EPIRUS-NET: A WIRELESS HEALTH TELEMATICS NETWORK IN GREECE

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Abstract- **The Region of Epirus, located in a rather isolated and up to now underdeveloped part of Greece, has made a significant effort in establishing and promoting an integrated environment for health care delivery through the development of a regional Health Telematics Network, the Epirus-Net. Epirus-Net is a fixed wireless data network, that gradually extends throughout the region and connects regional hospitals and health care centers. The network provides access to Integrated Electronic Health Record services, resource services (Directory of Healthcare Providers), educational services (distant learning courses on medicine) as well as specialized medical tele-conference and tele-consultation services. Within the context of this paper the network infrastructure and the computer-based patient record, CPR, system, is described.**

Keywords - **Healthcare Information Infrastructure, Integrated Regional Network Services, Integrated Electronic Record, Telemedicine.**

I. INTRODUCTION

Throughout the world, information and communication technologies form the basis of a new and constantly evolving area in the practice of medicine and the delivery of healthcare [1]. Within this rapidly changing environment, regional, national and international health telematics networks are increasingly used to facilitate the sharing of medical knowledge and the provision of quality healthcare services to the communities they serve. Over the last years, significant efforts, both at European level [2] and worldwide [3][4][5][6][7] have been made in establishing health telematic networks and providing integrated health telematic solutions.

The great challenge in applying information and communication technologies in the healthcare sector is to balance the demand for efficient, reliable and cost-effective services (both in terms of network infrastructure and telematic applications) with the existing technological, fiscal, legal and political enabling factors and constraints.

Although Greece has presented a significant effort [8] in designing and implementing telemedicine applications, the results prove the inefficiency to establish, operate and maintain integrated healthcare networks, apart from a few remarkable exceptions at a regional level [9]. This is mainly due to the deficiency of healthcare policies to support regional development (the healthcare framework is centrally managed) and the inadequacy of facilities or prohibitive costs of telecommunication infrastructure. These constraints have resulted in a fragmented and underdeveloped healthcare system, since public healthcare providers have to pay for both health telematic applications, network infrastructure and interconnection.

The Region of Epirus, located in a rather isolated and up to now underdeveloped part of Greece, has made a significant effort in establishing and promoting an integrated environment for health care delivery through the development of a regional Health Telematics Network, Epirus-Net. Epirus-Net is a fixed wireless network, that gradually extends throughout the region and connects regional hospitals and health care centers. The network provides access to Integrated Electronic Health Record services (distributed CPR system), resource services (Directory of Healthcare Providers), educational services (distant learning courses on medicine sectors) as well as specialized medical tele-conference and tele-consultation services. In addition, other added-value services are currently under design and implementation, related to home care, pre-hospital emergency care, education and information to the citizen as well as health monitoring and disease prevention [10][11].

In this paper we describe the network infrastructure, the distributed CPR system and the experience from the use of integrated health telematic applications at a regional level.

II. METHODOLOGY

A. The network infrastructure

The region of Epirus presents strong morphological particularities, mountainous and isolated areas that constitute transportation and provision of healthcare, especially in emergency cases, very difficult. This was a strong motivation for creating a regional health telematics network. Epirus-Net is a wireless data network that extends throughout the region of Epirus, as shown in Fig.1, connecting a number of Local Area Networks, LANs, mainly hospitals and healthcare centers spread over long geographical distances in the region. The data transfer rate is 2 Mbps at the network backbone and 512 Kbps at the end-points (e.g. Healthcare Centers).

Although the network is designed with an all-IP backbone, it is still capable of supporting Frame Relay, FR, access, ATM trunking and FR to ATM inter-working via the existing switch and the backbone routers, should that need arise.

The transmission method used is Spread Spectrum. Spread Spectrum is considered to be one of the safest methods for transmitting data as it makes malicious interception and interference very difficult. Spread Spectrum technology is accomplished in the utilized

Report Documentation Page

Report Date	Report Type	Dates Covered (from... to)
25 Oct 2001	N/A	-

Title and Subtitle	Contract Number
EPIRUS-NET: A Wireless Health Telematics Network in Greece	
	Grant Number
	Program Element Number

Author(s)	Project Number
	Task Number
	Work Unit Number

Performing Organization Name(s) and Address(es)	Performing Organization Report Number
Dept. of Computer Science Medical Technology and Software Development Unit Univ of Ioannina, GR 45110, Ioannina, Greece	

Sponsoring/Monitoring Agency Name(s) and Address(es)	Sponsor/Monitor's Acronym(s)
US Army Research, Development & Standardization Group (UK) PSC 802 Box 15 FPO AE 09499-1500	
	Sponsor/Monitor's Report Number(s)

Distribution/Availability Statement
Approved for public release, distribution unlimited

Supplementary Notes
Papers from 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society, October 25-28, 2001, held in Istanbul, Turkey. See also ADM001351 for entire conference on cd-rom. , The original document contains color images.

