

Transforming Research & Education Through Unusual Collaborations

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Wondering about the title? 😊

Unusual Collaboration?

Transforming R&E?

Relevance to INDIS, i.e., networking + data intensive science?

“Convergence” as a new R&E paradigm

GRAND CHALLENGES FOR ENGINEERING

Introduction

Throughout human history, engineering has driven the advance of civilization. From the metallurgists who ended the Stone Age to the shipbuilders who united the world's peoples through travel and trade, the past witnessed many marvels of engineering prowess. As civilization grew, it was nourished and enhanced with the help of increasingly sophisticated tools for agriculture, technologies for producing textiles, and inventions transforming human interaction and communication. Inventions such as the mechanical clock and the printing press irrevocably changed civilization.

In the modern era, the Industrial Revolution brought engineering's influence to every niche of life, as machines supplemented and replaced human labor for countless tasks, improved systems for sanitation enhanced health, and the steam engine facilitated mining, powered trains and ships, and provided energy for factories.

Make solar energy economical 7

Provide energy from fusion 10

Develop carbon sequestration methods 13

Manage the nitrogen cycle 16

Provide access to clean water 19

Restore and improve urban infrastructure 22

Advance health informatics 25

Engineer better medicines 30

Reverse-engineer the brain 34

Prevent nuclear terror 37

Secure cyberspace 40

Enhance virtual reality 42

Advance personalized learning 45

Engineer the tools of scientific discovery 48

Convergence

- Deep **integration of knowledge, tools, and ways of thinking** from life and health sciences, physical, mathematical, and computational sciences, engineering disciplines, and beyond
- Does *convergence* represent a new paradigm in science and engineering research?



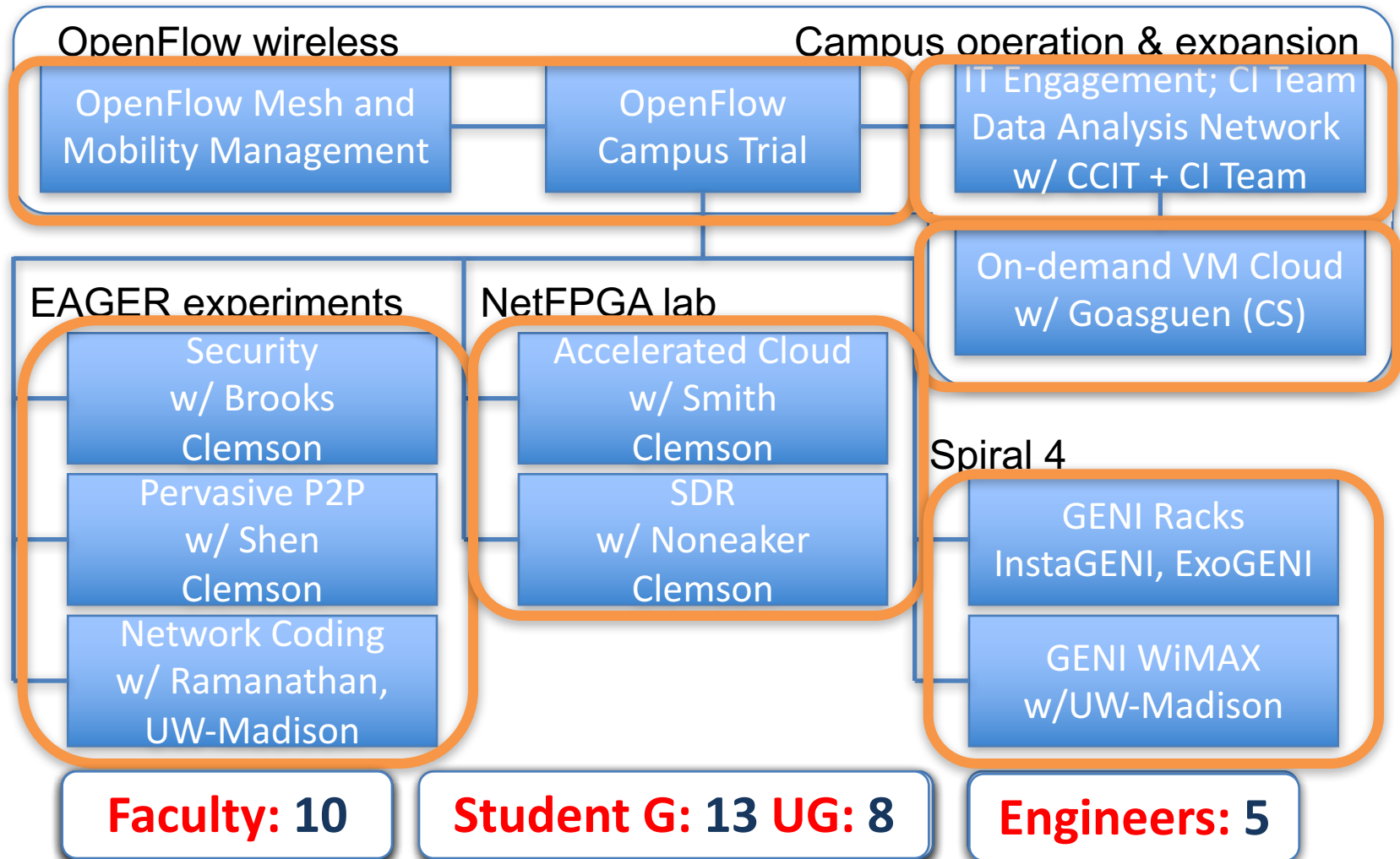
Pramod Khargonekar
Assistant Director for Engineering
National Science Foundation

Challenges for Academic Institutions –

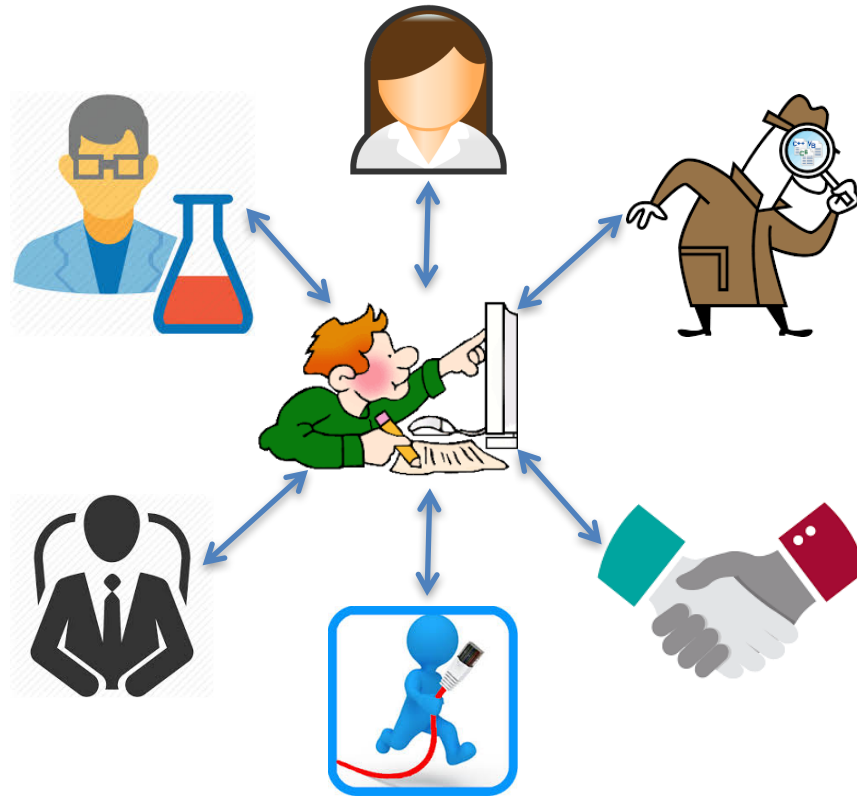
How to create flexible organizational structures to enable convergence research paradigm change?

