Communication Door: Real-Time Communication Middleware

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ABSTRACT We describe a real-time communication middleware system that enables solution providers to construct various applications, such as web conferencing systems and IP-based call centers. The middleware platform, called Communication Door, is a web-based application platform for real-time groupware. It includes a real-time web sharing function implemented with an HTTP-based push protocol and an audio-video communication function. By using this middleware, many real-time groupware applications can be customized by rewriting their designs and functionalities through a server-side web application while utilizing thin clients. Solution providers can customize the user interface design and the functions of real-time groupware by revising their server-side web applications. In this paper, we describe the architecture of the middleware and its applications.

KEYWORDS **Real-time communication, Web conferencing, Groupware, Web application, Middleware**

1. INTRODUCTION

This paper describes a real-time communication middleware platform called Communication Door. This system enables solution providers to develop tailored solutions, such as VoIP (Voice over IP), web conferencing, and call center applications, for various customers.

Recent progress in network access technologies such as ADSL (Asymmetric Digital Subscriber Line) and FTTH (Fiber To The Home) has increased the use of broadband Internet connections. Broadband Internet is becoming a new infrastructure for communication services, and it is reducing the costs of voice communication. Customers also now require communication services that provide higher value than conventional voice services. To satisfy various requirements for communication services, solution providers should rapidly deploy tailored solutions to their customers. Since conventional communication services, such as telephone service, require both dedicated terminals and a dedicated network in general, it is too expensive to rapidly satisfy varied customer requirements.

Communication Door is a middleware platform that enables solution providers to develop custom solutions in the same manner as the development of web applications. It supports three major features: 1) real-time synchronization of contents among web browsers connected to the same web application; 2) real-time voice and video communication; and 3) an HTTP-based push server that can autonomously send differences in data maintained by the server to web browsers connected to the application (as compared to a general HTTP server, which can send data only when a web browser requests it). By utilizing these capabilities of Communication Door, various communication services can be developed.

2. OUTLINE OF COMMUNICATION DOOR

Communication Door is a middleware application supporting various interactive communication forms via broadband Internet. It offers solution providers various functions for real-time communication.

2.1 Purpose

The purpose of Communication Door is to provide leverage to enlarge communication solutions in business by integrating information technology with networking technology.

As a new infrastructure for communication services, broadband Internet reduces the cost of voice communication, as in the case of telephone service. As a result, customers require higher value communication services, such as web conferencing and

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web-based call centers, as compared with voice communication services.

To satisfy these requirements, solution providers must rapidly develop various solutions suited to their customers' businesses. Therefore, solution providers require middleware enabling this sort of rapid development based on their customers' requirements.

2.2 Related Work and Issues

Several researchers[1-5] have proposed various communication functions that will be required in a real-time groupware system. These previous approaches have been implemented as dedicated systems. Therefore, custom applications based on these systems cannot work in a general-purpose system.

Other researchers[6,7] have proposed web-based groupware systems. The benefit of this approach is the ease of customizing applications by using development tools for web applications. Web-based applications, however, cannot support real-time functions because of the standard behavior of HTTP. Specifically, HTTP is a transactional protocol, meaning that a web browser can update contents on-screen only by accessing an HTTP server.

Another previously proposed approach, called "e-office"[8], supports real-time web conferencing but requires a dedicated server for real-time communication. In this system, a user's view is produced by a web application, but the application program has to be implemented as a client program of the dedicated server.

Many desktop conferencing systems based on ITU standards such as H.323 and T.120[9] have been developed. NetMeeting[10], developed by Microsoft Corporation, is an example of a desktop conferencing application based on the H.323 standard. Recently, other desktop conferencing systems have been based on proprietary protocols. Examples include Macromedia's Flash Communication Server[11] and Microsoft's Office Live Communications Server. These systems have rich functionality but require a higher level of expertise for solution providers to utilize them in customizing applications.

