geni
Exploring Networks of the Future

GENI

Exploring Networks of the Future

Building the At-Scale GENI Testbed

Mark Berman
GENI Project Director
www.geni.net

Sponsored by the National Science Foundation

Outline

- GENI – Exploring future internets at scale
- Testbeds Facilitate Investigation: an example
- Building the At-Scale GENI Testbed

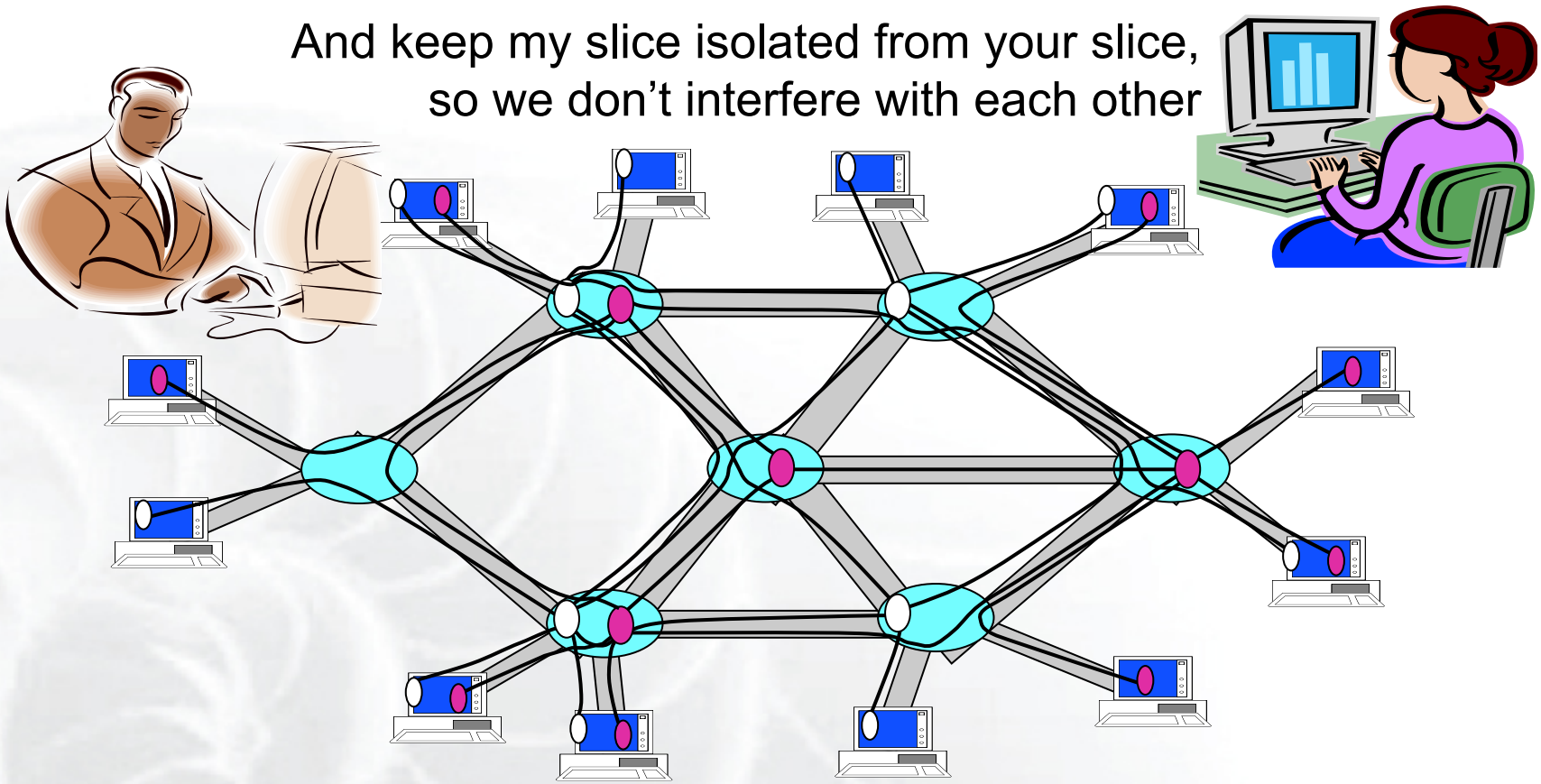
What is GENI?

