Robust Flow Assignment in Green Networks

By Nadeem Abji and Alberto Leon-Garcia

First we report on a study that considers the robustness of flow assignments in core IP networks where a subset of routers is powered by renewable energy sources. For a given traffic demand, we optimize the flow assignment of the traffic to minimize the energy cost. We find several interesting conclusions. The preference for utilizing renewable energy to minimize cost results in flow assignments that favor longer, greener, paths through the network. This preference causes an increase in total energy consumption, but a decrease in cost, carbon emissions and conventional energy consumption. Next we study the robustness of the flow assignments using the network criticality metric, and we demonstrate that there exists a trade-off between the robustness of the network and the cost and emissions of the network. We reformulate the optimization problem with a constraint on robustness, which enables fine- grained control over the solutions. We find that a significant portion of the network's power consumption results from the baseline power a router consumes while idle. We, therefore, investigate algorithms that strategically power off line cards to further reduce power consumption without compromising the robustness or performance of the network.

Finally we report on an investigation of robust, energy-aware lightpath assignment in dynamically provisioned transparent and hybrid IP-Optical networks. The approach assigns cut-through lightpaths, which limit the amount of power-intensive optical-electronic-optical conversions needed in a core network. Although beneficial from an energy perspective, lightpaths tend to be underutilized resulting in wasted resources. Application of the network criticality concept enables strategic selection of lightpaths that are best suited to handle both random and known traffic matrices. The algorithm also factors in energy consumption, which results from operating amplifiers along a fiber link which can be powered off when the link is not in use. The algorithm provides a balance between power efficiency and network robustness.

Bio: Professor Alberto Leon-Garcia is Professor in Electrical and Computer Engineering at the University of Toronto. He is a Fellow of the Institute of Electronics an Electrical Engineering "For contributions to multiplexing and switching of integrated services traffic". He is also a Fellow of the Engineering Institute of Canada. He has received the 2006 Thomas Eadie Medal from the Royal Society of Canada and the 2010 IEEE Canada A. G. L. McNaughton Gold Medal for his contributions to the area of communications. He holds a Canada Research Chair in Autonomic Service Architecture. Professor Leon-Garcia is author of the leading textbooks: Probability and Random Processes for Electrical Engineering, and Communication Networks: Fundamental Concepts and Key Architecture. He is currently Scientific Director of the NSERC Strategic Network for Smart Applications on Virtual Infrastructures.