GENI AT AGE THREE:
Origins, Objectives, Outlook

EuroView 2007

7th Würzburg Workshop on IP
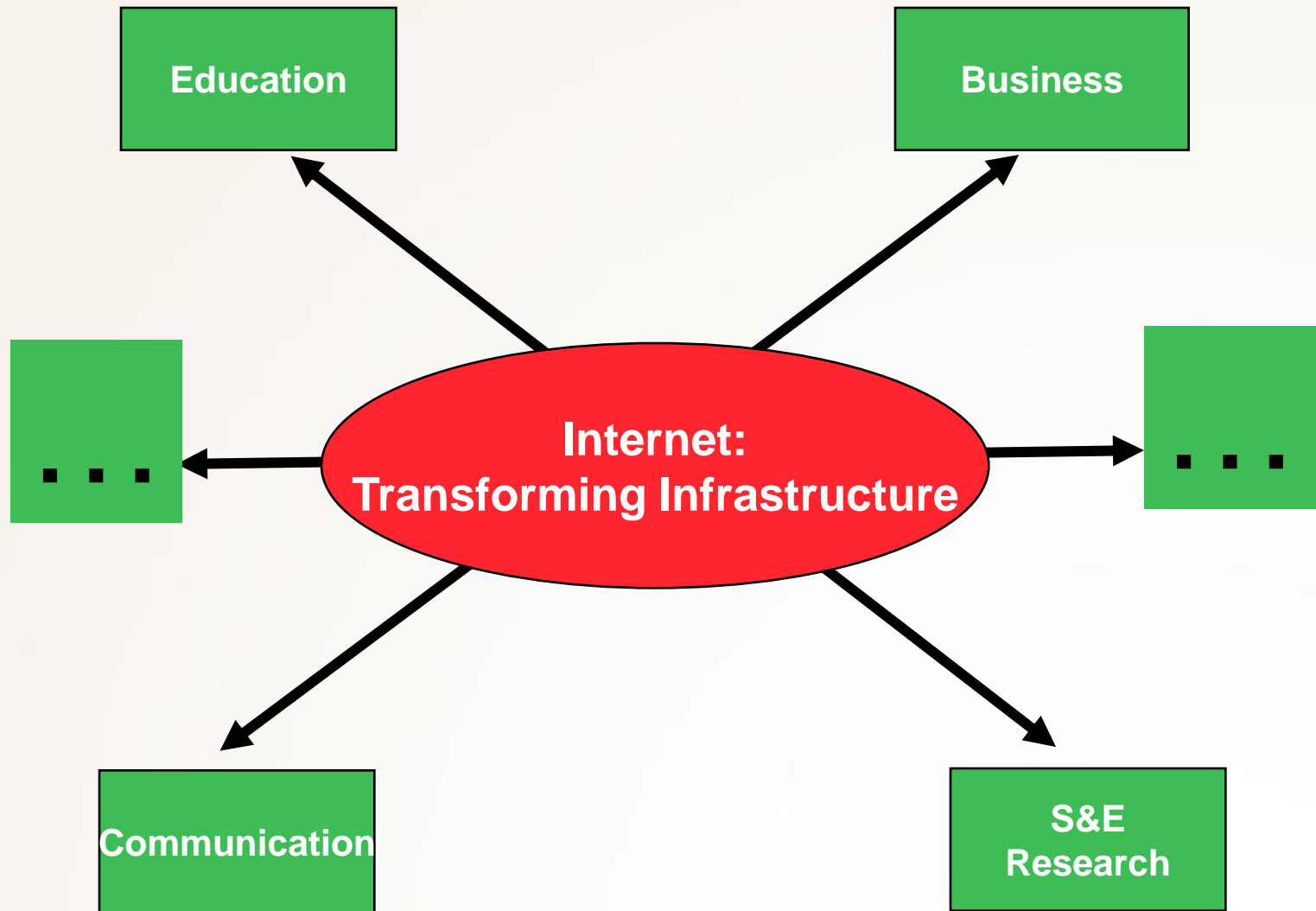23 July 2007

Peter A. Freeman
Emeritus Dean & Professor
(Former) Assistant Director, NSF

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DISCLAIMERS

- My role at NSF - executive sponsor

- Speaking as a private citizen, 6 months beyond any official involvement

- This talk prepared for workshop delivery; more thorough paper in preparation

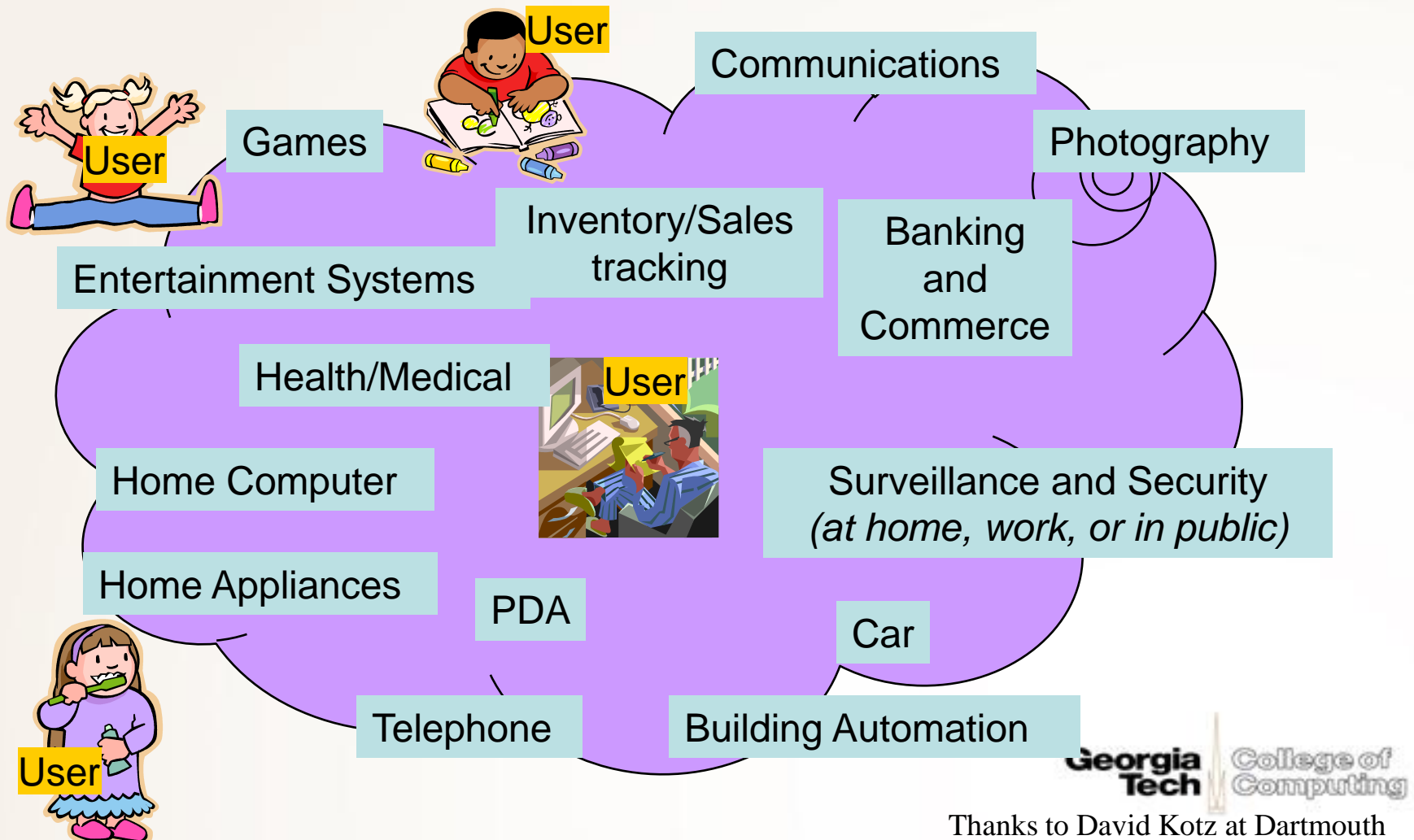- Credits to a number of people for the visuals used

Education

Business

Internet:
Transforming Infrastructure

...

...

Communication

S&E
Research

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Astounding changes in scope and impact over the past fifteen (thirty) years, essentially unforeseen by all.

Most astute observers believe that the changes in the future COULD be even greater.

Yet, barriers loom.

Digital Living *2010 - almost here!*

Tomorrow's users will be surrounded by pervasive devices, embedded sensors and systems… all connected to the Internet.

User

Communications

Games

Photography

User

Inventory/Sales tracking

Banking and Commerce

Entertainment Systems

Health/Medical

User

Home Computer

Surveillance and Security
(at home, work, or in public)

Home Appliances

PDA

Car

User

Telephone

Building Automation

Transportation

Critical Infrastructure

Global Networking: Ready for Future Roles?

GOVERNMENT SERVICES
FEDERAL
STATE
LOCAL

Telecommunications
Banking & Finance

The Future Global Network

Should

- **Be worthy of society's trust**
  - Even for managing and operating critical infrastructures
- **Provide a bridge between physical and virtual worlds**
  - Via instrumented and managed sensorized physical environments
- **Support pervasive computing**
  - From wireless devices to supercomputers
  - From wireless channels to all optical light-paths
- **Enable further innovations in research and commerce**
  - Seamless access to networked instruments, supercomputers, storage, etc
- **Create a world in which we would want to live**

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Challenges

- Technical (e.g. security)

- **Social (e.g. children's use)**

- **Political (e.g. posting false info)**

- **Policy (e.g. access)**

- **Legal (e.g. copyright)**

> *These fundamental issues are closely intertwined and must be addressed if we are to realize the opportunities before us.*

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There are fundamental issues with the current architecture and many of its mechanisms that cannot be fixed incrementally with additional engineering workarounds.