- 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 applications
- Key GENI concepts: 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

Outline

- GENI – Exploring future internets at scale
- Testbeds Facilitate Investigation: an example
- Building the At-Scale GENI Testbed

A bright idea

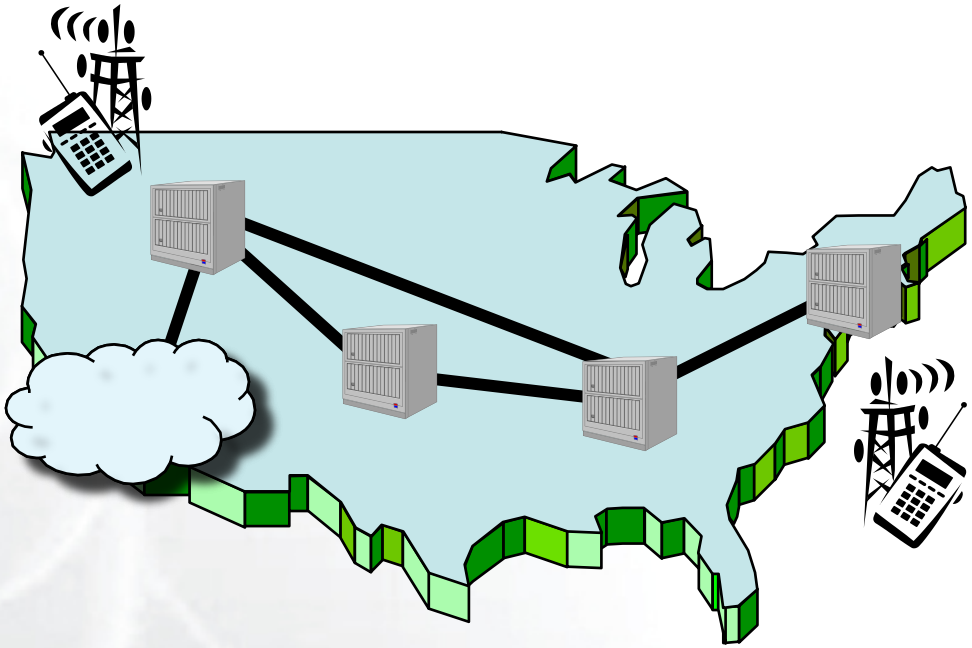
I have a great idea! The original Internet architecture was designed to connect one computer to another – but a better architecture would be fundamentally based on PEOPLE and CONTENT!

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.

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 . . .



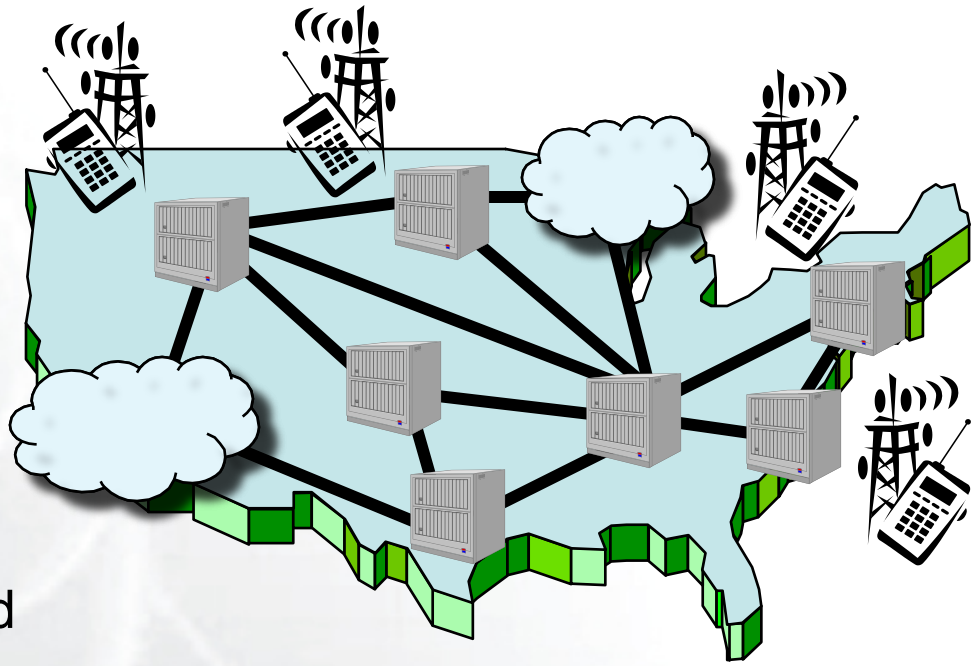
He uses a modest slice of GENI, sharing its infrastructure with many other concurrent experiments.

