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*The Origins of GENI: A Story of
Sustained Research Community Engagement*

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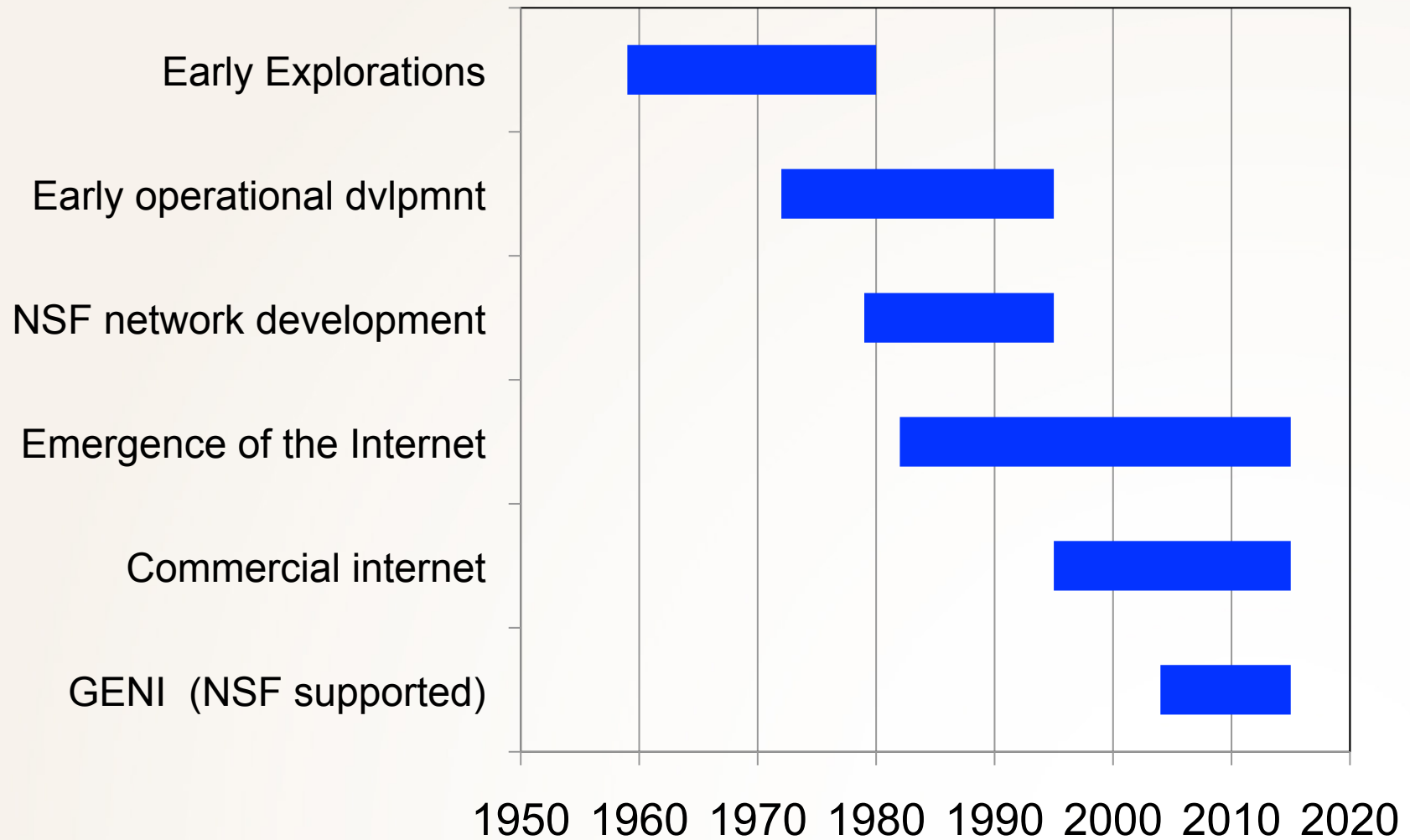Georgia Tech | College of Computing

WHAT IS GENI?

