Improving Rumor Spreading

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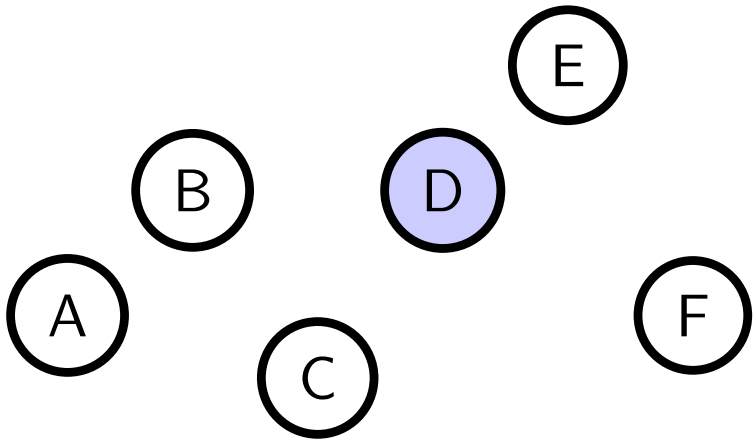
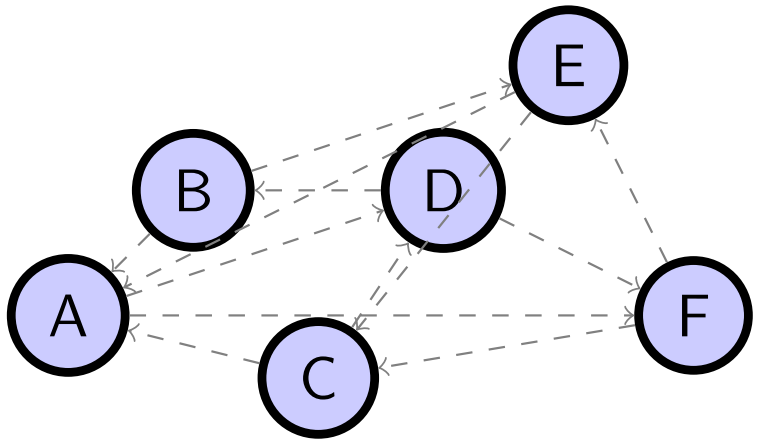
What achieves Rumor Spreading?

Deliver a message to every nodes of a group with high probability.



(a) Before



(b) After

Nodes in blue know the message

Use cases for Rumor Spreading

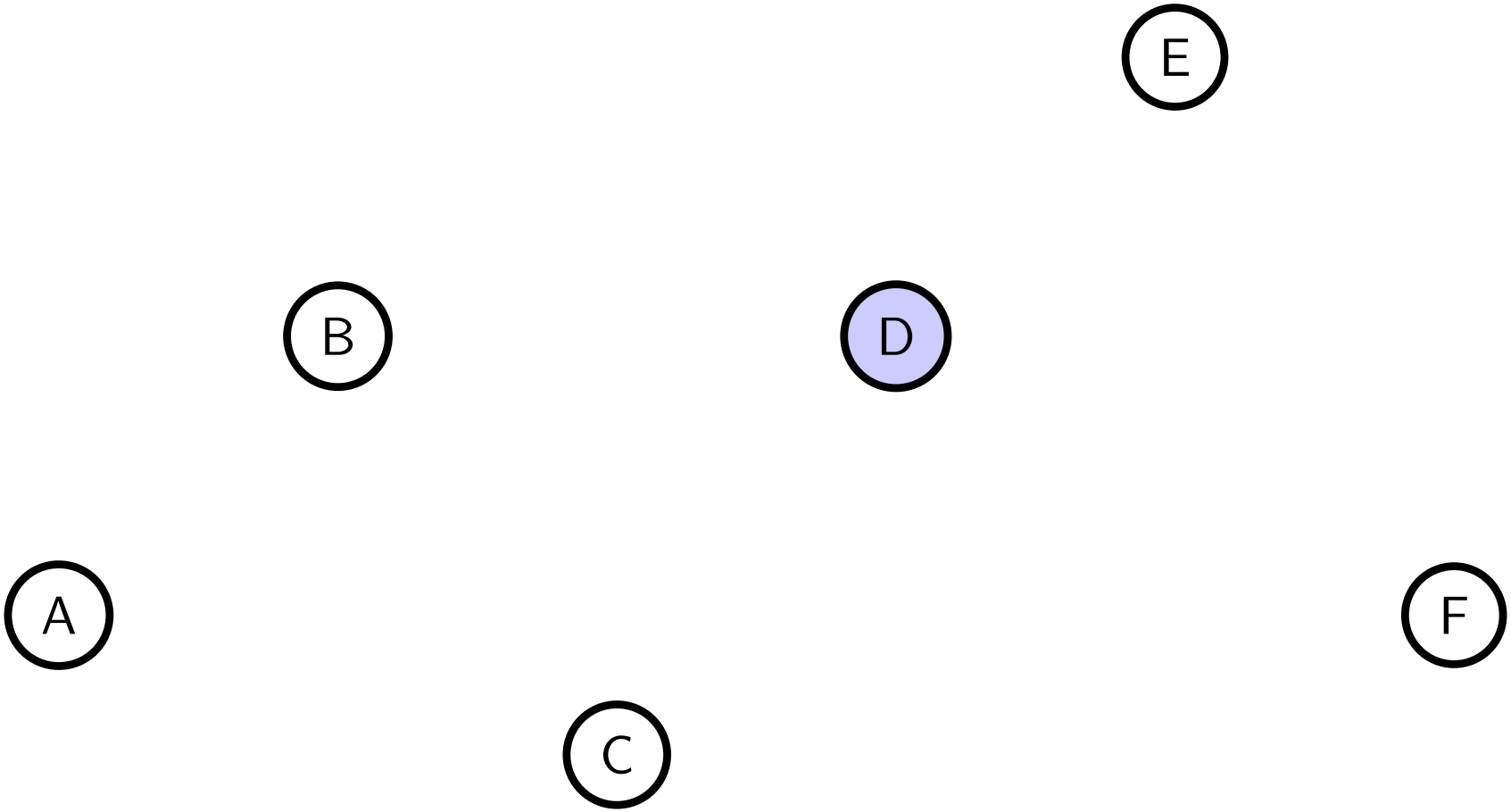
- Collaborative Platforms
  - Chat, Communication Platform (eg. Rumor Monger)
  - Collaborative Editors (eg. CRATE)
- Collaborative News Feeds (could replace WebSub or Atom/RSS)
- Sensor Network
- Membership

Basically any publish/subscribe mechanism

Naive solution

At the beginning, only D knows the message.

D sends the message to every nodes of the network.



