PLANETLAB

And Network Virtualization

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Desculpa

- Perdão a todos, mas esse é o único slide em português.

Overview

- PlanetLab history
- Concepts and Architecture
- What is it used for?
- Unblocking Network Architecture research
  - Overlay networks
  - Network Virtualization
- Conclusion

PlanetLab is…

- Large collection of machines spread around the world for distributed systems research
- Focus/catalyst for systems and networking community
- Intel project ⇒ consortium of companies and universities

The value proposition

- “Collectively owned”
- Institutions join, provide nodes
  - IA32 architecture servers
  - Hosted outside the firewall
  - Provide power, cooling, & bandwidth
- In exchange, researchers get to use a small “slice” of many machines worldwide.

Origins: wide-area distributed systems research c.2002

- Researchers had no way to try out real systems
  - Architectures, simulations, emulation on large clusters, calling 17 friends before the next deadline…
- but *not* the surprises and frustrations of experience at scale to drive innovation
- How can research systems be validated?

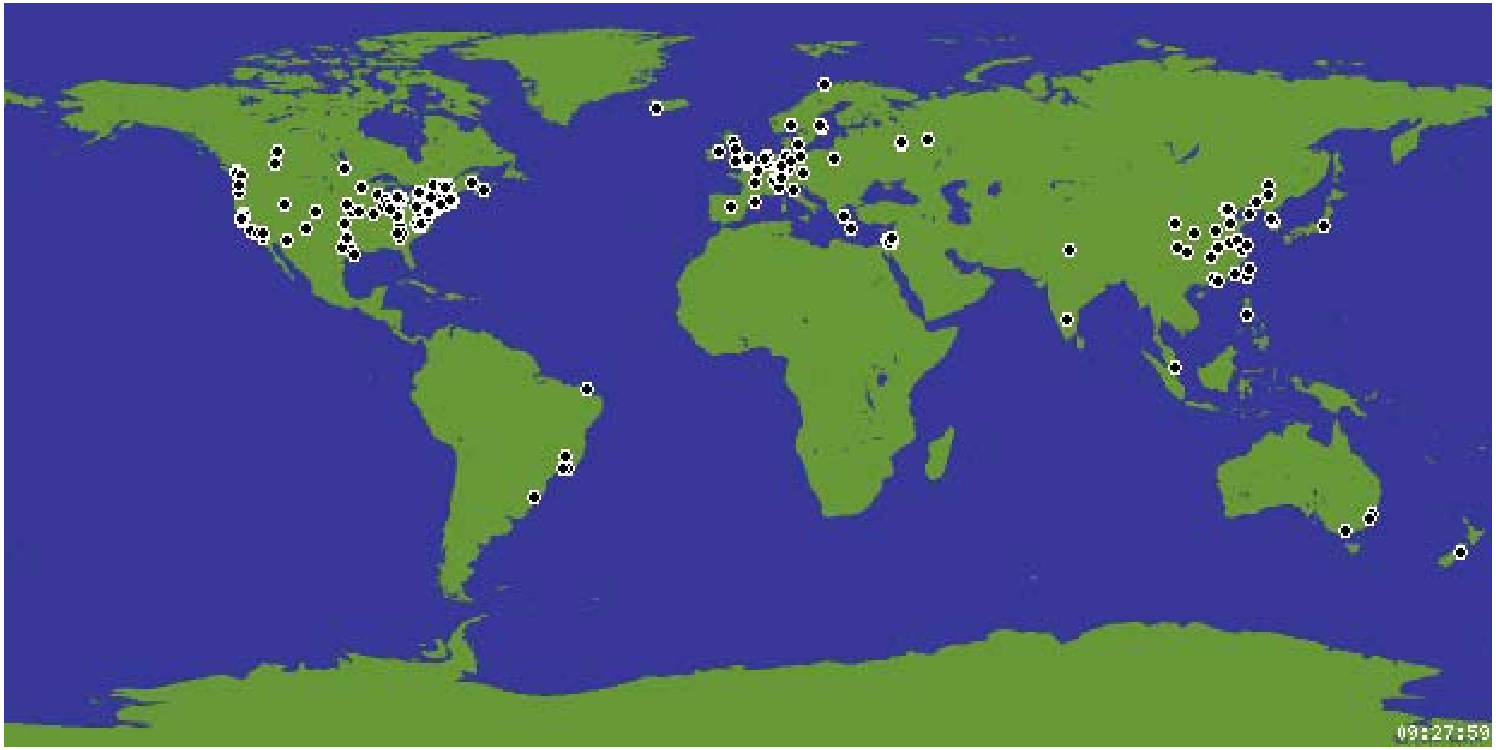
Origins: large-scale networking research c.2002

