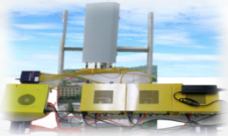


GENI

Towards Software Defined Infrastructure (SDI)

Phase 0 SDN Exchange (SDX) Demo

March 18, 2014

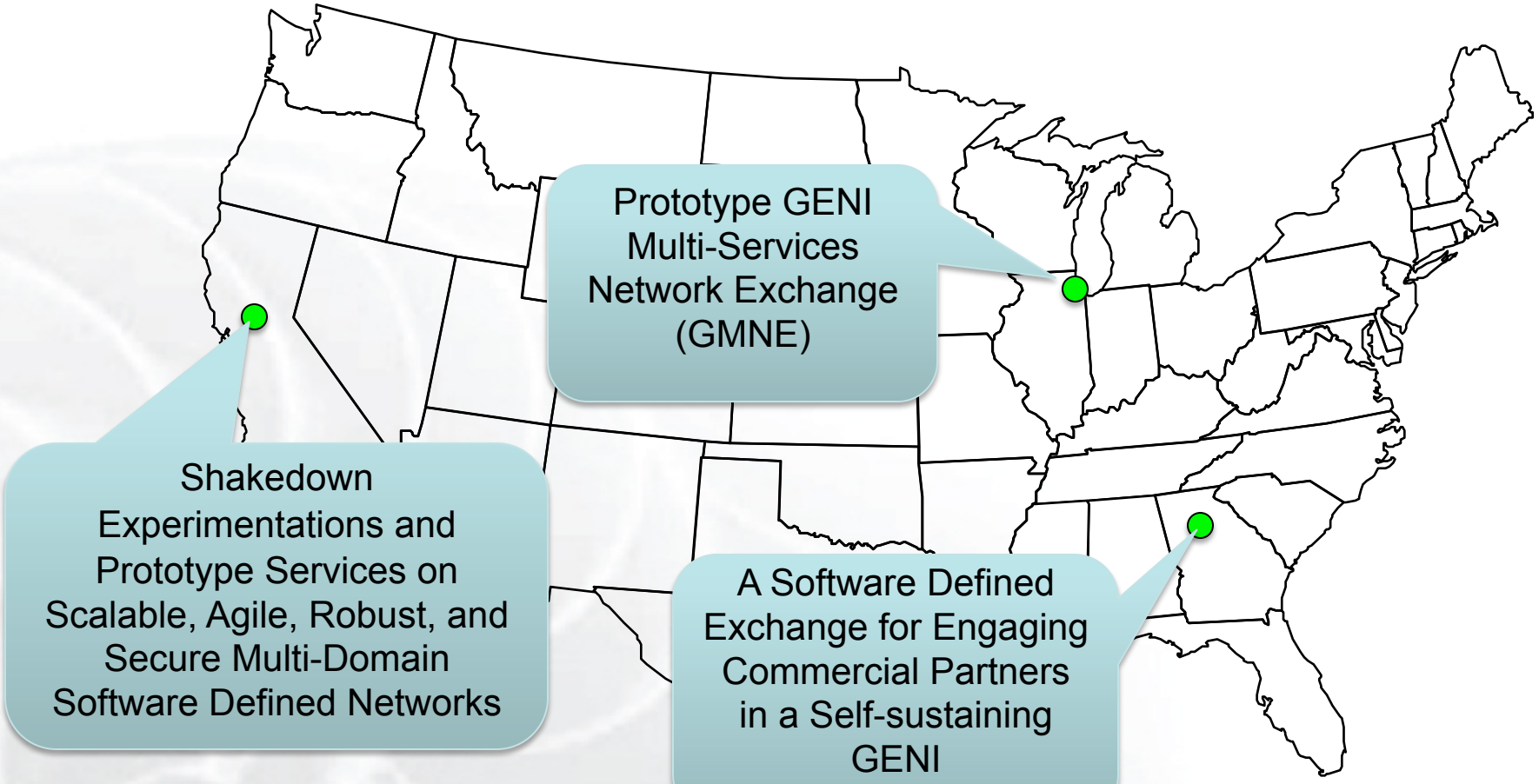
www.geni.net

Sponsored by the National Science Foundation

Emerging SDN Capabilities are Virtually Certain to Require Multi-Domain Infrastructure

- OpenFlow and software defined networking play an important role in GENI
  - GENI is deploying a multi-domain SDN federation at ~50 campuses nationwide
  - Key technology for enabling GENI's deep programmability capability
- Because GENI is built as a federation, there's a clear need for SDN infrastructure to span multiple operating domains
  - GENI infrastructure is owned and operated by the host institutions
  - Experiments and services need to exert control across these borders in a consistent and controlled way
  - These needs are repeated at a larger scale when GENI federates with other peer infrastructure, nationally and internationally

Multi-Domain SDN GENI Projects



SDN Exchange – Phase 0

- Some GENI teams have begun prototyping the SDN exchange (SDX) concept
  - Perhaps roughly analogous to existing concepts in today's Internet, such as peering and colocation
  - But great potential for much more sophisticated capabilities
- This is very preliminary work
  - The functions of a SDX are not yet well understood
  - Prototype teams started these efforts just a few months ago under GENI solicitation 4 – they are demonstrating their early work as a proof of concept
- The potential for these concepts goes well beyond GENI and towards sharable, rapidly configurable software defined infrastructure.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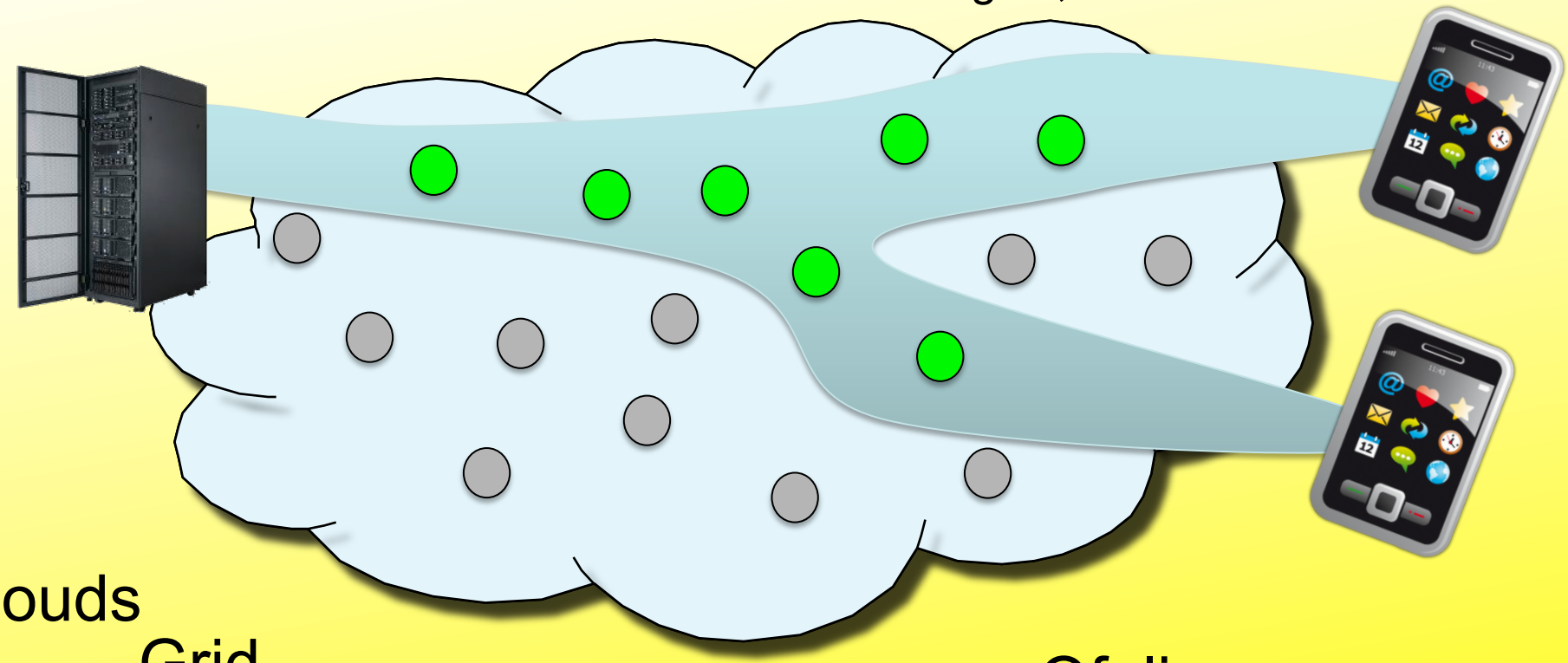
The bigger picture

