

Web- Based Control System Design and Analysis

By Qingcang Yu, Bo Chen,
and Harry H. Cheng

The World Wide Web has provided an opportunity for design and analysis of control systems through the Internet. An increasing number of Web-based software packages have been developed to enhance the teaching and design of control systems [1]. Today, one of the most popular applications in control systems is Web-based educational environments and laboratories. As an example, the interactive study support environment presented in [2] provides course management, online exercises, and laboratories. Based on VCLab [3], which contains Java applets and MATLAB plug-ins, the system allows students to enter MATLAB commands on the Web page and submit these commands to the MATLAB program for execution. The output generated by these commands can be displayed on the same Web page. To use this Web-based study environment, however, the MATLAB software has to be installed on the client machines. Instead of using MATLAB plug-ins to perform numerical computation on the client side, Java applets are sometimes used for numerical computation on the client side. For example, applications of Java applets can be found in the Web-based two-degrees-of-freedom robot manipulator simulation system [4] and the Virtual Control Lab [5]. Due to the lack of powerful numerical computing capabilities in Java and its applets, however, applications using Java applets alone in the simulation of dynamic systems are limited. Web-based laboratories can be divided into two categories: virtual and remote. A virtual laboratory allows clients to continuously access a simulation process in a remote server. The simulation engine in the server could be MATLAB or any other control tool kit. A remote laboratory offers a physical experimental apparatus to remote users through the network. Most Web-based laboratories use MATLAB as the computational engine. For example, Sanchez et al. [6] proposed a virtual and remote laboratory using Java and MATLAB. In this system, a Web page with Java applets is used as the graphical user interface (GUI) for remote access of the lab. The computations for controller design and analysis are performed in MATLAB in a separate process invoked by an application server called Internet Virtual Lab (IV-Lab). The application server communicates with the Web server using TCP/IP sockets. The implementation of such a virtual control laboratory is complicated because of the inherent deficiency in interfacing MATLAB with external programs. Instead of writing an application server on their own, other remote laboratories [7], [8] use the MATLAB Web server (MWS) to communicate between the HTTP

Web server and MATLAB. However, even when using MWS, the communication between the HTTP Web server and MATLAB is inefficient. In our experience, software based on MWS is difficult to develop and maintain. We have developed a Web-based interactive control design and analysis system (WCDAS) [9] based on Ch, which is a C/C++ interpreter [10], [11], and the Ch control systems toolkit (CCST) [12], [13]. WCDAS covers many classical and modern techniques for control systems design and analysis. Most functions in the system support both continuous-time and discrete-time linear time-invariant systems modeled in state space, transfer functions, or zero-pole-gain representations. Users can select a design and analysis method and specify system model type, system type, and system parameters in the Web browser. These data are transferred to the server for numerical computation, and the simulation results are sent back to the client through the common gateway interface (CGI) using the Ch interpretive environment. Because both CGI scripts and simulation programs are written in Ch, data exchange between client and server is easily achieved. The system is available for use through the Web without any software installation, system configuration, or programming. This Web-based system is ideal for teaching as well as for solving practical problems in control systems design and analysis. The software packages Ch, CCST, and WCDAS are available for downloading on the Web [12]. The design, implementation, and salient features of WCDAS are described in this article.