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AN EXECUTION MANAGER FOR PARALLEL SIMULATION EXPERIMENTS WITH NS-3

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1 Part A

1.1 Project Description

Scientists and engineers seek to quantify the performance of many different systems ranging from processes in the natural physical world to engineered machines systems. In many of these applications, we seek to quantify the effect of changes to the system. Analyzing this behavior through computer simulation can provide insight into the behavior of systems which would otherwise be prohibitively expensive to construct, dangerous, or otherwise difficult to observe.

The specific application of interest in this project is the simulation of computer networks. Computer simulation allows one to study networks of thousands of wired and wireless computers under arbitrary scenarios of operation. Simulation can help researchers evaluate design options for various communication protocols or help to understand how well networking hardware performs in new or different applications.

In order to produce credible and accurate simulation results, however, the user who conducts experiments must follow proper simulation methodology. This includes proper experiment setup of valid models and parameters as well as the application of statistically sound output processing techniques. Many of the steps necessary in proper simulation methodology and statistical analysis are often taken for granted, as indicated in the literature [4]. For this reason, it is important for different simulators to include tools for model development and experiment automation so that the user can be assured that results are accurate and all the proper methodology was applied [6].

In addition to enhancing the credibility of simulation studies, a framework for experiment automation can provide the simulation user with the following features and capabilities:

- The framework can be used to distribute simulation execution to multiple computers so as to reduce the amount of time taken in running the experiment.
- The framework can help a novice simulation user through the process of constructing valid simulation experiments. This is particularly important in simulators which are complex and can be difficult to configure.
- The framework can provide functionality for the user to generate plots of collected data that include confidence intervals for the metrics estimated with simulation.
- The framework can also be used to share results over the Internet through the use of a web interface. This enhances the credibility of published results as the authors of scholarly articles can provide online access to the results they generate and to their experimental setup. This is important because it enables third parties to reproduce the results published in scholarly articles.

In this project we propose to build such an experiment automation framework for the popular network simulator ns-3 [2].

1.2 Methods

In order to provide a comprehensive suite of tools for both the novice and the experienced user, we will develop two types of interface to this framework: one to be used from command line terminals and another to be used through a standard web browser. The command line interface will allow access to more advanced functionality and customizability.

To reach these goals, we will use an eXtensible Markup Language (XML) based language to describe the simulation models and the experiment configuration. The development of these languages has largely been done in previous independent studies (CSCI 378) by myself and Andrew Hallagan (BSCSE '11).

The web interface will be developed using the popular web application development framework Django. The web application will provide many different user functionalities including the novice user model configuration, experiment automation, results analysis and post processing including plotting, and a mechanism to publish results to the web.

A database will be used to store all of the simulations, configurations and results. Having a single place to store all the experiments' data will allow all the different components of the framework to have easy access to the same dataset. Furthermore, managing the data will be less cumbersome to the user.

In order to take advantage of the computational resources available at Bucknell University, or any other facility that may use our software, it is important to be able to distribute simulations to run on multiple different computers in parallel. By doing so we can reduce the amount of time an experiment takes to complete. This functionality will be accomplished through the use of the *client-server model*. A central server will dispatch the simulations of an experiment to other computers. The clients will receive simulations from the server, execute them, and report back results to the server. As the clients execute on different computers, they will run experiments in parallel, what will reduce the total time spent in simulations. This model is similar to that used in the Akaroa Project [5, 1].

1.3 Outcomes

In the summer of 2008, I worked with Dr. Perrone on developing a similar tool called SWAN Tools [7] for the Simulator for Wireless Ad-Hoc Networks (SWAN). The tool was a proof of concept prototype as SWAN cannot be redistributed due to the licensing restrictions in one of its models. We published the details of the SWAN Tools architecture as articles in two international conferences and have gained the attention of many in the simulation community. In this project we will take the lessons learned from SWAN Tools and develop a more sophisticated, robust, and flexible framework for ns-3. This framework has been proposed for development under the funding of a NSF grant which is currently under review. The ns-3 community has expressed a need for such a framework, and it is expected that this project will be widely used by many researchers in the field of network simulation. Our current design for this framework will be presented in the ns-3 Workshop (WNS3) co-located with SIMUTools 2010, in Torremolinos, Spain, where Andrew Hallagan and I will also present a poster about the prototype we built in the fall.

We expect that we will be able to write additional papers about this automation framework for ns-3, which we will make available to a large community of users. Finally, I expect that this project will lay the groundwork for the honors thesis that I will write in the next academic year.

1.4 Timeline

The development of this framework can be broken into a phases, each of which is expected to take approximately two weeks. The first phase of the project will be to create a database for the framework, which will store the configuration files for experiments together with the simulation result. This will implement and extend the work that Andrew Hallagan and I did last fall in our computer science independent study courses (CSCI 378). The second phase will the creation of a program that generates the simulations runs to execute and create the server process which will dispatch them to remote clients. The third phase will include instrumenting client simulations to report results their to the dispatcher. The last phase will be the creation of tools to help users analyze and manipulate results, that is, as a plotting utility similar to that which was developed for either SWAN Tools [7] or ANSWER [3].

2 Part B

2.1 Research Environment

To develop and test the project I will make use of Bucknell's network of workstations and potentially the computing cluster. I will also have access to Dr. Perrone's research cluster, which has 16 processors. The project will be developed using exclusively open source software including but not limited to Python, Django, MySQL, and the network simulator ns-3 itself.

Dr. Perrone will work with an "open door" policy for research, so I will be able to consult with him at any time during the summer. We will also have scheduled meetings a few times a week. We will both be in close communication with the developers of ns-3 so that we can negotiate any changes that need to be made to the simulator itself to make this framework possible.

References

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