FaxWeb: accessing the WWW using the fax machine

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Abstract

In order to provide an alternative way for accessing WWW, we propose a FaxWeb system to access WWW services using a fax machine in this paper. Based on the FaxWeb system, users, who do not have computers or who do not have the capability of using computers, can access WWW services using fax machines. In this way, people can adopt not only computers but also fax machines, which belong to the traditional consumer/office electronics and are getting less expensive gradually, to access WWW at client sites. The user spectrum of WWW can be expanded to those people who lack the capability of using computers. To have convenient use, the FaxWeb system contains a voice response and touch-tone WWW browsing facility for accessing WWW using fax machines. The system architecture and the system development of FaxWeb are presented in the paper. © 1999 Elsevier Science B.V. All rights reserved.

Keywords: Computer telephone integration (CTI); Internet telephony; Browsing; Fax

1. Introduction

Due to the wide use of WWW, more and more information is being put in the WWW environment [1,2]. For example, plenty of (i) daily communication services, e.g. headline news service [3], flight reservation service [4], and restaurant/hotel information service [5], and (ii) commercial business services [6], e.g. banking and stocks information services, have been built on the WWW environment. Since not all of the people are used to computers, some alternative ways should be provided for those people who do not use computers for some reasons. Such people may be behind the times because of their inability to access the information storage [7–9].

In this paper, a fax-accessed WWW service system named FaxWeb will be proposed. The goal of the FaxWeb system is two-fold. One is to permit users to adopt fax machines as the output devices for accessing WWW services. In this way, an alternative approach is provided for users to access the WWW. The other is to browse the WWW space without using any visual interface. Users still can browse web pages in the WWW space without “seeing” the embedded hyperlinks. To achieve this goal, some oral guidance mechanism will be installed in the FaxWeb system. With the usage of the telephone set and the help of the oral guidance, users can press the corresponding keys, which are like clicking the hyperlink buttons on the screen, on the telephone set to browse the WWW space.

To realize a fax-accessed WWW service system, a delegate mechanism for fax users to access the WWW is required. FaxWeb is a fax browsing agent which delegates the requests from fax users to access the WWW. Fig. 1 depicts the abstract execution environment of FaxWeb. Using the FaxWeb system, users can (i) have a fax request for accessing some web pages, and (ii) obtain facsimile copies of the requested web pages from a fax machine. To facilitate the above usage, the FaxWeb system should have the following capabilities: (i) setup the telephone call connection from the user to the FaxWeb system, (ii) playback some part of the pages’ content in the voice format in order to orally guide the user to have some fax requests, (iii) accept the fax requests from the user and then have Internet connections to the corresponding WWW servers, (iv) retrieve the requested web pages over the Internet, (v) convert the retrieved web pages into the corresponding facsimile image copies, and (vi) fax out the facsimile image copies to a fax machine that is designated by the user. In summary, the FaxWeb system should provide (i) the facility of internetworking telephone network and Internet, (ii) the facility of delegating fax requests and providing oral guidance for users to have non-visual-based browsing through the corresponding web servers, and (iii) the facility
of capturing and converting a page document into a facsimile image copy.

The rest of this paper is organized as follows. Section 2 presents related works about fax matters over the Internet. Section 3 describes system architecture, main components, and working flow of the FaxWeb system. Sections 4–7 detail technical issues encountered in the system development. Section 8 describes the scenario about browsing the WWW space and then obtaining web pages in the facsimile format using the FaxWeb system. Section 9 has discussion and concluding remarks.

2. Related works

With the rapid growth of Internet-enabled services, many fax-related applications, e.g. fax over Internet, web to fax, e-mail to fax, and fax to e-mail, are created. In this section, we briefly introduce these fax-related matters.

2.1. Fax over Internet

A Fax over Internet system allows users to exchange their messages from one fax machine (fax party #1) to another fax machine (fax party #2) over Internet [10]. Fig. 2 depicts the abstract execution configuration of the Fax over Internet. System components of Fax over Internet contains several fax machines (fax parties) and fax gateways (fax gateways), where a fax party and its (local) fax gateway are interconnected through telephone network, and several fax gateways are interconnected through the Internet [11]. Typical examples of Fax over Internet are the NeTrueFax system [12], PSINet’s InternetPaper [13], and P•Bradley’s Fax-em [14].

2.2. Web to fax

Web to fax allows computer users to send facsimile messages to fax users via the Internet. The Web to fax system often resides in a web server. The abstract execution configuration of Web to fax is depicted in Fig. 3, in which user computer and Web server are interconnected through the Internet, and the Web server is connected to fax party via telephone network.

The Web server can deliver some HTML forms specified in a web page to the destined fax machines. These forms are originally stored in the Web server and are delivered to the user computer, where a user connects to the Web server for fax. CGI server can adopt some external gateway applications, e.g. a C-coded program, to generate these HTML forms. An external gateway application communicates with the Web server via Common Gateway Interface (CGI) [15]. Typical examples are the Web-to-Fax system in [16] and BBS Services’s wFax Web Fax Server [17].

2.3. E-mail to fax

An E-mail to Fax system allows users to send messages to a fax machine via an e-mail system [18,19]. Fig. 4 depicts the abstract execution configuration of E-mail to Fax. In Fig. 4, user computer and fax gateway are interconnected through the Internet, and fax gateway is connected to fax party via telephone network. The mail server residing in the user computer is responsible for sending user messages to the fax gateway via the e-mail system. Typical examples are the Virtual Fax system [20] and the FaxSAV system [21].

2.4. Fax to E-mail

A Fax to E-mail system allows users to e-mail messages using fax machines. The abstract execution configuration is the same as that depicted in Fig. 4.

In Fig. 4, the fax party can initially connect to a fax gateway to input the target e-mail address, and then fax out a facsimile image to the fax gateway. The fax gateway converts the facsimile image into an MIME file [22]. According to the target e-mail address, the fax gateway automatically sends this MIME file to the target user computer through the e-mail system. Typical examples of Fax to E-mail are the Virtual Fax system [20] and the Digital Mail system [23].