NSF's response was:

Support for serious experimentation to provide the scientific basis for design of future networks and distributed systems, via:

– **The GENI Research Program**, which will drive and is the reason for this experimental approach
– **The GENI Facility**, which will provide an instrument (testbed) for at-scale experimentation

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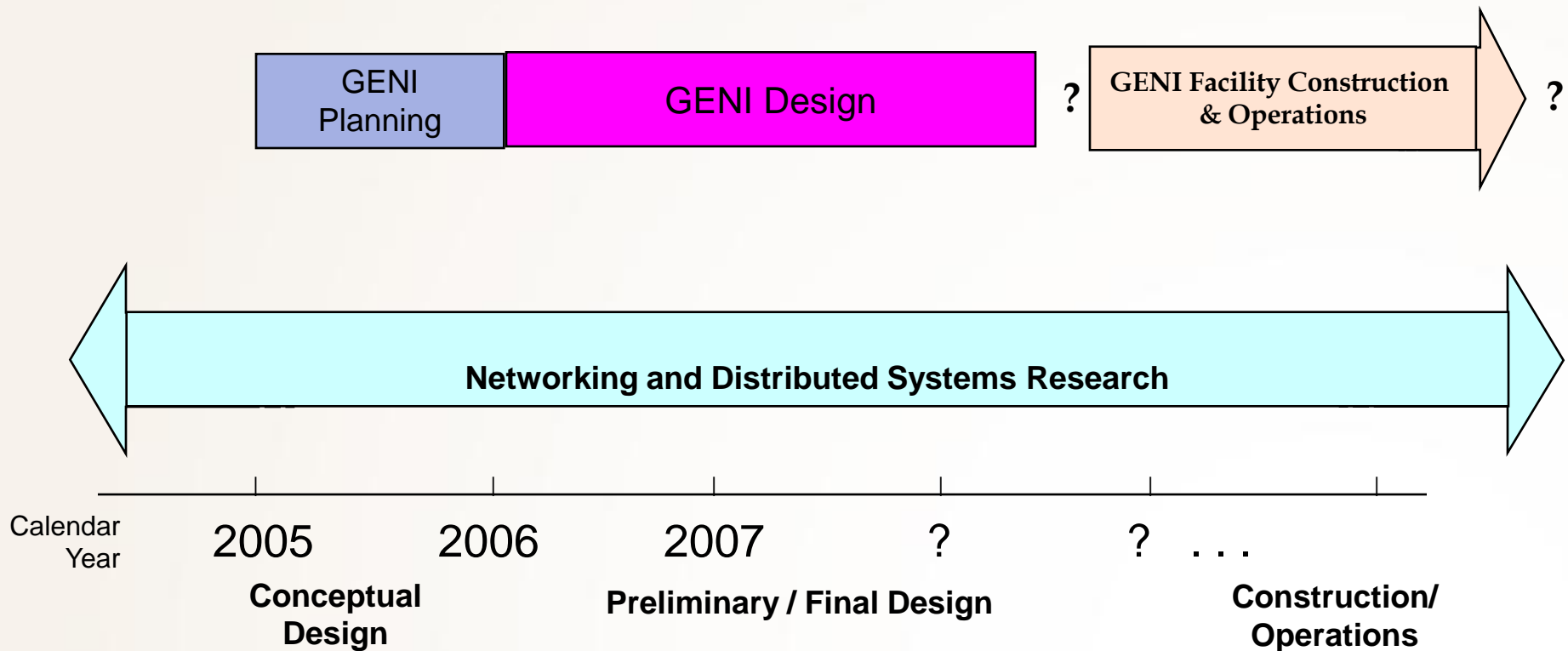
THE GENI PROJECT
(<u>G</u>lobal <u>E</u>nvironment for <u>N</u>etworked <u>I</u>nnovations)

An effort under way by NSF to encourage and enable research to provide a body of knowledge for future network design

- GENI Research

- GENI Facility

Snapshot of GENI Activities

GENI OBJECTIVES

- <u>Primary</u>: develop and evaluate ideas for future networking design

- <u>Secondary</u>: encourage related research

- <u>Necessary enabler</u>: provide an instrument for at-scale experimentation

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Research
is the primary driver
of GENI

Snapshot of research challenges

| **Security and Robustness** | **Pervasive Computing w Mobility** | **Bridging Physical and Cyber space** | **Realize Potential of Opto-Electronics** |

GENI

| **Capability:** Information Access with High Availability & Trust | **Capability:** Seamless information access any where and any time | **Capability:** Access to information about physical world in real time | **Capability:** Access to Bandwidth-on-Demand with low latency & guarantees |

FIND

(part of the NeTS call for proposals)

Future INternet Design (FIND): **Projects will explore revolutionary architectures to develop the "Future Internet" and will address requirements such as core functionalities, security, robustness, openness, economic utility, and social needs as well as support for new technologies and services.**

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Partial list of questions of interest in FIND

 * exploration of fundamental policy and engineering trade-offs in the design of secured, privacy protecting, and robust networked systems or fundamental new requirements and capabilities in such areas;

 * exploration of new paradigms of communication that go beyond packet and circuit switching;

 * consideration of new models of information dissemination;

 * co-design of data, control, and management planes;

 * further advances in self-evolving networks with virtualized overlays; and,

 * architectures that promote healthy economic models.

