Minimizing Churn in Distributed Systems

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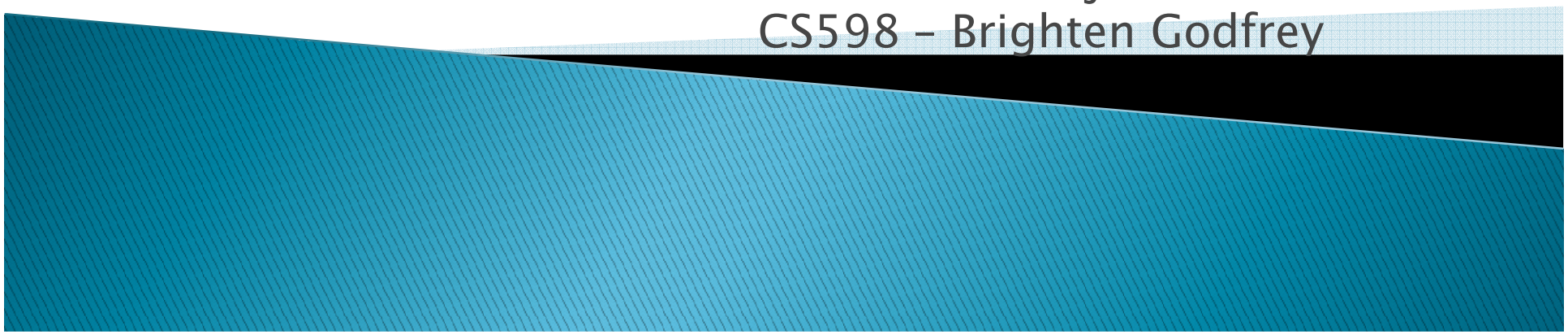
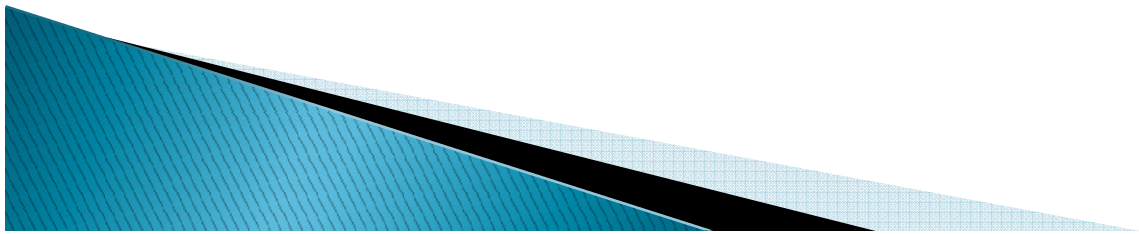


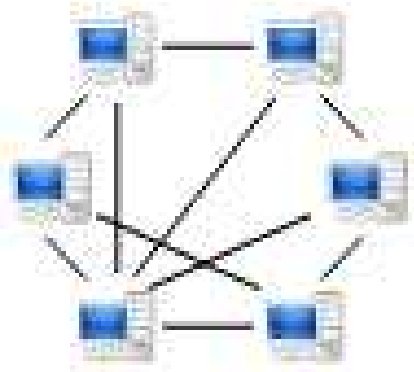
Outline

- Peer to Peer Networks
- Churn and Overlay Networks
- Motivation to reduce churn in Peer to Peer networks
- Existing Solution
- Proposed Solution
- Results



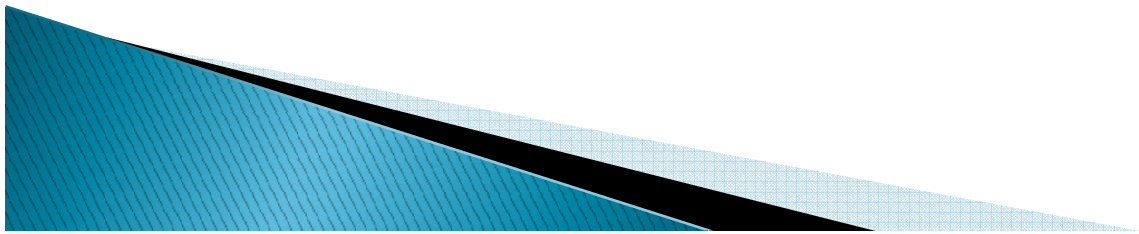
Peer to Peer Networks

- Peer-to-peer (P2P) computing or networking is a distributed application architecture that partitions tasks or work loads between peers.
- Peers are equally privileged, equipotent participants in the application.
- Eg: Napster, Gnutella



