OceanStore Status and Directions

ROC/OceanStore Retreat 1/13/03

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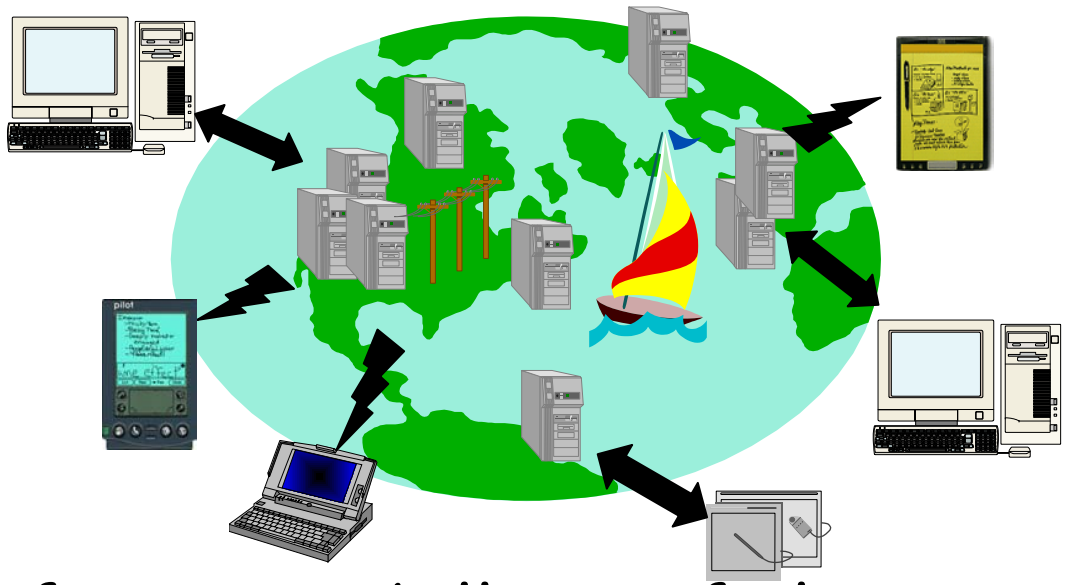
Everyone's Data, One Utility

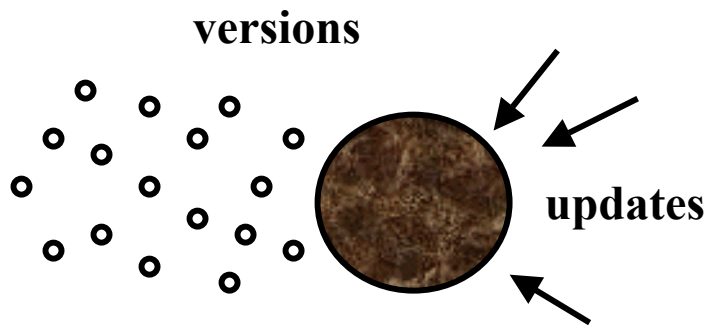


- Millions of servers, billions of clients ….
  - 1000-YEAR durability (excepting fall of society)
  - Maintains Privacy, Access Control, Authenticity
  - Incrementally Scalable ("Evolvable")
  - Self Maintaining!
- Not quite peer-to-peer:
  - Utilizing servers in infrastructure
  - Some computational nodes more equal than others

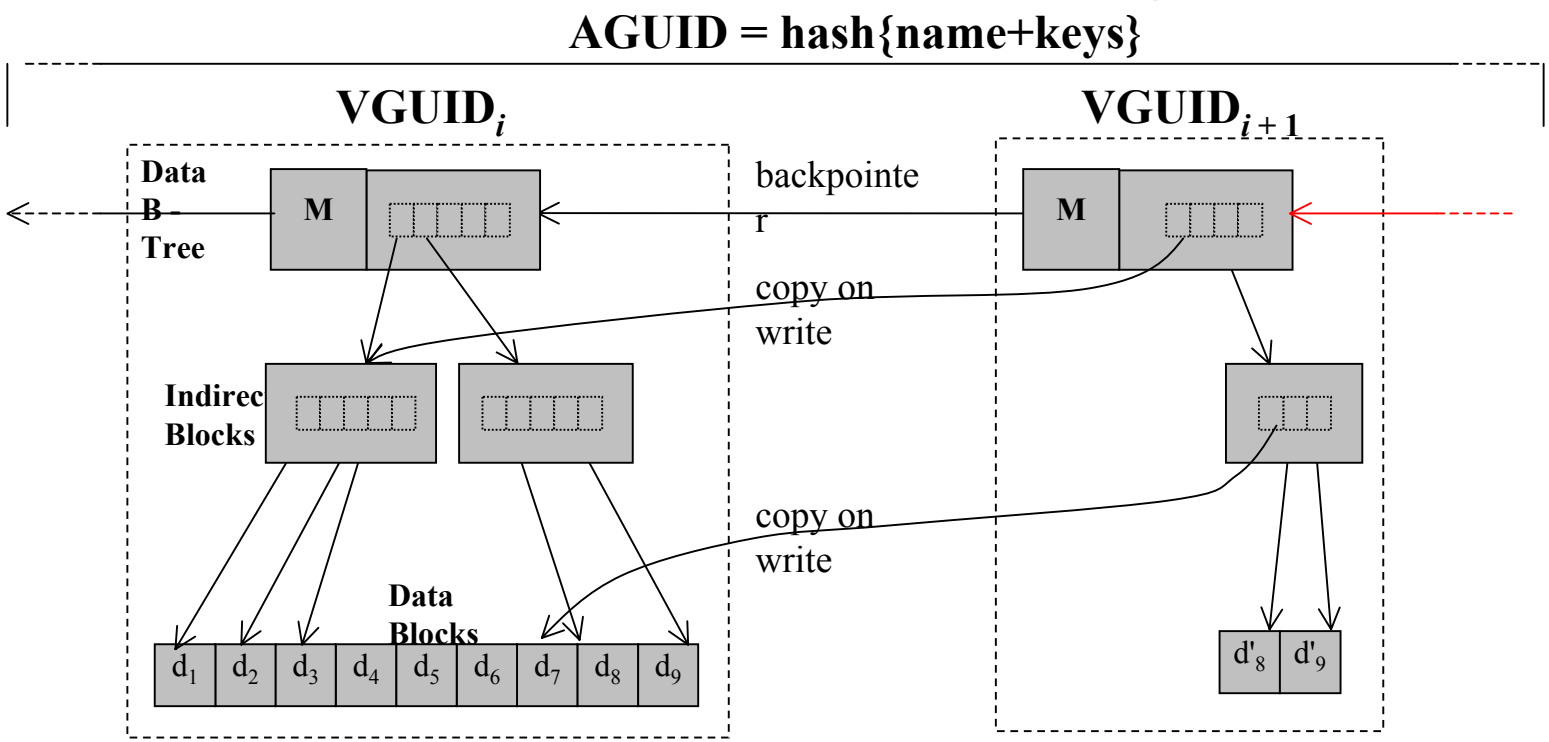
OceanStore Data Model

- Versioned Objects
  - Every update generates a new version
  - Can always go back in time (Time Travel)
- Each Version is Read-Only
  - Can have permanent name
  - Much easier to repair
- An Object is a signed mapping between permanent name and latest version
  - Write access control/integrity involves managing these mappings