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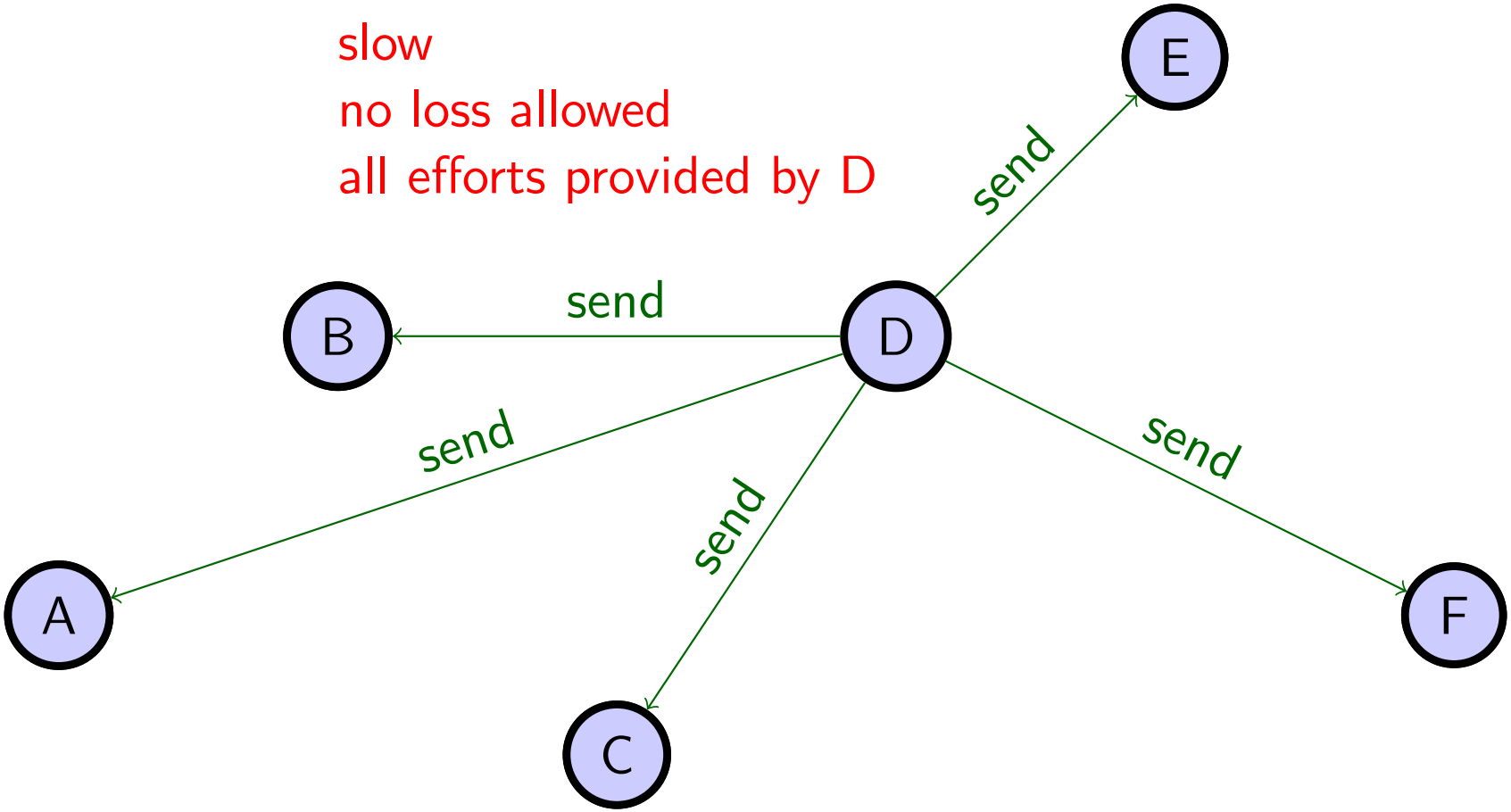
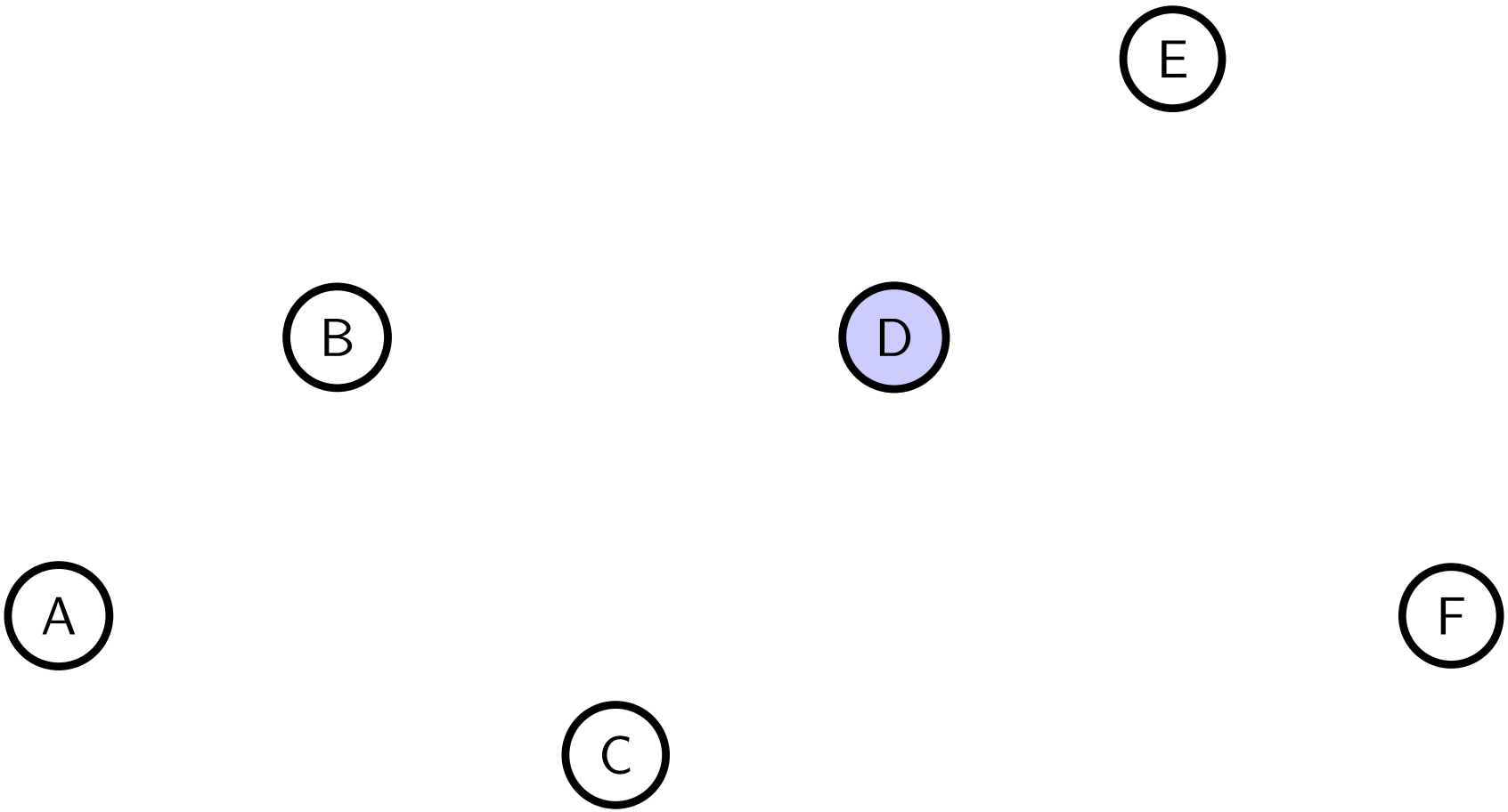


Make nodes collaborate: a push only protocol

At the beginning, only D knows the message.

Each nodes forward the message 2 times to a random node.



Infect and Die with fanout = 2

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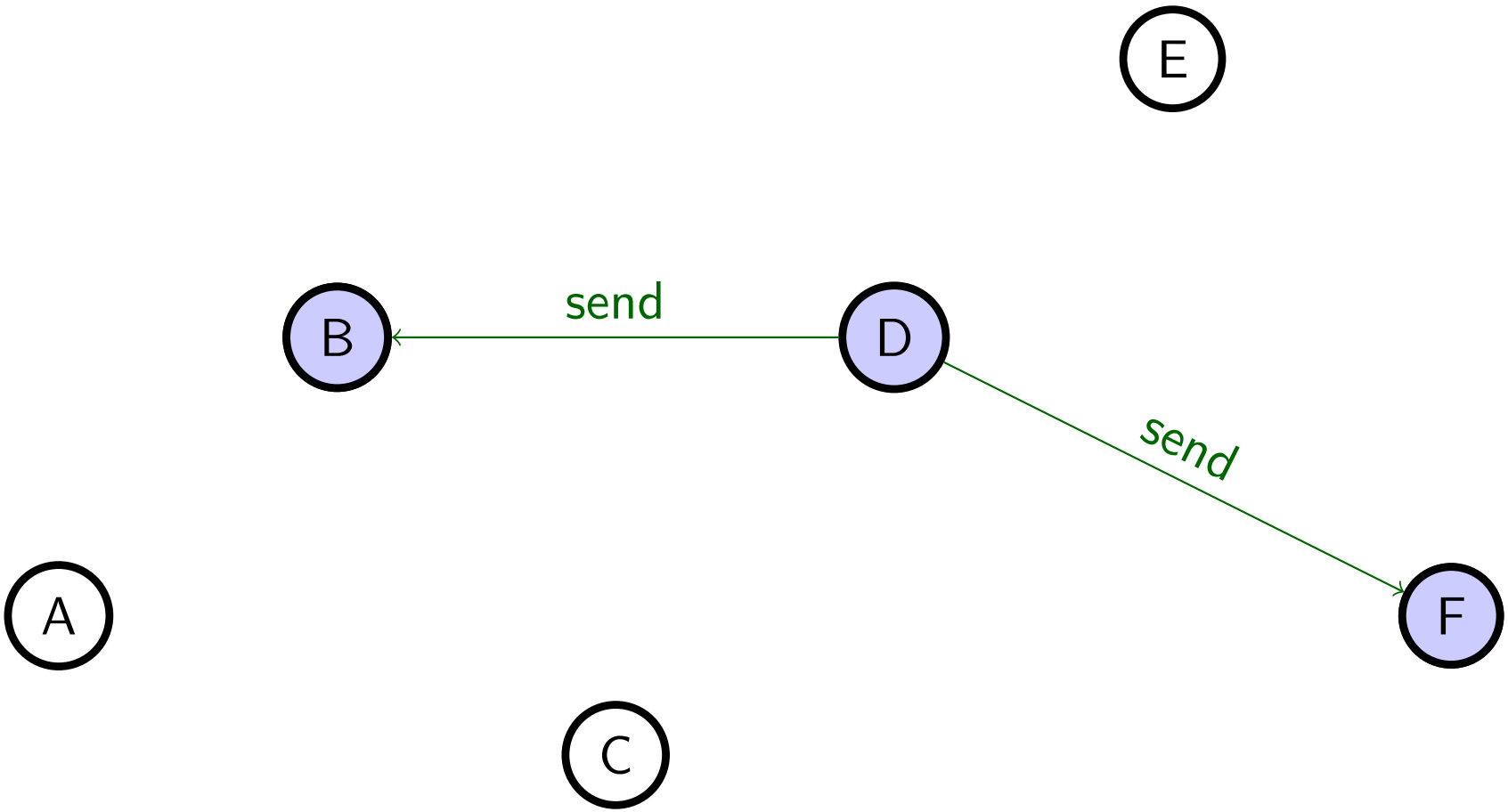

