GreenSDN: an Emulation Environment Towards the Development of Network Energy Efficiency Capabilities

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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. However, the characteristics of environments to emulate and validate such solutions are not discussed as much as the capabilities. In this regard, this work propose an environment that is able to support not only the development of network energy-saving solutions, but the development of management applications considering energy-saving primitives. The GreenSDN implement capabilities that are representative of each network scope (ports, node and network) in the Mininet environment, taking as basis the software defined network paradigm. We present a preliminary validation with different experiments inspired on the RNP topology.**

I. Introduction

Triggered by the continuous growth of users with broadband access and the growth on the number of services provided, the energy consumption reduction has become a key issue for network service providers [1]. As data centers represent one of the main categories in Information and Communication Technologies (ICT) and its power demand is the fastest growing among all categories, various approaches to reduce its power consumption have been proposed. The demand including servers, cooling and networking grew 7% from 2012 to 2013, reaching an annual/yearly energy consumption of near 350 TWh. It is predicted that it will grow 81% by 2020, reaching near 630 TWh yearly [2]. Although there is no consensus on how much networks contribute for the power demand, studies indicate that the numbers vary between 4% to 23%

To reduce the amount of energy consumed by networks a range of energy-efficiency protocols and capabilities have been proposed. Proposals range from specific chip-level components to capabilities employed at the network level. However, characteristics of environments to emulate and validate such proposals are not discussed. In this regard, it is presented an environment to develop and validate energy efficiency capabilities as well as power management applications (detailed in [3]). In Section II we review main emulation environments, and in Section III energy efficiency capabilities. We presented the proposed architecture in Section IV followed by a preliminary validation in Section V. Final considerations are given in Section VI.

II. Emulation Environments

Since the growth of virtualization in network infrastructures, there are efforts to emulate or simulate programmable networks in order to provide environments supporting realistic user traffic, at scale, and with interactive behavior (e.g. ns, Emulab , GENI, OFELIA, Mininet). Among the available solutions to emulate a programmable OpenFlow network, Mininet combines the desirable features of simulators, testbeds and emulators, being considered the most popular and easier to use due to its capability to execute locally into a virtual machine [4]. While Mininet is the most popular SDN emulation tool, POX is one of the most popular OpenFlow Controller. It is a python-based controller which has gained popularity due to its easiness of use and available documentation. Its open source code makes it easier to modify and add features.

III. Energy Efficiency Capabilities

There are many different solutions for managing a network focusing on energy efficiency, ranging from local chip-level enablers for a more power-efcient node to routing protocols. The existing functionalities can be applied in the network level (knowledge of the entire network) or at the device level (local knowledge). Such capabilities can be separated by their scope of actuation: a component of a node, a complete node, or the whole networks. Figure 1 lists some examples for each scope.

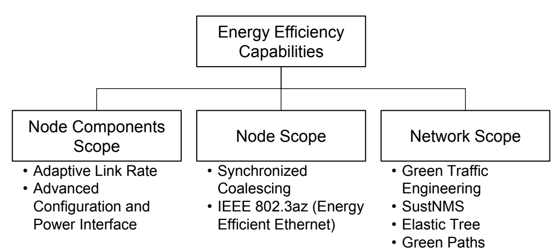

Fig. 1. Energy Efficiency Capabilities Classification

Considering the capabilities available, was selected three capabilities to be implemented in GreenSDN. Each of them is representative of its network layers: Adaptive Link Rate (ALR) - Node Components Scope, Synchronized Coalescing (SC) - Node Scope and SustNMS (Network Scope). The literature contains good technical descriptions of ALR and SC to help us with the implementation, while SustNMS is a previous work performed in the research group so the source code was made available to us.

IV. Proposed Arhictecture

The architecture proposed in [3] is depicted in Figure 2. It is composed by the controller and adjacent worker modules to support the green capabilities.

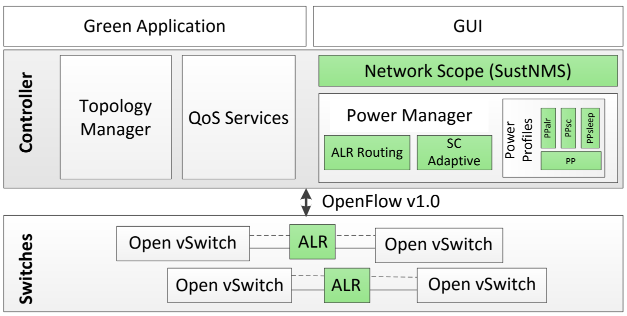

Fig. 2. Emulation Environment Architecture.

