Sistemas Distribuídos

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Coordination

- Distributed system usually defined as:
  - Collection of autonomous computing elements

    but
  - Resulting in a single coherent system
- This is possible as computing elements coordinate to perform a coherent function

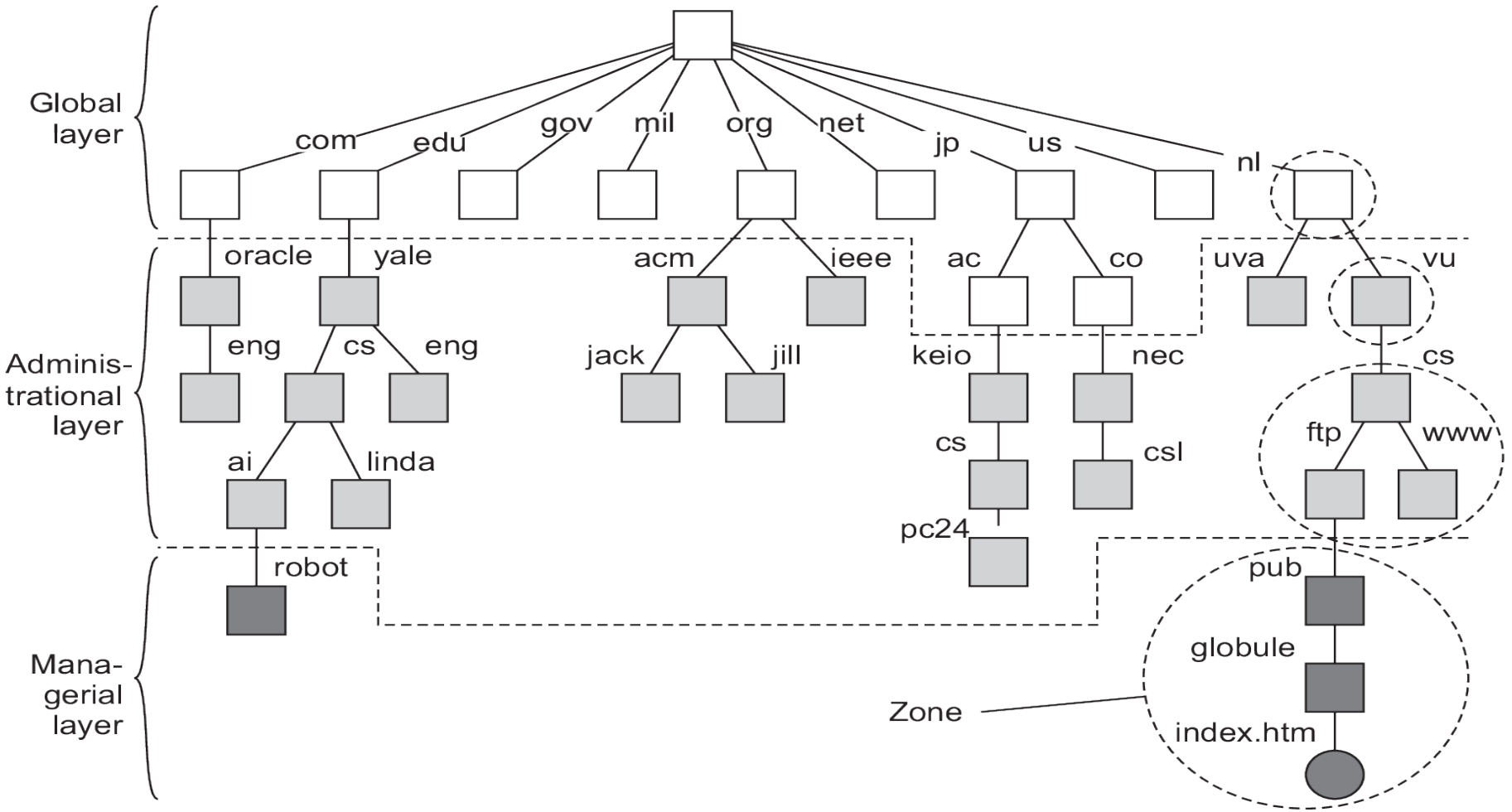
Learning outcomes

- Recognize how concrete real world problems map to generic distributed systems problems
- Recommend a solution that fits a given environment
  - Know the trade-offs of each algorithm!

Decentralized systems

- Distributed systems with:
  - Very large number of participants
  - Dynamic participation (churn)
  - Geographically distributed
  - Multiple authority and administration domains
- Typical problems:
  - Lookup by name (e.g., file sharing)
  - Information dissemination (e.g., streaming)
- A.k.a. peer-to-peer or P2P

