geni
Exploring Networks of the Future

Ramping Up Experiments in GENI

Mark Berman

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www.geni.net

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Panel: GENI Update

- Mark Berman (GENI Project Office, Cambridge)
  - Ramping Up Experiments in GENI
- Rick McGeer (HP Labs, Palo Alto)
  - TRANSCLOUD: Design Considerations for a High-Performance Cloud Architecture Across Multiple Administrative Domains
- James Sterbenz (University of Kansas, Lawrence)
  - Resilience Experiments in the GpENI Programmable Future Internet Testbed
- Michael Zink (University of Massachusetts, Amherst)
  - NowCasting: UMass/CASA Weather Radar Demonstration
- Additional Discussion

Outline

- GENI – Exploring future internets at scale
- Introducing GENI: an example
- What's new for experimenters
- Experiments going live!
- Ramping up GENI support for experimenters

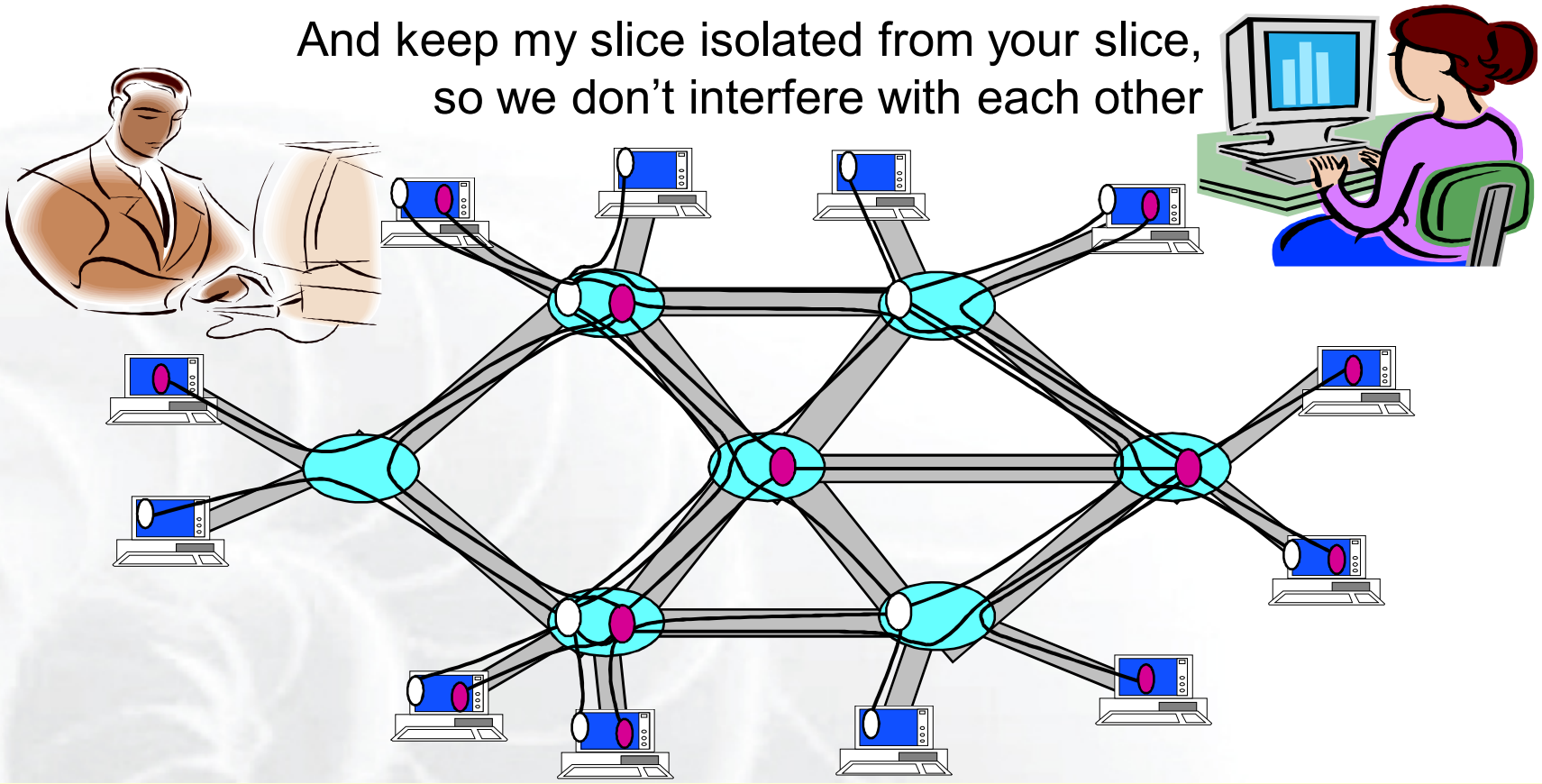
What is GENI?

