

Beyond IPv6

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Directorate for Computer & Information Science & Engineering



COMMENT

Regrettably, due to dangerous driving conditions early morning on December 9, I was unable to deliver this talk in person. I have inserted frames such as this one at various points in the presentation to communicate the main point or points I would have made with the following frames had I been able to deliver the talk in person.

The primary focus of the presentation is to give the motivation for a long-range (5 to 10 years before significant results might appear) research project - GENI - that NSF is currently planning.

The fundamental purpose of GENI will be to develop and experiment at scale with new networking architectures that will be needed in the time frame of 2010-2020 to meet the requirements for the Internet of the Future.

Current information is posted at www.nsf.gov/cise/geni/ .



COMMENT

NSF is the primary U.S. Government agency funding basic research in all areas of science, engineering, and mathematics. NSF's primary mission is the production of new, fundamental knowledge and insuring the production of the research workforce for the nation.

The charter for NSF is very broad, giving us the responsibility to identify and support needed areas of research well in advance of industry and other parts of the government.

NSF does its work primarily through research grants to U.S. universities. Currently there are approximately 30,000 active grants covering all areas of science and engineering research and education, funding, at least partially, approximately 200,000 people.



The U.S. National Science Foundation (NSF)



NSF Mission

National Science Foundation Act of 1950
(Public Law 810507) established NSF:

- to promote the progress of science;
- to advance the national health, prosperity, and welfare;
- to secure the national defense;
- and for other purposes.



NSF Activities

- **basic scientific research & research fundamental to the engineering process;**
- programs to strengthen scientific and engineering research potential;
- science and engineering education programs at all levels and in all fields of science and engineering; and,
- a knowledge base for science and engineering appropriate for development of national and international policy.



NSF Strategic Focus

- **People:** to develop a diverse, internationally competitive and globally-engaged workforce of scientists, engineers, and well-prepared citizens
- **Ideas:** to provide a deep and broad fundamental science and engineering knowledge base
- **Tools:** to provide widely accessible, state-of-the-art science and engineering infrastructure



COMMENT

NSF is organized into seven Directorates and three Offices that provide funding.

The Computer and Information Science and Engineering (CISE) Directorate's annual budget of \$500 million provides over 85% of all Federal funding for basic computer science research at academic institutions in the United States.

A key part of CISE's research support is for networking and related areas.



The CISE Directorate has three goals

To:

