BRISA:
Combining Efficiency and Reliability in Epidemic Data Dissemination

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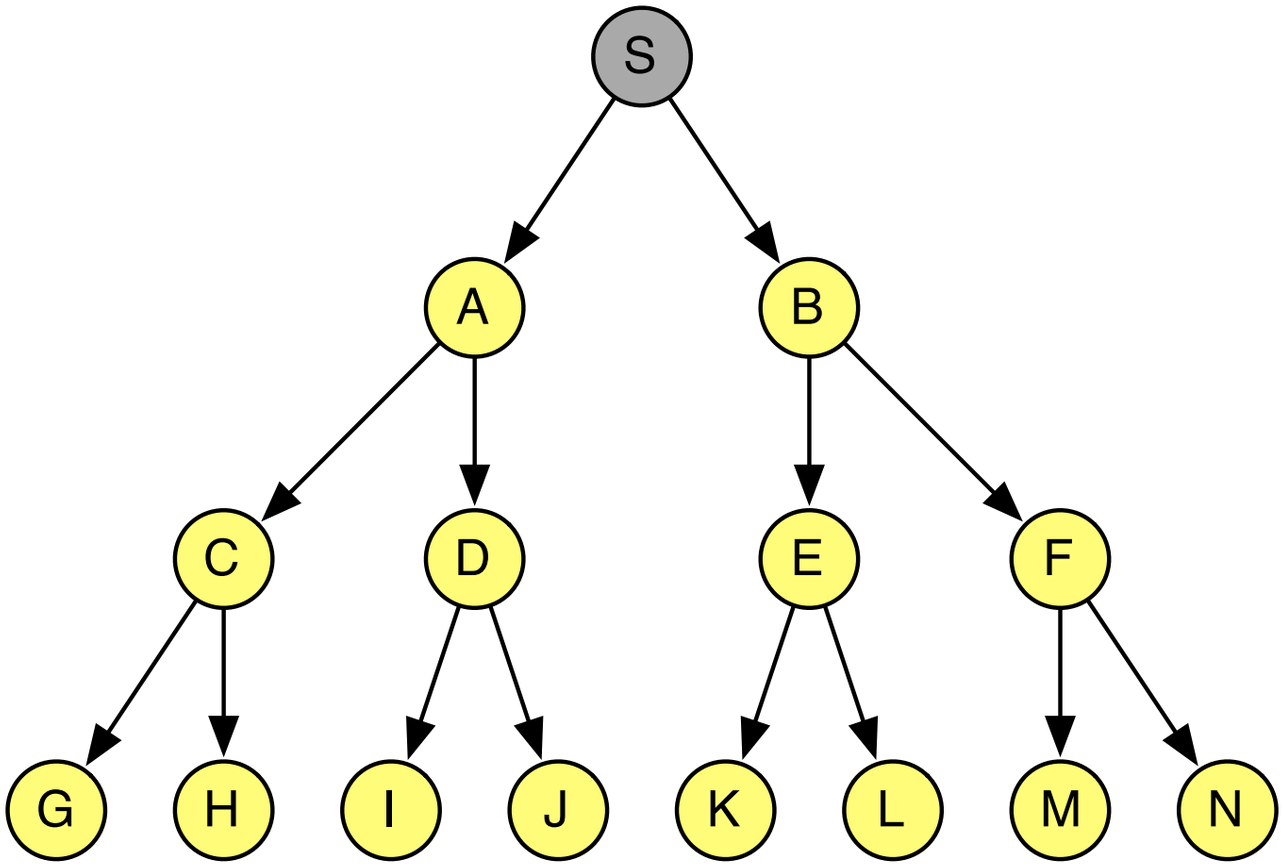
Motivations

- Broadcast of small or medium sized messages
- Challenging environment
  - (very) Large scale
  - Highly dynamic
- Performance criteria
  - Low delays for all
    - Distribution of first reception time
  - Low overhead (overlay construction)
  - Low message count (for disseminations)
- + Simplicity!

Using a tree?


S
A
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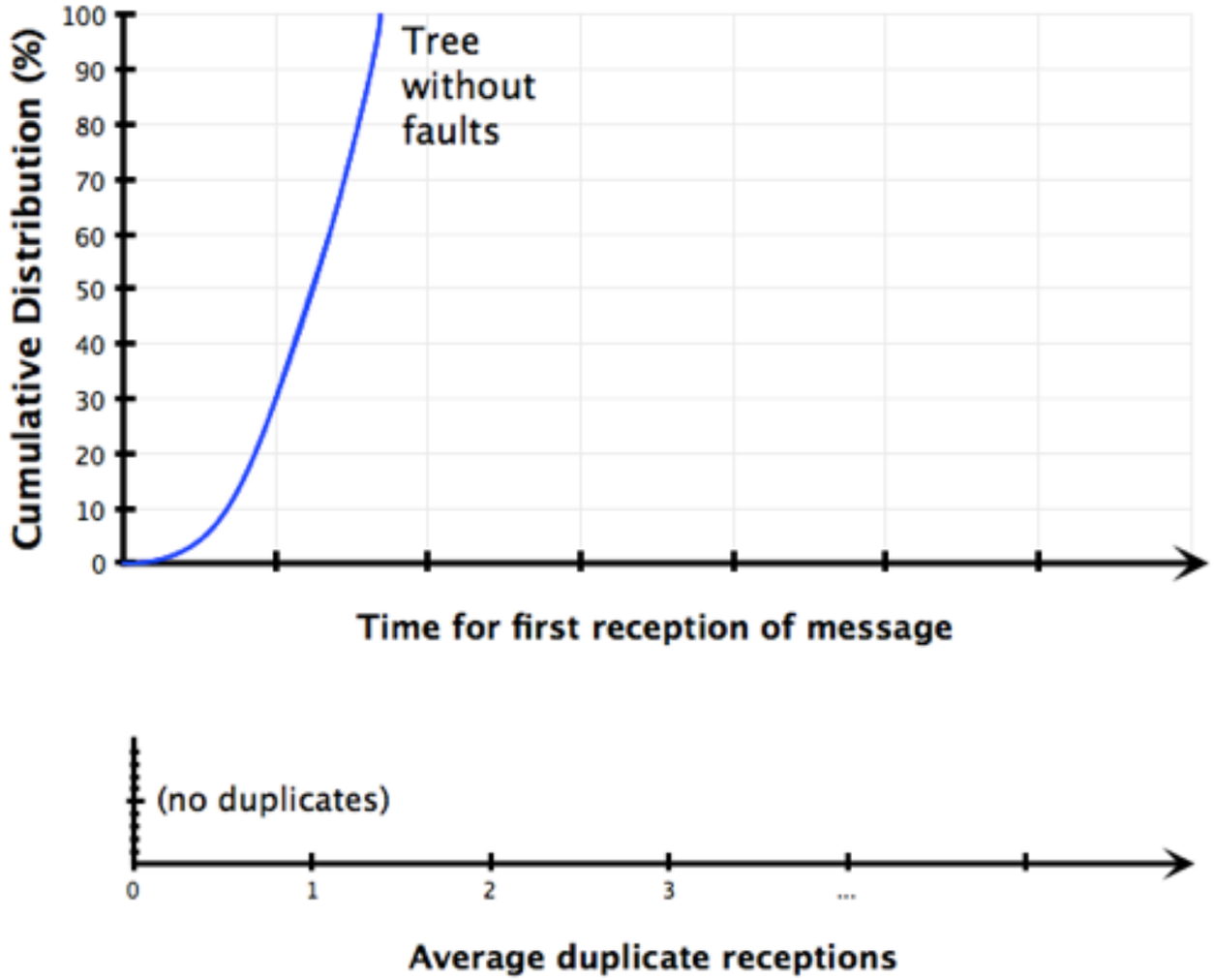
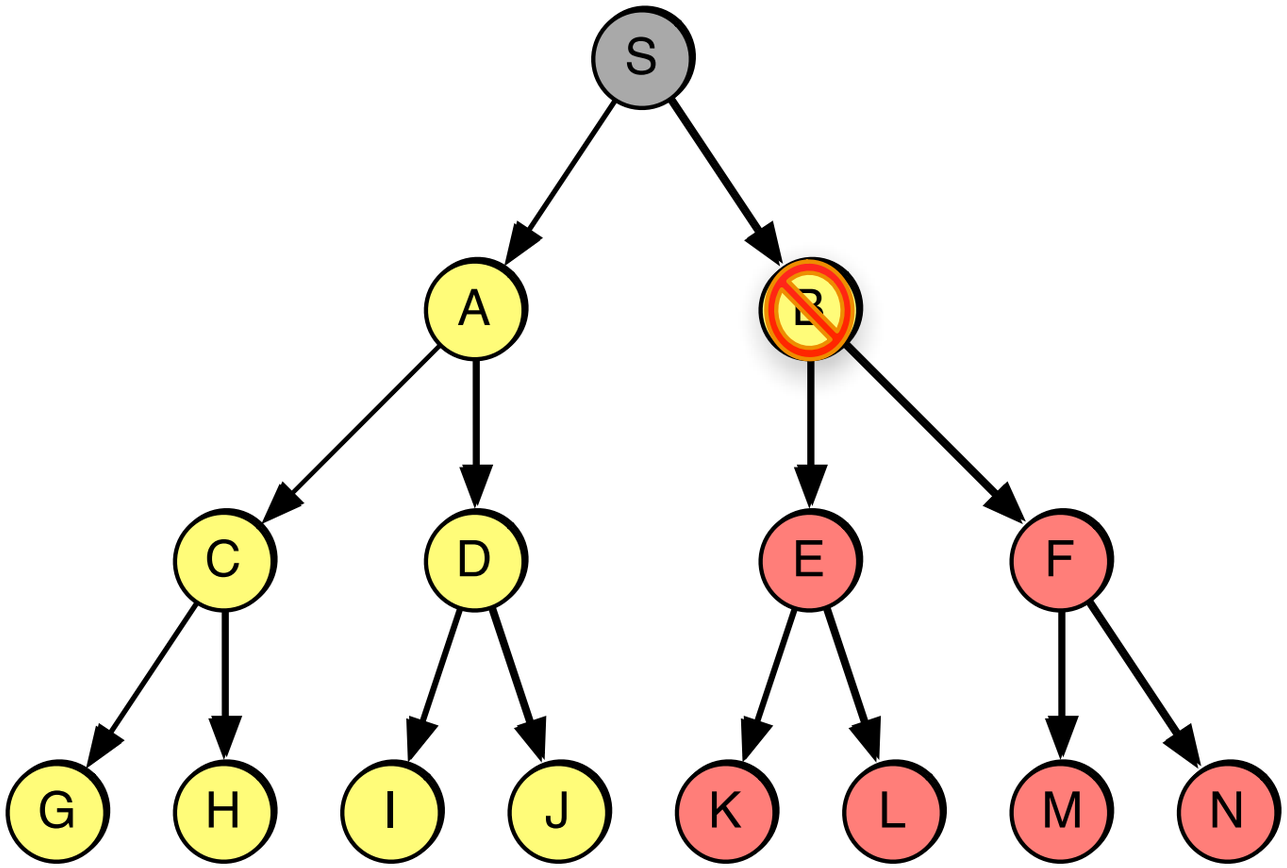
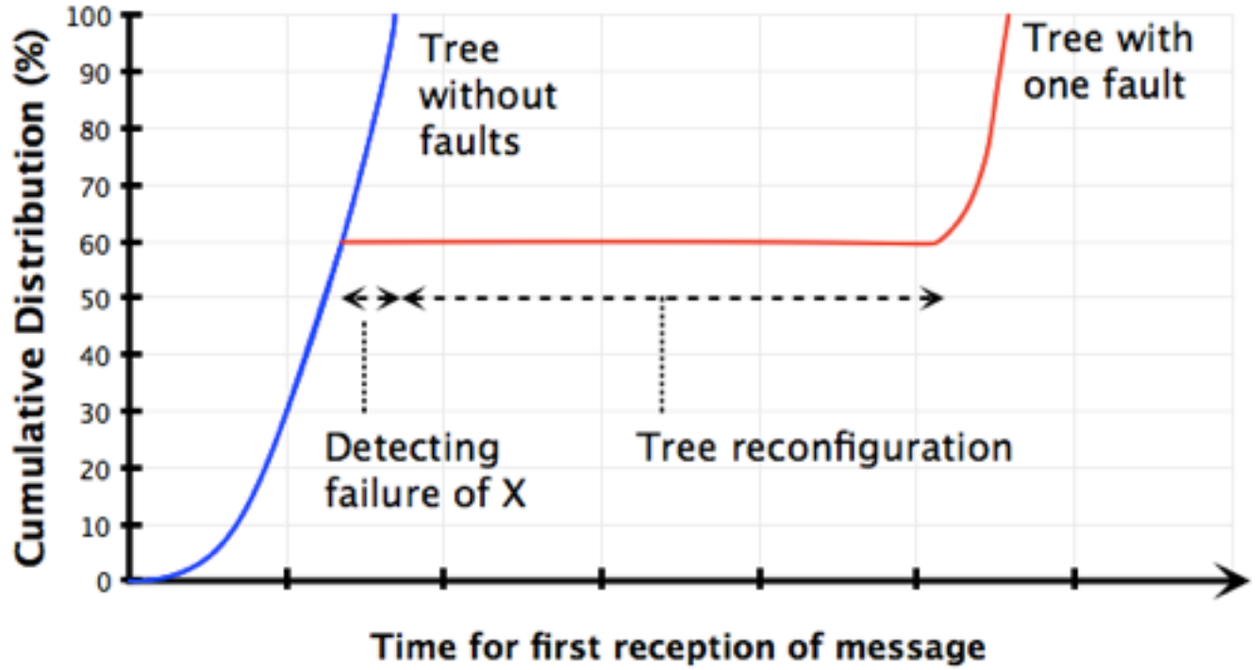
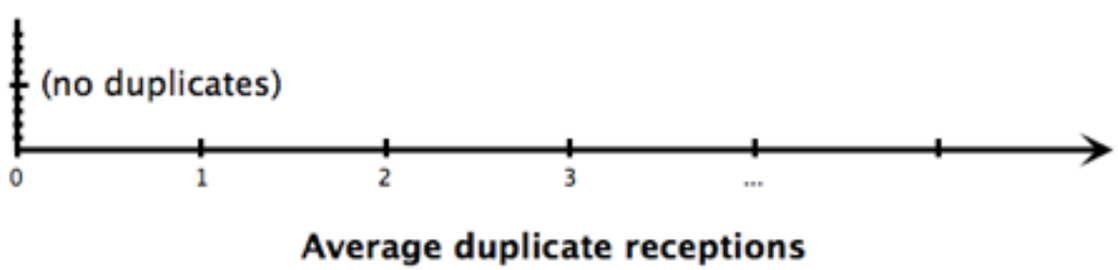

Cumulative Distribution (%)
100
90
80
70
60
50
40
30
20
10
0
Tree without faults
Time for first reception of message
(no duplicates)
0
1
2
3
...
Average duplicate receptions