- GENI is a virtual laboratory for **exploring future internets at scale**, now rapidly taking shape in prototype form across the United States
- GENI opens up huge new opportunities
  - **Leading-edge research** in next-generation internets
  - **Rapid innovation** in novel, large-scale services
- Key GENI concept: slices & deep programmability
  - Internet: open innovation in application programs
  - GENI: open innovation deep into the network

Slices and Deep Programmability

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

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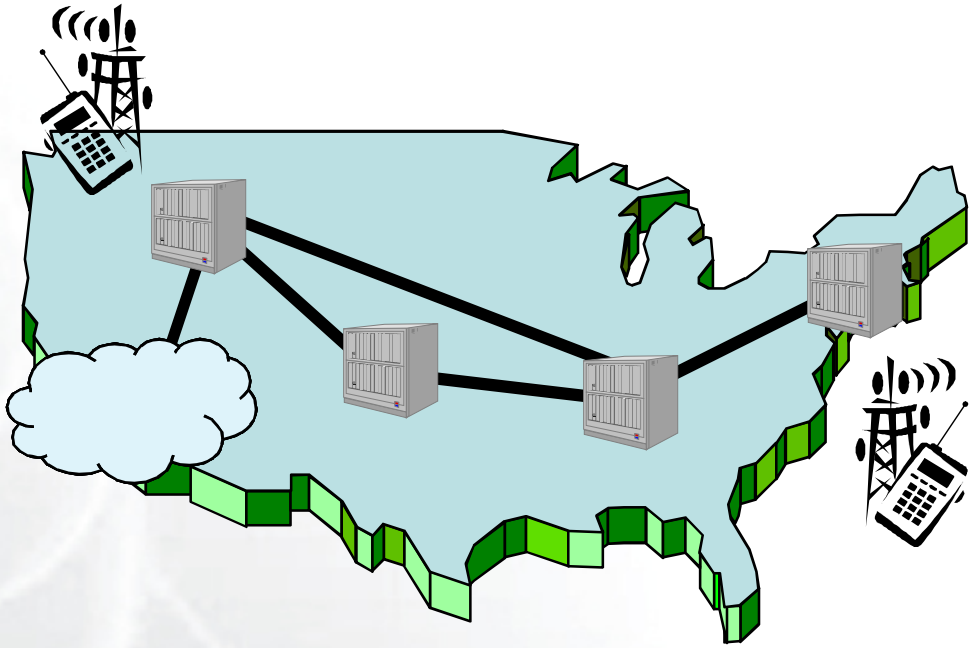
A bright idea

I have a great idea! The original Internet architecture was designed to connect one computer to another – but a better architecture would be fundamentally based on PEOPLE and CONTENT!

That will never work! It won't scale! What about security? It's impossible to implement or operate! Show me!

Trying it out

My new architecture worked great in the lab, so now I'm going to try a larger experiment for a few months.



He uses a modest slice of GENI, sharing its infrastructure with many other concurrent experiments.

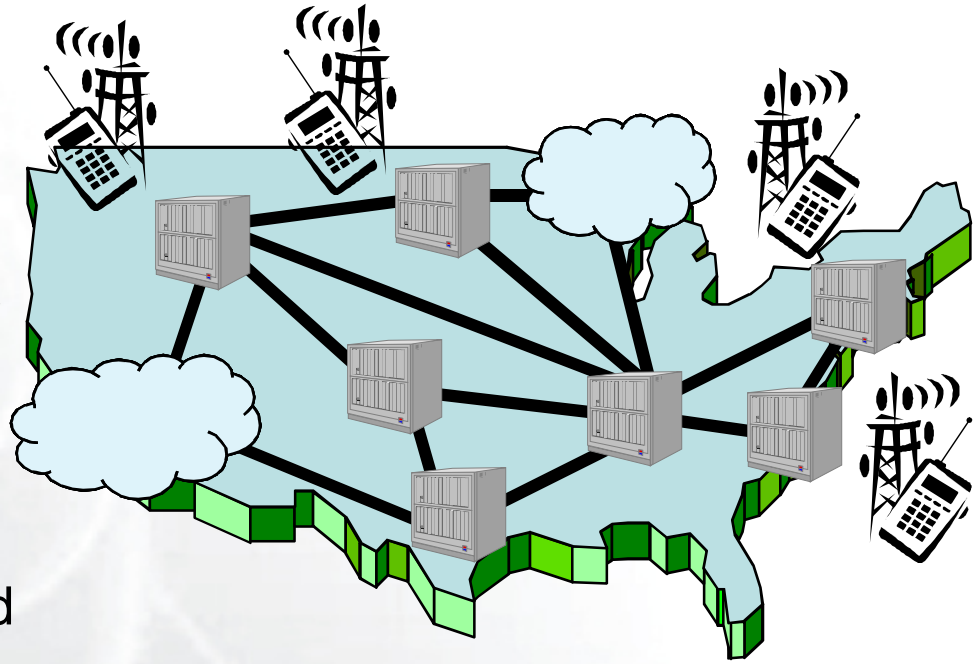
And so he poured his experimental software into clouds, distributed clusters, bulk data transfer devices ('routers'), and wireless access devices throughout the GENI suite, and started taking measurements . . .

It turns into a really good idea

Boy did I learn a lot! I've published papers, the architecture has evolved in major ways, and I'm even attracting real users!

Location-based social networks are really cool!

His experiment grew larger and continued to evolve as more and more real users opted in . . .



His slice of GENI keeps growing, but GENI is still running many other concurrent experiments.

Experiment turns into reality

My experiment was a real success, and my architecture turned out to be mostly compatible with today's Internet after all – so I'm taking it off GENI and spinning it out as a real company.

I always said it was a good idea, but way too conservative.

Meanwhile . . .

I have a great idea! If the Internet were augmented with a scalable control plane and realtime measurement tools, it could be 100x as robust as it is today . . . !

And I have a great concept for incorporating live sensor feeds into our daily lives !