- GENI is a networking research infrastructure being developed by the U.S. National Science Foundation.

- It will be a continental-scale (N. America) network for experimentation at-scale.

- Collaboration with and ultimately extension to efforts in other countries is planned.

- There is heavy involvement (100s of people) of U.S. and some foreign researchers (all largely university-based).

- Next talk by Chip Elliott will provide more detail and current status.

- This is the story of the <u>origins</u> of GENI – the context, the objectives, the early development.

- Why did it happen, when it did?

- What were the conditions that allowed it to grow?

- What can you learn from this?

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NETWORKING HISTORY (in one slide!)

Timeline chart (Gantt-style) showing networking history phases from 1950 to 2020:

- **Early Explorations** — approx. 1960–1980
- **Early operational dvlpmnt** — approx. 1972–1995
- **NSF network development** — approx. 1980–1995
- **Emergence of the Internet** — approx. 1982–2015
- **Commercial internet** — approx. 1995–2015
- **GENI (NSF supported)** — approx. 2005–2015

Axis labels: 1950 1960 1970 1980 1990 2000 2010 2020

HISTORY SUMMARY
(focus on research community involvement)

- ~1959-1980: Paul Baran, Len Kleinrock, Bob Kahn, Vint Cerf, many others develop the basis for current networks

- ~1972-1994: ARPANET; commercial, government, private networks emerge

- ~1979-1995: TheoryNet, CSNet, NSFNET

- ~1982-present: current Internet emerges

- ~1995-present: commercial internet, open internetworking protocols, browsers, exponential growth

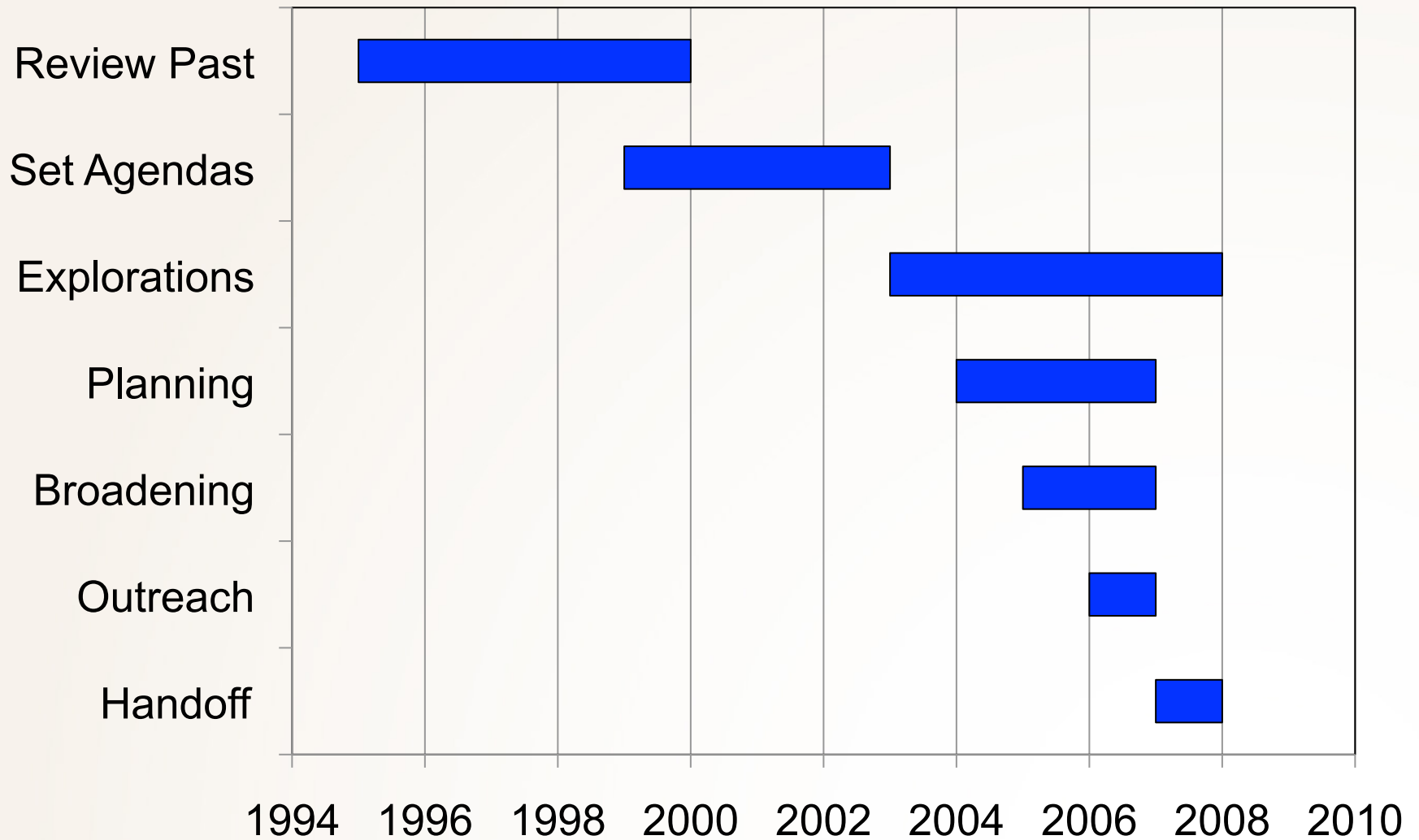- ~ 2004-present: NSF-supported GENI Project

