

Beacon Nodes

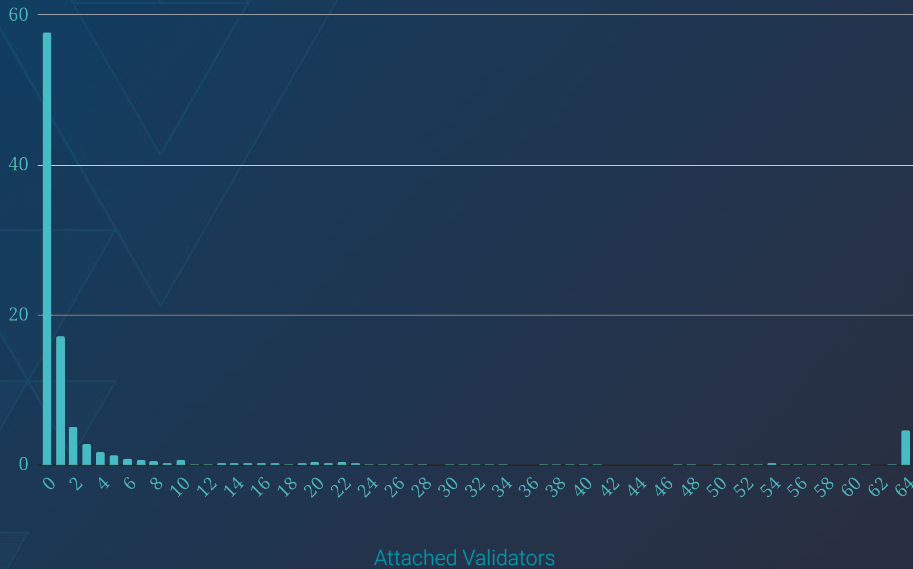
There are a number of production beacon nodes:

- Lighthouse
- Teku
- Prysm
- Nimbus
- Lodestar



Although we'll be looking at data from Lighthouse, the issues addressed are generic and apply to all clients.

Validators Per Node Distribution

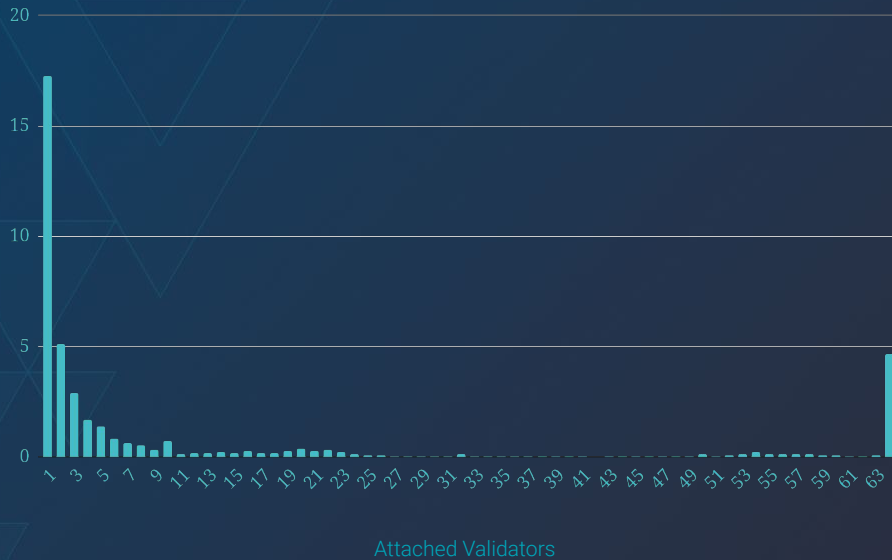


Validator Distribution

Three main groups of nodes:

- Nodes without validators
- Low validator counts (<10) - Indicative of home stakers
- High Validator Counts (64+) - Institutional stakers

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Hitting bandwidth limits leads to reduced validator performance

Downsides of High Bandwidth

- Increased cost
- Lowers environment diversity -> decentralization
- Spikes in home internet activity -> degrade validator performance (missed/late attestations and blocks).
- Future Ethereum upgrades will require more bandwidth

Beacon Node Network Internals

Discovery



Discv5



Transport: UDP



Encryption: AES-GCM



Handles the discovery of new peers and their capabilities

Not-Discovery



Gossipsub



libp2p

Eth2 Req/Resp



Transport: TCP



Encryption: Noise XX
(Libp2p negotiated)



Rapid object dissemination through the network
Direct p2p communication, including initial syncing.