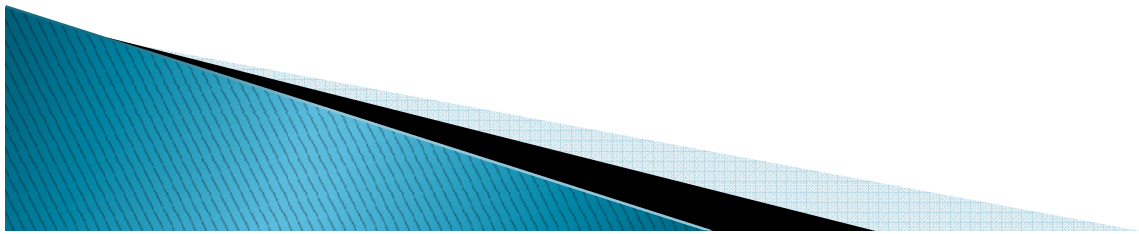
Recap – Churn and Overlay Networks

- Churn rate is the rate of turnover of nodes in a collective over a specific period of time
- Overlay Network is a network built on top of another network by virtual or logical links. Each of these links may be composed of one or more physical links.



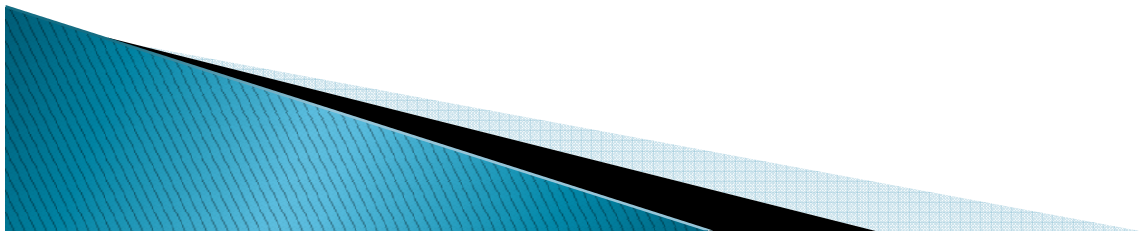
Motivation

- Price of Churn –
  - dropped messages
  - data inconsistency
  - increased user experienced latency
  - decreased service quality
- Selecting a reliable set of nodes to host replicas of data
- Choosing nodes in a tree where failure is most costly



Related Work

- J. Mickens and B. Noble. Predicting node availability in peer-to-peer networks. In *ACM SIGMETRICS poster, 2005*
- Three types of predictors for predicting nodes which will be online for a greater period of time
- Non-equitable distribution of storage due to bias towards highly available nodes

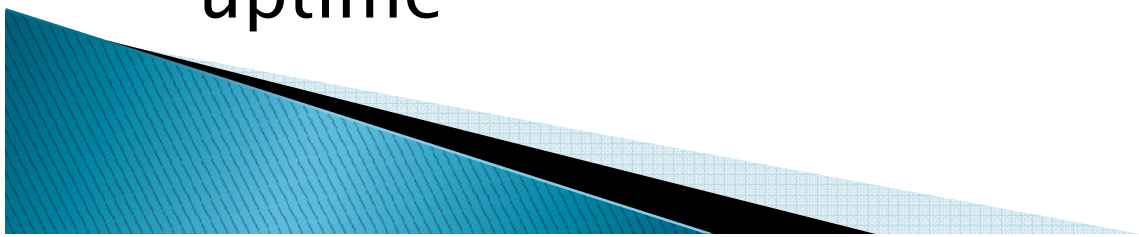


Node Selection Strategies

- Stability- Predictive - based on individual node characteristics e.g. past uptime
- Stability-Agnostic - ignore any information
- Fixed – never replaces a failed node
- Replacement – always replaces a failed node
- Example :-