- Strong feeling the Internet had ossified
  - Intellectually, infrastructure, etc.
  - NRC "looking over fence at networks"
- New ideas abandoned as undeployable
  - Overlays as a way out of the impasse
  - Next internet emerges as overlay (again)
- How can researchers deploy overlays?

Early timeline

- David Culler and Larry Peterson discuss initial idea early 2002
- "Underground" meeting at IRB March 2002
- Position paper (Anderson, Culler, Peterson, Roscoe) June 2002.
- Intel seeds project, core team, 100 nodes
- First node up July 2002
- By SOSP (deadline March 2003) ~25% of accepted papers refer to PlanetLab
- Large presence at SIGCOMM
- 11 out of 27 papers in NSDI 2004

PlanetLab today



About 560 nodes, 269 sites, 30 countries, 5 continents
Universities, Labs, POPs, CoLos, DSL lines
Huge presence in research conferences
Several thousand researchers, students, faculty

PLANETLAB

Intel Research Berkeley

The PlanetLab Consortium

- Modelled on the W3C
- Run by Universities
  - U. Washington, U.C. Berkeley, U. Cambridge, Princeton U.
  - Based in Princeton, NJ, USA.
- Funded by Industry and Govts.
  - NSF, EU, Cernet, etc.
  - Intel, HP, Google, AT&T, FranceTelecom, etc.

The PlanetLab Consortium

- Node resources provided by member institutions
- Small "support" team NOC in Princeton
  - Additional NOCs planned in Europe (Paris), China (Tsinghua)
- Steering Committee
  - University representatives
  - Top-level industrial sponsors

PlanetLab Architecture

Timothy Roscoe, 10 May 2005

Short-term requirements

(March 2002)

To support current research work in distributed & P2P systems and networking:

- Shared by many simultaneous users
- Isolation and protection
- Use familiar API (Linux)
- Networking flexibility
- Manageable
- Must be fully operational in 3 months!

