COP5615- DISTRIBUTED OPERATING SYSTEM PRINCIPLES

PROGRAMMING ASSIGNMENT #3 – GOSSIP AND PUSH-SUM SIMULATIONS

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Introduction

The Gossip Algorithm Performance Report presents an analysis of the performance of gossip-based algorithms implemented in a distributed network using Akka.NET. This report aims to evaluate the convergence time of gossip algorithms in different network topologies and sizes. The goal is to gain insights into the behavior of these algorithms under varying conditions.

Program Overview

Our program is built using Akka.NET, a framework for building highly concurrent, distributed, and fault-tolerant systems. We have implemented gossip-based algorithms in an actor-based model, where each node in the network is represented as an actor. Actors communicate via message passing to simulate the spread of information or rumors.

Design for Implementation:

The Gossip Algorithm achieves convergence when an actor receives the gossip 10 times. For the Push Sum Algorithm, convergence is determined by the difference in the s/w ratio, which should not exceed (10/-10) for three consecutive rounds. Once an actor satisfies this condition, it no longer actively participates in the convergence process but may still contribute to the overall convergence of all nodes.

Key Observations:

The order of convergence, ranked from fastest to slowest, is Full, Imperfect 2D Grid, 2D Grid, and Line for both the Gossip and Push Sum Algorithms.
Results suggest that convergence is influenced by the number of neighbors each node has.
In the Full topology, every node is directly connected to every other node, facilitating quick algorithm spread and accessibility from any node.
Imperfect 2D Grid outperforms 2D Grid as each node is connected to an additional random neighbor from the grid, enhancing convergence.
Line topology faces the most challenges, with each node connected to at most two others, potentially causing obstacles for convergence.

Running the Program

To run the program, follow these steps:

Note: Ensure you have the .NET runtime and Akka.NET library installed.

```
dotnet build

dotnet run <numNodes> <topology> <algorithm>
```

Replace `<numNodes>` with the desired number of nodes, `<topology>` with the network topology (e.g., ring, full, 3D grid), and `<algorithm>` with the gossip algorithm to use.

Example : dotnet run 20 full gossip
dotnet run 100 3D grid gossip
dotnet run 50 ring push-sum

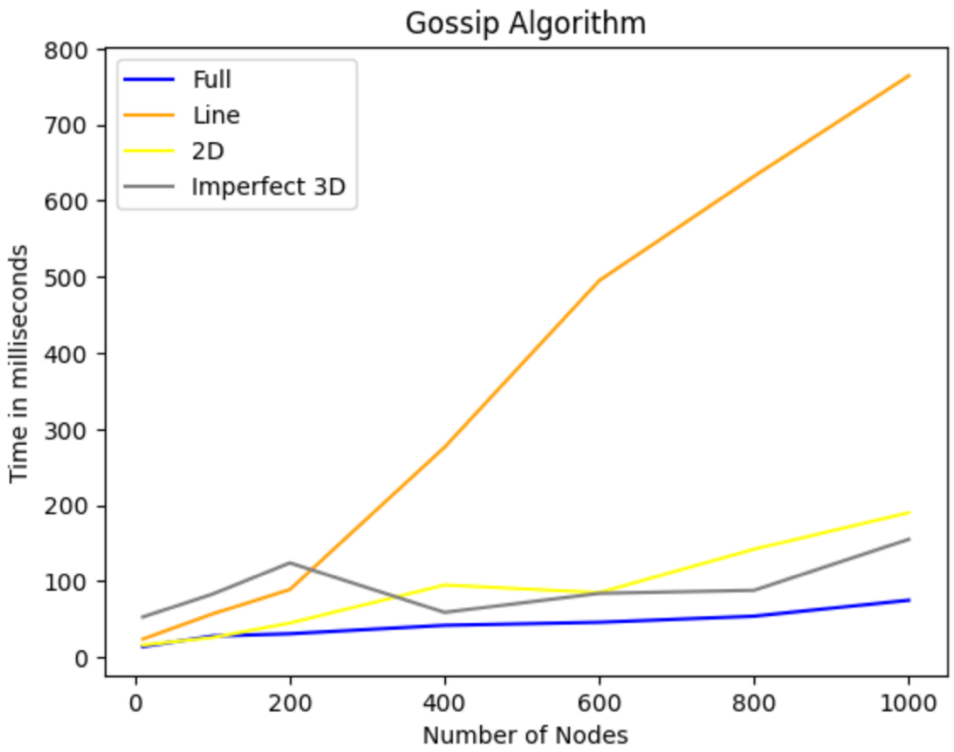
Results

Our program successfully simulates the behavior of gossip-based algorithms in a distributed network. It accurately tracks the time taken for convergence, allowing us to analyze the performance of different algorithms and topologies.

