Introduction to Interactive Web Design

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Preface

Currently web programming is viewed as the domain of computer science majors and out of the reach of most computer users. One of the aims of this book is to provide a path for putting web programming expertise into the hands of any motivated computer users.

This text has been designed to be accessible to non-programmers assuming only that they have a strong interest in learning how to build interactive web sites. The material presented here has evolved over five years of teaching web programming in an Introduction to Computers class attended primarily by non-science majors. We have developed a bounty of evidence that bright students (and others) can easilly learn to develop interesting and sophisticated interactive web sites within a few short weeks.

In the process of learning to build interactive web sites, you will also have a general introduction to computer programming and the joys and frustrations of this enterprise. I wish you a satisfying journey!

Foreword

The web is a rapidly evolving technology that has already changed many aspects of our lives, from the mundane to the sublime. It is rapidly becoming a kind of super encyclopedia where we can search for the latest information on movie stars or cancer treatments. It is also evolving into a new communication medium – email has saturated the population in developed countries and now, in 2002, instant messaging is rapidly expanding into the youth culture.

Part of the great success (or at least growth) of the internet is due to the fact that it is a collaborative enterprise. Every computer that is connected to the internet can offer web services, such as hosting web pages or running instant messaging clients or acting as a remote file sharing server for MP3's or other data. One does not need a licence from the government to offer such services, but some internet access providers have been putting restrictions on home services that can be offered.

During the first five years (1990-1995) of the World Wide Web most of the web content that had been developed was in the form of web pages. As we will see in this book, web pages are written in a very simple language called HTML (HyperText Markup Language) which was designed to be easy learn, which would in turn encourage non-scientists to develop web content and help build the web. This design decision has been spectacularly effective. Personal web pages are becoming increasingly common among college students (and even among high school students). Most often these pages are a kind of autobiographical folk art. They provide a glimpse into the author's life and provide a few links to sites of personal interest. Occasionally though these web authors find a topic of deep personal interest and they create an informational web site dedicated to that topic – favorite bands or movie stars are a common theme, political or religious causes are also frequently found. Many web authors publish their photography, poetry, or other creative works. A less common, but perhaps more influential, class of web authors are those that develop well-designed and useful informational sites such as web sites listing local bike paths and hiking trails.

During the second five years (1995-2000) we saw the rise of interactive sites. There have always been search engines, but the late 90's saw the rise of ecommerce and other forms of interactive web pages. For the most part, this type of web content has remained within the purview of the computer science professionals.

There are several reasons for interactive web page development to be slow to

spread to the general population. Originally, web pages were only served from dedicated machines and system administrators were loathe to allow any but the most trusted of their colleagues to deploy interactive web pages. There are good reasons for this. A poorly written interactive web page can be a major security risk. It can also devour system resources and greatly slow down, if not crash, a server. In the past few years this has become less of a problem as most personal computers now come with preinstalled web servers; thereby democratizing the process for all those who have an internet connection.

The more important impediment to the spread of interactive web pages among general users is that the langauges for developing such pages have just been too difficult for novices to learn. Originally these pages were written in primarily in PERL, an interesting but rather bizarre language favored by hackers both for its power and for its mystique! More recently, Java has become a popular language for writing these pages, but this still requires authors to have at least one semester's worth of programming experience before they can even start to build interactive web pages.

Goals of this book

In this book, we return to the original ideals of the World Wide Web and present a simple language, Scheme, for developing interactive web pages and other web programs. Scheme is similar to HTML in that it is easy for non-experts to learn the basic language and to build build fairly sophisticated interactive web pages. Scheme is a dialect of Lisp (a language which was first developed in 1957 at the dawn of the computer era).

We begin with an introduction to HTML and CSS for developing static web pages.

Next we give an introduction to writing Scheme servlets, the most basic form of interactive web page. These pages are written in a mixture of Scheme and HTML.

We then introduce the JLIB windowing library and show how to write and deploy programs that use Graphical User Interfaces. These programs are entirely written in Scheme.

In the second part of the text we move on to more sophisticated topics such as developing web programs that access databases and writing programs that involve communication among multiple users.

Hardware and Software Requirements

The software that is used in this text is all free and open source. It can be easily downloaded and installed on almost all platforms (Windows, Mac, Linux, Unix). If this text is being used in a course, we also provide instructions for setting up a central server which removes the requirement for all students to

set up their own server. On the other hand, it is relatively easy to do and a lot more fun to run your own web server.

Chapter 1

The Internet

The internet is a worldwide network of computers with the property that each computer can send data to and receive data from any other computer on the internet.

1.1 A brief history of the internet

The idea of connecting computers via phone lines or some other long distance network was first tested in 1965 when two university researchers, Larry Roberts and Thomas Merrill, connected a computer in Massachusetts with one in California using a phone line and demonstrated that they coould run programs and receive data on the remote machines. A key idea behind this research was that the computers would communicate by breaking up their data into many small packets and sending these packets individually. If any packets were lost (due to background noise on the line), they could easily be resent.

This experiment led directly to a Defense Advanced Research Projects Agency (DARPA) proposal in 1967 to build the ARPANET, which is a military precursor of the internet. In 1968 a group led by Frank Heart at BBN in Boston won the government contract to build the initial ARPANET hardware. In 1969, the initial ARPANET was constructed and consisted of four computers: three in California and one in Utah. In 1972, Roberts wrote the first email program, and email quickly became the most frequently used network application. In 1973, Vint Cerf and Robert Kahn proposed a new set of communication rules for the computer networks called TCP/IP (Tranmission Control Protocol/ Internet Protocol) which allowed users to implement a wide range of network applications including network telephony, email, and network disk sharing. The ARPANET was converted to a TCP/IP net in 1983 at which point it was split into two nets: the MILNET for military applications and the ARPANET for civilian applications. Throughout the 70's several other networks were developed. These included CSNET (connecting Computer Science Departments), USENET (connecting UNIX computers), and BITNET (connecting academic

mainframe computers).

The 80s saw the rapid prolifieration of PC's and workstations combined into small local area networks (LANs) and these LANs came to be added to the ARPANET in greater numbers, resulting in a rapid growth of the internet. Also, in 1985, the NSFNET was formed by the National Science Foundation with the stipulation that a university could connect to this network only if it provided access to all scholars at the institution, not just the science departments. Another important development during the 1980's was the connection of networks into a single internet all using the TCP/IP protocol for communication. The 90's saw the birth of the World Wide Web and the rapid expansion of the internet both in terms of size and in terms of its use by the general population.

1.2 Internet Addressing: domain names and IP addresses

The internet currently consists of about 100 million servers although this number grows every month (and actually oscillates minute by minute for reasons that will become clear). Each computer on the internet has a unique identification number called its IP address (for Internet Protocol). An IP number consists of a sequence of four numbers in the range 0-255. For example, a typical IP address at Brandeis in 2002 is 129.64.2.10, where the numbers in the IP address are separated by periods by convention. This is the dotted decimal form of an IP address.

IP addresses are actually stored on the computer and transmitted as 32 bit long binary numbers. Please read the appendix on binary numbers to learn about binary numbers and how they are used to represent decimal numbers.

Most computers on the internet also have an identifying name known as a domain name. For example, the domain name for the main Brandeis web server is /tt www.brandeis.edu and its IP address is `129.64.99.138`. The relationship between domain names and IP addresses is available on the net from computers known as domain name servers.

The internet actually consists of a large number of networks which are seamlessly interconnected. For example, the Local Area Network (LAN) at Brandeis University consists of a few thousand computers. These computers are all directly connected to the internet and have IP addresses of the form

```
129.64.xxx.yyy
```

where xxx and yyy are numbers in the range 0-255. Conversely, any IP address of this form refers to the Brandeis LAN. Thus, the Brandeis LAN can expand to include up to 256 x 256 = 65536 computers which can all be simultaneously directly connected to the internet. This method of allocating IP addresses in blocks is widely used today.

1.3 Ports, Sockets, and Services

The computers on the internet interact in a wide variety of ways, but their interaction is nonetheless restricted. It would not be wise to allow any computer on the internet to have full access to every other computer on the net because an unscrupulous user might decide to delete all of your disk files or to otherwise use your computer without permission.

To get around this problem, the internet is modelled on an abstract view of the net in which each computer specifies exactly what kinds of interactions it will allow. These types of interactions are called **services** and each computer on the net can offer up to 65536 services.

These services are specified by a number from 0 to 65535 called a **port**. Typically, the ports with numbers under 1024 are reserved for system services (such as email and web page serving), but anyone is free to offer any service they please on ports numbered greater than 1024.

A computer that offers a service to another computer is called a **server** and a computer that requests a service is called a **client**. It is typical for computers on the internet to be both clients and servers and the same time. The communication between client and server is initiated by the client by specifying the IP address of the server computer and the port number of the service to be provided. If the specified computer is offering that service, then a special connection called a **socket** is created. The socket allows the two computers to send data back and forth between themselves.

1.3.1 Common Services on the net

Some of the more common system services are listed in Figure 1.1. Each service has a set of rules governing how the client and server interact. These rules are called protocols and they simply represent the conventions that the two computers will use when communicating on that port.

You can access some of these ports from Linux using the telnet command. For example, Figures 1.2 and 1.3 give examples of accessing the date and echo services respectively: The date service returns the local time on the server being queried. The echo service is used for testing whether a connection is active and just echo back each line of text that it receives.

Here we access the "echo" service, which is mainly used to see whether the link is working correctly.

1.4 Web Browsers and Servers

The HTTP service is perhaps the most revolutionary service that has been developed for use on the internet. It provides a mechanism for clients to access files on the server by giving the name of the file in the webserver folder. The HTTP server then responds to such a request by returning several lines of information about the file (e.g. what kind of data it contains, text, image, movie,

- Echo (port 7) an echo service, simply echos back what it receives
- Daytime (port 13) this returns the date and local time and ignores client input
- FTP (ports 20,21) allows the client to transfer files of data to and from the server.
- Telnet (port 23) allows the client to interact with the servers operating system remotely
- SMTP (port 25) offers an email service for delivering email to a user on the server
- DNS (port 53) domain name serving, returns IP addresses for domain names
- WWW (port 80) uses the HTTP protocol and sends specified web pages to the client.
- POP3 (port 110) offers another email service

Figure 1.1: Some of the most common services

```
USER  % telnet www.cs.brandeis.edu 13
      Trying 129.64.2.3...
      Connected to diamond.cs.brandeis.edu.
      Escape character is '^]'.
      Thu Aug 31 15:55:41 2000
      Connection closed by foreign host.
```

Figure 1.2: Accessing the date service on port 13

```
USER  % telnet www.cs.brandeis.edu 7
      Trying 129.64.2.3...
      Connected to diamond.cs.brandeis.edu.
      Escape character is '^]'.
USER  This is the echo port
      This is the echo port
USER  bye bye
      bye bye
USER  ^]
      telnet>
USER     quit
      Connection closed.
```

Figure 1.3: Accessing the echo service on port 7

```
USER  % telnet www.cs.brandeis.edu 80
      Trying 129.64.2.3...
      Connected to diamond.cs.brandeis.edu.
      Escape character is '^]'.
USER  GET /~cs2a/index.html HTTP/1.0

      HTTP/1.1 200 OK
      Date: Thu, 31 Aug 2000 20:21:23 GMT
      Server: Apache/1.3.4 (Unix)
      Last-Modified: Wed, 23 Aug 2000 21:32:40 GMT
      ETag: "4962a3-217-39a442f8"
      Accept-Ranges: bytes
      Content-Length: 535
      Connection: close
      Content-Type: text/html

      <HTML>
      <TITLE>Brandeis University, Intro to Computers, CoSci 2a, Aut 99</TITLE>
      <BODY bgcolor="#ffffff">
      <META HTTP-EQUIV="Refresh" CONTENT="1; URL=http://www.cs.brandeis.edu/~tim/Classes/Aut00/CS

      The Home page for CS2a has moved to
      <A HREF="http://www.cs.brandeis.edu/~tim/Classes/Aut00/CS2a/">
      http://www.cs.brandeis.edu/~tim/Classes/Aut00/CS2a
      </A>
      <p>
      You can click
      <A HREF="http://www.cs.brandeis.edu/~tim/Classes/Aut00/CS2a/">
      here
      </A>
      to get to that page.
      <p>
      Sorry for the inconvenience.
      <p>
      Tim Hickey

      </BODY>
      </HTML>
       Connection closed by foreign host.
```

Figure 1.4: Accessing the HTTP service on port 80

sound, etc.) when it was last modified, how large the file is, etc. HTTP services are generally provided on port 80.

The HTTP service is one half of the technological foundation of the World Wide Web. The other half is the HTML language. HTML is an acronym for Hypertext Markup Language. HTML specifies the layout of webpages and provides mechanisms for including links to other webpages and to images, sounds, movies, and other content. In the next Chapter we will provide an introduction to HTML and some related technology (CSS and XML).

Figure 1.4 gives an example of the use of this service to request the web page "/ cs2a/index.html" from the server "www.cs.brandeis.edu". Observe that the request specifies the page to access and the response provides quite a bit of information about the file including its size, its last modification date, its size, what type of information is in the file, the kind of server that is providing the service, the locate time at which the page is being served, and some more arcane information as well.

There are many web browsers that are currently available. The most common browsers at the moment are Internet Explorer and Netscape, but some of the lesser known browsers such as Opera and Amaya, provide additional features which are not currently supported by the mainstream browsers such as mathematical and graphical markup processing.

1.5 The Tomcat Server

Most current personal computers come with a preinstalled browser as well as a preinstalled web server. In this book we shall use an open source web server (called the Jakarta Tomcat server) that allows you to easily build sophisticated interactive web programs fairly easily.

Appendix A explains how to download and setup the Tomcat server on your PC, Mac, or Linux platform. When you install the tomcat server, a folder `scheme` will be created. This folder represents the public web services that you will offer to the world. The types of service that you can currently offer using this version of Tomcat are listed below and are determined by the suffix of the filename. Each different suffix refers to a different web programming language that is handled by the server:

html Files ending in `.html` are simply sent directly to the client as `text/html` files.

css These are cascading style sheet files and are used to define extensions of the basic HTML language.

brls These are scheme XML files which provide a mechanism for reading information from HTML forms and using that information to generate web pages which are then sent to the client. (There are two other variants of this type of file with the extensions `sssp` and `sxml`. They are essentially the same language, but have slightly different grammars).

applet These are programs that run on the browser that downloads the page. These programs usually pop up windows with menus, buttons, textfields, choices, and all the usual facets of graphical user interfaces that you have become accustomed to.

snlp These are programs that also run on the client machine, but they require the Java Web Start plugin and, once downloaded, they can be run without the browser. One particular interesting type of snlp program that we will consider is the class of peer-to-peer programs. The Napster and IM programs are a well-known examples of this type of application. But there are many others possible uses for peer-to-peer computing.

Part I

Static Web Site Design

Chapter 2

HTML

A fundamental component of the original conception of the World Wide Web is that it should be a collaborative enterprise. The web was designed so that everyone would be able to add content. To make this feasible, the language for constructing web pages (HTML) was designed to be simple, powerful, and easy for non-computer specialist to master.

In this chapter we give an introduction to the design of static webpages using HyperText Markup Language (HTML), Cascading Style Sheets (CSS), and eXtensible Markup Language (XML). As you will see, these languages are quite easy to master as they are each based on a few simple ideas.

We begin with HyperText Markup Language (HTML). In this section we provide a sufficient introduction so that you will be able to design static web pages using the most common markup elements. For more information you can visit the official HTML website at `http://www.w3c.org` or peruse any of the many HTML texts.

HTML is build upon one fundamental idea which is the notion of expressing the layout for a web page using HTML elements. As we will see below there are a few dozen basic elements which are used to express the basic layout of the page including line breaks, headings, layout of images, tables, and lists.

2.1 Simple HTML elements

Simple HTML elements have the form

```
<TAGNAME>
   .....
</TAGNAME>
```

where `TAGNAME` is the name of the tag. A complete list of the HTML 4.01 elements is available at the URL of the official source for HTML, the World Wide Web Consortium:

`http://www.w3.org/TR/html4/index/elements.html`

There are 90 different standard tag names, but we will only discuss the most common of these.

Thus a web page consists of an html element that contains a head and body element. The head element in turn contains a title element.

