3LS - A Peer-to-Peer Network Simulator

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Abstract

Peer-to-Peer (p2p) networks are the latest addition to the already large distributed systems family. With a strong emphasis on self-organization, decentralization and autonomy of the participating nodes, p2p-networks tend to be more scalable, robust and adaptive than other forms of distributed systems. The much-publicized success of p2p-networks for file-sharing and cycle-sharing have resulted in an increased awareness and interest into the p2p protocols and applications. However, p2p-networks are difficult to study due to their size and the complex interdependencies between users, application, protocol and network. This paper presents a 3-level simulator designed to study complex p2p networks.

1. P2P-Network Simulation

The field of P2P networks is still undergoing major changes with new applications and protocols emerging on a nearly monthly basis. However, due to the difficulties in evaluating them prior to their large-scale deployments, they are often short-lived – disappearing as fast as they emerge – normally due to bad performance. What seemed to work well when using a small number of nodes, high bandwidth, low latency, attractive services/content and highly cooperative users often fails in real world deployments.

Testing a system performance prior to its deployment is a fairly common element in the software development of applications.

P2P networks tend to be large, heterogeneous systems with complex interactions between the physical machines, underlying network, application and user. Hence, testing of a "running" p2p-network or protocol in a realistic environment is often not feasible. However, it is possible to use a simulation of a p2p-network to evaluate the applications and protocols in controlled environment.

Researchers, who wanted to simulate a p2p system, tend to avoid the development of a complex simulator and focus on some selected areas (such as caching schemes). While some may choose to start an implementation from scratch an increasing number of researchers build their simulators on top of existing tools (e.g. the agent platform JADE [2]) to speed-up the development. The general problem of having only special-purpose simulators is that the results obtained with one simulator are difficult to validate and often impossible to achieve with another simulator due to the many hard-coded assumptions of every simulator.

Figure 1 shows a high level view of the 3LS simulator. 3LS is a time-stepped simulator that uses a central step-clock is used to simulate the timing. In 3LS the models for network, p2p protocol and user model are clearly separated. With the separation of the network, protocol and application model from each other, the simulation of various network topologies, for different protocol, applications, and user models becomes possible. Hence, three levels have been defined:

- Network level (bottom),
- Protocol level (middle) and
- User level (top).

Communication can only happen between the directly connected levels. The protocol-level, that is responsible for simulating the p2p-protocol and application, and serves as the interface between the user-level and the network-level. Input information from the user is fed into the network level through a GUI interface or a file. Upon starting the simulator it is possible to either create the models (fig. 2) for the three described levels or to choose among a library the ones most suited models/combination for the simulation run. As the simulation is running, the events are displayed on the command prompt screen. After the simulation has been completed, all simulation data is saved into a file for future analysis. Though simulation languages provide most of the features needed in programming a simulation model and the details of the simulation models can be easily changed, a general-purpose language was selected to provide "greater programming flexibility". Since Java is the preferred language of many p2p programmers it was chosen as the host-language for the 3LS simulator. Visualization of the network is done with the aid of the tool

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AiSee [1]. AiSee was selected for its, ease of use, simple installation, availability (runs under various OS), functionality and performance in rendering. When screenshots of the p2p-network are to be visualized, files containing the information of the graph are created by 3LS using the Graph Description Language (GDL). Once the file is created a user can use AiSee to render an image of the graph (see figure 3).

