Decentralized Systems Engineering

CS-438 – Fall 2024

DEDIS

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EPFL

Credits: P. Tennage, C. Basescu, et al.

Communicating with (many, unknown) peers

- Same machine
  - a file in a shared directory, or Linux `wall` command
- Local networking
  - shared drive, intranet website
- Global networking, centralized trust
  - mailing lists, forums, Reddit, …
- Decentralized
  - ??? → today's lecture

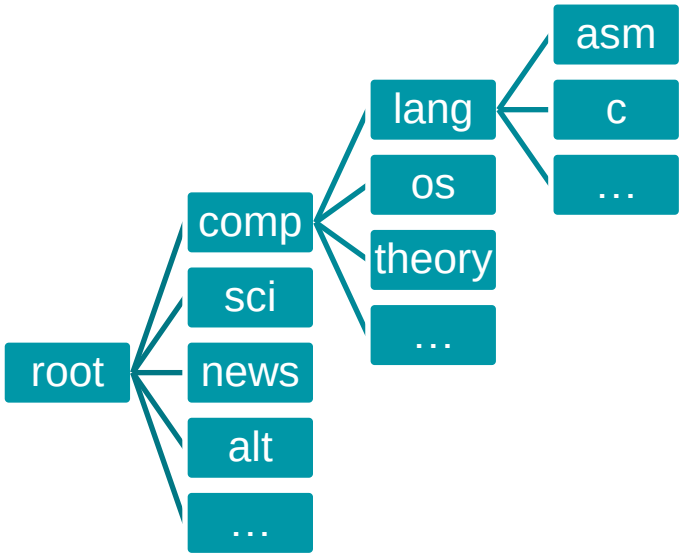
Decentralized Communication

Usenet & Gossip

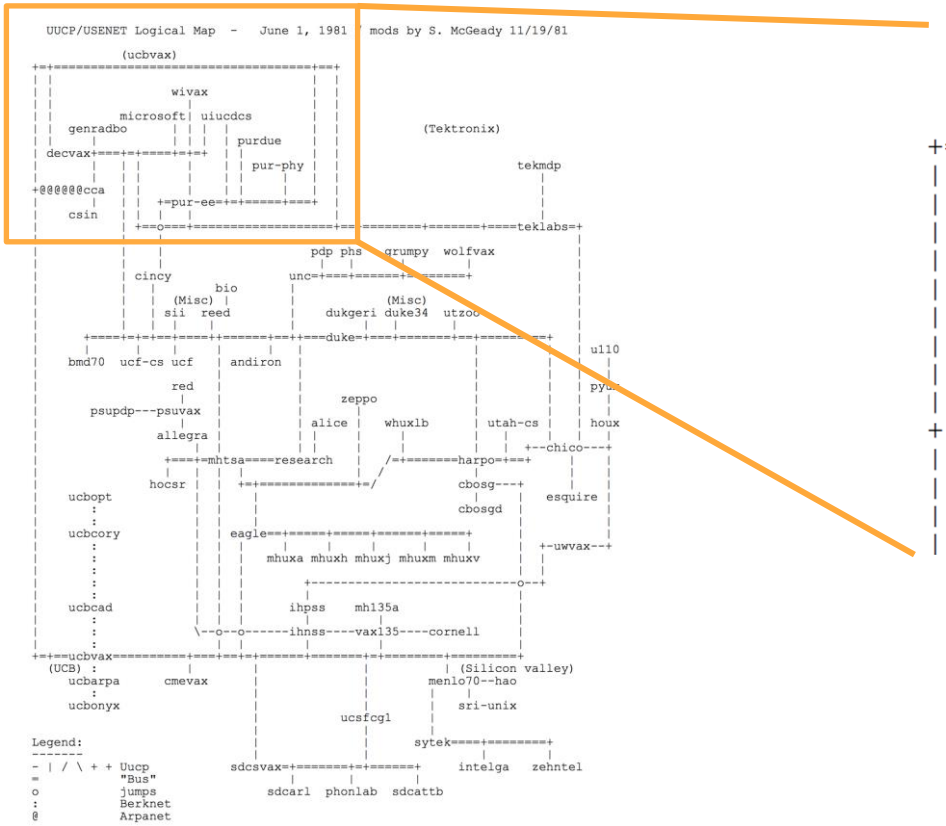
(Homework 1)

What is Usenet ?

