



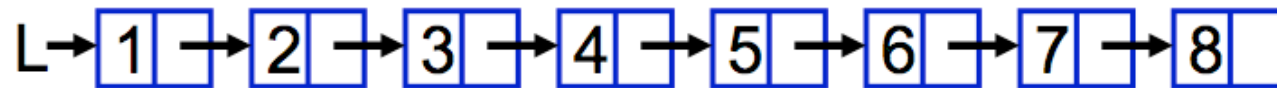
# Peer-to-Peer Networks

## 08 Skip-Net and Skip-Graph

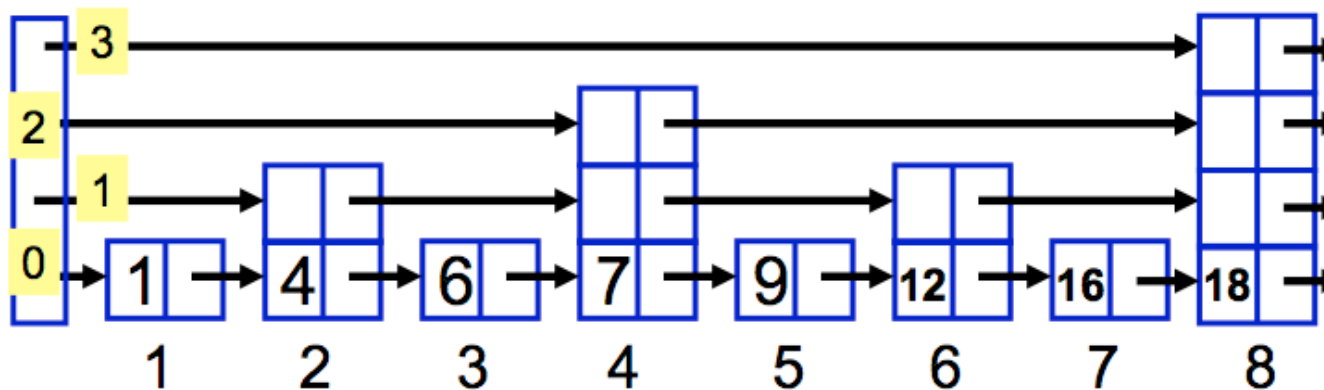
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# Skip-Lists