How a “Typical Faculty Member” Collaborate

- My own little GENI exercise (2009-2012)

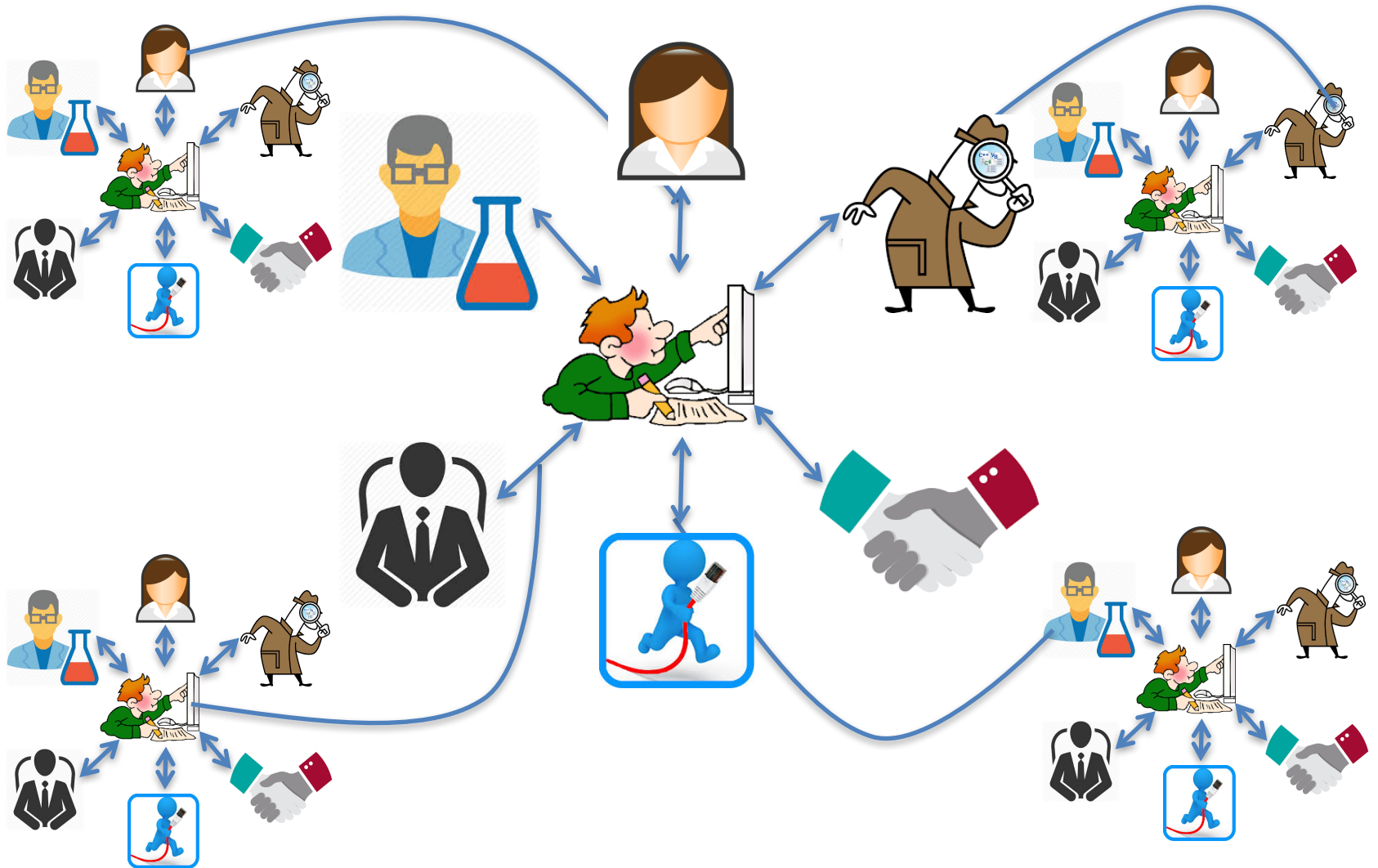


The Model of Collaboration ...

