Medical Infobahn for Europe
A. Hasman et al. (Eds.)
IOS Press, 2000

Distributed Information System Architecture For Primary Health Care

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Abstract: We present a distributed architectural framework for Primary Health Care (PHC) Centres. Distribution is handled through the introduction of the Roaming Electronic Health Care Record (R-EHCR) and the use of local caching and incremental update of a global index. The proposed architecture is designed to accommodate a specific PHC workflow model. Finally, we discuss a pilot implementation in progress, which is based on CORBA and web-based user interfaces. However, the conceptual architecture is generic and open to other middleware approaches like the DHE or HL7.

Keywords: *Workflow management, Electronic health care record, Middleware, CORBA, WWW.*

1 Introduction

Health care, as well as the medical science in general, is a demanding information consumer. The beneficial impact of the introduction of core information technologies in health care is a natural consequence of this fact. Databases and information retrieval technology changed the way medical records are used in health care by providing on the spot and timely access to huge medical archives. However, most medical information systems currently in operation suffer from their centralised nature that fails to satisfy the distributed requirements of a regional or national health care system. This need to support distributed access to medical information is most important and essential in Primary Health Care (PHC) provisioning.

In this paper, we present a generic architecture that adopts the middleware approach and employs Intranet/Internet technologies in order to provide a distributed framework for efficient medical information systems within the PHC environment. We describe the key architectural principles and we discuss and evaluate implementation issues raised by our work in progress.

2 Motivation - Objectives

The main drive of the research work presented in this paper, emanated from the requirements analysis and the evaluation of results from various medical informatics projects that our group participated in. Our involvement in these R&D efforts made us realise the need for a distributed approach in PHC information systems. Further, the user requirements collected and the workflow model constructed within the ITHACA project (Telematics HC 1029) [2] provide an attractive starting point for developing such a distributed framework. The objective of this effort is to provide a generic architectural framework that will satisfy the following needs associated with distribution of medical information:

- Location-transparent access to the Electronic Health Care Record (EHCR) in a wide area scale.
- Secure data transfer and distributed access to the EHCR.
- Low response delays in accessing the record.
- Fault tolerant distribution scheme.
- Focus on primary health care.

3 Proposed Architecture

3.1 User requirements – Workflow model

The design process of the proposed architecture was influenced by the user requirements analysis and functional specification performed within the ITHACA project. This analysis considered medical professional and patient groups from ten PHC sites (nine in Europe and one in Canada) and produced a detailed workflow model through the application of a common user requirements functional model [4]. This model is presented in Figure 1 and describes the workflow and key functions within a PHC Centre (PHCC).

The main requirement that guided our design is derived from the distributed nature of the information that supports the PHC workflow. Consider the following scenario, which is typical in a regional or national PHC system that consists of multiple PHCCs: Patient "Jim" lives near PHCCn and his health record has been registered in its local health information system (Jim's EHCR is stored in PHCCn). During one of Jim's visits to another region, Jim has to visit PHCCm to treat an incident. In order to increase the efficiency of the diagnosis and treatment it is important to have on the spot and direct access to the remote EHCR of the patient.

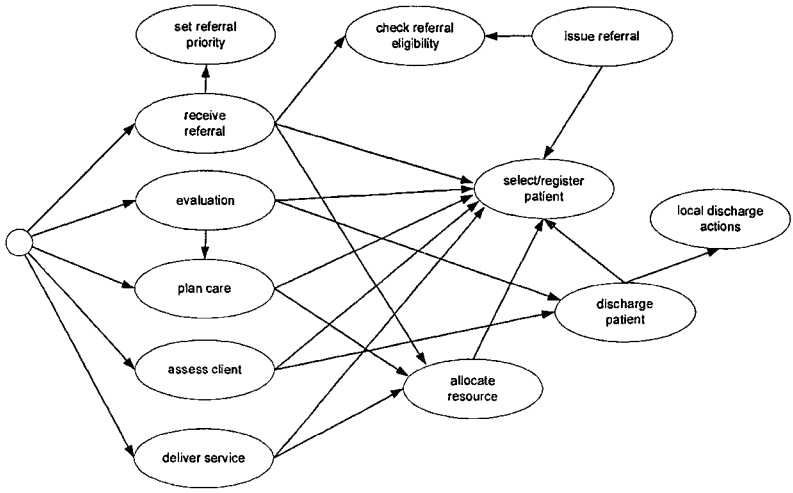

Figure 1: The Supported Workflow Model

3.2 Architecture outline

Figure 2 presents a conceptual outline of the proposed architecture. All PHCCs are equipped with local health information systems (HIS) which are interconnected via an IP-based WAN (Primary Health Care Intranet). Each site maintains a local database for storing and managing locally registered EHCRs. The key feature of the proposed distributed approach is introduced in the concept of the Roaming EHCR (R-EHCR): the EHCR migrates to the appropriate PHCC in order to follow the patient entries to the PHC system. Consequently, in addition to the local EHCR database, each HIS maintains a caching database for storing the R-EHCR images.

The Roaming Manager (RM) is an additional entity with the responsibility to maintain a global index of all the EHCRs. The location (specific local HIS) of any EHCR can be found through this index. A cached copy of the global index is maintained at the local HIS and it is incrementally updated from the global index (periodically or under specific conditions). Finally, the Certification Authority is another centralised entity within the PHC Intranet that is responsible for issuing certificates and ensuring the correctness and validity of keys, as described in [1].

