# Experiences in Building and Operating ePOST, a Reliable Peer-to-Peer Application

Alan Mislove[†‡] Ansley Post[†‡] Andreas Haeberlen[†‡]
Peter Druschel[†]

[†]Max Planck Institute for Software Systems
[‡]Rice University


# Reliable P2P Systems: Myth or Reality?

- For the past few years, much research interest in p2p
  - Highly scalable in nodes and data
  - Utilization of underused resources
  - Robust to large range of workloads and failures

- Most deployed systems are not reliable [Kazaa, Skype, etc]
  - None attempt to store data reliably, durably, or securely
  - Lead some to conclude p2p can't support reliable applications

- Question: Can peer-to-peer systems provide reliable service?

# Demonstration Application: ePOST

- ePOST is an email service built using decentralized components
  - Completely decentralized, no ‘email servers’

- Email one of the most important Internet applications
  - Privacy
  - Integrity
  - Durability
  - Availability

- Wanted to develop system to a point where people rely on it

# ePOST: Deployment

- Built and deployed ePOST within our group
  - Running for over 2 years
  - Processed well over 500,000 email messages

- Built ePOST to be more reliable than existing email systems
  - 16 users used ePOST as primary email
  - Even my advisor!

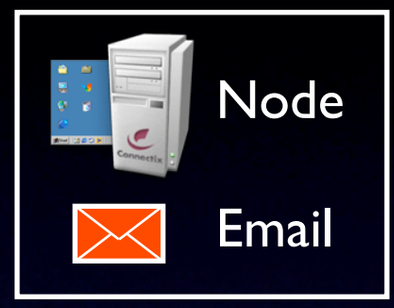
- Many challenges found by building the system
  - After challenges solved, provides reliable service
  - Robust; numerous times ePOST was only mail service working

# Rest of Talk

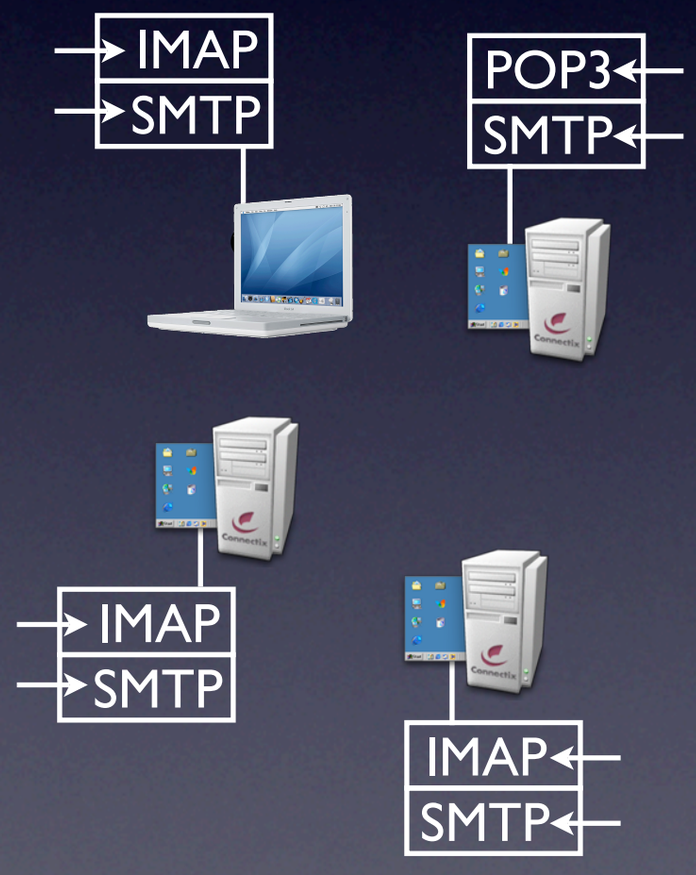
- ePOST in detail
- Challenges faced in building and deploying ePOST
- Conclusion

# ePOST: Architecture

- Each participating node runs mail servers for the local user
  - Email service looks the same to users




- Data stored cooperatively on participating machines
  - Machines form overlay
  - Replicated for redundancy

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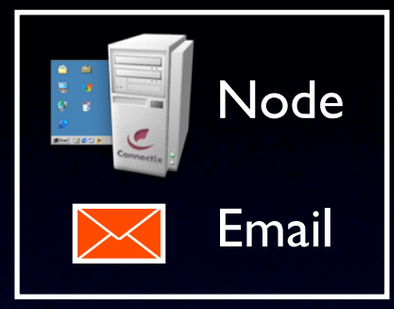


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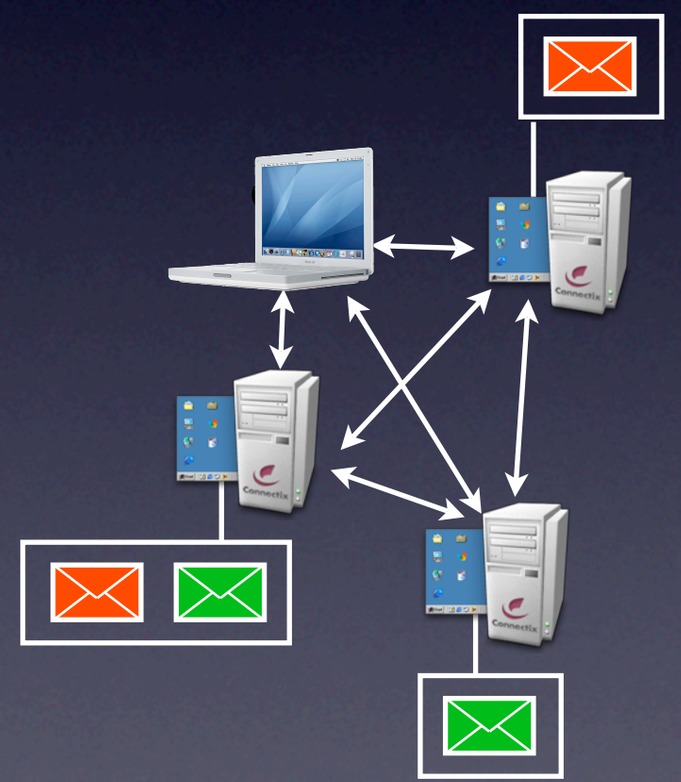

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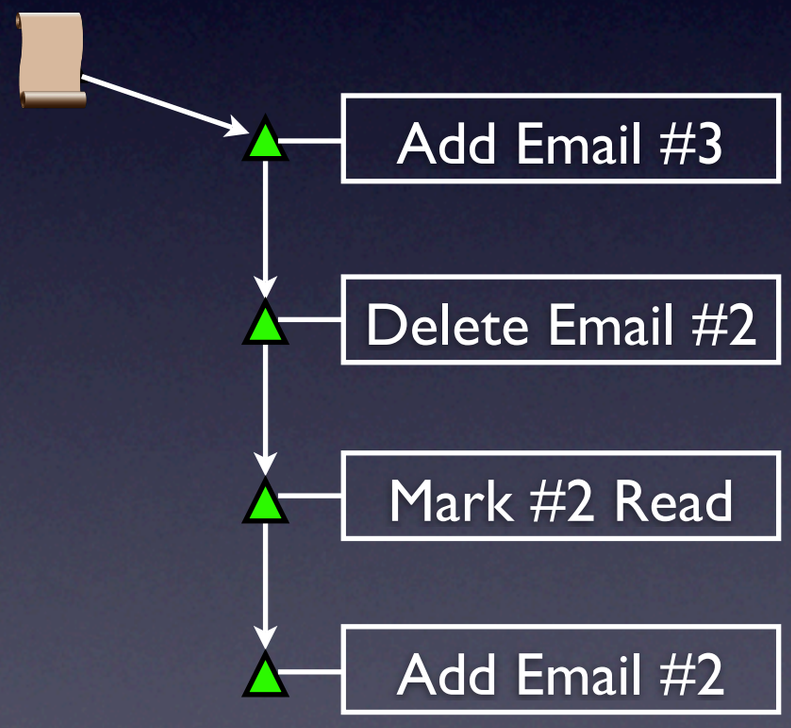


