Project Report: Enhancing Navigability in Multiplex Energy Networks

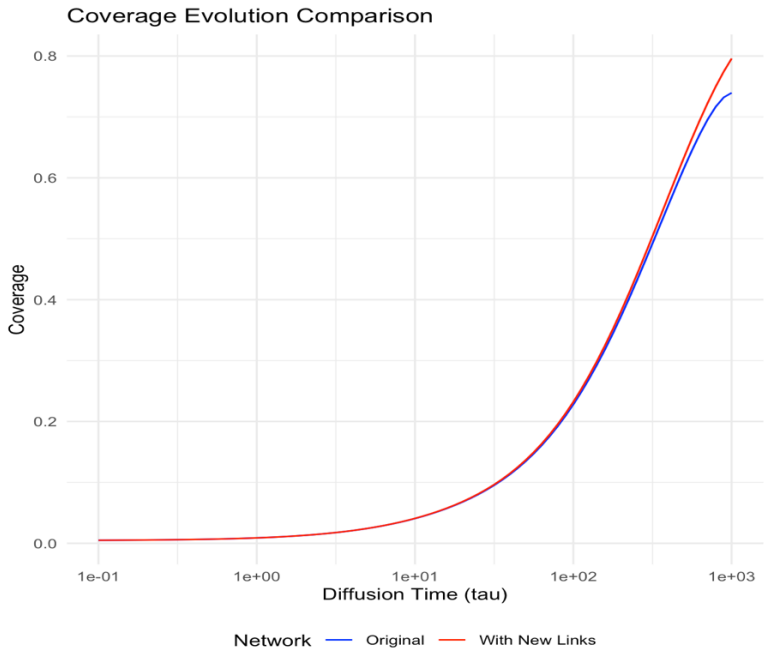
Abstract: This project addresses the challenge of improving navigability in multiplex energy networks by modifying traditional link prediction algorithms. The objective is to reflect the complex interdependencies within such networks, specifically those comprising electricity and gas nodes.

Introduction: The study of multiplex networks, which encapsulate multiple types of interactions among nodes, is crucial for understanding complex systems. This research explores this through the lens of energy infrastructures, aiming to enhance the robustness and efficiency of these critical systems.

Methodology:

1. **Network Construction:**
    - Constructed multiplex networks from data reflecting various node shutdown scenarios.
    - Developed five distinct network configurations resulted from different combinations of nodes shutdowns of electricity and gas nodes.
2. **Network Trimming and Anonymization:**
    - Applied a custom trimming logic to filter out less significant edges based on flow values to anonymize the network.
    - Retained edges with flow values at or above 90% of the maximum flow for that edge across all cases.
3. **Exclusive Neighbors Identification:**
    - Identified exclusive neighbors for each node within the network layers.
4. **Algorithm Modification:**
    - Customized the traditional link prediction approaches to consider the specific multiplex structure, emphasizing neighbors unique to each layer.
    - Modified the Jaccard and Adamic-Adar algorithms to utilize exclusive neighbors for link prediction.
    - Predicted new links with weights assigned based on the probability and the average flow between nodes.

5. **Results Normalization and Analysis:**
    - Normalized the link prediction results to a standard scale for evaluation.
    - Calculated edge weights for the predicted links, integrating the probability of link formation and average flow metrics.
6. **Navigability Assessment:**
    - Employed coverage evolution analysis to measure network navigability.
    - Utilized the **muxViz** package for calculating and comparing coverage before and after the integration of new links.



Results: The comparison of navigability, as indicated by coverage evolution comparison, demonstrated that networks augmented with links predicted by the modified algorithms exhibited enhanced navigability. The project's methodology resulted in a multiplex network with improved information diffusion efficiency.

Conclusion: The modifications to traditional link prediction algorithms for application in multiplex networks have shown significant potential in advancing the study and optimization of energy networks. By considering the unique characteristics of multiplex networks, this project lays the groundwork for future research aimed at achieving more resilient and efficient energy infrastructures.

Future Work: Further research will explore different layers combinations of the multiplex network and assess the impact of predicted link on network navigability.