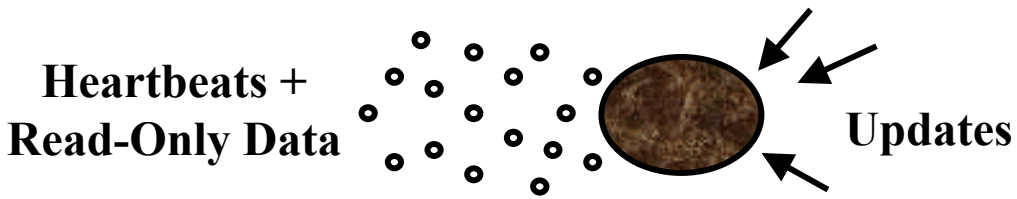
Comet Analogy



Self-Verifying Objects

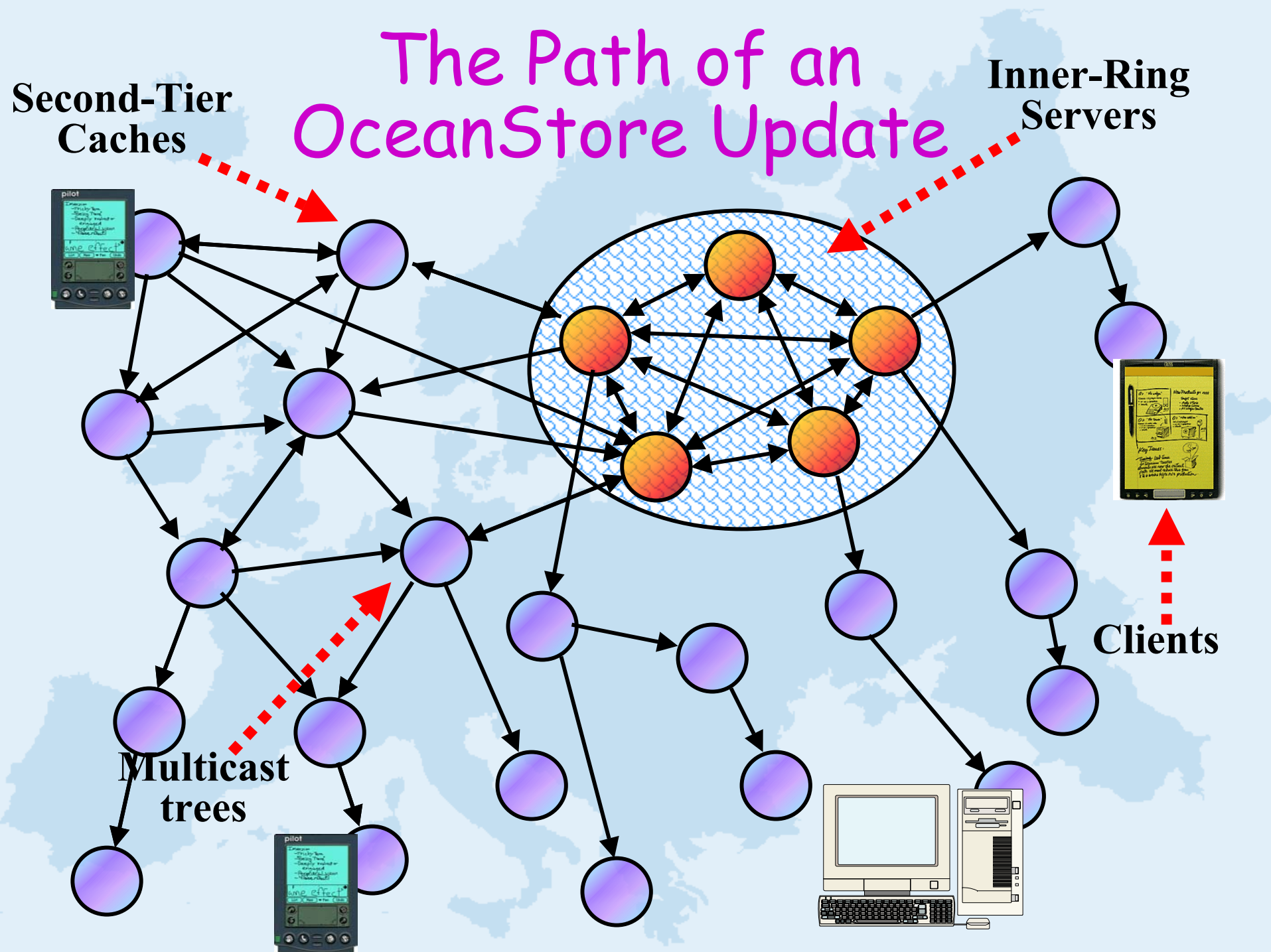


♥ **Heartbeat: {AGUID,VGUID, Timestamp}$_{signed}$**



Patrick Eaton: Discussions of the Future formats

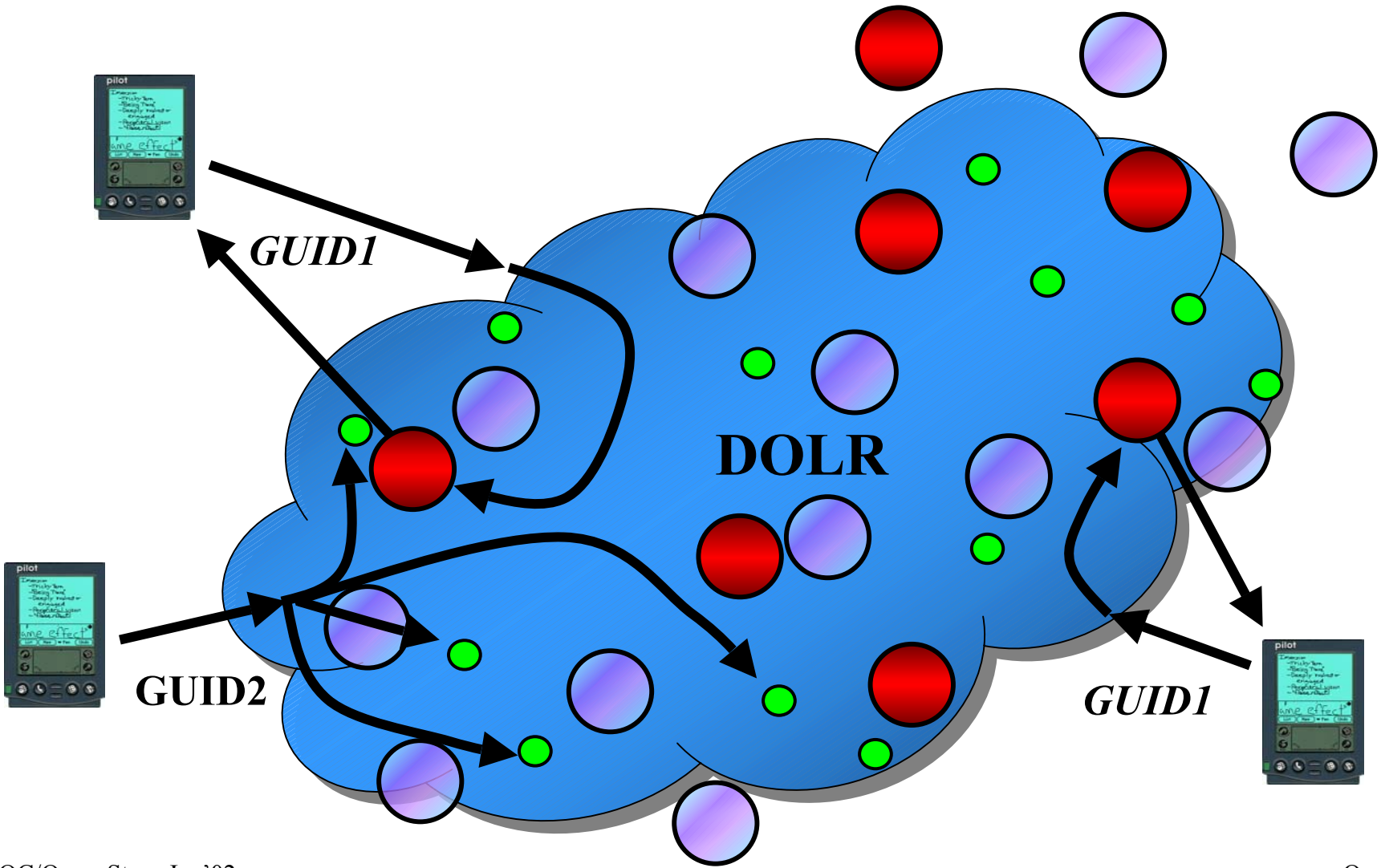
The Path of an OceanStore Update



OceanStore Goes Global!

