











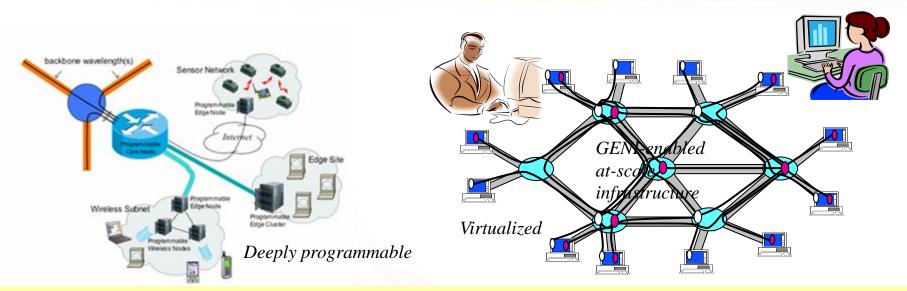
Aaron Falk GENI Project Office March 23, 2010 www.geni.net



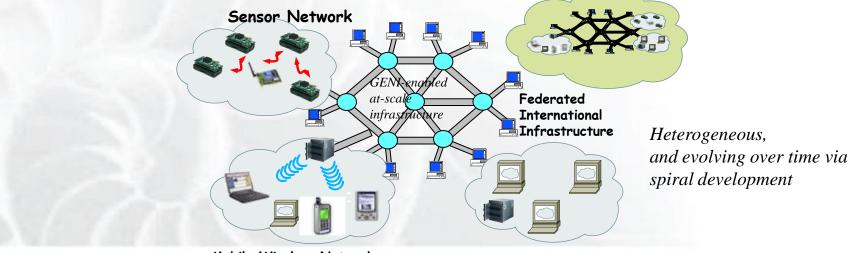
- GENI is a virtual laboratory for exploring future internets at scale.
- GENI creates major opportunities to *understand, innovate, and transform* global networks and their interactions with society.
- GENI opens up new areas of research at the frontiers of network science and engineering, and increases the opportunity for significant socio-economic impact.

GENI Conceptual Design Infrastructure to support at-scale experimentation





Programmable & federated, with end-to-end virtualized "slices"



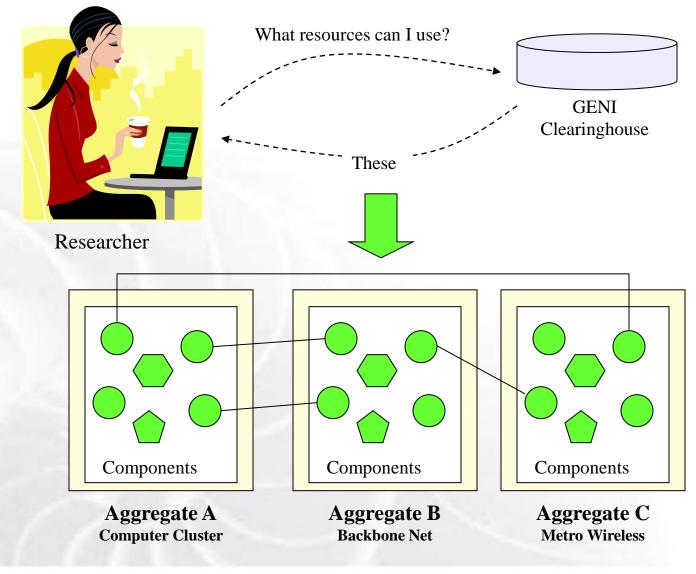
Sponsored by the National Science Poundation Wireless Network IETF-77 - NVRG Edge Site



GENI for the Short-Attention Span

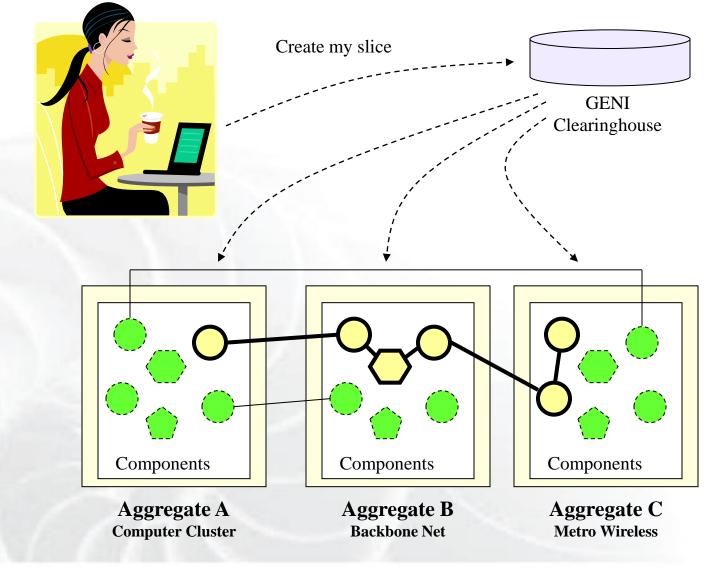


Resource discovery Aggregates publish resources, schedules, etc., via clearinghouses