Abstract

Subject Terms

Report Classification	Classification of this page
unclassified	unclassified

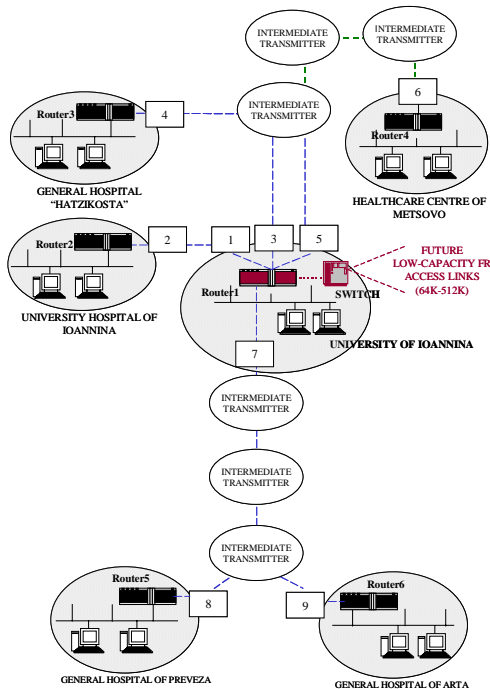| Classification of Abstract	Limitation of Abstract
unclassified	UU

Number of Pages
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Fig. 1. The regional telematic network in Epirus

SKYPLEX models, by rapidly changing the phases of the modulation signal through digitally multiplying the data with a pseudo-random noise, PN, code. The demodulated signal is de-spread (combined) in the receiver by a similar multiplication with the same PN code. This type of spread spectrum modulation is referred to as "direct sequence." A major advantage of spread spectrum modulation is a more efficient spectrum utilization and greater tolerance to interference. This permits many users to occupy the same bandwidth in close proximity. The FCC and other international regulatory agencies have set aside an unlicensed band at 2.4 GHz for use by spread spectrum systems.

The Epirus-Net wireless devices operate in the 2400 – 2483 MHz band (Industrial Scientific and Medical Band) and allow the communication among the network nodes using a variety of higher-level protocols (HDLC, PPP, and Frame Relay).

To the upper protocol layers, the physical link is presented as a TDM E1 link, which can be used as Unframed E1 or as a Nx64 channelised fashion.

At the Data Link Layer the PPP protocol is used. This gives the capability of using other 3rd layer protocols beyond IP (as AppleTalk or IPX), if such need exists and the flexibility of implementing access VPNs using a variety of tunnelling protocols (L2F, PPTP, and L2TP).

At the network level, the prominent protocol in use is the IP protocol. MPLS-based switching integrates IP routing and switching within the same networking environment. Epirus-Net can deliver various connection services including leased-line, Frame Relay, and Internet dial access while deploying advanced IP services, including virtual private networks (VPNs), managed intranet and

extranet solutions, voice over IP, video over IP, Web hosting, and electronic commerce applications.

B. Provision of health telematic services

Most of the provided services are Web-based and are installed at the central Epirus-Net Web server and include: the distant learning courses, the healthcare providers' directory service, the electronic patient record system and the medical videoconference system.

The Electronic Patient Record and VideoConference Systems are installed at hospitals (end-points of the network), on separate servers. The videoconference application uses H.323 and IP protocols and it is implemented using object-oriented Delphi environment for Windows '95 and VDK (VCON Development Kit). The Electronic Patient Record system is based upon the distributed objects architecture of CORBA. All applications are recently installed and tested. Traffic is currently being monitored in relation to the performance of the network.

C. The integrated electronic health record

The integrated electronic health record serves the specific needs of the cardiology and orthopedic clinics and is currently extended to cover the needs of other medical sectors (e.g. gynecology). It is currently installed in all hospitals and healthcare centers connected to Epirus-Net as well as the University Hospital in Larisa. The system open architecture and design adopts public interfaces and standards (e.g. HL7, DICOM) while pays special attention to all related security issues.

