Chord: A Scalable Peer-to-Peer Lookup Service for Internet Applications

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The landscape

Goal

Distributed lookup table

Existing/competing implementations

- DNS
- Freenet storage system
- Plaxton protocol
- CAN

Features

- Load balance
- Decentralization
- Scalability
- Availability
- Flexible naming

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Potential applications

- Cooperative mirroring
- Timeshared storage
- Distributed indices
- Distributed computation

Chord protocol

Assume keys are mapped to a particular node

Components

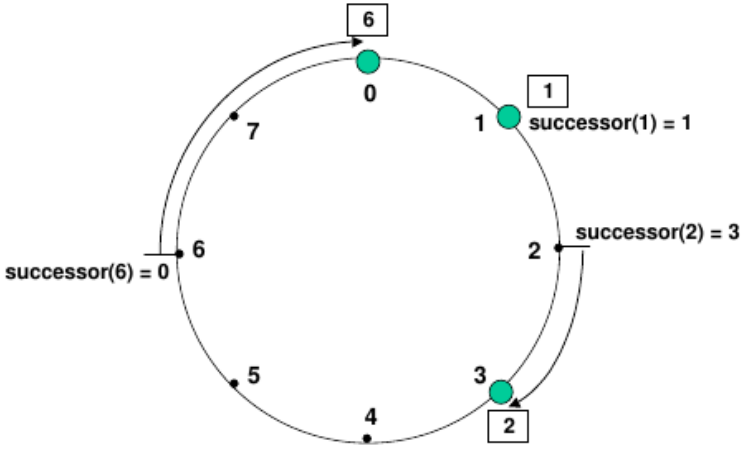
- Finding location of keys
- Handling nodes joining/exiting system
- Handle state inconsistencies/suboptimality

Location of keys

Location of keys

Main idea

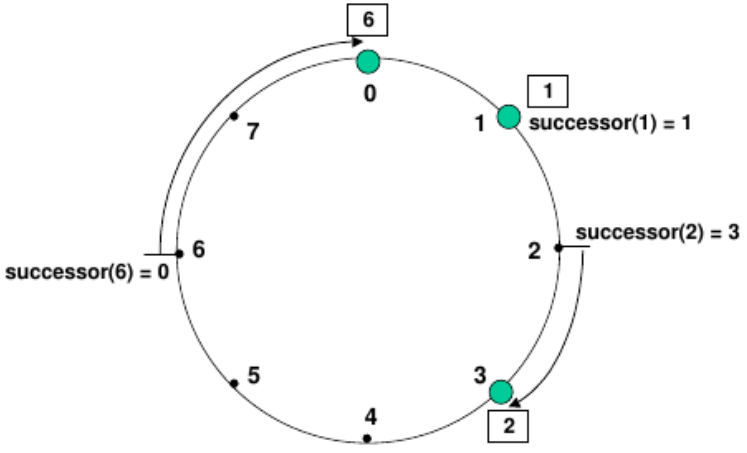
Consistent hashing



Location of keys

Main idea

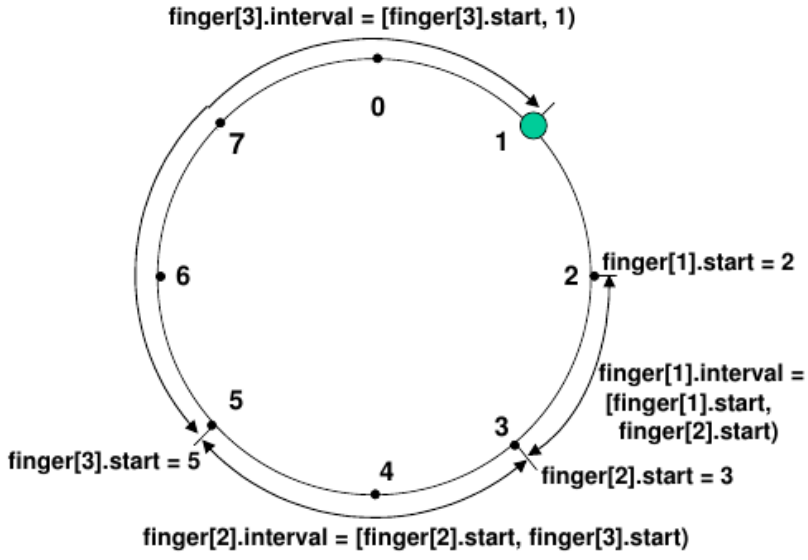
Consistent hashing; requires global information



