SHPSIM: A Simulator for Structured Hierarchical Peer-to-Peer Protocol

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***Abstract*—** when new network architecture is designed, it is usually not possible to practically implement it and then test for the various pitfalls and shortcomings as it may require huge amounts of resources and time. Hence, before deployment, the network is simulated using a computer simulator in which hundreds of nodes can be tested for various parameters such as the performance in searching for a data item, cost of adding nodes to the existing network, scalability, bandwidth consumption, etc. A computer simulation is an attempt to model a real life or hypothetical situation on a computer so that it can be studied to see how the system works. The paper describes the ShpSim developed for structured hierarchical p2p protocol.

***Keywords*—** Simulator, structured hierarchical p2p, ShpSim, Event, Query.

I. INTRODUCTION

A simulator is a device in which a simplified model of the system under consideration is run in a controlled artificial environment for studying. Simulations are performed because it is usually too costly, too dangerous or perhaps infeasible to study the system in it's actual environment. Simulator is one of the most powerful tools available to decision makers responsible for the design and operation of complex process and systems. It makes possible the study, analysis and evaluation of situations that would not be otherwise possible. With the increasing challenges of technology development simulation becomes the most suitable methodology for problem solving for engineers, designers and managers. Simulation enables the study of, and experimentation with, the internal interactions of a complex system without the real presence of that system. The changes in environment, its effects can be observed which helps in a greater amount in suggesting improvement in the system. It can be used to experiment with new designs or policies before implementation, so as to prepare for what might happen. And thus the estimates for cost and performance can be made based on the simulation models and the simulators before implementing the system. Moreover, using a simulator, a system can be considered to be having uniform characteristics throughout and having no effect of environmental factors that might introduce uncertainty in the results. Hence, we can get the actual characteristics of the system under study.

A typical computer network consists of thousands of nodes. When a new network system is designed, it is often desired to know how the new network will perform in the real world. However, it is not possible to actually implement the network for the purpose of studying it. This is due to the reasons stated as – cost will be too high in using real hardware, too much time would be required to test the network for a variety of scenarios and any change would require reconfiguring all the machines in the network to reflect the change.

A. Peer-to-Peer

1) The Peer to Peer system is defined as an autonomous, self-organized, scalable distributed system with shared resource pool without a single point of failure in which all nodes have identical capabilities and responsibilities and all communications are normally symmetric; and where main characteristics of the participants are decentralized resource usage and decentralized self-organization.

B. Structured P2P

In structured p2p system the query is executed within deterministic steps. The structured p2p system maintains a DHT (Distributed Hash Table) or a graph to identify all peers and data. A detailed discussion of a structured p2p protocol is done in [9].

II. SURVEY

Before devolpment of ShpSim simulator a thourough survey had done to find out a suitable simulator for structured p2p systems. It came across planetSim [4], overSim [2], omnet++ [21], openChord [8], peersSim [12], p2pSim [14], agentJ [19], GPS [22], 3LS [20], neuroGrid [6], narses [13], DhtSim [3], overlay weaver [16] etc. The planetSim is an overlay network simulator. It is developed using Java. Chord [18][17] and Symphony [10] have been implemented in planetSim. The overSim is an overlay and open source p2p simulator which is
based on omnet++ framework. It is flexible as it can simulate both structured and unstructured overlay networks like chord, pastry [15], bamboo and koorde [7]. The omnet++ itself does

not provide components for simulations, instead there are simulation medels and frameworks which are used with it. Omnet++ has extensive GUI support, and due to its modular architecture, the simulation kernel can be embedded easily into different applications. The open Chord provides an interface for Java application where peers take part within the DHT and arbitrary data are stored and retrieved. In case of openChord, the time complexity of simulation increases exponentially with increase in the number of nodes. The peerSim simulator has been designed to be both dynamic and scalable but due to the lack of documentation the performance
is quite unknown. The p2pSim is a multithreaded, discrete event simulator which runs in several unix like operating system and doesnot provide any simulation visualization or a GUI support. The agentJ uses the popular and well-established NS-2 simulator. The GPS (general purpose p2p simulator) is described as a message-level simulator, which works at the application level of the network stack. It provides a GUI for the visualizations of a simulation. The 3LS (3 level simulator) is developed to simulate unstructured overlay like gnutella 0.4 [1][5]. The neuroGrid is a single threaded, Java based, and discrete event simulator. It is designed to work with distributed and decentralized networks. The narses is a scalable, discrete event, flow based network simulator designed to avoid overhead of packet level simulator. Narses does not contain implementation of any overlay protocols. The DhtSim is a event simulator for structured overlays. It does not include much functionality for extracting statistics. An overlay weaver simulator supports routing algorithm such as chord, kademlia [11], koorde, pastry and tapestry [23].