2.3 Concept of Communication Door

As described above, the purpose of Communication Door is to enable solution providers to develop communication systems in the manner of web development rather than the development of dedicated systems. Users of web applications can select services according to their businesses by specifying URLs (Uniform Resource Locators) in their web browsers. Users of Communication Door can thus select real-time communication services in this way, by specifying URLs.

Figure 1 shows the relationship between real-time communication services and Communication Door. Such real-time communication services as TV telephony, web conferencing, and call centers can be implemented as applications based on Communication Door. Communication Door supports the common functions of real-time communication, including voice

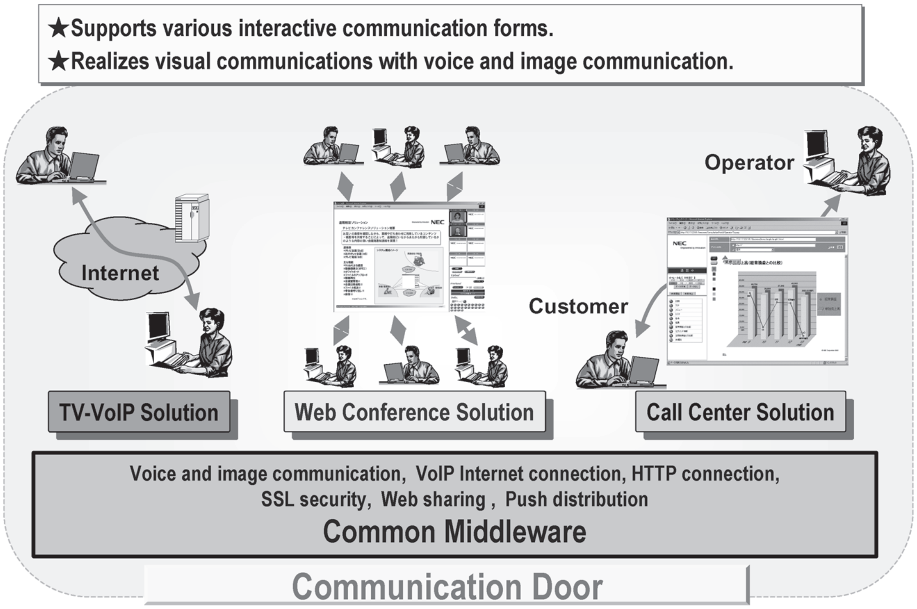

★Supports various interactive communication forms.
★Realizes visual communications with voice and image communication.
Internet
Operator
Customer
TV-VoIP Solution
Web Conference Solution
Call Center Solution
Voice and image communication, VoIP Internet connection, HTTP connection,
SSL security, Web sharing , Push distribution
Common Middleware
Communication Door

Fig. 1 Outline of Communication Door.

and video communication, real-time sharing, and content synchronization.

The advantages of Communication Door are that it supports flexible customization and ensures real-time performance.

(1) Flexible Customization

Communication Door is designed to support flexible customization as a middleware platform for web applications. The methodology of developing web applications is widely accepted as providing such flexibility. Conventional web applications, however, do not support real-time updating of the contents of web browsers. Our middleware extends to both server technology and client technology. The server technology, called Push Server, pushes data from a web application to web browsers. The client technology, called LiveComm, receives the data sent by Push Server and updates the contents of a web browser.

A web application based on Communication Door can update the contents of all connected web browsers in real time. Thus, by utilizing the APIs (Application Programming Interfaces) of Push Server and LiveComm, solution providers can develop real-time communication services as web applications synchronizing among web browsers.

(2) Ensuring Real-Time Performance

Communication Door is designed to ensure the real-time performance of web applications. As mentioned above, Push Server can send any data to web browsers. Communication Door supports functions for propagating the differences in web contents, i.e., HTML documents, to reduce the time for sending data. When Push Server sends both an identifier and the differences in an HTML document to a web browser, LiveComm, running on the web browser, can identify parts of the HTML document from the identifier. Then, LiveComm replace the specified parts in the document with the differences sent by Push Server.

