PlanetLab: A Blueprint for Introducing Disruptive Technology into the Internet

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Innovator's Dilemma

- The Internet is an enormous success story
  - commercially
  - impact on our daily lives
  - global reach
- Success has an unexpected cost: *ossification*
  - difficult to deploy disruptive technologies
    - correct vulnerabilities
    - introduce new capabilities

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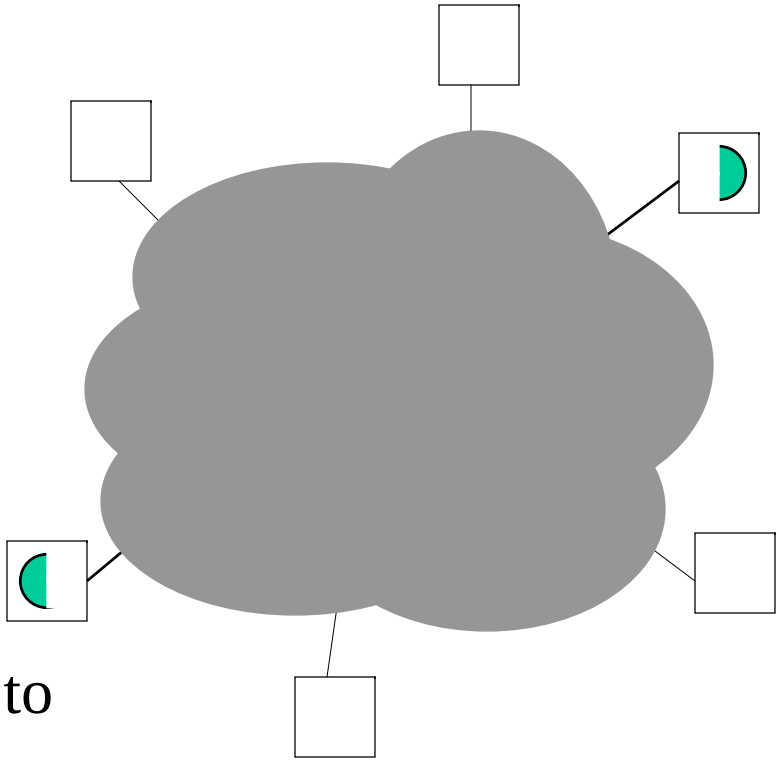
Today's Internet

Best-Effort Packet Delivery Service



Limitations

- The Internet is "opaque" making it difficult to adapt to current network conditions
- Applications cannot be widely distributed (typically split into two pieces: client and server)

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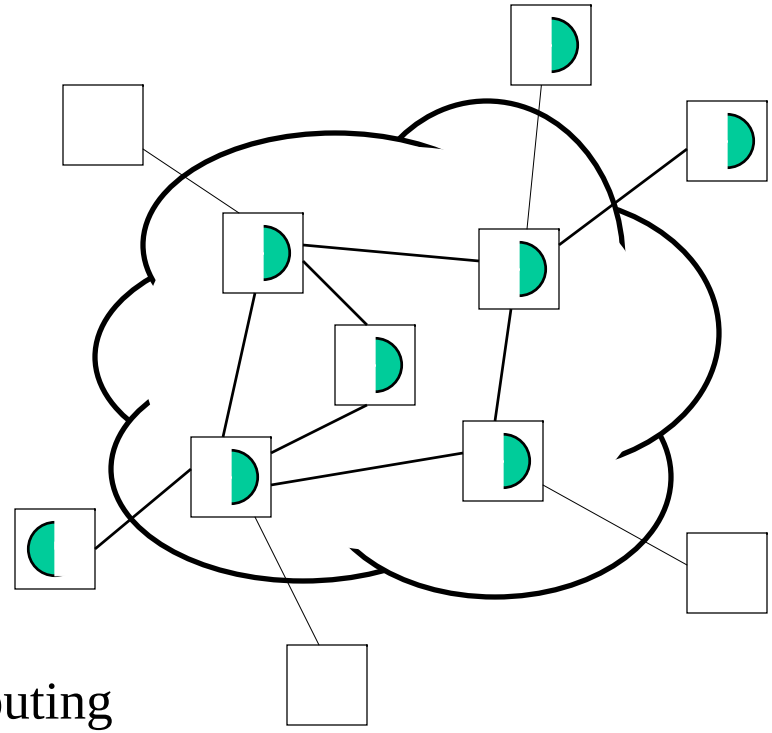
Tomorrow's Internet

