Peer-to-Peer Networks

9 Skip-Net and Skip-Graph

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Skip-Lists

- Start with a directly connected list

\[ L \rightarrow 1 \rightarrow 2 \rightarrow 3 \rightarrow 4 \rightarrow 5 \rightarrow 6 \rightarrow 7 \rightarrow 8 \]

- Toss a coin to select nodes with probability 50%
- Connect elements in the next level as simple directed list
- Repeat recursively until no elements are left
Skip-Graphs


Idea
- „Heads“ and „Tails“ of a coin toss recursively participate in an own game

Properties
- highly resilient
- Diameter and degree $O(\log n)$ with high probability
- Ordering of data remains
Skip-Net

- Same data structure invented twice in parallel
- Harvey, Jones, Saroiu, Theimer, Wolman, SkipNet: A Scalable Overlay Network with Practical Locality Properties 2003

Principle
- Data is sorted stored on peers on a ring
- Node-ID serves as random number for skip-graph

Lookup for Data
- Choose the farthest pointer on the ring which does not pass the peer storing the data

Lookup for numeric node-ID
- Recursively choose ring with same prefix

# hops: $O(\log n)$ w.h.p.
- if the node-IDs are chosen randomly
Search for Name-ID
Search for Num-ID
Alternative Representation

- From: P2P Network Structured Networks of Pedro Garcia Lopez, Universitat Rovira I Virgili
Inserting Peers


Algorithm
- Lookup of correct place according to node name
- Insertion into higher ranks

Runtime: $O(\log n)$ hops and $O(\log n)$ messages with high probability
Fault Tolerance

- Independent Node failures
  - can be compensated by using the upper rings

- Partial network failures
  - can be repaired by removing the partial ring in higher levels
Locality of Content and Routing

- Locality of content
  - underlying ordering
- Alternative mapping of data
  - data can be stored using num-id
- Locality of Routing
  - if the hosts are sorting along domains then local routing within a domain can be facilitated where possible
Range Search

- Num-ID range search
- Name-ID range search
- Intersection of Num-ID and Name-ID

Running time:
- $O(\log n)$ for first element
- Then constant time for each succeeding elements
Extensions

- Increase the basis
  - e.g. use dice instead of coin
  - reduces degree
  - increases diameter

- Replace duplicate pointers
  - with more pointers
Using SkipNet in DHTs

- Omit Hash Table
- Single Overlay
  - Use numbering of Chord in Chord
- Multiple Overlay
  - Use multiple P2P network structures at the same time
Skip-Net with Random Numbers

- Harvey, Munro, „Deterministic Skip-Net“
- Rotation of nodes if unbalance is detected
- Rotation:
  - Insert a node in the other layer if there is a too long sequence of same level nodes
- Rebalance Skip-Net
- Network construction without randomness and without probabilistic analysis
- Lookup: $O(\log n)$ in the worst case
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