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The Character of G-Lab

An Analysis of the German Lab for Future Internet Research and its Opportunities for Experimentally Driven Service Development

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Overview

- The G-LAB Initiative
  - Objectives
  - G-LAB Structure
  - Overview of Projects
- Two Project Examples
  - Future Internet Routing: FIR@Würzburg/Berlin/Munich
  - Future Multicast Services: H∀Mcast@Hamburg
- Experimental Facility
  - Federated Experimental Approach
  - Experimental Sites
  - Performance Aspects: G-Lab versus PlanetLab
- Conclusions & Outlook

G-LAB Objectives

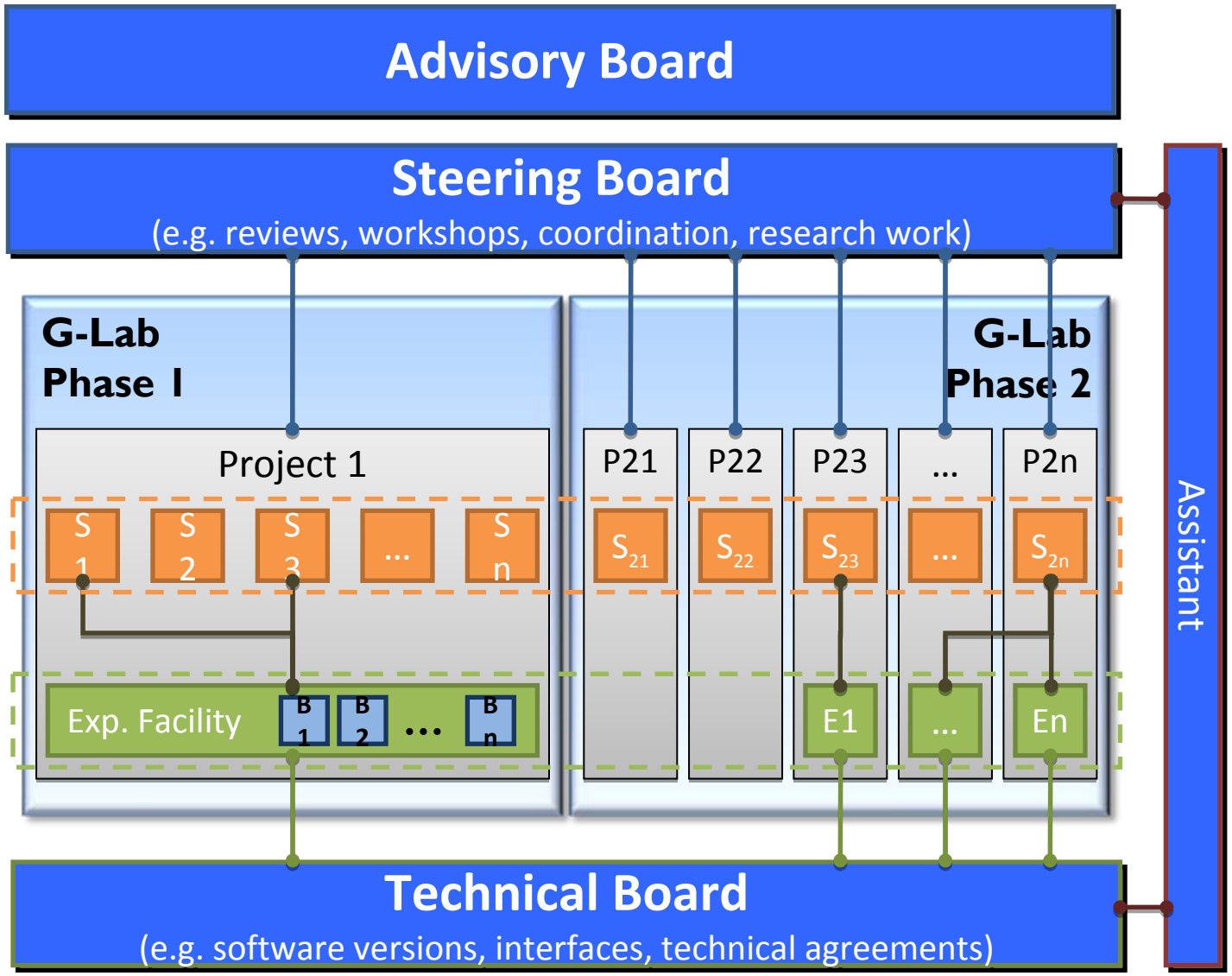
- Provide an Environment for Network Research that Stimulates
  - Discussions and exchange for groups from academia and industry
  - Open, flexible experimental facilities
  - Funding of new ideas

- Foster Heterogeneous Approaches and Contributions
  - Topics range from core technologies to distributed computing services
  - Include concurrent and competitive work
  - Grant room for the development of new prospects
  - Focus on experimentally driven work and exploration
  - Common denominator: Good communication research

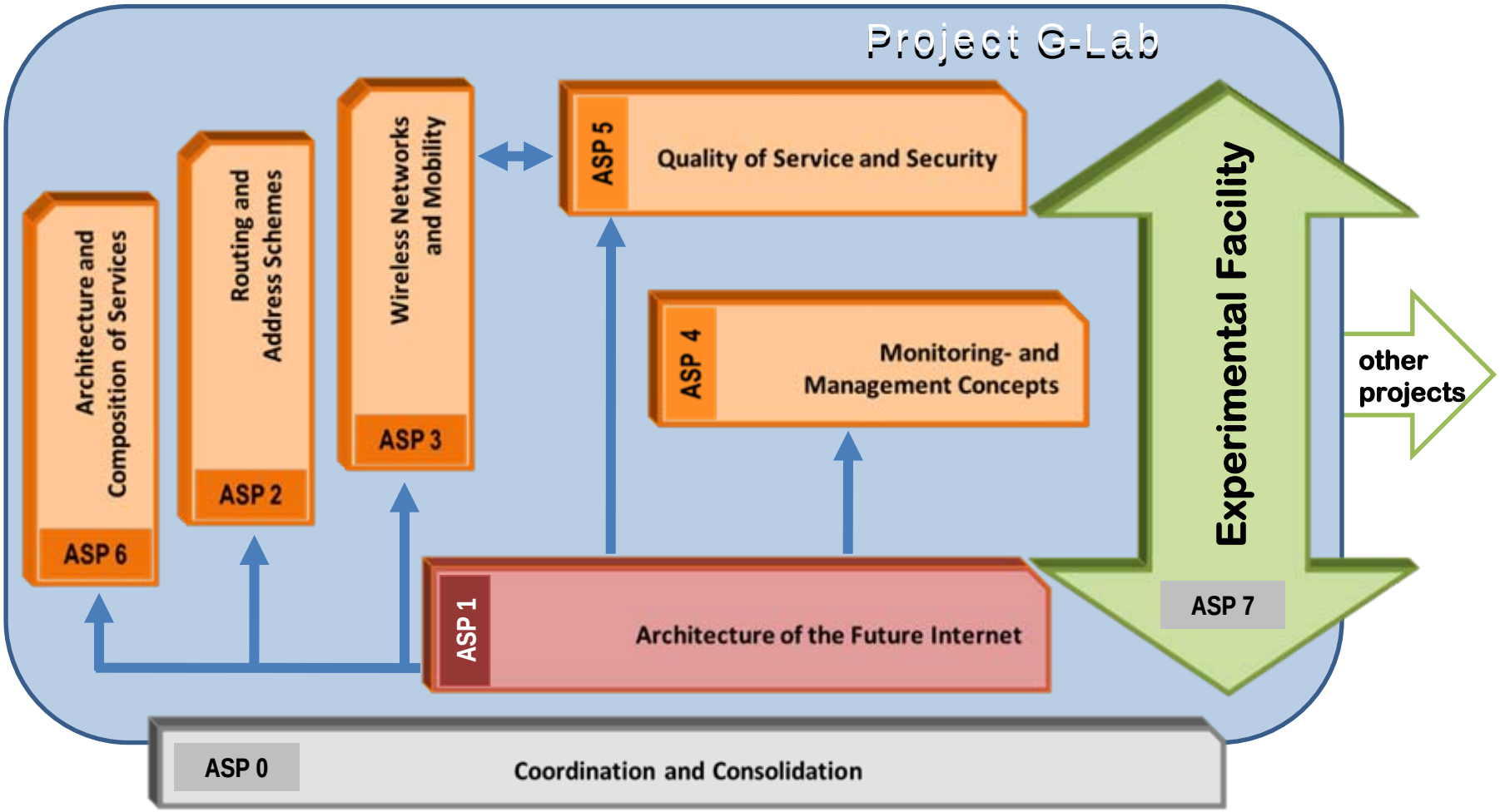
"No special initiatives from top down are needed at all"