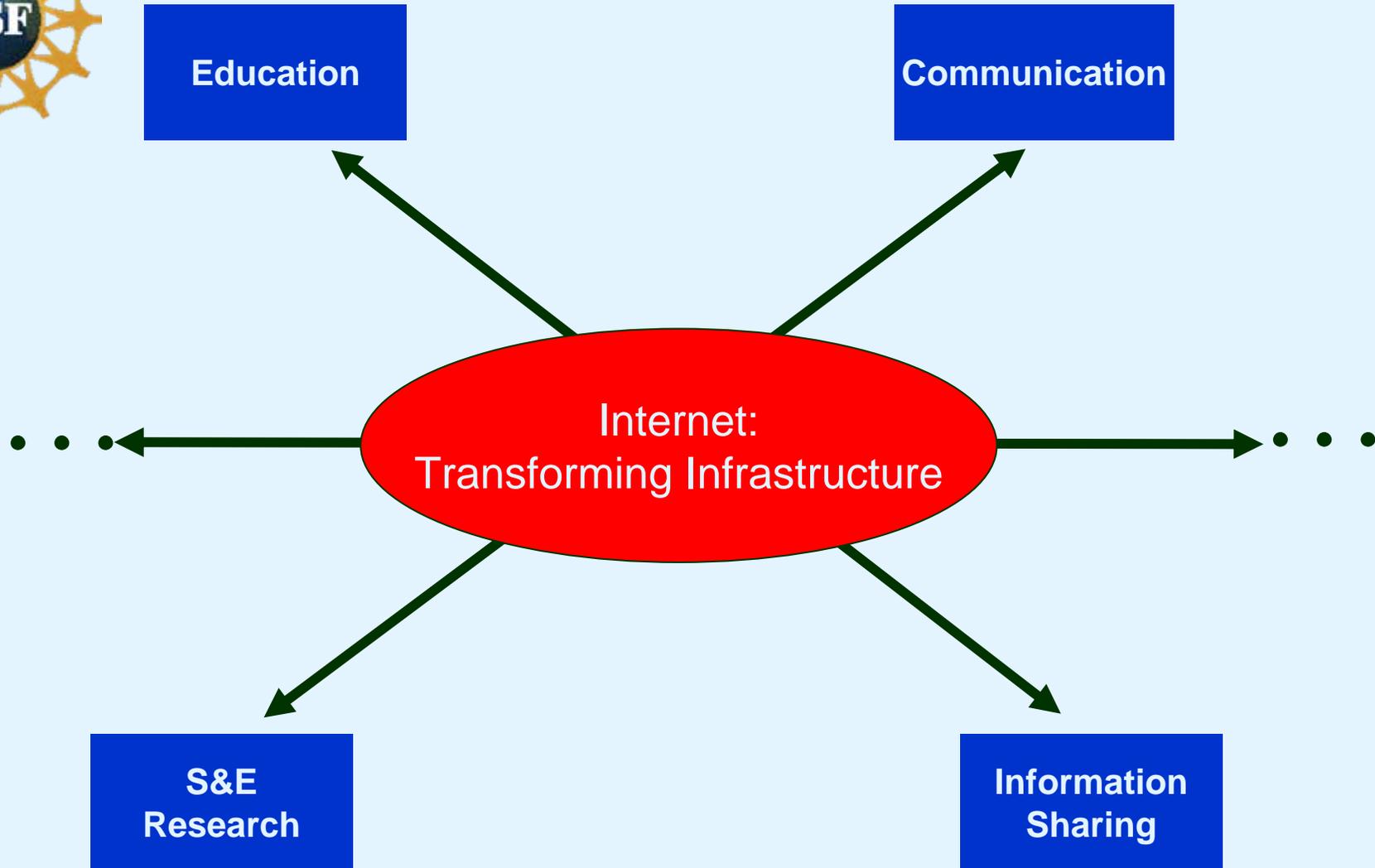
- **enable the United States to lead in computing, communications, and information science and engineering;**
- promote understanding of the principles and uses of advanced computing, communications, and information systems in service to society; and
- contribute to universal, transparent, and affordable participation in an information-based society.



COMMENT

The Internet has already transformed almost all areas of activity in advanced societies.

The transformative nature of the Internet is essential for the future and must be enabled to continue.





COMMENT

Looking into the future, we can already see significant requirements for the Internet of the Future.

Indeed, many of those requirements - security, for example - need to be met today.



Imagine

A Global Network Infrastructure that

- Is worthy of our society's trust
 - Even for managing and operating critical infrastructures
- Provides a bridge between physical and virtual worlds
 - Via instrumented and managed sensorized physical environment
- Supports pervasive computing
 - From wireless devices to supercomputers
 - From wireless channels to all optical light-paths
- Enables further innovations
 - Seamless access to networked instruments, supercomputers, storage, sensor networks, ...



And permits

- Sensors for diverse civil applications
- Large scale data grid with vast personal/commercial data stores
- Pervasive integration of mobile wireless devices
- Disaster mitigation and recovery
- Exploitation of new transport technologies
- . . .



COMMENT

NSF and others have for some years supported studies, workshops, and meetings to assess what is needed to meet the clear requirements for the future - to say nothing of providing the basis for meeting as yet unknown requirements.

The broad and fundamental conclusion of the most knowledgeable networking experts, including those responsible for the current Internet, is that current networking architectures have fundamental limitations that will make it difficult or even impossible to meet networking requirements in the time frame 2010-2020. This includes IPv6, no matter how valuable it may be in the near term.

The conclusion is that the community must undertake research now to prepare us for the future.