Rapidly create entire “sliced” cyberinfrastructure / networks on demand

Fast spin new protocols, switching strategies, virtual machines



Clouds

Grid

Network function virtualization

Software defined networks

Inter-cloud

Vnode

Wivi

Ofelia

FLARE

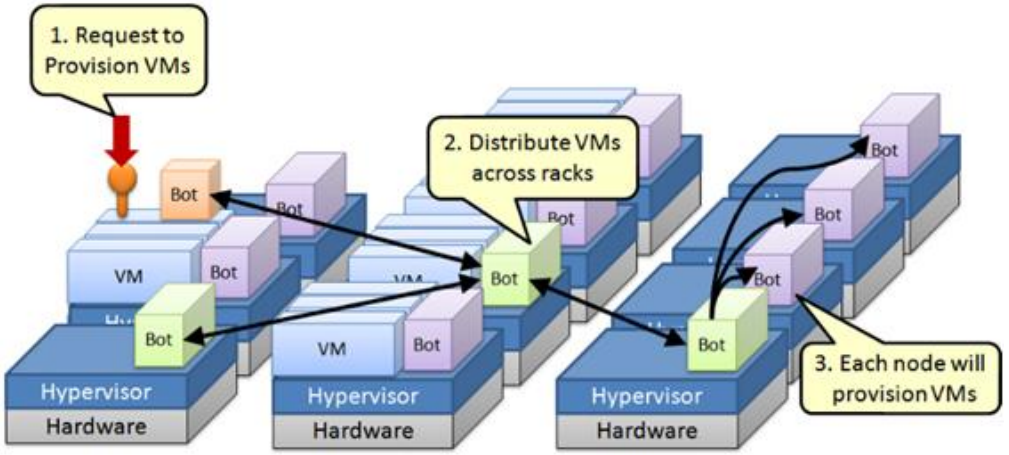
US Ignite

GENI

“Virtual machine” -> New service model

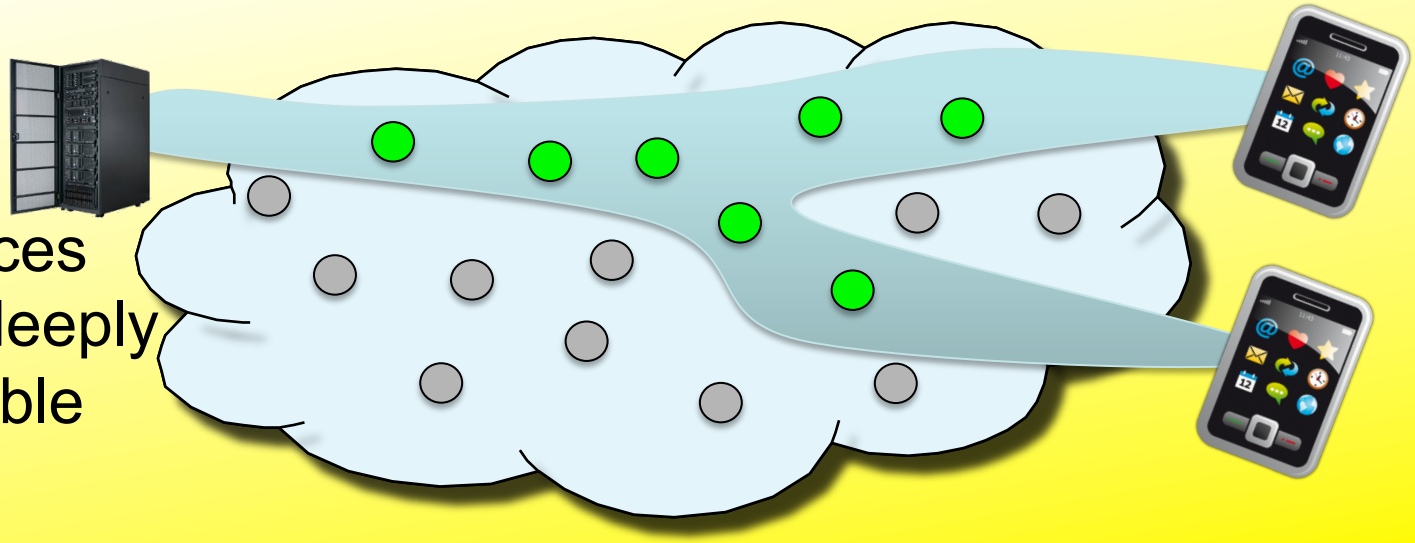
Machines

Virtual machines



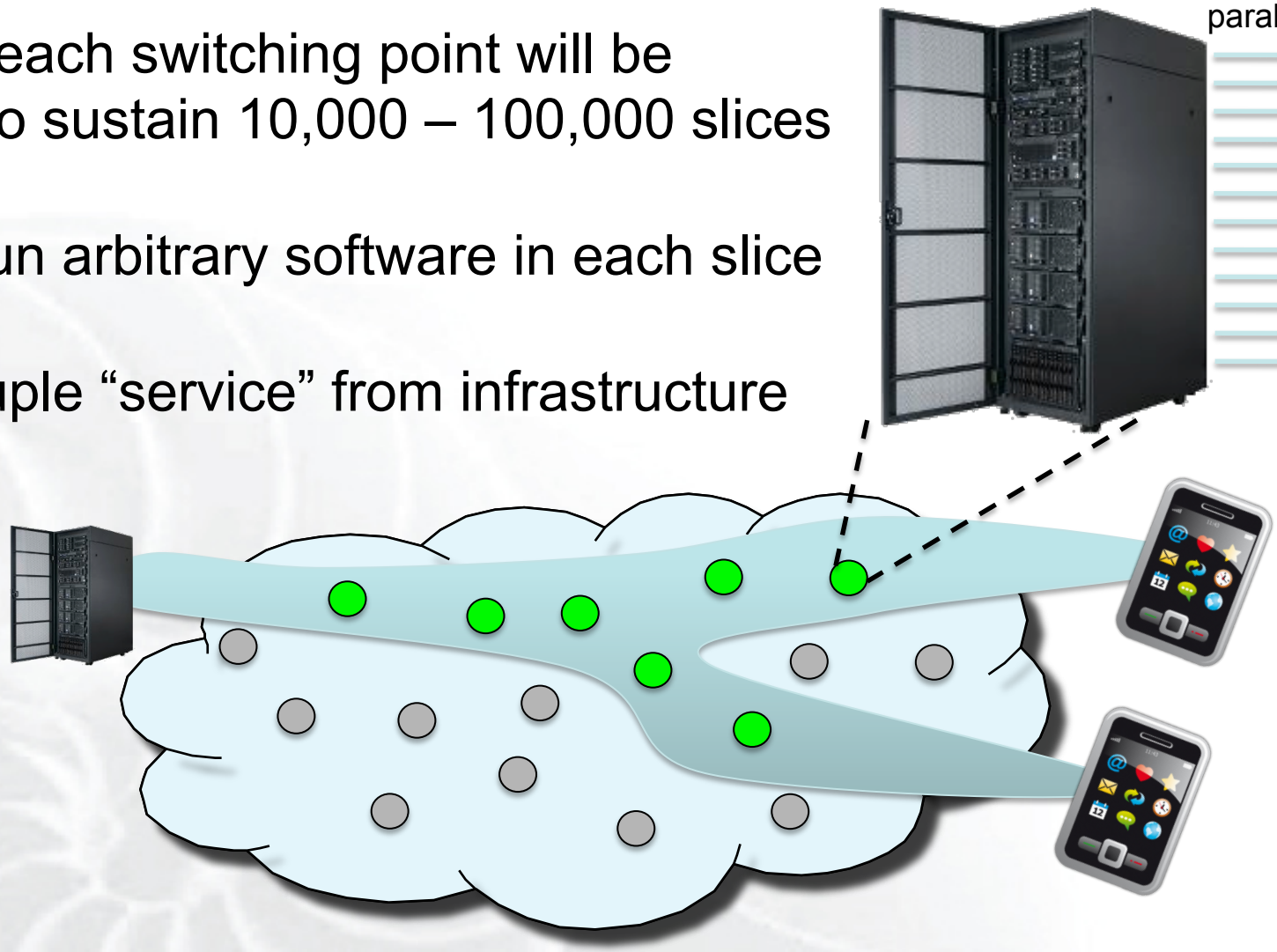
Multi-tenant data centers

Novel services running in deeply programmable slices

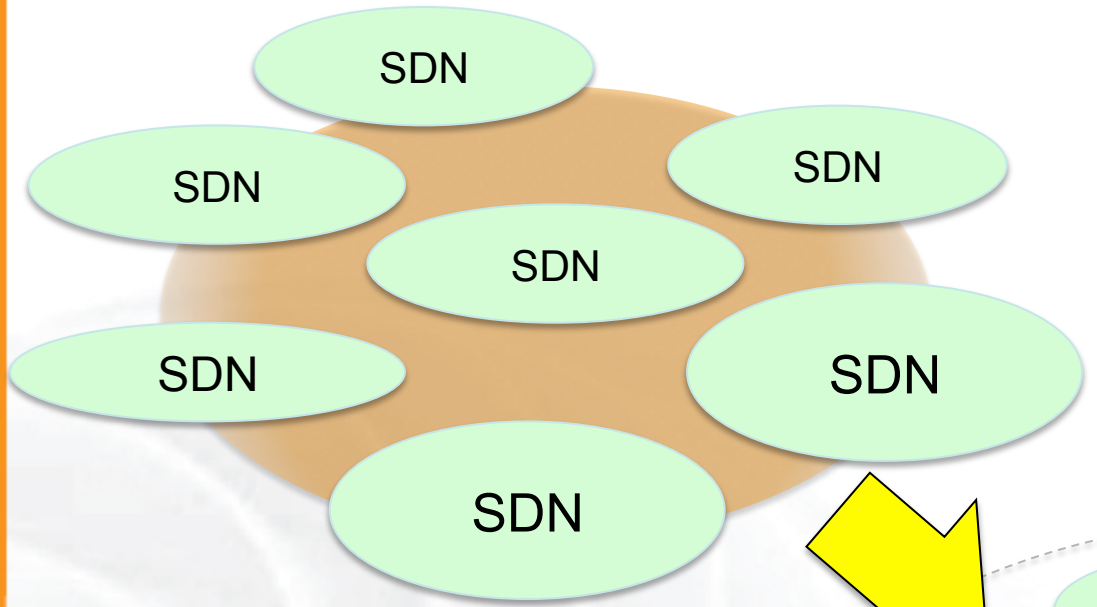


Instantiating services into slices

- Soon each switching point will be able to sustain 10,000 – 100,000 slices
- Can run arbitrary software in each slice
- Decouple “service” from infrastructure

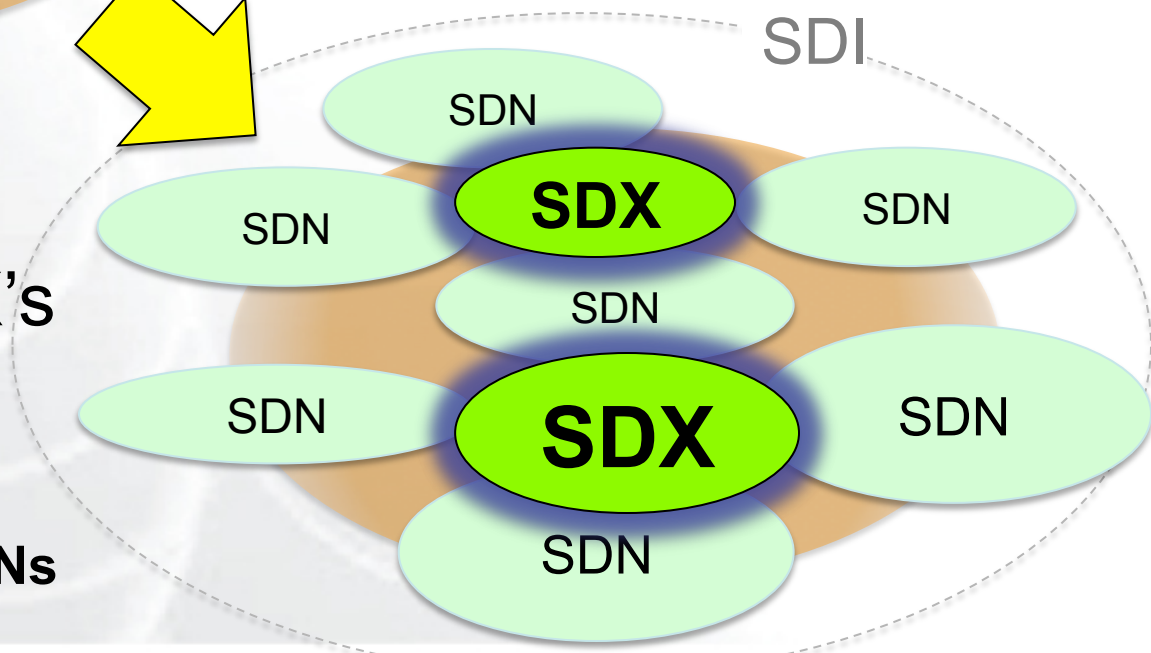


Create SDX's to bridge "SDN islands"



Today: "SDN islands"

GENI slices & VLAN stitching help point the way



Next Step: Add SDX's

Build a "Rev 0" control plane, run native next-gen apps and scientific instruments **spanning multi-domain SDNs**

SDX's build the human community

- **Basic concept**
  - "SDN Exchange"
  - Open meeting point
  - Support end-to-end applications across multiple SDN domains
- **Key benefit: Very OPEN**
  - Good way to rapidly build / grow tech community
  - Good way to create & share open-source tool chains
  - Good way to try out different approaches, perhaps vendor specific, in early days
  - Later, we can move to private peering points

- **Working together . . .**
  - US Industry
  - Network operators
  - Next-gen app developers
  - Scientific Instrument developers and users
  - Researchers

"National SDN Workshop"

December 2013 – Washington, DC

Inder Monga
ESnet Chief Technologist

About 100 networking experts from academia, industry, national labs and federal agencies

SDN Workshop – Key themes (1)

- Software-Defined Networking (SDN) is understood as the entire distributed infrastructure needed for next-generation commercial and/or scientific applications – i.e., **closely integrated compute, storage, and networks**.