SING

(part of the TF call for proposals)

The TF cluster continues to invite proposals in the Scientific Foundations for Internet's Next Generation (SING). This topic merges elements of the theoretical foundations of computing, communications, signal processing, and network science into a foundation for a clean-slate redesign of the Internet

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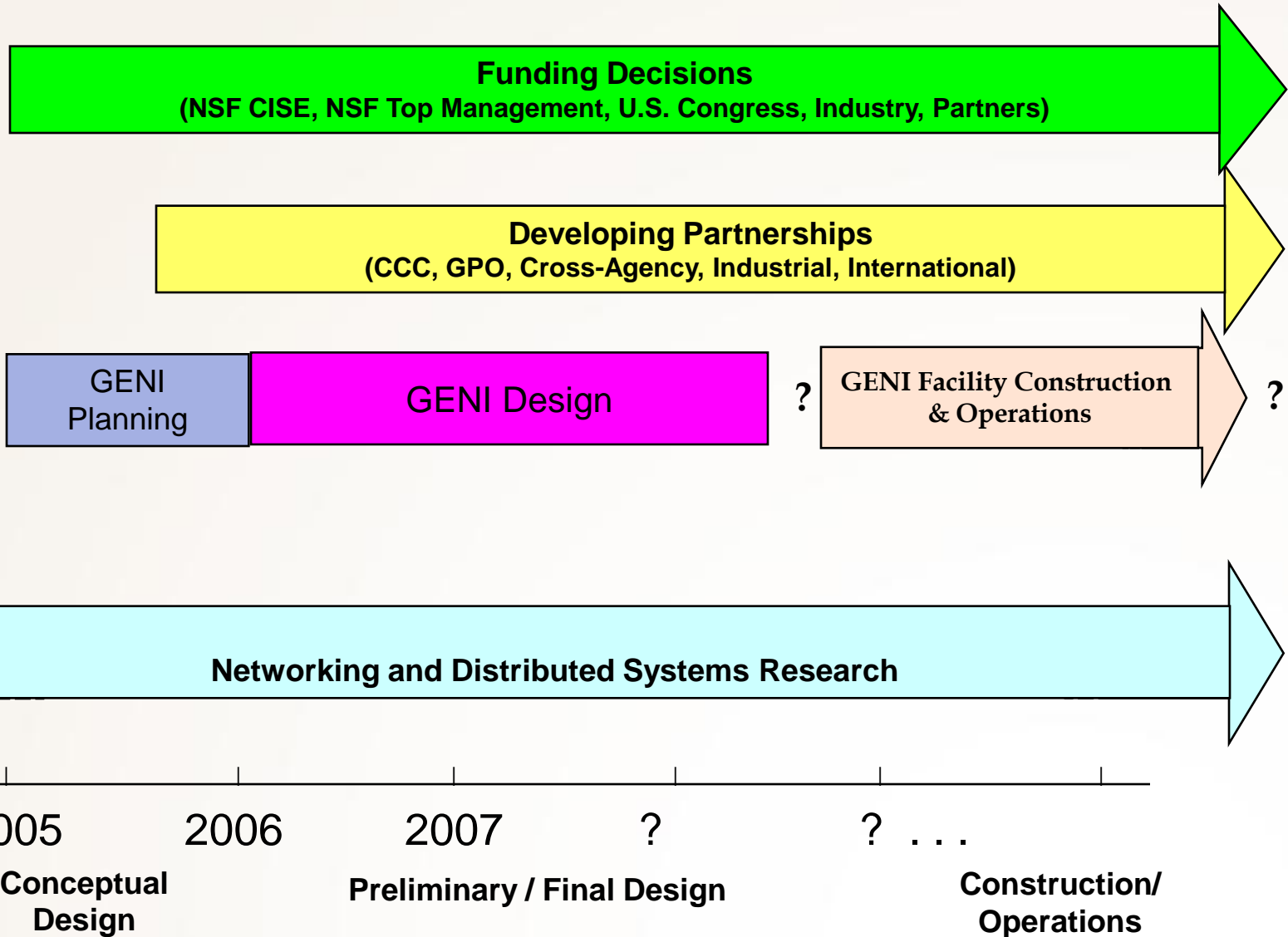
Partial list of questions of interest in SING

- **Core theory**: formulating a new framework for computing and communication systems considering the temporal and spatial distribution of information and power. Interplay between information and queuing theory; theory for sensing and control networks. New networking theories inspired by economics, biology and physics.