For example, the following text defines a simple "Hello World" webpage

```
<html>
  <head>
    <title>My first web page
   </title>
  </head>
  <body>
    This is my first web page.
  </body>
</html>
```

If you put this in a file called `first.html` and then view the webpage with your browser (using the Open... menu item). You will see a simple web page consisting only of the words "This is my first web page" whose title bar contains the phrase "My first web page." If you bookmark this page, then the title "My first web page" is what will appear in the bookmark.

2.2 HTML elements with attributes

The most general form of HTML tags is as follows:

```
  <TAGNAME A1=V1 A2=V2 ... An=Vn>
     .....
  </TAGNAME}
```

where `A1,A2,...,An` are the names of attributes that are allowed for that tag, and `V1,V2,...,Vn` are values that those attributes can accept. In general, the attributes should always be enclosed in double quotes as this will simplify migration to XHTML which is poised to become the successor to HTML4.0 as the next interational standard.

For example, to include an image in a webpage you use the `img` tag as follows:

```
  <img src="mypic.jpg" alt="picture of the author" width="200">
```

The `src` attribute of the image tag specifies the name of the image file to display, the `alt` attribute species the closed-captioned reading of the image, and the `width` specifies the size to make the picture (in pixels). In this case, the attributes are used to provide information needed to properly display the element.

For another example, the `<body>` tag allows one to specify the background color of the page using the `bgcolor` attribute and to specify the color of the text on the page using the `text` attribute. It also has attributes for specifying

the color of unvisited links `link`, already visited links `vlink`, and links that are being clicked `alink`.

For example, the following HTML specifies a page with red letters on a black background and also specifies the link colors:

```
<body bgcolor=black text=red link=yellow alink=blue vlink=red>
  ....
</body>
```

2.3 Style and class attributes

One of the most common problems encountered when writing HTML pages is that each tag has its own set of attributes, and one must know which attributes are allowed for which tags. For example, almost all tags have a `bgcolor` attribute, but `body` is the only tag with a `text` attribute. The CSS language, discussed in detail in the next section, was developed partly in response to this problem. It provides a uniform method of specifying the "style" (e.g. color, font, border, etc.) of any HTML tag. For example, the CSS-method for specifying the red-on-black body tag shown above is the following:

```
<html><head><title>test</title></head>
  <body style="background:black; color:red">
    ....
  </body>
</html>
```

The CSS language can be used to specify four kinds of properties: fonts, colors, borders, and text spacing.

To simplify the presentation of HTML and CSS in this text, we will only use the CSS-method for specifying style and will ignore all other methods (e.g. style-based attributes of HTML tags). This allows us to ignore many HTML tags (e.g. the ones that change the font type or font color) and many HTML attributes. Indeed, Figure 2.1 show the 28 tags that we will consider and also shows their main attributes.

The tags are divided into groups that we consider one at a time. We have already seen the first four tags.

2.4 Hyperlinks

The hyperlink element has the form:

```
<a href="WEBADDRESS"> CONTENTS </a>
```

The CONTENTS is typically some text or an image. The WEBADDRESS is a URL that specifies the location of some web content online. The most commonly used URLs are

```
Structural Elements
   HTML
   HEAD
   TITLE
   BODY    link=COLOR vlink=COLOR alink=COLOR
Links
   A       href=URL name=STRING
Images
   IMG     src=URL alt="TEXT" ...NO-CLOSE-TAG
Headings, text separation
    H1,H2,H3,
    H4,H5,H6
    HR                         ...NO-CLOSE-TAG
    P
    DIV
    BR                         ...NO-CLOSE-TAG
    SPAN
Preformated text
    PRE
Lists
    OL
    UL
    LI
Tables
    TABLE  cellspacing=DISTANCE cellpadding=DISTANCE
    TR
    TD
    TH
Frames
    FRAME  name=STRING src=URL  ...NO-CLOSE-TAG
    FRAMESET rows=LENGTHS cols=LENGTHS
    NOFRAMES
Forms
    FORM     method=POST action=URL
    INPUT    type=TYPE name=STRING ...NO-CLOSE-TAG
    TEXTAREA  name=STRING
    SELECT    name=STRING size=NUMBER multiple
```

Figure 2.1: The Main Elements/Attributes of HTML 4.01

- names of files on the server,e.g. `report.html` or `doc/manual.html`
- addresses of other pages on the web, e.g. `http://www.whitehouse.gov`
- mailto URLs which send the browser to a send-mail program, e.g. `mailto:gwb@whitehouse.gov`.
- a link to some other form of media, e.g. a movie or document `home.mov` or `whitepaper.pdf`.

2.5 Images

The image element has the form:

```
<img src="WEBADDRESS" alt=TEXT width=NUM height=NUM>
```

This is one of the few tags that does not have a matching "close" tag. The only required attribute is the `src`, but it is a good idea to include a description of the image for the vision-impaired in the `alt` attribute. This may even by mandatory if you want the page to meet minimum Federal Accessibility Standards.

The `width, height` attributes are optional and they can be used to rescale the size of your image. Giving only the width will cause the height to scale proportionately. Giving height and width may result in a picture that looks stretched or flattened.

2.6 Headings

There are six levels of headings; from the largest `h1`, to the smallest `h6`. There general form is

```
<h1> CONTENT </h1>
```

where CONTENT is typically text and/or images. The `style` attribute can be used to specify the font size, background color, and text color.

2.7 Text Separation

HTML offers several elements that can be used to separate text on a page. When these elements are combined with CSS, they allow the web page designer to specify the style of different sections of the webpage.

The `span` element is used to group together some part of a line (or lines) of text. It has the form:

```
<span> CONTENT </span>
```

where the CONTENT is typically text and/or images. The span element does absolutely nothing by itself. It only becomes useful when combined with CSS, as it allows one to apply a `style` attribute to a short inline segment of words and/or images as in

```
See the blue <span style="border: thick blue solid"> box </span> around a single word
```

The `span` element was introduced as a hook on which to attach CSS to small segments of text.

The `br` elemeent is used to insert line breaks into the page. It has the form:

```
<br>
```

and observe that it does not have a close tag. Another way to break lines is to insert a horizontal rules, which is a solid line that stretches across the page. These are inserted using the

```
<hr>
```

tag which does not have a close tag.

Paragraphs are inserted into a page using the

```
<p>
 CONTENT
</p>
```

tag, where CONTENT is typically text and other markup with some restrictions (e.g. it can not contain any `p` elements).

Finally, the most general way to separate the content in a page is to use the `div` element, which has the form:

```
<div>
  CONTENT
</div>
```

where CONTENT can be any of the HTML elements that can appear in the body, including `p` and `div` elements.

2.8 Preformatted text

Browsers, by default, will reformat any text that you provide so that it fits the page nicely. Thus, if you type a paragraph as one long line, the browsers will generally add appropriate line breaks. Sometimes however, one wants the browser to respect the formatting and not to insert any line breaks or remove any spaces or tabs. This effect is provided using the `pre` element which has the form

```
<pre>
     Pre
       Formatted
   Content
</pre>
```

The preformatted content inside the `pre` element typically contains images and text.

2.9 Lists

HTML offers several different types of lists. We consider only two types here: `ul` and `ol` The `ul` element is used for "unnumbered lists" and has the form:

```
<ul>
  <li> Content </li>
  ....
  <li> Content </li>
</ul>
```

Observe that the `ul` element must contain a sequence of `li` elements, and each `li` element can contain any of the HTML elements that can appear in the body. These lists are rendered with asterisks or bullets or some other non-alphanumeric list item markers. CSS can be used to specify the type of list item maker used.

The `ol` lists are used for "ordered lists" and have the same format:

```
<ol>
  <li> Content </li>
  ....
  <li> Content </li>
</ol>
```

but they render their list item markers using numbers. CSS can be used to specify that letters or roman numerals be used instead.

2.10 Tables

Tables are a very useful formatting tool for web pages. They provide a mechanism for presenting tabular data and specifying how the table should appear on the page. The general form of the table element is:

```
<table cellspacing=DISTANCE cellpadding=DIST>
 <tr>
   <th>Content</th> .... <th>Content</th>
 </tr>

 <tr>
   <td>Content</td> .... <td>Content</td>
 </tr>

 ....

 <tr>
   <td>Content</td> .... <td>Content</td>
 </tr>
</table>
```

the contents of the table must consist of a sequence of `tr` elements representing the rows of the table. Each row consists of a sequence of `td` elements corresponding to the data stored in each cell of the table. Optionally, the first row can contain `th` elements which correspond to heading data. The `cellspacing` attribute is used to specify how much space should appear between the cells of each table. The `cellpadding` attribute specifies how much space should appear within a cell around the content of that cell.

2.11 Forms

Forms provide a mechanism for soliciting information from the user and sending it to the server. The `form` element contains attributes that specify which "server" the information should be sent to (`action`) and how the information should be sent (`method`). The simplest `action` to use is a `mailto` URL which will cause the contents of the form to be sent emailed to the specified address. For example, the following form solicits information and mails them to the page owner:

```
<form action="mailto:gwb@whitehouse.gov" method="post">
   Who did you vote for in 2000?
   <input type="text" name="comment" size="20">
   <input type="submit">
</form>
```

There are three main HTML elements for getting input from the user: `input`, `select`, and `textarea`. Each of these elements must have a `name` parameter which gives a name to the data that is sent to the server. The server will then use this name to determine how to handle the data.

The `input` element The input element has several variants including checkboxes, textfields, and file browers. We describe the most common variants below. All of these variants have the following form:

```
<input type=TYPE name="NAME" value="VALUE" size=SIZE>
```

Observe that there is no close tag for the `input` element. The `type` attribute can have one of the following values: `text, password, checkbox, radio, submit, reset, file, hidden, image, button`.

The `text` and `password` variants create a textfield in which the user can enter characters. The initial size is SIZE characters and the textfield is initialized with the string of characters in "VALUE". The password variant displays asterisks for each character typed by the user.

The `checkbox` and `radio` variants create checkable buttons. If a button is checked, then its "VALUE" will be sent to the server. Several buttons can have the same name, in which case the server will receive several values for that name. The `radio` variant allows the user to check at most one of the buttons that share the same name.

The `submit` variant sends the data to the server when it is pressed and the `reset` variant sets all fields in the form to their initial values.

The last four are more specialized and won't be discussed in detail here: `file` is used for selecting a file on the users disk, `hidden` is an element that doesn't appear on the webpage (but still specifies a value to be sent to the server), `image` specifies a graphical submit button, and `button` is used for client-side scripting, which we do not discuss here.

The `textarea` element This element is used for soliciting multiline input from the user, it has the form

```
<textarea name=NAME rows=ROWS cols=COLS>
  initial text goes
  here
</textarea>
```

In addition to the `name`, you must specify the size of the textarea in rows and columns.

The `select` element The select element is used to provide a fixed list of choice from which the user must choose. It has the form:

```
<select name=NAME size=SIZE multiple>
  <option value=V1> A1</option>
  <option value=V2> A2</option>
  ...
  <option value=Vn> An</option>
</select>
```

If the `multiple` keyword is present in the attribute list of the `select` element, then the user is allowed to select several of the options simultaenously; otherwise, the user can only select one. The `value` attributes in the `option` elements are sent to the server if the item is selected. If there is no `value` attribute then the text between the `option` tags is sent in its place.

2.12 Comments

You add comments to an HTML page using the following syntax:

```
<!--  comment goes here
      can include any text, except
      cannot have two consecutive dashes (-)
      as that indicates the end of the comment
  -->
```

Note that the "–" dashes delimit the comment part of the tag. The tag's name is "!" and it has not close tag. Also, spaces are forbidden between the ! and the –.

2.13 Frames

Frames provide a mechanism for combining several webpages into a single webpage.

Chapter 3

CSS

Cascading Style Sheets (CSS) is a language for specifying various aspects of the style of HTML elements. In this section we will provide only an overivew of the most common uses of CSS. The reader who want to go into more depth can visit the official source for CSS, the World Wide Web Consortium site at

```
http://www.w3.org/Style/CSS
```

There are several ways of adding style to HTML. We will focus on the "inline" method and discuss the other methods briefly at the end.

3.1 The Style Attribute

The key idea behind CSS is that it provides *uniform* methods for defining the style of HTML elements. The `style` attribute is one such method.

Every HTML element in the body of an web page can have a `style` attribute. The style attribute has the form:

```
style="Prop1:Value1; Prop2: Value2; ... ; PropN: ValueN"
```

Observe that that the style specification is enclosed in double quotes and consists of a sequence of `Prop:Value` specifiers, separated by semicolons.

There are eight basic properties: font, color, background, margin, padding, border, width, height. These are applied to an HTML element by imagining that the element is contained in an invisible box. The element can be as small as a single charater,chapter like `<span>word</span>`. At the other extreme, the box for the `bod` tag is the entire web page.

3.2 The `font` Property

The `font` property accepts values that specify how the text that appears within the element should be rendered. The minimal form of the font propery specifier is

```
style="font: SIZE FAMILY ; .... "
```

where `SIZE` is typically expressed in points, e.g. `12pt`, and `FAMILY` is one of the following standard font families: `serif`, `sans-serif`, `cursive`, `fantasy`, `monospace`. Thus, one could create a heading with large sans-serif letters as follows:

```
<h1 style="font: 60pt sans-serif">Intro to CSS</h1>
```

One can also specify that the font should be `italic` or `bold` and one can specify the spacing between the lines along with the font size. For example, the following element defines a paragraph with a bold italic 12 point serif font, and the paragraph is doubled spaced as the spacing between every two lines is 24 point.

```
<p style=
     "font: bold italic 12pt/24pt serif">
   This is bold, italic font in a 12 point serif font
   with 24 point interline spacing
</p>
```

The five font families listed above are supported on all CSS-capable browsers, but CSS allows the web designer to specify less common font families as well (e.g. 'Helvetica'). One problem that may arise with this freedom is that there is no guarantee that the browser that views your web page will have the font you have specified. CSS compensates for this by allowing the designer to specify a sequence of font families, separated by commas, ending with one of the standard font families. A CSS-capable browser will use the first font on that list which is currently available, and in the worst case will just use one of the five generic families. For example, the following heading specifies that the `Irish Ultra` font should be used if possible, otherwise the browser should use ariel, or helvetica, or if all else fails, sans-serif.

```
<h1 style=
      "font: 60pt 'Irish Ultra',ariel,helvetica,sans-serif">
  CSS Fonts
</h1>
```

3.3 The `color` Property

The `color` property of a style attribute specifies the text color of an HTML element. The color particular color itself can be specified in several ways:

- Using one of the sixteen standard HTML colors: aqua, black, blue, fuchsia, gray, green, lime, maroon, navy, olive, purple, red, silver, teal, white, and yellow.
- As a hexadecimal number in the form `#rrggbb` where `r,g,b` are hexadecimal digits: 0,1,2,3,4,5,6,7,8,9,a,b,c,d,e,f.

- As a 3 digit hexadecimal number `#rgb`
- As a term of the form `rgb(R,G,B)`, where `R,G,B` are numbers between 0 and 255
- As a term of the form `rgb(R%,G%,B%)`, where `R,G,B` are decimal numbers between 0.0 and 1.0.

In each case but the first, the color is specified as a combination of red, green, and blue light, and the R,G,B parameters specify how much of each of the primary colors to use in the desired color.

For example, the following html segment shows how to specify the color of individual words in a sentence:

```
Here are a few colors:
<span style="color:red"> red,</span>
<span style="color:#ffff00"> yellow,</span>
<span style="color:#0f0"> green,</span>
<span style="color:rgb(0,0,255)"> blue,</span>
<span style="color:#rgb(0.9\%,0.8\%,0.7\%)">brown</span>
```

3.4 The background Property

The `background` property can be used to specify the color of the background using the same syntax as the `color` property. For example, to make a heading with red letters on a black background you could use:

```
<h1 style="font: 48pt serif; color:red; background: black">Warning!</h1>
```

This property is more versatile however, in that it can also be used to specify a background image rather than a color. In this case, the value of the property is a webaddress of the form

```
url(page.gif)  or url(http://x.com/page.gif) or
```

For example, the following body tag specifies that the“sincos.gif” image should be used as the background for the page:

```
<body style="background: url(sincos.gif)">
  ...
</body>
```

3.5 The border Property

CSS allows you to put borders around the box enclosing any HTML element. The general form is

```
style="border: WIDTH STYLE COLOR"
```

where

- `WIDTH` is one of `thin`, `medium`, `thick`, or is a distance measured in pixels (e.g. `10px`,) or absolute units, e.g. `0.1in`, `1cm`, `8.2mm`, `2pt`, `0.3pc`.
- `STYLE` is one of `none, dotted, dashed, solid, double, groove, ridge, inset, outset`
- `COLOR` is a color as specified in the color property discussed above.