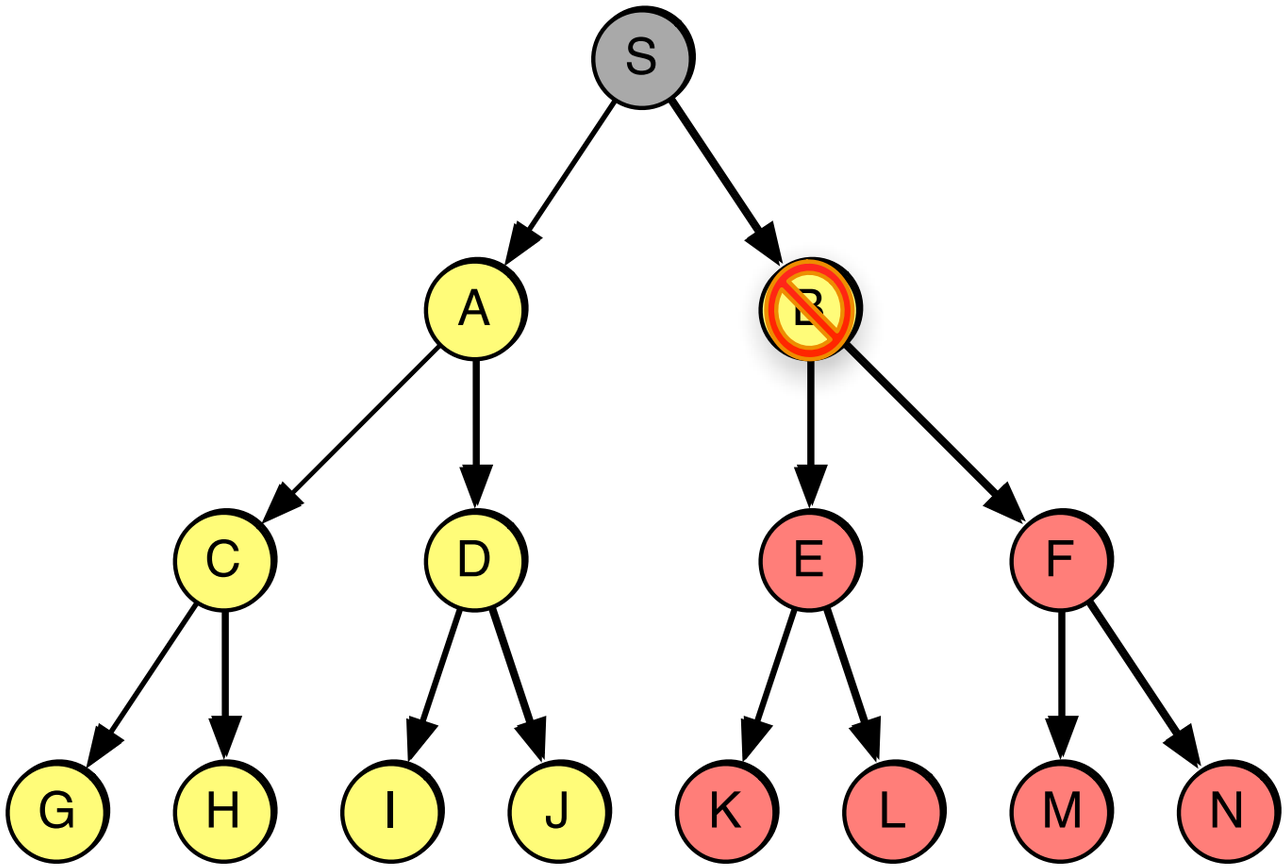
Faults happen

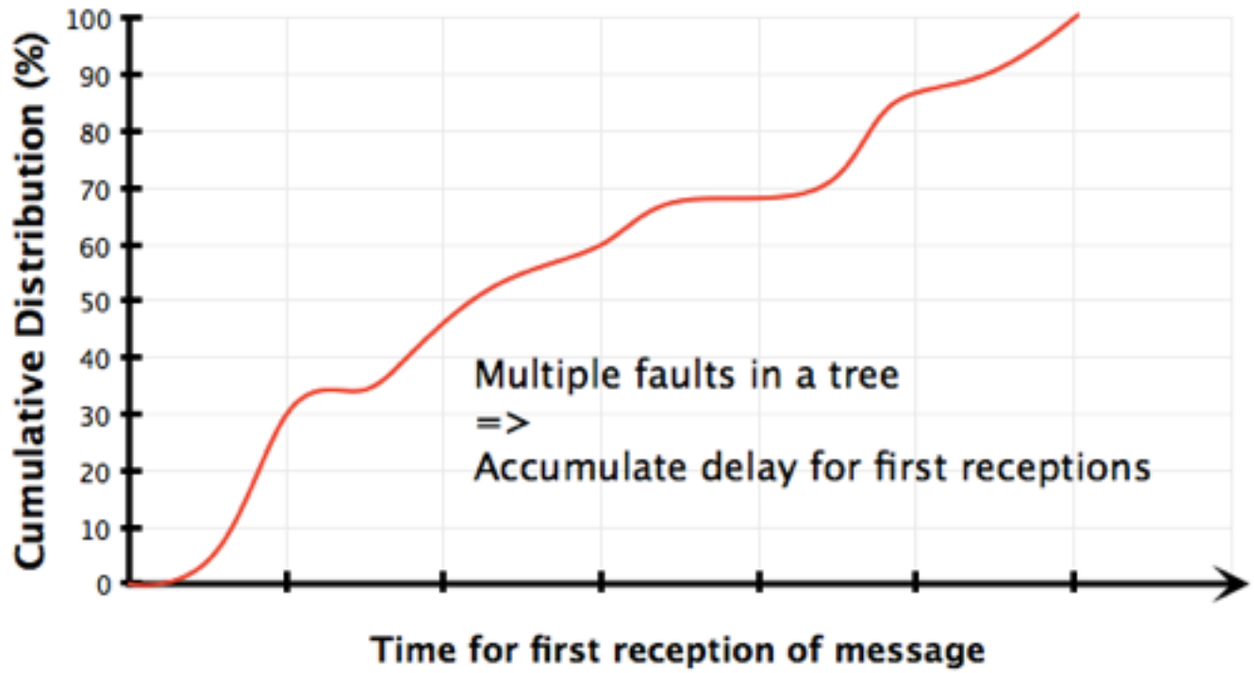


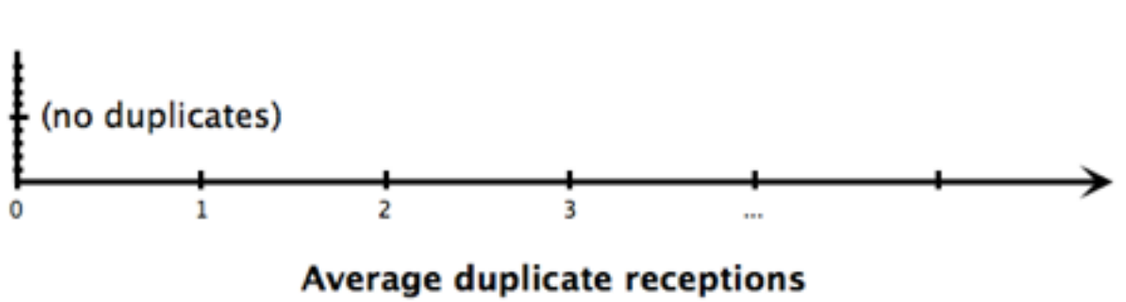




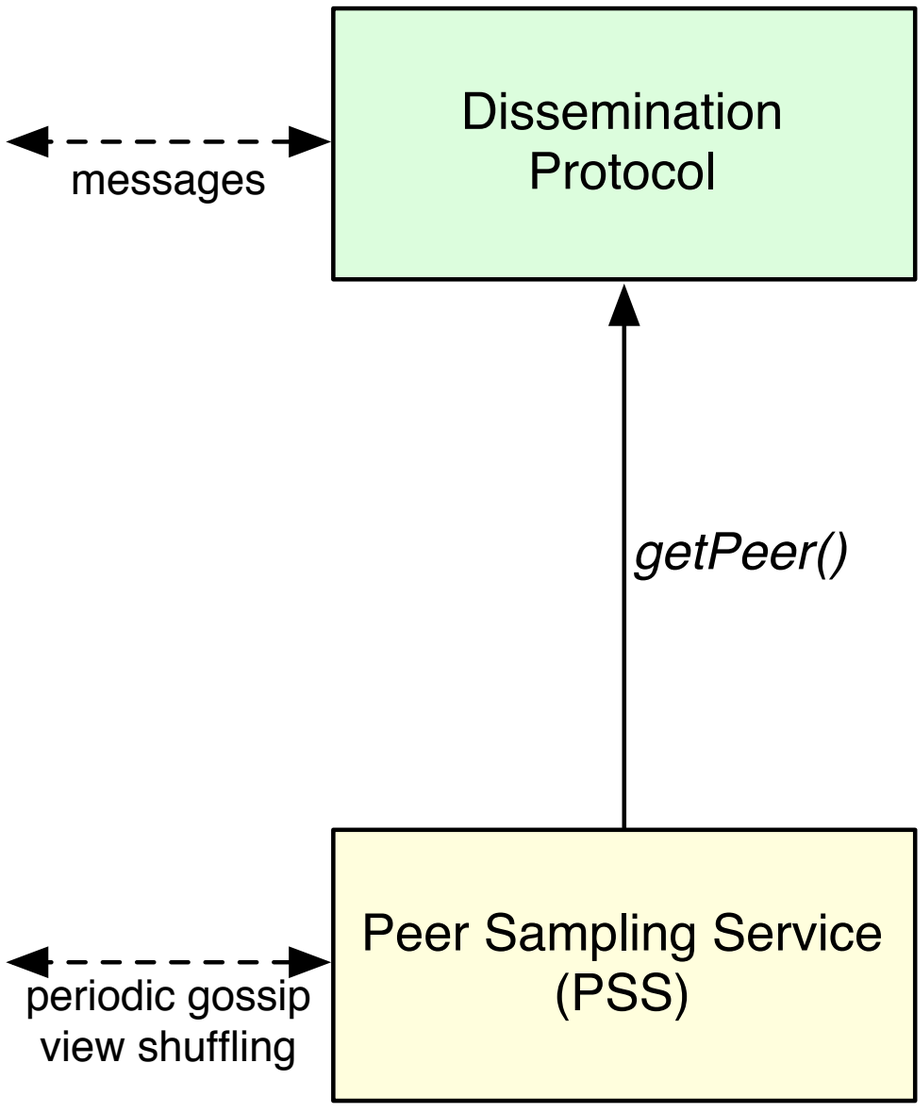
Faults cumulate







Classic epidemic-based dissemination



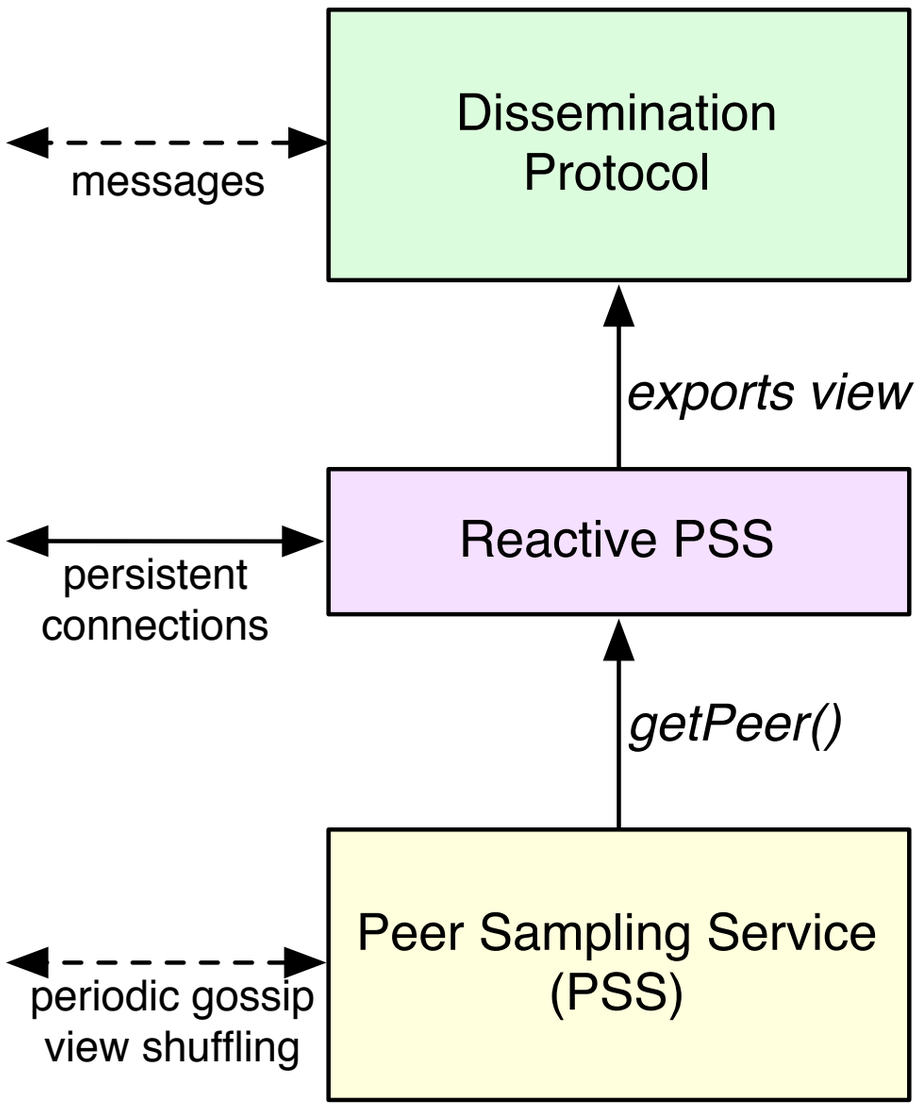
Flooding: send message to all nodes upon first reception

=> Probabilistic Broadcast

Provides constant *stream* of random peers

=> Membership Management
=> Avoids Partition
=> Insert new peers, forget old ones