Collection of Planetary-Scale Services



<u>Opportunities</u>

- multiple vantage points
  - anomaly detection, robust routing
- proximity to data sources/sinks
  - content distribution, data fusion
- multiple, independent domains
  - survivable storage

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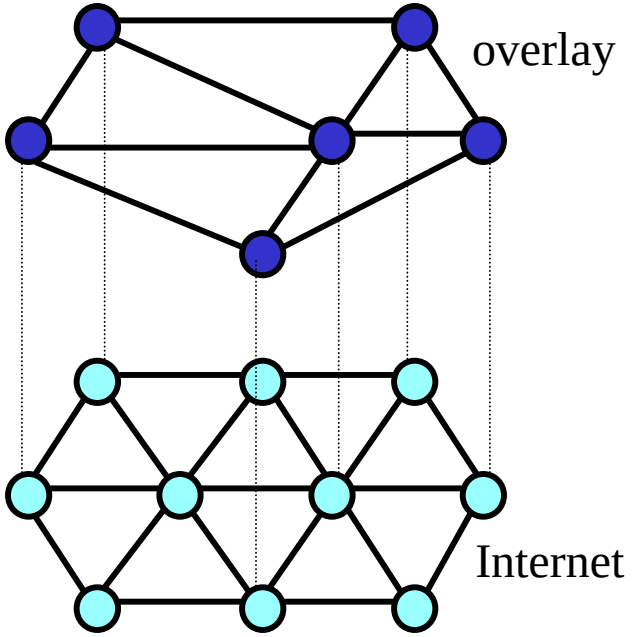
Evolving the Internet

- Add a new layer to the network architecture
  - overlay networks
    - purpose-built virtual networks that use the existing Internet for transmission
    - the Internet was once deployed as an overlay on top of the telephony network



- Challenge
  - how to innovate & deploy at scale

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The Story So Far

- The Internet is a tremendous success, but…
  - The architecture has fundamental limits
  - Its very success makes it hard to change
- The research community is teeming with innovative planetary-scale services (more later)
  - Exploit multiple points-of-presence throughout the net
- Overlays offer an attractive way to introduce disruptive technology into the Internet, but…
  - There is a high barrier-to-entry

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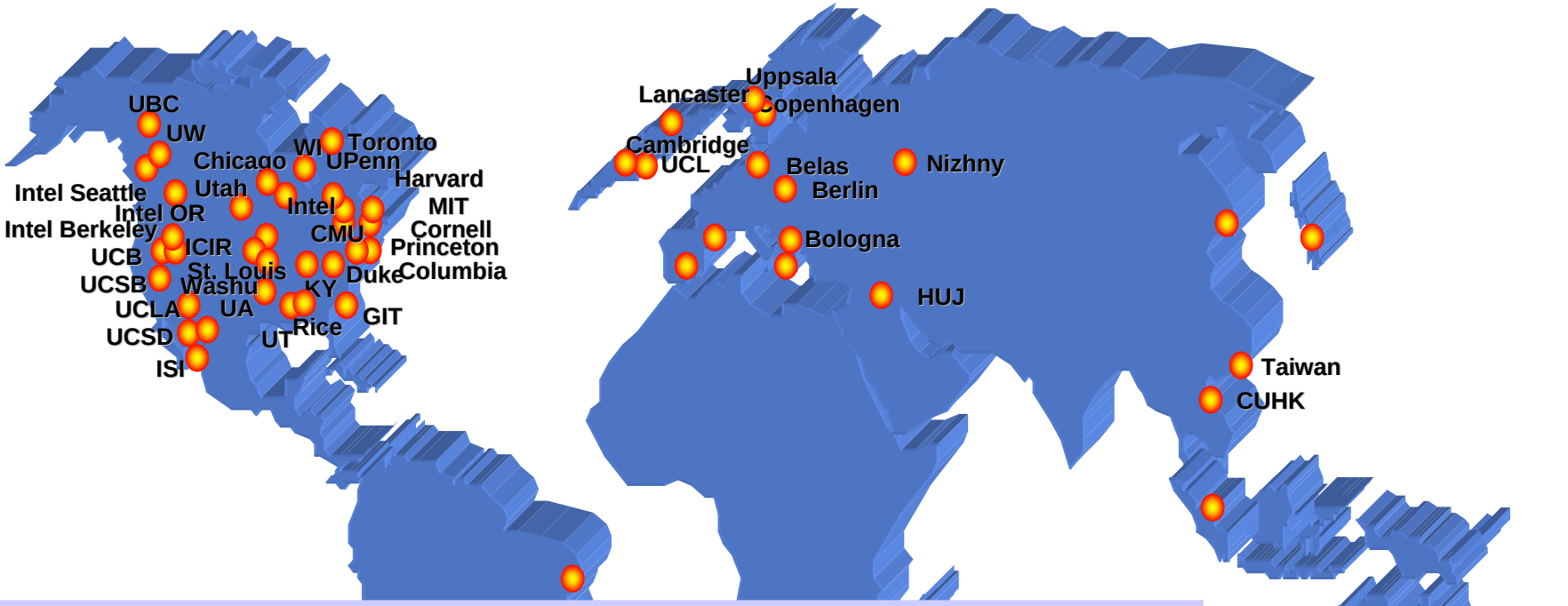
PlanetLab is…