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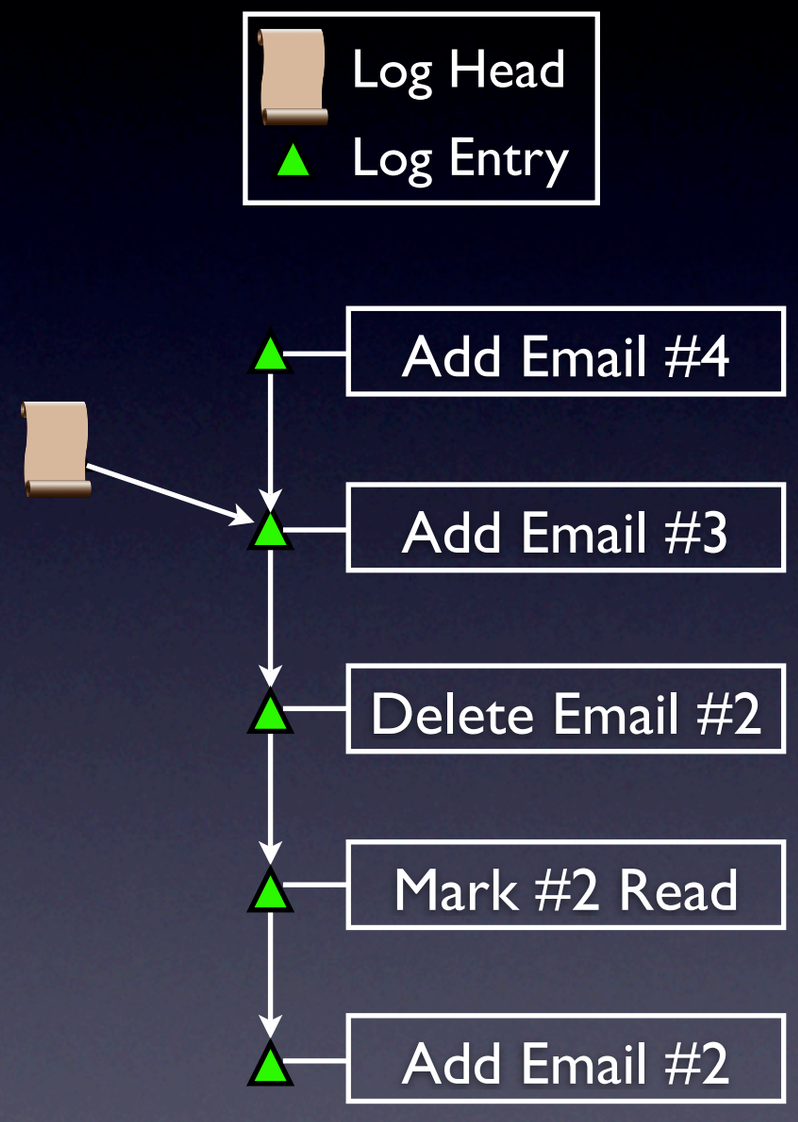




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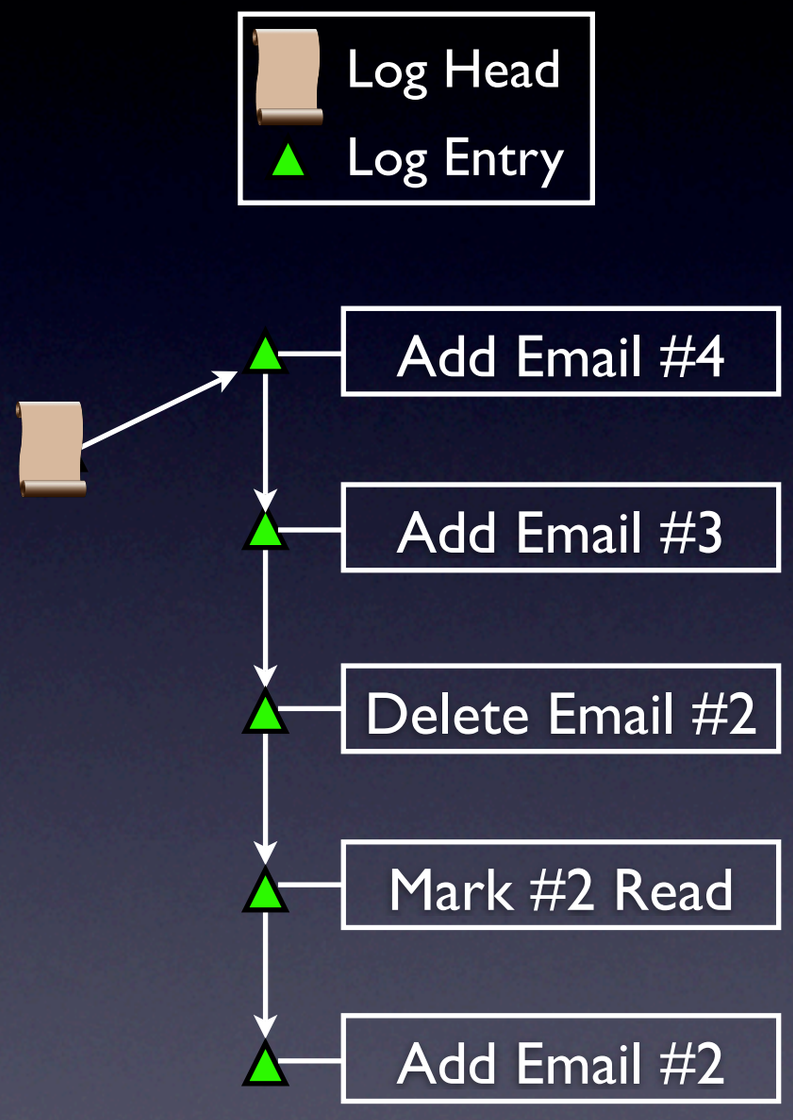




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- Network partitions
- NATs and firewalls
- Routing anomalies
- Node churn
- Correlated failures
- Resource consumption
- Data storage
- Slow nodes
- Hidden single points of failure
- Data corruption
- Comatose nodes
- Complex failure modes
- Very unsynchronized clocks
- Lost key material
- Disconnected nodes
- Power failures
- Resource exhaustion
- Spam attacks on relays
- Java eccentricities
- Congested links
- PlanetLab slice deletion
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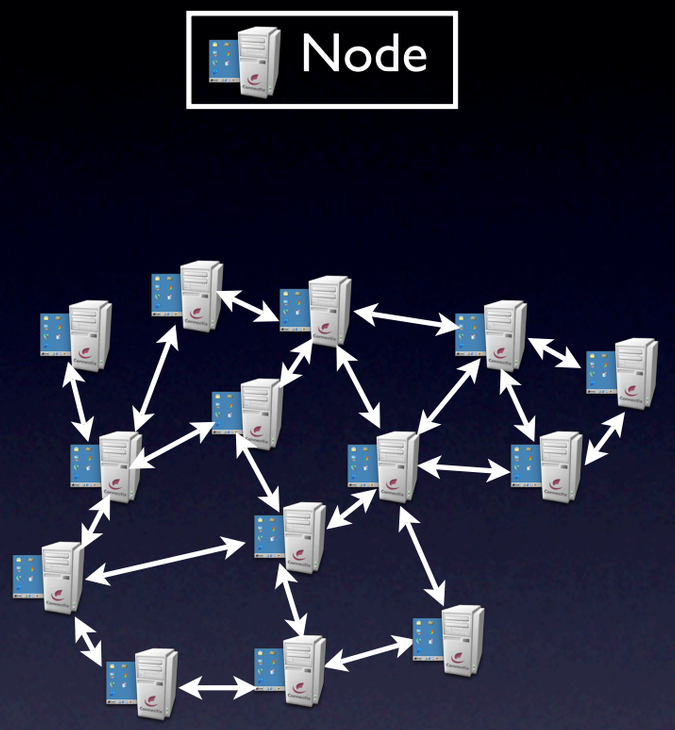

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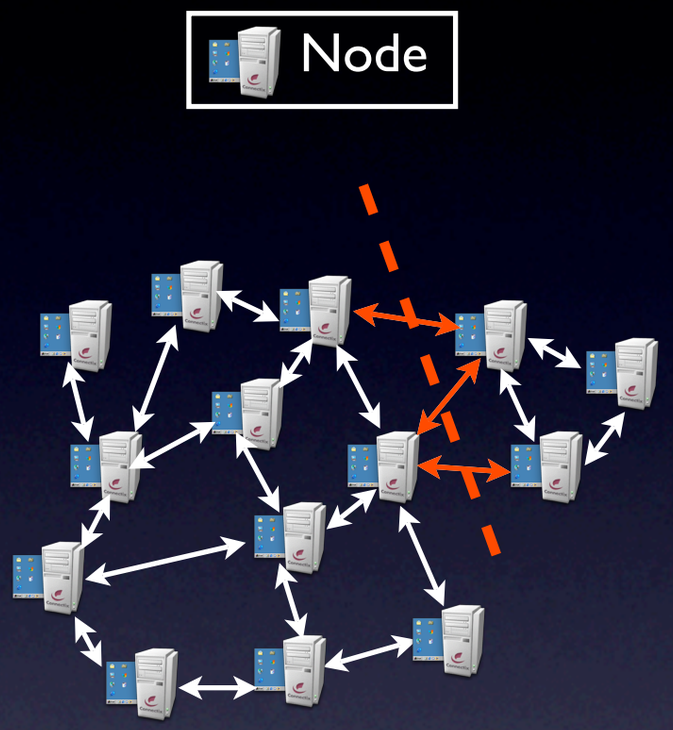