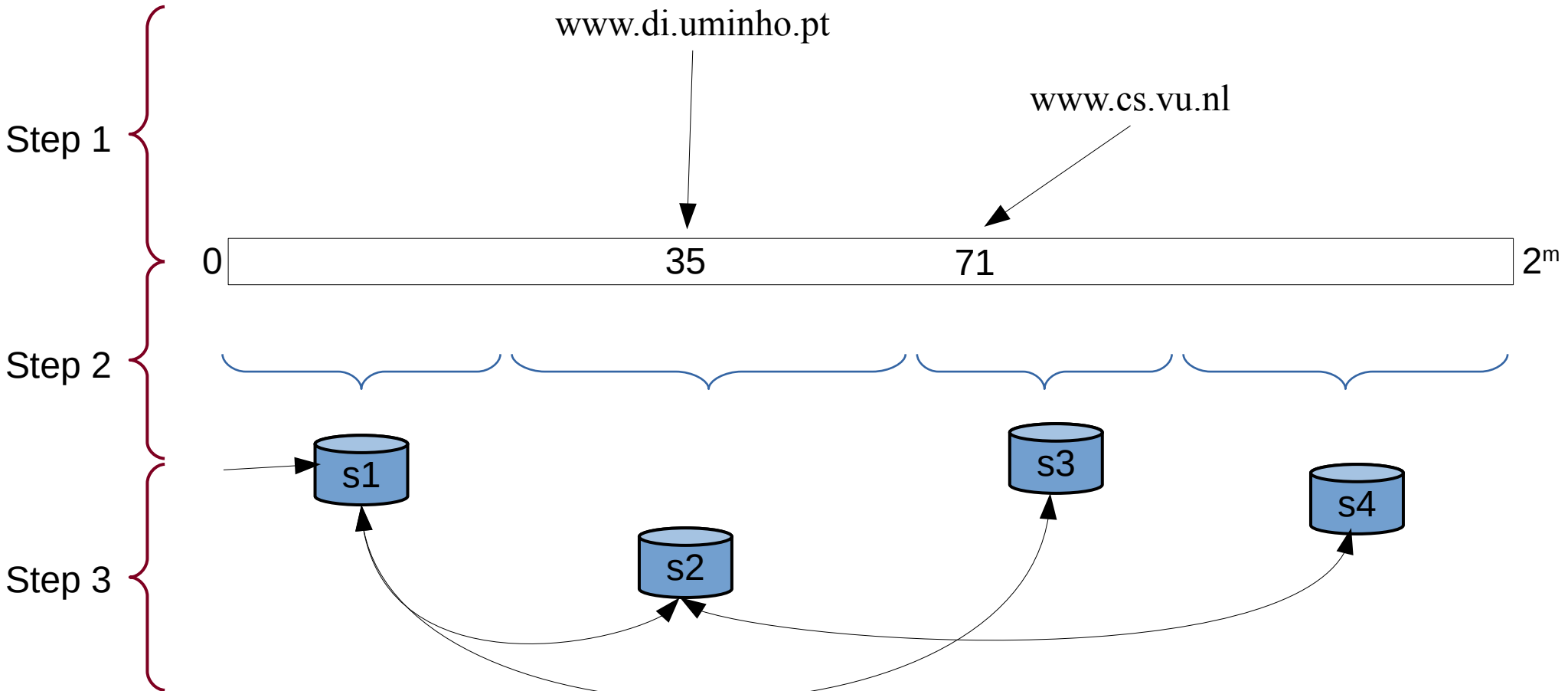
Hierarchical lookup



Hierarchical lookup

- Efficient lookup:
  - Depth of tree and number of hops is ~log N
- Allows distributed but coordinated administrative authority
- There is still a bottleneck and SPOF at root node

Distributed Hash Table (DHT)

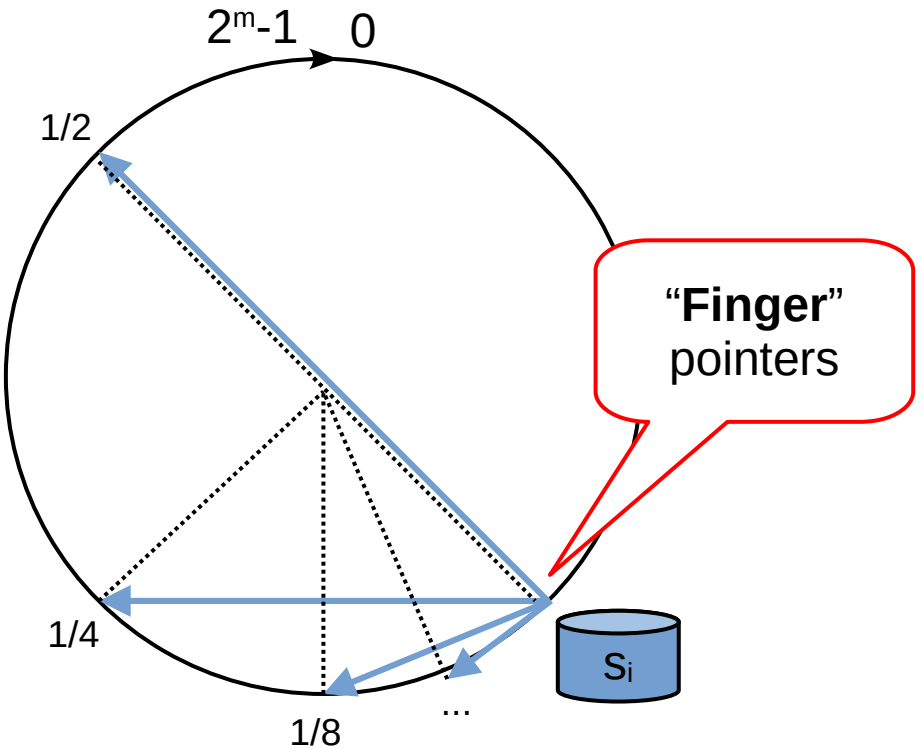


Distributed Hash Table (DHT)

