2009 International Conference on Communication Software and Networks

A Service-oriented Framework of Distributed QoS Measurement Based on Multi-Agent for Overlay Network

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***Abstract*—Recently, overlay network is increasingly popular as a means to enhance end-to-end application performance and availability. It is a virtual network constructed over the underlying Internet infrastructure by the end systems(i.e. hosts or servers), and provides some special services. The best predominance is that overlay network can be deployed rapidly, economically and flexibly without changing the underlying communication infrastructure. Because of its advantages, More and more applications are emerged on overlay network. To suit a overlay network dynamically, knowledge about network characteristics(i.e. Quality of Service(QoS)) is necessary for overlay network applications. Overlay network applications can use the characteristics to recover from path outages and periods of degraded performance of overlay network. However, the measurement of such characteristics is often a burden on the overlay network applications because it is not their intended purpose. So as one solution to this problem, this paper presents a service-oriented QoS measurement framework through the introduction of multi-agent technology. The framework is distributed, scalable and cooperative, and it can provide a independent service for overlay network applications that measures the QoS parameters.**

Keywords—Overlay Network; Quality of Service(QoS); QoS Measurement; Multi-Agent

I. INTRODUCTION

With the development of computer network, Internet has been becoming an important part of the main streaming of human being. A large number of new applications, especially, many new multimedia applications, such as video conference, video-on-demand and distance learning, are emerging on Internet. And people require Internet to be with large-scale extensibility, guarantee of quality of service, supporting mobility, security, creditability, reliability and manageability, and so on. But existing Internet has been unable to meet the people's growing demand for new services. As a solution to the existing problems of Internet, overlay network is increasingly popular, and a series of service solutions including quality of service, multicast, mobility, content delivery, event service, etc. have been proposed. Overlay network is a virtual network constructed over the underlying Internet infrastructure by the end systems(i.e. hosts or servers), and provides some special services. The best predominance is that overlay network can be deployed rapidly, economically and flexibly without changing the underlying communication infrastructure[1][11].

Because of its advantages, more and more applications are emerged on overlay network, and in order to adapt to overlay network conditions dynamically, knowledge about network characteristics(i.e. Quality of Service(QoS)) is necessary for applications. Applications can use the characteristics to recover from path outages and periods of degraded performance of overlay network. Interest in measuring overlay network characteristics continues to grow. Currently, applications on overlay network perform measurement by themselves. However, the measurement of such characteristics is often a burden on overlay network applications because it is not their intended purpose[3]. Moreover, this situation is a waste of resources for some network characteristics(RTT, throughput, etc.) are communal among applications and portions of measurement data can be reused. So as one solution to this problem, this paper presents a service-oriented QoS measurement framework which can provide a independent service for overlay network applications that measures the QoS of overlay network through the introduction of multi-agent technology. The framework is composed of measurement agents that run on monitoring nodes and carry out all the measurement procedures. Furthermore, the framework is distributed, scalable and cooperative, and it enables the application developers to make use of the overlay network characteristics and to avoid the measurement cost.

The rest of this paper is organized as follows: Section 2 depicts the survey of overlay network briefly; Section 3 proposes the architecture of the framework and implementation of measurement agent. Section 4 details and analyzes the network characteristics which are measured on a test bed of overlay network. Section 5 finally concludes the paper.

978-0-7695-3522-7/09 $25.00 © 2009 IEEE
DOI 10.1109/ICCSN.2009.15

II. BRIEF SURVEY OF OVERLAY NETWORK

Overlay network is a virtual computer network which is built on top of another network such as the Internet, as seen in Figure 1. The overlay nodes is a subset of the underlying network nodes and the overlay links are virtual paths which may consist of many physical links in the underlying network. Overlay nodes act as user-level routers, forwarding packets to the next overlay link toward the destination. At the physical level, packets traveling along a virtual link between two overlay nodes follow the actual physical links which form that virtual link. Overlay network can be used to change part of the properties of the underlying network, facilitate deployment of new functionalities, and provide value-added network services. As it does not need to modify the underlying network infrastructure, and can be used to deploy new emerging applications.

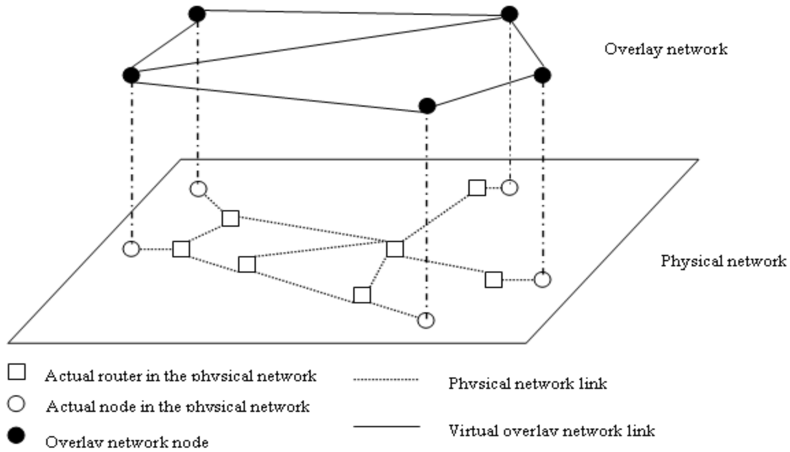

Figure 1. An overlay network example.

