Peer-to-Peer Systems and Applications

Lecture 9: P2P Testbeds, EMANICSLab, and PlanetLab

TECHNISCHE UNIVERSITÄT DARMSTADT

* Original slides for this lecture provided by David Hausheer (TU Darmstadt, Germany), Larry Peterson, Vivek S. Pai et al. (Princeton University) and Timothy Roscoe (Intel Research Berkeley)

0. Lecture Overview

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1. Introduction to PlanetLab
   1. Idea and Concept
   2. Relation to P2P
   3. Services
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   5. PlanetLab @ TUD
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   6. Federation

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1. PlanetLab

Idea, Concept, Relation to P2P,
Services and Tools

*Based partially on original slides by Larry Peterson, Vivek S. Pai et al. (Princeton University) and Timothy Roscoe (Intel Research Berkeley)

1. PlanetLab - What it is

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- Large collection of machines spread around the world for distributed systems research
- Established in 2002 by UC Berkeley, Princeton University, and University of Washington
- Now a consortium of companies and universities
  - E.g. Intel, HP, and Google

1. PlanetLab - Value Proposition

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- Institutions join, provide 2 nodes at minimum
  - Hosted outside the firewall
- In exchange, researchers get a small slice of many machines worldwide
  - High benefit from a small entry fee

1. PlanetLab Today

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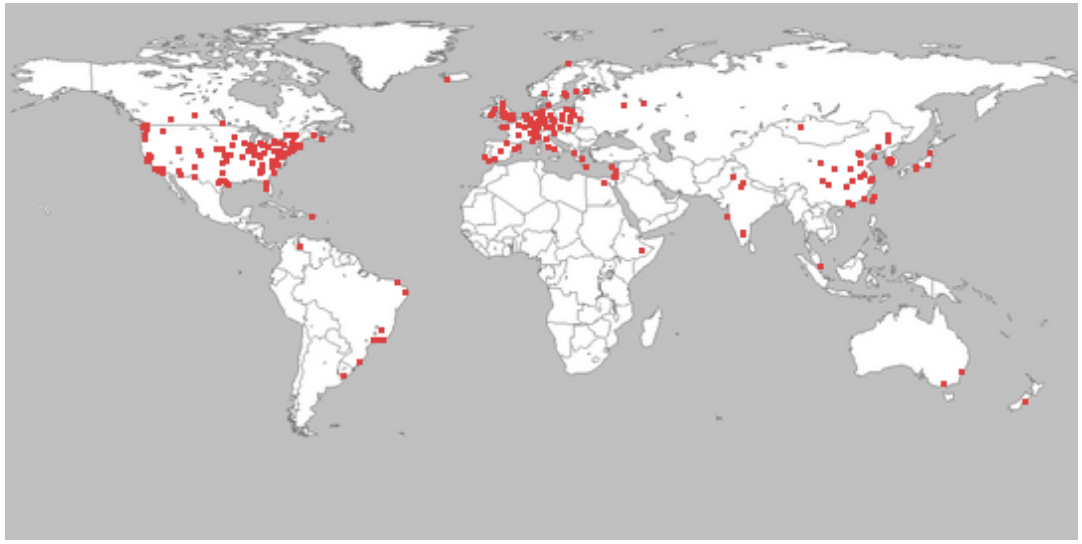

- 1171 nodes spanning 552 sites and over 35 countries
  - Nodes within a LAN-hop of over 3M users
- Supports *distributed virtualization*
  - Each of over 500 network services running in their own *slice*
- Carries real user traffic
  - Generating over 4 TB / contacting over 1M unique IP addresses every day

1.1. PlanetLab Idea

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- New paradigm for network research infrastructure
  - Support experimental validation of new services
    - Simultaneously support real users and clean slate designs
  - Provide plausible deployment path
- Key ideas
  - Virtualization
    - Multiple architectures on a shared infrastructure
  - Programmable
    - Virtually no limit on new designs
  - Opt-in on a per-user / per-application basis
    - Attract real users
    - Demand drives deployment / adoption

1.1. PlanetLab Entities and Roles

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- Sites
- Nodes
- Users
  - Administrator
  - Principal Investigator
  - Technical Contact
  - User
- Slices (and Slivers)

1.1. PlanetLab Concept: Slices

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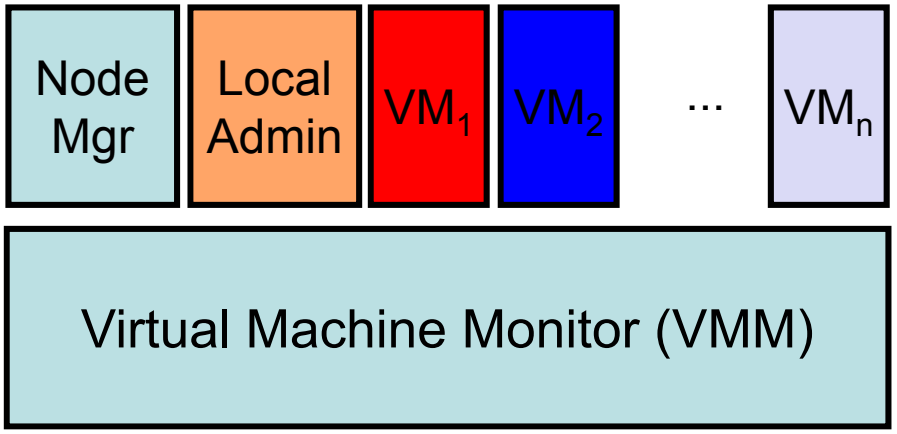
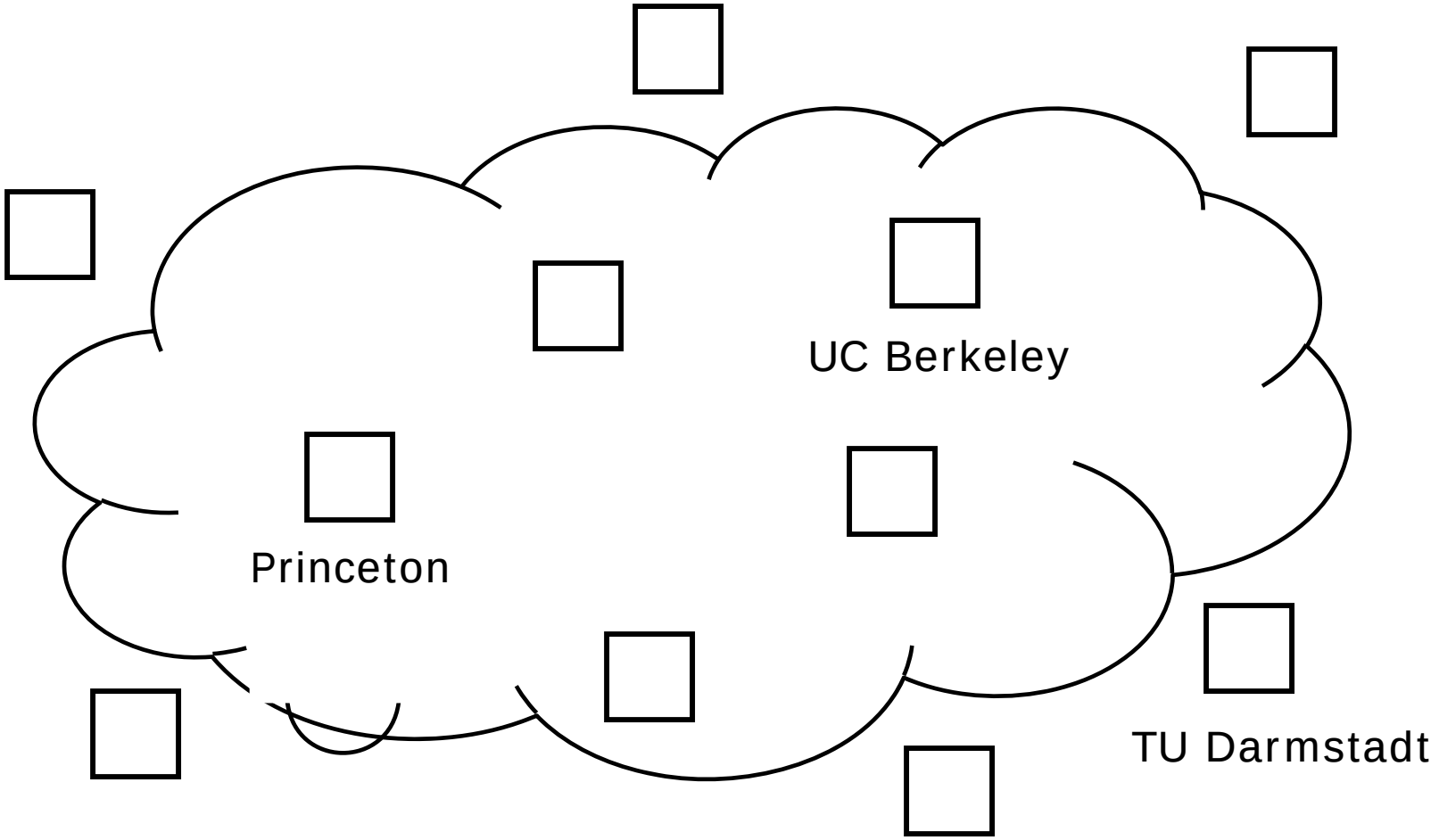
- Services run in *slices*
  - Slice: set of virtual machines (*slivers*)
  - Slivers provide „root access“ to service manager
  - Created by *slices creation service*



- VMM: Virtual Machine Monitor
  - Isolates the virtual machines from each other
  - Currently Linux with vserver extensions
  - Could eventually be Xen

1.1. PlanetLab Concept: Slices



1.1. PlanetLab Service Example 1

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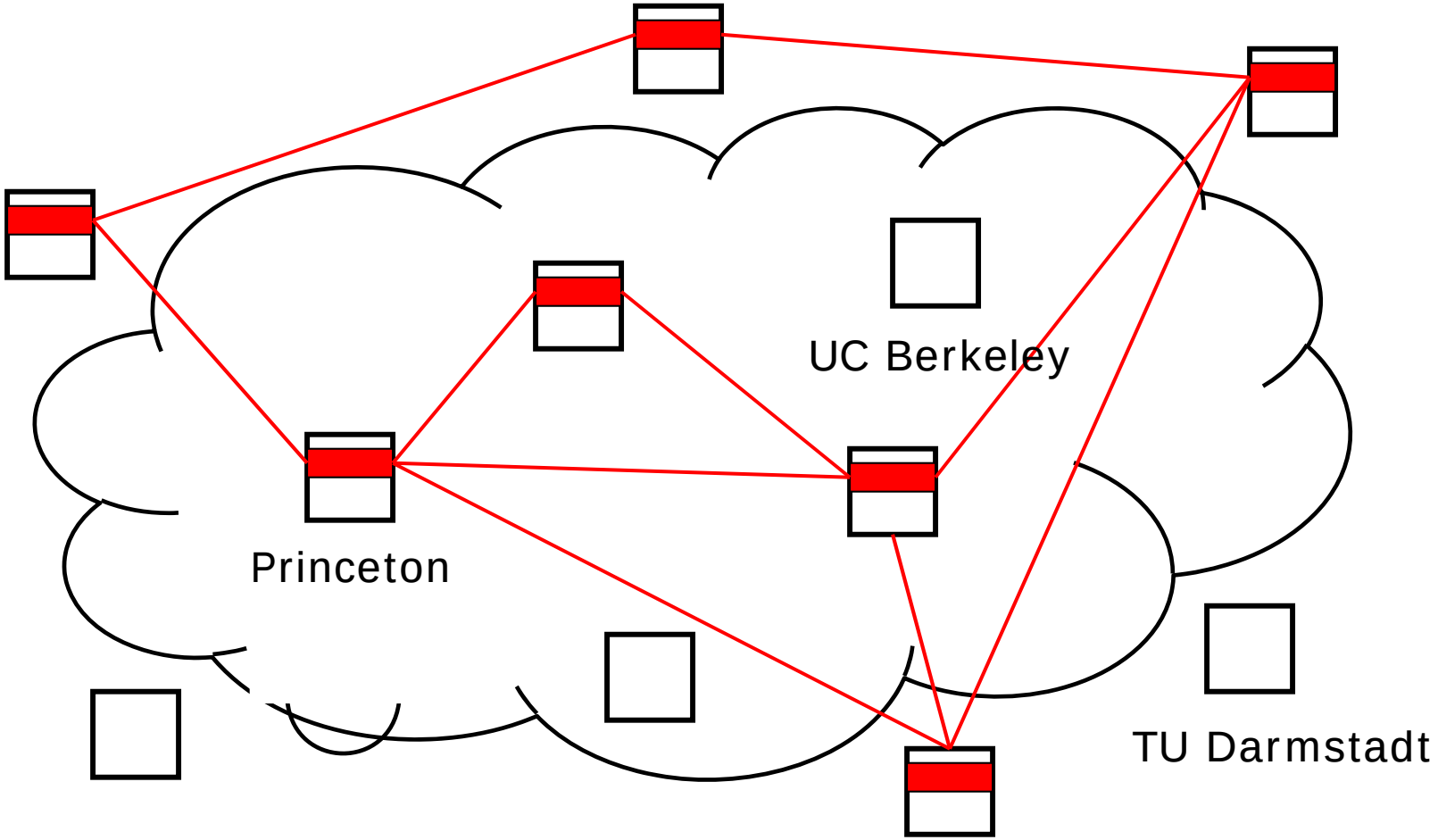