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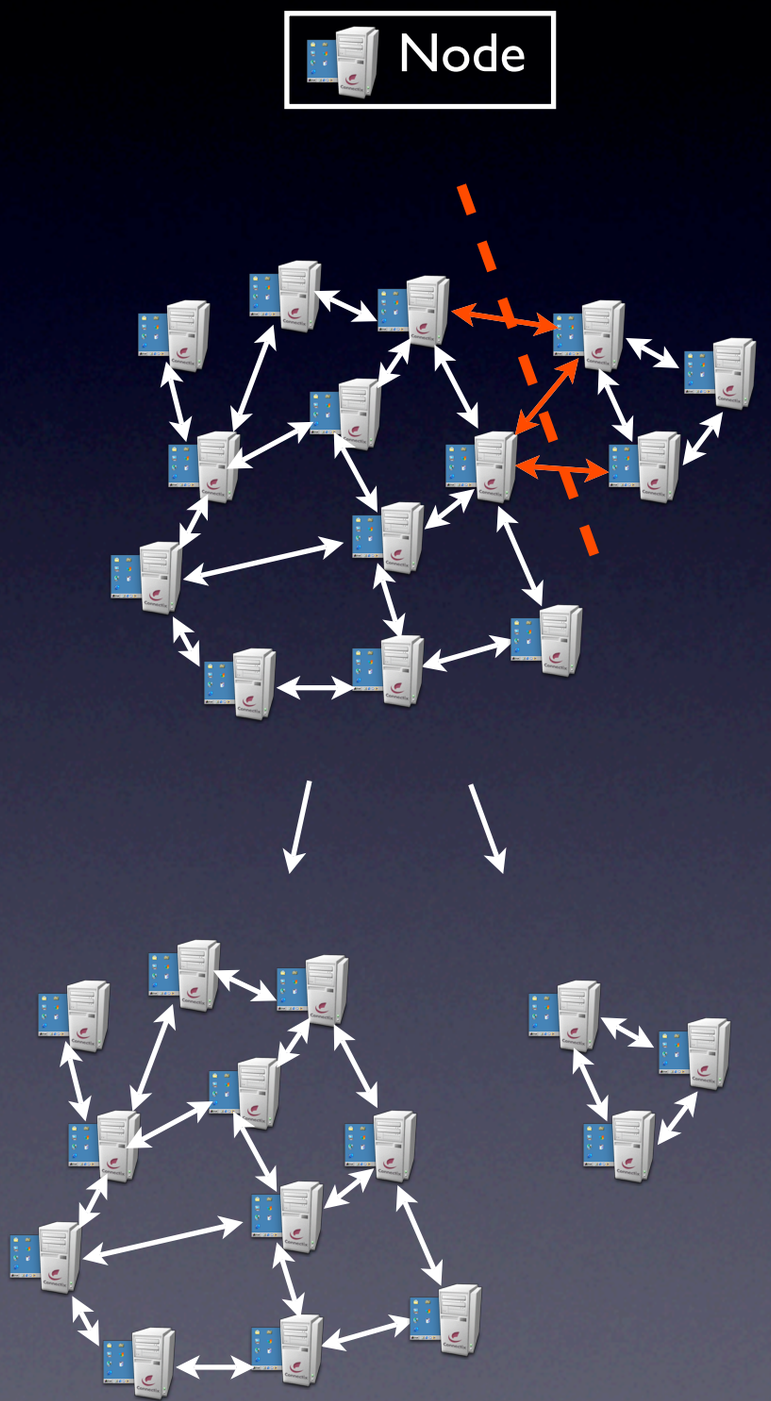
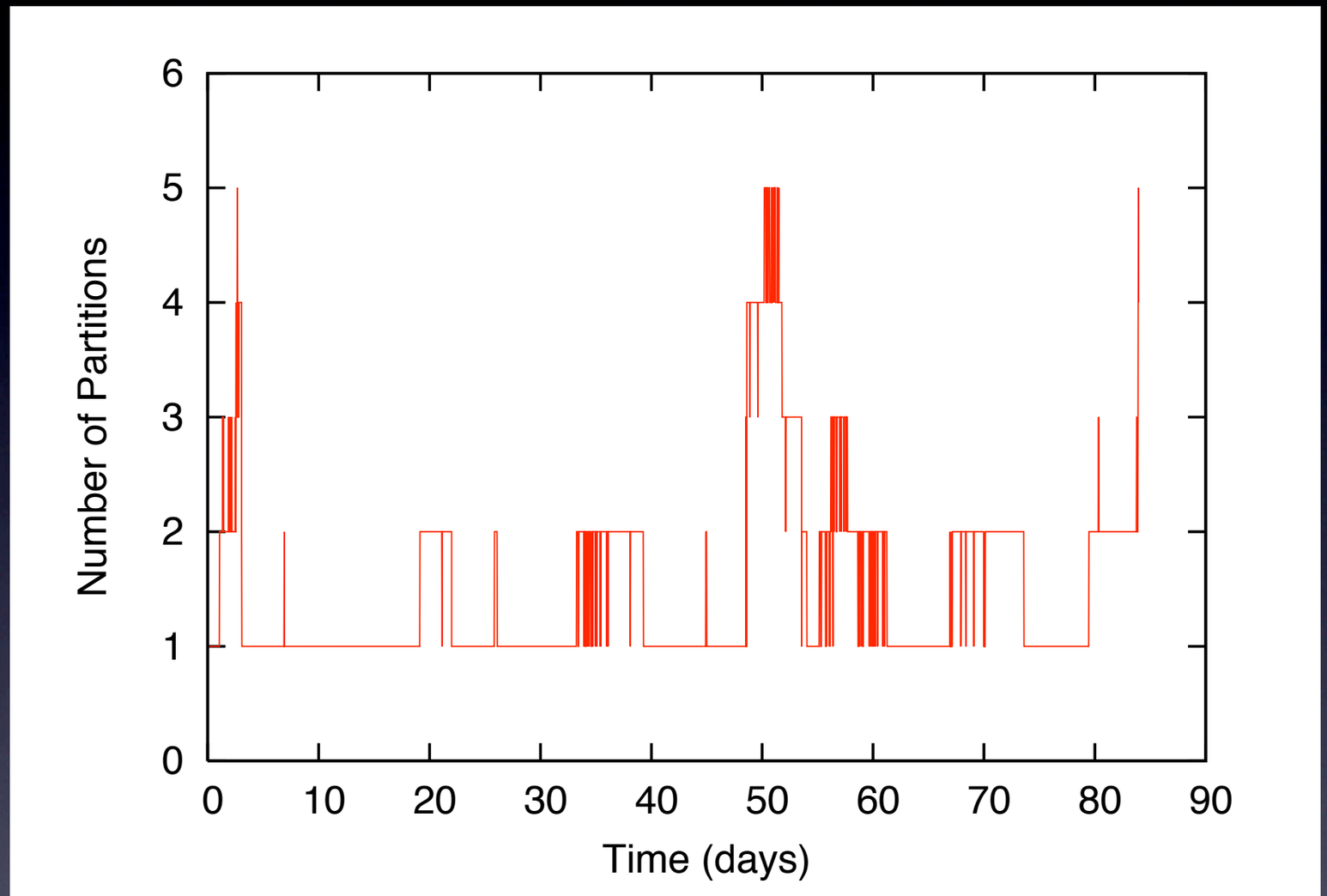
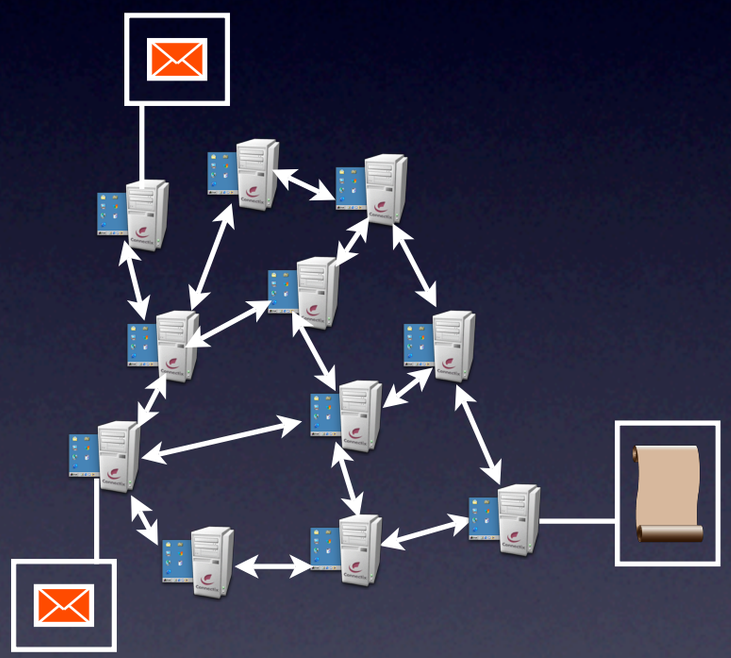