- User’s Network
- Worldwide, distributed discussion system
- Hierarchical organization of topics
- Context – early 1980s:
  - Pre-Internet (1980)
  - Mainframes, then minicomputers
  - Intermittent, dial-up connections (at best 56kbit/s)
  - Resilient: censorship- and failure-resistant



Early UUCP/Usenet Map



UUCP/USENET Logical Map - June 1, 1981 /
(ucbvax)
wivax
microsoft
uiucdcs
genradbo
purdue
decvax
pur-phy
+@@@@@@cca
+=pur-ee=+=+=====+===+
csin
+==o===+=====+=======+=======+==+:

Why think of Usenet in 2023 ?

- 1980s computers are still relevant
  … they are just way smaller today:
  Embedded systems, Internet of Things (IoT), Sensors, etc.

- 1980s networks are still relevant:
  Low-Power Wide-Area Networks (e.g. LoRaNET / LoRaWAN)
  - [0.3, 50] kbit/s
  - 256 bytes / message
  - Per-message pricing (~ 2 CHF / MB)

- Power and batteries are their limit

Building Usenet : specifications

- Worldwide, distributed discussion system
- Hierarchical organization of topics / newsgroups
- Messages are (eventually) received by all subscribers
- It is possible to respond privately (pre-email)
- Resilient: censorship- and failure-resistant
- Intermittent, dial-up connections – slow & costly !
- Limited computing resources (1980s)

Building Usenet : network messages

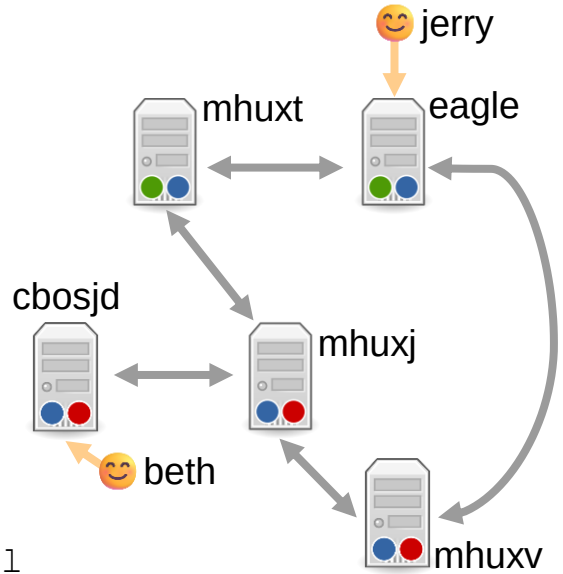
Header

- From: jerry@eagle.uucp (Jerry Schwarz)
- Path: cbosgd!mhuxj!mhuxt!eagle!jerry
- Newsgroups: news.announce
- Subject: Usenet Etiquette -- Please Read
- Message-ID: <642@eagle.ATT.COM>
- Date: Fri, 19 Nov 82 16:14:55 GMT
- Organization: AT&T Bell Laboratories, Murray Hill
- Expires: Sat, 1 Jan 83 00:00:00 -0500