- **Fundamental algorithms**: Cooperative communications. Scalability, complexity, and interactivity problems. Security. Adaptive compression. Signal processing techniques to support content analysis. Power aware processing. Tradeoffs between communication and computation and storage. Models for mobility enhanced information dissemination. Search and information retrieval, complex queries, full text search. Peer-to-peer communications. Auctions. Manipulating massive data sets. Algorithmic distributed mechanism design and distributed control. Quality of service driven mobility. Traffic engineering.

- **Applications**: enabled by new theoretical foundations; mobile and sensor networks, ad hoc networks. Quality of service models. Control loop applications over the network, Signal processing, computing, and communications techniques enabling pervasive computing and communication environments.

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GENI Science Plan

- **A community committee (under the direction of the GENI Science Council) is engaged in defining research programs for:**
  - new applications techniques
  - distributed systems
  - network architectures
  - real-time systems
  - wireless networks
  - theoretical descriptions
  - mobile databases
  - . . .

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OUTLOOK

Funding Decisions
(NSF CISE, NSF Top Management, U.S. Congress, Industry, Partners)

Developing Partnerships
(CCC, GPO, Cross-Agency, Industrial, International)

GENI Planning

GENI Design

? **GENI Facility Construction & Operations** ?

Networking and Distributed Systems Research

Calendar Year

2005

2006

2007

?

? . . .

Conceptual Design

Preliminary / Final Design

Construction/ Operations

Now that the GENI is out of the bottle – any Questions?

For More Information
(starter list)

- **Technical**
  - www.geni.net (primary source for updated information on GENI)
  - www.nsf.gov/pubs/2007/nsf07507/nsf07507.htm (FIND)
  - www.nsf.gov/pubs/2007/nsf07525/nsf07525.htm (SING)
- **Policy**
  - www.oii.ox.ac.uk/research/
  - www.issues.org/22.3/p_nelson.html
  - **www.oecd.org/topic/0,2686,en_2649_37441_1_1_1_1_37441,00.html**
  - **www.caida.org/home/ (also technical)**
- **Legal**
  - www.cyber.law.harvard.edu/home/
  - www.cyberlaw.stanford.edu/

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CONTACT
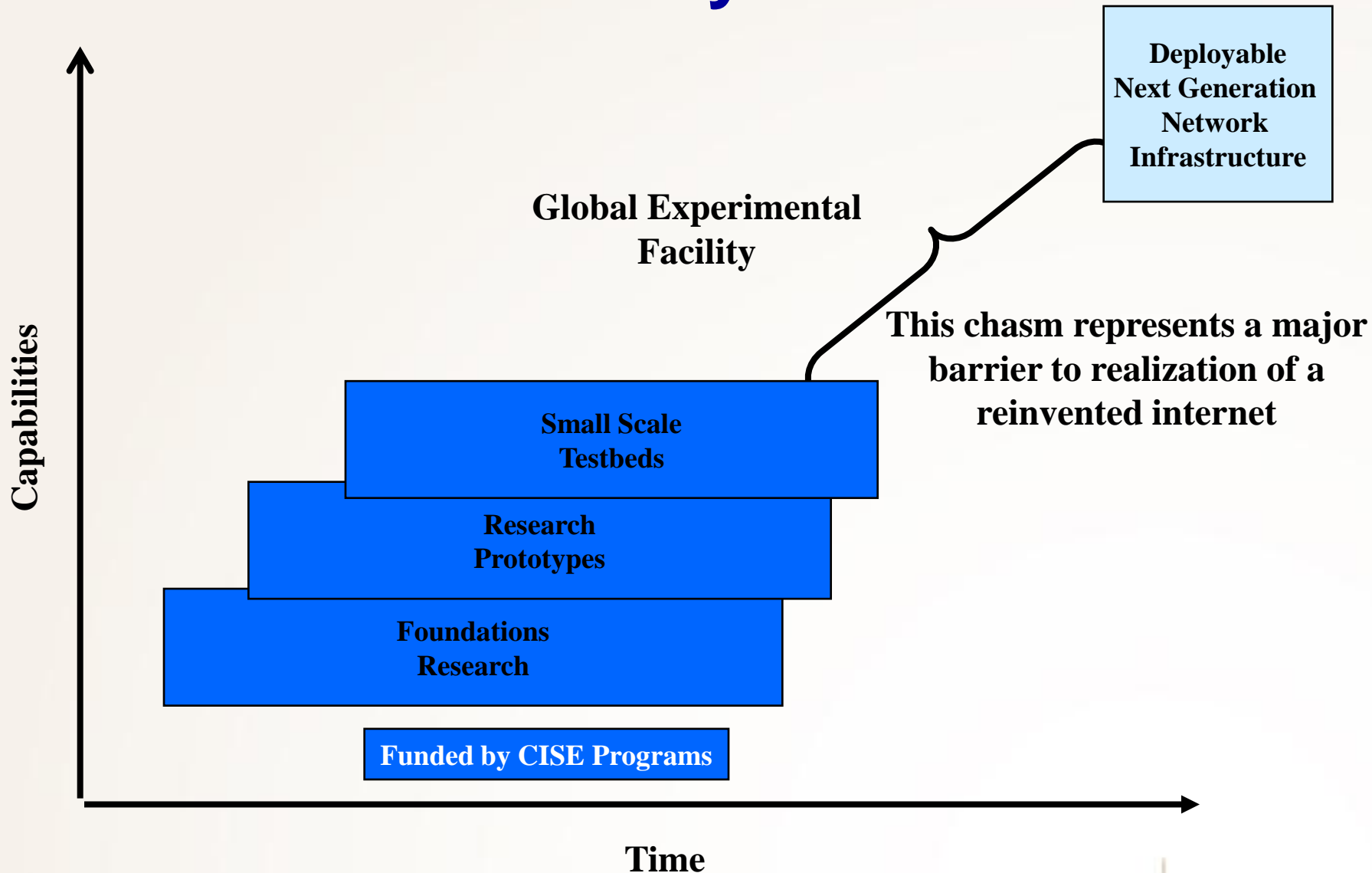
Dr. Peter A. Freeman