- SDN technology has the potential and momentum to provide **game changing innovation to the entire Internet eco-system.**

- Using SDN technology, we can now envision (and in practical terms, create) **scientific "instruments on demand" or app-specific "infrastructure on demand" across multiple networks (multi-domain),** on a worldwide scale.

SDN Workshop – Key themes (2)

- The time is right for deploying prototype operational, multi-domain SDNs.
- The focus of initial SDN deployments should include **Software-Defined Exchanges (SDXs)** to enable interoperability, co-designed in close collaboration with US industry.
- These efforts should actively **engage key scientific instruments and next-generation applications as design and prototyping partners.**
- A vigorous and sustained research program should investigate the **security implications** of multi-domain/ multi-layer SDNs.

What you're going to see now

- A **conceptual demo** of SDX's in action
- Running a next-gen scientific instrument / app . . .
  . . . spanning multiple SDNs across the US. . .
- Note – this demo helps illustrate the concept,
  but it's **only a concept** – real SDX's don't yet exist!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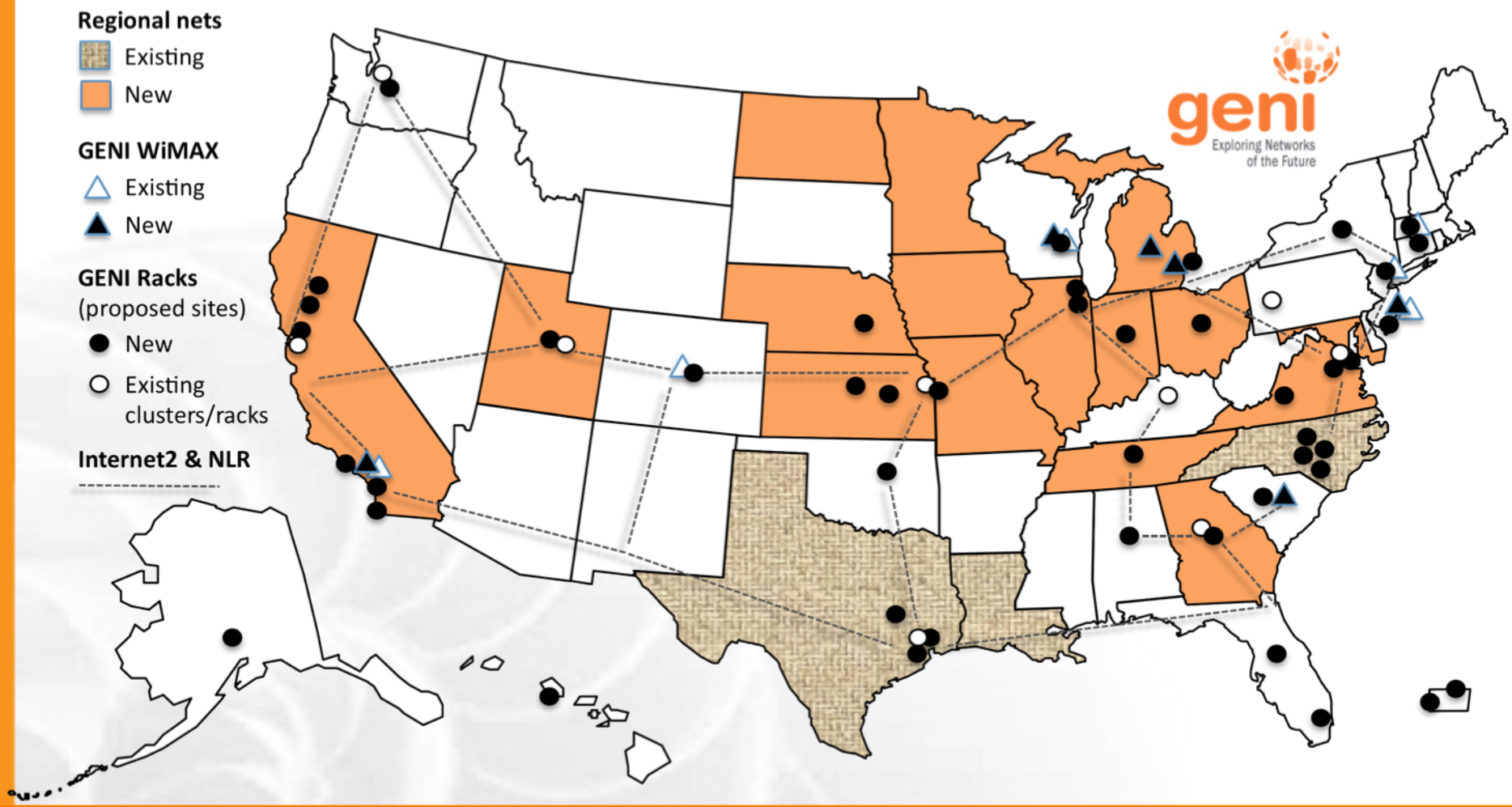
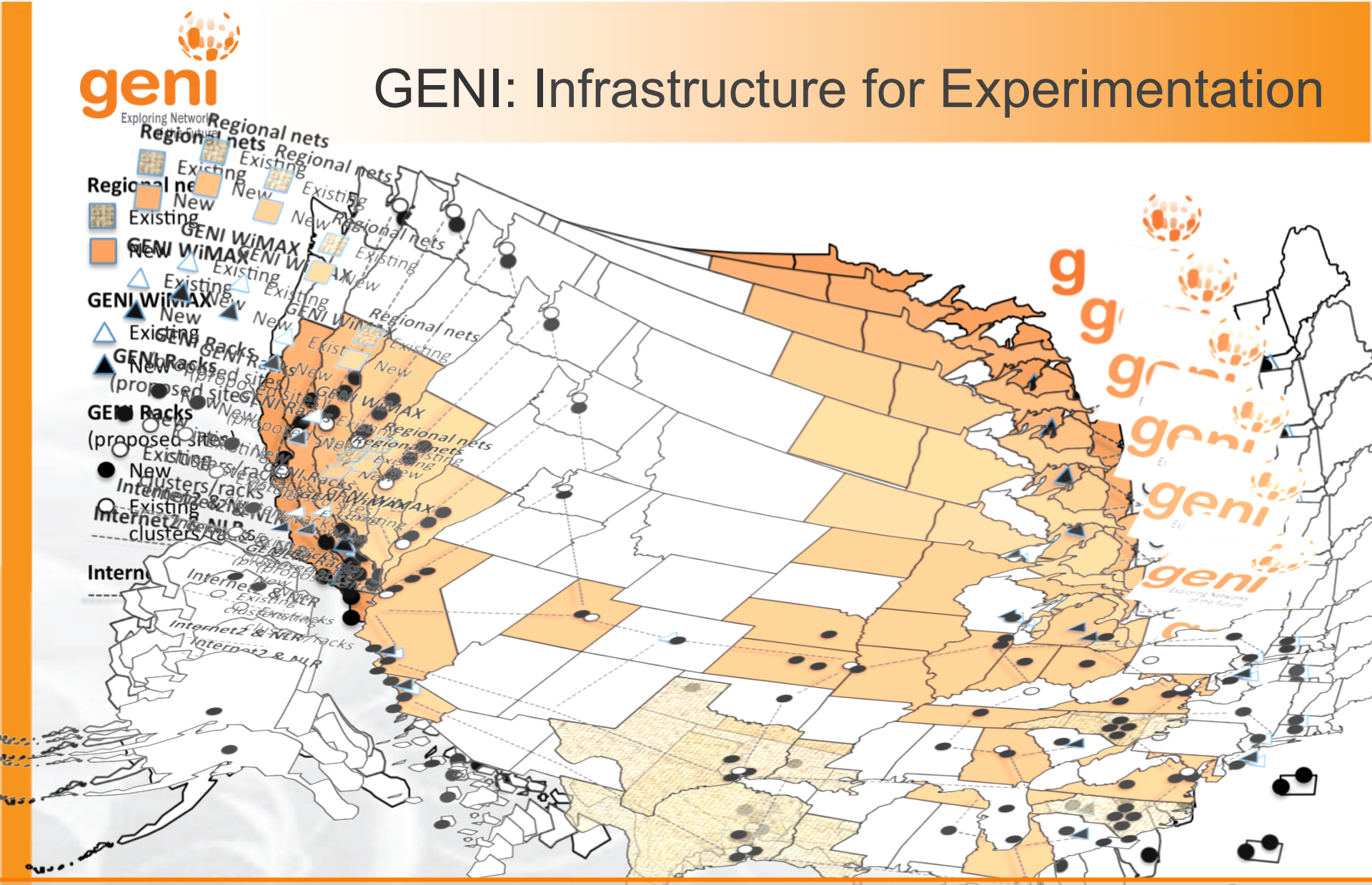
GENI: Infrastructure for Experimentation



GENI is a large multi-domain SDN testbed

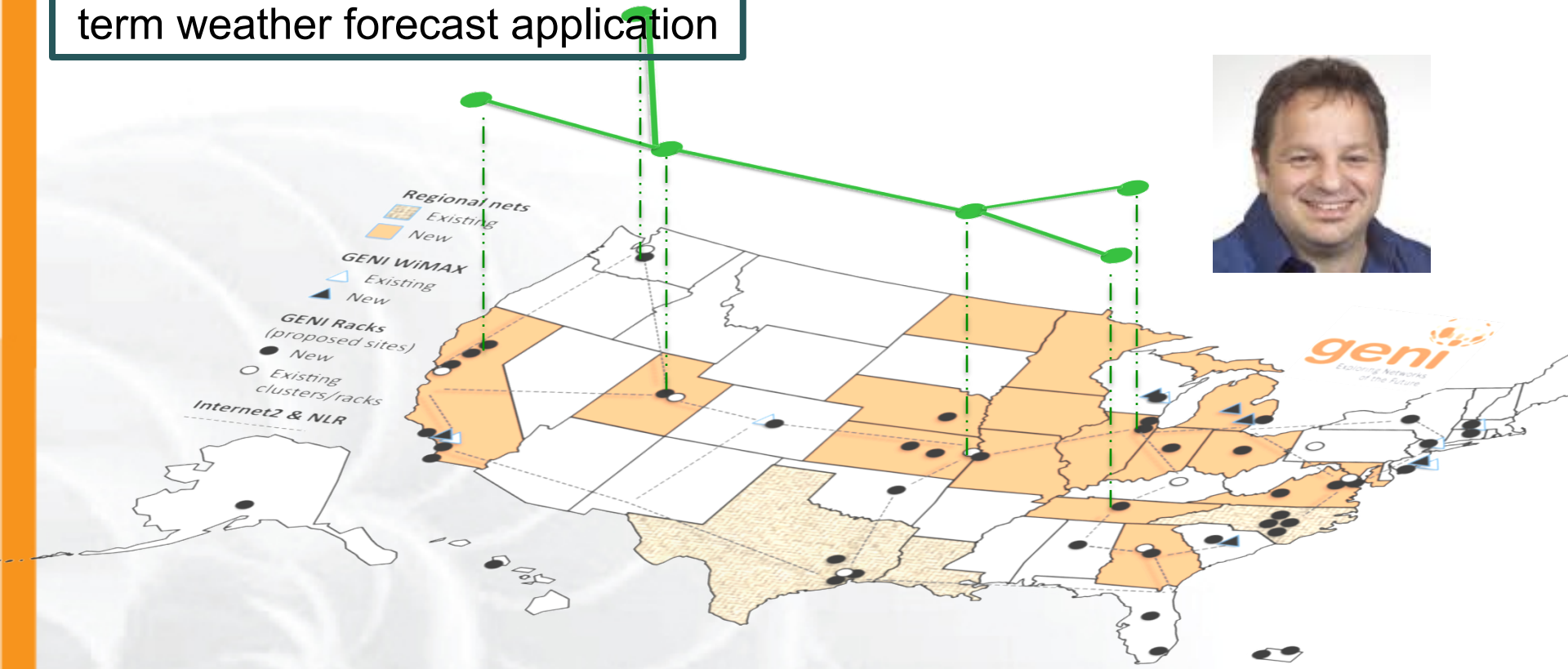
GENI: Infrastructure for Experimentation