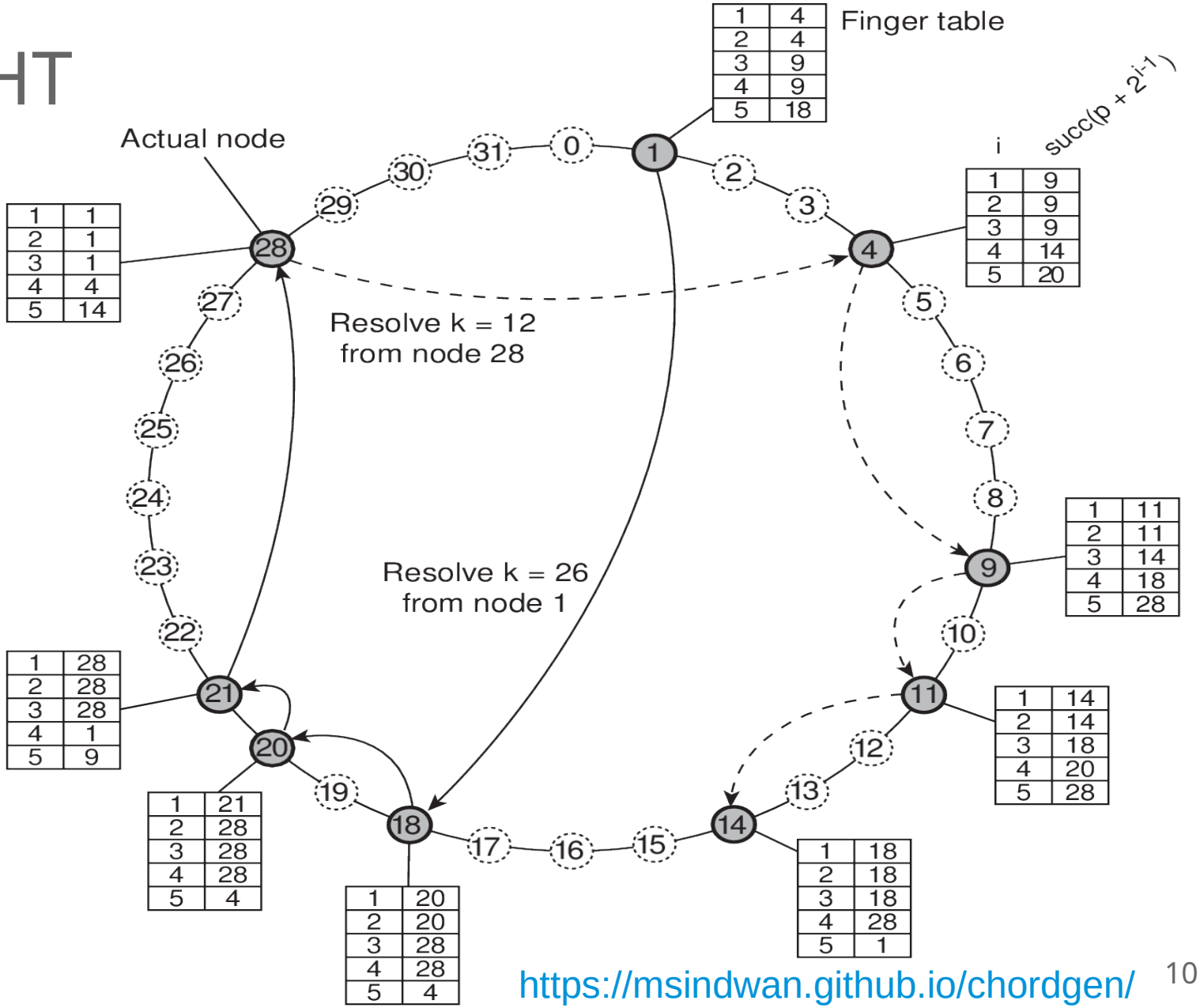
- Steps in distributed hashing:
  1) map names to integers in an interval (bucket)
  2) map integer intervals (buckets) to servers
  3) build overlay network that finds the desired servers
- Within each server, use any data structure to map names to objects

Chord DHT

- Wrap around hash space
- Split in halves:
  - At most m times
- Results in m pointers in each node
- Lookup: O(m)