The Fax over Internet system allows users to send messages from a fax machine to a remote fax machine.
The Web to Fax system allows a user to fill out a form and then sends the text content contained in the filled form to a designated fax machine. The E-mail to Fax system allows users to send e-mails to some users who do not have e-mail access facility but have fax machines. The Fax to E-mail system allows users to receive e-mails from users who do not have the e-mail facility but have fax machines.

With the rapid growth of WWW services, lot of valuable and convenient services have been created in the Internet. To enlarge the user spectrum of WWW, not only computer equipment but also some widely used electronic devices should be provided for people to browse and to access the WWW. Otherwise, persons not capable of operating computer devices or those who have a dislike to using computers will be behind the times because they cannot/do not access WWW using computers. The goal of this paper is to implement a system named FaxWeb that allows users to have WWW services using fax machines and to browse the WWW space using a telephone set.

3. System architecture

FaxWeb is a fax agent that bridges the Internet and telephone network to service web requests from fax users. The main tasks of FaxWeb are as follows: (1) Pickup incoming calls from users and provide users with some browsing guidance in the voice format. (2) Delegate users’ requests from telephone network to the Internet. (3) Capture web documents that the user requests after setting up the connection to the corresponding WWW server. (4) Translate the retrieved web document into the corresponding facsimile format. (5) Faxing the facsimile image copy of the retrieved web documents to users. (6) Handle unexpected system events to guarantee robust system functioning.

3.1. Main components

The FaxWeb system consists of four major components: phone voice browser (PVB), World Wide Web processor (WWW-P), fax image translator (FIT), and system exception handler (SEH). Among the above six main tasks that FaxWeb has to deal with, the PVB is responsible for the tasks (1), (2), and (5), the WWW-P is responsible for task (3), the FIT is responsible for task (4), and the SEH handles task (6). Components of the FaxWeb system work cooperatively with one another to complete these tasks.

Using PVB, a user can take a telephone call to connect to the FaxWeb system and then to have a request of faxing a web page according to the provided voice-based browsing guidance. According to the received request from PVB, WWW-P connects to the target web server and retrieves the requested web page document. After that, the FIT converts the retrieved web page document into a facsimile image copy, and then the PVB delivers the facsimile image copy to the designated fax machine. Additionally, SEH handles any system exception, which includes unexpected network errors, user behaviors, hardware errors, etc. Functions of each component are described below.

3.1.1. Phone voice browser (PVB)

Phone voice browser (PVB) should be able to (1) play some explanations in the voice format to guide users for browsing the WWW space, (2) support interactive telephone operations for receiving and delegating users’ fax requests that are from a telephone set, and (3) fax the facsimile image copies of the retrieved web documents to users. (6) Handle unexpected system events to guarantee robust system functioning.
FIT and is in the G3 compressed format, to the designated fax machine.

3.1.2. World wide web processor (WWW-P)

WWW-P provides a mechanism (1) to connect with the target WWW server, to retrieve the requested web page document, to store the retrieved web page document on the local disk, (2) to parse the retrieved page document for TTS and to filter out unnecessary HTML tags in the retrieved web page document for fax, and (3) to display the page view of the readily modified web page document on the screen. In order to obtain a clear/readable facsimile copy of the requested web page document by most fax machines, some background image or colored image, e.g. a black or a deep blue background, should be filtered out because these kinds of page content could garble the appearance of the facsimile image copy. If the colored image is directly converted into the monochrome image, the whole facsimile image copy becomes black and unreadable. Therefore, WWW-P should have the ability to filter out those tags that are related to background image or color specifications. To achieve the above purposes, WWW-P consisting of the following sub-components: HTTP-ACCESSER, HTML-FILTER, and HTML-LAYOUTER, is presented and is depicted in Fig. 6.

The HTTP-ACCESSER, which is depicted in Fig. 6, is responsible for the above task (1) of the WWW-P. HTTP-ACCESSER connects with the target WWW server by setting up an HTTP connection to retrieve requested web page documents, and to store retrieved web page documents into the local disk for further processes.

The HTML-FILTER (Fig. 6), is responsible for the above task (2) of the WWW-P. HTML-FILTER provides a mechanism to parse the retrieved web page for TTS and to modify some tags, which are not suitable for the facsimile image copies. In HTML-FILTER, we design an HTML document parser named H-PARSER. H-PARSER can parse web page documents retrieved for TTS, find unsuitable background image and color tags, and then modify these tags.

The HTML-LAYOUTER (Fig. 6), is responsible for the above task (3) of the WWW-P. HTML-LAYOUTER provides the capability of displaying retrieved web page documents, which have been modified by the HTML-FILTER, into the screen image buffer.

3.1.3. Fax image translator (FIT)

FIT would be able to (1) convert the screen view of a retrieved web page document into the monochrome image...
and (2) compress the monochrome image into the CCITT T.4 facsimile image format. Two sub-components of FIT are: IMG-CAPTURER and IMG-CONVERTER as depicted in Fig. 7. In Fig. 7, IMG-CAPTURER is responsible for task (1) of the FIT. IMG-CAPTURER has the capability of capturing the layout image of a retrieved web page document on a screen. IMG-CONVERTER is responsible for task (2) of the FIT. IMG-CONVERTER can convert the colored image into the monochrome image that a fax machine can handle.

3.1.4. The system exception handler

System exception handler provides a mechanism (1) to deal with unexpected events, (2) to handle error conditions, and then (3) to release some already allocated system resources.

3.2. System working flow

Fig. 8 shows the working flow of the FaxWeb system. Initially, a user can take a phone call to dial in the FaxWeb system. (1) PVB waits for incoming phone calls, and then activates corresponding components. (2) PVB can reply a segment of voice guidance to users as the browsing guidance. (3) After hearing the voice-based browsing guidance, the user can input the URL of the requested web page. (4) After receiving the user input, the PVB sends a URL request message to WWW-P. (5) After receiving the URL request message, the WWW-P connects to the WWW server and requests the corresponding web page. (6) The WWW server can reply the request and transmit the web page document to WWW-P. (7a) After retrieving and processing the web page, WWW-P sends the parsed text result to PVB for TTS. (7b) WWW-P also delivers the layout message to the FIT. FIT lays out the modified web page document and converts it into the facsimile image format. (8) After that, the FIT sends the facsimile image copy to the PVB for fax. (9) PVB receives the facsimile image copy and faxes out the copy to the designated fax machine. Each FaxWeb’s component has its own development technical issues. In the following four sections, we present several technical issues and the associated solutions.