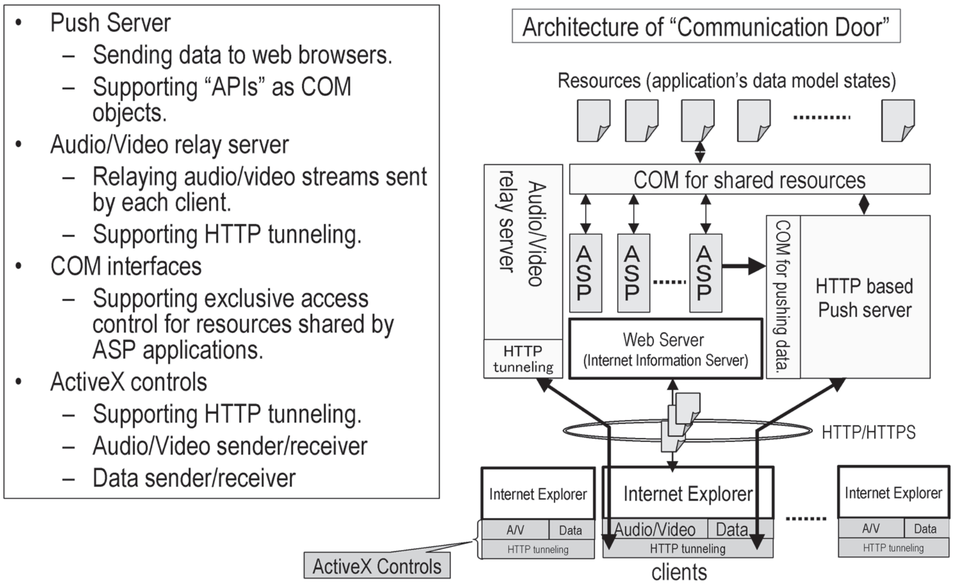
3. ARCHITECTURE

Communication Door is designed as a system platform for web-based real-time communication applications.

3.1 Overview

Communication Door consists of a web server, Push Server, and web browsers. It is characterized by the establishment of a persistent, real-time connection over HTTP with low latency time. Applications based on Communication Door can support real-time communication with voice, video, image, and text data over HTTP.

Communication Door provides solution venders with server-side modules and ActiveX controls running in web browsers, as shown in **Fig. 2**. By using the APIs of these modules, solution venders can develop web applications based on ASP (Active Server Pages) to control the modules.



- Push Server
  - Sending data to web browsers.
  - Supporting "APIs" as COM objects.
- Audio/Video relay server
  - Relaying audio/video streams sent by each client.
  - Supporting HTTP tunneling.
- COM interfaces
  - Supporting exclusive access control for resources shared by ASP applications.
- ActiveX controls
  - Supporting HTTP tunneling.
  - Audio/Video sender/receiver
  - Data sender/receiver

Fig. 2 System architecture.

3.2 ASP Applications and COM Interfaces

The ASP applications are implemented on a web server, by applying IIS (Internet Information Server), developed by Microsoft Corporation. An ASP application consists of HTML documents that include script programs calling COM (Component Object Model) interfaces. Since Communication Door supports COM interfaces for shared resources and Push Server, programmers can develop ASP applications to control exclusive access to shared resources and Push Server.

In general, ASP applications create HTML documents for each web browser accessing the application, and they send these documents back to the browsers. The browsers then display the documents through HTML rendering. As a result, ASP applications can customize individual users' views by creating individual HTML documents.

3.3 ActiveX Controls

ActiveX controls are modules running on Microsoft's Internet Explorer web browser to extend its functionality. Communication Door supports two major ActiveX controls: an audio/video sender and receiver, and a data sender and receiver. The audio/video sender encodes audio/video streams and sends them to an audio/video relay server. The receiver receives the encoded audio/video streams from the relay server, decodes them, and plays them back. The data sender sends data created by script programs running on web browsers to Push Server. The receiver receives the data from Push Server and transfers it to the script programs on the web browsers, which render the data.

