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# Proposal of an Architecture for the National Integration of Electronic Health Records: A Semi-Centralized Approach

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**Abstract.** This paper proposes a novel architecture for the national integration of Electronic Health Records (EHRs), the semi-centralized approach, in which summarized EHRs are maintained centrally at a nation-wide system with references to their comprehensive versions at their original locations on the various healthcare providers' databases. The idea is to allow the clinicians to have an idea of what is included inside the patient's EHRs at each healthcare provider's database and to have a general view of the patient's medical history, and when needed to retrieve the complete EHR of the patient from a remote healthcare providers' systems. A high level system architecture needed to integrate EHRs from various sources on a nation-wide basis using the proposed semi-centralized approach is described. Best practices and essential requirements are the central to the evolution of the approach taken.

**Keywords.** Semi-Centralized EHR; Distributed EHR; EHR-integration;

## Introduction

An Electronic health Record (EHR) represents observations of a patient taken by a particular healthcare provider. Each EHR normally has a unique identifier within the healthcare provider's database. The goal of EHR-integration system is to aggregate the EHRs concerning a particular patient on different healthcare providers to provide a complete medical history of the patient. This integration would enable clinicians to access complete medical histories of their patients in a standardized way.

Typical approaches for the national integration of EHRs are the *centralized architecture* and the *distributed architecture with reference links*. In this paper, a mixture between centralized and distributed approaches is used to introduce a semi-centralized approach which takes over the strengths of both models while minimizing their problems. In the semi-centralized approach, summarized EHRs are maintained centrally at a national healthcare system with references to their comprehensive versions at the distributed healthcare providers' databases. This solution has the advantages of fast access to summarized patient's medical history on the national healthcare system, with the possibility to retrieve a comprehensive EHR from a remote

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healthcare provider's system, and that it holds the up-to-date data on the patient's history of care.

## 1. Literature review

### *1.1. Centralized Architecture*

In this architecture, duplicates of EHRs are transmitted to a central nationwide system, which works as a repository of the all patient's EHRs across a country or a nation. This is referred to as a 'push' model, based on the concept of pushing the data from the healthcare providers to the central site [1]. The 'pushing' of medical data from the medical centers to the central repositories occurs periodically; for example, In Denmark, it happens every night. Examples of this approach are the e-health architectures in Canada [2], Australia [3], and Denmark [4].

Centralized control is the main advantage of this approach which may require fewer technical risks. Centralized maintenance of health records would be relatively easy from a technical viewpoint. However, the data on the central system may not be up-to-date and the creation of nationally accessible system that contains all patients' data would increase the risk of security breaks [5].

### *1.2. Distributed Architecture with Reference Links*

In this architecture, all information would be stored and maintained locally with the various healthcare providers and facilities. Centrally maintained reference links at a central healthcare system would indicate where the original data records are located. This is referred to as a 'pull' model, since the central agency requests all the data needed from the providers whenever a request for a patient's EHRs is issued. Note that the pull model does not involve a central repository, since data may only be requested when needed by a requesting user [1]. This approach is adopted by Netherlands [6].

This architecture has a unique advantage of data consistency and that it accesses the latest information about the patient as needed. Also, this approach helps assure protection of patient information and addresses concerns about threats to privacy and security, because patient information remains at the source rather than being duplicated in a centralized database. However, queries to access patient's data on remote healthcare providers may take a long time to complete. It places additional overhead burdens on the communication network and the source systems being accessed, thus access delays are likely to be unacceptable [1].

## 2. High Level Architecture of the Proposed System

The proposed system assumes that summarized EHRs of patients are saved at a nation-wide central system, the National Healthcare Center (NHC) that is built around a country and keeps summarized EHRs for all people in that country. The NHC also provides access to comprehensive versions of these summarized EHRs from the distributed healthcare providers, the Healthcare Centers (HC).

The eventual network for EHR transactions between the NHC and the distributed HCs is proposed to be conducted over a secure, private wide area network where each HC is connected to the NHC through a direct line connection as shown in Figure 1.Although such a connection may cost more than having the connection carried out over the World Wide Web, it provides a the required degree of security, privacy, and peed of delivery of the medical data.

Currently, HCs have widely differing information systems, which have been written in different application languages, and store the data in different structures and in different database models. This results in a severe interoperability problem that impedes the communicating of patient's data from one HC to another. Therefore, a small system called Health Information System Broker (HISB) is proposed to be built at each HC to control the communication of patient's data from local database at the HC to the NHC. It is connected to the Healthcare center's database and acts as a means through which local patient data is prepared, and submitted to the national healthcare center. HISB must be designed specifically for each HC's database to be able to deal with its specific data structures, formats and terminologies.

The NHC presents all the system's services to the end users and coordinates all the system processes. Clinicians in different HCs can access all the system's services through the WAN connection which is secure, fast, and private. Also, to provide clinicians a means to access essential system services from outside their HCs or while they are in mobility (for example: in emergency cases), and to provide patients an access to their medical data on the NHC, the NHC provides a web portal that is accessible through the World Wide Web (WWW) which provides access to the basic services needed by both clinicians and patients.