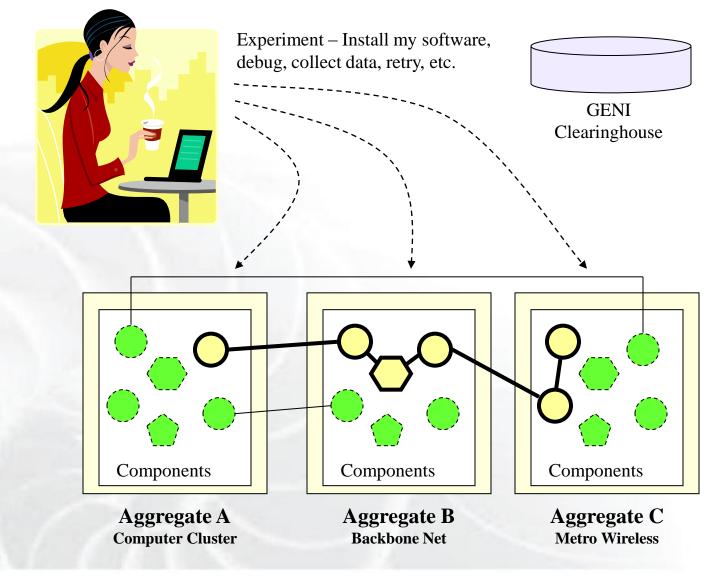
Slice creation Clearinghouse checks credentials & enforces policy Aggregates allocate resources & create topologies







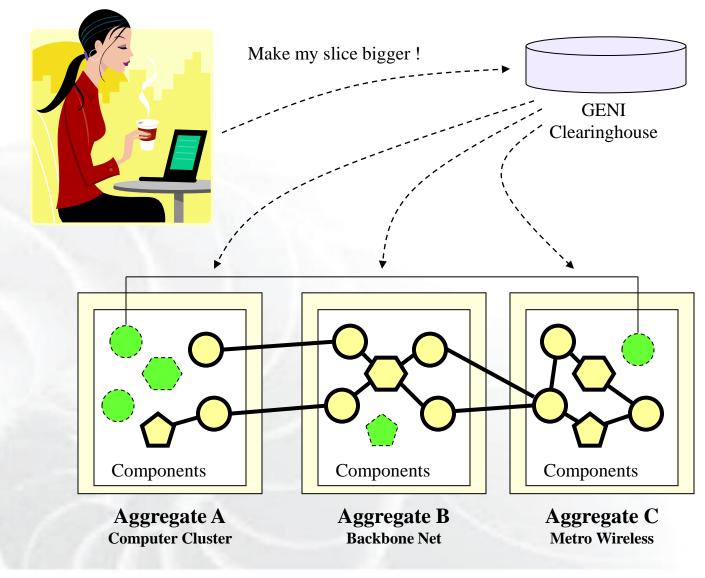
Researcher loads software, debugs, collects measurements





Slice growth & revision

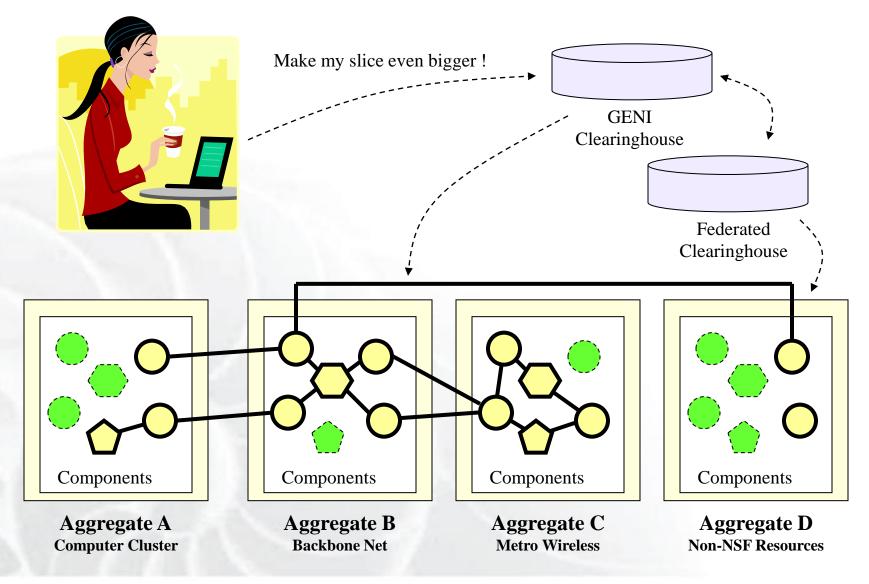
Allows successful, long-running experiments to grow larger