# How frequent are partitions?




- Partitions occur often in PlanetLab
  - Usually a single subnet (PlanetLab site) becomes partitioned

# Impact of Network Partitions

- Tradeoff between consistency and availability under partitions
  - Well-known tradeoff
  - ePOST resolves this in favor of availability
- Partitions cause consistency problems
  - Small partitions have data inaccessibility
  - Mutable data can diverge
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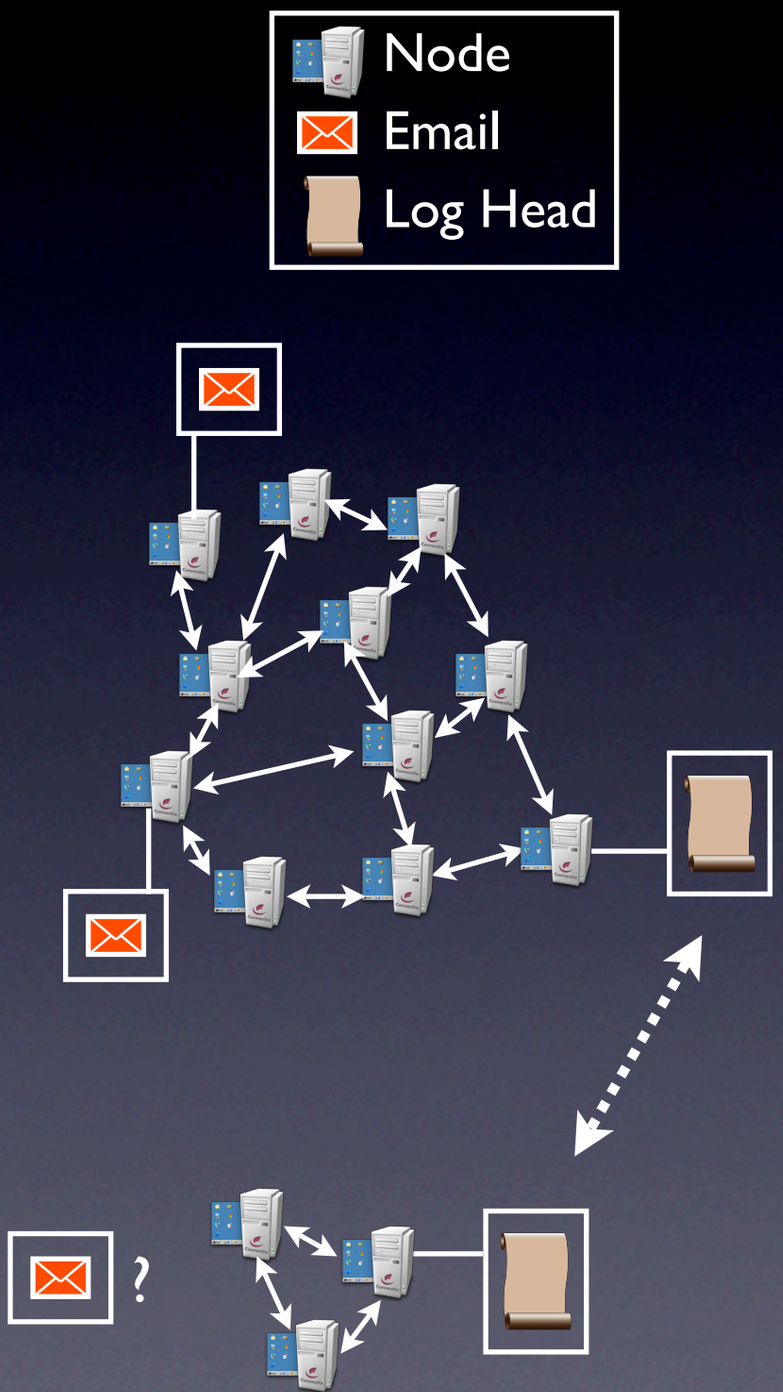


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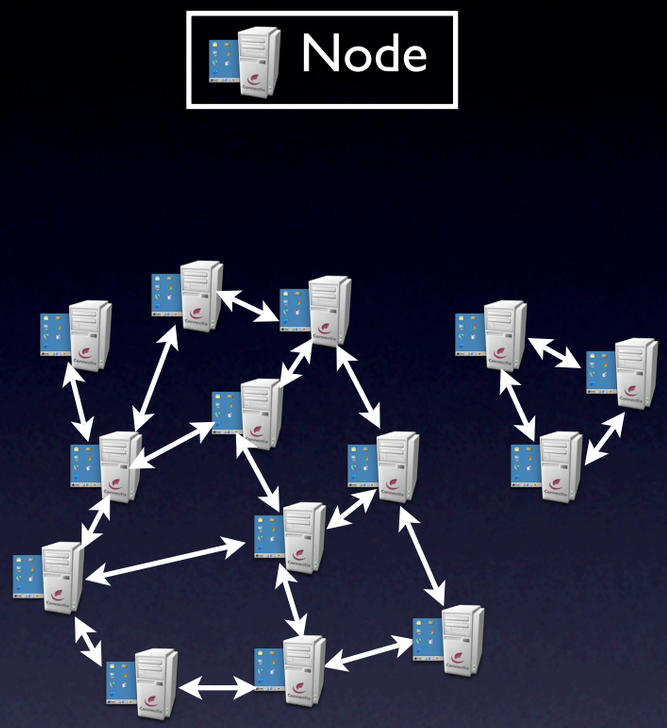
  - Periodically query these nodes, and integrate missing nodes into overlay

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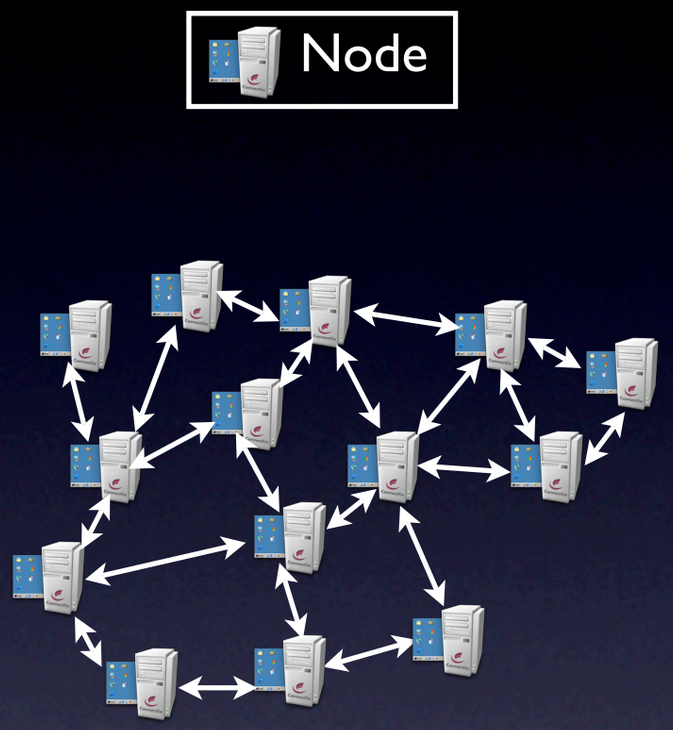


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  - Data divergence unlikely due to single-writer behavior

