Network Simulation and Remote Laboratory Systems for Students with Vision Impairment

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Abstract— **This paper describes further developments in laboratory and simulation tools for use in the Cisco Academy for the Vision Impaired (CAVI) program. Due to the geographic distribution of vision impaired students it is necessary to offer the normally "hands on" aspects of the Cisco Academy Program in a remote, virtual or simulated manner. Two major issues currently faced in delivering this program is that of the inaccessibility of Packet Tracer and scheduling equipment access to the Remote Bundles.**

Keywords-component; Remote laboratories, network simulaltion, assistive technology, blind, vision impairment

I. INTRODUCTION

The Cisco Academy for the Vision Impaired (CAVI) is a learning environment that modifies the "standard" Cisco Networking Program in a manner that is suitable for people with significant vision impairment. Students at CAVI acquire skills in computer networking design and administration through a variety of tailored facilities, such as a laboratory of network equipment that can be accessed remotely via the Internet.

Disabilities inhibit many from obtaining gainful employment and the building of skills in IT enables those with a vision disability to be better equipped to take on employment in the IT industry. With an unemployment rate of more than 60% in Australia, the vision impaired battle to compete for employment with those who are sighted [2]. Technology has become an integral part of the business world with little being achieved without some use of information and communication technologies. In many cases organizations use technology to gain a competitive advantage, hence the need for IT skills is paramount for employment in today's business world. Education courses in introductory skills in computing are offered by many disability support organizations to their members, however very few advance beyond the basics of how to use email, Word, and how to search the Internet. A scan of the literature on accessible e-learning environments results in little in the way of new developments.

People who are blind rely on computers and the Internet for information essential to their lives, availability of goods and services, directions to get from one location to another, pay bills and do their banking, communications with other people, transferring information and documents to businesses, family and friends. The ability to set up their own home computers and networks is a great advantage to them. With advanced IT skills they can also troubleshoot problems and fix their own systems when they fail. They can also do this for their employer, making IT help desk and network administration a relevant employment role for people with vision impairments.

E-learning environments suitable for remote delivery of accessible IT curriculum have been a long time emerging. The needs of those with vision disabilities are specialized, requiring assistive technologies to access the information technology and curriculum. Research and reporting of advances in this area have not been forthcoming, with pockets of work on accessible teaching methods and curriculum, but little spans the digital divide between sighted and vision impaired students in the area of information technology and network administration education. Employing an e-learning environment consisting of a virtual classroom, remote laboratories and curriculum fully accessible to the vision impaired, the Cisco Academy for the Vision Impaired (CAVI) delivers advanced IT network education to students situated around the world. Students access the learning system via the Internet, enabling those in remote locations to work through the courses at their own pace and within their own time zones. This paper describes the remote e-learning environment designed for the delivery of advanced IT networking to vision impaired students so that others may benefit from the low-cost and effective design.

The paper first describes the development of an accessible external application to connect with Packet Tracer.

Secondly, users of the remote laboratory face the problem of not knowing ahead of time whether the equipment is going to be occupied or not. Therefore, a mechanism for scheduling laboratory usage is required. This mechanism must also be accessible and usable by vision impaired students. This paper presents a prototype booking system that fulfills these requirements. This booking system was designed with assistive technologies in mind, and implemented as a web-based application

II. THE LEARNING ENVIRONMENT

The CAVI accessible e-learning environment was established to deliver advanced IT networking courses to vision impaired students situated in different parts of the world. The presentation of Cisco curricular were also redesigned to ensure the teaching and learning materials were accessible, however the environment structure can be applied to any learning environment that has accessible educational materials. The curriculum presented is comprised of the Discovery, Exploration (previously CCNA courses) and IT Essentials that form part of the Cisco Networking Academy Program. "Networking Academy utilizes a blended learning model that combines face-to-face teaching with engaging online content and hands-on learning activities to help students prepare for industry-standard certifications, entry-level and advanced careers, and higher education in engineering, computer science, information systems, and related fields."[4]. Details on the modifications to the various curricular may be found in [5].