1.1. PlanetLab Service Example 2

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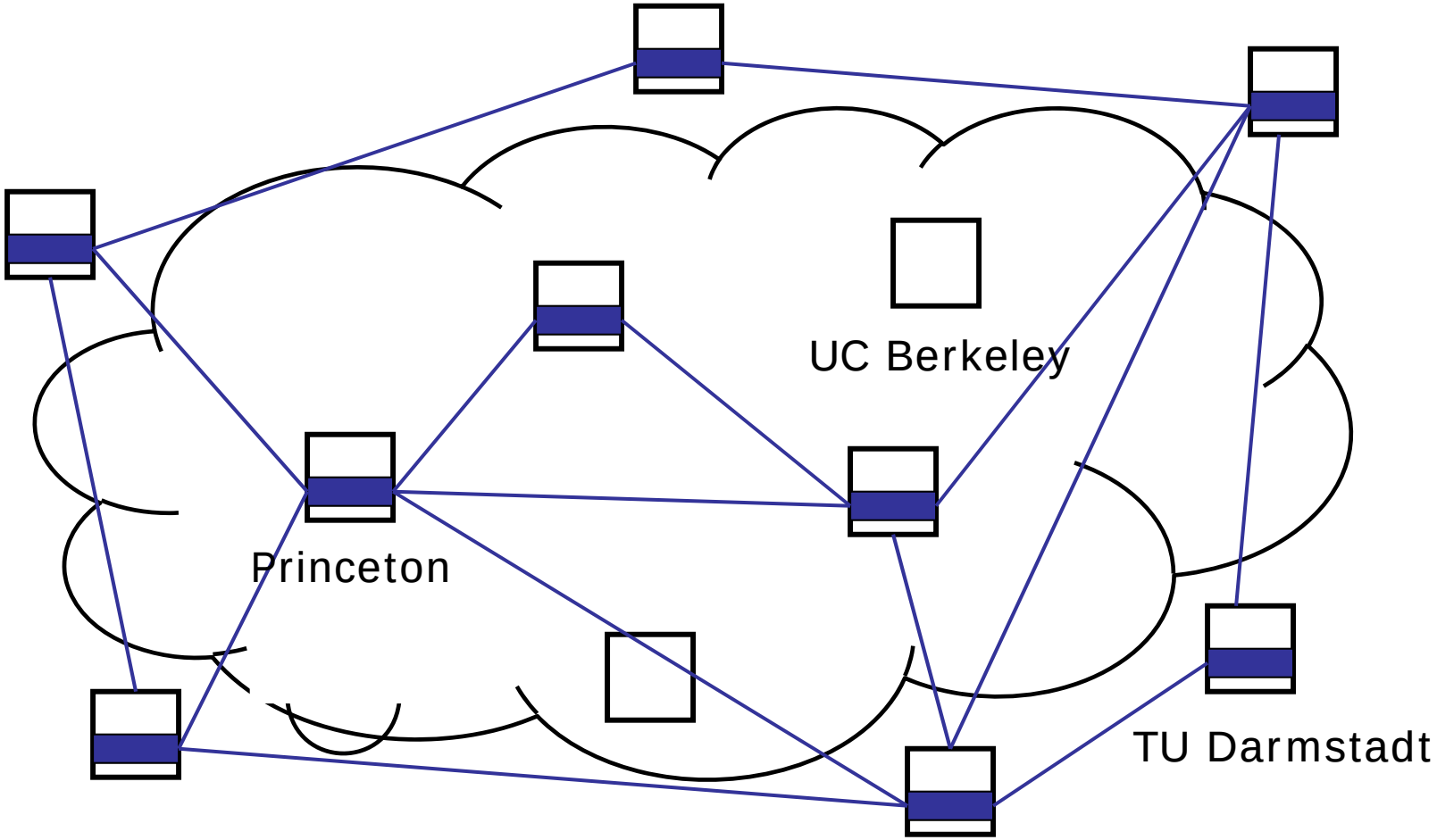

1.1. PlanetLab Concept: User Opt-in

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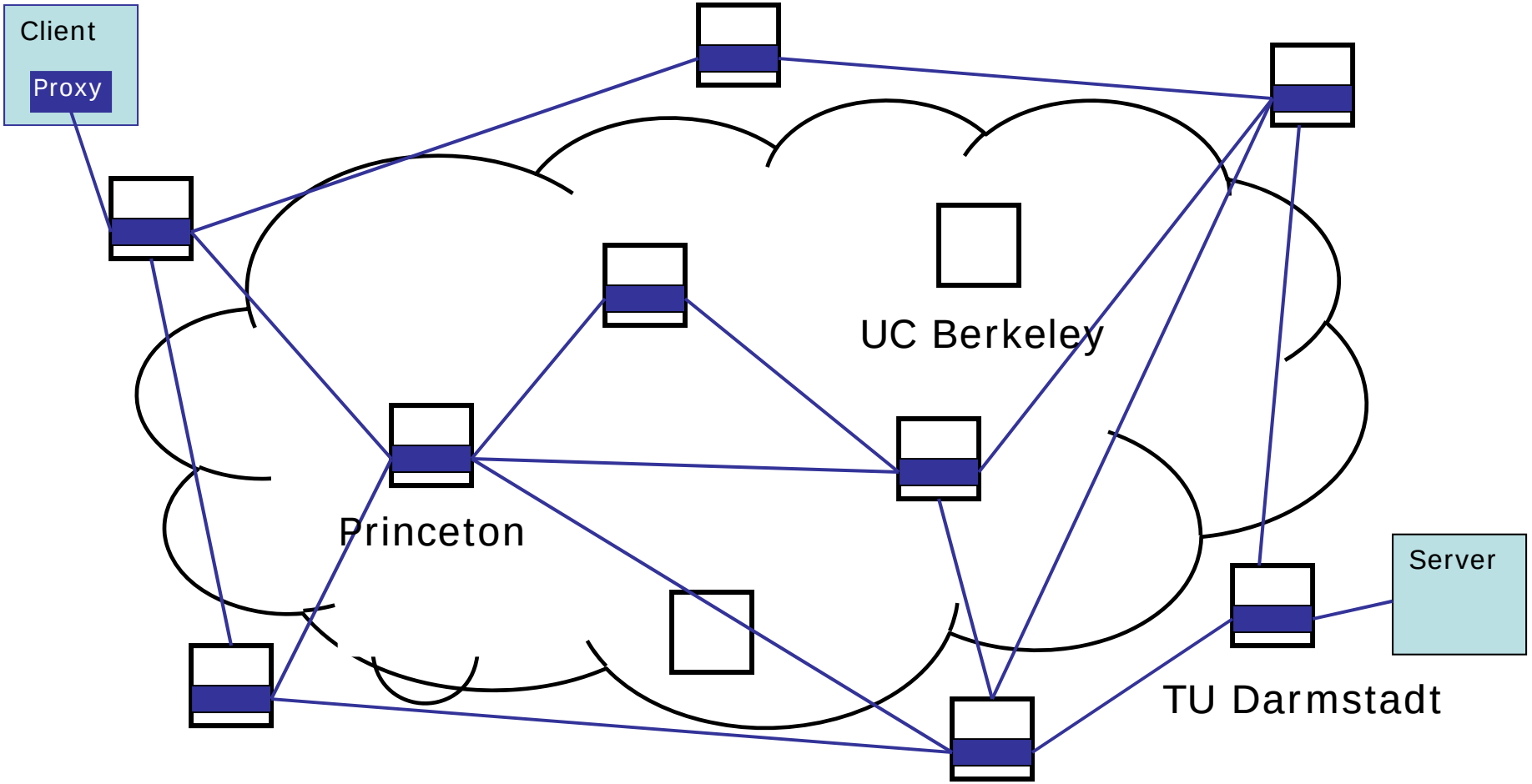

1.1. Permissions of User Roles

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- Administrator
  - Enable, disable sites
- Principal Investigator
  - Enable, disable, and delete user accounts
  - Create / delete slices
  - Assign users to slices
  - Allocate resources to slices
- Technical Contact
  - Add, configure, maintain nodes
- User
  - Add nodes to slices

1.1. PlanetLab Concept: Management

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- PlanetLab Central (PLC)
  - Trusted intermediary between node owners and node users
  - Control of operating systems on nodes
  - Access permissions and resource allocation to services
  - Operated by PlanetLab administrators at Princeton University
  - Accessible via PLC API (XML-RPC) or http://www.planet-lab.org/
- MyPLC
  - A complete PlanetLab Central (PLC) installation
  - Includes the core components of PLC: a web server, an XML-RPC API server, a boot server, and a database server
  - Allows users to deploy their own “private” PlanetLab
  - Next step: Federation of private PlanetLabs

1.2. PlanetLab: What does it have to do with P2P

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- PlanetLab is a hybrid P2P system
  - Nodes are relatively autonomous
  - Local control through admin slice
- PlanetLab enables
  - Deployment of P2P applications at planetary scale
    - Across jurisdictional and administrative boundaries
  - Evaluation of P2P applications in a realistic setting
    - Real latencies between nodes, nodes may be unreliable
    - Nothing works as expected at scale!
- Many P2P applications are tested on PlanetLab
  - E.g. OceanStore, Bamboo, Chord, PeerMart
- PlanetLab Challenge
  - Remove PlanetLab Central entirely

1.3. Services based on PlanetLab

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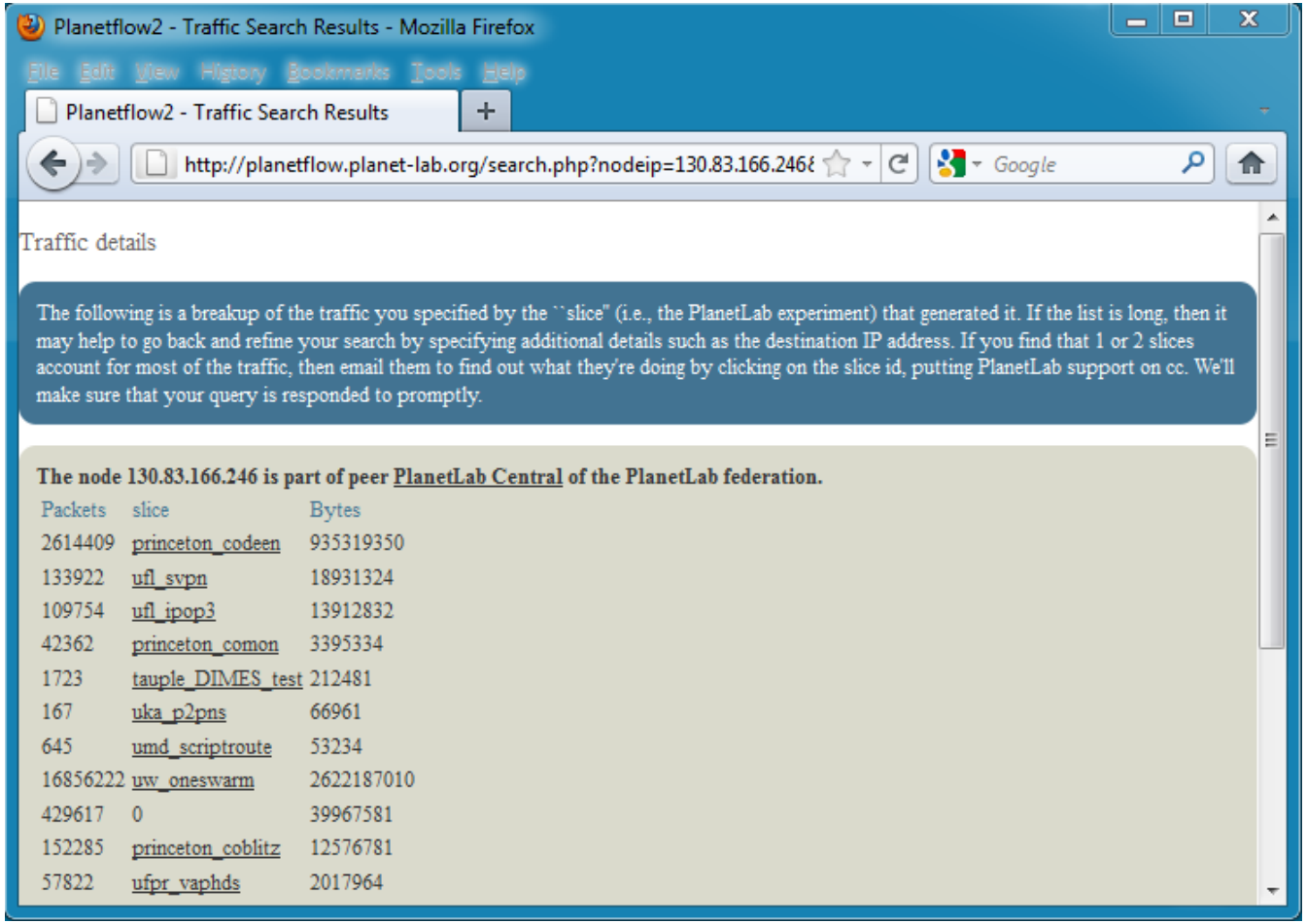

1.3. PlanetLab: Example Service – CoDeeN

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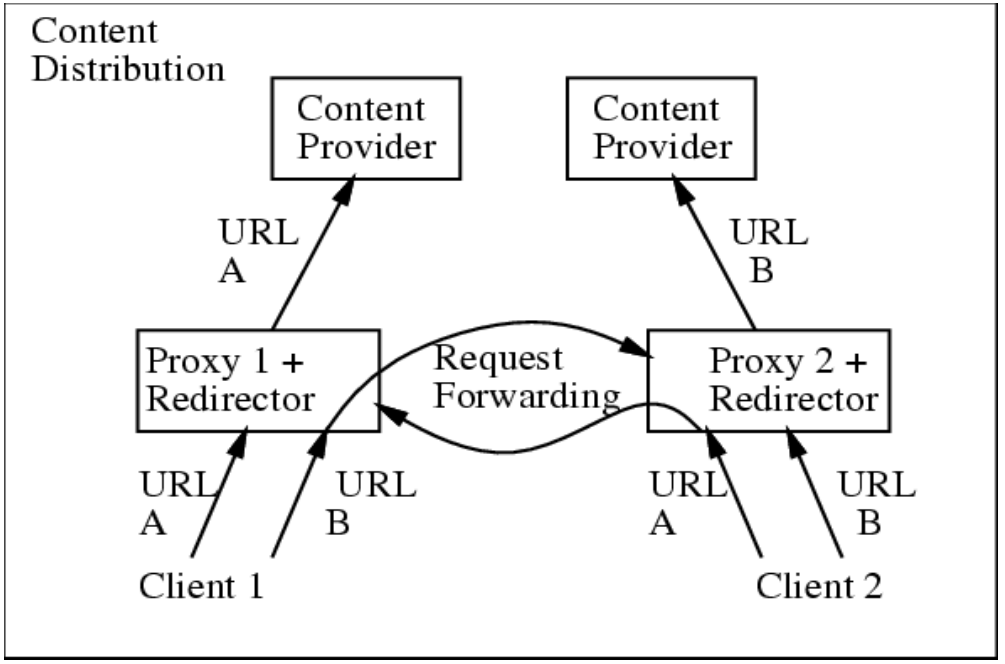
- A Content Distribution Network (CDN)
  - Redirects/caches HTTP requests
- An Open Proxy Network
  - Probably the largest in existence
- How Does It Work?
  - Clients specify proxy to use
  - Cache hits served locally
  - Cache misses forwarded to CoDeeN nodes
    - Maybe forwarded to origin servers