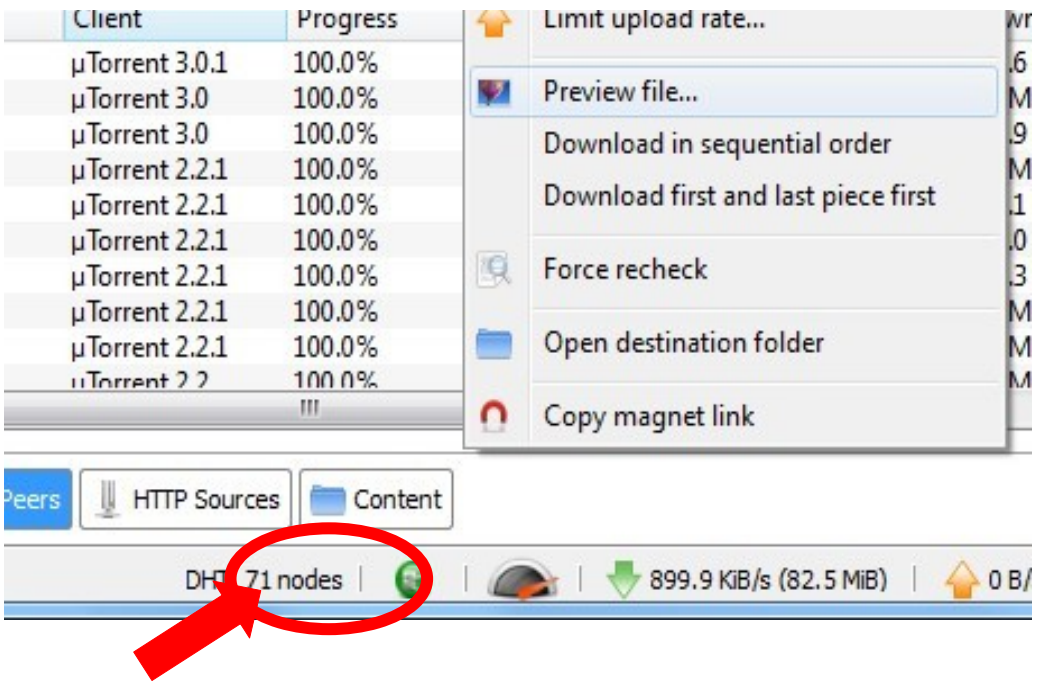
Chord DHT



https://msindwan.github.io/chordgen/

Distributed Hash Table (DHT)

- No single root node:
  - No bottleneck and no SPOF
- Efficient lookup:
  - ~log N hops
- Example: BitTorrent



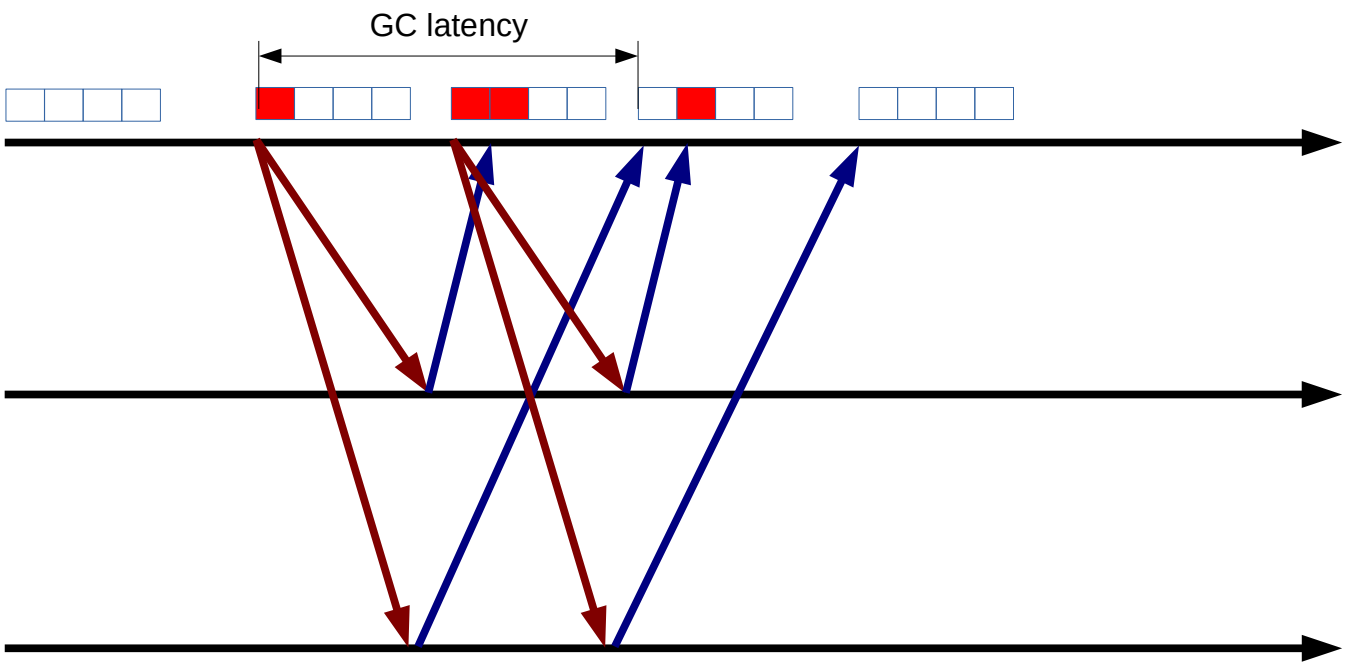
Application Level Multicast

- Reliably send to multiple destinations (group)
- Informally, reliability means that:
  - all destinations deliver all messages sent
- In reality, senders and receiver fail, thus:
  - all correct destinations deliver the same messages