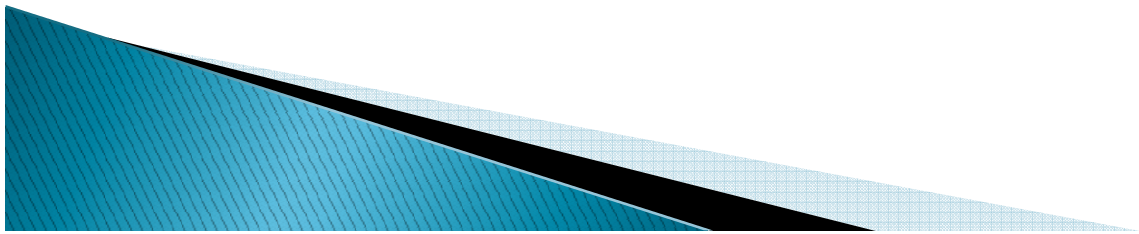
  1.Predictive Fixed - Planet lab nodes

  2.Predictive Replacement – Dynamically minimize churn based on longest current uptime



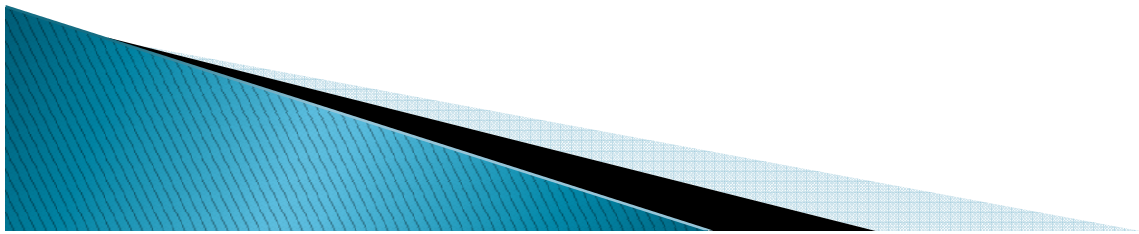
Churn Simulations

- Model – Nodes may be “up” or “down”. The “up” nodes may be “in use” or “available”. There are k nodes selected from a total of n nodes using the below strategies where $k = \alpha n$
- Selection Strategies – Predictive Fixed, Agnostic Fixed , Predictive Replacement , Agnostic Replacement
- Traces Collected From – PlanetLab, Web Sites, Microsoft PC’s, Skype superpeers, Gnutella peers

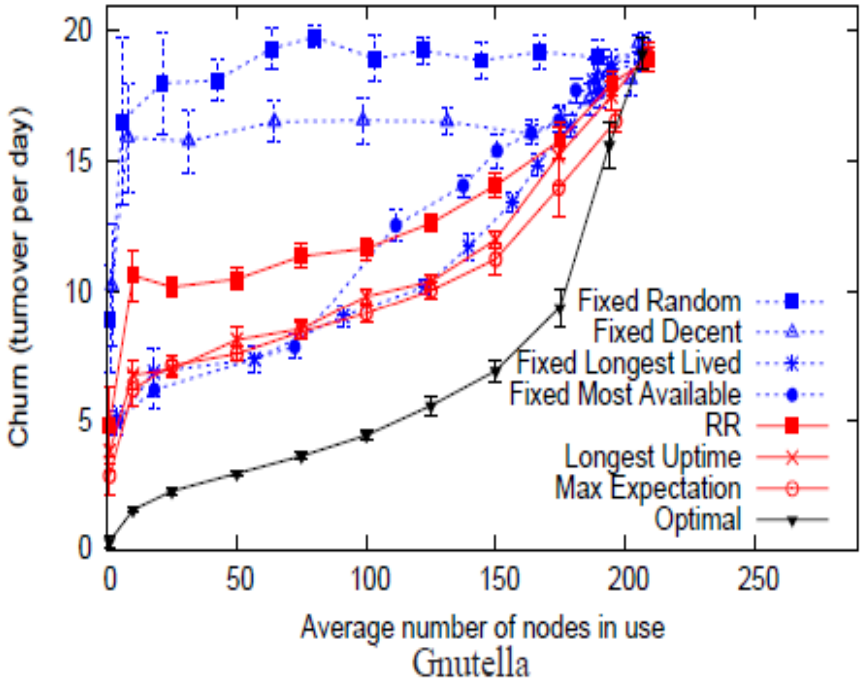


RR and PL

- Random Replacement (RR) is a kind of Agnostic Replacement strategy where you replace a failed node with a uniform-random available node.
- Preference List (PL) is also a kind of Agnostic Replacement strategy where you replace a failed node with the highest ranked node in a preference list.