Overlay network has been proposed as a way to improve Internet routing, such as through quality of service guarantees to achieve higher-quality streaming media, and overlay network can be incrementally deployed on end-hosts running the overlay protocol software, without cooperation from ISPs. Comparing to the existing network, overlay network has the following metrics[11]:

(1) Overlay network can easily provide new services to implement in the current network infrastructure, and can provide developers with a flexible and powerful platform on which to create new services.

(2) We can use overlay network to fast deploy application services without changing the existing global network protocol stack and upgrading the Internet routers.

(3) Overlay network can effectively avoid burdening the underlying network and utilize application-layer information to provide better services.

(4) Overlay network can take advantage of processing, memory, and permanent storage available at overlay nodes to perform tasks.

III. OVERALL ARCHITECTURE OF THE FRAMEWORK

The framework is completely composed of test agents which are programs running on the overlay nodes. The test agents perform all the measurement procedures cooperatively and obtain the required QoS parameters that can be used by overlay network applications. The framework is an end-to-en model, and passive measurement is used in the framework. Figure 2 shows the overall architecture of the framework.

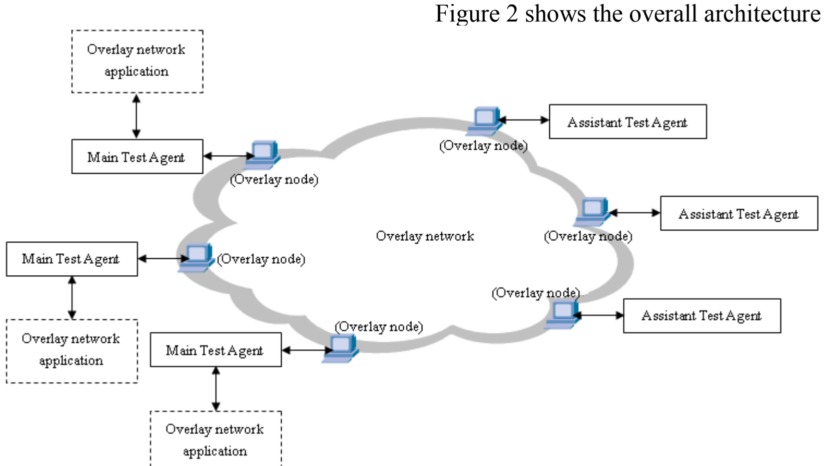

Figure 2. Overall architecture of the framework

There are two types of test agent in the framework. One is Main Test Agent, the other is Assistant Test Agent. The details of them will be described later. Many test agents can be deployed in the framework, and these test agents are divided into a lot of groups. One group concludes two test agents which are one Main Test Agent and one Assistant Test Agent. One Main Test Agent with one Assistant Test Agent can finish a test to get QoS parameters of overlay network. Main Test Agent also has a service interface that can be requested for QoS parameters by overlay network applications and provide QoS parameters to overlay network applications.

IV. IMPLEMENTATION OF THE TEST AGENTS

Here we describe the design and implementation of Main Test Agent and Assistant Test Agent. Main Test Agent is composed of five components: a database, a service provider, a test manager, a test packet generator and a test data gather. Figure 3 shows the logic structure of Main Test Agent.