An HTTP tunneling module provides these ActiveX controls with persistent bi-directional connections, i.e., an upload connection and a download connection, between the controls and Push Server through firewalls, without utilizing dedicated lines [14,15].

In the conventional way, a client application based on HTTP standards connects to a web server to utilize resources on the server, and it disconnects afterward. Since stream data, such as audio and video, continue to flow, persistent bi-directional connections are required. Also, through such bi-directional connections for text and image data, client applications can send and receive data to and from server applications in real time.

3.4 Push Server

Push Server sends data to the data sender-receiver ActiveX controls on the web browsers via HTTP or HTTPS. When a web browser accesses an ASP application, it downloads an HTML document with a script program calling the control. After downloading the document, the browser interprets it and activates the control. The activated control then connects to Push Server and establishes a persistent bi-directional connection. After being connected, Push Server can send and receive data to and from the control in real time. Also, web applications can request Push Server to send data to the ActiveX controls on web browsers through Push Server's API.

3.5 Audio/Video Relay Server

The audio/video relay server relays the audio and video streams sent by the audio/video sender-receiver (ActiveX control) on one browser to the audio/video sender-receiver controls on others. Since the server is implemented on the HTTP tunneling module, it can relay audio/video streams through firewalls or NAT routers in an Intranet or the Internet.

4. DEVELOPING AN APPLICATION WITH COMMUNICATION DOOR

We now explain how to build and customize a web conferencing application, as a typical example of a web application, by using Communication Door.

4.1 Web Conferencing System

A web conferencing system is one example of a desktop video conferencing system. In a conventional desktop conferencing system, users have to install a client application and configure its settings in order to connect to the conferencing server in their network. Users of web conferencing systems, however, need only a web browser. First, a user accesses a web server for conferencing, then he or she downloads the client application. The downloaded application is activated automatically by the web browser and joins a virtual conferencing room on the server. In many web conferencing systems, the client application is implemented as an independent application, i.e., as a user interface or a conferencing function built into the application. Also, many web conferencing systems are designed as package applications. As a result, the costs of customizing web conferencing systems tend to be higher.

In contrast, a web conferencing system based on Communication Door is implemented as a web application. Since it describes the user interface through an HTML document, the user interface can easily be customized by upgrading the web application to produce an appropriate HTML document.

4.2 Design System Behavior

Developers can design the system behavior of web applications based on Communication Door, as we describe here for the example of a web conferencing system, as illustrated in **Fig. 3**.

First, a user accesses the initial page on the web server and downloads the ActiveX controls (the audio/video and data sender-receivers) to his computer. Then, he navigates to the login page on the web server and logs in with a username and password to a virtual conferencing room. After the login procedure, he downloads the initial HTML document including the definition of the user interface. For example, the main view shown in **Fig. 4** is described by an HTML document consisting of many frames, including a main frame for displaying shared documents, a video frame, and frames for tools.

After loading the initial HTML document, the web browser activates the ActiveX controls. The activated controls establish persistent connections to both Push Server and the audio/video relay server.

When a user manipulates objects in the frames for tools, a script program in the initial HTML document creates data and sends it to the web application through the HTTP connection. The web application processes the data and creates a new HTML document. Since the application can maintain differences between the original document and the new document, it can immediately send the differences to the web browser by calling Push Server. The differences are received by the data sender-receiver control on the web browser. After receiving the differences, this control transfers them to the script program in the HTML document, which then rewrites the HTML document displayed in web browser accordingly. As a result, the HTML documents displayed in each web browser are synchronized in real time.

