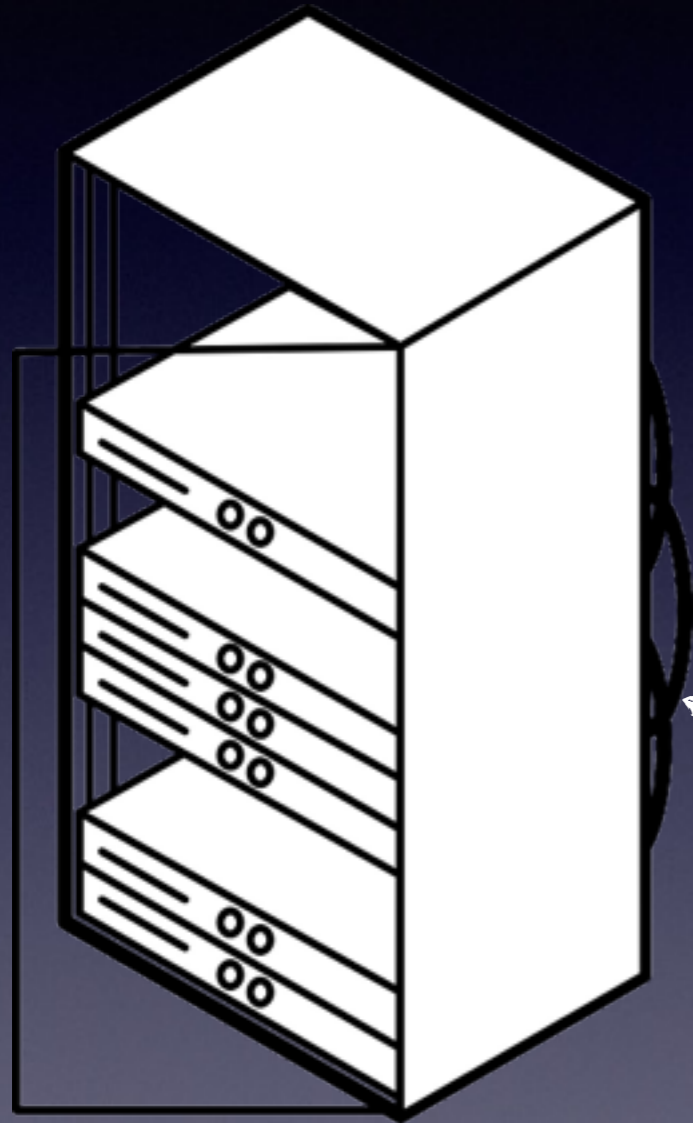
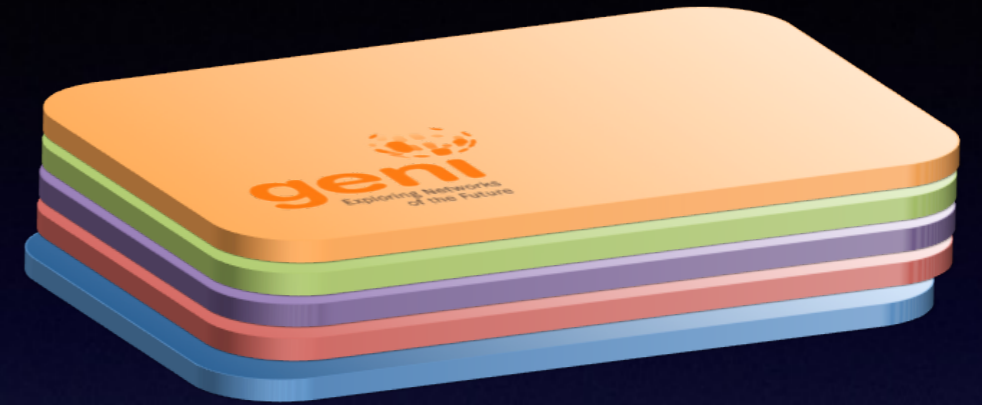
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# Slicing In a GENI Rack



# Slicing In a GENI Rack



GENI resources are grouped into aggregates, collections of resources under common management (usually at a single site).

# Slicing In a GENI Rack

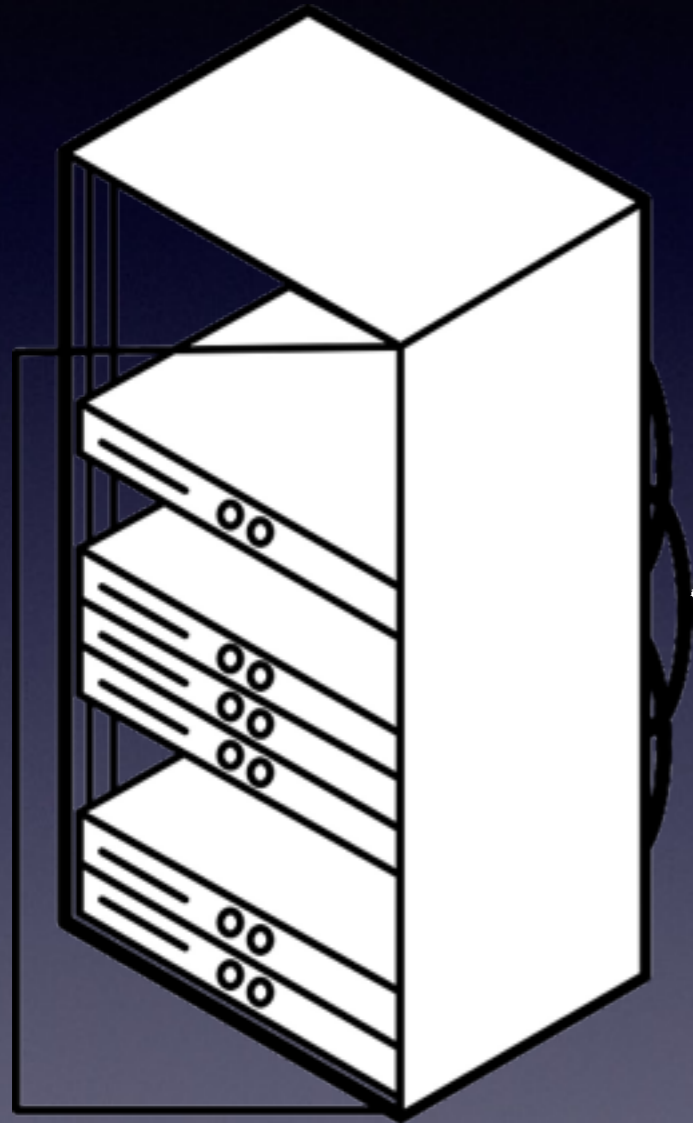


AM API ↓

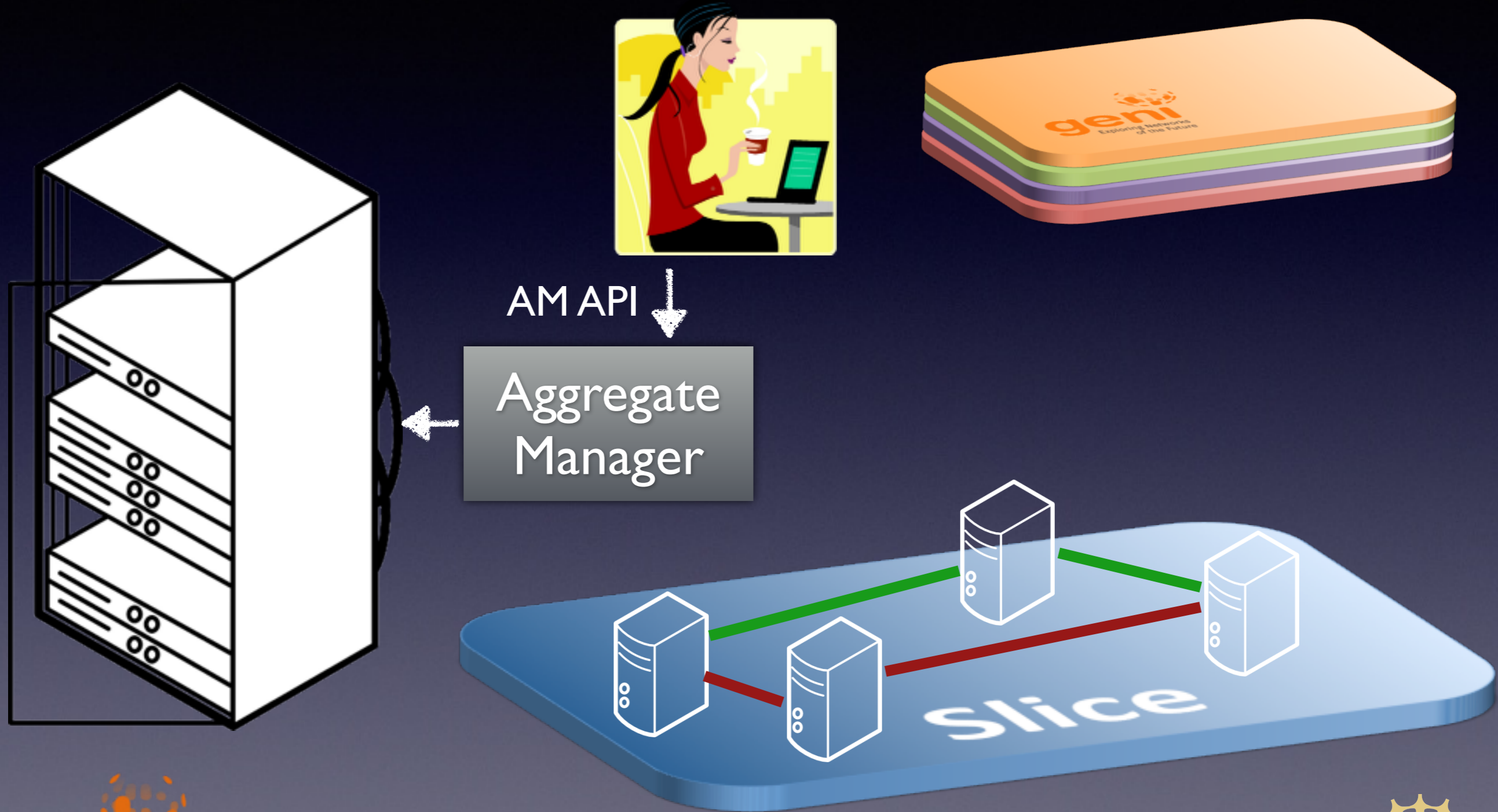
Aggregate  
Manager



Aggregate Managers  
(AM), one per aggregate,  
provision & configure all  
GENI resources



