Distributed Teleworking Platform for Radiology Applications

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1. INTRODUCTION

Developments in telecommunications technologies have led to advanced telecommunication services which will strongly affect the clinical practice. Co-operative work on Radiology Images is probably one of the most intensive application area relevant to the benefits provided using the new developments [1], [2]. The paper presents a new platform for co-operative work on modality-generated diagnostic images*.

The co-operative work platform (CWP), is a software package running at low cost computers under the MS-Windows 95 environment. CWP is independent of the communication medium used for data delivery. The minimal bandwidth required is 128Kbps in the form of two ISDN B channels, while the total performance may be improved using additional B channels [3]. CWP is most functional in parallel with a videoconferencing service between the communicating stations. CWP allows the delivery of diagnostic data including several modality-generated images plus patient data and annotation. After this procedure the co-operating physicians can discuss the images using voice, telepointers and markups of Regions of Interest (ROI). In addition a number of image processing algorithms can be initiated remotely. This feature allows the creation of secondary images without additional loading of the communication links. The CWP platform is integrated with teleconferencing hardware (cameras, etc.) and software. The system will be extensively evaluated under real clinical conditions in four clinical sites spread over Europe.

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2. SYSTEM DESCRIPTION

The CWP software operates as a component of a complete system, which includes the following major elements: the Communication components, the CWP Software and the Videoconferencing (V/c) component. The Communication components include the physical connections and links, the intermediate internetworking devices (i.e. routers and switches), the network adapters (ISDN boards), and the communication software [4]. The CWP Software is described in detail in the following paragraphs. The Videoconferencing (V/c) component, which is totally independent of the CWP, is usually an available of the self-product. Videoconferencing is an optimal complement of CWP but it is clear that CWP functionality is not affected by the existence or not of a V/c product [5]. The above structure is depicted in Figure 1. During consultation the roles of the calling and the called stations are totally symmetric and only during the initial call procedure they have different roles (the calling station pre-transmits the images to the called station).

2.1. The CWP Modules

CWP can be conceived as a set of interoperable modules. The set includes the following modules: the Network Interface Module (NIM), the Recovery Module (RM), the Local Image Handling Module (LIHM), the Login Support Module (LSM), the Encrypt-Decrypt Module (EDM), the Remote Procedure Initiator Module (RPIM) and the Conference Setup Module (CSM). The Network Interface Module is responsible for transmitting and receiving data. The Recovery Module is activated in cases of abnormal interruption of bulk data transfer and include mechanisms for resuming the transmission of the data from the point of the interruption. The Local Image Handling Module is developed for local manipulation of stored diagnostic images. It includes an image browser and a limited set of image processing and file manipulation tools. The Login Support Module is used for the login and logout procedures of the user. The Encrypt-Decrypt Module provides data encryption and decryption over the network for medical data confidentiality [6]. The Remote Procedure Initiator Module (RPIM) is responsible for initiating remote image processing algorithms. This approach minimises the bandwidth requirements during the conference. The Conference Setup Module provides a set of mechanisms the setup of rendezvous between two stations. It also includes an option for a visual answering machine facility.

2.2. The required environment

CWP operates over the standard TCP/IP communication environment accessible via a standard TCP socket library. The CWP software is implemented for PC-based stations running Microsoft Windows version 3.x equipped with Win32s or Windows 95 or the Windows NT operating system platforms. Thus the system operates over the Winsock 1.1 implementation of the TCP socket library.

Future activities are focused on the development of a Unix based CWP version which will be operable over the standard Berkley BSD4.2 socket library.

The user interface is based on graphical tools like menus, dialog boxes, icons, etc. It uses the Microsoft MDI protocol, which includes a central application window and many smaller ones containing different forms of pictures or text.