Location of keys

Idea

Consistent hashing with finger tables



Provides scalable key location with $O(\log N)$ entries in finger table

Node joining/leaving

Invariants

- Each node's successor is correctly maintained
- For every k, `successor`(k) is responsible for k

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Theorem

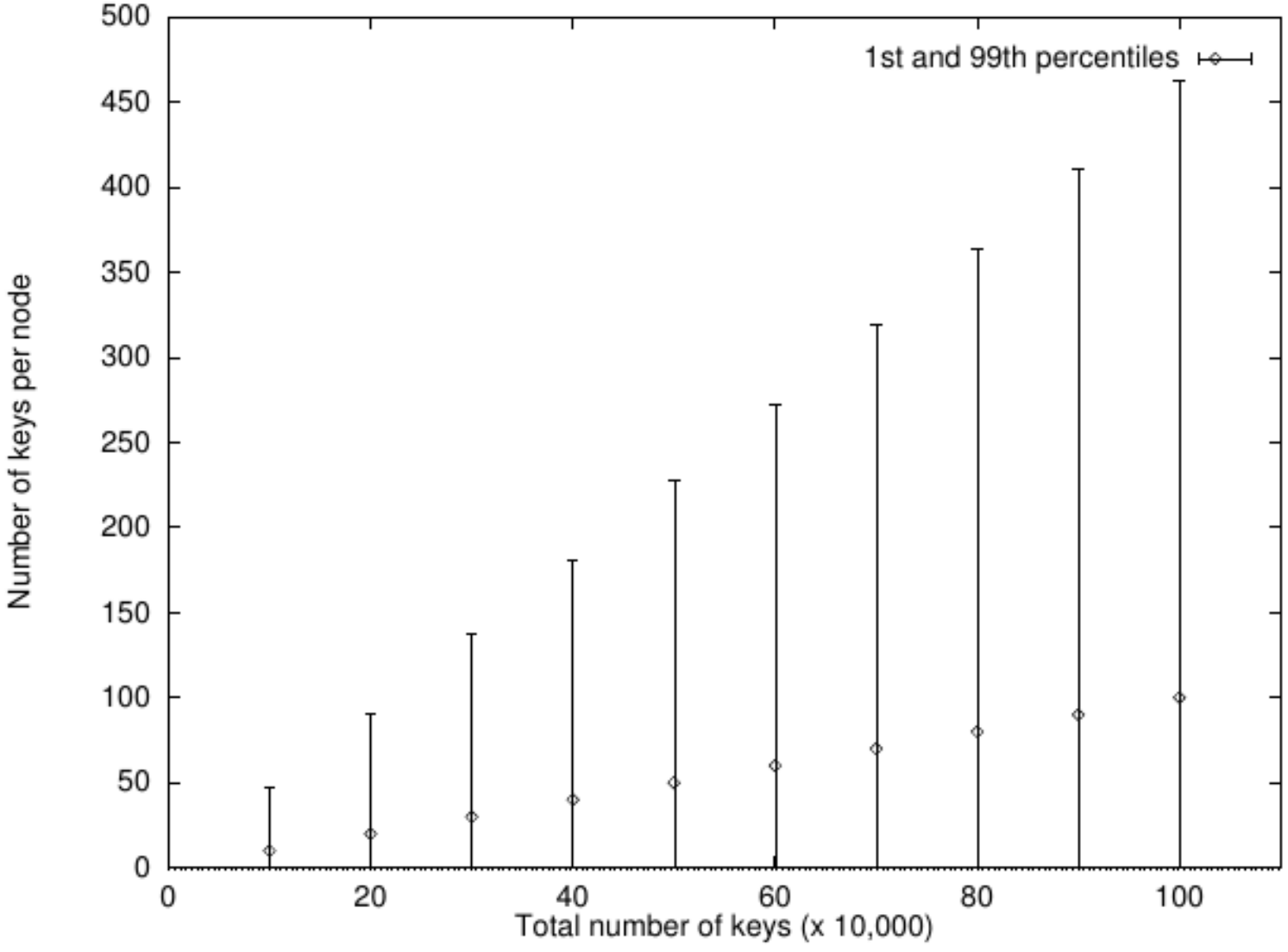
Any node joining/leaving the network can use $O(\log^2 N)$ messages to establish the invariants and finger tables