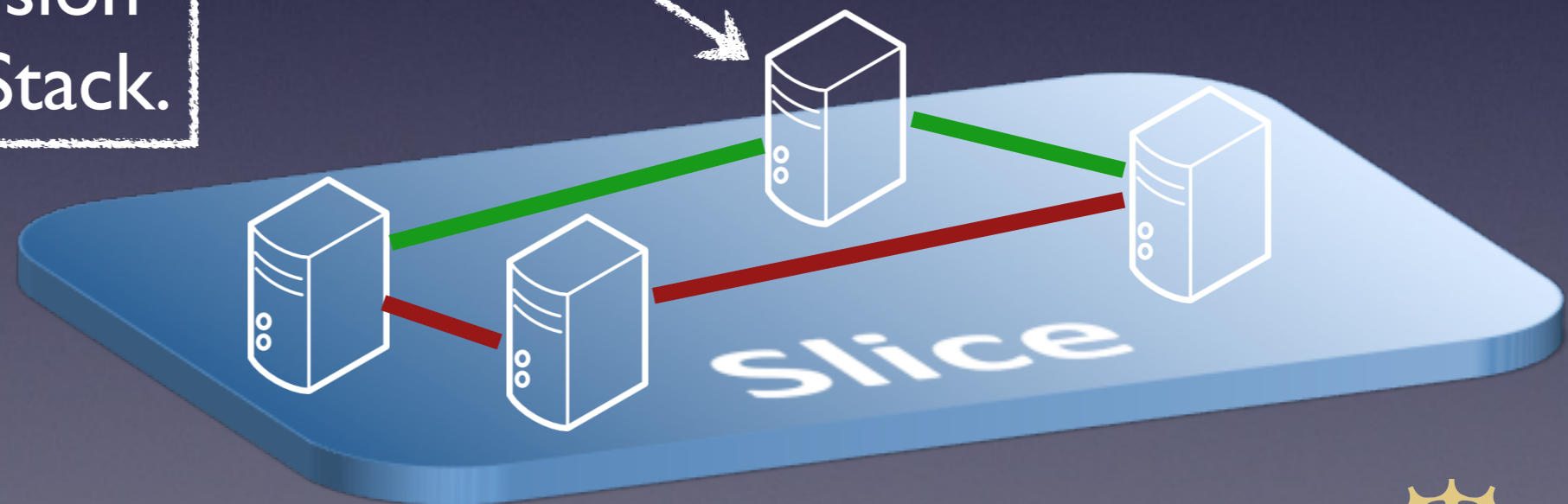
# Slicing In a GENI Rack



# Slicing In a GENI Rack

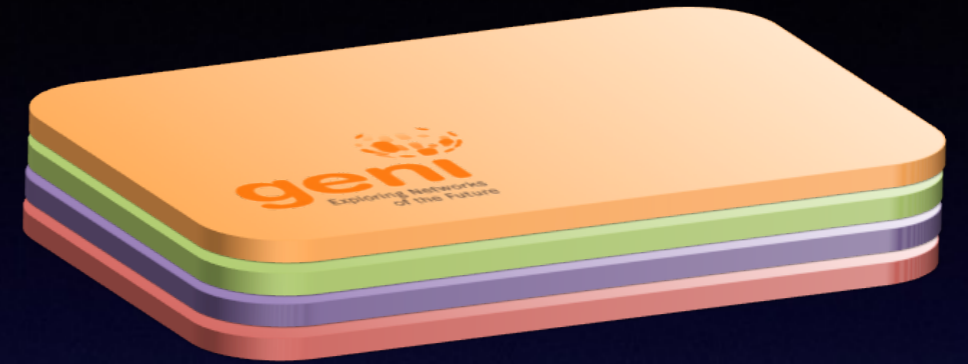
Compute resources may be “bare metal” or VMs.

Provisioning mechanism is an implementation choice.  
Current racks provision via Emulab or OpenStack.

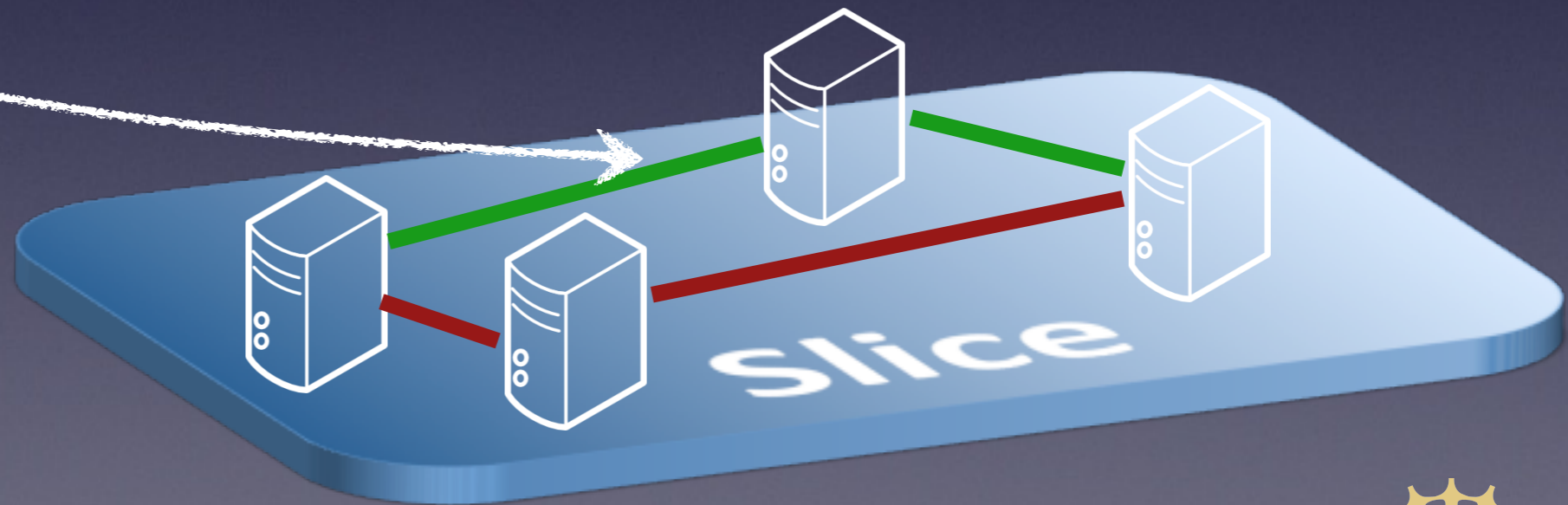




# Slicing In a GENI Rack



Within a rack, network is sliced by VLAN.



# Slicing GENI Wireless Resources



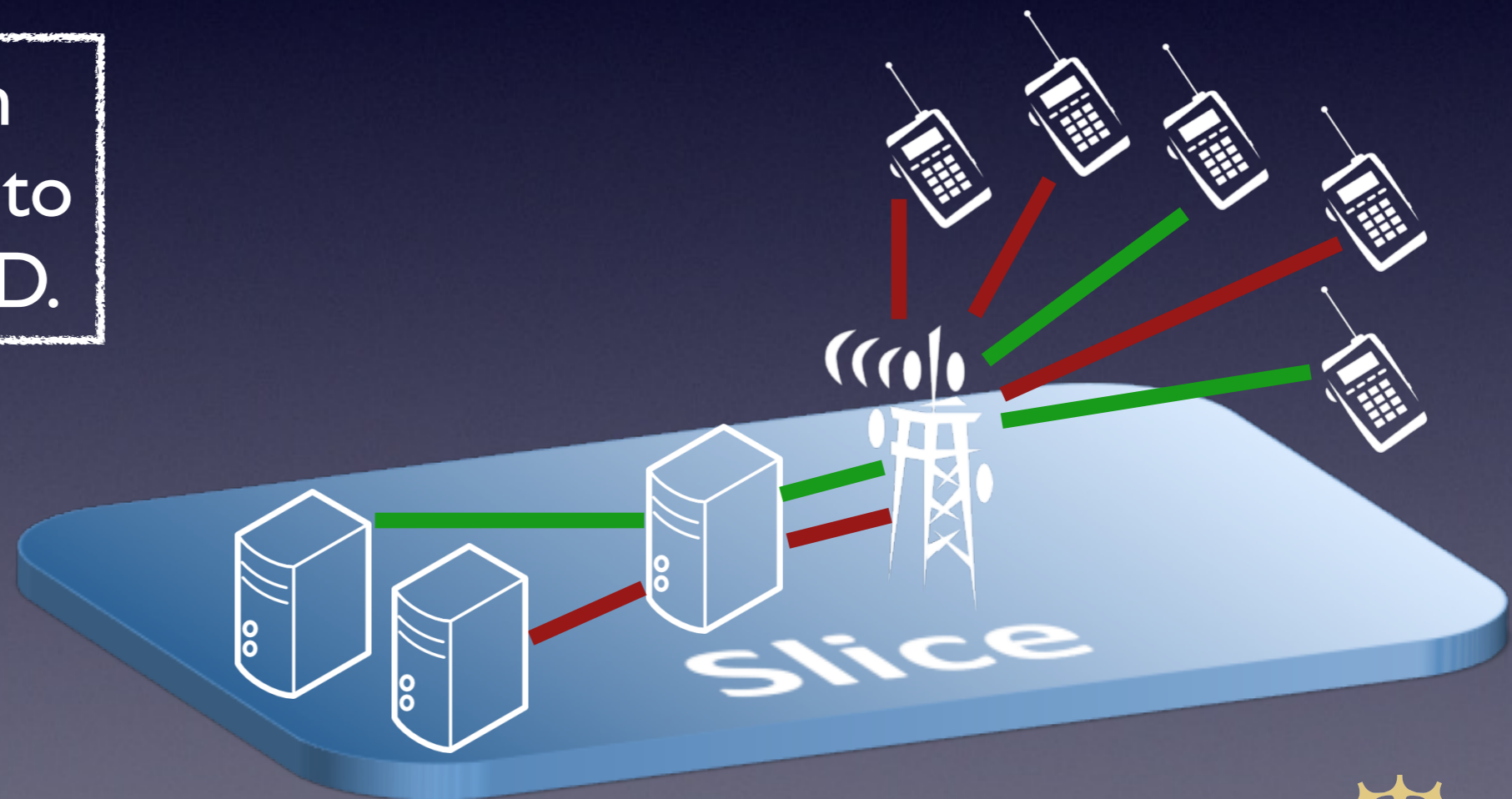
GENI wireless base stations  
are virtualized as well.