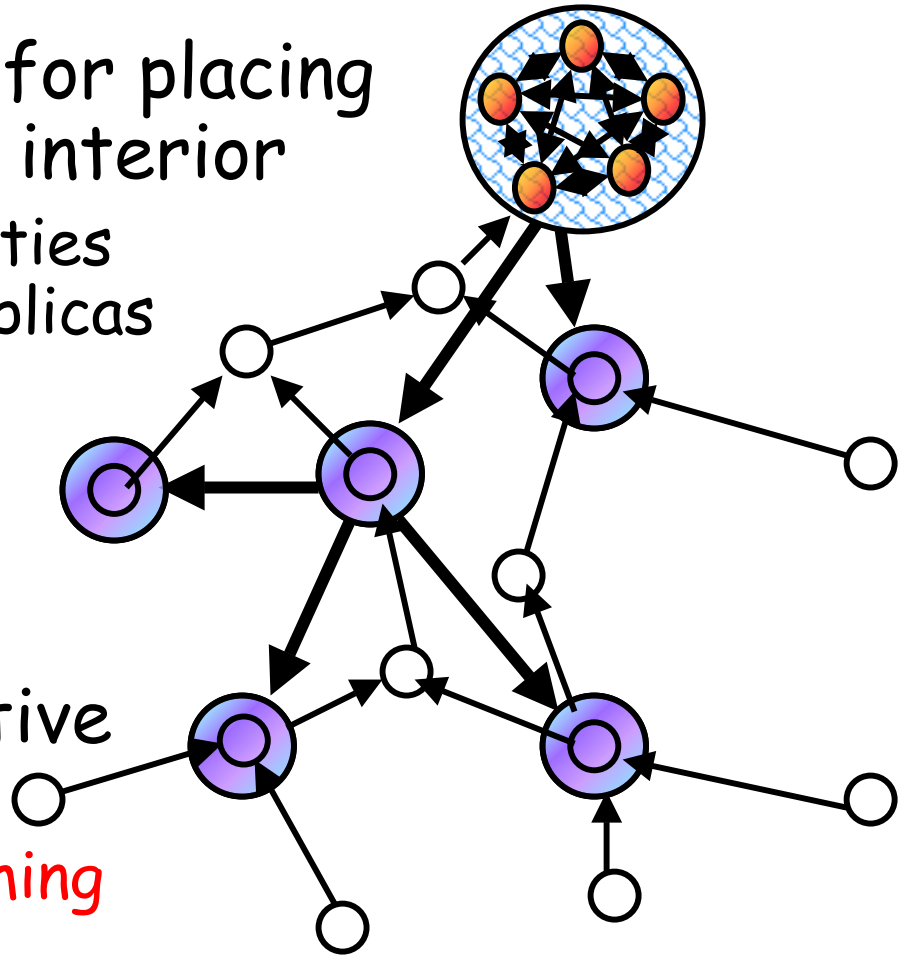
- Planet Lab global network
  - 98 machines at 42 institutions, in North America, Europe, Australia (~ 60 machines utilized)
  - 1.26Ghz PIII (1GB RAM), 1.8Ghz PIV (2GB RAM)
  - North American machines (2/3) on Internet2
  - OceanStore components running "globally:"
- Word on the street: it was "straightfoward."
  - Basic architecture scales
  - Lots of Communications issues (NAT, Timeouts, etc)
  - Locality really important
- Challenge: Stability and fault tolerance!
- Dennis Geels: Analysis (FAST 2003 paper)
- Steve Czerwinski/B. Hoon Kang: Tentative Updates

Enabling Technology: DOLR
(Decentralized Object Location and Routing)
"TAPESTRY"



Self-Organizing second-tier

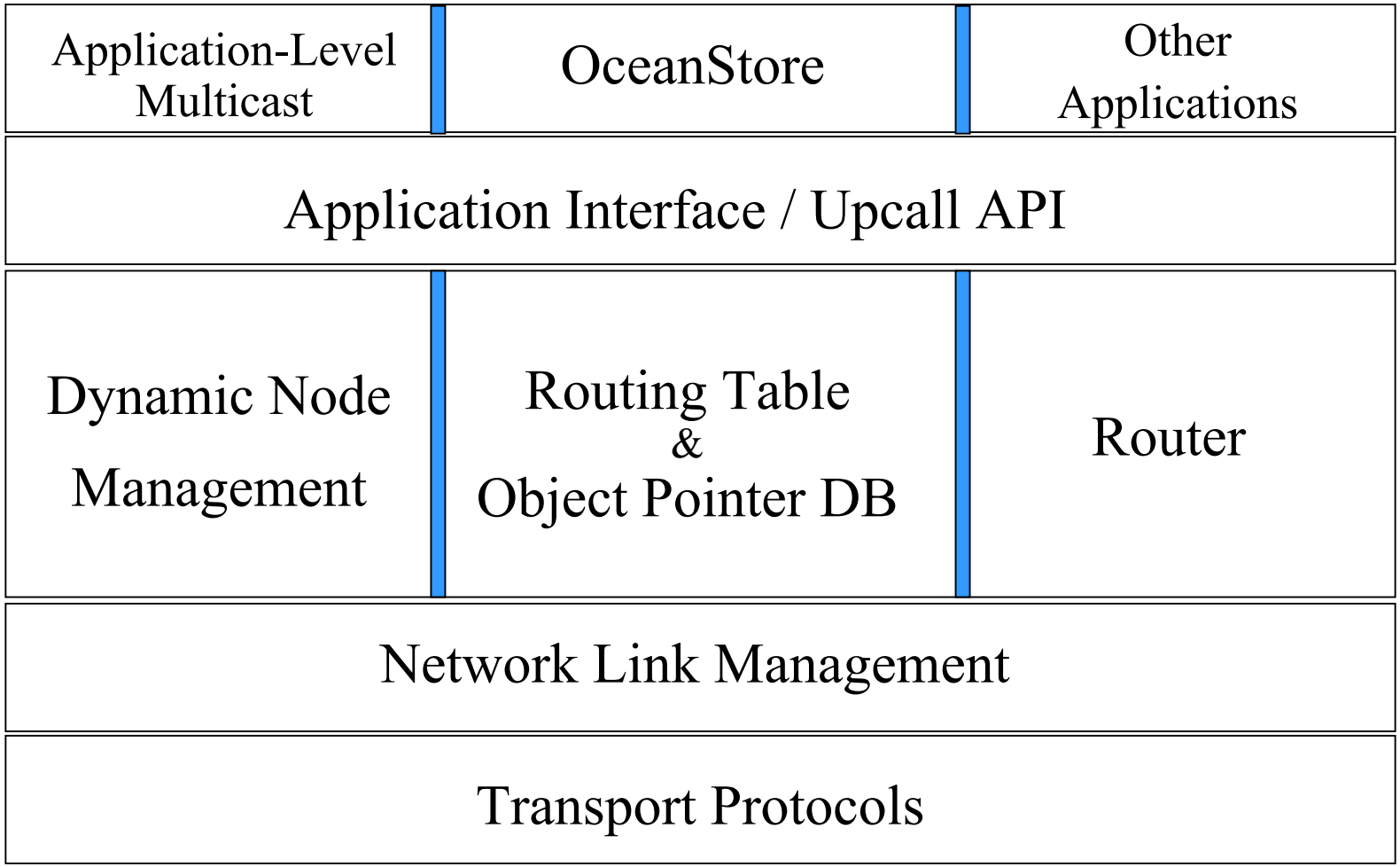
- Have simple algorithms for placing replicas on nodes in the interior
  - Intuition: locality properties of network help place replicas
  - DOLR helps associate parents and children to build multicast tree
- Preliminary results show that this is effective
  - Dennis will talk about effectiveness for streaming updates



Tapestry Stability under Faults

- Instability is the common case….!
  - Small half-life for P2P apps (1 hour????)
  - Congestion, flash crowds, misconfiguration, faults
- *Must Use DOLR under instability!*
  - The right thing must just happen
- Tapestry is natural framework to exploit redundant elements and connections
  - Multiple Roots, Links, etc.
  - Easy to reconstruct routing and location information
  - Stable, repairable layer
- Thermodynamic analogies:
  - Heat Capacity of DOLR network
  - Entropy of Links (decay of underlying order)