III. SHPSIM

The SHP is designed using 3-tier hierarchy. The participating nodes are classified according to their stability, performance, and amount of time in the network. These are temporary node, stable node and fully stable node. Temporary nodes are normal nodes which just enter into the network access the resources and leave without affecting the system performance. Temporary nodes are upgraded to stable nodes after satisfying some resource requirements and timestamp. Fully stable nodes are the highly stable nodes in the network and these are used to connect different stable nodes to from a group. In the survey of simulators for P2P systems, it studied three standardized simulators, namely overSim, openChord and planetSim. Each one of them has their own advantages and disadvantages. However, it could not find any standardized network simulator that supports the simulation of hierarchical P2P systems. Hence, it leads to develop a simulator that simulates SHP to give an insight into how the system performs. The ShpSim is a p2p simulator designed to simulate SHP protocol [9].

A. Assumptions

A model of a system is a simplified version of a system and in simulation; it often takes a simplified environment. Hence, some assumptions are made for the process of simplification and make the simulation easy to run and also focus on only the relevant parts of the system.

The following assumptions are made while developing the simulator-

1) There is no packet loss in the network.
2) The bandwidth is infinite.
3) Latency in the network is zero.
4) No nodes crash.
5) Loads are evenly distributed among the nodes.

B. Features

1) Open Source simulator - Free to modify and more networks can be easily added by other developers.

2) Event driven simulation - The simulator is event driven, hence suitable for executing a large number of events in a small time.

3) Event file - All simulation events are stored in an event file and the same simulation can be run any number of times.

C. Steps to simulate in ShpSim

The simulator is run in the following steps-

1) Generate Event File - In this step, an event file is generated according to user chosen parameters such as size of network, number of events, etc. The events are completely random. The user input data for the generation of events file are:

a) T STABILITY : Time required to make a node fully stable
b) T AVG : Time required to make a node stable
c) Number of Nodes in each Group: The maximum number of nodes in a group
d) Number of Groups: Maximum number of groups in the network
e) Key interval: The interval between the data keys generated
f) Total number of Events: The total number of random events that are to be simulated.

2) View Event File - This is an optional step in which users can view the event file generated and see each event that occurs with its respective timestamp.

3) Simulate SHP - This step starts the simulation of a structured hierarchical P2P network with events taken from the event file.

D. Comparison

In this section, comparison is done between two by observing the simulation results. A comparison of

ShpSim with OverSim, open Chord, and planetSim simulators is given in Table-I.

TABLE I

COMPARISON OF SIMULATORS

	overSim	openChord	planetSim	ShpSim
GUI	Yes	No	Yes	Yes
Source Code	Open	Open	Open	Open
Network supported	Many	One	Few	Two
Finger Table	Viewable	Viewable	Viewable	Viewable
Manual events possible	No	Yes	Yes	No

IV. Conclusions

ShpSim is an open simulator which forms a networking environment and simulates it with the structured hierarchical protocol (SHP) designed for hierarchical P2P networks. ShpSim forms the network with events generated randomly according to the parameters specified by the user. The workload of the network considered here is the number of messages passed during each event in the network. The simulator is programmed with Java in the netbeans environment and is completely modular. The modules are connected in a hierarchical way, and are also compound modular. There is the advantage for the extension of the simulator to implement other network protocols for the P2P environment by using the same network environment, only the algorithms need to be implemented on the network already formed. The aim of the simulator is to observe the messages passed which signifies the performance of the network protocol used and to strive for more efficient protocol, if any implemented further by the user. Thus comparison of different protocols can be done and the best algorithm can be chosen.

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