Epidemic-based dissemination on reactive PSS



Deterministic flooding: send message to all nodes on first reception

=> Total Broadcast

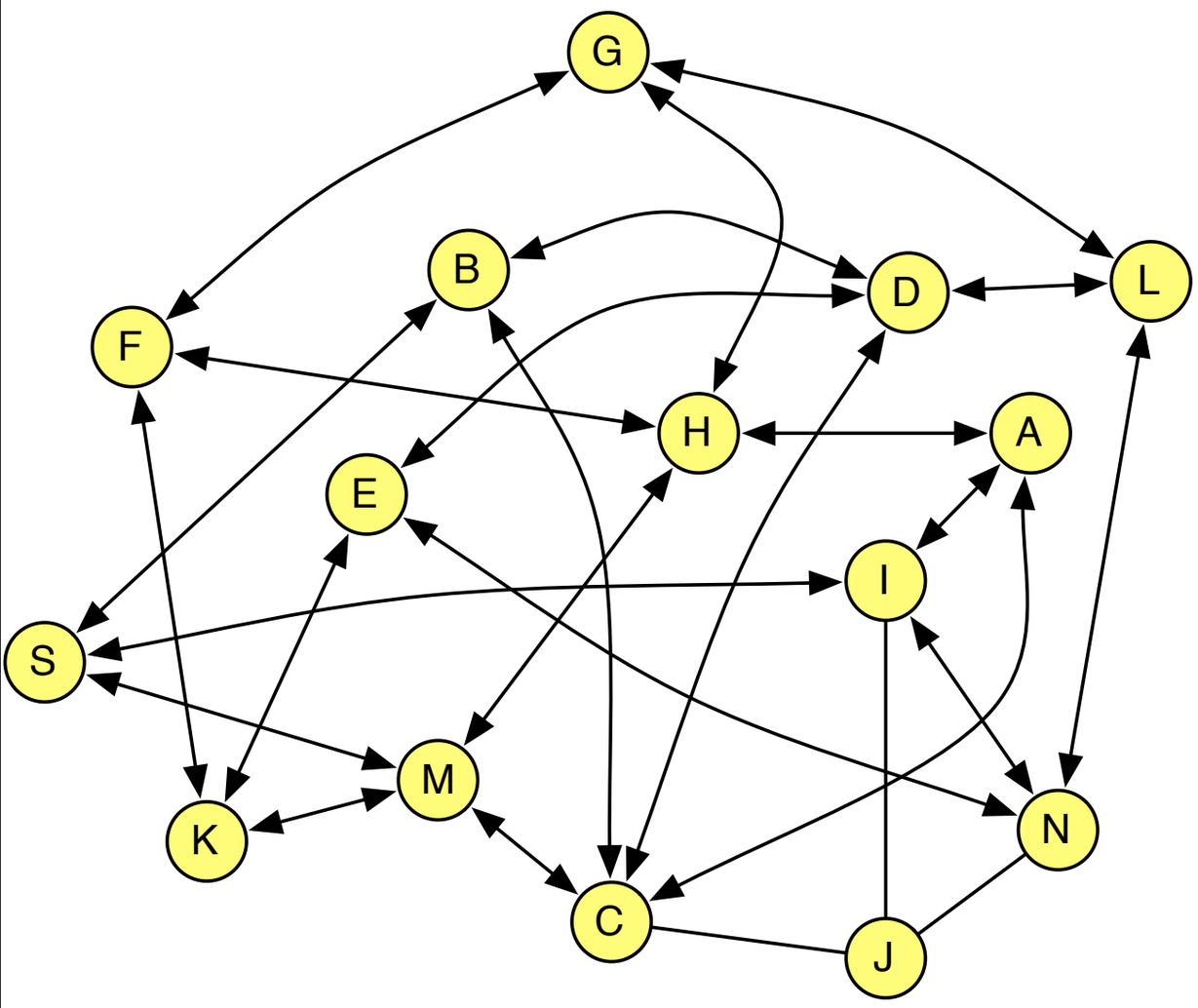
Reactive view management

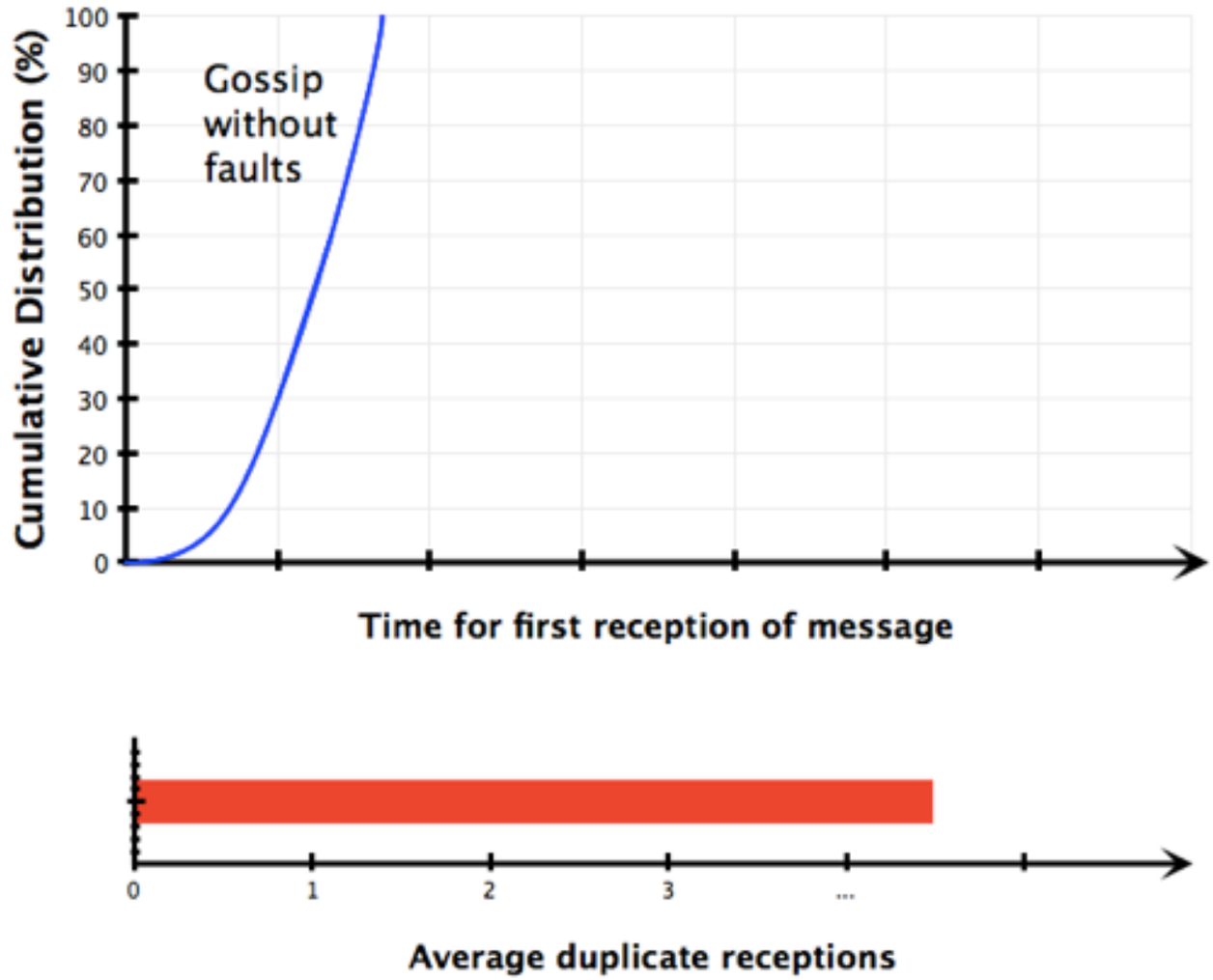
Maintains **persistent** connections to peers
Bi-directional links
Fault Detection
Replaces failed peers from PSS getPeer()

Provides constant *stream* of random peers

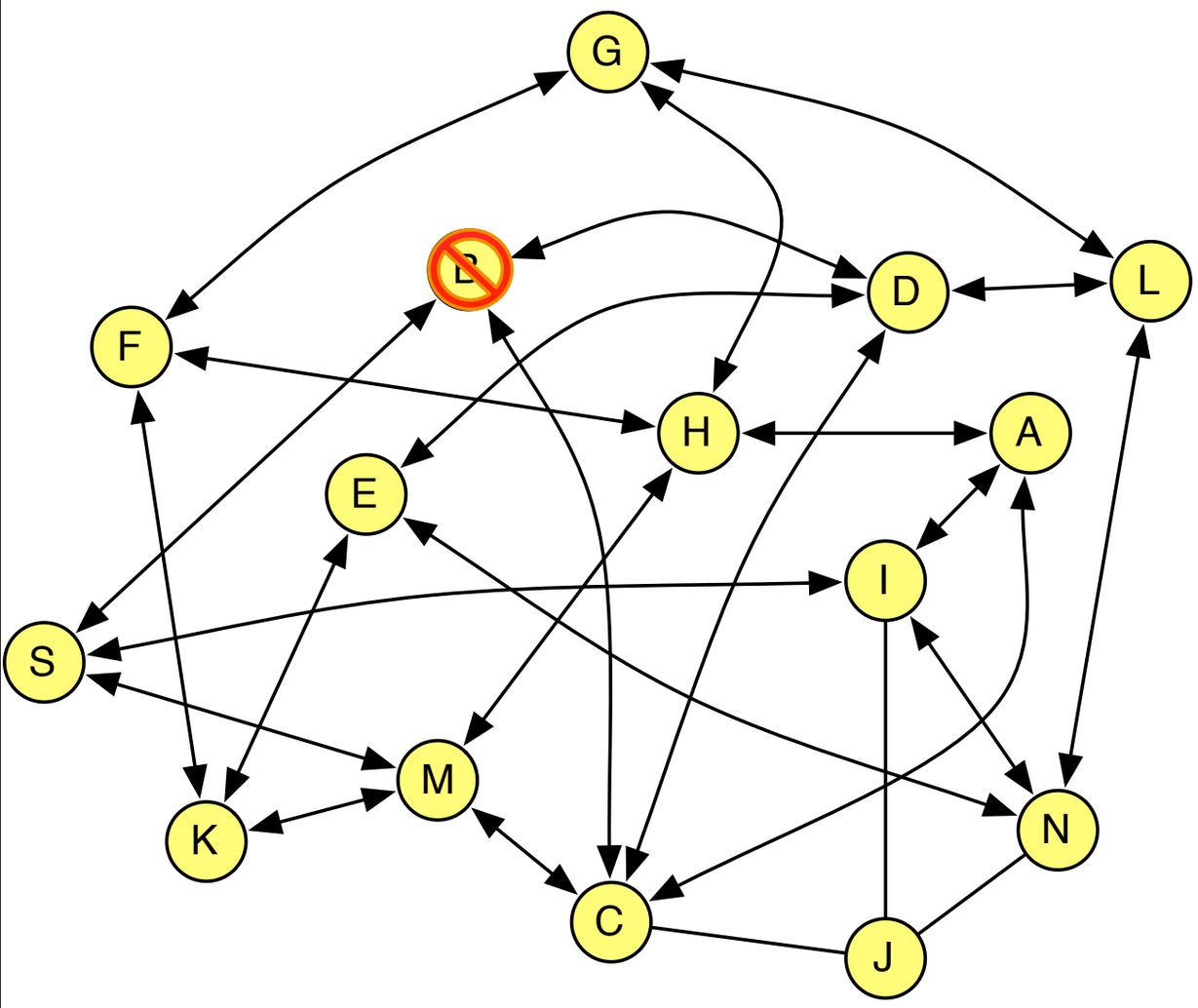
=> Membership Management
=> Avoids Partition
=> Insert new peers, forget old ones