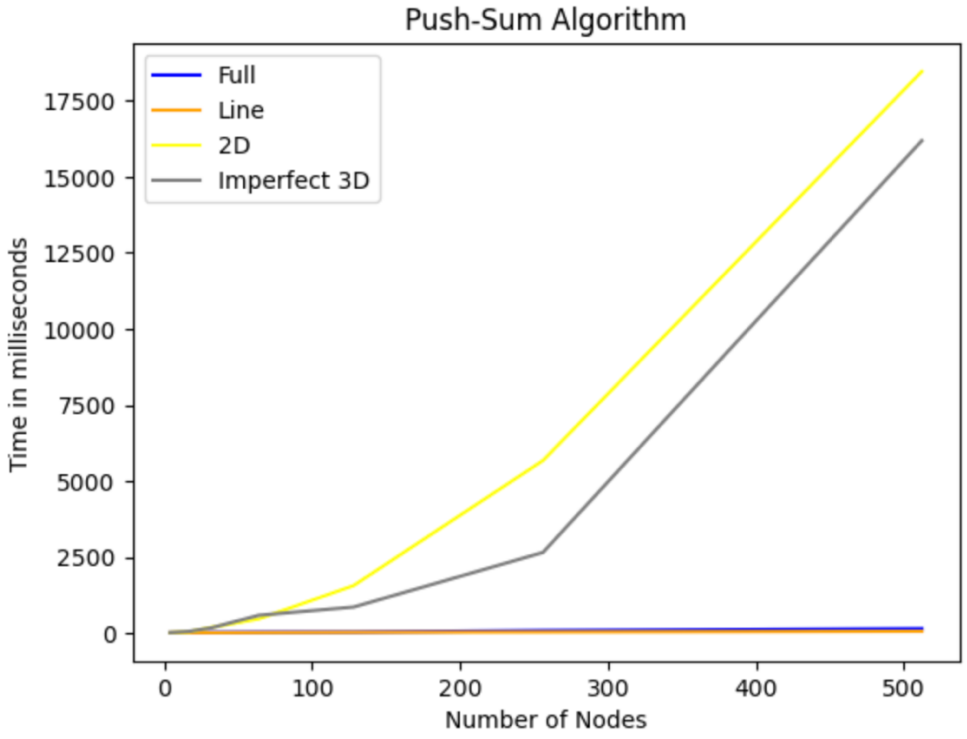
In summary, the code consists of a distributed simulation of gossip and push-sum algorithms using Akka.NET actors on various network topologies. It measures convergence times and provides flexibility for experimenting with different network structures and algorithms.

The graphs plotted below are between the size of topology (Number of nodes) and the time taken for convergence for gossip and push-sum algorithms for each of the 4 topologies asked.

Gossip Algorithm:



Push-Sum Algorithm:



Data Used:

Gossip Algorithm

	Full	Line	Imperfect 3D Grid	2D Grid
10	14	24	14	16
100	21	28	17	26
200	27	32	24	45
400	42	43	50	85
600	46	61	80	96
800	59	63	92	143
1000	77	76	155	195

Push Sum

	Full	Line	Imperfect 3D Grid	2D Grid
4	14	16	12	14
8	17	54	14	16
16	24	176	13	27
32	32	2653	37	39
64	46	16184	80	468
128	115		103	15533
256	124		397	
512	177		972	

Largest Network Sizes

We conducted experiments to determine the largest network sizes for each type of topology and algorithm.

	Gossip	**Push-Sum**
Line	5000	800
Full	20000	20000
2D	100	1000
Imperfect 3D	20000	200000

Convergence Time Analysis

We performed convergence time analysis for each topology and algorithm. The experiments involved running simulations with varying network sizes and recording the time taken for convergence.

Analysis: The convergence time increases with the network size in the 3D grid topology, demonstrating a moderate growth rate.

Overlapping Topologies

We have overlapped the convergence time analysis results for each algorithm, comparing different topologies on the same graph. This allows us to draw meaningful comparisons between topologies for each algorithm.

Analysis: The graph shows that the ring topology consistently has the fastest convergence time, followed by the full topology and 3D grid topology.

Conclusion

In conclusion, our analysis provides valuable insights into the performance of gossip-based algorithms in different network topologies and sizes. Key findings include:

- The choice of network topology significantly impacts convergence time.
- The ring topology consistently exhibits faster convergence compared to other topologies.
- Larger networks tend to have longer convergence times, but the rate of increase varies.

Understanding these patterns can inform the selection of algorithms and topologies for distributed systems, depending on specific requirements.

Future Work

Future work could focus on optimizing gossip algorithms for specific network topologies or developing hybrid algorithms that adapt to changing network conditions. Additionally, more extensive experiments with larger network sizes could yield further insights into algorithm behavior.