Some other considerations

- Stabilization
- Concurrent joins/failures

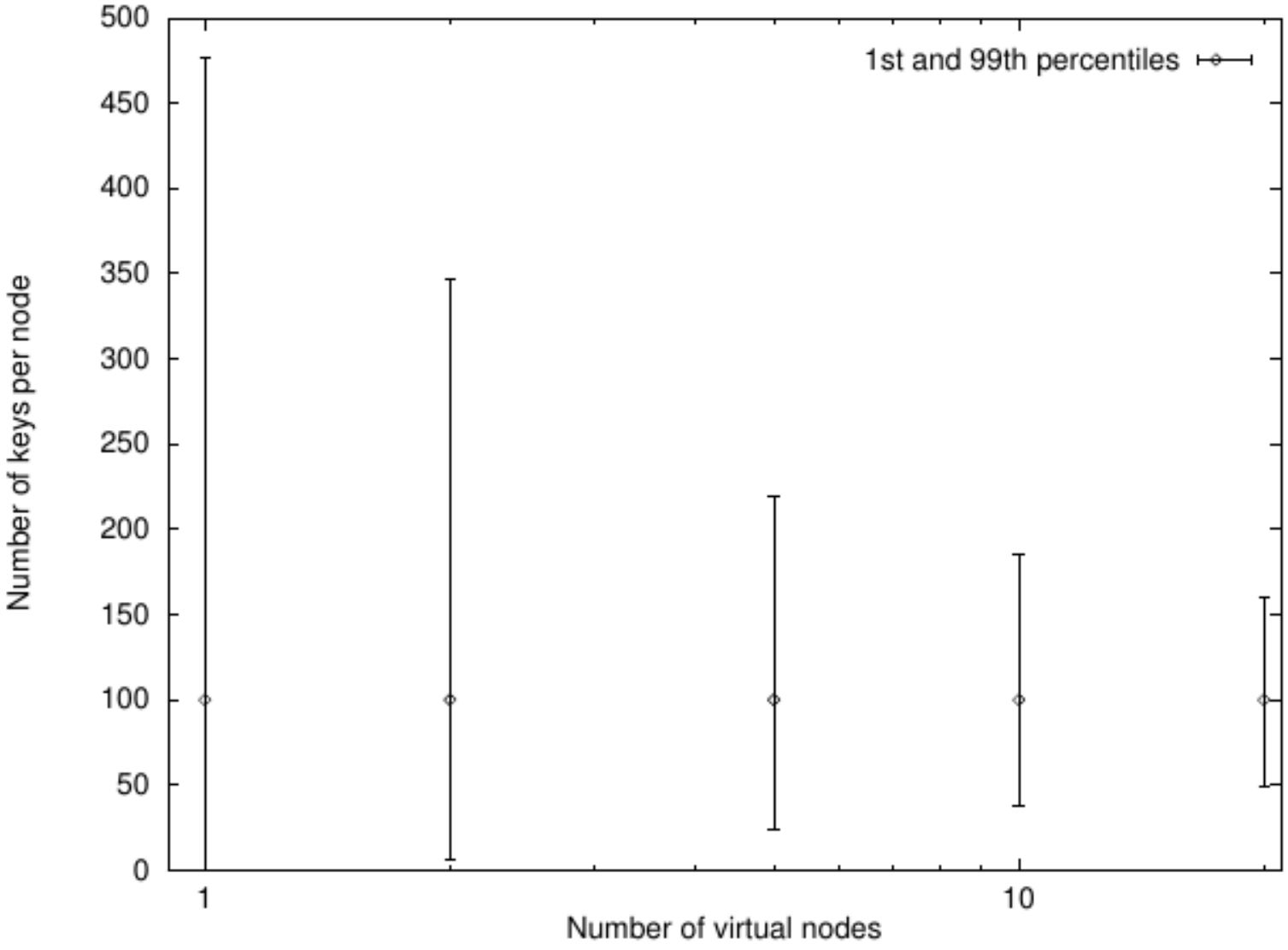
Performance

Load is somewhat unbalanced