For example, we can specify a heading with a thin, solid, blue border as follows:

```
<h1 style=
      "border: thin solid blue; font: 24 sans-serif">
  Greetings
</h1>
```

Observe that the order of the width, style, and color parameters is not important.

3.6 The `width, height` Property

These two properties refer to the size of the box that contains the element. These can be expressed in distance units (as with the WIDTH property of borders above). The width can also be exrpessed as a percentage (being interpreted as a percentage of the width of the parent element.) For example, the following code creates a 1x2 inch blue box:

```
<div style="width:1in; height:2in; background: blue; color:black">
</div>
```

3.7 The `margin` and `padding` Properties

The padding is the distance between the border of an element and the content. The margin specifies the distance between the parent and the border of an element. These can be expressed as lengths or as percentages of the parent elements width. You can express a single distance for the padding of all four sides (top, right, bottom, left) as

```
<li style="padding:0.5in">first example</li>
```

Or you can specify a separate padding for each, in the order top, right, bottom, left.

```
<li style="padding:0.1in,0.2cm,0.3in,10px">second example</li>
```

The margins are specified in the same way:

```
<li style="margin:0.5in">first example</li>
<li style="margin:0.1in,0.2cm,0.3in,10px">second example</li>
```

3.8 The vertical-align and text-align Properties

The horizontal alignment can be specified to be one of the following `left, right, center, justify`. For example, a centered heading is specifed by

```
<h1 style="text-align:center; font: bold 24pt sans-serif">Greetings</a>
```

Finally, the vertical alignment of an HTML element can be specified to be one of `baseline, sub, super, top, text-top, middle, bottom, text-bottom` or a percentage (which is relative to the interline width and can be negative for lowering an element). For example, you can lower an image by

```
<img src="abc.jpg" alt="dog" style="vertical-align: -50\%">
```

3.9 Other CSS Capabilities

There are several more CSS properties (especially having to do with text, paragraph indenting, etc.), but these are the most common ones.

3.10 Using CSS via the Class attribute

In this section we show how to give names to styles in the "head" element of a webpage.

This allows you to define the style once and then use it many places. The style definitions can go into the head element of the html tag for example, the following code defines a "toocool" class and uses it for a heading and a sentence:

```
<html>
  <head><title>test</title>
    <style type="text/css" media="screen">
      <!--
        .toocool  {background:black; color:red}
        p         {background:white; color:red}
        p.toocoll {background:black; color:white}
        .bland    {background:white; color:black}
      -->
    </style>
  </head>
  <body>
    <h1 class="toocool">Cool page</a>
    This is neat and
    <span class="toocool">this is too cool!</span>
    <p> This is a normal paragraph with CSS style</p>
    <p class="toocool">This uses the special toocool-paragraph
    style</p> and
```

```
    <p class="bland">This is a bland paragraph</p>
  </body>
</html>
```

The style file has the form:

```
NAME {STYLE-SPEC}
NAME {STYLE-SPEC}
NAME {STYLE-SPEC}
```

where the STYLE-SPEC is a specification of the style as we have seen for inline CSS. There are three ways of naming a style. You can either assign the style to an entire html tag (e.g. `p`) in which case it is applied whenever that tag appears. Or you can can give it a class name that can be used with any tag. The `NAME` in this case should start with a period (.) as in `.toocool`. Finally, you can name the style with both an HTML tag and a class name, as in `p.toocool`. In case of conflicts, the most specific specification is used, e.g. `p.toocool` style will be used in a paragraph with the `toocool` attribute. Likewise, the `bland` style will be used in a bland paragraph. Finally, note that the style names can be any name you wish to create. The names must begin with a letter and contain only letters, digits, and dashes (-).

The "media" specification in the style tag allows you to specify different styles for different media. Current media include "screen" for usual webpage browsing, "print" for printing, and "aural" for screen readers.

You can also store the CSS in a separate file and link it to the current page using a "link" tag in the head:

```
<html>
  <head><title>test</title>
    <link rel="stylesheet" href="demo.css" media="screen">
  </head>
  <body>
    <h1 class="toocool">Cool page</a>
    This is neat and
    <span class="toocool">this is too cool!</span>
  </body>
</html>
```

The final interesting use of CSS is that one style sheet can import one or more style sheets, creating a cascading effect. This is done with the `@import` directive in the style file or style definition, e.g.

```
<html>
  <head><title>test</title>
    <style type="text/css" media="screen">
      <!--
        @import url(http://www.whitehouse.gov/css);
        .toocool  {background:black; color:red}
```

```
      -->
    </style>
  </head>
  <body>
    <h1 class="toocool">Cool page</a>
    This is neat and
    <span class="toocool">this is too cool!</span>
  </body>
</html>
```

Part II

Dynamic Web Site Design

Chapter 4

Scheme Servlets

In this chapter we explain how to develop interactive web pages. These pages will typically prompt the user for some information (using a web form or a hyperlink) and then will generate a new web page, based on the user input. They may also perform other actions such as read/writing information on the servers disk, sending email, or accssing a database.

The language we use to specify these interactive web pages is a simple combination of Scheme, HTML, and CSS. For most of the examples in this section, the scheme will be used in relatively simple ways and hence you will not need to know much about the language itself beyond the few examples we demonstrate below. In Chapter ??, we will give a full introduction to Scheme and you can then use that to build even more complex servlets.

4.1 Dynamic Content and BRLS

The key idea behind BRLS[1] servlets is that they provide a way of "escaping" from HTML into the Scheme programming language whenever you want to add some dynamic content, i.e. content that may change based on the users actions.

For example, one of the most common types of dynamic content is a line on a webpage that gives the current time on the server. The servlet in Figure 4.1 gives some simple examples of dynamic content.

The curly braces "{" and "}" at the beginning and end of the `date.brls` servlet indicate that the page contains HTML [2]

The square braces "[" and "]" in the `date.brls` servlet tell the server that the element they enclose is a Scheme expression that should be run to get its

[1] BRLS standands for the BRL-like Servlet. It is so named because of its similarity to the BRL syntax developed by Bruce R. Lewis. The BRL approach interleaves Scheme and HTML, whereas BRLS employs nesting of Scheme and HTML.

[2] Actually, they indicate that they contain characters that should be sent verbatim to the client's browser, except for the sections enclosed in square brackets, which are processed as described above.

```
{<html>
 <head><title>Current Time and Date</title></head>
 <body>
   The current local time and date is <br>
   [(Date.)]
   <br>
   (This page is powered by Scheme servlets!)
 </body>
</html>}
```

Figure 4.1: The `date.brls` servlet

```
The current local time and date is
Sun Jan 20 07:46:44 EST 2002
(This page is powered by Scheme servlets!)
```

Figure 4.2: The result of the `date.brls` servlet

value. That value is then inserted directly into the page. We'll discuss Scheme expressions in the next section and throughout the rest of the book.

To run this `date.brls` servlet, you need to store it in a file with the suffix ".brls" (say for example `date.brls` and then move this file into the `scheme` subfolder of the `webapps` folder of the tomcat `folder`. If you then visit the URL
`http://127.0.0.1:8080/scheme/date.brls`
you will get a web page that contains the text in Figure 4.2. The URL 127.0.0.1 is the standard IP address for the local system. If your computer is connected to the internet, then it has a world-viewable IP address which can then be substituted for 127.0.0.1 in the above example.

Exercise 1 *Write a servlet that reports on the client's CPU and operating system using the Scheme calls*

```
   [(.getHeader request ua-os)]
```
and
```
   [(.getHeader request ua-cpu)]
```

Exercise 2 *Write a servlet that displays a random number using*

```
[(Math.random)]
```

4.2 Captioned Images and Abstraction

In this section, we show how to use Scheme to create your own tags. We use captioned images as an example.

```
<html>
         <head><title> Title</title></head>
         <body>
      <h1> Some captioned images</h1>

      <table border=5>
        <tr> <td style="padding:12pt;
                  background:rgb(255,225,195);color:white">
            <img src="TimothyHickey.gif" alt="Tim Hickey">
         </td></tr>
         <tr><td style="text-align:center;padding:12pt;
                        font: italic 11pt Helvetica,sans-serif;
                       background:rgb(255,225,195);color:black">
            Tim Hickey</td></tr>
      </table>



    </body>
     </html>
```

Figure 4.3: Scheme tags

```
[(begin
   (define (captioned-image C I)
     {
      <table border=5>
        <tr>
        <td style="padding:12pt;
                   background:rgb(255,225,195);color:white">
            <img src="[I]" alt="[C]"></td></tr>
        <tr><td
             style="text-align:center;
                        font: italic 11pt Helvetica,sans-serif;
                        padding:12pt;
                        background:rgb(255,225,195);color:black">
            [C]</td></tr>
      </table>})

   (define (generic-page Title Body)
     {<html>
         <head><title> Title</title></head>
         <body> [Body]</body>
     </html>})

   (generic-page
     "abstraction demo"
     {
      <h1> Some captioned images</h1>
      <table>
        <tr>
         <td>[(captioned-image
                      "Tim Hickey" "TimothyHickey.gif")]</td>
         <td>[(captioned-image
                     "Tim Hickey" "TimothyHickey.gif")]</td>
         <td>[(captioned-image
                    "Tim Hickey" "TimothyHickey.gif")]</td>
       </tr></table>

    })
)]
```

Figure 4.4: Scheme tags

```
[(let ()
   (define (captioned-image C I)
     {
      <table border=5><tr><td class="image">
         <img src="[I]" alt="[C]">
      </td></tr><tr><td class="caption">
         [C]
      </td></tr></table>})
 {<html>
   <head>
    <title> Abstraction Demo</title>
    <style><!--
     {td.image
       \{padding:12pt;background:rgb(255,225,195);color:white\}
      td.caption
       \{text-align:center;font: italic 11pt Helvetica,sans-serif;
         padding:12pt; background:rgb(255,225,195);color:black\}}
     --></style>
   </head>
   <body>
    <h1> Some captioned images</h1>
    <table><tr><td>
     [(captioned-image "Tim Hickey" "TimothyHickey.gif")]
     </td><td>
     [(captioned-image "Tim Hickey" "TimothyHickey.gif")]
     </td><td>
     [(captioned-image "Tim Hickey" "TimothyHickey.gif")]
    </td></tr></table>
   </body></html>
})]
```

Figure 4.5: Scheme tags

Figure 4.6: Scheme tags

Figure 4.7: Scheme tags

4.3 Scheme Expressions and the BRLS notation

The text between the square braces is called a scheme expression. The scheme expressions in the servlet above both have the form:

```
( OPERATOR ARG1 ARG2 ... ARGK )
```

For example, in the first scheme expression in Figure 4.1

```
(* 12345679 8)
```

the operator is the addition operator "+" and the arguments are the numbers `12345679` and `8`. The second scheme expression

```
(java.util.Date.)
```

in Figure 4.1, has no arguments and its operator is `java.util.Date.` which is the name of an operator for finding the current Date.

This book uses the Jscheme dialect of Scheme. The core Scheme language provides about 200 basic operators (like "+"). The Jscheme dialect additionally provides access to all of the procedures in the Java standard libraries (which is over 33,000 for Java 1.4.0). For example, "java.util.Date." is a constructor for the Date class in the java.util package. We will use only a very small subset of these built-in operators. Appendix C contains a description of that subset of the Scheme language which is used in this text, including the complete list of operators used here.

4.4 Processing HTML form data

Perhaps the most common use of servlets is to process form data generated by an HTML page. For example, consider the HTML in Figure 4.8 which creates a simple form requesting the users name, birth year, and favorite color: Recall that the HTML form elements require a "name" attrribute which will be associated to each of the user inputs.

We will now write a servlet that processes this data by generating a personalized page containing the user's name in her favorite primary color and stating the user's approximate age in millions of seconds. The servlet appears in Figure 4.9.

The simplest way to process user input is to use the `servlet` form which has the following shape:

```
[(servlet (param1 param2 ... paramk)

 {<html>
    ...print out the response page using
     [param1] .... [paramk]
  </html>}
)]
```

```
<html>
 <head><title>Simple Form Demo</title></head>
 <body>
   Please enter the following data:
   <form method="post" action="simpleform.brls">
   <ul>
    <li> Your First Name: <input type=text name="firstname"></li>
    <li> Your BirthYear: <input type=text name="birthyear"></li>
    <li> Your Favorite Primary Color: <select name="favcol">
       <option>red</option>
       <option>green</option>
       <option>blue</option>
       <option>yellow</option>
     </select>
   </ul>
   <input type=submit>
   </form>
 </body>
</html>
```

Figure 4.8: The `simpleform.html` servlet

```
[(servlet (firstname birthyear favcol)
 {<html>
   <head><title>Simple Servlet Demo</title></head>
   <body>
    Greetings
    <font color=[favcol]>
     [firstname]</font>,
    <br>
   Your age, in millions of seconds is about
    [(* 0.000001 365.25 24 60 60
       (- 2002 (Double. birthyear)))]
 </body>
</html>
})]
```

Figure 4.9: The `simpleformresponse.brls` servlet

This statement first reads the input that the user has supplied in the HTML form and stores this input in Scheme variables "param1", "param2", etc. These variables must be Scheme symbols (e.g. they cannot contain spaces or parentheses) and they correspond to the "name" attributes in the HTML form that prompted the data from the user.

There is one problem with the way we have implemented this servlet. The problem arises if someone clicks on the `simpleform.brls` servlet directly. In this case, the form parameters will have the value `#null`. This will cause an error when we try to convert `#null` to a number using `Double.` and instead of a nice web page, the servlet will return a mysterious page with an error notice on it.

One solution to this problem is to combine the HTML page that produces the form and the BRLS page that processes the form data into a single BRLS page. Figure 4.10 shows this new approach. On this new page, the servlet first check whether one of the parameters (say `firstname`) is `#null`. If so, then it generates the HTML form to gather the data from the user, if not then it processes the form data. This conditional test is done with the `if` expression in Scheme. The syntax of the `if` expression is

```
(if TEST THEN-EXPRESSION ELSE-EXPRESSION)
```

and this is processed by **first** evaluating the `TEST` expression. If this test returns the true value (represented by `#t` in Scheme) then it evaluates the `TEST-EXPRESSION` if the test returns the false value (represented by `#f`, the `ELSE-EXPRESSION` is evaluated[3]. The code that implements this strategy is shown in Figure 4.10

[3]If the `TEST` returns a value which is neither true, nor false, the `THEN-EXPRESSION` is evaluated. This is the optimist strategy, anything other than a direct `false` is considered to be `true`!

```
[(servlet (firstname birthyear favcol)
  (if (equal? firstname #null)

   {<html>
    <head><title>Simple Form Demo</title></head>
    <body>
     Please enter the following data:
     <form method="post" action="simpleform.brls">
     <ul>
      <li> Your First Name:
           <input type=text name="firstname"></li>
      <li> Your BirthYear:
           <input type=text name="birthyear"></li>
      <li> Your Favorite Primary Color:
       <select name="favcol">
         <option>red</option>
         <option>green</option>
         <option>blue</option>
         <option>yellow</option>
       </select>
     </ul>
     <input type=submit>
     </form></body> </html>}

   {<html>
     <head><title>Simple Servlet Demo</title></head>
     <body>
      Greetings <font color=[favcol]> [firstname]</font>, <br>
     Your age, in millions of seconds is about
      [(* 0.000001 365.25 24 60 60
         (- 2002 (Double. birthyear)))]
    </body></html>}
))]
```

Figure 4.10: The `simpleform.brls` servlet

Chapter 5

Examples of Scheme Servlets

In this chapter we present several, increasingly more interesting, examples of Scheme servlets. Each servlet will introduce a few more concepts about Scheme servlets. Hopefully, by the end of the chapter you will begin to understand how to create your own Scheme servlets.

5.1 pw-protected pages

It is often useful to restrict the audience that has access to any given webpage. One way to restrict access is to require the users to enter a password before they can gain access to any other pages on the site. In this first example, we show how to create a simple password protected page that uses one password for all users. A more interesting application would allow users to register and select their own password, but we will get to that later.

