Don't Optimize Existing Protocols, Design Optimizable Protocols

Jiayue He, Mung Chiang, and Jennifer Rexford
Princeton University, USA
Email: {jhe, chiangm, jrex}@princeton.edu

As networks grow in size and complexity, network management has become an increasingly challenging task. Many protocols have tunable parameters, and optimization is the process of setting these parameters to optimize an objective. In recent years, optimization techniques have been widely applied to network management problems, albeit with mixed success. Network optimization has had a particularly large impact in the area of traffic management, which controls the flow of traffic through the network. Today, this spans across congestion control, routing and traffic engineering. Inside the network, operators tune parameters in the existing routing protocols to achieve some network-wide objective in a process called traffic engineering, see Figure 1.

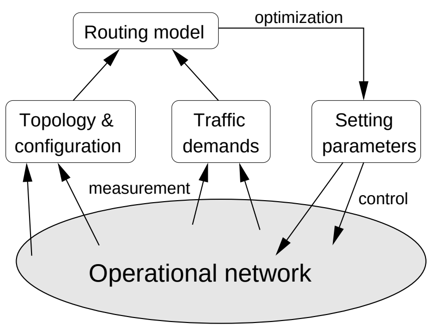

Fig. 1. Components of the route optimization framework.

Realizing that optimization problems in network management are induced by assumptions adopted in protocol design, we argue that instead of optimizing existing protocols, protocols should be designed with optimization in mind from the beginning. If a set of architectures and protocols lead to intractable optimization problems for network management, we argue that, instead of trying to solve these problems by ad hoc heuristics, we can revisit some of the underlying assumptions in the architectures and protocols so that easier problems are presented to network management system. Such explorations may provide superior simplicity-optimality tradeoff curves, see Figure 2.

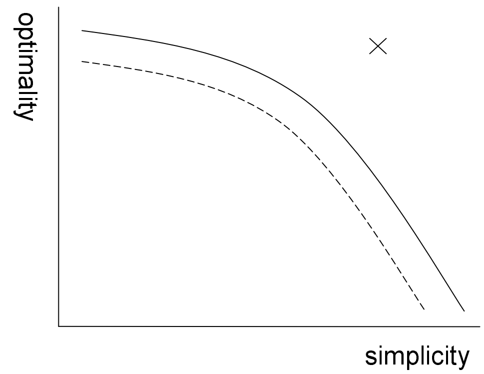

Fig. 2. Different trade-off curves in the optimality versus simplicity in design space. The dotted line is the original trade-off curve, the solid line and the cross are possible when underlying assumptions are perturbed.

Drawing from our own research experiences in traffic management, we propose three guiding principles for making optimizable protocols which correspond to three aspects of an optimization problem *i.e.*, constraints, variables and objective. First, changing the constraint set can turn an NP-hard optimization problem into an easy problem and reduce the optimality gap, [1]. Second, increasing degrees of freedom (by introducing extra parameters) can break tightly coupled constraints, [2]. Finally, embedding management objectives in the protocol can lead to alternative architectures, [3]. Still, protocols changes must be made *judiciously* to balance the gain in performance with the extra consumption of network resources.

Ultimately, the design of manageable networks raises important architectural questions about the appropriate division of functionalities between network elements and the systems that manage them. This paper represents a first step toward identifying design principles that can guide these architectural decisions. The open challenges which remain suggest that the design of manageable networks may continue to be somewhat of an art, but hopefully one that will be guided by more and more design principles. We believe that providing a new, comprehensive foundation for the design of manageable networks is an exciting avenue for future research.

References

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