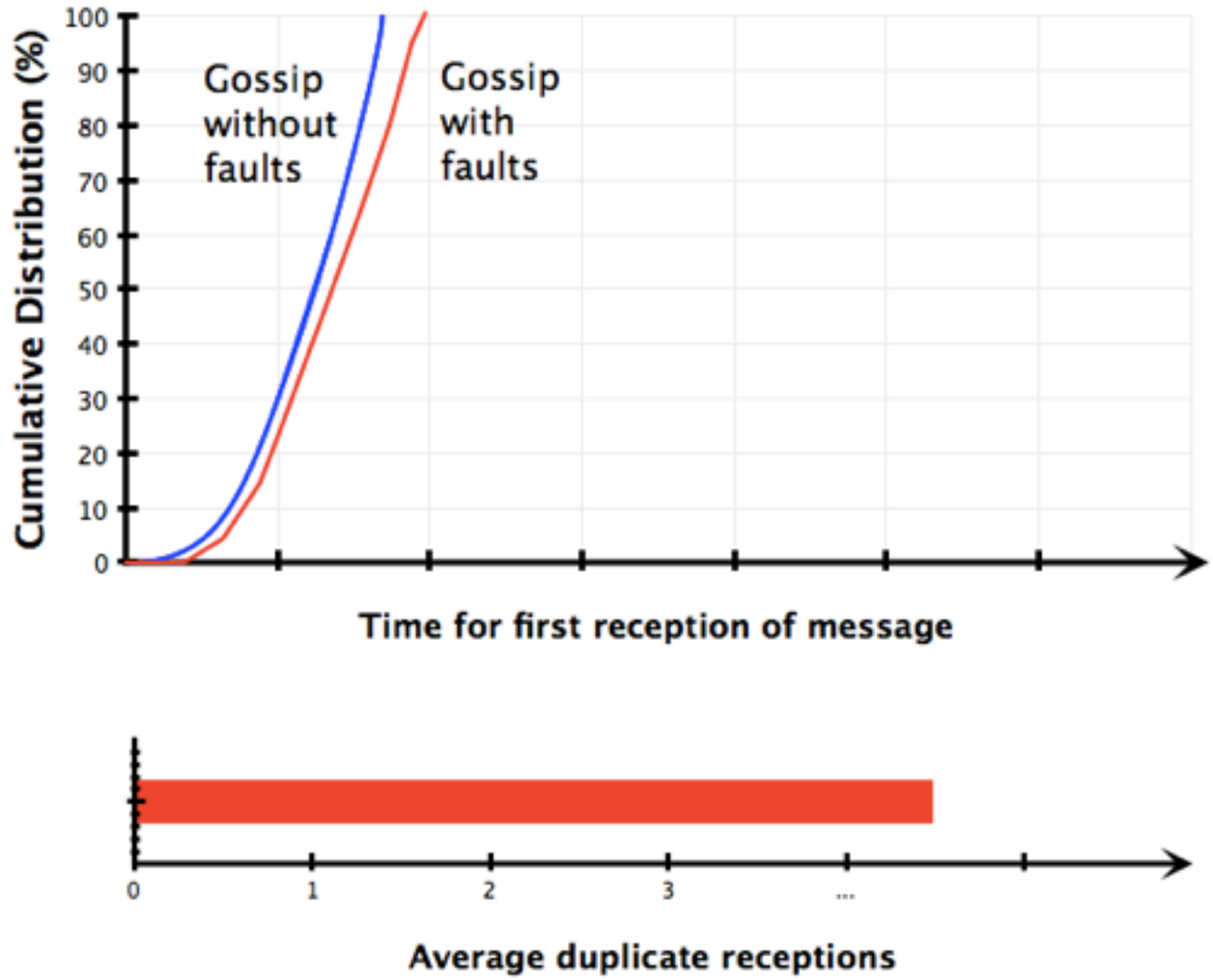
Epidemic-based dissemination



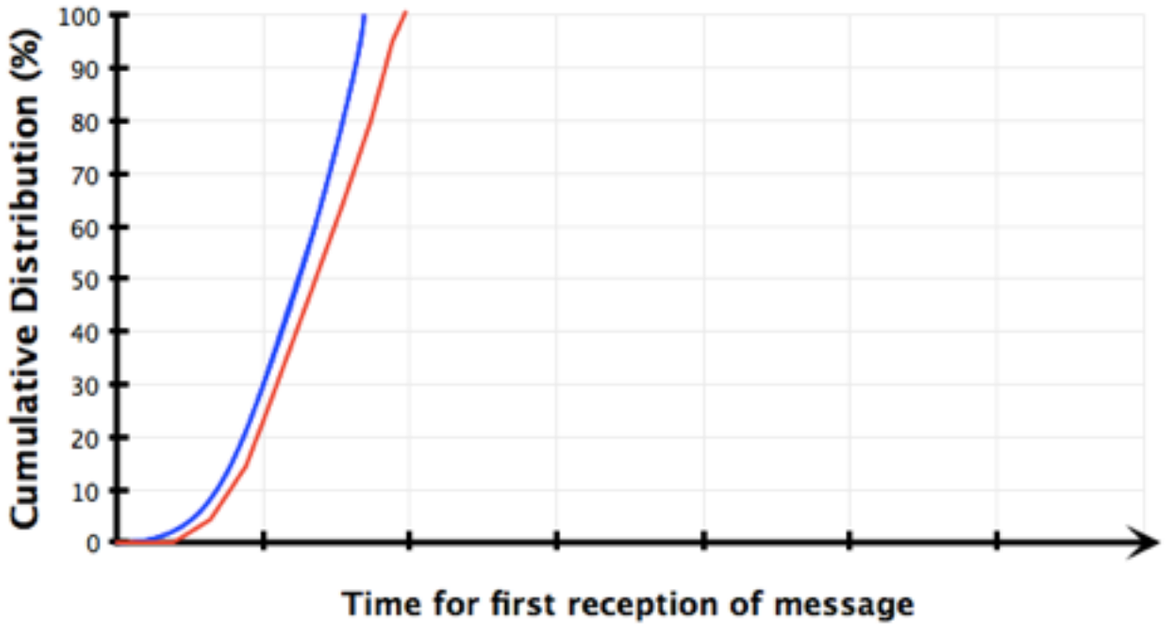


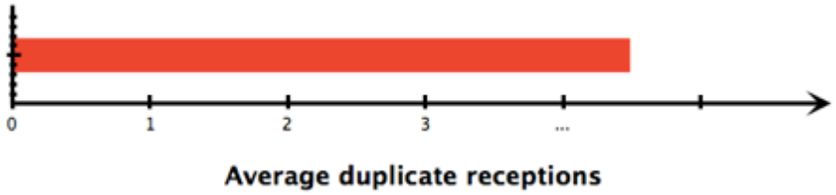
Epidemic-based dissemination



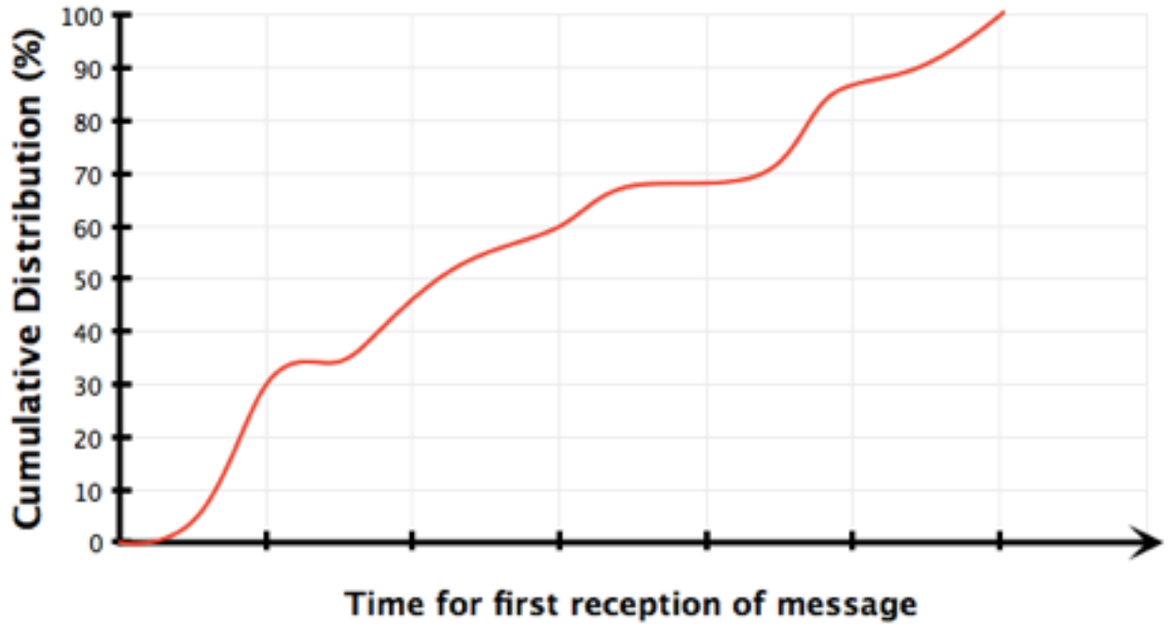


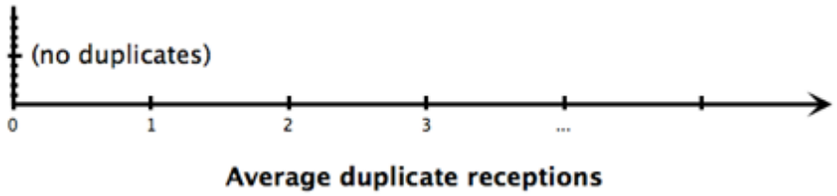
Gossip



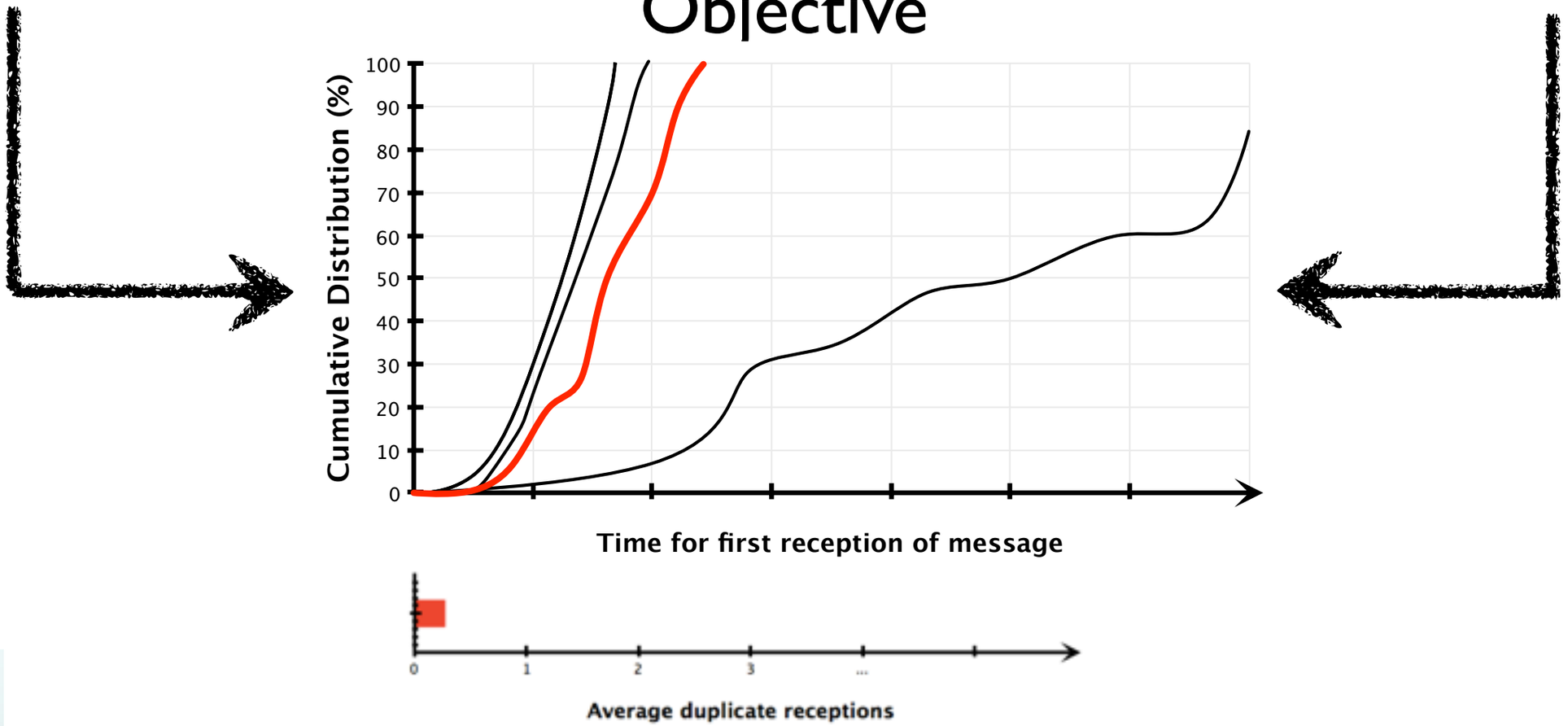


Tree





Objective



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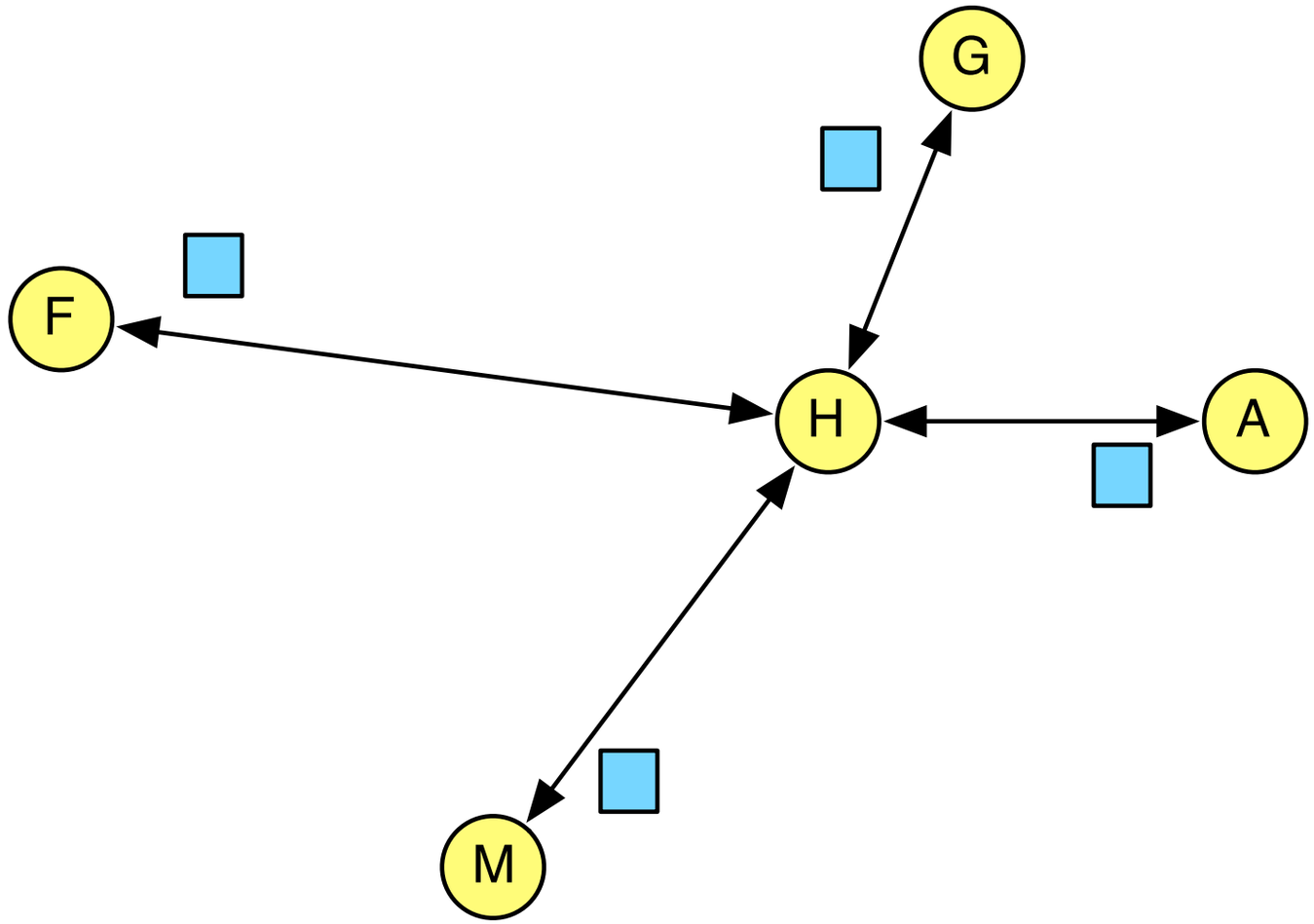
BRISA *in a nutshell*

- Start from existing *Reactive Peer Sampling Service* (RPSS)
  - First dissemination = flooding over RPSS
- Emerge an embedded tree
  - Select between the links maintained by the RPSS
    - One of the receptions = parent link
    - Others deactivated
- Allow only a small number of duplicates
  - Upon join
  - Upon failure
- Quick recovery based on RPSS persistent connections and quick fault detection

Emerging a tree through deactivations



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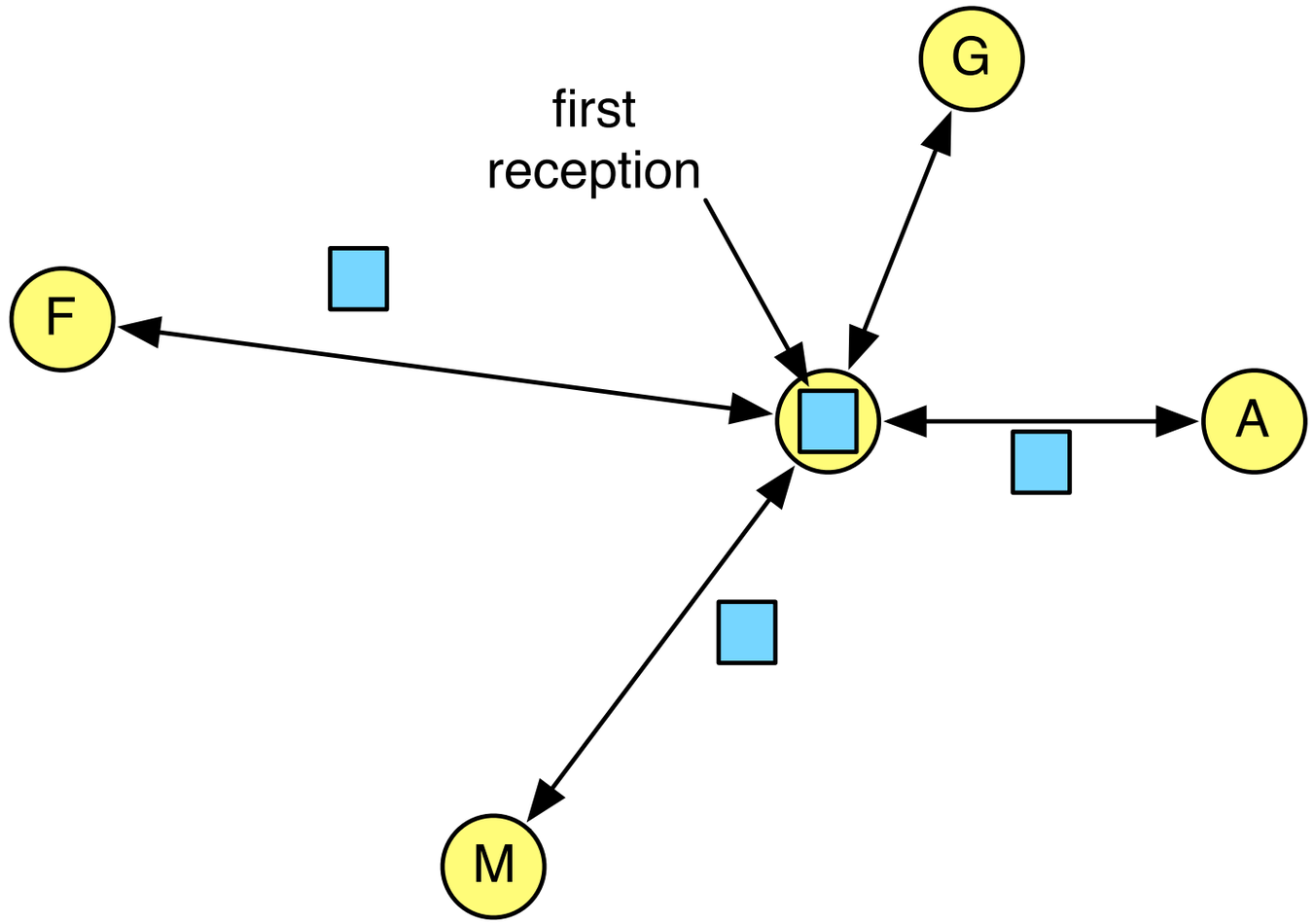
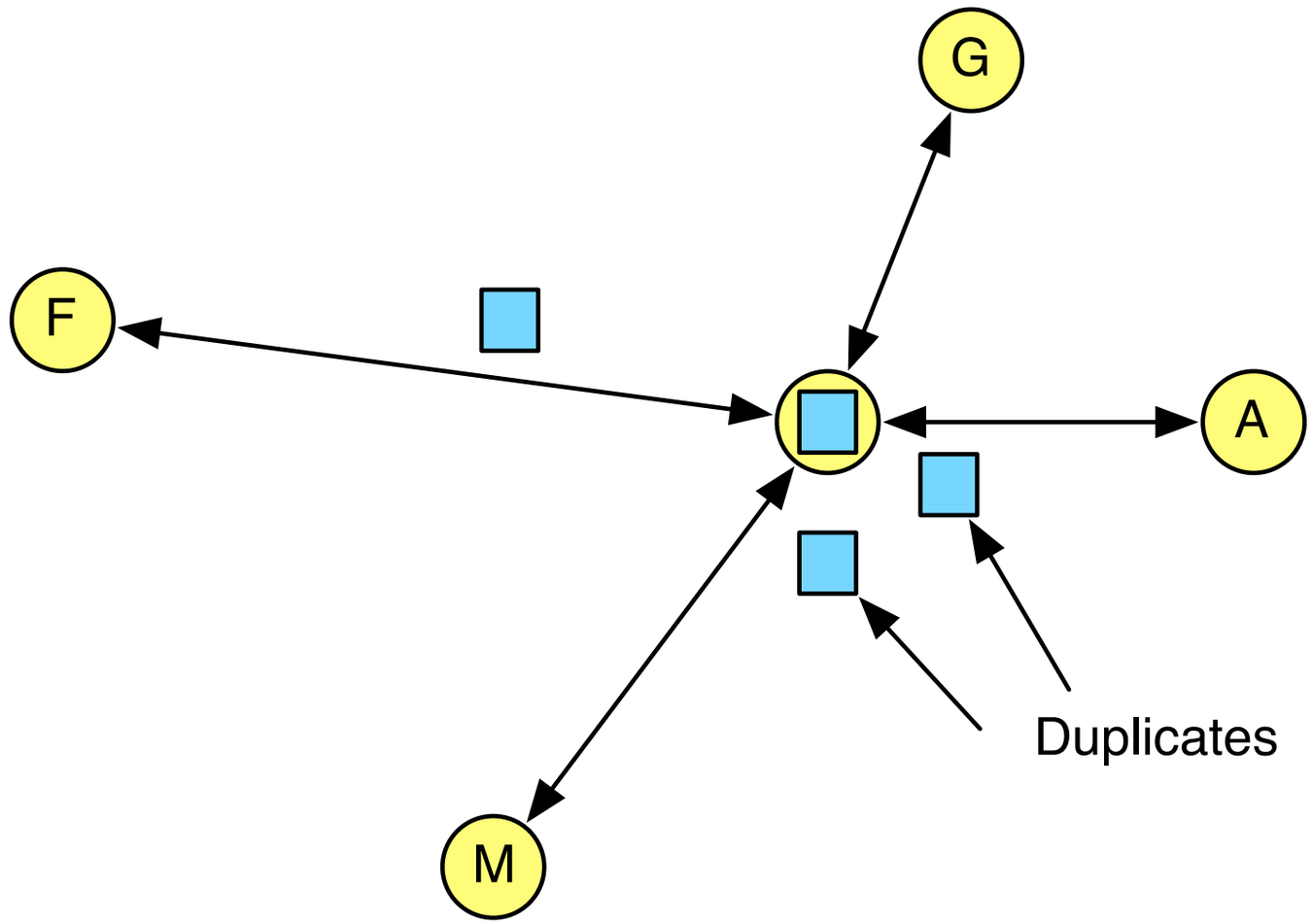
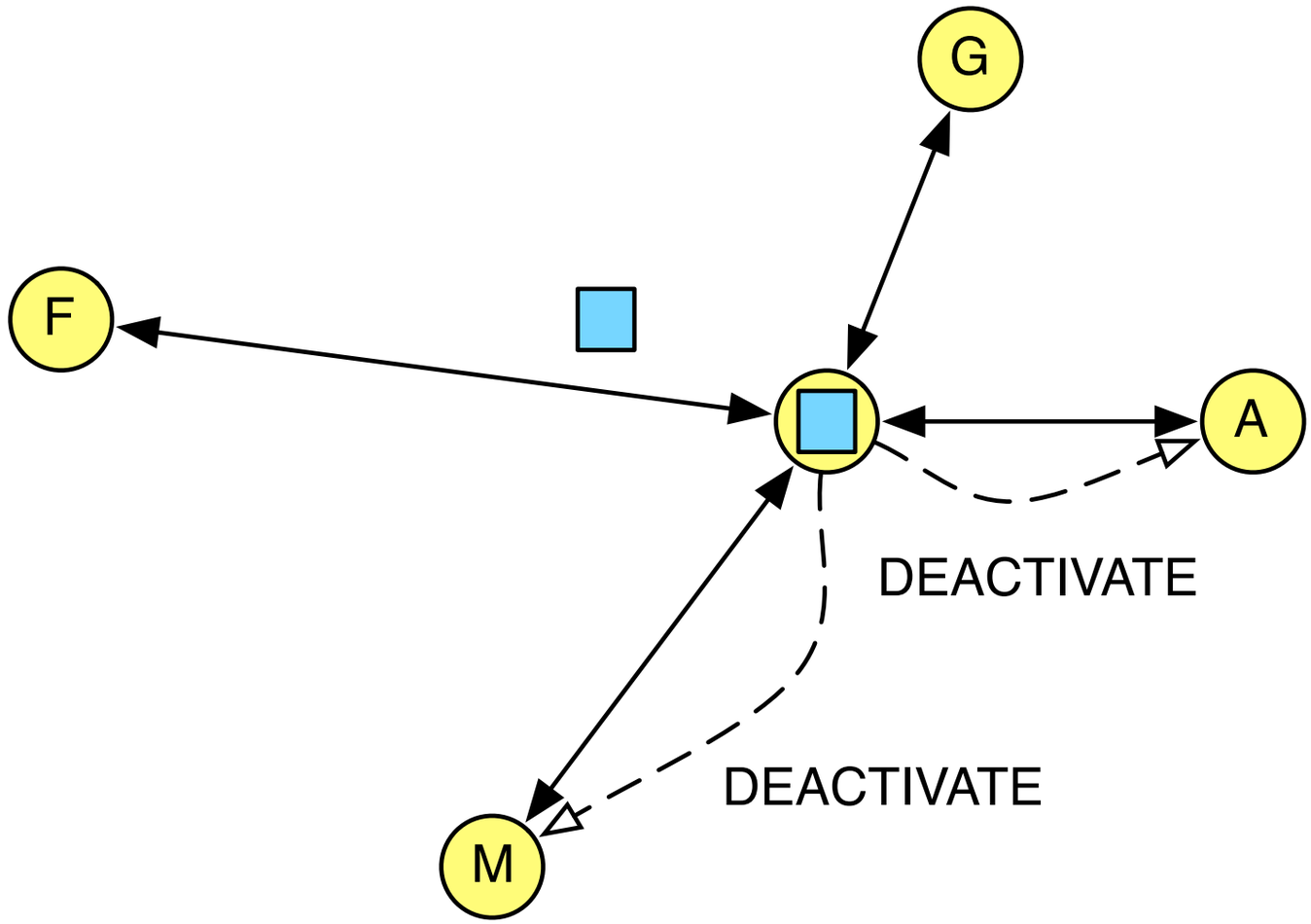