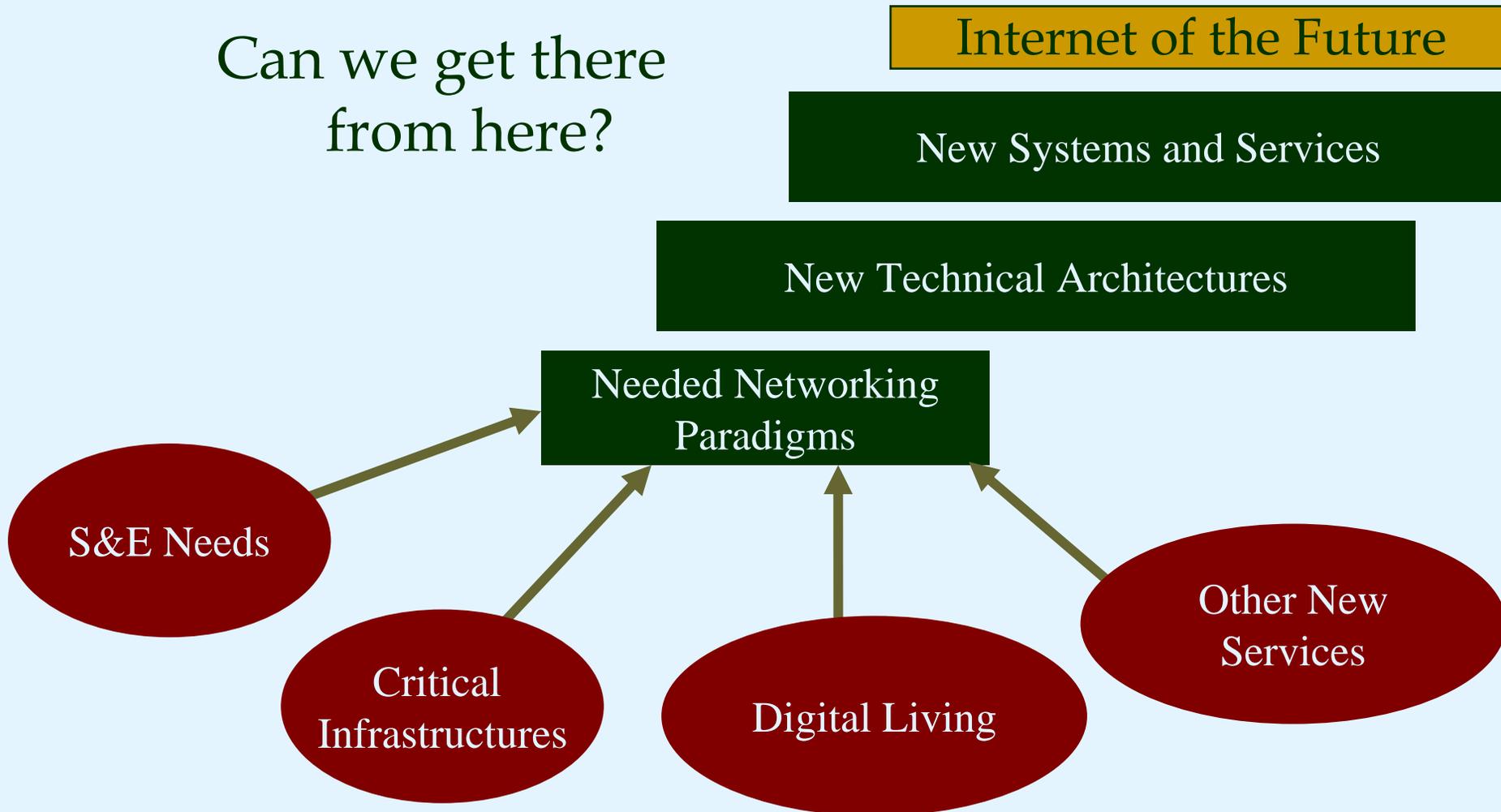
Fundamental Limitations

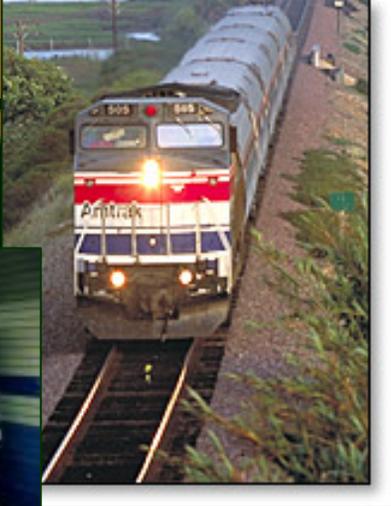
- **Security and robustness**
 - Built-in assumptions about trust
 - Lack of emphasis on control and management
- **Scalability**
 - Built-in assumptions about end-hosts and transport networks
- **Internet Ossification**
 - No incentive for providers to innovate at network level
- **Others**
 - Quality of service, exploitation of new technologies . . .



Are major changes needed?

Can we get there
from here?





Critical Infrastructure



Transportation

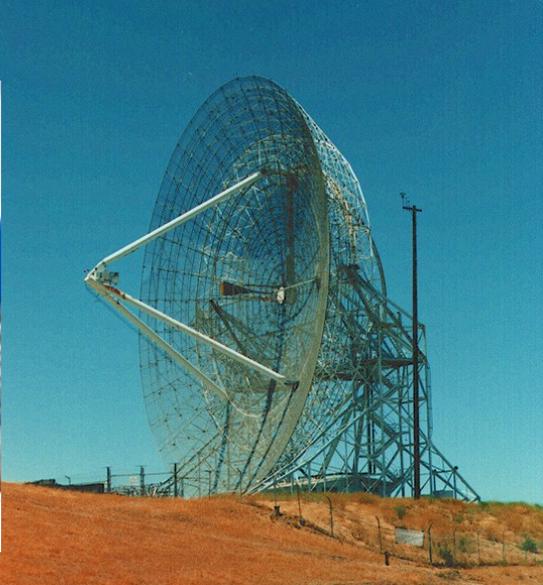
**Internet
Not Ready for
Its Future Roles**

**Telecommunications
Banking & Finance**



GOVERNMENT SERVICES

FEDERAL
STATE
LOCAL





COMMENT

In the context of NSF's responsibility of supporting truly fundamental research, we believe that the best way to provide for the future of networking is to rethink networking from scratch in light of today's technologies and the requirements for the future as they are becoming clear.

We believe this "clean-slate" approach will produce a supply of ideas that can then be used to evolve the networks of today into the Internet of the Future.

Clean-slate reinvention of the Internet



COMMENT

Based on past experience, it is clear that it will be important to explore new networking architectures experimentally before they are put into widespread usage. This experimentation, however, needs to go beyond simulations and small-scale testbeds that have been used in the past.

Ideas for facilities for experimentation “at-scale,” with real users doing real work, are emerging and can provide the technical basis for the GENI facility.

The GENI Initiative is in the process of being developed through a series of planning grants, some of which have been in force for almost two years.

We are now entering the phase in which major funding for the needed experimental facilities is being sought.