Moral of this story

- GENI is meant to enable . . .
  - **At-scale experiments**, which may or may not be compatible with today's Internet
  - **Both repeatable and "in the wild" experiments**
  - '**Opt in' for real users** into long-running experiments
  - Excellent **instrumentation and measurement** tools
  - **Large-scale growth for successful experiments**, so good ideas can be shaken down at scale

GENI creates a huge opportunity for ambitious research!

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GENI is out of its start-up phase, and now growing rapidly

- **Substantially ramp up research experimentation**
  - Expand from today's 20 experiment teams
  - Support experimenters via training, course materials, summer camps, and help desk
  - Transition to reliable operations
- **Enhance the growing meso-scale GENI**
  - Increase number of GENI-enabled campuses
  - Enhance build-outs in campuses and backbones
  - GENI-enable 5-6 regional networks
  - Deploy 50-80 GENI-racks throughout US
- **Begin to grow from meso-scale to "at scale" GENI**

What's new for GENI experimenters

Tools are becoming more capable and easier to use.

- Point-and-click tools (e.g., Flack, sface)
- Command-line tools (e.g., omni, gush, raven)
- Built-in tool support for multi-aggregate slices
  - Flack support for connectivity via GRE tunnels, ION, and GpENI, instrumentation via INSTOOLS
  - Gush and Raven support mixed PlanetLab and ProtoGENI host configurations

Experiment Templates

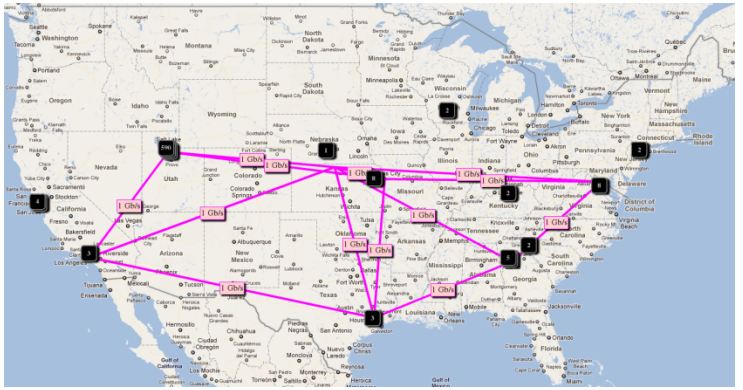
- "Standard" experiment designs that provide a starting place for many potential experiments

GENI Experiment Templates

"Ready-to-Go" starting points for experimentation

Wide Area IP / non-IP experiments

- ProtoGENI + Internet2 at 8 sites
- Software routers (eg Click)
- Easy-to-use graphical interface