The key idea programming concept that this example demonstrates is the "if expression." The general form of the "if expression" is

```
(if TEST THEN ELSE)
```

where `TEST`, `THEN`, and `ELSE` are Scheme expressions. When this expression is evaluated in Scheme, it first evaluates the `TEST` expression. If it evaluates to `#f` (i.e. the "false" value), then the `ELSE` expression is evaluated; otherwise, the `THEN` expression is evaluated.

The servlet is Figure5.1 shows our servlet. Observe that the first line starts off with a semicolon. This indicates that the rest of the line is a comment and will be ignored by the Scheme interpreter. After the comment we have a "let" expression which reads in the "pw" parameter (if any) and stores it in the variable "pw." Then we test to see if the password is correct. If it is, then we show the secret page. If it is not, then we generate a page containing a form for getting the correct password.

```
[(servlet (pw)

  (if (equal? pw "yes! scheme")

      {<html><head><title>Secret Page</title></head>
        <body>
          <h1 style="font: bold 24pt Times,serif">
            Welcome to the secret page
          </h1>
           The answer is 6!
        </body>
       </html>}

      {<html><head><title>Password Form</title></head>
        <body>
          <h1>Please enter the correct password below</h1>
          [(java.util.Date.)]
          <br>
          <form method="post" action="pwpage.brls">
            Please enter the password for this page:
            <input type="password" name="pw" size=20>
           <br><input type="submit">
          </form>
        </body>
       </html>}
))]
```

Figure 5.1: A simple Password Protected Page

The first time a user visits this page, there will be no form data (and the "pw" variable will have the value `#null`, which is a Scheme constant representing an empty object. In this case, a form will be generated. If the user fills out the form and presses the submit button, the servlet will then read an non-null value from the "pw" parameter. If the password is correct, the secret page will be displayed otherwise, the user will be prompted for the correct password again!

Security Warning – note this is not very secure because the source code contains the password. Generally, the source code will not be visible to the outside world, but if you make a backup copy of your servlet and store it in some file that doesn't end in ".brls" (say ".txt") then the server will assumet that the file is just text and will let anyone see the contents of this file. It is very common for editors to make exactly this kind of a backup file and hence by editting a file in your servers webapp folder, you could let everyone see the password!

There are various techniques for getting around this, but the general lesson

```
[(begin
  (define count
         (+ 1 (read-from-file httpservlet request "count" 0)))

    (write-to-file httpservlet request "count" count)

    {<html><head><title>counter</title></head>
      <body style="background:white; color:black">
        <h1> You are visitor number [count]</h1>
      </body> </html>}
)]
```

Figure 5.2: A simple counter program

is that passwords are not helpful unless they are very carefully hidden! We will discuss security in more detail later.

5.2 counters

Next we show how to implement webapage that contain counters. These keep track of how many times a page has been visited. There are many strategies one can employ for such counters. For this example, we will write a servlet "counter.brls" that stores its count in a file called counter.brls_count.

The code for the "counter.brls" servlet is in Figure 5.2. This servlet introduces a few new ideas. First of all, it relies on a small library "forms.scm" of scheme procedures for reading and writing to the count file. The servlet must first load the library before it can use the special counter library procedures. This is done using the "load" procedures

```
(load "webapps/scheme/lib/forms.scm")
```

Also, since the servlet now does two things: load in a library and generate a webpage, we must use a begin statement to group these two together. The general form of a "begin" statement is

```
(begin
  E1
  E2
  ...
  En
)
```

and Scheme will evaluate each of the expressions E1, ... En, in turn, and will return the value of the last one. Thus, in our case, the last expression is the one that generates the web page that will be returned to the browser.

```
[; this is in the file "logger.brls"
(begin
  (load "webapps/scheme/lib/forms.scm")
  (append-to-file httpservlet request "log"
     (java.util.Date.))
  (let (
    (logdata (read-string-from-file httpservlet request
                                    "log" ""))
      )

    {<html><head><title>logger</title></head>
      <body style="background:white; color:black">
        <h1> The list of visitors to this site is </h1>
        <pre>[logdata]</pre>
      </body>
     </html>}
))]
```

Figure 5.3: A simple log servlet

The "forms.scm" library defines the "read-from-file" and "write-to-file" procedures. These procedures are always called with the following arguments

```
(read-from-file httpservlet request COUNTERNAME INITIAL_VALUE)
(write-to-file httpservlet request COUNTERNAME NEW_VALUE)
```

where "INITIAL_VALUE" is the value to be returned in case there is no such file (e.g. the first time one uses a counter, there will not yet be a counter file), "NEW_VALUE" is the new value that should be stored in the counter file, and "COUNTERNAME" is the name of the counter file. Actually, the counter will be stored in a file whose name is "NNNNN.brls_COUNTERNAME" where "NNNNN.brls" is the name of the servlet using the counter. This allows you to have several servlets with counter and not worry about the counter interfering with each other.

5.3 log files

In this next example, we show how to create a servlet that generates an entry in a log file for each time the servlet is visited. The logger servlet in Figure 5.3 is quite similar to the counter servlet above.

As before we begin by loading in the forms.scm library. Next we append the current date and time to the logfile "logger.brls_log" of "writing" to the counter file, we "append" to the log file. Then we read the logfile and store it in the "logdata" variable which we include in the HTML file sent back to the user.

```
[{<html><head><title>table demo</title></head>
    <body style="background:blue; color:black">
        <h1> Office hours</h1>
        <table cellpadding=10 cellspacing=10 border=5
         style="background:lightgreen; color:black">
        [(make-trs '(
          ( name  mon   tue   wed   thu  fri  sat  sun)
          ( 9     th    -     -     th   -    -    -  )
          (10     -     aj    -     -    -    -    -  )
          (11     -     aj    -     -    -    -    -  )
          (12     -     aj    -     -    -    -    -  )
          ( 1     -     -     -     -    -    ef   ef )
          ( 2     -     -     -     -    -    ef   ef )
          ( 3     -     -     -     -    -    -    -  )
          ( 4     -     -     rs    rs   rs   -    -  )
         ))]
       </table>
      </body></html>}]
```

Figure 5.4: A simple table servlet

5.4 automatic table generation

Next we give an example of using Scheme to create HTML tables. This will turn out to be quite useful when we are working with databases, as the answer to a database query often takes the form of a table. Figure 5.4 gives an example of creating an HTML table from a list using the "make-trs" from the "table.scm" library. To explain this servlet, we first need to discuss how Scheme handles lists.

The new Scheme idea we need to use here is the notion of a list. One of the most powerful features of Scheme is that it allows you to work with lists of data is a relatively simple way. You can create a Scheme constant by putting a single quote in front of a parenthesized sequence of scheme terms:

```
'(mon tue wed thu fri)
```

The single quote indicates to the Scheme interpreter that the following term is just "data" and should not be "evaluated. " For example,

```
(+ 1 2 3)
```

evalutes to 6, but

```
'(+ 1 2 3)
```

evalutes to the list `(+ 1 2 3)`.

Scheme lists can contain sublists and this is a convenient way of representing a table of data, e.g.

```
'(
  (name age sex)
  (john 22  male)
  (jiri 20  male)
  (anzy 18  female)
  (miri 17  female)
 )
```

To make this into a table we use the "make-trs" procedure defined in the "table.scm" library. This procedure takes a list of lists (one for each row) and creates a "tr" element for each of these lists.

5.5 surveys

The best way to run a survey is to use a database to store the results as one can then easily analyze the survey results. However, in this section, we show how to collect survey data and store it in a log file.

Figure 5.5 shows a very simple survey servlet. The first time it is visited the parameters have value `#null` because the user has not filled out the form. The servlet therefore generates an HTML form containing the survey. When the user completes this form and submits it, the servlet collects the user responses and the current time/date and logs it in the file "survey.brls_log"

5.6 email response pages

Our final example of basic servlets demonstrates how to write a servlet that sends email. Again, here we must load a library "mail.scm" which, in this case, defines the send-mail procedure which is called as follows:

```
(send-mail request TO FROM SUBJECT TEXT)
```

Here TO, FROM, SUBJECT, and TEXT are strings. For example, to send mail to someone@xxyyzz.com from "me@myserver.com" you would write

```
(send-mail request  "someone@xxyyzz.com" "me@myserver.com"
  "This is a test"
  { Cool, this really works and I can include
        scheme expressions like this:
      [(* 111 111)] is 111 squared! })
```

5.7 A Survey Servlet

For our last example we show how to implement a Bulletin Board that allows users to read, post, and respond to messages. The general strategy will be to number each message that is posted (using a counter to keep track of the next

```
[; this is in the file "survey.brls"
(servlet (firstname birthyear favcol)

  (if (equal? #null firstname)

  { <!-- firstname=#null for the first visit the the page
         and hence we generate the survey form page -->
    <html><head><title>Simple Form Demo</title></head>
     <body>
       Please enter the following data:
       <form method="post" action="survey.brls">
       <ul>
        <li> Your First Name:
             <input type=text name="firstname"></li>
        <li> Your BirthYear:
             <input type=text name="birthyear"></li>
        <li> Your Favorite Primary Color:
              <select name="favcol">
           <option>red</option>  <option>green</option>
           <option>blue</option>  <option>yellow</option>
         </select></li>       </ul>
       <input type=submit></form></body></html>}

  (begin  ;; in this case the form has been filled in
    ;; now we store the survey results in the log
    (append-to-file httpservlet request "log"
        (list (java.util.Date.) firstname birthyear favcol))
    {<html><head><title>logger</title></head>
      <body style="background:white; color:black">
        <h1> Thanks [firstname]<br>
             for completing the survey</h1>
      </body></html>}
)))]
```

Figure 5.5: A simple survey servlet

```
(begin  ;; in this case the form has been filled in
  (load "webapps/scheme/lib/mail.scm")
  ;; now we email the survey results to the user
  (send-mail request email email
     "survey results"
      (list (java.util.Date.) email birthyear favcol))
  ;; and finally generate the survey confirmation
  {<html><head><title>email survey</title></head>
    <body style="background:white; color:black">
      <h1> Thanks [email]<br>
           for completing the survey</h1>
    </body></html>})
```

Figure 5.6: Response expression of email survey servlet

number) and so store the Nth message in a file named `bb.brls_N`. So the first message will be in `bb.brls_1`, the second in `bb.brls_2`, etc. Finally, we will generate one more file `bb.brls_msgs` that stores the HTML rows of a table of pointers to the messages.

The basic structure of the servlet is as shown below. The key idea is that the servlet will consist of a sequence of forms. Each form will have a parameter named `command` which states which action the servlet should take. There are three possible actions:

- post: show the list of previous messages, and let user enter a new message
- view: show the user a single message, and let user post a followup
- respond: thank user for posting a message (and actually handle the posted info)

we might also want to add a password page to limit the access to the BB:

```
{<html><head><title>Simple BB Demo </title></head>
 <body style="color:black; background:white">
 [(begin
    ... load in the necessary libraries
   (let (
     (command (.getParameter request "command"))
     ... read in other variables needed below
      )
   (if (equal? #null command)
    {... generate page showing the messages
     ... and ask if user wants to post a new message}

    (case command
      (("view" "post")
```

```
        {.... show the message (if command = view)
         .... then allow user to post a message
         .... with a form with command=respond})
     (("respond")
       {.... read the message parameters from HTML form
        .... store message in a file, update counter,
        .... update the list of links to messages
        .... generate a response page})
      (else  {.... generate an error page!}))
  )))  ]
</body></html>}
```

```
[(servlet (command msg who subj)

  (define count
     (read-from-file httpservlet request "count" 1))

{<html><head><title>Simple BB Demo </title></head>
 <!--
  this is a simple implementation of a bulletin board
  it allows threading, but doesn't sort by threads
 -->
 <body style="color:black; background:white">

 [(if (equal? #null command)

     {<h1>Simple BB</h1>
      <!-- display the links stored in the "msgs" file -->
      <table border=5>
       <tr><th>msg</th><th>in RE</th><th>date</th>
           <th>from</th><th>subject</th></tr>
       [(make-trs (read-all-from-file httpservlet request
                                      "msgs" ()))]
      </table>
       <br><a href="bb.brls?command=post">Post a message</a> }

   (case command
     (("view" "post")
       .... possibly show a user method
       .... then allow user to post a message)
    (("respond")
       .... read the message parameters from HTML form
       .... store message in a file, update counter,
       .... update the list of links to messages
       .... generate a response page)
     (else  .... generate an error page!))
  )))  ]
</body></html>}
```

Figure 5.7: A bulletin board servlet: part 1. Note that we have commented out the main parts of this servlet. The missing code is shown in the next Figure.

```
(case command
  (("view" "post")
    { <!-- allow user to post a followup message -->
    [(if (equal? command "post") ""
         {<h1>Message number [msg]</h1>
             <xmp style="color:black;background:yellow">
          [(read-string-from-file httpservlet request
               msg "ERROR: MISSING PAGE")]</xmp> })]
    <br><form method="post" action="bb.brls">
     <input type=hidden name="command" value="respond">
     <input type=hidden name="msg"
            value="[(if (equal? #null msg) 0 msg)]">
     [(if (equal? command "view")
          {<br><br><h1>Post a response</h1><table>}
          {<br><br><h1>Post a new message</h1><table>})]
     <tr><td>From:</td>
         <td><input type=text name="who"></td></tr>
     <tr><td>Subj:</td>
         <td><input type=text name="subj"></td></tr>
     </table>
     <br><textarea name="response" rows=5 cols=50></textarea>
     <br><br><input type=submit value="post it!"> })
  (("respond")
   (write-to-file httpservlet request count {
     From:[who]
     Date:[(Date.)]
[   (.getParameter request "response")]  })
    (write-to-file httpservlet request "count"
                   (+ 1 (Integer. count)))
   (append-to-file httpservlet request "msgs" {[(.toString
     (list  count msg (.toString (Date.)) who
          {<a href="bb.brls?command=view&msg=[count]">[subj]</a>}
       ))]})
   (let ((msglist
            (read-all-from-file httpservlet request "msgs" ())))
      {<h1>Thanks for your response</h1>
       <table border=5>
       <tr><th>msg</th><th>in RE</th><th>date</th>
           <th>from</th><th>subject</th></tr>
        [(make-trs msglist)] </table>
       <!-- display the links stored in the "msgs" file -->
      <br><a href="bb.brls?command=post">Post a new message</a>
     }))
 (else {I don't understand the command [command]}))
```

Figure 5.8: A bulletin board servlet: the case expression

Chapter 6

Databases

In this chapter we give an introduction to the use of databases in web programming. Databases provide a means of storing and retrieving large amounts of data efficiently. In the previous chapter, we have seen a simple way to read data from and write data to the server's disk. For small amounts of data this works well, but it becomes unacceptably slow for large data sets.

We will first give an introduction to databases in general and to the SQL (Structure Query Language) in particular, then we explain how to process database queries in Scheme. In the next Chapter we give several examples of accessing databases from Scheme servlets.

6.1 Database concepts

A **database** is a named collection of data which is organized into **tables**. When you create a table, you must provide a unique name for the table, and you must specify the number of `columns` in the table and the names for each columns. Moreover, you must specify what type of value each column can contain. The most common types are

- `INTEGER` for whole numbers
- `DECIMAL` for decimal numbers
- `VARCHAR` for character strings

6.2 Intro to SQL, SQL clients, and SQL servers

SQL (Structured Query Language) is the most widely used language for managing databases. It is a relatively simple language that allows you to

- create new databases and tables
- put data into a table

- add users to a database and give them permissions
- select information from a database
- modify information in a database

An SQL system usually consists of two components:

- an SQL engine that creates, modifies, and searches through the databases, and
- an SQL client that connects to the engine and provides a graphical interface for the user to construct and execute SQL queries.

The SQL server can often be setup as a web service, so that anyone can connect to the server over the web and make SQL queries, provided they know a user name and password for accessing the system.

In this Chapter we will describe the use of one particular open source database server and client, the hsql Database Engine – a sourceforge open-source project. We have chosen this database because it is multiplatform, easy to install, and free. Like almost all software, it comes with no warranty, and in this case, it should not be used for commercial purposes unless you invest great care in analyzing the code looking for security problems. Nevertheless, it will serve fine as an educational tool. Another database

The hsqldb system and its documentation can be downloaded from

```
http://hsqldb.sourceforge.net
```

We have included the hsqldb system itself in the scheme webapp (actually it is in the file `tomcat/webapps/scheme/WEB-INF/lib/hsqldb.jar`.

