CSE 486/586 Distributed Systems

Gossiping

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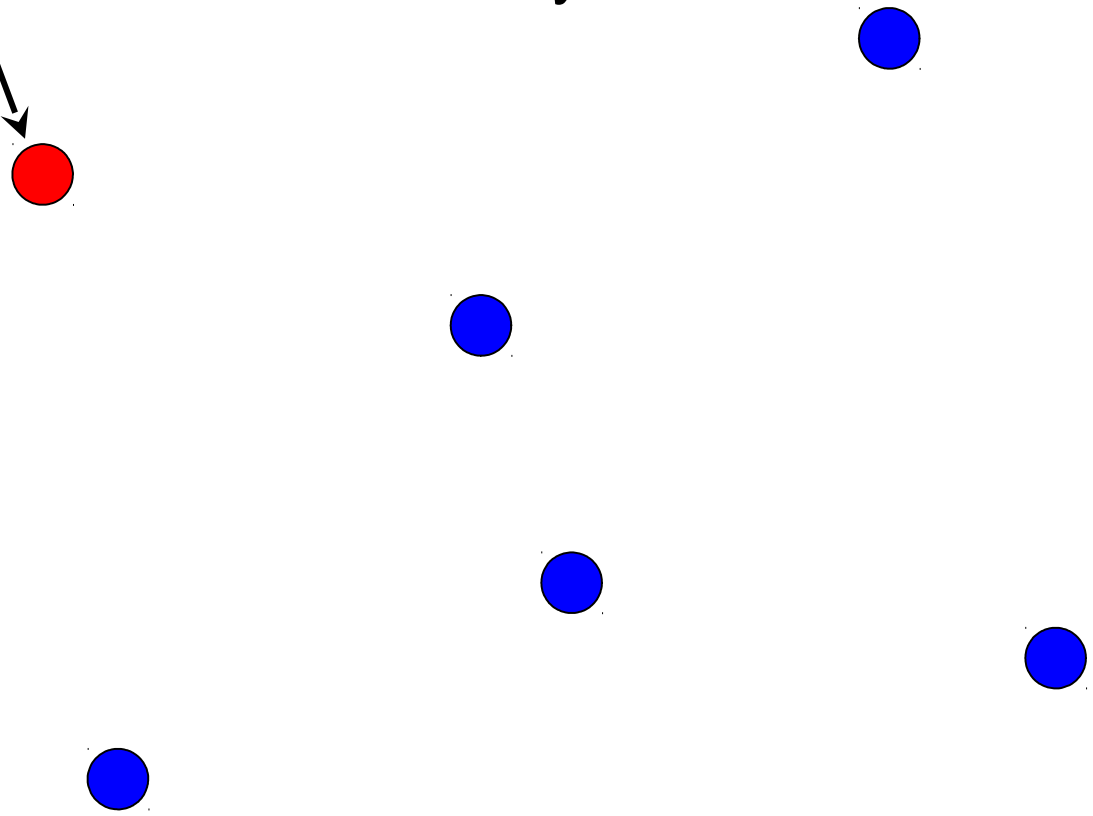
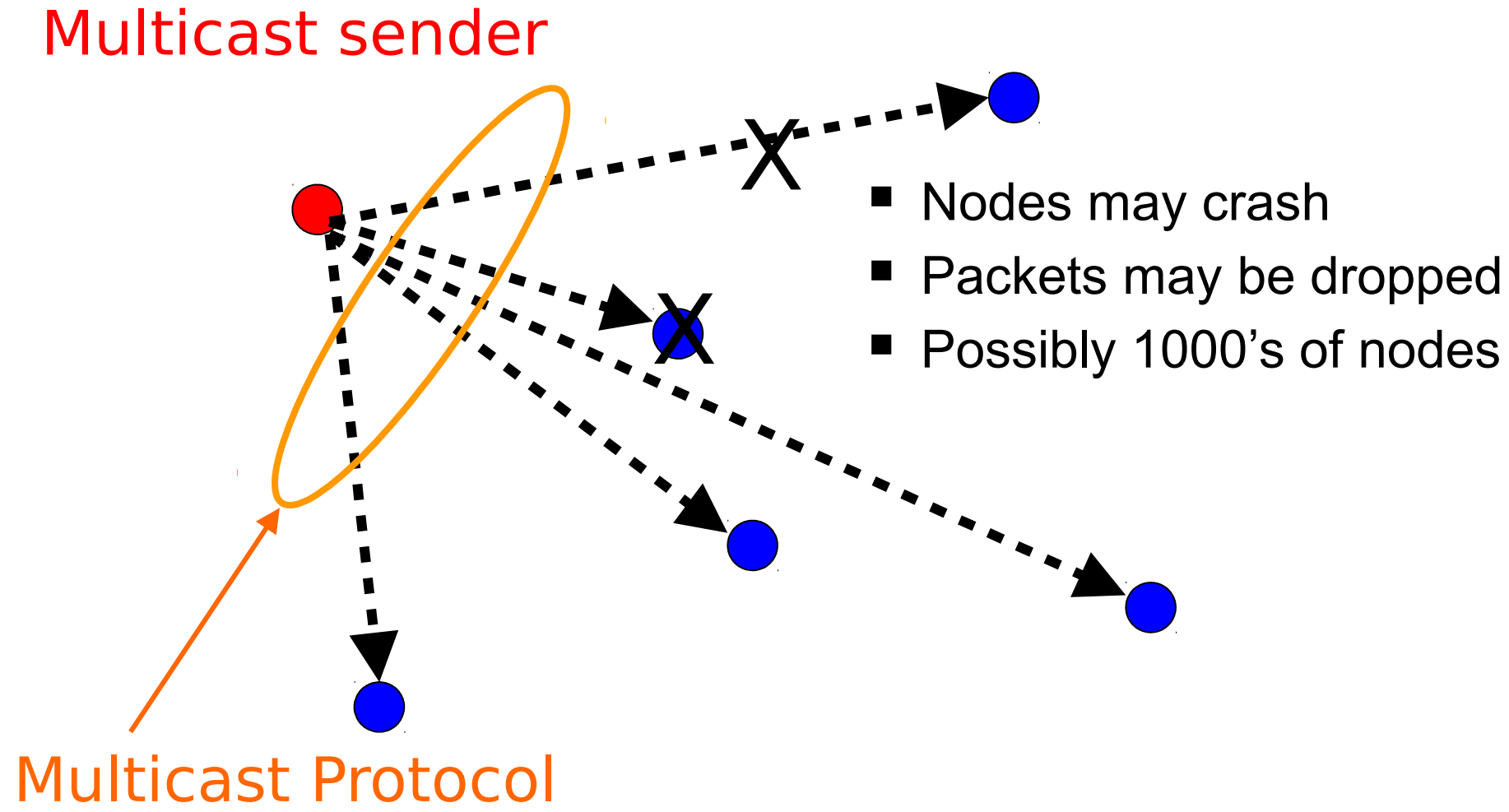
Revisiting Multicast