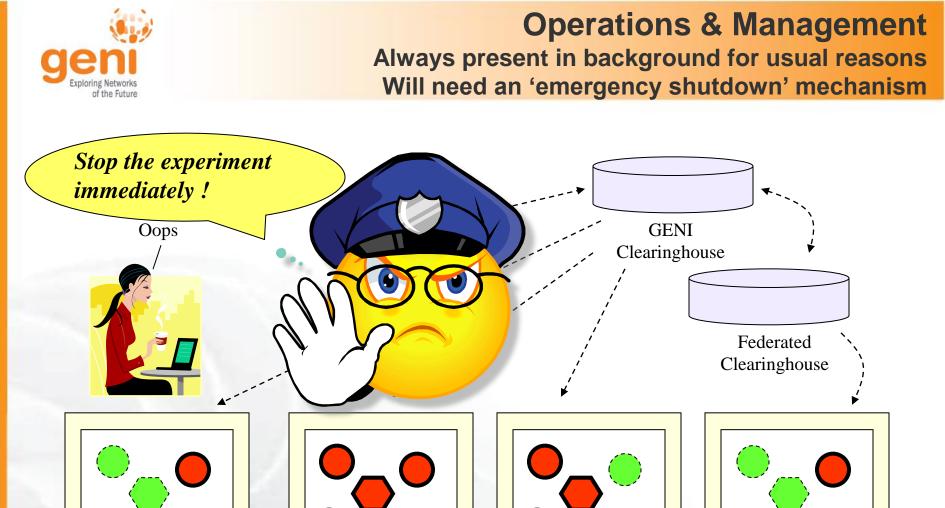




Federation of Clearinghouses

Growth path to international, semi-private, and commercial GENIs





Sponsored by the National Science Foundation

Components

Aggregate A

Computer Cluster

Components

Aggregate C

Metro Wireless

Components

Aggregate B

Backbone Net

Components

Aggregate D

Non-NSF Resources



Spiral 2 Academic-Industrial Teams

Project Name	Project Lead	Project Participants	
1. CMUlab	Carnegie Mellon University		
2. D Meas, LEARN	 University of Houston 	- Columbia University	
Digital Object Registry	 Corporation for National Research Initiatives (CNRI) 		
4. CLOUD-CTL, DOME, VISE	University of Massachusetts Amherst		
5. DTunnels	 The Georgia Institute of Technology 		😂 at&t 🛛 🥠
EnterpriseGENI, OpenFlow	 Stanford University 	- Princeton University	
		— University of California, Berkeley	- invent
	Georgia Institute of Technology		
	Indiana University		
	Princeton University		luniper (11)
	Rutgers University		
	University of Wisconsin -		NETWORKS
	University of Washington		NETWORKS CISCO
7. GENI4YR	Langston University		
8. GMOC, netKarma, K-GENI	 Indiana University 		ARISTA <i>infinera</i>
9. GpENI	 University of Kansas 	- Kansas State University,	
	The University of Missouri-Kansas City	University of Nebraska-Lincoln	Innicia
10. GushProto		- UC San Diego	
11. INSTOOLS, ISM Infrastructure	 University of Kentucky 		Microsoft ciena
12. KANSEL OTM		- Wayne State University	
13. MAX	University of Maryland		LUZI IC.
14. MeasurementSys	University of Wisconsin-Madison —	Boston University	
		Colgate University	
15. MillionNodeGENI, Security	University of Washington		
16. ORBIT, WIMAX	 Rutgers University ————————————————————————————————————	- UCLA, Los Angeles, CA	
		— University of Colorado, Boulder, CO	
	Polytechnic University of NYU, Brooklyn, NY	University of Massachusetts, Amherst	
		 University of Wisconsin, Madison, WI 	IM I
17. ORCA/BEN	 The Renaissance Computing Institute (RENCI) 		NETRONOME
18. PlanetLab, Scaffold, Federation		- Universite Pierre et Marie Curie (UPMC)	
19. ProtoGENI 20. PROVSERV	 University of Utah University of Arizona 		\sim
20. PROVSERV 21. ERM	Columbia		
22. REGOPT	 Pittsburgh Supercomputing Center (PSC) 		
23. SECARCH, Distributed Identity	 SPARTA, Inc. 		
24. SPP	 Washington University 		
25. TIED		University of California, Berkeley	SPARTA
26. UB OANets	SUNY Buffalo		VIANA
27. UMLPEN	University of Massachusetts Lowell		Dettelle
28. CR-GENI	 University of Colorado Boulder 	Radio Technology Systems LLC	Battelle
		Rutgers University	
29. CRON-T	 Louisiana State University 		CNRI
30. Design of Information Subs	• MIT		CIUR
31. DSL, HIVE	😐 UC Davis	- Batelle CA Labs	
32. EXP-SEC	 University of Alabama 	- CA Labs	
33. FPGA-RADIO	 Clemson University 		
34. GENI IMF	North Carolina State University	The Renaissance Computing Institute (RENCI)	Owest.
54. 0041 101		 Columbia University 	nicira
35. IGENI	Northwestern University ————————————————————————————————————	 University of Illinois Chicago 	
36. LAMP	 University of Delaware 	Internet2	
37. LEFA, Supercharged Planetlab	o Internet2	Brown University	
38. NLR	Cypress, CA		Radio Technology Systems
39. OpenCIRRUS	HP Labs, Palo Alto ————————————————————————————————————	-® UCSD	
40. OKGems	 Oklahoma State University 		
41. PIGEON-NET	 Howard University 		JEFFREY HUNKER ASSOCIATES LLC
42. PrimoGENI	 Florida International University 		Technology Government Global business Insight with impact
43. QUILT	 The Quilt 		
44. \$3-GENI		- HP Labs	
45. SEC-POL	 University of Illinois (NCSA) University of Alaska Esideante 		11
46. VMI	 University of Alaska Fairbanks 		

