Report: Project 2

Gossip and Push-Sum protocol

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Description:
This project is on implementing the Gossip and Push-Sum protocols for various network topologies like 3D, random 2D, full, torus, line and imperfect line. These algorithms and topologies are then simulated for different value of {# of nodes} and the results are analyzed in the subsequent sections to determine their convergence.

Gossip Algorithm: It works by sending a rumor to a random neighbor (based on the topology) and we keep track of how many times each node has heard the rumor. The algorithm ends when each node has listened for N times. N in our case is 10, we say that the convergence is reached when each node has listened the rumor 10 times.

Push-Sum Algorithm: This algorithm works by sending and receiving messages in the form of pairs (s,w). S is the value of each actor (that is the it's number ranging between [1..maxActors]), w is equal to 1 for each actor initially. When the message is sent to another actor, half of s and w is kept and half is added in the message.

For this algorithm, we have assumed that the convergence is reached when s/w ratio has not changed by more than a factor of 10^{-10} in 3 consecutive rounds of receiving messages.

Assumption: We have assumed that the difference between new (s,w) and old(s,w) is calculated after the s and w values are halved, as it is mentioned in the same order in the project description.

The output is the time until convergence (a timer is started at the beginning of the node communication and stopped at the end). If there is no output, the network never converges.

Topologies implemented: 3D, random 2D, Full, Torus, Line, and Imperfect Line

Full: Every actor is a neighbor of all other actors.
3D: Actors form a 3D grid.
Random 2D Grid: Actors are randomly position at (x,y) coordinates on a [0-1.0]X[0-1.0] square.
Torus: Actors are arranged in as a Torus. That is, each actor has 4neighbors (similar to the 2D grid) but both directions are closed to form circles.
Line: Actors are arranged in a line. Each actor has only 2 neighbors (one left and one right, unless you are the first or last actor).
Imperfect Line: Line arrangement but one random other neighbor is selected from the list of all actors.

Running the program: After extracting the contents of the program to project2 folder. Follow these steps to execute the program:

1. CD /path/to/project2
2. Mix compile –force
3. Mix run /lib/project2.ex <numNodes> <Topology> <Algorithm>
4. To calculate time run command : time Mix run /lib/project2.ex <numNodes> <Topology> <Algorithm>

Simulation Settings: We simulated the program for the following values of total number of nodes for both the algorithms.