4. Related technical issues in the WWW processor

The technical issues that exist in the WWW-P are (1) HTTP connection, (2) page scrolling, (3) page concatenating, (4) path attachment, and (5) background image and color.

4.1. HTTP connection

In the FaxWeb system, in order to connect with the Web server and fetch requested Web pages, the FaxWeb system needs a network component to communicate with the web server via the HTTP protocol. Microsoft Visual C++ provides the high-level programming library that effectively reduces the complexity of Winsock programming in implementing the HTTP protocol. Microsoft Foundation Classes (MFC) library provides both CInternetSession and CHttpConnection classes for setting up the client connection with a WWW server. A programmer can use class CInternetSession to create and to initialize a single or several simultaneous Internet sessions and can use class CHttpConnection to set up the connection to a WWW server. Steps for connecting with the WWW Server are depicted in Fig. 9.

4.2. Page scrolling

Sometimes a user browsing the WWW space using a regular WWW browser, e.g. Netscape Navigator or Microsoft Internet Explorer (IE4), might encounter some situation, where the whole Web page needs several screen views to be displayed. A scroll bar is usually used to scroll down or up these screen views in order to display the lower or upper part of the currently visiting Web page. In order to fax documents that are displayed on several screen views,
FaxWeb must support a similar scrolling mechanism in WWW-P. To achieve this purpose, the problem “How to scroll down or up the screen view automatically in WWW-P?” becomes a main issue to be resolved. Without solving this problem, we cannot fax out the whole retrieved Web page document to the fax machine.

To ease the implementation and facilitate the layout of Web page documents, WWW-P adopts the ActiveX component “IE4” to implement the layout component, i.e. HTML-LAYOUTER. Since the IE4 ActiveX component does not support the “sending message” method to control the scrolling of the client window, the scrolling control should be achieved by the scroll method that IE4 provides. IE4 has many ActiveX components to support parsing and layout of retrieved web page documents. In the FaxWeb system, the ActiveX component “IHTMLWindow2” is adopted for scrolling the client window, because it provides some scroll bar control methods. The provided method “scroll()” is evoked to set the client window’s scroll bar and thus to refresh the screen view of the retrieved Web page document. Steps of using this approach are depicted in Fig. 10.

4.3. Page concatenating

Essentially, there is no concept of pages in the facsimile equipment. That is, the fax machine does not define how large a page to be printed is. Thus, a mechanism is proposed to set the page size of the facsimile image copy, so that the user can have better visual copies from the fax machine. The page size on the FaxWeb system is defined as the valid area of a client window on a screen with the resolution of 800 × 600 pixels.

As has been mentioned previously, sometimes the retrieved Web page document is too long to be displayed on the window using a WWW browser. In this situation, the scroll bar is used to scroll down or up the screen view on the window so that views of the retrieved web page document beyond the window’s border are made visible. In order to have better visual copies from the fax machine, the page concatenating mechanism is adopted to concatenate some page views, which have been captured by using the image capturing mechanism in the FaxWeb system, into one page of the facsimile image copy. In this way, we can get a seamless facsimile image copy. The pseudo code for concatenating some screen views of a retrieved web page document into a page view is shown in Fig. 11. Fig. 12 depicts a page concatenation example.

4.4. Path attachment

In the WWW system, a Web page document is a system resource, which is addressed by a Uniform Resource Identifier (URI) [24]. Essentially, a Web page document can be addressed either by an absolute URI or by a relative URI. Owing to the fact that it is more convenient to specify a relative URI than that to specify an absolute one, a lot of relative URIs frequently appear in a Web page. In the FaxWeb system, a Web page document must be retrieved into the local disk for further processes. However, the FaxWeb system could not directly retrieve web pages that are addressed by relative URIs from WWW servers. In order to retrieve Web pages, which are addressed by relative URIs from WWW servers, and to retrieve Web pages that are addressed by relative URIs from WWW servers, the corresponding absolute URIs of those web pages should be carried out. Therefore, “How to convert a
relative URI into the corresponding absolute one?” becomes an issue, which is called Path Attachment, for retrieving Web pages in the FaxWeb system.

In the WWW space, a URI is a compact string that is the representation of (i) a location (URL) or (ii) a name (URN) for a WWW resource [25]. URIs provide a simple and extensible means for identifying resources in the WWW space. The URI scheme is a hierarchical addressing system, which constructs the hierarchical address in the WWW space by using the delimiter “/” to separate each component of the address. The Path Attachment can be solved as follows.

Suppose there exists a ‘relative’ form of the URI specification. The ‘relative’ URI can be in conjunction with the ‘base’ URI, which is the address string of the original WWW server, to produce the absolute URI. In the FaxWeb system, Path Attachment can be solved by the similar way. For example, the user visits the WWW server “www.hinet.net” and retrieves a web page document into the local disk, the following tag in the retrieved web page may be found.

\[
\text{\texttt{<img src} “pictures/logo2.gif” alt = “HiNet’s Logo” hspace = “20”} \]

The above tag is for a hyperlink, which addresses an image file named “pictures/logo2.gif”. The hyperlink is in a relative form of URI. According to the relative URI, FaxWeb retrieves the corresponding media file from the local site, where the FaxWeb system itself resides. This result could lead to a dangling reference. That is, the media file to be retrieved does not exist at the local site; instead, the media file resides in the remote site “www.hinet.net”. In order to solve this problem, the FaxWeb system should convert a relative URI into the corresponding absolute URI, i.e.

\[
\text{\texttt{<img src} “http://www.hinet.net/pictures/logo2.gif” alt = “HiNet’s Logo” hspace = “20”} \]

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\[
\text{\texttt{<img src} “http://www.hinet.net/pictures/logo2.gif” alt = “HiNet’s Logo” hspace = “20”} \]
The procedure used for Path Attachment is as follows.

