Exploring PGAS-based Gossiping Algorithms for Knödel Graphs

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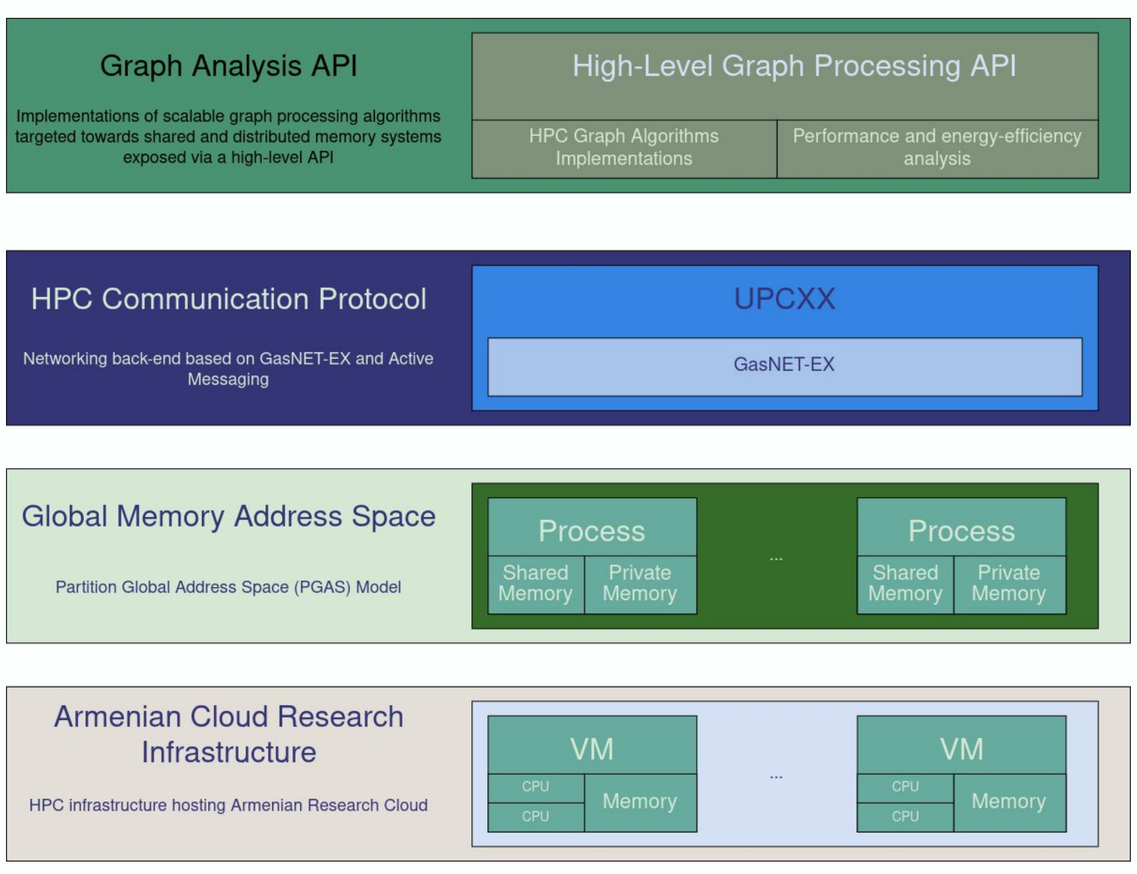
Introduction

Knödel graphs of even order n and degree $1 \leqslant \Delta \leqslant \lfloor \log_2(n) \rfloor$, $W_{\Delta,n}$, are regular graphs that have an underlying topology that is time optimal for algorithms gossiping among n nodes. Because of their distinctive properties, Knödel graphs act as a time-optimal topology for broadcasting and gossiping, thus arising in many settings, including social and communication networks or agent-based modeling simulations. Experimentation, often based on the extensive generation and analysis of complex networks, relies on high-performance computational resources to efficiently simulate the flow of information. The efficacy of such processing commonly depends on parallel processing and proper provisioning of distributed resources. The study aims to develop a complete approach devoted to the experimental research of Knödel graphs and to evaluate the memory usage pattern based on global memory address space abstraction. The sequential and parallel generation of synthetic datasets and simulation of asynchronous randomized push-first and broadcast-based gossiping algorithms with detailed analysis of resource usage and runtime have been studied.

Methodology

Architecture

A high-performance UPCXX C++ library backed by GasNET-EX and the computational resources of the Armenian Research Cloud infrastructure have been used for the experiments to address the networking requirements of runtime systems.