The Topology Manager deals with the network management operating switches and ports. it implements methods to manage flow-tables, installing or removing flows whenever SustNMS requests a new path.The QoS Service is responsible for the monitoring task, handling the response of flows and ports status requests. A Graphical User Interface gathers information from the controller and displays information about the topology, overall network consumption, packet loss and capabilities enforced. A Green Application Control is implemented as a button, used to enable or disable capabilities. Lastly, the Controller the manage the exchange of information among modules, applications and capabilities.

V. Preliminary Validation

The topology (Figure 3) implemented in GreenSDN is inspired on the 10 Gigabyte RNP (*Rede Nacional de Ensino e Pesquisa*) backbone. Each pair of nodes is interconnected using parallel links, configured with different rate limits (30 Mbps standard and 10 Mbps reduced). We considered two main flows, from north to south and west to east, placing two *Sources* in north extremes and two *Sinks* in south extremes. The generation of traffic between the hosts is in charge of the Iperf tool, already available in Mininet.

The baseline consumption represent nodes operating with the regular power consumption. The 10 Mbps evaluation, Figure 4, present similar savings for ALR and SustNMS with both presenting savings around 15% with a small difference. The SustNMS modifies the routing for workloads higher than 15 Mbps to avoid losses by flows sharing switches. For workloads smaller than 15 Mbps, in our case the 10 Mbps evaluation, its maximizes the savings by concentrating traffic. Considering that ALR is intended for Ethernet rates and was defined a 30 Mbps link capacity, it presented savings in 10 Mbps and huge losses in 30 Mbps evaluation.

VI. Final Considerations & Future Works

The GreenSDN is a first step towards an environment to emulate and validate distinct green capabilities. The preliminary validation results pointed out that this work is aligned

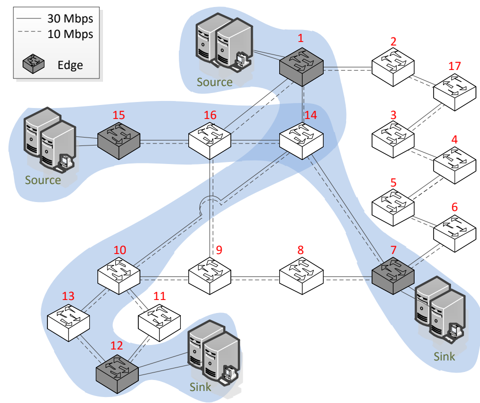

Fig. 3. RNP Topology.

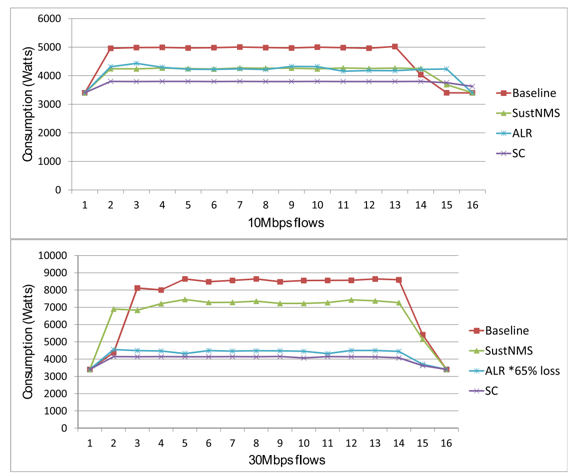

Fig. 4. Energy Savings evaluation considering 2 Flows.

with our expectations based on previous works with SustNMS, ALR and SC. As future works, it may lead to interesting points of research, such as the orchestration of green capabilities. For a detailed description we refer the reader to [3].

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References

[1] R. Bolla, R. Bruschi, F. Davoli, and F. Cucchietti, “Energy efficiency in the future internet: a survey of existing approaches and trends in energy-aware fixed network infrastructures,” *Communications Surveys & Tutorials, IEEE*, vol. 13, no. 2, pp. 223–244, 2011.

[2] A. Riekstin, G. Januario, B. Rodrigues, V. Nascimento, T. Carvalho, and C. Meirosu, “Orchestration of energy efficiency capabilities in networks,” *Journal of Network and Computer Applications*, pp. –, 2015. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S1084804515001435

[3] 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.

[4] B. Lantz, B. Heller, and N. McKeown, “A network in a laptop: Rapid prototyping for software-defined networks,” in *Proceedings of the 9th ACM SIGCOMM Workshop on Hot Topics in Networks*, ser. Hotnets-IX. New York, NY, USA: ACM, 2010, pp. 19:1–19:6. [Online]. Available: http://doi.acm.org/10.1145/1868447.1868466