Results



Fixed Random *(Agnostic Fixed Strategy):* Pick k uniform-random nodes

Fixed Descent *(Predictive Fixed Strategy)*: Discard the 50% of nodes that were up least during the observation period. Pick k random remaining nodes

Fixed Longest Lived *(Predictive Fixed Strategy)*: Pick the k nodes which had greatest average session time

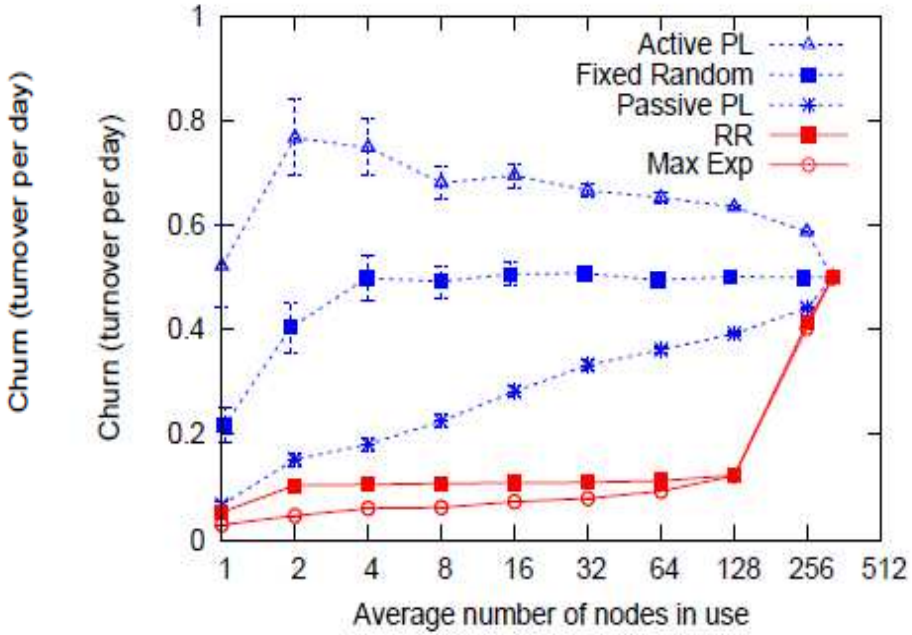
Fixed Most Available (*Predictive Fixed Strategy)*) : Pick the k nodes that spent the most time up

Longest Uptime (*Predictive Replacement Strategy)*: Select the node with longest current uptime

Max Expectation (*Predictive Replacement Strategy):* Select the node with greatest expected remaining
uptime, conditioned on its current uptime

Optimal (*Predictive Replacement Strategy):* Select the node with longest time until next failure.
This requires future knowledge, but provides a useful comparison.
It is the optimal replacement strategy

Results



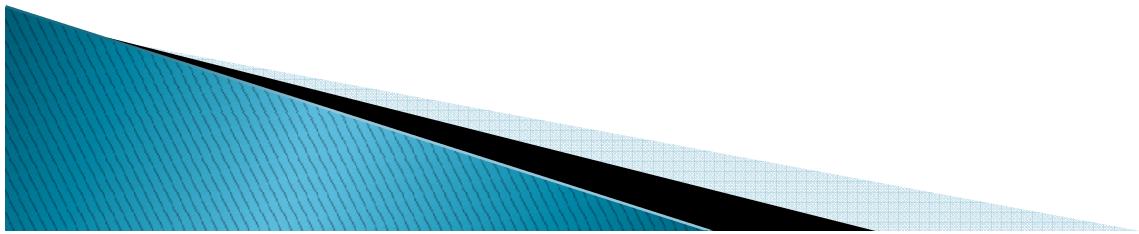
Passive PL *(Agnostic Replacement Strategy) :* Given a ranking of the nodes, after an in-use node fails, replace it with the most preferable available node.

