

# Report

## Team Members:

Anip Mehta (UFID: 96505636)

Aniket Sinha (UFID: 69598035)

What is working?

The algorithms: 'gossip' and 'push-sum' for the following topologies:

```
1.line
2.imperfect-line
3.random-2d
4.torus
5.full
6.3d
```

What is the largest network you managed to deal with for each type of topology and algorithm?

- Following is the table showing the maximum problem size(the number of nodes) that the Gossip Algorithm solved for each topology :

Topology	Number of Nodes(Max. Problem size)
-----	
Line	25
Imperfect-Line	20000
Random-2D	5000
Torus	20000
Fully connected	15000
3D	10

- Following is the table showing the maximum problem size(the number of nodes) that the Push-Sum Algorithm solved for each topology :

Topology	Number of Nodes(Max. Problem size)
-----	
Line	100
Imperfect-Line	10000
Random-2D	10000
Torus	10000
Fully connected	50000
3D	15000

### Interesting observations:

1. In Fully connected topology, the algorithms always seemed to converge regardless of the number of nodes.
2. In Line Topology, the algorithms failed to converge after 25 nodes or so. This is because every node has just 2 other neighbors. If both neighbors of a node happen to hear the rumor 10 times, the node becomes disconnected and is unable to hear any more rumors. Hence, it never hears the target number of rumors i.e. 10. And the algorithm never converges.
3. In 3D topology, the gossip algorithm did not converge even for small values of number of Nodes whereas the push-sum algorithm performed really well for 3d topology.

### Output for Gossip:

```
project2 — mix /Users/anip/Develop/elixir/DOS/project2 — beam.smp -- -root /usr/local/Cellar/erlang/21.0.6/lib/erlang -prognome er...
^C
act2 on master * mix run proj2^C
~/D/e/D/project2 on master * mix run proj2.exs 50 3d gossip 22:12:48
Building Toplogy - 3d
3
Topology built in: 3 milliseconds
Rumour Heard: 1/50
Rumour Heard: 2/50
Rumour Heard: 3/50
Rumour Heard: 4/50
Rumour Heard: 5/50
Rumour Heard: 6/50
Rumour Heard: 7/50
Rumour Heard: 8/50
Rumour Heard: 9/50
Rumour Heard: 10/50
Rumour Heard: 11/50
Rumour Heard: 12/50
Rumour Heard: 13/50
Rumour Heard: 14/50
Rumour Heard: 15/50
Rumour Heard: 16/50
Rumour Heard: 17/50
Rumour Heard: 18/50
Rumour Heard: 19/50
Rumour Heard: 20/50
Rumour Heard: 21/50
Rumour Heard: 22/50
Rumour Heard: 23/50
Rumour Heard: 24/50
Rumour Heard: 25/50
Rumour Heard: 26/50
Rumour Heard: 27/50
Rumour Heard: 28/50
```

It can be seen that only 28 out of 50 actors heard rumor 10 times. For 1000, nodes, it was observed that 729 actors heard the rumor 10 times while 271 did not.