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!

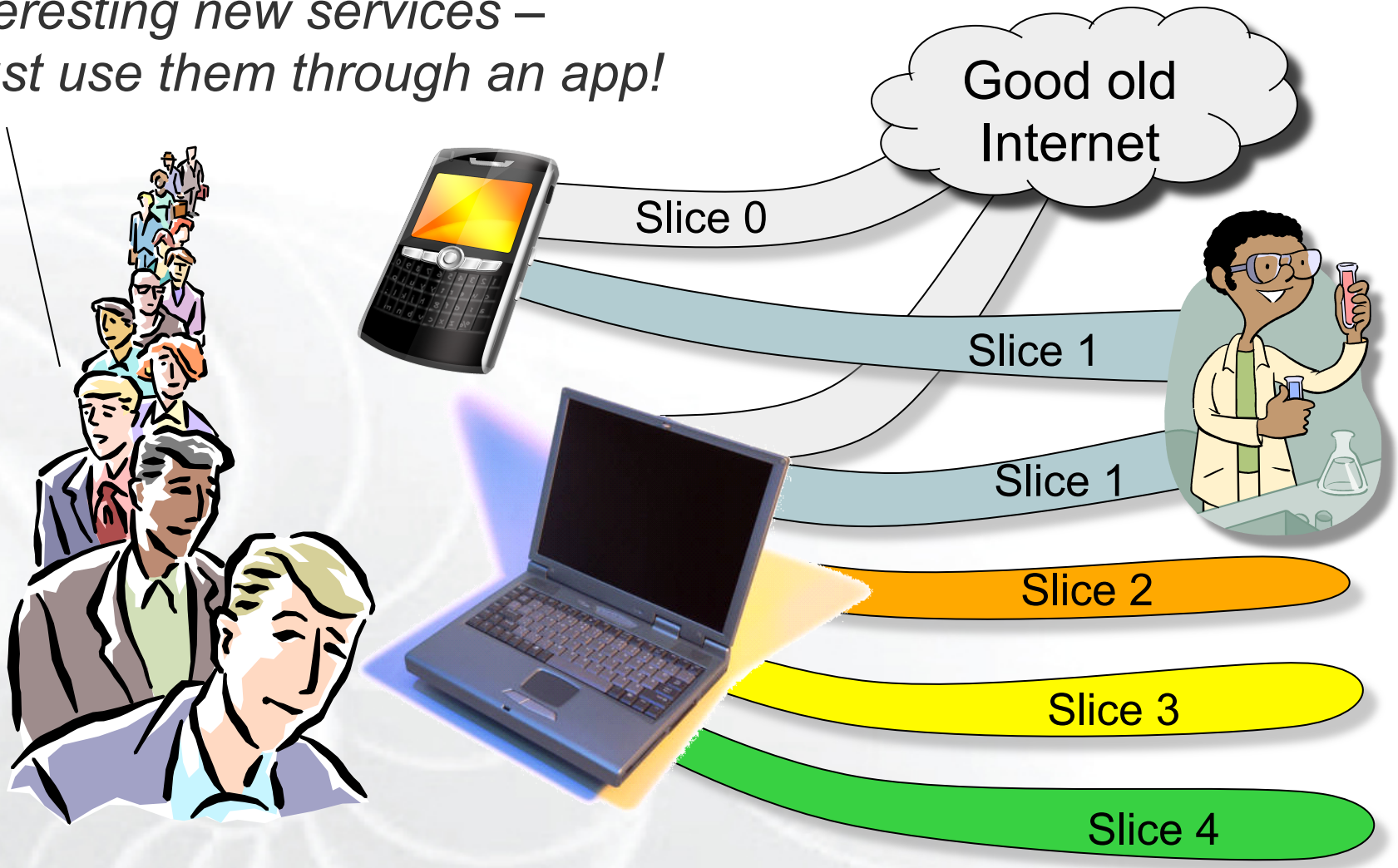
His experiment grew larger and continued to evolve as more and more real users opted in . . .