- Worst case scenario: Message to only some of the destinations

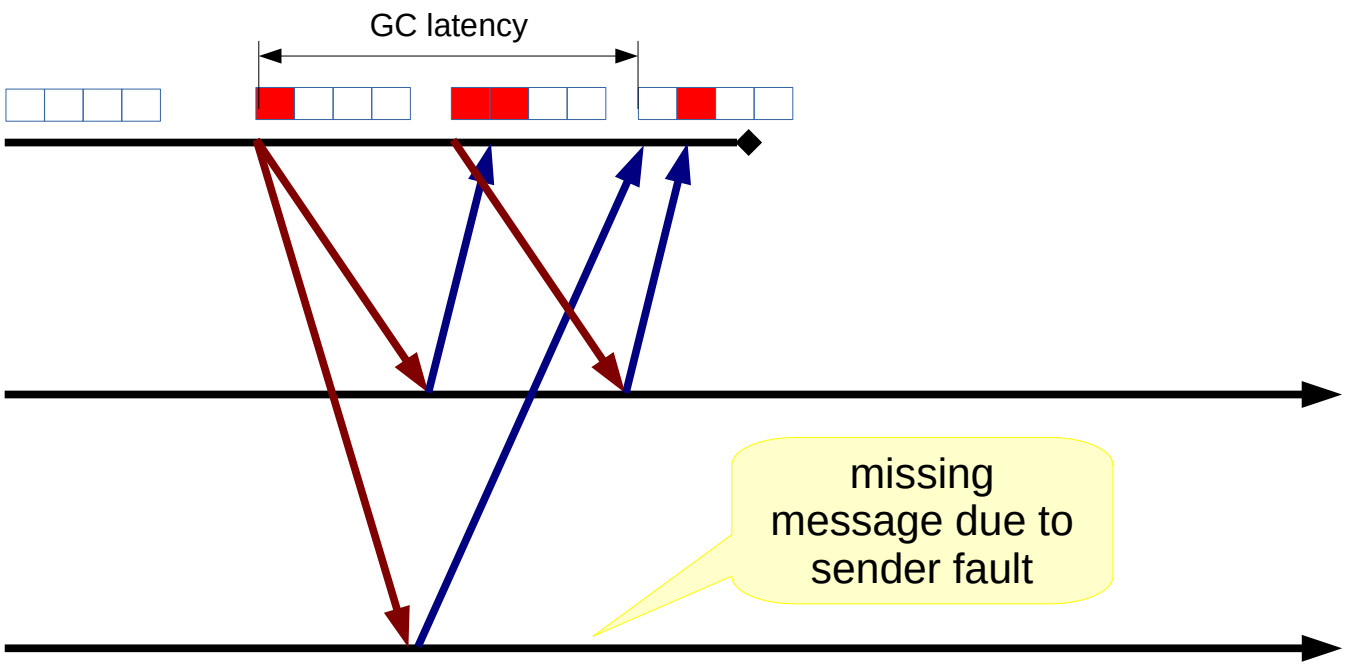
General approach

- Buffer and retransmit until acknowledged



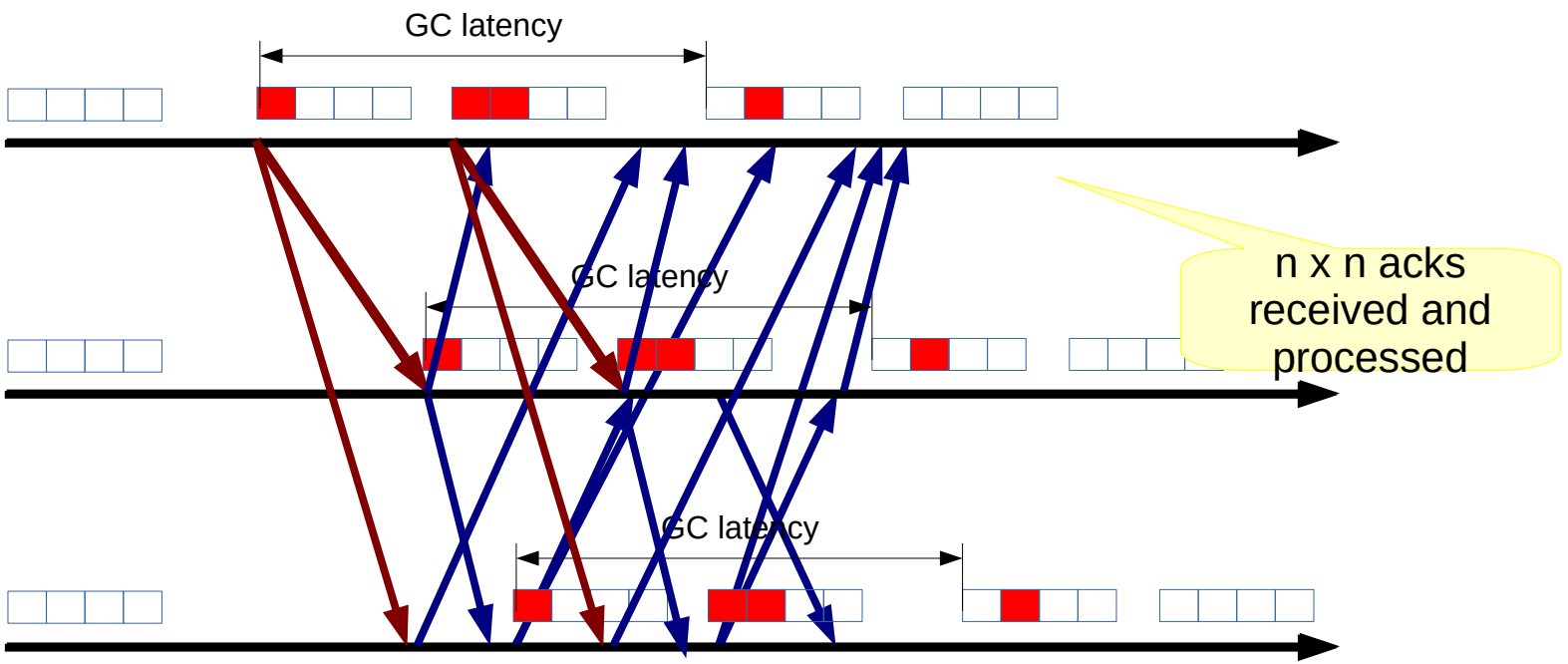
General approach

- Depends on sender correctness:



Multicast with agreement

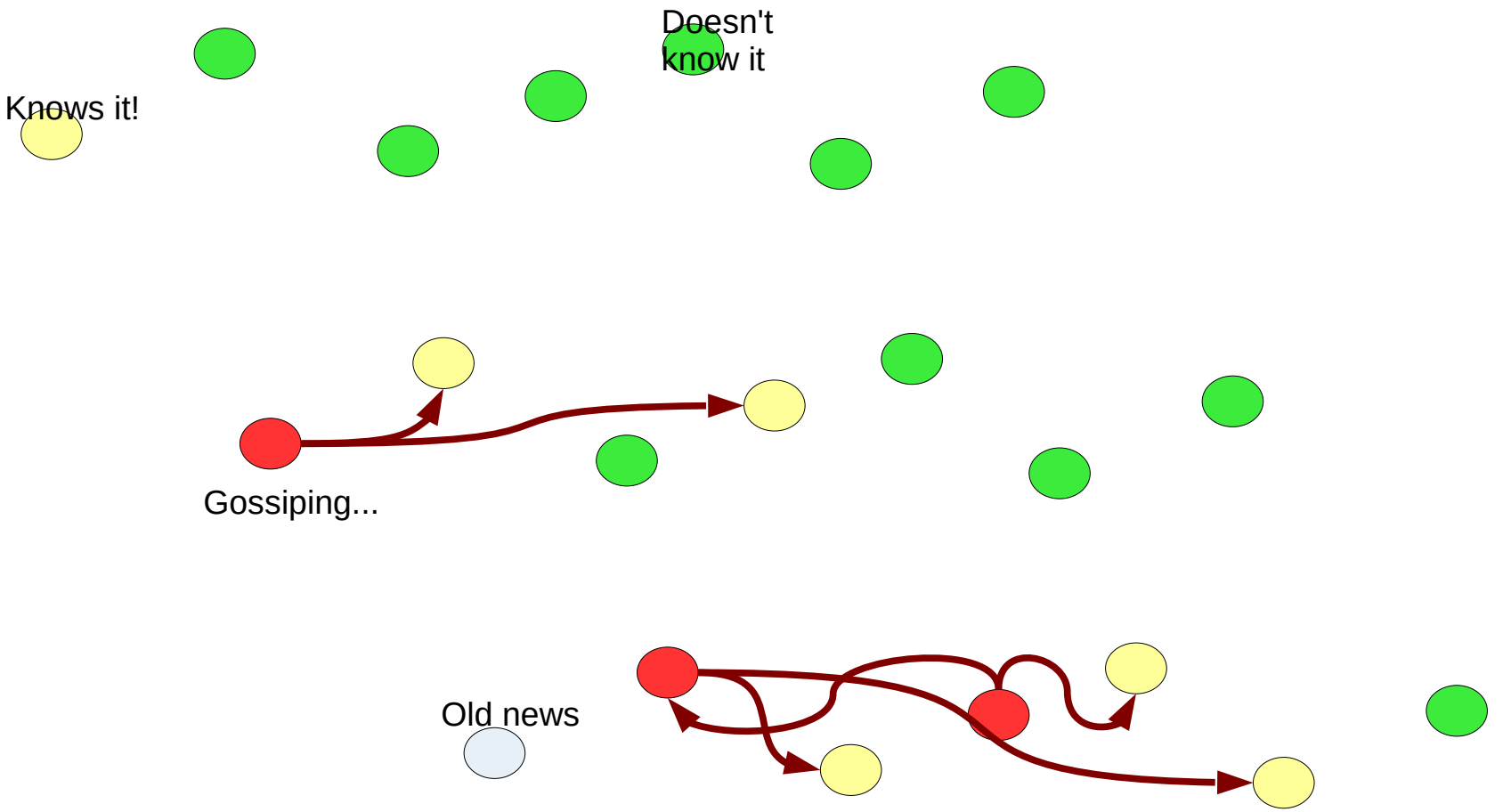
- Acks need to be sent to all destinations resulting in "$O(n^2)$ ack implosion":