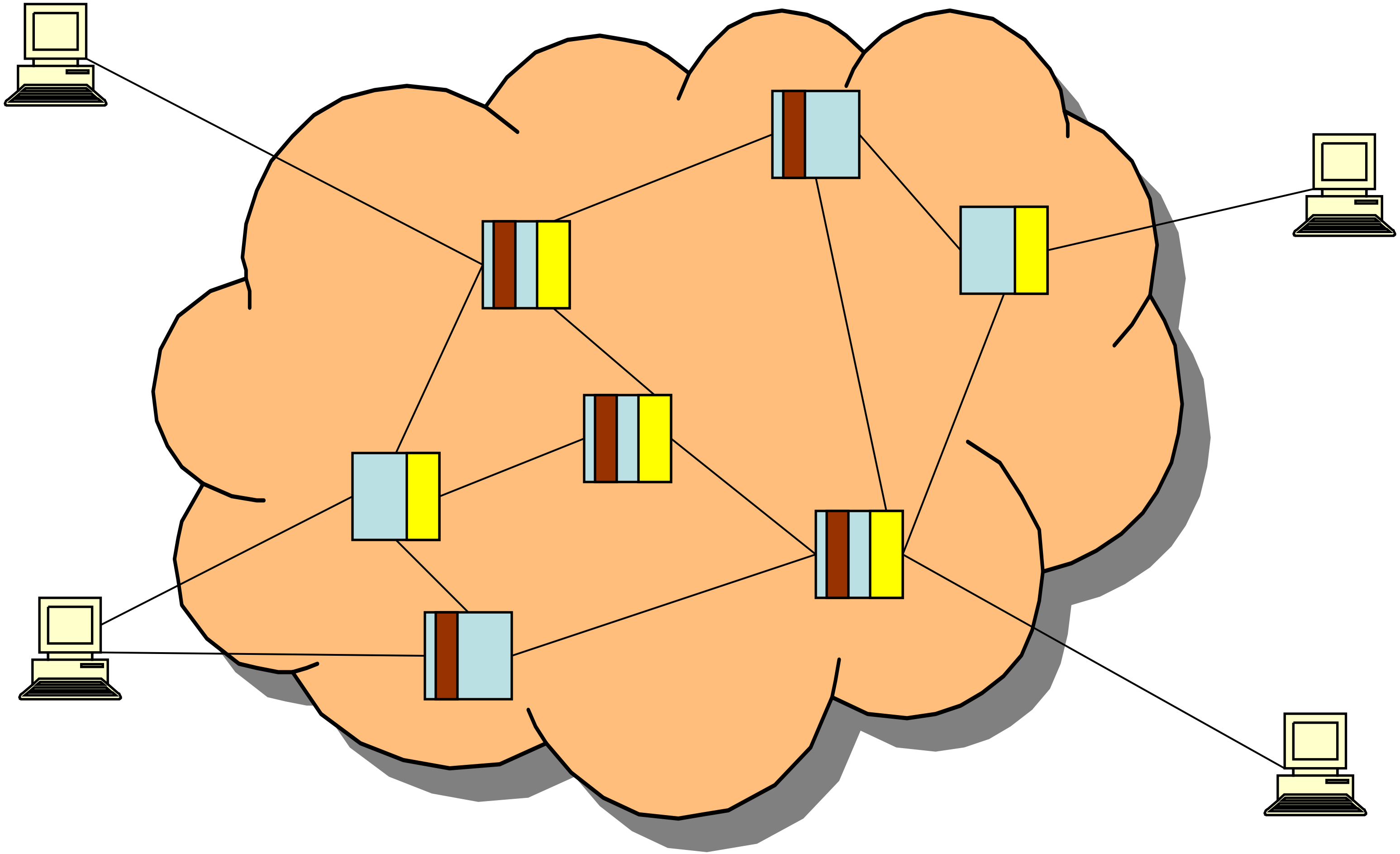
Long-term requirements

- To change the world by incubating the next Internet:
  - Must evolve over time
  - Community replaces all functionality (including O/S)
  - Allow parallel approaches to coexist
  - Produce a viable replacement for the existing network and services