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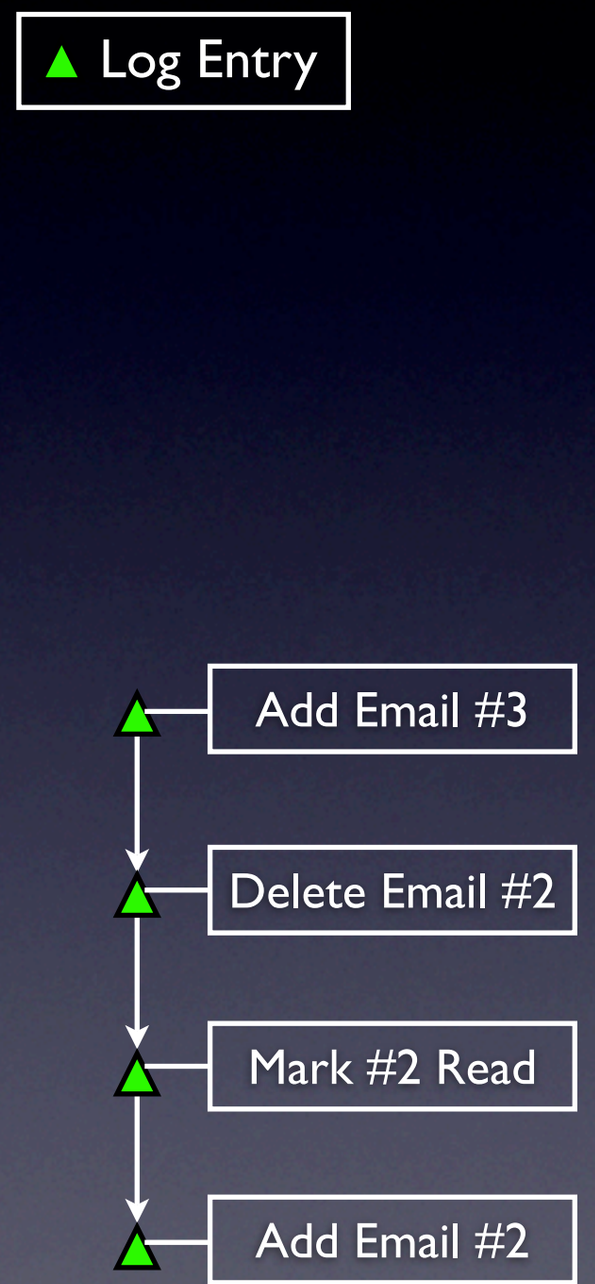

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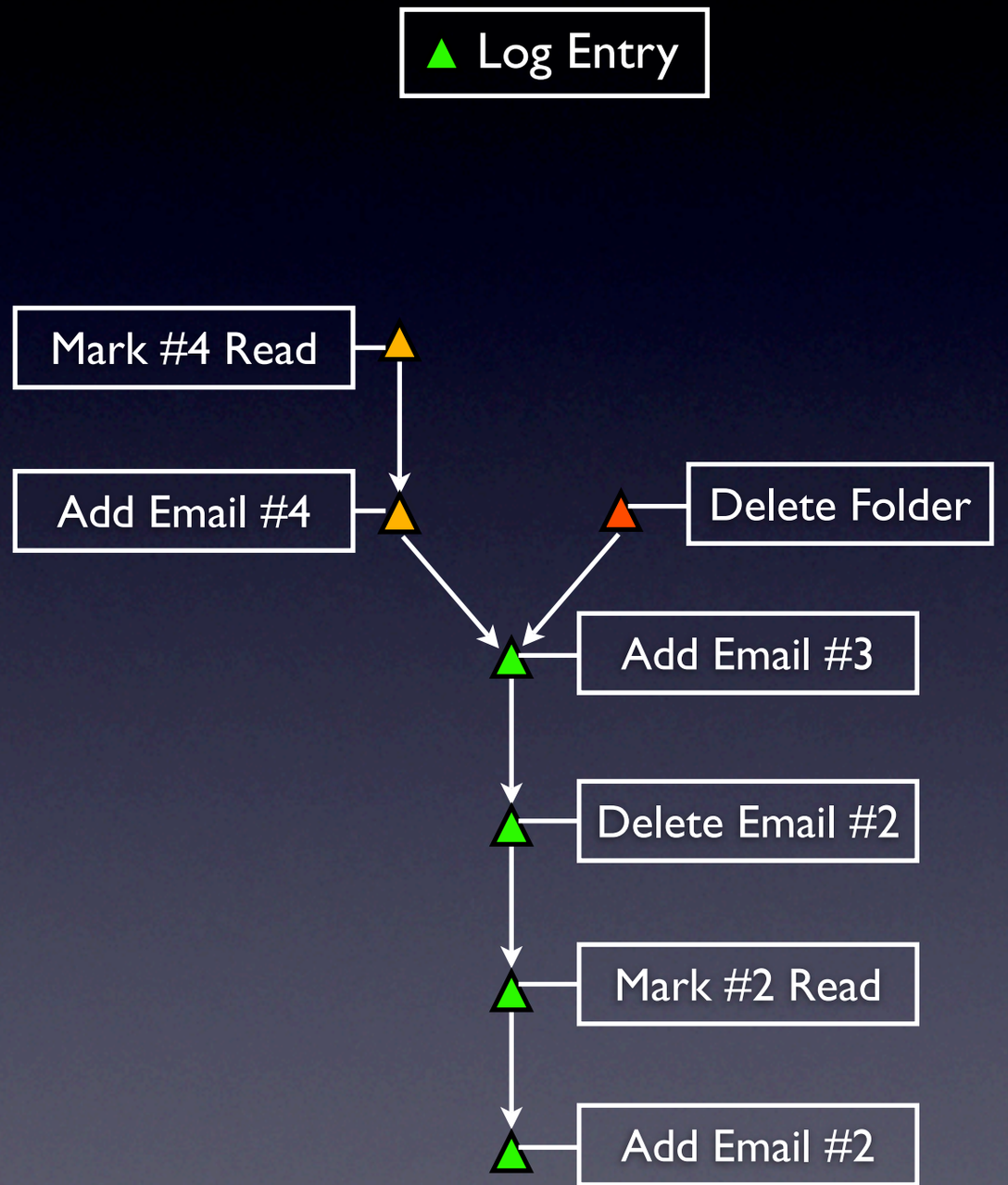


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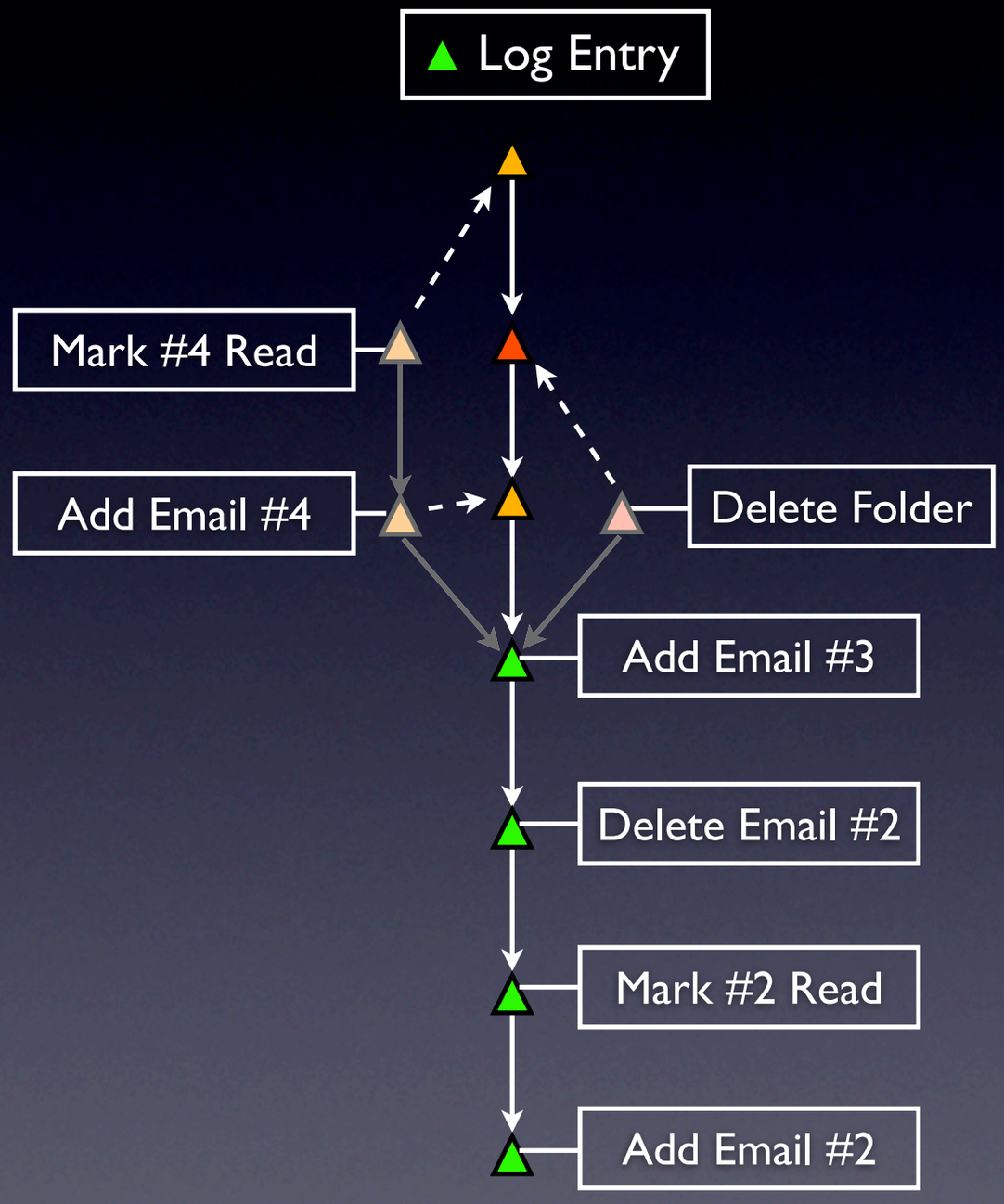