Testbed/Deployment Platform of 1,000 servers

- today: 350 machines, 140 sites, 20 countries
- widely distributed: edge sites & network cross-roads
- 450 active research projects

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PlanetLab's Beginnings

- Started as a grass-roots effort
  - 35 researchers gathered in March 2002
  - Academic and corporate research groups
- Research Approach for Internet-Scale Services has Significant Gap:
  - Simulation
  - Lab-Scale Emulation
  - Ask "family and friends" for accounts elsewhere
  - …
  - Deploy on the Internet (how?)
- PlanetLab fills the gap

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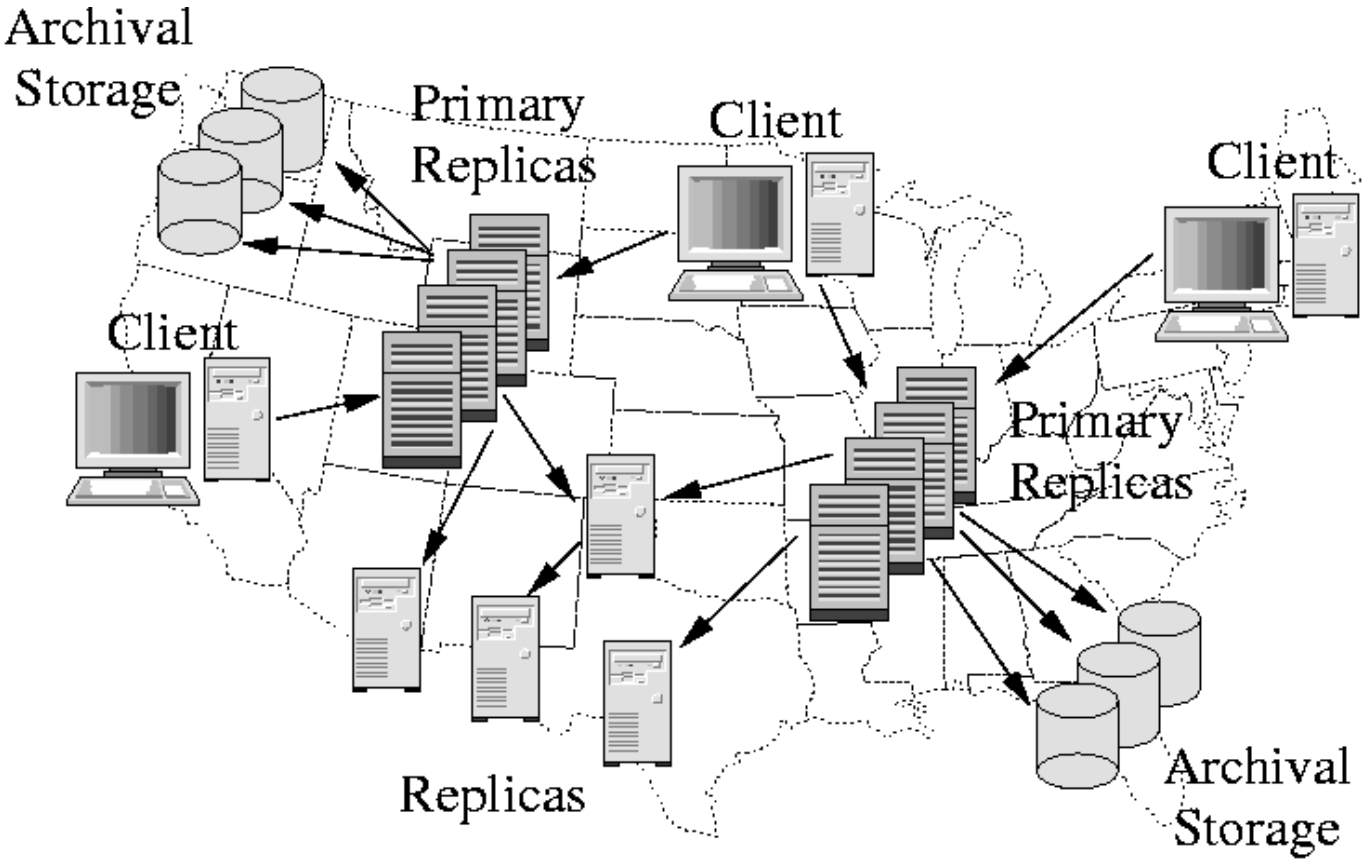
Berkeley: OceanStore