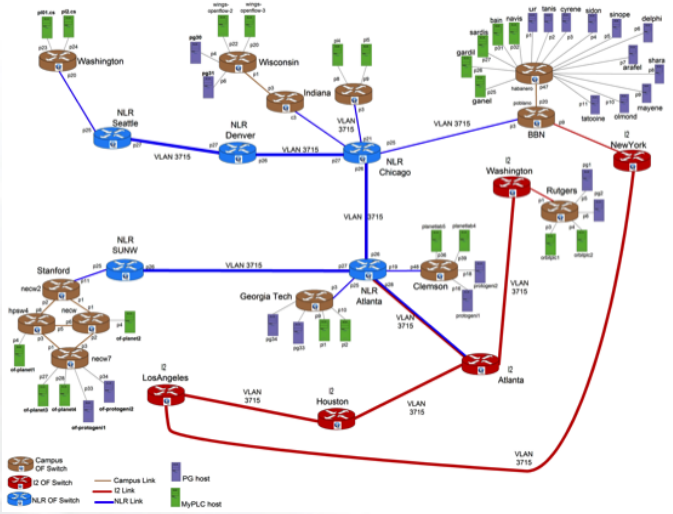


NetServ

- Modular router components dynamically deployed to ProtoGENI hosts

Today's Meso-scale infrastructure

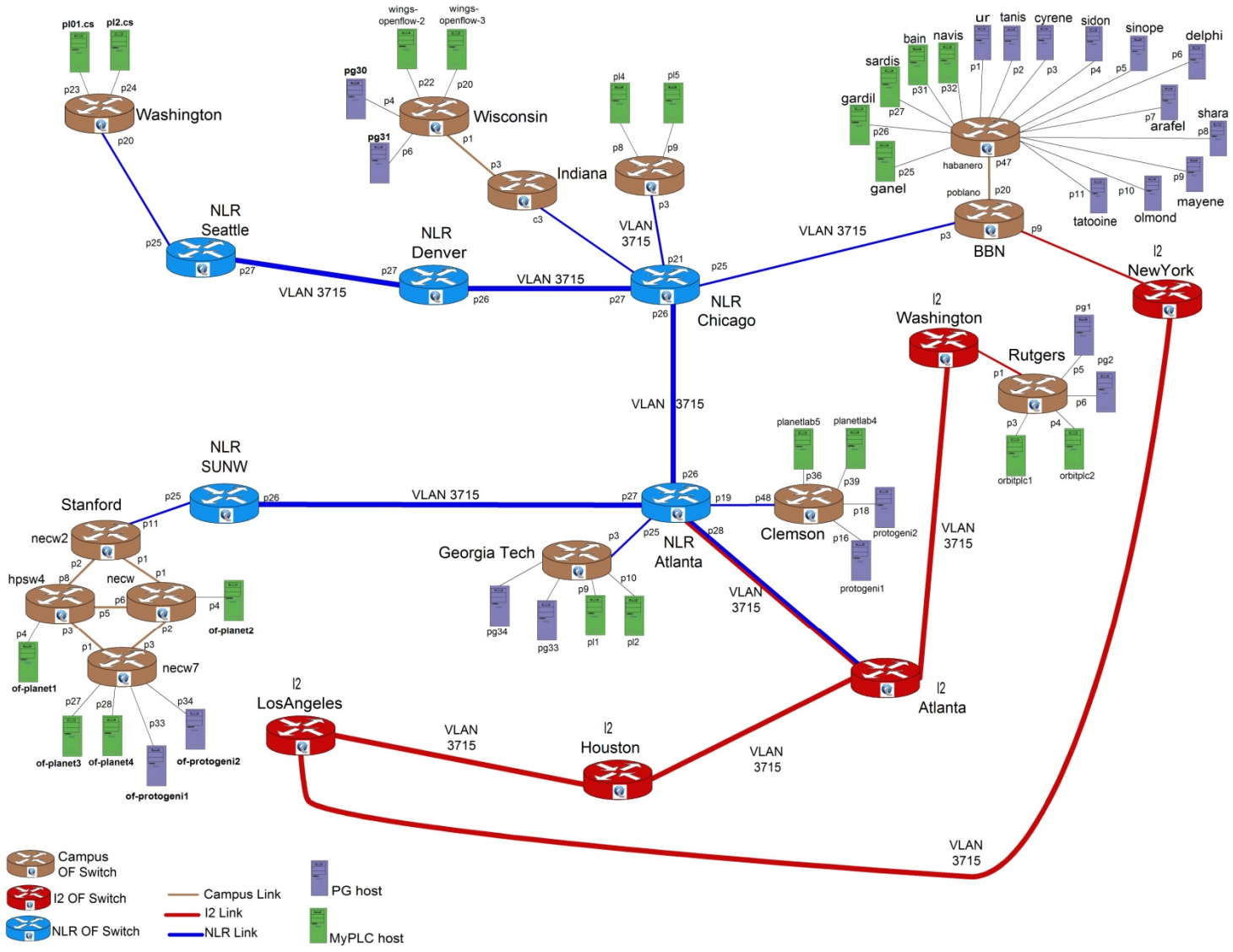
- 8 campuses with OpenFlow, ProtoGENI, and MyPLC, plus OpenFlow through Internet2, NLR
- IP and non-IP experiments using OpenFlow-controlled switches



Today's meso-scale GENI

- Layer 2 slices span campuses, Internet2, and NLR
- Each VLAN contains ~ 25 OpenFlow switches and 40+ computers (PlanetLab & ProtoGENI)
- OpenFlow / FlowVisor manages slices within a VLAN
- Ongoing federated ops (8 campuses, 2 backbones, GMOC), each organization with its own operators, policies, etc.
- Now shaking down large-scale slices

PlanetLab, ProtoGENI, OpenFlow resources spanning multiple campuses, Internet2, & NLR



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9 major experiments demo'd at GEC 9 (Nov 2010)

- **Some of the nation's best young researchers . . .**
  - Academic and industrial
  - Networking and distributed systems
  - Some helped build GENI, most have not
- **Demonstrating their earliest research experiments**
  - Many different ideas for "future internets"
  - Now being **tried out experimentally** for the first time
- On the nationwide, "meso-scale" GENI prototype

GENI supported 9 different future internet experiments, simultaneously, each in its own slice

Pathlet Architecture

GEC 9 experiment demonstration

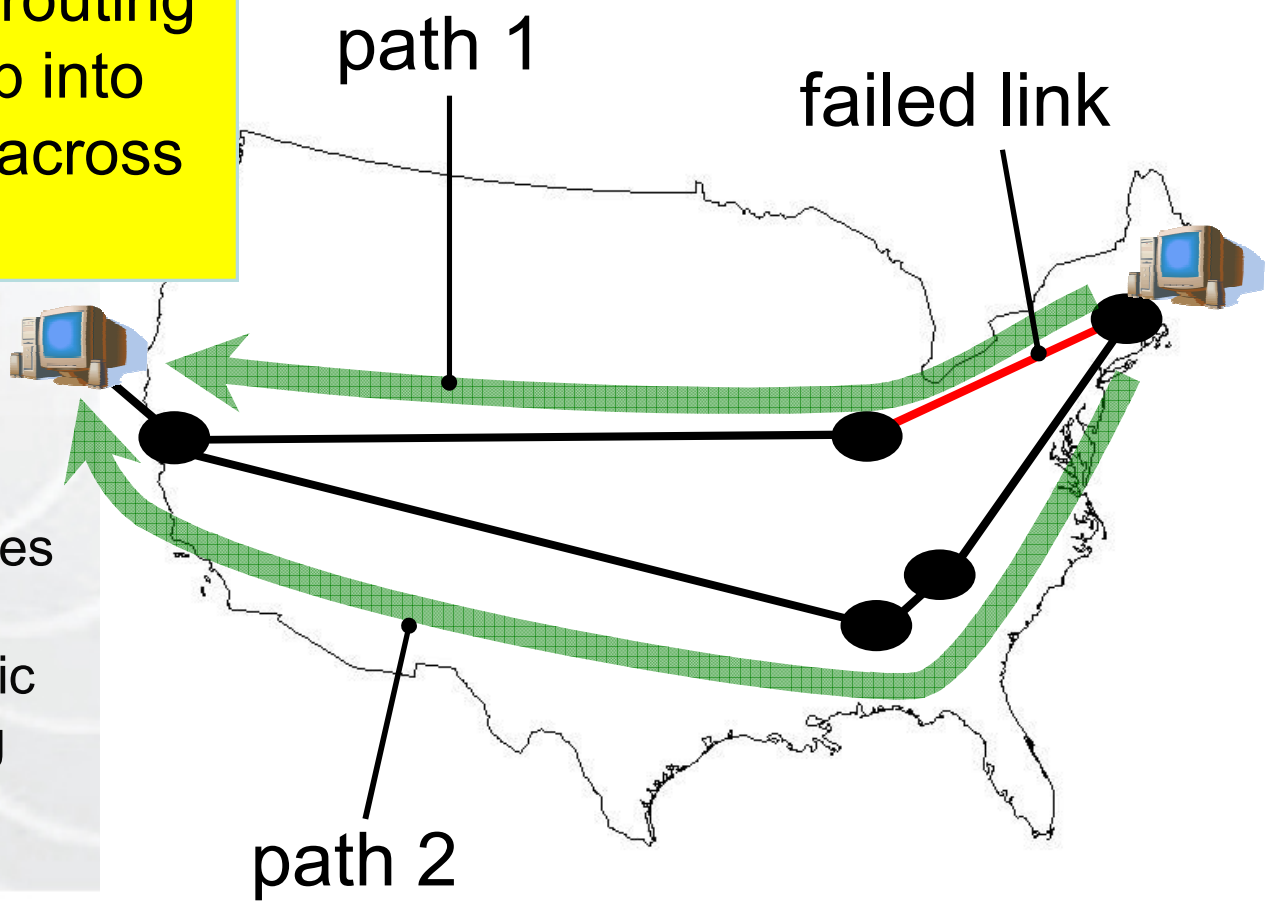
ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Resilient Routing in the Pathlet Architecture