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

The (opt-in) user's view

Interesting new services –
I just use them through an app!



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 !

If **you** have a great idea, check out the
NSF CISE research programs for current opportunities.

Moral of this story

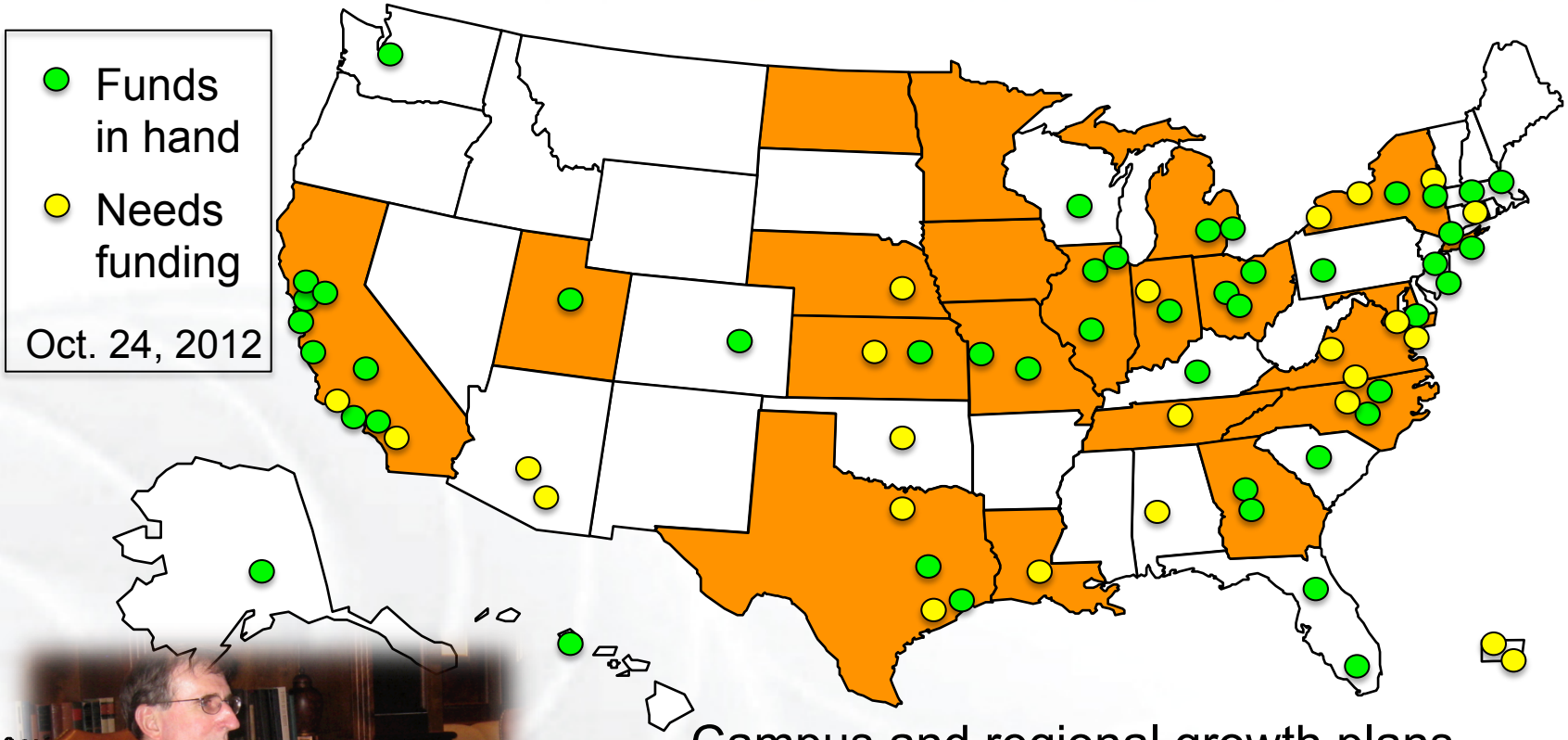
- GENI is meant to enable . . .
  - **At-scale experiments**, which may or may not be compatible with today's Internet
  - **Both repeatable and "in the wild" experiments**
  - '**Opt in' for real users** into long-running experiments
  - Excellent **instrumentation and measurement** tools
  - **Large-scale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