1. A URI is parsed into three components: site, path, and object components. The common URI expression used in the http URI scheme is as follows:

   http://site/path/object

   For example, in “http://www.math.uio.no/faq/compression-faq/part1.html”, the site component is “www.math.uio.no”, the path component is “/faq/compression-faq/” and the object component is “part1.html”.

2. If the path component is empty and the site component is unspecified, then the URI is a relative one.

3. If the site component is specified, then the control of the procedure is changed to Step 6. Otherwise, the site component of the URI is assigned with that of the ‘base’ URI.

4. If the path component begins with the delimiter “/”, then the URI is regarded as an absolute one and the control flow is switched to Step 6.

5. A relative URI is converted into an absolute one in this Step. The relative URI needs to append to the ‘base’ URI. To have convenient processing, a string buffer is adopted to help the conversion from a ‘relative’ URI to an absolute one.

   a. The whole ‘base’ URI string is copied to the string buffer except the last segment of the ‘base’ URI string.

   b. The relative URI’s path component is appended to the string buffer.

   c. Each occurrence of “." in the string buffer is removed.

   d. If the string in the string buffer ends with “..”, the “.” is removed.

   e. For each occurrence of “/(segment)/.. “, the included “..” is removed from the string buffer. The removal is performed repeatedly, i.e. removing the leftmost matched pattern on each iteration, until no matched pattern is left.

   f. If the string in the string buffer ends with “/(segment)/.”, the included “..” is removed.

   g. If the resulting string buffer still begins with one or more path segments of “..”, then the URI is considered to be erroneous.

   h. Now, the content of the string buffer is the correct absolute URI. The control flow skips over Step 6 and quits the procedure.

6. The resulted URI components, including those inherited from the ‘base’ URI, are concatenated together into an absolute URI. Table 1 depicts those variables that are used in this process. The pseudo code for the concatenation is depicted in Fig. 13.

### Table 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site</td>
<td>Contains the site component of a URI</td>
</tr>
<tr>
<td>Path</td>
<td>Records the path of a URI</td>
</tr>
<tr>
<td>Fragment</td>
<td>Keeps the sub-string, which follows the hash sign ‘#’, of a URI</td>
</tr>
<tr>
<td>Query</td>
<td>Contains the sub-string, which follows the question mark '?', of a URI</td>
</tr>
<tr>
<td>Result</td>
<td>Contains the resulting URI</td>
</tr>
</tbody>
</table>

4.5. Background image and color

By viewing a Web page document in HTML using regular WWW browsers, a BACKGROUND tag can effect the colored page background. However, most facsimile equipment can just print the bi-level image data format. The bi-level image means that the color of the facsimile image is in two colors only, i.e. white and black. Since most of currently existing fax machines are for bi-level facsimile copies, the FaxWeb system mainly focuses on how to produce a bi-level facsimile copy from a visually colored web page document.

On producing the bi-level facsimile copy, the colored background image could likely garble the resulting bi-level facsimile copy to be unreadable. For example, let the background color be blue and the textual text color be black. If the colored image is directly converted into the bi-level one, the resulting bi-level facsimile copy will become black and unreadable. In order to solve this problem, the specification of color attribute specified in the BACKGROUND tag should be changed, and the background image tag should be removed. In this way, the facsimile copy of a retrieved Web page document becomes clear and readable. The pseudo code for the process of changing background color and removing background image tags from a Web page document is depicted in Fig. 14. Fig. 15
shows the view of a Web page before/after removing the background image tag from the web page document.

5. Related technical issues in the FIT

Main concerns of the FIT are (1) image capturing, (2) page size enlargement, (3) G3 conversion, (4) the conversion from a colored image to a bi-level bitmap, and (5) the conversion from the G3 image format into the TIFF/F image format.

5.1. Image capturing

To have fax machine users to get the similar view of a Web page document as that of using regular WWW browsers, the image capture mechanism is used to achieve this purpose in the FaxWeb system. In a window system, the layout result of a document is stored in the screen image buffer. By capturing and by processing the content of the screen image buffer, the layout result can be converted into the facsimile image copy. By utilizing this functionality, the FaxWeb system permits fax users to get a similar page view like that of desktop computer users by exploiting regular WWW browsers.

In the FaxWeb system, both Internet Explorer 4.0 (IE4) and an ActiveX object are adopted as the layout component. The layout component presents a retrieved Web page document into a document view, which is stored in the screen image buffer of the operating system. IE4 is one of the most powerful ActiveX objects to implement a WWW browser based on Microsoft Windows System, because it supports many high-level programming interfaces to parse and to layout HTML documents. IE4 can parse an HTML page document and then extract the embedded multimedia data of the document. After that, IE4 can present these objects on computer peripherals.

The action of copying the displayed image on a computer screen is what we called “image capturing”. The exact data entity of a document view, which is displayed on the screen, is stored in the screen image buffer of the adopted operating system. In a window system, “hdc” (Handle of Device Context) records the peripheral information, e.g. color and image buffer. Based on the “hdc” of the document view, Fig. 16 shows the steps that are used to capture the image copy from the screen image buffer. In Step 1, the system allocates a block of memory for storing the image copy. In Step 2, by referring to “hdc” of the document view, the information of this document view can be retrieved. Due to the system limitation, the bitmap data of a layout image cannot be directly retrieved. For this reason, a memory device context, which is abbreviated as DC, is allocated for retrieving bitmap image data. In Step 3 SelectObject() can map the layout image to the related BITMAP object for further processes. In Step 4 BitBlt() can indirectly copy the layout image according to the mapping made by Step 3. Step 5 releases the resources that have been allocated. After executing these Steps, the memory block “Hscreenbmp” contains the content of the screen image buffer.