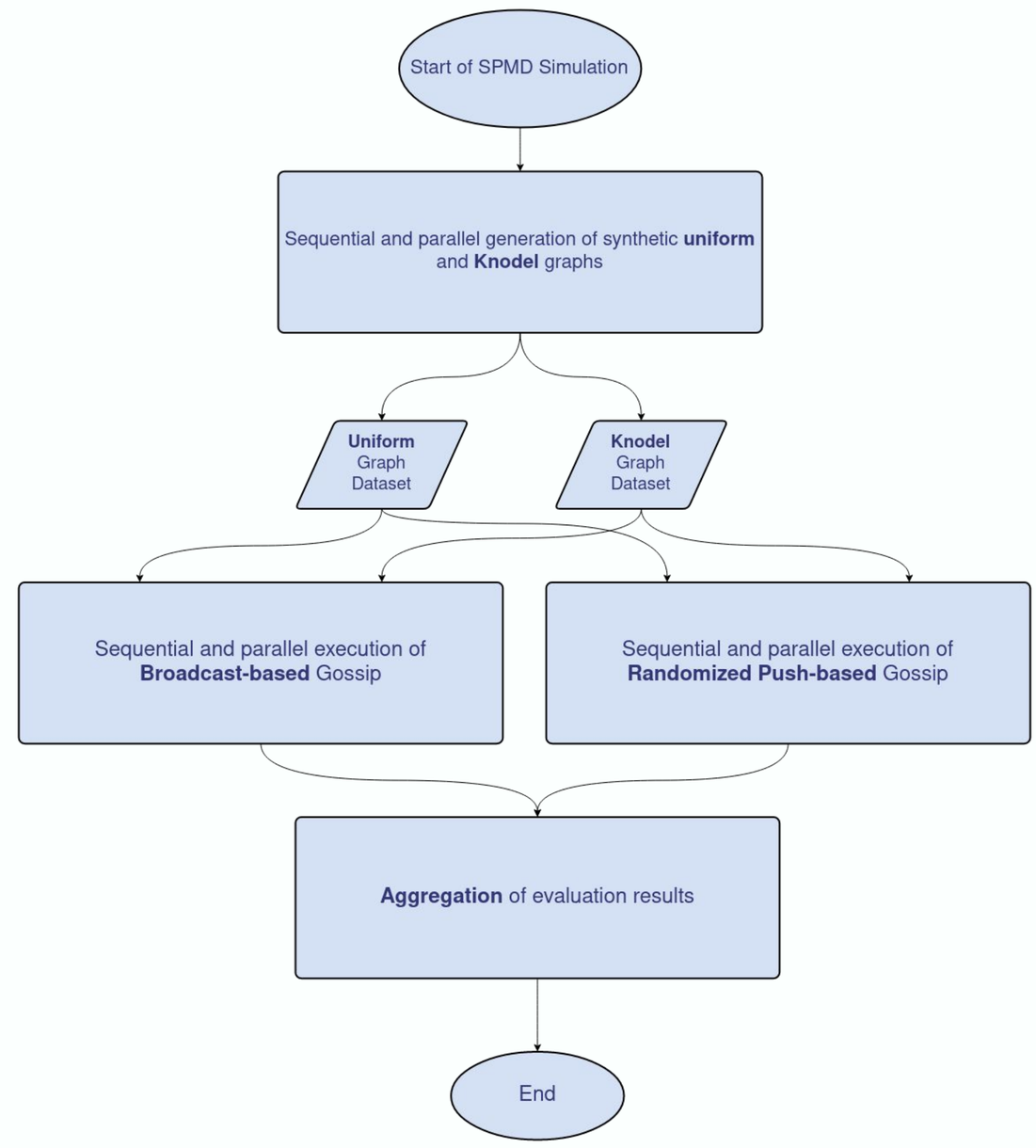
Network Models

One of the central abstractions for network science is different network models representing varying real-world structures such as social networks, telecommunication networks, or protein binding networks. Each model imposes properties important for specific use cases, one of which is gossiping.

PGASGraph

PGASGraph is a UPCXX-based C++ library designated to provide a solid foundation for HPC graph analysis. Currently, PGASGraph supports parallel and distributed generation of synthetic uniform and Knödel graphs based on node count and varying densities, and graphs. PGASGraph exposes a highly scalable, parallel-merge-based minimum spanning tree algorithm. With this research, PGASGraph is populated with parallel and asynchronous randomized push-first and broadcast-based algorithms designed to perform gossiping in connected graphs with unique nodes.

Evaluation



Conclusion

Experimentation revealed the effectiveness of asynchronous, rank-based RPC executions in pairs with careful work distribution and parallel processing showing linear scalability with up-to 16 processes. Further research will investigate possibilities for the high-performance generation of a greater class of network models, as well effective implementation of parallel graph algorithms, and optimization patterns for network science.