Ashish Vulimiri and Brighten Godfrey
University of Illinois at Urbana-Champaign

Deploy innovative routing architecture deep into network switches across the US

- Lets *users* monitor and select their own network paths to optimize their services
- Protects critical traffic even without waiting for adaptation time



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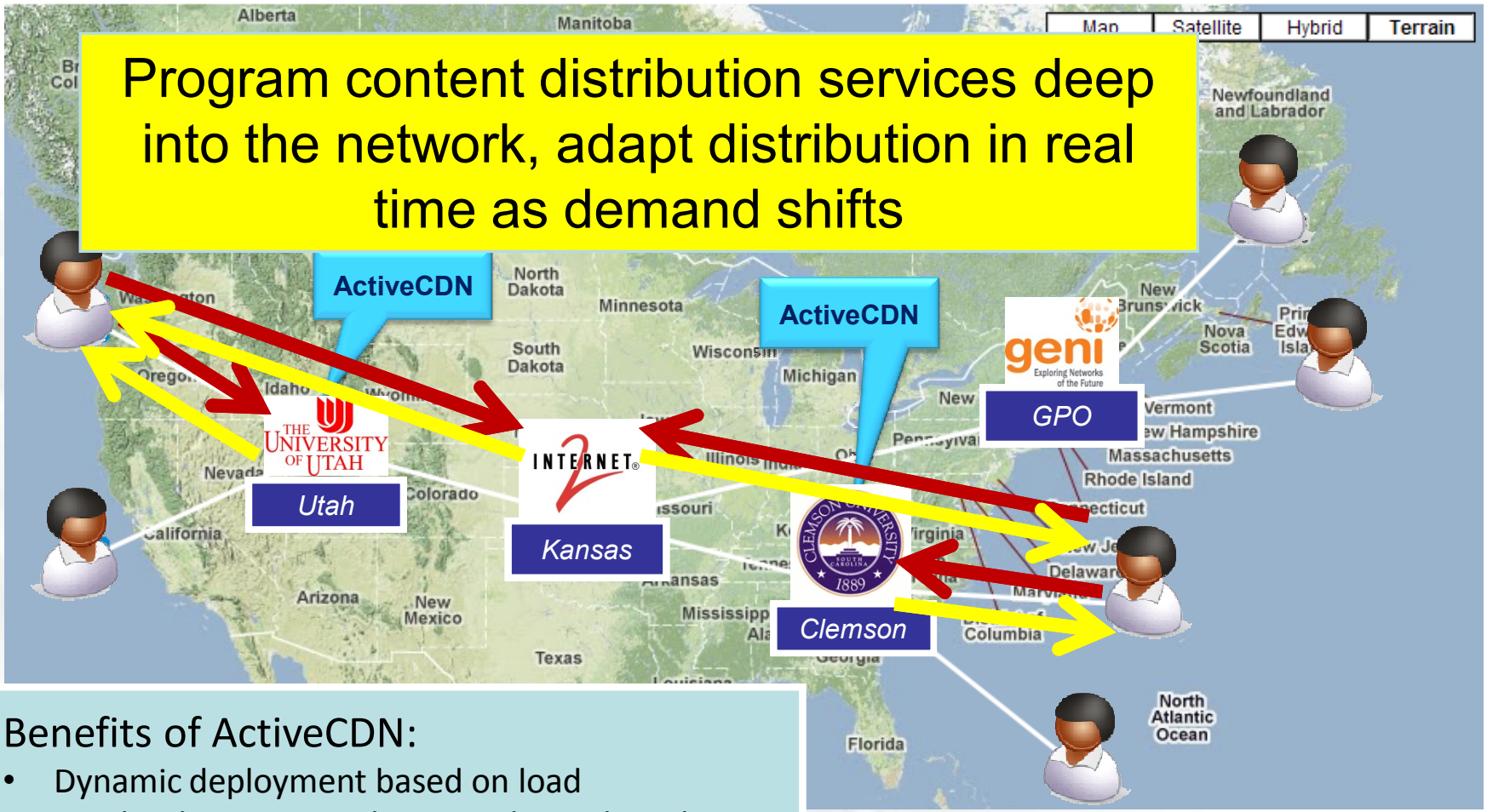
ActiveCDN