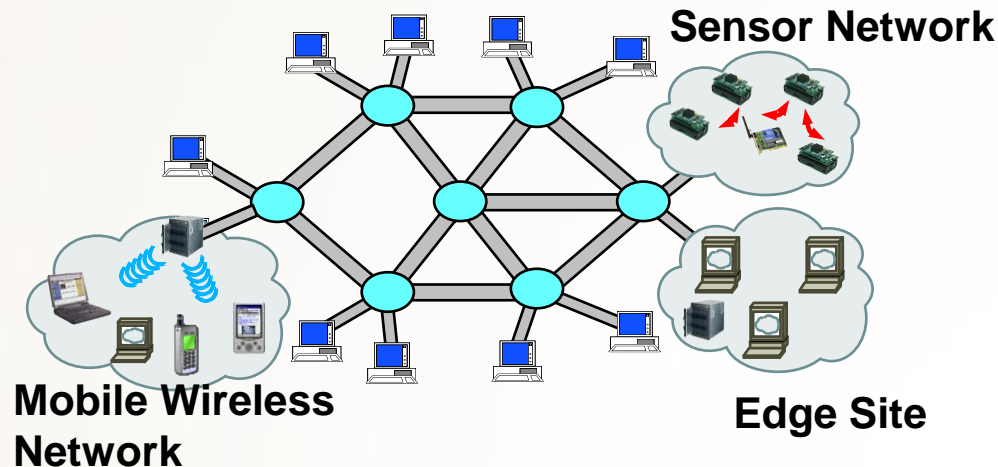freeman@cc.gatech.edu

BACK UP SLIDES

THE GENI FACILITY

Case for GENI Facility

As envisioned, the GENI Facility will be an advanced, flexible, programmable instrument for networking and distributed systems research.