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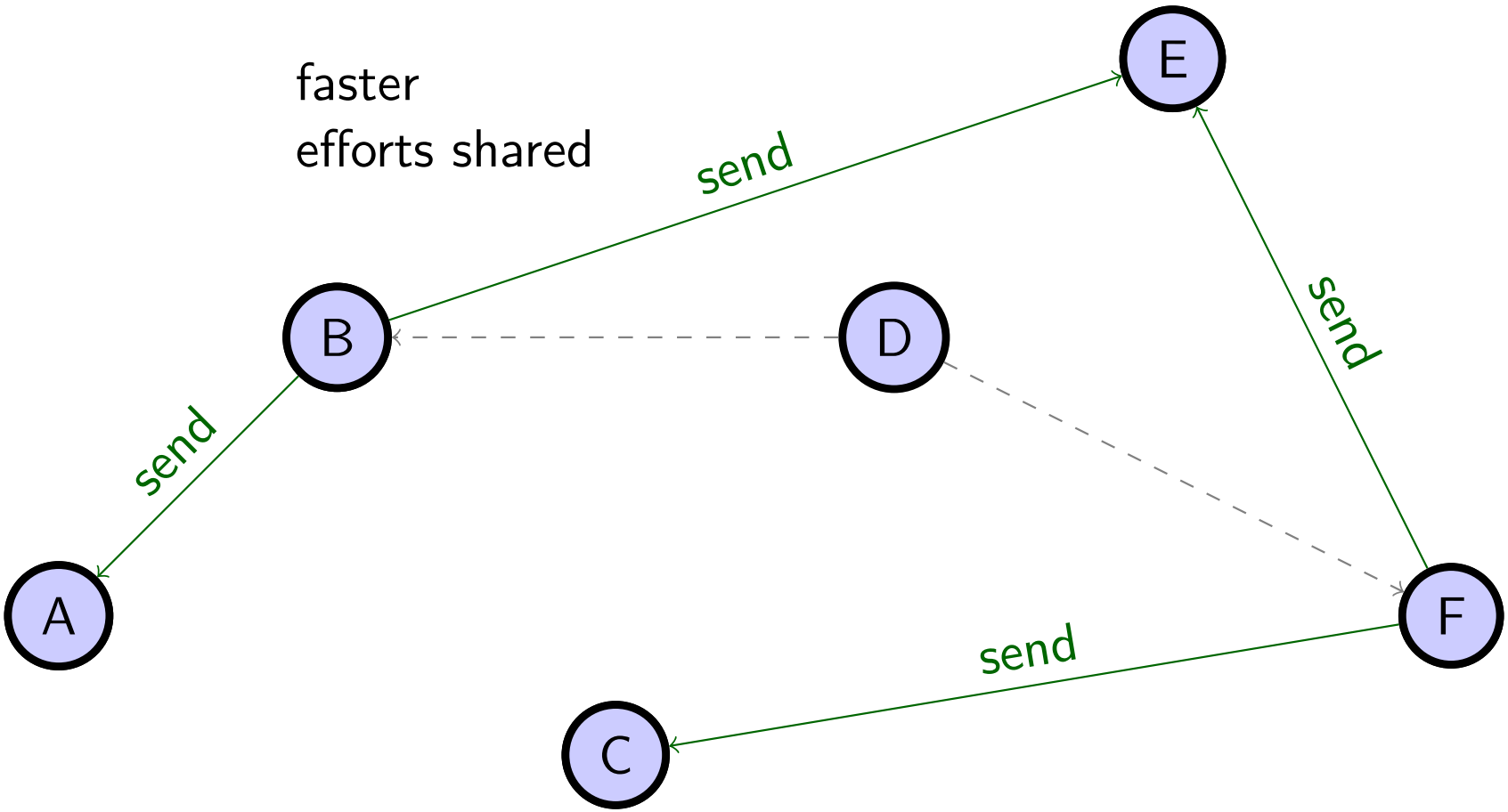

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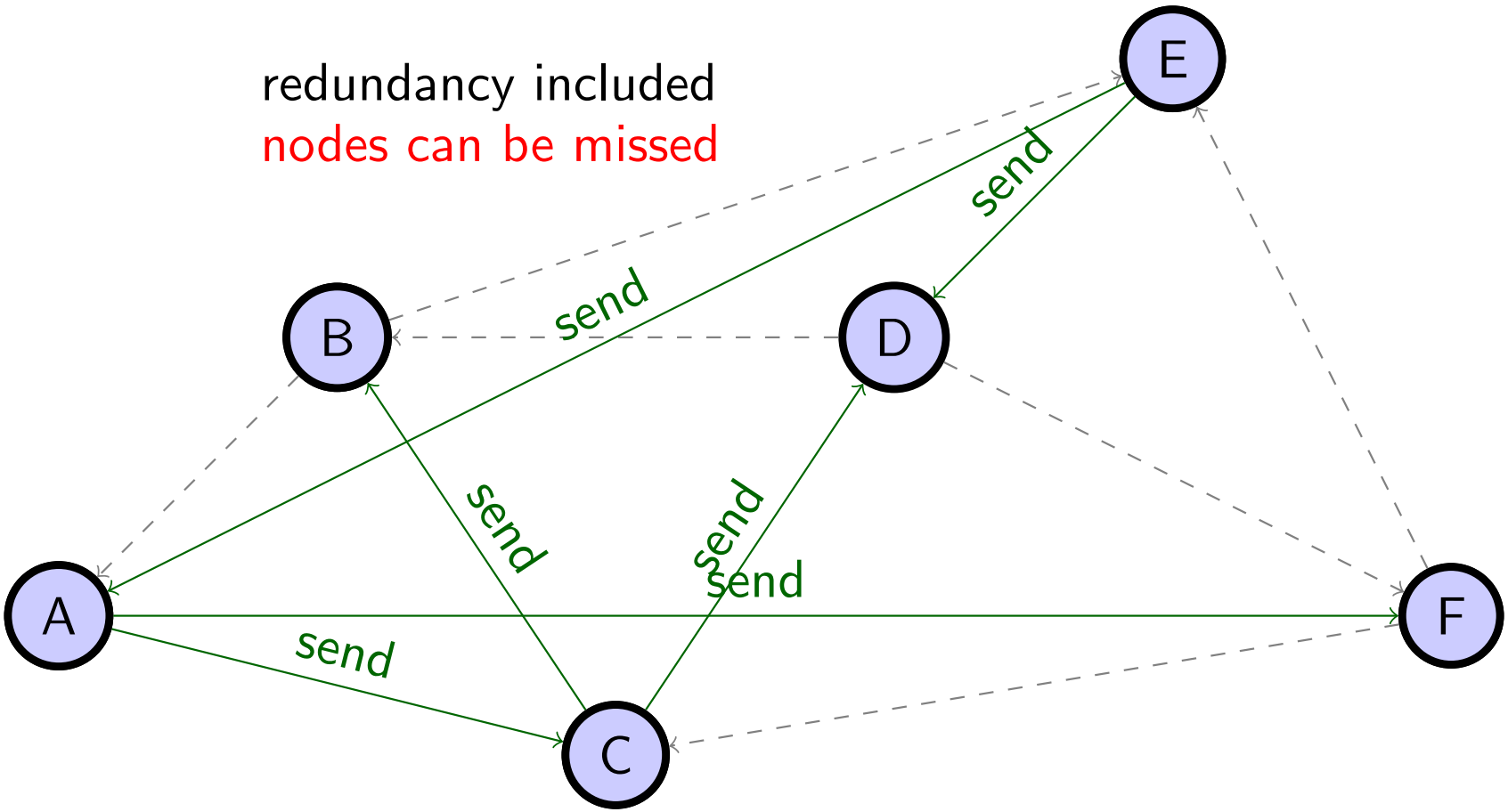

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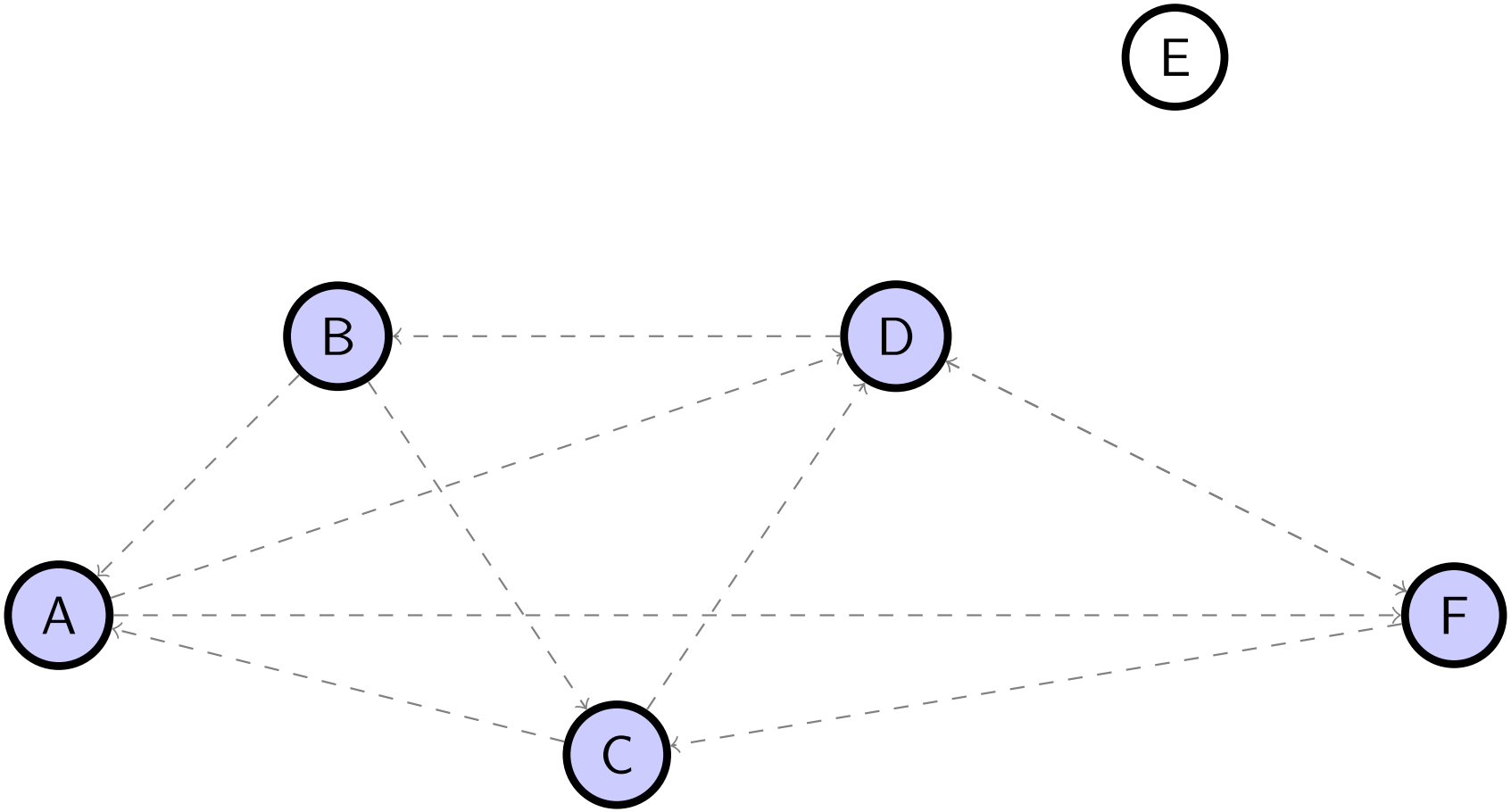
Ask for the message: a push-pull protocol

It is costly to reach every nodes with high probability.
Adding a pull phase can help last nodes retrieve the message.