Single Node Tapestry

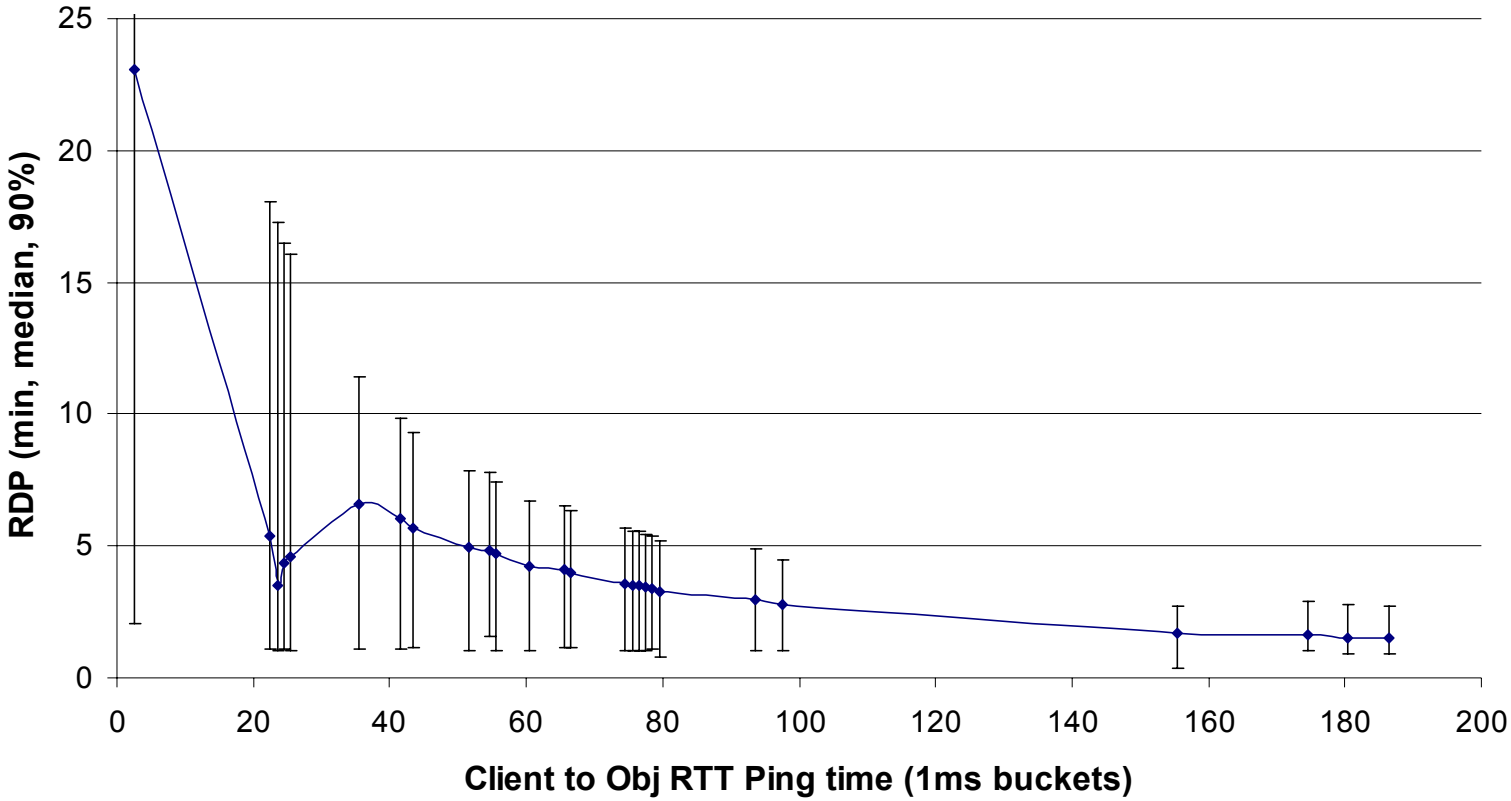


It's Alive On Planetlab!

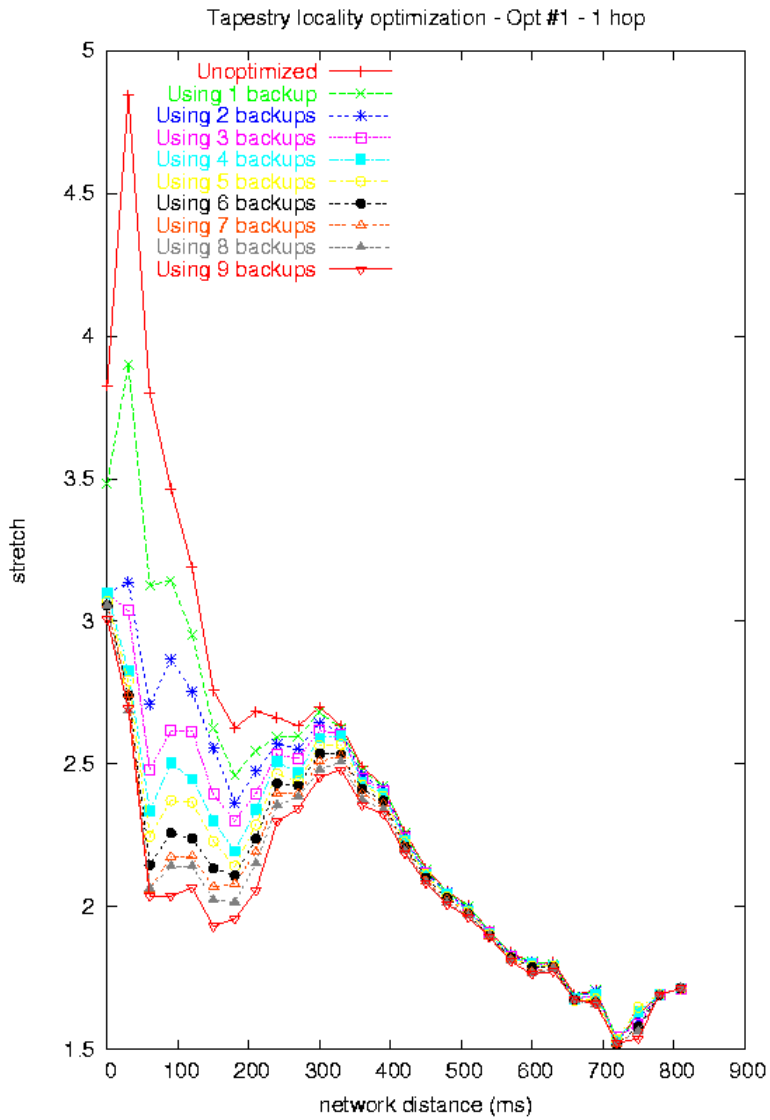
- Tapestry Java deployment
  - 6-7 nodes on each physical machine
  - IBM Java JDK 1.30
  - Node virtualization inside JVM and SEDA
  - Scheduling between virtual nodes increases latency
- Dynamic insertion algorithms mostly working
  - Experiments with many simultaneous insertions
  - Node deletion getting there

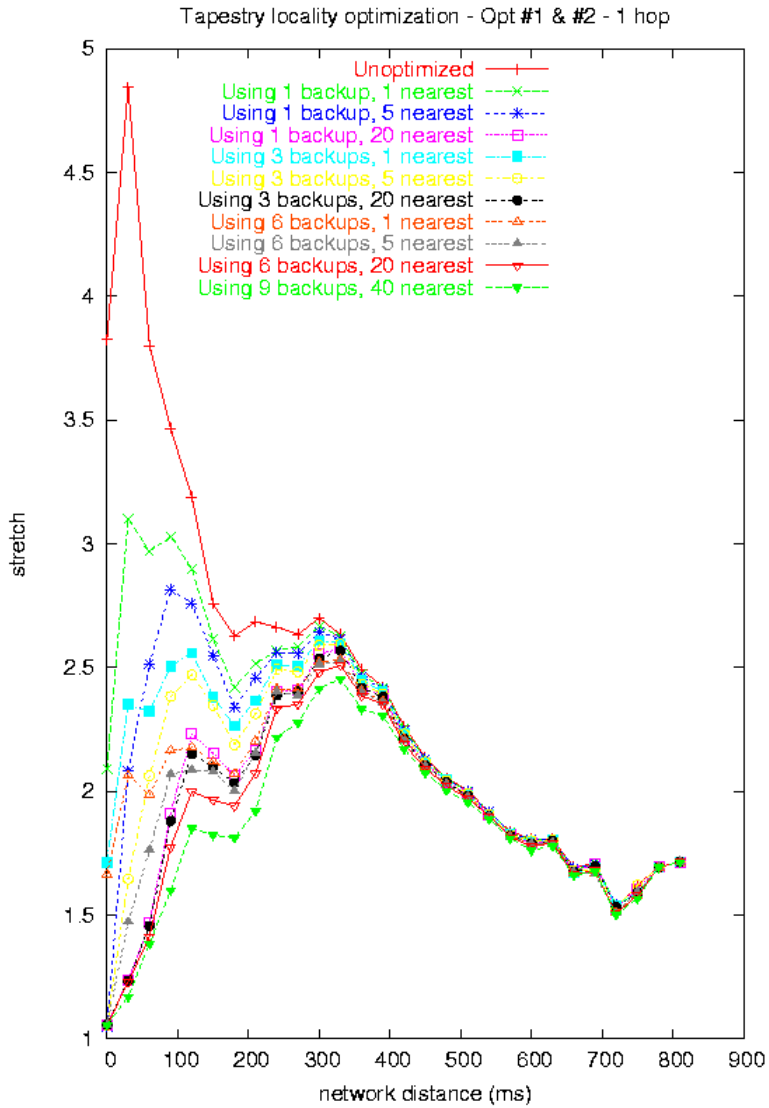
- Tomorrow: Ben Zhao on Tapestry Deployment