The CAVI e-learning environment is illustrated in Figure 1 and comprises:

1. a local classroom where local vision impaired students can attend and where lectures and tutorials are broadcast for the virtual classroom,
2. support academies situated at other remote locations providing local vision impaired tutors,
3. direct access via the Internet for remote learners at home,
4. a curriculum server housing the Cisco e-learning materials and a file and applications server housing the course management system plus additional accessible teaching materials and applications,
5. a local laboratory where local students can carry out their laboratory exercises,
6. a virtual classroom consisting of a voice server, webserver, and podcast server,
7. a remote laboratory where students can configure the network equipment and test their configurations.

Vision impaired instructors deliver the lectures and tutorials in the local classroom and these are broadcast to the support academies and remote students. Vision impaired tutors provide a one-on-one capacity with students to further explain and walk through concepts and exercises. The lectures and tutorials are recorded and the audio files are stored for later access by the students on demand. The virtual classroom enables the students to interact with the instructors and other students during the broadcasts. The virtual classroom also provides the opportunity for lectures and tutorials to be delivered by lecturers in remote locations, as the physical location of the teaching staff is flexible. Assessing assignments can also take place electronically. Students can complete and submit their work electronically, and lecturers in any location can grade the students' work. One-on-one communication between instructors, tutors and remote students is carried out via Skype.

The above components allow the vision impaired students to login and hear broadcast lectures and tutorials,

and then work through the accessible curriculum at their own pace. The curriculum and applications enable the students to design network architectures, then implement and test these in the remote laboratory which is a real networked environment.

The Cisco courses require students to design and build IT networks, and trouble-shoot these networks. This means the vision impaired students must have access to network equipment and/or simulation software so that they may configure and test configurations, hence the need for an accessible remote laboratory facility and simulation software.
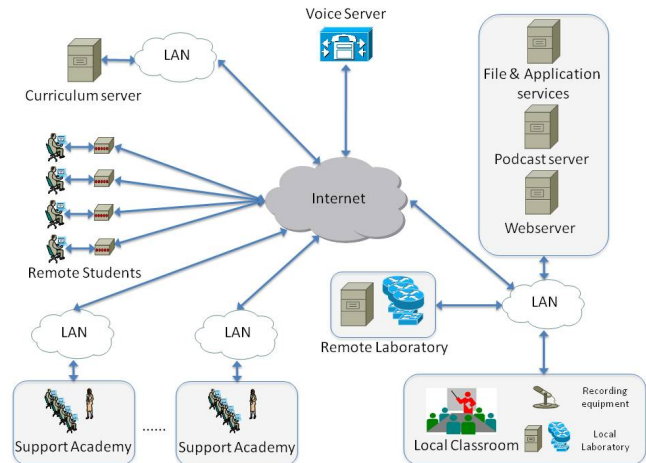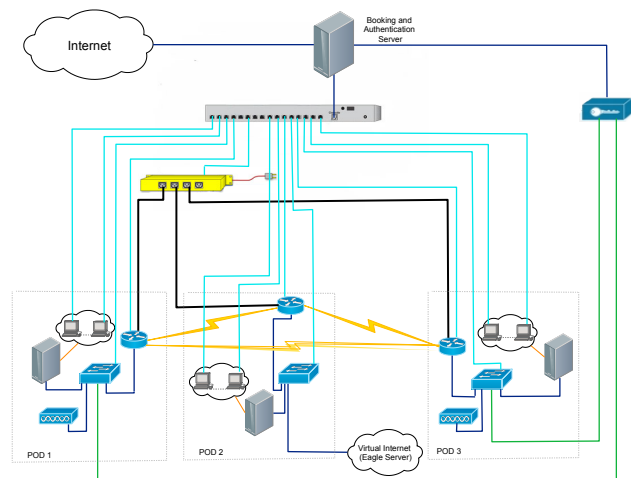

Figure 1. CAVI Teaching environment

Figure 2. Remote Laboratory "bundles" utilised in the CAVI program.

