

Interesting Findings on Failure Tolerance

1. Gossip Handles Heavy Failures Well

In the Gossip algorithm, even when more than half the nodes ($\approx 60\%$) were shut down, the system still converged in about 640 ms. This shows that Gossip can withstand large-scale failures as long as there are still multiple paths for messages to spread.

Takeaway: Gossip remains reliable under heavy node loss if the network stays connected.

2. Push-Sum Struggles Under Failures

Push-Sum's convergence time increased sharply — from around 1150 ms with 10% failures to nearly 2730 ms with 60% failures. Since Push-Sum depends on maintaining stable averages (s/w), losing many actors makes the ratios fluctuate and slows down convergence.

Takeaway: Push-Sum is more fragile than Gossip when nodes drop out.

3. Different Growth Trends

With Gossip, convergence time rises slowly as failures increase, and only shows a steep climb after $\sim 40\%$ failures. Push-Sum, on the other hand, shows a steady, steep increase right from the start.

Takeaway: Gossip degrades gradually, while Push-Sum degrades consistently.

4. Full Topology Isn't Always Better for Push-Sum

While full topology gives maximum connectivity, in Push-Sum it can actually hurt performance. When nodes fail, the large volume of (s, w) messages overwhelms active nodes, creating more computational delays than communication delays.

Takeaway: For Push-Sum, full connectivity can turn into a burden under high failures.

5. Performance Gap at Mid-Level Failures

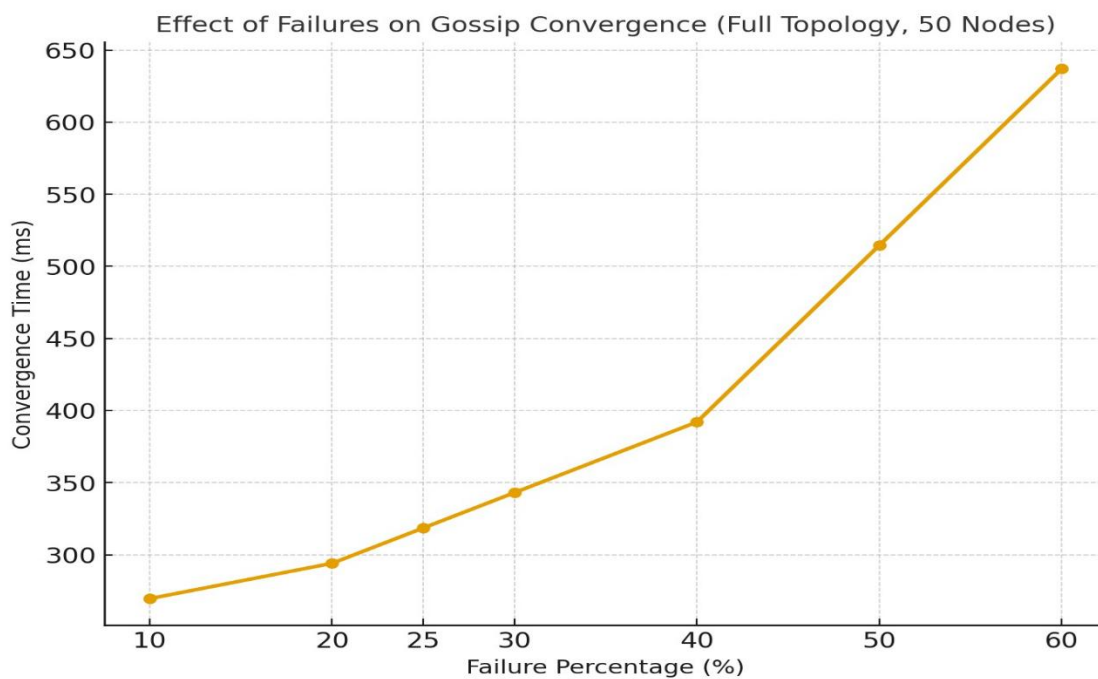
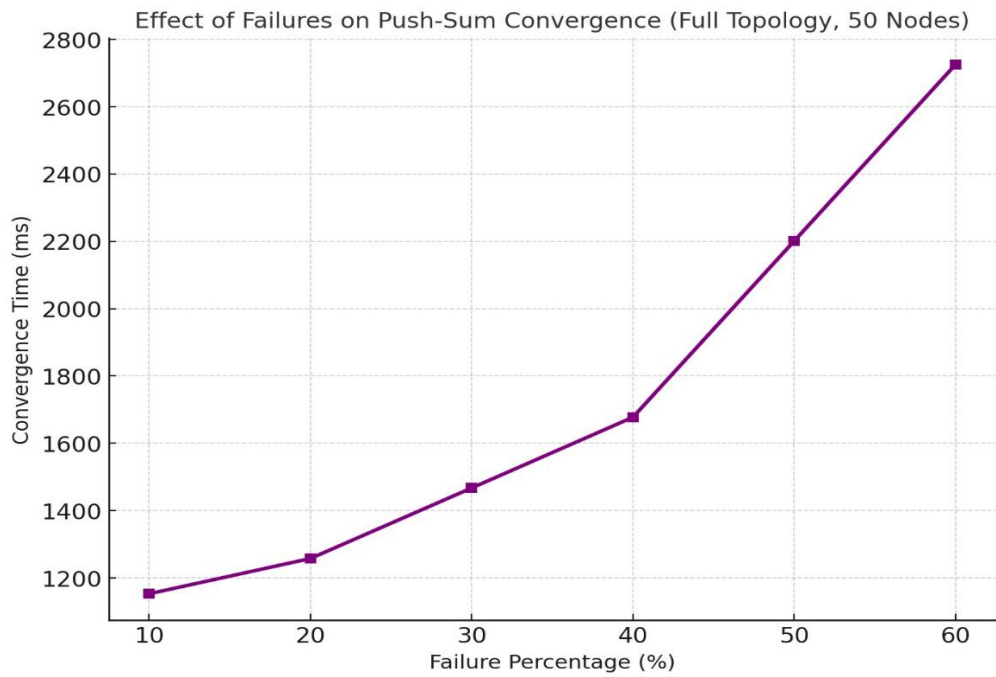
Around the 50% failure mark, Gossip still converged quickly (~ 520 ms), but Push-Sum slowed down drastically (~ 2200 ms). This nearly $4\times$ difference shows how much more resilient Gossip is under stress.