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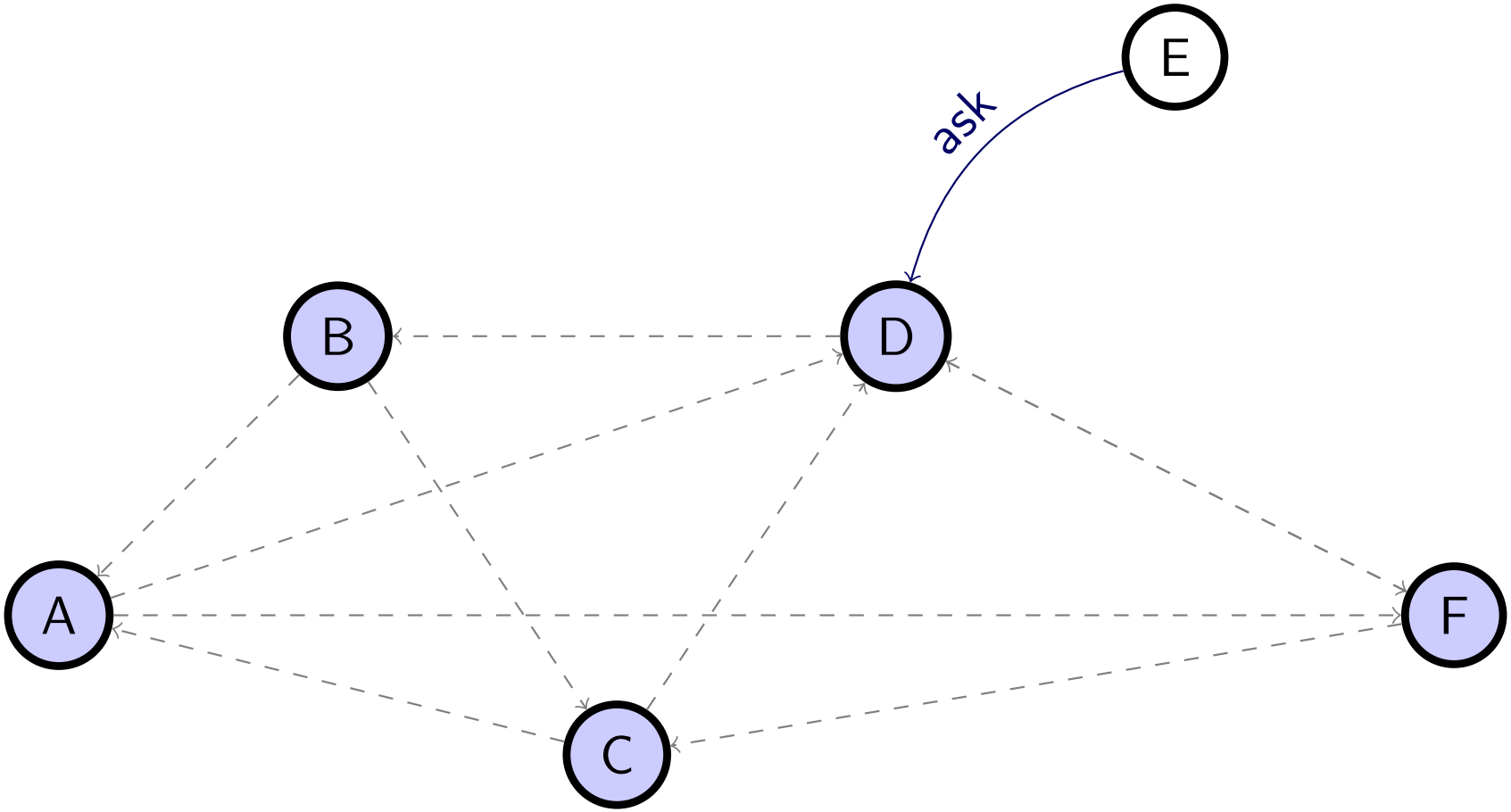

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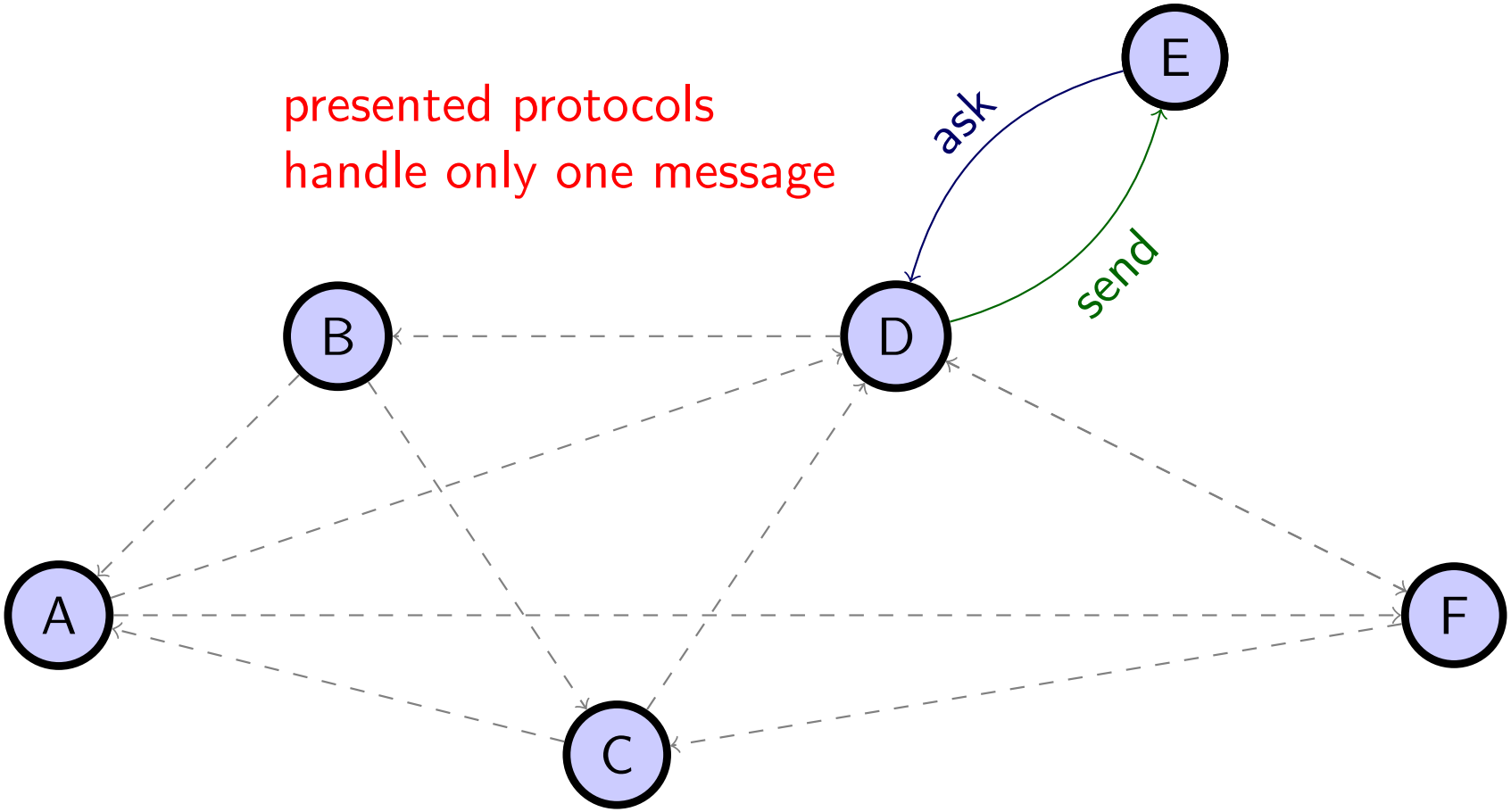
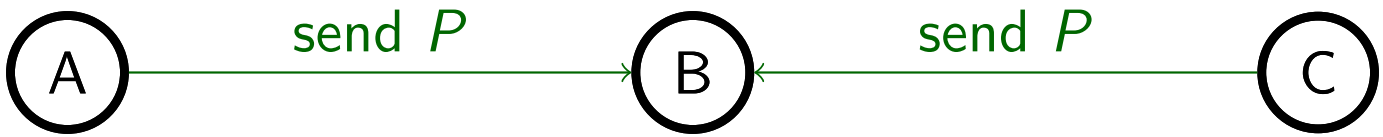


Working with multiple messages

With P being the payload of a message, how to know if it's a new message? How to discover missing messages?