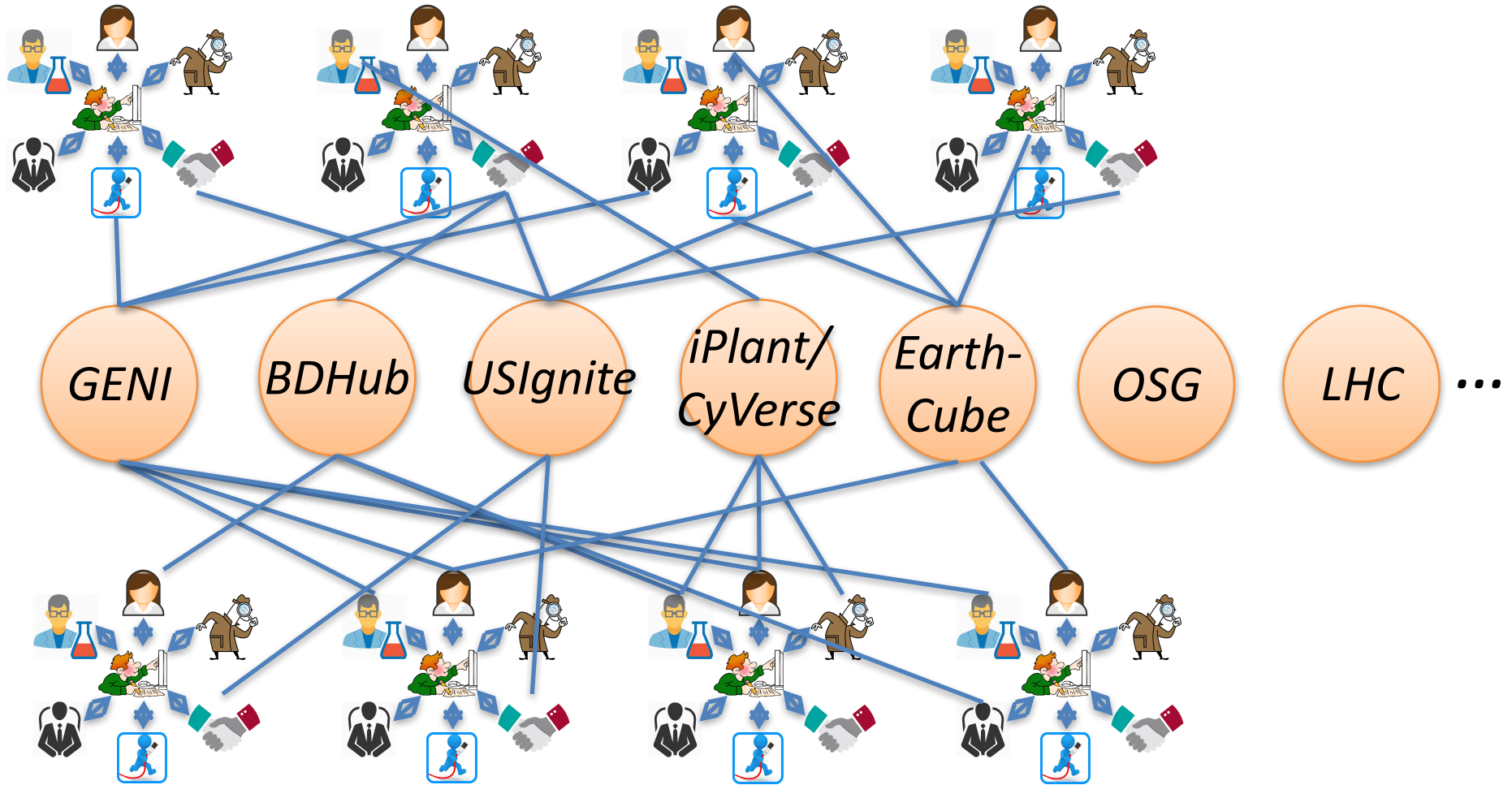


Classic, single researcher-centric collaboration

Scaling Up?



“Project Collaboratives”



A Look at Some of Our Recent Projects

	CC* (3 projects)	CIF21 DIBBS: TriPal	CloudLab	NRT-DESE
People	10+ organizations Students/postdoc ~10 staff/engineer	4 organizations N students	6 organizations	7 colleges 14 departments 28 faculty 24 students
Infrastructure	Mesh of new/old relationships			BD
Scale	IT as critical anchor			5-year project, \$3M
Communities	<ul style="list-style-type: none"> IT Bioengineering Business Open source Companies 	<ul style="list-style-type: none"> IT NIH 	<ul style="list-style-type: none"> IT domains" Companies 	<ul style="list-style-type: none"> IT Broad data sciences Computing & Networking Companies

Large degrees of collaboration

Mesh of new/old relationships

IT as critical anchor

All about Data, Networks, Computing

Data Sciences at Clemson



- Campus wide, from STEM to humanities
 - **Distinct domains and forms**
 - 80 faculty & staff members with “data research”
 - **Inter-domain collaboration**
 - Teams after NSF BIGDATA, BD-HUB, NRT-DESE, CRISP, ...
 - **University-level collaboration**
 - President survey of data science curriculum campus-wide
 - Clemson-MUSC Joint PhD Program on Biomedical Data Science & Informatics

Clemson Big Data Research Survey

led by Alex Feltus, Prof. of Genomics

Collaboration structure among

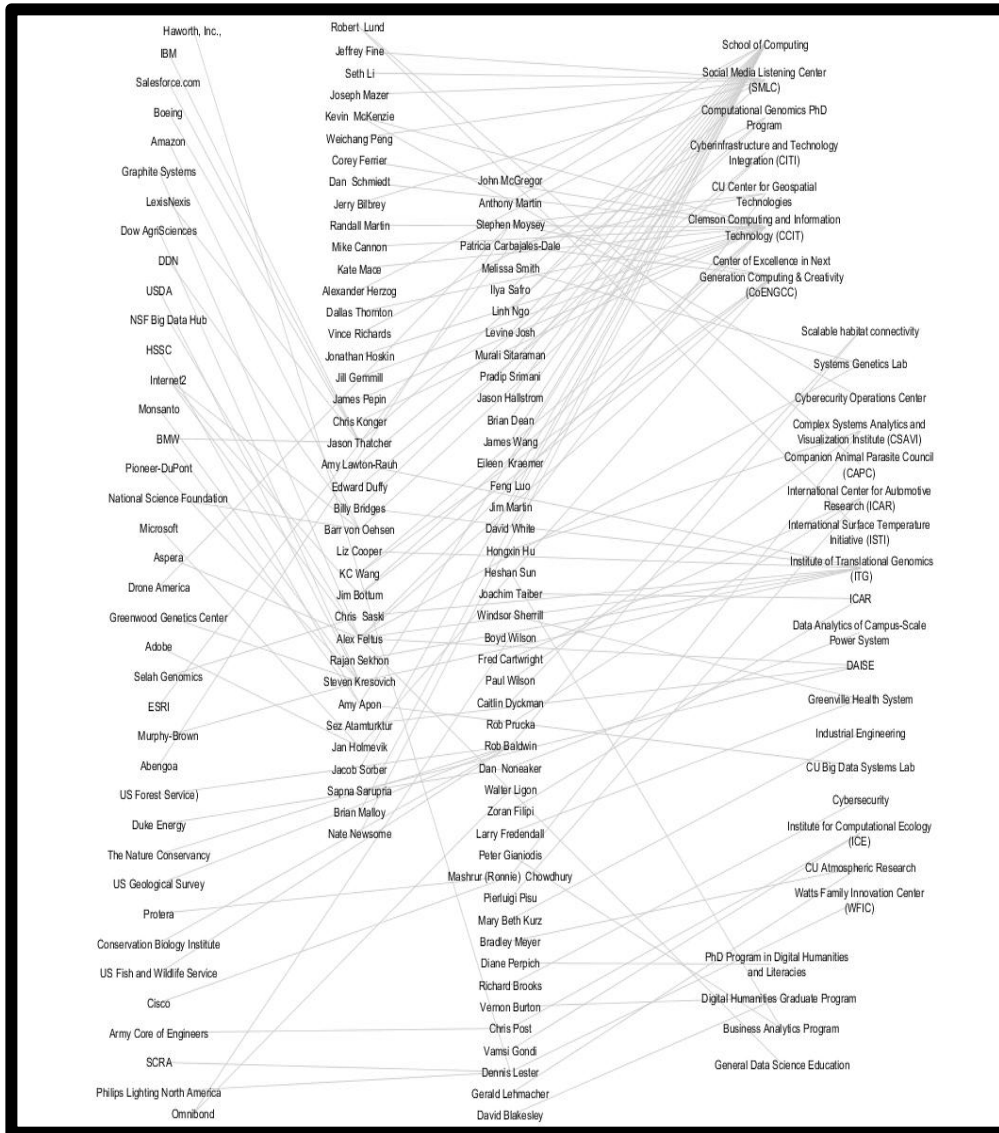
- **80 faculty & staff**
- **5 colleges, 27**
- **depts/centers/institutes, 31 groups**
- **15 industrial sectors, 32 partners**
- **7 sponsor agencies**