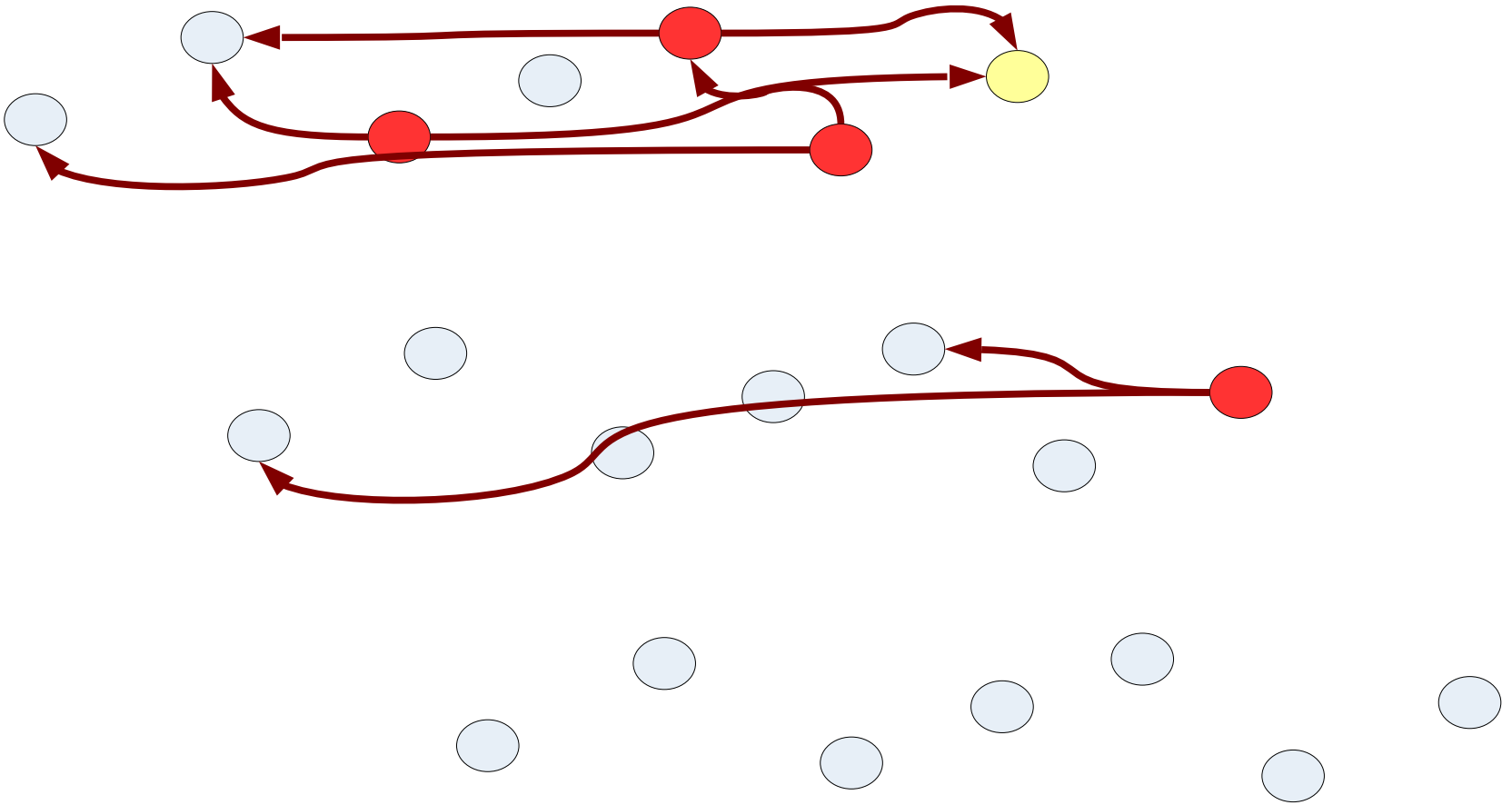
Gossip

- Simple protocol to multicast a message:
  - Select a small subset of random targets
  - Forward message only to those targets
  - Discard message
- Upon receiving a new message, act as the sender