5.2. Page size enlargement

A computer screen resolution of 1024 × 720 pixels is
1. Create a block of memory for storing the image copy.
   Haccreenbmp=CreateCompatibleBitmap(hdc, W, H);

2. Get the handle "hdc" of the document view and then create a memory block copy (in "hmemdc").
   hdc=GetDC(0);
   hmemdc=CreateCompatibleDC(hdc);

3. Let the "Haccreenbmp" be the BITMAP of "hmemdc".
   SelectObject(hmemdc, Haccreenbmp);

4. Indirectly copy a specific snapshot of the memory block "hmemdc" to "Haccreenbmp".
   BitBlt(hmemdc, 0, 0, W, H, hdc, srcX, srcY, SRCCOPY);

5. Release the "hdc" and the "hmemdc".
   ReleaseDC(0, hdc);
   DeleteDC(hmemdc);

Fig. 16. The procedure that is used to capture the image from the screen image buffer.

1. Calculate the scaled image size.
   int nScaleHeight=(int)(nHeight * nScaleFactor);
   int nScaleWidth=(int)(nWidth * nScaleFactor);

2. Use system function to enlarge the image.
   StretchBlt(hmemdc, 0, 0, nScaleWidth, nScaleHeight, hdc, 0, 2, nWidth, nHeight, SRCCOPY);

Fig. 17. The procedure that is used to solve the page size enlargement problem.

about 96 dots per inches (DPI) on the fax machine in print size. By printing the image copy captured from the computer screen (1024 x 720 pixels) using a laser printer, the print size of the image is almost half of that by using the fax machine (96 DPI). In the FaxWeb system, the fax device resolution is better, which is about 200 DPI. To generate better visual copies on the fax machine, the image captured from the computer screen buffer should be enlarged to fit the device resolution of a fax machine. Otherwise, the output facsimile image copy will be too small to be readable even if some fax machines with higher resolution are as the output devices.

In order to enlarge the size of the image, Microsoft Windows API StretchBlt() is adopted to solve this problem. The StretchBlt() function enlarges a bitmap from a source rectangular area to a destination rectangular area by stretching or compressing the bitmap to fit the size of the destination rectangular area. Fig. 17 shows the steps that are used to solve the page size enlargement problem.

5.3. The conversion from a colored image to a bi-level bitmap

The layout image, which is produced from IMG-CAPRURER, is a colored image. The colored image cannot be directly delivered to some fax machines, because a fax machine may accept only bi-level bitmap images. Therefore, the conversion from color image to bi-level bitmap becomes a main issue to be resolved. That is, how to convert a pixel of a colored image to a dot on a facsimile image copy is the critical problem in this issue. A pixel of a colored image is displayed according to the content value of 24 bits, i.e. R, G, and B bytes. Therefore, a pixel can have \(2^{24}\) colors to be displayed on the screen. In order to convert the colored image into the bi-level bitmap, a color converter is required. In the FaxWeb system, the color converter adopts a simple formula to determine the bi-level color of a pixel in a colored image. This formula is listed as follows.

\[
\text{Value} = \left(\frac{R + G + B}{384}\right)
\]

where the value is the quotient of the sum of R, G, and B byte values over 384. The divisor, i.e. 384, is obtained from our experiment that has been tried many times to have a better visual facsimile copy.

The Value denotes the bi-level color critical value. If the Value is greater than or equal to 1, then a colored pixel with the RGB color is converted into a bi-level dot with the black color; otherwise, the colored pixel is converted into a bi-level dot with white color. Steps for converting a colored image into the bi-level bitmap are depicted in Fig. 18.

The bitmap image data is stored byte-by-byte in memory after the above process. However, the acceptable fax image should be stored in the raw data format. In other words, the fax image should be in the bit-stream format. Therefore, the

1. Allocate a block of memory for storing the bi-level image data.
   BWarray=new char[...];

2. Calculate the R, G, and B bit values of the current pixel.
   R=lpbitmaps[...];
   G=lpbitmaps[...];
   B=lpbitmaps[...];

3. Determine the bi-level color (Black/White) of the corresponding pixel.
   BWarray[k]=((R+G+B)/384)>0.5);
   k++;

4. Go to Step 2 until the end of the image file is reached.

Fig. 18. Steps for converting a color image into the bi-level bitmap.
conversion from byte-stream data to bit-stream data is required. Fig. 19 depicts the procedure for converting byte-stream data to bit-stream data.

5.4. G3 conversion

After obtaining the bi-level bitmap, the associated facsimile image copy should be in a data format that is acceptable to a fax machine [26]. The G3 data format is widely supported by most of fax machines. In order to allow most of existing fax machines to be operational in the FaxWeb system, the G3 data format is chosen as the data format of facsimile image copies.

There are two types of G3 coding schemes in CCITT T.4, i.e. CCITT Group 3 one-dimensional and CCITT Group 3 two-dimensional types. In the FaxWeb system, we choose the CCITT Group 3 one-dimensional coding scheme as the system’s encoding scheme, because it is simple and popular for fax machines. The CCITT Group 3 one-dimensional coding scheme uses code words, which have variable lengths, called the Modified Huffman (MH) code. Based on the Modified Huffman (MH) coding scheme, an image is composed of a series of scan lines. A scan line of an image is encoded as a series of code words in variable lengths and each code word represents a run with either all white or all black pixels. The code word of an EOL (End-Of-Line) code word ends each scan line of data. This EOL code word is required and is placed prior to the code words of the first scan line. Six consecutive EOLs form a special code word called RTC (Return To Control), which indicates the end of an image.

The FaxWeb system uses findwhitespan() and findblackspan() to find specific runs and uses putspan() to put related code words of runs into the code string of the facsimile image copy. The procedure for G3 conversion is shown in Fig. 20.

5.5. The conversion from the G3 image into the TIFF/F image

In order to deploy the fax capability in the FaxWeb system, we choose the well-known Dialogic fax card to develop the FaxWeb system. The Dialogic fax card supports a fax function library. The fax function library provides fax functions that are useful for developing fax and integrated voice/fax applications. The programming interface provided by the fax function library supports transmitting TIFF Class F (TIFF/F) files to facsimile equipment [27,28]. Thus, using the supported fax library interface for faxing the G3 image to facsimile equipment, the G3 image should be encapsulated into a TIFF/F format file. In other words, the conversion from G3 image into TIFF/F image becomes an issue.