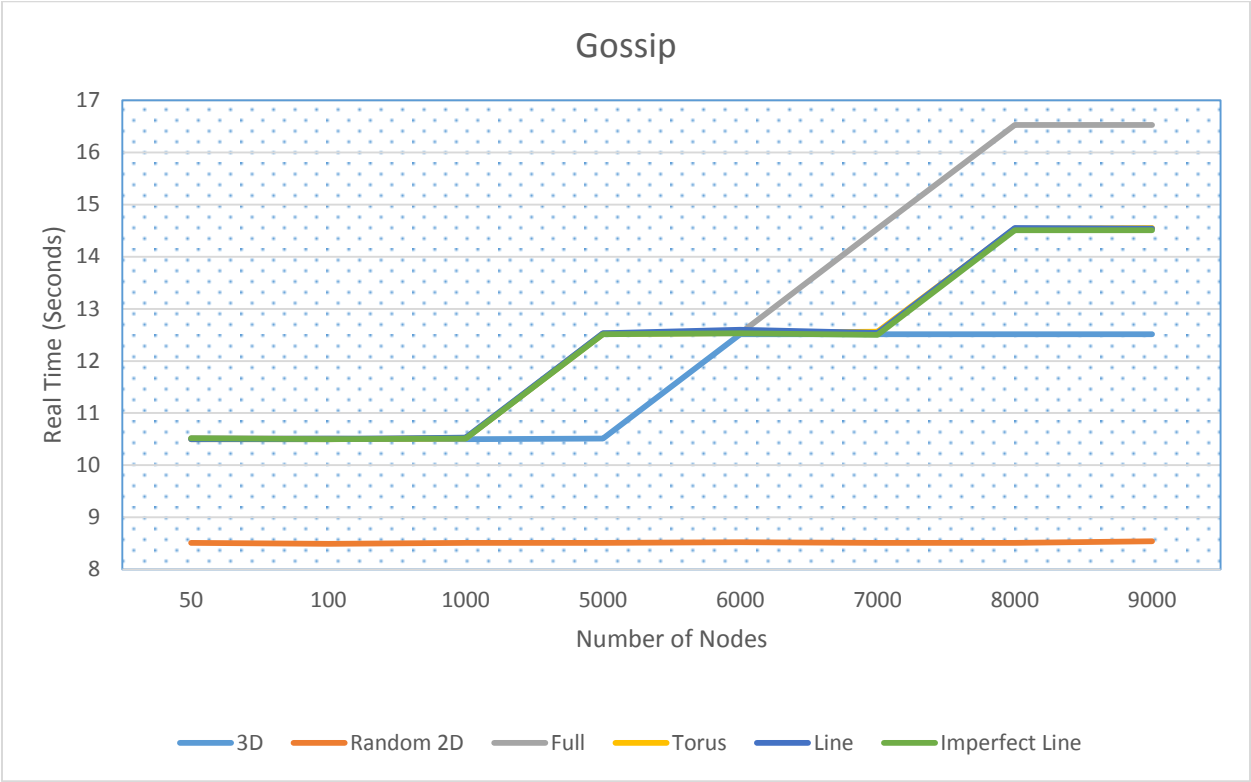
50
100
1000
5000
6000
7000
8000
9000

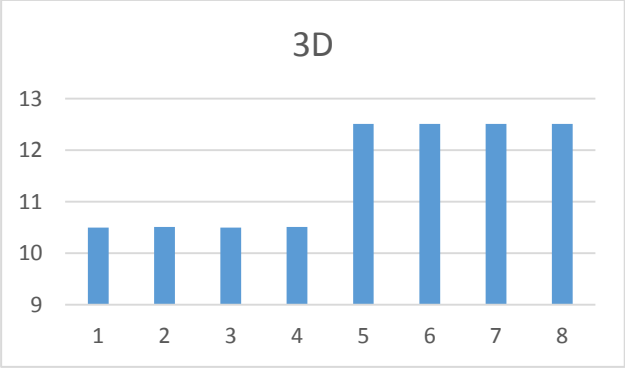
We performed the experiment on a machine with 6 physical cores.

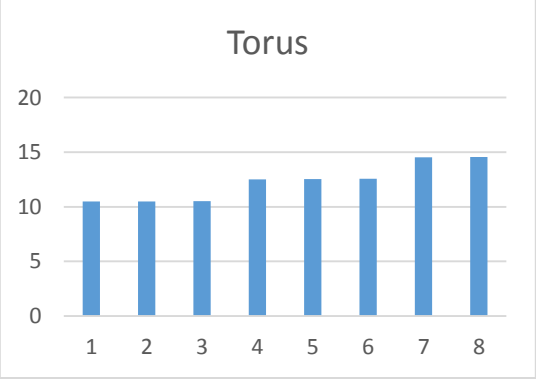
Simulation results summary:

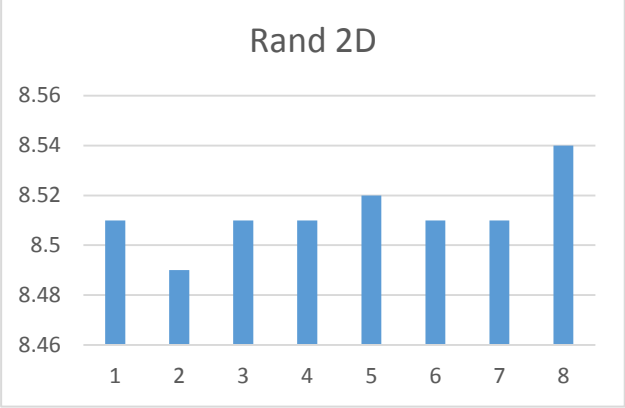
GOSSIP Algorithm:

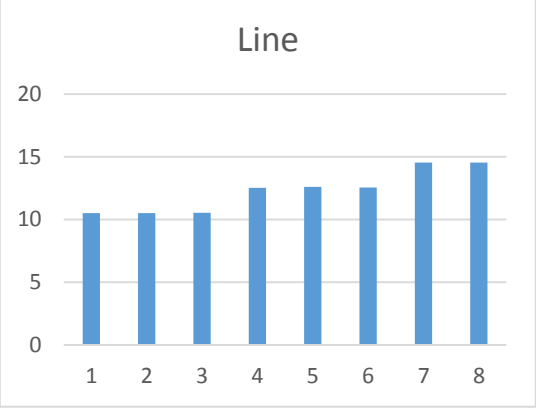
NODES	3D	RAND 2D	FULL	TORUS	LINE	IMPERFECT LINE
50	10.5	8.51	10.52	10.5	10.5	10.52
100	10.51	8.49	10.51	10.5	10.5	10.5
1000	10.5	8.51	10.51	10.52	10.53	10.51
5000	10.51	8.51	12.53	12.52	12.53	12.51
6000	12.51	8.52	12.53	12.54	12.6	12.53
7000	12.51	8.51	14.54	12.56	12.54	12.5
8000	12.51	8.51	16.53	14.54	14.55	14.51
9000	12.51	8.54	16.53	14.55	14.54	14.51

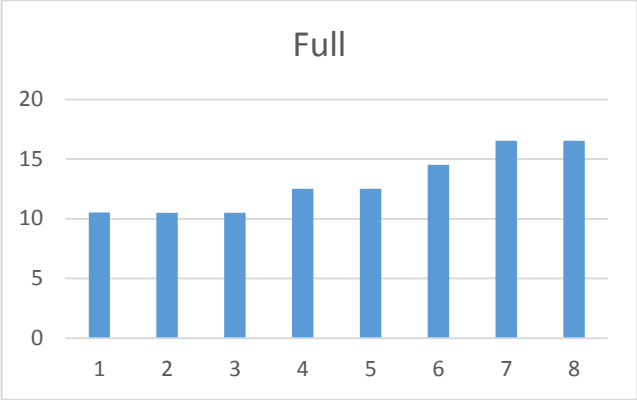

Gossip
Real Time (Seconds)
17
16
15
14
13
12
11
10
9
8
50
100
1000
5000
6000
7000
8000
9000
Number of Nodes
3D
Random 2D
Full
Torus
Line
Imperfect Line