# Slicing GENI Wireless Resources



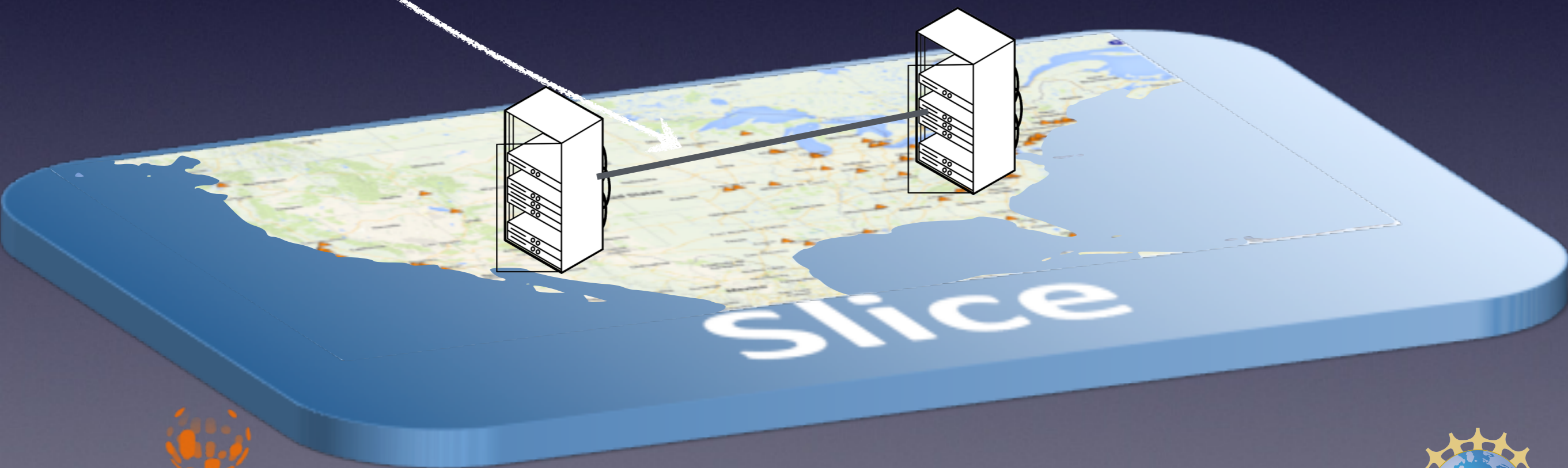
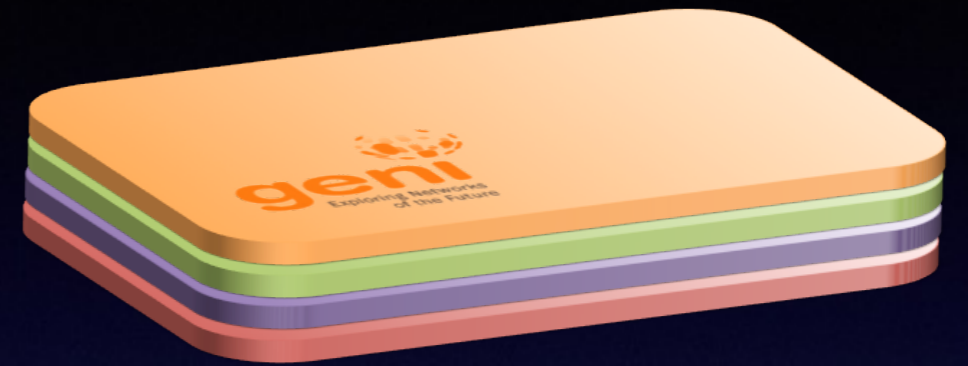
The base station maps each device to a slice by device ID.



# Slicing Across GENI

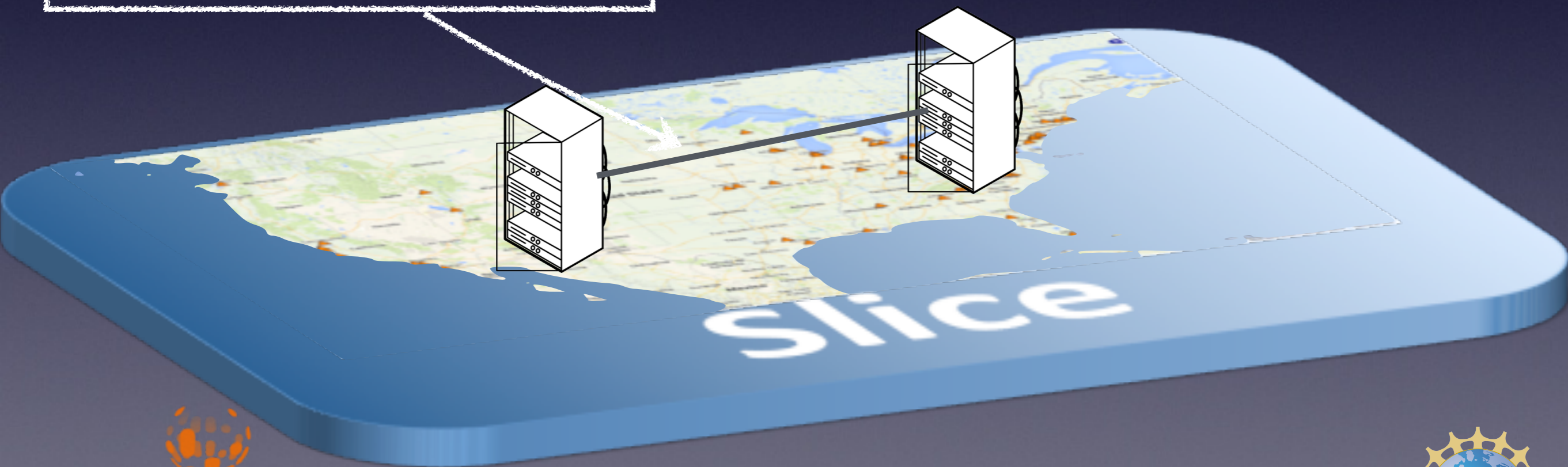
Between racks, network may be sliced by

- VLAN
- Dynamic circuit
- OpenFlow flowspace



# Slicing Across GENI

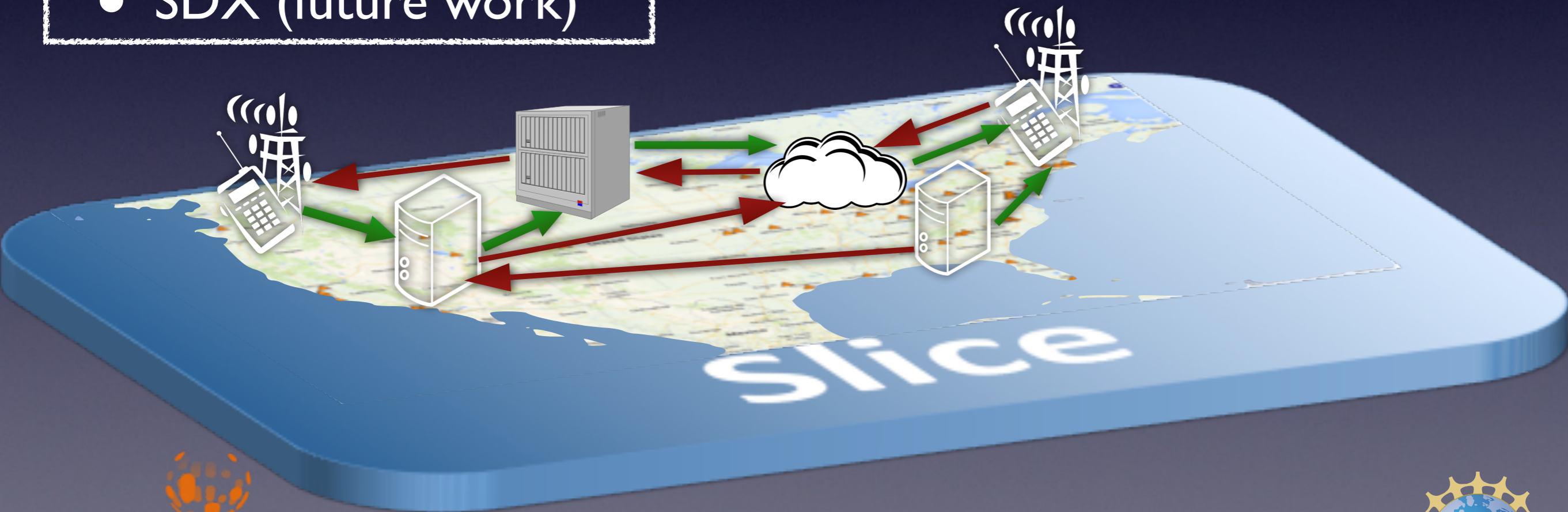
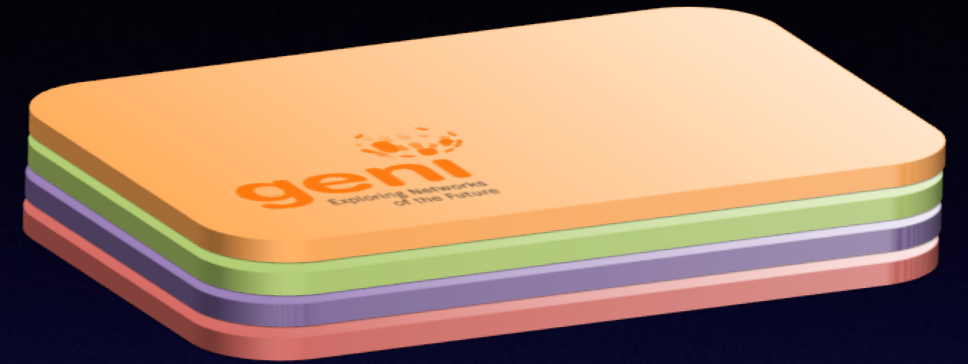
Initial flowspace slicing used FlowVisor, but simpler strategies meet experimenter needs, and are turning out to be more robust.