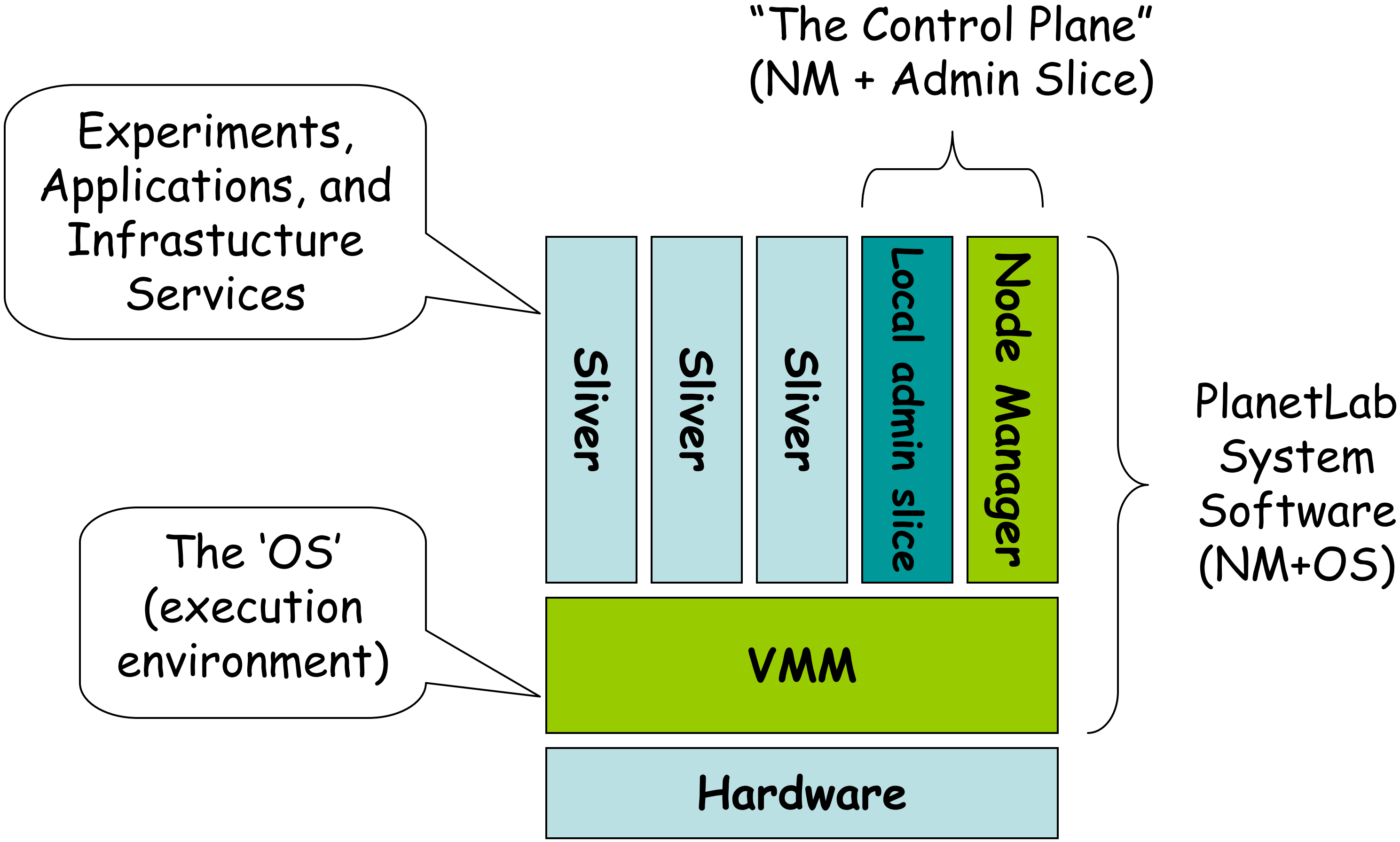
Distributed Virtualization

- *Slices*
  - Basic unit of isolation and sharing
  - Distributed set of virtual machines (slivers)
  - Services & applications run "in" slices
- *Nodes*
  - Physical machines, grouped into *Sites.*
  - One node hosts many slivers
- Infrastructure Services
  - Provide functionality to developers or other services rather than users

Slices



Node architecture


"The Control Plane"
(NM + Admin Slice)
Experiments, Applications, and Infrastucture Services
The 'OS' (execution environment)
Sliver
Sliver
Sliver
Local admin slice
Node Manager
VMM
Hardware
PlanetLab System Software (NM+OS)

Uses and Lessons

What is PlanetLab good for?

- *Planetary-Scale* applications:
  - **Low latency** to widely spread users
  - **Span boundaries:** jurisdictional and administrative
  - **Simultaneous viewpoints:** on the network or sensors
  - **Hardware deployment** is undesirable

What do people use it for?
(a few we know about)

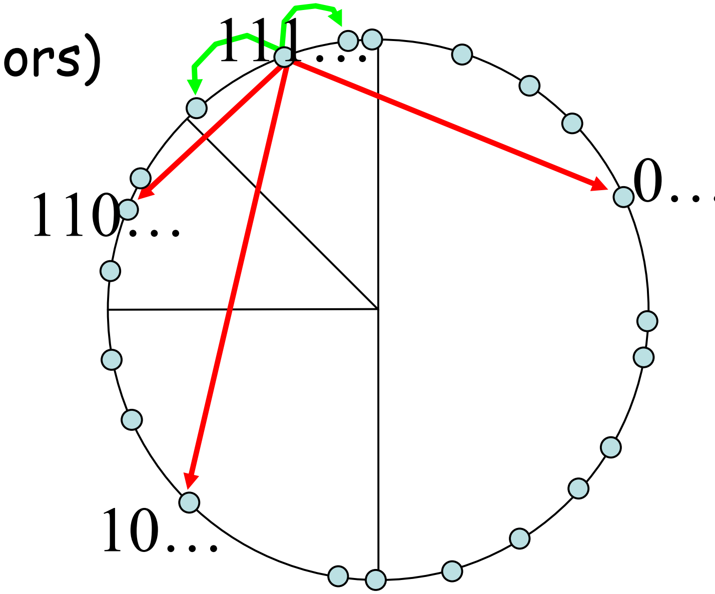
- Overlay Networks
  - RON, Pluto, Violin, etc.
- Network measurement
  - Scriptroute, *Probe, I3, Gnutella mapping.
- Application-level multicast
  - ESM, Scribe, TACT, etc.
- Wide-area P2P distributed storage
  - Oceanstore, SFS, SFS-RO, CFS, Palimpsest, IBP
- Resource allocation
  - SHARP, SHARE, Slices, XenoCorp, Automated contracts
- Distributed query processing
  - PIER, SDIMS, Sophia, etc.
- Content Dist. Networks
  - CoDeeN, Coral, Beehive
- Management and Monitoring
  - Ganglia, InfoSpect, Sword, BGP Sensors, etc.
- Distributed Hash Tables
  - Chord, Tapestry, Pastry, Bamboo, Kademlia, etc.
- Virtualization and Isolation
  - Xen, Denali, VServers, SILK, Mgmt VMs, etc.
- Router Design implications
  - NetBind, Scout, NewArch, Icarus, etc.
- Testbed Federation
  - NetBed, RON, XenoServers
- Etc., etc., etc.