III. AN ACCESSIBLE INTERFACE TO PACKET TRACER

iNetSim [3] was an early prototype application that allowed vision impaired students to run basic network configuration simulations. Whist this prototype was successful in its aim of illustrating that network simulators may be made fully accessible if accessibility is built into the design stage of application development, maintaining and building a separate simulator for use by the vision impaired is not feasible. Any such application would lag development

and features of commercial, well resourced projects such as Packet Tracer. It was therefore decided to develop an external application to connect to Packet Tracer utilizing the newly released APIs and multi user features. Initial development has aimed at examining the flexibility and ability of the framework underlying the Packet Tracer application development environment. The information obtained was then used to decide on the feasibility of an external application for vision impaired people, allowing them to use and manipulate the Packet Tracer software package to carry on networking simulation, particularly where the CCNA curriculum is concerned.
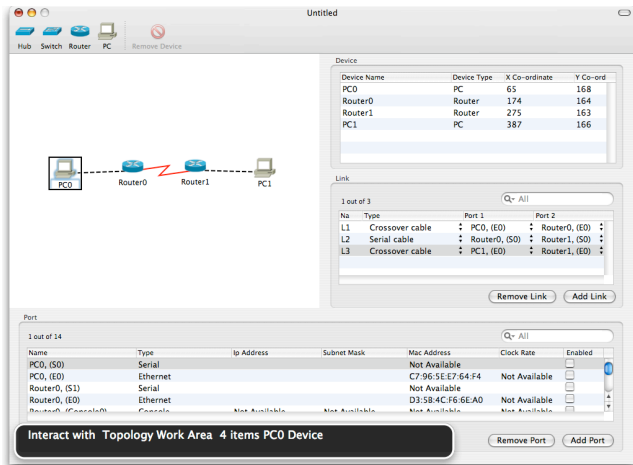

Figure 3.   Example iNetSim Scenario

As may be seen when comparing the iNetSim interface (Figure 3) and that of the new prototype, some modification to the layout have been made in particular the reduction in the number of tables used in the connection and devices configuration areas. This is intended to increase the navigation speed when using a screen reader.
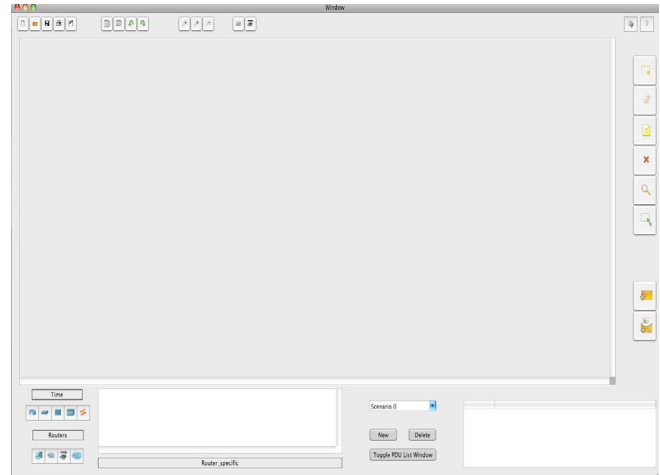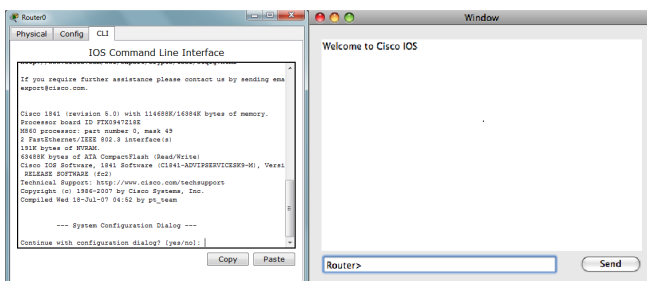

Figure 4.   Example screen captures of the external application communication with a running instance of Packet Tracer

IV.   REMOTE LABORATORY BOOKING SYSTEM

A.   Available Booking Systems

As stated earlier, users of the remote laboratory face the problem of not knowing ahead of time whether the equipment is going to be occupied or not and therefore an accessible booking system is required.

One possible booking system is contained within the Netlab appliance by Network Development Group (NDG). While it is tailored towards remote laboratory setups such as the one within CAVI, there are areas where this particular system falls short of CAVI's needs. Firstly, NDG prices the initial purchase of its Netlab Academy Edition appliance at $6795 USD [6]. Armstrong and Murray [7] also note how the cost of the appliance prevented its use within the CAVI remote laboratory, but perhaps more importantly, they describe how the Java based applications in Netlab, including the booking system, are not accessible by screen reader software. Figure 5 below shows a screenshot of Netlab's booking system interface.
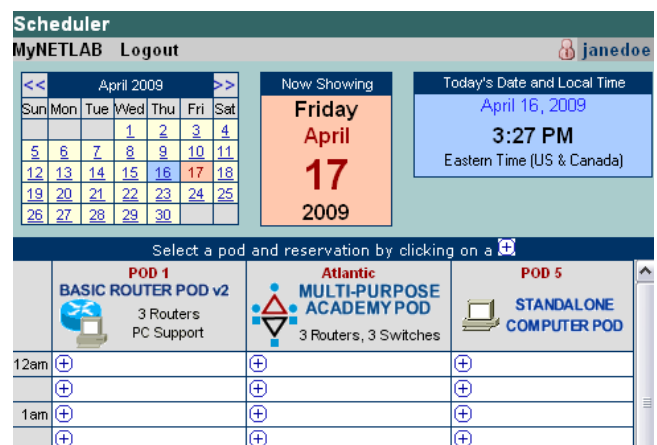