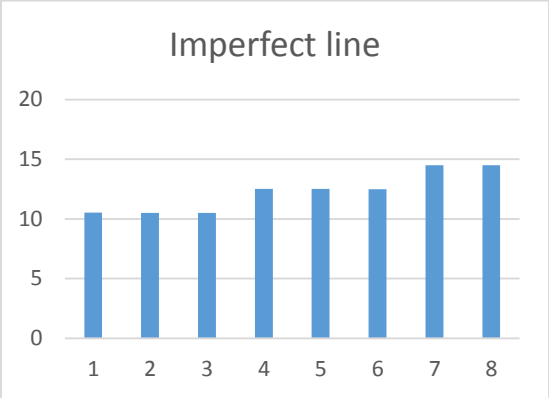

3D
13
12
11
10
9
1
2
3
4
5
6
7
8


Torus
20
15
10
5
0
1
2
3
4
5
6
7
8


Rand 2D
8.56
8.54
8.52
8.5
8.48
8.46
1
2
3
4
5
6
7
8

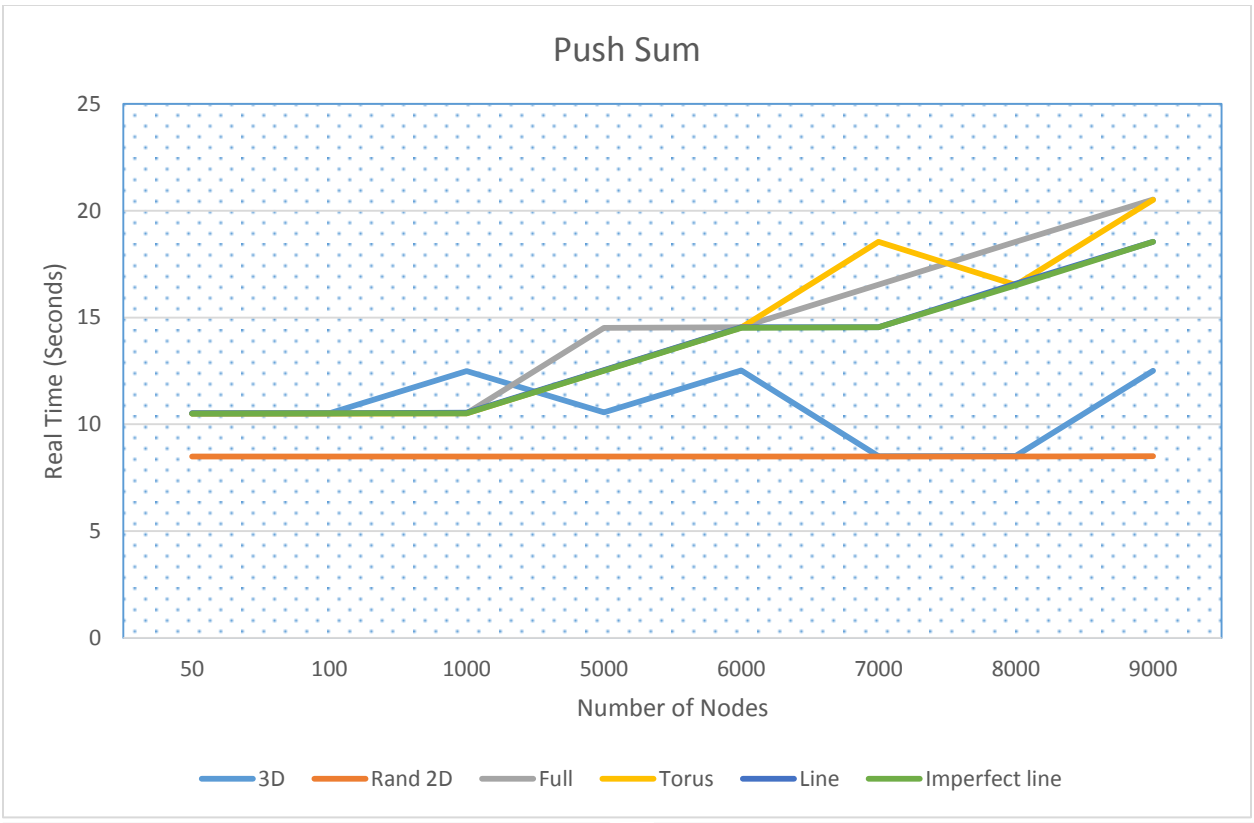

Line
20
15
10
5
0
1
2
3
4
5
6
7
8

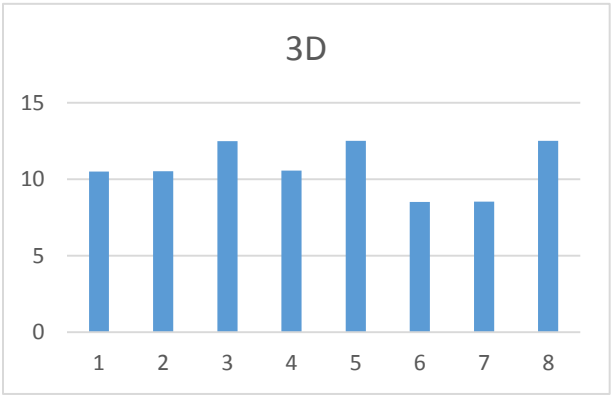


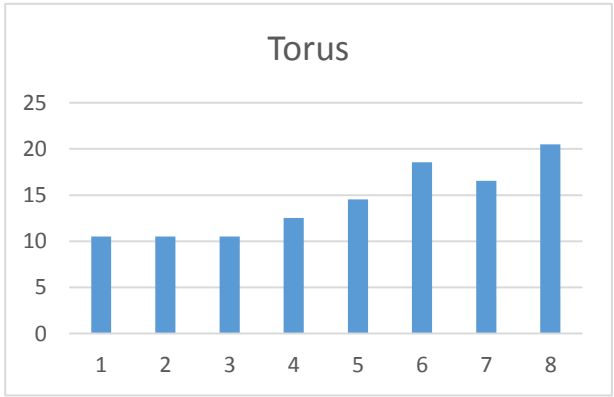


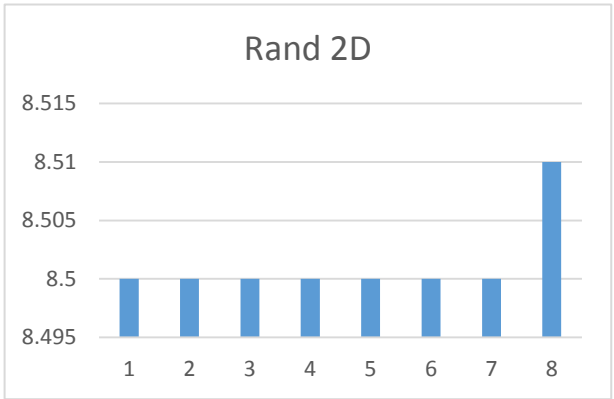
Push-Sum Algorithm:

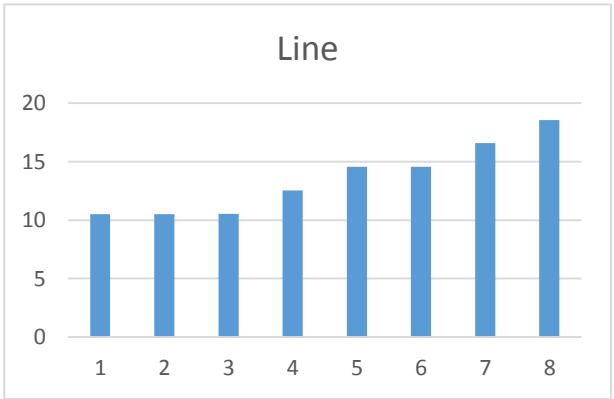
NODES	3D	RAND 2D	FULL	TORUS	LINE	IMPERFECT LINE
50	10.51	8.5	10.51	10.5	10.51	10.5
100	10.52	8.5	10.51	10.5	10.52	10.51
1000	12.5	8.5	10.51	10.52	10.54	10.52
5000	10.56	8.5	14.52	12.53	12.54	12.51
6000	12.52	8.5	14.54	14.53	14.55	14.52
7000	8.51	8.5	16.54	18.54	14.55	14.54
8000	8.53	8.5	18.55	16.53	16.59	16.51
9000	12.51	8.51	20.53	20.51	18.54	18.54


Push Sum
Real Time (Seconds)
25
20
15
10
5
0
50
100
1000
5000
6000
7000
8000
9000
Number of Nodes
3D
Rand 2D
Full
Torus
Line
Imperfect line


3D
15
10
5
0
1
2
3
4
5
6
7
8


Torus
25
20
15
10
5
0
1
2
3
4
5
6
7
8


Rand 2D
8.515
8.51
8.505
8.5
8.495
1
2
3
4
5
6
7
8


Line
20
15
10
5
0
1
2
3
4
5
6
7
8

Observations:

The most expected observation is that the randomized topologies have better or atleast equal performance as compared to their non-randomized counterparts. This can be shown in both Gossip and Push-Sum algorithms for Line and Imperfect Line topologies.

The peformance of Randomized 2D algorithm is by far the best amongst all other topologies, for either algoirthms and the worst is shared by Line and Full algorithms.

For Gossip: The trend of time taken to reach convergence is basically different after the number of nodes increased beyond 6000. The trend is:
(From max -> Min time)

Number of nodes less than 6000:
Line> Full > Torus > Imperfect Line > 3D Grid > Random 2D

Number of nodes more than 6000:
Full> Line> Torus > Imperfect Line > 3D Grid > Random 2D

For Push-Sum, the above trend occurs after 5000 Nodes.
Also, in this algorithm the 3D Grid topology behaves anomalously for 7000-8000 Nodes, where its performance is slightly better than its actual performance for nodes < 7000.

Bonus

The optional 4th argument passed is a parameter p where $0.0 \leq p \leq 1.0$. In this case the probability of a node going offline P(off) = p. It is then set online once again. The following chart displays the change in outcome as compared to a normal run of the program. It's apparent that the degree to which the nodes are affected is based on the topology and the reliance on "bottleneck" nodes. Interestingly, Random-2D was more consistent in both algorithms and even converged in the case of Push-Sum.

Number of nodes reached using Gossip with $p = 0.1$, $N = 1000$

Full	3D	Random 2D	Torus	Line	Imperfect 2D
967	50	752	31	363	411

Number of nodes reached using Push-Sum with $p = 0.1$, $N = 1000$

Full	3D	Random 2D	Torus	Line	Imperfect 2D
18	32	**1000**	19	36	821