# A Demonstration of Energy Efficiency Capabilities Orchestration in Networks

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***Abstract*—Various energy efficiency network capabilities have been proposed in recent years in response to the demand of reducing the amount of energy consumed by the network infrastructure. In this regard, we demonstrate SOS, a method able to orchestrate different energy efficiency capabilities considering the possible combinations and conflicts among them, as well as the best option for a given bandwidth utilization and network characteristics, such as topology and power profiles of devices. The method was tested on GreenSDN, a testbed based on the Mininet environment and the POX controller, which emulates the effects of different energy efficiency capabilities. During the demonstration, we will show the energy efficiency achieved by the orchestration method, highlighting the additional savings due to capabilities orchestration, and, at the same time, considering performance constraints and different policies.**

## I. Introduction

Energy costs related to networking are among the most significant that operators and datacenter service providers have to absorb, impacting also in Greenhouse Gases (GHG) emissions [1]. For datacenters, the amount of energy spent by networks is not a consensus, but is significant, ranging from 10% to 30% [2] of the total. For networks, a significant example comes from the Verizon's 2013 Sustainability Report, in which the company reported that 92% of the carbon emissions was due to electricity to run its networks [3]. The ICT total electricity consumption is forecasted to increase almost 60% until 2020, to almost 1,100 TWh [1].

In order to reduce the networking energy expenses, several capabilities ranging from green traffic engineering to port-level capabilities have been proposed. However, there was no proposal on how to coordinate or combine such capabilities in the same network, neither considering policy-based network management (PBNM) concepts. In this context, Riekstin et al. [2] proposed the Sustainability Oriented System (SOS), a method to orchestrate energy efficiency capabilities bringing business directives to the network operation. In conjunction, Rodrigues et al. [4] developed an SDN testbed to deploy and test energy efficiency capabilities, the GreenSDN.

In the demonstration, we show the SOS orchestration method running on the GreenSDN testbed for a seventeen nodes topology with load proportional switches. We show different capabilities being selected considering diverse bandwidth utilization scenarios and the savings achieved in each situation, besides the possible performance trade-offs.

## II. Proposed Method and Testbed Environment

The Sustainability Oriented System (SOS) proposed in [2] is a method able to orchestrate different energy efficiency capabilities considering the possible combinations and conflicts among them. The method is able to choose the best capability or combination of capabilities for a given workload and network characteristics, refining high-level policies down to the network operation. Figure 1 describes the Architecture of SOS and GreenSDN together.

The SOS method uses Table Lookup for high-level policies translation (Module 1). The translation is supported by Sustainability-Oriented Information Models to represent policies, which also support policies time dynamicity. The energy efficiency capabilities orchestration is supported by a Utility Function (UF), described in Equation 1. The UF selects the capability (or a combination of capabilities) that maximizes the benefits considering the energy efficiency and quality of service (QoS) trade-off (Module 2): if the savings are high, but the packet losses are also high (*pl*), the UF loses points (*pl* is reduced). If the performance is high, but the savings are smaller than other options, the UF also loses points.

The refinement will result in Decision Trees, containing the best capabilities for the network topology and bandwidth usage for different time periods (Module 3). A different decision tree is expected for each period of the day with a specific energy efficiency policy. During the operation phase, the decision trees are deployed in the controller and then monitored by a Policy Decision Point (Module 4). The controller monitors the network and, based on the decision trees, applies the capabilities using the GreenSDN Modules.

$$UF = pl * \frac{1}{\frac{\sum_{k=0}^{n} EnergyAfterSavings_{RouterK}}{\sum_{k=0}^{n} EnergyBaseline_{RouterK}}} \quad (1)$$

The SOS method was tested using GreenSDN. GreenSDN is a green testbed designed to deploy and test energy efficiency capabilities in a Software Defined Network environment [4]. It was deployed using the Mininet network emulator in conjunction with the POX controller and OpenFlow 1.0. Three capabilities were implemented in GreenSDN, each one as a representative of a different scope of actuation: Adaptive Link Rate (ALR), components scope; Switch Coalescing (SC), device scope; and SustNMS, network scope. Rodrigues et al.[4] describe how the capabilities were implemented.