6.3 A Simple Database-backed Survey

In the next section we give a complete example of setting up a database and a table and building a servlet that uses that table to implement a simple survey and analyze the results. In the later sections we will discuss the concepts underlying this example. In the following Chapter we give more examples of database-backed servlets.

6.3.1 Overview of the survey servlet

The survey is just an html file that asks the users age, political party, and and who they voted for in the last presidential election. When the user answers these questions and submits the form, the data will be stored as a row in a database and then several queries will be run to analyze the data gather so far. This data will then be presented to the user on the response page.

Thus we must create a database with a table to store the survey answers, an HTML page to get the users answers and a servlet page to store the data in

the database and generate a response page with a summary of the poll results so far.

It would be better to try and make sure the same person from the same computer doesn't vote many times to influence the outcome, but in this simple example we will ignore these concerns.

6.3.2 Creating a new database

The first step is to start a SQL client and create a database and table for your data. You start the client with the following commands from inside the hsqldb folder:

```
% cd demo
% java -cp ../lib/hsqldb.jar org.hsqldb.utils.DatabaseManager
```

Note: Windows users must use backslash instead of slash. Also, you must set your path so that it contains the java program.

Starting the DatabaseManager pops up a window titled "Connect" with five fields. You should select the following field values:

```
PROMPT    VALUE                              DEFAULT VALUE
Type:     HSQL Database Engine Standalone (the second choice)
Driver:   org.hsqldb.jdbcDriver           (this one)
URL:      jdbc:hsqldb:webDB               (jdbc:hsqldb:test)
USER:     sa                              (sa)
Password:                                 ("")
```

The USER "sa" is the System Administrator, which is the only user able to create new databases and to have full control over the database. The "webdb" in the URL, is the name of your new database.

Once you click "OK" you will have created the `webdb` database (if it didn't already exist it will be created) and you will see the "HSQL Database Manager" window which provides a front-end to the database.

6.3.3 Creating a new table in the database

You can now create the "survey" table by selecting `CREATE TABLE` from the `Command` menu, and then completing the command to read as follows:

```
CREATE TABLE survey(age INTEGER,party VARCHAR,votedfor VARCHAR);
```

Hitting the `Execute` button will create that table and you can examine it by selecting the `Refresh Tree` menuitem in the `View` menu.

Next change the system administrator password to what ever you want by executing the following query.

```
SET PASSWORD mynewpassword;
```

This will prevent others from being able to connect to your server as the system adminstrator. The next time you visit this database, you will need to specify "mynewpassword" as the "sa" password, rather than the default empty password.

6.3.4 Starting a server for the database

Next you should go to the tomcat/webapps/scheme/WEB-INF/db folder and start up the hsqldb database engine server as follows:

```
% cd webapps/scheme/WEB-INF/db
% java -cp ../lib/hsqldb.jar org.hsqldb.Server -port 9001 -database webdb
```

This starts a service on your computer allowing access to the webdb database on port 9001. If you want to provide access to several different databases, you need to start a new server for each one, and use different ports for each database.

6.3.5 The survey servlet

We have now finished creating the database and table. Next, we discuss the servlet `dbsurvey.brls` which creates an HTML form and processes the user's responses to that form. The code for the form is shown in Figure 6.1.

The general structure of the servlet is that it first gets the three form parameters (age, party, and votedfor) from the browser. If `age` is `#null` this means that the user has not yet visited the form page, so the servlet generates the HTML form. If `age` is not `#null`, then we must store the user vote in the database, get the current tally, and generate a webpage with the current tally on it.

```
[; this is in the file "dbsurvey.brls"
 (let (
  (age (.getParameter request "age"))
  (party (.getParameter request "party"))
  (votedfor (.getParameter request "votedfor"))
    )
(if (equal? #null age)  ;; first visit to this page
  THEN ....make web page with form to get user data....
  ELSE ....store user data in database, report current tally....
))
]
```

We have already seen how to create an HTML form, and there is nothing new here, so lets look at the "ELSE" part of the "if" expression.

Before we can access the database, we need to load the "db.scm" library. Also, we will be converting a database answer into an HTML table, so we need the "table.scm" library. The code for storing the user's vote into the database uses the `runquery` procedure defined in `lib/db.scm` and has the following form

```
[; this is in the file "dbsurvey.brls"
 (let (
  (age (.getParameter request "age"))
  (party (.getParameter request "party"))
  (votedfor (.getParameter request "votedfor"))
    )
(if (equal? #null age)  ;; first visit to this page
  {<html><head><title>Survey Form </title></head> <body>
     Please enter the following data:
     <form method="post" action="dbsurvey.brls">
      <ul>
       <li> Your age: <input type=text name="age"></li>
       <li> Your political party:
         <select name="party"> <option>democrat</option>
         <option>republican</option><option>green</option>
         <option>other</option>  </select></li>
       <li> Who you voted for in last election:
         <select name="votedfor">
           <option>Bush</option><option>Gore</option>
           <option>Nader</option><option>other</option>
         </select></li>       </ul>
       <input type=submit></form> </body></html>}
  (begin
    (load "webapps/scheme/lib/db.scm")
    (load "webapps/scheme/lib/table.scm")
    (runquery "jdbc:hsqldb:hsql://localhost" "sa" "mynewpassword"
      {INSERT INTO survey VALUES([age],'[party]','[votedfor]')})
    {<html><head><title>Survey response</title></head></body>
     <h1> Thank you for your response</h1>
      The current tally is
     <table border=5 cellpadding=5 cellspacing=5>
      [(make-trs (runquery "jdbc:hsqldb:hsql://localhost"
                           "sa" "mynewpassword"
       {SELECT VOTEDFOR,count(*)  FROM survey GROUP BY VOTEDFOR}
       ))]
     </table></body></html>}
)))]
```

Figure 6.1: The database-backed survey servlet

```
(runquery
  HOST/DB USER PASSWORD
  QUERY)
```

where the HOST/DB is given by a string that refers to the SQL server and the USER and PASSWORD are the current system administrator USER and PASSWORD. [1] In our case, we will make two database queries. The first will insert the user's selections into the database. The second will summarize the voting totals for each listed candidate. Both of these queries have the following form:

```
(runquery
  "jdbc:hsqldb:hsql://localhost:9001" "sa" "mynewpassword"
  QUERY)
```

where QUERY is the actual SQL query that accesses or modifies the database. Note that we have set up a server on port 9001 which is serving the `webdb` database that contains the `survey` table we created above. This query provides access to that database and that table, assuming the server is running.

The first SQL query, that inserts the user's choices into the `survey` table is :

```
{INSERT INTO survey VALUES([age],'[party]','[votedfor]');}
```

The SQL keywords are capitalized and the words that we have created are lowercase. The `INSERT INTO` query always has the form

```
{INSERT INTO ..tablename... VALUES([value1],'[value2]',... );}
```

where the string values must be enclosed in single quote ('), but the numeric values should not be quoted.

Observe that the query is enclosed in curly braces "" so that it is just viewed as data by Scheme. The age, party, and votedfor variables are enclosed in square brackets "[]" indicating that their values as Scheme variables should be used. This may be a little confusing at first, but all SQL queries in Scheme servlets have this form. They are enclosed in curly braces and the parts come from the users data are enclosed in square brackets.

The next part of the servlet generates the webpage that will be returned to the user. It consists of the usual HTML code, but we escape into scheme to create the rows of an HTML table:

```
[(make-trs
  (runquery "jdbc:hsqldb:hsql://localhost" "sa" "mynewpassword"
   {SELECT VOTEDFOR,count(*)  FROM survey GROUP BY VOTEDFOR ;}
))]
```

[1] It would be safer to create a new user and grant them limited access to the database, but that will take us too far afield for the moment.

Note that we are again using the `runquery` procedure, but this time we are using the `SELECT` query. Its syntax will be described in more detail later in this section. This particular query returns a table whose rows consist of the distinct strings in the VOTEDFOR column of the table, together with a count of how often that string occurred in the table.

The `runquery` procedure always returns a list of lists. Each inner list corresponds to a row of the table, except the first, which is a row of column names. The `make-trs` converts this list into a sequence of HTML `tr` rows.

For this example, the "runquery" procedure returns a list of the voting totals of the form:

```
((Bush 1) (Gore 1) (Nader 2))
```

The "make-trs" procedure turns this into rows of an HTML table of the form

```
<tr><td>Bush </td><td> 1</td></tr>
<tr><td>Gore </td><td> 1</td></tr>
<tr><td>Nader</td><td> 2</td></tr>
```

6.4 A Quick Intro to SQL

A complete list of the SQL commands which are supported by `hsqldb` is given at the hsql website:

`http://hsqldb.sourceforge.net/internet/hSql.html`

In this section, we will give several examples of SQL queries that can illustrate these general commands.

6.4.1 Creating and removing tables

The "CREATE TABLE" command, creates a table in the current database. You must specify the name of the table as well as the names and types of each column. For example, the following command creates the "movies" table in the current database:

```
CREATE TABLE movies(title VARCHAR,minutes DECIMAL,rating VARCAR);
```

The name of the table is "movies" and it has three columns. The first and third columns are strings of characters and the middle column is a decimal number. The names of the three columns are "title,minutes,rating" respectively. Each column must have a name and a type. The simplest types are VARCHAR (for strings of characters), INTEGER (for whole numbers), and DECIMAL (for decimal numbers). Removing an entire table is easy:

```
DROP TABLE movies;
```

but note that this is a permanent operation. You cannot easily undo a dropped table.

6.4.2 Adding,Modifying, and Removing rows of tables

To insert a row into a table we use the `INSERT INTO` command. The values we insert must be in the same order in the `CREATE TABLE` command.

```
INSERT INTO movies VALUES('Star Warriors', 150, 'G');
```

Once values are in a table we may want to modify or delete them. We can remove all rows that meet some criterion using the `DELETE FROM` command.

```
DELETE FROM movies  WHERE title='Star Warriors';
DELETE FROM movies  WHERE minutes/60 > 3.5;
DELETE FROM movies  WHERE (rating='R') OR (rating = 'NR');
```

The "where" section allows you to specify a fairly complex condition using equality, arithmetic, comparison, and logic operations (AND, OR, NOT). Likewise, we can update individual columns in the rows of a table using the update command:

```
UPDATE movies SET rating='NC17' WHERE rating='X';
```

This would change all rows with an "X" rating to the new "NC17" rating.

6.4.3 Selecting rows of a table

One of the most common uses of databases is to select out some interesting subset of rows. This is done using the `SELECT` command For example, the following query returns a table with two columns (the title and the duration in hours) containing all movies with a G rating:

```
SELECT title,minutes/60 FROM movies WHERE rating='G';
```

You can also compute summary data use SQL. The following query computes the number of movies of each rating:

```
SELECT COUNT(*),rating FROM movies GROUP BY rating='G';
```

Chapter 7

Examples of Database Servlets

In this section we present some examples of servlets that interact with databases.

7.0.4 A webpage incorporating database content

Our first example is an expanded version of the survey demo in the previous example. The code appears in Figure 7.1.

In this example, the survey asks several questions and then provides various types of summary data. The overall structure of this first servlet is

```
{<html>...GENERATE HTML HEADER...
 <body style="color:black; background:white">
[(begin ... LOAD LIBRARIES...
  (let ((command (.getParameter request "command")))
    (if (equal? #null command)
       {... DISPLAY ALL MESSAGE IN DB,
            GENERATE LINK TO ADD A NEW MESSAGE:
            <a href="db1.brls?command=newmsg">
               Add a new message</a>}
       (case command
        (("newmsg")
         {... GENERATE FORM GETTING MESSAGE INPUT FROM USER
              AND SENDING IT To db1.brls with "command=addmsg"})
        (("addmsg")
         {... STORE USER'S MESSAGE IN THE DATABASE
           GENERATE AN ACKNOWLEDGEMENT, AND PROVIDE
           A LINK BACK TO THE TOP})
         (else {unknown command: [command]}))))))]
 </body></html>...GENERATE BOTTOM OF HTML PAGE... }
```

```
{<html><head><title>Simple DB Frontend Demo </title></head>
 <!--  this is a simple front end to a database
   it assumes the database contains a table created by
   CREATE TABLE news(d DATE, t TIME, subj VARCHAR, msg VARCHAR);
  -->
 <body style="color:black; background:white">

 [(begin ;; we need these libraries for file I/O and table making
   (load "webapps/scheme/lib/db.scm")
   (load "webapps/scheme/lib/table.scm")
   (let ((command (.getParameter request "command")))
   (if (equal? #null command)
    {<h1>Simple Frontend for the NEWS database</h1>
       <!-- display the links stored in the "msgs" file -->
       <table border=5>
        <tr><th>date</th><th>time</th>
            <th>subject</th><th>message</th></tr>
        [ (make-trs
           (rest
            (runquery "jdbc:hsqldb:hsql://localhost"
                      "sa" "mynewpassword"
              {SELECT * FROM news})))]
       </table>
        <br><a href="db1.brls?command=newmsg">
            Add a new message</a>}

   (case command
    (("newmsg")
      {<form method="post" action="db1.brls">
        <input type="hidden" name="command" value="addmsg">
        Subject:<br><input type="text" name="subject">
        <br>Message:
        <br><textarea name="msg" rows=10 cols=60></textarea>
        <br><input type="submit">
       </form>})
   (("addmsg")
    (let ((subject (.getParameter request "subject"))
          (msg     (.getParameter request "msg")))
      (runquery "jdbc:hsqldb:hsql://localhost"
                "sa" "mynewpassword"
        {INSERT INTO news
           VALUES(CURDATE(),CURTIME(),'[subject]','[msg]')})

      {Posted message<br>Subject:<br>[subject]<br>Message:
       <br>[msg]<br><a href="db1.brls">back to top</a>}))

   (else {unknown command: [command]})))))]
 </body> </html>}
```

Figure 7.1: The database-frontend servlet

Thus, this servlet generates three different pages depending on the value of the parameter "command." If it is "#null" then the servlet shows the "front page" which displays all the messages in the database and provides a link to the "newmsg" page. The "newmsg" page is just an HTML form soliciting the desired info from the user and sending the data back to itself, but with "command=addmsg" This last page stores the user data in the database and generates an "thank you" page with a link back to the front page.

The front page is generated by the following brls code:

```
{<h1>Simple Frontend for the NEWS database</h1>
   <!-- display the links stored in the "msgs" file -->
   <table border=5>
    <tr><th>date</th><th>time</th>
        <th>subject</th><th>message</th></tr>
    [ (make-trs
       (rest
        (runquery "jdbc:hsqldb:hsql://localhost"
          "sa" "mynewpassword"
          {SELECT * FROM news;})))]
   </table>
    <br><a href="db1.brls?command=newmsg">
        Add a new message</a>  }
```

which is mostly static HTML except for the table. The SQL query to retrieve all rows in the table is

```
SELECT * FROM news;
```

The `rest` procedure removes the first row from the result (the first row is always a list of the column names).

The "newmsg" page generates an HTML form requesting the subject and message from the user:

```
{<form method="post" action="db1.brls">
  <input type="hidden" name="command" value="addmsg">
  Subject:<br><input type="text" name="subject">
  <br>Message:
  <br><textarea name="msg" rows=10 cols=60></textarea>
  <br><input type="submit">
 </form>}
```

There is nothing new here except for the use of the "hidden" input element. This input element sets the value of the "command" parameter to "addmsg", but it does not appear on the user's page. It's sole purpose is to tell the servlet which subpage the data should be processed by.

The "addmsg" page stores the user's data in the database, shows the user what has been stored, and provides a link back to the front page:

```
(let ((subject (.getParameter request "subject"))
      (msg     (.getParameter request "msg")))
  (runquery "jdbc:hsqldb:hsql://localhost"
    "sa" "mynewpassword"
    {INSERT INTO news
        VALUES(CURDATE(),CURTIME(),'[subject]','[msg]');})

  {Posted message<br>Subject:<br>[subject]<br>Message:
    <br>[msg]<br><a href="db1.brls">back to top</a>})
```

The SQL query for inserting the data show the use of two SQL procedures `CURDATE()` and `CURTIME()` which return the current data and the current time respectively.

7.0.5 Extensions

There are many ways that this example can be extended. We discuss a few of them here.