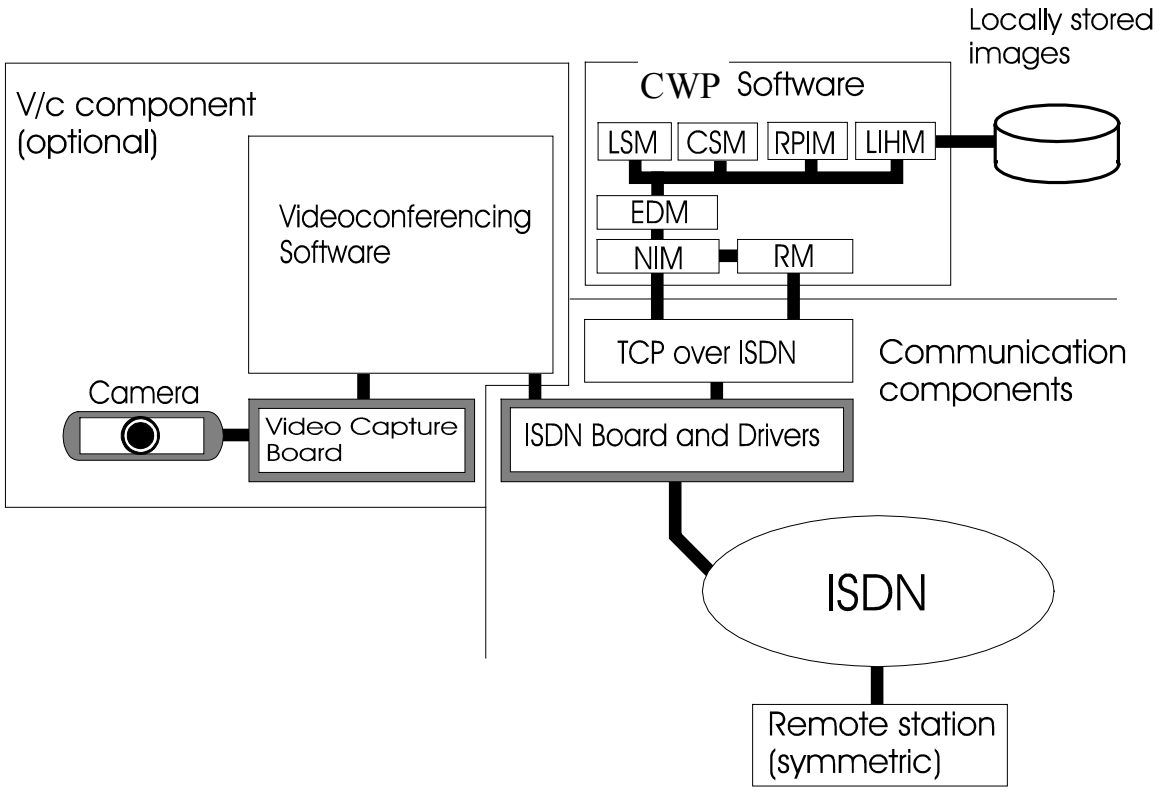

Figure 1. System components and CWP structure

3. CWP FUNCTIONALITY

The system has the capability to pre-transmit diagnostic images from one station to the other and then to discuss on a remote basis the diagnostic findings. Discussion is supported by a telepointing service, a ROI telemarking service, a videoconferencing channel and a service allowing the initiation of image processing algorithms remotely. In every transaction there exist the following four separate phases: Idle, Call, Prefetch, Consultation. During Idle, communication is disabled. Local operations, like browsing of images are executed. During Call a user calls a remote station and negotiates on a Consultation (time, on what case, etc.) This phase may include an automated answer to the calling user provided by the CWP Answering Machine. This phase

normally ends with a setup of a rendezvous for a Consultation. During Prefetch bulk data are transferred to the called station in order to save bandwidth during discussion. During Consultation the two stations are communicating through voice, pointers and remote image processing algorithms. The above procedures are depicted in Figure 2. The CWP functionality is clarified through the following Table 1, which includes the available services, the corresponding phases per service, and the sites at which the services operate on data.