Emerging a tree through deactivations



Emerging a tree through deactivations



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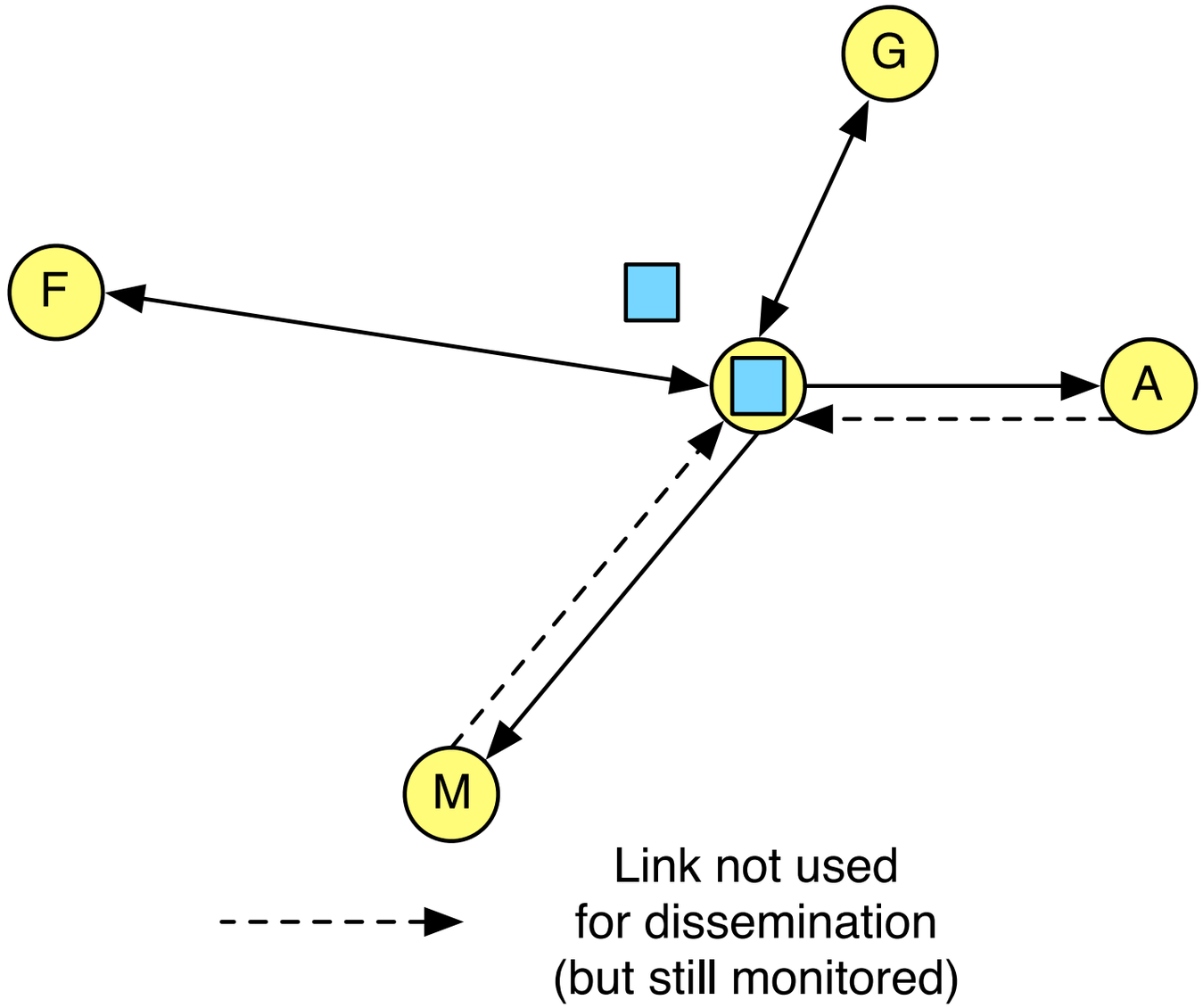
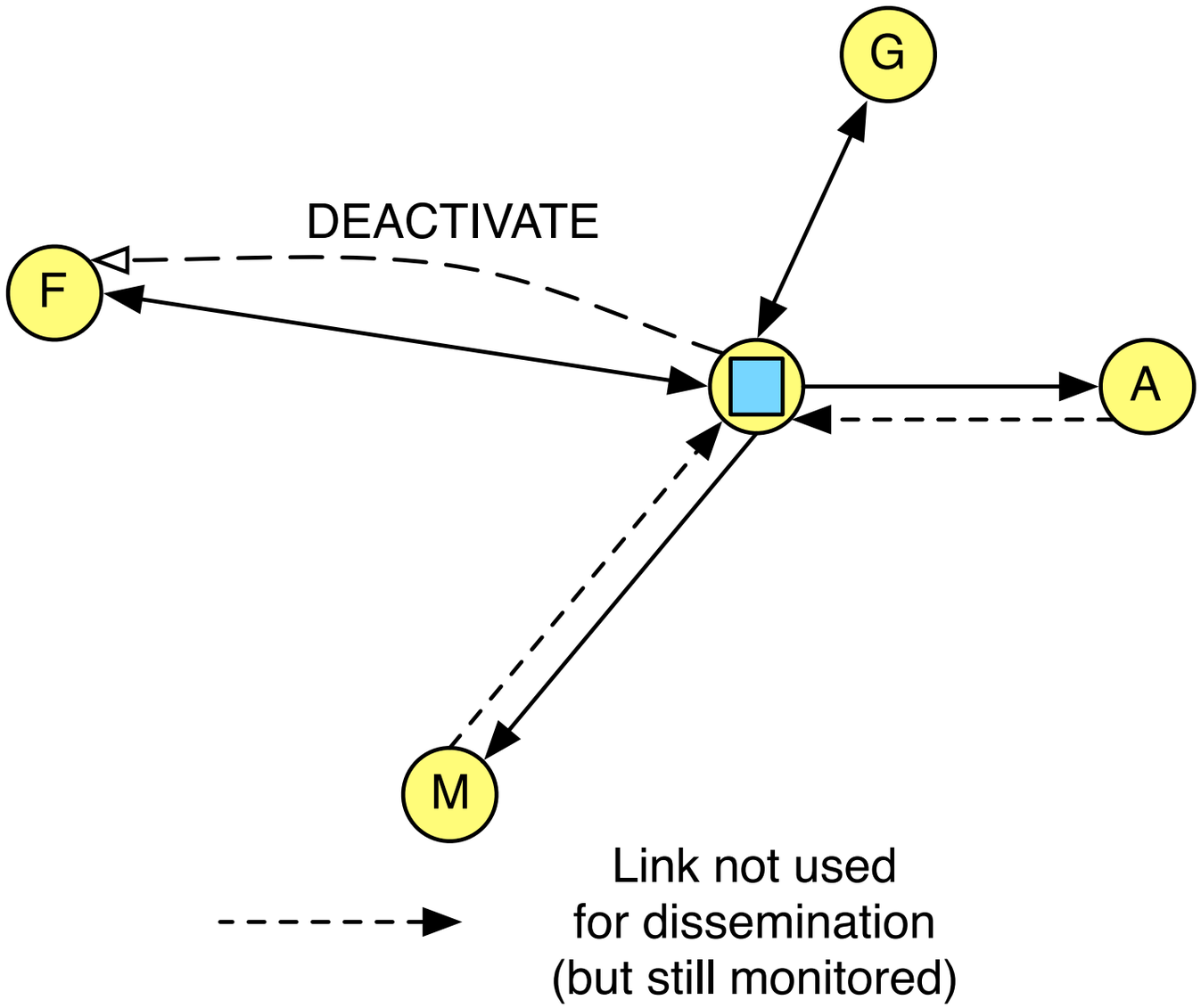
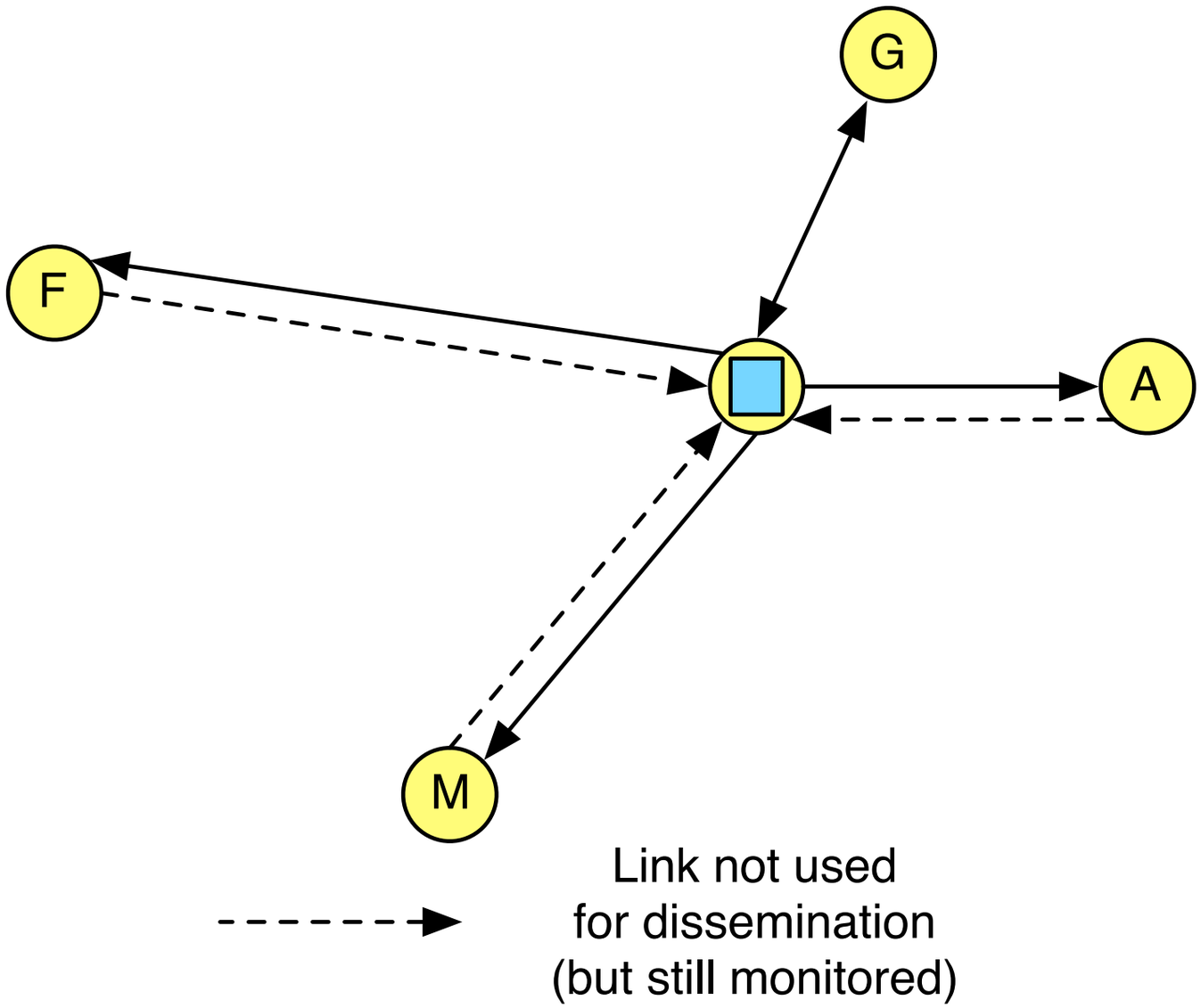