Active PL *(Agnostic Replacement Strategy) :* Same as Passive PL, except when a node becomes available that's preferable to one we're using, switch to it, discarding the least preferable in-use node

Random Replacement *(Agnostic Replacement Strategy) :* Pick k random initial nodes. After one fails, replace it with a uniform-random available node.

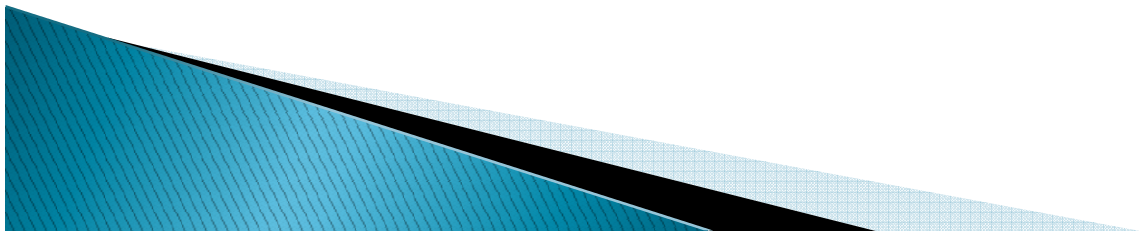
Why RR is better than PL?

- In RR the longer that a node has been active the greater probability of it being in the “in use” set already.
- The longer a node has been active the greater the probability of it being available in the future. This is only true in typical failure patterns.
- RR performs best when there is skewed session time of nodes