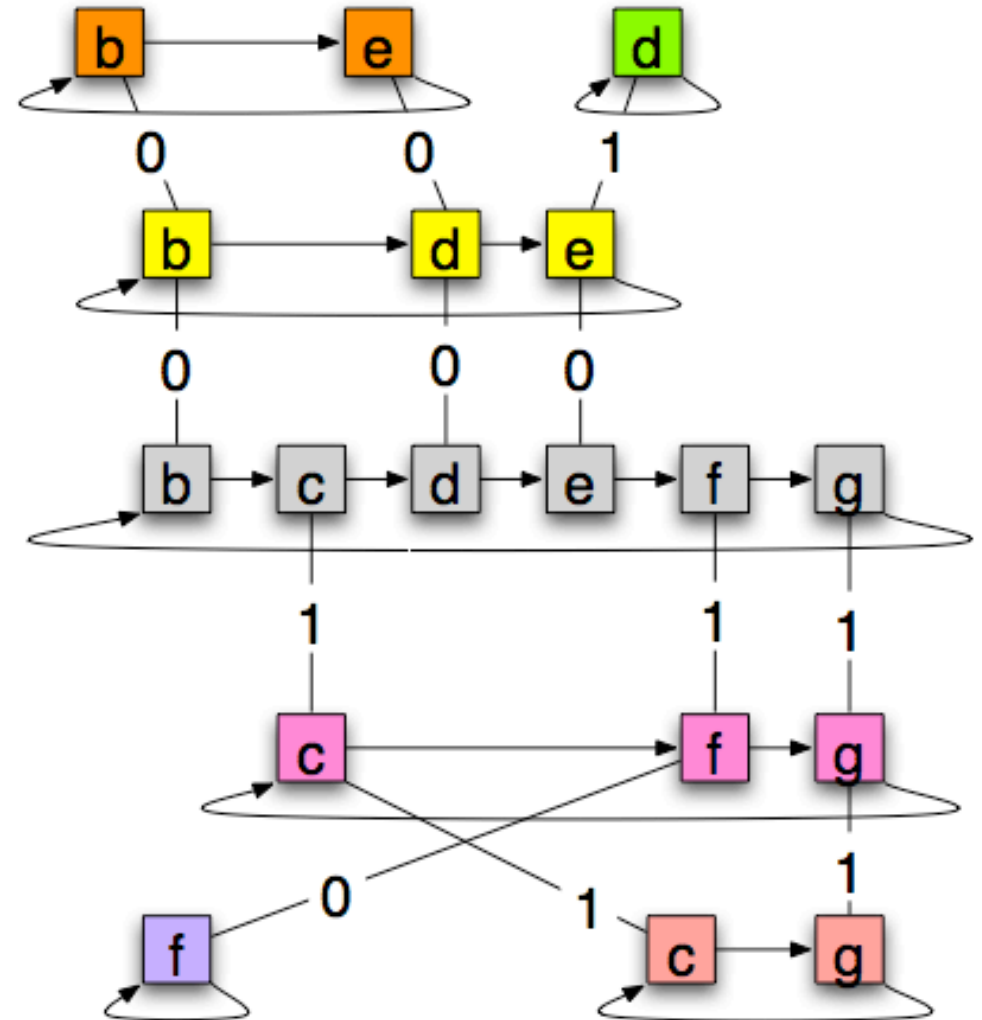
- Start with a directly connected list



- 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

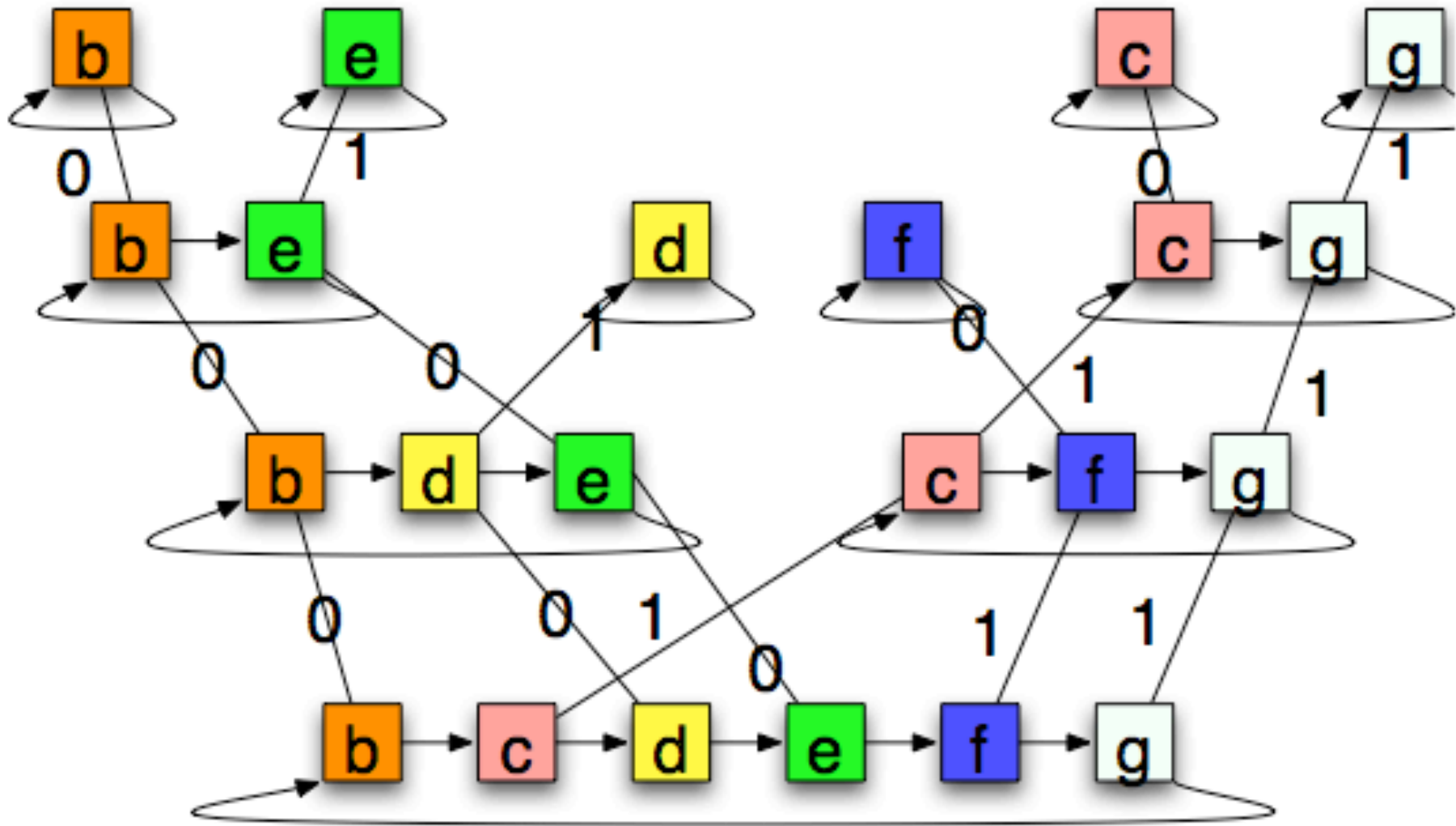


- J. Aspnes and G. Shah.  
Skip graphs, 2003
- Idea
  - „Heads“ and „Tails“ of a coin toss recursively participate in an own game
- Properties
  - highly resilient
  - Diameter and degree  $O(\log n)$  with high probability
  - Ordering of data remains