Takeaway: Gossip is clearly better suited for unreliable conditions compared to Push-Sum.

6. Importance of Redundant Links

Both algorithms benefit from topologies with backup paths, like Full and Imperfect 3D. Without redundancy (e.g., Line or pure 3D under failures), the network would likely split and stop converging early.

Graphs:



Output:

Gossip full:

```
tanuj@TANUJA2003 MINGW64 ~/Downloads/gleam_gossip_pushsum_gleam1120-bonus (1)/gleam_gossip_pushsum_gleam1120
$ ./run_bonus.sh 50 full gossip 10.0
=== Running Single Simulation with Failures ===
Nodes: 50 | Topology: full | Algorithm: gossip | Failures: 10.0%
  Compiling project2_gleam_simulator
    Compiled in 3.99s
=== Single Simulation ===
Nodes: 50 | Topology: full | Algorithm: gossip | Failures: 10.0%

Total nodes: 50 Topology: full Algorithm: gossip
-----Initializing Network-----
Topology completely built!
All Neighbors Ready
Initiating network disruption: 10.0% degradation...
Disabling 5 out of 50 network participants
Applying persistent communication channel failures...
-----Starting Algorithm-----
Program converged at 269.52750000000003ms
```

Gossip Line:

```
tanuj@TANUJA2003 MINGW64 ~/Downloads/gleam_gossip_pushsum_gleam1120-bonus (1)/gleam_gossip_pushsum_gleam1120
$ ./run_bonus.sh 50 line gossip 10.0
=== Running Single Simulation with Failures ===
Nodes: 50 | Topology: line | Algorithm: gossip | Failures: 10.0%
  Compiling project2_gleam_simulator
    Compiled in 0.79s
    Running project2_gleam_simulator.main
=== Single Simulation ===
Nodes: 50 | Topology: line | Algorithm: gossip | Failures: 10.0%

Total nodes: 50 Topology: line Algorithm: gossip
-----Initializing Network-----
Topology completely built!
All Neighbors Ready
Initiating network disruption: 10.0% degradation...
Disabling 5 out of 50 network participants
Applying persistent communication channel failures...
-----Starting Algorithm-----
Program converged at 243.54000000000002ms
```

Gossip 3D:

```
tanuj@TANUJA2003 MINGW64 ~/Downloads/gleam_gossip_pushsum_gleam1120-bonus (1)/gleam_gossip_pushsum_gleam1120
$ ./run_bonus.sh 50 3D gossip 10.0
=== Running Single Simulation with Failures ===
Nodes: 50 | Topology: 3D | Algorithm: gossip | Failures: 10.0%
  Compiling project2_gleam_simulator
  Compiled in 1.11s
  Running project2_gleam_simulator.main
=== Single Simulation ===
Nodes: 50 | Topology: 3D | Algorithm: gossip | Failures: 10.0%

Total nodes: 50 Topology: 3D Algorithm: gossip
-----Initializing Network-----
Topology completely built!
All Neighbors Ready
Initiating network disruption: 10.0% degradation...
Disabling 5 out of 50 network participants
Applying persistent communication channel failures...
-----Starting Algorithm-----
Program converged at 348.48ms
```