Node with a piece of information to be communicated to everyone



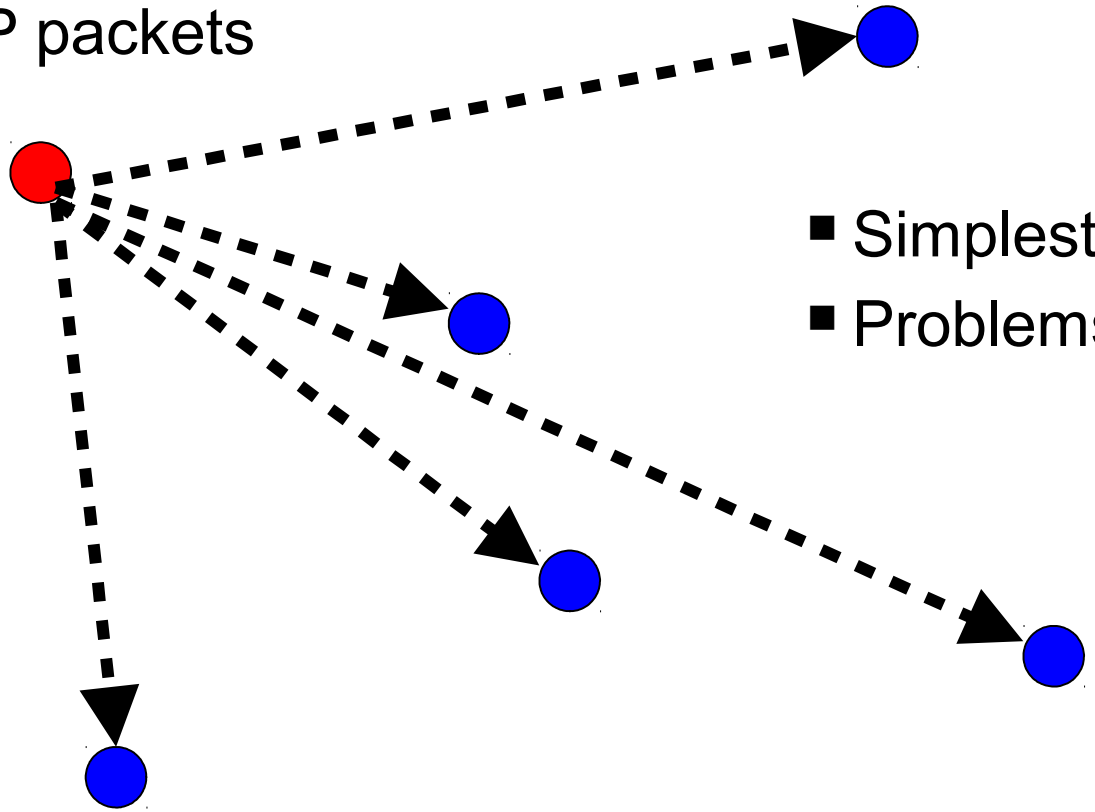
Distributed Group of "Nodes" = Processes at Internet-based hosts