ORIGINAL GENI VISION

- Reinvention of the Internet to be more secure, robust, flexible, higher capacity, responsive, and diverse needed.

- Research program and a Facility for experimentation to be created.

- Facility intended to be a state-of-the-art, global, experimental network allowing for at-scale experimentation under realistic loading conditions.

- Not envisioned to directly replace the current Internet, but to inform the design and implementation of new networking mechanisms and policies.

GENI stages guided & funded by NSF

Gantt chart of GENI stages:

Stage	Timeline
Review Past	1995 – 2000
Set Agendas	1999 – 2003
Explorations	2003 – 2008
Planning	2004 – 2007
Broadening	2005 – 2007
Outreach	2006 – 2007
Handoff	2007 – 2008

Years axis: 1994 1996 1998 2000 2002 2004 2006 2008 2010

1995-1999: Community Workshops

- Final report on GigaBit Test Bed Project.

- Celebration of success of past work in creating the Internet.

- Participation in IETF and governance forums.

- Reflection on and analysis of earlier work.

- Growing sense of loss of purpose and involvement in further development of the Internet.

- Community workshops began to develop a vision for the future.

1999-2003: Community Agenda Setting

- Growing sense of emerging problems for the Internet.

- Search for relevance and ways to participate.

- Workshops continued to serve as mechanisms for setting agendas.

- Changes at NSF enabling new focus on networking.

2003-2004: Funded Explorations

- New NSF funding starting in early 2003.

- Experimental Infrastructure Network Program (EIN)

- Network Research Testbeds Program (NRT)

- Permitted researchers to again be actively engaged in developing operational technology.

- Resulted in several important forerunners of GENI: PlanetLab, Emulab, Orbit

2004: GENI Initiation

- Several related ideas brought together by Guru Parulkar and presented to NSF management.

- Encouraged, approved, and enabled.

- Funds for planning and workshops immediately allocated.

- Clear motivation by PlanetLab, Emulab, Orbit, and other results of EIN and NRT.

- Additional areas, objectives, and people added to initial efforts

2005: Broader community engagement

- Multiple workshops to engage research community.

- Discussions with rest of NSF community.

- Private discussions with wide range of technical community.

- Planning for major funding.

- Review by senior group of experts.

- Public announcement.

2006: Outreach & detailed planning

- Outreach to industry.

- International outreach.