1.3. CoDeeN: Malicious Traffic

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- Spammers
  - SMTP tunnels, POST forms, IRC channels
- Bandwidth hogs
  - Google crawls, steganographers, X-Pacific
- Hackers & Spreaders
  - Yahoo dictionary attacks, IIS vuln tests
- Content thieves
  - E-journals/databases, local content

Restrict ports & HTTP methods

Multi-scale req & bw accounting

Signature database & Robot test

Determine location & privilege

1.4. PlanetLab Tools

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- Pssh: Parallel ssh
  - Provides the parallel versions of the *openssh* tools
  - Can be used to control large collections of nodes in a network
  - http://www.theether.org/pssh/
- PLDeploy: PlanetLab Slice Deploy Toolkit
  - A set of Perl scripts to help users manage their slices
  - Allocating a sliver, pushing code to multiple slivers and pulling results back
  - http://psepr.org/tools/
- Many more: Plush, PIMan, vxargs, ...
- https://www.planet-lab.org/tools

1.5. PlanetLab @ TUD

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- TUD is a member of PlanetLab
- Currently, TUD hosts 3 PlanetLab nodes:
  - host1.planetlab.informatik.tu-darmstadt.de
  - host2.planetlab.informatik.tu-darmstadt.de
  - host3.planetlab.informatik.tu-darmstadt.de
- TUD staff members and students are eligible for a PlanetLab account.
- In order to apply for an account, you have to register:
  - https://www.planet-lab.eu/db/persons/register.php
    - Select site “Technische Universität Darmstadt”

Changed!

- Contact Principal Investigator (PI) to get a slice
  - Robert Rehner <rehner@dvs.tu-darmstadt.de>

1.6. References

- L. Peterson, T. Anderson, D. Culler, and T. Roscoe: *A Blueprint for Introducing Disruptive Technology into the Internet*; First ACM Workshop on Hot Topics in Networking (HotNets), October 2002.
- A. Bavier, M. Bowman, B. Chun, et al.: *Operating System Support for Planetary-Scale Services*; First Symposium on Network Systems Design and Implementation (NSDI), March 2004.
- L. Peterson, A. Bavier, M. Fiuczynski, and S. Muir: *Experiences Building PlanetLab*; Seventh Symposium on Operating System Design and Implementation (OSDI), November 2006.
- http://www.planet-lab.org/

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2. EmanicsLab

Overview, Monitoring, Management,
Future Extensions

2. Drawbacks of PlanetLab

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- PlanetLab configuration and control is done centrally by PlanetLab administrators
  - Users needs cannot always be accommodated
  - Could be a problem if strong trust relationships and access protection mechanisms are required
    - E.g., for trace repositories
- Resources in PlanetLab are limited
  - Standard disk quota only 5GB per user on each node
  - Distributed flow collection requires much more storage
  - A load average of 7 is not uncommon on PlanetLab nodes

2. EmanicsLab

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- European research network initiated in 2007
- Funded from 2007-2009 by the EU NoE EMANICS
- Based on myPLC - backend management infrastructure of PlanetLab
- Maintained by the Communication Systems Group (CSG) at the University of Zurich (UZH).

- Since 2010 governed by the EmanicsLab Steering Committee
- EmanicsLab currently consists of 22 nodes at 11 sites across Europe
- EmanicsLab partners use the network for research activities in the area of network and service management, including
  - Distributed flow collection and analysis systems
  - Distributed intrusion detection systems
  - Distributed monitoring and accounting systems

2.1. Benefits of EmanicsLab

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- EmanicsLab is dedicated to its members
  - Enables the flexible allocation of resources to research activities
  - Ensures that the control of the testbed stays within the EmanicsLab consortium
  - Access to the testbed can be restricted if necessary
  - Extensions or changes to the testbed can be done
    - E.g., use of a different virtualization platform
  - Specific services supporting research on network and service management can be provided
    - E.g., distributed trace repositories

2.1. EmanicsLab Sites

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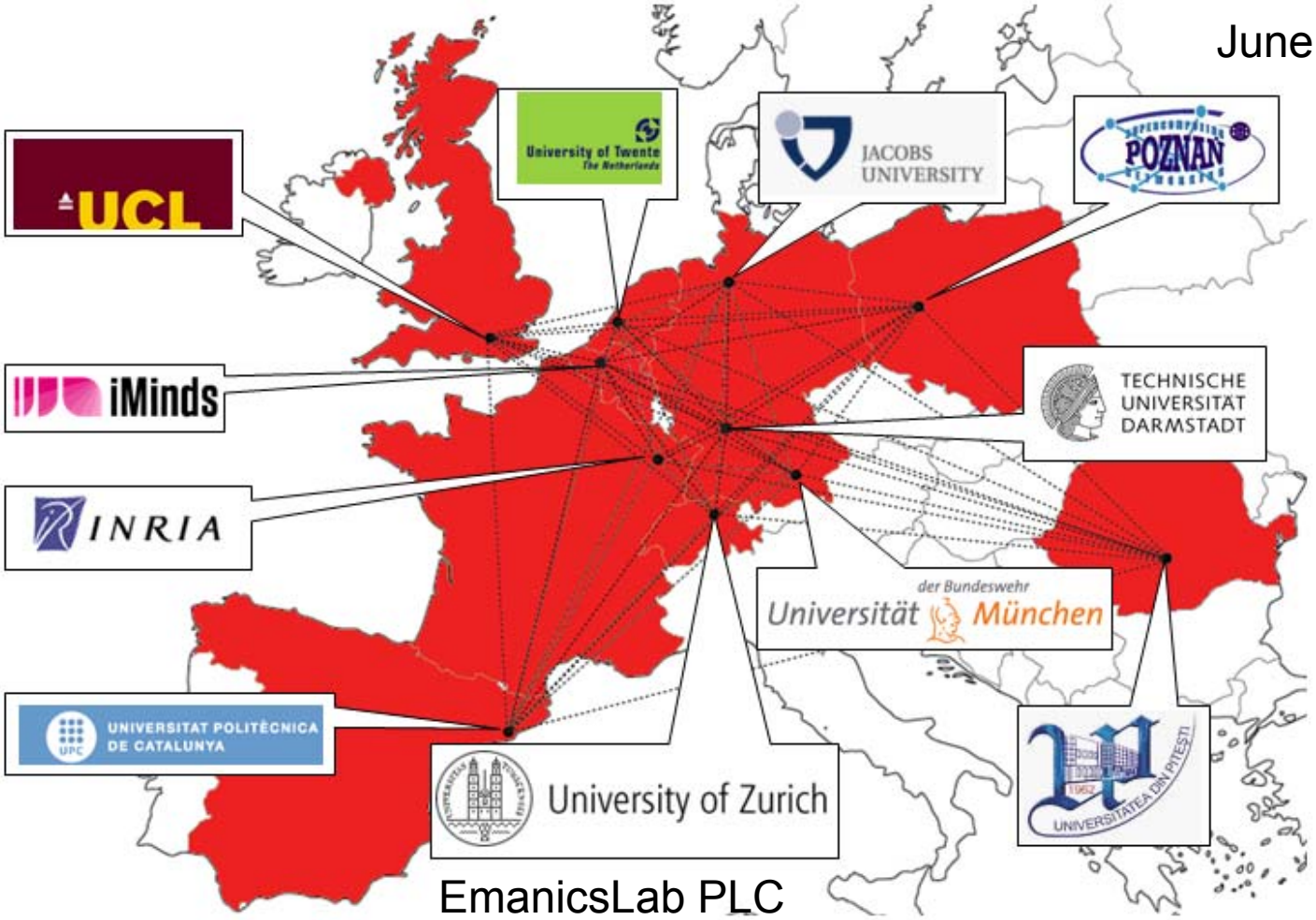
Total:
- 11 sites
- 22 nodes
- 75 users
- 10 slices



2.1. EmanicsLab Administrator

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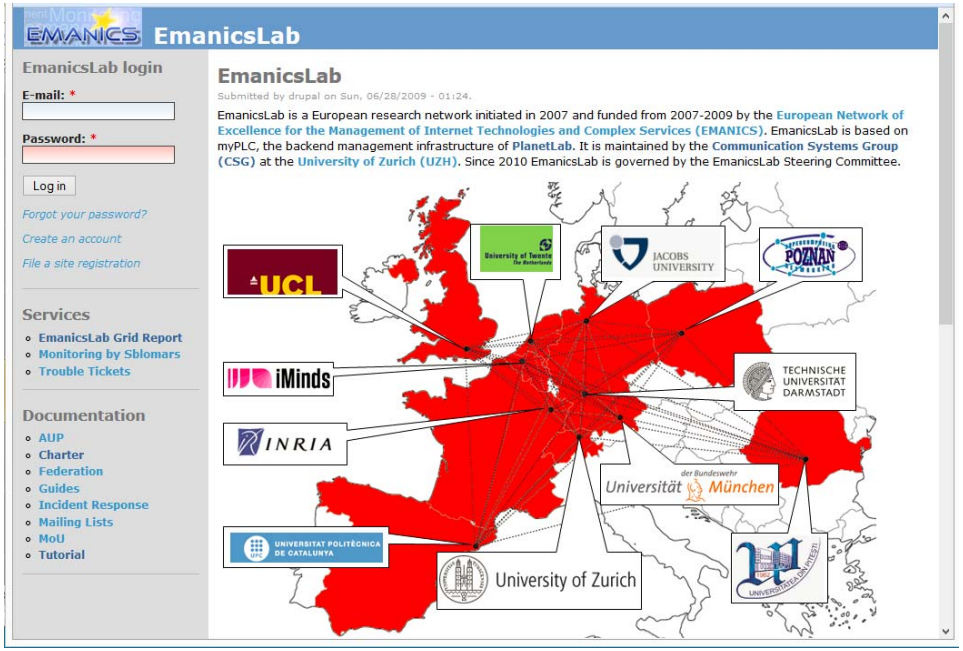
- Trusted institution running myPLC for EmanicsLab
- Primary contact for any technical and administrative questions
- Responsible for the execution of peerings with other organizations such as PlanetLab Europe

- Currently: UZH/
  David Hausheer

- EmanicsLab's administrators can be contacted at
  emanicslab@ifi.uzh.ch



2.1. Acceptable Use Policy

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- Usage of the EmanicsLab infrastructure is regulated by an acceptable use policy
- EmanicsLab - due to its federation with PlanetLab Europe (PLE) - is a part of the overall world-wide PlanetLab infrastructure
- This implies that all EmanicsLab sites have to be members of either PLE or PlanetLab Central (PLC) and as a result are bound by a PlanetLab acceptable use policy (AUP)
- For the latest PlanetLab acceptable use policy (AUP), please visit: http://www.planet-lab.eu/doc/aup
- Read the AUP carefully, before running an experiment on any EmanicsLab or PlanetLab nodes.
- To report a suspected violation of this policy, contact EmanicsLab Support (emanicslab@ifi.uzh.ch).

2.1. Federation with PlanetLab Europe (PLE)

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- Since March 2011 EmanicsLab federates with PlanetLab Europe (PLE)
  - PlanetLab Europe is the European branch of the global PlanetLab system
  - Federation goverend by a Memorandum of Understanding (MoU)
    cf. https://www.emanicslab.org/?q=node/11
- EmanicsLab users can access hundreds of PLE nodes and vice-versa
- Central management of EmanicsLab nodes remains under control of EmanicsLab administrator
- Federation achieved using Slice-based Federation Architecture (SFA)
- For further information see
  http://onelab.eu/index.php/services/testbed-federation.html
- Description of the EmanicsLab use case:
  http://onelab.eu/index.php/services/
  testbed-federation/use-cases/485-emanicslab.html

2.1. Mailing Lists

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- All EmanicsLab users are required to subscribe to the EmanicsLab mailing list: https://lists.ifi.uzh.ch/listinfo/emanicslab
- The mailing list is used for announcements such as node down times
- EmanicsLab's administrators can be contacted at emanicslab@ifi.uzh.ch

2.1. EmanicsLab Nodes (1)

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Site	Hostname	RAM	HDD	CPU
UZH	emanicslab1.csg.uzh.ch emanicslab2.csg.uzh.ch	3 GB 3 GB	500 GB 120 GB	Pentium 4, 3.6 GHz Pentium 4, 3.6 GHz
JUB	emanicslab1.eecs.jacobs-university.de emanicslab2.eecs.jacobs-university.de	1 GB 1 GB	80 GB 500 GB	Pentium D, 2.8 GHz Pentium D, 2.8 GHz
TUD	emanicslab1.ps.tu-darmstadt.de emanicslab2.ps.tu-darmstadt.de	4 GB 4 GB	750 GB 1000 GB	Dual Core Xeon, 1.6 GHz Dual Core Xeon, 2 GHz
UniBW	emanicslab1.informatik.unibw-muenchen.de emanicslab2.informatik.unibw-muenchen.de	2 GB 2 GB	150 GB 150 GB	Dual Core Xeon, 3.0 GHz Dual Core Xeon, 3.0 GHz
UPC	moscu.upc.es muro.upc.es	4 GB 1 GB	500 GB 250 GB	Dual Core i5, 3.2 GHz Core 2, 2.13 GHz
INRIA	host1-plb.loria.fr host2-plb.loria.fr	2 GB 4 GB	160 GB 750 GB	Pentium 4, 3.0 GHz Core 2, 2.93 GHz