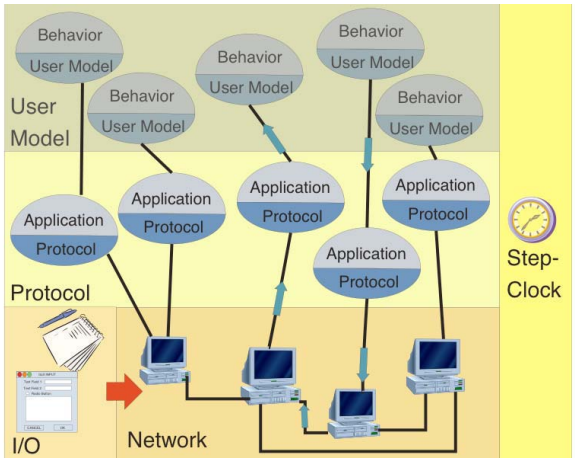

Figure 1: Architecture of the 3LS

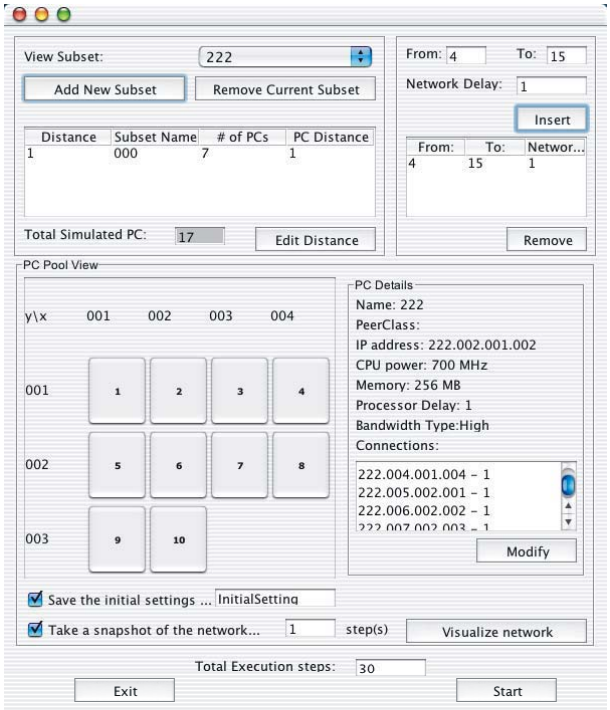

Figure 2: Screenshot of 3LS – Network-Model

2. Future Work

Future work focuses on collecting data for the various layers e.g. human desktop usage and network traffic. We are currently testing the simulator by comparing its results for a Gnutella 0.4 network [3] with the "real data" obtained from running Gnutella 0.4 clients in a controlled network. Using Comtella [4] clients we are able to adjust the various parameters of the simulation and verify the simulation results. Early results in a small network (less than 20 nodes) indicate that the simulator works as expected but more testing is needed.

3. Code

The complete code of the 3LS simulator is available upon request by sending an email to one of the authors. 3LS requires a Java 1.3.1 or higher version of the JDK.

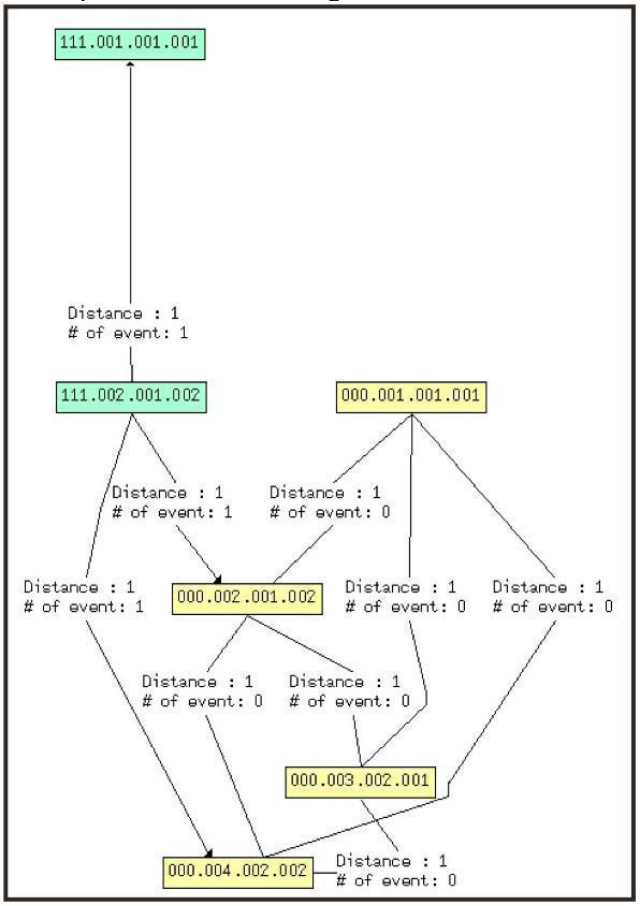

Figure 3: Example of network view using AiSee.

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