Fault-Tolerance and Scalability



B-Multicast

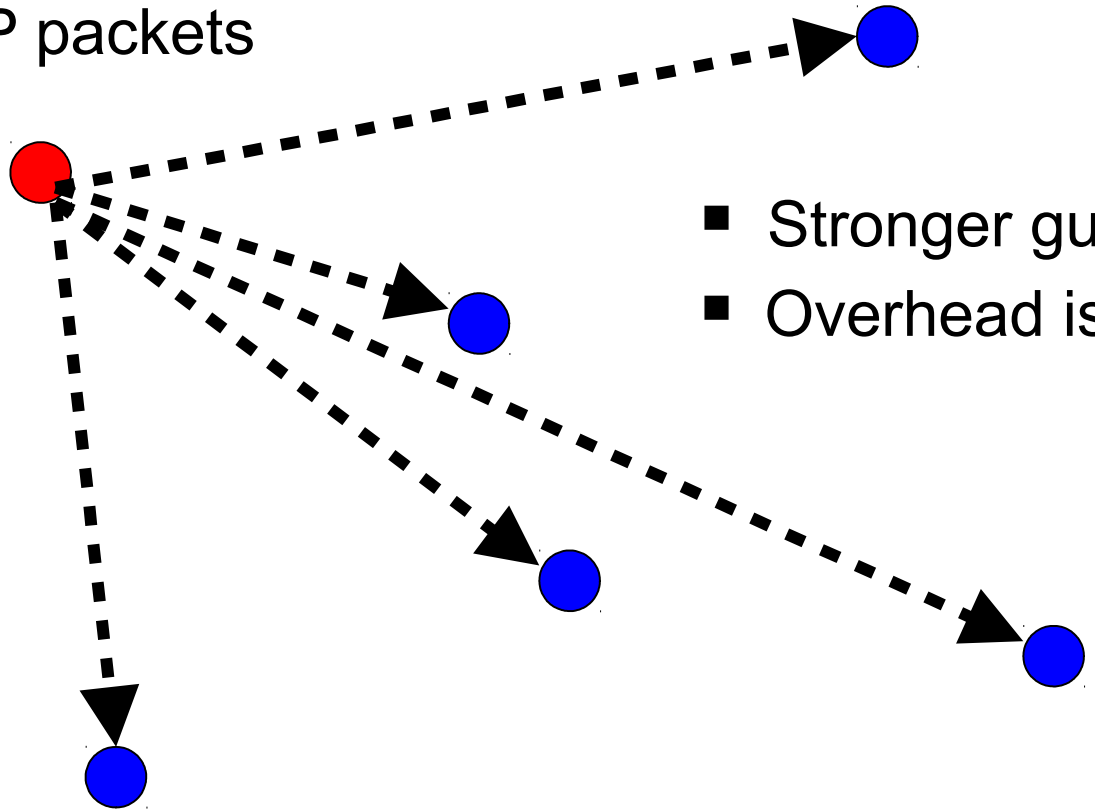
UDP/TCP packets



- Simplest implementation
- Problems?

R-Multicast

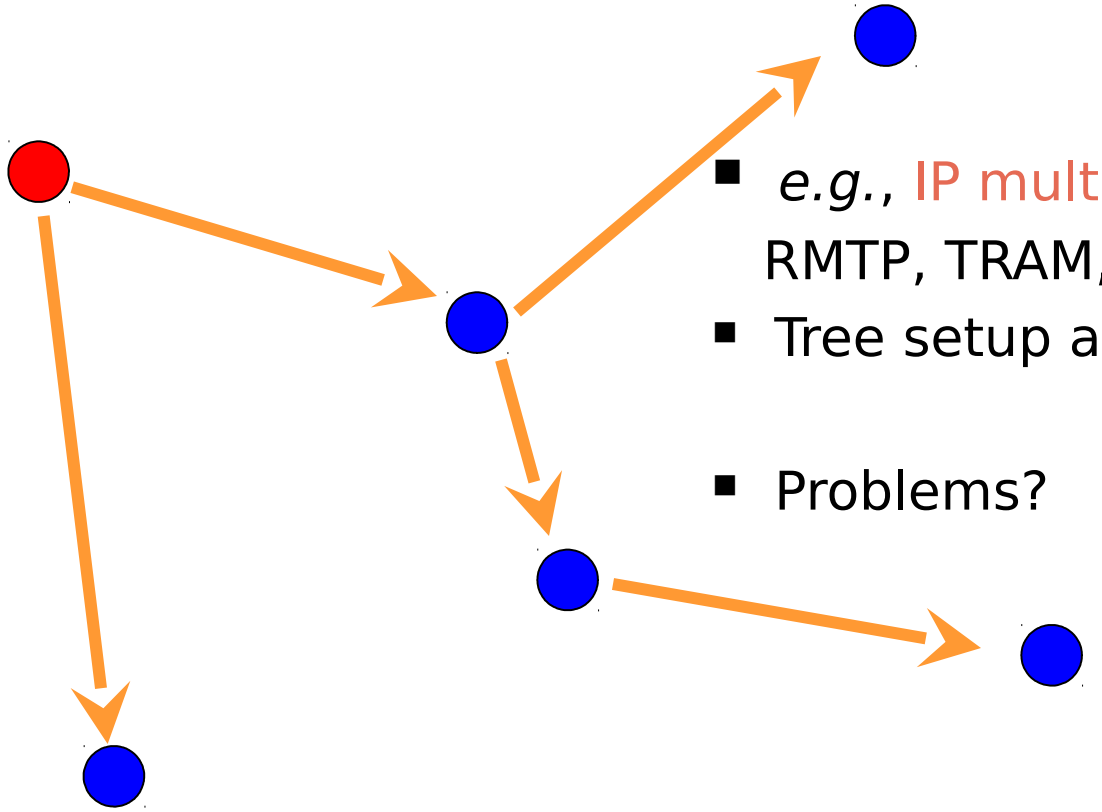
UDP/TCP packets



- Stronger guarantees
- Overhead is quadratic in N

Any Other?