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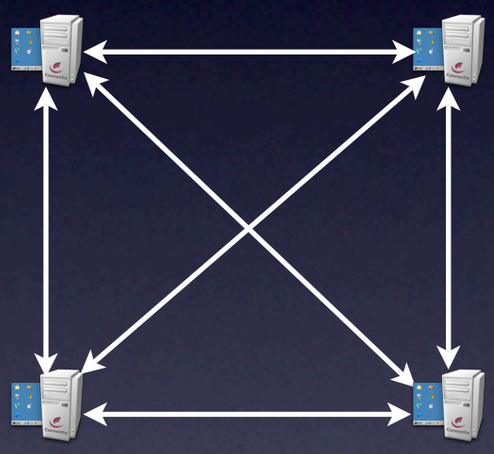


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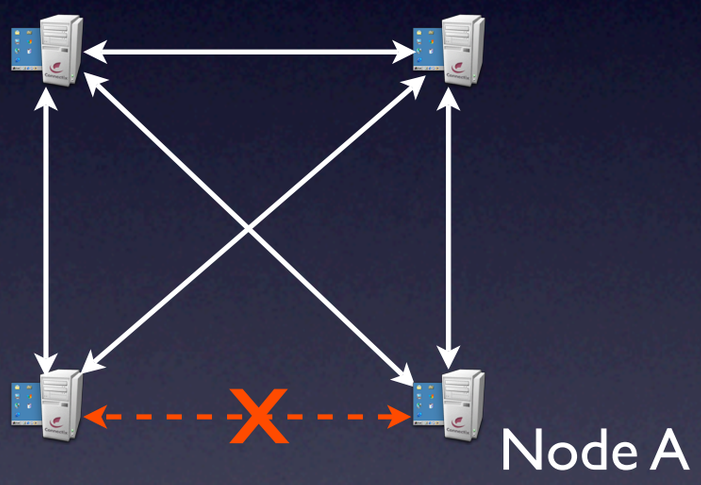


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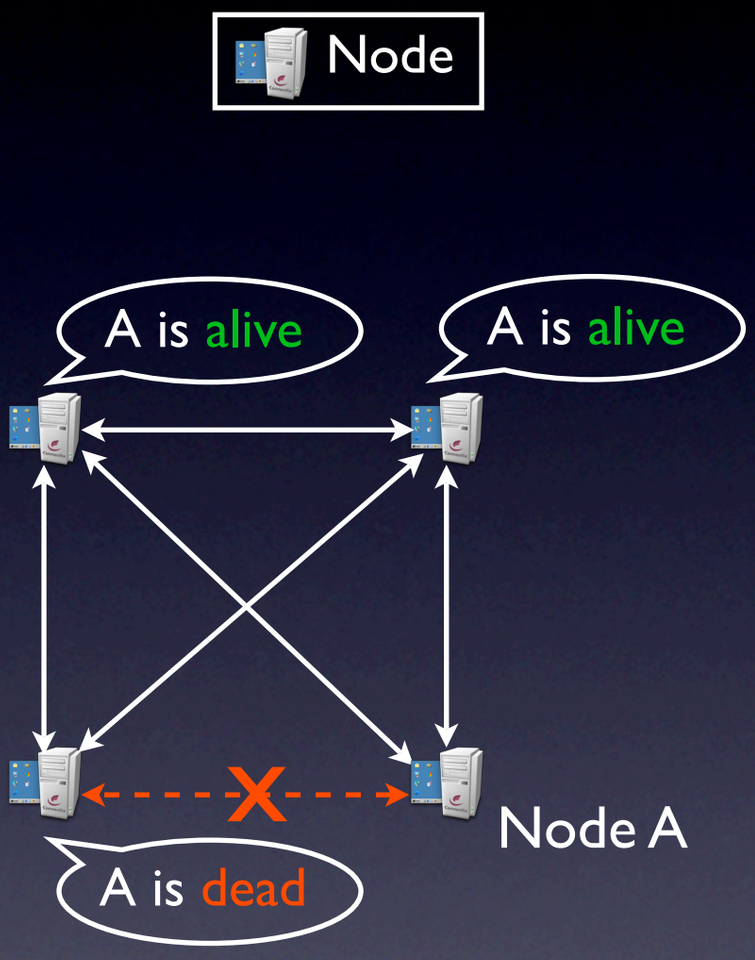


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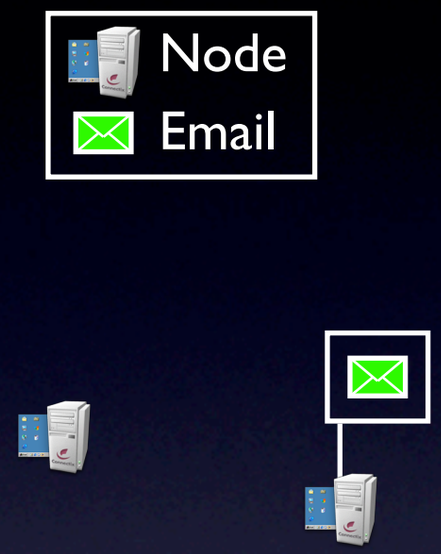

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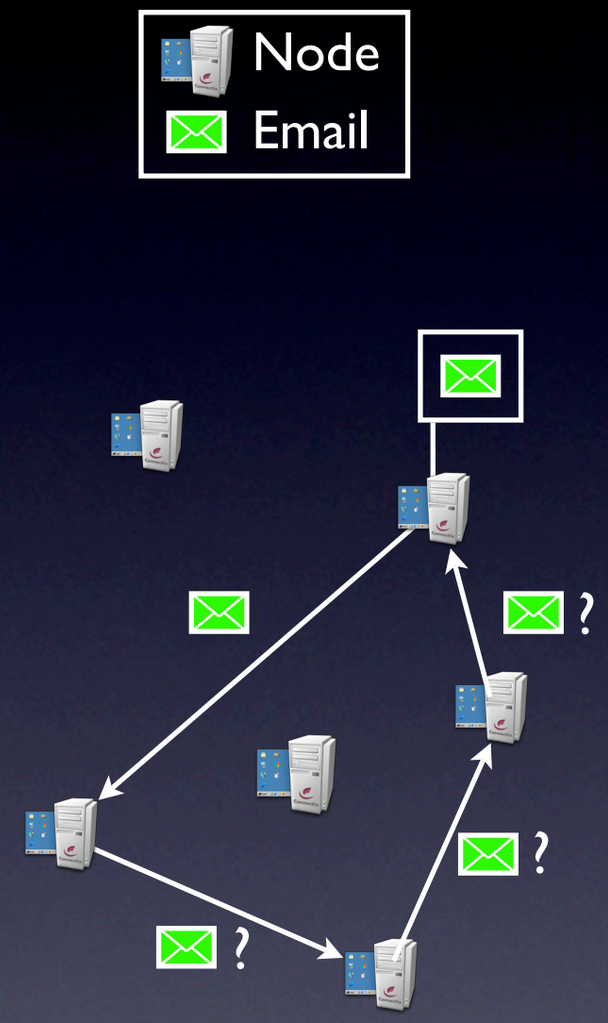

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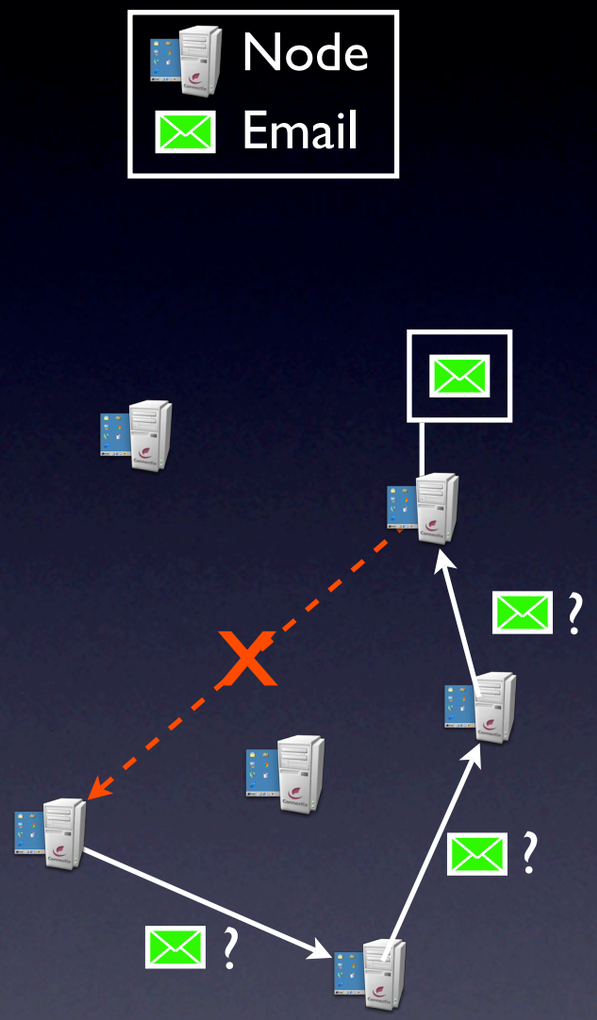