GENI creates a huge opportunity for ambitious research!

Outline

- GENI – Exploring future internets at scale
- Testbeds Facilitate Investigation: an example
- Building the At-Scale GENI Testbed

Growing the deployed GENI Campuses and Regional Networks



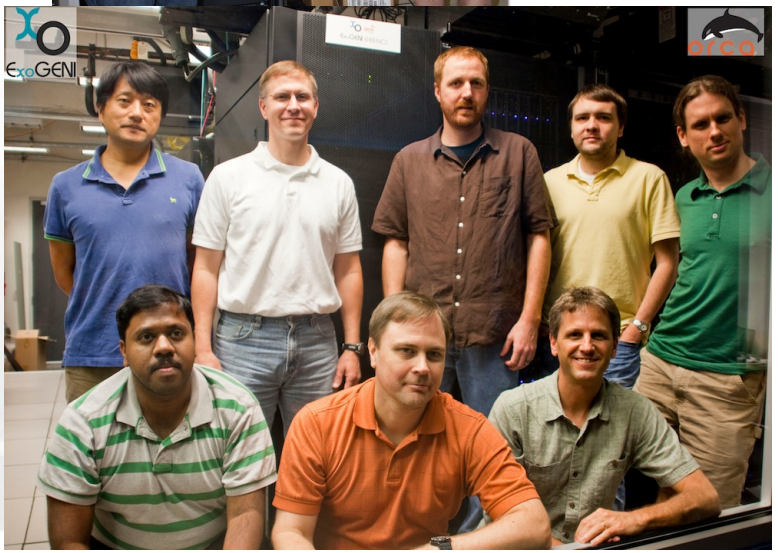
"GENI-enabled" campuses . . .
OpenFlow + GENI racks, plus WiMAX on some campuses

Campus and regional growth plans

- Today: 16 campuses & 8 regionals
- In a year: 42 campuses & 9 regionals
- Targeting 100 – 200 campuses
- NSF's CC-NIE program will accelerate and amplify the effects

Growing the deployed GENI
GENI Racks

- First GENI racks in use by intrepid experimenters
  - Expected operational this winter
- Rapid deployment schedule
  - 3 GENI racks today
  - 17 GENI racks by March 2013
  - 46 GENI racks in the next year
- Complemented by spontaneous, commercially-driven rack developments
  - Interoperability is key to empowering experimenters



GENI is Taking Off in Many Ways
Commercial Adoption of Key GENI Enablers

- **OpenFlow / SDN**

- **GENI racks**

hp invent

IBM

DELL

CISCO (*)