Jon Crowcroft (Future Internet Enervation)

G-Lab Structure



G-Lab Phase 1 Project Structure



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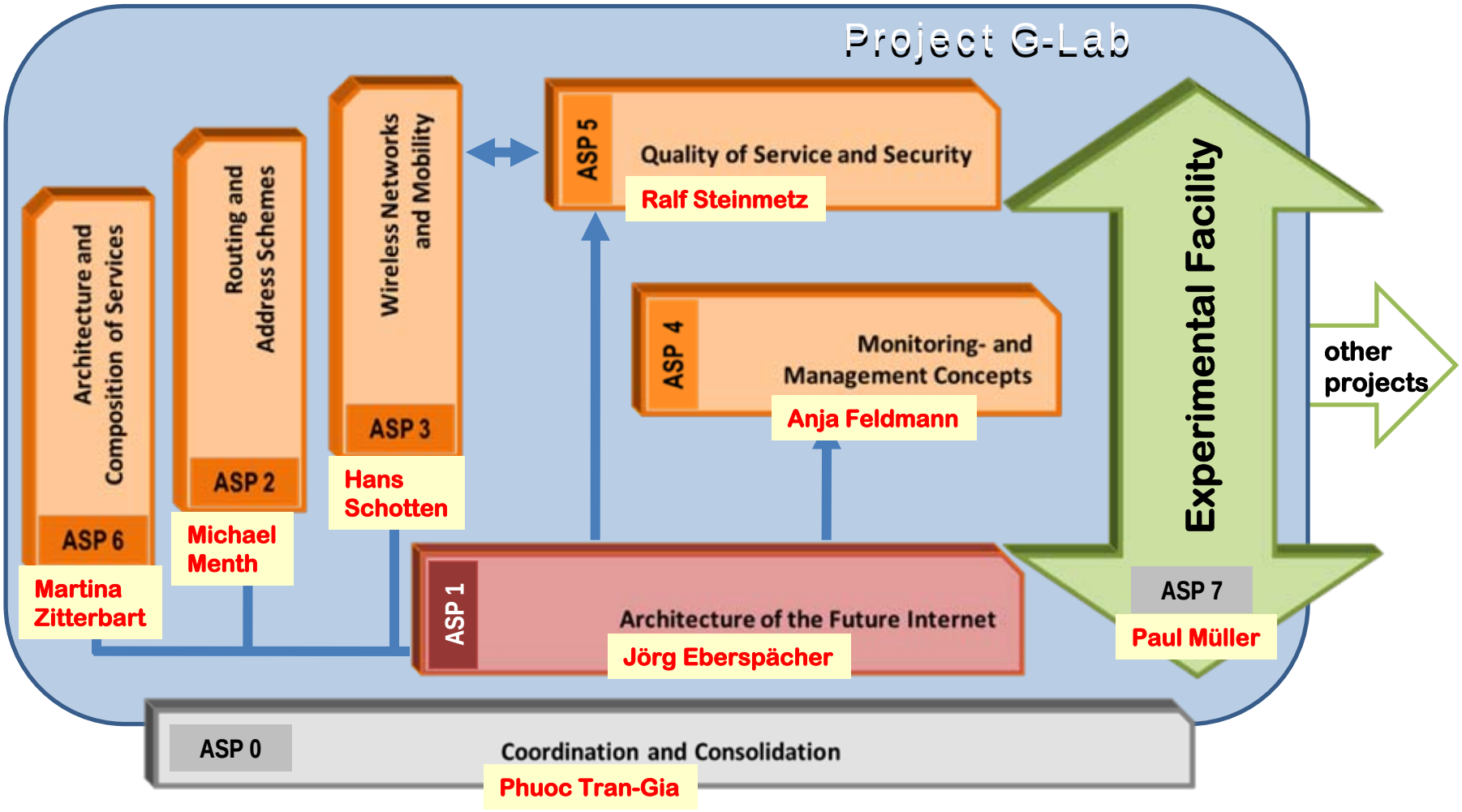


G-Lab Phase 2: Projects

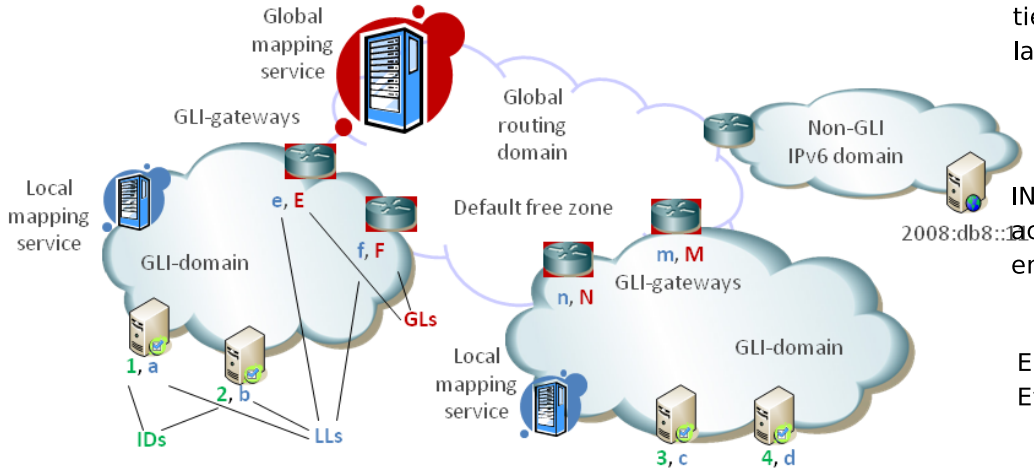
- **CICS (Convergence of Internet and Cellular Systems)**
  - Develop architectures and protocols to support mobility and quality of service
- **COMCON (Control and Management of Coexisting Networks)**
  - Use of virtualization to support the introduction of new services and new transport networks
  - Provider and operator-grade management and control of coexisting networks (by network virtualization)
- **Deep (Deepening G-Lab for Cross-Layer Composition)**
  - Explore innovative composition-approaches for cooperation between network and services with the focus on security in the future internet.
- **FoG (Forwarding on Gates)**
  - Enable dynamic function injection in a network
  - Bridging connection oriented and connectionless

G-Lab Phase 2: More Projects

- **Ener-G (Energy Efficiency in G-Lab)**
  - Exploration of energy-efficient operation
  - Energy-aware virtualization and consolidation of communication
- **H∀Mcast (Hybrid Adaptive Mobile Multicast)**
  - Universal multicast service middleware
  - Decouple the processes of application development and infrastructure deployment
- **NETCOMP (Network-Computing for the Service Internet of the Future)**
  - Create technology to extend network agnostic grid and cloud computing to real-time multimedia communication:
- **Real-World G-Lab**
  - Provisioning of a base for Internet of Things (IoT) research through integration of Wireless Sensor and Mesh Networks
- **VirtuRAMA**
  - Concurrent virtual networks
  - Live migration of virtual routers

Proposals for FIR Architectures

- Evolutionary approaches
  - LISP (Cisco)
    - Already operational pilot networks http://www.lisp4.net/
    - Gateways for map&encaps
    - Routing on identifiers in edge networks
  - Uni WÜ: GLI-Split
    - Loc+ID coded in IPv6 address
    - Multiple benefits
    - Demo EuroView 2009

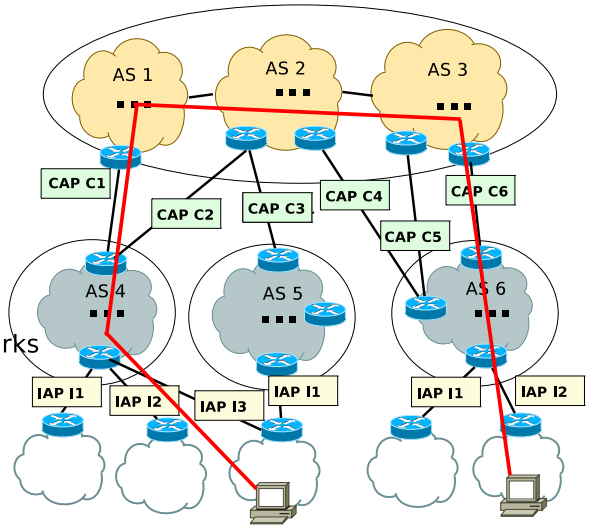


- Clean-slate approaches
  - TU Berlin: „HAIR: Hierarchical Architecture for Internet Routing”
    - Hosts compose complete addresses instead of gateways
    - Demo EuroView 2009
  - TU Munich: A Novel DHT-Based Network Architecture for the Next Generation Internet