Example: CoDeeN
(Princeton)

- Content Distribution Network
  - ~330 (open) caching proxy servers
  - Open to all users (see URL)
- Highly available (after lots of work!)
- Spawned many subprojects / services:
  - CoBlitz, scalable distribution of large files.
  - CoDeploy, efficient synchronization for slices.
  - CoDNS, fast and reliable name lookup.
  - CoMon, node monitoring for PlanetLab
  - CoTest, login debugging tool for nodes
  - PlanetSeer, distributed network anomaly tracing
- Illustrates how deployment of a real service spurs research
  - http://codeen.cs.princeton.edu/

Example: Bamboo
(Intel Research / U.C. Berkeley)

- P2P Distributed Hash Table (DHT)
  - Like Pastry, Chord, CAN, Tapestry, etc.
- Each DHT node has
  - An identifier in $[0,2^{160})$
  - Leaf set (Predecessors, Successors)
  - Routing table
    - Nodes w/similar prefixes
    - Choose node for each prefix by *proximity* (in network latency)
- Each node responsible for keys closest to its ID



Bamboo, contd.

- Arose from frustration!
  - PlanetLab deployment showed up many problems with existing DHTs
- Pastry topology, new maintenance
  - Highly robust under churn
- Used by new research projects
  - OpenDHT (opendht.org: Intel & UCB)
  - PIER (P2P relational queries: Intel / UCB)
  - Xenosearch (multidim. search: U. Cambridge)
- http://www.bamboo-dht.org/

Lessons from PlanetLab

- Nothing works as expected at scale!
  - Many unintended and unexpected consequences of algorithmic choices
  - Simulation results do not carry over well
    - Simulate, deploy, measure, edit cycle
- Evaluating competing approaches "in the wild" refines techniques
- The ability to try things out "for real" seems to stimulate ideas

Lessons from PlanetLab (2)

- "Unusual" traffic triggers intrusion detection systems
  - Network is often brittle & paranoid!
- UDP w/CC replaces TCP
  - Overlays and P2P applications have many options for next-hop
- Reliable distributed systems from unreliable components *are* possible!
  - OpenDHT: 99.99% availability

What about networking?