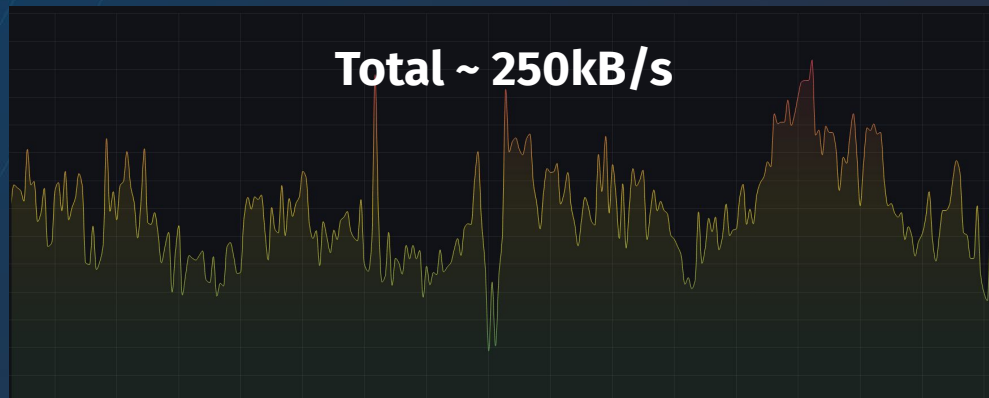
Beacon Node Internals: Total Bandwidth



Discovery vs Libp2p Bandwidth



Discovery vs Libp2p Bandwidth



Consensus Layer - Gossipsub

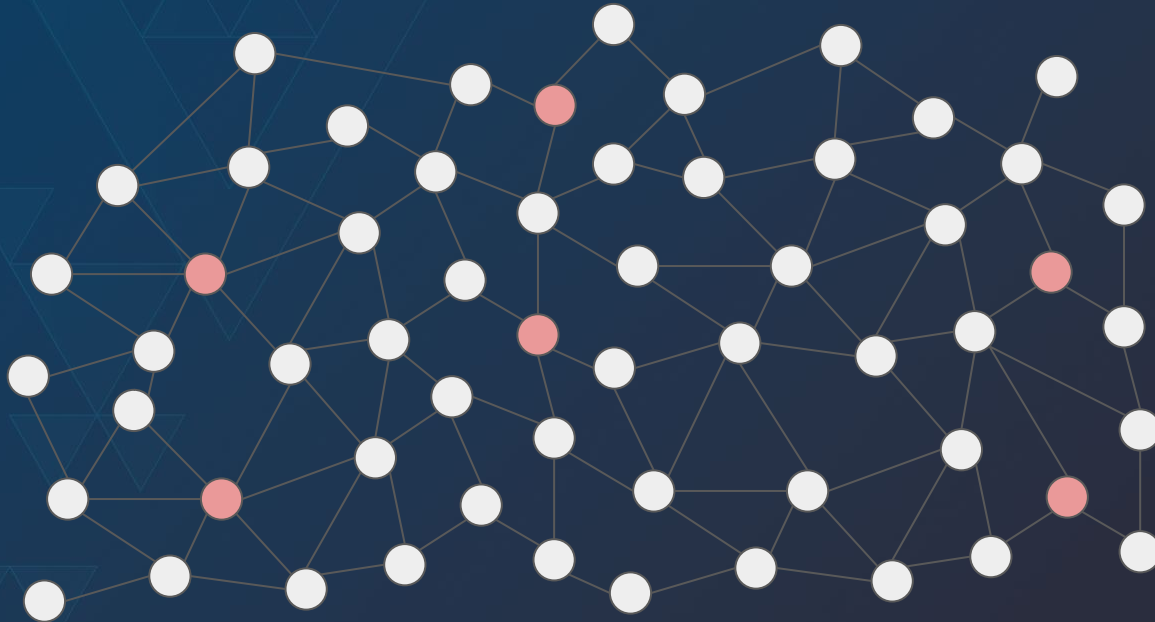
Gossipsub is a publish-subscribe system:

- Subscribe to “topics” to receive messages
- Rapid dissemination of messages
- Large amounts of traffic is split into subnets
 - There are 64 attestation subnets
- A node must subscribe to 1 subnet for every attached validator
- Subscribing to a subnet means receiving and propagating traffic on that subnet
- Bandwidth use is proportional to subscribed subnets

High bandwidth is due to Gossipsub traffic.

Gossipsub Internals

Example: mesh degree: 3



- Beacon Node (Validator)
- Beacon Node
- Beacon Node (message)

Gossipsub Internals

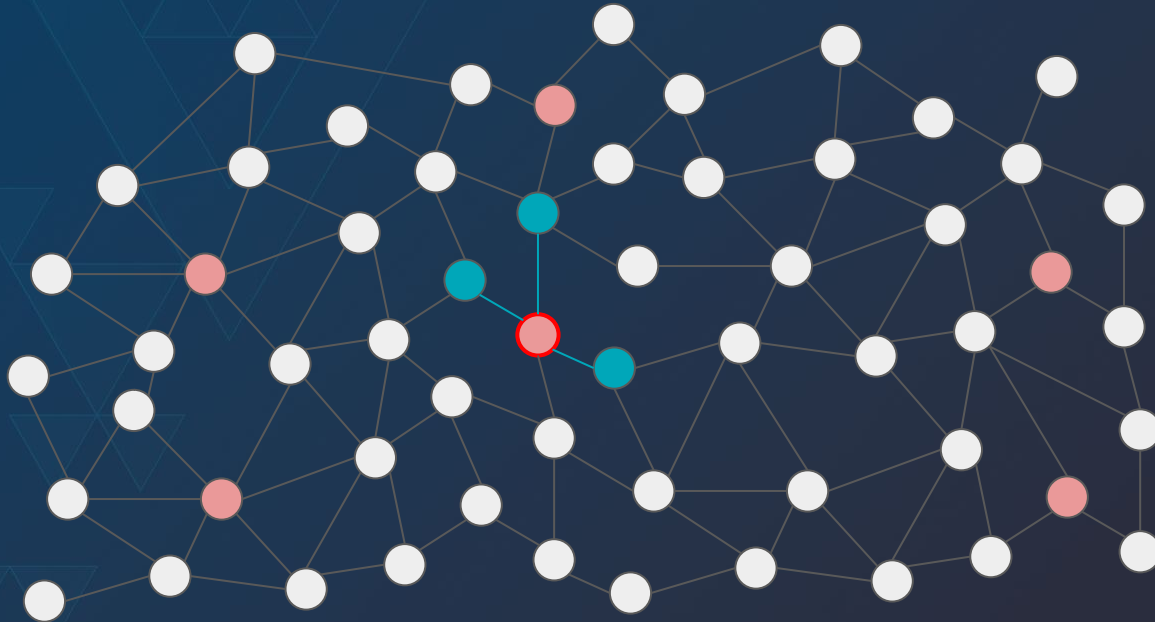
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Gossipsub Internals

