

GENI: Global Environment for Networking Innovations

To Reinvent the Internet

Lawrence H. Landweber
CISE/NSF
Landweber@aol.com
September 26, 2006

*“The Internet has been the center of
our prosperity.”*

Lawrence Lessig



Security Trends

- Increasing vulnerabilities, viruses, spyware, worms ...
 - 120,000 known viruses and worms -- 50 new ones per day
 - Large scale attacks doubling every year
- Increasing economic cost
 - Viruses alone => \$60B
 - Some ISPs have more than 90% traffic that is spam

29 September 2006

3

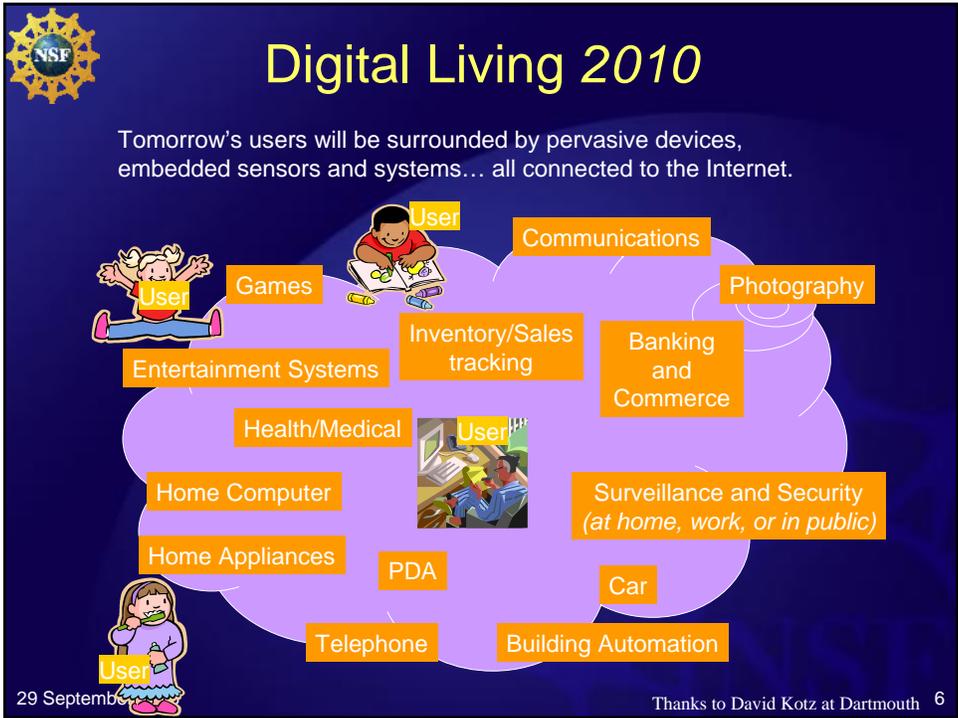
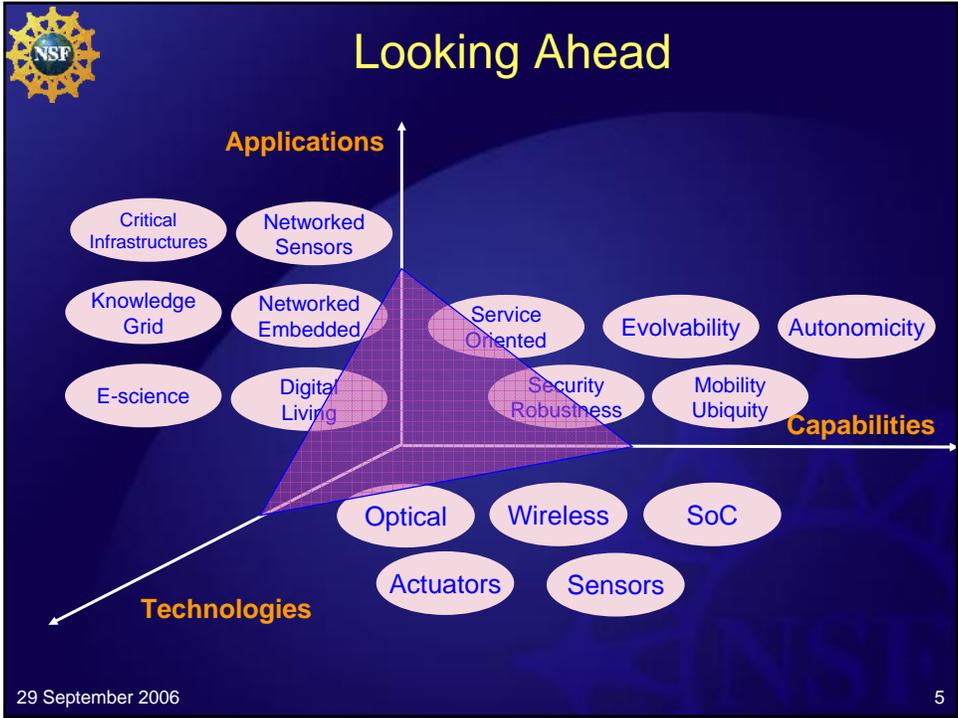