Blank line

Body

```
The message itself comes here, after a blank line.
Hello, world !
```

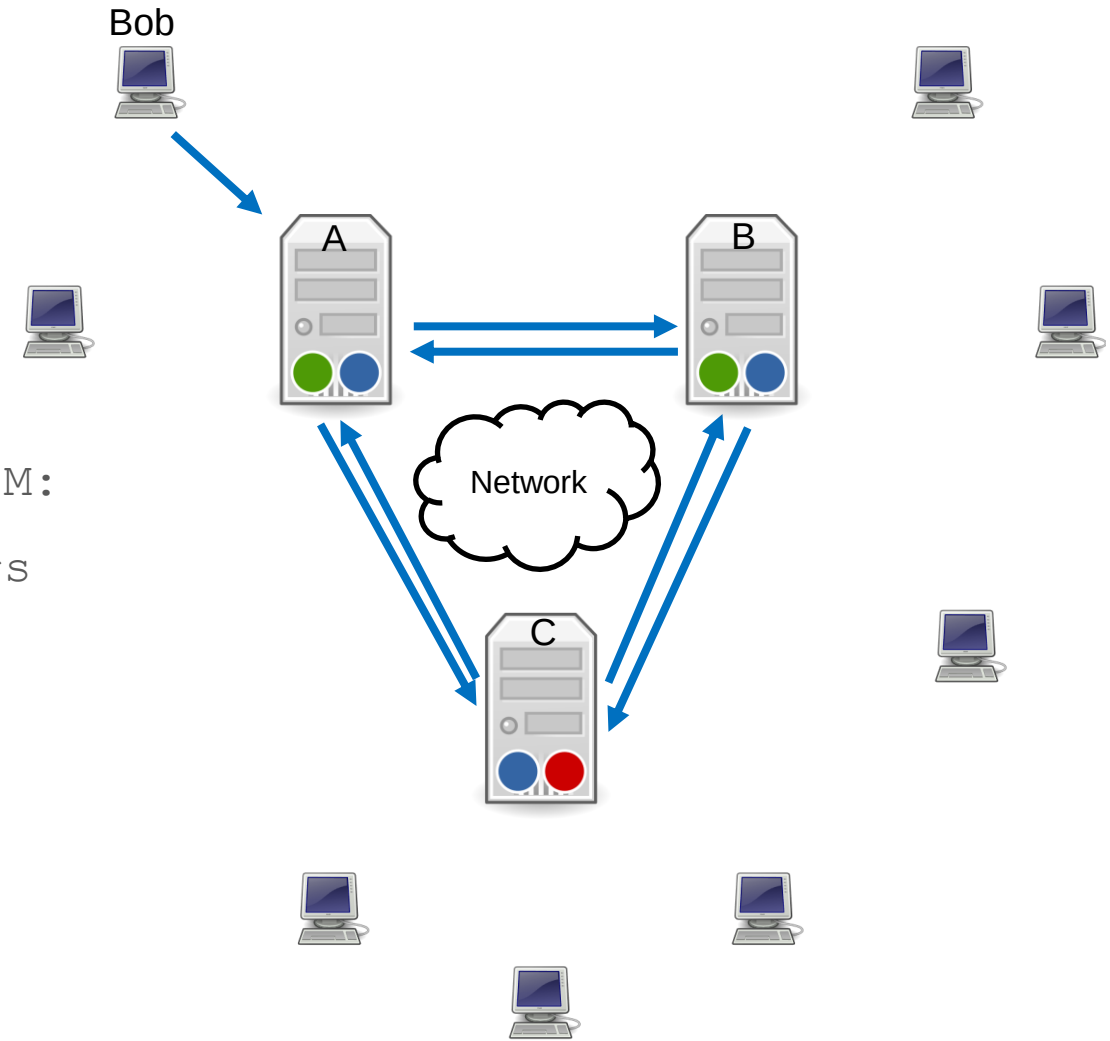


Naive Broadcast

```
On receiving message M:

    Send M to all peers
    (except sender)
```

What's the problem here ?