RAID distributed over the whole Internet



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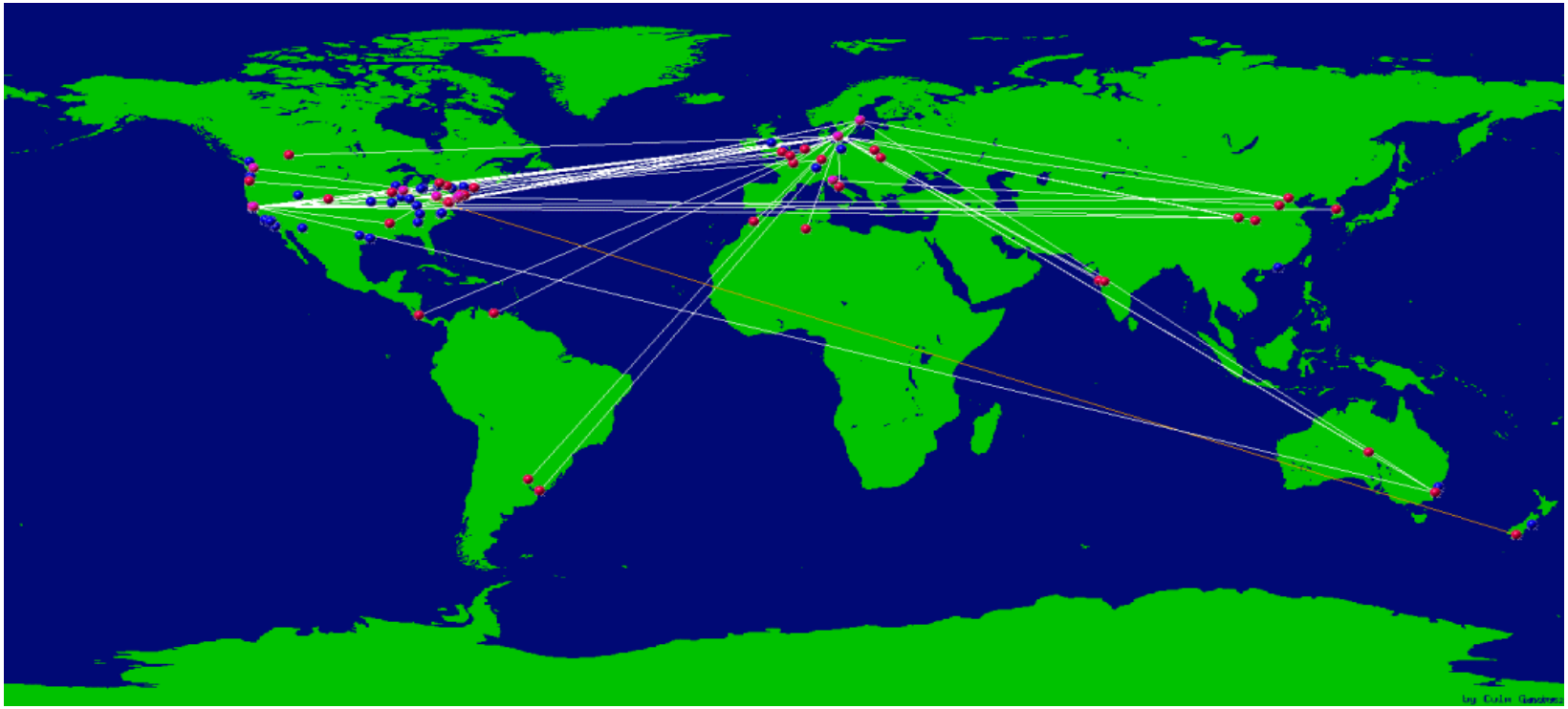
Intel: Netbait