Sensor Network

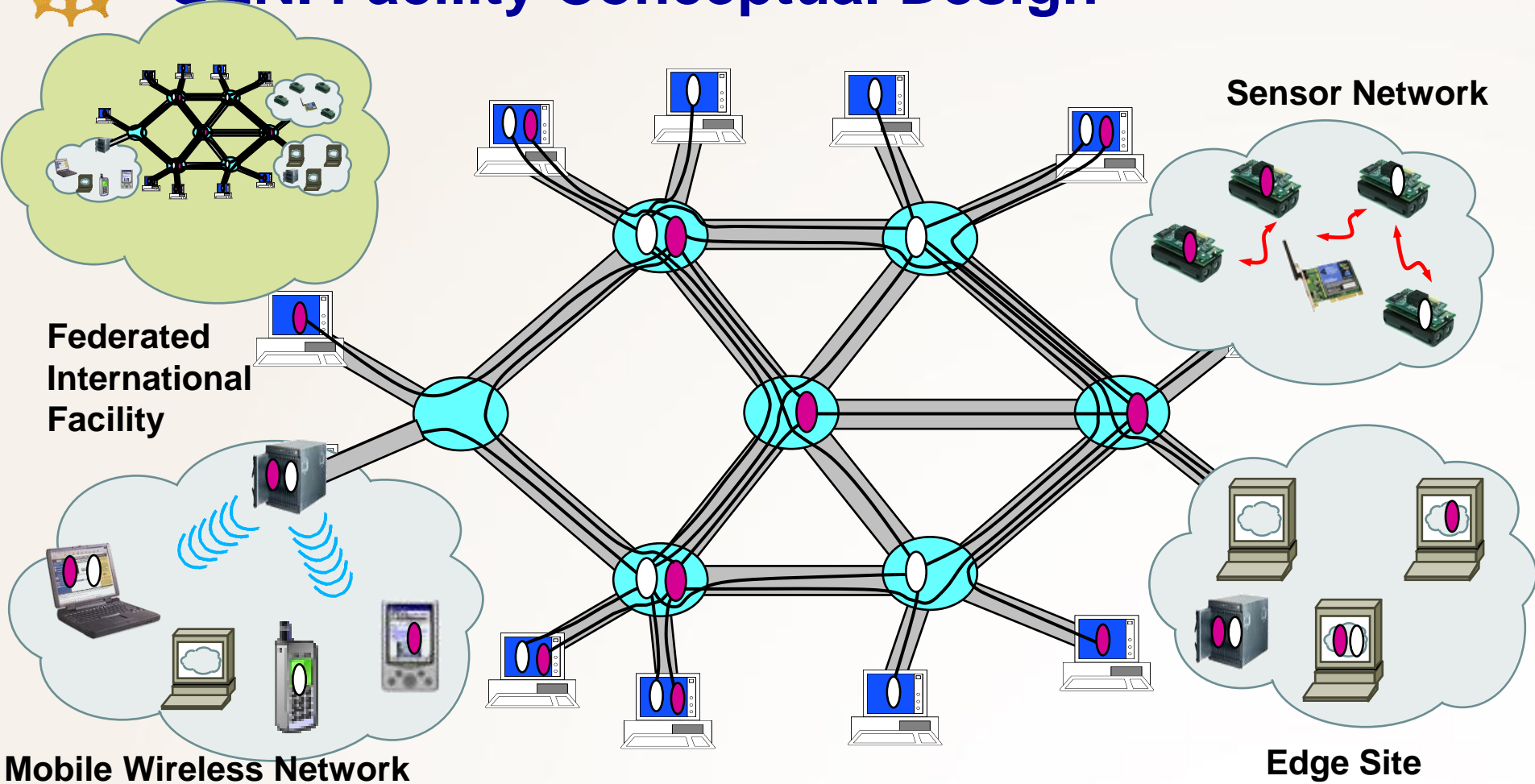**Mobile Wireless Network**

Edge Site

GENI Facility Will Enable

- Experimentation with complex systems to provide deeper understanding of their dynamics, stability, evolvability, emergent behaviors, and more.

- Evaluation of alternative networking architectures.

- Exploration of the competing goals a network architecture must meet.

- Evaluation of different services.

- In general, to help get us to the Future Internet

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GENI Facility Conceptual Design

Sensor Network

Federated International Facility

Mobile Wireless Network

Edge Site

Slicing, Virtualization, Programmability

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GENI Will Allow

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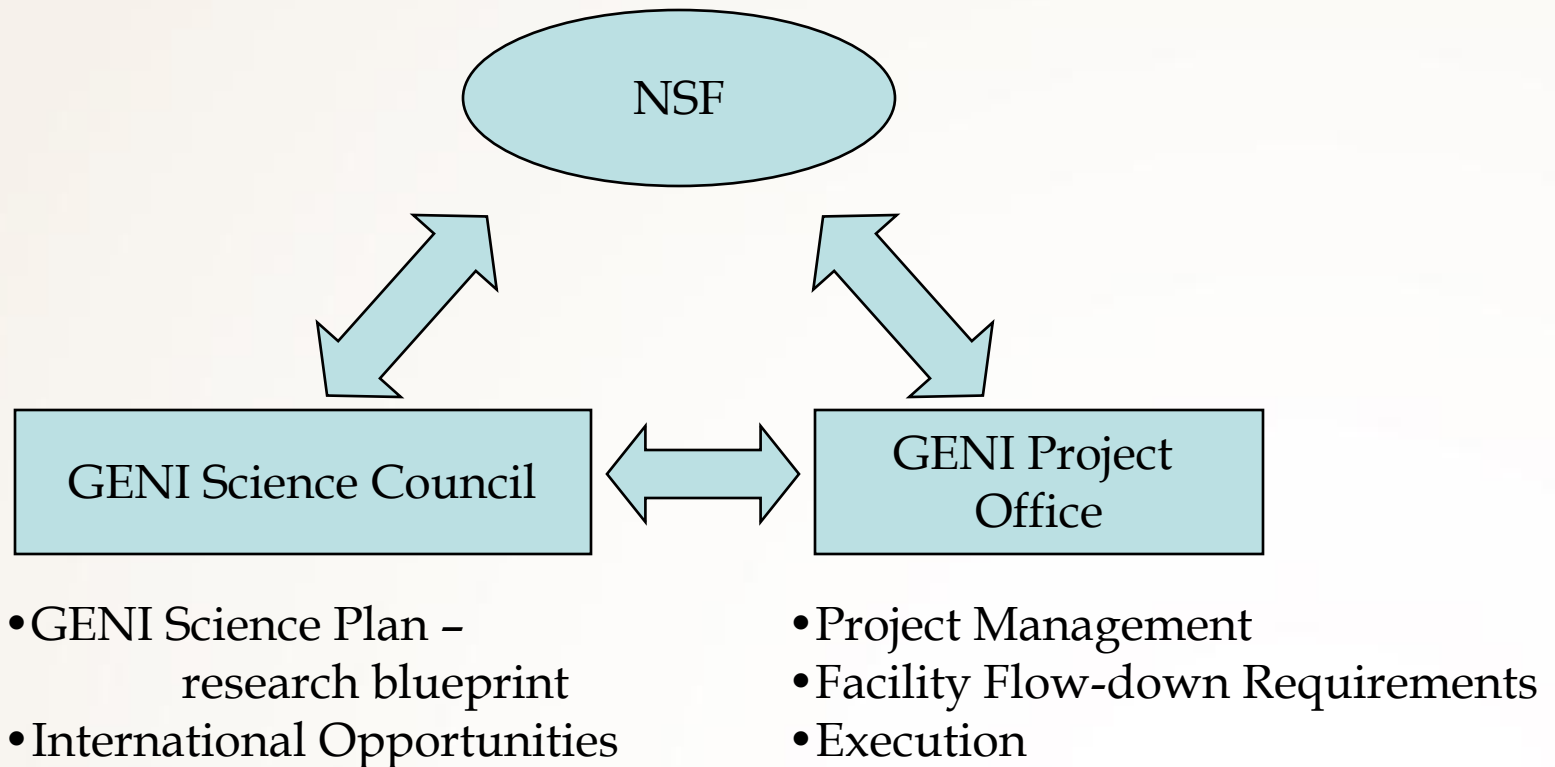**Georgia Tech** | College of Computing

