Graph Neural Networks for Dynamic Spectrum Access

Yanzhi Li, ECE Department/Northwestern University,
yanzhili2026@u.northwestern.edu

BACKGROUND

An efficient dynamic spectrum access framework requires two highly relevant components:

An accurate model of interference patterns among current network links/nodes, and an allocation algorithm that uses this interference model to distribute spectrum efficiently. For spectrum, this means maximizing utilization by parallelizing non-interfering transmissions whenever possible.

RESEARCH QUESTIONS

How to construct an accurate interference model (e.g., Conflict Graph) without exhaustive RSS (Receiving Signal Strength) measurements?

What is the proper interference model for designing spectrum allocation algorithms?

With the interference model, how to design the allocation algorithms?

METHODS AND MATERIALS

- Both the inference model and spectrum allocation problems can be formulated as graph structure or graph optimization problems.
- Graph neural networks emerge as a powerful tool to to solve the two problems by leveraging the structural information.
- MPGNNs (Message Passing Graph Neural Networks) predicts interference from sparse RSS measurements and Potts model to allocate spectrum by casting it as a graph coloring problem.

RESULTS

Conclusion and Discussion

- GNN effectively predicts the RSS matrix of network links from sparse measurements (<5% RSS entries), achieving a NRMSE < 0.15.
- GNN with Potts model as its loss function can effectively allocate spectrum without causing interference.
- Further evaluations are required to validate GNN to allocation spectrum.
- Signal to Interference and Noise Ratio (SINR) model may be utilized in the GNN loss functions.
- GNN is very robust against corrupted data measurement compared to optimization approaches.
- The execution time of GNN is efficient.
- By separating the spectrum access problem into predicting interference map and allocation spectrum, we gain more interpretability and insight.

CONCLUSION

Conclusion and Discussion

- Interference Map has the low rank property and graph structure. We leverage the structure information among wireless APs to predict the interference graph avoiding exhaustive measurements.
- We model wireless networks as wireless channel graphs and formulate the spectrum allocation problem as graph coloring problem.
- GNN with different loss functions design can effectively solve the two problems and powerful in designing the dynamic spectrum access framework.

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