CORE:
tier-1 ASs
large Providers

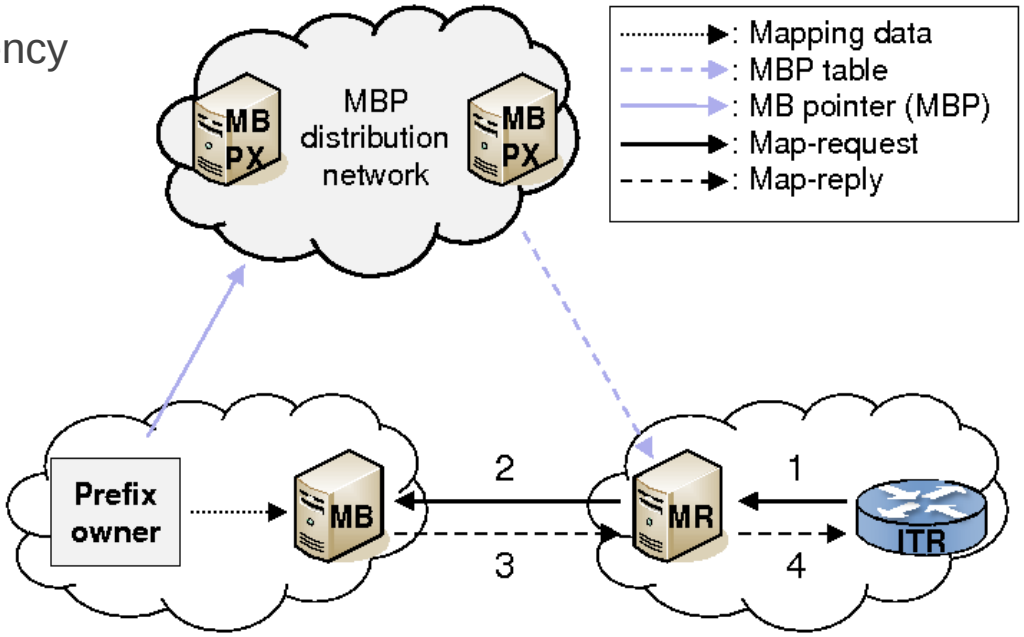
INTs:
access provider
enterprise networks

EDGEs:
Ethernet



Proposals for Mapping Systems

- Requirements
  - Scalability
  - Security & resilience
  - High performance & low latency
  - Packet forwarding

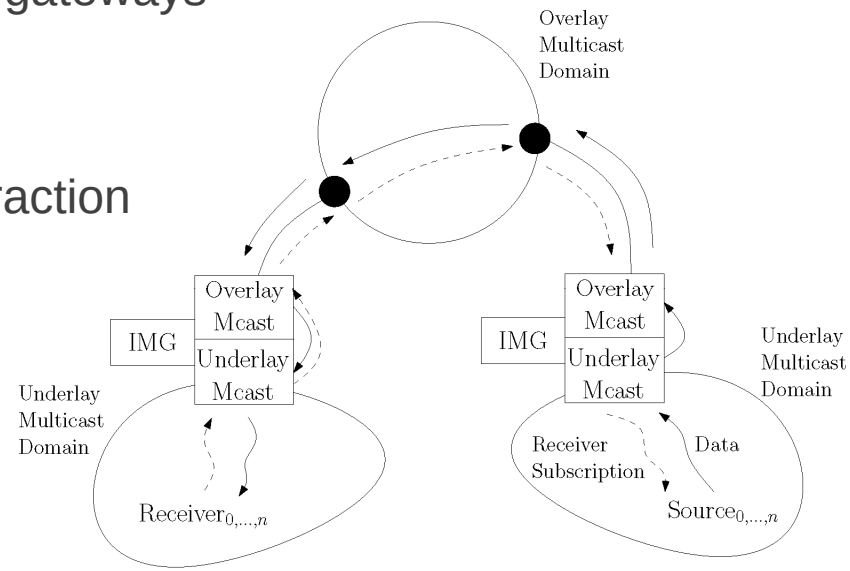


- FIRMS (UniWü)
  - Map-base (MB)
  - MB pointer (MBP)
  - Map-resolver (MR)
  - Ingress tunnel router (ITR)
  - Demo EuroView 2009
  - Protoype (ongoing)
- HiiMap (TUM)
  - Global mapping system: ID-to-regional-prefix
  - Regional mapping systems: ID-to-Loc
  - Prototype (ongoing)

H∀Mcast – Hybrid Adaptive Mobile Multicast

- Evolutionary widening of the architecture heading at a Multiservice Internet
  - Abstraction of the Socket API
  - Increased, heterogeneous network functions at end systems
  - Optional gateways (explicit and implicit)

- Hybrid, open architecture
  - Multilayered, including intelligent gateways
- Mobility-transparent Routing
  - At network and application layer
- Optimization on overlays by ISP interaction
  - Focus on Peering Points
- Secure member authentication in group applications



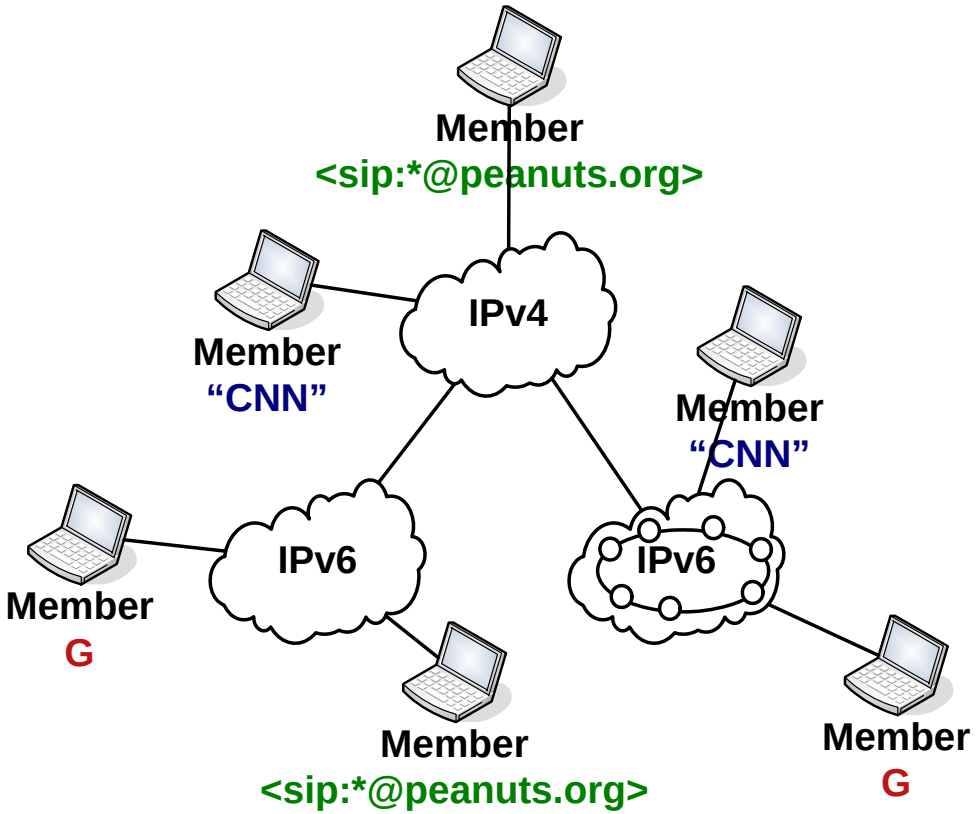
Naming and Addressing

"Multicast addresses are a set of distributed application names"