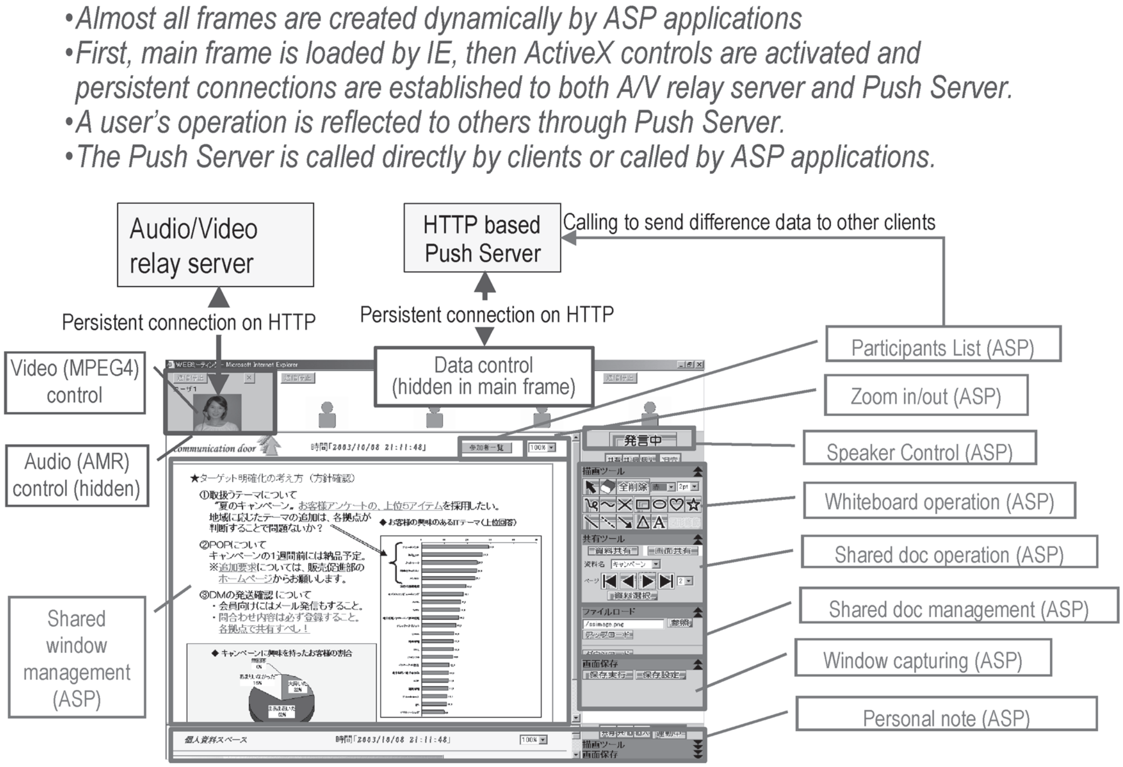
In addition, the audio/video sender-receiver on the user's web browser automatically sends his voice and video data to the audio/video relay server.

5. OTHER APPLICATIONS

We now describe two other applications based on Communication Door: an IP-based call center system, and a TV-VoIP system.

(1) IP-Based Call Center System

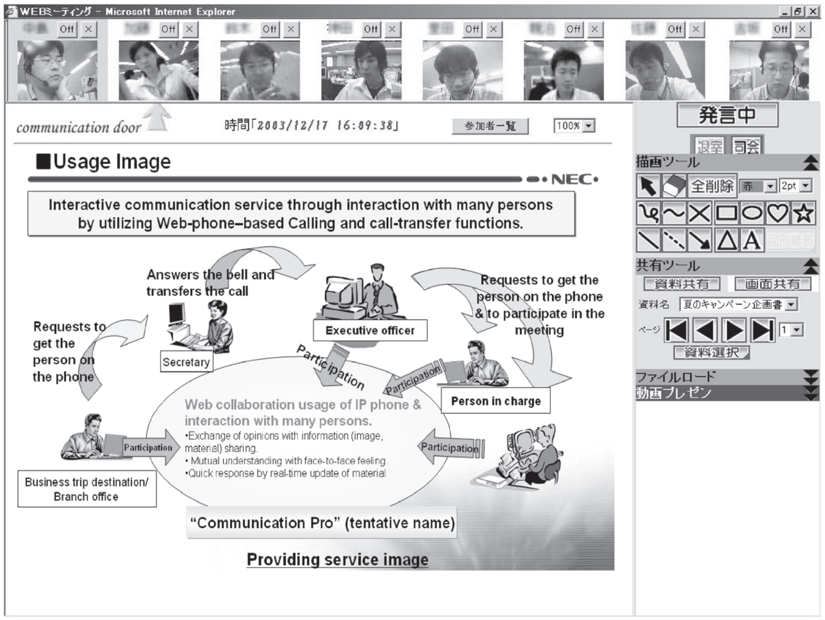
An IP-based call center system enables users to contact a company's help desk. **Figure 5** shows examples of screens for an IP-based call center system: the left side shows the customer's view, while the