Data sciences come in different

- Domains, scales, forms, methods

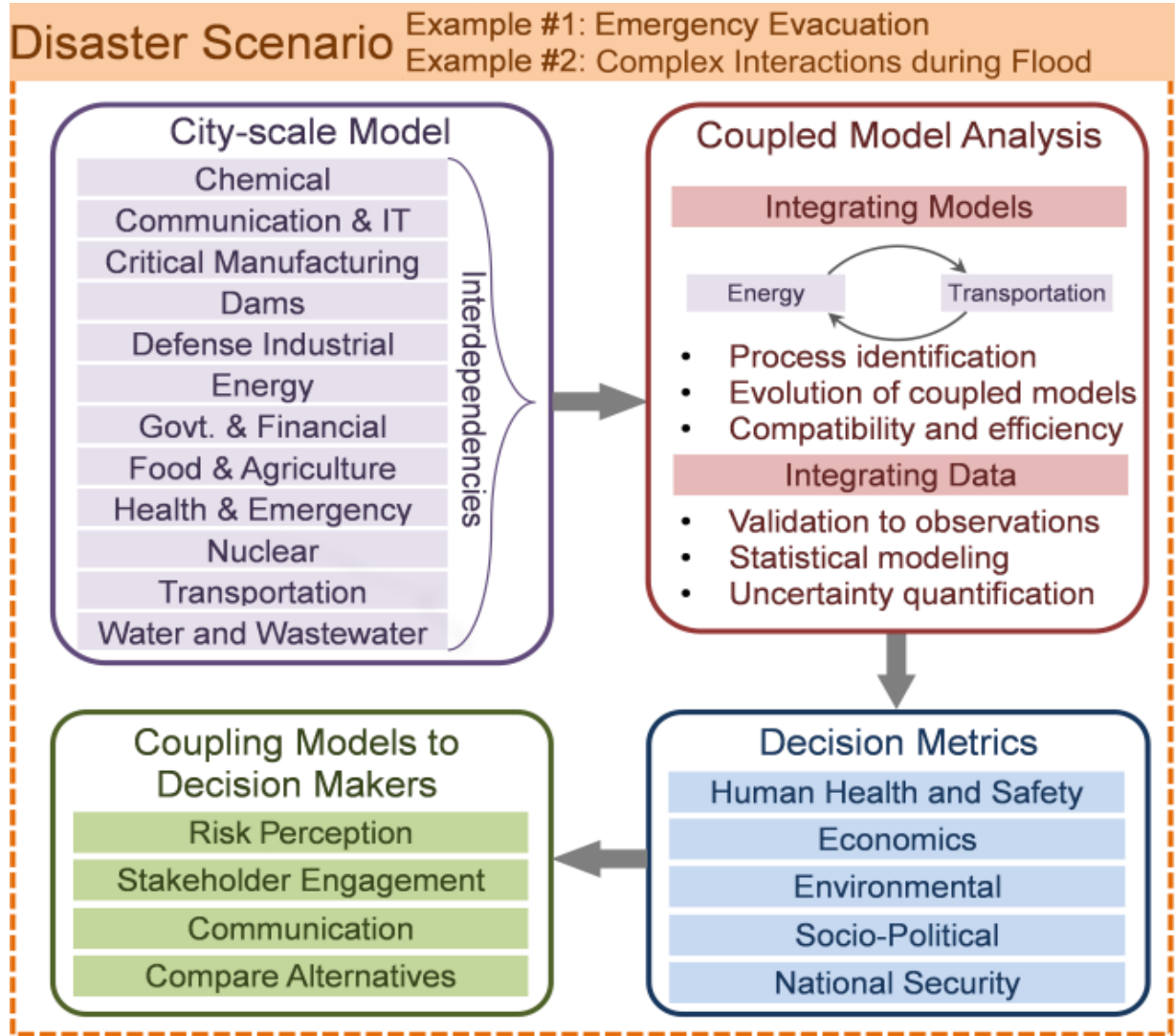
Collaboration not always easy

- *Researcher herding researchers*
 - *Good shepherds needed!*
- Word-of-mouth + leap of faith
- Always under time pressure
- **True collaboration takes time & understanding of mutual priorities**



NRT-DESE: PROACTIVE

Highly Cross-disciplinary Data Science R&E



As the project takes shape, it becomes apparent the program needs a university level platform -



Clemson Center of Excellence for Next Generation Computing & Creativity

RESEARCH & EDUCATION

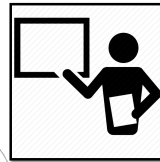
FORWARD

- **Next Generation Research & Education** will transcend domain boundaries

STUDENTS



FACULTY



- **Knowledge & Resource** across university == ingredients for success

- **Collaboration** takes efforts, but its worth it and easier with a system!

STAFF



COMPUTING



- **“Collaboration” as pervasive as an IT service** brings transformation to our university

As an **unprecedented experiment**, we – a group of like-minded faculty partners with CCIT to:

- Develop innovative **learning environments** for our students & faculty,
- Develop **technology & human infrastructure** for research,
- Develop cross-campus, national, and global **partnerships**

Building on our success in teamed science in **nationally collaborative initiatives**

We believe COE can transform university R&E,
By Assisting Researchers to Envision

Cross-disciplinary by default

Collaborate by default

Big teams & grand challenges

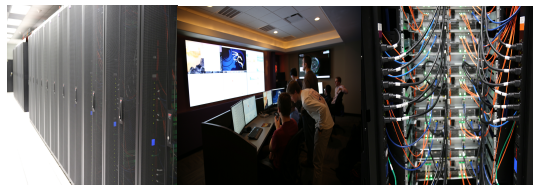
One Team – Multiple Fronts for Collaboration

Clemson and Beyond!

Computing

Geospatial Technologies

Creativity



HPC

Data Science

Visualization

Cybersecurity

Education,
Outreach &
Training

Clemson Center for Geospatial Technologies

Center Mission:

Build a community of interdisciplinary geospatial science practitioners through the support of **research, teaching, and outreach** activities using technologies that enable the collection, analysis, and application of spatial data *across disciplines*.

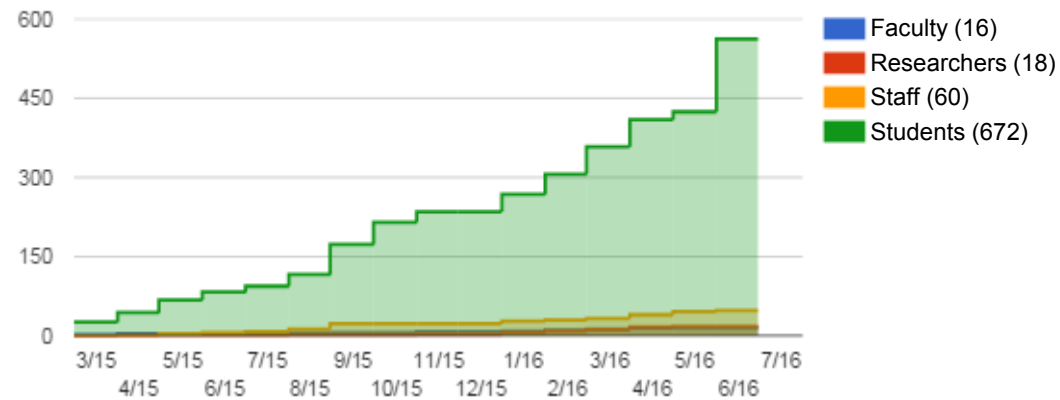
- CCGT provides services advancing academic and research excellence for all Clemson faculty, students, and staff.
- CCGT was initiated as a component of the CoE in 2015 through a partnership between CCIT & Libraries, but has already grown to be a valuable component of Clemson's core campus infrastructure.

