MFoCS Dissertation Project:

Algorithmic Mechanism Design in Inter-Domain Routing

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An aspect of inter-domain routing that has received much attention in the past half decade is *incentives*. The autonomous systems (such as Internet service providers) are evidently independent economic entities, each with its own goals. They cannot be relied upon to follow any *prescribed* routing policy if they could profit by deviating from it. Further much of the information relevant to the selection of good paths, such as costs and connectivity, is known privately to individual autonomous systems; thus even if there were a central authority capable of enforcing a policy, it could not detect strategic reporting of this information. How can a central authority incentivize (i.e. compute payments to) autonomous systems in such a way that the dominant strategy of each autonomous system is to be honest about its cost, yielding a welfare-maximizing *strategyproof mechanism* for the routing problem?

In their seminal paper [5], Nisan and Ronen observed that the *Vickrey-Clarke Groves (VCG) mechanism*, well-known to be *truthful*, solves the lowest-cost path (LCP) mechanism design problem, and they proved that it can be computed in polynomial time. Feigenbaum et al. [2] extended the approach to inter-domain routing: they introduced an efficient *distributed* algorithm that implements a strategyproof mechanism for the LCP problem.

However subsequent developments aimed at realistic, expressive inter- domain routing policies that admit truthful, BGP-compatible (i.e. *routing-tree* and *policy* based) computation of routes and payments have yielded negative results. In [3], Feigenbaum et al. considered the well-known model of Griffin et al. [4] but with *cardinal* (as opposed to ordinal) preferences; they showed that it is NP-hard to maximize welfare with general policies, and for next-hop preferences it reduces to finding a maximum weight aborescence. In [1], Feigenbaum et al. proved that it is NP-hard to $O(1)$-approximate a welfare-maximizing routing tree with forbidden-set policies.

The aim of this dissertation is to present a survey of some of the recent developments described above. Time permitting, a number of interesting directions may be investigated.

Relevant courses

This project requires prior knowledge of complexity theory, and a basic understanding of (graph) algorithm design. Some basic understanding of the following would be an advantage though not necessary: game theory (especially mechanism design), routing in the Internet.

References

[1] J. Feigenbaum, D. Karger, V. Mirrokni, and R. Sami. Subjective-cost policy routing. *Theoretical Computer Science*, 378:175–189, 2007. Special issue of selected papers from Proc. WINE'05.

[2] J. Feigenbaum, C. Papadimitriou, R. Sami, and S. Shenker. A bgp-based mechanism for lowest-cost routing. *Distributed Computing*, 18:61–72, 2005. Special issue of selected papers from Proc. of ACM PODC'02.

[3] J. Feigenbaum, R. Sami, and S. Shenker. Mechanism design for policy routing. *Distributed Computing*, 18:293–305, 2006. Special issue of selected papers from Proc. of ACM PODC'04.

[4] Timothy G. Griffin, F. Bruce Shepherd, and Gordon Wilfong. The stable paths problem and interdomain routing. *IEEE/ACM Trans. Netw.*, 10(2):232–243, 2002.

[5] N. Nisan and A. Ronen. Algorithmic mechanism design. *Games and Economic Behavior*, 35:166–196, 2001.

Note. All the above references are viewable on the Web using an `ox.ac.uk` machine: just Google them.