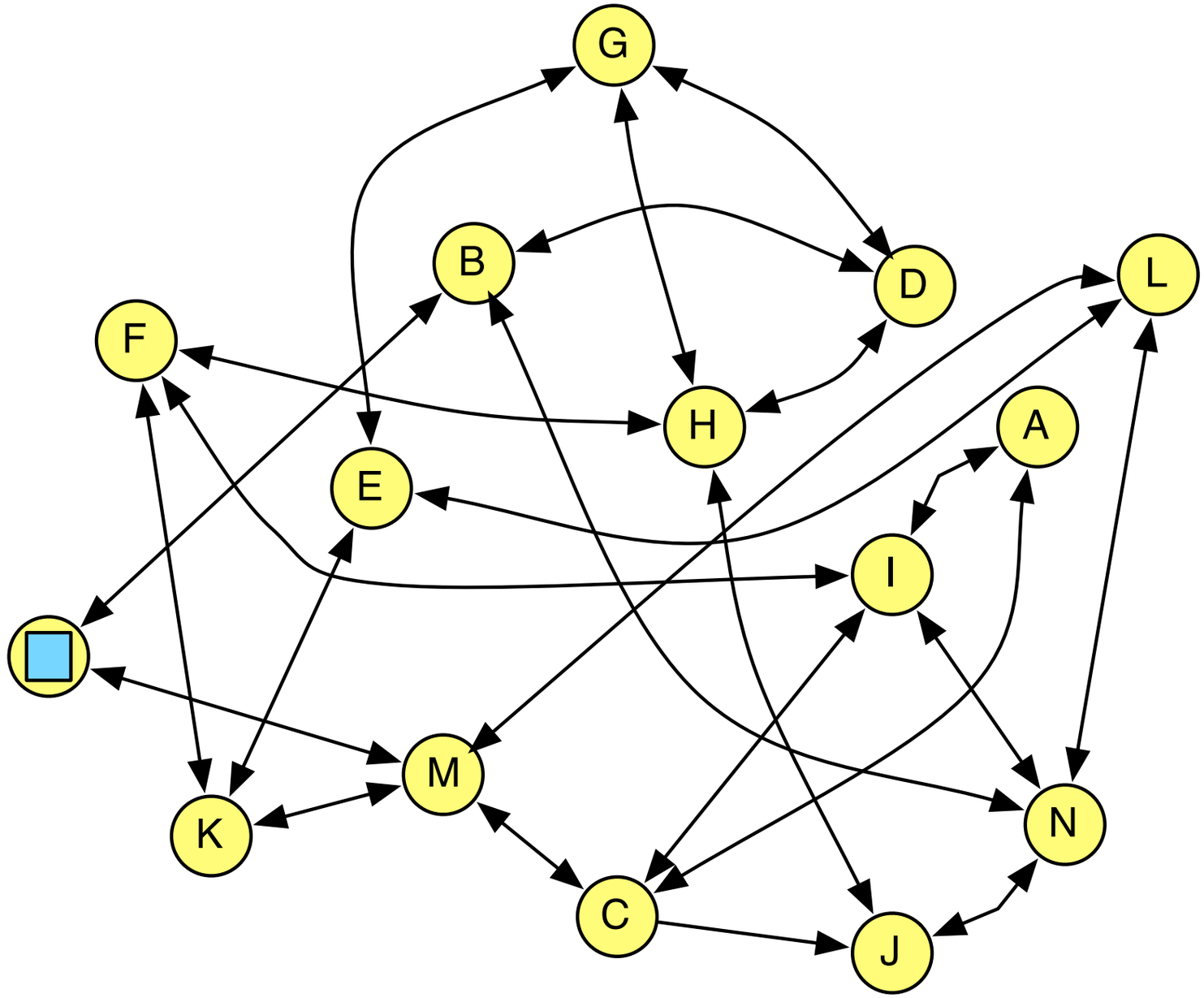
Emerging a tree through deactivations



Emerging a tree through deactivations

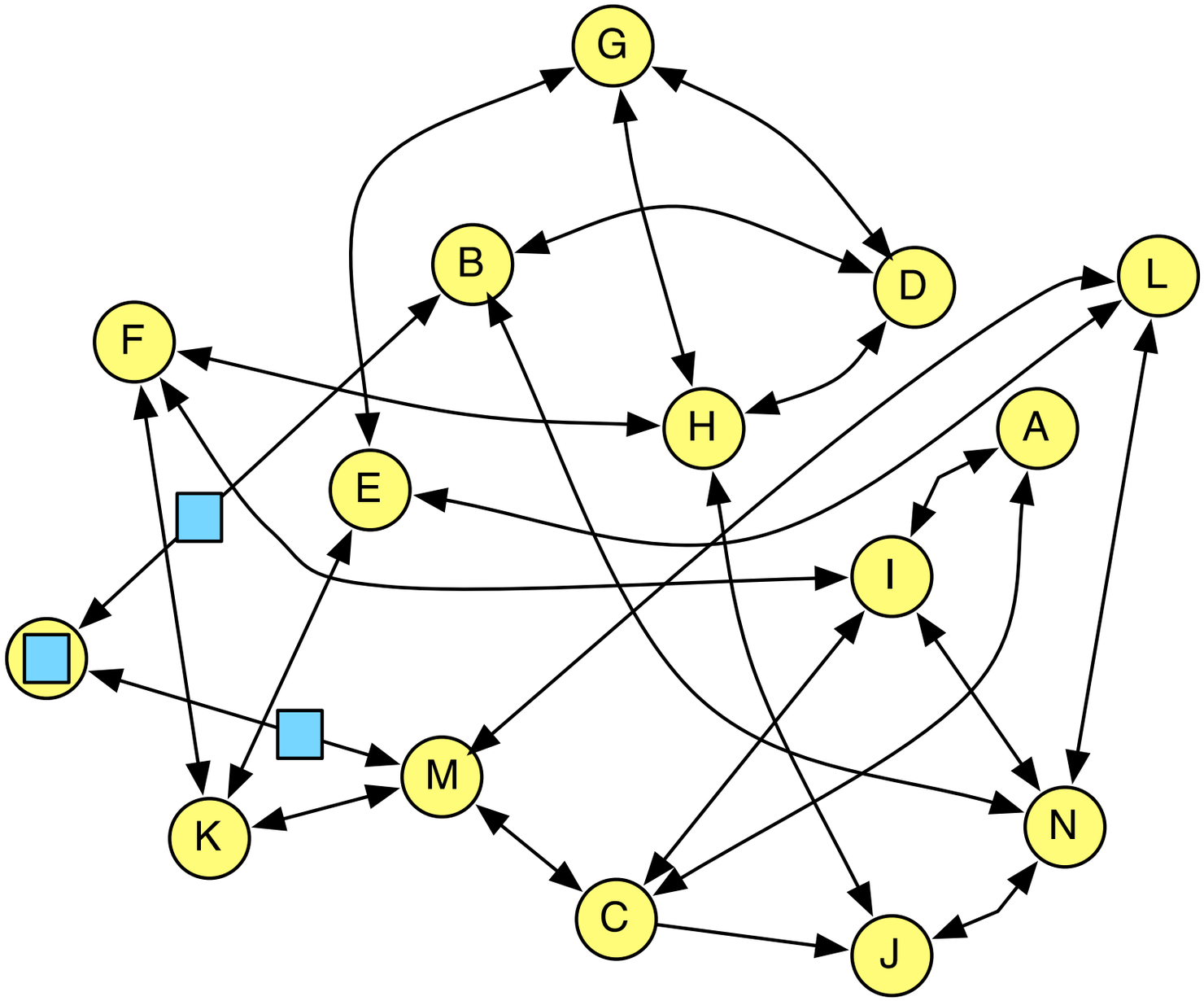


BRISA in action



(Inactive Links not shown)

BRISA in action



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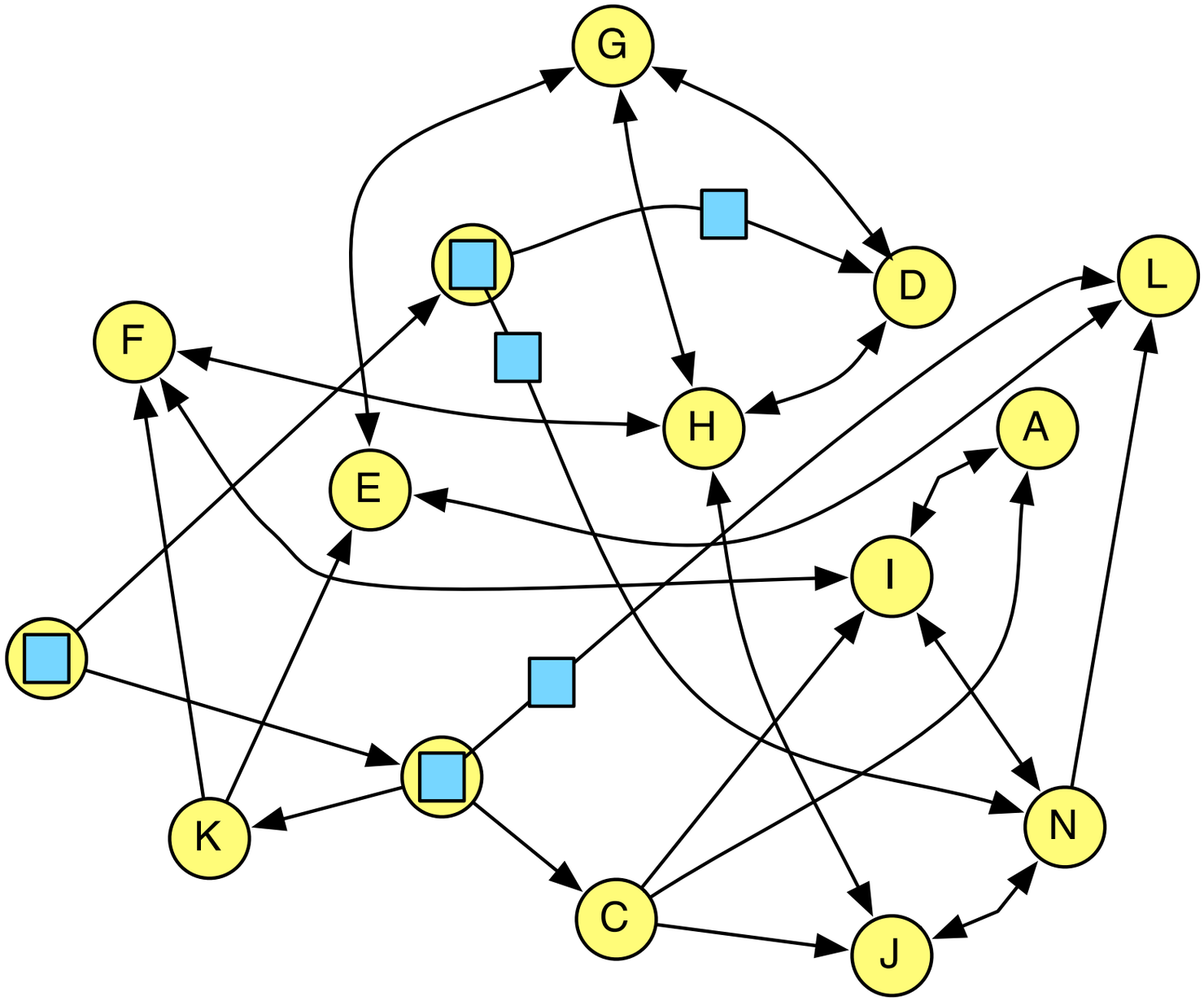
BRISA in action



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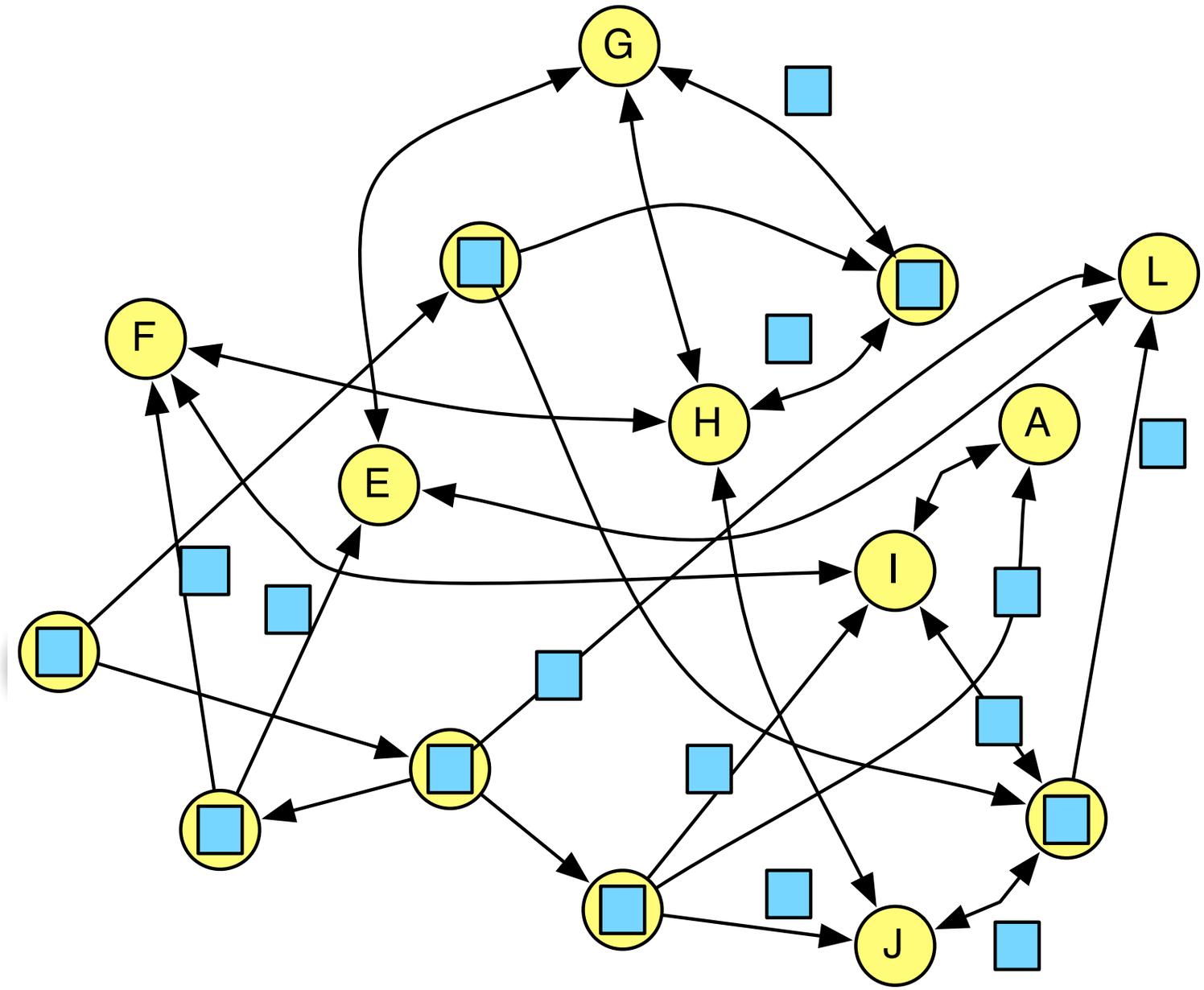