GENI is the largest multi-domain SDN testbed

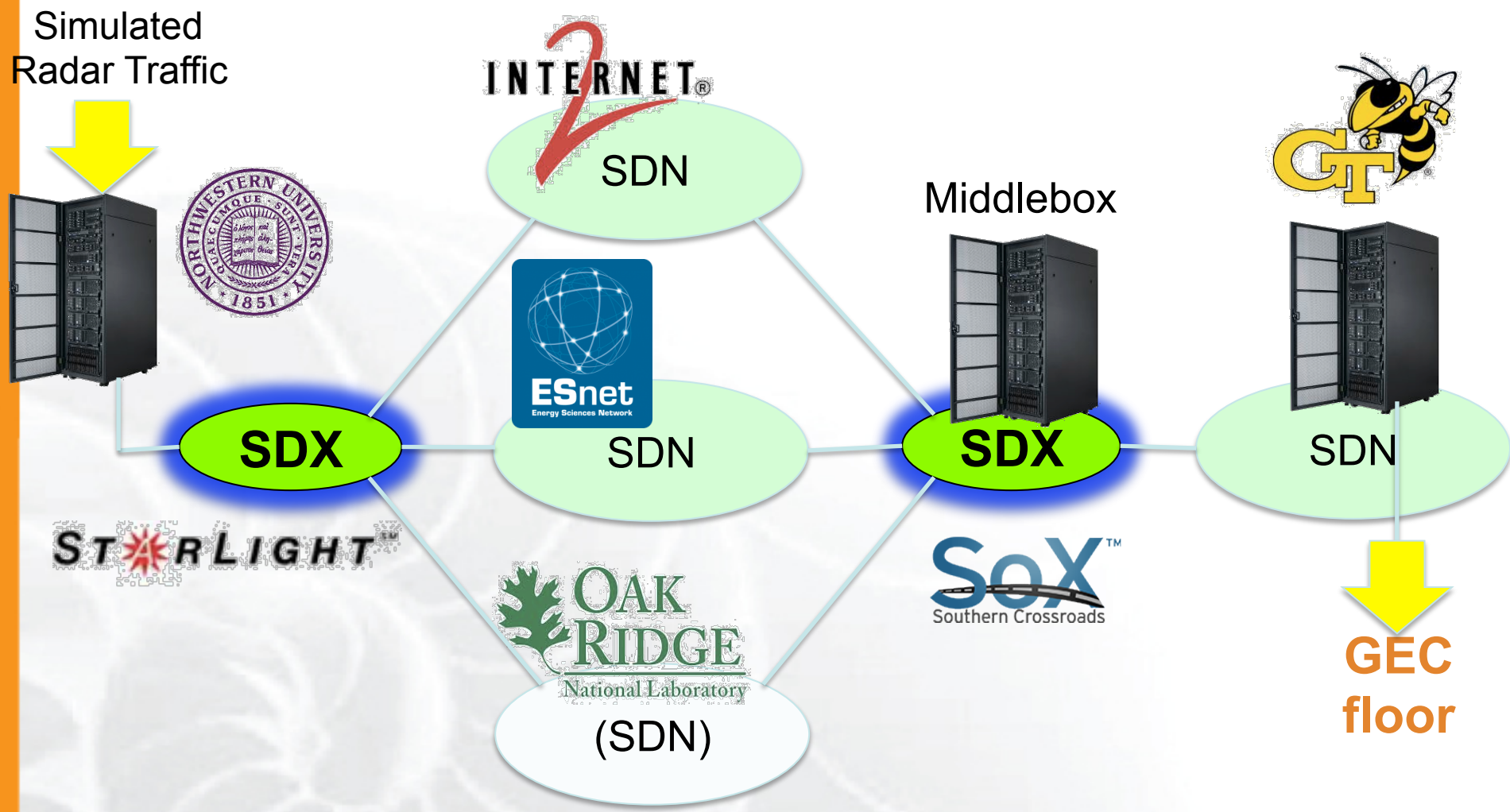
Setting up an SDX Experiment

Study the benefits of SDX on NowCast, a time-critical short-term weather forecast application