Object Location



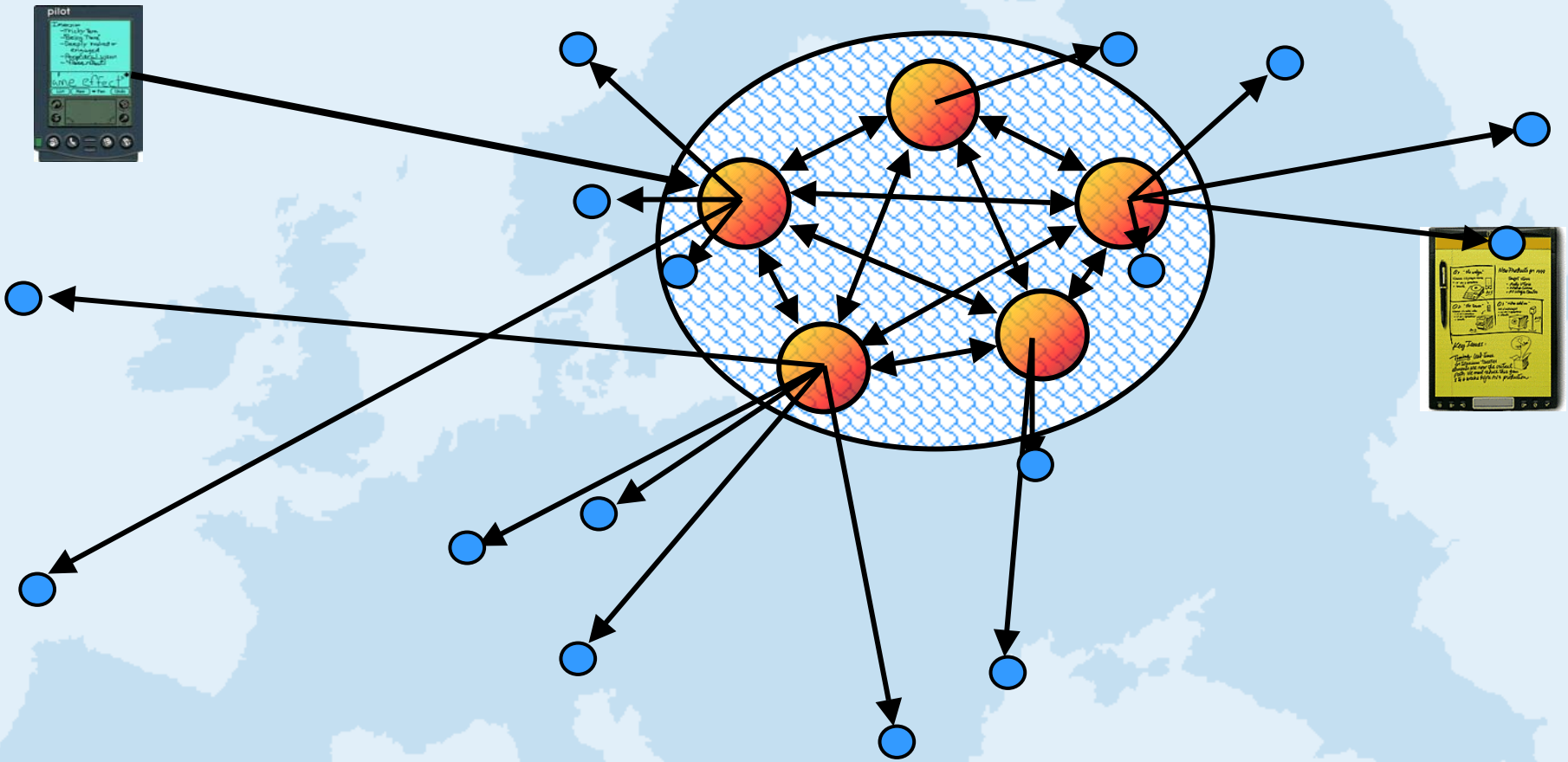
Tradeoff: Storage vs Locality



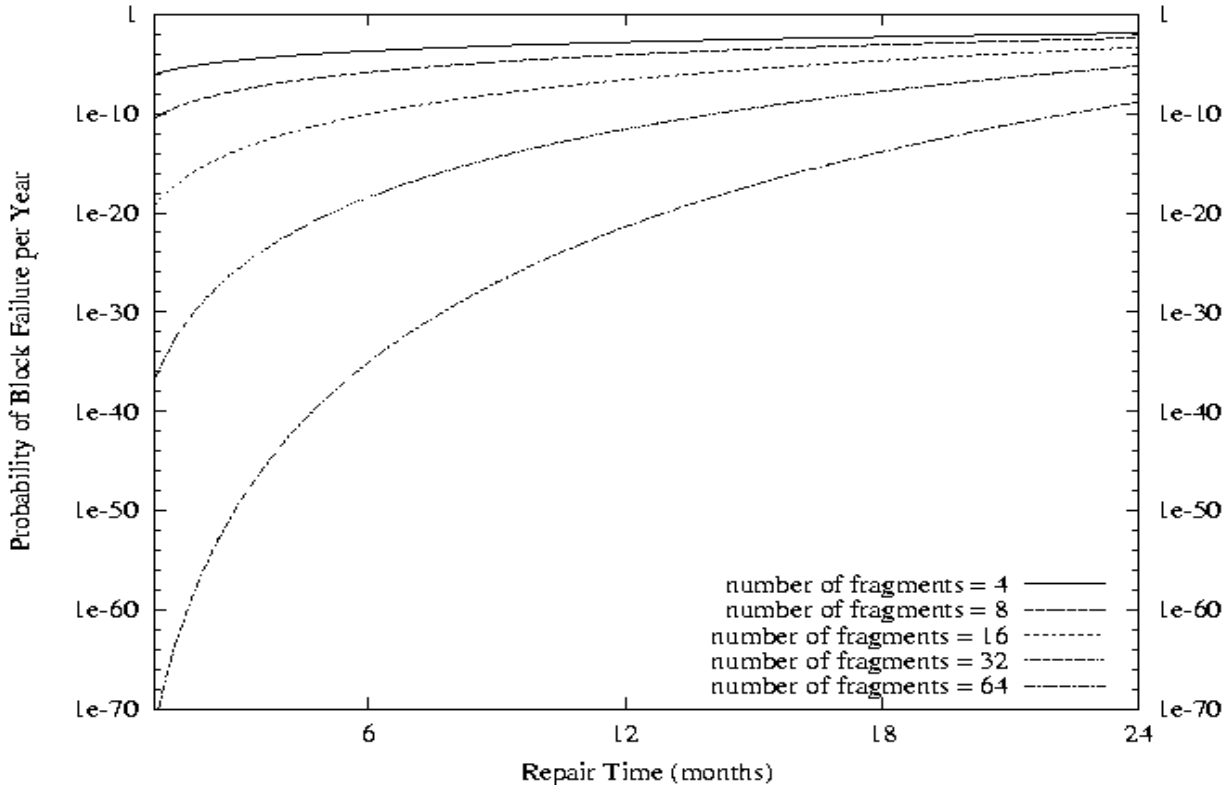


Tomorrow: Jeremy Stribling on Locality

Archival Dissemination of Fragments