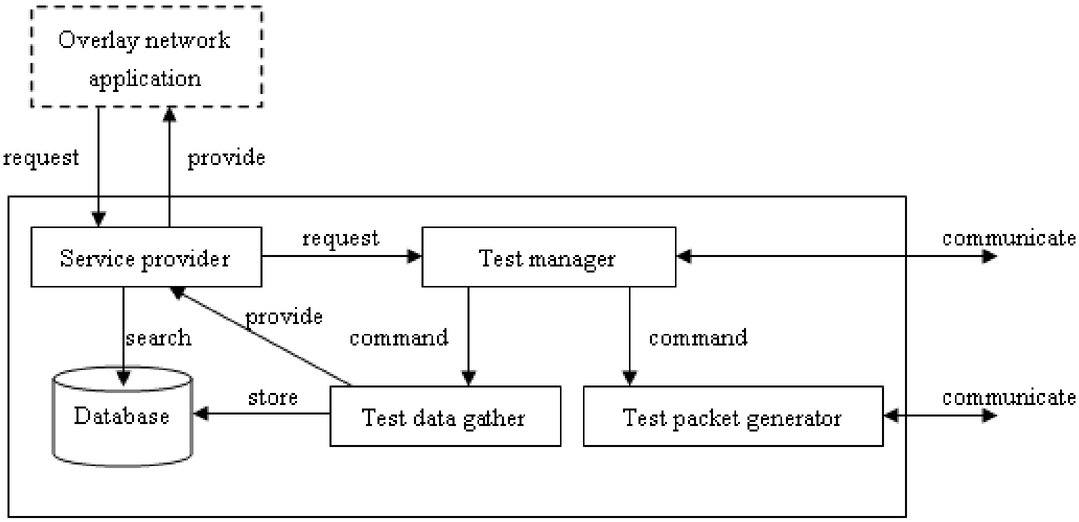

Figure 3. Logic structure of Main Test Agent

The database is a repository of QoS parameters that are collected by measurements. The service provider is an interface between a Main Test Agent and an overlay network application. An overlay network application requests its required QoS parameters from the interface, and the service provider performs a decision-making procedure based on the request to provide the QoS parameters. The decision-making procedure includes two policies: **Policy 1**. When the service provider accepts the request for QoS parameters from an overlay network application, to reduce test costs and improve responsiveness, it firstly searches for the QoS parameters in the database. If the service provider can get the QoS parameters from the database, it directly sends the QoS parameters to an overlay network application, or else, the policy 2 of the decision-making procedure will be performed. **Policy 2**. When the service provider can not find the QoS parameters that are requested from an overlay network application in the databse, it makes a request to the test manager to measurement the QoS parameters which an overlay network application needs with the help of Assistant Test Agent. The test manager is the test control center which constructs test instructions according to the request inputted from the service provider, and commands the test packet generator and the test data gather to finish the measurement cooperatively, and also consults with the test manager of Assistant Test Agent on measurement. The test packet generator answers for constructing test packets according to the test instructions that the test manager commands, and executes a test by actively sending the test packets to Assistant Test Agent via overlay network. The data gather presides over collecting QoS parameters, and sends the QoS parameters to the service provider, and at the same time the data gather stores the QoS parameters into the database.

Compared to Main Test Agent, the constitute of Assistant Test Agent is simple, which is composed of test manager and test packet receiver. Figure 4 shows the logic structure of Assistant Test Agent.

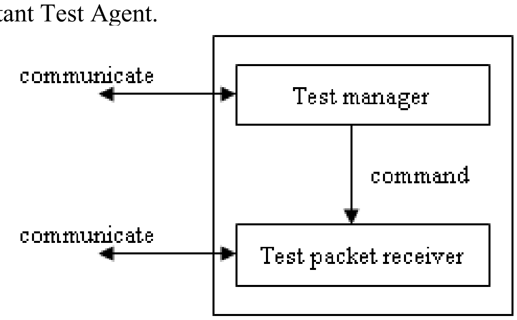

Figure 4. Logic structure of Assistant Test Agent

At the beginning of measurement, the test manager communicates with the test manager of Main Test Agent to consults the test instructions, and commands the test packet receiver to collaborate with Main Test Agent to perform a test. The packet receiver receives the test packets transmitted from the test packet generator of Main Test Agent and cooperates with Main Test Agent to accomplish a test.

V. EXPERIMENTS

In this section, to illustrate the scalability and availability of the framework, we measurement the QoS parameters of throughput and round trip time on a testbed using our framework. The topology of the testbed is shown in Figure 5.

