Project Proposal: Optimizing Financial Contagion Modeling

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1 Introduction

The propagation of financial shocks across interconnected systems is a critical area of study. This field informs strategies for mitigating risks and ensuring systemic stability. In this instance, contagion models are commonly used to not only analyze potential failures in systems, but understand cascading failures.

It comes as no surprise, that the problem of financial propagation shock can be viewed as an Influence Maximization problem. Accordingly, the Independent Cascade Model (ICM) is one of the most widely used models for studying diffusion processes. Its probabilistic nature necessitates multiple iterations, often relying on Monte Carlo simulations to capture the stochastic dynamics. Existing greedy algorithms typically execute Monte Carlo simulations sequentially, which can be computationally expensive and time-consuming. Our group aims to optimize this aspect of the ICM, focusing on improving efficiency and scalability to better handle large and complex systems.

2 Problem Formulation

We aim to identify key entities in a financial network that will have the most significant cascading impact on the rest of the network. Given a graph $G = (V, E)$ where each $v \in V$ represents an entity and each $e \in E$ has an associated weight that represents the strength of the relationship between entities, we want to be able to select subsets $S \subset V$ and observe the influence of their shocks on neighboring entities $v \in V \backslash S$. In particular, our model will maximize the expected number of nodes influenced by the initial set S in order to identify critical entities in the network.

3 Implementation Plan

The project will implement a sequential greedy approach for the Independent Cascade Model (ICM) in Haskell as a baseline. Building on this, we will develop a parallelized version of the greedy approach using Haskell's concurrency and parallelism features. Both implementations will be benchmarked to evaluate performance metrics such as execution time, memory usage, and scalability across various network sizes and complexities.

The nature of financial shock propagation means that it will be challenging to find an existing and available dataset online. It is our intention to generate synthetic data to populate our graph. The nature of the project aims to evaluate the impact of parallelization on the ICM's performance as opposed to the correctness of the output of the ICM itself.

4 Expected Results

By implementing the proposed plan, we expect our model to achieve:

- Significant reduction in computation time - parallelization will allow for faster results
- Scalable experiments - time reduction will allow for analysis of larger networks

With these improvements, we expect to produce a parallelized model that performs faster risk analysis with higher accuracy on financial networks than a sequential model.

References

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