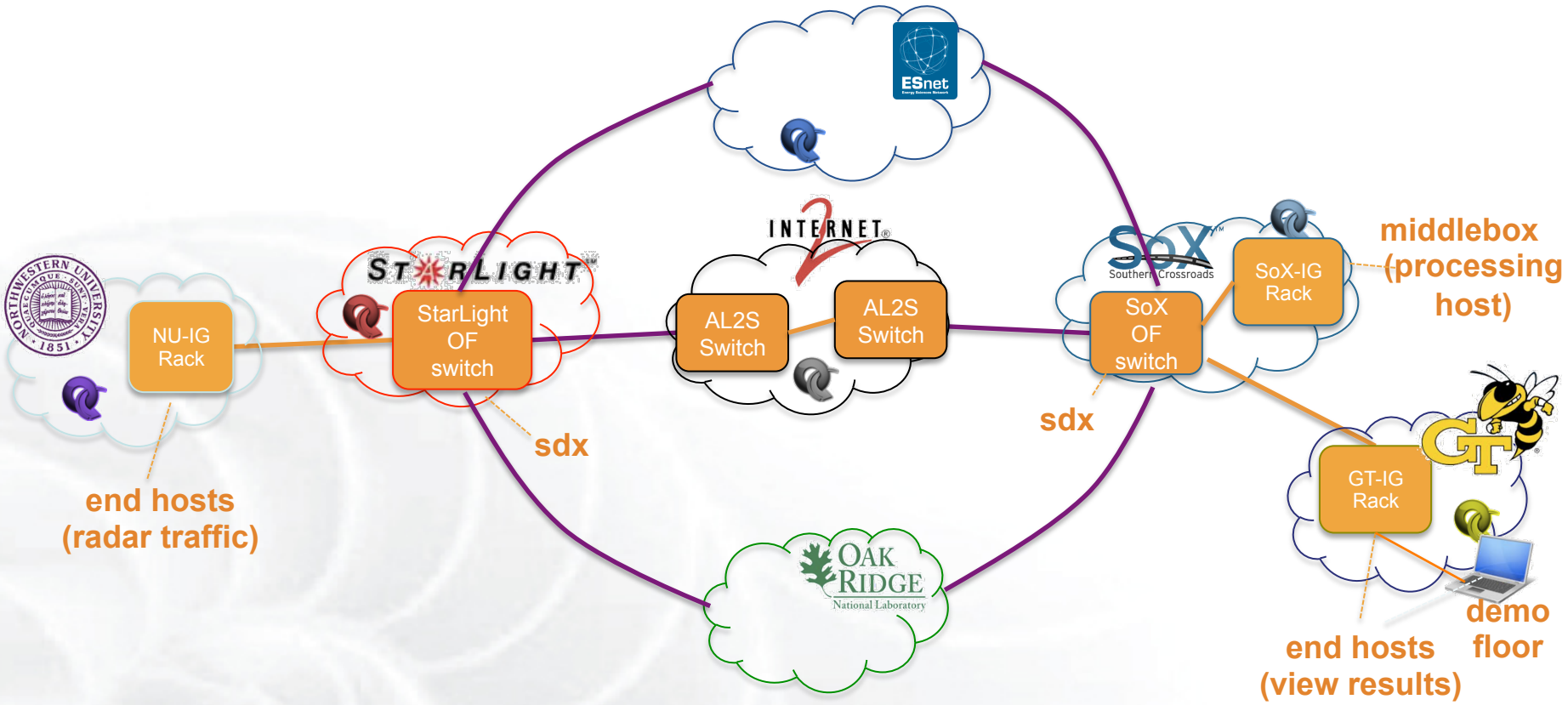


Deploy it on a GENI slice

Conceptual diagram

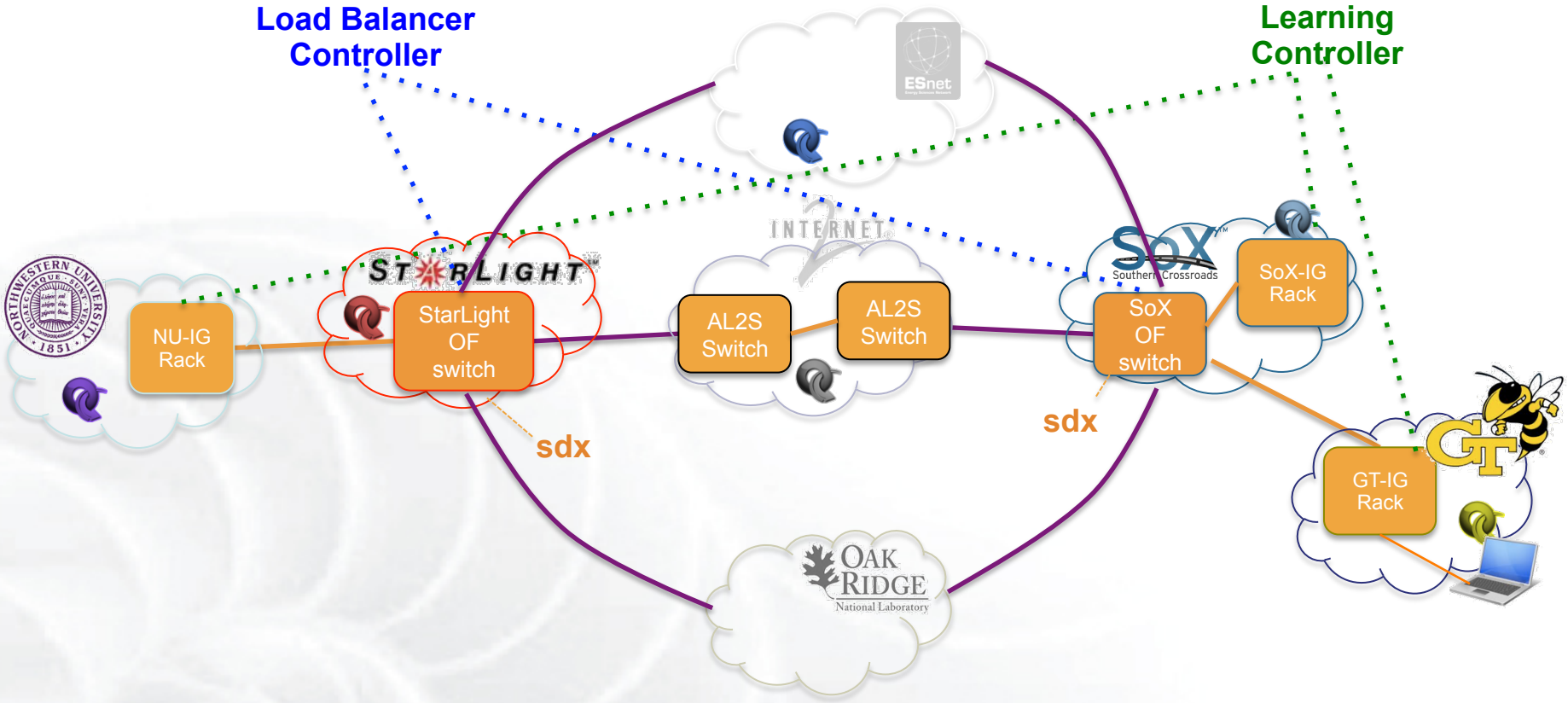


GENI Slice

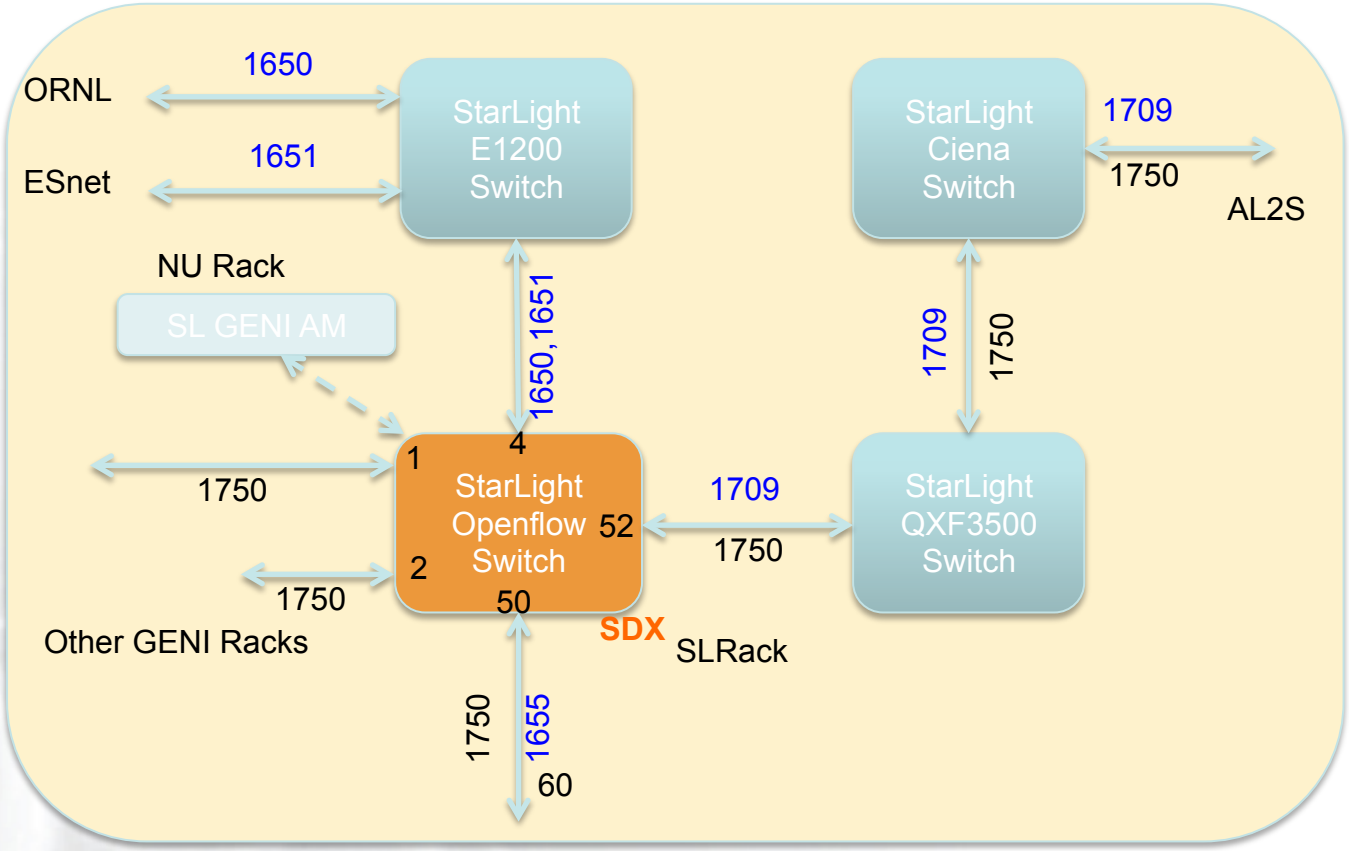


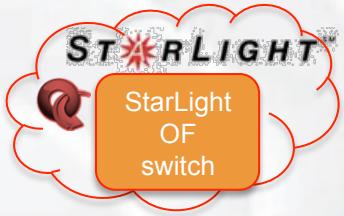
- Resource reservation with standard GENI tools

SDN Control



Experiment choice how to manage SDN resources





StarLight Network Diagram for SDX

Demo Configuration

- Demo runs on a multi-domain SDN, GENI slice
- Two experimenter-run OpenFlow Controllers
- Dynamic path switching controlled by App
- In-network processing

Thank You!

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GT-OIT

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Internet 2


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Nowcast on GENI Slice

Michael Zink

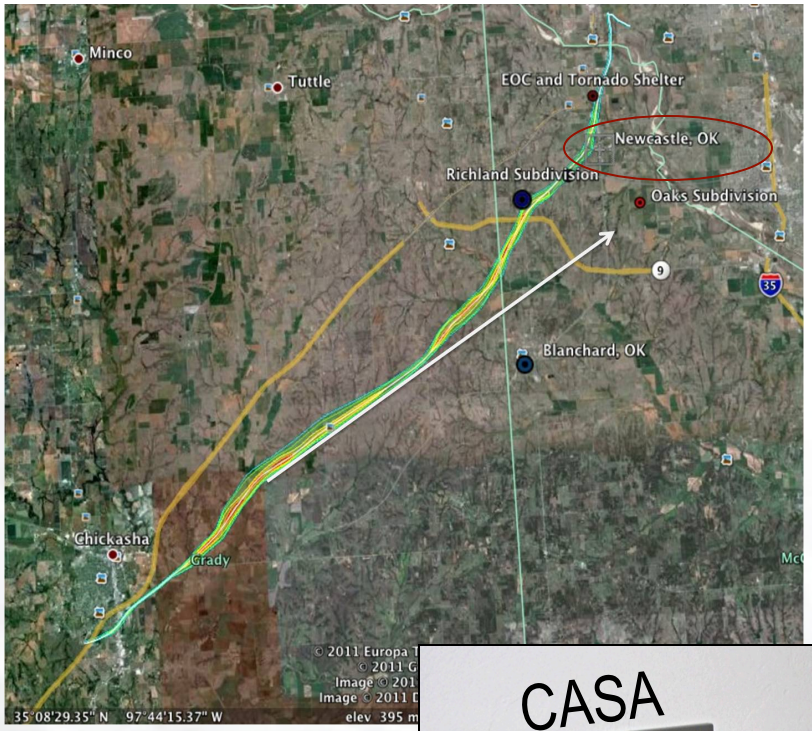
Electrical and Computer Engineering Department