7.0.6 Deleting rows

One useful extension is to allow users to delete as well as add messages. To make this easy we would like to have each row in the database have a unique number, so we could just say delete row 37 or delete all rows numbered less than 19. The best way to do this is to create the table with an additional column that will be automatically assigned an "identity" number each time a new row is inserted. This is done using the "INTEGER IDENTITY" type. So, for our example, the CREATE TABLE statement would need to be rewritten as

```
CREATE TABLE news
 (d DATE, t TIME, subj VARCHAR, msg VARCHAR, n INTEGER IDENTITY);
```

This also affects the other SQL queries. Since we now have an additional column, the INSERT commands have to include a NULL in the last position. This will cause the database engine to automatically insert the correct value in the table.

```
{INSERT INTO news
  VALUES(CURDATE(),CURTIME(),'[subject]','[msg]',NULL);})
```

The SQL for deleting the Nth message is then

```
{DELETE FROM news WHERE n=[N];}
```

7.0.7 Adding Password Protection

It would also be a good idea to require the user to present a password before letting them modify the database. This can be easily done using the HTML form. Just add a "password" input element and then modify the "runquery" procedure call to use the value of the password parameter

```
(runquery "jdbc:hsqldb:hsql://localhost"
   "sa" (.getParameter request "password")
    {......})
```

7.1 The database-backed webpage

Our next example is a webpage that uses the "news" table in the "webdb" database to add database content to a web page. The code for this servlet is in Figure 7.2. This page is quite similar to the previous one in that it generates a table from the database data. What is different about this demo is that it only shows the first row of the database and provides links which allow the user to access the first 10 or first 1000 messages. The procedure to return the first N elements of a list is defined, right after the libraries are loaded, by the following code:

```
(define (firstN N L)
  (if (or (< N 1) (null? L)) ()
      (cons (first L) (firstN (- N 1) (rest L)))))
```

This uses all four of the major "list" operations of Scheme:

- `(cons X L)` – creates a new list by putting the element X at the beginning of the list L, so `(cons 'a '(b c d))` returns the list `'(a b c d)`
- `(first L)` – returns the first element of a list so `(first '(a b c d)` returns the element `a`.
- `(rest L)` – returns a copy of the list L, but with the first element removed, so so `(rest'(a b c d)` returns the list `'(b c d)`
- `(null? L)` – returns the true value (`#t`) if `L` is the empty list, and returns the false value `#f`, otherwise.

The servlet also demonstrates some error checking when it is trying to compute the value of the variable `nummsg` which will be used to determine how many rows of the table to display. If the parameter `nummsgs` does not have a value (for example upon visiting the page for the first time), then `nummsgs1` will have the value `#null`, and trying to convert this into a number using `Double.` will generate an exception. The servlet handles this case, by trying to catch that exception, and returning 1 if indeed there is any error converting `nummsgs1` into a number. This is done with the

```
(tryCatch EXPR1 (lambda(e) EXPR2))
```

expression which first tries to evaluate EXPR1 to get the return value. If there is an exception, then it evaluates EXPR2 to either get the return value, or throw an exception.

```
[(begin ;; we need these libraries for file I/O and table making
   (load "webapps/scheme/lib/db.scm")
   (load "webapps/scheme/lib/table.scm")
   (define (firstN N L)
     (if (< N 1) ()
         (cons (first L) (firstN (- N 1) (rest L)))))

  (let* (
         (nummsgs1 (.getParameter request "nummsgs"))
         (nummsg (tryCatch (Double. nummsgs1) (lambda(e) 1)))
        )
 {<html><head><title>Simple DB-backed webpage Demo
       </title></head>
 <!--  this is a simple webpage
       getting some of its data from a database -->
 <body style="color:black; background:white">
    <h1>The DBDEMO project</h1>
     This is the main page of the DBDEMO project:
     <table border=10 width=80%>
       <tr>
         <td style="font:bold 40pt serif;text-align:center">
        STATIC CONTENT GOES HERE
       </td></tr></table>
     <br>
     <h2>Latest News</h2>
       <table border=5>
        [(if (> nummsg 1)
           {<tr><th>date</th><th>time</th>
                <th>subject</th><th>message</th></tr>}
           "")]
        [(make-trs
          (firstN nummsg
             (rest
               (runquery "jdbc:hsqldb:hsql://localhost"
                  "sa" "mynewpassword"
                   {SELECT * FROM news ORDER BY d,t desc;}))))]
       </table>
      <br>
      <a href="db2.brls?nummsgs=1000">View all messages</a><br>
      <a href="db2.brls?nummsgs=10">View last 10 messages</a>
 </body>
 </html>
}))]
```

Figure 7.2: The database-backed webpage

Part III

Web Programming

Chapter 8

Graphical User Interface Design in Scheme

In the previous chapters we have been concerned with server-side web programming in which the client interacts with the server using a browser. We used HTML with CSS to create the Graphical User Interface (GUI). The browser and the server communicate using the HTTP protocol, the responses to the users input are specified using Scheme (with the BRLS, SXML, or SSSP dialects).

In this section we consider another approach to web programming in which the Graphical User Interface is provided by a Scheme program rather than the browser. The communication is done by sending Scheme expressions back and forth between clients, and the responses to user input and to communication input is specified using Scheme.

Web programming, as we discuss in the next few chapters, provides a more interactive style of programming than is possible with web pages and servlets. In particular, we will show how to implement chat rooms and instant messaging programs, along with other type of groupware applications.

8.1 Intro to the JLIB toolkits

We begin with a introduction to a simple toolkit for building graphical user interfaces (i.e. windows, buttons, menus, etc.) The applets we consider will pop up one or more windows and allow the user to enter data, press buttons, connect to databases on the server, chat with other users, etc.

For example, the program in Figure 8.1 is stored in a file **"hello.applet"** and if you visit this file with your browser. You will see a page that contains the five lines of comments describing the program and its author, and your browser is Java-enabled, it will pop up a window with the word "greetings" at the top in red letters with a Helvetica Bold 60pt font, and a button labelled "goodbye" beneath. When you click on the button, the window disappears.

```
"Greeting"
"Tim Hickey"
"http://www.cs.brandeis.edu/~tim"
"This pops up a greeting window"
"http://www.cs.brandeis.edu/~tim/hickey.new.gif"

(jlib.JLIB.load)
(define win
  (window "hello"
   (col
    (label "Greetings"
         red  (HelveticaBold 60)
    (button
        "goodbye"
        (action (lambda(e) (.hide win))))))))
(.pack win)
(.show win)
```

Figure 8.1: hello.applet

If you change the filename from **hello.applet** to **hello.snlp**, and if you have installed the Java Web Start plug-in[1] then the browser will download the program as a Java Web Start application and it will again pop-up a window as before. The difference with Java Web Start is that the next time you visit that link, the browser will only download the program if there has been a change in the code. If not, then it will use the version it has stored on your disk. Moreover, you can disconnect your computer from the net and still run the stored copy of the program.

The program if Figure 8.1 illustrates a number of features of the JLIB toolkit. First, observe that it defines three components:

- a `label`
- a `button`, and
- a `window`.

Each of these components has a string written somewhere on it ("Greetings", "goodbye", and "hello" respectively). The `label` has also been given a specified color and font, and the `button` has been given an action. The relative position of the `label` and `button` has been specified by the `col` layout procedure, which states that the `label` and `button` should appear in a column. Finally, the `action` on the `button` causes the `window` to disappear when the `button` is pushed. The last two commands are `(.pack win)` which does the window layout

[1] `http://java.sun.com/products/javawebstart`

and determines the precise minimum size of the window so that everything just fits inside it. The `(.show win)` command makes the window appear.

Although this little program does quite a bit (requiring a paragraph to decide), the code for the program is relatively concise. Each word that appears in the program has a particular effect (except for the `lambda(e)` which we will explain later). By replacing `col` with `row` we would get a horizontal layout, and by replacing `label` with `button` our greeting would be able to take an action.

8.2 Overview of the JLIB toolkits

The key idea is to use the flexibility and expressiveness of Scheme to create a GUI-building library which allows complex GUIs to be built by evaluating a simple and declarative expression whose structure closely resembles the structure of the GUI itself.

The JLIB model is based on five fundamental concepts:

- COMPONENTS – there are a small number of ways to construct basic components (buttons, windows, ...)
- LAYOUTS – there are a small number of ways to layout basic components (row, col, table, grid, ...)
- ACTIONS – there is a simple mechanisms for associating an action to a component
- PROPERTIES – there are easy ways for setting the font and color of components
- TAGS – this is a mechanism for giving names to components while they are being laid out.

Another key idea is that operations on all components should be as uniform as possible. For example, there are procedures "readstring" and "writestring" which allow one to read a "string" from a component, and write a string onto a component. Thus "writestring" can change the string on a label, a button, a textfield, a textarea. It can also change the title of a window or add an item to a choice component. Likewise, readstring returns the label of a button, the text in a textarea or textfield, the text of the currently selected item in a choice, the title of a window, and the text of a label.

Similarly, JLIB is designed so that the component and layout constructors require a few initial arguments of specified types, followed by many optional arguments which may apper in any order and whose types are used to determine their effect.

For example, a font object will change the font of the component, a color object will change the background color, a Listener object will add an action listener to the component, a string will generally become the label of the object.

The current JLIB primitives are listed below:

8.2.1 Components

Components are created using the functions below. The optional arguments are described in the next section and can be used to set the color, font, and other properties of the component. The type of the argument is used to determine how it affect the component.

```
* (window TITLE arg1 arg2 ...)
* (button STRING arg1 arg2 ...)
* (textfield STRING NUMCOLS arg1 arg2 ...)
* (textarea NUMROWS NUMCOLS arg1 arg2 ...)
* (choice arg1 arg2 ...)
* (label STRING arg1 arg2 ...)
* (canvas W H ...)
* (menubar NAME arg1 arg2 ...)
* (menu NAME arg1 arg2 ...)
* (menuitem NAME arg1 arg2 ...)
```

8.2.2 Layouts

We begin with the Tabular layouts:

```
(row arg1 arg2 ...)
(col arg1 arg2 ...)
(table ROWS COLS arg1 arg2 ...)
(grid NUMROWS NUMCOLS arg1 arg2 ...)
```

These layouts all allow some additional arguments which specify how the components are placed in a cell and how they expand when the cell is enlarged:

```
placement: 'center 'north 'northeast 'east 'southeast ...
expansion: 'horizontal 'vertical 'both 'none
```

The next important layout is the "border" layout. This allows you to specify five components and place then in the north,south,east,west, and/or center of the layout. It has the form

```
(border arg1 arg2 ...)
```

The args can specify properties of the container (e.g. color, font, etc.) and they can also include the following terms which add up to five components to specified parts of the layout. When the layout is resized, the center component expands in both ways, the north and south components expand horizontally only, and the east and west expand vertically only. The following positional args must precede the other args (font/color/etc.)

```
(border
   (north COMPONENT)
   (south COMPONENT)
```

```
(east COMPONENT)
(west COMPONENT)
(center COMPONENT)
COLOR
FONT)
```

8.2.3 Arguments to Components and Layouts

For each component, the first few arguments are required (e.g. a button must have a label, a textarea must specify the number of rows and cols, a grid must contain one or more components, etc.) After the required arguments have been specified, all components may have several other arguments that may appear in any order and which specify the appearance and functionality of the component (i.e. its background color, font, and what happens when the user selects, pushes, or enters data into it). The order is not important because the desired use of the argument can be inferred from the type of value it specifies. There are three main values:

- Colors – these set the background color of the component
  - standard colors: black, white, red, green, ...
  - (color R G B)
  - (color 0xRRGGBB)
- Fonts – these set the font of the component
  - (Courier N) (CourierBold N) (CourierItalic N)
  - (TimesRoman N) (TimesRomanBold N) (TimesRomanItalic N)
  - (Helvetica N) (HelveticaBold N) (HelveticaItalic N)
  - (java.awt.Font. NAME STYLE SIZE)
- Strings
  - textarea – store string in the textarea
  - choice – add the string as one of the choices
  - menu – add the string as a simple menuitem
  - menuitem – set the label of the menuitem to the string

8.2.4 Actions

One of the most important arguments to components is the "action" argument which specifies what to do when the component is selected (e.g. when a button is pushed or a menuitem selected, or a choice selected, or a textfield value entered). The syntax for the action argument is:

```
(action (lambda (e) COMMANDS))
```

the "lambda" specifies that the "COMMANDS" are to be delayed until the action is performed. The "e" represent the kind of event that triggered the action. From the "e" variable we can get the time the action was triggered, which component it came from, where the mouse was (for a mouse event), etc.

The most common actions associated to simple GUIs involve reading some values entered or selected by the user, and using those values to compute some quantity that is then written onto another component. Thus we need to have a mechanism for reading and writing Scheme components. These procedures are shown below:

- Reading/Writing on Components
  - `(readstring COMPONENT)` – reads the text on a component as a string
  - `(readexpr COMPONENT)` – reads the text on a component as a Scheme term
  - `(readexprlist COMPONENT)` – reads the text on a component as a sequence of Scheme terms and returns a list containing those terms
  - `(writeexpr COMPONENT OBJ)` – convert the object to a string and write on the component
  - `(writelnexpr COMPONENT OBJ)` – same as above, but add a new line at the end
  - `(appendexpr COMPONENT OBJ)` – append the stringified object to the text on the component
  - `(appendlnexpr COMPONENT OBJ)` – same as above, but add a newline at the end
- Other Common Java Actions
  - `(.hide COMP)` `(.show COMP)` hiding or showing a component (or window)
  - `(.pack WIN)` `(.resize WIN)` resizing a window
  - `(.setForeground COMP COLOR)` `(.setBackground COMP COLOR)`
  - `(.setFont COMP FONT)`
  - `(.addMouseListener COMP`
    `(Listener. (lambda(e) (.getX e) (.getY e) ...)))`
  - `(.addMouseMotionListener COMP`
    `(Listener. (lambda(e) (.getX e) (.getY e) ...)))`
  - `(.fillRect (.getGraphics g) x y w h)`
  - `(.fillRect (.bufferg$ CANVAS) x y w h)`
    `(.repaint CANVAS)` – canvas objects have an associated backbuffer which you can access using `(.bufferg$ CANVAS)`.

```
(define w (window "test"
  (col
    (label "enter a number and hit return to double
    (t "x" (textfield "1" 20))
    (button "double" (action (lambda(e)
      (let ((val (readexpr (t "x"))))
        (writeexpr (t "x") (* 2 val))))))))))
(.pack w) (.show w)
```

Figure 8.2: A simple example of tagging and actions

8.2.5 Tags

As we will see it is often useful to be able to give names to components (for example if we want to read from or write to a component, we must have a way of refering to it). The "Tag" mechanism provides a simple way to name and refer to objects. A tagger is created using the following expression

```
(let ((t (maketagger)))
   EXPR)
```

This creates a tagger "t" which can be used in the following expression. To assign a name "abc" to an object "X" you use the syntax:

```
(t "abc" X)
```

to lookup the object whose name is "abc", you use the syntax

```
(t "abc")
```

For example, the program in Figure 8.2 shows the standard way of creating a textfield with an associated action that reads and writes data onto the textfield when a button is pushed.

8.3 Reactive Programs

We now describe a whole class of applets that can be written without requiring a great deal of programming. These are the programs which create a graphical user interface in which each action consists of some small number of primitive operations. For example,

- read from some textfields, use the values to compute some other values, and write those in other textfields, or
- pop up a window containing a description of the program, or
- make a window disappear, or

- draw some shapes on a canvas in a window, or
- read a textfield, check to see if the textfield contains the correct answer and write an approprite response in another textfield.

These examples all have the property that an action consists of some small number of basic steps which operate on the components of the GUI. In the next few subsections, we will give examples of each of these types of programs and in the process introduce you to more Scheme.

8.3.1 Calculator Programs

Here we give some examples of programs that get numeric input from components and use that to compute some numerical result. Our example is the Fahrenheit to Celsius converter in Figure 8.3.

Lets look over this application. First, the GUI itself uses a border layout with a menubar. The menubar has a File menu with a quit menuitem and when the user clicks the quit item, the window is hidden.

```
(menubar
 (menu "File"
  (menuitem "quit"
    (action (lambda(e) (.hide win))))))
```

The main part of the window has a label in the north, a labelled input textfield in the center, and two buttons with actions in the south. The actions are the trickiest part of this program. Lets look at them in detail.

```
(let* (
          (f (readexpr (t "x")))
          (c (* (/ 5.0 9.0) (- f 32.0)))
       )
  (writeexpr (t "x") c))
```

This action starts by reading the expression in the textfield (t "x"). It then uses that number, f, to compute the celsius equivalent. This is done by first subtracting 32 and then multiplying the result by 5/9. Once f and c have been computed, the value of c is written back onto the textfield with the "x" tag.