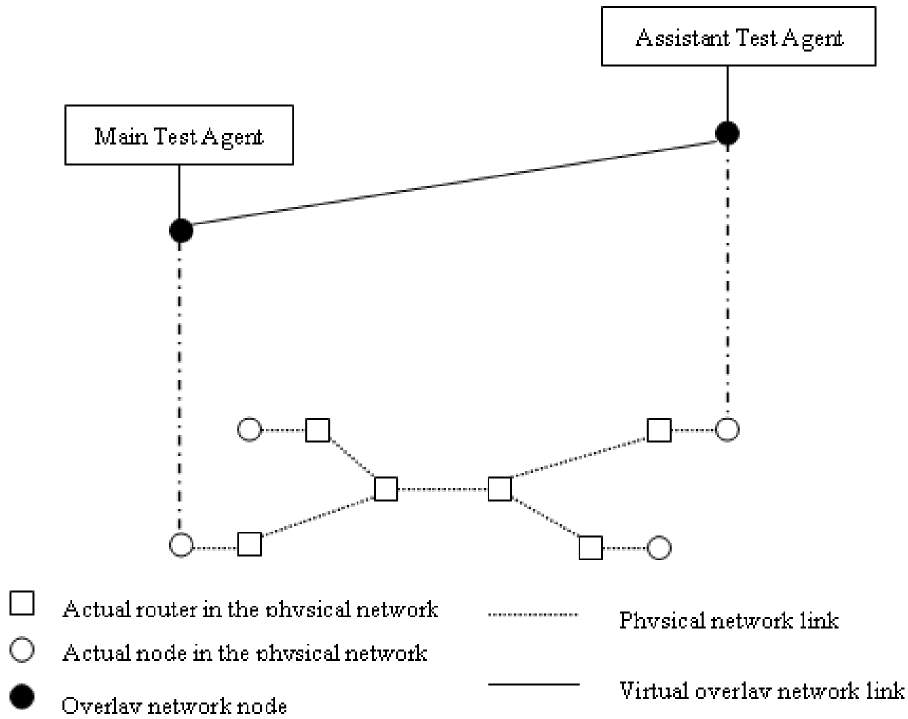

Figure 5. Topology of the testbed

Throughput is valuable in understanding end-to-end performance. Figure 6 shows the throughput results of the testbed for different packet size. The results in Figure 6 show that the throughput becomes bigger with the increase of the packet size.

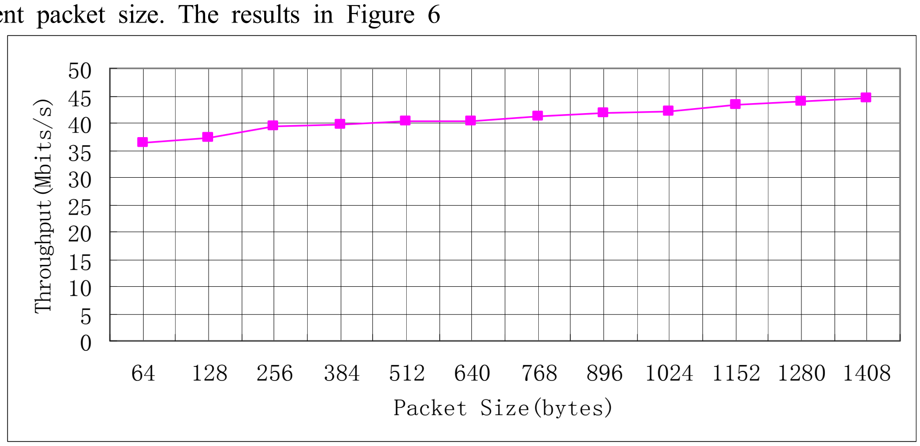

Figure 6. Results of throughput

Round trip time(RTT) is another metric in understanding end-to-end performance. Figure 7 shows the round trip time results of the testbed for different packet sizes. From the results in Figure 7, we discover that the larger the packet size is, the round trip time is longer.

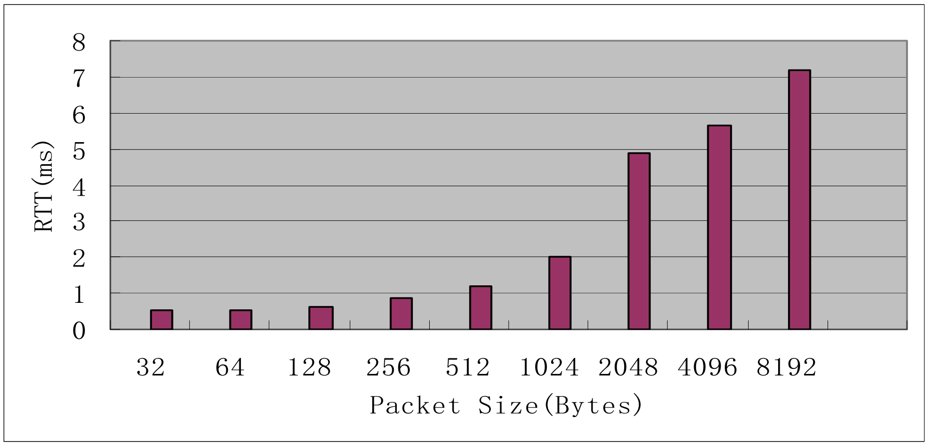

Figure 7. Results of round trip time

VI. CONCLUSION

In this paper, we proposed a service-oriented QoS measurement framework based on multi-agent. The framework can provide required QoS parameters for overlay network applications, and can reduce the measurement costs of overlay network applications. The framework is distributed, scalable and cooperative, and final experiments shows that the framework is available for providing a measurement service for QoS parameters to overlay network applications.

ACKNOWLEDGMENT

The helpful comments from anonymous reviewers are gratefully acknowledged.

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