The main architectural goal of the system is to provide with a unified view of the medical records, regardless of storage location, meaning that several hospital installations should be able to share medical record information among them. Before approaching the techniques that are used to facilitate such a mechanism, a detailed description of the objects (entities), according to the healthcare procedures has also to be made. The system is represented of three basic layers: the database layer, the middleware and the
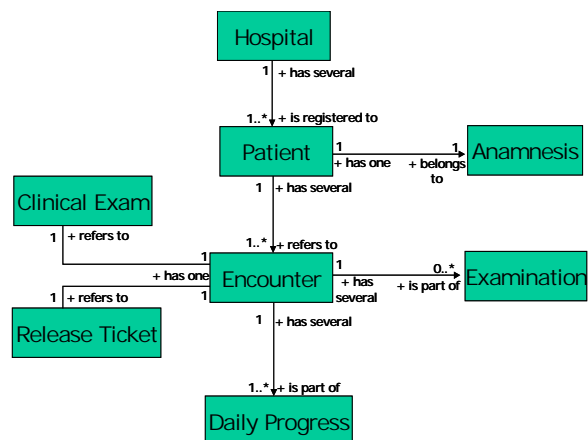

Fig. 2. CPR entities and relations

presentation layer.

The main object (entity) of the system is the Patient's Demographic Data. Each Patient entry is associated with the Hospital entry through the hospital ID, HID, attribute. This attribute, along with an identification number, ID, issued by the corresponding hospital, uniquely identifies the Patient entry. The patient's demographic data is supplemented by the patient's Anamnesis. The Encounter entry is uniquely identified by the incremental ID, IID, attribute. Each encounter entry is associated with a clinical examination entry. The Daily Progress entry depicts the patient's progress while being nursed in hospital. The Release Ticket entry contains a summary of the examinations, if any, along with recommendations. CPR entities and relations among them are presented in Fig. 2. In this diagram the attributes of the entities are depicted. Every object described is part of a database module referring only to a specific hospital installation. All the database modules comprise the database layer.

CPR server constitutes the middleware layer. It provides database connection mechanisms, connection access between clients and servers and also interaction with the MEDPACS system. The system uses two modules: Midas connection for accessing the database – providing clients with dataset (uses COM) and CORBA, to establish the communication methods between the CPR servers and the authentication server. The services of the CPR server are outlined in the IDL interface. The IDL interface, apart from the definitions of methods, contains definitions of structures related to the medical record items. The CPR clients access the CORBA server through this interface. Furthermore, the CPR servers themselves use the interface extensively while collaborating in the exchange of medical record items.

The IDL interface depicts the main entities of the system (Hospital, Patient, Anamnesis, Encounter, Clinical Examination, Daily Progress, Examination, Release Ticket), along with a number of auxiliary structures.

Authentication Server, as shown in Fig.3, is a system that holds user control access list and a list of medical records that are subject to strict security issues. According
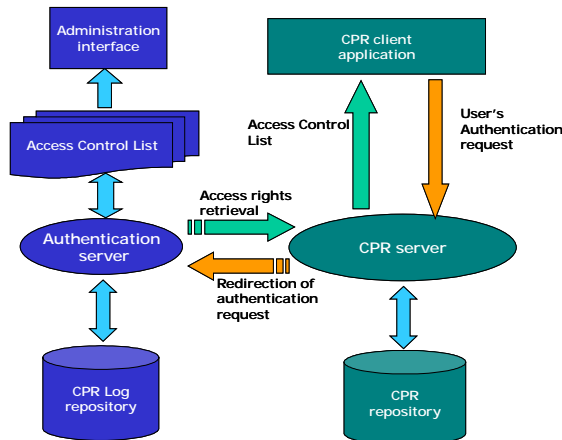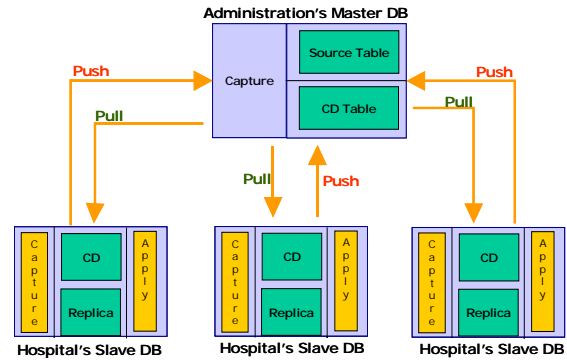

Fig. 4. The replication scheme Update Anywhere

to the user's occupation at the hospital in which they are working, a hierarchy is suggested in order to provide different levels of security. Reference to authentication server is made every time a user is a subject of authentication or every time a user requests a medical record to be displayed when it belongs to another hospital installation. A supervisor, through a unique interface, maintains administration of user access lists granting or revoking access rights when necessary.