2.1. EmanicsLab Nodes (2)

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Site	Hostname	RAM	HDD	CPU
UT	emanicslab1.ewi.utwente.nl emanicslab2.ewi.utwente.nl	4 GB 4 GB	2000 GB 2000 GB	Xeon, 2.66 GHz Xeon, 2.66 GHz
IBBT	planck232ple.test.iminds.be planck233ple.test.iminds.be	12 GB 12 GB	1000 GB 1000 GB	Dual Core Xeon, 2.4 GHz Dual Core Xeon, 2.4 GHz
PSNC	emanicslab1.man.poznan.pl emanicslab2.man.poznan.pl	1 GB 1 GB	500 GB 500 GB	Xeon, 2.66 GHz Xeon, 2.66 GHz
UCL	emanics1.ee.ucl.ac.uk emanics2.ee.ucl.ac.uk	4 GB 4 GB	750 GB 750 GB	Dual Core 2, 2.5 GHz Dual Core 2, 2.5 GHz
UPI	emanicslab1.upit.ro emanicslab2.upit.ro	3 GB 4 GB		
Total		**80 GB**	**13.4 TB**	

2.1. EmanicsLab Slices

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Sites	Principal Investigator	Slices	Users
TUD	David Hausheer	tud_fkaup tud_btlive	Fabian Kaup, Florian Jomrich, Matthias Wichtlhuber, Björn Scheurich Tamara Knierim
JUB	Juergen Schoenwaelder	iub_discaria iub_tcpprobe	Ha Manh Tran Jürgen Schönwälder
UPC	Jose Antonio Astorga Rivera	upc_sblomars	Josep M Tomas
UZH	Guilherme Sperb Machado	uzh_btcollector	Andri Lareida
PSNC	Szymon Trocha	psnc_flow3	Robert Szuman, Szymon Trocha
UT	Ramin Sadre	ut_snid_ut	Ramin Sadre, Anna Sperotto
ELC	David Hausheer	pl_elabmoni	Andrei Vancea, Cristian Morariu

2.2. EmanicsLab Monitoring: Ganglia

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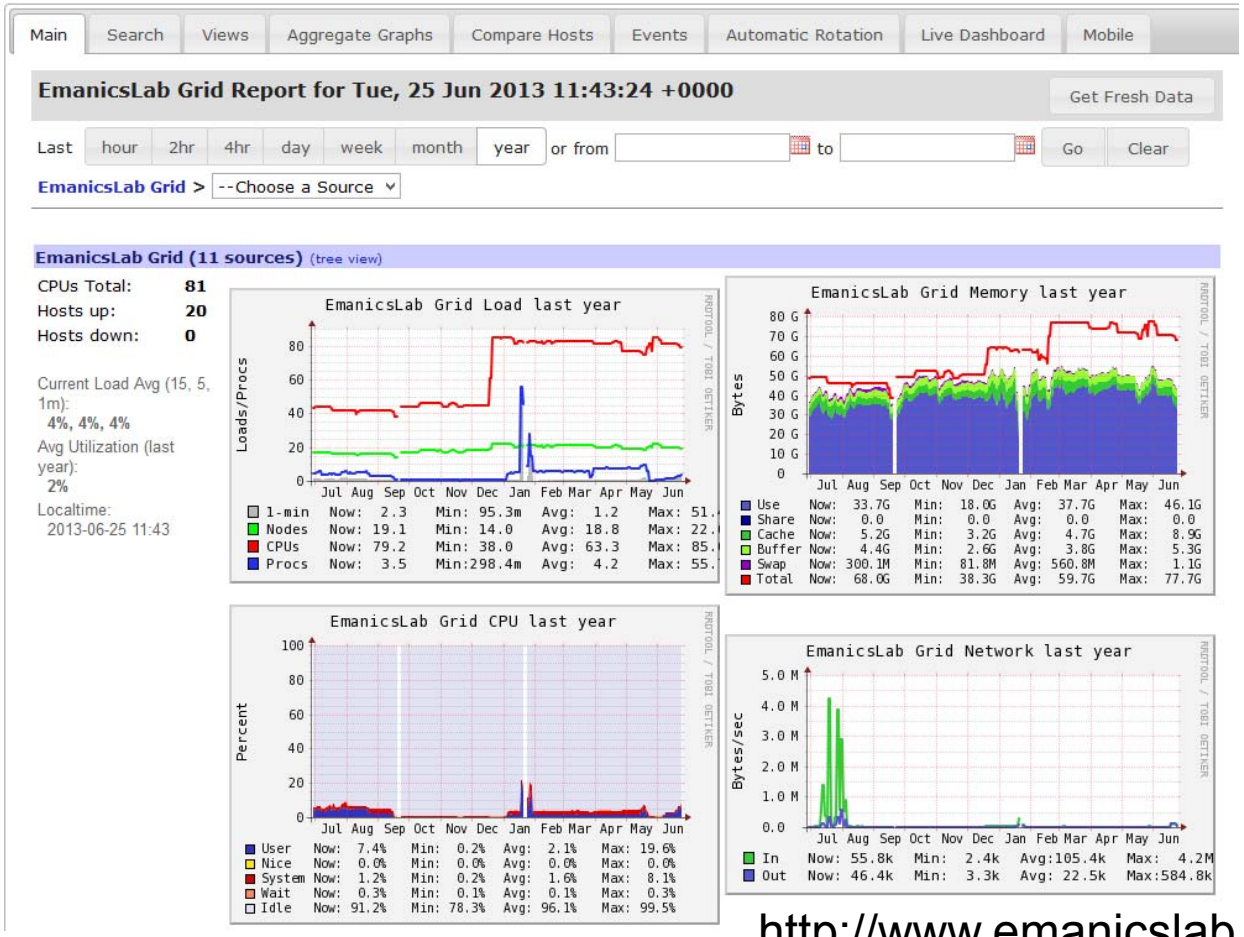
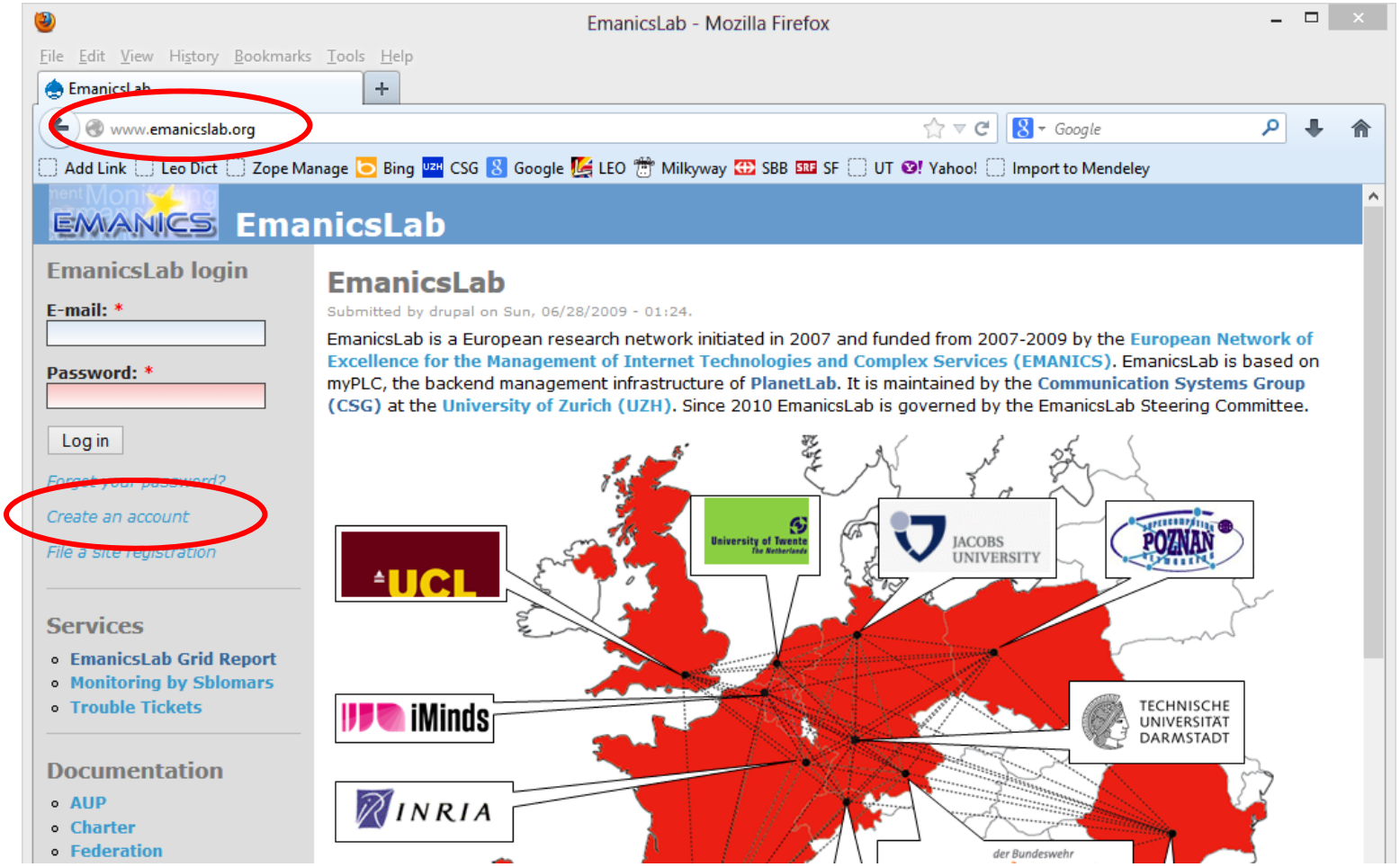


http://www.emanicslab.org/ganglia/

2.3. Account Creation



2.3. Registration

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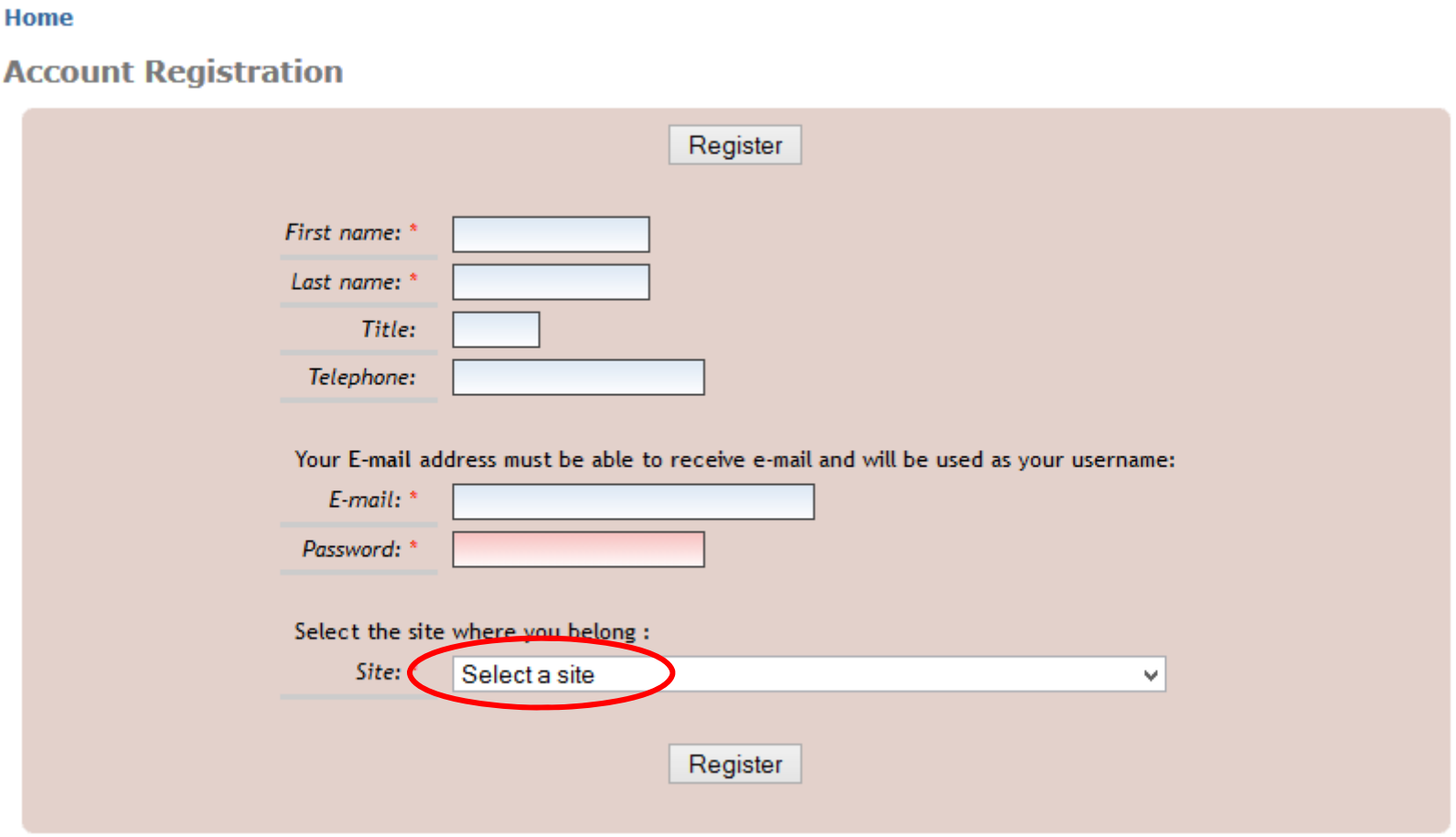
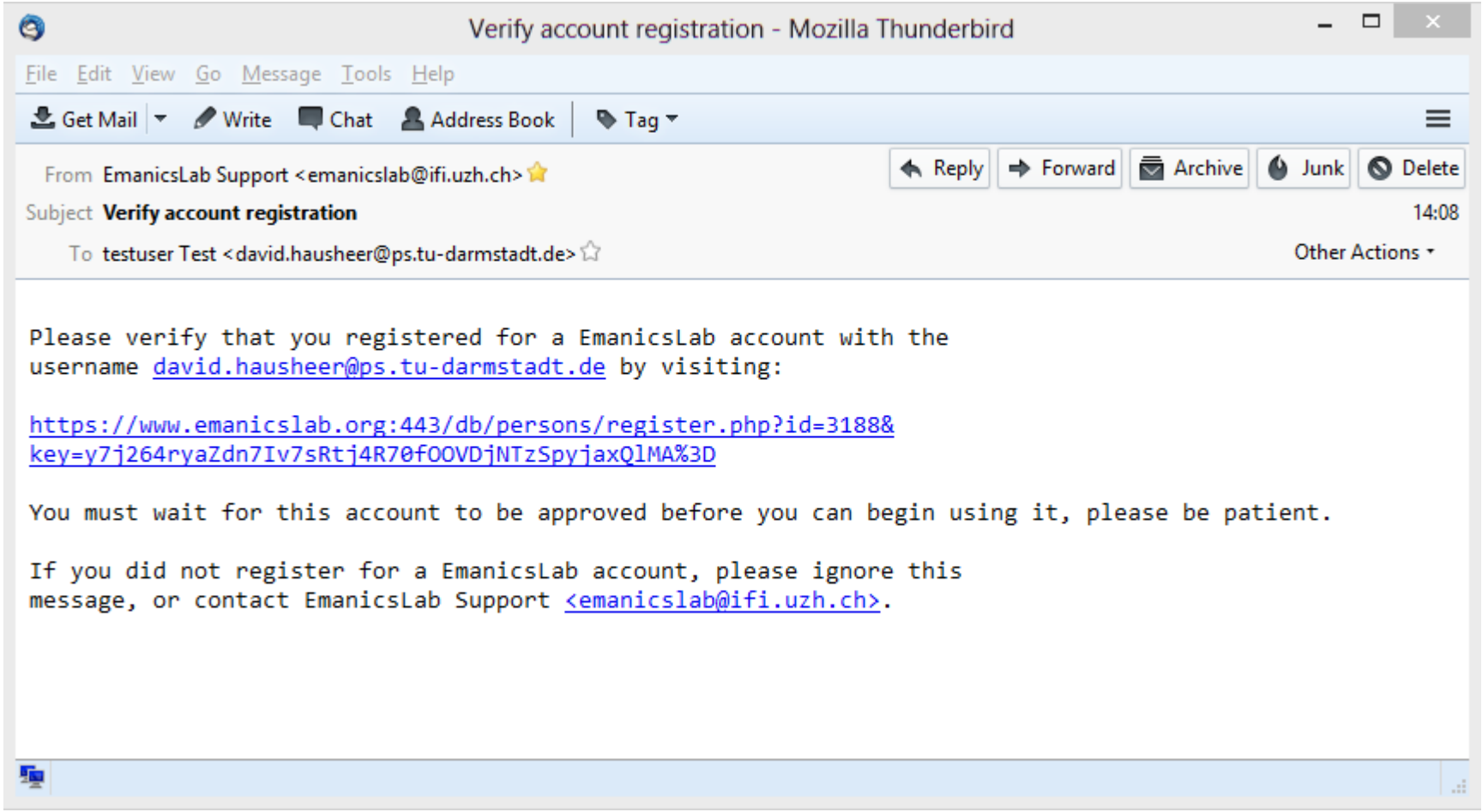