Figure 5.   Netlab scheduler interface (NDG 2010)

Even if a screen reader was able to interpret this Netlab Scheduler interface, it would still be of low usability to the vision impaired user. The screen reader would attempt to read every number within the monthly calendar aloud. The links within the monthly calendar are not meaningful on their own, and it is likely that a screen reader would ignore the colours associated with the selected date and the current date. Finally, while the interface may look relatively simple to a sighted user, this may not be the case for their vision impaired counterparts.

The Meeting Room Booking System (MRBS) and WebCalendar are two open source booking systems, and are geared towards more general purpose applications. They are free to use, but they also suffer from accessibility problems, similar to the ones that affected Netlab. Both systems are built using PHP, meaning that these systems generate HTML pages that are translatable by a screen reader. Like the Netlab scheduler, these open source systems also display monthly calendars which add unnecessary verbosity, and use links that cannot stand alone. Figure 6 below shows a screenshot of MRBS.
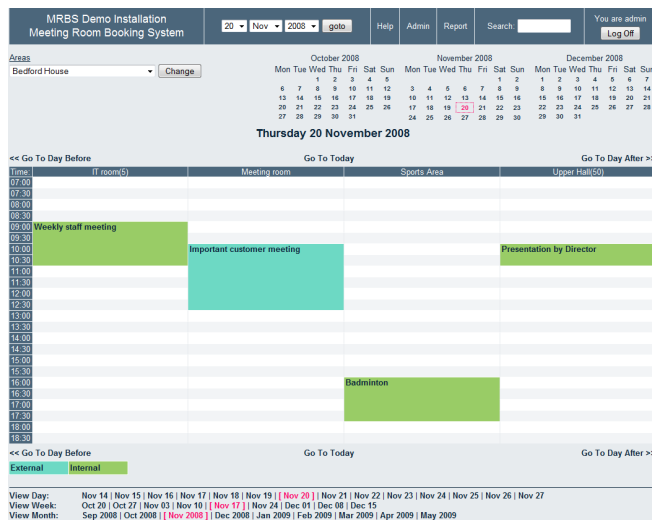

Figure 6.   Screenshot of MRBS (MRBS Development Team 2010)

It can be seen that MRBS employs colours in an entirely inaccessible fashion. From the home page of this system, a user of a screen reader would not be able to easily distinguish when a particular reservation starts or finishes, since this information is solely conveyed through the use of colour. The times listed to the left of the daily schedule, and the listings to the bottom of the home page would also be read aloud by the screen reader, which further reduces the simplicity and accessibility of this system.

B. Implementation

All the interfaces of the booking system (see Figure 7) use no more than these three colours: black, white, and red. The use of red is exclusively for the indication of error conditions, such as a missing username or missing password for the user login page. Users who are completely blind are still notified of any errors since their screen reader should be able to translate the textual error messages.

The titles of each page are designed to fully identify the purpose of each interface, and unambiguously distinguish these pages from any other websites the user may be browsing simultaneously. If the login interface here was simply entitled "Login", then a vision impaired user may not be able to tell if this was a login page for the CAVI booking system, or, for example, a login page for their online discussion board. The link to the administration interface does not appear to users who do not have the necessary privileges. This link is close to the top of the page in order to enable quick identification by vision impaired instructors, and hence save them from having to listen to the rest of the page in the instance where they only want to manage the booking system.

The two message lines that subsequently follow are placeholders for any notifications or error messages that are to be output to the user. When a user first logs in, these message lines are initially empty. In a manner similar to the user login interface, any error messages here are also printed in red. Furthermore, their location near the top of the page also allows a vision impaired user to speedily ascertain the results of their actions.