# Slicing Across GENI

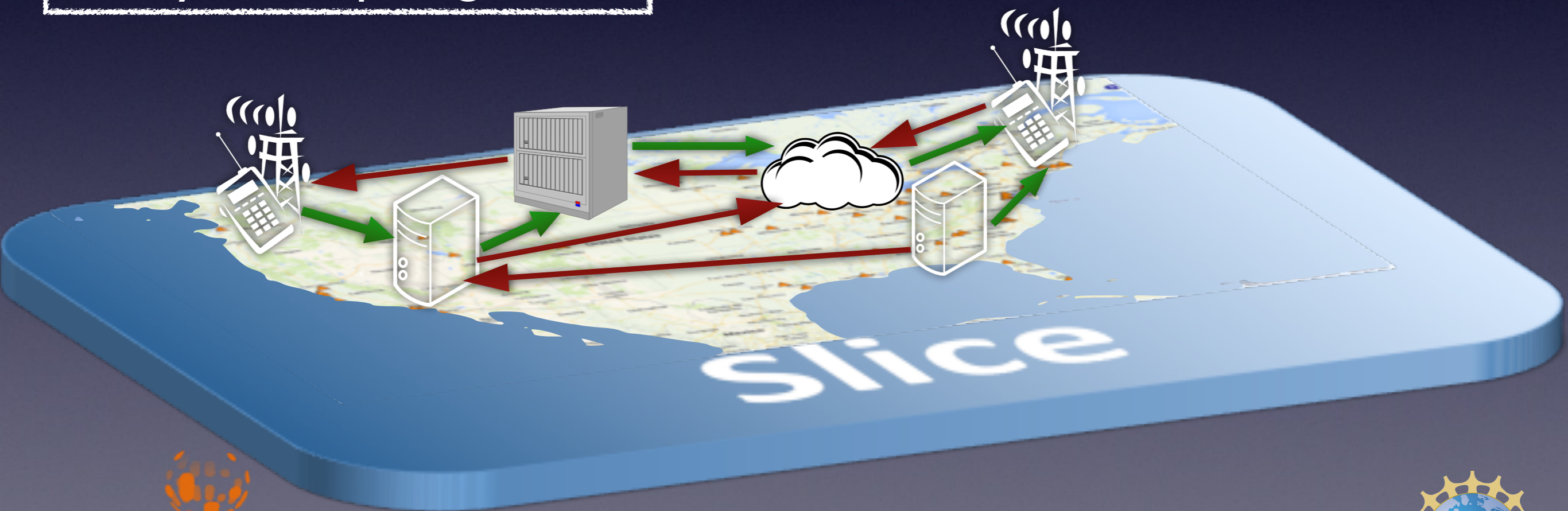
Slices are “stitched”  
across aggregates by

- VLAN translation
- SDN
- SDX (future work)



# Slicing Across GENI

GENI provides deeply programmable, wide-area, experimenter-specified layer 2 topologies.



# Key Capabilities in Core Network



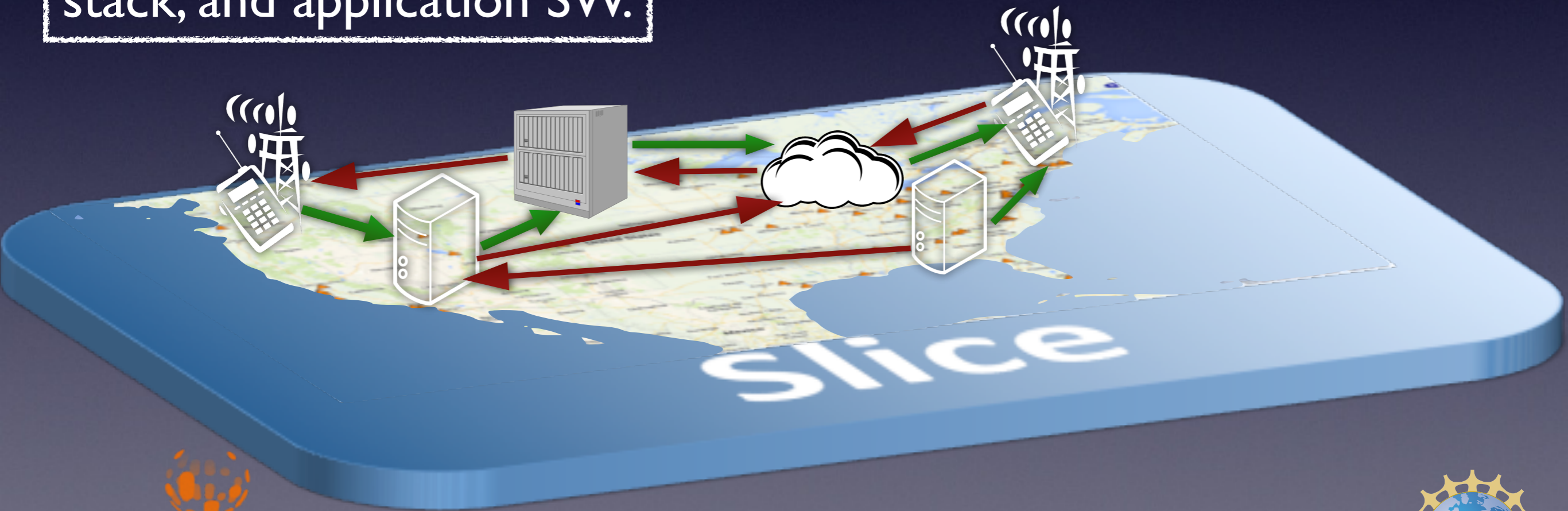
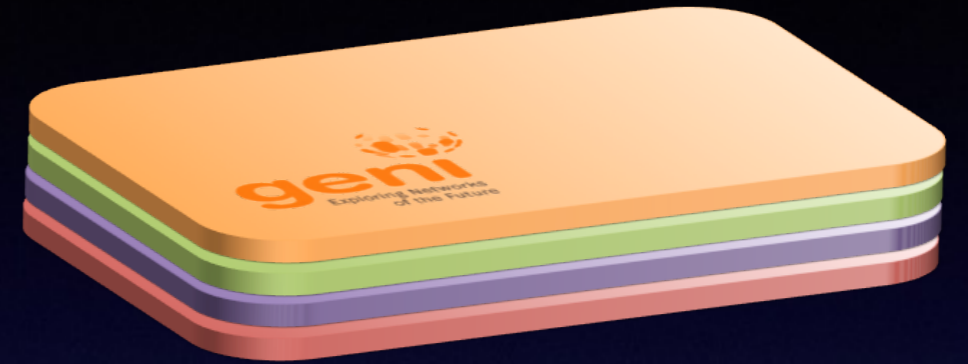
Collaboration with Internet2 to include key slicing and deep programmability capabilities in AL2S (Advanced Layer 2 Service), which uses OpenFlow natively

- AL2S OESS aggregate manager for dynamic virtual circuit provisioning to stitch slices
- Flow space firewall multiplexing OpenFlow controller proxy for deep programmability down to core network switches



# Deep Programmability - Compute

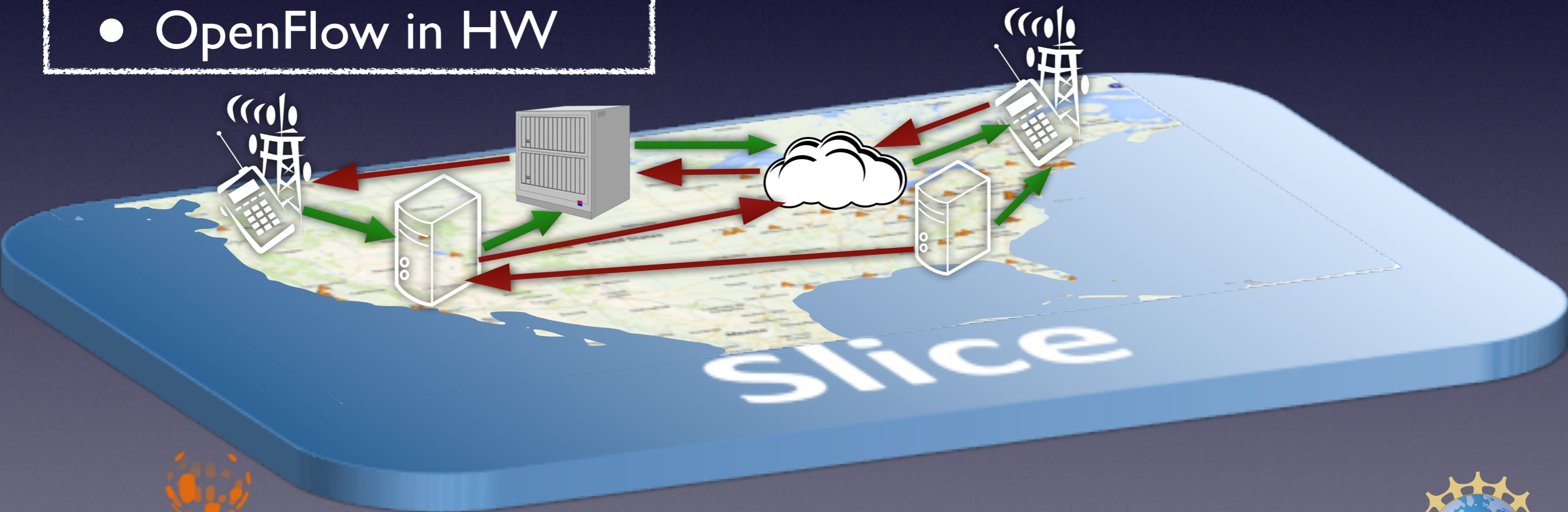
Experimenter has full access to program compute resources, including OS, network stack, and application SW.