Detect and track Internet worms globally



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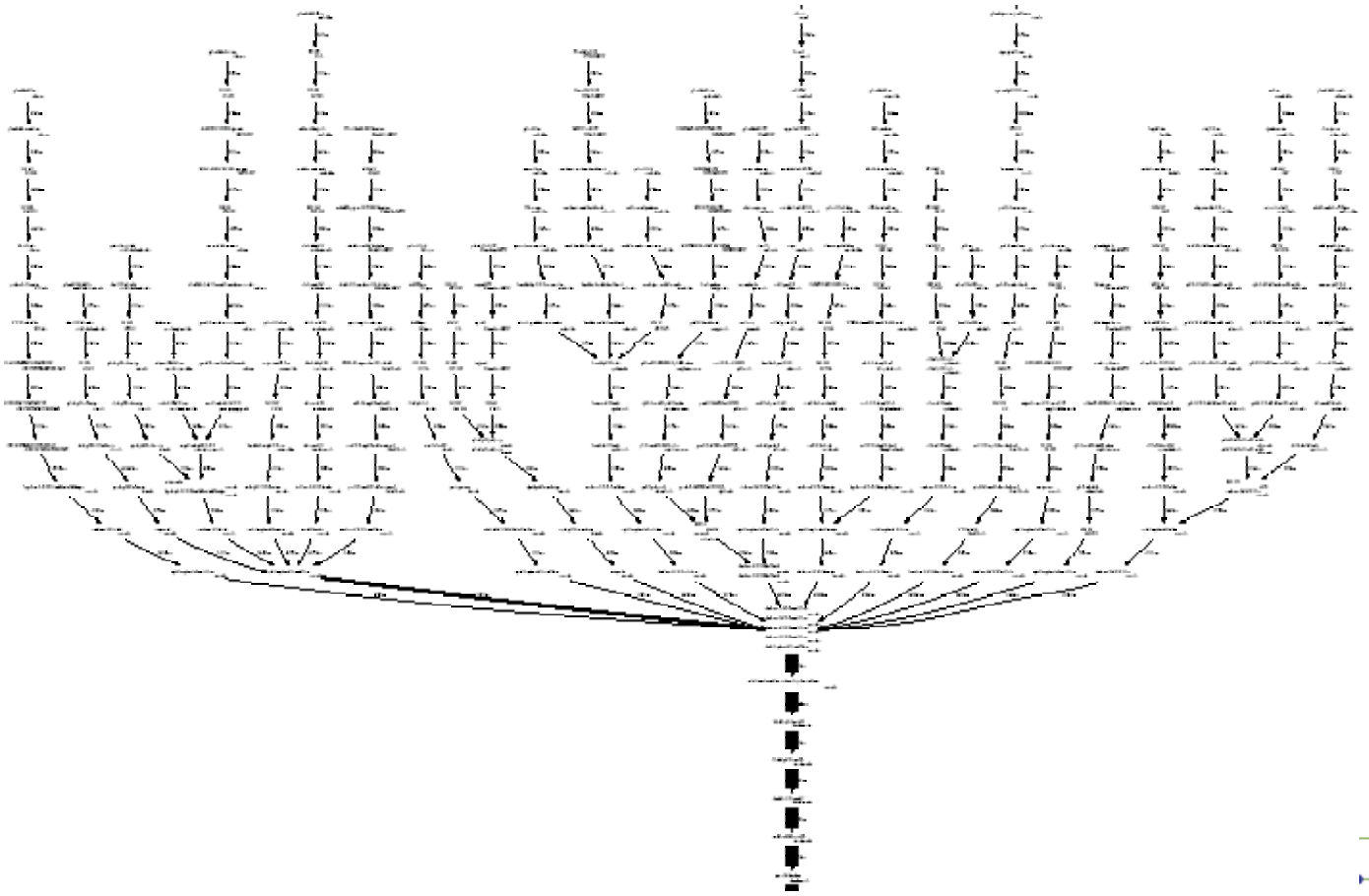
Washington: ScriptRoute