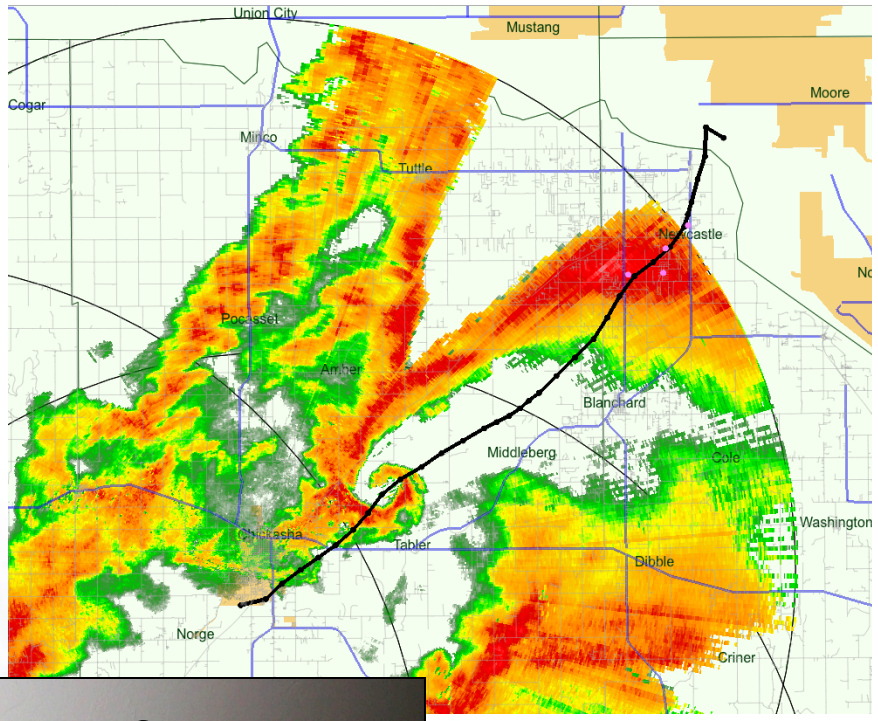
University of Massachusetts

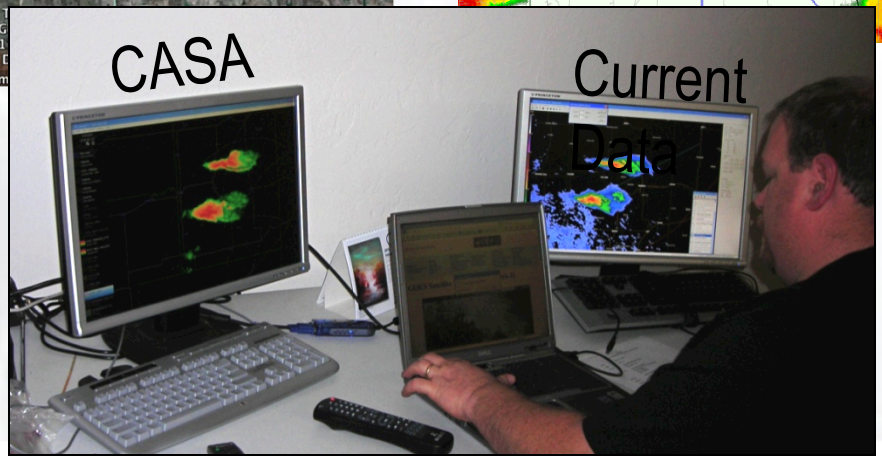
March 18th 2014

Sponsored by the National Science Foundation

May 24th 2011

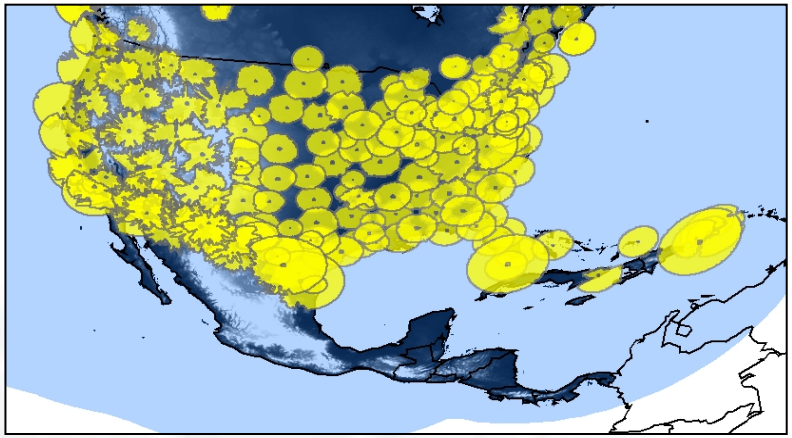




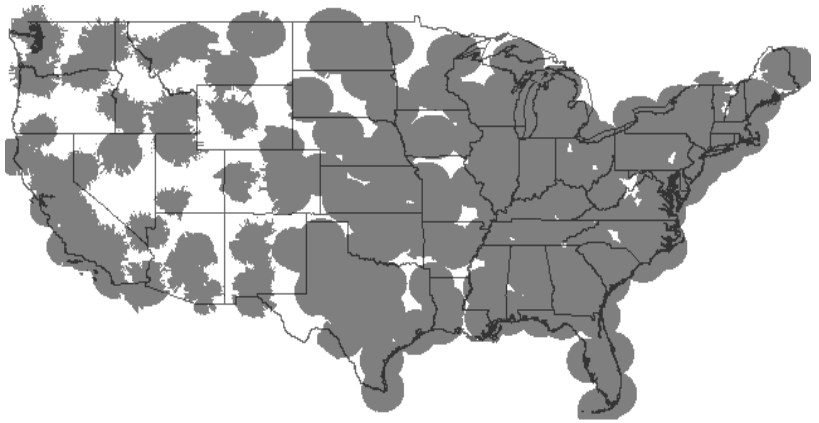


CASA data, EM decision-making protects first responders and public

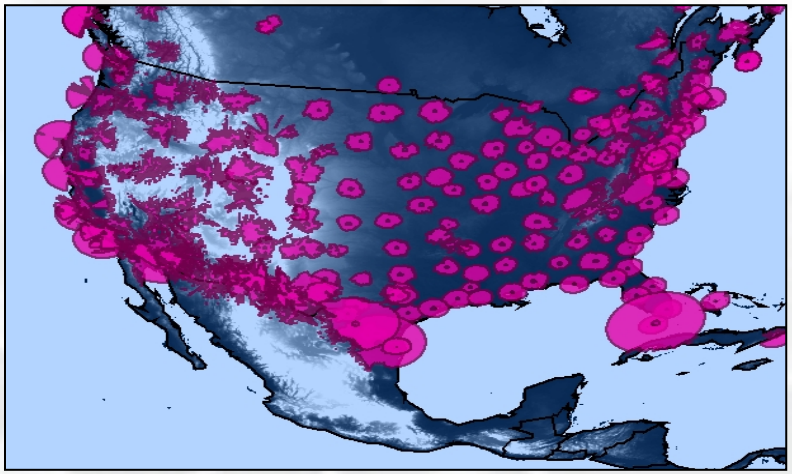
Today's Aircraft and Weather Surveillance



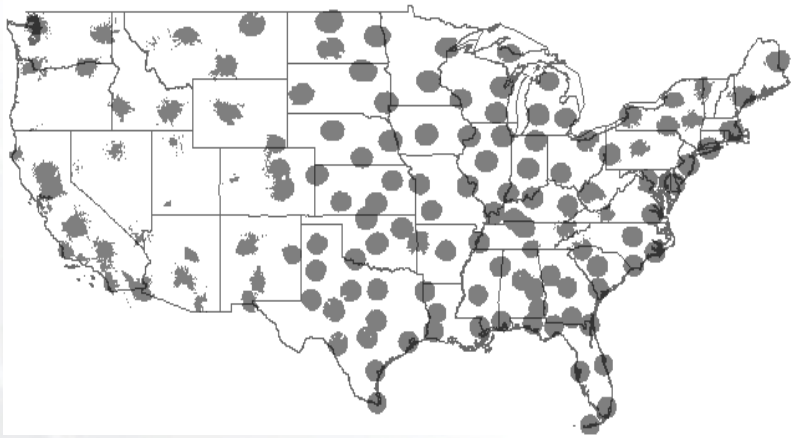
Aircraft at 5k ft



Weather at 3 km (~10k ft)



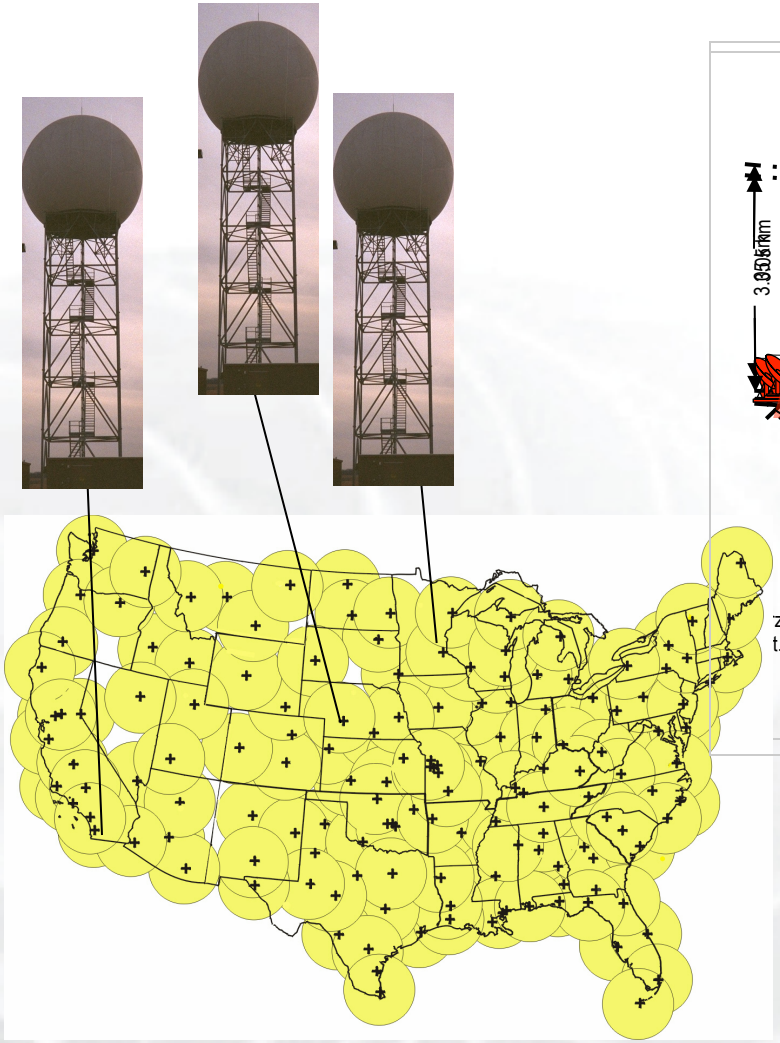
Aircraft at 1k ft

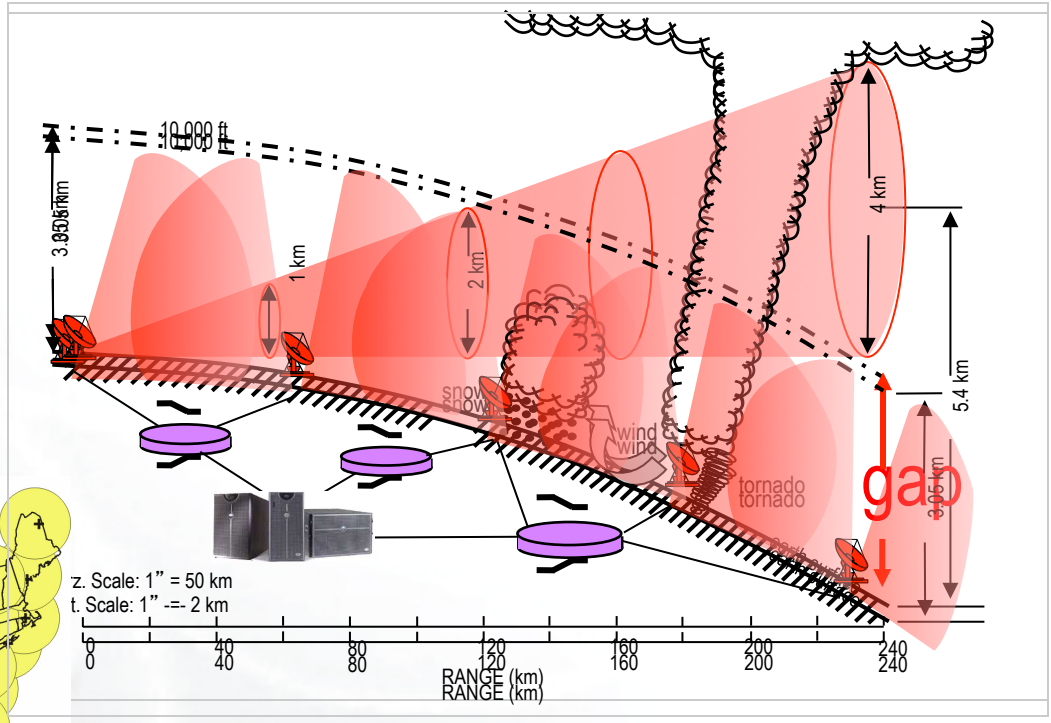


Weather at 1 km (~3200 ft)

