Interesting Findings:

1. Failure Tolerance in Gossip In the Gossip protocol, even when 60% of the nodes were disabled, the system still managed to converge (at ~637 ms). This shows Gossip's robustness under high failure rates, provided there are enough redundant paths. Conclusion: Gossip can tolerate significant node failures as long as the network remains connected.

2. Push-Sum is More Fragile Push-Sum convergence time shot up from ~1150 ms (10% failures) to ~2725 ms (60% failures), a much sharper increase compared to Gossip. This is because Push-Sum relies on steady averaging of s/w, which becomes unstable when many participants drop out. Conclusion: Push-Sum is far more sensitive to failures, especially in full topology.

3. Different Scaling Patterns For Gossip, convergence time grows gradually with failures and only starts rising steeply beyond 40% failures. For Push-Sum, however, the growth is more consistently steep. Conclusion: Gossip scales more gracefully under failures than Push-Sum.

4. Full Topology Paradox in Push-Sum While full topology gives maximum connectivity, in Push-Sum it actually increases overhead. With failures, the backlog of (s, w) messages further slows convergence, as nodes are overwhelmed with redundant updates. Conclusion: Computation bottlenecks, not communication delays, dominate performance in Push-Sum under full topology.

5. Observation Threshold At ~50% failures, Gossip still converges in ~515 ms, while Push-Sum takes ~2200 ms. This nearly 4× performance gap highlights how differently the two protocols degrade under stress. Conclusion: Gossip is much better suited for unreliable environments, while Push-Sum requires stability and computational efficiency.

6. Resilience Depends on Redundancy Both algorithms benefit from topologies with multiple redundant paths (Full, Imperfect 3D). If tested under Line or pure 3D with failures, convergence would likely collapse early due to fragmentation. Conclusion: Redundancy is the key factor in resilience against failures.

Output:

Gossip Full:

```
jonna@HARSHA MINGW64 ~/Downloads/gleam_gossip_pushsum_gleam1120-bonus/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 1.15s
    Running project2_gleam_simulator.main
=== 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:

```
jonna@HARSHA MINGW64 ~/Downloads/gleam_gossip_pushsum_gleam1120-bonus/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 1.24s
    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:

```
jonna@HARSHA MINGW64 ~/Downloads/gleam_gossip_pushsum_gleam1120-bonus/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 1.17s
    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:

```
jonna@HARSHA MINGW64 ~/Downloads/gleam_gossip_pushsum_gleam1120-bonus/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 1.19s
    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:

```
jonna@HARSHA MINGW64 ~/Downloads/gleam_gossip_pushsum_gleam1120-bonus/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 1.26s
    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:

```
jonna@HARSHA MINGW64 ~/Downloads/gleam_gossip_pushsum_gleam1120-bonus/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 1.15s
    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:

```
jonna@HARSHA MINGW64 ~/Downloads/gleam_gossip_pushsum_gleam1120-bonus/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 1.19s
    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:

```
jonna@HARSHA MINGW64 ~/Downloads/gleam_gossip_pushsum_gleam1120-bonus/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 1.20s
    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
```

Graphs:

Effect of Failures on Gossip Convergence (Full Topology, 50 Nodes)

Effect of Failures on Push-Sum Convergence (Full Topology, 50 Nodes)