09 Designing fault-tolerant networks

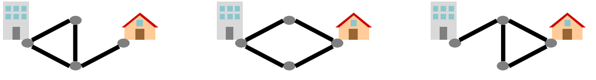
- Maximizing network reliability via binary decision diagrams -

Abstract

We show an optimization algorithm that can automatically find the positions to add links to infrastructure networks, including communication networks and road networks, that maximizes reliability of the network. Network reliability is the measure that shows how robust a network is against failures of its components. The optimization problem is known to be a hard problem since we have to count up exponentially many failure patterns. We use Binary Decision Diagram (BDD), data structure that can represent the set of failure patterns in a compact form, to solve the network reliability maximization problem. Our algorithm can find optimal solutions of the problems whose size is 10 times larger than those can be solved with existing methods. Our algorithm enables to design more reliable infrastructure networks with lower costs. In the future, we are planning to improve scalability of the algorithm to apply the algorithm to wider range of network designing problems.

Network reliability maximization problem

A problem of finding the positions to add links that maximizes network reliability, the probability that the terminal nodes can communicate with if some links fail, under the constraints on the cost to add links.

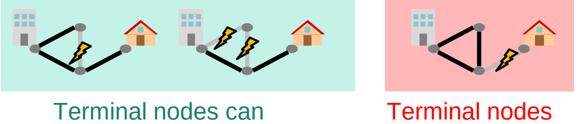


Which one is the most reliable network?

Reliability maximization is hard

Finding an optimal solution is a hard problem.

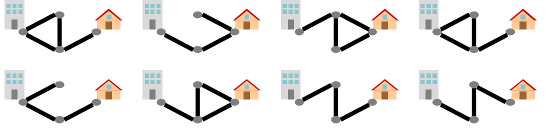
Difficulty 1: Need to count up exponentially many failure patterns with which terminals nodes can communicate to evaluate the reliability of a network.



Terminal nodes can communicate

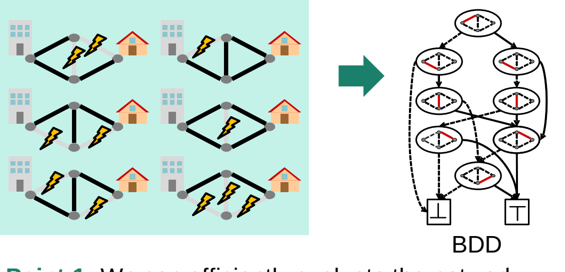
Terminal nodes cannot communicate

Difficulty 2: There exists exponentially many candidate solutions (network structures).

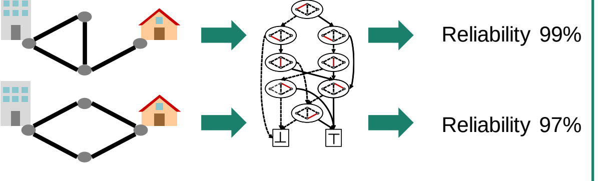


Efficient optimization using BDD

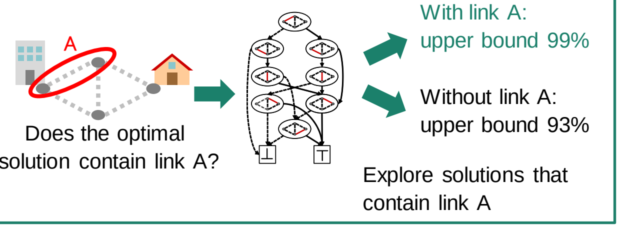
Using Binary Decision Diagram (BDD) to compactly represent the set of failure pattern to accelerate the optimization procedure.



Point 1: We can efficiently evaluate the network reliability of any feasible solutions by using a BDD.



Point 2: Pruning solution candidates with the upper bound of reliability estimated by using a BDD.



References

[1] M. Nishino, T. Inoue, N. Yasuda, S. Minato, M. Nagata, "Optimizing network reliability via best-first search over decision diagrams," In *Proc. IEEE Conference on Computer Communications (INFOCOM 2018)*, April 2018.

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