widely-spaced radars, low-altitude coverage gaps

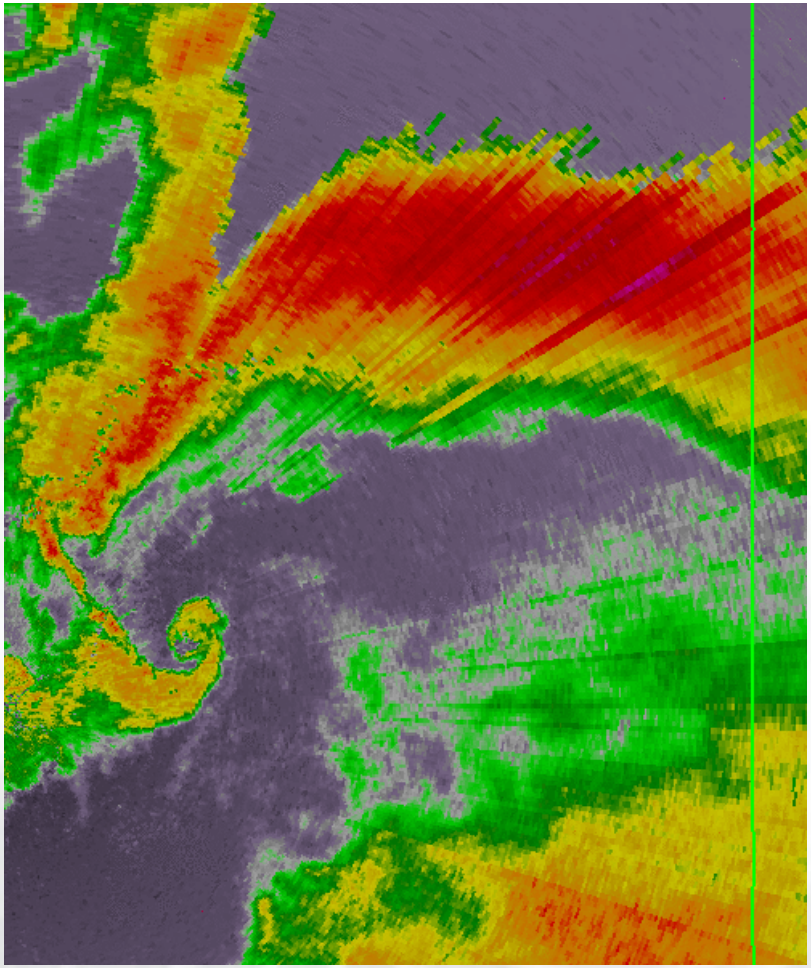
Tomorrow's Weather Radar Network



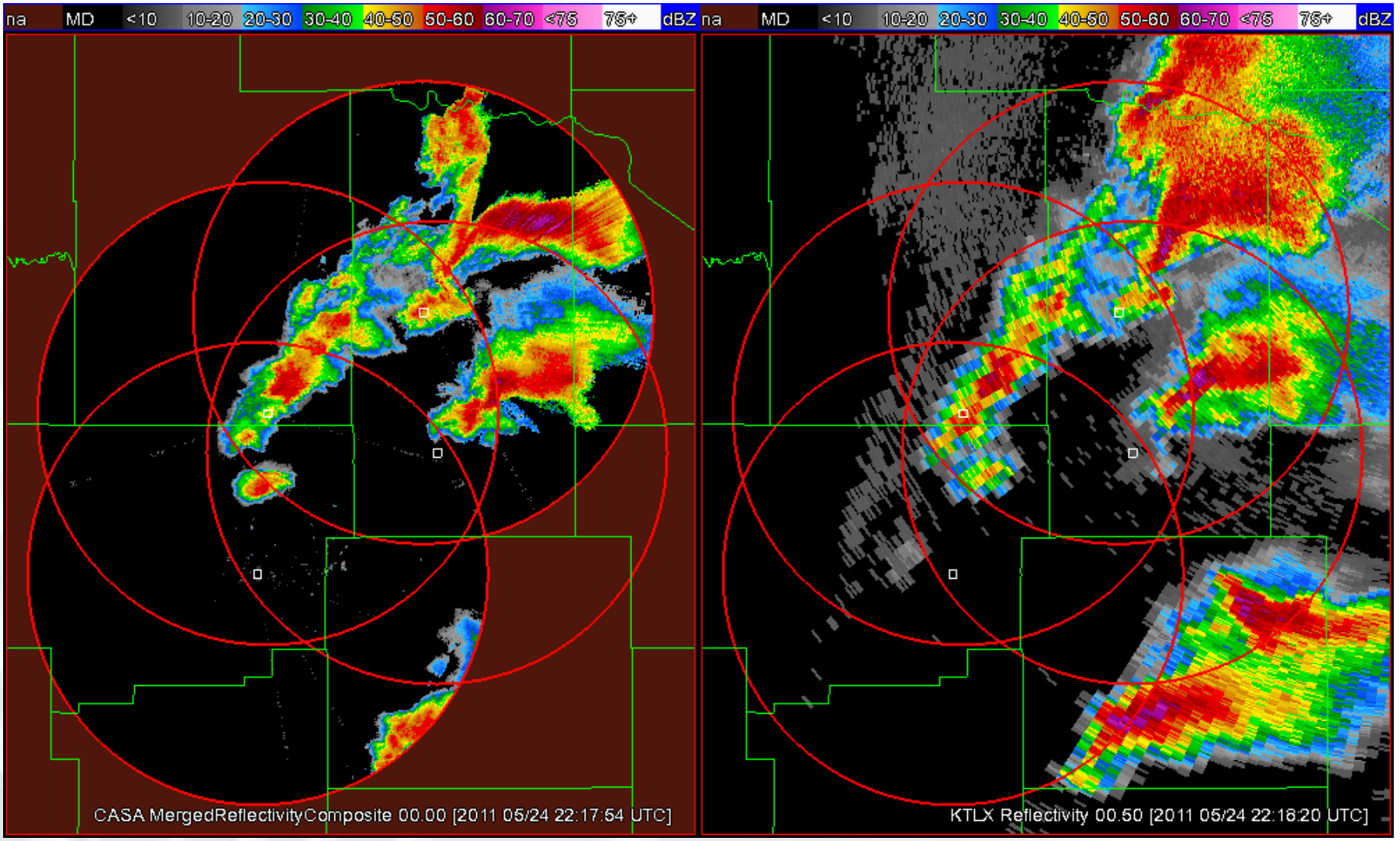


gap - earth curvature prevents 72% of the troposphere below 1 km from being observed.

May 24th 2011 Tornado



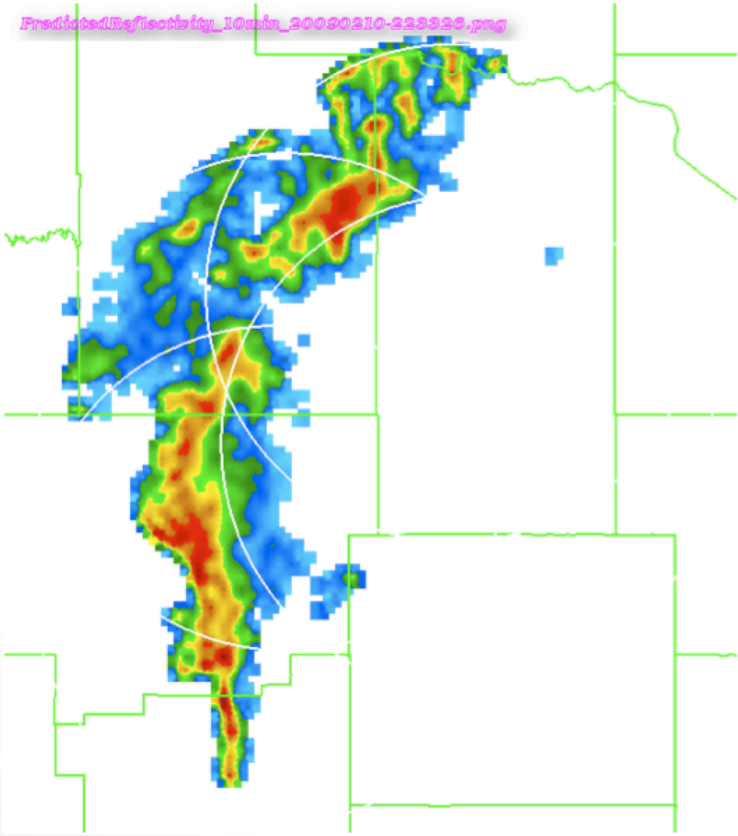
CASA – NEXRAD Comparison



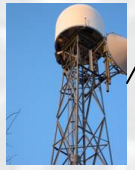
Nowcast

Goal: Increase warning lead time beyond observations

- Short-term (up to 30 minutes) forecast
  - Based on Dynamic & Adaptive Radars Tracking of Storms (DARTS)
- Different from full-blown forecast model



Nowcast – Processing



Dynamically provisioned SDN

Nowcast VM

Grid & Merge

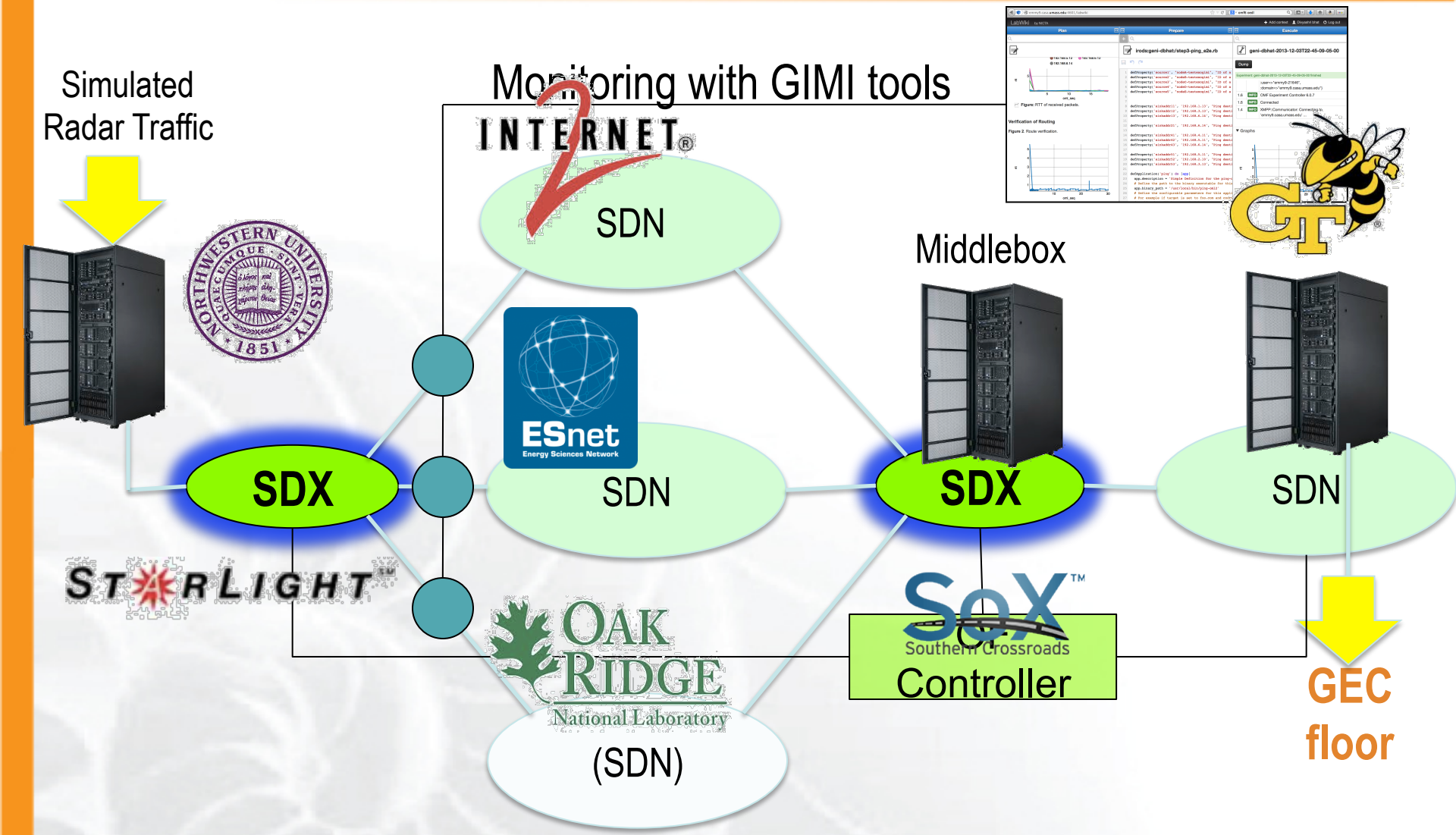
DARTS

Post-process

Webserver

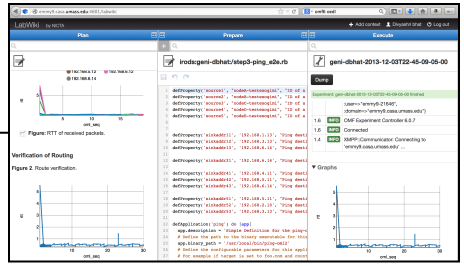
New nowcast every one minute!