2.3. Verify Account (User)



2.3. Confirmation (User)

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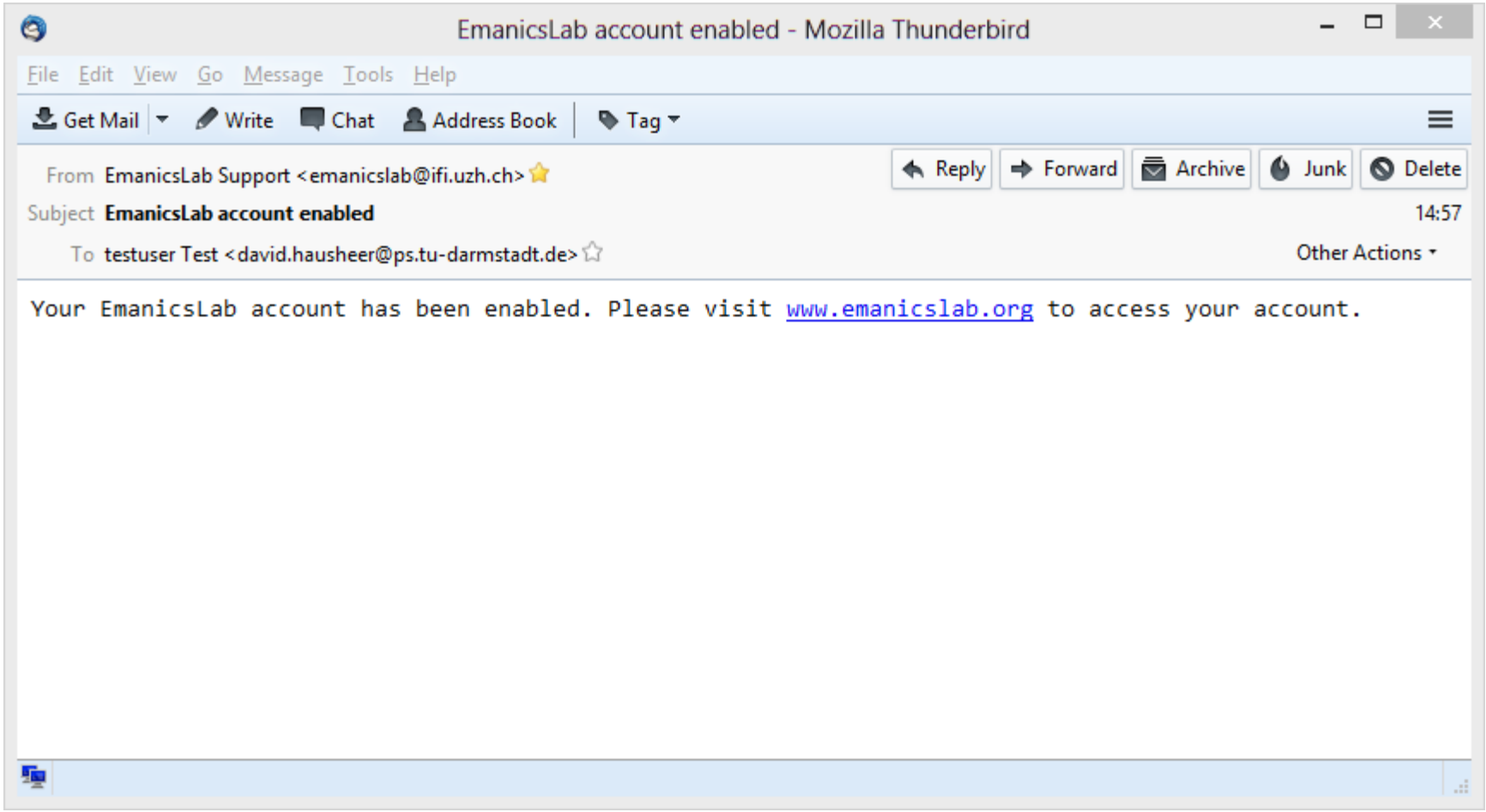

2.3. Login

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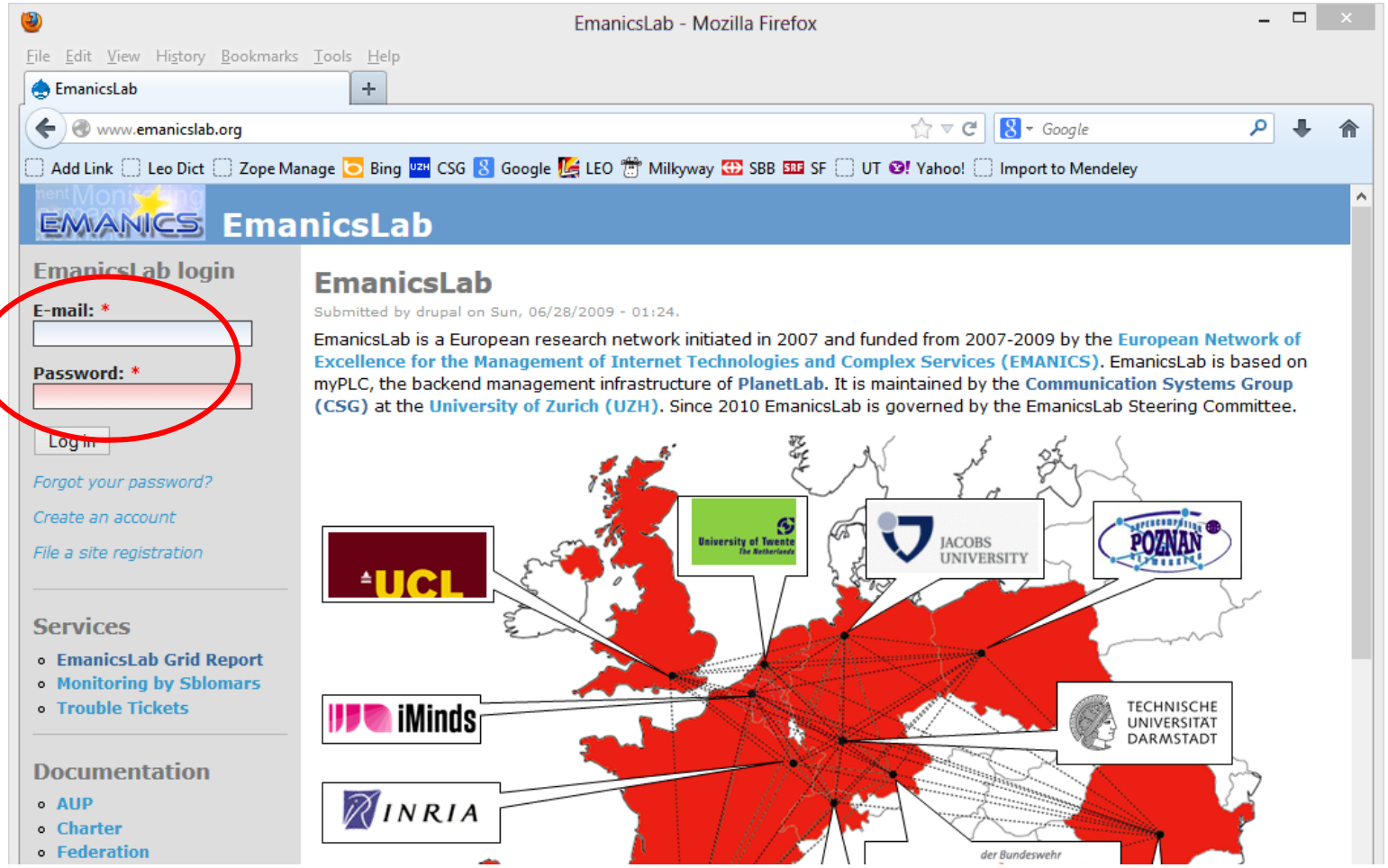

2.3. EmanicsLab Web Interface

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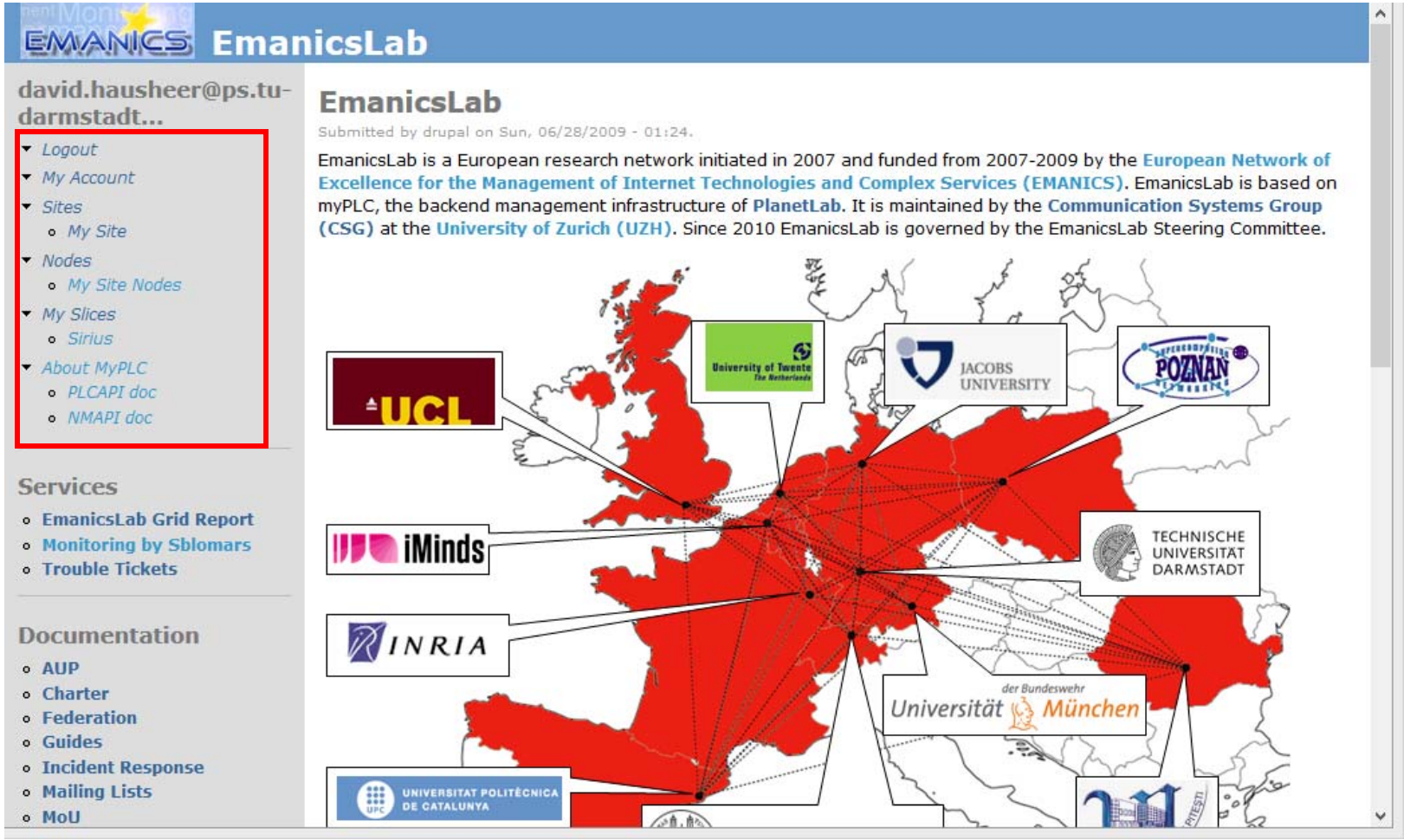