Rather than using two buttons, we could have used a "choice" component as follows:

```
(t "operation" (choice "convert to F" "convert to C"
 (action (lambda(e)
  (case (readstring (t "operation"))
    (("convert to F")
        (let* ( (f (readexpr (t "x")))
                  (c (* (/ 5.0 9.0) (- f 32.0))) )
          (writeexpr (t "x") c)))
```

```
"F to C converter"
"Tim Hickey"
"http://www.cs.brandeis.edu/~tim"
"This converts Fahrenheit to Centigrade"
"http://www.cs.brandeis.edu/~tim/hickey.new.gif"

(begin
  (jlib.JLIB.load)
  (define t (maketagger))
  (define win (window "F to C Converter"
    (menubar
     (menu "File"
      (menuitem "quit"
        (action (lambda(e) (.hide win))))))
    (border
      (north (label "F to C Converter" (HelveticaBold 32)))
      (center
        (row
         (label "temperature")
         (t "x" (textfield "212" 20))))
      (south
        (grid 1 2
          (button "convert to C" (action (lambda (e)
            (let* (
              (f (readexpr (t "x")))
              (c (* (/ 5.0 9.0) (- f 32.0))))
            (writeexpr (t "x") c)))))
          (button "convert to F" (action (lambda (e)
            (let* (
              (c (readexpr (t "x")))
              (f (+ 32.0 (*  c (/ 9.0 5.0)))))
            (writeexpr (t "x") f)))))))))
  (.pack win)
  (.show win)
```

Figure 8.3: FtoC.applet

```
    (("convert to C")
         (let* ( (c (readexpr (t "x")))
                    (f (+ 32.0 (*  c (/ 9.0 5.0)))))
            (writeexpr (t "x") f))))))))
```

The key points to notice here are that we use "readstring" because the choice labels have spaces in them and in the cases we use double-quotes around the strings, for the same reason.

Exercise 3 *Modify the calculator program so that it contains two textfields (labelled F and C). Add actions to the textfields such that typing a number in the F field and hitting return will write the equivalent Celsius temperature in the C field, and vice versa.*

8.3.2 A Chat Applet

This next example (Figure 8.4) shows an IM-like interface for talking with an electronic psychiatrist. The GUI consists of a central textarea for displaying the conversation (in an IM-like manner), together with a textfield at the bottom for the user's responses

```
(define t (maketagger))
(define w (window "doctor silicon"
  (border
    (center
       (t "ta" (textarea 10 60
 "Hello. Why don't you tell me how you are feeling today?")))
    (south
      (table 1 2
       (label ">> ")
       (t "user" (textfield "" 60 yellow (action (lambda(e)
            ....the action  goes here....
        )))))))))
(.pack w)
(.show w)
```

This psychiatrist randomly picks out responses from a short list every time you enter your own sentence. Observe that the GUI has exactly one action, which is applied when the user hits return after typing in a response.

```
  (appendlnexpr (t "ta")
       (string-append
           "\n\n Client: "
           (readstring (t "user"))
           "\n\n Doctor: "
           (respond (readstring (t "user")))))
     (writeexpr (t "user") "")
```

```
(jlib.JLIB.load)
(define (random N) (.intValue (Math.floor (* N (Math.random)))))
(define (pick-random L)
  (list-ref L (random (length L))))
(define (respond sentence)
    (pick-random '(
         "Relax. Tell me about your first memories."
         "I'm a computer. You can tell me anything!"
         "Are you often depressed?"
         "What is your deepest darkest secret?"
         "If you want my help, you're going to have to open up!"
         "Good. Now we are getting somewhere."
         "Ummmmm. Go on."
         "I see. Can you elaborate."
         "No. I just can't believe that."
         "Do you want my help or not?")))

(define t (maketagger))
(define w (window "doctor silicon"
  (border
    (center
       (t "ta" (textarea 10 60
 "Hello. Why don't you tell me how you are feeling today?")))
    (south
      (table 1 2
       (label ">> ")
       (t "user" (textfield "" 60 yellow (action (lambda(e)
           (appendlnexpr (t "ta")
             (string-append
                 "\n\n Client: "
                 (readstring (t "user"))
                 "\n\n Doctor: "
                 (respond (readstring (t "user")))))
           (writeexpr (t "user") "")
         )))))))
(.pack w)
(.show w)
```

Figure 8.4: An IM window with a robot-Doctor

The action appends the user's response to the center textarea (along with a tag identifying it as the user's sentence). It also generates a response to the sentence, and appends that one as well to the centeral textarea (this time with the "doctor" label).

Exercise 4 *Try extending the psychiatrist applet by adding more keyword lists and more responses.*

8.3.3 Graphics

The simplest way to create graphics using JLIB is to use the canvas procedure to create a panel for drawing on.

```
(define c (canvas 400 500))
```

The arguments to the canvas method specify the width and height in pixels.

There are several methods available for drawing on a canvas. They all require that you use the "graphics context" of the canvas which you get using

```
(.bufferg$ c)
```

The graphical operations you can use are:

```
(define g (.bufferg$ c))
(.setColor g (color R G B))
(.drawLine g x1 y1 x2 y2)
(.drawRect g x1 y1 w h)
(.drawOval g x1 y1 w h)
(.drawArc g x1 y1 w h a d)
(.fillRect g x1 y1 w h)
(.fillOval g x1 y1 w h)
(.fillArc g x1 y1 w h a d)
```

You can also draw a string S starting at location x,y using:

```
(.setFont g (Helvetica 12))
(.drawString g x y str)
\end{verbatgim}
General Polygons can be drawn by first creating a polygon from points, and then drawing
\begin{verbatim}
(define p (java.awt.Polygon.))
(.addPoint p x1 y1)
(.addPoint p x2 y2)
      ...
(.drawPolygon g p)
(.fillPolygon g p)
```

Figure 8.5 gives an example of a simple graphics program. The GUI code creates a "canvas" for drawing on, and two buttons – one for clearing the screen and one for drawing a face. Both procedures are called using the "run-it" procedure.

```
"gdemo0"
"Tim Hickey"
"http://www.cs.brandeis.edu/~tim"
"Simple demo showing use of graphics in JLIB"
""

(jlib.JLIB.load)
(define c (canvas 400 400)) ;; a 400x400 area for drawing
(define w (window "graphics1"
 (border
   (center c)
   (south
    (row
      (button "clear" (action (lambda(e) (run-it clear))))
      (button "draw" (action (lambda(e) (run-it drawface))))
     )))))

(define (run-it F) ;run animation and report errors
  (define ta (textarea 10 60))
  (define errwin (window "error" ta))
  (.pack errwin)
  (.start (Thread. (lambda()
      (tryCatch  (F)  ; run graphics code F
         (lambda(e)   ; display any errors that arise
           (writestring ta e)  (.show errwin)))))))


(define (clear)
  (define g (.bufferg$ c))
  (.setColor g white)
  (.fillRect g 0 0 1000 1000)
  (.setColor g black)
  (.repaint c))

(define (drawface)
  (define g (.bufferg$ c))  ;; get graphics object of canvas
  (.setColor g blue)
  (.fillOval g 200 200 100 100)  ;; draw a blue "face"
  (.setColor g red)
  (.fillOval g 220 220 10 10)    ;; draw left "eye"
  (.fillOval g 270 220  10 10)   ;; draw right "eye"
  (.fillOval g 220 260 60 30)    ;; draw mouth
  (.repaint c))

(.resize w 400 400)
(.show w)
```

Figure 8.5: A simple graphics program

```
(define (run-it F) ;run animation and report errors
  (define ta (textarea 10 60))
  (define errwin (window "error" ta))
  (.pack errwin)
  (.start (Thread. (lambda()
      (tryCatch  (F)  ; run graphics code F
         (lambda(e)   ; display any errors that arise
           (writestring ta e)  (.show errwin)))))))
```

The "run-it" procedure starts the graphics running in a separate "thread," this allows you to still interact with the program while the graphics are going on. Its not too important in this case, but if we had a long animation (e.g. with a face moving around the screen), you would want to be able to resize the window, change its position, close it, etc, and for this you need the graphics to be running "separately" from the rest of the program. The "run-it" procedure also contains a "tryCatch" expression. This is used for catching in errors and reporting them (in the lambda section).

The "draw-face" procedure shows a straightforward use of the graphics commands. The points to observe are that one must first get the graphics buffer "g" of the canvas before drawing on it, and finally that one must call "repaint" at the end to make the changes visible. The "repaint" command causes the current contents of the buffer to be drawn onto the canvas all at once.

Exercise 5 *You might try modifying this example to have the face move across the page when a new "move face" button is pushed. The idea is just to repeatedly clear the buffer and call "draw-face".*

8.4 A Network Database Front-end

In this section, we discuss a simple graphical user interface to a database. The code is in Figure 8.6.

Observe that most of the program is concerned with setting up the interface (creating and naming the components, specifying how they should be laid out on the screen, etc.). The only place where the database is involved is in the "submitquery" procedure.

```
(define (submitquery query)
 (tryCatch
      (runquery (readstring (t "host/db"))
                        (readstring (t "user"))
                        (readstring (t "pw")) query)
      (lambda(e) (list "ERROR: " e))))
```

This procedure reads the appropriate textfields to determine the URL of the database and the user/password information. It then creates sends the query to that database and returns the result. If there is an error then it returns a list containing the error.

```
(jlib.JLIB.load)
(load "db.scm")
;; this is webapps/scheme/lib/db.scm file(define tag (maketagger))

(define tag (maketagger))
(define win
 (window "DB DEMO"
     (border
        (north (col 'horizontal
           (label "JDBC Demo Page" (HelveticaBold 24))
           (table 3 2
                 (label "DatabaseURL")
                 (tag "host/db"
                    (textfield "jdbc:hsqldb:hsql://localhost" 50))
                 (label "User")
                     (tag "user" (textfield "sa" 50))
                 (label "Password")
                     (tag "pw" (textfield "mynewpassword" 50)))
           (row
             (choice "#sample queries"
               "create table demo(name VARCHAR, price DECIMAL);"
                   "drop table demo;"
                   "insert into demo values('abc','1123');"
                   "select * from demo where price > 500;"
                   "delete from demo where name='abc';"
                   (action (lambda(e)
                     (writestring (tag "query")
                     (readstring (.getSource e)))))))
           (tag "query" (textarea 5 50
           "create table demo(name VARCHAR, price DECIMAL);"))
             (row 'none
                 (button " SEND QUERY "
                         java.awt.Color.white$ (HelveticaBold 18)
                   (action (lambda (e)
                    (showresults
                    (submitquery (readstring (tag "query")))))))
                 (button "clear" (action (lambda(e)
                      (writestring (tag "results") ""))))))
       (center
           (tag "results" (textarea 10 50))))))
(define (showresults results)
   (for-each (lambda(x) (appendlnexpr (tag "results") x))
                    results))
(define (submitquery query)
(display (list 'runquery (readstring (tag "host/db"))
                         (readstring (tag "user"))
                         (readstring (tag "pw")) query)) (newline))

 (tryCatch
      (runquery (readstring (tag "host/db"))
                (readstring (tag "user"))
                (readstring (tag "pw"))
                query)
      (lambda(e) (list "ERROR: " e))))
(.pack win) (.show win)
```

This program also shows a way to get access to the a component without using a tagger. In the action for the "choice" component, the component itself is obtained using the ".getSource" procedure applied to the event "e". This is useful when one only needs to refer to a component in the component's action code.

Exercise 6 *Revise this database example so that it provides a custom front end to a particular database, i.e. so that it allows the user to add, delete, and search in the database just by pushing buttons and filling out fields. All the SQL querying should go on in the actions that you create.*

Exercise 7 *Write a general purpose GUI that allows the user to interact with a general database (specified in the "host/db" field) without having to know any SQL. These DB clients are quite popular and are not too hard to create.*

8.5 Security

The software we discuss in this chapter can be run in a browser or independently of a browser.

There are two approaches to running these programs in browsers. We assume they are being served by the Jscheme webapp of the Tomcat server described in the previous chapters.

If the program has the extension .applet it will be run as a java applet inside the browser. It it has the extension .snlp, it will be run as a Java Web Start application. In both of these cases, the program must begin with five lines of comments:

```
program name
program author
URL of program website
one line description of program
URL of image to be used as icon for program
```

The programs can also be run directly from a command window using the Jscheme archive file (jscheme.jar) which is available inside the webapps/scheme/lib folder in the jscheme tomcat webapp. The command for running the chat.applet is:

```
% java -cp jscheme.jar jscheme.REPL chat.applet
```

assuming that the jscheme.jar and chat.applet are in the same location.

The applet and snlp versions of the program will run in a "sandbox", which is a protected run space that prevents the programs from viewing or modifying any files on your computer. It also prevents the program from making certain internet connections and puts other more subtle limits on the program.

When the program is run directly from the command window there is no sandbox used by default.

Chapter 9

Peer to Peer programming

In this Chapter we provide an introduction to peer-to-peer computing. The first main example we will discuss is a chat room. The second is an enhanced chat program that manages multiple rooms and lets you join multiple rooms with multiple aliases.

9.1 Group-servers and Group-clients

The chat room examples will be implemented using a library (jlib.Networking) that allows us to create group-servers and group-clients. The group-clients are simple objects that allow you to

- join a group server, by selecting a name and group and specifying the host and port of the group server,
- send messages to everyone in the group (yourself included)
- specify actions that should be performed whenever a message arrives from the group

9.2 Starting a group server

You can start a group server by opening a command window and giving the following commands:

```
 java -cp jscheme.jar jscheme.REPL
> (jlib.Networking.load)
> (define S (make-group-server 23232))
>
```

This will start a group server running on port 23232 of your computer. (As usual, this assumes that you are in the directory containing jscheme.jar). You can shutdown the server by giving the command

```
 > (exit)
```

or by shutting down your computer!

You can test your group-server by opening another command window (possible on a different computer) and giving the following commands:

```
java -cp jscheme.jar jscheme.REPL
> (jlib.Networking.load)
> (define H "127.0.0.1")
;; use the IP address of your group server here

> (define P 23232)
 ;; use the port of your group server here

> (define G (make-group-client "me" "test" H P))
  ; connect to server

> (G 'add-listener 'mykey (lambda R (display R) (newline)))
   ;; this causes group-client to display msgs with key= 'mykey

> (G 'send 'mykey "Hello World" (* 1111 1111))
;;;; a response should appear here ....

> (G 'send 'otherkey "Hello World Again" 'a 'b 'c)
;;;; no response should appear here
;;;; as there is no listener on 'otherkey
```

Exercise 8 *Startup a server on one machine and two clients on two other machines and use the two clients to chat. Do this by setting up the listener as shown above and then making G calls of the form*

```
 (G 'send 'mykey "joe:.....")
```

to send messages.

9.3 A Simple Chatroom applet

Next we assume that you have started a group-server on port 23232 on your computer and you have also started a tomcat server with a jscheme webapp. If you insert the program in Figure 9.1 in the webapps/scheme folder, then it will provide users access to a single chatroom. The first part of the applet contains the documentation used to construct the applet page. The second part of the applet contains a procedure which creates a chat window given the username, chatgroup, host, and port of the group server. Most of this code is standard GUI code like that we have already seen. The three interesting parts of the program are where the group client is created

```
   (define S (make-group-client UserName ChatGroup Host Port))
```

```
"chat1a.applet"
"Tim Hickey"
""
"This is a simple example of a chat applet"
""

(begin
  (jlib.JLIB.load)
  (jlib.Networking.load)
  (let ()
    (define (chatwin UserName ChatGroup Host Port)
      (define t (maketagger))
      (define S (make-group-client UserName ChatGroup Host Port))
      (define w (window "test"
        (col
          (button "quit" (action (lambda (e)
                                   (S 'logout) (.hide w))))
            (t "chatarea" (textarea 20 50))
            (t "chatline" (textfield "" 50 (action (lambda(e)
               (S 'send "chat"
      (string-append UserName ": " (readstring (t "chatline"))))
               (writeexpr (t "chatline") "")
        )))))))
      (S 'add-listener "chat" (lambda R
       (appendlnexpr (t "chatarea") R)))
      (.pack w) (.show w)
      w
     )

   (define (rand N) (Math.round (* N (Math.random))))

   (chatwin
      (string-append "user-" (rand 1000))
      "chat"
      (.getHost (.getDocumentBase thisApplet))
      23456)
))
```

Figure 9.1: A multi-room chat program

and the action of the textfield, which reads what the user has written in the textfield and sends it to the group server with the keyword "chat"

```
(S 'send "chat"
 (string-append UserName ": " (readstring (t "chatline"))))
```

and finally the part of the program in which we add a listener to handle the messages that come in from the group server (including our own messages). In this case, we just append the messages with keyword "chat" to the end of the chatarea.

```
(S 'add-listener "chat" (lambda R
 (appendlnexpr (t "chatarea") R)))
```

Observe that the use of the keyword allows us to carry on several simultaneous group conversations on different topics with the same group client. Finally when the user presses the quit button, we logout of the group-client which causes the group-client to close its connection to the group-server

```
(S 'logout) (.hide w)
```

You might try to modify this applet so that it censors any message containing any of a small list of unsavory words (e.g. SH*T, but note that this might unfairly single out message about shitake mushrooms.)