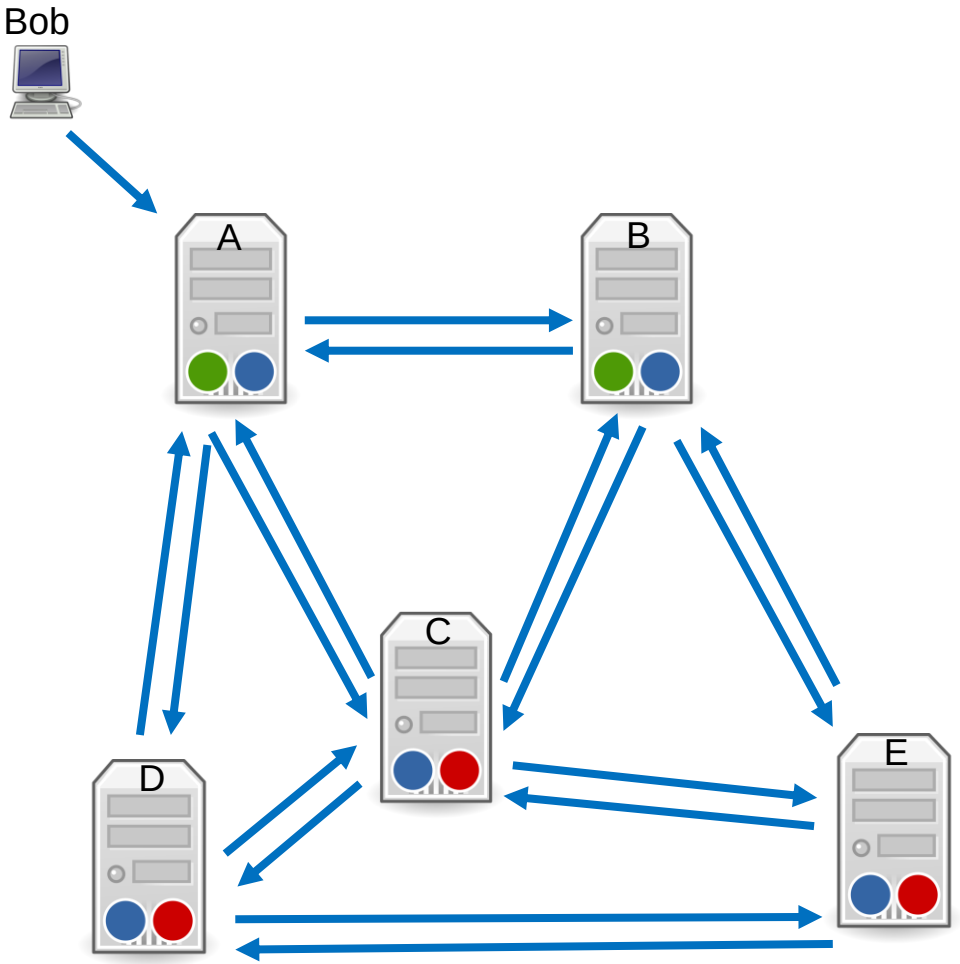
Naive Broadcast

Network meltdown !

- Exponential # of messages
- Too costly to operate

How do we fix this ?