2.3. Generate Key

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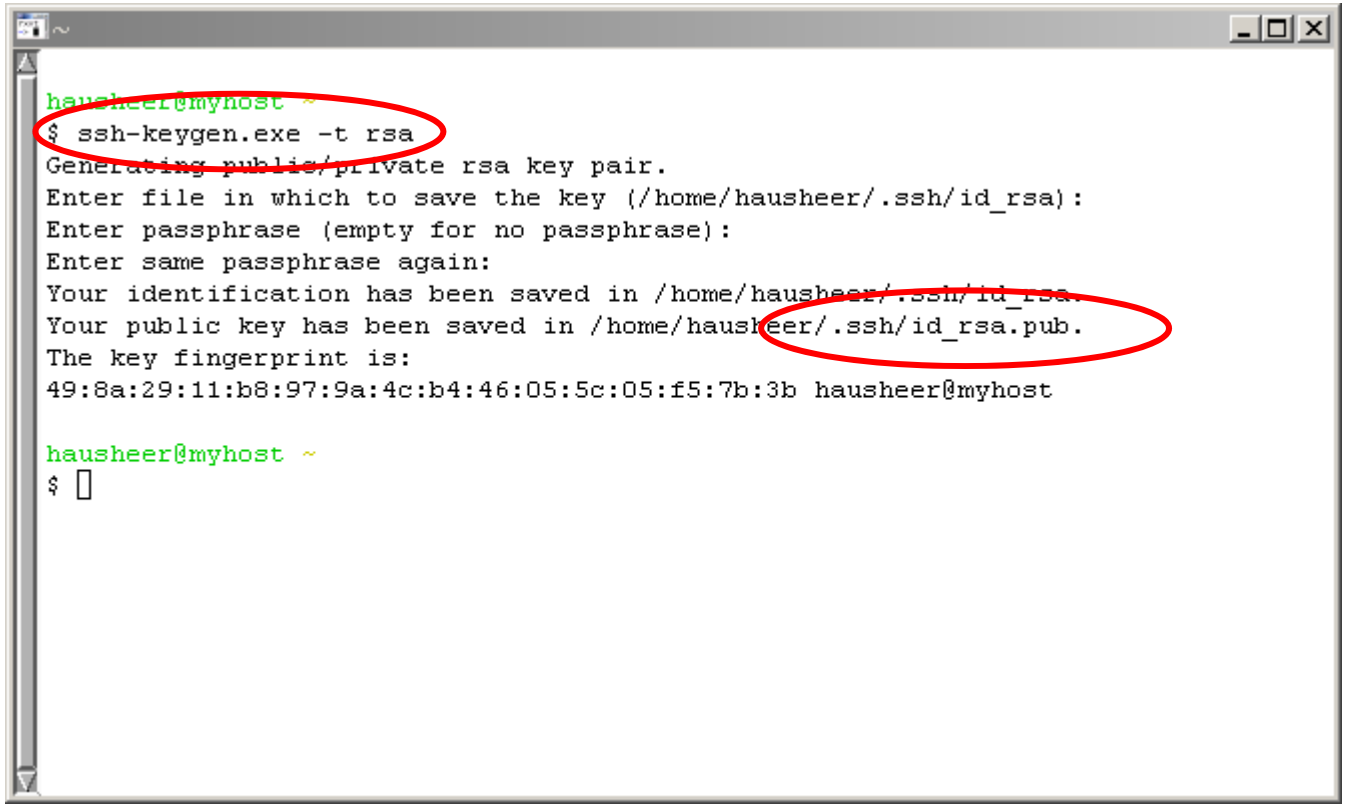

2.3. Manage Keys

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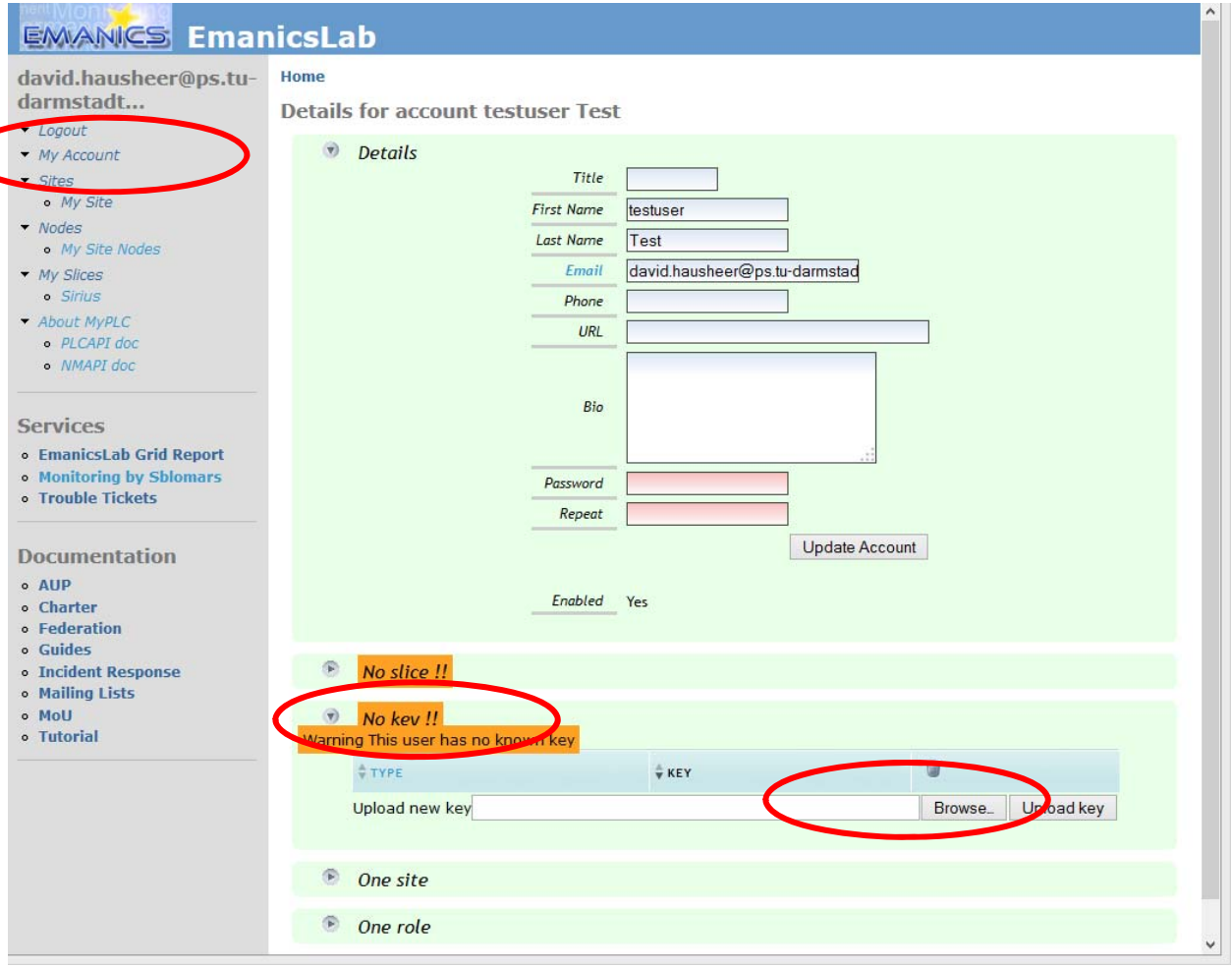

2.3. Slice Profile (User)

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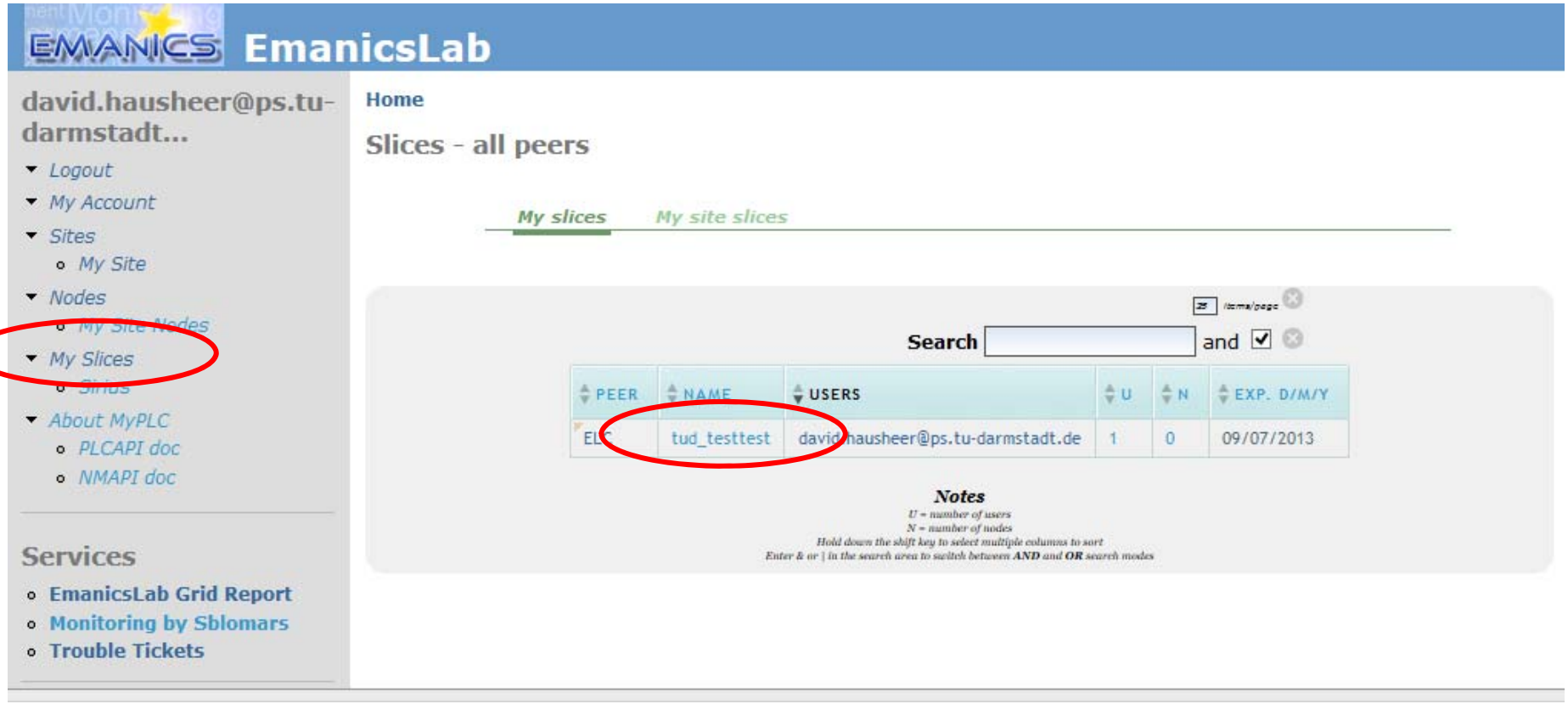
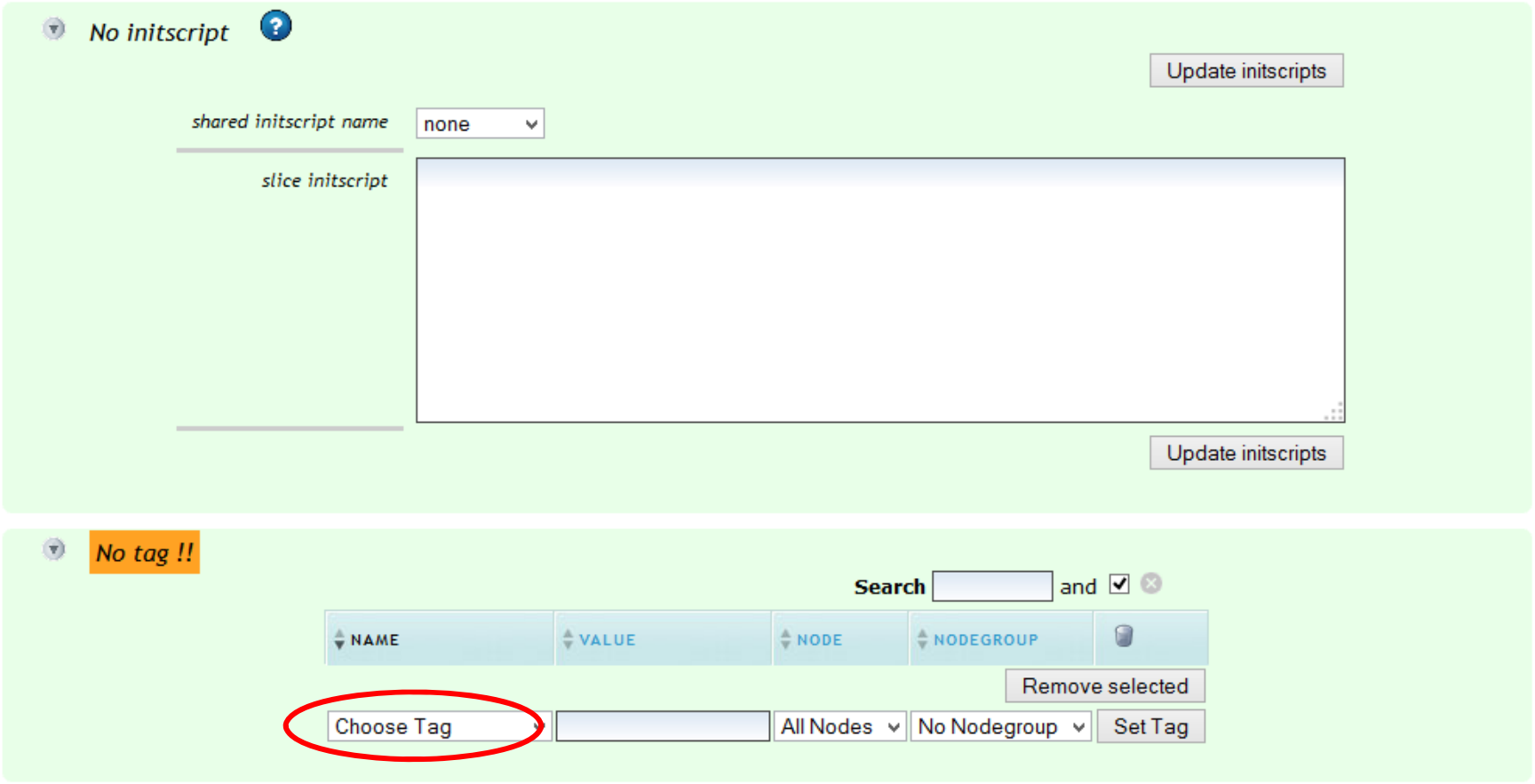