According to the above framework, the scenario described in the previous paragraphs would proceed as follows: Jim has his record registered in the local HIS (PHCC#n). When Jim enters a remote site (PHCC#1), the remote HIS will identify the location of Jim's EHCR through the locally cached index and it will retrieve it directly into the local EHCR cache (R-EHCR) and the Roaming Manager will be notified that a copy of Jim's record is stored in PHCC#1. Then, Jim will enter the workflow described previously in the text with the local copy of his record. The cached R-EHCR will be deleted after a specific time period, unless Jim visits PHCC#1 within this period. If Jim persists in visiting the new site beyond a specific time period, the roaming record will change to the master record (R-EHCR permanently migrates to PHCC#1), the old master record will be deleted from PHCC#n and the Roaming Manager will be notified accordingly.

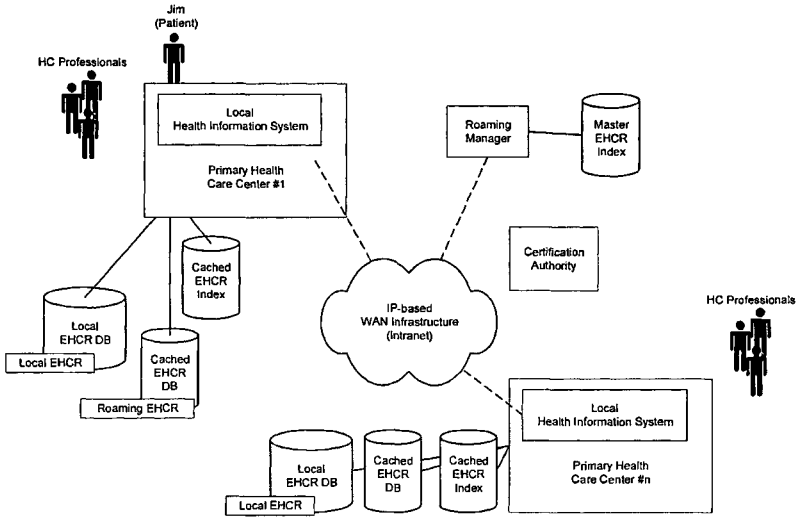

Figure 2: Conceptual Architecture Outline

Figure 3 presents an implementation of the proposed conceptual architecture based on the middleware approach (we selected CORBA for the pilot implementation) and web-based user interface (being implemented via Java Servlets).

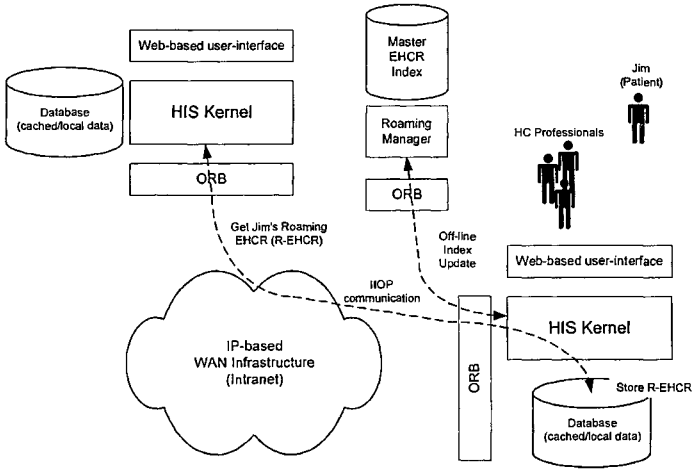

Figure 3: Proposed Implementation

According to this implementation every HIS needs to maintain a local database and it is equipped with a HIS Kernel module that implements the algorithm described in the previous paragraphs. This HIS architecture may prove too expensive to install and maintain in very small PHCCs (e.g. with two or three medical professionals). Figure 4 presents a solution for such PHCCs in the form of a "light" HIS implementation. This

approach exploits the web-based interface in order to implement the workflow using a remote EHCR.

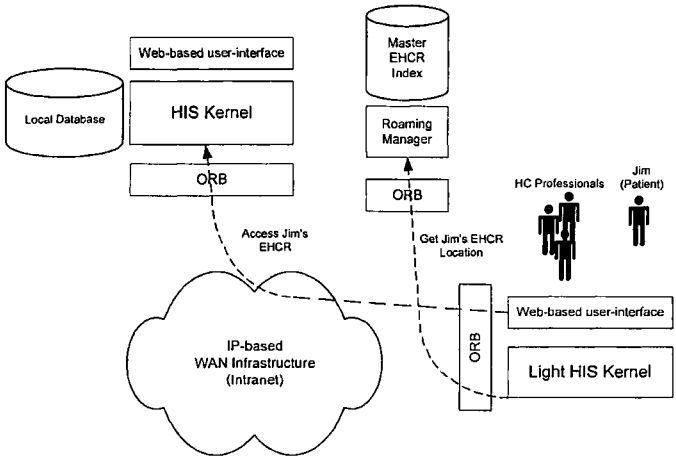

Figure 4: Proposed Implementation – "Light" HIS case

4 Synopsis - Future Work

We presented a proposed architectural framework for supporting PHC systems on a regional or national level and described the basic concepts based on the introduction of the roaming record (R-EHCR). We discussed a specific implementation that relies on the CORBA and web-based technologies, although the conceptual architecture is also open to other middleware approaches (like HL7 or DHE [4]). The proposed architecture is currently under development in the form of a pilot implementation aiming to evaluate the efficiency of our design. In parallel, we plan to validate the architecture and produce quantitative results via simulation experiments.

5 References

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