Internet Measurement Tool



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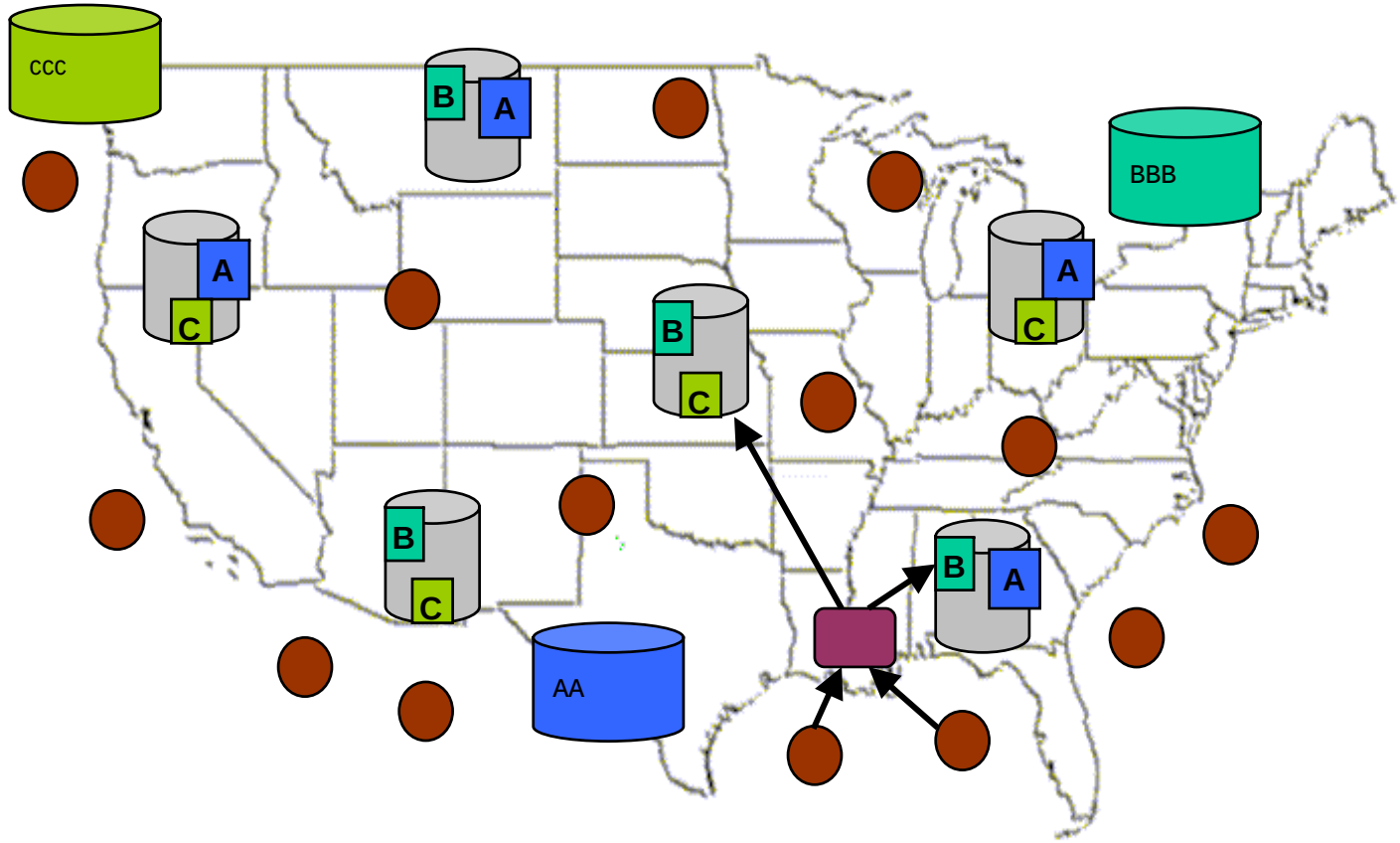
Princeton: CoDeeN