TIFF/F is used for the storage and interchange of facsimile images. A TIFF file begins with an 8-byte image file header that specifies byte definitions within a file. The image file header includes a magic number sequence that identifies the content as a TIFF file, and an offset that points to the first Image File Directory (IFD). An IFD is a sequence of tagged fields, which contain attributes of an image and pointers to the real image data. The tagged field format contains (1) a field ID, (2) a type, e.g., short, long, and rational, and (3) a value attribute that records the values/offsets of the field.

A TIFF file may contain a series of facsimile pages, which can be specified by IFDs within the TIFF file. Each facsimile page within a TIFF file document has its own IFD. Each IFD defines a facsimile page whose type is given in
Table 2

A summary of the minimal set of TIFF/F fields and values

<table>
<thead>
<tr>
<th>Field ID</th>
<th>Type</th>
<th>Value</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>BitsPerSample</td>
<td>SHORT</td>
<td>1</td>
<td>One bit per sample</td>
</tr>
<tr>
<td>Compression</td>
<td>SHORT</td>
<td>3</td>
<td>3 for T.4 (MH)</td>
</tr>
<tr>
<td>FillOrder</td>
<td>SHORT</td>
<td>2</td>
<td>LSB first bit filling</td>
</tr>
<tr>
<td>ImageWidth</td>
<td>LONG</td>
<td>1728</td>
<td>Image width in pixels</td>
</tr>
<tr>
<td>ImageLength</td>
<td>LONG</td>
<td></td>
<td>Required</td>
</tr>
<tr>
<td>NewSubFileType</td>
<td>LONG</td>
<td>Bit 1 = 1</td>
<td>Single page of multi-page file</td>
</tr>
<tr>
<td>PageNumber</td>
<td>SHORT</td>
<td>X/X</td>
<td>pg/tot, 0 base, tot in 1st IFD</td>
</tr>
<tr>
<td>PhotometricInterpretation</td>
<td>SHORT</td>
<td>0</td>
<td>0 is white</td>
</tr>
<tr>
<td>ResolutionUnit</td>
<td>SHORT</td>
<td>2</td>
<td>Inches (default)</td>
</tr>
<tr>
<td>RowsPerStrip</td>
<td>LONG</td>
<td>ImageLength</td>
<td>The whole physical image data in a strip</td>
</tr>
<tr>
<td>SamplesPerPixel</td>
<td>SHORT</td>
<td>1</td>
<td>One sample per pixel</td>
</tr>
<tr>
<td>StripByteCounts</td>
<td>LONG</td>
<td></td>
<td>Required</td>
</tr>
<tr>
<td>StripOffsets</td>
<td>LONG</td>
<td></td>
<td>Required</td>
</tr>
<tr>
<td>T4Options</td>
<td>LONG</td>
<td>Bit 0 = 0</td>
<td>MH</td>
</tr>
<tr>
<td></td>
<td>LONG</td>
<td>Bit 1 = 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LONG</td>
<td>Bit 2 = 0,1</td>
<td>Non-Byte-aligned, Byte-Aligned EOLs</td>
</tr>
<tr>
<td>Xresolution</td>
<td>RATIONAL</td>
<td>204</td>
<td>Units is per inch</td>
</tr>
<tr>
<td>Yresolution</td>
<td>RATIONAL</td>
<td>196.98</td>
<td>Units is per inch</td>
</tr>
</tbody>
</table>

the NewSubfileType field. The IFDs are organized as a linked list, so that the last tagged field in each IFD points to the next IFD (the tagged field in the last IFD is NIL). Within an IFD, the physical image data is composed of several strips, in which a strip is specified with some fields, i.e. StripOffsets, RowsPerStrip, StripByteCounts. StripOffsets is a pointer that points to related strips. RowsPerStrip specifies the size of the related strip in rows. StripByteCounts denotes the number of bytes per strip.

As the TIFF/F format has many variants, a common and minimal set of TIFF/F fields should be defined for the fax system. The minimal set of TIFF/F fields is strongly recommended in the implementation of a fax system. Based on the minimal set of TIFF/F fields, the fax system can guarantee the quality of the fax image. A summary of the minimal set of TIFF/F fields and values is presented in Table 2.

Based on the minimal set of TIFF/F fields, the G3 image is encapsulated into the TIFF-F format. In the FaxWeb system, a TIFF library, which is from Sam Leffler and Silicon Graphics [29], is adopted to set the image tag and to convert the image data into the TIFF/F format. For the ease of implementing the conversion between the G3 format and the TIFF/F format, the TIFF library is further encapsulated into a class HSUTiff, which is developed on the FaxWeb system. By using method SaveToFile() of the class HSUTiff, a G3 image can be converted into a TIFF/F format file. The specification of method SaveToFile() is as follows.

```c
int HSUTiff::SaveToFile(char * cSrc, int nWidth, int nHeight, char * cFilename)
```

There are four parameters in method SaveToFile(): “cSrc”, “nWidth”, “nHeight”, “cFilename”. Parameter “cSrc” is a pointer, which points to an image data; parameter “nWidth” indicates the image’s width; parameter “nHeight” indicates the image’s height; parameter “cFilename” is a filename, which refers to the resulted TIFF/F file. An example of using this function is as follows.

```c
HSUTiff faxTiff;
faxTiff.SaveToFile(cData, nScaleWidth, nScaleHeight, "fax1.tif");
```

In the above example, a block of memory for storing the G3 image is named “cData”. The file name “fax1.tif” is the resulted TIFF/F file.

6. Related technical issues in the PVB

By inputting the URL of the desired web page, users can retrieve the information that they want. Since voice is invisible, users cannot see what they input, “how can one browse the desired Web via a telephone set?” becomes a main issue of the FaxWeb system. Because non-visual telephone-based browsing differs from the visual computer-based browsing, some considerations should be included in the design of web pages for fax machines’ access. In order to achieve the telephone-based browsing function, e.g. input URLs, some tags for browsing the WWW space via telephones must be included in the corresponding Web pages that are to be accessible by the FaxWeb system. The following tags, which are included to enhance the capability of browsing WWW space via a telephone set, are based on the HTML grammar [30].