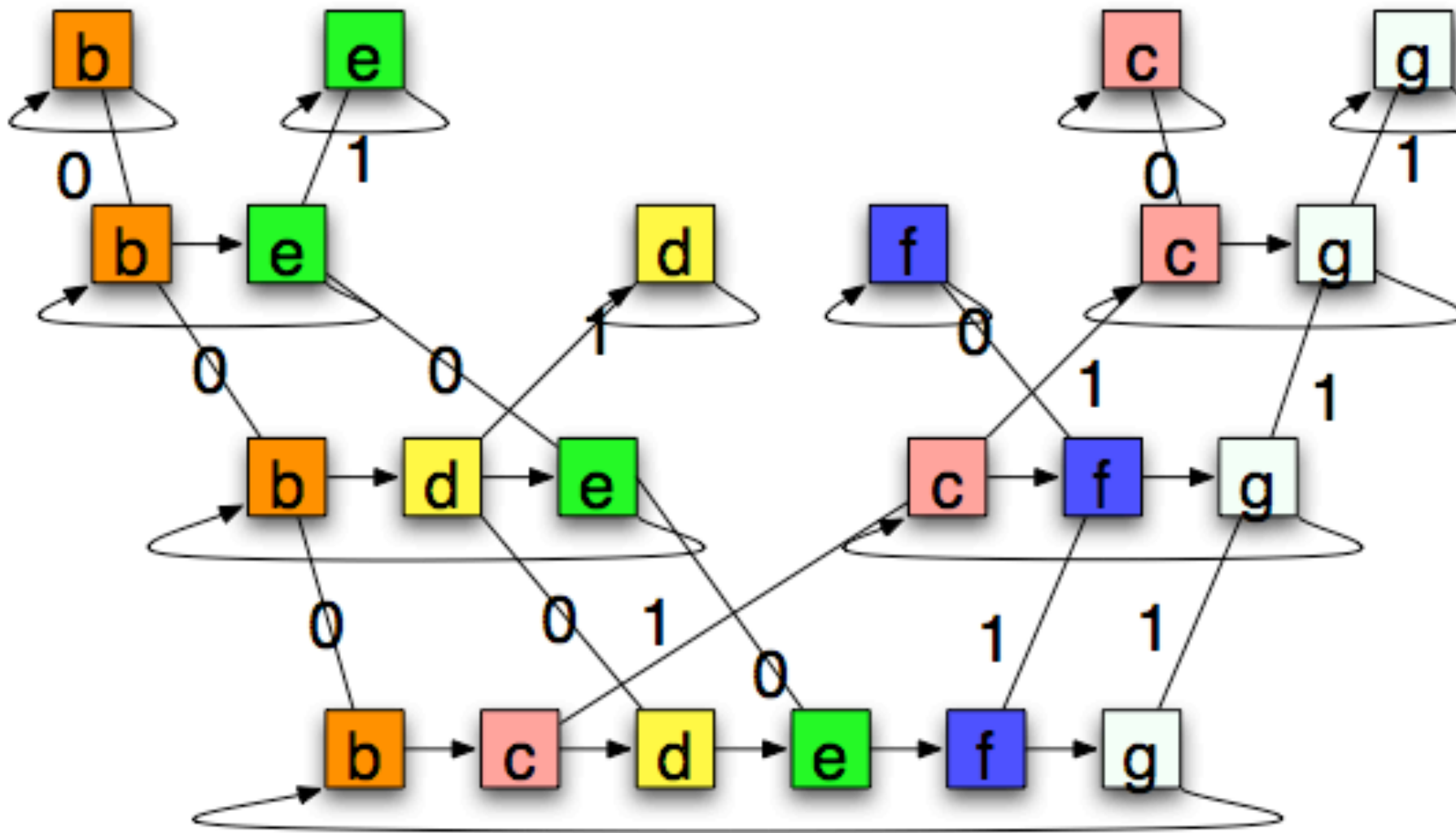


- Same data structure invented twice in parallel
- Harvey, Jones, Saroiu, Theimer, Wolman, SkipNet: A Scalable Overlay Network with Practical Locality Properties 2003
- Prinzipie
  - Data is sorted stored on peers on a ring
  - Node-ID serves as random number for skip-graph
- Lookup for Data
  - Choose 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