ORIGINS-2

Pre-history

- University/NSF role in forming the Internet

- Gigabit test beds,etc.

- Workshops, unrest/unease in research community

- Understanding of future digital possibilities coupled with consensus that current structures may not get us there

Outlook - 2

- MREFC process

- Incremental change accelerates
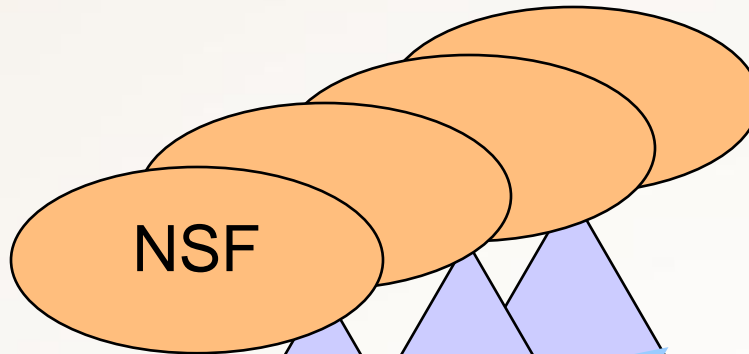
- World will demand some kind of fix

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GENI Governance

NSF

GENI Science Council ⟷ GENI Project Office

- GENI Science Plan – research blueprint
- International Opportunities

- Project Management
- Facility Flow-down Requirements
- Execution

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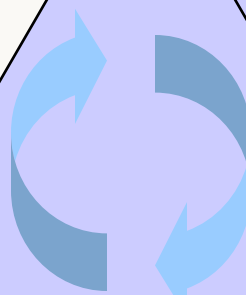
GENI Governance

- Funding
- Research oversight
- Facilitator

NSF

Partnering Possibilities

- Scientific leadership
- GENI Science Plan –
  research blueprint

GENI
Science Council

GENI Project
Office

- Project Management
- Facility Flow-down Requirements
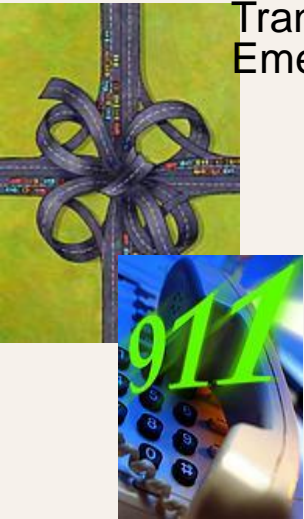- Construction execution & Operations

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GENI Addresses National Needs

Transportation & Emergency Response:

Ad hoc vehicular networks, collision avoidance, accident self-reporting; predictive health maintenance

Local (mobile) networks deployed, access to government data (e.g. weather, building conditions, etc.

Large Distributed Information Systems

- **Medical Systems**
- **Content Distribution Networks**
- **Real Time Planet Monitoring Systems**
- **Personal Info Systems**

Networking for Critical Infrastructures:

Trustworthy cyber-infrastructure
Real-time cooperative control

E-voting

Secure voting machines (hardware & software)
Tamper proof
Secure and anonymous @ home voting
Authentification of voter
Audit trails
Secure delivery, storage/databases

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