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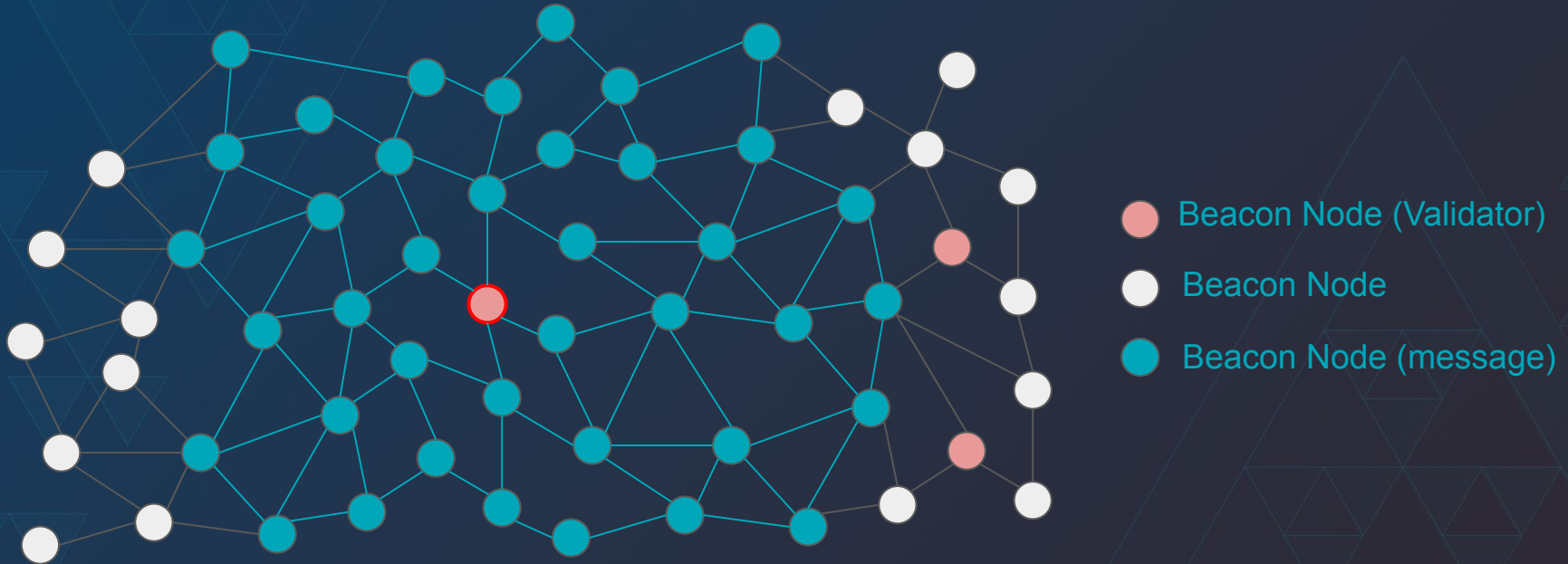
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Gossipsub Internals