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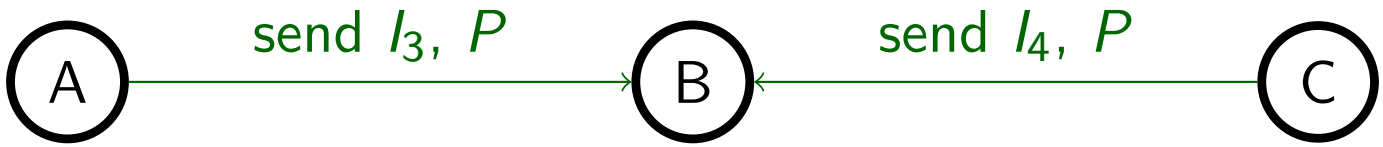

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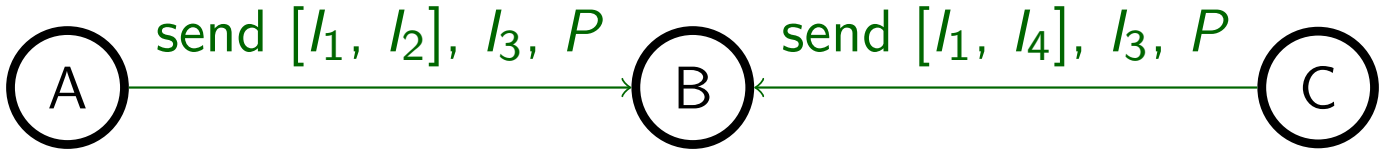

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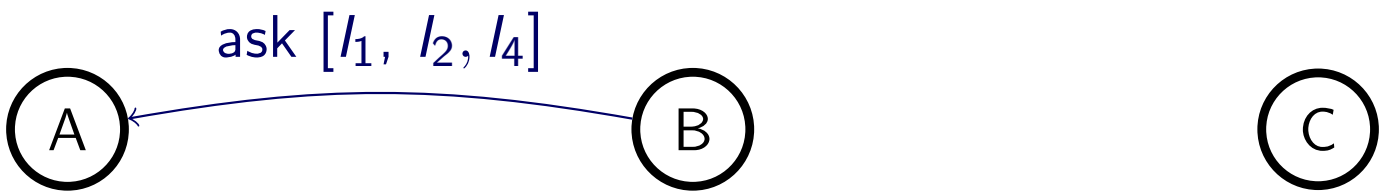

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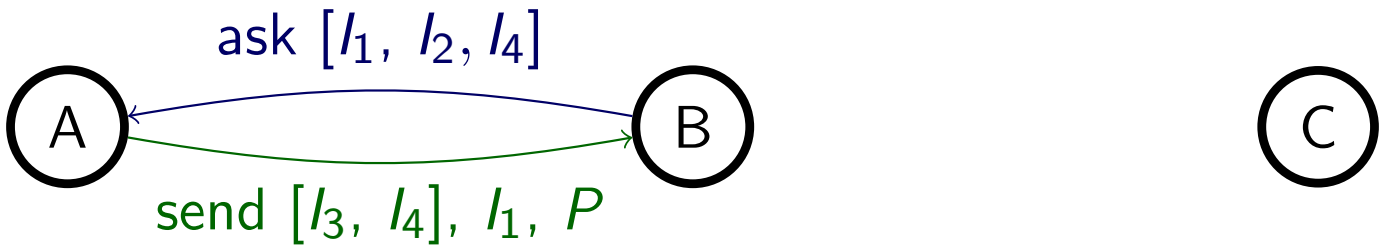
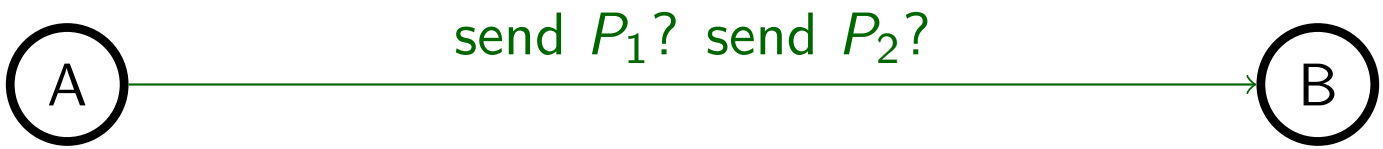


Encode messages to improve thoughput and latency

B already knows one message, either I_1, P_1 or I_2, P_2.



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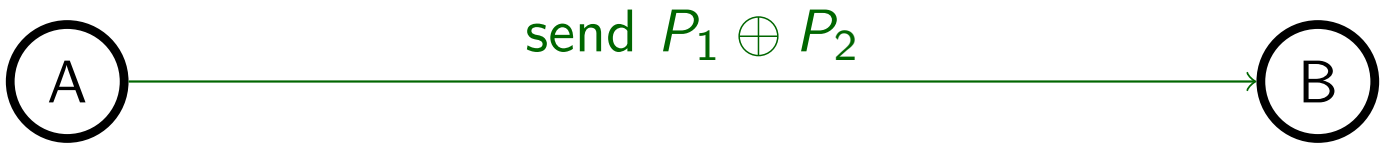

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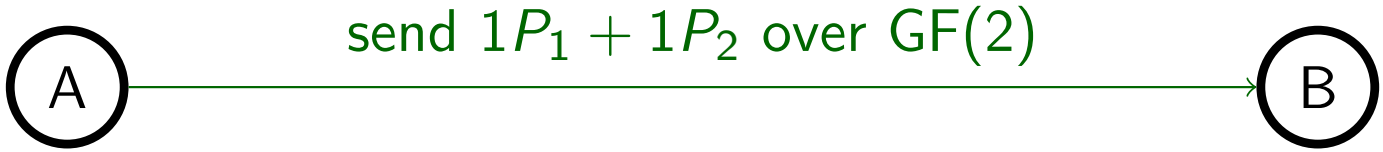

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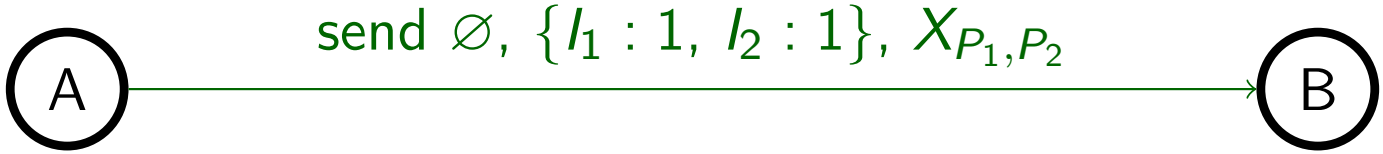
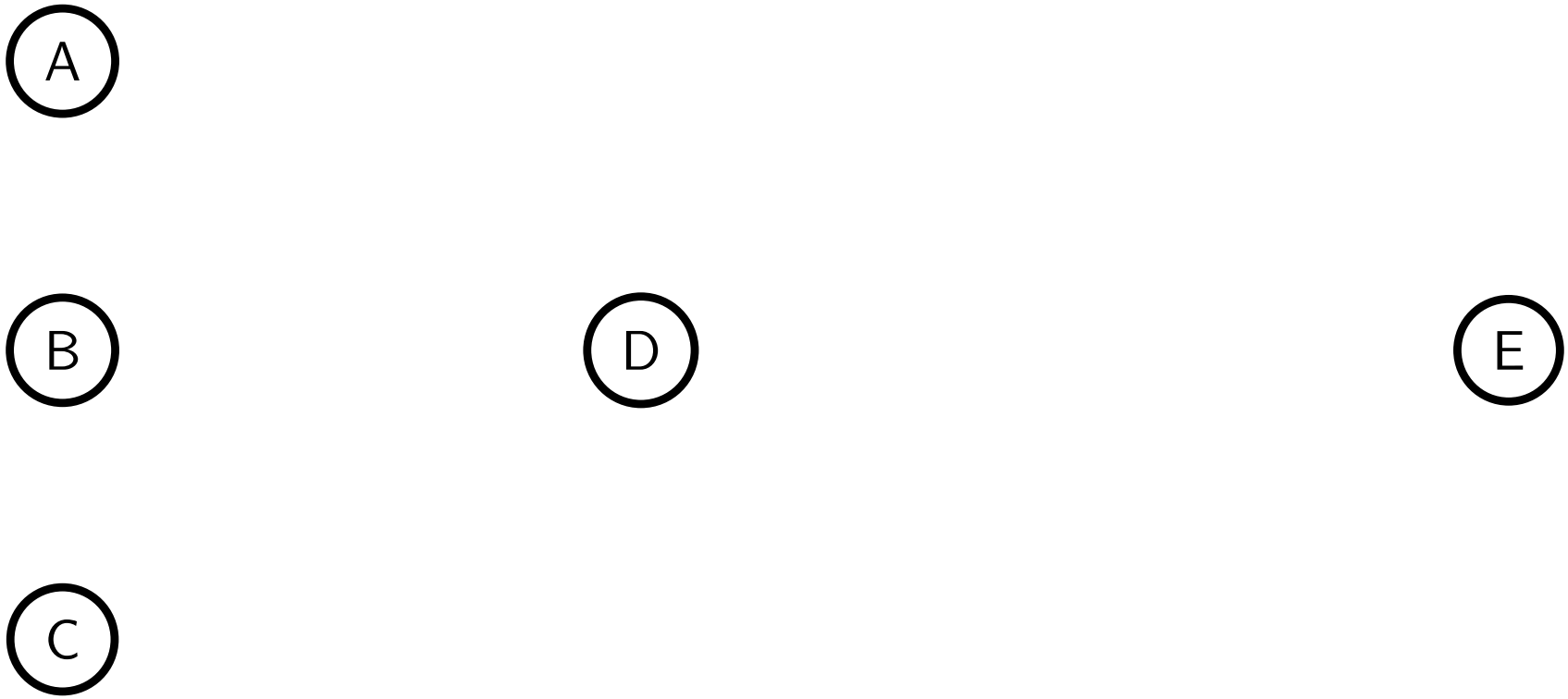


- Encoding messages increase the chance of providing new information.
- It can be expressed over a Galois Field
- Identifier is replaced by a list of identifiers and their associated coefficient. $X_{P_1,P_2} = P_1 \oplus P_2$ in this case.