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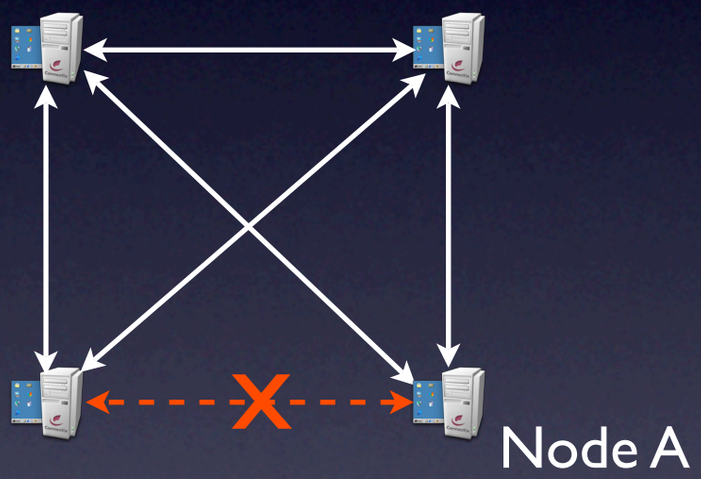


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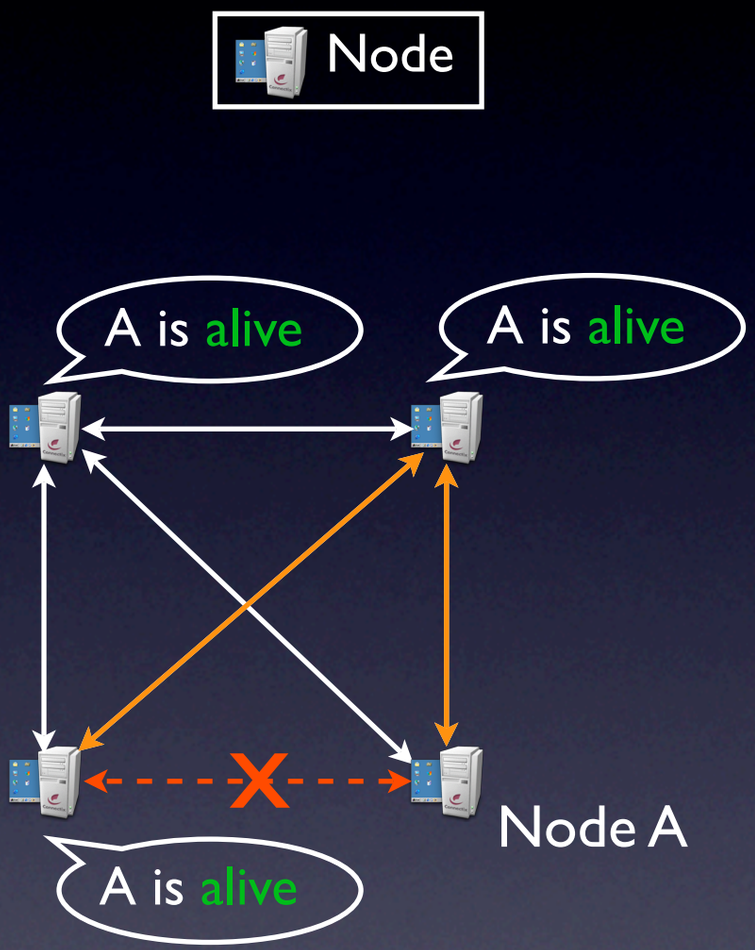


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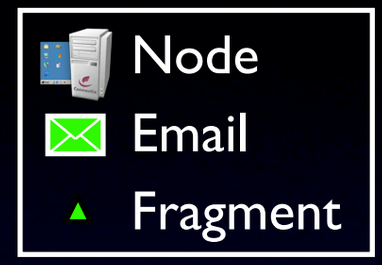


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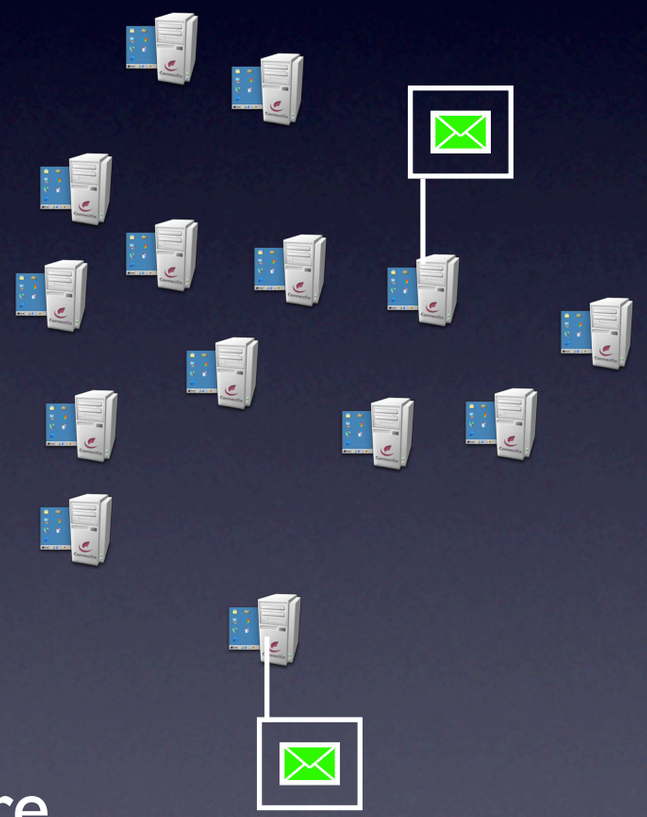

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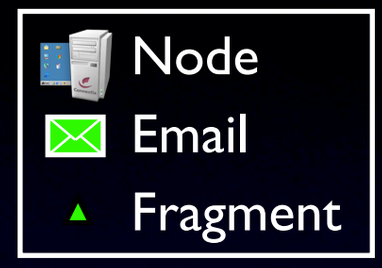


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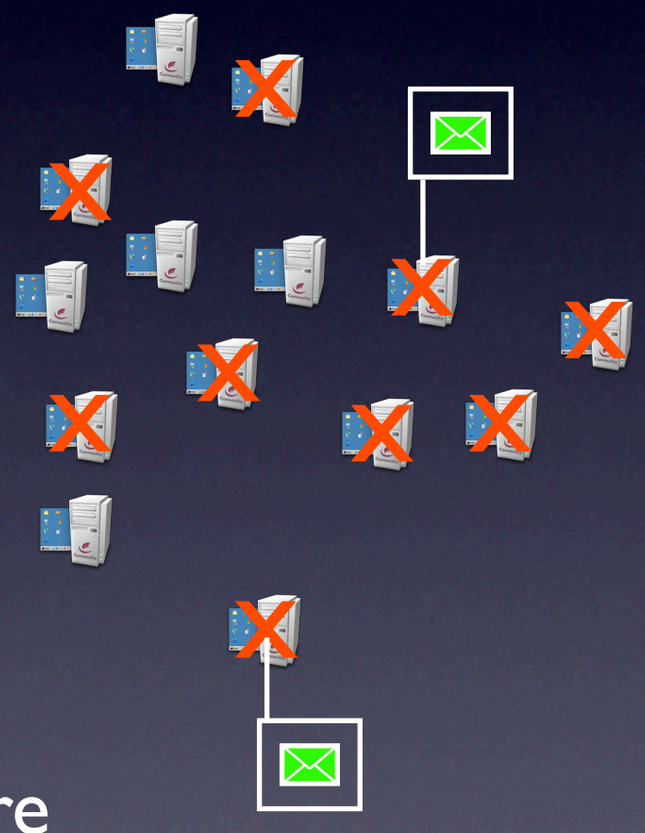

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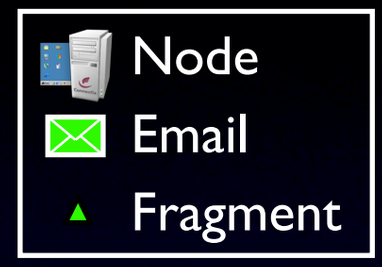