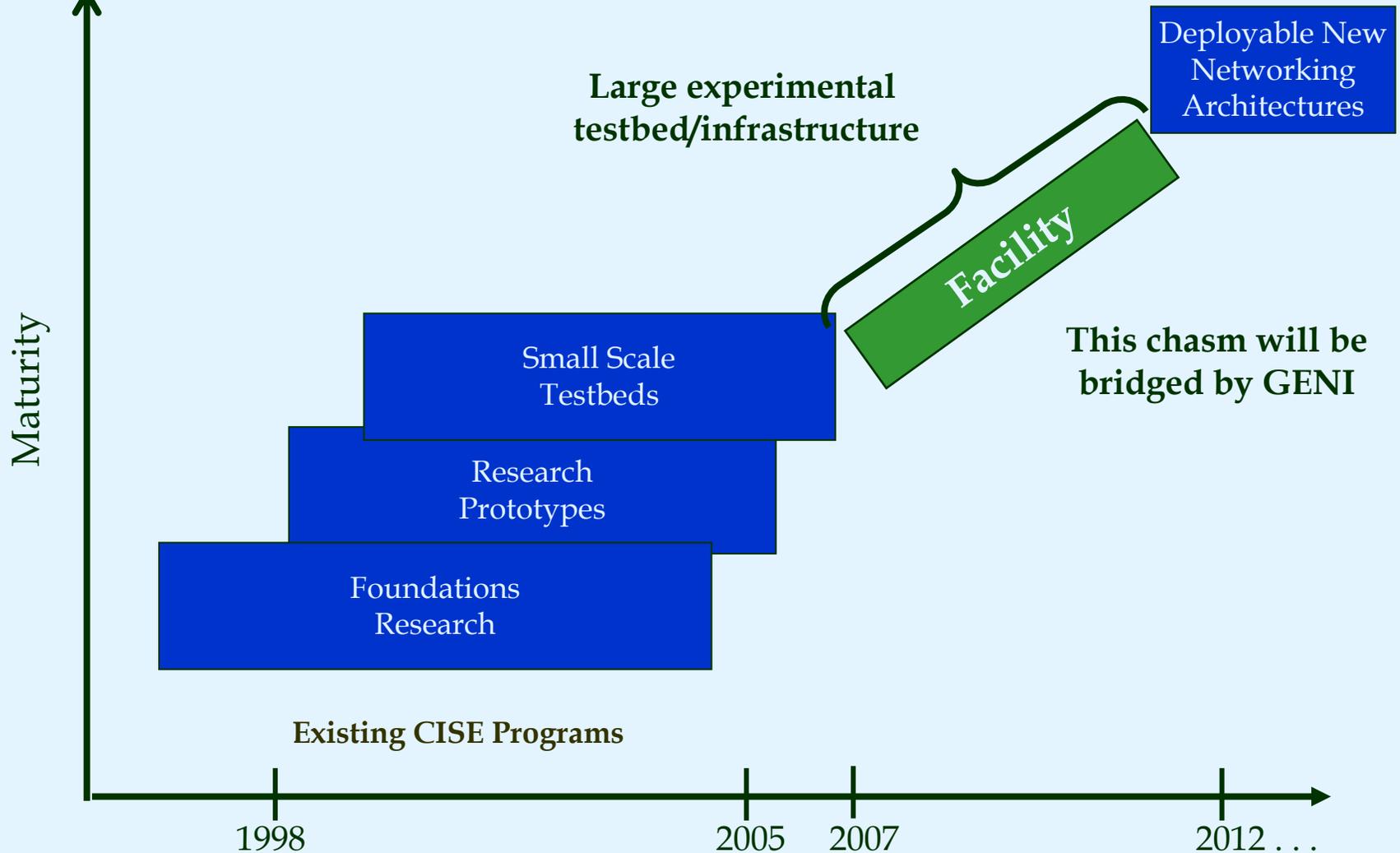
GENI

Global Environment for Networking Investigations

- Consists of two components:
 - GENI research program
 - GENI research facility
- GENI research program will continue CISE's long-term support for basic research and experimentation in networking and related topics.
- GENI research facility will be a state-of-the-art, global experimental facility to evaluate new networking architectures (at scale).
- *Status:* A planning effort initiated by the CISE Directorate



Need for GENI Facility





Outcomes as GENI Moves Ahead

- A stock of experimentally validated concepts to address the networking needs of the 21st century
- New platforms to permit the continued growth and enablement of innovation as in the current Internet
- Demonstration of the power of new mechanisms so that industry will pick up and build out future networking structures
- Results that can be applied to security and defense networking for the security of the Nation



COMMENT

The nature of research and advanced development, even in the world of computing and networking, is that it is often many years between the origination of a new idea and its deployment as a practical solution to real problems.

IPv6 has benefited from more than a decade of development to become a practical solution for today's world.

Tomorrow's networking world, however, may need to be as different from today's world as today's is different from that of the networking world of 1990.

The GENI Initiative will lay the groundwork for the world of 2010 and beyond.



Conclusion

- Current work on improving and deploying IPv6 is very important today
- Remember that efforts that led to IPv6 started over 10 years ago
- In the same way, the GENI effort is setting out to provide the basic mechanisms that will be needed for successful networking in the 2010-2020 time frame



Contact Information

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www.cise.nsf.gov