1. Recognize messages
2. Restrict the graph to a tree
   e.g., Ethernet (R)STP



Recognizing Messages with IDs

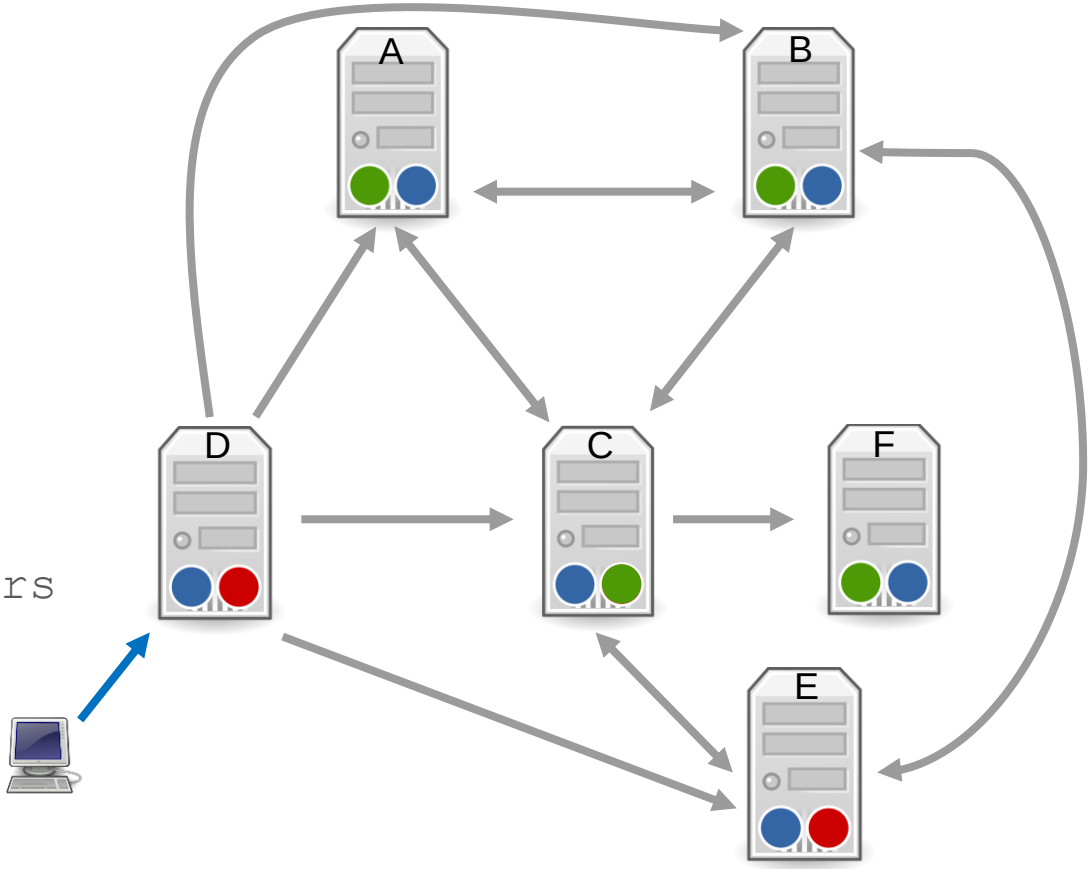
- How do you generate message IDs ?
  - Big random number (e.g., 256 bits)
  - Hash
  - Usenet: <sequence number>@<node>
- How do you detect / trace node misbehavior ?
  - Usenet: use message propagation path

Naive Broadcast (Fixed!)

```
On receiving message M:

    if M is known:
        ignore

    else:
        Send M to all peers
        (except sender)
```



Which issues do you foresee ?

Broadcast : Limitations

- Well-connected nodes often receive the same message many times
- What happens if some nodes failed ?
- Do we need to send the whole message every time ?
  - Early Usenet (UUCP)

    “better than accepting the delay of round-trips”
  - Late Usenet (NNTP) - binaries, high traffic volume, etc.

    “we can’t afford to”

Broadcast efficiency

How can we minimize duplication and reduce traffic ?

By comparing sets of messages !