Example: mesh degree: 3



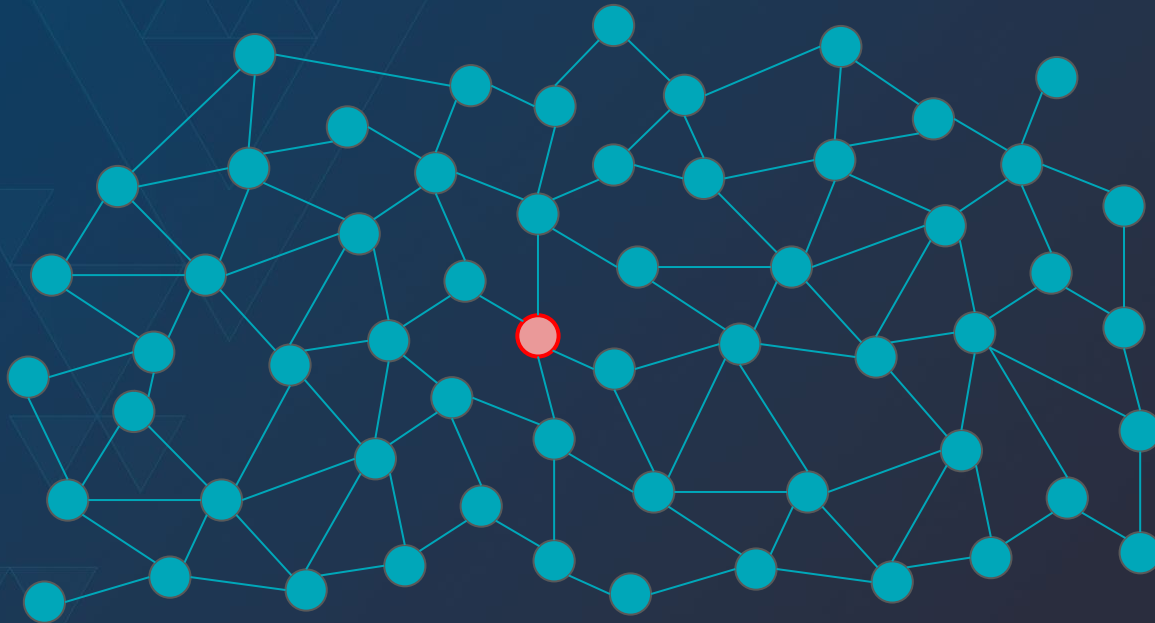
Gossipsub Internals

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Gossipsub Internals

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Consensus Layer - Gossipsub

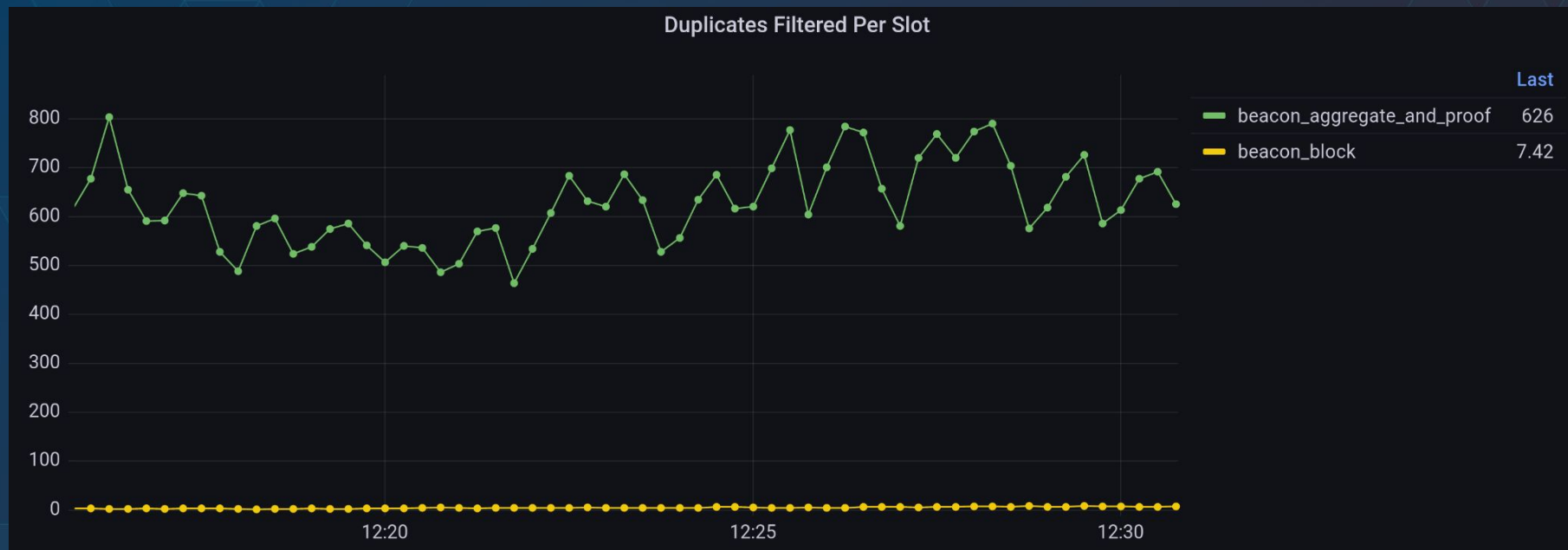
The current network specification dictates a mesh degree of 8 with a high value of 12.