### Output of Push-Sum:

```

x -/D/e/D/project2 on master * mix run proj2.exe 50 3d push-sum 22:14:06
Building Toplogy - 3d
3
Topology built in: 3 milliseconds
1/50This Actor Converged with ratio:14.000000001284077
2/50This Actor Converged with ratio:14.000000001407592
3/50This Actor Converged with ratio:14.000000001408607
4/50This Actor Converged with ratio:14.000000001408695
5/50This Actor Converged with ratio:14.00000000134835
6/50This Actor Converged with ratio:14.000000001385528
7/50This Actor Converged with ratio:14.00000000070914
8/50This Actor Converged with ratio:14.000000000344466
9/50This Actor Converged with ratio:14.000000000598362
10/50This Actor Converged with ratio:14.00000000069933
11/50This Actor Converged with ratio:14.00000000067882
12/50This Actor Converged with ratio:14.000000000125208
13/50This Actor Converged with ratio:14.00000000068623
14/50This Actor Converged with ratio:14.000000000501997
15/50This Actor Converged with ratio:14.000000000468182
16/50This Actor Converged with ratio:14.000000000130992
17/50This Actor Converged with ratio:14.000000000143121
18/50This Actor Converged with ratio:14.00000000029742
19/50This Actor Converged with ratio:14.00000000002247
20/50This Actor Converged with ratio:13.999999999785
21/50This Actor Converged with ratio:14.000000000140089
22/50This Actor Converged with ratio:14.000000000137058
23/50This Actor Converged with ratio:13.99999999995653
24/50This Actor Converged with ratio:13.99999999996751
25/50This Actor Converged with ratio:14.000000000076966
26/50This Actor Converged with ratio:14.00000000015828
27/50This Actor Converged with ratio:14.0000000001795
28/50This Actor Converged with ratio:14.000000000143547
29/50This Actor Converged with ratio:14.000000000226434
30/50This Actor Converged with ratio:14.000000000105409
31/50This Actor Converged with ratio:13.99999999992134
32/50This Actor Converged with ratio:14.000000000184992
33/50This Actor Converged with ratio:14.000000000101954
34/50This Actor Converged with ratio:14.00000000000963
35/50This Actor Converged with ratio:13.99999999985395
36/50This Actor Converged with ratio:13.9999999999143
37/50This Actor Converged with ratio:13.999999999896525
38/50This Actor Converged with ratio:14.00000000000881
39/50This Actor Converged with ratio:13.999999999881085
40/50This Actor Converged with ratio:13.999999999791568
41/50This Actor Converged with ratio:14.000000000056911
42/50This Actor Converged with ratio:13.999999999857172
43/50This Actor Converged with ratio:13.999999999910559
44/50This Actor Converged with ratio:13.99999999997107
45/50This Actor Converged with ratio:13.99999999995704
46/50This Actor Converged with ratio:13.999999999932507
47/50This Actor Converged with ratio:13.99999999987972
48/50This Actor Converged with ratio:13.99999999963999
49/50This Actor Converged with ratio:13.99999999995488
50/50This Actor Converged with ratio:13.999999999870575
All actors converged in: 13 milliseconds

```

For push-Sum algorithm, the 3D topology converges very fast.

4. It was observed for Random 2D topology that there were one or two nodes that became disconnected after other nodes stopped spreading the rumor (as they had already heard 10 rumors). And hence it too was not converging for any nodes > 1000.  
To overcome this problem, we designated the algorithm to have converged when 90% or more nodes had heard the target no. of rumors(10).After making this change, it was found that the algorithms ran fastest for this topology.
5. In case of Torus network, it was observed that building the topology took much more time than the actual run of the algorithm.

```
~/D/e/D/project2 on master x mix run proj2.exe 50 random-2d gossip
Building Toplogy - random-2d
Topology built in: 6 milliseconds
Rumour Heard: 1/50
Rumour Heard: 2/50
Rumour Heard: 3/50
Rumour Heard: 4/50
Rumour Heard: 5/50
Rumour Heard: 6/50
Rumour Heard: 7/50
Rumour Heard: 8/50
Rumour Heard: 9/50
Rumour Heard: 10/50
Rumour Heard: 11/50
Rumour Heard: 12/50
Rumour Heard: 14/50
Rumour Heard: 13/50
Rumour Heard: 15/50
Rumour Heard: 16/50
Rumour Heard: 17/50
Rumour Heard: 18/50
Rumour Heard: 19/50
Rumour Heard: 20/50
Rumour Heard: 21/50
Rumour Heard: 22/50
Rumour Heard: 23/50
Rumour Heard: 24/50
Rumour Heard: 25/50
Rumour Heard: 26/50
Rumour Heard: 27/50
Rumour Heard: 28/50
Rumour Heard: 29/50
Rumour Heard: 30/50
Rumour Heard: 31/50
Rumour Heard: 32/50
Rumour Heard: 33/50
Rumour Heard: 34/50
Rumour Heard: 35/50
Rumour Heard: 36/50
Rumour Heard: 37/50
Rumour Heard: 38/50
Rumour Heard: 39/50
Rumour Heard: 40/50
Rumour Heard: 41/50
Rumour Heard: 42/50
Rumour Heard: 43/50
Rumour Heard: 44/50
Rumour Heard: 45/50
90 percent or more nodes have heard the rumour....Convergence Achieved in: 5 milliseconds
```

It can be seen that the time for building the topology is 6 milliseconds whereas the time for convergence of algorithm is 5 milliseconds.