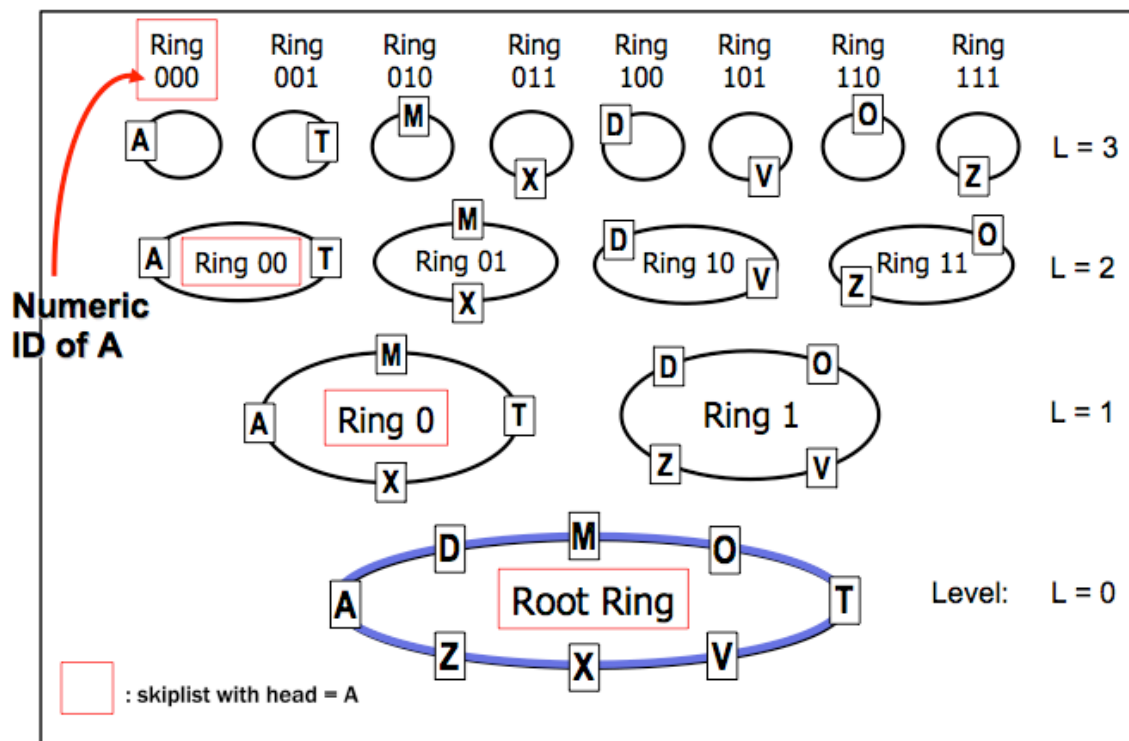


# Search for Num-ID



# Alternative Representation

- From: P2P Network Structured Networks of Pedro Garcia Lopez



- J. Aspnes and G. Shah. Skip graphs, 2003
- 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