# Deep Programmability - Network

## Network programming

- IP & non-IP protocols
- Software routers (e.g., Click)
- Open Virtual Switch
- OpenFlow in HW



# Program Everything

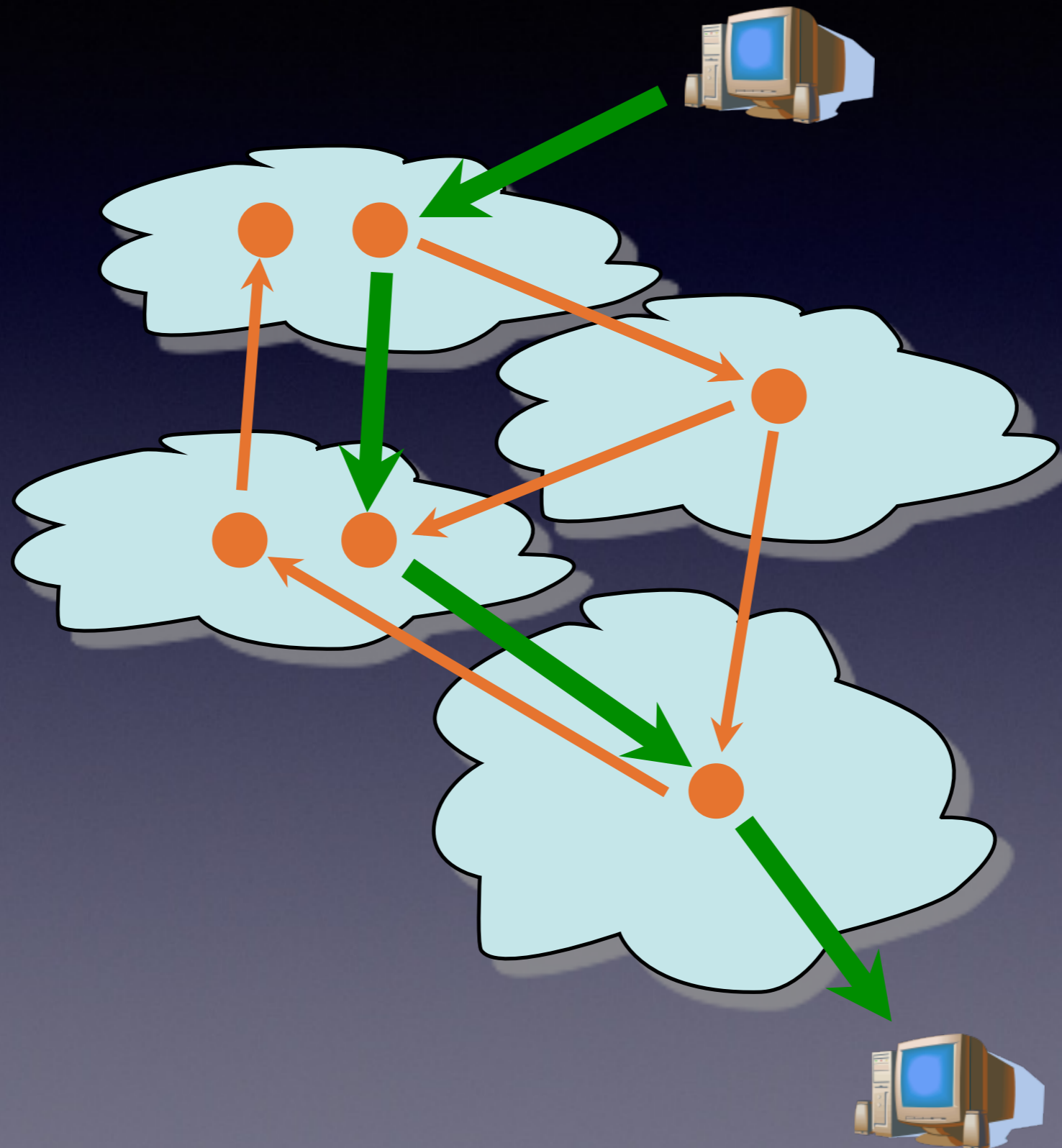
## Research Examples



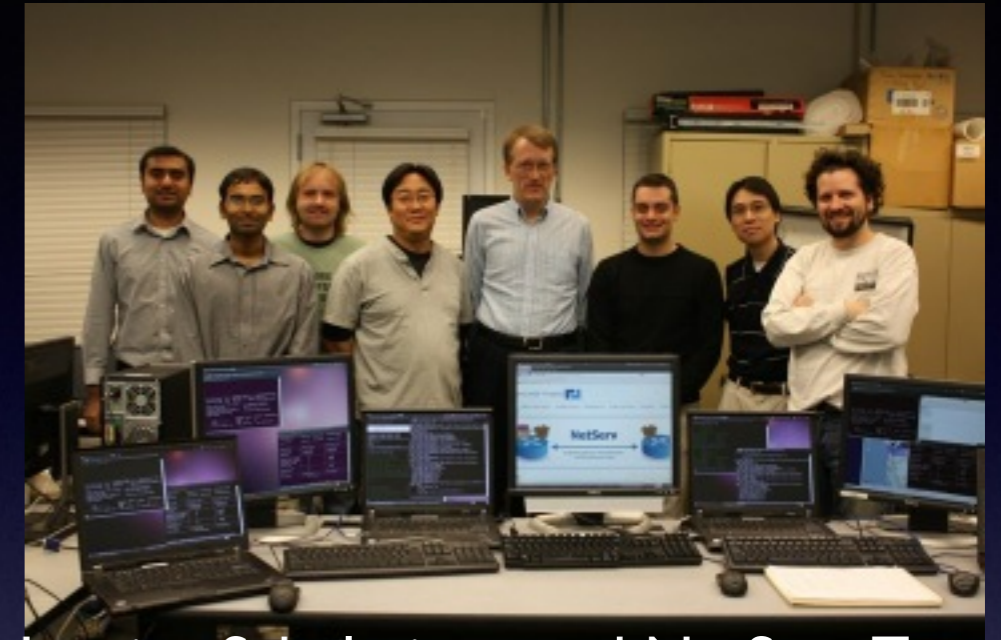
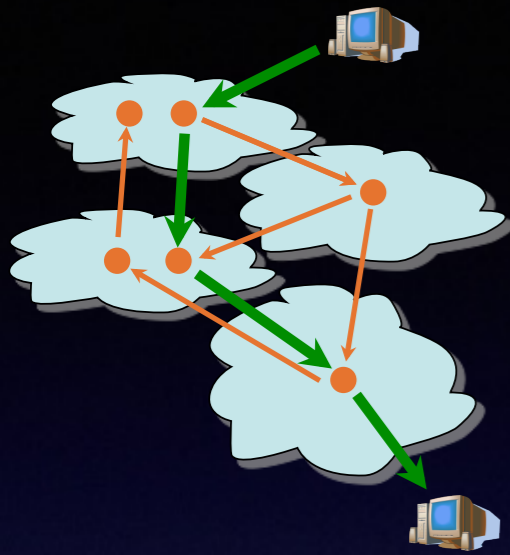
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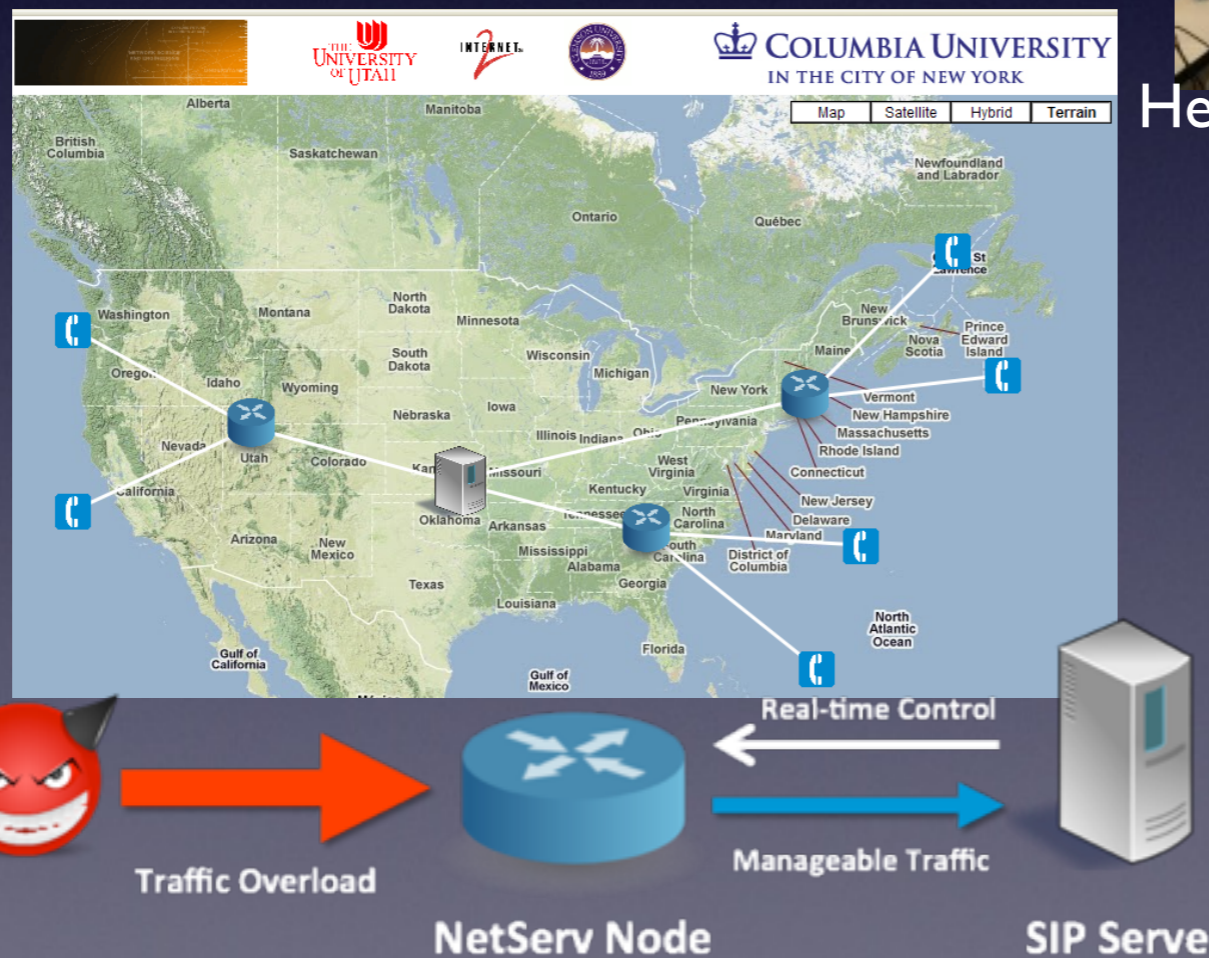
# Program Everything