2.3. Add Nodes to a Slice (User)

2.3. Add Attributes (User)



2.3. Renew Slice (User)

2.3. Login to a Node (User)

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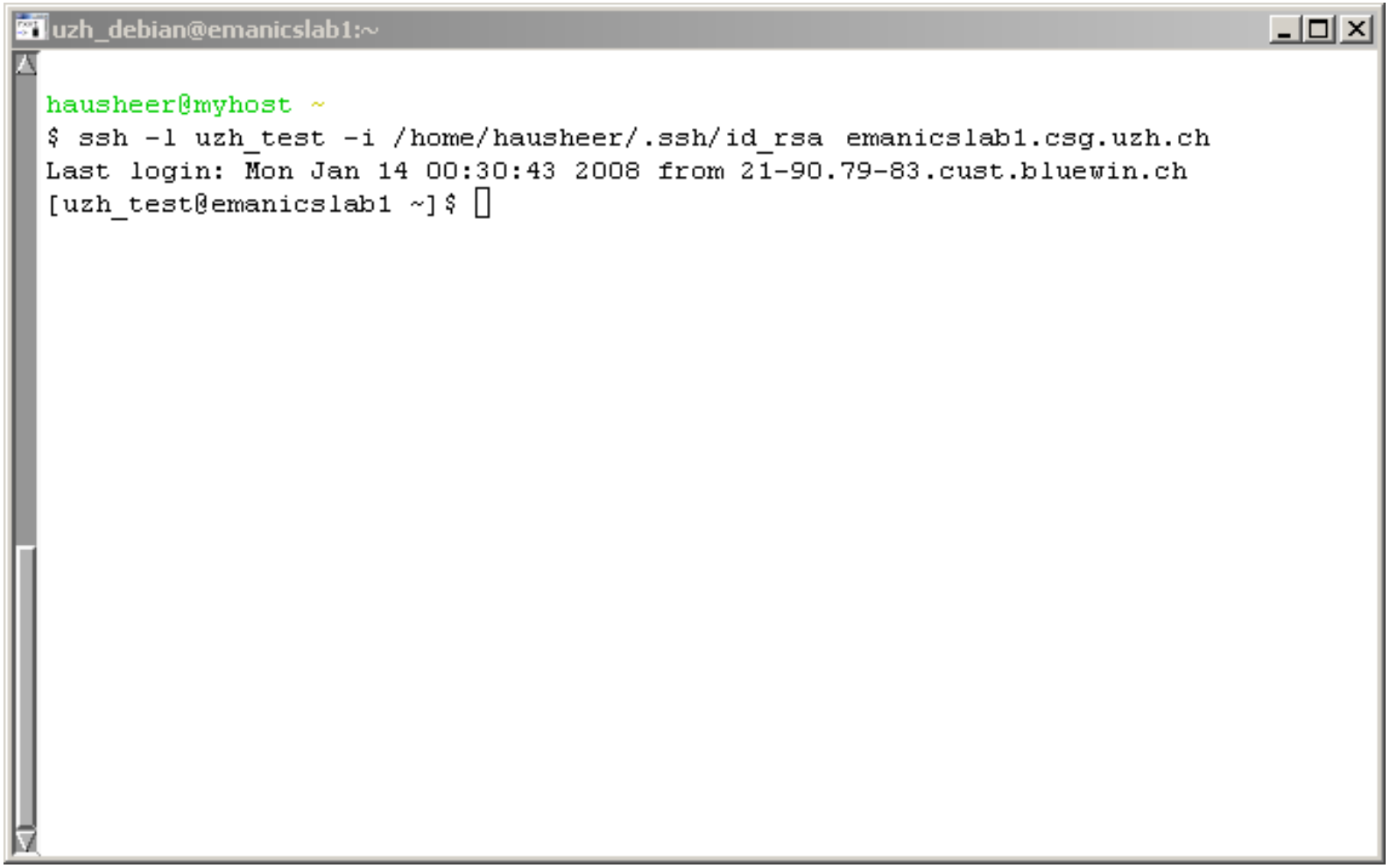

2.3. Install Software (User)

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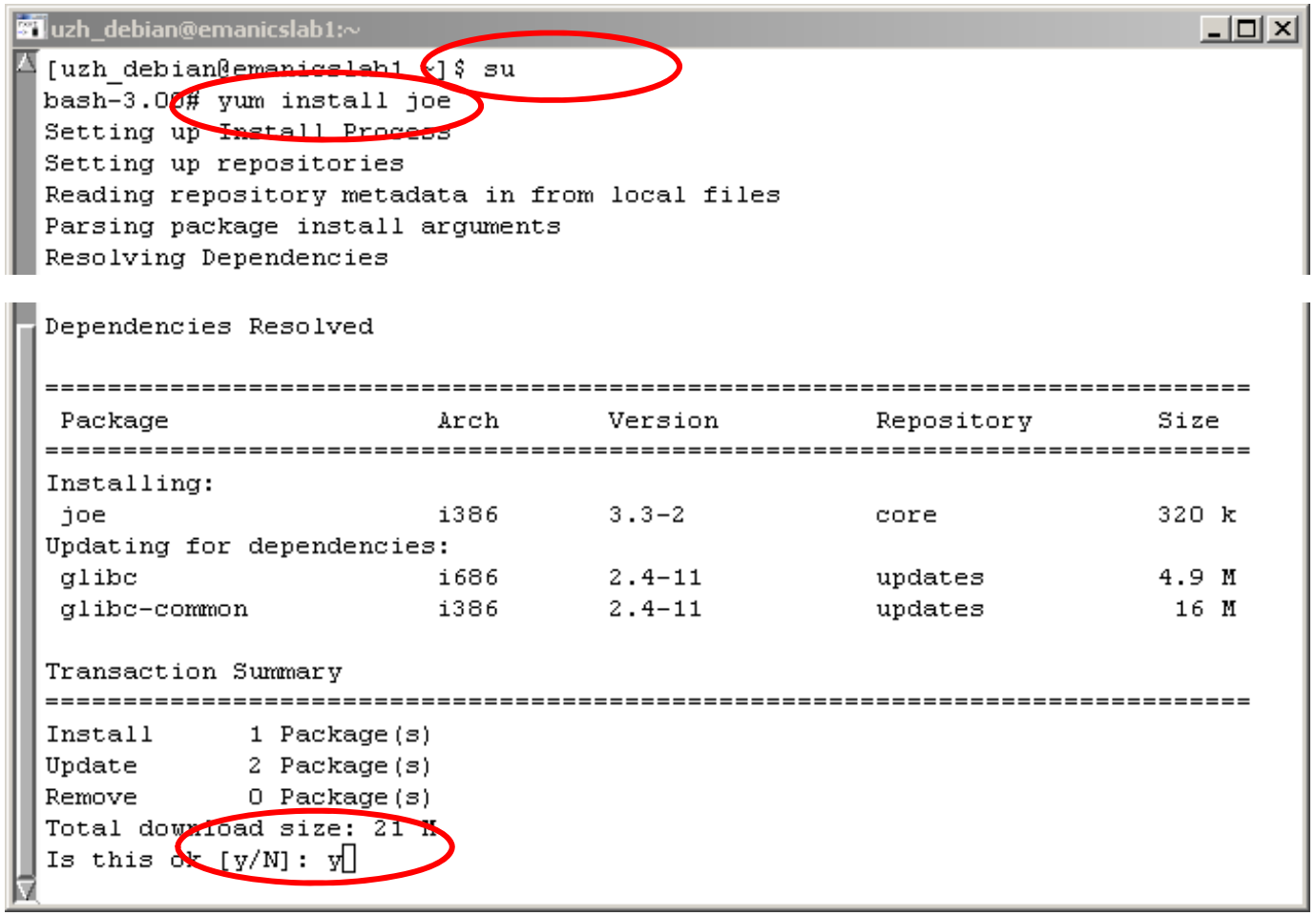

2.3. Further Guides

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- http://www.planet-lab.eu/doc/guides
  - User's Guide
  - Principal Investigator's Guide (PI Guide)
  - Technical Contact's Guide (Tech Guide)
  - Site Migration Guide

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3. Mobile Testbeds

Motivation, Requirements, CrowdLab, PhoneLab, SmartNets Lab, Federation

3.1. Observations

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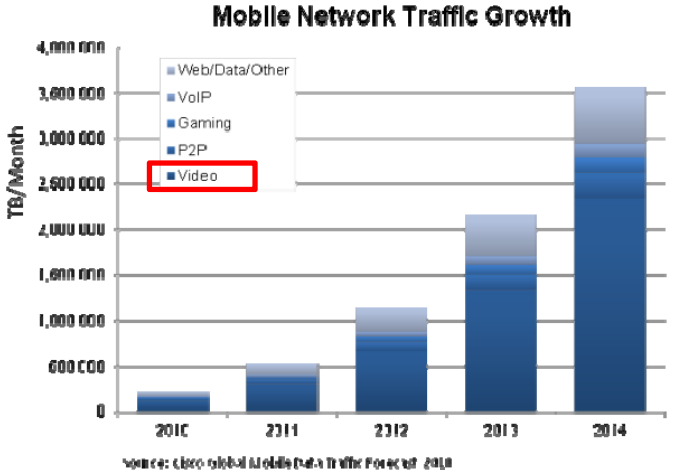
- Access from anywhere and anytime
- Mobile applications become increasingly large-scale and traffic-intense
  - E.g. mobile video streaming
- Smart phone users become service providers themselves
  - E.g. opportunistic / participatory sensing



3.1. Motivation

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- Planet Lab Benefit: Geographic diversity
- Mobile Testbed: Mobility, Sensing

- Mobile experimentation is hard
  - Mobility is fundamental but difficult to model
  - Location affects system behavior
  - Connectivity can be unpredictable
  - Devices are power constrained

- Existing Approaches
  - Programmed mobility
    - e.g., Orbit => Limited mobility
  - Vehicular mobility
    - e.g., CarTel, DieselNet => Limited locations
  - Human mobility
    - e.g., AnonySense => Limited access to resources

3.2. Requirements

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What do we want?

- Want experiments in any location
  - Cafes, shops, airports, etc
- Want to observe all levels of the stack
  - OS, drivers and applications
- Want local interactions
  - Ad-hoc network, sensing

How can we get there?

- Want experiments in any location
  - Rely on volunteer devices
- Want to observe all levels of the stack
  - Rely on hypervisor for isolation
- Want local interactions
  - Need coordination among devices

3.3. CrowdLab: An Architecture for Volunteer Mobile Testbeds

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- Expose mobile apps to real mobile human contexts like PlanetLab exposes systems to the real Internet
- Low-level access to wireless state
- Dual mode wireless abstraction
- Supports gang-scheduled instances
- Can support multiple architectures (x86 & ARM)

3.4. PhoneLab: A Participatory Smartphone Testbed

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- Scale: 1000 Nexus S 4G Smartphones
  - Providing an order of magnitude more participants than typical smartphone experiments
  - Enabling large-scale experiments
- Realism: Used by Real People
  - Distributed to students, staff, and faculty, enabling realistic experiments
  - Eliminating the need to recruit participants
  - Providing up to 1000 participants in the same area
- Power: Kernel & App Experimentation
  - Providing access to both the kernel layer and the app layer
  - Enabling low-level smartphone experimentation
  - Overcoming limitations of App Store or Android Market

3.5. SmartNets

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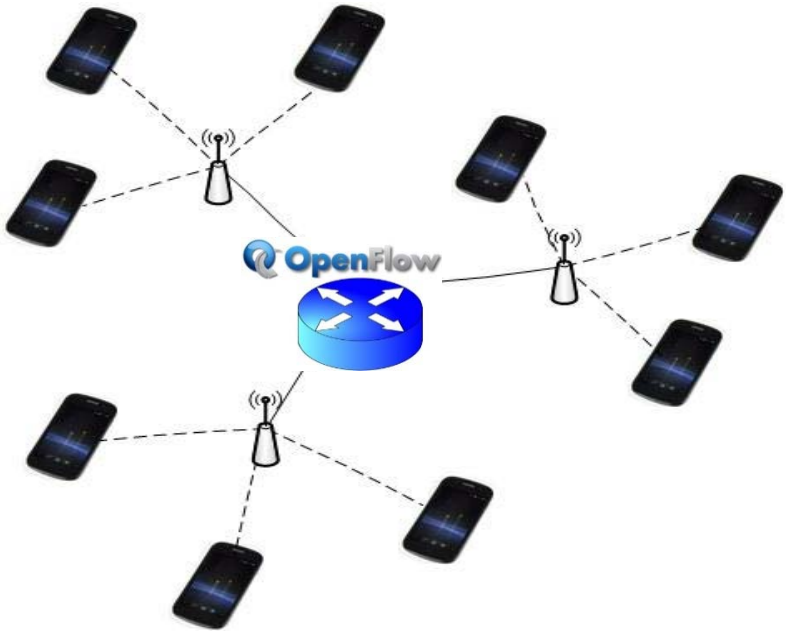
- SmartNets: A mobile testbed at TU Darmstadt
  - 12 Android smart phones (Type: Google Nexus S)
  - 3 wireless access points
  - Core switch running OpenFlow