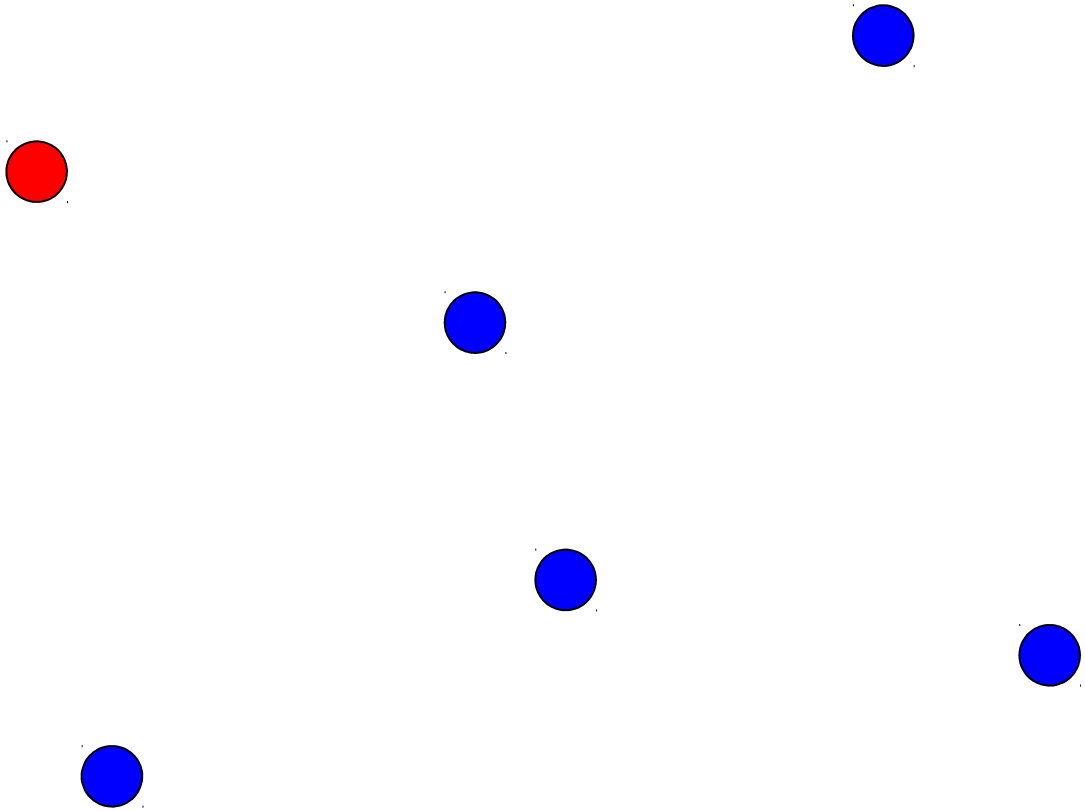
- E.g., tree-based multicast



- *e.g.*, IP multicast, SRM, RMTP, TRAM, TMTP
- Tree setup and maintenance
- Problems?