You might also add a password feature, or look into requiring each user to have a unique user name. You could hook up this applet to access a database of usernames and passwords of registered clients if you want a little more security.

9.4 A Multiroom Chat applet

In this section we show how to extend the previous example to allow for multiple rooms and to allow for some querying as to who is online.

The key idea here is to create a registration window that allows the user to ask the group-server questions about the user, groups, etc. currently being served. This is done using the "send-line" procedure from the "Networking.scm" library. The group-server will respond to three queries (as shown below) with a list of the users, groups, and users-in-group. For example, the action on the following button queries the server for a list of the active groups and then displays that list in the textarea:

```
(button "show groups" (action (lambda(e)
 (writeexpr (t "serverinfo")
     (send-line Host Port "groups\n")))))
```

This window also allows the user to startup a new chat window using the specified user/group/host/port to create a chatwindow. The code for the chat window is exactly as shown in the previous example, so we don't repeat it here.

The "send-line" procedure sends a string of characters to the specified host/port. You can use it to get the current local time on a server by sending an empty message to port 13

```
(send-line "129.64.2.3" 13 "\n")
```

Here we have sent a carriage return, but using the empty string "" would probably suffice for most servers anyway.

```
"chat2.applet"
"Tim Hickey"
""
"multi-room chat GUI"
""

(begin
  (jlib.JLIB.load) (jlib.Networking.load)

  (define (rand N) (Math.round (* N (Math.random))))
  (define (chatwin ....) ...) ;; as in previous example

  (define (make-register-window Host Port)
    (define t (maketagger))
    (define regwin (window "register"
      (border
        (center (t "serverinfo" (textarea 10 40)))
        (north
          (border
            (north (col
               (t "group" (textfield "test" 20))
               (t "user" (textfield "guest" 20))))
            (south
             (row
               (button "show users" (action (lambda(e)
                (writeexpr (t "serverinfo")
                    (send-line Host Port "users\n")))))
               (button "show groups" (action (lambda(e)
                (writeexpr (t "serverinfo")
                    (send-line Host Port "groups\n")))))
               (button "show users in group" (action (lambda(e)
                (writeexpr (t "serverinfo")
                     (send-line Host Port (string-append
                          "users-in-group\n"
                         (readstring (t "group"))))))))
               (button "join group" (action (lambda(e)
                   (make-chat (readstring (t "user"))
                       (readstring (t "group")) Host Port)
                 )))
            )))))
      (.pack regwin) (.show regwin) regwin   )

    (register-window
       (tryCatch
         (.getHost (.getDocumentBase thisApplet))
         (lambda(e) "127.0.0.1"))
      23456))
```

Figure 9.2: A multi-room chat program

Chapter 10

Examples of P2P Programming

This chapter is not yet ready.

10.1 Servents

10.2 Network-aware GUI components

10.3 Running a chat registrar

10.4 Whiteboards

10.5 Shared Textareas

Part IV

Appendices

Appendix A

The Tomcat server and Jscheme

A.1 Installation instructions for Mac/Linux

The Tomcat server will only run on your Mac if you have the Mac OS 10.1 operating system or higher. It should run under any Linux distribution. We assume from now on that you do have one of these operating systems and that you know how to run a browswer and open a terminal window

A.1.1 Installing tomcat

The installation process is fairly easy. First you need to open a browser and download the jscheme-tomcat.tgz file from the website

```
http://www.cs.brandeis.edu/~tim/Downloads/jscheme-tomcat.tgz
```

and store it somewhere on your system. Lets say your username is Joe and you store it in

```
/Users/joe/jscheme-tomcat.tgz
```

You can then close the browser.

Next you unpack it by opening a terminal window, go to the directory where you downloaded the tgz file and giving the unpack command as follows:

```
% tar xvzf jscheme-tomcat.tgz
```

This will create a folder called `tomcat` in that directory.

A.1.2 Starting/Stopping the Tomcat Server

Next, go into the tomcat directory and set the JAVA_HOME variable to be the path to the 1.3+ version of the Java Development Kit.

On the Mac, this is currently done by the following command:

```
% cd tomcat
% setenv JAVA_HOME /Systems/Library/Frameworks/JavaVM.framework/Versions/1.3.1/Home
```

Under linux its the same, but the JAVA_HOME is usually "/usr/java/jdk1.3". You can run the "locate javac" command to find where your Java files are located.

Now you are ready to start the server by issuing the command:

```
% bin/startup.sh
```

You can stop the server at any time by issuing the command

```
% bin/shutdown.sh
```

Or my shutting down your computer.

A.1.3 Adding content to the server

Finally, to add webcontent to your server, you should change directory into the `tomcat/webapps` folder. This shows all of the webapps that your server is currently delivering. Of particular interest for us is the `scheme` webapp. Change directory into the `scheme` folder and any files you create in here (or in subfolders) will be served on the web. Moreover, files ending in sssp, sxml, brls, applet, snlp will be processed as described in the main body of this text.

A.1.4 Accessing the server

Your server is now running on your machine on port 8080. If your machine has a registered domain name, say /tt mymachine.com, then you can access the scheme files on your server at the web address:

```
http://mymachine.com:8080/scheme
```

If you don't have a registered domain name (which is most often the case) then you must use the IP address itself as the address.

To find out your IP address on a MAC, you can select the "System Preferences" item in the "apple menu," then select Network, and have it show "Built-in Ethernet" or "Airport," whichever you are using. The screen will then show your IP address.

On a Mac or under Linux, you can also give the command

```
% ifconfig -a
```

and it will give you your IP address (along with lots of other info!)

A.2 Installation instructions for the PC

The Tomcat server will only run on your PC if you have also installed the Java JDK version 1.2 or higher. Older versions of windows have this preinstalled, but Microsoft decided not to preinstall Java in XP. You can download an install Java by visiting

```
http://java.sun.com/j2se/1.3
```

and selecting the "Microsoft Windows" download option.

We assume from now on that you do have this operating system and that you know how to run a browswer and open a dos window (start-¿programs-¿accessories-¿commandprompt).

A.2.1 Installing tomcat

The installation process is fairly easy. First you need to open a browser and download the jscheme-tomcat.zip file from the website

```
http://www.cs.brandeis.edu/~tim/Downloads/jscheme-tomcat.zip
```

and store it somewhere on your system. Lets say you store it at the toplevel in

```
C:jscheme-tomcat.zip
```

You can then close the browser.

Next you unpack it by opening a terminal window, go to the directory where you downloaded the tgz file and giving the unpack command as follows:

```
% cd C:
% unzip jscheme-tomcat.zip
```

This will create a folder called `C:tomcat`.

A.2.2 Starting/Stopping the Tomcat Server

Next, go into the tomcat directory and set the JAVA_HOME variable to be the path to the 1.3+ version of the Java Development Kit. This is currently done by the following command:

```
% cd C:tomcat
% set JAVA_HOME=C:\jdk1.3.1_02
```

where you will need to specify where Java is on your system. It usually installs in the top level of the C drive and has a name that begins with "jdk" Now you are ready to start the server by issuing the command:

```
% bin\startup.sh
```

You can stop the server at any time by issuing the command

```
% bin\shutdown.sh
```

Or my shutting down your computer.

If you get an "Out of environment memory error," when trying to start up the server, then you will need to increase the default size of the environment in the MSDOS window. Do this by right clicking on the MSDOS icon in the upper left corner of the DOS window. Then click on the memory tab, and then select the largest value for the initial environment (e.g. around 4000). Shutting down the MSDOS window (by typing "exit") and opening a new MSDOS window should eliminate that error. Just reenter the JAVA_HOME and startup the server.

A.2.3 Adding content to the server

Finally, to add webcontent to your server, you should change directory into the `webapps` folder. This shows all of the webapps that your server is currently delivering. Of particular interest for us is the `scheme` webapp. Change directory into the `scheme` folder and any files you create in here (or in subfolders) will be served on the web. Moreover, files ending in sssp, sxml, brls, applet, snlp will be processed as described in the main body of this text. Note that you must store these files as plain text (not as HTML, or Microsoft Word)

A.2.4 Accessing the server

Your server is now running on your machine on port 8080. If your machine has a registered domain name, say /tt mymachine.com, then you can access the scheme files on your server at the web address:

```
http://mymachine.com:8080/scheme
```

If you don't have a registered domain name (which is most often the case) then you must use the IP address itself as the address. You get the IP address by going to (start-¿.....)

A.3 Creating a certificate for secure web pages

THIS SECTION IS IN PREPARATION.

A.4 Configuring for email

THIS SECTION IS IN PREPARATION.

Appendix B

Installing the HSQL Database

Download instructions.

Starting the Server.

Starting the DatabaseManager

Changing the System administrator password.

Appendix C

The Scheme Dialect Used in this Text

THIS SECTION IS IN PREPARATION.

C.1 Core grammar of Scheme programs

Every Scheme program is a sequence of Scheme expressions where a Scheme expressions is either a constant, symbol, quoted element, or a compound expression called an s-expressions.

The constants are numbers, double quoted strings (e.g. "this is a string"), characters (e.g. `#'a', #' '`), and boolean values (true is `#t` and false is `#f`).

Symbols are typically sequences of printable characters (excluding spaces, quotes, double quotes, parentheses, square brackets, or curly brackets). For example, `name`, `feet->meters`, `cool!!!` are all variables.

A quoted element is formed by putting a single quote (') in front of the object. For example, `'a ''b '1.234` are three quoted elements, the second being a quote of a quoted element.

The only other kind of Scheme element is an s-expression, which is a kind of generalized list. A list is represented in Scheme by enclosing the elements of the list in a pair of parentheses:

```
( element1 element2 ... elementk)
```

For example, `()` is the empty list, `(1 2 3 4 5)` is a list of numbers and `(a b "cool list" 2.718281828459045 -3 #t)` is a list of various constants.

An S-expression is a list whose elements are either constants, symbols, quoted elements, or s-expressions. For example,

```
(a b '(c d () e) f g ((( h ''i j ))) 1.2 )
```

is an s-expression.

C.1.1 Math Primitives

```
(+ num num num ... num)  ;; addition
(* num num num ... num)  ;; multiplication
(- num num)              ;; subtraction
(- num)                  ;; negation
(/ num num)              ;; division
(sqrt num)
(sin num)
(cos num)
(tan num)
(asin num)
(acos num)
(atan num)
(exp num)
(log num)

(java.util.Date.)  ;; returns the current local date and time
(java.lang.Double. STRING) ;; converts a string to a decimal number
(java.lang.Integer. STRING) ;; converts a string to a whole number
```

C.1.2 Special Forms

There are about a dozen special forms in Scheme. Once you know the special forms and a reasonable subset of the primitives, you will find yourself able to write substantial programs fairly easily.

Special forms are the expressions in core scheme which are evaluated in some "special" manner. Most expressions `(F A ... B)` are evaluated by evaluating all of their components `F,A,...,B` to get Scheme objects `f,a,...,b` and then applying `f` (which must be a function) to the arguments `a,...,b`.

Special forms usually postpone the evaluation of some of their components until later.

Definitions

The simplest way to store a value in a variable in Scheme is to use the "define" special form. There are two versions of this. The first is for storing "constant" values, the second is for storing "procedures"

```
(define NAME EXPRESSION)
(define (NAME VAR1 ... VARk) EXP1 ... EXPk)
```

For example,

```
(define pi 3.14159265358979323846264338327 6)
(define (square x) (* x x))
(define (cylinder-volume radius height)
```

```
  (* height pi (square radius)))
;; call these using
(square 24)
(cylinder-volume 10 2)
```

Anonymous functions

Another way to define functions is using the "lambda" special form:

```
(lambda (V1 ... Vn) E1 ... Ek)
```

You can think of "lambda" as being a synonym for "function." It is used to define a function of n variables (V1,..., Vn). When the function is called it evaluates each of the expressions E1,..., Ek and returns the value of the last expression Ek. For example, we could rewrite the definitions above as

```
(define pi 3.14159265358979323846264338327 6)
(define square (lambda (x) (* x x)))
(define cylinder-volume
 (lambda (radius height)
   (* height pi (square radius))))
```

Changing defined values

You can cahnge the value of a defined variable using the "set!" special form (it is pronounced "set-bang")

```
(set! NAME EXPRESSION)
```

For example, in the following example, each time we call the square function it adds on to the variable "a. " This provides a way of counting how many times "square" is called.

```
(define a 0)
(define (square x) (set! a (+ a 1)) (* x x))
```

Conditional Execution

Scheme offers three special forms for conditional execution (that is for providing a means for testing the input and executing different code depending on the result of the test). The first is the if-then-else expression. It evalutes the TEST if the test is false (`#f`) it evaluates the ELSE code; otherwise, if the test is true (`#t`) it evaluates the THEN code. (In fact, if the test is any non-false value, it evaluates the THEN code):

```
(if TEST THEN ELSE)
```

For example, we can write the function that returns the maximum of its two inputs as follows:

```
(define (max2 a b)
  (if (< a b) b a))
```

Sometimes one has many different tests and for each test there is a different piece of code that should be evaluated. This can be implemented with nested "if"s, but a better approach is to use the "cond" special form:

```
(cond (
   (TEST1 E1 ... E2)
   (TEST2 F1 ... F2)
   ...
   (else G1 ... G2)
     )
)
```

The expression evaluates the first "TEST1" if it is true (actually just non-false), then it evaluates E1,... E2 and returns the value of E2. If "TEST1" is false, then it proceeds to TEST2, and repeats the process. If none of the tests are true, then it evaluates the expressions in the "else" clause (G1, ..., G2) and returns the value of the last one.

The case is a good expression to use when the tests are all of the form `(equal? X Vi)` for some constant values V1, V2, ... The general form of this expression is

```
(case EXPR
  ((C1 C2 ...) E1 ... E2)
  ((D1 D2 ...) F1 ... F2)
  ...
  (else G1 ... G2)
)
```

For example, the following procedure can be used to determine whether a symbol is a vowel, consonant, digit, or something else:

```
(define (classify-char L)
 (case L
  ((a e i o u y) 'vowel)
  ((b c d f g h j k l m n p q r s t v w x z) 'consonant)
  ((0 1 2 3 4 5 6 7 8 9) 'digit)
  (else 'non-alpha-numeric)))

(classify-char 'e)  ;; this returns 'vowel
```

C.1.3 Grouping for side effects

The "begin" expression is useful when you want to evaluate several expression and return the value of the last one. It has the form:

```
(begin
   E1
   ...
   E2
)
```

C.1.4 Local Variable Binding

Scheme provides several mechanisms for giving names to values for use in a sequence of expressions. The most common of these is the "let*" whose syntax is as follows:

```
(let* (
  (V1 E1)
  (V2 E2)
  ...
  (Vk Ek)
    )
 F1
 F2
 ...
 Fn)
```

This expression is evaluated by first evaluating "E1" and storing the value in "V1," then evaluating "E2" and storing the value in "V2", etc. Finally, these bindings are used to evaluate "F1", "F2",... "Fn" and the value of "Fn" is returned.

C.1.5 Exception Handling

Sometime procedures are unable to complete their task as expected. In such cases they often "throw an exception." A standard example of this is dividing 1 by 0. The "tryCatch" special form provides a way for handling such exceptions. Its syntax is:

```
(tryCatch E1 (lambda(e) F1 ... Fn))
```

It evaluates the expression "E1" and if there is an exception (say e), then it evaluates the expressions "F1",... and returns the value of "Fn"

Bibliography

[1] World Wide Web Consortium webpages.