# Program Everything



Henning Schulzrinne and NetServ Team, Columbia University



# Program Everything



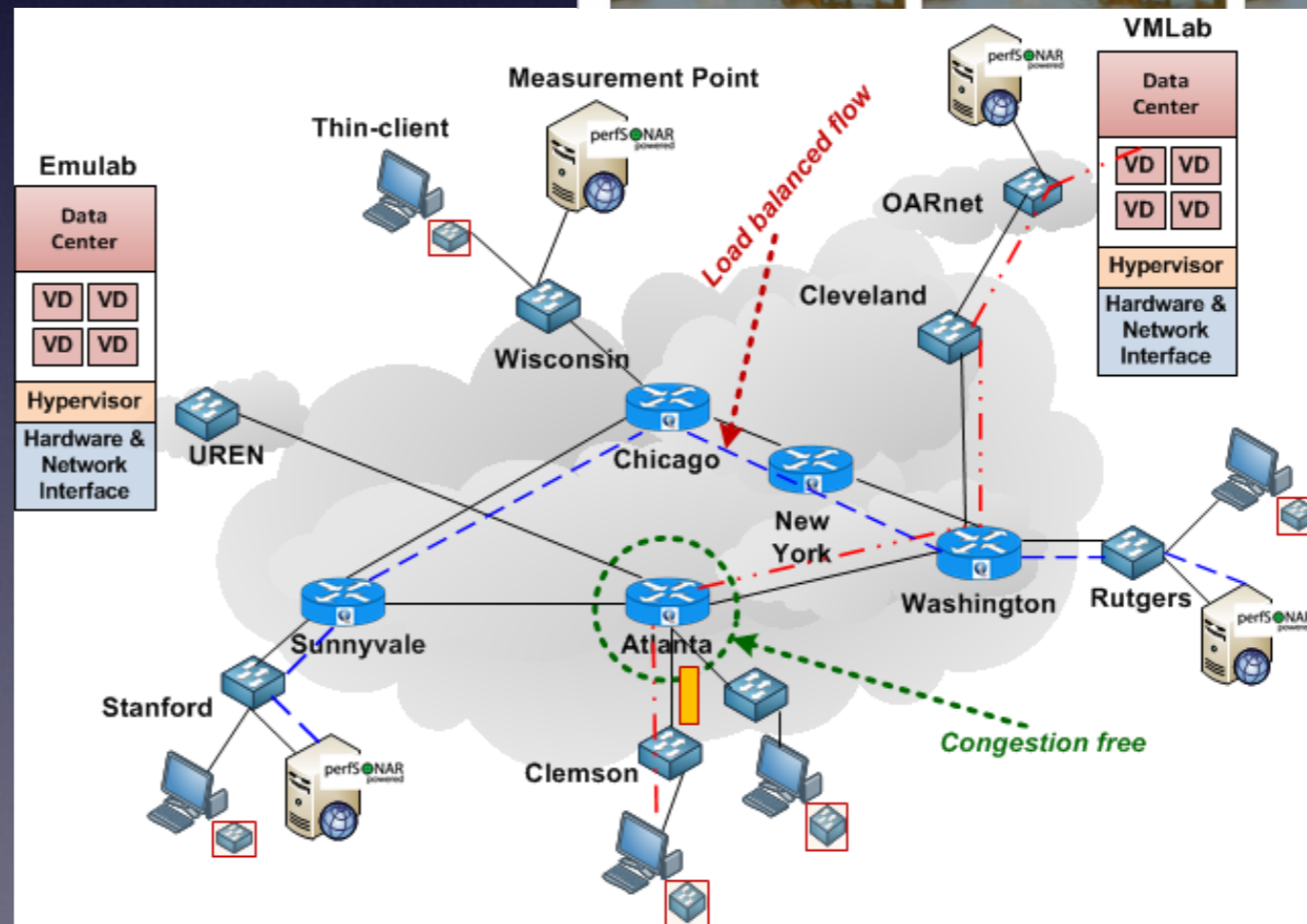
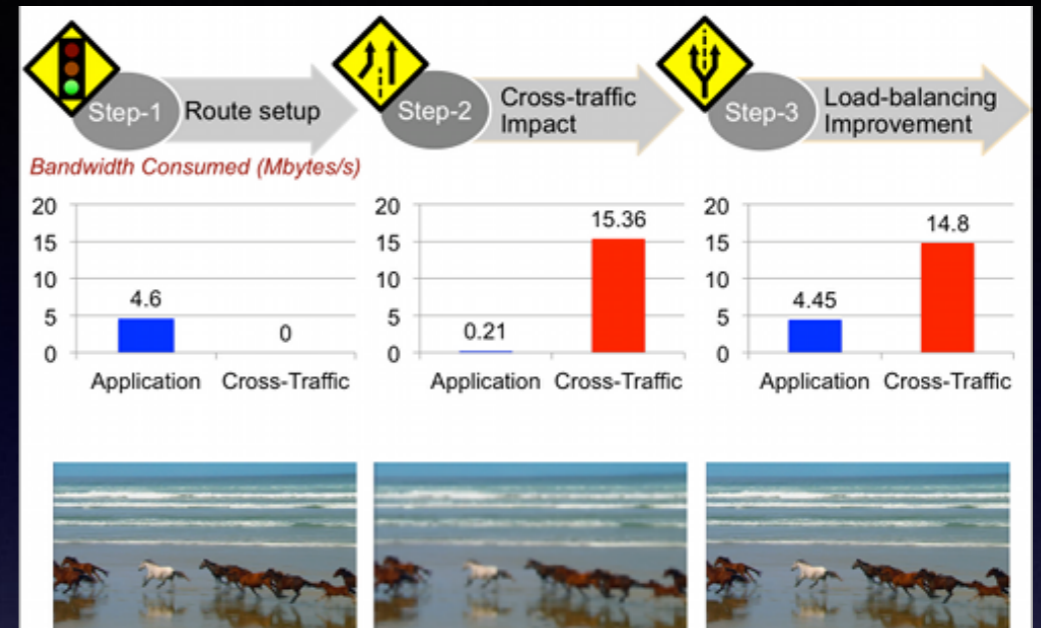
# Program Everything