A. ⟨Voice…key = “x”oralguide = “y”⟩, in which ⟨!Voice… indicates that it is a hyperlink for telephone-accessed users, “x” represents the corresponding keystroke x on the telephone keypad for the hyperlink, and “y” is the oral statement. This specification has no
effect for computer-accessed users because the regular HTML browser interprets the markup delimiters as some comments and just skips this specification. An example is as follows.  
\(<!\text{VOICE HREF} = \text{“http://bear.iee.ncku.edu.tw/~jangmy/apec/ehtml/rates.htm” KEY = “9” OralGuide = “If you want to get this page’s information again, please press 9.”}>\) 

With the example mentioned above,  \(<!\text{VOICE HREF} = \text{“http://bear.iee.ncku.edu.tw/~jangmy/apec/ehhtml/rates.htm”}>\) indicates the URL address of the linked Web page;  \(\text{KEY} = \text{“9”}\) identifies that keystroke 9 represents the associated hyperlink;  \(\text{OralGuide} = \text{“If you want to get this page’s information again, please press 9.”}\) specifies the oral statement that is used to help telephone-accessed users to input the correct keystroke, i.e. keystroke 9. The sentence, “If you want to get this page’s information again, please press 9.”, can be converted to speech using a Text-To-Speech (TTS) converter. In this way, a user can be guided to input keystroke 9 to visit the page after she/he has heard the oral statement. 

B. \(<!\text{SPEECH = “x”}>\), in which “x” is the piece of information that is played out to telephone-accessed users. Again, this specification has no effect for computer-accessed users because the regular HTML-based browser interprets the markup delimiters as some comments and just skips this specification. An example is as follows.  
\(<!\text{SPEECH = “Welcome to APEC International Bank!”}>\) 

With the example mentioned above,  \(<!\text{SPEECH = “Welcome to APEC International Bank!”}>\) describes a piece of welcome information that is to be presented to telephone-accessed users. The string “Welcome to APEC International Bank!” is converted to an equivalent speech using a TTS converter. The piece of information is not visible to computer-accessed users using a regular HTML-based browser because it is regarded as a comment specification.

Fig. 21 is the working flow that describes the behavior of VOICER. VOICER contains two modes: (a) browsing mode and (b) fax mode. In the browsing mode, VOICER waits for users to dial in. When VOICER gets a user’s dial-in, VOICER retrieves the system default Web page, which contains welcome and guidance messages, to guide users for browsing the FaxWeb system. In the browsing period, VOICER (1) plays a segment of the speech guidance, which is specified in special tags mentioned previously, for each retrieved Web page to inform users that the Web page is retrieved, and (2) also prompts users some content information of the retrieved Web page. In this way, users can browse Web pages using a telephone set.

VOICER provides two ways for inputting URLs in the browsing mode. One is called the Set-in type and the other is called the Dial-in type. With the Set-in type, each hyperlink is associated with a number. When the content of a Web page is played out, some orally guided information is played out to guide users to press the corresponding numbers. Effectively, pressing a number \(k\) is the same as clicking the corresponding hyperlink associated with \(k\). VOICER searches a mapping table to generate the corresponding hyperlink’s URL. With the Dial-in type, each hyperlink is associated with a series of keystrokes i.e. each alphabet and each symbol that may exist in the URL spelling is associated with a number. For example, “01” denotes “a”, “02” denotes “b”, etc. VOICER provides some orally guided information to help users to input a series of keystrokes for specifying/ inputting URLs. In this way, VOICER can get URLs to have Web page navigation from telephone-accessed users.

After inputting the URLs of the desired Web pages, VOICER connects to the corresponding WWW servers and retrieves the desired Web pages. If a user wants to fax out the retrieved Web page, she/he can press the special function key ‘98’ to get into the other mode, i.e. the fax mode. In the fax mode, VOICER prompts a segment of oral guidance to help users inputting the phone number of the target fax machine. After the user has input the phone number, VOICER prompts a segment of guidance speech to confirm the user’s input. If the phone number is valid, VOICER faxes out the retrieved Web page to the target fax machine; otherwise, the Exception Handler, which is explained in the following section, takes care of the exception handling.

7. Related issues in the SEH

In order to build a robust application, an exception handler is indispensable to deal with unexpected events that may occur during the run time. The main unexpected events that the exception handler deals with are unpredicted network errors, unpredicted user inputs, unknown errors of the WWW space, and hardware errors.

7.1. Unpredicted network errors

The network situation should be monitored before the HTML document is retrieved. If no exception is detected, then the HTML document is well fetched; if some exception occurs, the exception handler should release the connection resource and then inform the user with some error message, e.g. “Unable to connect to the web, please input another Web URL to continue browsing”. The exception handler returns the control to the system after releasing the system resource and recovering this exception.

7.2. Unpredicted user inputs

In the FaxWeb system, a user can input the URL and the telephone number that is needed for fax. But how can the user know the she/he has input the right key? Since the telephone is not a visual-based equipment, users cannot see what they input. Thus, the exception handler adopts a TTS converter to handle such a situation. The TTS converter
can generate the corresponding voice message of user inputs, then play the voice message to the user via telephone interface. For example, after inputting some keys, the user receives the confirm message “The URL is xxxxx, if right press 1, otherwise press 0”, where the voice part of xxxxx is generated by the TTS Converter. When users input some invalid keys, the exception handler sends error key voice messages to users and skips these invalid keys.