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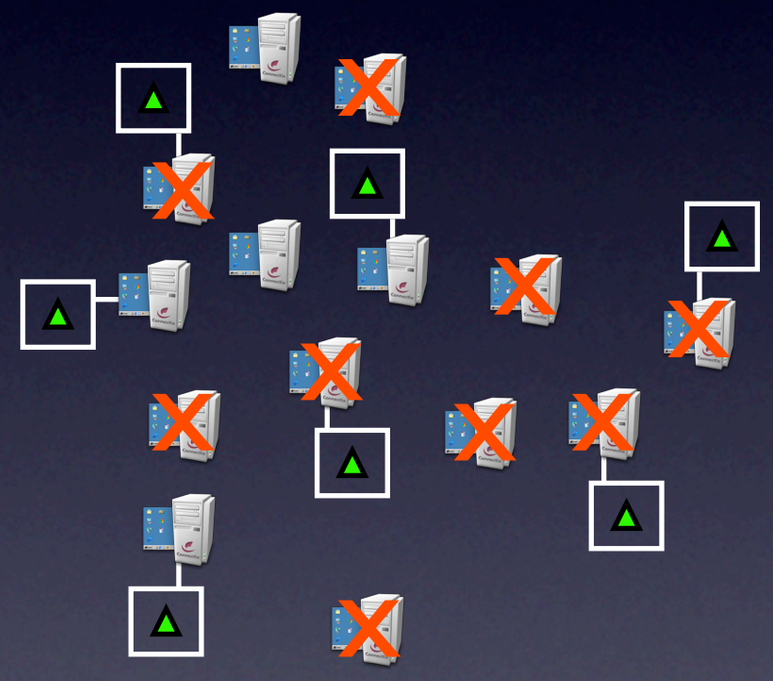

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# Challenge: Resource Consumption

- Studied hard drive growth vs. data creation rate
  - Determined sufficient space
- But did not anticipate spam explosion
- After 6 months, 75% garbage
  - Sufficient space, but high bandwidth
  - Maintaining replicas of garbage
- Solution: Lease-based storage
  - Renew useful objects
  - Avoids insecure delete operation

# Challenge: Unsynchronized Clocks

- Assumed loosely synchronized clocks
  - Error of a few hours


- Did not hold
  - One user was 2 years behind

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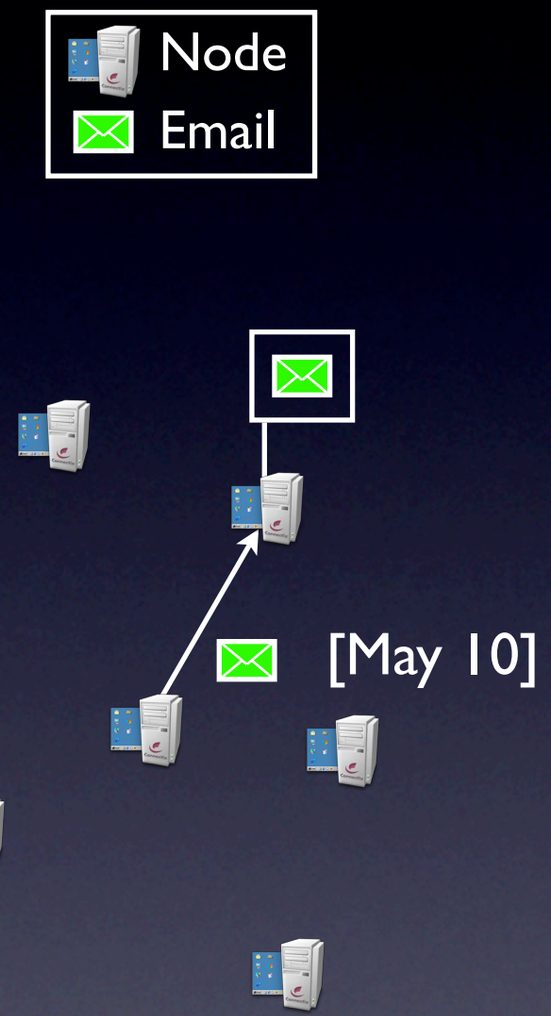

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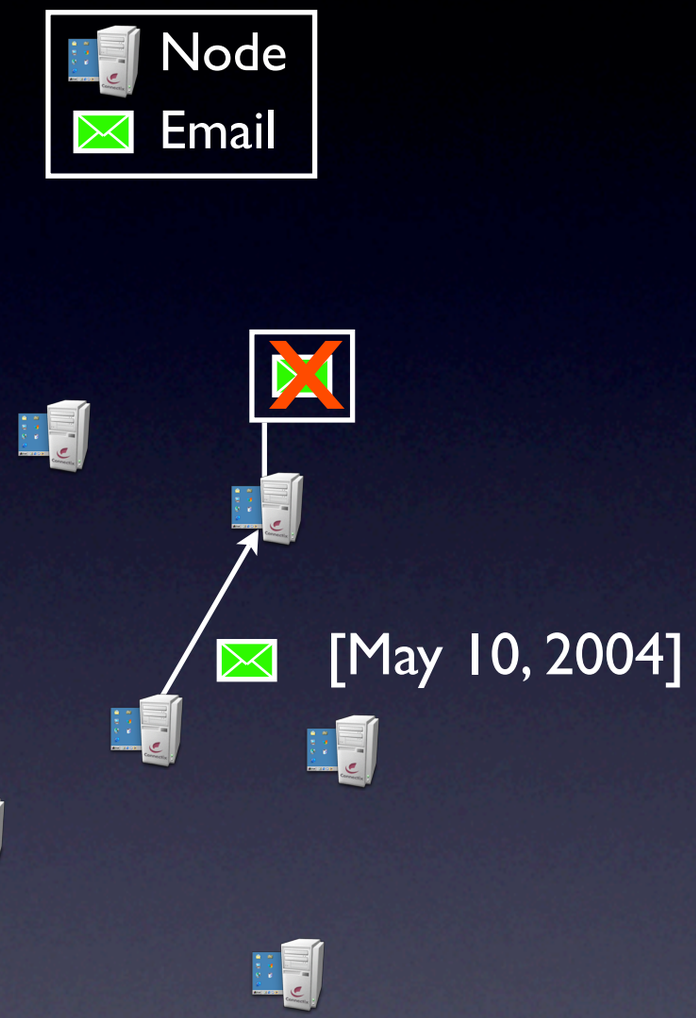

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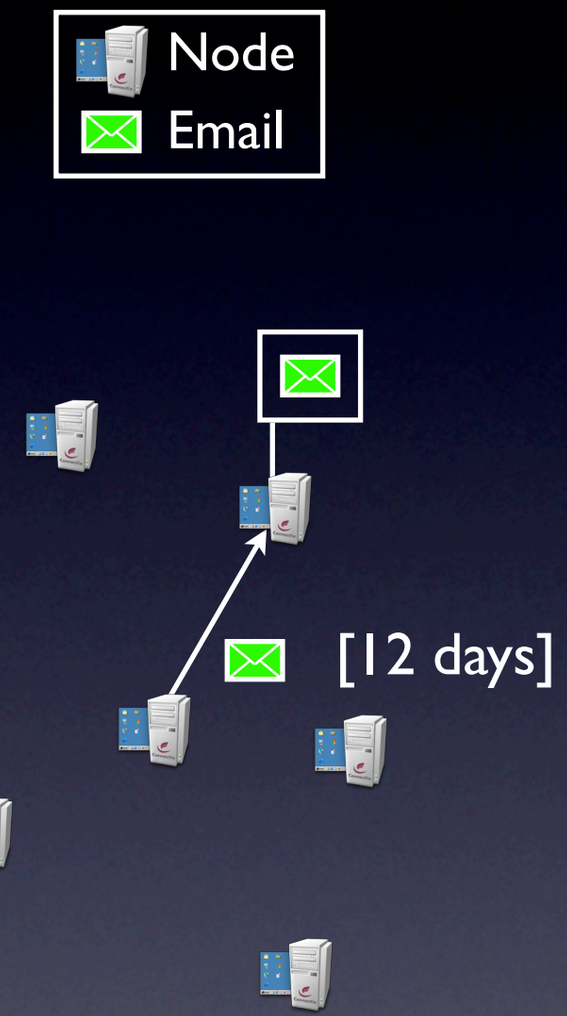

# Conclusion

- Question: Can peer-to-peer systems build reliable applications?
  - Yes!
- Built ePOST, a reliable decentralized mail system
  - Many users relied on ePOST for primary mail
- Many challenges to providing reliable service
  - Network partitions, routing anomalies, ...
- Challenges and techniques applicable to other systems
  - Human time-scale events, eventual consistency
  - Instant messaging, whiteboards, newsgroups, blogs, ...

# Questions?

**http://www.epostmail.org**

Thanks to all of the ePOST users!