- **WiMAX (-> LTE)**

NEC

Airspan

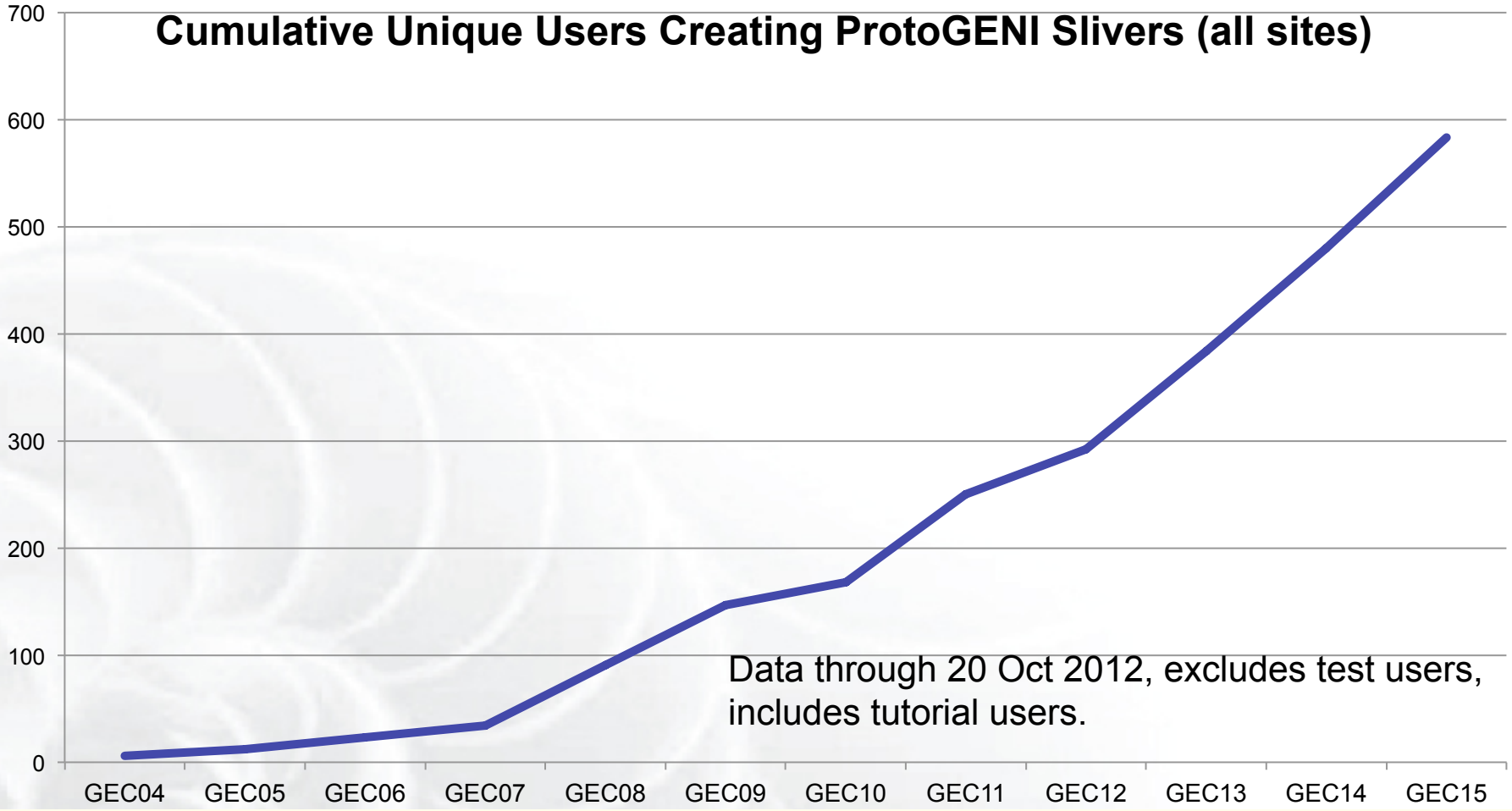
Alcatel·Lucent (*)

(*some indications)