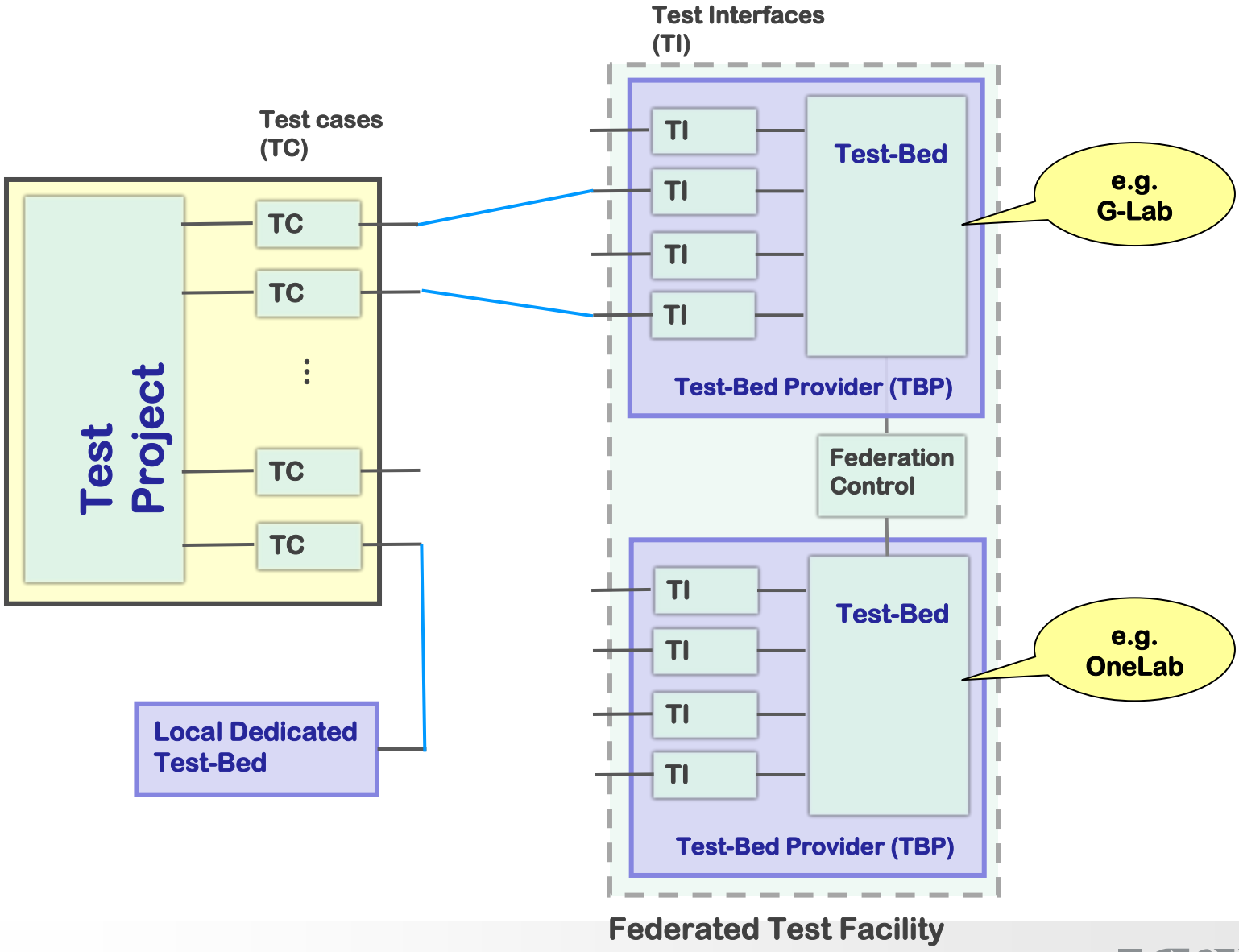
John Day (Patterns in Network Architecture)

Just use any application name?

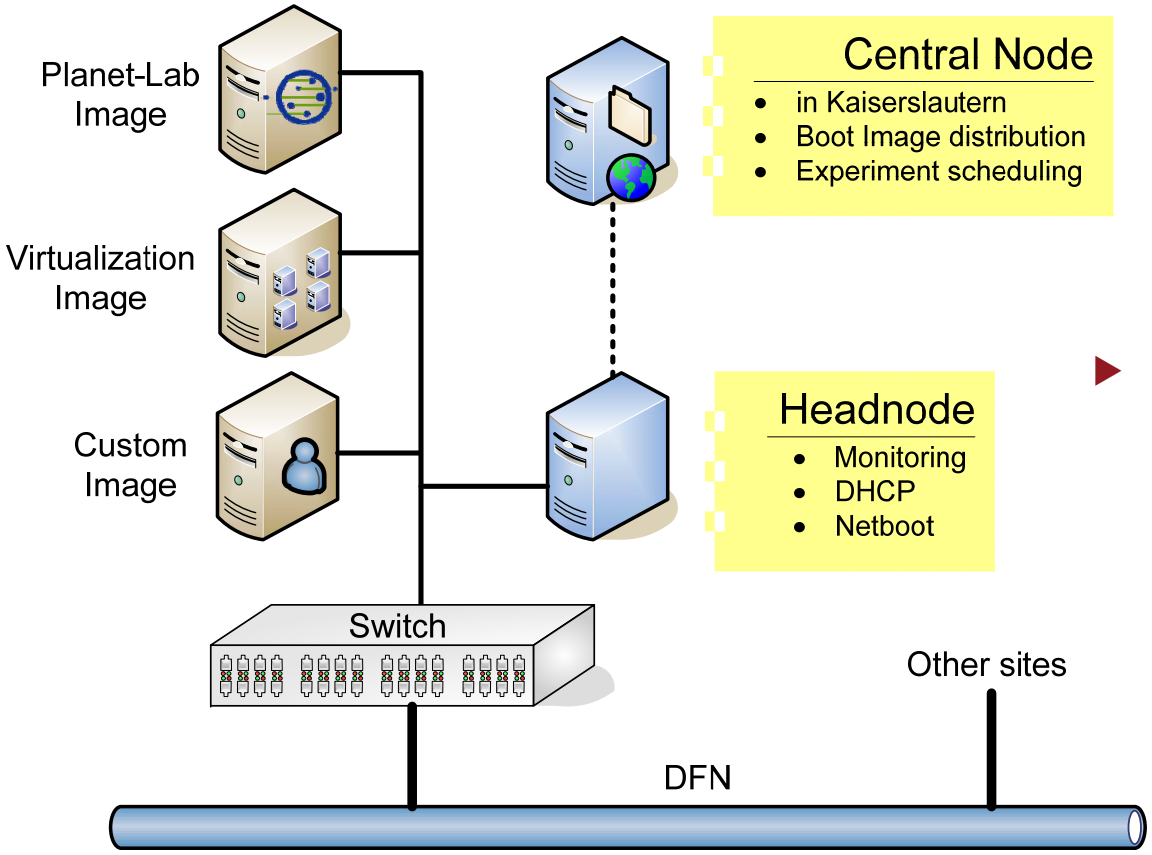
- Problem of mapping to network technologies:
- Domains may run same technology but remain isolated
- Domains may run distinct technologies but host members of the same group
- Proposal: Use abstract, namespace-aware data type - URIs for late binding + new API