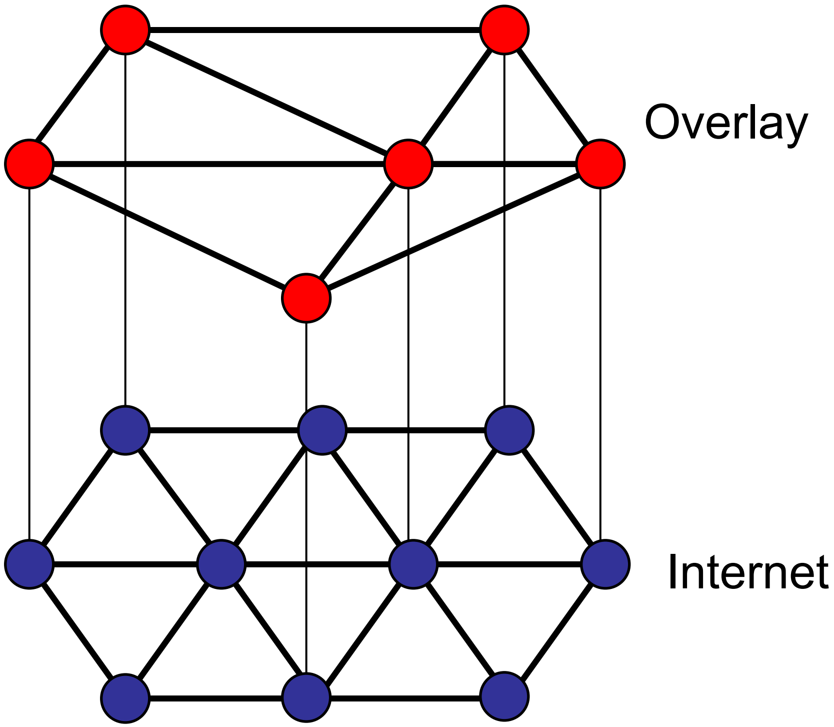
Research into *Internet Architectures*

- Network Management & Provisioning
- What replaces BGP?
- What replaces IP?
- Alternatives to packet switching

- How can University research in this area be validated?
- How can such research achieve impact on industry?

