

CSIM 19 User Story

Performance Modeling of Computer Hardware and Software for Packet Switches: The Gigabit Ethernet Project



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Introduction

I am a faculty member in the Department of Computer Science and Engineering at the University of South Florida. My research focuses on performance evaluation of computer networks, and I teach courses in several areas, ranging from Computer Networks to Capacity Planning to Simulation.

My students and I use CSIM 19 for performance modeling of packet switch architectures in high-speed networks. We model both hardware and software elements, and we use CSIM 19 to show that our designs, be they packet switch designs or some other network protocol or idea, are better than existing designs. We also use CSIM models to gain deep insight into how a particular design – whether new or old – really works. Using CSIM 19, we can study instability regions and other complex performance-related behaviors quite easily.

We chose CSIM 19 because our model building tasks require something more than straight C and something less than OPNET and other simulation packages, with key requirements in the following areas:

- Ability to build models quickly
- Speed of model execution
- Flexibility in modeling building
- Cost

We have no requirement for flashy interfaces that include animation or other features of no engineering value, so CSIM 19 is an excellent match for our needs.

Application Area:
*Computer Networks,
High-speed Packet
Switches*

Platform:
*Windows with Borland
compiler*

CSIM 19's Challenge:
*Modeling the
performance of high-
speed packet switch
architectures*

The Project

While I use CSIM 19 in a number of teaching and research applications, I would like to focus here on our group's most recent, high-profile project, entitled *Performance Evaluation of Gigabit Ethernet Networks, A Systems and Experimental Approach*, also known as the Gigabit Ethernet Project. This funded research project addresses the 'network of the future,' in which both fixed-size cell and variable-length packet networks will co-exist.

This project brought an existing switch architecture, the buffered crossbar, into the forefront of high-speed packet switch design by introducing innovative new ideas. Specifically, we pioneered the Combined Input and Crossbar Queued (CICQ) switch, which we have shown to solve many problems in existing switch architectures. We used CSIM 19 models to help us identify problems and bottlenecks in the existing architecture so that we could address them; we then used the models to illustrate the performance benefits of the new designs.

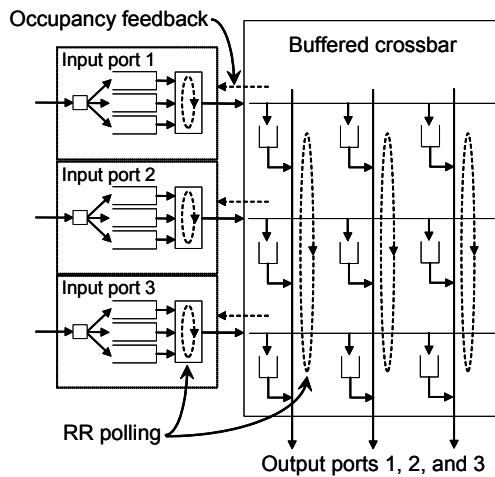


Figure 1

Figure 1 shows the architecture of a CICQ switch with round robin polling – a switch architecture pioneered in this project.

Our group has also created a number of tools that are freely available for use by students and instructors worldwide. The Christensen "tools page" web site features a collection of C source code tools for performance modeling and evaluation, including several CSIM simulations. You can find it online at <http://www.csee.usf.edu/~christen/tools/toolpage.html>



“While it is possible to write your own simulation framework or to use open source tools, I prefer commercial products that have somebody standing behind them. CSIM is truly bug free. I can claim only one “bug” find in CSIM and that was in about 1995 – and it was not a major bug at all. Mesquite fixed it in less than 24 hours. CSIM is stable and real.”

- Dr. Ken Christensen

Results with CSIM 19

We developed a number of models using CSIM 18 and 19 for the Gigabit Ethernet Project, including several models of output queued (OQ), input queued (IQ), combined input and crossbar queued (CICQ), and virtual input queued parallel packet switches (VIQ PPS). In addition, we created models for both variable-length packet versions and fixed packet length versions, also called “cells.”

The project web site contains all of the switch models and also includes models of other switch architectures (e.g. output queued switch) used for comparison. Please visit us at <http://www.csee.usf.edu/~christen/career/main.html> for more detail about the project.

You can also access the actual CSIM 18 and 19 models from the Gigabit Ethernet Project on the following page: <http://www.csee.usf.edu/~christen/career/models.html>

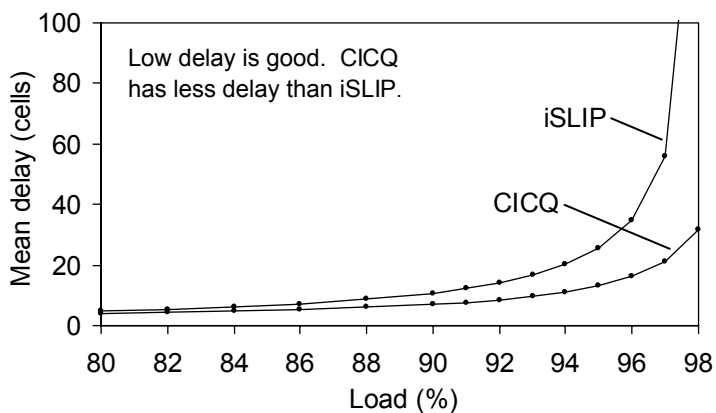


Figure 2

The graph in Figure 2, generated from a CSIM 19 model, shows the average delay of a CICQ switch compared to a so-called “iSLIP switch.” The iSLIP scheduling method is currently a leading method for implementing high-speed switches. You can see that the CICQ switch has much lower delay at high load, which is very important for real-time applications on the Internet. This graph shows the promise of the CICQ switch as the “switch architecture of the future” that can be the core of a faster and better Internet for future generations.

In order to search for particular behaviors in our system, such as when it becomes unstable, we often required many data points from our CSIM models – which, even with CSIM’s fast



“The models for this project are actually quite small – about five modules and hundreds (not thousands) of lines of code. This is the whole point of CSIM – you can build powerful models that are also manageable by one person. A straight C model would have required thousands or tens of thousand of lines of code. Given that the development time and number of bugs in a program is roughly proportional to the lines of code, a CSIM model can be built much faster, with fewer bugs.”

- Dr. Ken Christensen

native C and C++ environment, can take overnight or even days. To expedite our model execution, we developed a remote execution tool to run CSIM over the network. The REMOTE tool allows for automatic remote execution of console mode programs on network-connected Windows PCs. This tool enables network-attached computers to be used to complete simulation studies much faster than could a single computer. You can find the REMOTE tool at www.csee.usf.edu/~christen/career/remote.html



The findings of this project have made a significant contribution to the direction of future single-stage switch designs. We could not have built the models using any other tool, especially given our speed requirements. With straight C, we would still be coding and debugging. With other simulation packages, we would be both bankrupt and so constrained by the tool that there would be no model. CSIM 19 was a fundamental contributor to the success of the Gigabit Ethernet Project.

To learn more about the Gigabit Ethernet Project, please contact the author:

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"I find conceptualizing a model to be one of the most challenging aspects of model development. I usually start by building some 'baby models' that prove the concept, and then 'growing' these to below the full-blown models that I need. CSIM lends itself well to 'growing' models in this manner."

- Dr. Ken Christensen