The image shows a screenshot of the Clemson Center for Geospatial Technologies website. At the top, the Clemson logo is displayed with the text "CLEMSON CENTER FOR GEOSPATIAL TECHNOLOGIES" and navigation links for Home, Services, Software, Data, About, and Resources. Below the logo is a large aerial photograph of the Clemson campus with the text "GIS SERVICES" overlaid, followed by the subtext "Instruction Research support Data Cyberinfrastructure". Underneath the photo are three dark boxes with orange text: "GETTING STARTED" (with a "More info" button), "WORKSHOPS" (with a "More info" button), and "RESOURCES" (with a "More info" button). To the right of the main content is a vertical purple sidebar titled "CATALYST" containing five purple buttons: "Interdisciplinary Research & Collaboration", "Grant Funding", "Local & International Outreach", "Online Certificate Programs", and "Partnerships with Industry". At the bottom of the page is a horizontal row of six orange buttons: "Geospatial Data", "Research Support", "Instruction & Outreach", "Field Data Collection", "CyberGIS", and "Big data & social media".

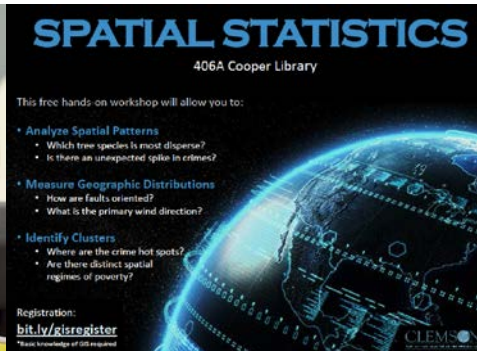
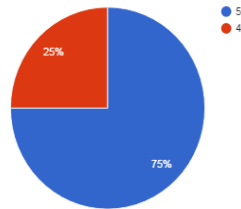
Training & Instruction

14 courses supported
 31 workshops developed
 57 workshops delivered
 766 workshop attendees

Attendees by status



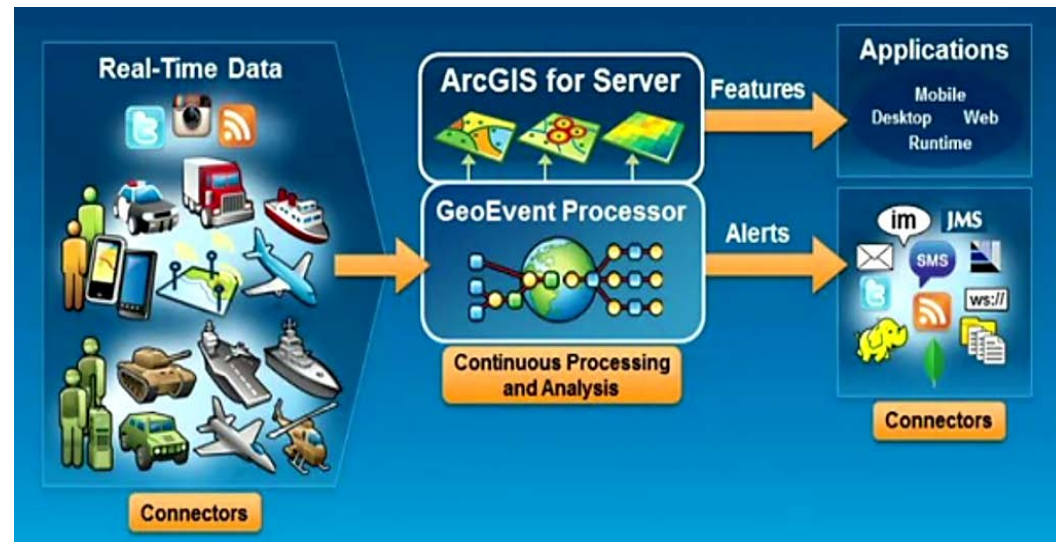
Quality of the workshop (1-5)



Research Support

- Provided **370** one-on-one research consultations: data, analysis, workflows, HTC, HPC, programming, visualization, cartography, etc.
- Cyberinfrastructure – storing, publishing, and analyzing real-time data; big data & social media, mobile apps, surveys, sensor data; condor cluster for GIS; software license management and support
- **Research Proposals** – supported 9 research proposals engaging >32 faculty from over 14 departments totaling >\$7M in requests. Awards ~\$3.5M (including NSF NRT)

Schedule a consultation!



Some More “Unusual” Collaborations

CIF21 DIBBS: Tripal Gateway, a Platform for Next-Generation Data Analysis and Sharing



PIs: Stephen Ficklin¹, Dorrie Main¹, Alex Feltus², Meg Staton³, Jill Wegerzyn⁴
Senior Personnel: Kuangching Wang⁵, Sook Jung¹.