A->B `ihave <id_1>, <id_2>, <id_3>, …  <B_address>`

A<-B `sendme <id_3>, <id_5>  <A_address>`

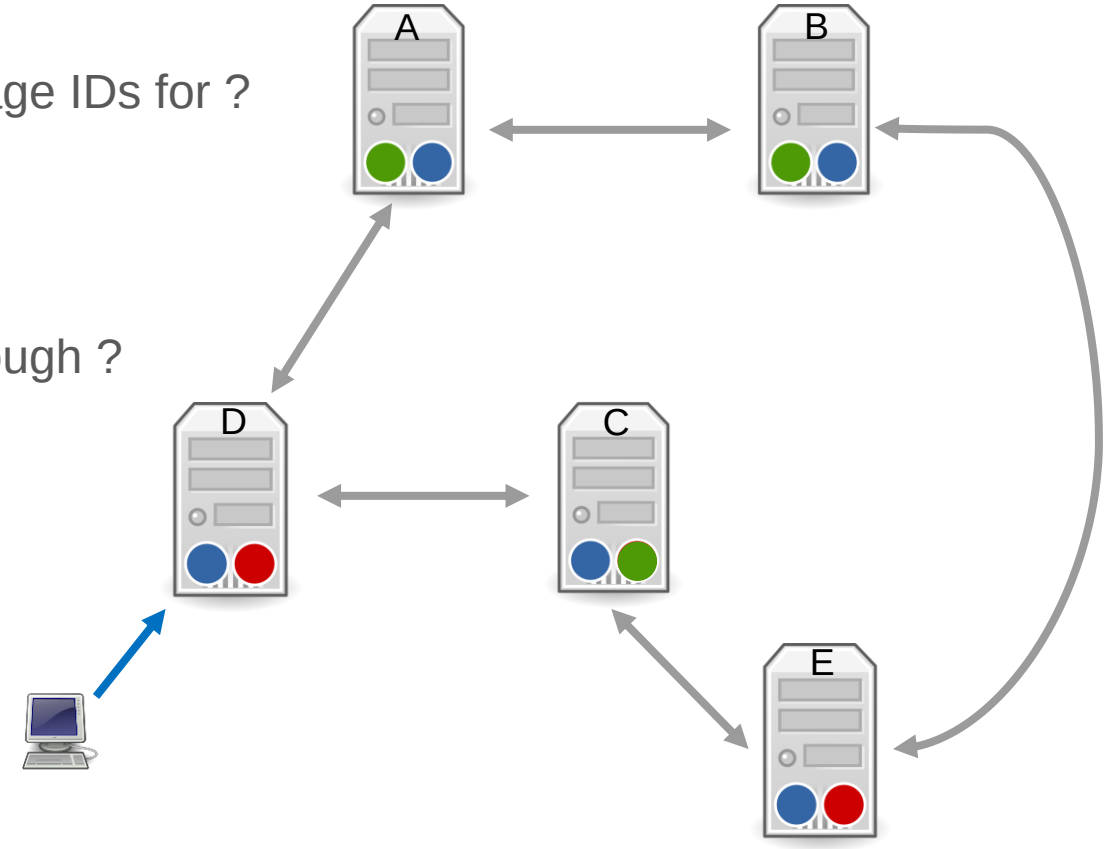
What implementation issues can you foresee ?

Message IDs : Trade-offs

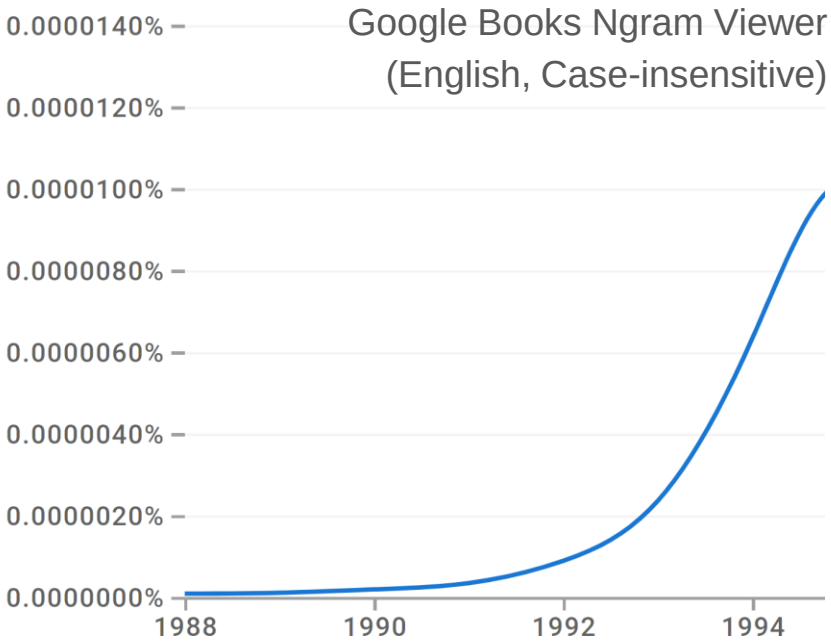
- How long do you store message IDs for ?

What happens if …

- you store them forever ?
- you don’t store them long enough ?



The Life of Usenet



What made it so successful ?