Another Approach

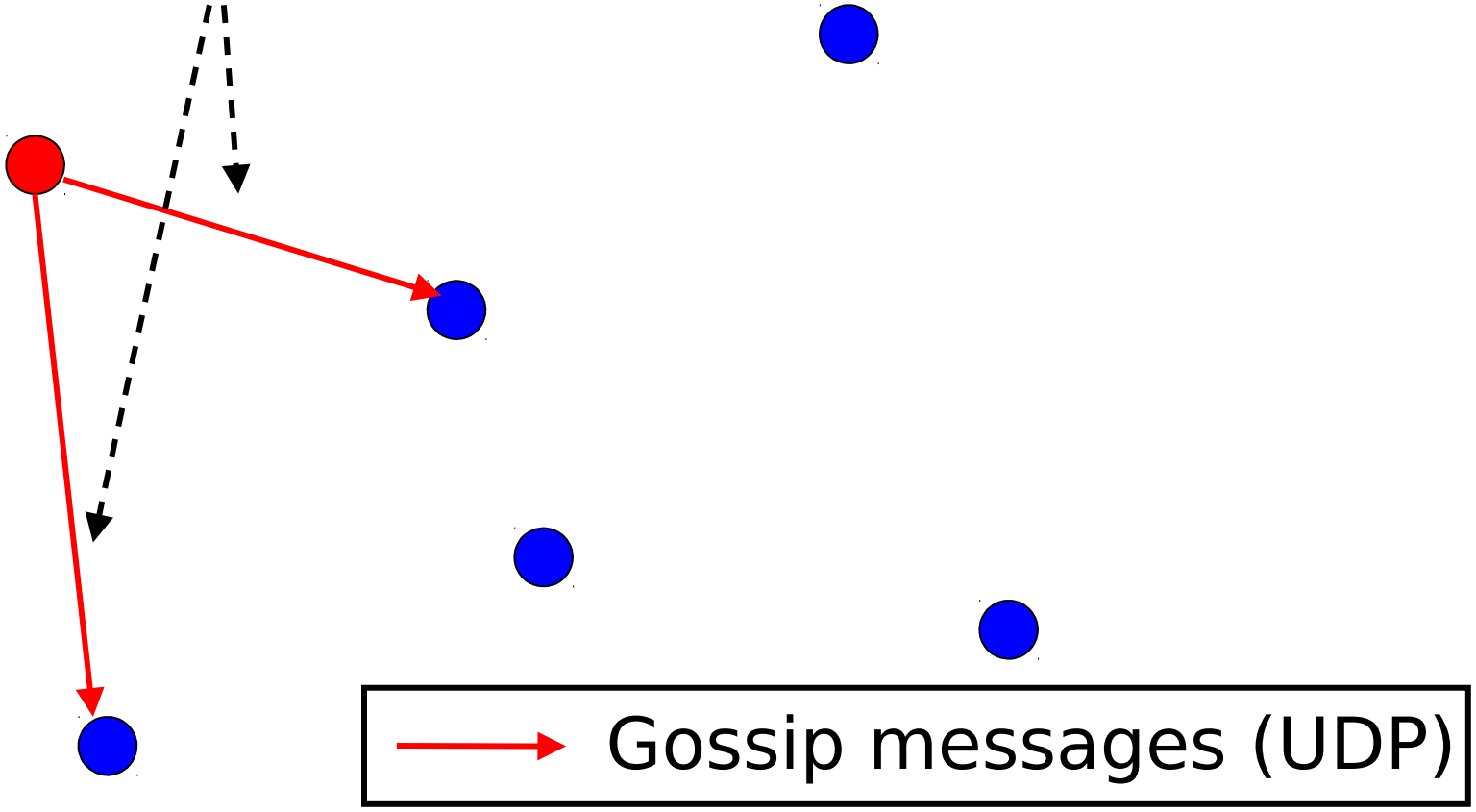
Multicast sender



Another Approach

Periodically transmit to

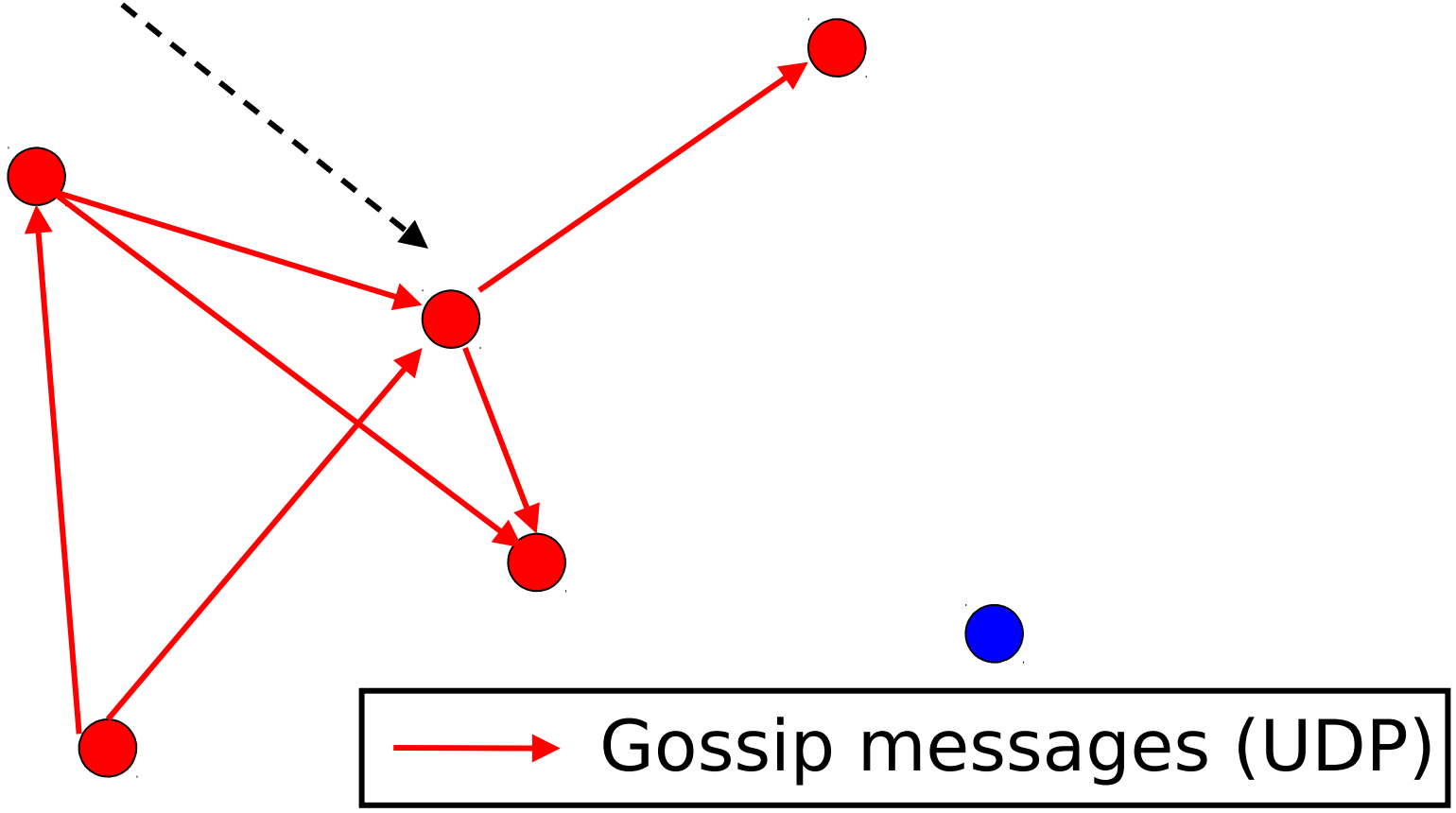
b random targets



Another Approach

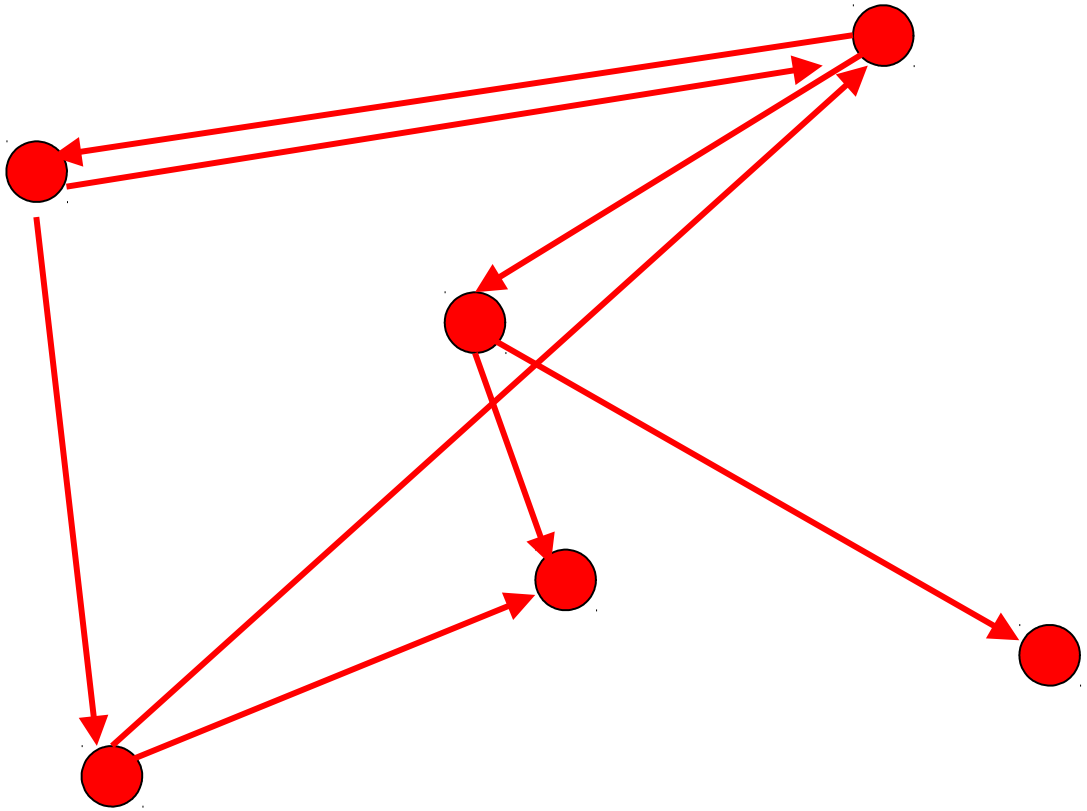
Other nodes repeat

after receiving multicast



Another Approach

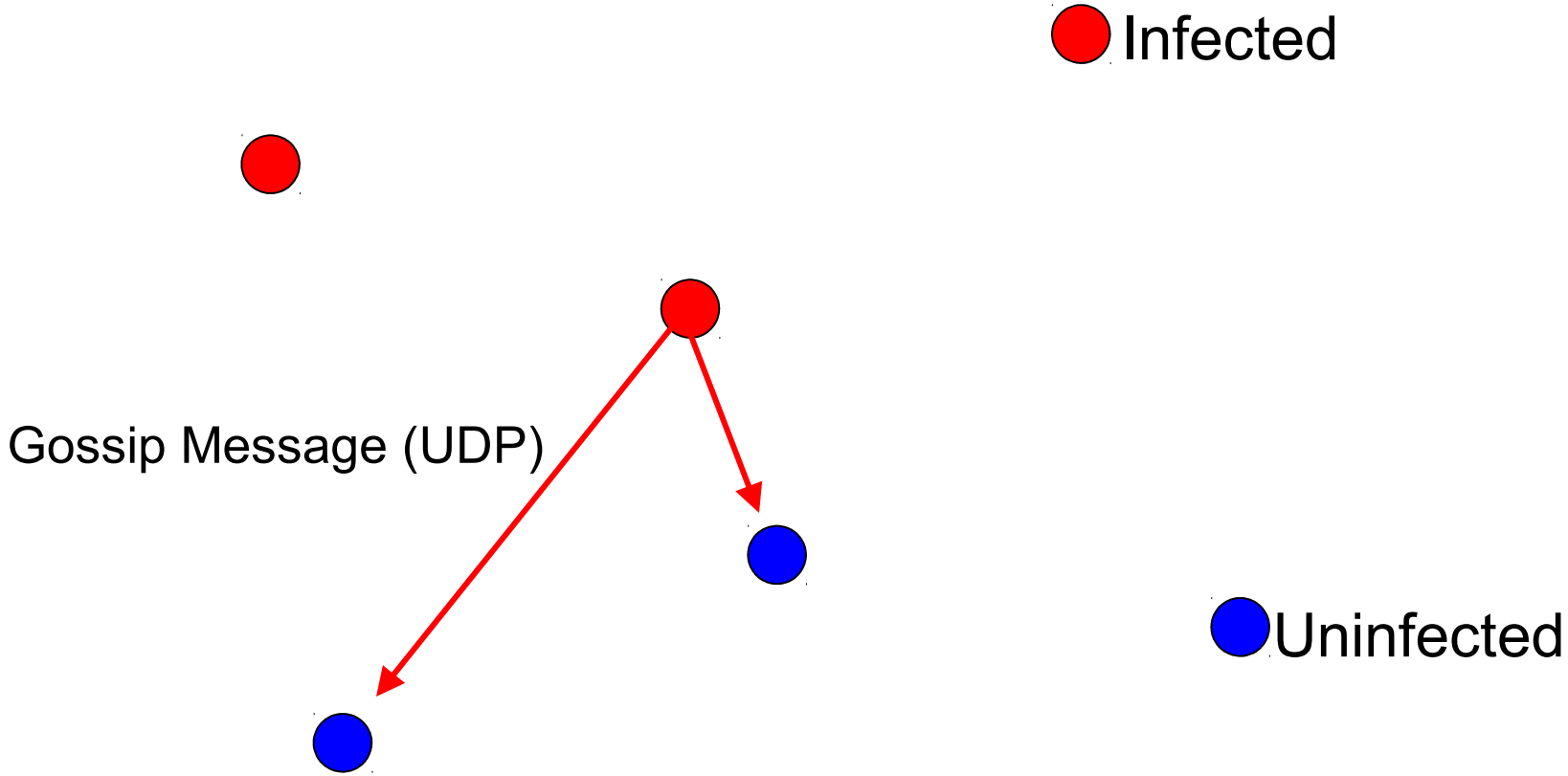
Iterate several times



“Gossip” (or “Epidemic”) Multicast

c protocol *rounds* (local clock)

b random targets per round



Properties

- Lightweight
- Rapid dissemination of information
- Highly fault-tolerant
- Analysis from old mathematical branch of *Epidemiology* [Bailey 75]
- Parameters *c, b*:
  - *c* for determining rounds: (*c*log(n)), b*: # of nodes to contact
  - Can be small numbers independent of *n, e.g., c=2; b=2;*
- Within *c*log(n)* rounds, [low latency]
  - all but $\frac{1}{n^{cb-2}}$ of nodes receive the multicast [reliable]
  - each node has transmitted no more than *c*b*log(n)* gossip messages [lightweight]