Results of the specification:

- Incredibly robust network
- Low message latency (lower hops)
- Large number of duplicate messages
- Redundancy resulting in high bandwidth

Beacon nodes have a mesh degree of 8.

Gossipsub duplicates



Summary of current state

- Bandwidth is proportional to the number of validators a node has
- High amplification in gossipsub (duplicate messages)

We need a solid peer set
subscribed to each subnet in
order to have stable subnets.

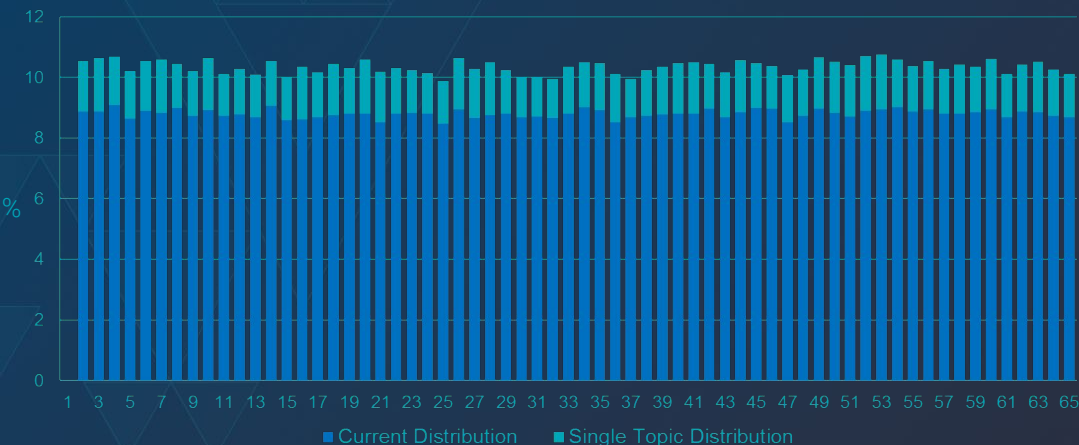
Subnet Stability

- Validators require peers on specific subnets at specific times in order to publish/aggregate attestations
- Finding peers is a slow process
- We need a stable set of peers on the network subscribed to subnets so validators can connect to them and publish/receive messages
- Current solution is: One “long-lived” subnet per attached validator to a beacon node:
 - Not enforceable - Beacon nodes could simply not do this (incentivised not to also)
 - Subnets are potentially over-subscribed
 - Excess/Redundant Bandwidth
- Why not every beacon node to subscribe to just one “long-lived” subnet?

<https://github.com/ethereum/consensus-specs/issues/2749>

Feasibility

Bandwidth vs Attached Validators



- 57% of scanned Beacon Nodes have no validators and contribute nothing to subnet stability
- Current subnet distribution provides each subnet with ~9% of all nodes
- The shift will force all beacon nodes to participate
- Subnet distribution should become ~1.5% of all nodes (configurable)
- Represents an 80% decrease from current subnet density
- ~10% of nodes (institutional) will see >90% reduction in bandwidth
- Enforceable - Subscription tagged to node-id

Episub

High mesh degrees cause high bandwidth.