Test cases and federation of Experimental Facilities



G-Lab Experimental Site Structure

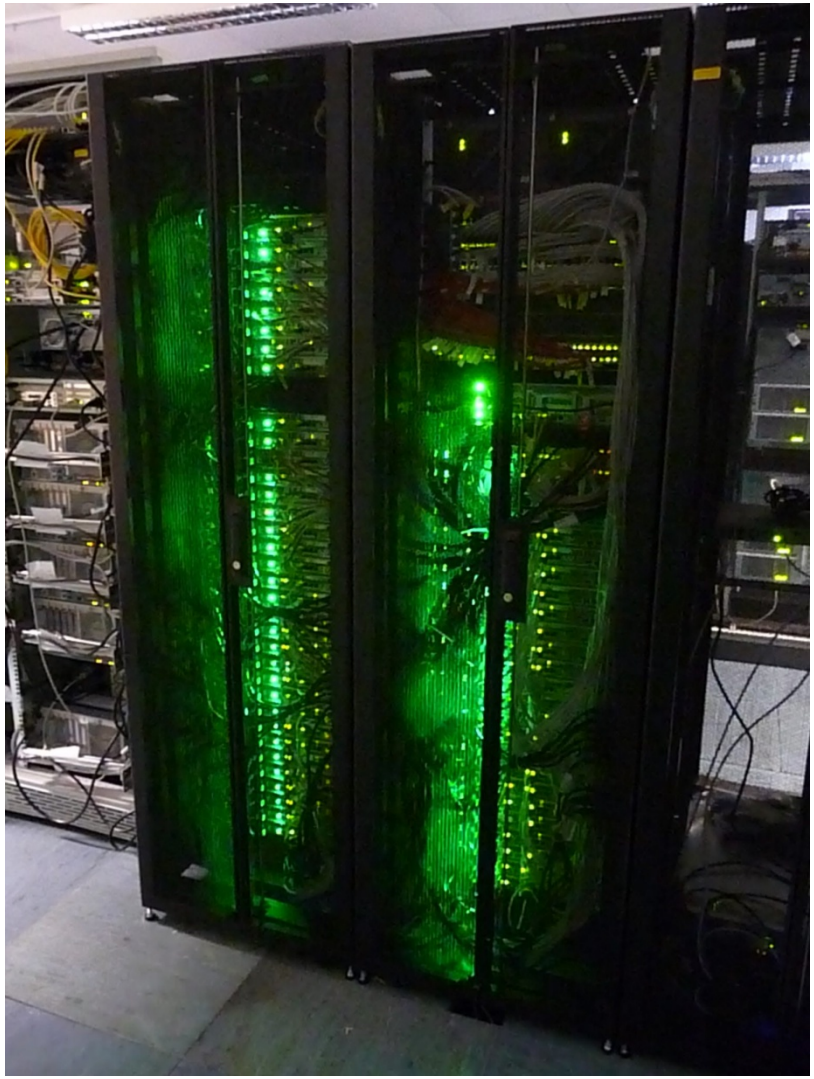


- Central Node
  - Resource management
    - Experiment scheduling
    - Resource provisioning
  - Boot Image management
    - Distributes Images
    - Assigns Images to nodes
- Each site has a Headnode
  - Manages local nodes
    - DHCP
    - Netboot
    - Monitoring
    - ILOM access
  - Executes orders from Central node
    - Local overrides possible

Hardware Equipment

- Normal Node
  - 2x Intel L5420 Quad Core 2,5 GHz
  - 16 GB Ram
  - 4x Gbit-LAN
  - 4x 146 GB disk
  - ILOM Management Interface (separate LAN)
- Network Node
  - 4 extra Gbit-Lan
- Headnode
  - 2x Intel E5450 Quad Core 3,0 GHz
  - 12x 146 GB disk
- 174 Nodes in total

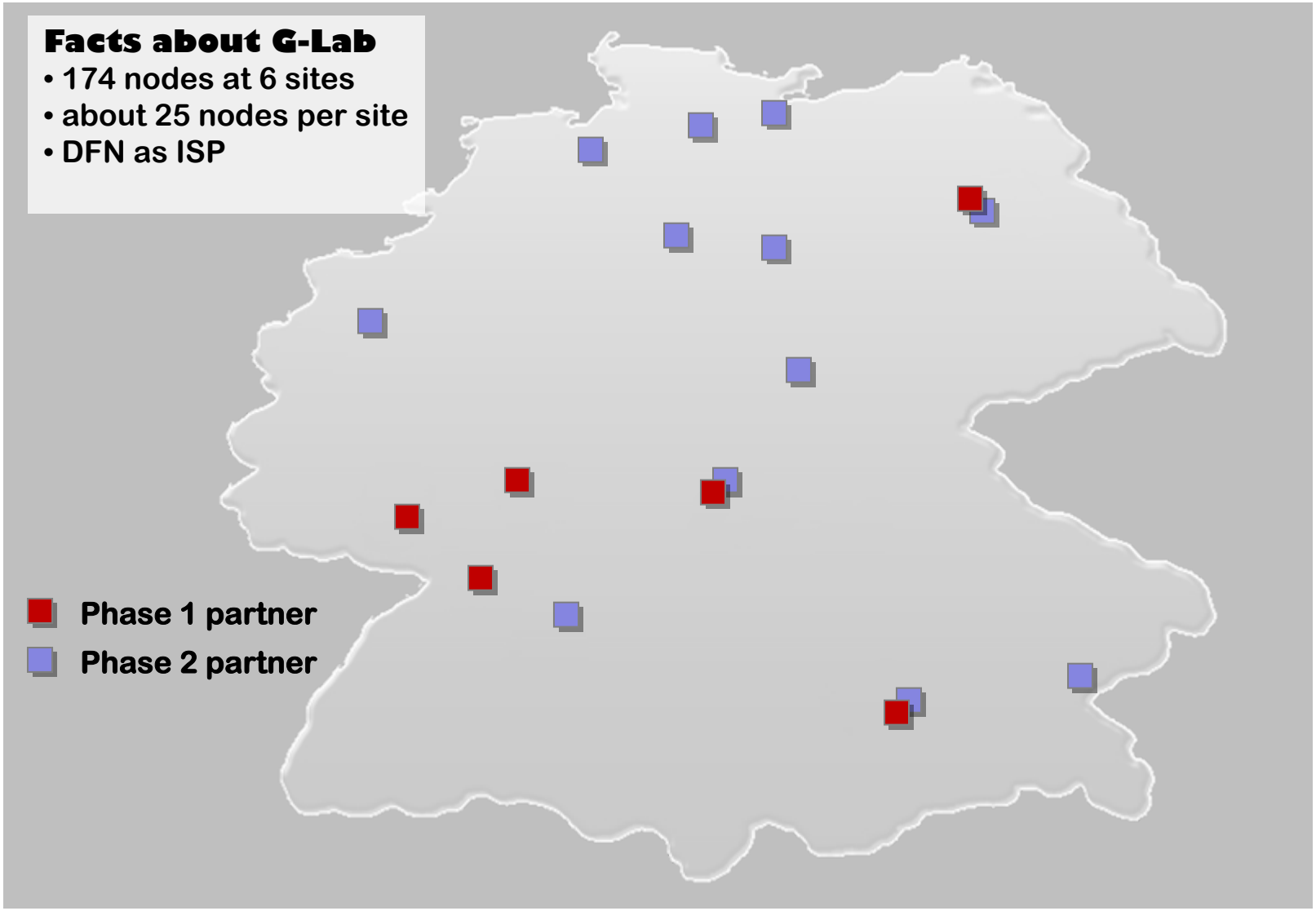
  (1392 cores total)