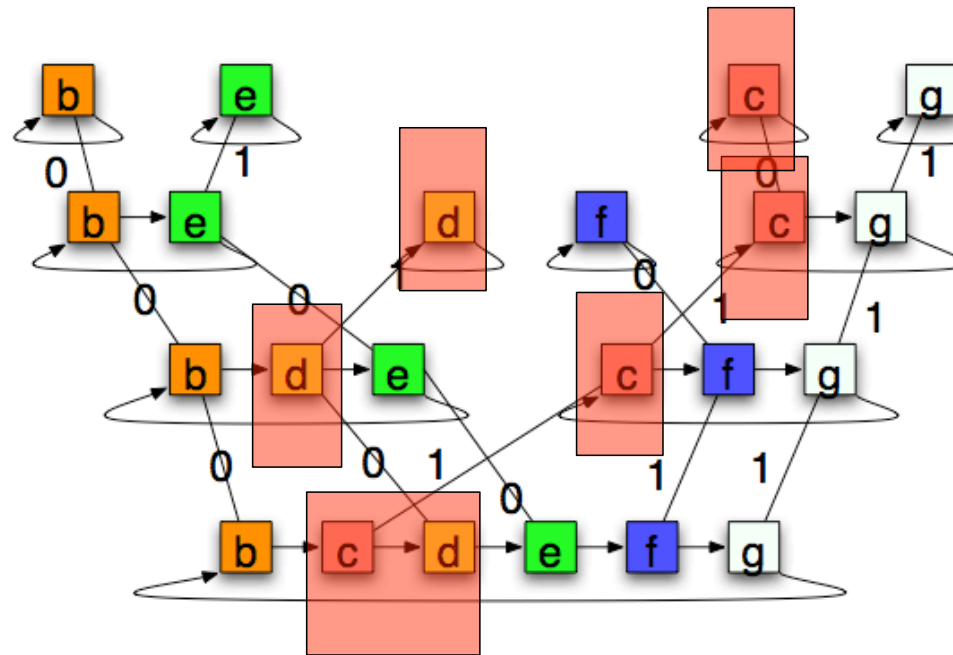


- Independent Node failures

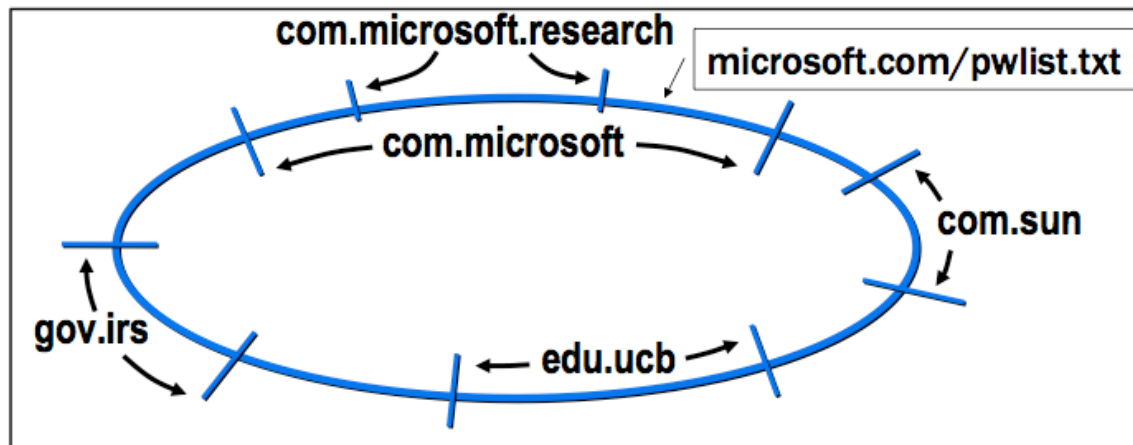
- can be compensated by using the upper rings

- Partial network failures

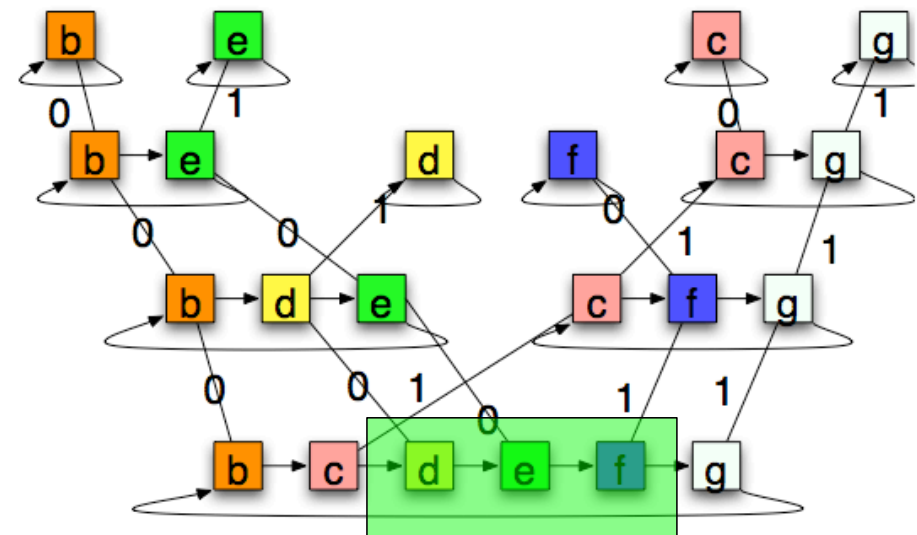
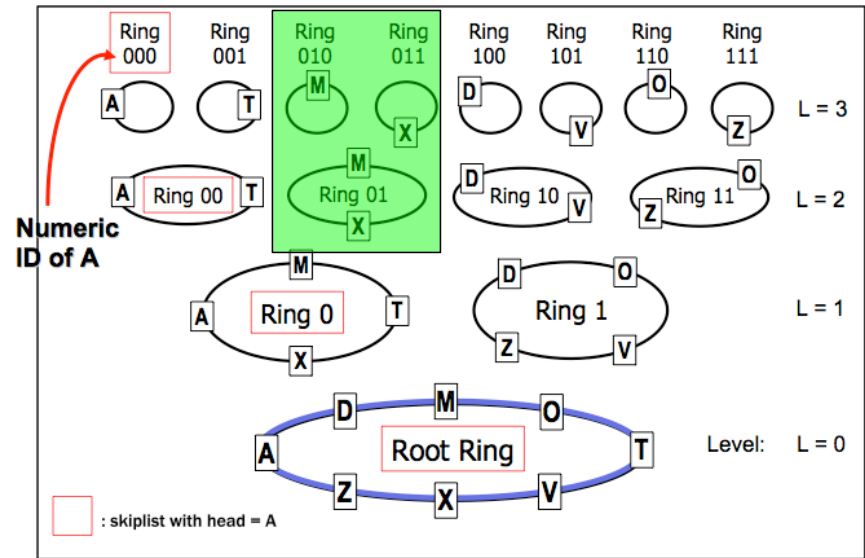
- can be repaired by removing the partial ring in higher levels