### One Assumption:

For Gossip algorithm, the convergence time is assumed to have been achieved even when 90% of the nodes have heard the target no. of rumors (10). The reason behind doing this has been explained in interesting observations wherein it was observed that for some topologies, a few nodes always didn't hear the target no. of rumors owing to the topology getting disconnected. Having this assumption made it easier to compare the response of different topologies to these algorithms.

### Measurement of Convergence Time:

Gossip Algorithm:

The start time was recorded after the topology was built and the algorithm was initiated. The end time was recorded when 90% of total nodes satisfied the convergence criteria i.e. when 90% of the nodes

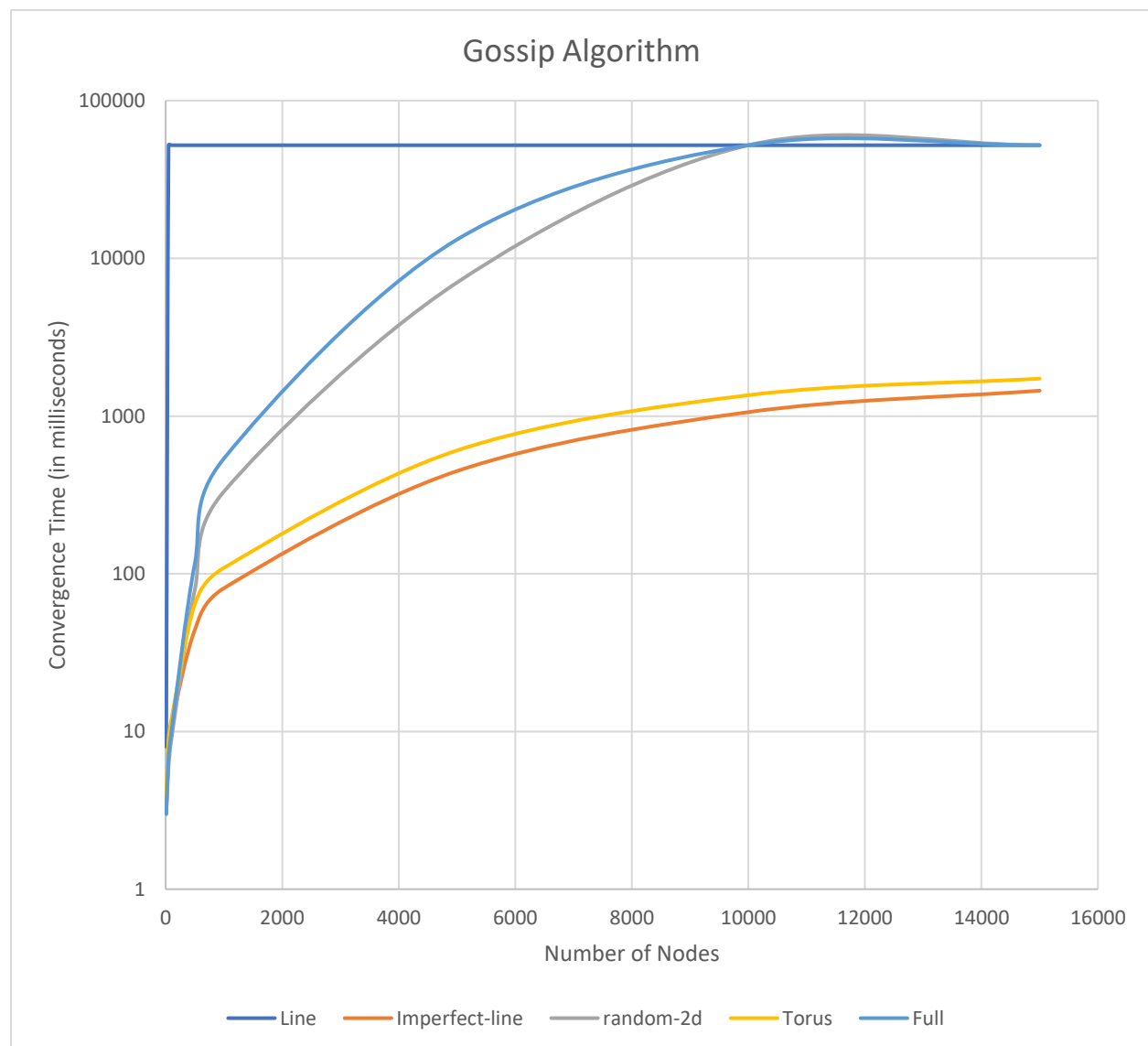
had heard the rumor 10 times. The difference between start and end time was recorded as the convergence time.