Network Centric Critical Infrastructures

   Transportation	  Essential Utilities
  GOVERNMENT SERVICES FEDERAL STATE LOCAL	  Telecommunications Banking & Finance

29 Sept

4





Mobile and Wireless Trends

Mobile computing and devices to dominate future computing and communication

- 2B+ cell phones
- 400M+ cell phones with Internet capability
- New data devices and services
- 240M vehicles on the road

29 September 2006

7



Mobile Wireless & Future Internet

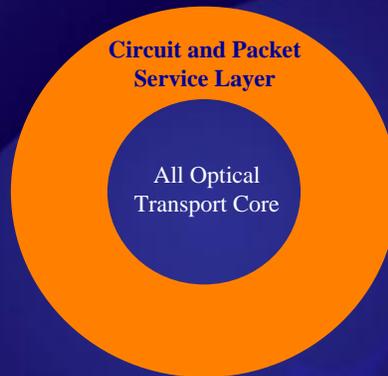
- Don't ask how mobile wireless fits within the existing Internet architecture
- Think how mobile wireless networks and devices at the edges can shape the Future Internet architecture in realizing their potential?

29 September 2006

8



Opto-Electronic Network Challenge



How can Future Internet exploit an optical core that can provide “bandwidth on demand” dynamically with low latency and guarantees?

29 September 2006

9



Distributed Systems Substrate

- Robust content distribution, search, data mining
- Real time multi-media distribution
- Management and sharing of personal information
- Identity management: human and object
- Location management: human and object
- Network-embedded storage
- Health monitoring
- Understanding planet in real time

29 September 2006

10



The Future Internet

Must

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

29 September 2006

11

**Challenge: Research Community to
Create Future Internet --
Internet for the 21st Century**



GENI Initiative

- Research Program plus Facility
- Invent innovative internet architectures and distributed system capabilities -- go beyond Internet
- Enable seamless conception-to-deployment process
 - Facility for experimentation at scale with apps and users
- Work with broader community
 - Academic and industry communities
 - Other US and international agencies

29 September 2006

13



GENI: Research Programs

Broad but goal oriented programs

NeTS	FIND: Future Internet Design
CyberTrust	Clean-slate secured network arch
CSR	New distributed system capabilities
CCF	SING
CRI	Network infrastructure for arch research
MRI	Network instruments for arch research
...	...

29 September 2006

14



FIND Goals

Can we reinvent the Internet so that it can

- Retain its strengths
- Support new technologies such as mobile wireless, sensors, optical networks
- Enable new class of applications and services made possible by new technologies
- Be secured, robust, manageable, evolvable, service-oriented, ...
- Promote economic viability of different players

29 September 2006

15



Focus of FIND

- On Reinvented Internet Architecture and not on individual network technologies
- Implications of emerging technologies on Future Internet is part of FIND

29 September 2006

16



What is Different This Time?

- Clean-slate approach
 - To overcome Internet ossification
 - Research not constrained by the features of the current Internet
- A comprehensive coordinated effort
 - Ability to try different approaches (We do not have a preconceived idea of what they are)
- Ability to experiment at scale
 - With real users and applications

29 September 2006

17



FIND - Different Process

- 26 of 98 projects awarded
- “Goal” oriented → Future Internet
 - Not typical for NSF research programs
 - Longer timescale with sustained funding
- Three phases -- iterative and overlapping
 - Exploration of architectural components and 1st cut e2e architectures
 - Convergence into multiple full-scale architectures
 - Experimentation with architectures at scale
- “Competitive cooperation” model
 - Competition – Proposal reviews
 - Cooperation – Among awardees
 - Regular meetings -- three times a year
 - Commitment to openness and transparency

29 September 2006

18



Stages of Research

Architectures as they emerge will be made operational and tested

- Simulation, Emulation
- Run on a large-scale GENI+ facility
- Experiment with new architectures at scale
- Small number of architectures developed