GENI is Taking Off in Many Ways Community Impact

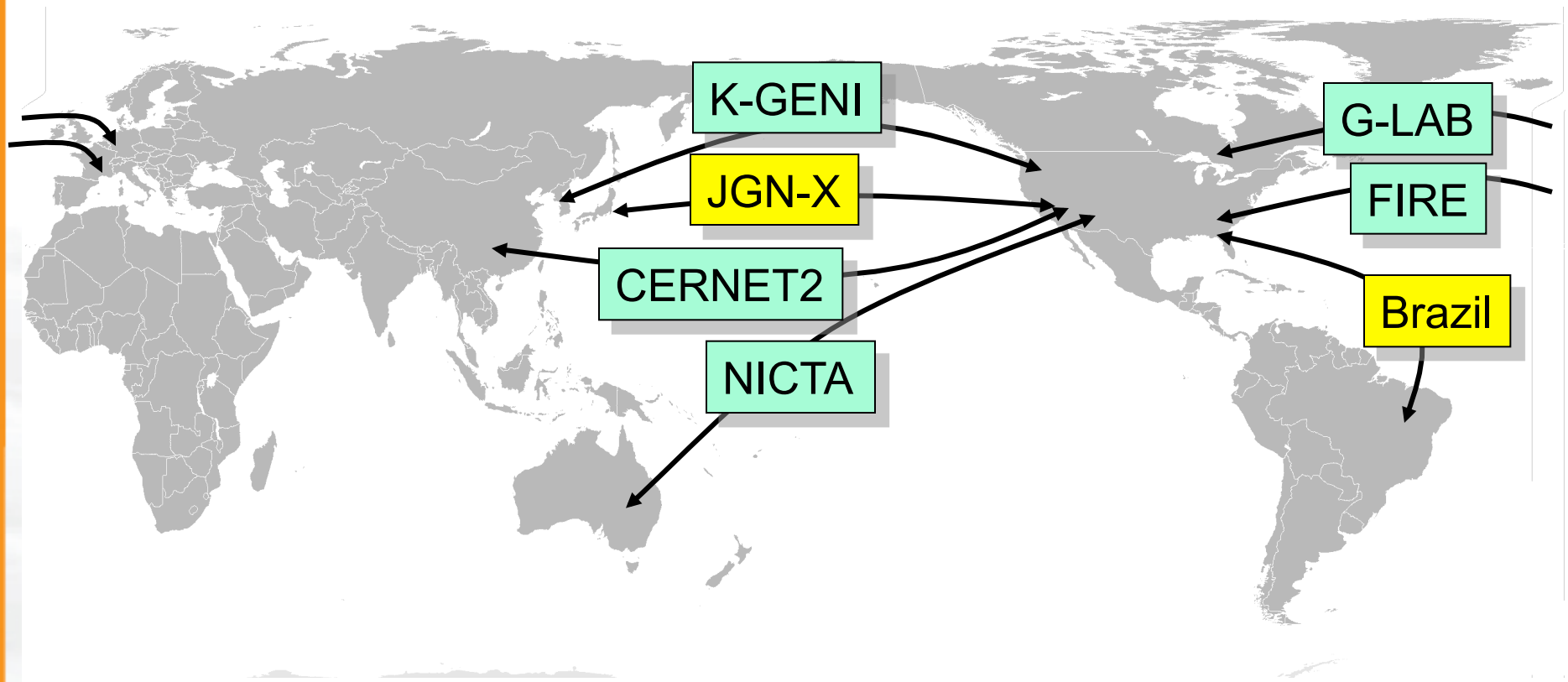
- GENI technology spreading to more campuses
  - Sometimes (not always) directly via GENI project
- Use of GENI in the classroom is accelerating
- Instructors are benefiting from curriculum modules with online examples
- GENI research visibility is growing in academic literature
  - See the GENI bibliography under the experimenter section of the GENI wiki
  - www.geni.net

GENI is Taking Off in Many Ways
Experimenter Uptake



Bring GENI to your experiment or class.
help@geni.net or www.geni.net/experiment

GENI is Taking Off in Many Ways
International Collaboration & Tech Exchange



The GENI project is actively collaborating with peer efforts outside the US, based on equality and arising from direct, “researcher to researcher” collaborations.

GENI Engineering Conferences
We welcome your participation in creating GENI

- **16th meeting, open to all:**
  March 19-21, Salt Lake City, University of Utah
  - Planning & discussion for experimenters, software, infrastructure
  - Tutorials and workshops
  - **Travel grants** to US academics for participant diversity
- **www.geni.net or help@geni.net**