Generalize with Random Linear Network Coding

Random coefficients with independant linear combination?

Use a bigger Galois Field. Example with GF(256):



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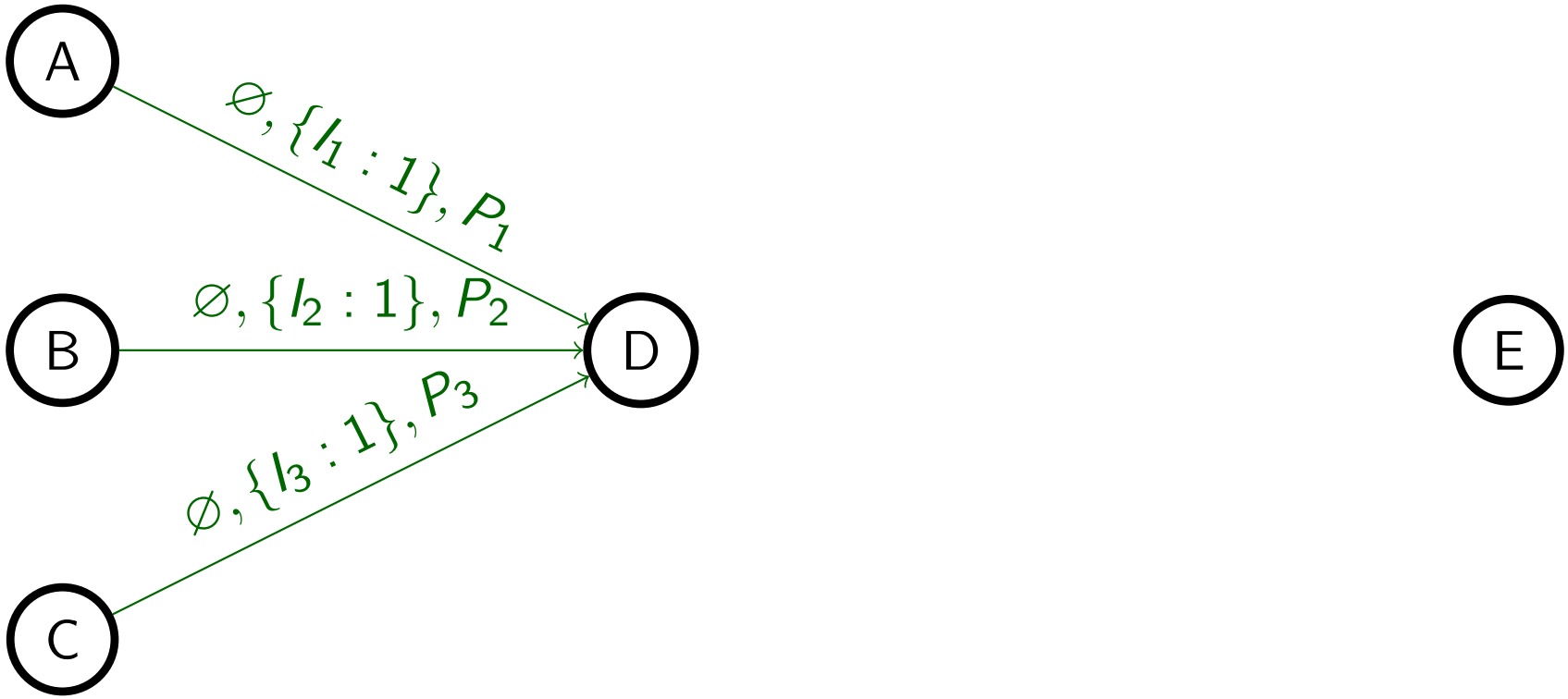

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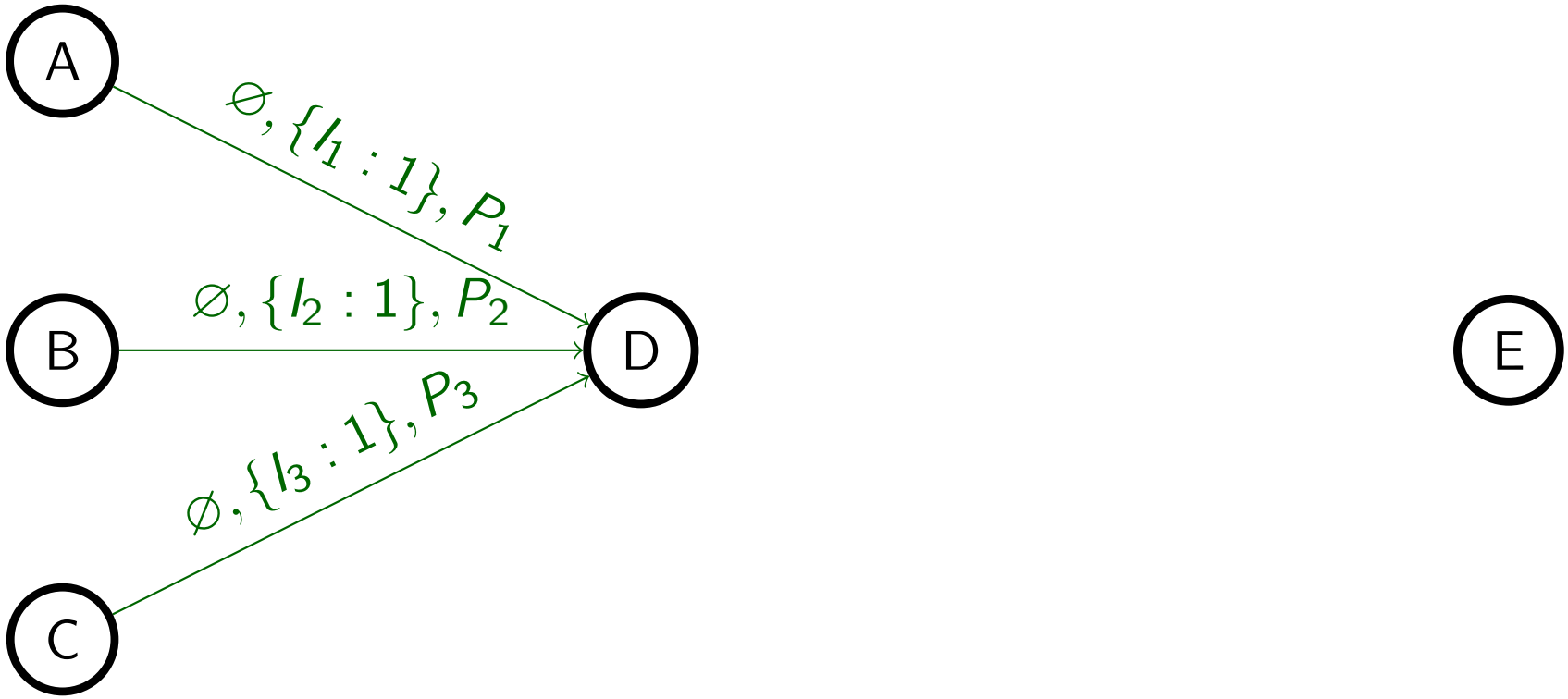

