Proposal for a PhD thesis
MAPi doctoral program

Title:
Evolutionary Computation based Internet Routing as a platform to Traffic Engineering

Supervisors:
Miguel P. Rocha – CCTC/ Univ. Minho
mrocha@di.uminho.pt

Pedro N. Sousa – CCTC/ Univ. Minho
pns@di.uminho.pt

Research Unit:
CCTC- Computer Science and Technology Center
Universidade do Minho

Background:

In the last few years, several new types of applications have been integrated into IP based networks, fostering the development of novel network solutions that aim to provide end-users with Quality of Service (QoS) support. To accomplish this aim, distinct QoS aware architectures and specific traffic control mechanisms were proposed by the networking research community to provide distinct service levels to networked applications.

Independently of the set of mechanisms that might be in place in any QoS capable infrastructure, there are some components which have a crucial importance irrespective of the particular solutions adopted. One of such components has the ability to control the data path followed by packets traversing a given network domain. In this regard, intra-domain routing protocols such as Open Shortest Path First (OSPF) are an attractive alternative, where the administrator assigns weights to each link in the network and these are the only parameters that control the routing behaviour. These protocols are simpler to deploy when compared to more complex alternatives such as MPLS.

Since, in these cases, the weight setting process is the only way administrators can affect the network behaviour, this choice is of crucial importance and may have a major impact in the network performance. Nevertheless, in practice, simple rules of thumb are typically used in this task, leading to sub-optimal network resource utilization.

Therefore, the use of optimization methods to set the parameters of these routing protocols (e.g. OSPF weights) makes an interesting approach to traffic engineering. In this case, it is assumed that the network administrator has access to the predicted demands between each pair of routers along with other possible QoS requirements (e.g imposed by service level agreements).

However, this optimization task is quite complex, as it has been shown that the underlying problem is NP-hard, even when the objective function is simply to minimize network congestion. In this context, methods from the Evolutionary Computation field are a promising solution that has been successfully applied in other domains, given their robustness, reliability and generality.

Objectives:

In this work, the major aim will be to address traffic engineering, using intra-domain routing protocols and considering a multi-constrained QoS approach. Therefore, a number of possibly conflicting objectives will be addressed, each representing a QoS related measure of the network behaviour (e.g. link congestion, end-to-end delays).

In detail, this thesis has the following scientific/ technological objectives:

- To study several optimization approaches in order to approach the previously defined traffic engineering task, namely meta-heuristic methods from the field of Evolutionary Computation that may be able to provide a good solution in useful time. These will be compared to standard approaches to the problem.

- To develop and fully evaluate multi-objective optimization methods that can approach the multi-constrained QoS objective functions, still based on the Evolutionary Computation arena. A generalization of these models will allow handling class-based networks or other possible QoS aware paradigms.

- To develop techniques that can handle issues such as: changes in demands or other QoS requirements, different demands in distinct time periods, link failures in the network, sensibility analysis of the solutions or others.

- To develop computational tools that can be used in real-world scenarios, that implement the previous methods, including (i) an intra-domain routing simulator able to monitor the network behaviour (ii) an optimization module with the proposed and existing algorithms and (iii) a module to generate test instances.

References:

1. B. Fortz and M. Thorup. Internet Traffic Engineering by Optimizing OSPF Weights. In Proceedings of IEEE INFOCOM, pages 519-528, 2000.
2. Z. Michalewicz. Genetic Algorithms + Data Structures = Evolution Programs. Springer-Verlag, USA, third edition, 1996.
3. R. K. Ahuja, T. L. Magnati, and J. B. Orlin. Network Flows. Prentice Hall, 1993.