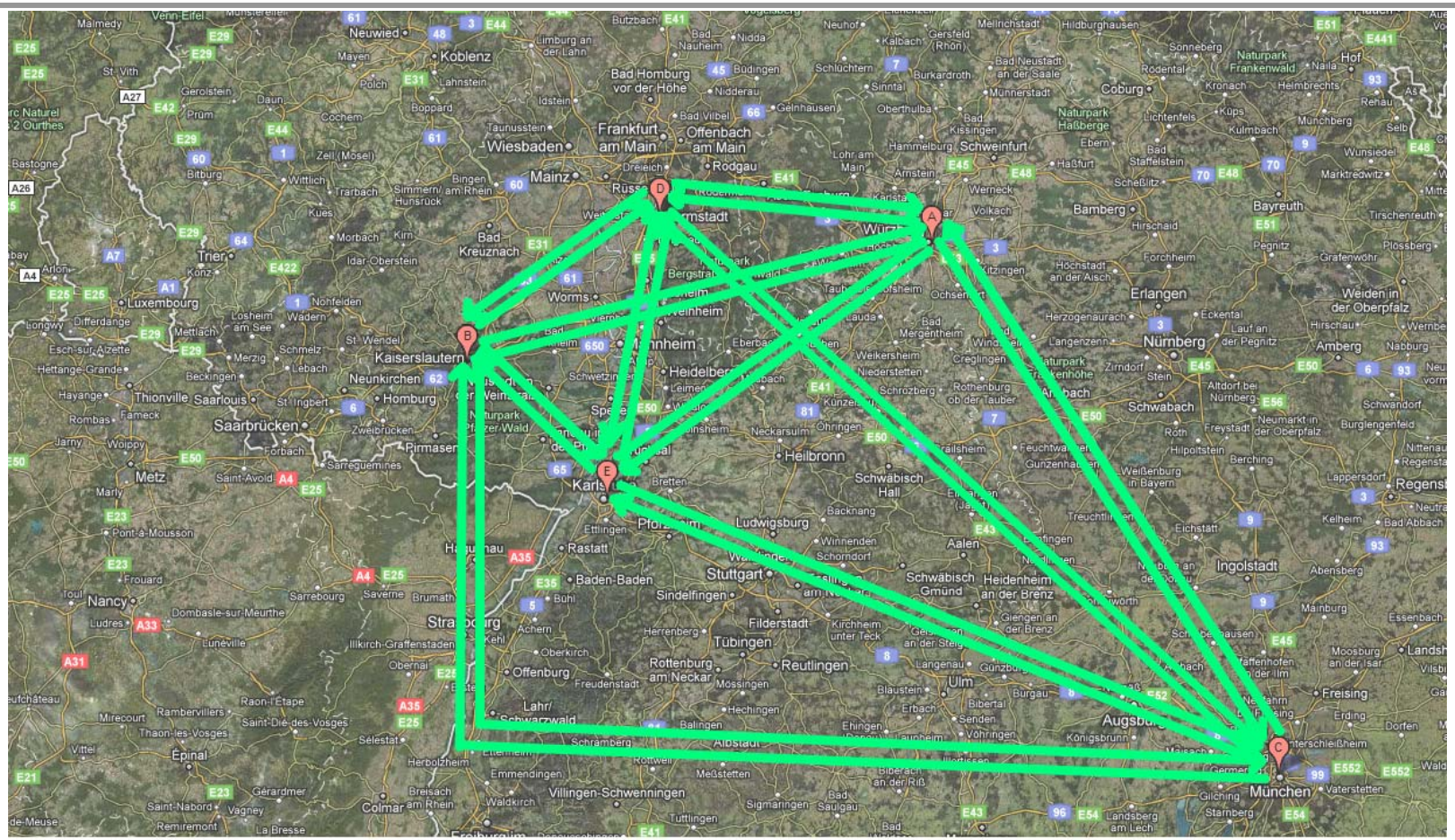
Experimental Flexibility

- Experimental Facility is part of research experiments
  - Facility can be modified to fit the experiments needs
  - Researchers can run experiments that might break the facility
    - Experimental facility instead of a testbed
- Research is not limited by
  - Current software setup
  - Current hardware setup
  - Restrictive policies
- Experimental Facility is evolving
  - Cooperative approach
    - „When you need it, build it“
    - Core team helps
  - Cooperation with other facilities (e.g. Planet-Lab, GENI)
  - Federation

Partner Locations



G-LAB Operational Picture (as of this June)



Legend

Round Trip Time colour scheme

- < 92 ms
- 92-150 ms
- 150-208 ms
- 208-266 ms
- 266-324 ms
- 324-382 ms
- 382-440 ms
- > 440 ms

Jitter

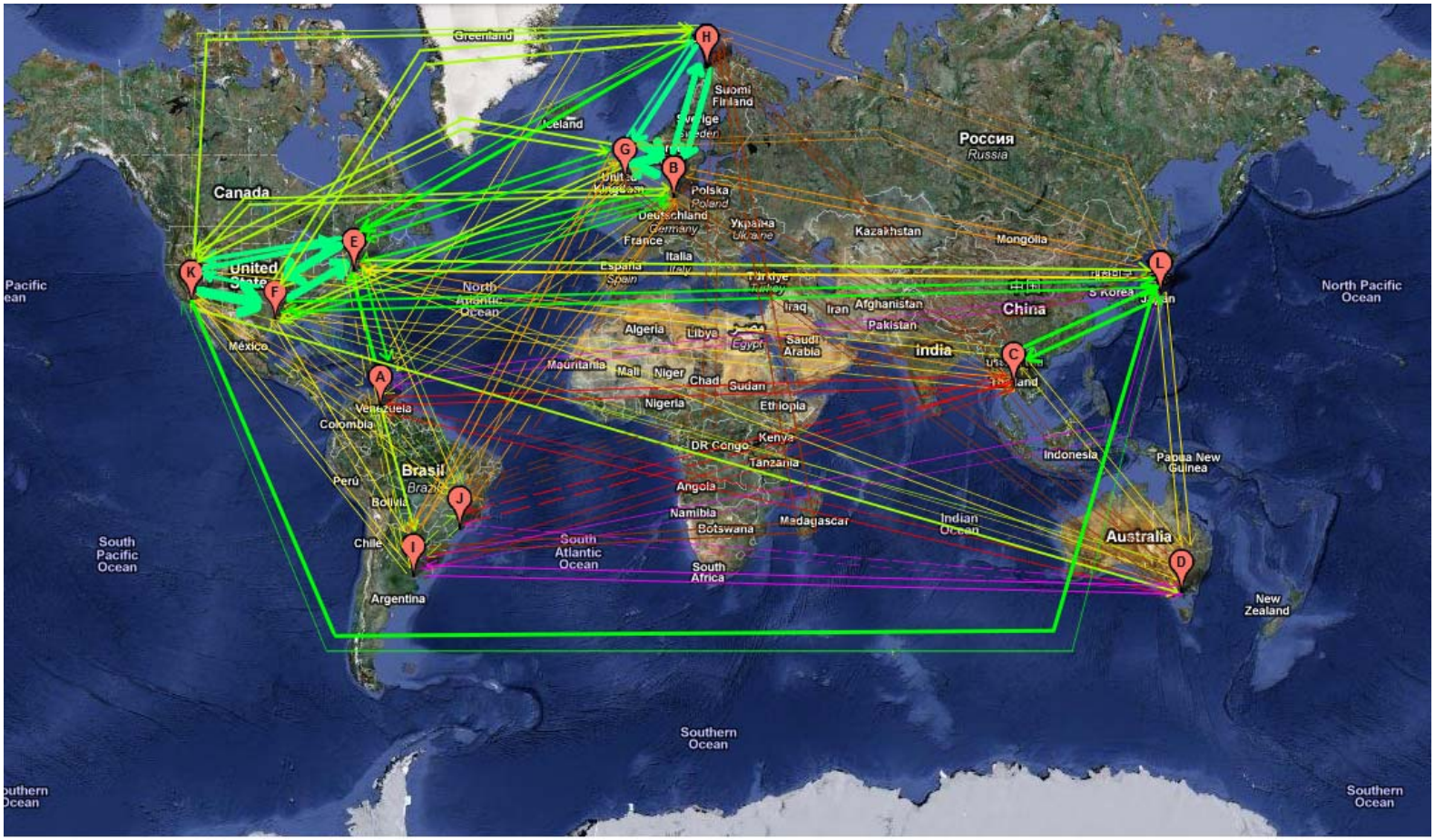
- < 2 ms
- 2-4 ms
- 4-6 ms
- 6-8 ms
- > 8 ms

Throughput rate

- < 263 kbps
- 263-474 kbps
- 474-685 kbps
- 685-896 kbps
- 896-1107 kbps
- 1107-1318 kbps
- 1318-1530 kbps
- > 1530 kbps

Packet Loss remarks: All communications between all nodes have less than 0.1% packet loss except the communication from Technische Universitaet Kaiserslautern to Technische Universitaet Darmstadt (0.3%)