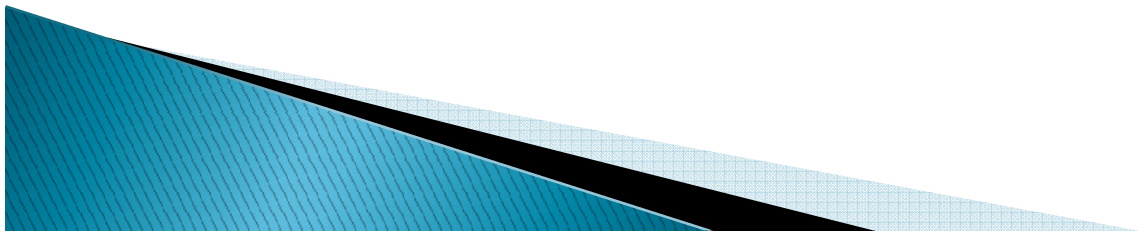
Applications

- DHT neighbor selection in Chord
- Multicast – overlay multicast tree , RON

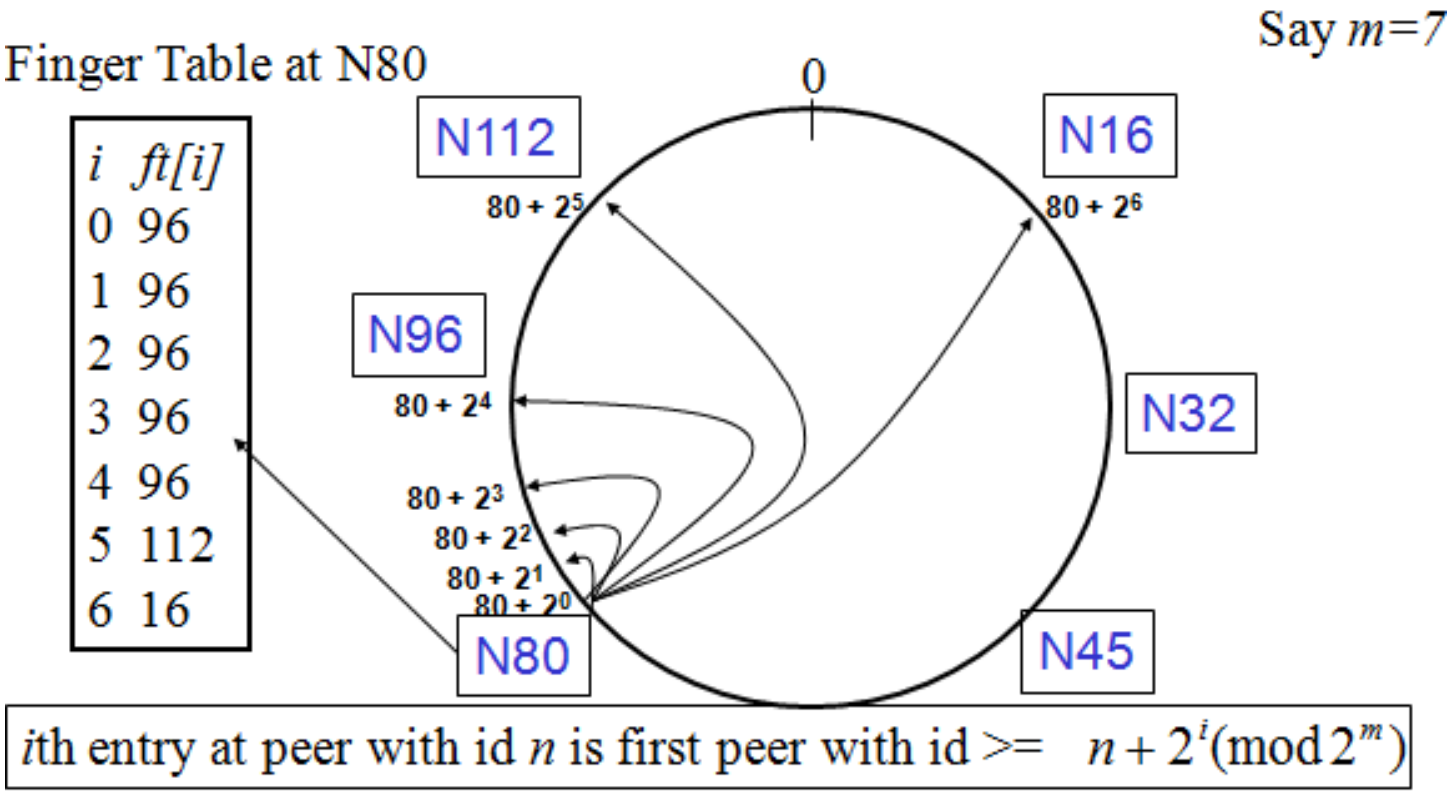


DHT

- A Distributed Hash Table is a decentralized Hash Table which allows you to perform Lookup, Select and Delete on (Key,Value) pairs.
- Load Balancing, Look up and Insert efficiencies and churn are some of the performance bottlenecks to consider
- Churn causes packet losses when there is latency in discovering that an overlay link has failed