Open Content Distribution Network

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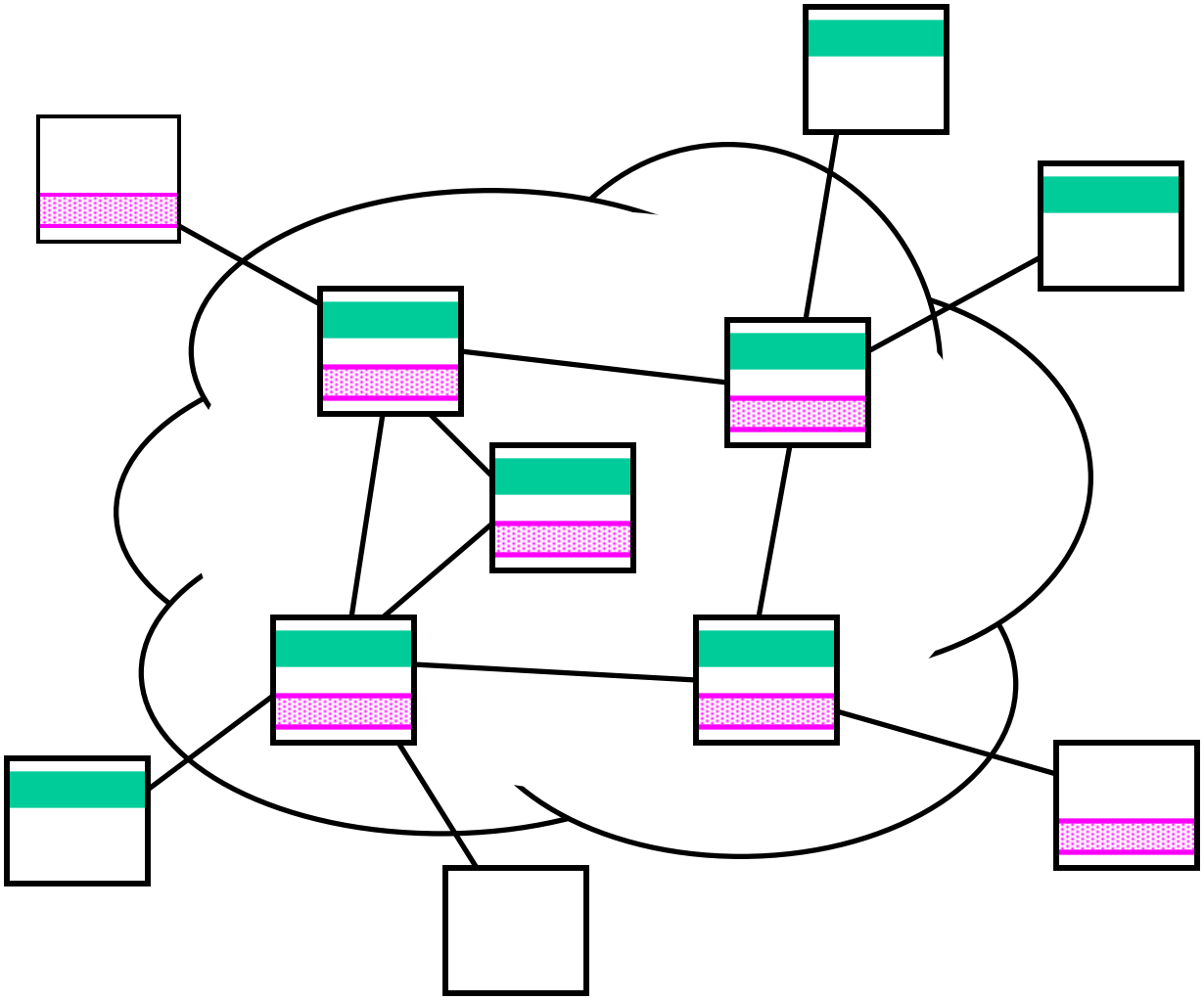
PlanetLab is…