The unified view of the medical records is possible through the collaboration of the CPR servers in order for a record to be located, delivered to the client, possibly modified and finally stored back at its "home" repository. This is accomplished through the services provided by the CPR servers by means of replicating patient's demographic data. The patient's demographic data replication is accomplished by utilizing the "Update-Anywhere" replication scheme provided by DB2 as shown in Fig.4. Master is one of the databases participating into the replication, while the rest of them share the characterization slave. Updates, which occur in a slave database, are replicated first to the master database, and then to the rest of the slave databases.

This particular replication scheme involves the use of appropriate software modules in order to capture and apply the changes in the replicated tables. At each slave database

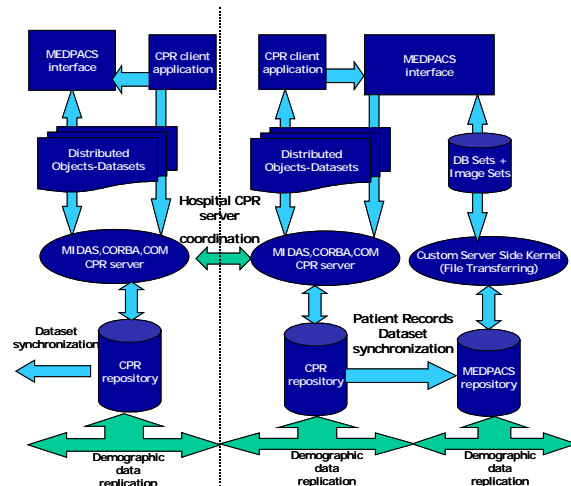Fig. 3. Architecture of the authentication server

Fig. 5. Distributed object architecture of the CPR servers

the capture and apply software modules are installed. At the master database only the capture module is installed. The capture module monitors the tables and records the changes. The apply module has a dual role: it pushes the changes back to the master database, when capture records change in a slave database, and it pulls the changes from the master database, when capture records change in the master database.

The attribute HID corresponds to the issuer of the patient's ID and is used by the CPR server in order to locate the medical record by contacting the appropriate remote CPR server as shown in Fig.5. Once the contact is initialized, parts of the medical record are fetched from the remote server to the client requested them.

MEDPACS is a medical management system that resides with every system installation, communicating with CPR server. It holds patient's images acquisitions into a separate repository, providing these image sets when requested by the client. Image association follows the DICOM Standard with patient entity in CPR repository. In order to facilitate the integration with MEDPACS, the CPR repositories share a subset of the demographic data. CPR client and security administration interface belong to the presentation layer of the system. It provides the management of patient's medical record along with the manipulation of user access lists.

CPR client application, at first, connects to the CPR authentication server redirected by the CPR server to establish user control access and then forwarded to the CPR server again, which is situated at the same hospital installation. Every user has a list of tools enabled and a list of possible actions that can be performed according to his security access profile.

III. DISCUSSION

Epirus-Net presents significant efforts in designing and implementing health telematic applications over a fixed wireless network infrastructure. Various reasons led to the selection of the specific network infrastructure such as the inadequacy of the existing telecommunication infrastructure in rural areas and its prohibitive cost (for both implementation and maintenance), the need for high bandwidth, independency and centralized management (without depending on third-party) as well as the flexibility of network expansion.

Backbone links are point to point. Several services need further improvement of the network to include local loops (point to multipoint connections). A local loop is under implementation for the area of Metsovo.

We have to emphasize the need for regional planning and political commitment in order to create a viable network infrastructure and services. Epirus-Net should address the issue of user acceptability to resolve potential legal issues, reduce capital and operational costs within the framework of providing quality healthcare services to all citizens.

Our final goal is to provide integrated telematic services and uniform access to networked information services. To meet this requirement, the described info and infrastructure architecture has been developed.

IV. CONCLUSION

Epirus-Net implements a regional healthcare information infrastructure to improve quality healthcare services and provides flexible and secure access to stored medical resources. For regional networks, wireless infrastructures present the only solution capable of ensuring the achievement of such objectives since it permits a low operational and installation cost and a flexible operation. The regional healthcare actors trust such systems. The developed services permit the integration of diverse system components through an incremental approach.

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