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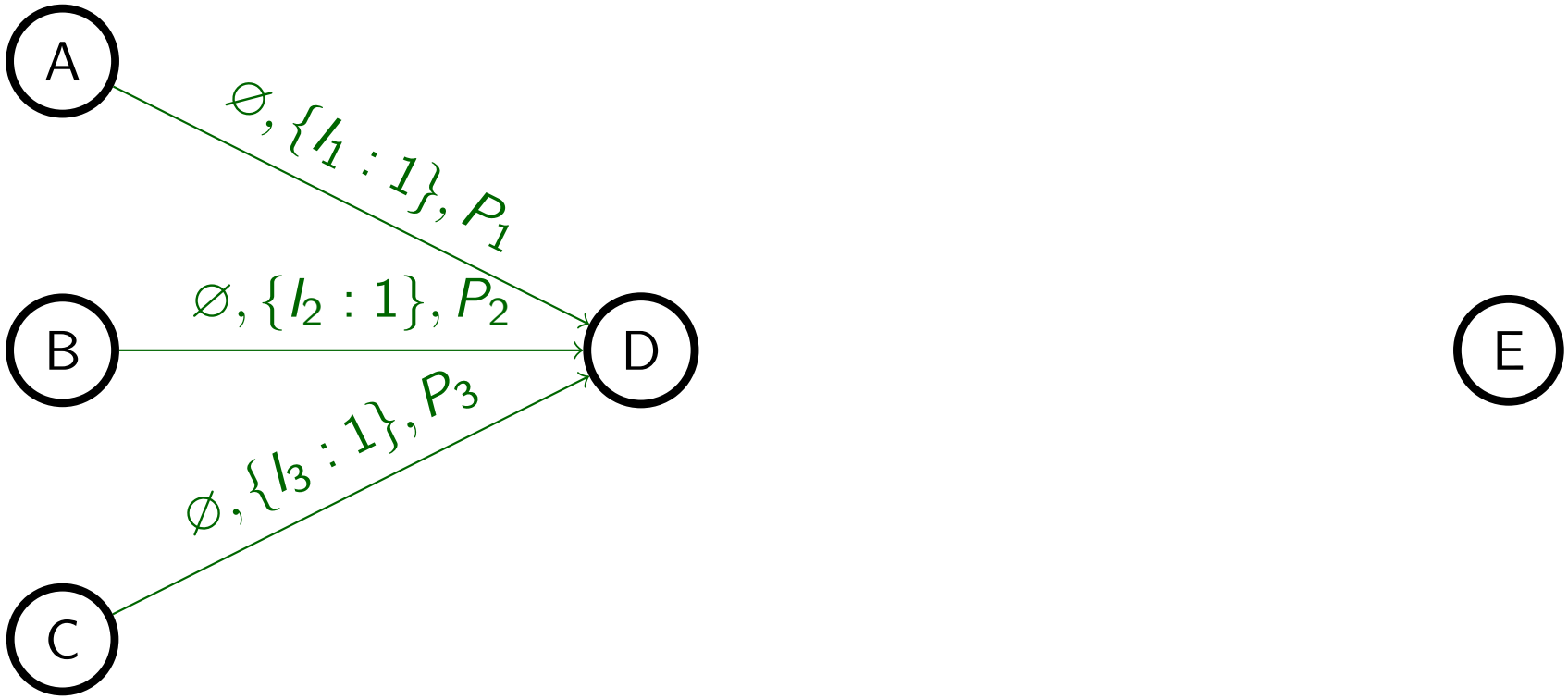

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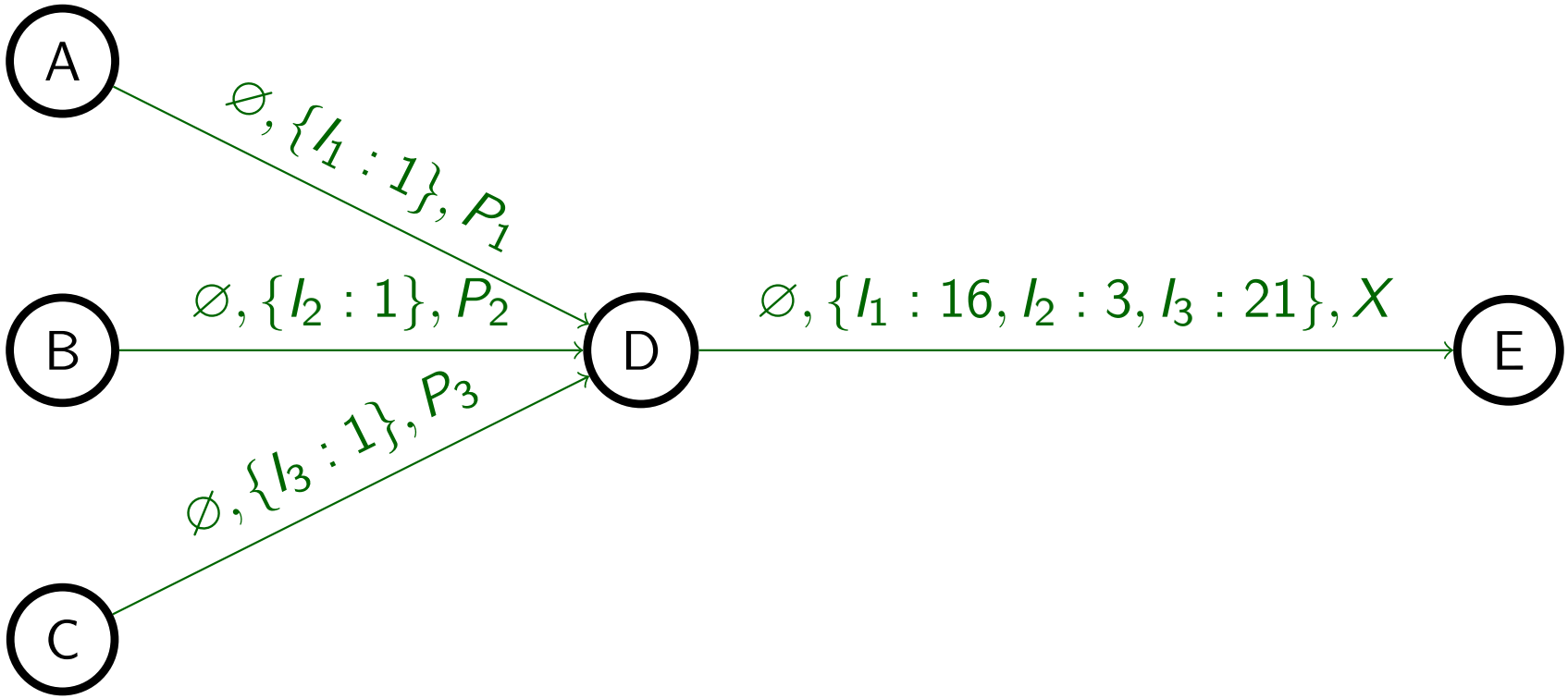

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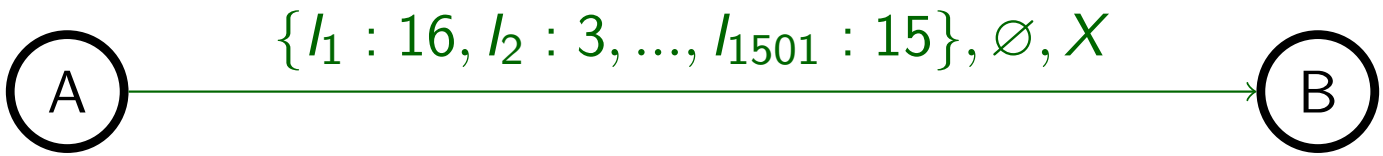
- Send the encoded message

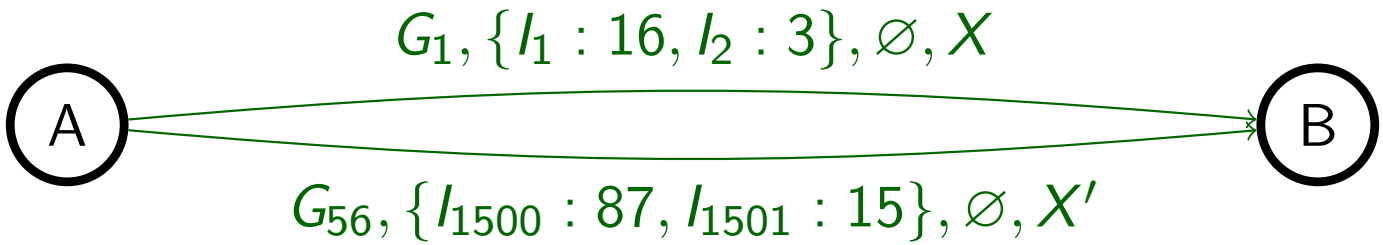
Group messages in generations

Coding explosion:



Group messages in generations

Encoding is only done between message of the same generation:



How to assign a generation to a message?

- Encode messages that are emitted in the same timeframe
- Every nodes start with a logical clock at zero
- When a node emits a message, it will assign its clock as message generation then increase its clock
- If a node forwards a message tagged with a generation bigger than its local clock, it updates its clock to match the generation it has seen