GEC 9 experiment demonstration

THE UNIVERSITY OF UTAH

INTERNET2

COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK

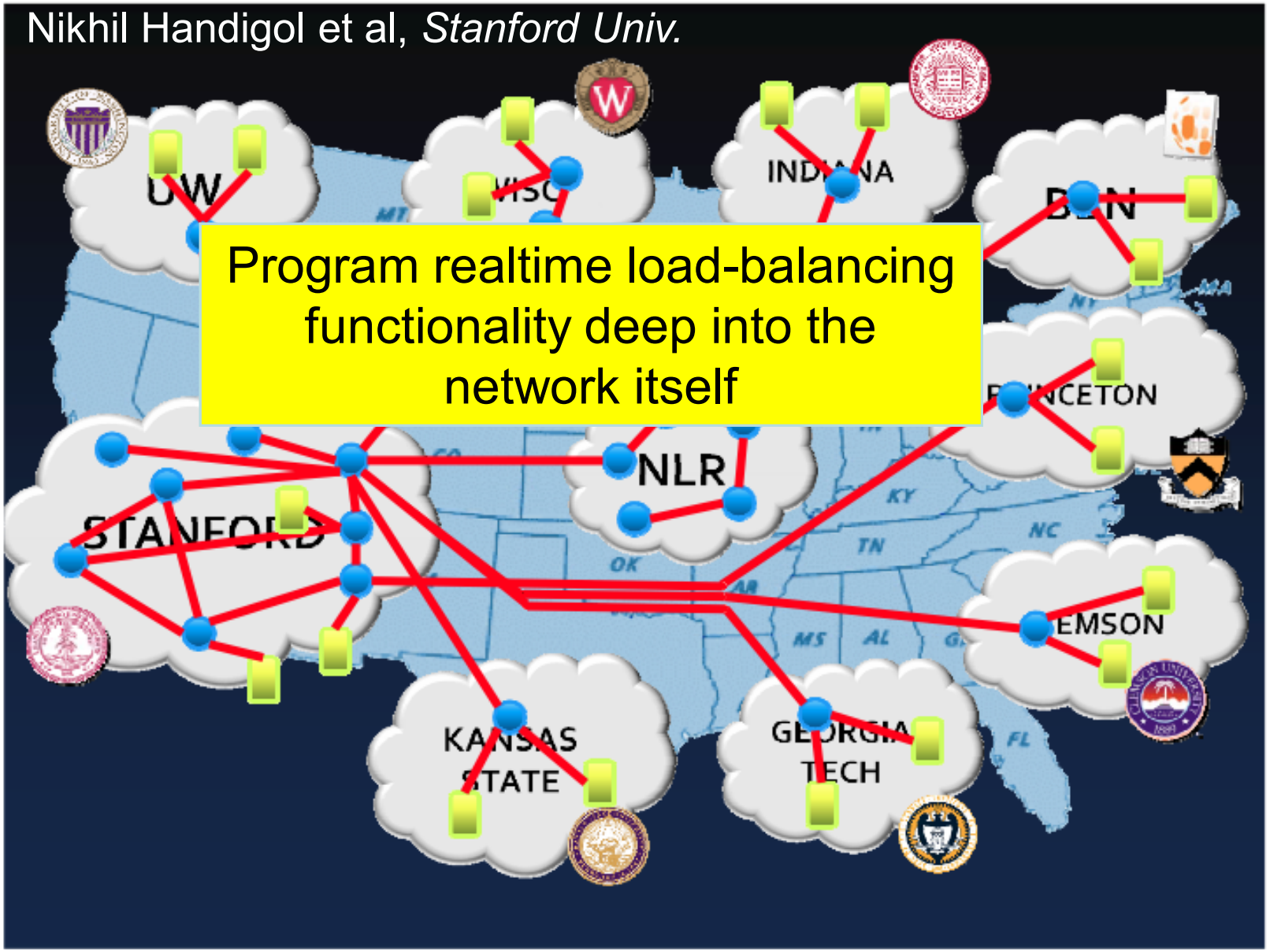


Benefits of ActiveCDN:

- Dynamic deployment based on load
- Localized services such as weather, ads and news

Jae Woo Lee, Jan Janak, Roberto Francescangeli, SumanSrinivasan, Eric Liu, Michael Kester, SalmanBaset, Wonsang Song, and Henning Schulzrinne
Internet Real-Time Lab, Columbia University

Aster*x Load Balancing (via OpenFlow)