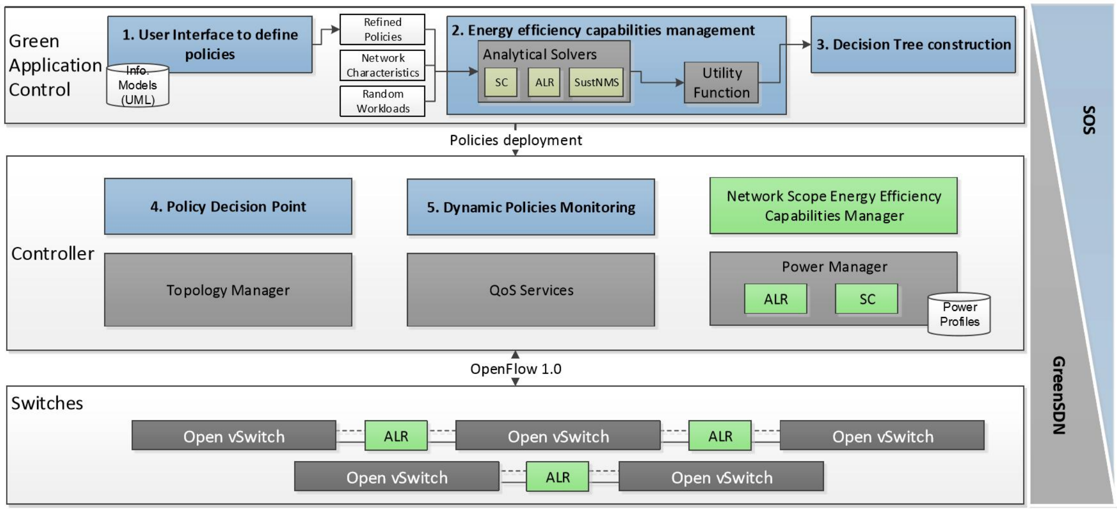


Fig. 1. SOS and GreenSDN Architecture for the Demonstration

The experiment to be demonstrated considers a topology with seventeen emulated nodes, inspired by the core part of the RNP network (Rede Nacional de Ensino e Pesquisa, the Brazilian National Research and Education Network), as illustrated in Figure 2. The nodes are Open vSwitches. The topology was configured to use two flows, from north to south and west to east. The generation of traffic between the hosts was in charge of the Iperf tool.

## III. Planned Demonstration

For the demonstration track, we will show the SOS operation supported by GreenSDN considering a baseline scenario comparing the energy consumption when there is no energy efficiency capability being applied. We will start showing the environment configuration and setup, starting the switches, traffic flows, and the controller. The refined business policies will be demonstrated, as well as the decision trees deployment. After the environment setup, we will demonstrate what happens when the network conditions changes: a different capability will be selected, or a combination of capabilities. In this step, different flows will be tested: (i) two small flows (expected selection: ALR and SC combined), (ii) one 14 Mbps flow, another of 6 Mbps (expected selection: SustNMS on sustainability mode plus ALR on the 6 Mbps flow), (iii) two flows of more than 10 Mbps (expected selection: SustNMS on sustainability mode for both paths), (iv) two flows greater than the network can handle (expected selection: SustNMS on performance mode, and two extra switches turned on, which means that, for this case, considering the UF, it is better to save less in order to lose less packets). To conclude, we will show the system reacting to a different policy, to be applied in another time period.

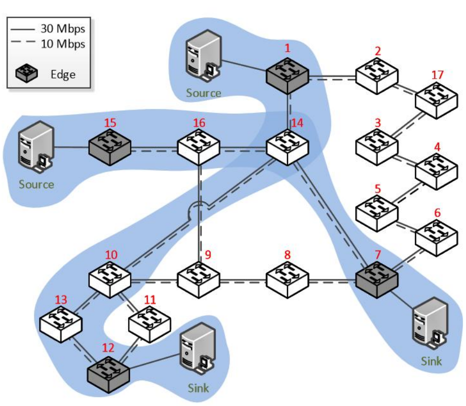


Fig. 2. Topology used in the experiments

The audience will observe the coordination of energy efficiency capabilities allowing the operator to optimize the energy consumption. Besides the possibility of saving more energy, the orchestration ensures a conflict-free operation. A conflicting operation could lead to undesired behavior, failures, and, consequently, reduced quality of service. Besides, applying a capability not suited to the current bandwidth utilization value might lead to congestion or packet loss. Business-level directives, refined down to the device and instance policy levels in an automated way, bring high-level goals to the network operation. Such automation turns the management task easier, less manual, and less prone to errors.

## Acknowledgments

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## References

[1] Ericsson, "Ericsson Energy and Carbon Report - On the Impact of the Networked Society," Ericsson, Tech. Rep., July 2013. [Online]. Available: http://www.ericsson.com/res/docs/2013/ericsson-energy-and-carbon-report.pdf

[2] A. Riekstin, G. Januario, B. Rodrigues, V. Nascimento, M. Pirlea, T. Carvalho, and C. Meirosu, "Orchestration of energy efficiency functionalities for a sustainable network management," in *13th Network Computing and Applications (NCA), 2014 IEEE*, Aug 2014, pp. 157–161.

[3] Verizon, "2013 Corporate Responsibility Supplement," Tech. Rep., 2013. [Online]. Available: http://responsibility.verizon.com/assets/docs/cr-report-supplement-2013.pdf

[4] B. Rodrigues, A. Riekstin, G. Januario, V. Nascimento, T. Carvalho, and C. Meirosu, "GreenSDN: Bringing Energy Efficiency to an SDN Emulation Environment," in *Integrated Network and Service Management (IM), 2015 14th IFIP/IEEE Symposium on*, May 2015, p. to appear.