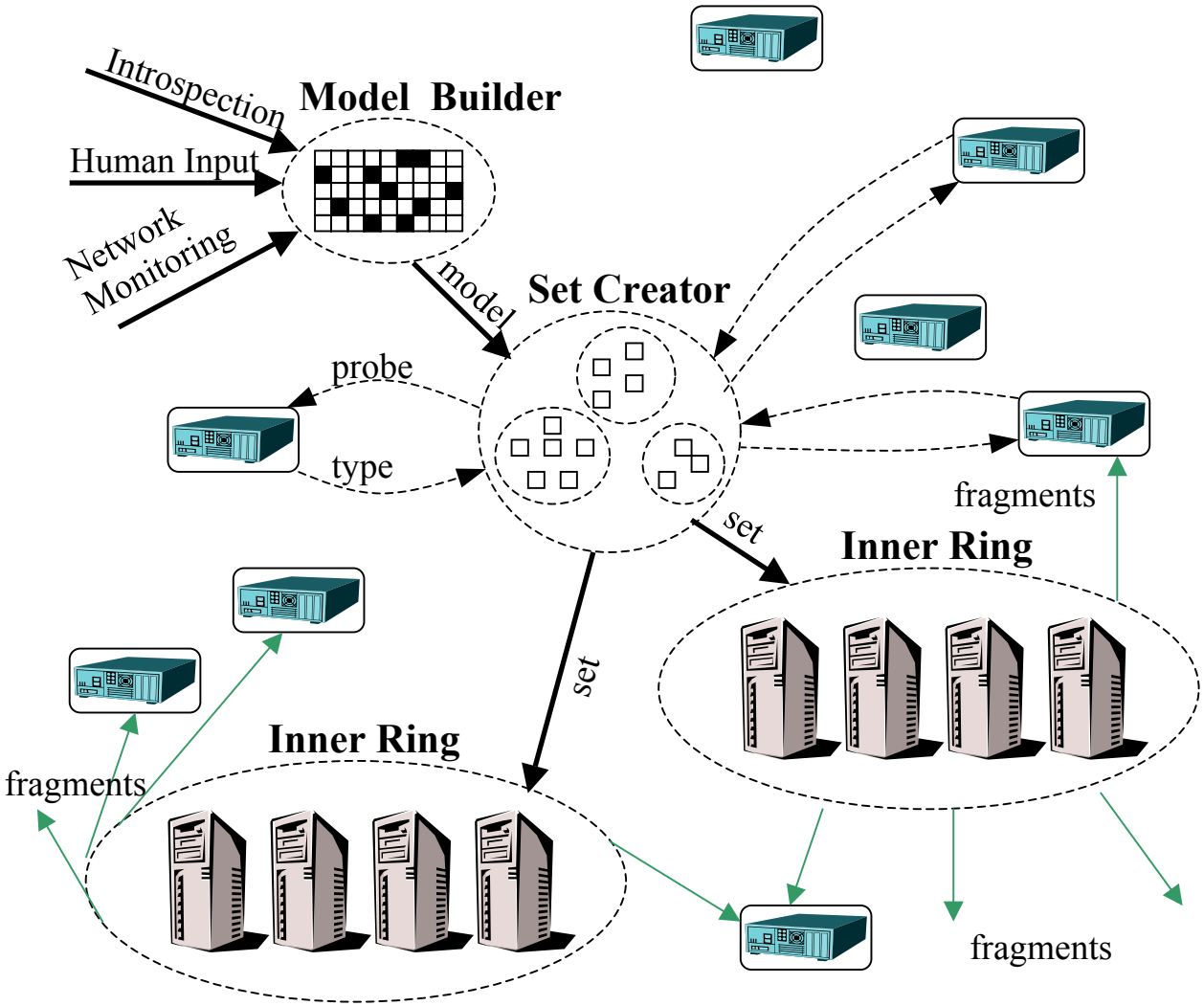


Fraction of Blocks Lost per Year (FBLPY)

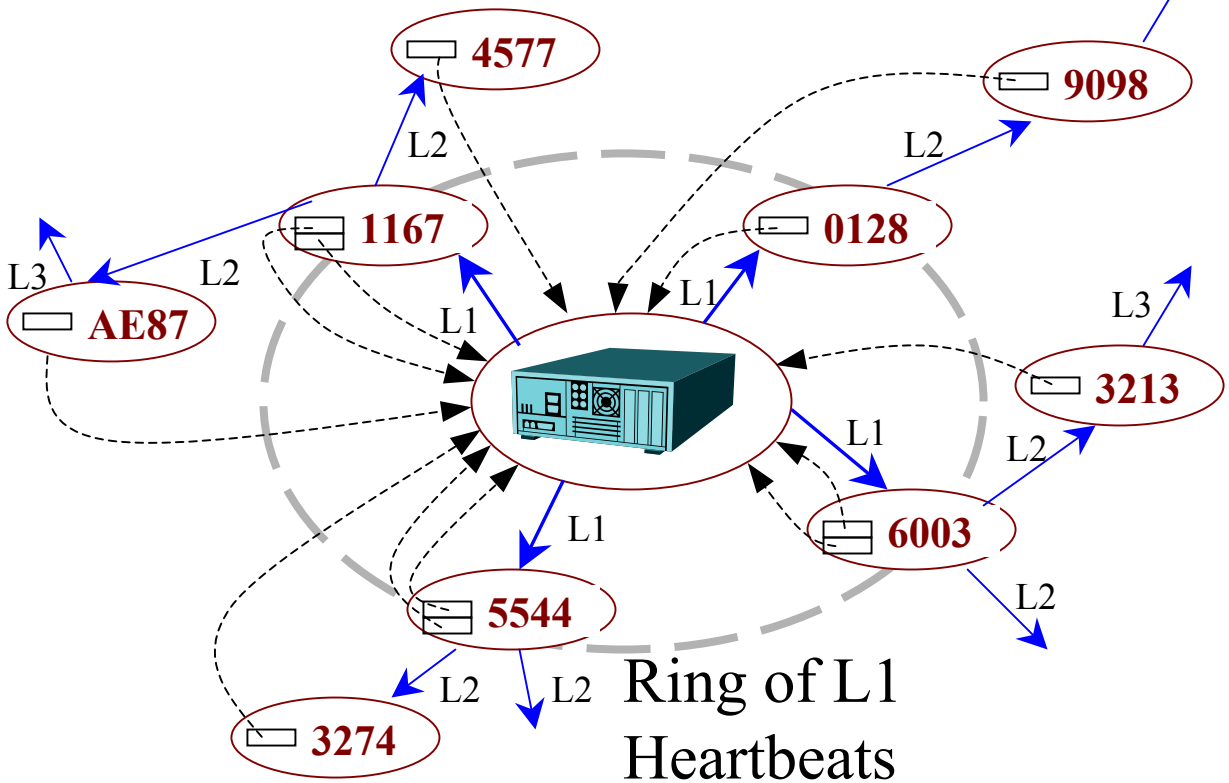


- Exploit law of large numbers for durability!
- 6 month repair, FBLPY:
  - Replication: 0.03
  - Fragmentation: 10^{-35}