- Purpose
  - Experimentation with large-scale distributed mobile applications
  - Evaluation of energy-efficiency and scalability aspects
  - Integration of smart networking concepts
    - P2P & service overlay networks (SON)
    - Programmable networks (OpenFlow)
  - Federation with other mobile testbeds

3.5. SmartNets Application Use Case: P2P-based Live Streaming

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- Functional requirements:
  - Setup and sharing of a new live video stream by any of the clients
  - Discovery and retrieving of the stream by a potentially large number of other clients
  - Decentralized (based on P2P techniques), not based on IP multicast
- Non-functional requirements:
  - Performance: fluid playback
  - Delay: small differences in the playback delay
  - Energy consumption: consume as less energy as possible, balanced over all clients
  - Robust against peer churn: peers (except the source) may leave the overlay

3.5. Measuring Energy Consumption on Smartphones

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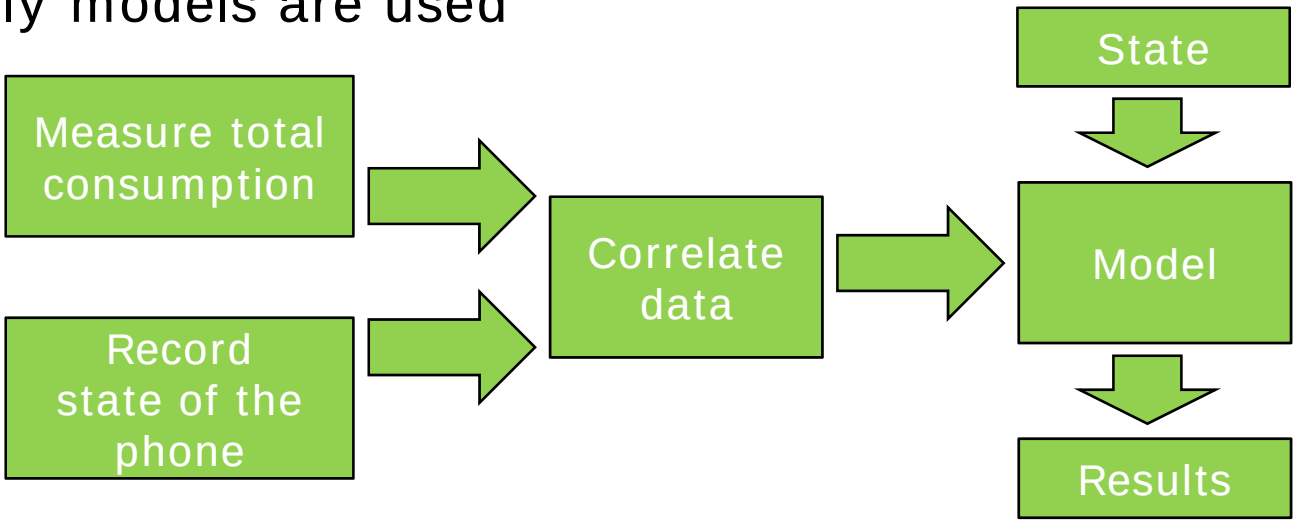
- Hardware usually does not provide this information
- Hardware consists of many different components (WiFi, GPS, CPU, ...)
  - Each component might be in a different state (awake, asleep, ...)
  - Single components may provide multiple services
- Usually models are used



3.5. Example App: PowerTutor

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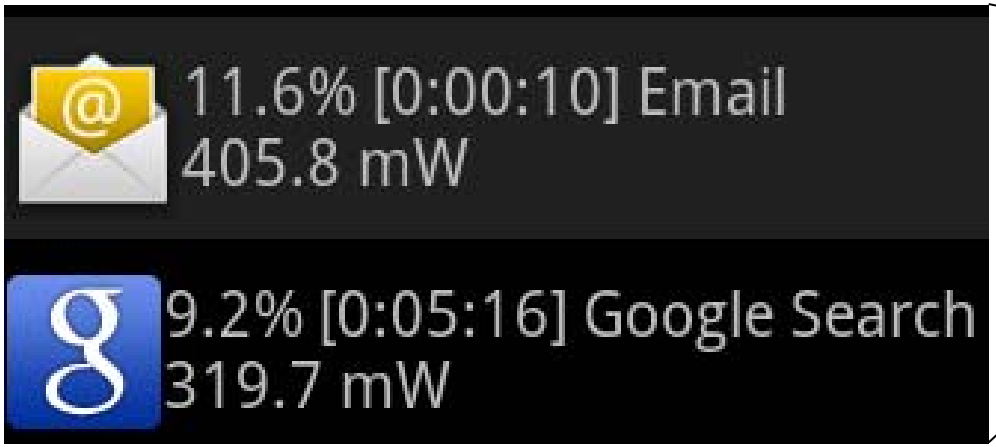
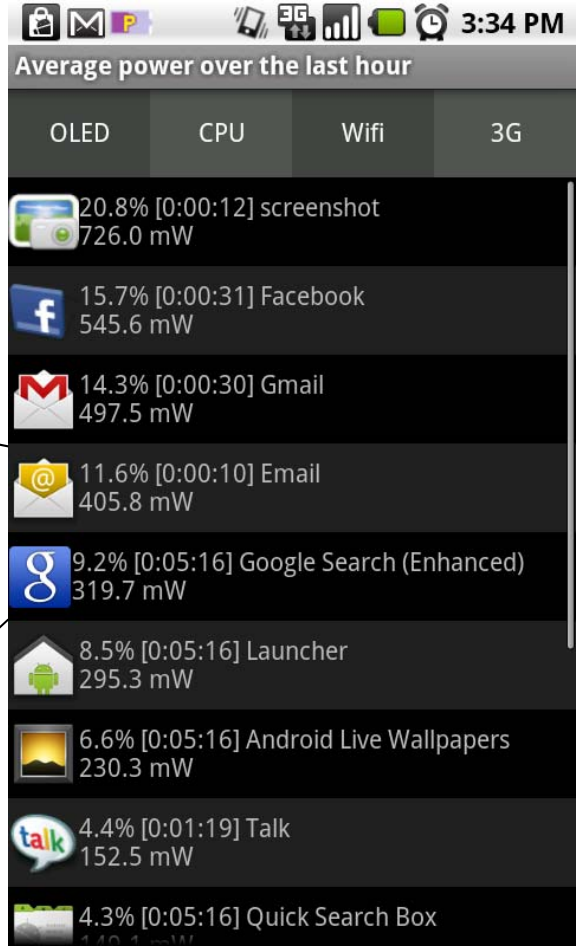
- Enables fine-grained measurements:
  - Per app consumption
  - Consumption of different components





3.5. Example App: PowerTutor

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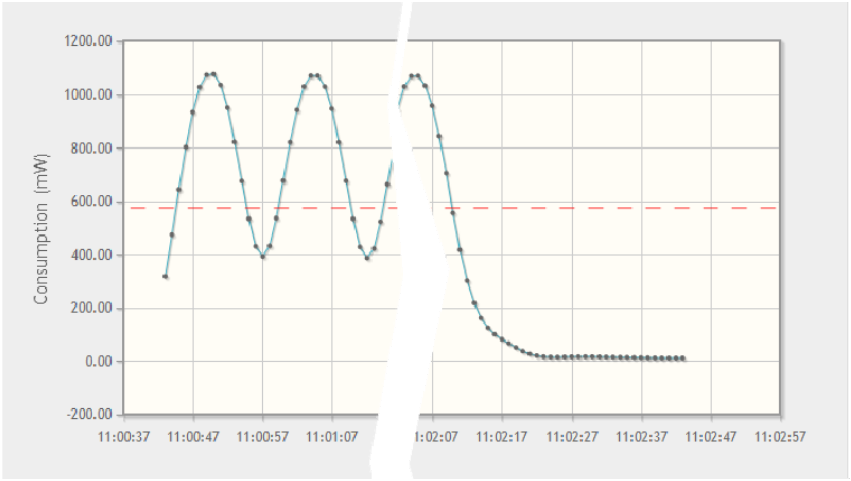
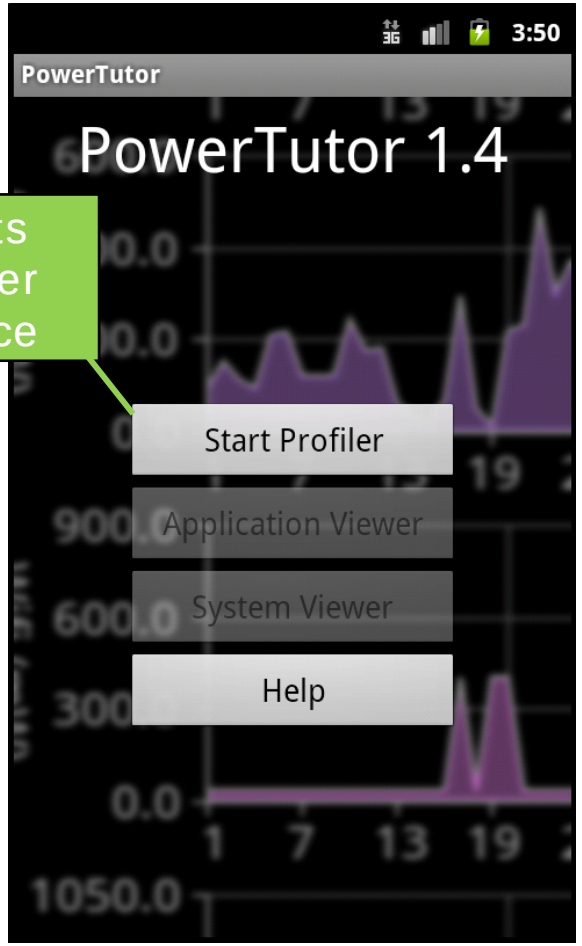
- A modified version of PowerTutor has been integrated into SmartNets
  - Centralized measurement of all the phones in the overlay
  - Monitoring via web interface





3.6. Federation of Mobile Testbeds

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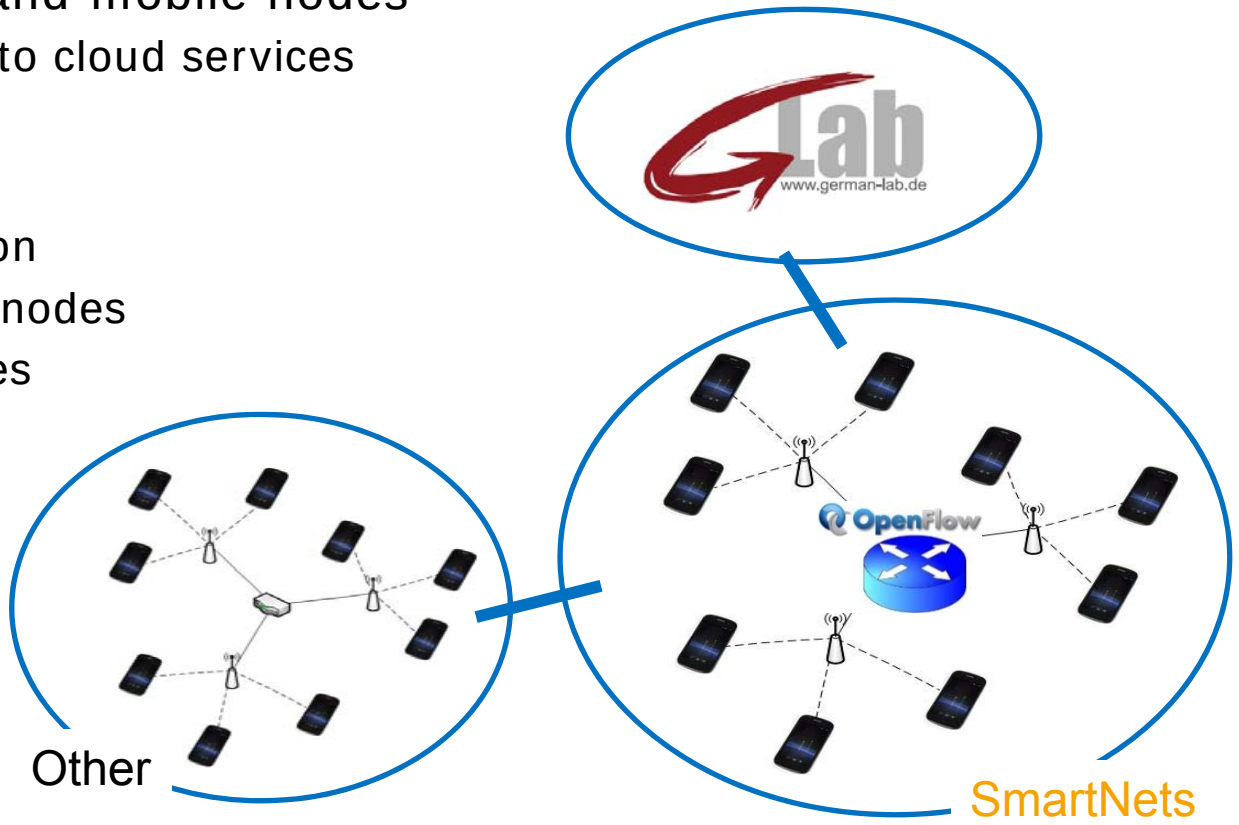
- Combination of diverse mobile nodes into a large-scale testbed
- Integration of fixed and mobile nodes
  - E.g. mobile access to cloud services
- Issues
  - PlanetLab integration
  - High dynamicity of nodes
  - Scarcity of resources
  - Exchange policies



3.6. Federation: Issues

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- High dynamicity
  - Asynchronous sliver creation and experiment setup needed
    - Enqueue experiment, execute when enough resources are available
    - Dynamic adaptation of slivers during experiments
- Scarcity of resources
  - Maximum slice resources need to be redefined
    - Idea: New maximum energy budget per slice
- Exchange Policies
  - Integration of fixed and mobile nodes: need to define equivalent of sliver in fixed and mobile testbed
  - Energy consumption as an additional metric for exchange
    - Time-invariant, correlates with induced costs