Compare to Planet-Lab



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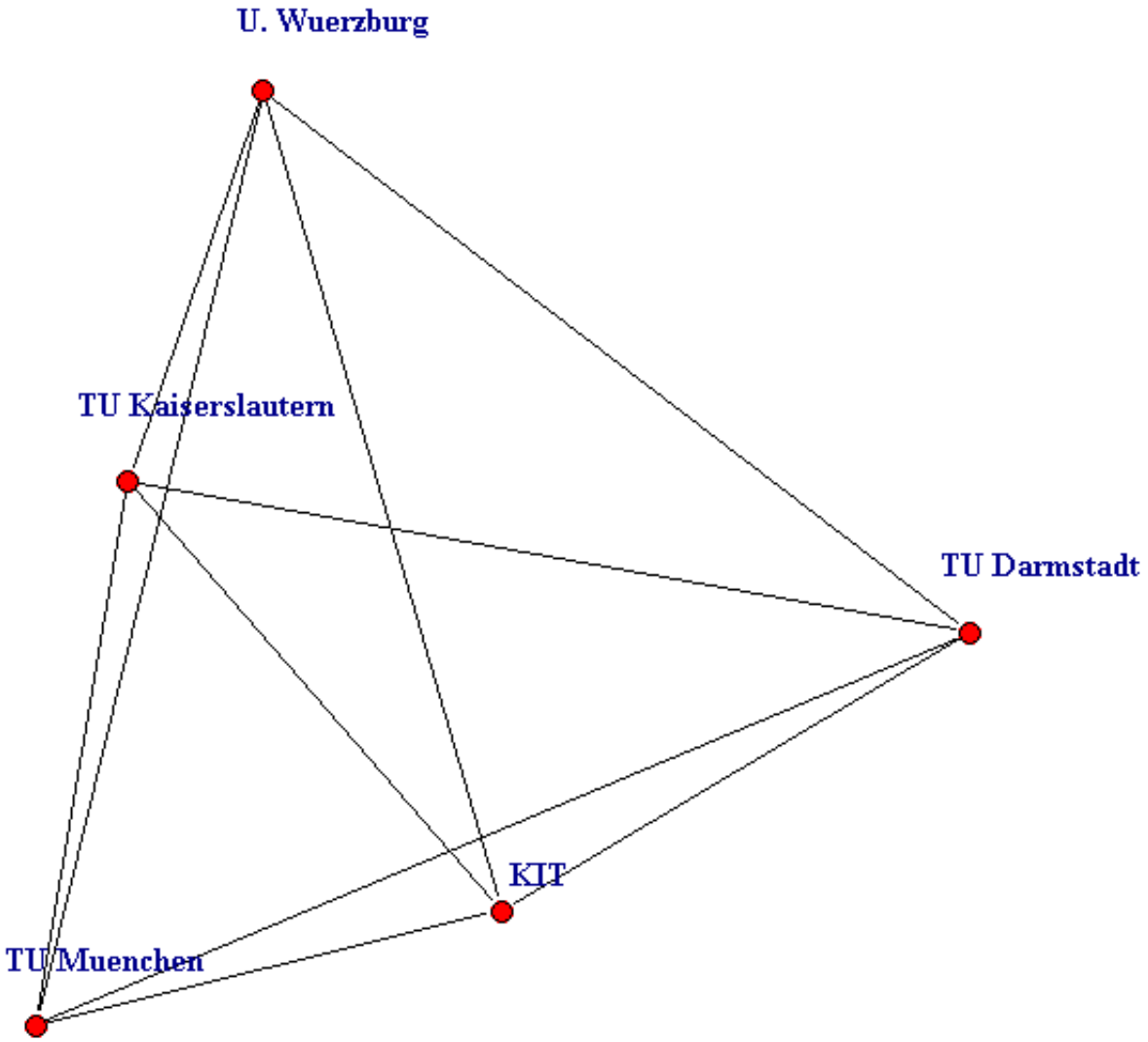
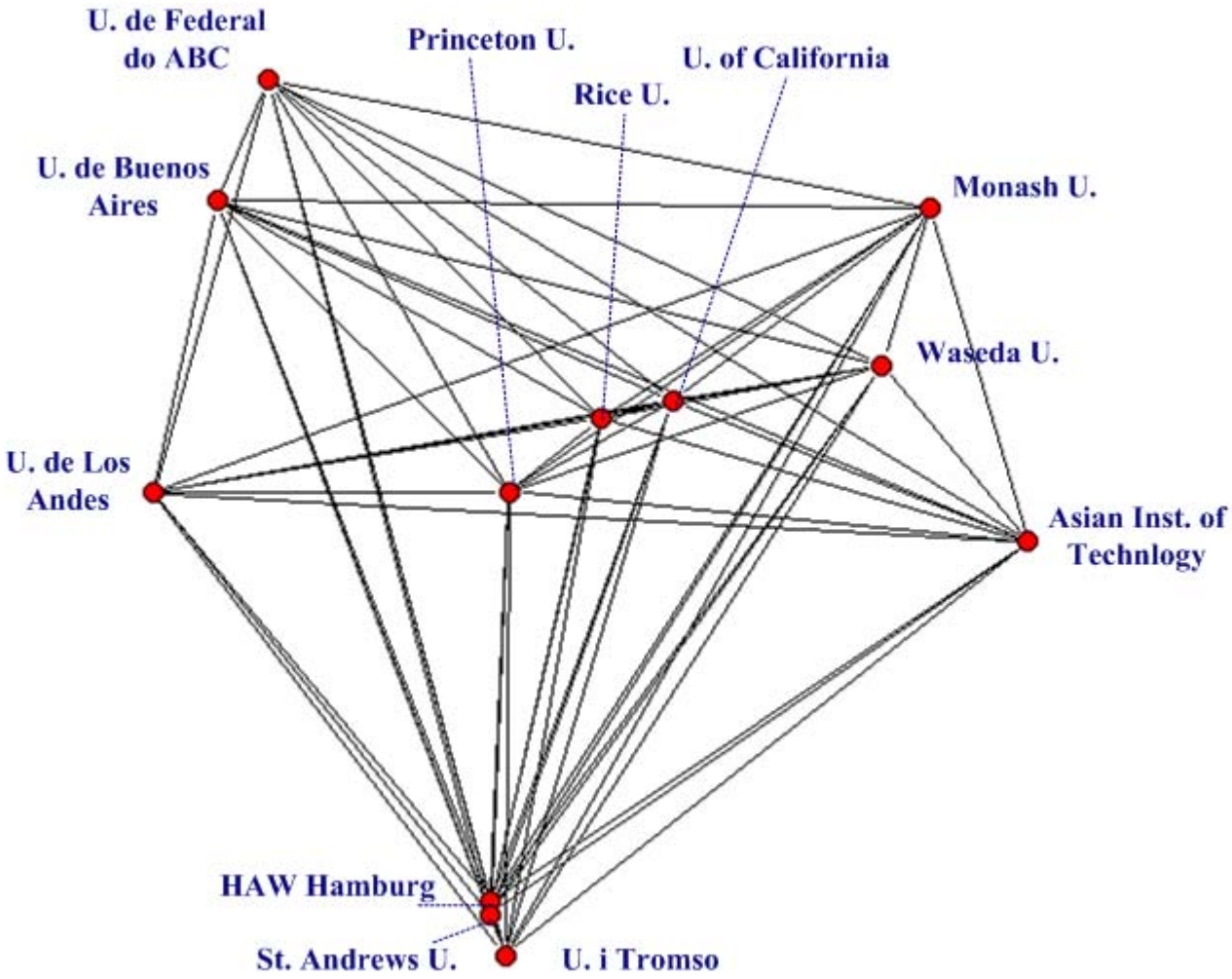
Packet loss remarks: All communications between all nodes have less than 0.5% packet loss except the communication from Princeton university to Universidad de Buenos Aires (0.71%), from Universidad de Buenos Aires to Universidade Federal do ABC (0.71%), from Waseda university to Universidad de Los Andes (0.71%), from Waseda University to Universidade do ABC (0.79%) and vice versa (0.71%).