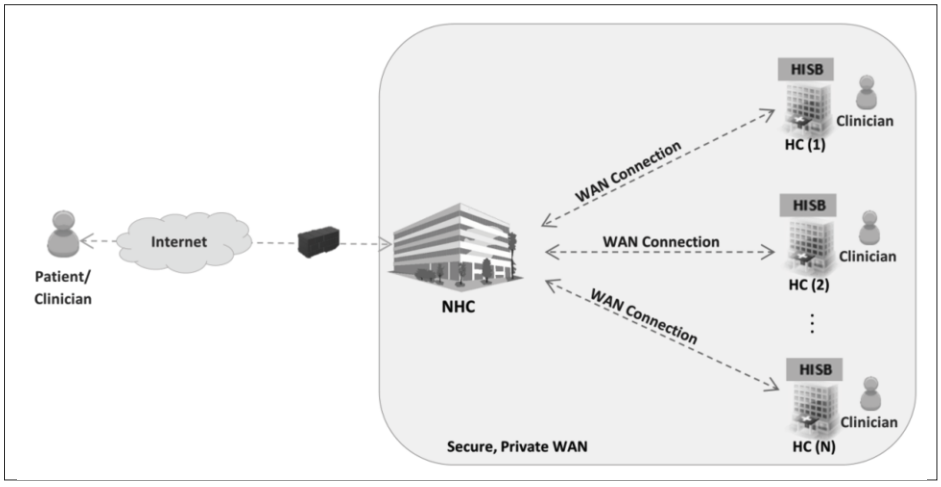


**Figure 1.**The high level architecture of the proposed system

## 3. Components of the Proposed System

The system is composed of five main components as shown in Figure 2. It is based on a three-tier design which has been proven to be an effective approach to the development of robust and easy maintainable systems.

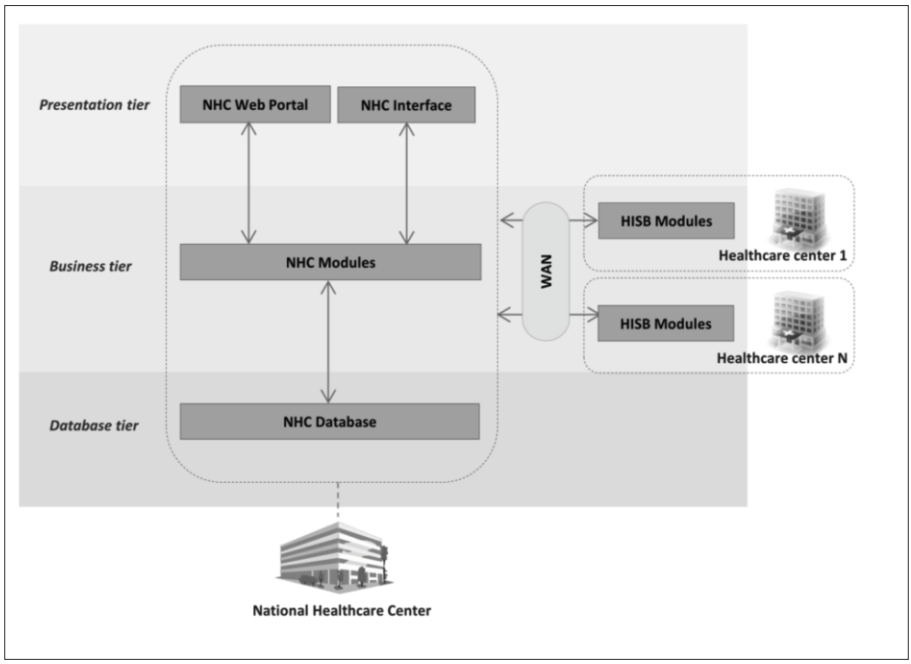


**Figure 2.**The components of the proposed system

### *3.1. The National Healthcare Center Database (NHC database)*

The NHC database stores all the patients' summarized EHRs as well as references to their original comprehensive versions on the original HCs. The EHR summary contains only an indication of the contents of the original EHR (for example: health problems summary, medications summary, and the names of tests taken). The NHC database also holds information on: patients, clinicians, HCs, clinicians' logs and other data required to control the privacy of patient's data.

### *3.2. The National Healthcare Center Modules (NHC Modules)*

The NHC is the major component that contains the main system modules. It manages access to the summarized medical data stored locally in the NHC database, and provides access to the comprehensive medical data stored remotely at the HCs.

### *3.3. The Health Information System Broker Modules (HISB Modules)*

The main roles of HISB modules are: 1) to submit a summary of any new patient data (including: new patient records, encounters and tests) to the NHC database on time without human intervention, and 2) To submit a standardized copy of complete patient record or encounter details from the HC's local database to the NHC server as a result of a user request on the NHC server. This ensures data interoperability and consistency and eliminates the need for human intervention in the transmission of patient's data from the HC to the NHC.

### *3.4. The National Healthcare Center Interface (NHC Interface)*

The NHC Interface handles identification and authentication and presents the system services to the clinicians through the WAN connection.

### *3.5. The National Healthcare Center Web Portal (NHC Web Portal)*

The NHC Web portal handles identification and authentication and presents the system services to the patients and clinicians through the Internet connection. For security, and efficiency purposes, the services of the system that involve communication with HISB cannot be implemented over the NHC Web portal. Such services are provided for clinicians through the NHC Interface only, i.e., through the WAN connection.

## 4. Conclusion

The centralized architecture for the national integration of EHRs has the features of performance, speed of query response, simplicity, maintainability, mobility and availability. The distributed architecture with reference links has the features of consistency, security and privacy. The semi-centralized architecture proposed in this paper provides an effective framework for achieving interoperability, consistency, security, privacy, mobility, maintainability, fast query response, centralized control of services, and accessibility for both patients and clinicians. This solution would presumably provide the simplest and the most effective option to maintain electronic health records on a nation-wide basis. Future work will focus on the challenge of matching patient multiple IDs at different healthcare providers.

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