- Continuation of preliminary technical work.

- Development of detailed engineering project plans.

- Budget development.

- RFP & award for community consortium to provide technical guidance.

- RFP for engineering firm to build a national-scale research testbed.

2007: Project engineering award

- Major funding denied by NSF management

- Budget recalibrated

- Award to Bolt, Beranek, & Newman (BBN) for engineering work

- End of Origins story

LESSONS LEARNED

- Vision is needed to crystallize good ideas into an active project with a goal.

- Size of project ≠ eventual impact.

- Eventual impact is often unpredictable.

- Clear goals that don't conflict are essential.

- External factors often alter a project.

- Vision and leadership must be maintained for the life of a project.

Vision…

- **Examples:**

  - Paul Baran had a vision of how to organize damage-resistant communications. *RESULT: Major!*

  - There are many good ideas on cybersecurity; but no compelling vision or coordinated effort. *RESULT: To date, just chaos.*

- **GENI** started with visions of future networking, experimentation on real systems, and project effectiveness. *RESULT: ???? (TBD)*

Project size ≠ impact

- **Examples:**

  - Baran's development of packet switching was a one-man effort. *RESULT: 1-person, huge impact.*

  - Many people working to develop better cybersecurity. *RESULT: many people, overall security has not really improved*.

- **GENI** Project is large. *RESULT: Unknown at this time, but its impact could be less than envisioned.*

Eventual impact unpredictable

- **Examples:**

  – Baran and others responsible for the basic elements of the Internet did not envision the Internet. *RESULT: A profound technical development.*

  – Strong encryption, fire walls, and other mechanisms were seen as providing desired levels of security. *RESULT: Level of security has not kept up with demands.*

- **GENI** set out to "reinvent the Internet." *RESULT: it is impossible to predict if this will happen.*

Clear goals …

- **Examples:**

  – Baran's clear goal was to develop a damage-resistant communications network. *RESULT: Success!*

  – The goals of better cybersecurity R&D are not clear. *RESULT: Little real progress.*

- **GENI** Project has had mixed goals that sometimes conflict. *RESULT: Progress has been less than it could have been.*

External Factors

- **Examples:**

  - Baran stopped implementation of his ideas due to perceived incompetence of implementation teams. *RESULT: Functioning network could have emerged earlier.*

  - Commercial interests often prevent the adoption of important cybersecurity mechanisms. *RESULT: Security today is less than it could be.*

- **GENI** Project made a decision in the beginning on how to fund development. *RESULT: It might have turned out differently but a change in funding sources was imposed.*

Maintain vision and leadership

- **Examples:**

  - Baran had a vision that was achievable and he was able to maintain control. *RESULT: Success.*

  - Multiple visions of a secure, public Internet, but insufficient leadership. *RESULT: many efforts, often conflicting.*

- **GENI** started with a vision and coherent leadership, but as personnel changed, the vision changed and overall was leadership lost. *RESULT: ???? (TBD)*

SUGGESTIONS FOR YOU!

- Develop a strong community.

- Develop leaders with vision.

- Understand the difference between engineering research and engineering development.

- Understand the context in which you work, then set the objectives for your work to match.

- Remember that "small" developments and/or those that seem to have no immediate use may be the most useful eventually!

THANK YOU!

For More Information

- ***The Origins of GENI: An Informal Development History***, Peter A. Freeman, June 2014, submitted for publication, http://www.cc.gatech.edu/~freeman/publications.html

- ***Inventing the Internet***, Janet Abbate, MIT Press, 2000.

- ***Where Wizards Stay Up Late: The Origins of the Internet***, *Katie Hafner and Matthew Lyon, Simon & Schuster, 1998.*

- ***The Future of the Internet--And How to Stop It,*** Jonathan Zittrain**,** Yale University Press, 2008.

- ***Website of the Internet Society:*** http://www.isoc.org/internet/history/

- ***Website of the GENI Project:*** http://www.geni.net/

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