Green Paths: Reducing the carbon footprint of networking infrastructure

Authors

Karel van der Veldt, Paola Grosso, Cees de Laat,
Sowmya Balasubramanian, Jon Dugan, Inder Monga

Email addresses

{karel.vd.veldt, p.grosso, delaat}@uva.nl,
{sowmya, jdugan, imonga}@es.net

Affiliations

System and Network Engineering Group – University of Amsterdam
Energy Sciences Network – Lawrence Berkeley National Lab

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Abstract

Given the threat of global warming looming over the horizon, it is important to investigate methods to decrease the global carbon footprint. The ICT sector is an ever-growing segment of our society, and is expected to contribute approximately 3% of global carbon emissions in the near future, possibly overtaking the aviation industry.
UvA and ESnet are cooperating to investigate the contribution of carbon emissions of networking infrastructure. Our first common result has been a model for the various contributions of networking devices. Together we developed a tool where we applied this model to user specified data transfer scenarios. This tool was demonstrated for the first time at SuperComputing 2013 in Denver, and we plan to show an improved and extended version at TNC 2014.

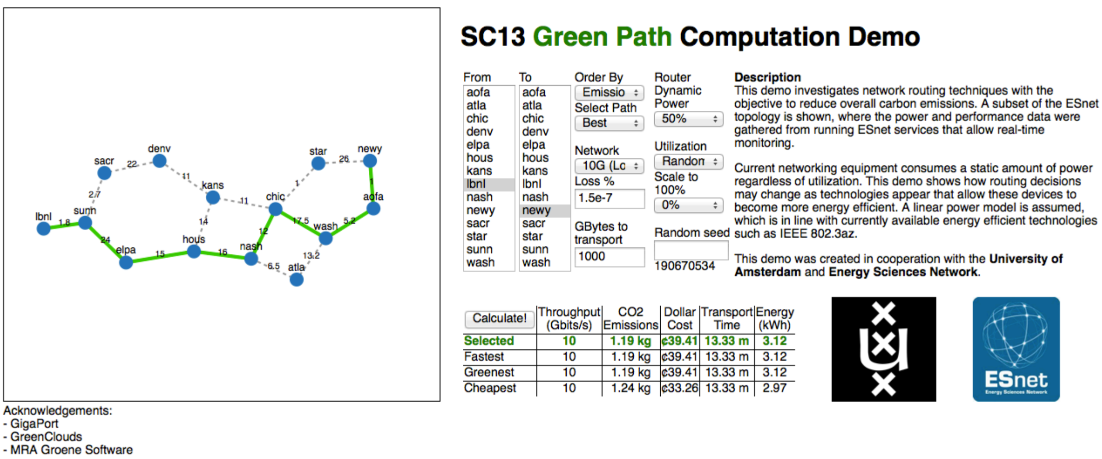

Fig 1: Screenshot of the demo.

Our main research question is as follows: *How can we identify and select "green" paths with the goal of reducing the overall carbon footprint of the network?* Green paths are paths from one endpoint to another in a network that are chosen such that they lead to a lower carbon footprint of the network, as opposed to choosing the fastest or cheapest (monetary) paths. How do the greenest, fastest, and cheapest paths compare? Moreover, how do networking infrastructures with different properties compare? What impact do, or can, energy efficient technologies have? Are significant reductions even possible and realistic?
Our model can help answer these questions.

Our model calculates the carbon emissions in grams CO2 of transporting N GBytes of data over a given path. Doing so requires knowing the following:

1. The transmission time (inverse of throughput).
2. Power measurements of all the devices participating in the data transfer in the path: switches, routers, DWDMs, etc.
3. Information about the energy production mix of the energy sources of all nodes in the path. This depends on the regions where the nodes are physically located. For example, some regions may depend mostly on fossil fuels while other regions may use a mix of coal, nuclear, and solar power.

From points 1 & 2 we can calculate kiloWattHours. However, energy dissipated is NOT the same as carbons emitted. It is very well possible to have high amounts of energy dissipated but still have relatively low amounts of carbon emissions. It depends on the energy sources. Thus we need the data from point 3 to calculate the total carbon emissions in grams CO2.