¹ Washington State University, Department of Horticulture

² Clemson University, Department of Genetics and Biochemistry

³ University of Tennessee, Department of Entomology and Plant Pathology

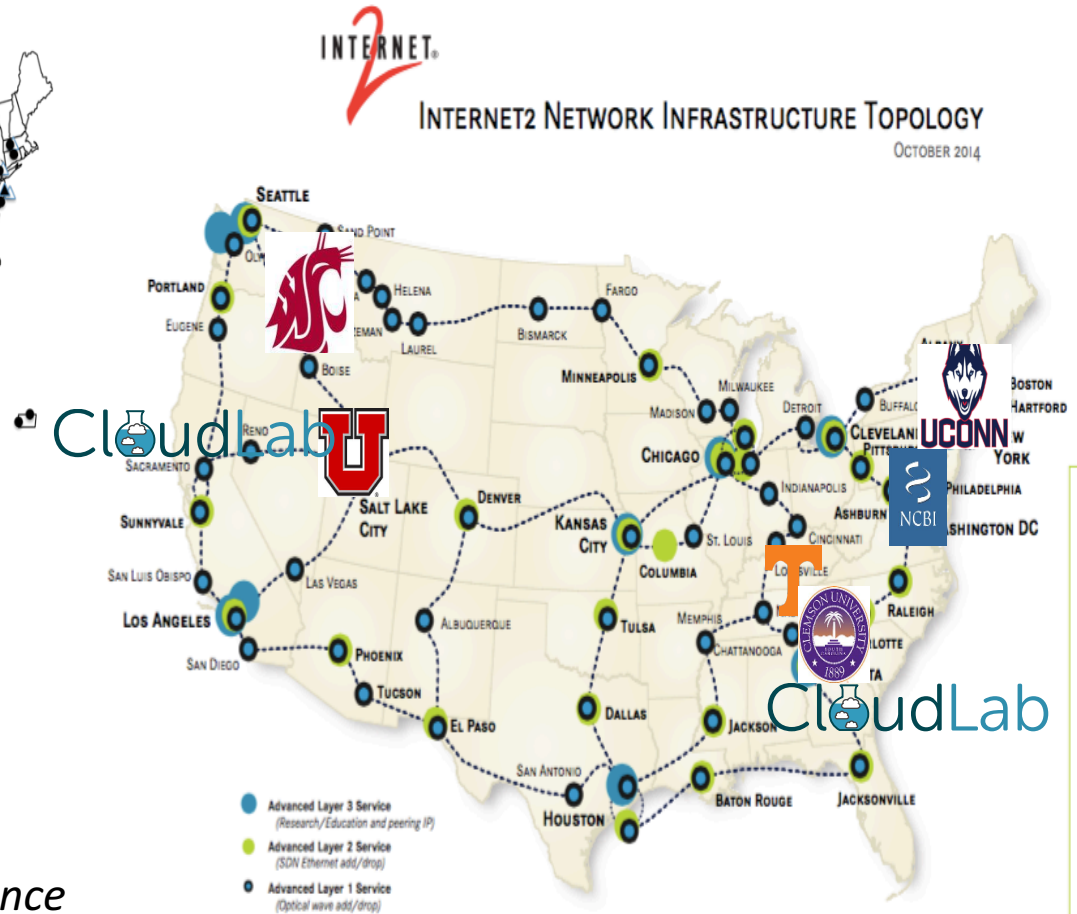
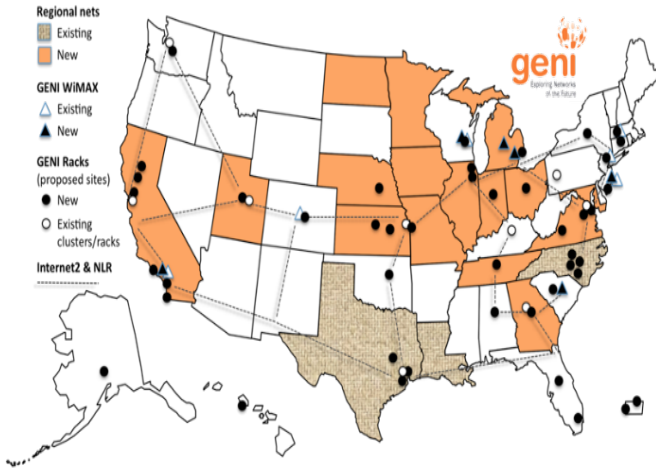
⁴ University of Connecticut, Department of Ecology and Evolutionary Biology

⁵ Clemson University, Department of Electrical and Computer Engineering



Tripal Data Transfer / SDN

Research Data Transfer Networks: Internet2 & GENI



12 Topology courtesy of Florence Hudson @ Internet2; GENI topology from www.geni.net

INTERNET2 NETWORK BY THE NUMBERS

17	JUNIPER MX2400 ROUTERS SUPPORTING LAYER 3 SERVICE
34	BROADCOM AND JUNIPER SWITCHES SUPPORTING LAYER 2 SERVICE
60	CUSTOM COLLOCATION FACILITIES
200+	AMPLIFICATION RACKS
15,217	MILES OF NEWLY ACQUIRED DARK FIBER
8.8	TPBS OF OPTICAL CAPACITY
100	GBPS OF HYBRID LAYER 2 AND LAYER 3 CAPACITY
300+	Ciena ACTIVEFLEX 5500 NETWORK ELEMENTS
2,400	MILES PARTNERED CAPACITY WITH ZAYO COMMUNICATIONS IN SUPPORT OF THE NORTHERN TIER REGION

IN SUPPORT OF
U.S.JCAN

NETWORK PARTNERS

ciena

CISCO

INDIANA UNIVERSITY

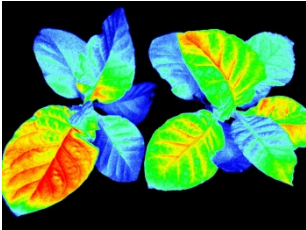
infinera

JUNIPER NETWORKS

Cyberinfrastructure

Data Acquisition

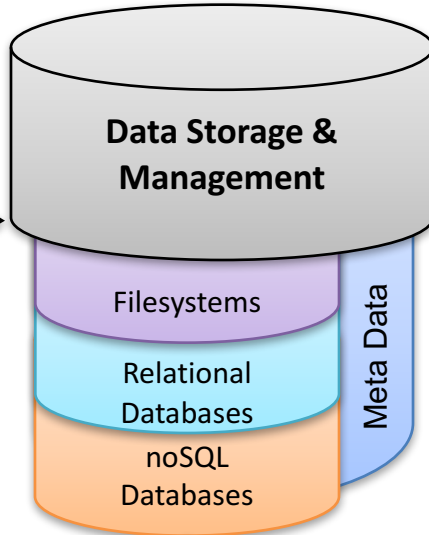
HiSeq 2000



e.g. laboratory, core facility, sensor network...

Data Transfer

local, national and global network infrastructure

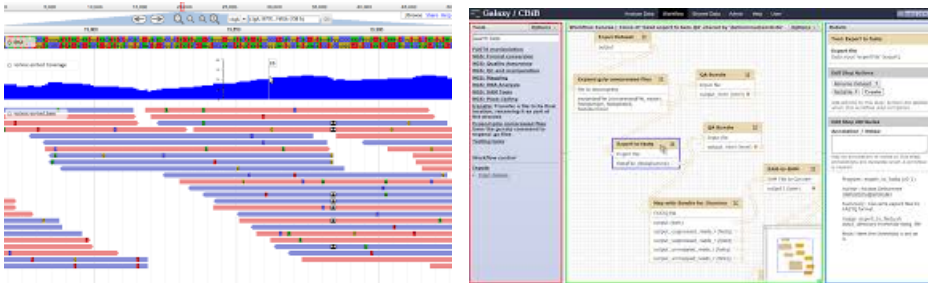


Data Integration, Processing & Analysis



e.g. parallel high-performance and high-throughput computing, GPUs, co-processors, MapReduce.

Data Mining, Visualization & Online Analytics.