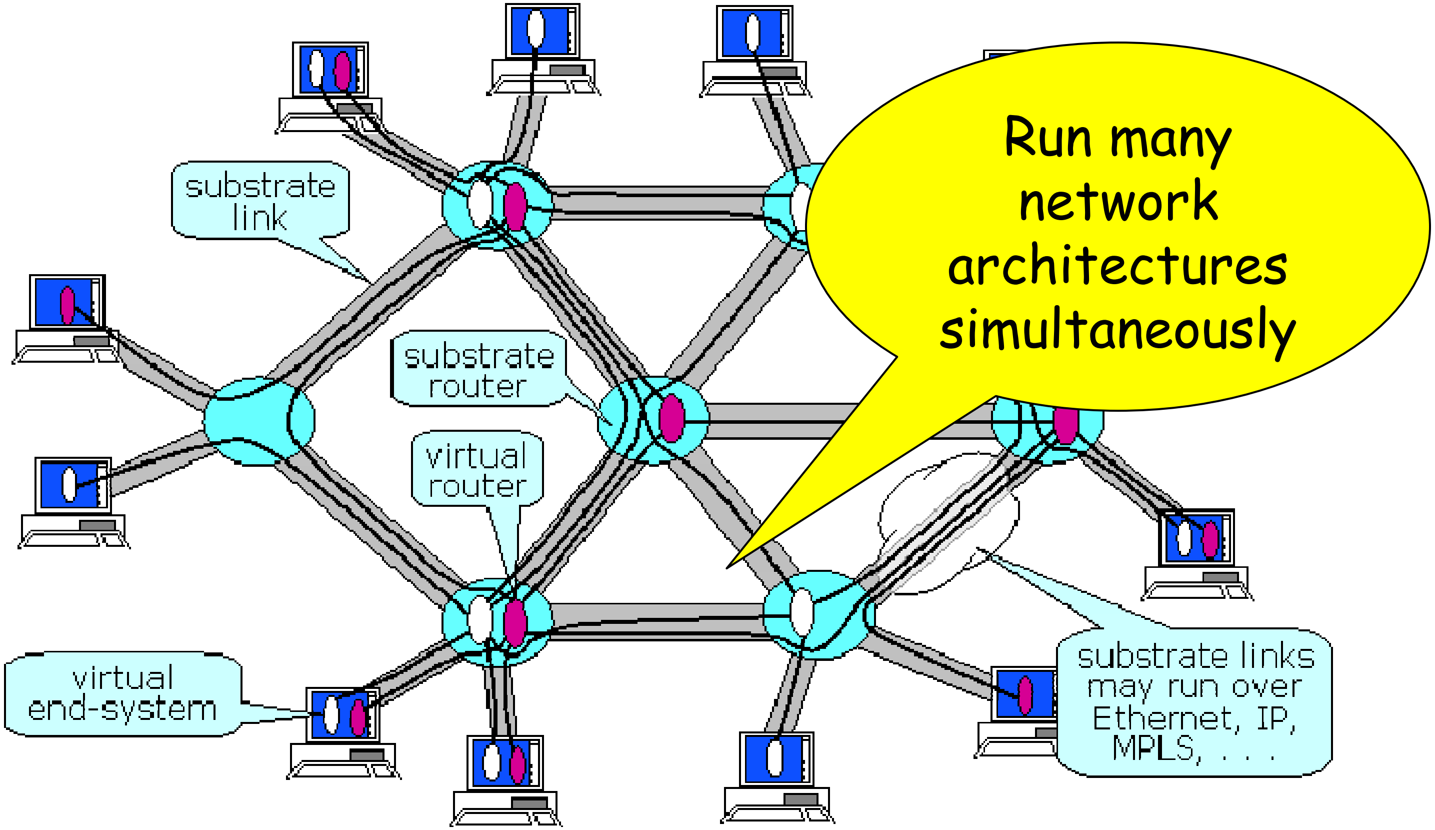
Evolving the Internet: Overlay Networks

- Add new layer to the network architecture.
- Purpose-built virtual networks using existing Internet



Network virtualization

http://www.arl.wustl.edu/netv/



Run many network architectures simultaneously

Enabling architecture research: requirements

- Localizable *computational* resources on demand (control & management)
- Provisioned *links* between computational nodes (emulate physical links)
- Way to *share* resources (parallel research efforts)
- Way for users to *access* overlays over the existing network

Role of PlanetLab

- PlanetLab can provide the computational resources required
- Slices provide the means of sharing them
- Access mechanism: later in talk…
- **Missing piece**: network provisioning

Network provisioning for virtualized networks

- Recent NSF report recommending funding of provisioned links for virtualized network architecture
  - Exploit existing PlanetLab deployment
  - Use IP VPNs, MPLS, LambdaRail, etc.
  - New form for US network testbeds
- Similar efforts discussed in Europe
- Perhaps the only significant extra cost of this line of research

Accessing an IPvN overlay

- “Towards a deployable IP anycast service”: Hitesh Ballani, Paul Francis, WORLDS 2004
- “Towards an Evolvable Internet Architecture”: Sylvia Ratnasamy, Scott Shenker, Steve McCanne, SIGCOMM 2005

Summer Intern Project: Deploy IP Anycast for Overlay Redirection!

- Use a /22 prefix and AS number for anycast
  - Deploy "anycast gateways" at IRB, Cornell
  - Advertise prefix via BGP (help from ISPs)
- Deploy an experimental "IPvN" architecture
  - Actually, a "Default Off" (explicit authorizatoin) network.
- Long term: offer the gateways as generic service for overlay providers.
  - Acts as extension to PlanetLab facilities

Conclusion

- PlanetLab provides an unprecedented platform for experimenting with large distributed systems “in the wild”
- Network virtualization is a technique to unblock radical innovation in network architecture
- Only requires incremental investment over PlanetLab (pipes)
- Enables small groups to perform large-scale architecture research

The Debate: Purism vs. Pluralism

- Purism: virtualization is a way to determine which features the "next" network architecture will have.
- Pluralism: virtualization *is* the next network architecture.

Obrigado!

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and many others…

PlanetLab is not the Grid, #1

- The Grid aims at location-transparency for large computations
  - “I don’t care where this protein-folding job runs as long as it’s done by Monday”

- PlanetLab is all about small, long-running services in specific locations
  - “I need to run a new secure file cache for the next 6 months in Seoul, Sydney, Tromsø, and Vancouver”

PlanetLab is not the Grid, #2

- The Grid is about *standardizing* one particular paradigm for large-scale utility computing.
- PlanetLab provides a low-level platform over which *many* distributed computing paradigms can be tried.
  - You could build the Grid over PlanetLab's abstractions if you really wanted

PlanetLab is not the Grid, #3

- The Grid starts from scratch in putting together an execution environment for remote computation (e.g. OGSA)
- PlanetLab starts with a well-known, simple interface and encourages the community to evolve multiple, competing execution environments

PlanetLab is not the Grid, #4

- The analogy with networking…

OGSA ⇔ ISO OSI

PlanetLab ⇔ TCP/IP

Enough said.