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Journal of Network and Computer Applications 29 (2006) 343–360
Journal of NETWORK and COMPUTER APPLICATIONS
www.elsevier.com/locate/jnca

Application-level network emulation: the EmuSocket toolkit

M. Avvenuti*, A. Vecchio

Dipartimento di Ingegneria dell'Informazione, Università di Pisa, Via Diotisalvi 2, I-56122 Pisa, Italy

Received 4 June 2004; received in revised form 23 December 2004; accepted 10 January 2005

Abstract

EmuSocket is a portable and flexible network emulator that can easily be configured to mimic the communication characteristics, in terms of bandwidth and delay, that occur with low-performance networks. The emulator works with Java applications by intercepting and perturbing application traffic at the socket API level. As traffic shaping takes place in the user-space by means of an instrumented socket implementation, using the toolkit does not require a modified interpreter. The way the emulator perturbs the communication preserves the TCP connection-oriented byte stream semantics.

Keywords: Network emulation; Internet application; Java; Distributed computing

1. Introduction

The ever increasing diffusion of distributed applications that communicate over wide-area or wireless networks makes it more and more critical to be able to assess system performance under realistic network conditions. The reason is that networks that connect such applications vary significantly in size and performance, and applications have to tolerate large fluctuations in the level of network service.

Unfortunately, running an application within a local area network, as is usually done during the development phase, is very different, in terms of communication behavior, from running the same application in the operational environment. In fact, the bandwidth

* Corresponding author. Tel.: +39 050 2217531; fax: +39 050 2217.
E-mail addresses: m.avvenuti@iet.unipi.it (M. Avvenuti), a.vecchio@ing.unipi.it (A. Vecchio).

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doi:10.1016/j.jnca.2005.01.002

and the latency offered by local communication may outperform by several orders of magnitude those available through long-haul or wireless connections. Such a difference makes the evaluation phase less effective and may hide important design issues that affect the user's perception of system performance. Network emulation is the preferred approach to this problem, as it can expose real application traffic to adverse and repeatable network conditions without requiring complex testbeds (Fall, 1999; Rizzo, 1997).

Despite the popularity of Java in the distributed programming arena, none of the available network emulators is particularly attractive from a Java programmer point of view. As outlined in the 'Related works' section, binaries of existing emulators are not portable across different operating systems. Some of them are not portable even at the level of source code, because they are bound to specific operating system features. Clearly, the lack of portability is in contrast with Java's goal of programming for heterogeneous hw/sw platforms. In addition, most of emulators have been conceived for studying network-level rather than application-level protocols. This network-orientation forces programmers to deal with low-level details, which are often meaningless when the emulator is used to evaluate the overall performance of applications.

Contribution. This paper describes the *EmuSocket toolkit*, a portable Java-based network emulator. Using the toolkit, distributed applications running on a single machine or in a LAN can perceive a network behavior similar, in terms of throughput and latency, to the one they would experience if they were running over a real set of hosts interconnected by either long-haul or wireless links.

The toolkit is based on the idea of inserting, in the user-space, a software layer that simulates the desired level of network service (Avvenuti and Vecchio, 2002). EmuSocket is a configurable socket implementation that intercepts and regulates the flow of data between the application and the socket API used to access the network. This solution allowed us to shape real application traffic without affecting the operating system and the network stack.

To the best of our knowledge, EmuSocket is the only network emulator written in Java that provides full source code portability. Moreover, since the toolkit implementation does not require a modified interpreter, in many cases even binaries are portable. Thus, the emulator can be used to test Java-based distributed systems and wireless applications regardless of platform heterogeneity.

As the toolkit is specifically designed to study application behavior rather than network protocols, programmers only need to make a limited effort to configure the emulator and interface it with existing applications. Also, the basic functionalities can be easily extended by adding user-defined classes to the EmuSocket package.

2. System description

The EmuSocket toolkit provides an application-level, approximate emulation of low-performance networks. In particular, the system changes the observed characteristics of the underlying network by manipulating the bandwidth and the delay involved in communication.

By *application-level* emulation we mean that (i) traffic is intercepted at the level of the socket API, (ii) emulation takes place in the user-space with unmodified interpreters,