Comparison against Pulp, a push-pull algorithm

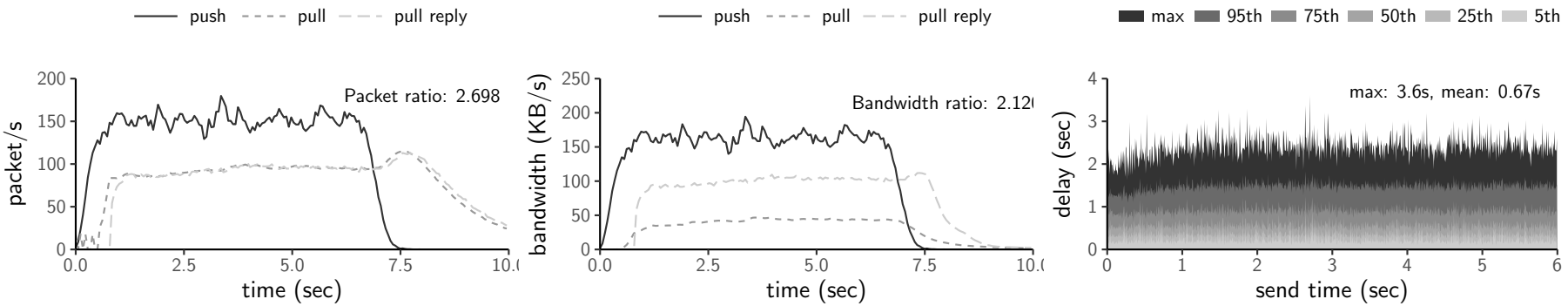


Figure: Pulp original

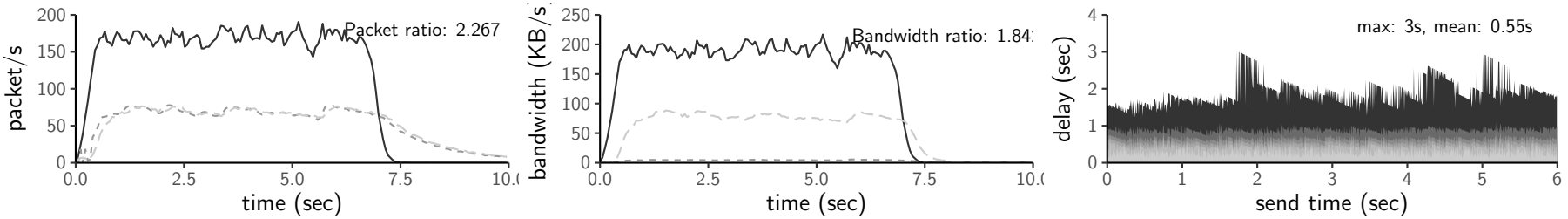


Figure: Our algorithm

Why pull frequency must be adapted

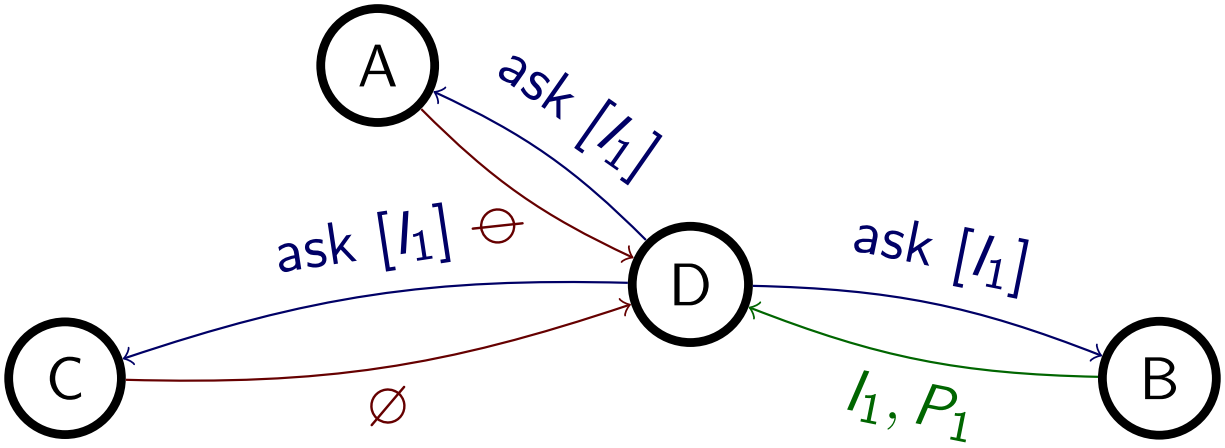


Figure: Too fast

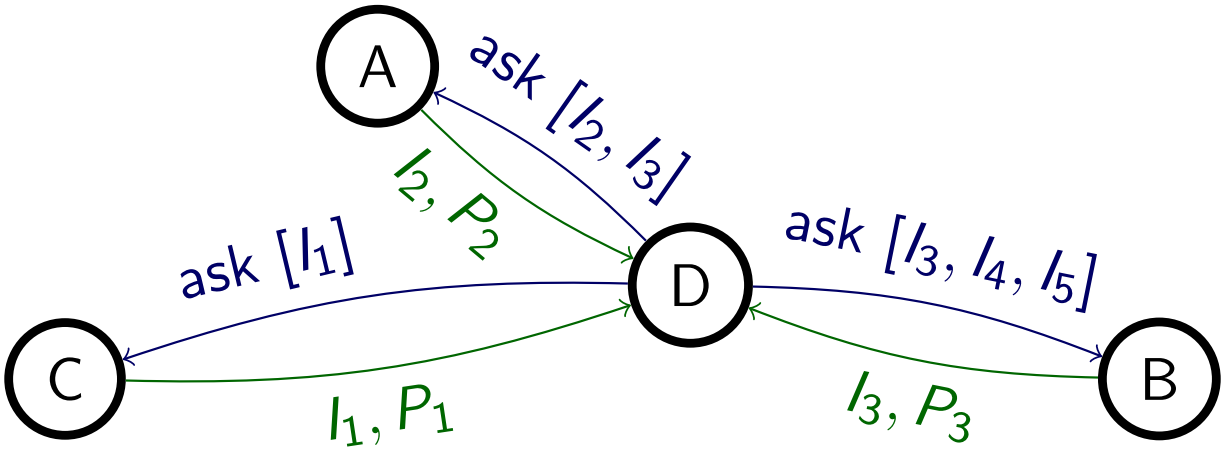


Figure: Too slow

Can we use control theory?

We want:

- to control
  - pull usefulness (number of useful pull / number of total pull)
  - delivery delay (by monitoring known missing messages evolution)
- to take action on pull frequency

Looked at:

- Open Loop vs Closed Loop
- Binary Feedback (used in TCP Congestion Control)
  - Additive (or Multiplicative) Increase, Additive (or Multiplicative) Decrease
- Proportional-Integral-Derivative (PID) Controller

Problem: unstable environment
(message rate, loss, churn, network size, latency)

- Adaptive Controller
- System Identification

Pulp adaptiveness analysis

Reminder: control usefulness and missing messages, act on pull frequency

Take a sample every $\Delta adjust$ time
2 strategies:

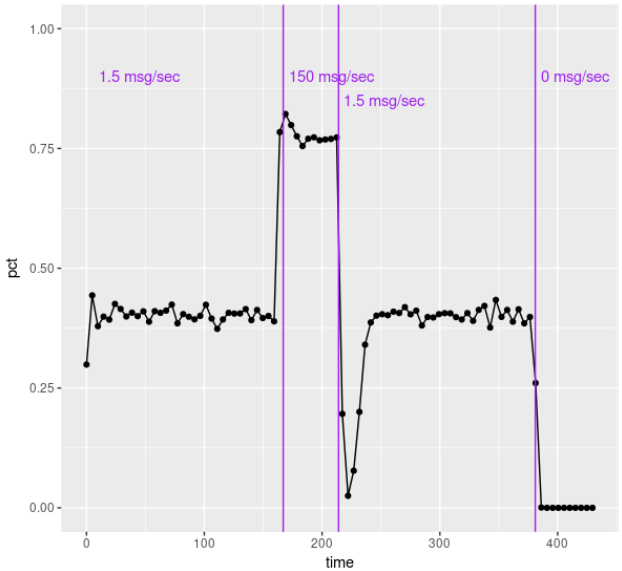
- $\Delta missing$ increased
  - Apply this formula (open loop):

$$\Delta pull = \frac{\Delta adjust}{\Delta missing + useful}$$

- otherwise, apply Multiplicative Increase Multiplicative Decrease
  - if $usefulness > 0.5$, decrease $\Delta pull$
  - otherwise increase $\Delta pull$

First experimentations

Start at 1.5 msg/s, then emit 150 msg/s, then go back to 1.5 msg/s
We graph usefulness (useful pull / total pull) over time



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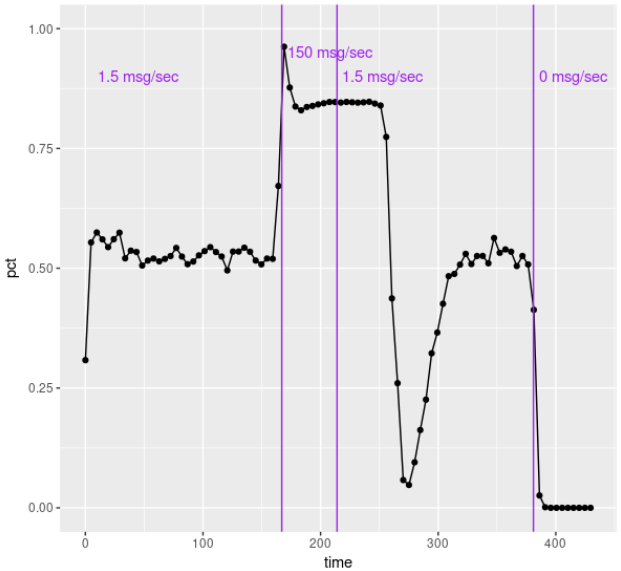
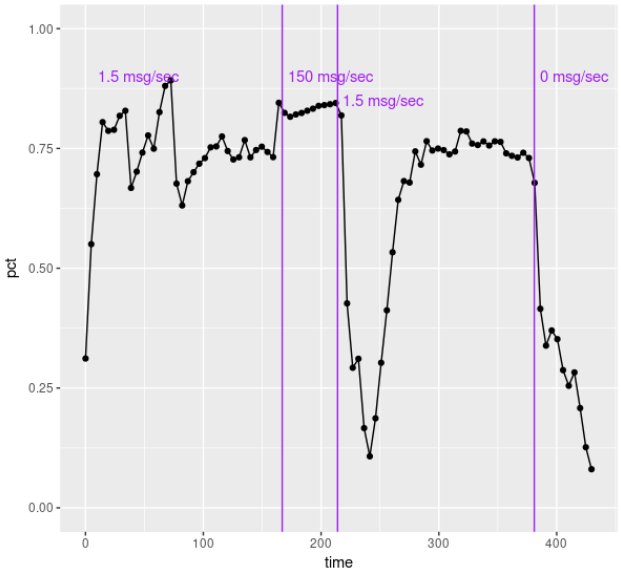


(b) MIMD



(c) PID

Conclusion and future works

Goal: provide a versatile Gossip-based dissemination brick by:

- Improving performances
- Improving ease of use

Future work:

- Better handle unstable environment
- Provide adaptiveness on more parameters
- Create a real world implementation
- Model problem, provide bounds, etc.