Nowcast – Experiment

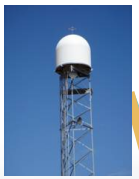


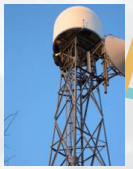
Nowcast – Data Flow

Simulated Radar Traffic



Monitoring with GIMI tools





SDN

SDN

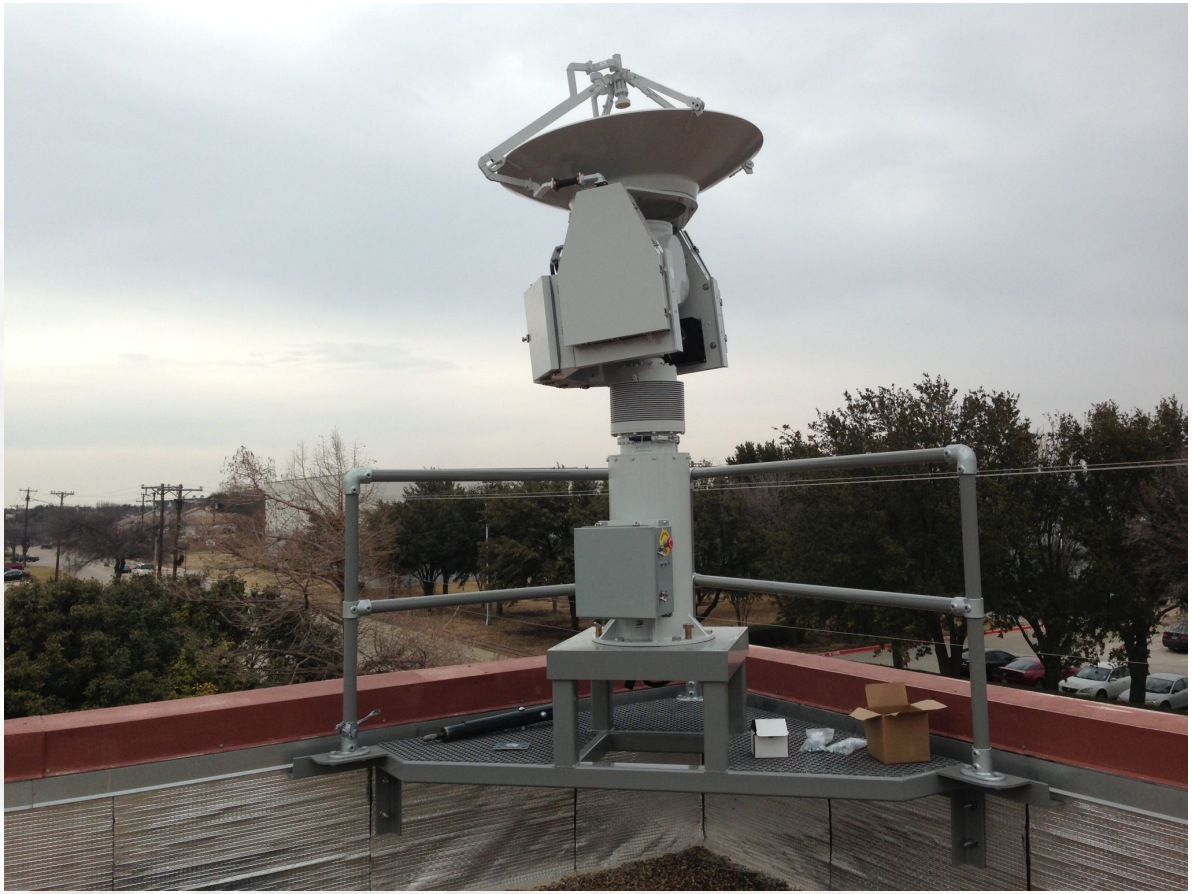
(SDN)

Middlebox

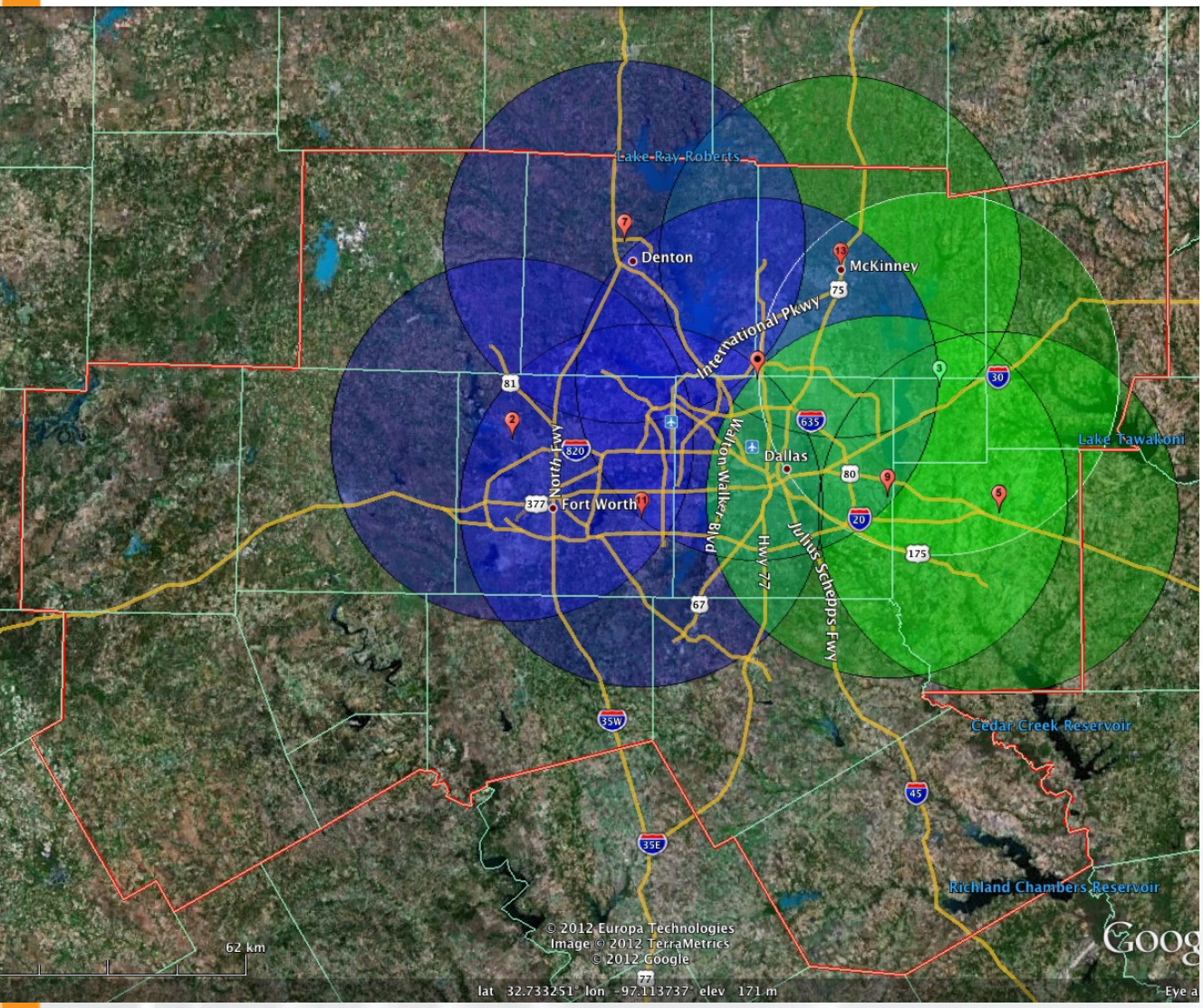
SDN

GEC floor

DFW Testbed



DFW Radar Deployment



NETWORK ROLLOUT

First phase in blue
Second phase in green
NCTCOG region in red

UNT, Denton
Discovery Park campus

UTA, Arlington
Carlisle Hall

Town of Addison
General Services bldg.

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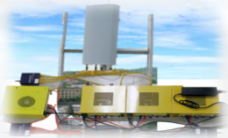

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What you have seen

- A **conceptual demo** of SDX's in action
- Running a next-gen scientific instrument / app . . .
  . . . spanning multiple SDNs across the US. . .
- Note – this demo helps illustrate the concept,
  but it's **only a concept** – real SDX's don't yet exist!

SDI

- Programmable Resources + Virtualization
  - compute, storage, network, switching, sensor, radio
- Technologies: SDN, multi-tenant datacenter, NFV, cyber-physical, mobility, internet of things
- “Software Defined Infrastructure (SDI)” consists of programmable, network connected, virtualizable, resources and the technologies they enable
- SDI will enable radically new classes of distributed end-end virtualized applications and dynamically defined distributed instruments

Precursors

- GENI
  - Clearinghouse: programmable resource identification/ allocation + authentication
  - Racks: mini datacenter, SDN, virtualization
  - Multi-domain / federated SDN-based
- Internet2 and ESNET
  - SDN enabled national-scale backbones
- Campus backbones / SDN
- Peer projects in many countries / regions
- International SDN-enabled links
- Commercial clouds and use of NFV

Goal

SDN → MD SDN + SDX-Phase1

→ MD SDI + SDX-Phase2

Multi-domain / Federation

- GOAL: a multi/domain Federated SDI
- First steps (already underway)
  - Phase 0 SDX demonstrating an important application
  - International collaboration on Federated Distributed Clearinghouses
  - Development of tools to provide for Layer 2 end-end stitching
  - NCO workshop on a national multi-domain SDN deployment

Roadmap

1. Identify, prototype and deploy new SDI-based applications at all stages
2. Specify and prototype a Phase 1 SDX for a multi-domain SDN
3. Deploy Phase 1 SDXs in an operational multi-domain SDN testbed
4. Determine requirements for a Phase 2 SDX that will support a multi-domain SDI
5. Prototype and deploy Phase 2 SDXs supporting an operational multi-domain SDI

Next Steps

- Standup and operate multiple SDXs as open focal points for this effort complemented by an **interop-like** process
- Engagement of researchers; R&E network operators; campus IT organizations; industry, government and international collaborators
- Workshops to continue charting the US roadmap, first to operational multi-domain SDN and then to operational multi-domain SDI
- Active participation by you and your students!
- Support from funding agencies!


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