- *Almost all frames are created dynamically by ASP applications*
- *First, main frame is loaded by IE, then ActiveX controls are activated and persistent connections are established to both A/V relay server and Push Server.*
- *A user's operation is reflected to others through Push Server.*
- *The Push Server is called directly by clients or called by ASP applications.*

Audio/Video relay server
HTTP based Push Server
Calling to send difference data to other clients
Persistent connection on HTTP
Persistent connection on HTTP
Data control (hidden in main frame)
Video (MPEG4) control
Audio (AMR) control (hidden)
Shared window management (ASP)
Participants List (ASP)
Zoom in/out (ASP)
Speaker Control (ASP)
Whiteboard operation (ASP)
Shared doc operation (ASP)
Shared doc management (ASP)
Window capturing (ASP)
Personal note (ASP)

Fig. 3 Primary system behaviors.



■Usage Image

Interactive communication service through interaction with many persons by utilizing Web-phone–based Calling and call-transfer functions.

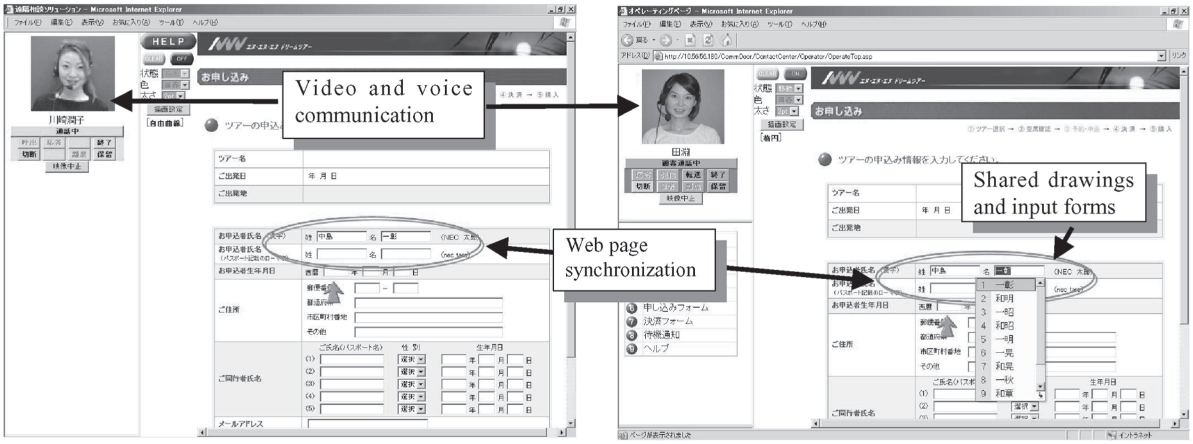
Web collaboration usage of IP phone & interaction with many persons.
•Exchange of opinions with information (image, material) sharing.
• Mutual understanding with face-to-face feeling.
•Quick response by real-time update of material

“Communication Pro” (tentative name)

Providing service image

WEBミーティング - Microsoft Internet Explorer
communication door
時間「2003/12/17 16:09:38」
参加者一覧
100%
NEC
Answers the bell and transfers the call
Requests to get the person on the phone
Requests to get the person on the phone & to participate in the meeting
Secretary
Executive officer
Person in charge
Business trip destination/ Branch office
Participation
発言中
退室
司会
描画ツール
全削除
2pt
共有ツール
資料共有
画面共有
資料名
夏のキャンペーン企画書
ページ
資料選択
ファイルロード
動画プレゼン

Fig. 4 Web conferencing view on-screen.