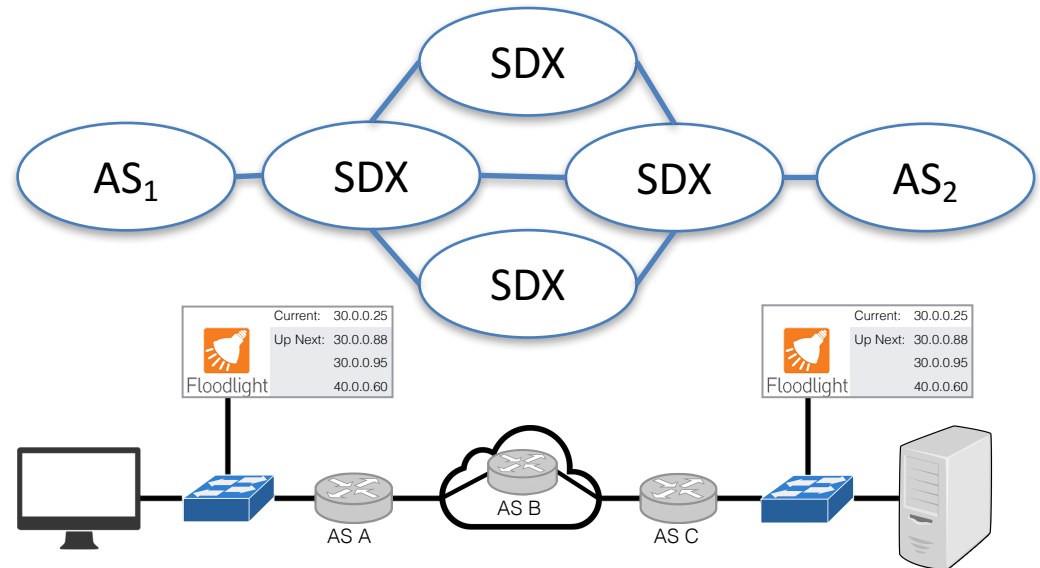
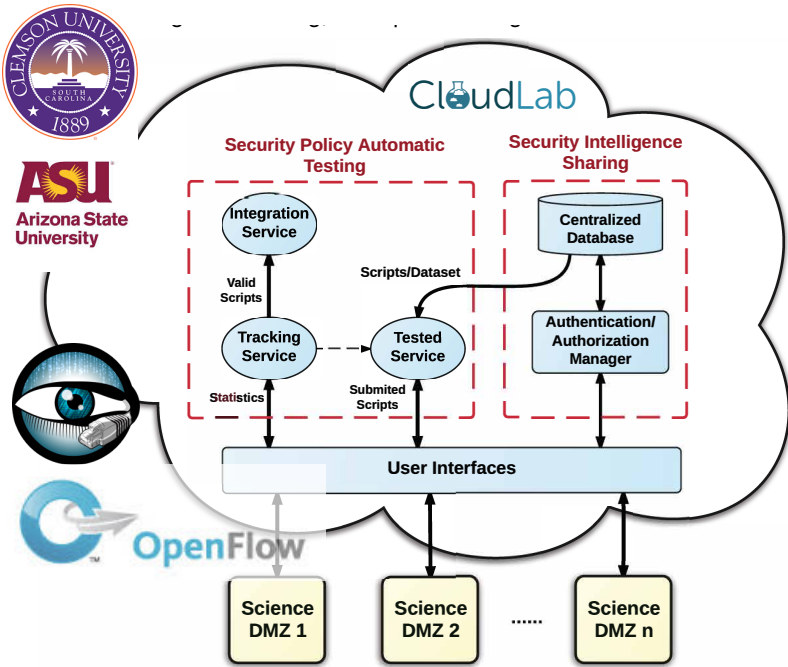
e.g. online databases, web services, semantic web, web-based analytical tools

Data Exchange:
Semantic Web,
Web Services

SDN + NFV + Cybersecurity + Science DMZ

+ ASU, GENI, CloudLab, PEERING, Internet2 & Internet!

- **NSF CICI:** Secure and Resilient Architecture: SciGuard: Building a Security Architecture for Science DMZ Based on SDN and NFV Technologies (#1642143, **SDN-NFV-Cyber security collaboration**)
- **NSF SATC EAGER:** Towards a Traffic Analysis Resistant Internet Architecture (#1643020, **SDN-Cybersecurity collaboration**)

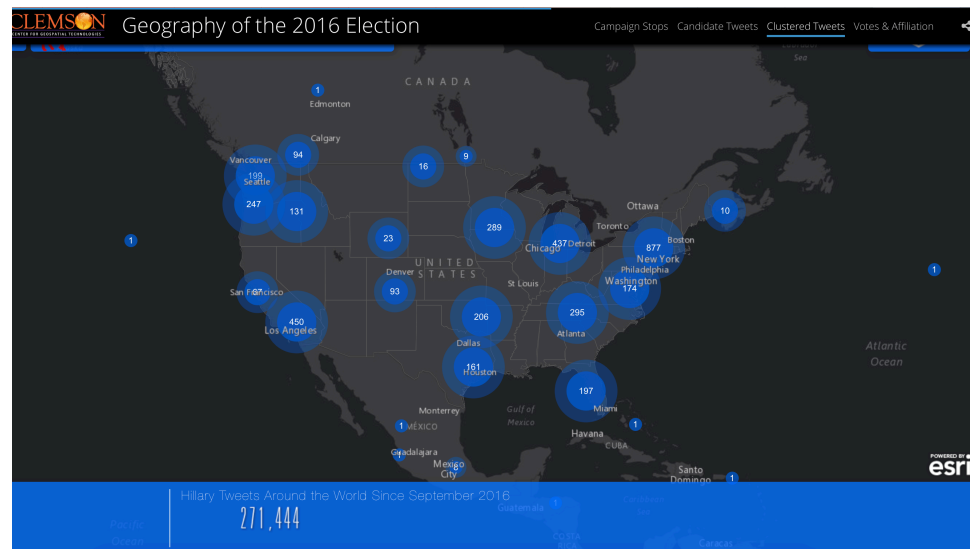
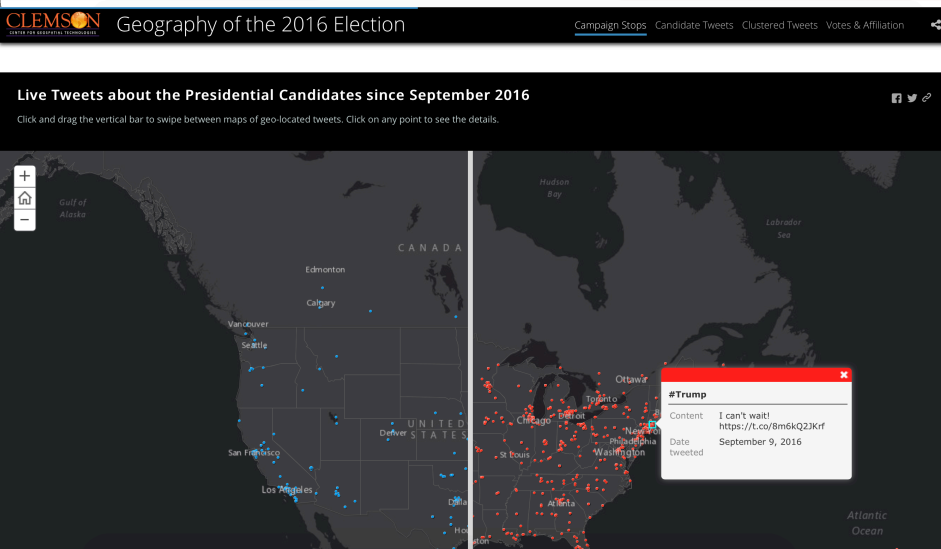


