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THE DESIGN OF WEB-BASED INTERFACES FOR A SIMULATION WORKFLOW SYSTEM

GREG SCHROCK

CLASS OF 2016
BOX C0781
BU ID: 11307514
CELL PHONE: 301-268-4854
gls022@bucknell.edu

LUIZ FELIPE PERRONE (FACULTY MENTOR)
ASSOCIATE PROFESSOR
DEPARTMENT OF COMPUTER SCIENCE
perrone@bucknell.edu

Greg Schrock

PART A

PROJECT DESCRIPTION

The value of computer networks in our modern world cannot be overstated. History has shown that computer networks have had significant influence in shaping the modern world. Today, the Internet has grown to reach most of the planet and is transforming the lives of those with whom it comes in contact.

As existing networks grow and new networks are created, engineers must resort to computer simulation so they can understand how well a network design will operate before it is implemented. The vast possibilities for network topology and the sheer number of devices now being connected to a given network makes it nearly impossible to physically implement and connect a network of devices in order to test its reactions to various scenarios and operating conditions. This can produce a great deal of uncertainty as developers attempt to produce new forms of networks to accommodate the rapidly evolving world of connectivity.

Because it is very important to know the expected behavior of a network prior to its deployment, an incredibly useful means of dealing with this network testing dilemma is simulation. Simulation benefits an engineer in at least two very important ways. First, it allows one to test various aspects of a design without needing to physically build the system. In the absence of simulation, the amount of time and money that are required to physically assemble a network capable of testing a given design grows disproportionally with the number of computers involved. Thus, physical experimentation with large-scale network designs is simply impractical. Second, simulation allows engineers to work in an experimentation environment where models of network designs are fully controllable and observable. The experimenter can not only expose network simulation models to a wide variety of test scenarios but also observe the reaction of any performance metrics of interest. The combination of these factors makes simulation very interesting and oftentimes preferable to experimentation with physical network prototypes.

While there are clear advantages to using simulation for evaluating the performance of a network prototype, it is very difficult to run simulations in such a way that the results are credible. Initially, one must create a model that captures the behavior of the real network and that includes only the aspects of interest to the engineer. Then, an experimental scenario must be specified, which involves defining the components of a network, how they are interconnected, and how they are subjected to a variety of test conditions. Finally, one must execute the simulation program, collect and organize the data it produces, and display them to the experimenter in an easy to interpret format. A small mistake in any one of these steps can compromise the validity of the results. As the literature indicates many experienced researchers have introduced errors in one or more of these several steps. [4] [10] [13]

Fortunately, computer software can be written to help experimenters avoid mistakes in simulation. [5] [6] The use of *workflow software* to guide a user through complex scientific experimentation is becoming popular. Workflow applications leverage a collection of tools to ensure that appropriate experimental procedures are followed. These applications allow a standardized development process and help to ensure the integrity of the results. Workflow tools also allow step-by-step replication of a scenario. Because repeatability indicates the reliability of an experiment, this reproduction of distinct conditions can greatly improve verification. Up until now, this type of software has very rarely been applied to modeling and simulation. [14] However, this is an ideal utilization of this software that could enhance simulation by improving results, making the development process more efficient, and producing a more user-friendly experiment design and execution experience.

My efforts this summer will benefit the Simulation Automation Framework for Experiments (SAFE), a project which was financially supported by the National Science Foundation for the last four years. [9] SAFE supports the popular *ns-3* network simulator by providing a workflow environment that enforces best-practice simulation methods, implements tools for proper data analysis, and makes the simulator easier to use for experienced users and novices alike. [7] When using *ns-3* by itself, the user is in charge of every step of the experimental process: defining the experiment parameters, running multiple replicas, collecting the output data, storing it, and processing and creating visualizations from it. The simulator doesn't help in any of these steps, other than in running the experiment. If a researcher doesn't take care of recording the experimental scenario to distribute together with the results of a study, other scientists cannot possibly reproduce and verify the correctness of the experiment. SAFE takes all this burden from the experimenters' hands and automates the entire process.

Currently, SAFE provides only command-line tools that have to be invoked from a terminal. Although these tools are comfortable and useful for experienced users, they are still too complex for the average novice (like an undergraduate student, for instance). However, in its next stage of development, the SAFE project will create a web-based application to provide a higher layer of abstraction and address the needs of novices. My research project this summer will be the design and the implementation of this web-based user interface. The functions that my work will provide will be carried out through a normal web-browser and will include: configuring an experiment, launching and monitoring its execution on one or multiple computers, and visualizing the output produced. This work will build upon the contributions of other Bucknell undergraduates. [1] [2] [3] [8] One of the most important aspects of this new web-based interface is that it will allow undergraduates who study computer networks to perform simulations they otherwise would not be able to stage on their own.

METHODOLOGY

In the process of developing this project, there are a number of technologies which I will need to study and evaluate before considering them for adoption. One example is the Django web-application framework, which is based on the Python programming language. This will allow me to expand my proficiency with Python, which I have used extensively in introductory courses for my major in Computer Science and Engineering. I expect that Javascript will also be an invaluable technology which I will need to learn, as this project requires me to build a state-of-the-art web interface. The design process will require considerable research into the fields of user interface design and Human-Computer Interaction (HCI). I will have a number of references for this purpose including. [11] Furthermore, I will critically evaluate the work of others who have attempted similar interfaces and learn from their products. [12] In this process I will be expanding upon the efforts of a number of previous students who have worked in developing this project through summer research, independent studies, and honors thesis. These tools and skills that I will develop are highly valued in industry and academia, and achieving a high level of proficiency with them will be invaluable in my future endeavors.

OUTCOMES

There are two major outcomes I envision to result from my summer work. First, I will develop the described software interface to enhance the SAFE project and allow workflow guidelines and ease of use for novices. All software, when produced, will be released publicly so that others in the ns-3 community can use and improve upon it. Secondly, my mentor and I intend to write a paper to disseminate the lessons learned with the design of this web-based interface, placing our contributions in the context of the state-of-the-art.

TIMELINE

I will first spend a few days in familiarizing myself with the SAFE system so that I am aware of the design requirements as I do my research. I then expect to spend one to two weeks reading and researching literature and books on topics of GUI design and HCI. Throughout this time I will also learn the Django framework and Javascript essentials. I will spend at least one more week experimenting with the interfaces of other projects such as Akaroa2 [12] and OMNeT++. In this time, I will critically evaluate their designs based on what I will have learned in the first two weeks of preparation. Most likely, I will spend several subsequent weeks crafting and refining prototypes of my web-based interface for SAFE. Finally, I anticipate that the remainder of my time will be required to iterate through development, debugging, and evaluation of my contributions.

PART B

RESEARCH ENVIRONMENT

Throughout the course of the summer, I will be in close contact with Professor Perrone. We will have daily meetings in the morning and will work with an "open door" policy through the rest of the day so that I may, at any time, approach him with questions and concerns as I go about my work. Professor Perrone will be on campus throughout the course of the project and will be working closely with me in my endeavors.

My research will be performed on campus at Bucknell. The Breakiron 167 computer lab will be my primary place of work and I will also have access to Linux and Macintosh machines in Breakiron 164 for my project. Through Bertrand Library and Prof. Perrone's personal collection, I will have access to books for my investigation of user interface design, DJango, Javascript, and other programming technologies. I will also have access to digital libraries (ACM and IEEE) for research into the state-of-the-art of computer simulation.

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