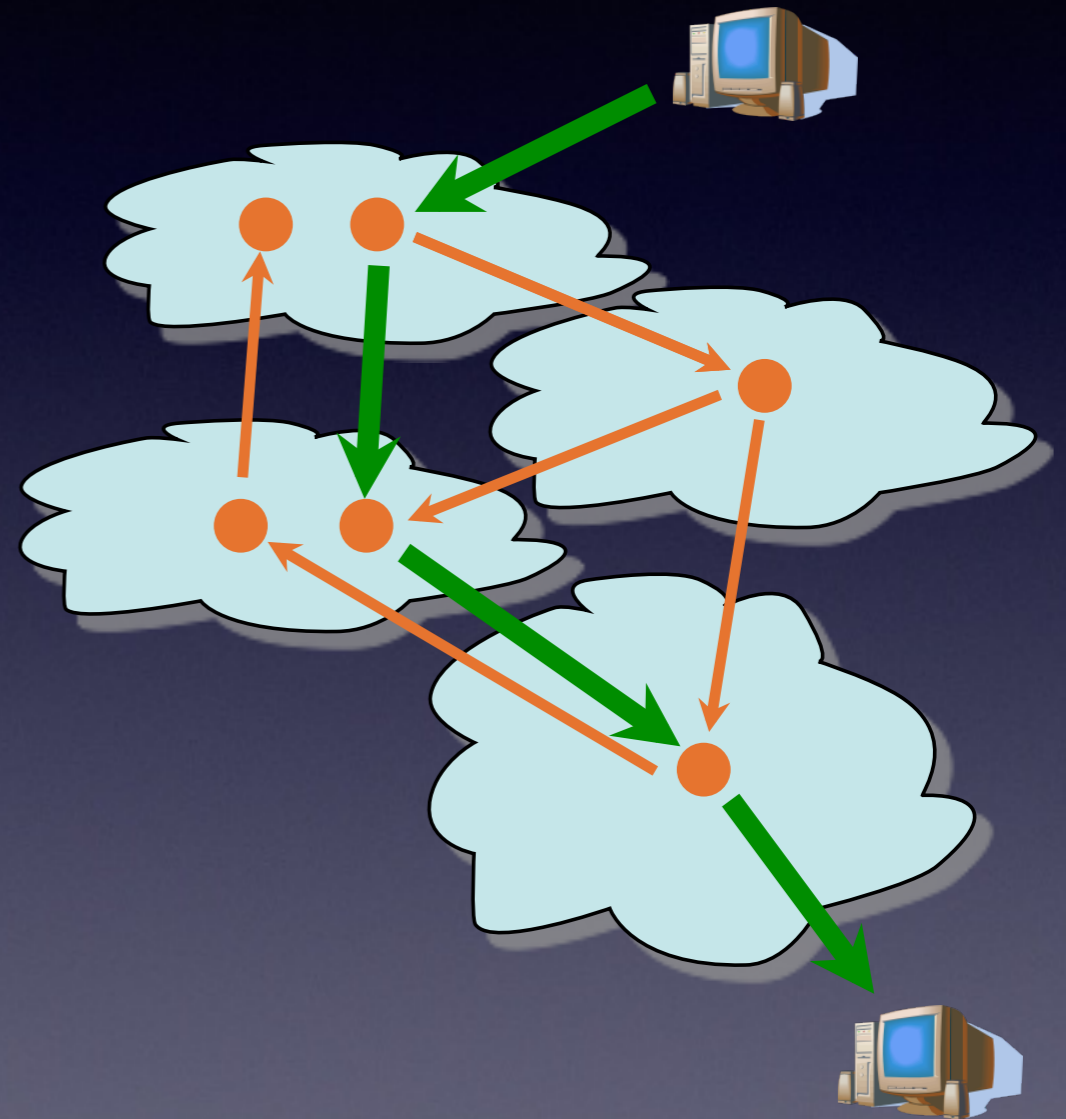
## Virtual Desktop Clouds



Prasad Calyam, University of Missouri - Columbia

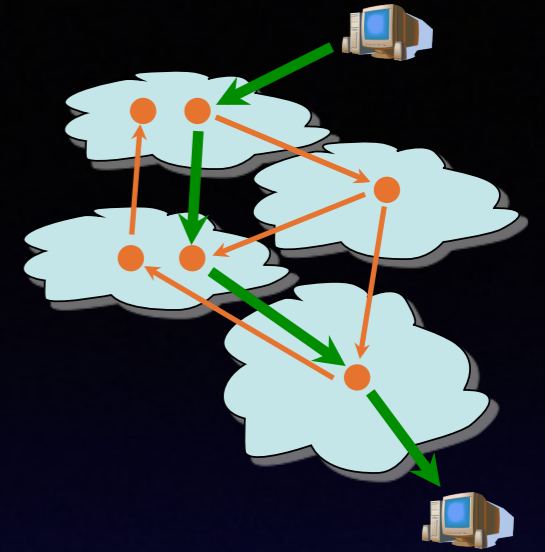


# Program Everything

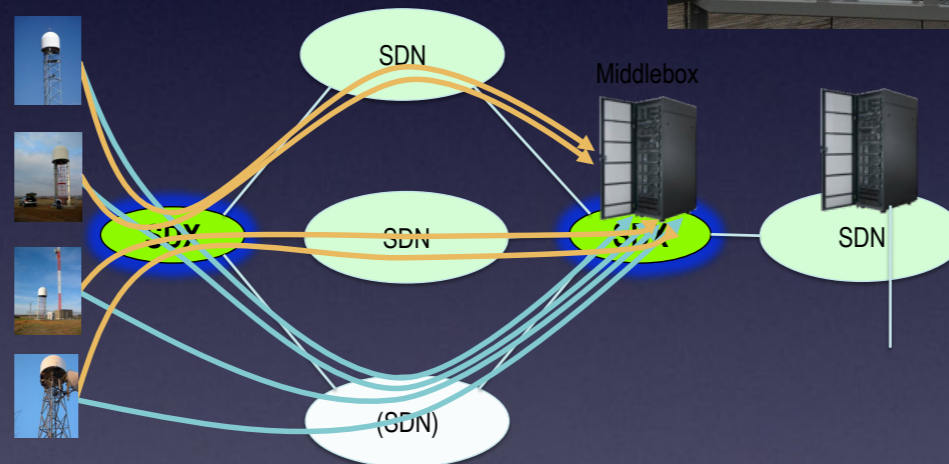




# Program Everything

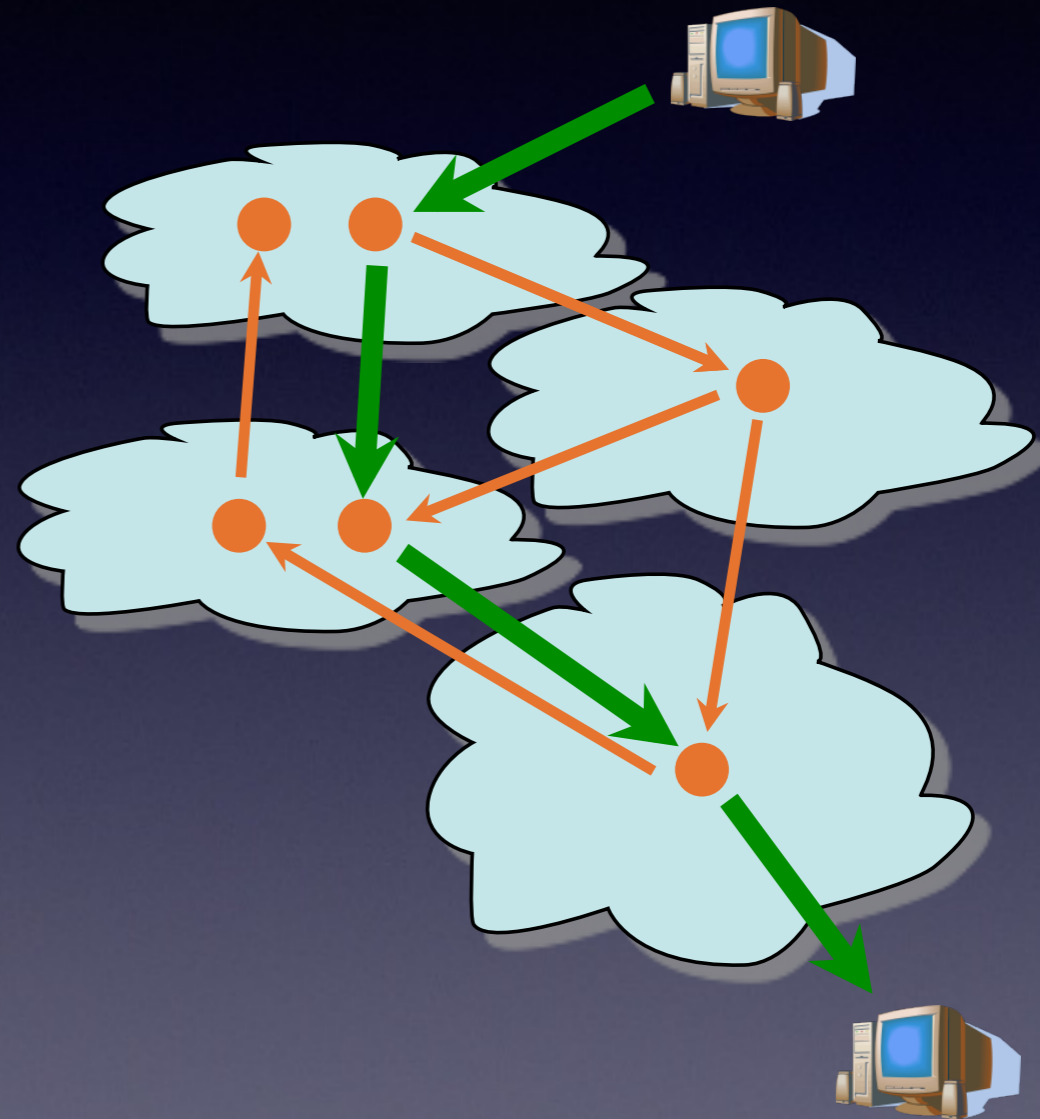


Michael Zink, University of Massachusetts - Amherst

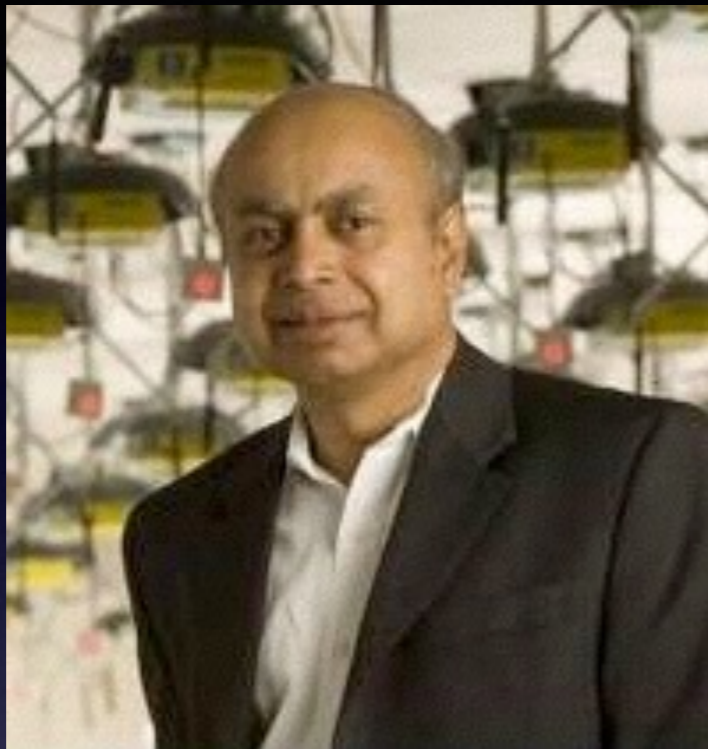


Using SDX to Enable Short-Term Severe Weather "Nowcast" Service

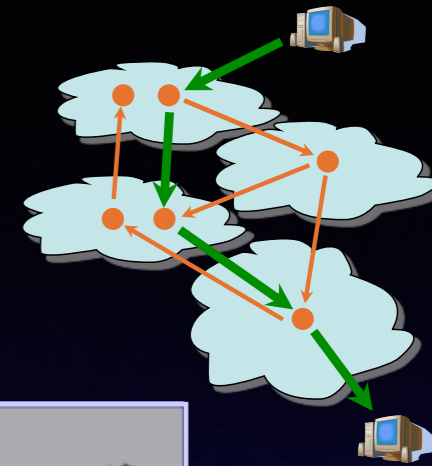
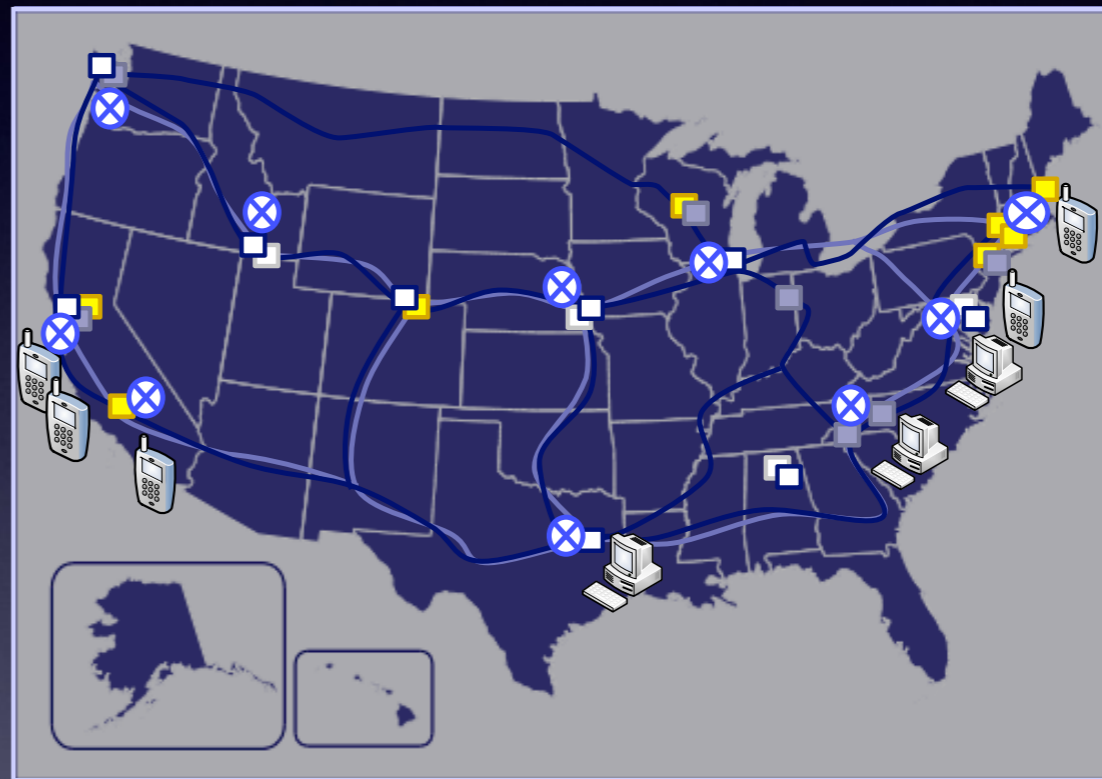
# Program Everything