- It worked !
- Engineering simplicity
- Decentralization
- “Democratizing”

The Life and Death of Usenet

Google Books Ngram Viewer
(English, Case-insensitive)

What killed Usenet ?

Cause #1: Spam !

- Jan 1994 : Global Alert for All : Jesus is Coming Soon
- Apr 1994 : Green Card Lottery – Final One?

Other causes:

- Better alternatives
- Slow evolution

Beyond Usenet: Gossip Efficiency

What if we wanted to further minimize traffic ?

A closer look at `ihave/sendme` :

- **V** message content is only sent once per node
- **X** still requires P2P interaction, sending IDs redundantly

Can we minimize bandwidth usage without interaction ?

- Naive broadcast $O(n \cdot d)$, n = # nodes, d = max. degree of any node
- Can we reduce to $O(n)$?

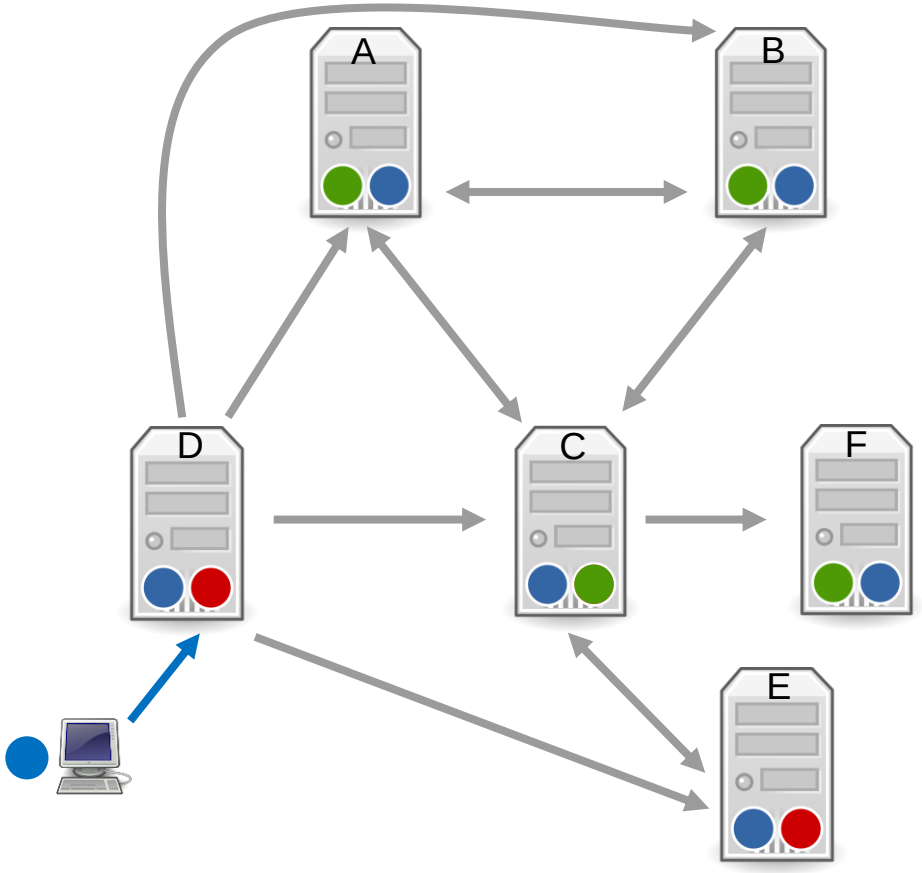
Improved Gossiping

What can we learn from people ?
Rumor mongering

```
On receiving message M:

   pick random neighbor, send M
   neighbor replies: new rumor?

   if new:     repeat
   else:       flip_coin()
               if head: repeat
               else:    stop
```



What's good about this ? Which issues do you foresee ?

Improved Gossiping (cont'd)

How can make sure messages reach *every* node?
Anti-entropy

```
Periodically (when timer fires):

  pick random neighbor
  send "anything new?"
  reduce entropy (ihave/sendme)
```

What's good about this ? What's limiting ?

This (slowly) ensures complete dissemination, at $O(n)$ per period