without virtual nodes



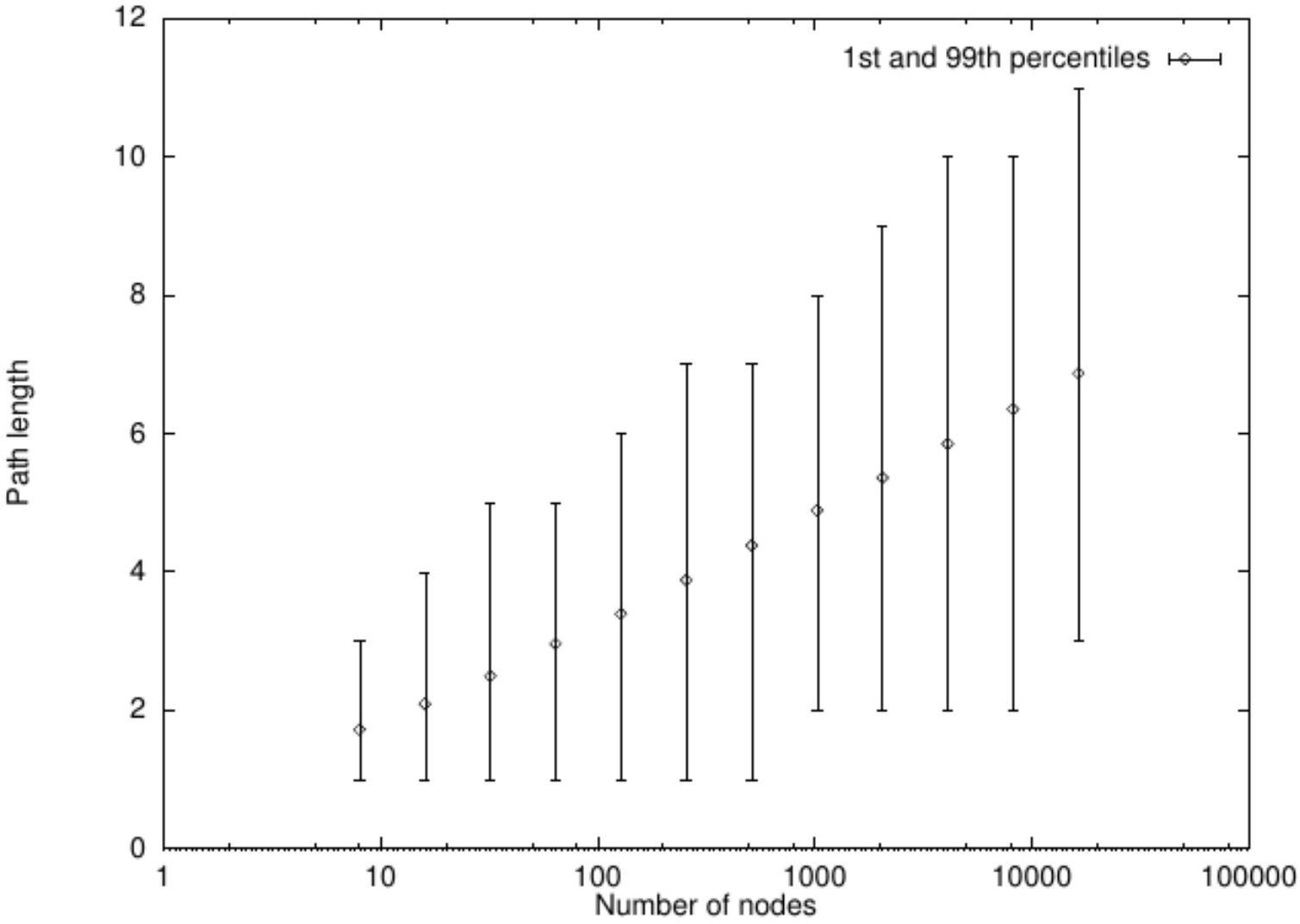
Performance

Load balancing with virtual nodes



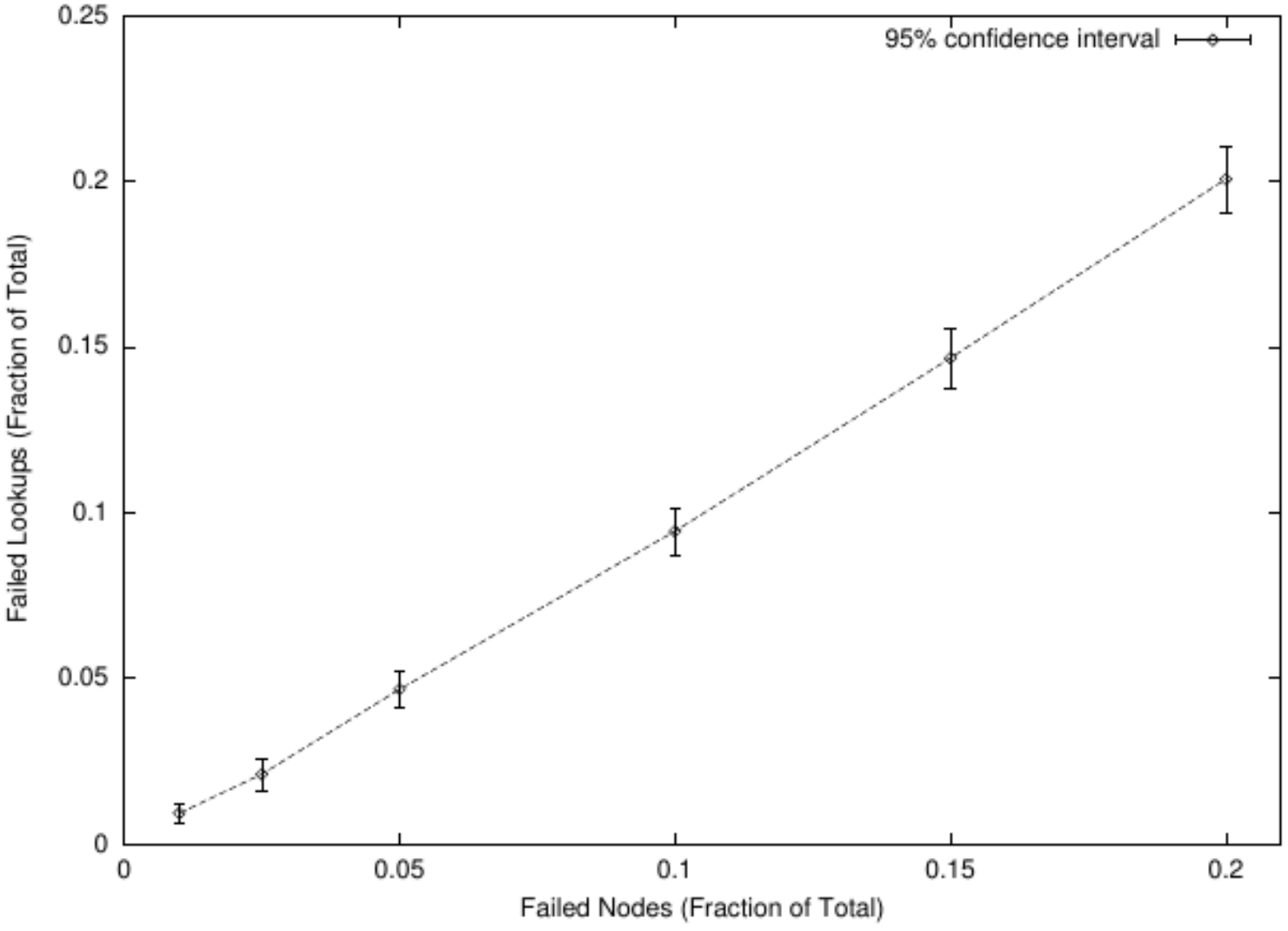
Performance

Path length of lookup query



Performance

Simultaneous node failure



Performance

Lookup failure due to state inconsistency