The Dissemination Process: Achieving Failure Independence



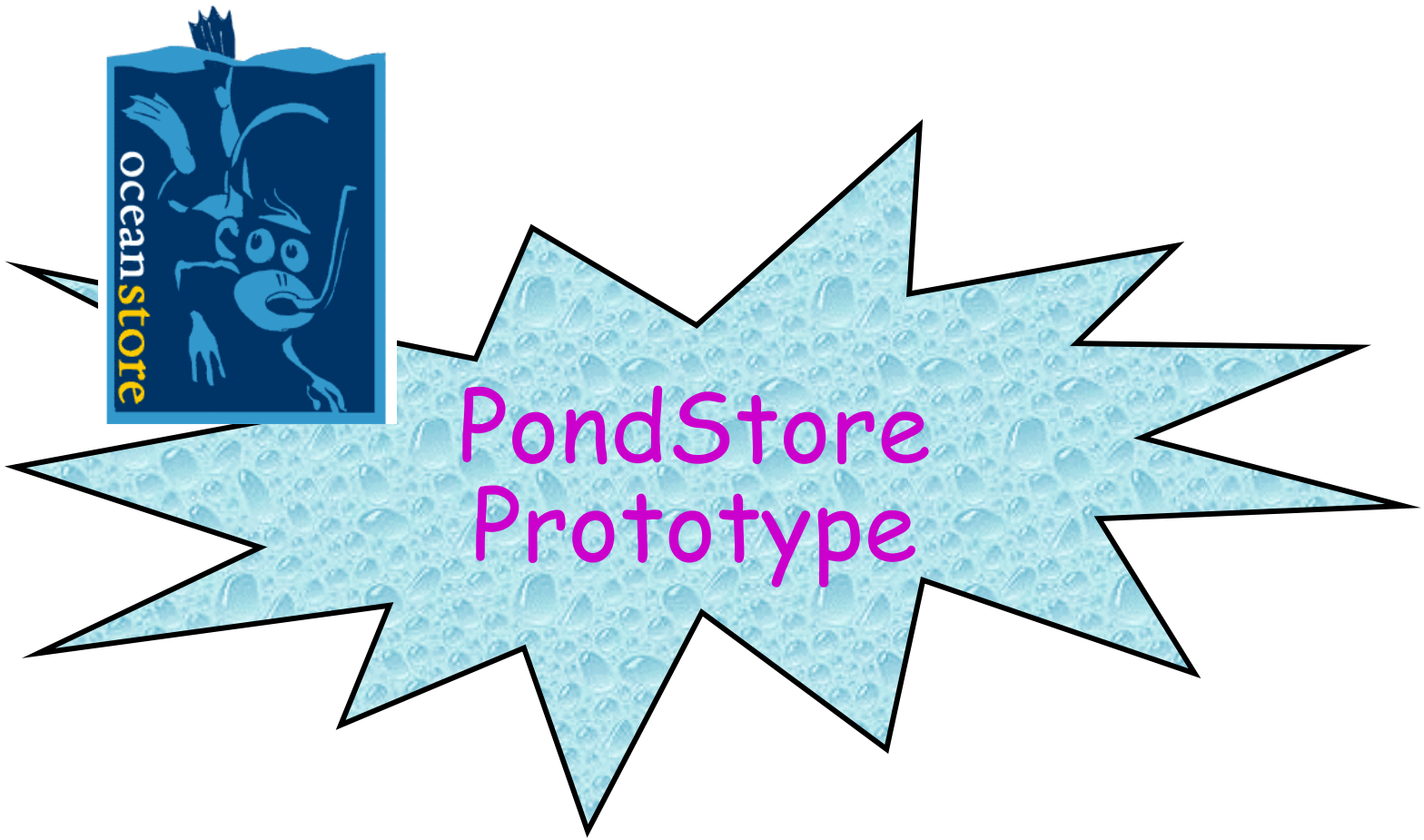
Active Data Maintenance



- Tapestry enables "data-driven multicast"
  - Mechanism for local servers to watch each other
  - Efficient use of bandwidth (locality)

Project Seagull

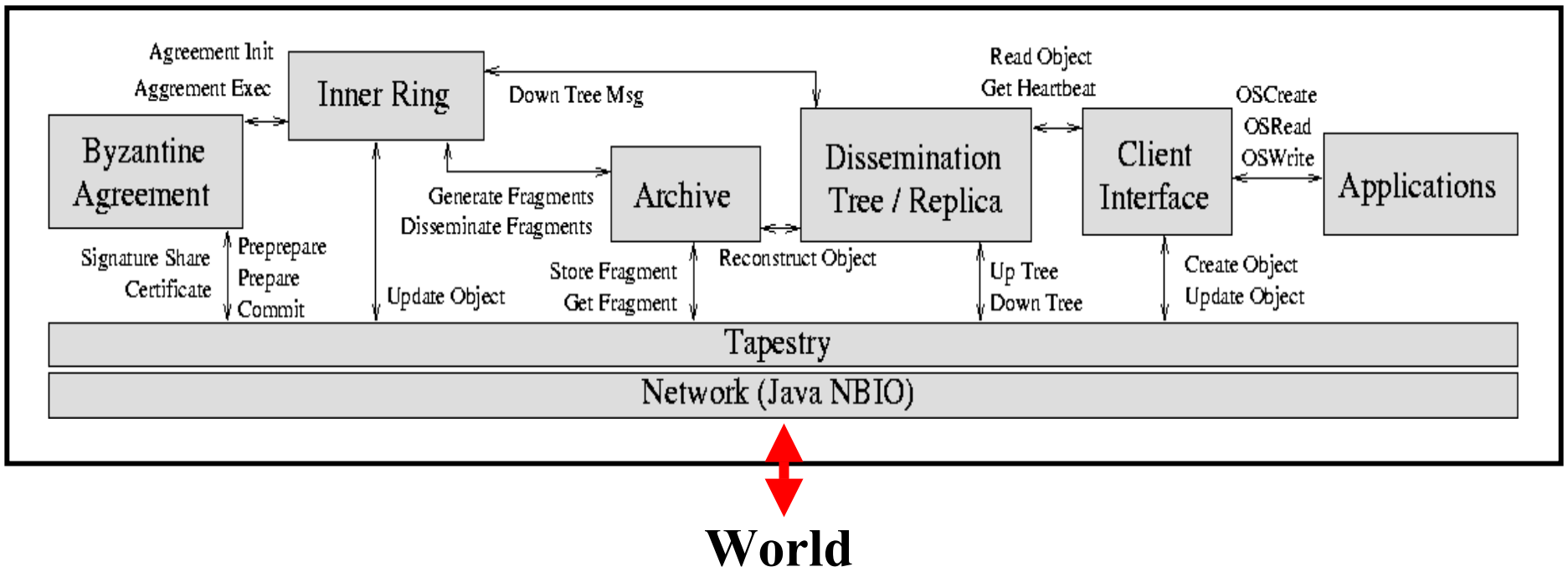
- Push for long-term stable archive
  - Fault Tolerant Networking
  - Periodic restart of servers
  - Correlation analysis for fragment placement
  - Efficient heart-beats for fragment tracking
  - Repair mechanisms
- Use for Backup system
  - Conversion of **dump** to use OceanStore
  - With versioning: yields first-class archival system
- Use for Web browsing
  - Versioning yields long-term history of web sites


oceanstore
PondStore
Prototype

First Implementation [Java]:

- Event-driven state-machine model
  - 150,000 lines of Java code and growing
- Included Components
  - ✓ DOLR Network (Tapestry)
    - Object location with Locality
    - Self Configuring, Self R epairing
  - ✓ Full Write path
    - Conflict resolution and Byzantine agreement
  - ✓ Self-Organizing Second Tier
    - Replica Placement and Multicast Tree Construction
  - ✓ Introspective gathering of tacit info and adaptation
    - Clustering, prefetching, adaptation of network routing
  - ✓ Archival facilities
    - Interleaved Reed-Solomon codes for fragmentation
    - Independence Monitoring
    - Data-Driven Repair
- Downloads available from www.oceanstore.org