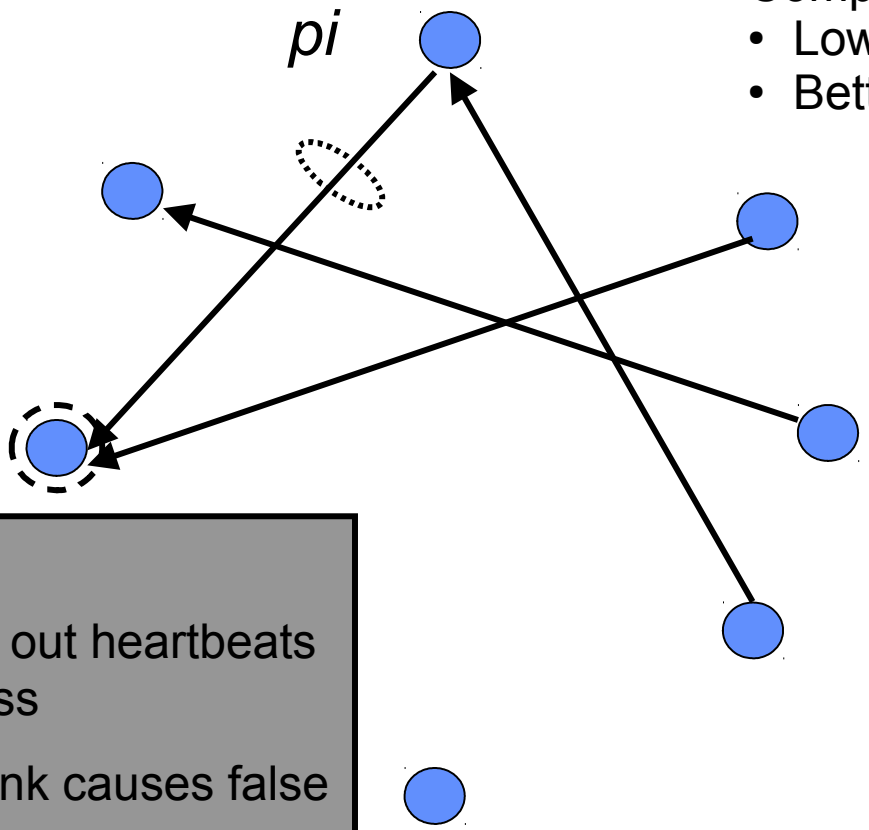
Fault-Tolerance

- Packet loss
  - 50% packet loss: analyze with *b* replaced with *b/2*
  - To achieve same reliability as 0% packet loss takes twice as many rounds
- Node failure
  - 50% of nodes fail: analyze with *n* replaced with *n/2* and *b* replaced with *b/2*
  - Same as above

Fault-Tolerance

- With failures, could the epidemic might die out quickly?
- Possible, but improbable:
  - Once a few nodes are infected, with high probability, the epidemic will not die out
  - So the analysis we saw in the previous slides is actually behavior *with high probability*
- The same applicable to:
  - Rumors
  - Infectious diseases
  - An Internet worm
- Some implementations
  - Amazon Web Services EC2/S3 (rumored)
  - Usenet NNTP (Network News Transport Protocol)

Using Gossip for Failure Detection: Gossip-style Heartbeating



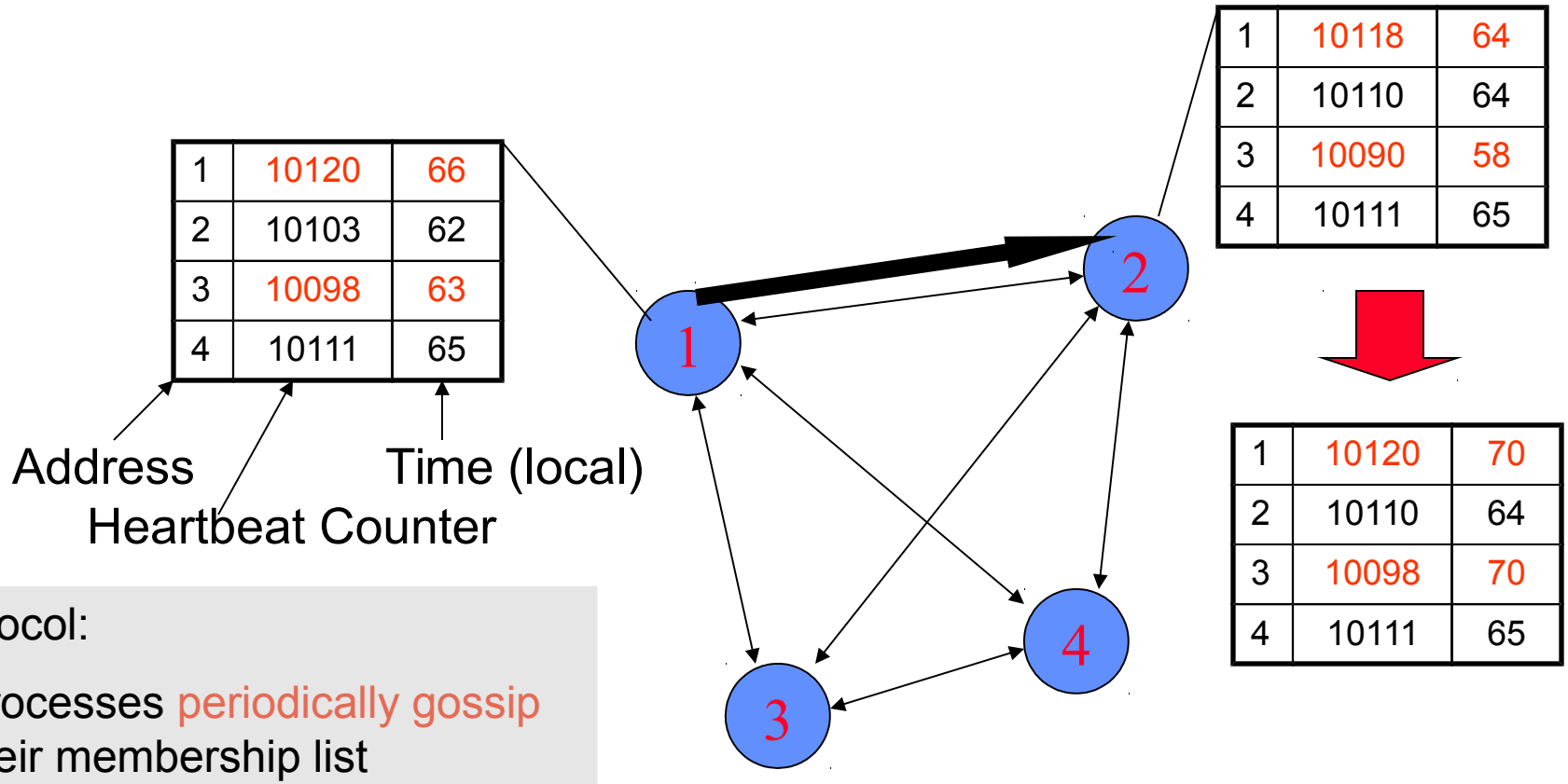
Comparatively, gossip has:

- Lower overhead
- Better accuracy

All-to-all heartbeating

- Each process sends out heartbeats to every other process
- Con: Slow process/link causes false positives

Gossip-Style Failure Detection



Protocol:

- Processes periodically gossip their membership list
- On receipt, the local membership list is updated

Current time : 70 at process 2

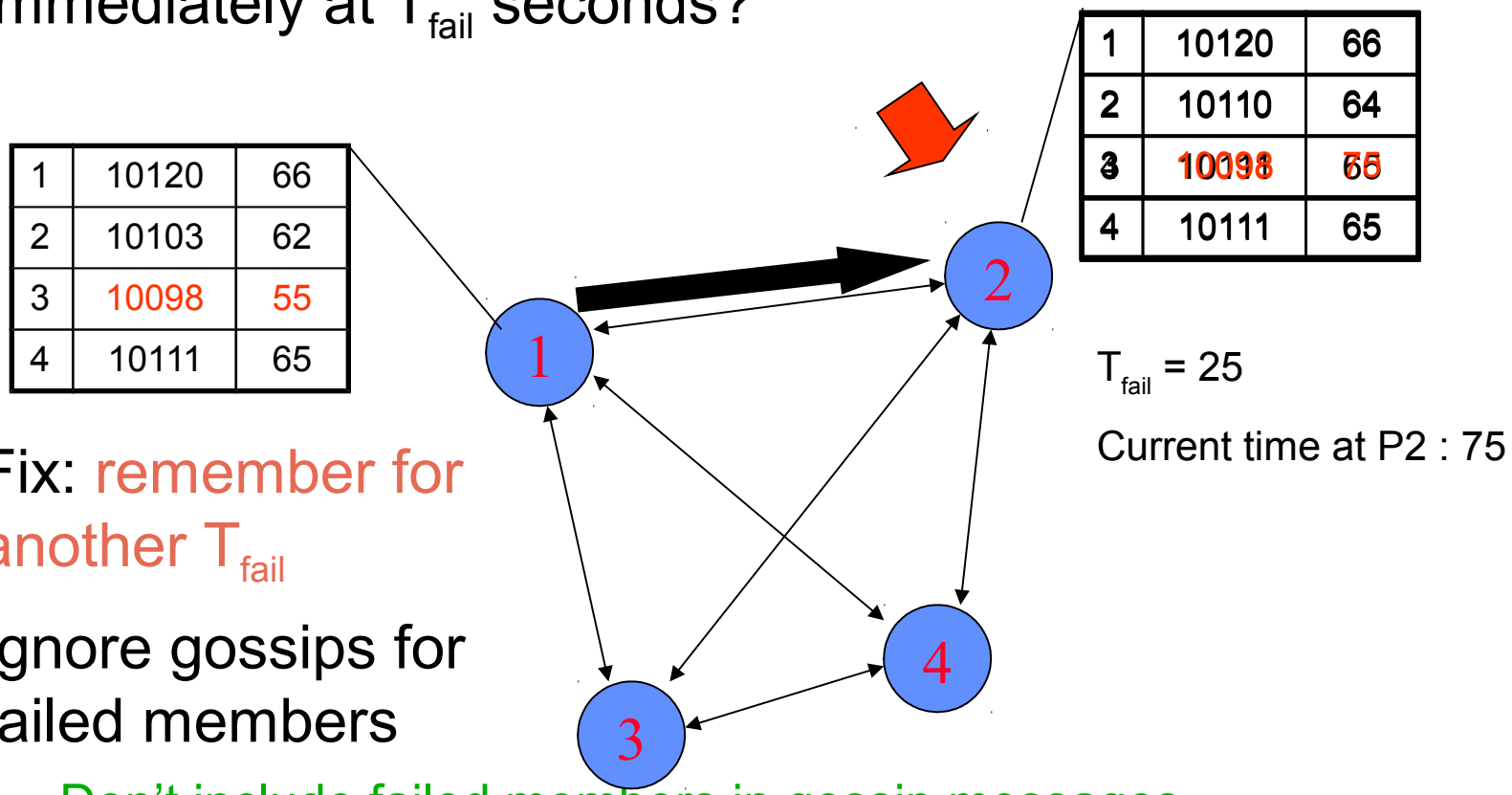
(asynchronous clocks)

Gossip-Style Failure Detection

- If the heartbeat for P_i has not increased for more than T_{fail} seconds (according to local time), P_i is considered failed
- But don't delete it right away
- Wait another $T_{cleanup}$ seconds, then delete P_i from the list

Gossip-Style Failure Detection

- What if an entry pointing to a failed process is deleted immediately at T_{fail} seconds?



- Fix: remember for another T_{fail}
- Ignore gossips for failed members
  - Don't include failed members in gossip messages

Gossip Consistency

- Consistency guarantees are chosen *to suit the application*.
  - Sound familiar?
- The protocol discussed here does not consider ordering.
  - Could be: causal, FIFO, total, […]
- Higher consistency, ordering guarantees increase cost.
  - More packets exchanged
  - Updates may be delayed
  - (One may be traded for the other in some cases)

Summary

- Eager replication vs. lazy replication
  - Lazy replication propagates updates in the background
- Gossiping
  - One strategy for lazy replication
  - High-level of fault-tolerance & quick spread
- Another use case for gossiping
  - Failure detection

References

[1] Textbook section 18.4 front matter and 18.4.1. **Required Reading.**

[2] Lorenzo Alvisi, Jeroen Doumen, Rachid Guerraoui, Boris Koldehofe, Harry Li, Robbert van Renesse, Gilles Tredan. *How robust are gossip-based communication protocols?* ACM SIGOPS Operating Systems Review – Gossip-based computer networking, Vol. 41 No. 5. October 2007. pp. 14-18. **Required Reading.** https://infoscience.epfl.ch/record/109302/files/robustgossip-final.pdf

[3] Rivka Ladin, Barbara Liskov, Liuba Shrira, and Sanjay Ghemawat. *Providing High Availability Using Lazy Replication.* ACM Transactions on Computer Systems, Vol. 10 No. 4. November 1992. pp. 360-391 http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.112.6129&rep=rep1&type=pdf

Acknowledgements

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