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SDNSandbox — Enabling learning-based innovation in provider networks

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ABSTRACT

Provider networks are looking to follow the footsteps of cloud-based networks/data centers and incorporate Software-Defined Networking (SDN) technology. This move is problematic for various reasons, such as the networks' size and the providers' inability to control users' activity. Additionally, research into these networks is handicapped by the lack of information stemming from the confidentiality of these complex networks.

To that end, we have created SDNSandbox — an SDN-based provider network simulator prototype. SDNSandbox is an open-source, easy-to-use, provider-network in-a-laptop simulator. It aims to facilitate the creation of reproducible experiments and large-scale synthetic datasets. In its current prototype form, it uses a basic traffic generator module alongside real-world provider topologies. SDNSandbox allows users to simulate provider networks, enabling them to conduct research in the field and examine practical applications.

To demonstrate SDNSandbox, we use the prototype to simulate basic traffic conditions over several topologies. We then feed the generated datasets to DCRNN, a Convolutional Neural Network (CNN) traffic patterns prediction module. We adapt DCRNN to accept SDNSandbox output and show that it can predict traffic conditions at various points within the network tens of seconds into the future. We further compare its performance with other baseline algorithms.

Our results demonstrate that SDNSandbox can also be used as a testbed for a digital twin, creating datasets that are hard to replicate in production networks. It also serves as a demonstration of the framework's power and versatility as a modular research tool.

1. Introduction

In recent years, Data Centers (DCs) have begun employing Software-Defined Networking (SDN) technology to improve efficiency and performance. This surge has gained the interest of large service providers, who seek to embed the technology to benefit from the flexible and scalable nature of SDNs. For example, AT&T's Domain 2.0 Vision [1] pledged to move to software-based networking to provide a more flexible product line. The benefits are numerous: SDN aims to lower Capital Expenditure (CAPEX) on dedicated networking hardware — as software control components can run on generic hardware. In addition, Operational Engineering Expenditure (OPEX) is lowered by utilizing the power of configurable, version-controlled, and scalable software.

However, several marked differences exist between DCs and large provider networks, and these pose significant challenges: unlike DCs, provider networks span large geographical areas, sometimes whole continents; they deliver concurrent connectivity to millions of users and have limited control over the behavior of users (e.g., ISPs do not get advanced notice when a user starts a high-load HiDef streaming session). These conditions lead to a less structured and known environment, reducing providers' abilities to overcome and recover from extreme events, such as overload and congestion.

A new paradigm for learning and recovering suggested these days is the use of a digital twin [2] coupled with a machine learning algorithm. Research on this topic, however, is hampered by the fact that the real-life data needed to realize such a paradigm (topology, data rates, links, failure conditions, etc.) is considered a providers' trade secret and hence confidential, limiting academia's ability to develop such settings for research purposes.

To enable the research of SDN technology in provider networks, we present a testbed for SDN experiments — SDNSandbox. SDNSandbox aims to extend the premise of the SDN simulation tool Mininet [3] from a Network-in-a-Laptop vision to a Provider-Network-in-a-Laptop one. SDNSandbox is a low-cost, low-fidelity simulation of a provider topology based on the Mininet toolchain. It allows a "one-click" setup of a provider topology, generation of traffic within the network, and monitoring of said traffic. The resulting monitored traffic can be used for various provider network learning tasks, from modeling the network's

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