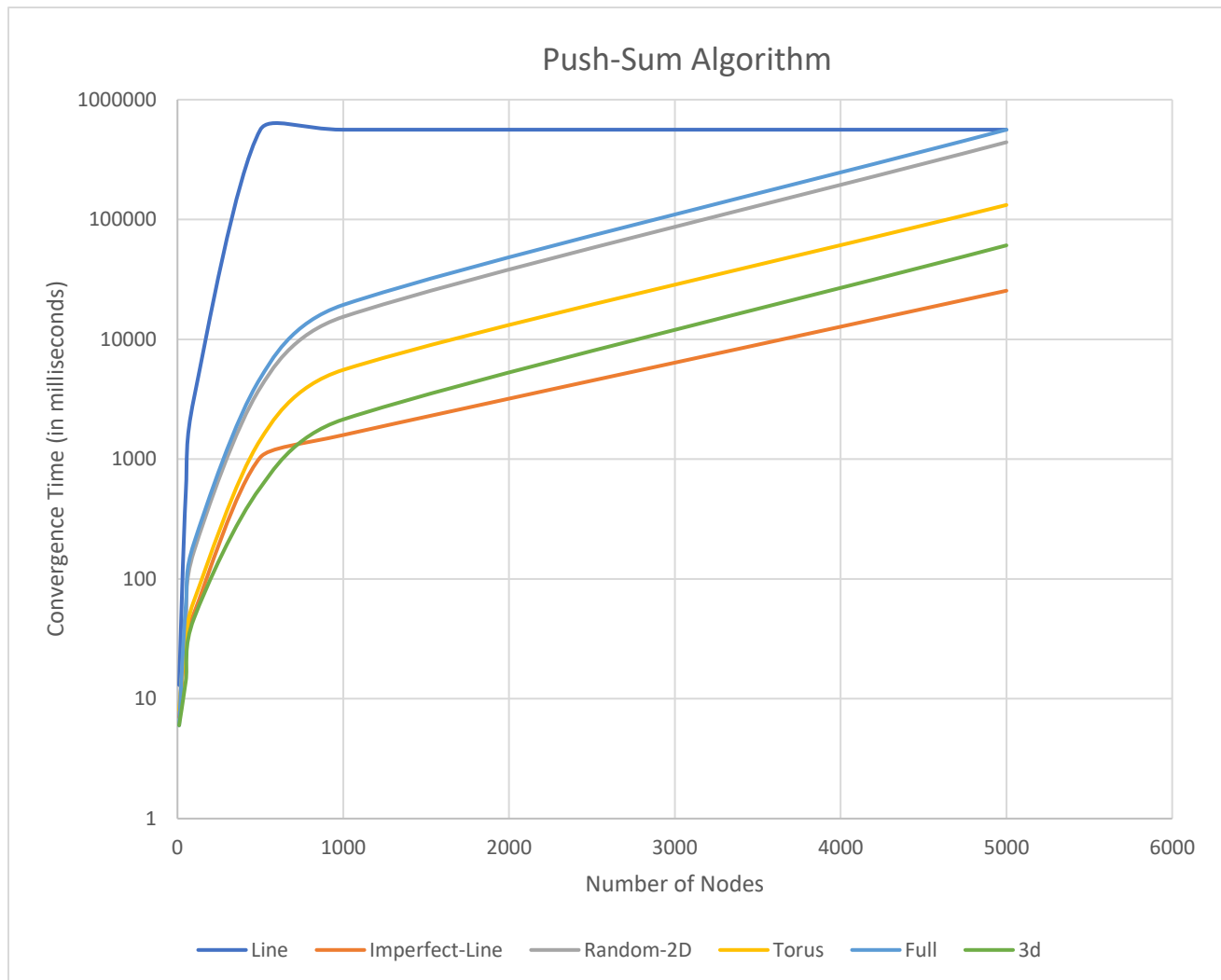
#### Push-Sum Algorithm:

No such assumption was necessary for push-sum algorithms. Each node maintains, the  $s$  and  $w$  value as its state. When the difference between the earlier ratio of  $(s/w)$  and final ratio  $(s/w)$  became less than  $\text{pow}(10,-10)$  and when this happened for 3 consecutive times, the actor stopped propagating. The end time was recorded when all the actors stopped propagating.

#### Graphs

The graphs showing the dependency of convergence time as a function of the size of the network are shown below for the two algorithms for different topologies:





## Input

Syntax:

- `mix run proj2.exs (number of nodes) (topology) (algorithm)`

Examples:

- `mix run proj2.exs 1000 random-2d gossip`
- `mix run proj2.exs 1000 torus push-sum`

The topology above can accept the following values :

line

```
imperfect-line
random-2d
torus
full
3d
```

The algorithm above can accept values:

```
gossip
push-sum
```

## Output

- Convergence Time in milliseconds

Sample outputs:

```
x> ~/D/e/D/project2 on master x mix run proj2.exe 10 full gossip
Building Toplogy - full
Topology built in: 0 milliseconds
Rumour Heard: 1/10
Rumour Heard: 2/10
Rumour Heard: 3/10
Rumour Heard: 4/10
Rumour Heard: 5/10
Rumour Heard: 6/10
Rumour Heard: 7/10
Rumour Heard: 8/10
Rumour Heard: 9/10
90 percent or more nodes have heard the rumour....Convergence Achieved in: 4 milliseconds
```

```
x> ~/D/e/D/project2 on master o mix run proj2.exe 10 torus push-sum
Building Toplogy - torus
Topology built in: 9 milliseconds
1/16This Actor Converged with ratio:8.500000000211623
2/16This Actor Converged with ratio:8.4999999997902
3/16This Actor Converged with ratio:8.50000000031209
4/16This Actor Converged with ratio:8.500000000119126
5/16This Actor Converged with ratio:8.50000000044226
6/16This Actor Converged with ratio:8.49999999976295
7/16This Actor Converged with ratio:8.50000000046295
8/16This Actor Converged with ratio:8.50000000041288
9/16This Actor Converged with ratio:8.50000000019623
10/16This Actor Converged with ratio:8.5000000004967
11/16This Actor Converged with ratio:8.5000000001675
12/16This Actor Converged with ratio:8.5000000008406
13/16This Actor Converged with ratio:8.5000000002712
14/16This Actor Converged with ratio:8.5000000001604
15/16This Actor Converged with ratio:8.50000000034093
16/16This Actor Converged with ratio:8.50000000006516
All actors converged in: 8 milliseconds
x> ~/D/e/D/project2 on master o
```

Note: The program continues to run in infinite loop even after the algorithm has converged. This is done to ensure that the main process does not die before getting all the print statements on the console. Press Ctrl+C to exit the main process after getting the output.