Table1
CWP Services

CWP Services	Phase of transaction	Operation site
Open Images Folder	Idle	Local
Change Images Folder	Idle	Local
Delete Image	Idle	Local
Move Image	Idle	Local
Browse Local Images	Idle	Local
Zoom Local Images	Idle	Local
Darken Local Image	Idle	Local
Lighten Local Image	Idle	Local
Mark Local Images	Idle	Local
Transmit Images	Prefetch	Remote
Open Call List	Call/Idle	Local
Call remote station	Call	Remote
Add name to Call List	Call/Idle	Local
Remove name from Call List	Call/Idle	Local
View Remarks	Call/Idle/Consultation	Local
Enable Answering Machine	Idle	Local
Enable Rendezvous Setup	Idle	Local
Setup Rendezvous	Call	Remote
Point on Image	Consultation	Remote
Mark Remote ROI	Consultation	Remote
Browse Remote Images	Consultation	Remote
Zoom Remote Image	Consultation	Remote
Darken Remote Image	Consultation	Remote
Lighten Remote Image	Consultation	Remote
Annotate Local Image	Idle	Local
Transmit Text	Consultation/Prefetch	Remote
Disable voice	Consultation	Local

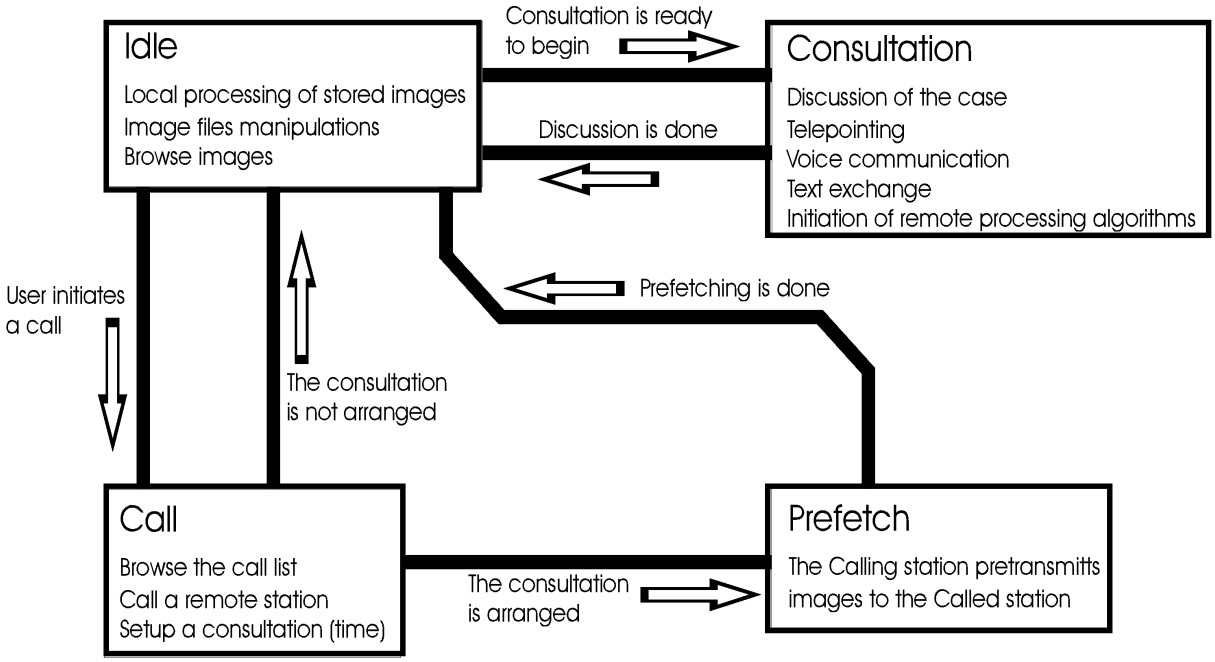

Figure 2. Transition between phases during CWP operation

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