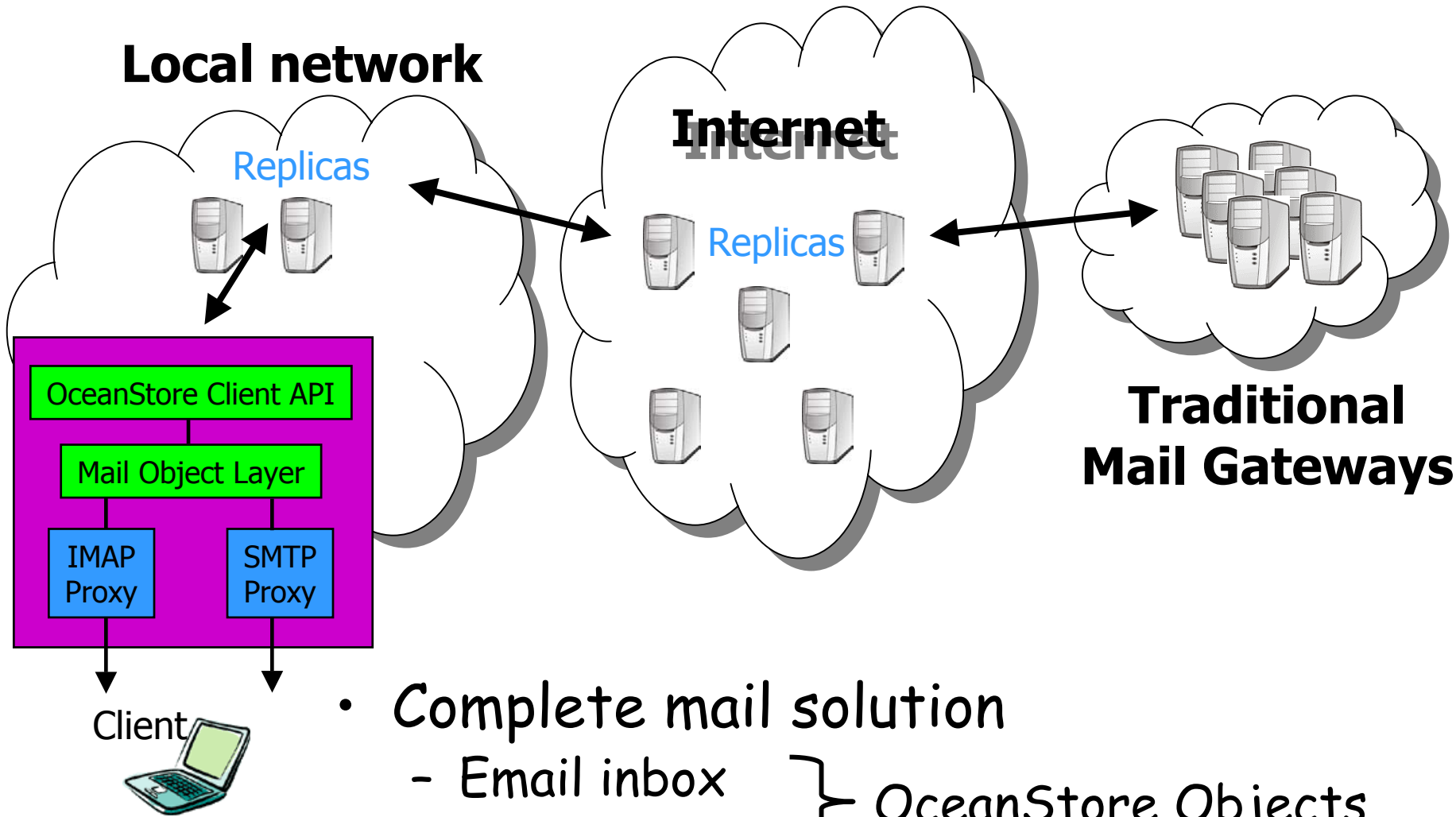
Event-Driven Architecture of an OceanStore Node



- Data-flow style
  - Arrows Indicate flow of messages
- Potential to exploit small multiprocessors at each physical node


Working Applications

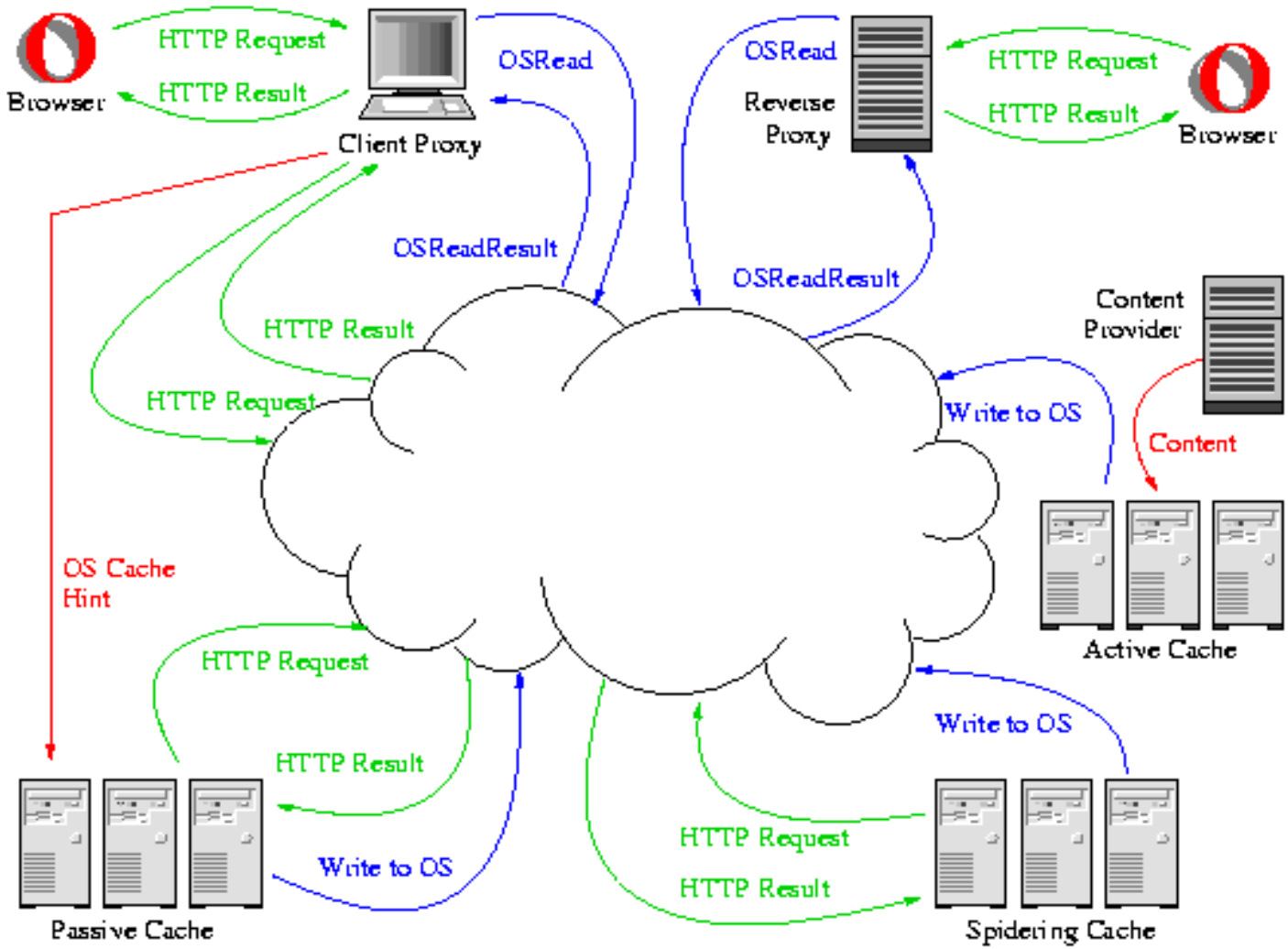
MINO: Wide-Area E-Mail Service



- Complete mail solution
  - Email inbox
  - Imap folders

} OceanStore Objects

Riptide: Caching the Web with OceanStore



Other Apps

- Long-running archive
  - Project Segull
- File system support
  - NFS with time travel (like VMS)
  - Windows Installable file system (soon)
- Anonymous file storage:
  - Nemosyne uses Tapestry by itself
- Palm-pilot synchronization
  - Palm data base as an OceanStore DB
- Come see OceanStore demo at Poster Session: IMAP on OceanStore/Versioned NFS

Future Challenges

- Fault Tolerance
  - Network/Tapestry layer
  - Inner Ring
- Repair
  - Continuous monitoring/restart of components
- Online/offline validation
  - What mechanisms can be used to increase confidence and reliability in systems like OceanStore?
- More intelligent replica management
- Security
  - Data Level security
  - Tapestry-level admission control
- "Eat our Own Dogfood"
  - Continuous deployment of OceanStore components
- Large-Scale Thermodynamic Design
  - Is there a science of aggregate systems design?

OceanStore Sessions
http://10.0.0.1/

- ROC: Monday (3:30pm – 5:00pm)
  - OceanStore Pond Deployment
  - Evolution of Data Format and Structure
  - Tentative Updates
- Shared: Monday (5:30pm – 6:00pm)
  - OceanStore Long-Term Archival Storage
- Sahara: Tuesday (8:30am-9:10am)
  - Tapestry status and deployment
  - Peer-to-peer Benchmarking (Chord/Tapestry)
  - Tapestry Locality Enhancement
- Sahara: Tuesday (11:35-12:00am)
  - Peer-to-peer APIs

For more info:
http://oceanstore.org

- OceanStore vision paper for ASPLOS 2000
  - "OceanStore: An Architecture for Global-Scale Persistent Storage"
- OceanStore Prototype (FAST 2003):
  - "Pond: the OceanStore Prototype"
- Tapestry algorithms paper (SPAA 2002):
  - "Distributed Object Location in a Dynamic Network"
- Upcoming Tapestry Deployment Paper (JSAC)
  - "Tapestry: a Global-Scale Overlay for Rapid Service Deployment"
- Probabilistic Routing (INFOCOM 2002):
  - "Probabilistic Location and Routing"
- Upcoming CACM paper (not until February):
  - "Extracting Guarantees from Chaos"