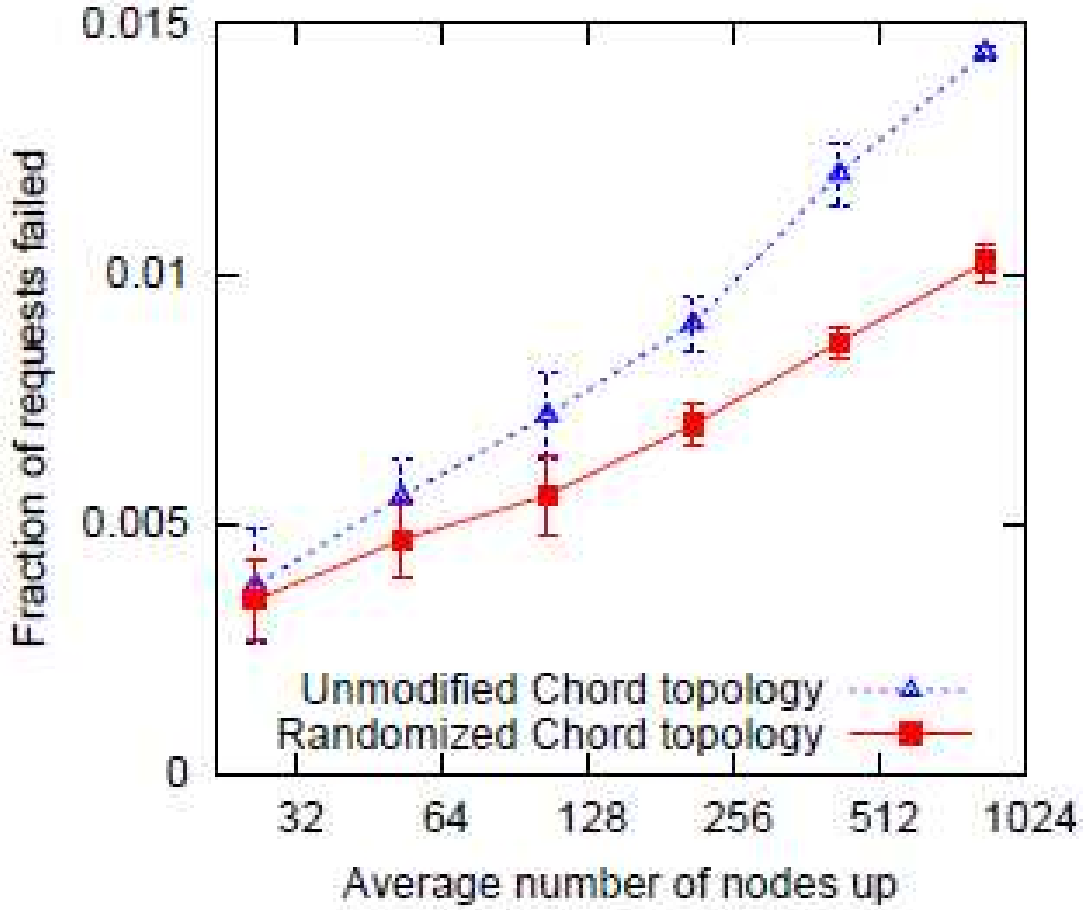


Chord


Say $m=7$
Finger Table at N80
i ft[i]
0 96
1 96
2 96
3 96
4 96
5 112
6 16
0
N112
N16
N96
N32
N45
N80
80 + 2^5
80 + 2^6
80 + 2^4
80 + 2^3
80 + 2^2
80 + 2^1
80 + 2^0
ith entry at peer with id n is first peer with id >= $n + 2^i \pmod{2^m}$