(a) Customer view.

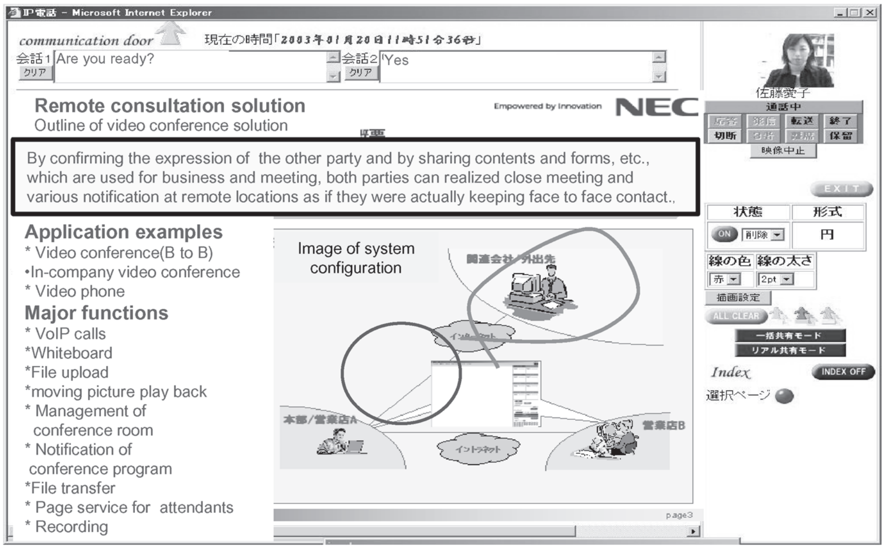
(b) Operator view.

Fig. 5 IP-based call center screens.

right side shows the operator’s view. Both the customer and the operator can communicate with each other while watching the same web page. Since the shared page is synchronized, the images, input text, and pointers on the page appear on both screens in real time. As a result, the customer can consult with the operator through voice and video communication while watching a synchronized web page.

(2) TV-VoIP System

A TV-VoIP system based on Communication Door can add image communication and a function for sharing information to an ordinary VoIP system. A user can search for and confirm other users’ statuses and call them. Users can also communicate with each other by sharing contents, such as written materials or papers, as shown in **Fig. 6**. Thus, they can achieve close meeting and send various notifications to remote locations as if they were actually maintaining face-to-face contact by viewing each other’s facial expressions and sharing contents.



Are you ready?

Yes

Remote consultation solution
Outline of video conference solution

By confirming the expression of the other party and by sharing contents and forms, etc., which are used for business and meeting, both parties can realized close meeting and various notification at remote locations as if they were actually keeping face to face contact.,

Application examples
* Video conference(B to B)
•In-company video conference
* Video phone

Major functions
* VoIP calls
*Whiteboard
*File upload
*moving picture play back
* Management of conference room
* Notification of conference program
*File transfer
* Page service for attendants
* Recording

Image of system configuration

Fig. 6 TV-VoIP view on-screen.

Since these applications, including the web conferencing system, are implemented as web applications running on a web server, users can select communication services by simply entering URLs in their browsers.

6. CONCLUSION

We have described Communication Door, a middleware platform that enables solution providers to build various communication services as web applications. By using Communication Door, solution providers can implement communication systems tailored to their customers' requirements in the same manner as the development of web applications. It is easier to customize web applications than conventional client-server applications. Hence, Communication Door provides a system platform for real-time communication services.

Our future work is to ensure scalability for a large number of users. For example, in a web conferencing system, increasing the number of participants reduces the performance of real-time communication. We plan to extend Communication Door to ensure a high level of scalability.

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Received July 14, 2004

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