29 September 2006

19

GENI Facility



Facility Goals

Enable exploration of new network architectures, mechanisms, and distributed system capabilities

A shared facility that allows

- Concurrent exploration of a broad range of experimental networks and distributed services
- Interconnection among experimental networks & the commodity Internet
- Users and applications able to “opt-in”
- Observation, measurement, and recording of outcomes

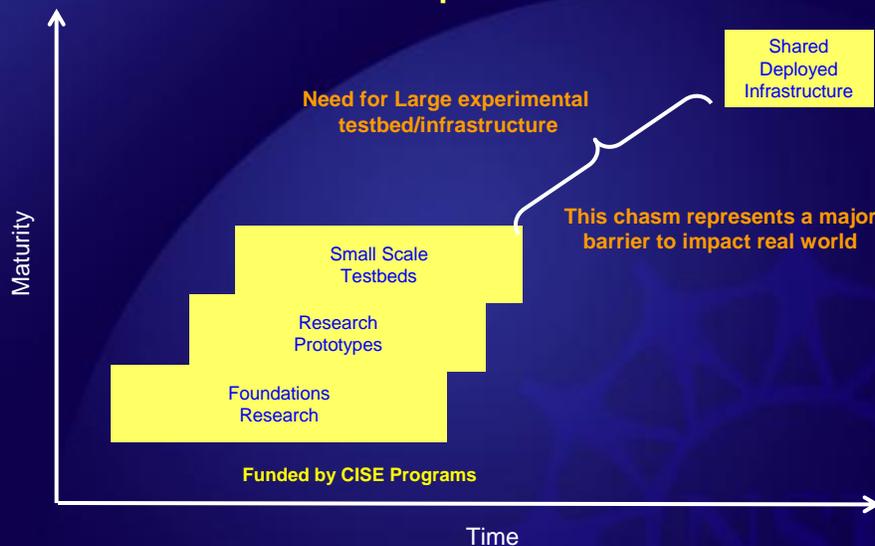
Help develop stronger scientific base

29 September 2006

21

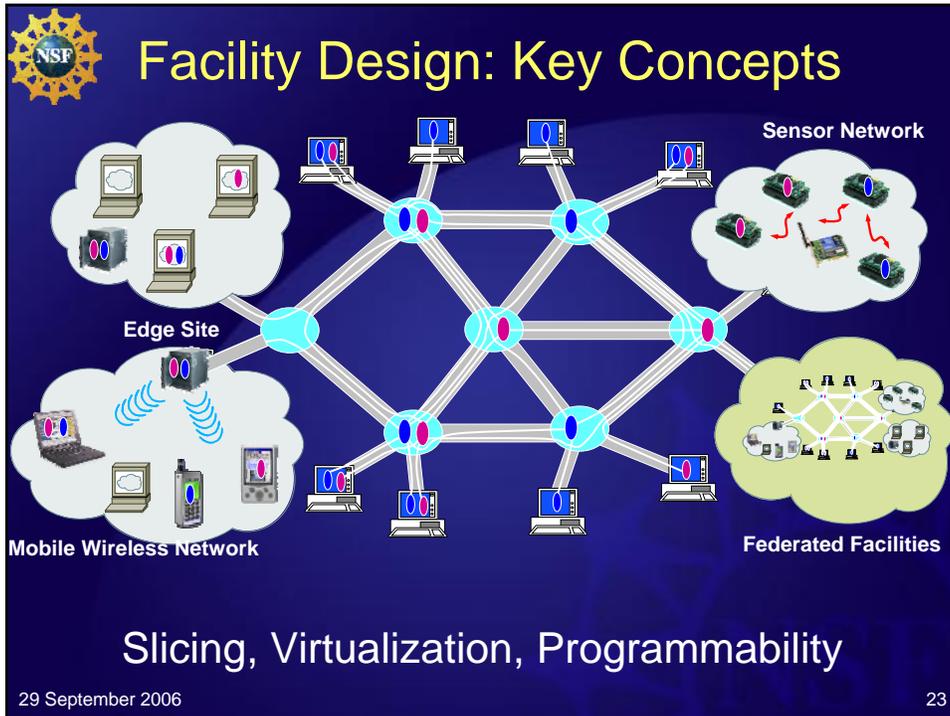


GENI Facility: Different Scale and Emphasis



29 September 2006

22



-
- NSF Diversity of Networks & Devices**
- Emulation facilities
 - Wired and wireless
 - Mobile wireless networks
 - Generic kits to be widely distributed
 - Relatively large facilities: urban and suburban
 - Cognitive radio based networks
 - Sensor networks
 - Generic kits
 - Large facilities with real applications
 - Edge networks
 - With large enough clusters and storage
- 29 September 2006 24