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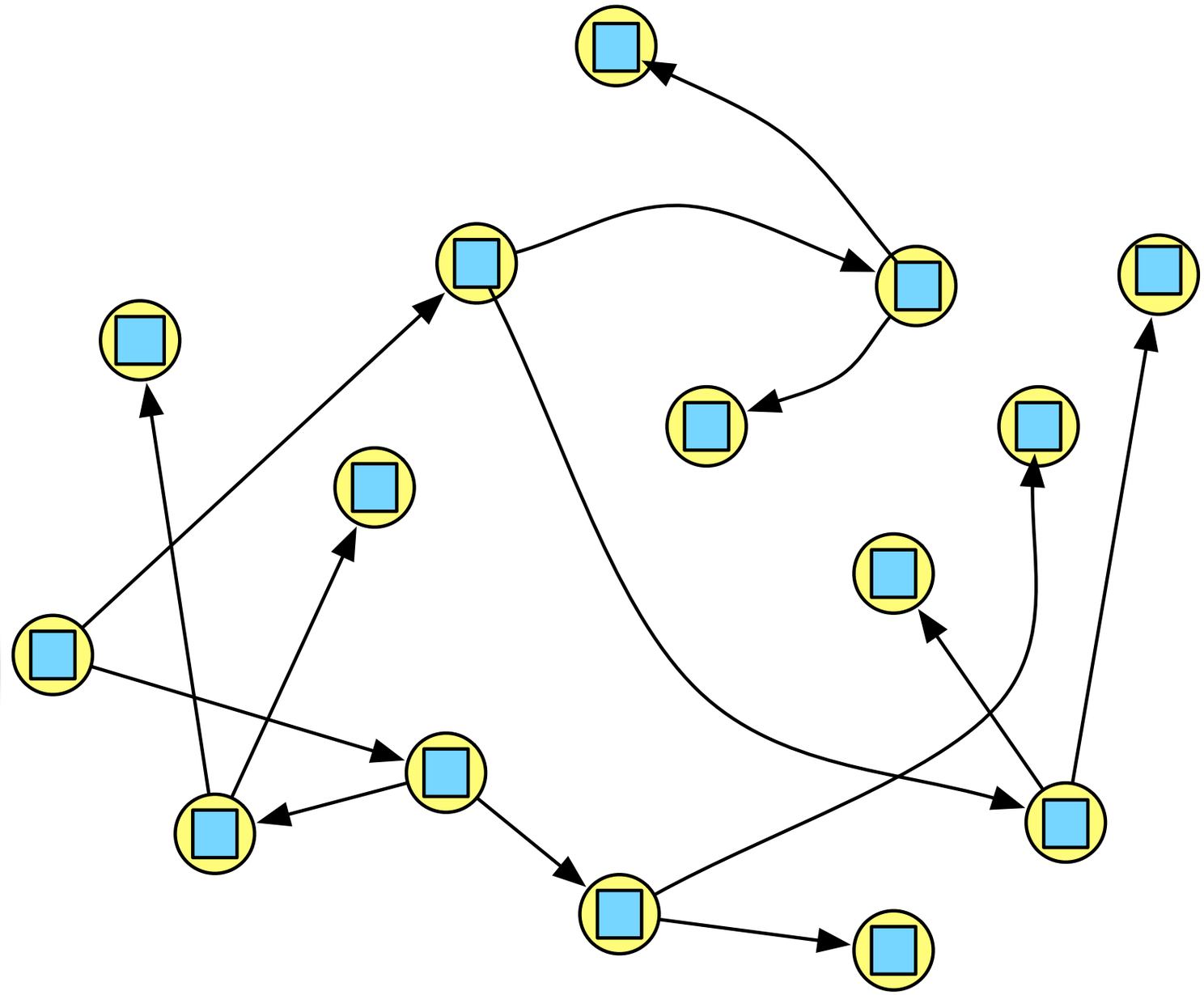
BRISA in action

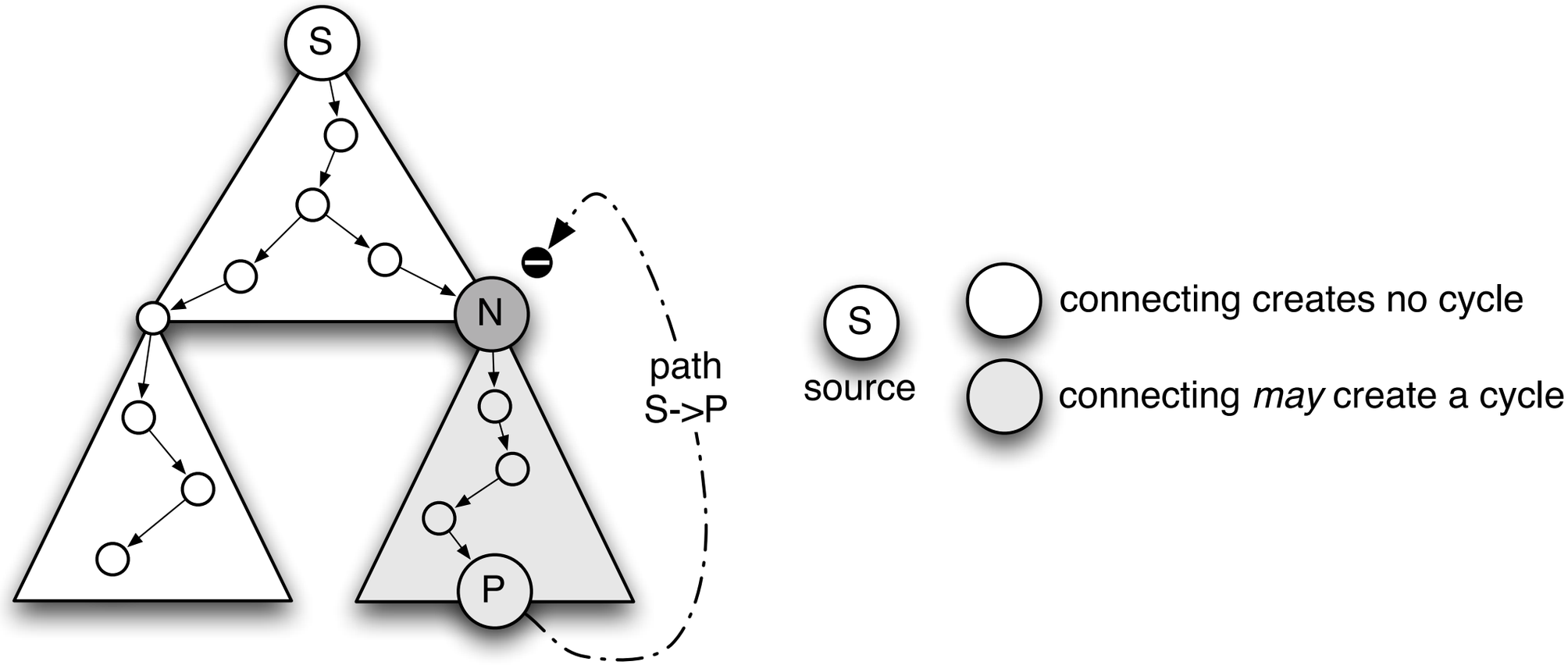


(Inactive Links not shown)

Failure Detection: RPSS level

- Parent failure implies reactivating a link
  - Send *activate* to one peer
  - Remember that connections are persistent
- Problem:
  - Which peer to reactivate ?
    - Avoid creating cycles
- Cycle detection mechanism
- Selection between eligible peers
  - Performance criteria
  - Criteria on tree structure

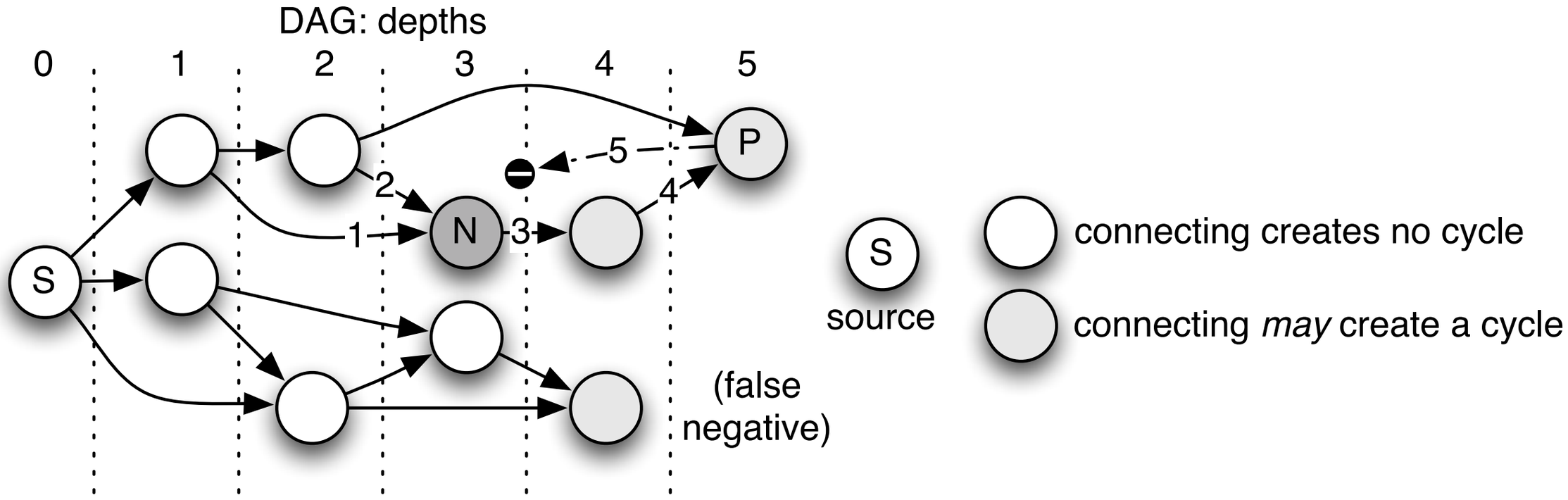
Avoiding cycles



Parent selection strategies

- Selection of peer to reactivate among eligible peers
- Simplest: first-come first picked
- Performance criteria
  - Delay-aware
- Criteria on tree structure
  - Heterogeneity-aware
    - Favors peer with most available bandwidth
- Load-balancing
  - Seeks to reduce out-degree variance
- Gerontocratic
  - Favors peers with highest uptime
  - Observations show that these peers are more stable

Extension to DAGs



- DAG = more than one parent
  - Control the number of received duplicates
  - Allows supporting higher churn levels
  - Lazy parent replacement
    - Service continuity if at least one parent remains
- Path-embedding is impossible for DAGs
  - Use node depth instead

Evaluation Setup

- Evaluation using a prototype
  - Supported by the Splay distributed system evaluation framework
- Two testbeds
  - 15 nodes cluster with Splay lightweight virtualization
    - 512 nodes
    - Uses Splay's churn replay mechanism
  - 128 nodes on PlanetLab

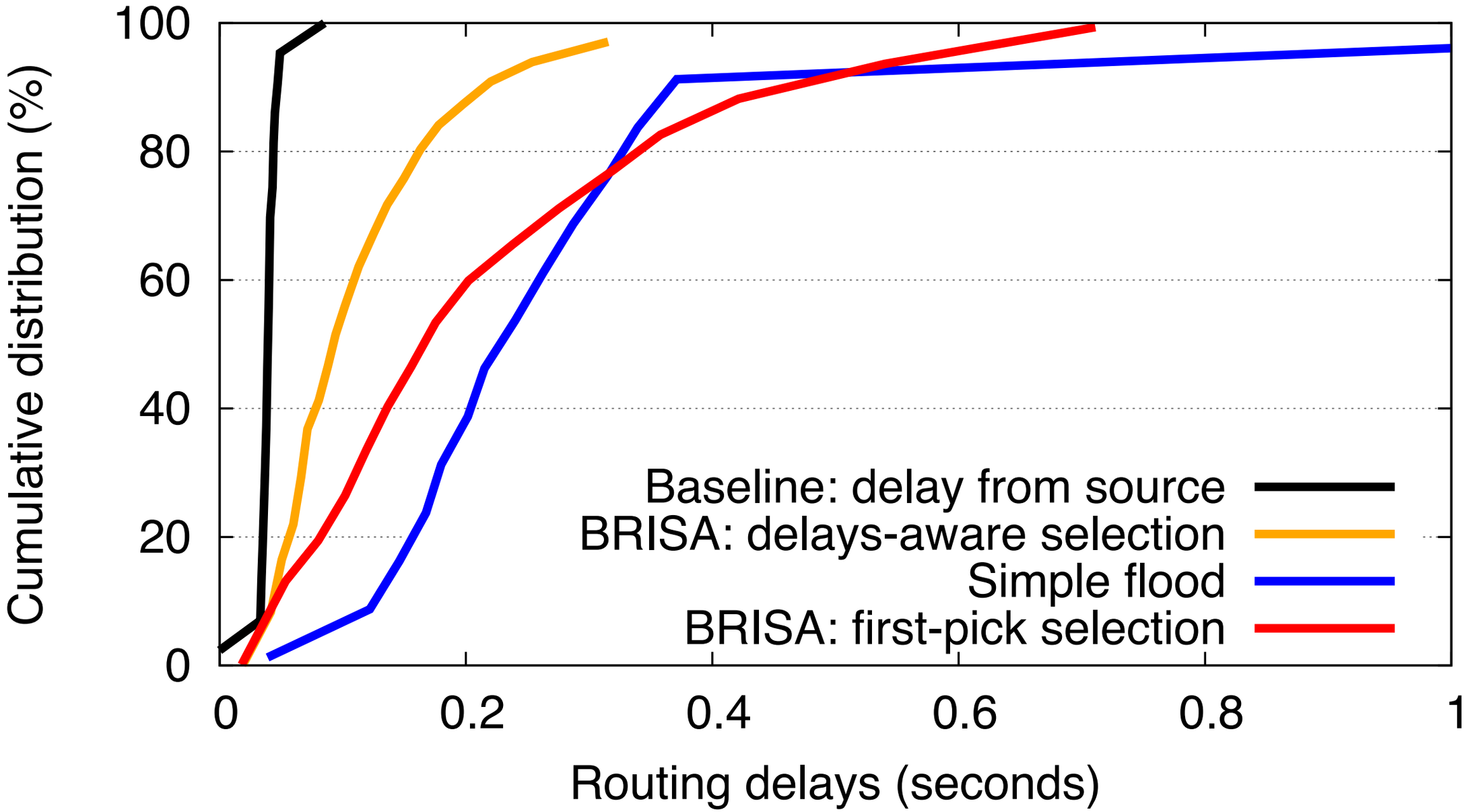
http://www.splay-project.org/

Evaluation Setup

- SimpleTree: statically constructed tree-based protocol
- SimpleGossip: traditional gossip-based protocol
- TAG [Liu & Zhou]
  - Closest related work
  - Another protocol that combines trees and epidemic overlays
    - Overlay used to build and repair the tree
    - No cycle detection: data is pulled from the overlay and from the tree
    - Tree repairing done by traversing the overlay

