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User Interfaces for the Simulation Automation Framework for Experiments

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ABSTRACT

This poster describes the development of user interfaces for the Simulation Automation Framework for Experiments (SAFE). The overarching goal of this project is to provide assistance to users of the popular *ns-3* network simulator, so that they can rely on the framework for tedious and/or error-prone activities in the configuration, execution, and output data analysis of an experiment. In a certain sense, SAFE is a "computer aided-simulation" tool with differentiated user interfaces for novices and experienced users. We illustrate how these interfaces work via their application in the workflow of a typical simulation experiment defined according to the multiple replications in parallel paradigm. Most importantly, the poster focuses on recent developments in the construction of a web-based user interface and a module for the graphic visualization of simulation results.

1 USER INTERFACES

Perrone, Main, and Ward (2012) describe the goals and the general architecture of SAFE. The use cases of the framework include provisions for user interfaces to support the work of experienced users (those with solid knowledge of network simulation with *ns-3*) and of novices (possibly students), who have too little expertise to create simulation programs and to define reliable simulation experiments. Most of the experienced user interface is realized by applications and scripts accessed from the terminal and work nearly directly with SAFE's core backend, which is written in Twisted, a Python-based network programming engine. The use cases for novices are addressed by a web-based interface (WUI), based on the Django web development framework, written in Python around the *model, template, and view* design pattern. This additional interface implements a higher-level layer of abstraction that builds upon the functionality provided by the core backend.

2 VISUALIZATION

Since its conceptualization, the design goals of SAFE have included the functionality to allow users to construct graphic visualizations of simulation output data. The visualization component built to meet this goal interacts with a potentially large database that serves as a persistent repository of all the data collected throughout the simulation experiment. Since the needs of both expert and novice users include trying to "make sense" of this large body of data, SAFE's visualization tool supports interactive graphical explorations and allow for the easy generation of customizable, publication-quality graphics. We found it sensible to provide for both types of users through one common interface, namely the WUI. This design decision is justified by the power of expression and the flexibility in rendering graphical information inherent to modern JavaScript libraries, such as D3.js and Rickshaw.

The amount of data that the visualization tool may potentially manipulate guided us toward the application a *micro-macro* visualization technique (Tufte 1990). Such a visualization gives the viewer an

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overall picture of the data, while maintaining the ability to drill down to any particular data point. Our development has been guided by Shneiderman (1996) *Visual Information Seeking Mantra*: "Overview first, zoom and filter, then details-on-demand." Still, since the field of interactive data visualization is relatively young and experiencing rapid growth, many undocumented problems often present themselves during the development of tools in this area and we are experimenting with different possibilities.

Our current design defines the interactive view of simulation results around two main displays. The first display is a micro-macro time-series plot of the entire experiment execution. The user selects one or more metrics through an intuitive drag-and-drop interface, and has them plotted on the same grid. An overview plot with a visual slider is displayed directly below the main plot, a technique commonly referred to as "overview plus detail" or "context plus focus" (Shneiderman 1996). Such a plot allows the user to see how a metric evolved over the course of the experiment, compare it to another metric, and then drill down to as little as a single data point from any metric. The second display is the static view of simulation results, which gives users a variety of options in generating customizable static plots. The user is presented with a web form that offers a variety of options for generating static plots, such as scatterplots, box-plots, time-series plots, and others for the comparison of distributions. This plot generation tool ensures the adherence to best practices identified by data scientists such as Cleveland (1993), Tukey (1977), and Tufte (2001).

3 CONCLUSION

Our work on the development of user interfaces for staging experiments and for visualizing output data fits within the broader context of a project that automates the simulation workflow so as to reduce the likelihood of user-induced errors, thereby increasing the credibility of results. This poster describes the design choices we have made in the development of SAFE and showcases their implementation. The contributions we make are in the realm of simulation tool construction and in creating an infrastructure to address the needs of the *ns-3* community.

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