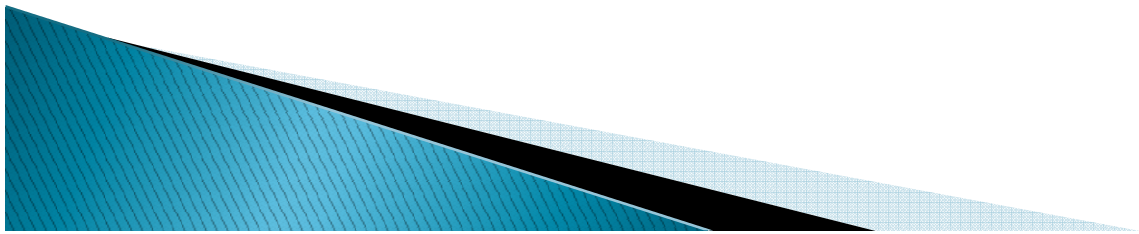
Results

Randomized Topology has 29% fewer failed requests when avg n = 850

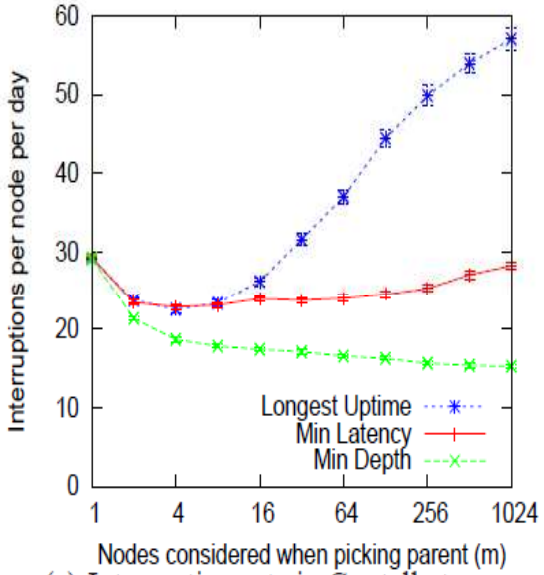


Multicast

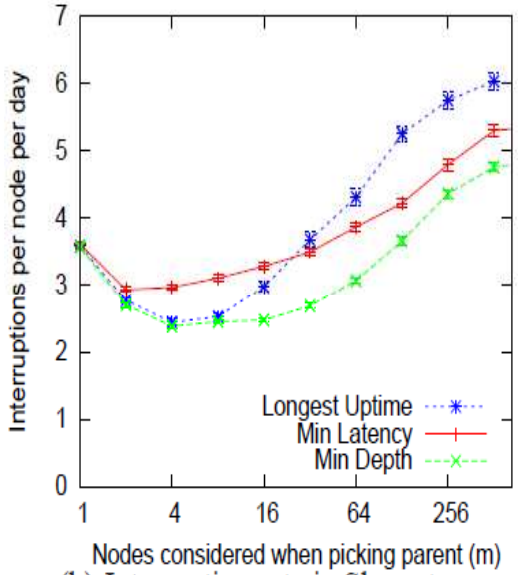
- Multicast Overlay Networks- Messages broadcast from one node to only nodes belonging to a particular group
- The single source multicast tree consists of a root that never fails
- When a node fails, each of its decendants experiences an “interruption”
- The three strategies for selecting the parent among m random suitable nodes – Longest Uptime, Minimum Depth and Minimum Latency



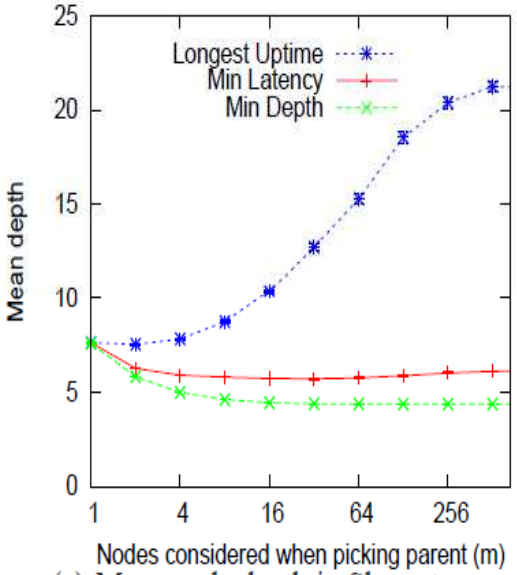
Multicast–Results



(a) Interruption rate in Gnutella trace



(b) Interruption rate in Skype trace



(c) Mean node depth in Skype trace

References

- P. Brighten Godfrey, Scott Shenker and Ion Stoica. Proc. Minimizing Churn.ACM SIGCOMM, Pisa, Italy, September 2006.
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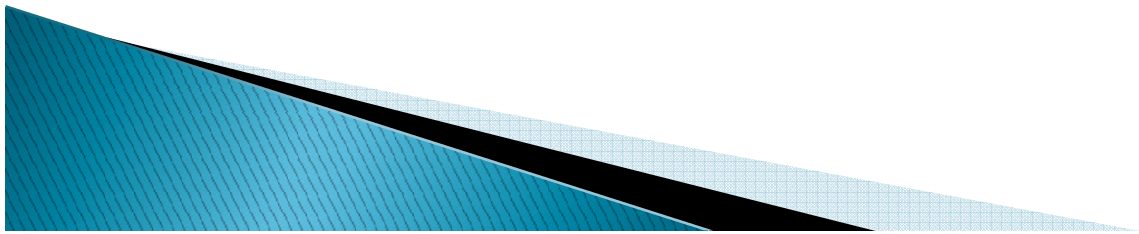
- David G. Andersen, Hari Balakrishnan, M. Frans Kaashoek, and Robert Morris.Resilient Overlay Networks.Massachusetts Institute of Technology, May 2001.
- I.Gupta. CS425-Fall2010.Lecture 10



Questions