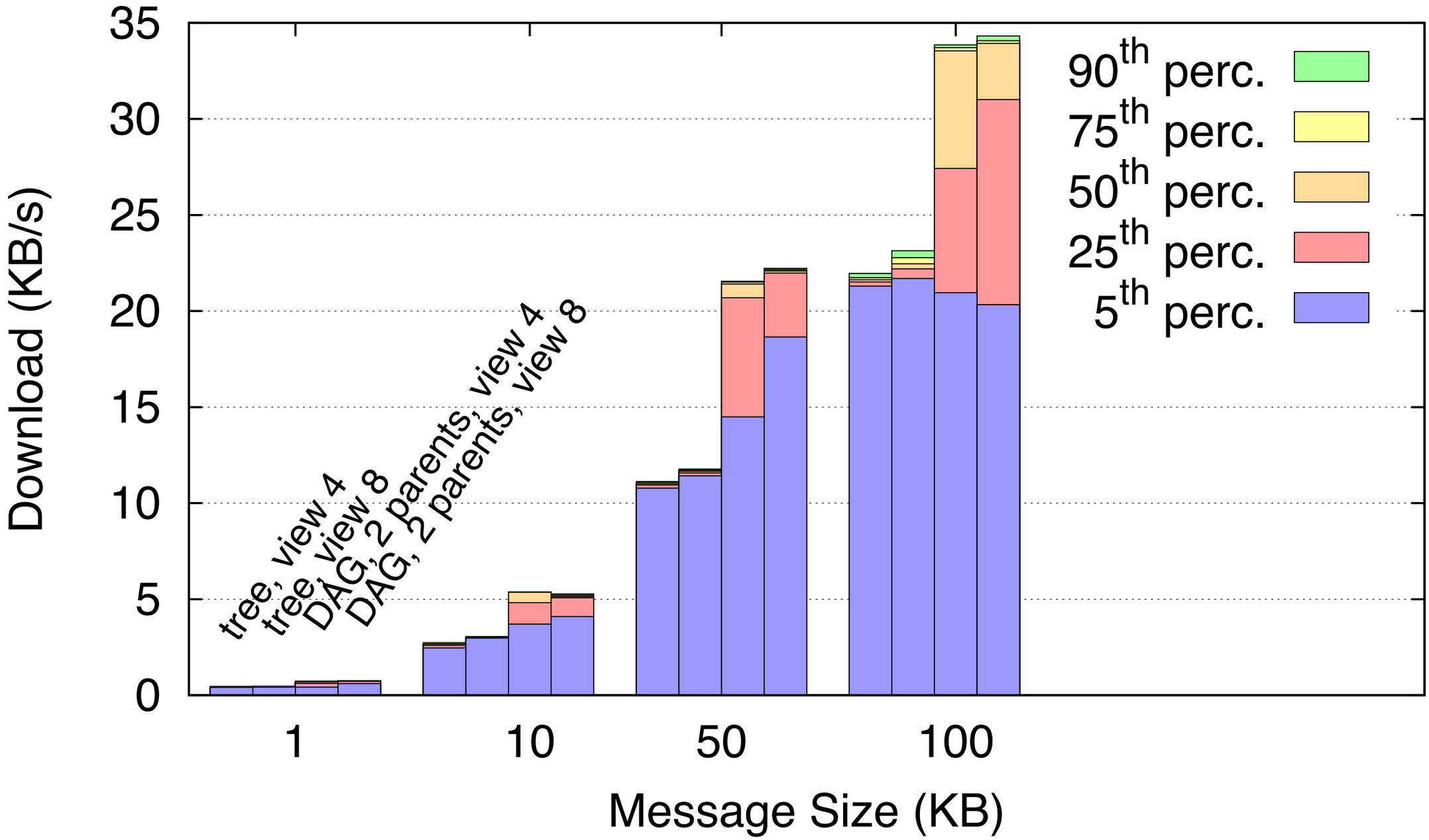
BRISA Dissemination Delay

150 PlanetLab nodes, 1KB



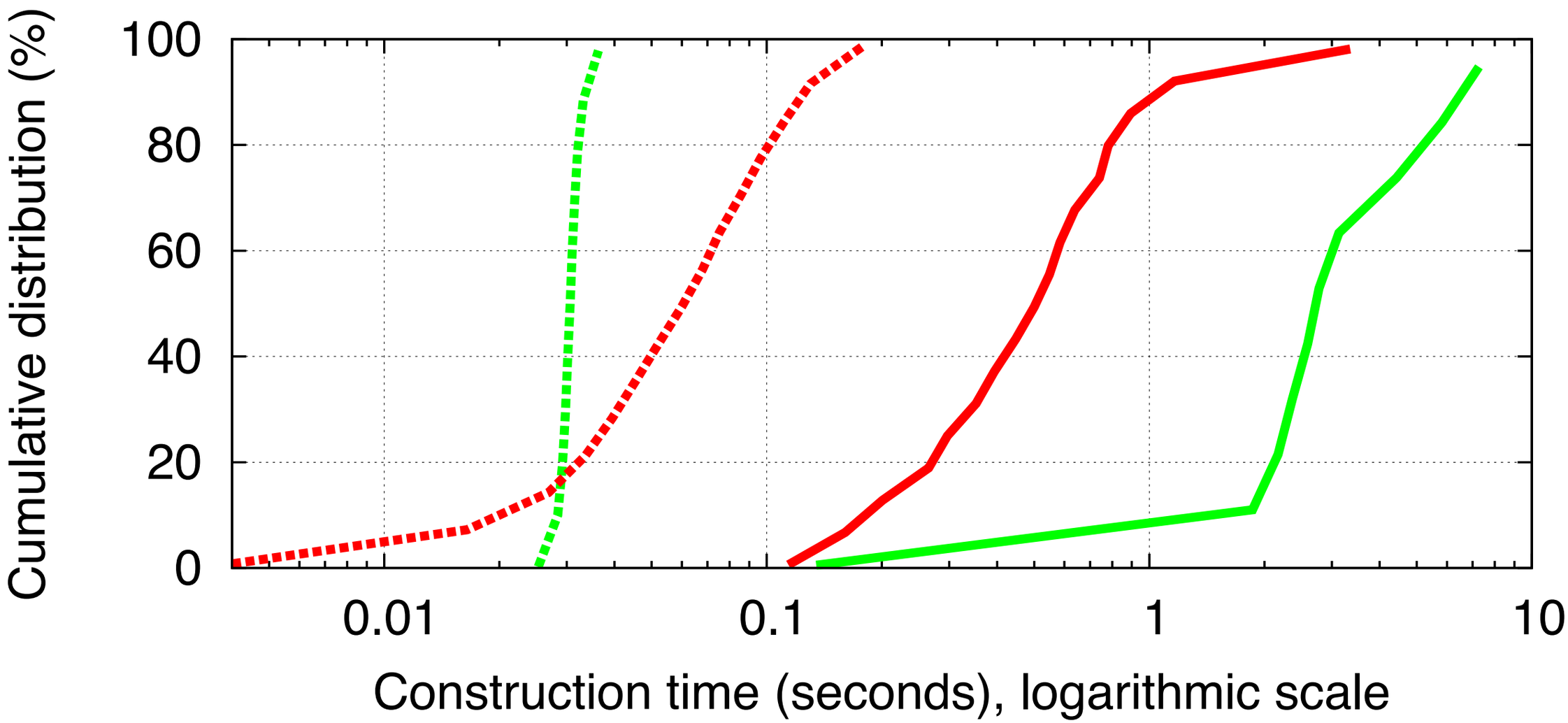
BRISA Bandwidth usage: download

512 cluster nodes



Structure construction time

512 nodes



Dissemination Latency

512 cluster nodes, 500 x 1KB message, 5 msg / sec.

Protocol	*Latency (seconds)*	*Overhead*
SimpleTree	**100.02**	**-**
BRISA	**106.59**	**+6%**
SimpleGossip	**128.23**	**+28%**
TAG	**200.48**	**+100%**

Churn

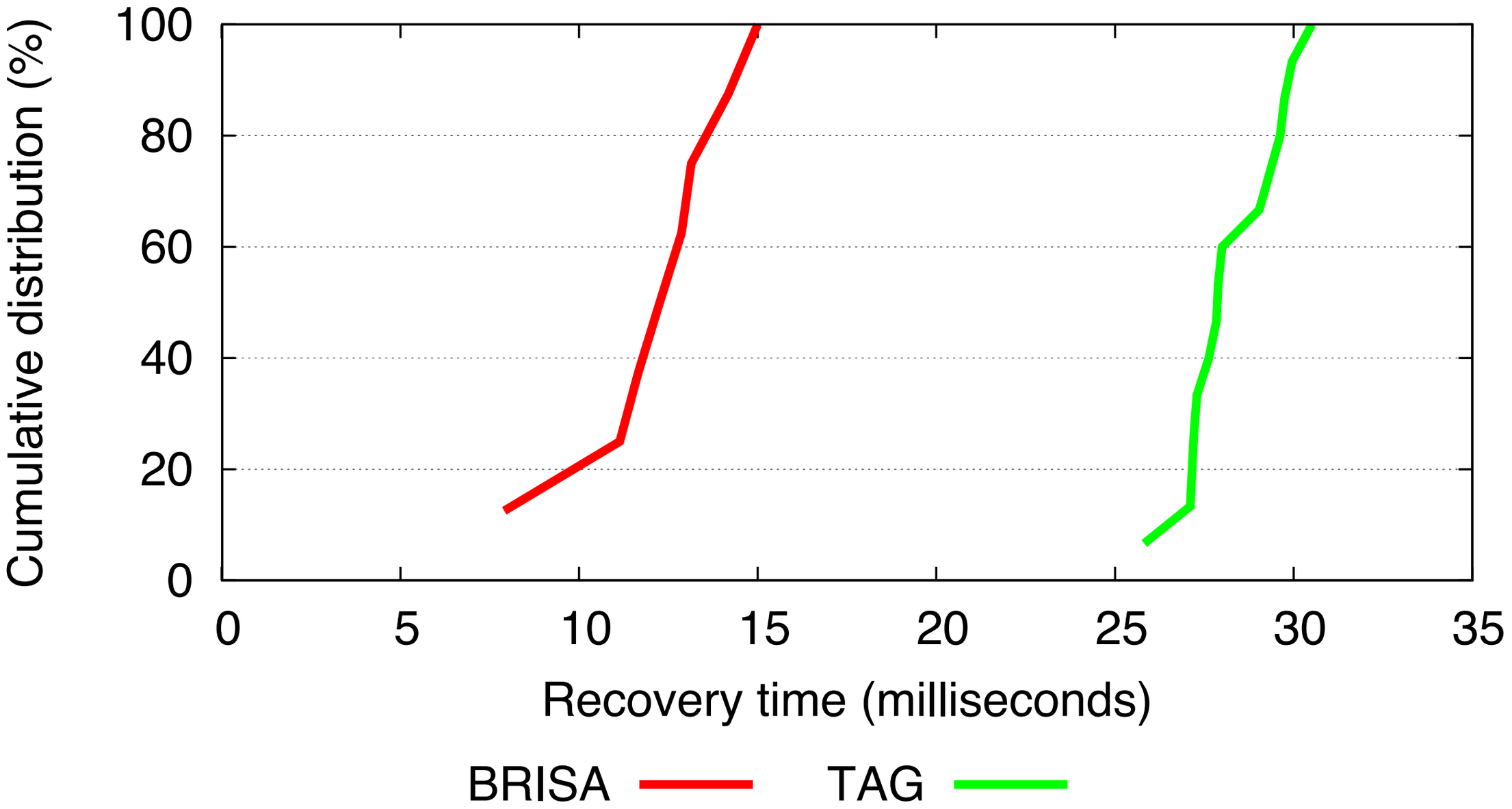
128 cluster nodes, 10 minutes

	Churn rate	*Parents lost/min*	*Orphans/ min*	*Direct fallback on RPSS link*	*Tree rejoin*
Tree	***3% replacement per minute***	**2.3**	**2.3**	**87%**	**13%**
DAG, 2 parents		**4**	**0.2**	**92.5%**	**7.5%**

(average per minute)

Parent recovery delay (tree rejoins)

128 cluster nodes; churn rate 3%



Conclusion & perspectives

- BRISA *combines* advantages of tree-based dissemination with advantages of epidemic dissemination
  - Robust to faults and churn
  - Quick failure recovery
  - Low overhead
  - Low latency
- Perspectives
  - Use DAGs as base for multiple trees
  - Low latency and overhead makes BRISA suitable for video streaming

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Combining Efficiency and Reliability in Epidemic Data Dissemination

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Backup slides

Future Perspectives

- More elaborate parent selection strategies
- Use DAGs as base for multiple trees
- Low latency and overhead makes it suitable to video streaming

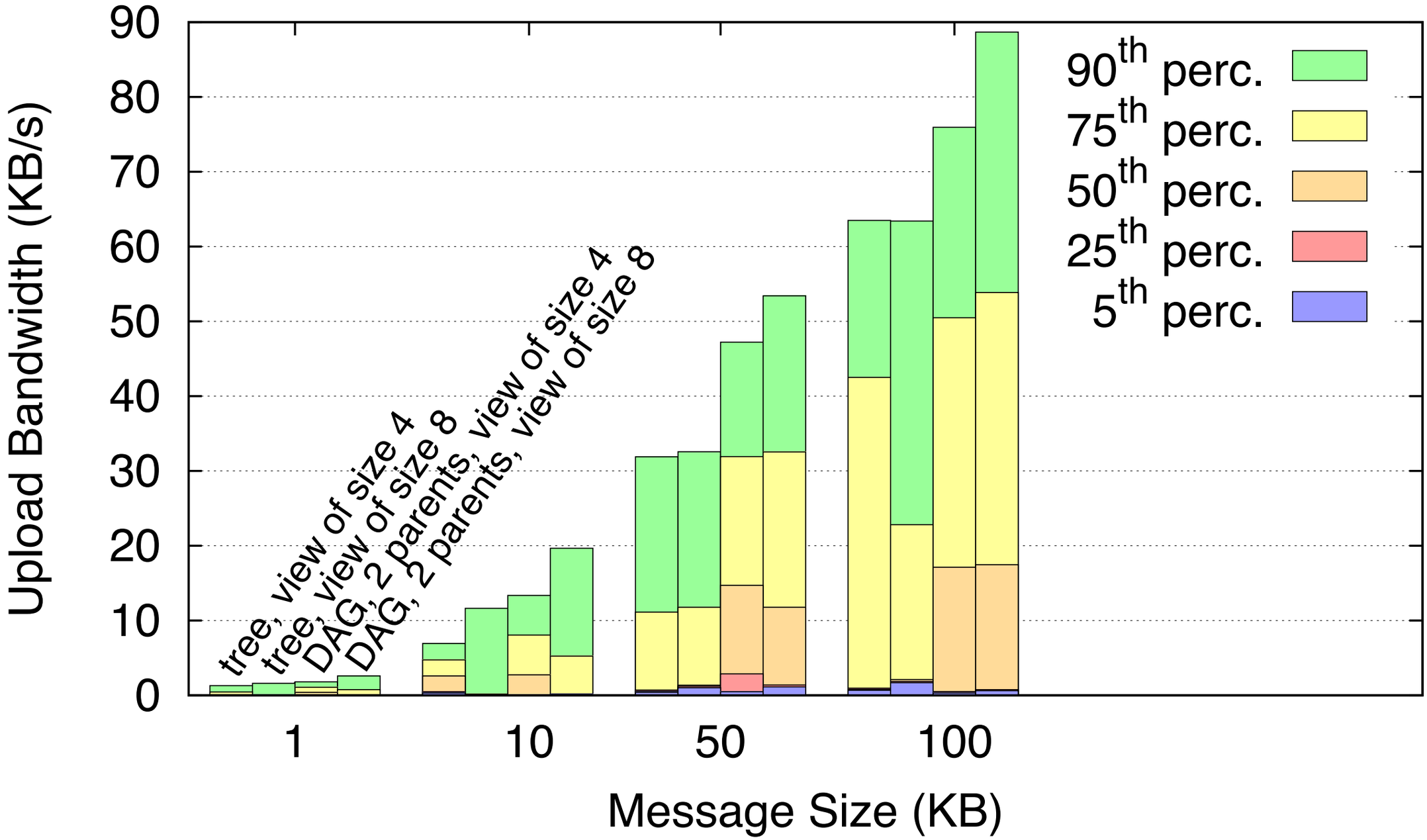
Failure Detection

- At the *Reactive Peer Sampling Service* (RPSS) level
  - Constant neighbors monitoring
    - Takes place on persistent connection
    - Also for links not used for dissemination
  - Classical failure detector
- "Informed" failure detector
  - Use hint from dissemination layer
  - Use deactivated links to send notifications of received message *ids*
    - Reception of a id for an (yet) unknown message
      => triggers instantaneous monitoring of parent
  - Allows reducing monitoring frequency while keeping reactiveness

➡ Detection of failed parent triggers link reactivation

BRISA Bandwidth usage: upload

512 cluster nodes



Goals

- Efficient: management overhead is low with respect to application data; low latency
- Robust: service continuity even under faults and churn
- Scalable: able to handle system growth sublinearly