A Network-level Empirical Characterization of Testbed Environments

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Abstract

Researchers rely on networking testbeds, such as Emulab, to evaluate their systems. Yet, they spend very little time understanding the network-level characteristics of the testbed environment which will strongly influence their results. In this paper, we conduct an empirical study of the network level characteristics of four Emulab-based testbeds. We study the delay, jitter, packet loss, and bandwidth characteristics of the testbed network when using unicast and multicast routing. We discuss the implications our finding and the impact they will have on evaluations conducted on the testbed.

1 Introduction

Networking testbeds are prevalent and researchers use them all the time to evaluate their technologies But, evaluation are influenced by the underlying software and hardware environment

Currently, there are no tools that enable characterizing the testbed enviroments hence influence of the underlying environment and how it imacpts the results is never accounted for

This is especially important when using applications based on multicast and federation technolgoies We show that different evironments can influence the results in different ways. loss is different based on packet size loss is different based on CPU type loss is different in different testbeds The different in network assumptions, impact the mechanisms that are needed in the end application.

In this paper we first discus applications that may be especially sensitive to such variance in software/hardware environments In the methods section, we present out method In the reustl section we present out results

Our contributions are: a characterization for testbed environments we consider two testbeds characterize based on traffic mix, characterize based on unicast based on multicast, and federation links.

2 Motivation

There are more than 50 emulab-based testbeds across the world [**?**]. For example, DETERLab is one example of an emulab-based testbed located at USC Information Sciences Institute with 566 general computers and specialized hardware computers. In this paper, we will use the term Emulab to refer to all such testbeds.

Emulab-based testbeds are widely used for networking and distributed system research. These different emulab-based testbeds use a common ns-2-based experiment description for creating different topological structures and configuring the experiment nodes. This has enabled networking researchers to rapidly port experiment descriptions from one testbed to another. However, we observed very different results when using the *same* experiment description on different testbeds.

We believe these difference in results are due to variations in both the facility hardware and the software system implementations across different Emulab-based testbeds. These variations impact the measurements taken on the testbed. Researchers can rarely account for them, they are typically not adjusted for. However, they impact the repeatability and the correctness of the results.

2.1 Background

Emulab provides a common interface to configure the resources required for a networked experiment. A networked experiment consists of a network topology with one or more end hosts. The network topology defines the structure that connects the end hosts with each other. A network topology consists of nodes and links [1]

[1] Emulab also offers creating LANs using similar mechanisms that we do not discuss in the paper.

A *node* can be an end host or a router en-route to two end hosts. A node's hardware and software can be configured as part of the experiment description. The node's hardware can be chosen from a predefined set of available hardware types. The node's software, that is the operating systems, libraries and tools, can installed by the researcher. A *link* is a connection between two nodes. A link's bandwidth,delay and queuing characteristics can be configured as part of the experiment description. The link is realized using VLANs and link emulation mechanisms. The VLAN creates a virtual point to point link, possibly across multiple switches, on the testbed. The bandwidth, delay, and queuing characteristics of a link are realized using a delay node that provides the link emulation capabilities. Many emulab-based testbeds implement the delay node differently. For example, the DETERLab uses Click-based delay nodes and does not permit changing queue sizes.

Each node in emulab is connected to two networks. An *experiment network* configured based on the network topology specified in the experiment description and a *control network* that enables access to the nodes to control and configure them. In this paper we will focus primarily on the network-level characteristics of the experiment and control network and how they impact the experiment results.

2.2 Intra-testbed Links

Multicast is a IP-level mechanism to provide one to many communication. It leverages network-level functionality within the routers to replicate a packet only when the topology of the network requires it. While not used commonly on the Internet, multicast is widely used in emulab-based testbeds for experiment configuration and control. Emulab-based testbeds also provide a controlled environment to develop and evaluate multicast applications such as content delivery networks and streaming video.

We observed network-level characteristics of the multicast implementation is different on different testbeds. Also, after a recent upgrade of network switches on one of the testbeds, a multicast-based application that was working previously, stopped working. Multicast is widely used with UDP-based transport protocols. UDP is not reliable and does not guarantee the delivery of a message. Hence messages may be dropped, delivered multiple times, or delivered out of order, leading to different performance characteristics as we discuss in Section 4

2.3 Inter-testbed Links

Many networking experiments include links that span across the Internet. In such cases, the link characteristics are governed by the dynamic connectivity and congestion conditions between the two nodes. When evaluating a distributed system across such a link, it is important to correctly characterize and account of the dynamics in the network link properties.

For example, when exploring energy cyber physical models based on dependent, time synchronized CPS models spanning the across testbeds. Such models are delay sensitive and require hard real time guarantees. Hence it is important to quantify the delay properties of the underlining cyber substrate so that the models can correctly designed for this environment.

We need to have a mechanism that ensure the network-level constraints are exposed to the design of the experiment. The network-level assumption, about delay, bw, are invariant and hold throughout the duration of the experiment. Hence to expose these underlying network-level constraints and need to provide mechanisms that allow the experimenter to ensure the required invariants hold through put the experiment

Testbed environments are complex. Virtualization is prevalent, federation is common mininet and simulation environments combined with emulation for scale. Ensuring the correctness of the environment that is, making the sure the requested network-level characteristics are satisfied is not easy.

3 Methods

We use...

Loss Burst Jitter Packet size

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4 Results

We find...

5 Conclusion

yet to be done