In our original scenario, we considered several regions (states) of the United States. Given (a subset of) the Energy Sciences Network topology, we look at the possible paths to transport a certain amount of GBytes from point A to point B. Which path should be taken that results in the least carbon emissions, and how does that path change as the parameters change?

Our demo calculates and shows the path, and also compares it to the fastest and cheapest paths. Most of the nodes are in different states, and thus have different energy production mixes. In reality the energy production mix can change on a daily basis, but this information is usually not publically available and so we have to rely on yearly averages. The power consumption of current network equipment in the underlying topology consumes a static amount of power regardless of utilization (traffic load), but with our model and the associated tool we can show what would happen if a portion of the power draw of networking devices scaled linearly with utilization. In other words, what the effect of new energy efficient technologies may be. We chose a simple linear model as that is in line with currently available energy efficient technologies such as IEEE 802.3az.

At TNC2014 we will present an improved and extended version of our tool, which will include ESnet and SURFnet topology. It will include information on the devices and energy production mixes in the newly transversed countries. This tool may help answer several of the questions we have raised in this text.

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Author biographies

Karel van der Veldt is a PhD candidate in the SNE group of the University of Amsterdam. He obtained his master's in Computer Science at the University of Amsterdam and his bachelor in Computer Engineering at the Hogeschool van Amsterdam. His research interests are green computing in networks and data centers, and high performance and distributed computing.

Paola Grosso is assistant professor in the SNE group. She is the lead researcher of the group activities in the field of optical networking, distributed infrastructure information modelling and GreenIT. She leads the UVA activities in the GigaPort Research on Network projects to develop network models and control plane for lambda networks and topology handling. Her research interests are green ICT, provisioning and design of hybrid networks for lambda services; development of information models for hybrid multi-domain multi-layer networks.
http://www.science.uva.nl/~grosso

Cees de Laat chairs the System and Network Engineering (SNE) research group. Research covers optical and switched networking and workflows for processing of big data in PetaScale e-Science applications, Semantic Web to describe e-infrastructure resources, information complexity, Authorization architectures and Systems Security & privacy of information in distributed environments. Prof. de Laat serves as gfsg member of Open Grid Forum, is chair of GridForum.nl and serves on the Lawrence Berkeley Laboratory Policy Board on matters regarding ESnet, is co-founder and organizer of several past meetings of the Global Lambda Integrated Facility (GLIF) and founding member of CineGrid.org.

Sowmya Balasubramanian joined ESnet in 2010. She works to develop and maintain perfSONAR (PERFormance Service Oriented Network monitoring ARchitecture), a network testing and troubleshooting system. During an internship at the Lawrence Berkeley National Laboratory last summer, Balasubramanian was one of the primary developers of ESnet's Network Weathermap monitoring software. Balasubramanian, originally from Chennai, a city in South India, graduated with a M.S. in information networking from Carnegie Mellon University. She completed her undergraduate education at SSN College of Engineering of Anna University in India.

Jon Dugan is based in Chicago, Illinois. His professional experience has centered around UNIX-like systems, IP networking and programming. His first years in UNIX system administration were at Wolfram Research. He spent many years at the National Center for Supercomputing Applications at the University of Illinois at Urbana-Champaign in Urbana, IL first as a student employee, then as a network engineer and finally as a senior network engineer. He recently joined

ESnet at Lawrence Berkeley National Lab as a network engineer where he is involved in network engineering and tool development.

Indermohan (Inder) S. Monga serves as the Chief Technologist and Area Lead of network engineering, tools and research at Energy Sciences Network. Mr. Monga plays a key role in developing and deploying advanced networking services for collaborative and distributed "big-data" science. Mr. Monga's research interests include network virtualization, software-defined networking, energy efficiency and distributed computing, he serves as co-chair of Network Services Interface working group as well as is appointed as ONF Research Associate. He currently holds 17 patents and has over 15 years of industry and research experience in telecommunications and data networking at Wellfleet Communications, Bay Networks, and Nortel. He earned his undergraduate degree in electrical/electronics engineering from Indian Institute of Technology in Kanpur, India, before graduate studies at Boston University's EECS Department.