- Locality of content
  - 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



- 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

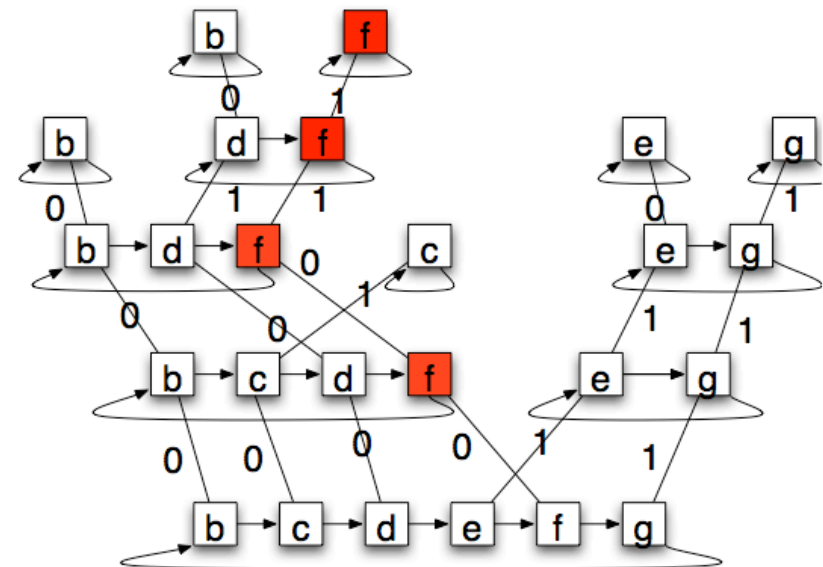
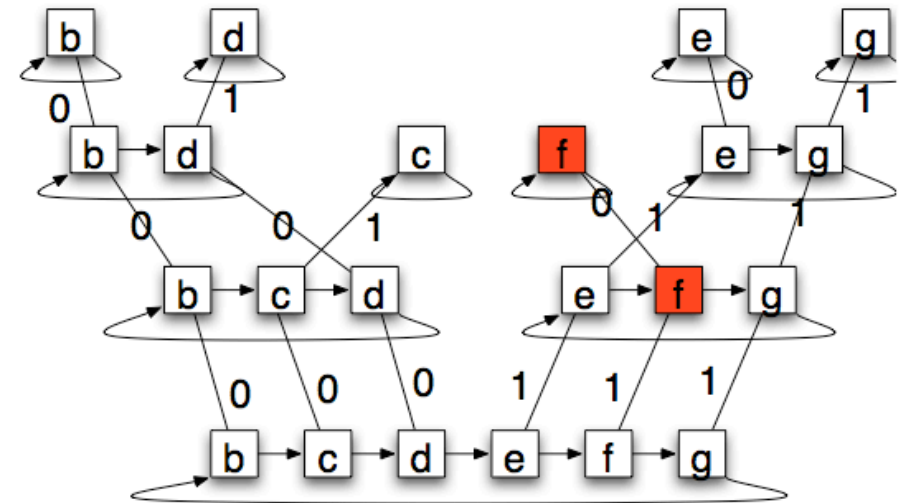


- Increase the basis
  - e.g. use dice instead of coin
  - reduces degree
  - increases diameter
- Replace duplicate pointers
  - with more pointers

- 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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## 08 Skip-Net and Skip-Graph

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