A common software architecture featuring

- Distributed virtualization
  - each machine (server) is virtualized
  - *slice* → a network of virtual machines
  - slice isolation
    - isolate services from each other
    - protect the Internet from PlanetLab
- Unbundled Management
  - OS defines only local (per-node) behavior
    - global (network-wide) behavior implemented by services
  - multiple competing services (overlays) run in parallel

Slices



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PlanetLab is…

A test-bed for experimenting with network services

- Advantages
  - experiment at scale
  - experiment under real-world conditions
  - potential for real workloads and users
  - low entry cost

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PlanetLab is…

A deployment platform

- Continuously-running services
  - **CoDeeN** content distribution network (Princeton)
  - **Sophia** distributed query processing engine (Princeton)
  - **ScriptRoute** network measurement tool (Washington)
  - **Chord** scalable object location service (MIT, Berkeley)
  - …

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PlanetLab is…

A microcosm of the next Internet

- Fold services back into PlanetLab
  - evolve core technologies to support overlays and slices
- Examples
  - Sophia used to monitor health of PlanetLab nodes
  - Chord provides scalable object location
- Long-term goals
  - develop open protocols and standards
    - allow federation of public & private “PlanetLabs” to co-exist
  - discover common sub-services
    - e.g., measurement

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Growth Strategy

- Phase 0: Seed the testbed
  - 100 centrally managed machines
  - pure testbed (no expected client workload)
- Phase 1: Scale the testbed
  - grow to 1000 nodes with user-provided hardware
  - continuously running services (researchers as clients)
- Phase 2: Cultivate a user community
  - non-researchers as clients
  - PlanetLab spinoffs interpreted as success

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Status

- Funding
  - Intel Seed Funding
  - NSF
  - PlanetLab Consortium
- Transition Phase (through mid-2004)
  - Moving “ops” from Intel to Princeton

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PlanetLab Consortium

- Princeton, Berkeley, University of Washington
  - Initial Corporate Research Members: Intel, HP, Google
- Build out the PlanetLab infrastructure
  - operations and engineering support
  - equipment renewal
  - bandwidth at network crossroads
- Broaden and catalyze the community
  - academic and corporate researchers
  - lower the barrier to entry for research and teaching
  - drive the research agenda

Current Institutions

Academia Sinica, Taiwan
Boston University
Caltech
Carnegie Mellon University
Chinese Univ of Hong Kong
Columbia University
Cornell University
Datalogisk Institut Copenhagen
Duke University
Georgia Tech
Harvard University
HP Labs
Intel Research
Johns Hopkins
Lancaster University
Lawrence Berkeley Laboratory
MIT
Michigan State University
National Tsing Hua Univ.
New York University
Northwestern University
Princeton University
Purdue University
Rensselaer Polytechnic Inst.
Rice University
Rutgers University
Stanford University
Technische Universitat Berlin
The Hebrew Univ of Jerusalem
University College London
University of Arizona
University of Basel
University of Bologna
University of British Columbia
UC Berkeley
UCLA
UC San Diego
UC Santa Barbara
University of Cambridge
University of Canterbury
University of Chicago
University of Illinois
University of Kansas
University of Kentucky
University of Maryland
University of Massachusetts
University of Michigan
University of North Carolina
University of Pennsylvania
University of Rochester
USC / ISI
University of Technology Sydney
University of Tennessee
University of Texas
University of Toronto
University of Utah
University of Virginia
University of Washington
University of Wisconsin
Uppsala University, Sweden
Washington University in St Louis
Wayne State University

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Summary

- PlanetLab: an open, global network test-bed for pioneering novel planetary-scale services.
- A model for introducing innovations into the Internet through the use of overlay networks.
- A collaborative effort involving hundreds of academic and corporate researchers from around the world.

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More Information

www.planet-lab.org

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