Service Servic



HP ProCurve 5400 Switch

Juniper MX240 Ethernet Services Router

NEC WiMAX Base Station

Cisco 6509 Switch

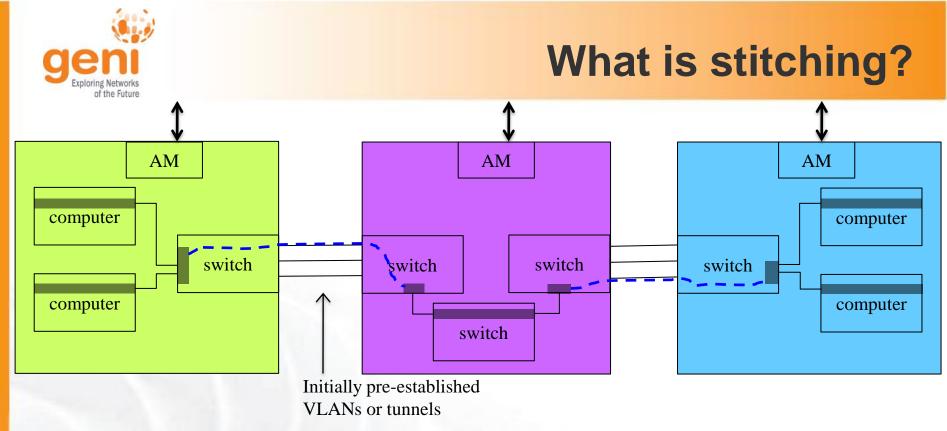
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NEC IP8800 Ethernet Switch



Network Virtualization in GENI

- GENI uses multiple network virtualization strategies...
 - Tunnels over IP (GRE, OpenVPN)
 - Ethernet VLANs (incl QinQ Ethernet tunnels)
 - OpenFlow (switch forwarding rules based on any header field)
- ...to connect sliceable computation
 - Dedicated hosts (e.g., Emulab)
 - Virtual machines (e.g., PlanetLab, XEN, OpenVZ)
 - Clouds (e.g., Amazon EC2, Eucalyptus)
- ...and programmable network devices
 - Programmable switches (e.g., OpenFlow)
 - FPGA-based switches & routers (e.g., PEN, SPP, netFPGA)
 - Virtualizable routers (e.g., Juniper M7i)



- "Aggregate managers" orchestrate resource allocation locally
- "Stitching" is used to connect aggregates
- Establishes linkages among slivers or other entities created by different AMs
 - The near term emphasis is on Ethernet carriage, i.e., VLANS and tunnels that can carry Ethernet frames
 - Will want to extend this to other layers
- Several stitching approaches are under consideration