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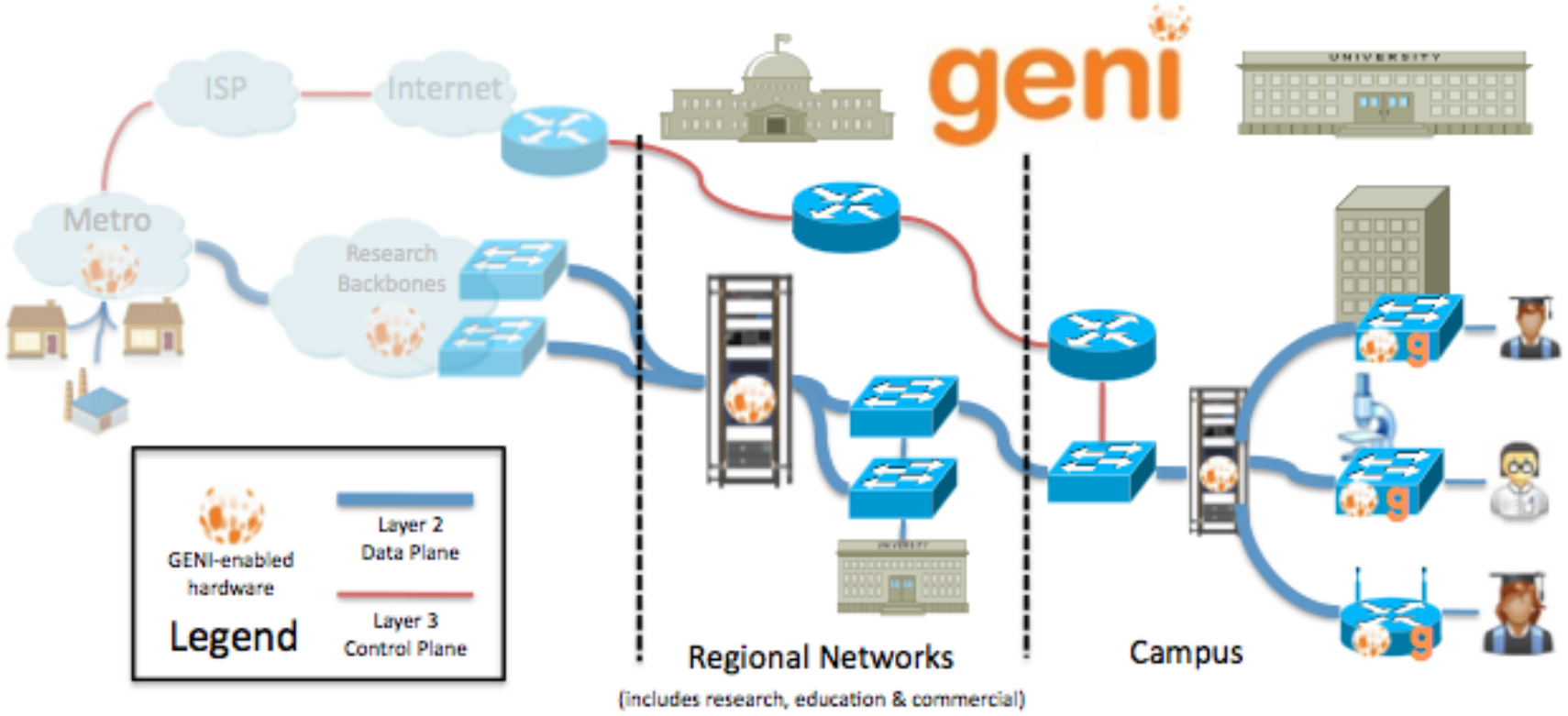
Looking forward
Growing to the "at scale" GENI