The values of the user bookings table are populated dynamically from the database. If a user has no bookings for the future, then the table does not appear. Information regarding a user future bookings and the selected day's open timeslots was not arbitrarily placed above the drop boxes for a new booking. As a screen reader goes through the page, it will read out the open timeslots and the future bookings first, which will in turn give the vision impaired user an idea of when to (or when not to) book before they encounter and use the drop boxes for their next booking. This can increase the interface's usability. If the arrangement was reversed, then a user could hastily select drop box options to start with, only to change their choices soon after when they later discover through their screen reader that their timeslot was actually not available.

CAVI Remote Lab Booking System

You are logged in as: [Username]Click Here to LogoutClick Here to Enter Administration Interface

[MessageLn1]
[MessageLn2]

[PlaceHolder "OpenBookingsPlaceHolder"]

Your bookings for today and in the future:

Booking Date & Time	Pod
Databound	Databound
Databound	Databound
Databound	Databound
Databound	Databound
Databound	Databound

For a new booking, choose a date, time, and location in the drop-down lists below.
Note that timeslots are on Australian Western Standard Time (GMT+8). 1 timeslot lasts for 1 hour.
[1 ▾] [January ▾] [2010 ▾] [12:00 AM ▾] at [Databound ▾]

[Make Booking] [Find Open Timeslots For This Day & Pod]

CAVI Remote Lab Booking System

You are logged in as: username1 Click Here to Logout

Your bookings for today and in the future:

Booking Date & Time	Pod
Nov 7 2010 6:00PM	Pod 2

For a new booking, choose a date, time, and location in the drop-down lists below.
Note that timeslots are on Australian Western Standard Time (GMT+8). 1 timeslot lasts for 1 hour.
[4 ▾] [November ▾] [2010 ▾] [4:00 PM ▾] at [Pod 1 ▾]

[Make Booking] [Find Open Timeslots For This Day & Pod]

Figure 7.   The booking interface

V.   CONCLUSIONS

A. Packet Tracer Accessibility

Although the developments described are in their early stages of implementation several significant milestones have been achieved. A functional and fully accessible external application to communicate with Packet Tracer has been implemented. At this point only basic functionality has been included it is only a matter of coding additional calls to the Packet Tracer APIs to further increase usability.

Ideally, resources would be allocated to the developers of Packet Tracer to modify the user interface so that there is no longer the need for an external application. This project has shown that network simulators may be designed to be accessible to people with vision impairment without reducing the appeal and usability for sighted students.

B. Remote Laboratory Booking System

The accessible booking system has met its design specifications but still requires further development and refining. The achievements so far include:

- The design of an equipment booking system for the CAVI remote laboratory. This design encompassed aspects of its user interfaces, system architecture, and user processing.
- The development and implementation of the booking system as an accessible application that can be hosted on a web server.
- Research into the methods of integrating the booking system into the CAVI remote laboratory environment.
- The design, development, and implementation of this prototype booking system can serve to prove the feasibility of a complete laboratory front-end system. The work also demonstrates that such a system can be accessible to the vision impaired, and can be realised at an economical cost.

The developed booking system only constitutes a core component of the CAVI remote laboratory's front-end system. In order to refine and improve the current system, several courses of action can be pursued in the future.

Firstly, the booking system should be ported to a free and open-source implementation. Although the development tools employed during the project are available without monetary cost, the current implementation does bias itself towards a Windows-based web server. This is due to the use of ASP.NET and C#, which are both Microsoft technologies [8][9]. This can be attained by converting the interface pages' markup and programming logic into PHP. MySQL can also be used to host the booking system's database in the future. Alternatively, a Linux-based web server can execute ASP.NET pages and C# code using the Mono platform and the mod_mono Apache module [10].

The user authorisation mechanisms should also be incorporated into the booking system, but a method of relaying generated passwords to the booking system server will have to be devised. User accounting functions may be of use. To be more precise, student users may be tracked to see whether they actually use the laboratory equipment at their chosen booking time.

If the management console switch was to be retained when integrating the booking system server, then a customised Telnet client could be written and embedded into one of the system's web interfaces. This can free the user from having to Telnet into the booking system server, and could in turn obviate the need to run a Telnet daemon on the server.

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