Ways to reduce bandwidth:

- Lower our mesh degree
- Dynamically adjust mesh degree
- Lower clients peer count

Episub:

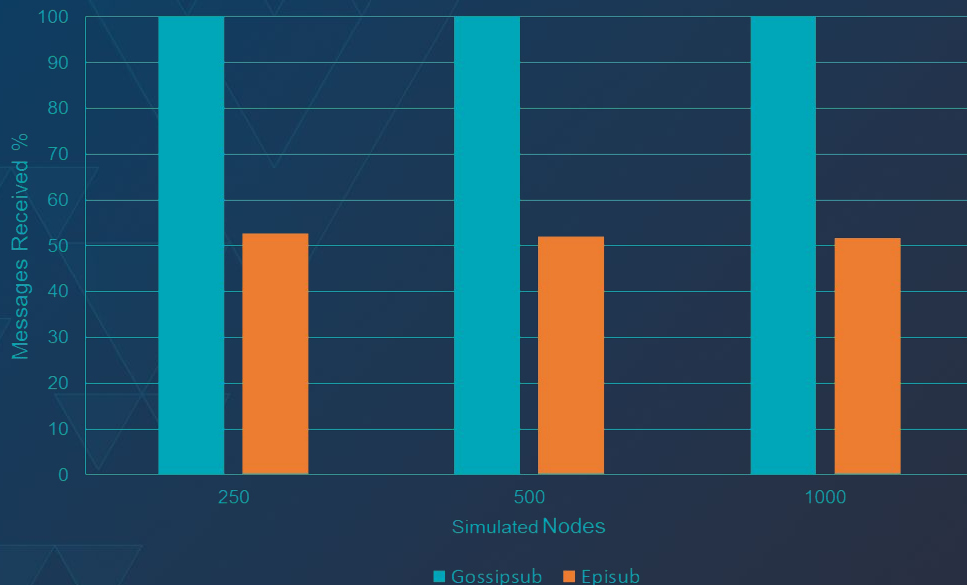
- Prevent peers from sending us duplicates on the mesh dynamically
- Dynamically make our mesh more efficient - reduce duplicates and latency

High mesh degree provides faster messages and greater resilience at the cost of high bandwidth

Episub - Preliminary Results

Total Messages Received Relative to Gossipsub

(300 Messages, 20 sources, latency p90, n: 6)



Vyzo (libp2p, protocol-labs) has completed some preliminary simulations

<https://github.com/vyzo>

Simulation (300 messages, 20 sources):

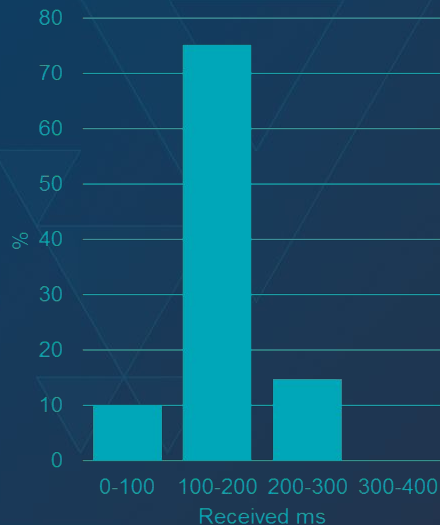
- 250 Nodes
- 500 Nodes
- 1000 Nodes

<https://github.com/vyzo/gerbil-simsub>

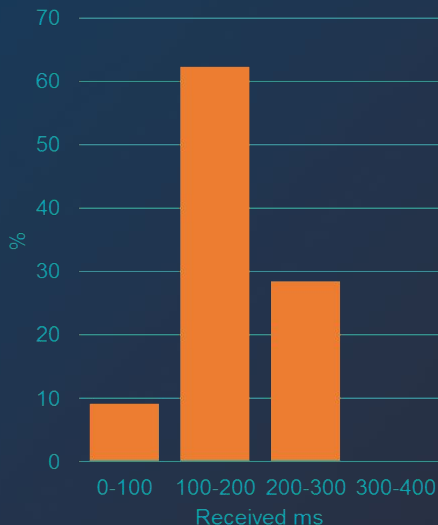
Episub - Preliminary Results

Latency Distribution, 1000 Nodes

(300 Messages, 20 sources, latency p90, n: 6)



■ Gossipsub



■ Episub

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Simulation (300 messages, 20 sources):

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What do I need to do?

Nothing! Just wait





Thank you!

Diva & Adrian

 **sigma**prime

 @agemanning