Gossip



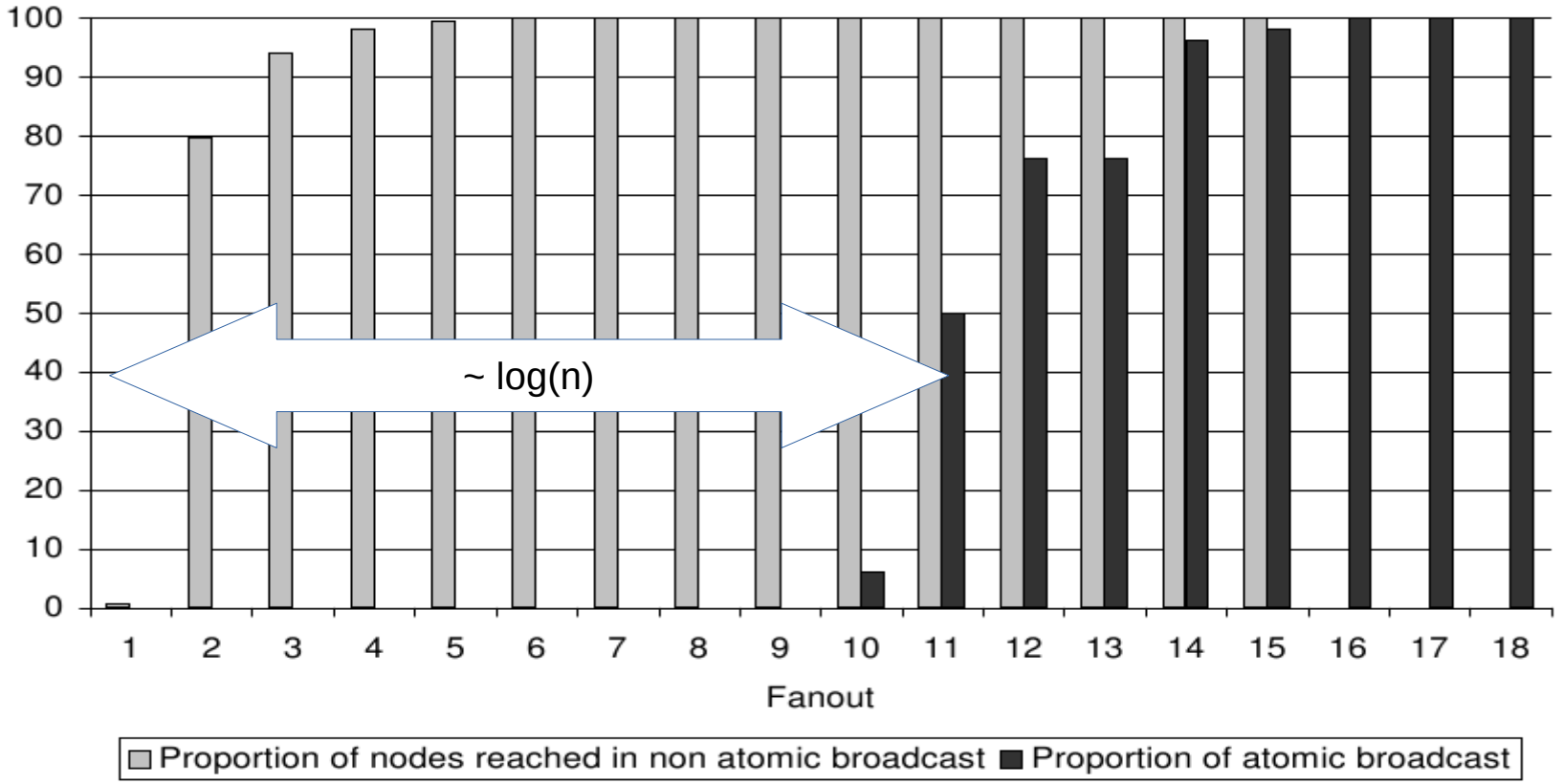
Gossip



Gossip and Epidemics

- Similarity with epidemics:
  - Sender = contagious = spreads rumor
  - Receiver = infected = knows rumor
  - Ignores duplicated = dead = old news…
- Interesting parameters:
  - n – size of the population
  - f – number of targets

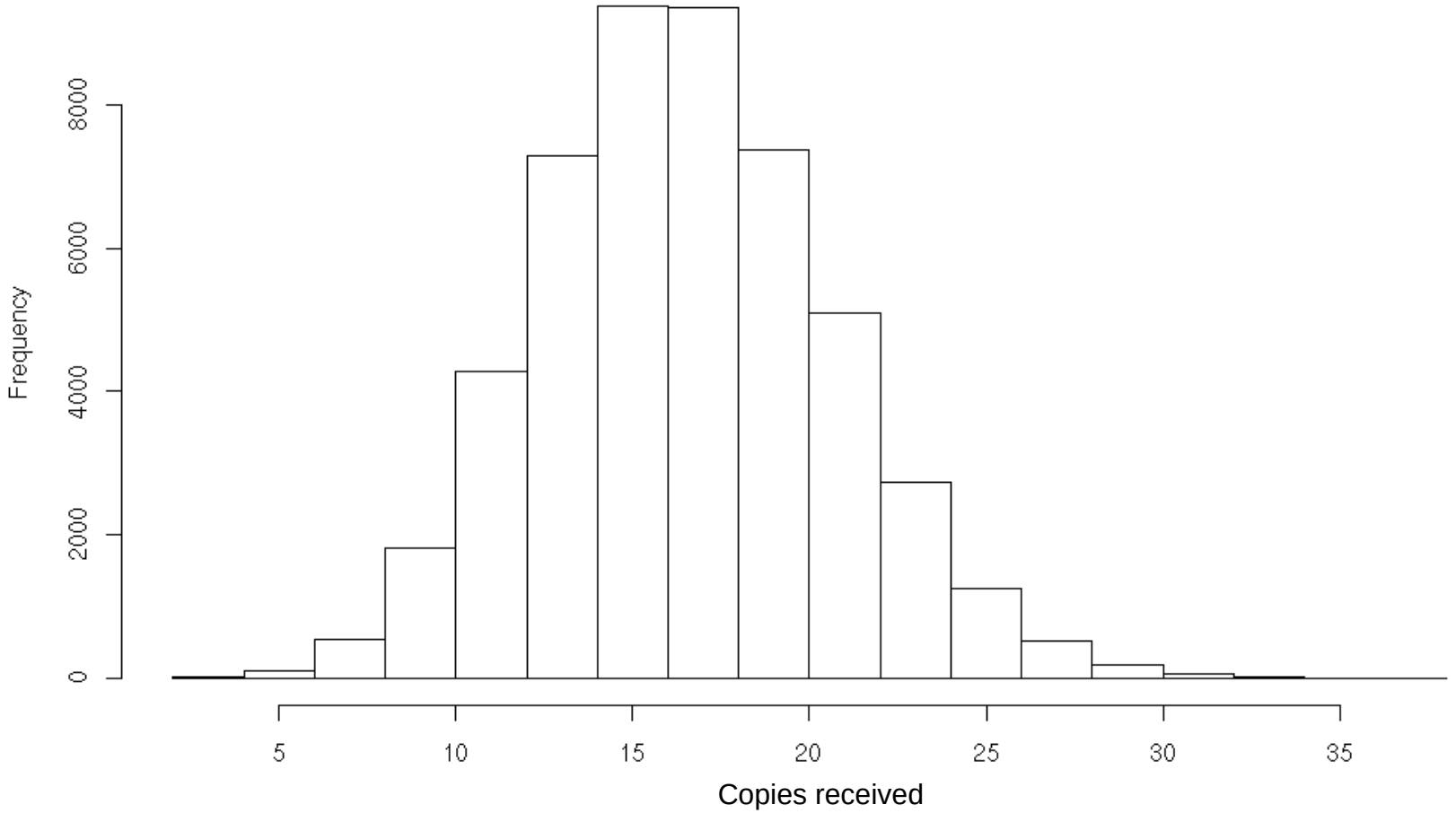
Fanout vs Reliability



(50000 destinations)

In From Epidemics to Distributed Computing.
P. Eugster et al. IEEE Computer, 2005.

Redundancy



(50000 destinations)

Summary

- DHTs are now the scalable, dependable, widely used solution to distributed search
- Gossip protocols implicitly ensure w.h.p. that all correct processes have received the same messages