

Optimization of the Routing Process by Finding Paths in Graph Structures, using Machine Learning

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Motivation

With ever increasing demand on computer networks, there is an ever more present need for a routing protocol, which would be better suited to utilizing available resources of the computer networks to ensure the best performance in terms of the quality of service (QoS). One of the possible research avenues is the incorporation of the ideas of the centrally controlled networks with routing schemes capable of making routing decision dynamically based on the current state of the computer network. Since such goals are often algorithmically hard to well describe and are often computationally expensive, a machine learning approach could potentially be effectively used to make routing decisions. The new routing protocol could be used to make routing decisions for each new data flow in a centrally controlled network, based on this network's current state.

Results

The experiments were performed on multiple topologies, see Fig. 3, using all the proposed routing schemes and the control algorithmic approaches. To ensure correctness of the experiments, all the experiments on the same topology were performed with the same data flows, regardless of the used routing scheme. The obtained results, shown in Fig. 1 and 2, show, that the proposed routing schemes outperformed algorithmic approaches in most of the cases. On different topologies, different proposed routing scheme outperformed the rest of the routing schemes. Overall, the best results were obtained using the combined routing schemes in terms of the stability and the performance. The combined routing scheme performed well on all topologies, even in cases when one partial routing scheme failed to perform well. This could be attributed to the fact, that one of the partial routing schemes could compensate for the shortcomings of the other partial routing scheme, which could, as demonstrated, lead to a better performance when combined.

Conclusion

In conclusion, this thesis provides an in-depth view of the possibilities of the usage of the machine learning in the field of routing in computer networks. Two adaptations of existing proposals were implemented and a third novel routing schemes was proposed, which combines the previous two routing schemes into a single routing scheme. As was shown in the performed experiments, the proposed approaches can systematically outperform more traditional routing approaches. It can also be seen, that combining two existing routing schemes can lead to an improved overall performance of the routing schemes in terms of the performance and stability on topologically different computer networks. The findings of this thesis along with the experimental results were also published in an article [1].

References

- [1] E. A. Katonova, J. Jurcisin, R. Petija, E. Slapak and P. Fecilak, "A Deep Reinforcement Learning Framework for Centralized Dynamic Routing Optimization via Integrated Link Weight Prediction and Path Selection," in IEEE Access, vol. 14, pp. 86605-86632, 2026, doi: 10.1109/ACCESS.2026.3700962.

Methodology

This thesis investigates the possibility of the usage of machine learning approaches to make routing decisions in centrally controlled computer networks. Three routing schemes were proposed in this thesis, specifically:

- using machine learning to assign link weights to each link in a computer network,
- using machine learning to select a path from a list of possible paths between the source and destination nodes,
- and combining the previous two routing schemes into a single combined scheme.

While the first two routing schemes were based on existing research, all be it with significant modifications, the last routing scheme provides a novel approach to routing data flows in a computer network. All these routing schemes are described in Fig. 4. From the machine learning perspective, all the proposed approaches are implemented using deep neural networks and trained using deep reinforcement learning algorithms. For comparison, two purely algorithmic approaches were also implemented. To experimentally evaluate the performance of the proposed approaches and the implemented algorithmic approaches, a network model was proposed and implemented based on the M/M/1/k model of the queueing theory.

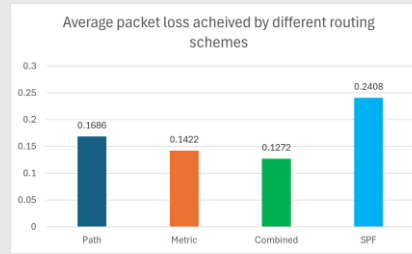


Fig. 1 Average packet loss achieved using different routing schemes.

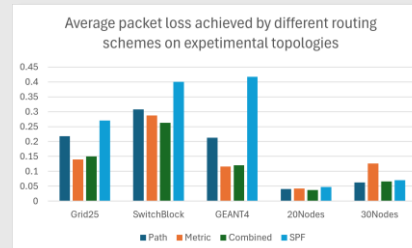


Fig. 2 Average packet loss achieved using different routing schemes on different topologies.

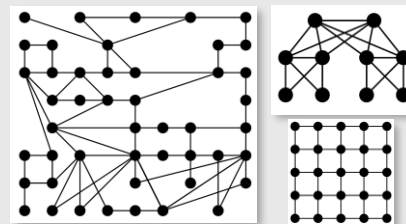


Fig. 3 Examples of the topologies used in the experiments.

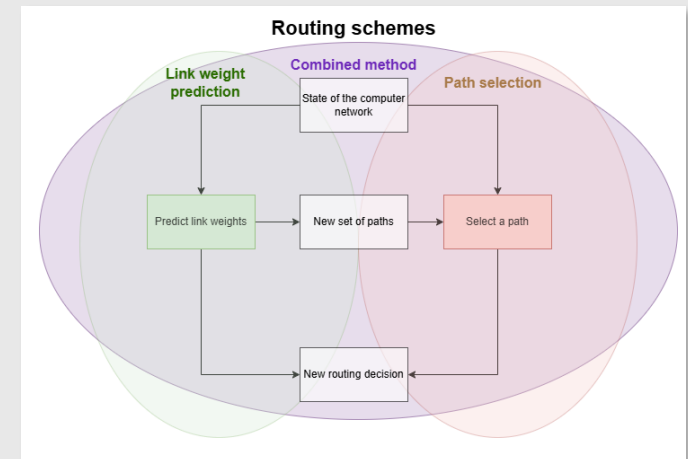


Fig. 4 Visualization of the relationship between the proposed routing schemes.