Network Architecture Ideas

- Network virtualization
- Architecture with middle boxes
 - Network embedded computing and storage
- Naming and addressing architectures
 - Digital objected oriented architectures
- Architectures with sub-networks with dynamic topologies
 - Dynamic optical networks
 - Cognitive radios

29 September 2006

25



Network Architecture Ideas

- Architectures with location awareness support
- Management plane
 - Management of routing systems
- Measurement & instrumentation infrastructure
- Clean-slate secured network architecture

29 September 2006

26



GENI as a Scientific Instrument

- Observability
 - Any quantity of interest
- Reproducibility
 - Experiment measurements reproducible
- Generality
 - GENI universal and can host many different networks
- Fidelity
 - Measurements with GENI correlated with real deployment

29 September 2006

27



Ongoing Activities

- Science plan and connection to the GENI facility
- Security of facility and support for security research
- Role of layers 1 and 2
- Integration of sensor network components
- Community consensus and convergence
 - Without curbing creativity and radical thinking
- Global collaboration
 - With agencies and research communities
 - Effective federation: technical as well as policy solutions

29 September 2006

28



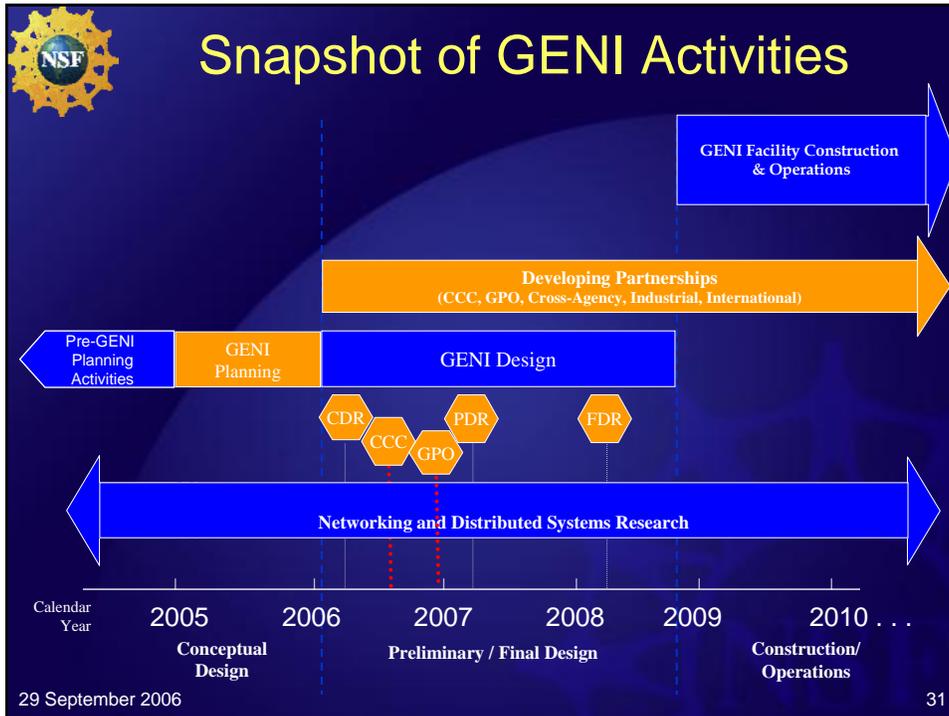
Success Scenarios

- Internet evolution influenced by clean-slate approach
- Alternate Internet architecture emerges
 - Alternate architecture(s) coexist with the current Internet
 - Single architecture emerges and dominates
- New services and applications enabled
- Many other payoffs
 - Some unexpected

29 September 2006

29

GENI Process



Summary

- Internet impacted the world in a way few inventions have
 - Federal agencies played a critical role in Internet's success
- Scientific foundation of future networking & distributed systems key
- Urgent and important need to reinvent the Internet
 - We have an opportunity and obligation to lead
- GENI a compelling initiative in support of this mission

The result may be even greater and far-reaching than the invention of current Internet

The NSF logo is in the top left corner. The date "29 September 2006" is at the bottom left, and the number "32" is at the bottom right.