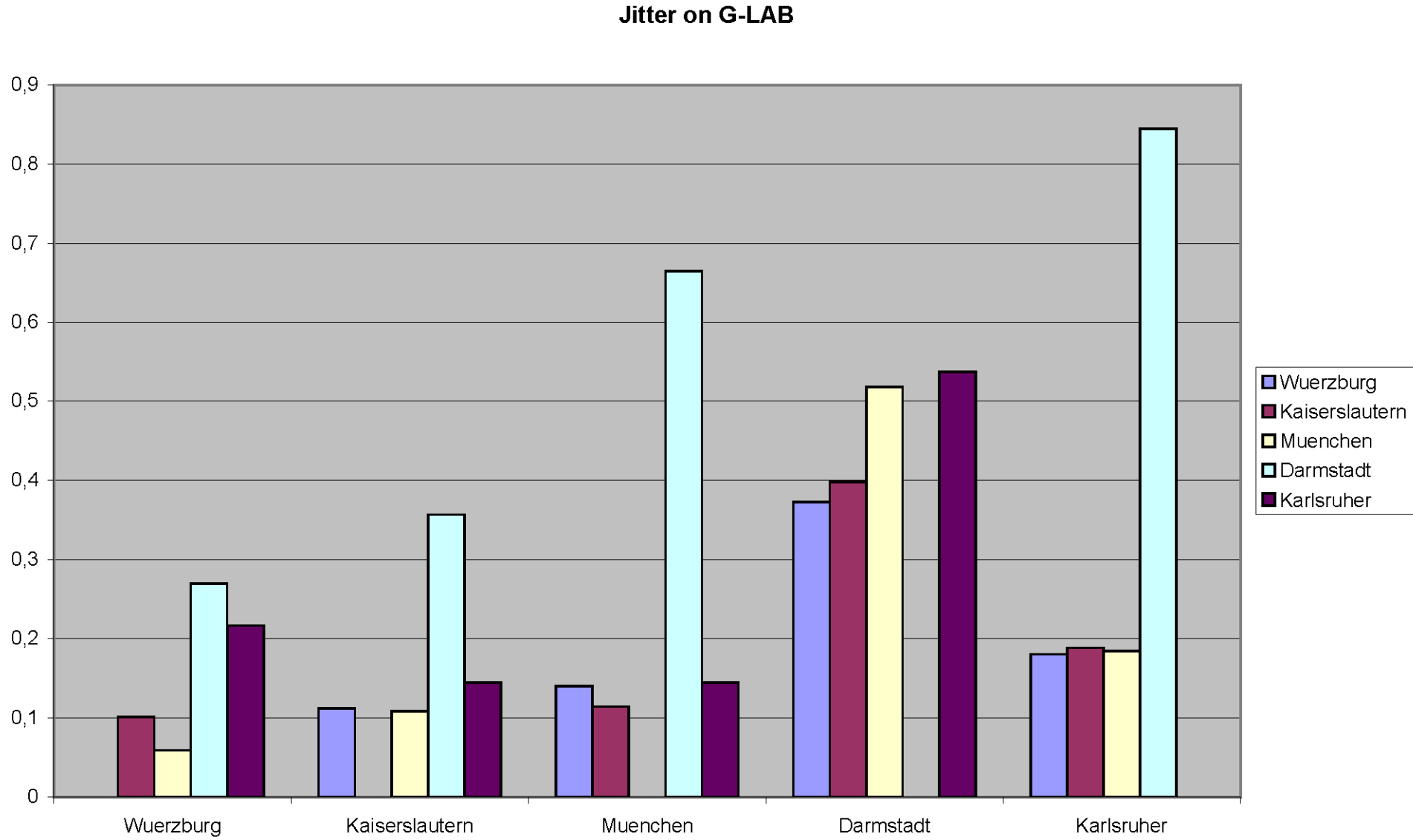
G-LAB Delay Space



Planet-Lab Delay Space



The Jitter Pictures



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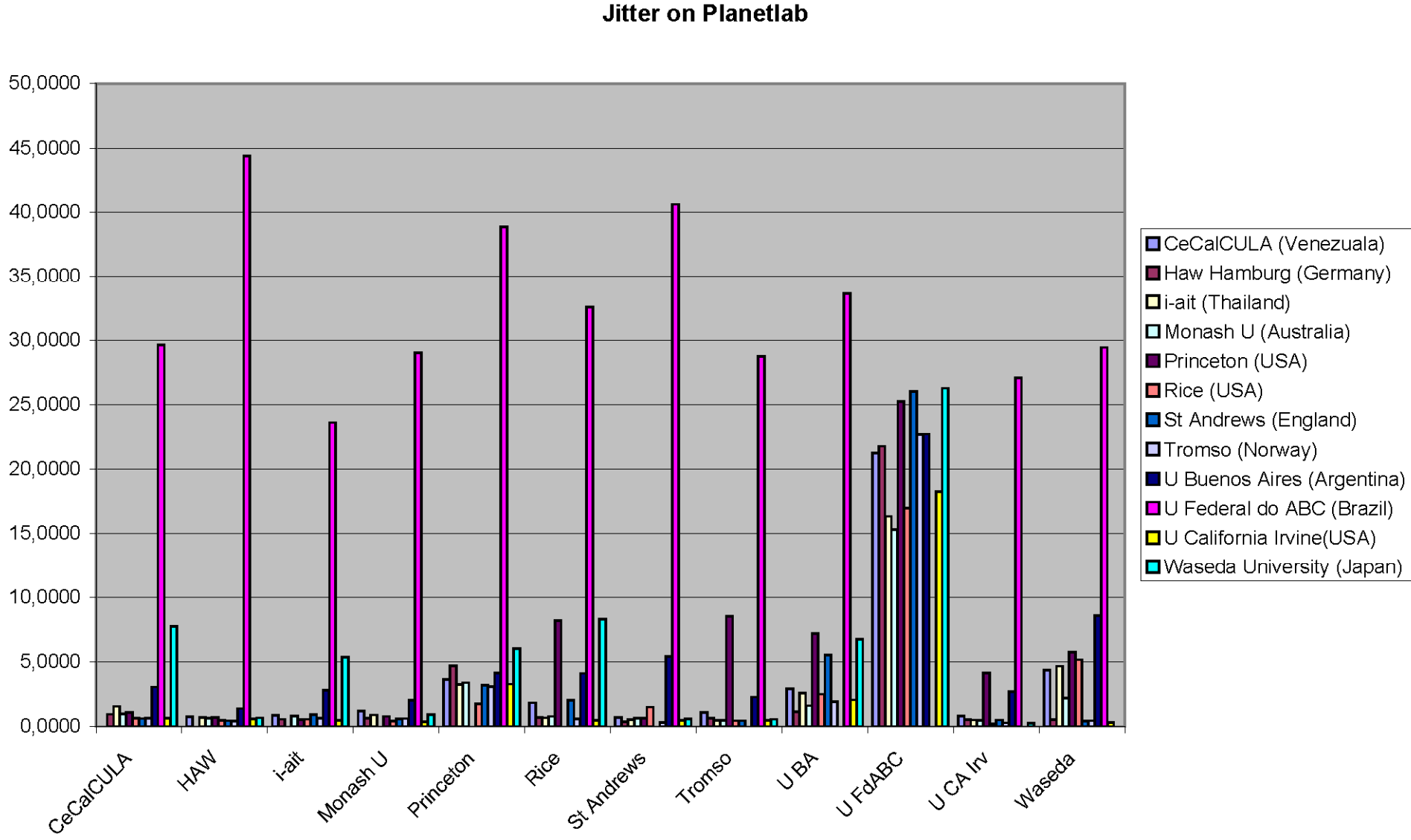


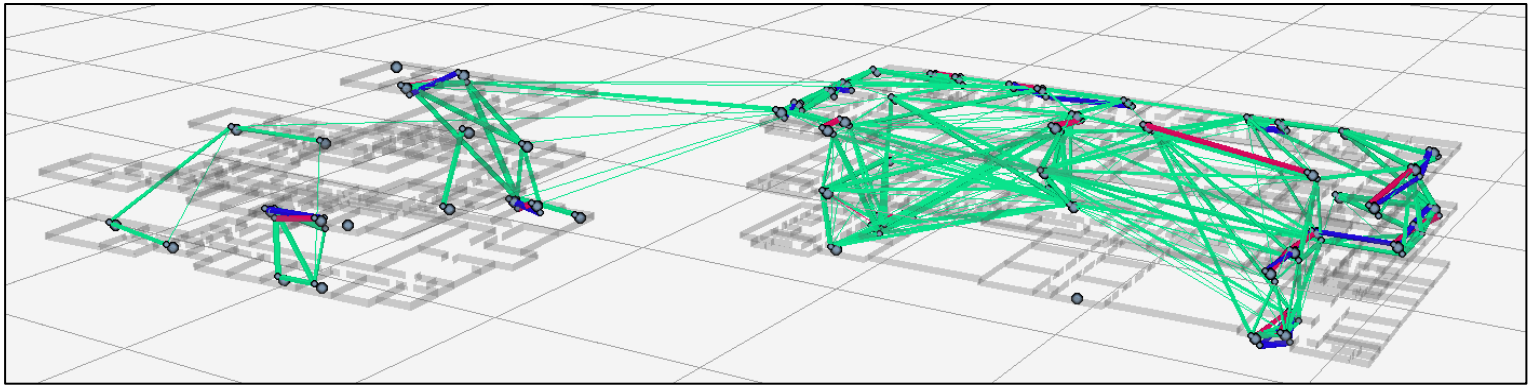
What‘s special ?

- So, G-Lab pretty much looks like our private lab, in fact:
  - All nodes within one AS
  - Machines can be individually reserved
  - Can run private images
- But, G-Lab offers full community control
  - Experiments can be performed under reproducible conditions
  - Easy and more efficient start into more complex global experiments
- Users can extend G-Lab
  - By federations with other testbeds
  - By extending the facility itself
- … and users do!

G-Lab Extensions: Two Examples from Berlin

- Additional site at the Berlin BCIX (Project H∀Mcast)
  - Individual AS-holder & BGP Peer
  - Directly connected to the IXP
  - Allows for BGP experiments
  - Opens the opportunity for controlled ISP/IXP interactions & measurements

- Wireless mesh network at FU Berlin (Project Real-World G-Lab)
  - 120 nodes (indoor and outdoor)



Conclusions & Outlook

- The G-Lab future Internet project is federal & pluralistic
  - … just as we expect a future Internet to be
- The G-Lab experimental facility is different from Plant-Lab
  - More like a large home lab
  - But open to extensions and interesting contributions
  - A powerful pool of resources shared within a group of large enough to be rich of ideas, but small enough to collaborate easily
- Next steps for the H∀Mcast group:
  - Open up the dialog with providers
  - Investigate interaction with ISP and IXP

Thanks!

1st IEEE Workshop on Pervasive Group Communication (IEEE PerGroup)

Miami, FL, USA, December 6, 2010
held in conjunction with IEEE GLOBECOM 2010
and co-sponsored by IEEE HCCTC sub-committee
Submission deadline: 25. June 2010

http://pergroup.realmv6.org