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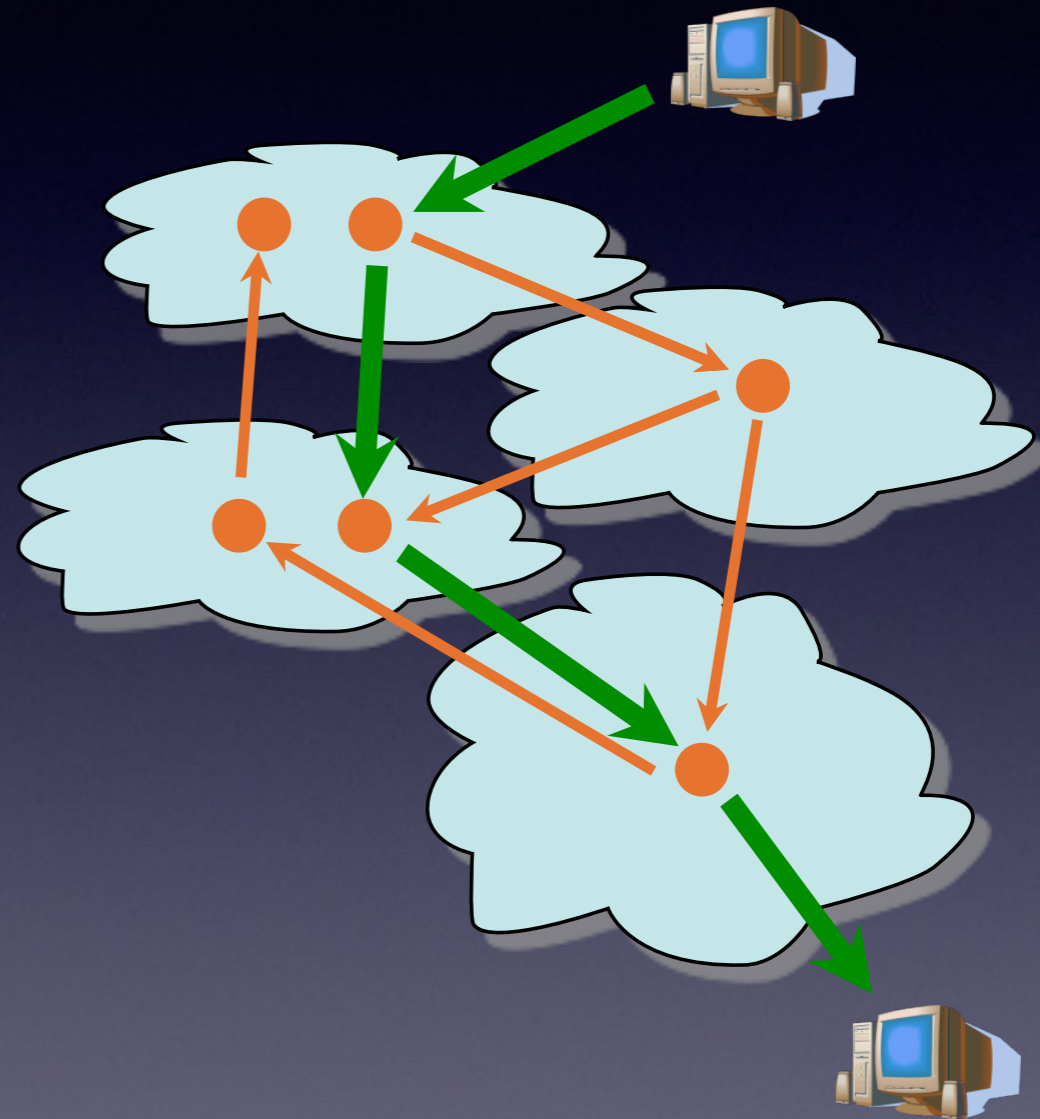


Dipankar (Ray) Raychaudhuri,  
Rutgers University

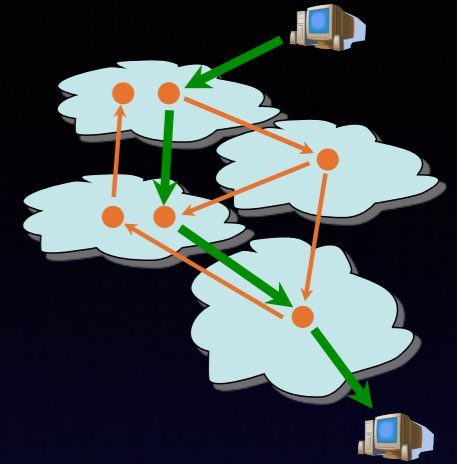


MobilityFirst scalable future  
Internet architecture for  
emerging mobility services

# Program Everything



# Program Everything



Thanasis Korakis and Fraida Fund,  
NYU Polytechnic

“Classroom as a service”  
virtual wireless networking lab

# What's next?



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# What's next?

Two upcoming trends in Future Internet and Distributed Cloud (FIDC) Testbeds:

- Software Defined eXchanges (SDX) & Infrastructure (SDI)
- International federation of FIDC testbeds



Chip Elliott will discuss SDX in his talk.

# What's next?

Two upcoming trends in Future Internet and Distributed Cloud (FIDC) Testbeds:

- Software Defined eXchanges (SDX) & Infrastructure (SDI)
- International federation of FIDC testbeds

Let's look quickly at some federation activities.



# A Few (Possibly Obvious) Observations Motivating Federation

GENI is not the only project pursuing these goals

- Many national / regional-scale FIDC testbeds in progress
- There is strong overlap in basic concepts

Federating testbeds is in all our best interests

- Experimenters want access to resources around the world
- Federation extends the reach of experimenters in each cooperating region
- Federation preserves the unique capabilities of participating testbeds

# Current International Federation Activities

## An Emerging FIDC Testbed Federation



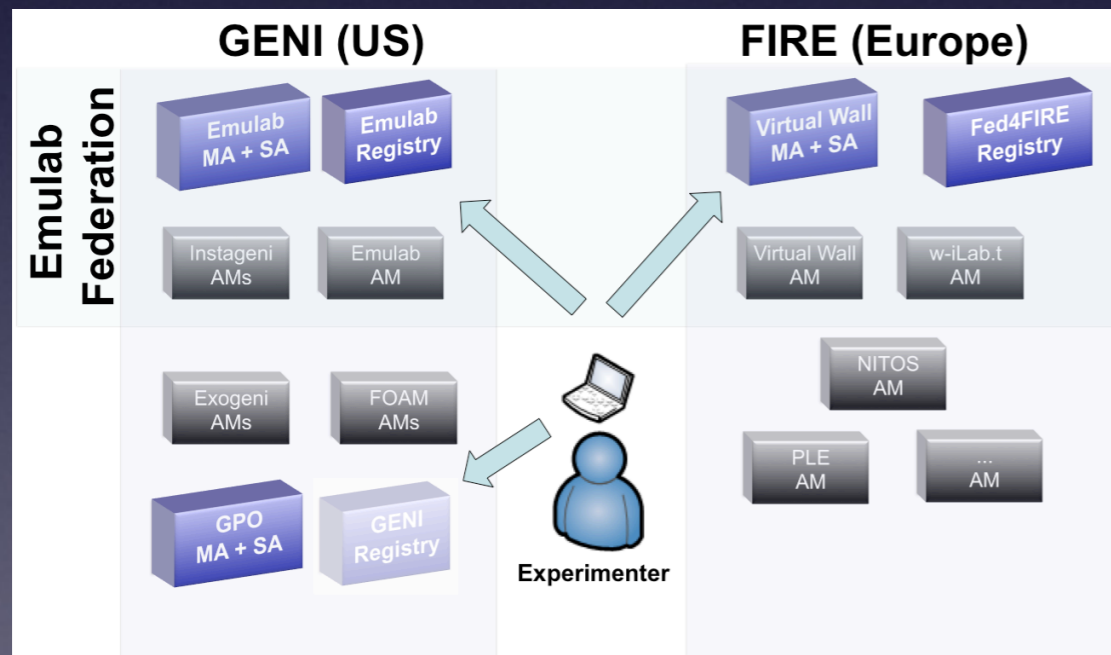
Early federation  
participants

Discussions began summer 2013 to define control and data plane federation approach and stand up multi-lateral federation infrastructure.

# Federation Is Progressing Quickly

International federation API for clearinghouse functions

- Joint EU / US capability up and running, with shared access to resources from FIRE and GENI



International Federation Monitoring

Testbed Name	Ping latency (ms)	GetVersion Status	Free Resources
FIU PGv1	unreachable	not ok	not ok
InstaGeni BBN	91.75	ok	0
InstaGeni Clemson	137.47	ok	0
InstaGeni GATech	134.49	ok	0
InstaGeni Illinois	154.69	ok	0
InstaGeni Kettering	167.36	ok	0
InstaGeni MAX	100.19	ok	0
InstaGeni Missouri	152.4	ok	0
InstaGeni NorthWestern	172.11	ok	0
InstaGeni Nysernet	98.48	ok	0
InstaGeni Princeton	102.79	ok	0
InstaGeni SOX Atlanta	134.86	ok	0
InstaGeni Uky	146.76	ok	0
InstaGeni Utah DDC	156.21	ok	0
ION internet2 AM	129.58	not ok	not ok
KetteringU emulab	167.51	ok	0
Larc Usp Brazil	unreachable	not ok	not ok
LSU CRON	164.05	ok	0
NYU genirack	93.61	ok	0
Orca BBN SM	92.74	ok	3
Orca Duke SM	114.16	ok	3
Orca ExoSM	114.45	ok	42
Orca FIU SM	148.3	ok	3
Orca NICTA SM	300.36	ok	3
Orca OSF SM	161.72	ok	2

Image courtesy Brecht Vermeulen, iMinds

# Worldwide Growth in FIDC Testbeds



National/regional  
FIDC testbed activity.

Building a multi-national group of FIDC testbeds,  
seeking new partners, working from a basis of equality  
to expand opportunities for researchers worldwide.

# How You Can Get Involved

Your participation is invited in GENI and in the developing international federation of FIDC testbeds.

- GENI is available at no charge to research users:  
[geni.net/experiment](http://geni.net/experiment)
- GENI rack designs available on web site
- Open source implementations of AMs and other key software are available
- Try a GENI Engineering Conference - next are Oct. (Indiana) and March 2015 (Washington DC)

Contact [help@geni.net](mailto:help@geni.net) with questions

Thank you for your interest.

Questions?

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