7.3. Unknown error of the WWW space

Some errors may occur in the WWW space. For example, (a) the Web page does not exist, and (b) typos from Web page designers. The exception handler should handle errors of the WWW space. When the exception handler detects case (a), it replies a voice message: “The Web page document does not exist, the system is back to the previous
Welcome to APEC International Bank, We provide the best bank service on the world. If you want to:
- Listen to the information about Saving, press '1'
- Listen to the information about Loans, press '2'
- Listen to the information about Rates, press '3'
- Listen to this page again, press '8'
- Fax out this page, press '98'
- Leave the bank service, press '99'

Welcome to the service of rates information. If you want to:
- Listen to the information about Foreign Exchange Rates, press '1'
- Listen to the information about NTD/Foreign Currency Deposite Rates, press '2'
- Listen to this page again, press '8'
- Back to the previous page, press '9'
- Back to the home page, press '10'
- Fax out this page, press key '98'
- Leave the bank service, press '99'

Welcome to the service of Foreign Exchange Rates. The Rate of NT dollars to other currencies are as following:
- USD dollars, buy in 32.5200, sell out 32.6200
- GBP dollars, buy in 53.81600, sell out 54.16600
- HKD dollars, buy in 4.17800, sell out 4.22800

If you want to:
- Listen to this page again, press '8'
- Back to the previous page, press '9'
- Back to the home page, press '10'
- Fax out this page, press '98'
- Leave the bank service, press '99'

APEC International Bank

Foreign Exchange Rates

<table>
<thead>
<tr>
<th>Currency</th>
<th>BUYING RATE</th>
<th>SELLING RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>USD</td>
<td>32.52000</td>
<td>32.62000</td>
</tr>
<tr>
<td>CNY</td>
<td>22.17000</td>
<td>22.97000</td>
</tr>
<tr>
<td>GBP</td>
<td>31.81600</td>
<td>32.56000</td>
</tr>
</tbody>
</table>

Fig. 22. A scenario of using FaxWeb.
page!” to notify user. After the user hears the message, she/he can decide to skip this Web page or input a new URL to retrieve another Web page. In case (b), when WWW-P parses the retrieved Web page that has a tag typo or a tag that WWW-P cannot accept, it raises an exception to the exception handler. The exception handler recovers this error and then sends a message to WWW-P in order to skip the error tag. In this way, typos from Web page designers will not affect the system execution. The user can continue to browse the WWW space. Therefore, the FaxWeb system can continue being operational.

7.4. Hardware errors

The Dialogic card generates some error messages when the device is not well initiated and enabled. In the FaxWeb system, the exception handler handles this situation by prompting a message box and sending the error message to the system administrator. The system administrator can read the message on the screen. At the same time, the exception handler releases the system resources that have been allocated for enabling the Dialogic card.

8. A scenario of using FaxWeb

The scenario of using the FaxWeb system is as follows. Let a virtual electronic bank be installed with the FaxWeb system. (1) The user takes a phone call to dial-in the FaxWeb system. (2) When the dial-in is successful, FaxWeb prompts a segment of speech guidance about the system operation. (3) The user inputs a command to connect to the virtual electronic bank, and the FaxWeb system prompts a segment of speech about the bank services. (4) The user presses the corresponding key for the required bank service. (5) She/he can then get a segment of speech response and the facsimile image copy of the requested information.

9. Discussion and conclusion

A FaxWeb system is presented in the paper. The system architecture for fulfilling the FaxWeb system is introduced, and also the associated technical issues encountered on the system development are resolved. Using the FaxWeb system, users can adopt fax machines and telephone sets to browse WWW without using computers. By doing so this way, (i) more popular and cheaper I/O devices, i.e. fax machines and telephone sets, can be adopted to access the WWW, (ii) the user spectrum of the WWW can be extended to non-computer professionals, (iii) people who are not capable enough or who are not comfortable with...
computers can also use fax machines to get information that is stored in the WWW, and (iv) instead of maintaining two different systems, i.e. telephone information system and the WWW information system, an Internet Service Provider (ISP) can provide the dual information service, which can be created in the FaxWeb system, to computer professionals and non-computer professionals at the expense of only maintaining the FaxWeb system.

By further increasing the service lines of the FaxWeb system, the number of users that a FaxWeb system can serve concurrently can be scaled. Fig. 23 depicts a possible configuration of the scalable FaxWeb service. In Fig. 23, Telephone-net Interface (TI) contains some devices, e.g. a set of PCs, which contains a lot of telephone/fax cards and the corresponding FaxWeb system. Internet Interface (II) contains a lot of computers that have WWW-P. TI (II) is responsible for the communication with telephone network (Internet). TI and II are connected via a network, e.g. Ethernet. Each TI (II) is associated with a telephone number (an IP address). Each call is associated with a process, which is in charge of the URL connection and browsing the WWW space, in II and in TI respectively. Since TI and II are connected via a network, TI (II) should allocate a process to send/receive packets to/from TI (II). In this way, (i) TI can receive several phone calls concurrently, (ii) the FaxWeb system can serve as many concurrent calls as possible, and (iii) the FaxWeb system can connect to as many URLs as possible based on the configuration depicted in Fig. 23.

Currently, many telephone information service, e.g. a fax-on-demand system for acquiring product catalogs or TV programs, are provided for telephone/fax users; many WWW services are also provided to service Internet users. Due to the impact of the rapid growth of the WWW services, Computer Telephone Integration (CTI)-related research is also targeted towards providing Web-based services. From the system service viewpoint of FaxWeb, the telephone information system and the WWW information system can be combined into a single service system, i.e. the FaxWeb system, that can serve not only telephone/fax users but also computer users. In this way, companies that need to provide information to both types of users do not have to create and to maintain two different service systems, in which one is for telephone/fax users and the other for Internet users. All that the companies need is the FaxWeb system which is more cost-effective than the two information service systems namely, the traditional telephone information system and the WWW-based information system.

Based on its easy and convenient use, the WWW is likely to become the information service backbone of human life in the future. From the above viewpoint, people who cannot use computers can neither enjoy the happiness that WWW brings nor can access the information available on the WWW. These people will be behind the times if no alternative access devices can be provided for them to access WWW. Therefore, some convenient access facilities is desired to be setup such that WWW is accessible more easily no matter who and where the users are. A convenient choice is the telephone-based I/O devices, e.g. telephone sets and fax machines, which are adopted in the FaxWeb system and are widely used in the worldwide communication.

**Acknowledgements**

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**References**

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