Chapter 5

Stochastic Approximation–Based Transport Profiling for Big Data Movement Over Dedicated Connections

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ABSTRACT

High-performance networks featuring advance bandwidth reservation have been developed and deployed to support big data transfer in extreme-scale scientific applications. The performance of such big data transfer largely depends on the transport protocols being used. For a given protocol in a given network environment, different parameter settings may lead to different performance, and oftentimes the default settings do not yield the best performance. It is, however, impractical to conduct an exhaustive search in the large parameter space of transport protocols for a set of suitable parameter values. This chapter proposes a stochastic approximation-based transport profiler, namely FastProf, to quickly determine the optimal operational zone of a protocol over dedicated connections. The proposed method is evaluated using both emulations based on real-life measurements and experiments over physical connections. The results show that FastProf significantly reduces the profiling overhead while achieving a comparable level of transport performance with the exhaustive search-based approach.

INTRODUCTION

Extreme-scale scientific applications are generating colossal amounts of datasets, now frequently termed as “big data”, which must be transferred over long geographical distances for distributed processing and analysis. Such big data transfer requires stable and high-speed network connections, which, unfortunately, are not readily available in traditional shared IP networks, e.g., the Internet. High-performance
Networks (HPNs) such as ESnet (ESnet, 2017), Internet2 (Internet2, 2017), and Google’s B4 (Jain et al., 2013) that provide on-demand dedicated high-speed network connections realized by technologies such as MPLS (Andersson & Swallow, 2003) and OpenFlow (McKeown et al., 2008) have emerged to support these data- and network-intensive applications. More recently, significant progress has been made for big data movement in various aspects including the deployment of 100Gbps networks with future 1Tbps capacity, the increase in end-host capabilities with multiple cores and buses, and the use of parallel file systems. However, such technology advancement and infrastructure investment have not led to corresponding improvement in big data transfer performance, especially at the application level.

Maximizing the data transfer performance over such dedicated connections is still challenging, mainly because: i) the optimal operational zones of transport protocols are affected by the complex configurations and dynamics of the network segments, end-hosts, and protocol itself; ii) different parameter settings may lead to very different performance and oftentimes the default parameter setting does not yield the best performance; iii) due to the lack of accurate models for high-performance transport protocols such as UDT (Gu & Grossman, 2007), a widely used protocol in the HPN community (UDT, 2017a), and the complex dynamics of network environments, it is generally very difficult to model and derive the optimal parameter values analytically. For a given data transfer protocol, a careful selection of parameter values may result in a significant performance improvement over its default settings. As a motivating example, Figure 1 shows the instantaneous UDT throughput performance with different block sizes over a local back-to-back 10Gbps connection, where the performance is improved by three times on average through a simple adjustment made on the block size.

Figure 1. Instantaneous throughput measurements of UDT over a 10Gbps back-to-back connection with different block sizes