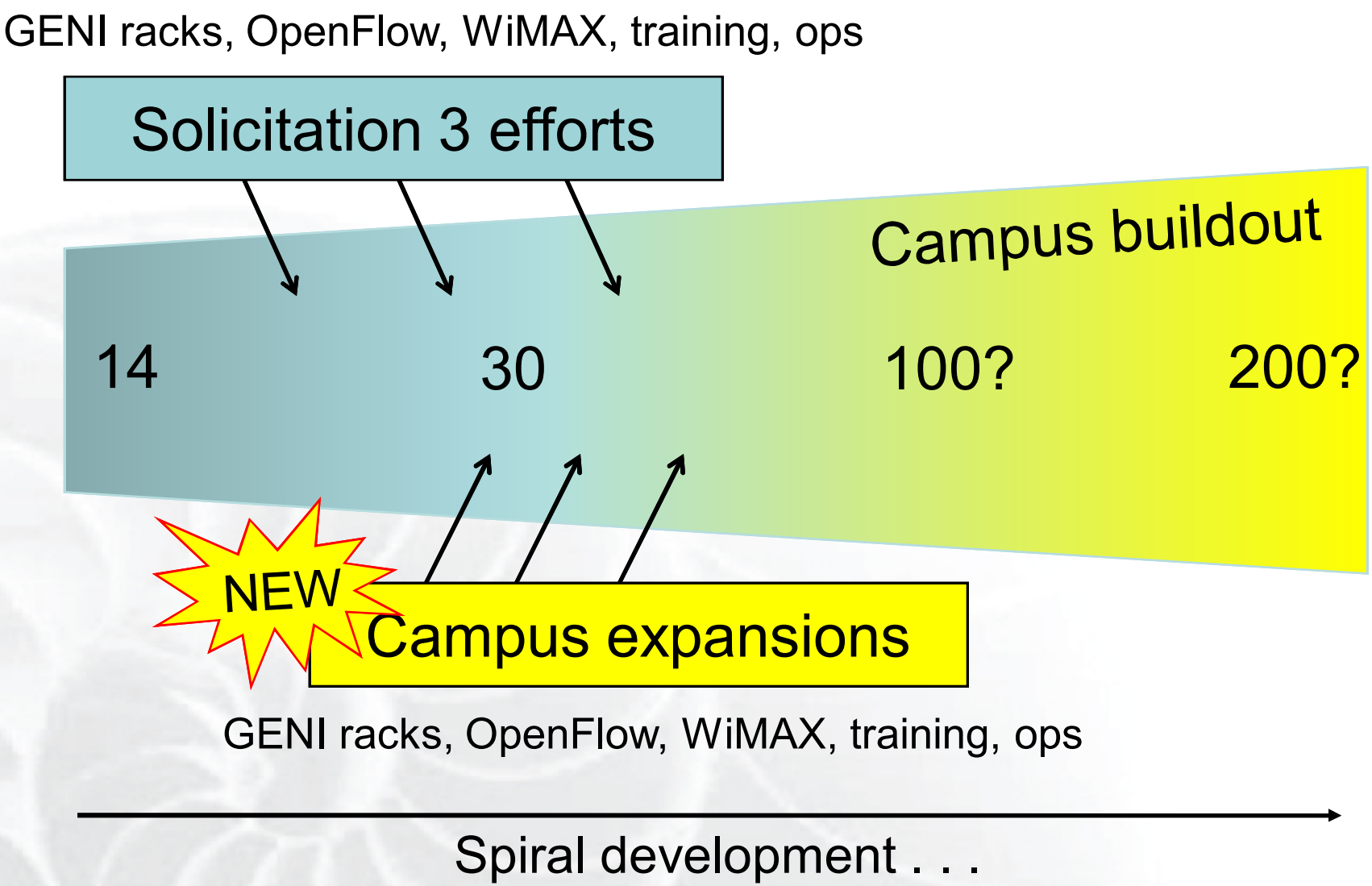
- Suggest 100-200 US campuses as target for "at scale"
  - Both academia and national labs
  - GENI-enable the campuses
  - Their students, faculty, staff can then "live in the future" using both today's Internet and many experiments
  - Build out backbones, regionals, and shared clouds to support the campuses
- Grow via ongoing spiral development
  - Identify, understand, and drive down risks
  - Learn what is useful and what is not
  - Early GENI campuses can help later ones
- Transition to community governance

Envisioned architecture



- Flexible network / cloud research infrastructure
- Also suitable for physics, genomics, other domain science
- Support “hybrid circuit” model plus much more (OpenFlow)
- Distributed cloud (racks) for content caching, acceleration, etc.

Growing GENI to 100-200 campuses



Solicitation 3's role in campus buildouts

- GENI Solicitation 3
  - More **WiMAX base stations** with Android handsets
  - GENI-enable 5-6 **regional networks**
  - Inject more **OpenFlow switches** into Internet2 and NLR
  - Add **GENI Racks** to 50-80 locations within campuses, regionals, and backbone networks

GENI Racks serve as programmable routers, distributed clouds, content distribution nodes, caching or transcoding nodes, etc

A new solicitation coming GENI-enabling 20+ campuses

- Growing to 20+, then 100-200 campuses
  - Plan roughed out at 2nd CIO workshop, July 7, 2011 (thank you EDUCAUSE)
  - "Buddy system" for each meso-scale campus to guide 2-3 new campuses
  - Increase GENI-enabled campuses from 14 to 40-50 in a staged manner, over several years
- GENI candidate campuses are now being lined up
  - Two-person teams will visit candidate campuses this fall, helping campus CIOs draw up plans and proposal material
  - "Campus expansion" solicitation expected ~ Dec 2011

GENI-enabled cities
First concrete step in US Ignite activity

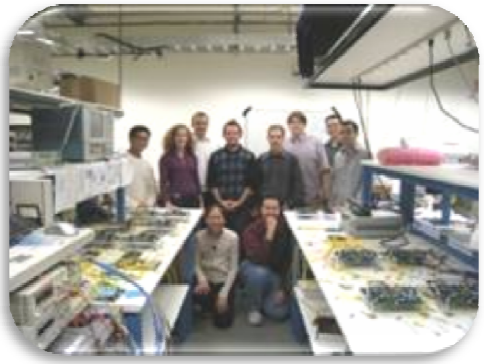
- Very strong interest from 6 US cities to date
  - Chattanooga, Cleveland, Lafayette LA, Philadelphia, Salt Lake City region, Washington DC
  - Their citizens will be able to “live in the future”
- Cities can be GENI-enabled very rapidly
  - We have visited all 6 cities for surveys, discussions
  - GENI rack, OpenFlow, and Layer 2 connectivity appear quite feasible
  - Can be federated into GENI very quickly
- Can support experimental, gigabit applications in GENI slices through cities
  - Creates **tremendous** new research opportunities

GENI is a huge opportunity - Get involved!

ViSE Team

PlanetLab Team

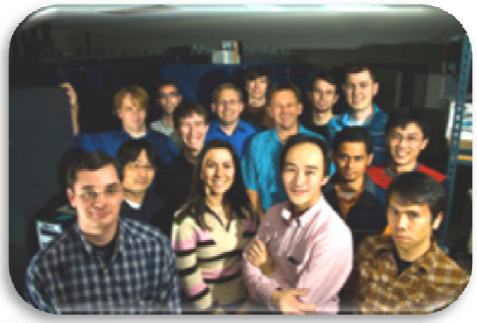
ERM Team



ORCA/BEN Team

GUSH Team

Enterprise GENI Team



GPO points of contact

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