A Special Project for 2016



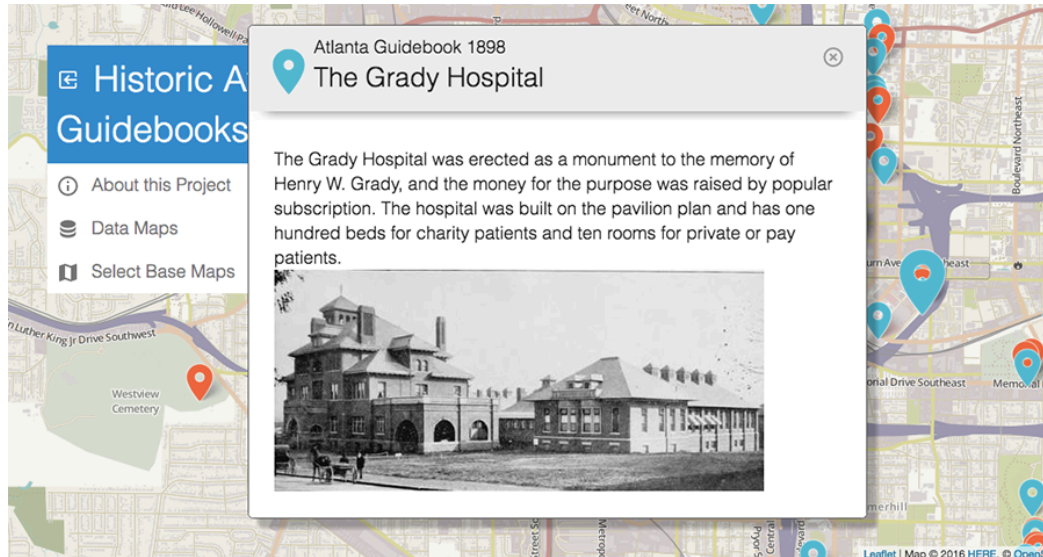
Yes, we meant research 😊:
+ Twitter Data Gateway
+ Streaming Data Analytics
+ Real time GIS rendering

Courtesy of:
Patrick Clafin, Patricia Carbajales, Palak
Matta, Blake Lytle, Clemson Center of
Geospatial Technologies



Digital Humanities Data + Computing

Project ATLMaps, by our friends in Atlanta



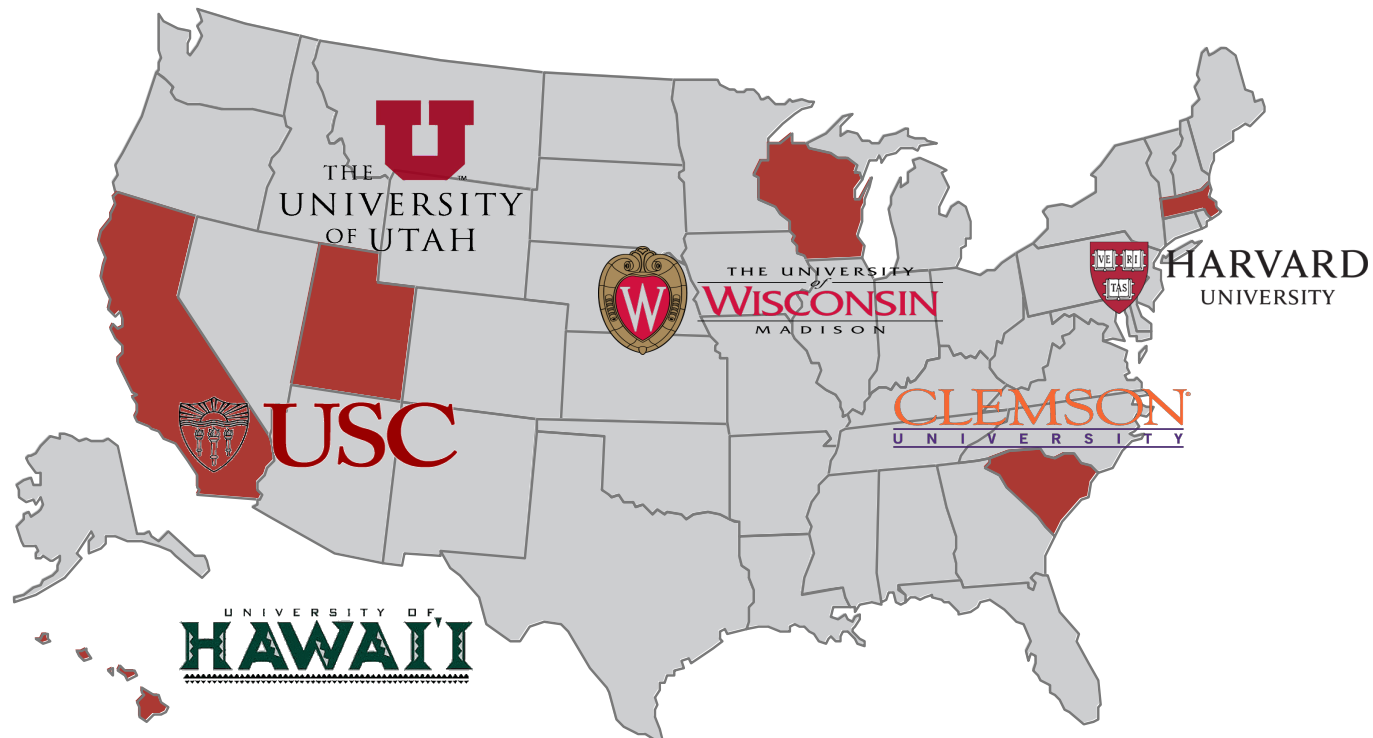
ATLMaps.com is a project led by Georgia State University and Emory University, a web platform hosting:

- **Maps:** Atlanta maps
- **Data:** Myriad of geo-coded city data archives
- **VR:** 3D Atlanta Explorer

Imagine endless more data that can be on it.

From ACI-REF to CaRC

- Award for NSF-sponsored workshops held in 2012 helped define the needs of the broader community
- Goal: Advance our nation's research & scholarly achievements through the transformation of campus computational capabilities and enhanced coupling to the national infrastructure.



Back to INDIS: A Critical Role, A Significant Time

- We all understand the need of convergence.
- The solution is not hard to envision, but ...
 - It is NOT in the usual “business model” of the day
 - People collaborate, appreciate team work, but few have the time, visibility, and leverage to enable innovative partnership.
- The R&E networks are
 - Already highly collaborative
 - Well positioned to connect distinct domains and communities
 - A key enabler and good shepherd for collaboration!
- Lets solve some grand challenges together 😊

We Believe True Transformations Are Around the Corner

- We are excited as we shape up our Center of Excellence.
- We are always interested to find like-minded partners.
- Many paths forward possible.

Comments and collaborations are welcome!

kwang@clemson.edu

COME TO Booth #430 for more info &
Featured talks on ACI-REF, CloudLab & more