Gossip Imp 3D:

```
tanuj@TANUJA2003 MINGW64 ~/Downloads/gleam_gossip_pushsum_gleam1120-bonus (1)/gleam_gossip_pushsum_gleam1120
$ ./run_bonus.sh 50 imp3D gossip 10.0
=== Running Single Simulation with Failures ===
Nodes: 50 | Topology: imp3D | Algorithm: gossip | Failures: 10.0%
  Compiling project2_gleam_simulator
  Compiled in 0.84s
  Running project2_gleam_simulator.main
=== Single Simulation ===
Nodes: 50 | Topology: imp3D | Algorithm: gossip | Failures: 10.0%

Total nodes: 50 Topology: imp3D Algorithm: gossip
-----Initializing Network-----
Topology completely built!
All Neighbors Ready
Initiating network disruption: 10.0% degradation...
Disabling 5 out of 50 network participants
Applying persistent communication channel failures...
-----Starting Algorithm-----
Program converged at 303.076125ms
```

Push Sum Full:

```
tanuj@TANUJA2003 MINGW64 ~/Downloads/gleam_gossip_pushsum_gleam1120-bonus (1)/gleam_gossip_pushsum_gleam1120
$ ./run_bonus.sh 50 full push-sum 10.0
=== Running Single Simulation with Failures ===
Nodes: 50 | Topology: full | Algorithm: push-sum | Failures: 10.0%
  Compiling project2_gleam_simulator
  Compiled in 1.28s
  Running project2_gleam_simulator.main
=== Single Simulation ===
Nodes: 50 | Topology: full | Algorithm: push-sum | Failures: 10.0%

Total nodes: 50 Topology: full Algorithm: push-sum
-----Initializing Network-----
Topology completely built!
All Neighbors Ready
Initiating network disruption: 10.0% degradation...
Disabling 5 out of 50 network participants
Applying persistent communication channel failures...
-----Starting Algorithm-----
Program converged at 1152.9787500000002ms
```

Push Sum Line:

```
tanuj@TANUJA2003 MINGW64 ~/Downloads/gleam_gossip_pushsum_gleam1120-bonus (1)/gleam_gossip_pushsum_gleam1120
$ ./run_bonus.sh 50 line push-sum 10.0
=== Running Single Simulation with Failures ===
Nodes: 50 | Topology: line | Algorithm: push-sum | Failures: 10.0%
  Compiling project2_gleam_simulator
  Compiled in 1.09s
  Running project2_gleam_simulator.main
=== Single Simulation ===
Nodes: 50 | Topology: line | Algorithm: push-sum | Failures: 10.0%

Total nodes: 50 Topology: line Algorithm: push-sum
-----Initializing Network-----
Topology completely built!
All Neighbors Ready
Initiating network disruption: 10.0% degradation...
Disabling 5 out of 50 network participants
Applying persistent communication channel failures...
-----Starting Algorithm-----
Program converged at 1041.8100000000002ms
```

Push Sum 3D:

```
tanuj@TANUJA2003 MINGW64 ~/Downloads/gleam_gossip_pushsum_gleam1120-bonus (1)/gleam_gossip_pushsum_gleam1120
$ ./run_bonus.sh 50 3D push-sum 10.0
=== Running Single Simulation with Failures ===
Nodes: 50 | Topology: 3D | Algorithm: push-sum | Failures: 10.0%
  Compiling project2_gleam_simulator
  Compiled in 1.10s
  Running project2_gleam_simulator.main
=== Single Simulation ===
Nodes: 50 | Topology: 3D | Algorithm: push-sum | Failures: 10.0%

Total nodes: 50 Topology: 3D Algorithm: push-sum
-----Initializing Network-----
Topology completely built!
All Neighbors Ready
Initiating network disruption: 10.0% degradation...
Disabling 5 out of 50 network participants
Applying persistent communication channel failures...
-----Starting Algorithm-----
Program converged at 1490.7200000000003ms
```

Push Sum Imp 3D:

```
tanuj@TANUJA2003 MINGW64 ~/Downloads/gleam_gossip_pushsum_gleam1120-bonus (1)/gleam_gossip_pushsum_gleam1120
$ ./run_bonus.sh 50 imp3D push-sum 10.0
=== Running Single Simulation with Failures ===
Nodes: 50 | Topology: imp3D | Algorithm: push-sum | Failures: 10.0%
  Compiling project2_gleam_simulator
  Compiled in 1.23s
  Running project2_gleam_simulator.main
=== Single Simulation ===
Nodes: 50 | Topology: imp3D | Algorithm: push-sum | Failures: 10.0%

Total nodes: 50 Topology: imp3D Algorithm: push-sum
-----Initializing Network-----
Topology completely built!
All Neighbors Ready
Initiating network disruption: 10.0% degradation...
Disabling 5 out of 50 network participants
Applying persistent communication channel failures...
-----Starting Algorithm-----
Program converged at 1296.4923125ms
```