

Integrated Teleconsultation Services in Cardiology

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Abstract

Integrated regional networks provide an infrastructure for the deployment of accountable, accessible, and secure teleconsultation services. In addition, the use of clinical protocols, combined with the automated retrieval of relevant health data, can improve the effectiveness and efficiency of teleconsultation sessions. In the context of HYGEIAnet, the regional health telematics network of Crete, integrated teleconsultation services based on clinical protocols are being developed to support the remote screening of patients with suspected heart problems, aiming not only to benefit the patient but also to contribute to the optimum use of healthcare resources.

1. Introduction

Integrated teleconsultation services in HYGEIAnet use middleware services of the regional healthcare information infrastructure for healthcare resource information as well as user authorization and security. The teleconsultation architecture is based on WebOnCOLL, a web-based collaboration infrastructure that manages Teleconsultation Folders (TCFs) as shared workspaces. Each teleconsultation session is associated with a TCF that includes relevant medical multimedia documents, such as reports, digitized x-rays, biosignals, ECGs, progress notes, etc. In a synchronous teleconsultation that involves video conferencing, the TCF maintains not only the teleconsultation records but also the activity logs. Medical data in the TCF adhere to relevant standards: DICOM for medical images, SCP for resting ECG signals, XML for medical reports, ICD9/10 for terminology etc. Furthermore, each item in the TCF is digitally signed by its author or originating health record system. The use of XML combined with terminology standards promotes reuse and standardization, while facilitating efficient search of archived teleconsultation records. It is through clinical protocols and guidelines that teleconsultation documents are customized to the suspected medical problem, eliminating the need for extensive data entry.

As shown in Figure 1, shared TCFs also contribute to continuity of care and collaboration between the healthcare actors involved in cardiac emergencies. For example, consider an episode of acute myocardial infarction (AMI) diagnosed in a remote healthcare center

where the patient is treated with thrombolytic medication under telematic support from a regional telecardiology center. During the transfer of the patient to the nearest intensive care unit, the health emergency coordination center reviews data in the TCF and possibly adds a progress note. When the patient is admitted to the intensive care unit, the TCF provides an overview of the episode. Finally, after the episode is closed, the TCF becomes part of the patient's medical history. Actually, this represents an important requirement in HYGEIAnet, since TCFs should cooperate with clinical information systems (CIS) for the creation of the patient's Integrated-Electronic Healthcare Record (I-EHR).

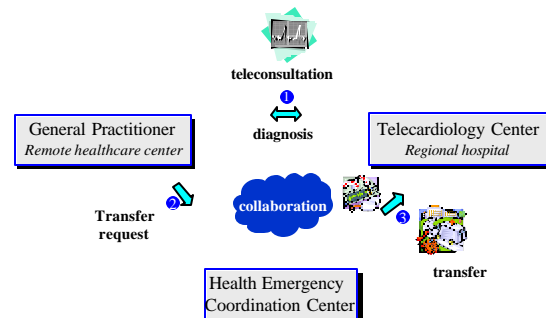


Figure 1: Teleconsultation folders facilitate collaboration of the healthcare actors involved in a cardiac emergency such AMI.

Based on this architecture, a teleconsultation protocol for suspected AMI has been deployed between primary healthcare facilities and a regional hospital [1]. The application has been well received by doctors and administrators, and there is strong evidence that in the long term it will not only benefit the patient but will also contribute to the optimum use of healthcare resources.

Section 2 discusses the teleconsultation architecture; section 3 presents the teleconsultation protocol for AMI; then, section 4 discusses integration issues relevant to the automatic extraction of clinical data from the health record in the context of submitting a request. Finally, section 5 presents our conclusions.

2. Teleconsultation architecture

The objective of the teleconsultation architecture is to

provide secure and accountable teleconsultation services. The arrival of a new request in the reception of the teleconsultation center triggers the creation of the TCF and the notification of a specialized cardiologist. The requesting General Practitioner (GP) may collaborate with the medical expert by placing additional multimedia medical documents, such as progress notes, questions, and examination results, in the TCF. In response, the medical expert may add a consultation report or request additional data. Thus, the teleconsultation architecture should handle incoming teleconsultation requests promptly, locate an appropriate medical specialist, mediate active collaboration, and archive TCFs when the teleconsultation is completed. Furthermore it should provide access upon authorization to archived TCFs.

The architecture of the teleconsultation center is based on WebOnCOLL [2], a web-based collaboration platform. WebOnCOLL implements collections of heterogeneous objects as shared workspaces, offering notification on content updates as well as user awareness services. Thus, agents (human users or applications) connected to a workspace are notified of changes in the contents of the workspace and are aware of all other agents connected to the same workspace. WebOnCOLL uses a regional directory service to authenticate users and retrieve user certificates [3].

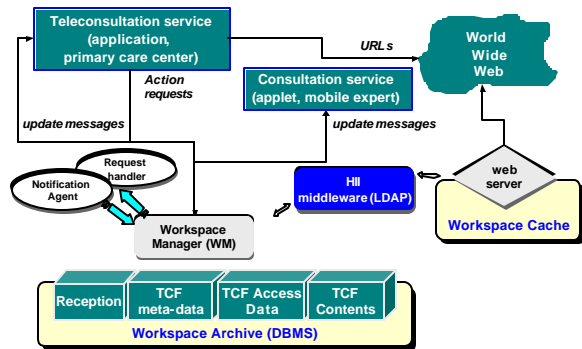


Figure 2: Specialized workspaces and software agents extend the collaboration infrastructure of WebOnCOLL to support teleconsultation.

The basic components of WebOnCOLL shown in Figure 2 are a dedicated *web server*, the *workspace manager*, and the *workspace archive*. The web server enables secure authorized http access to the contents of activated workspaces. Activated workspaces are workspaces with one or more active connections. When the last connection to a workspace is terminated the workspace data is removed from the web server.

The workspace manager is an application server that mediates collaborative access to shared workspaces, providing notification and awareness services to connected agents. The workspace archive maintains the

list of available workspaces (*workspace meta-data*), their contents, as well as access data associated with recent connections. A workspace may be *active*, in which case its contents may be changed, or *archived*, in which case read-only action is allowed. In any case, the workspace manager maintains a detailed log of the interaction with the workspace. In addition, it maintains a list of users and agents authorized to interact with the workspaces. The current version of the workspace manager is an application server written in standard Java. WebOnCOLL clients connect to the workspace manager through the workspace API. The workspace API includes calls through which the agents may login and interact with various workspaces. In addition, through the workspace API an agent may register to receive messages about other connected users and updates of contents.

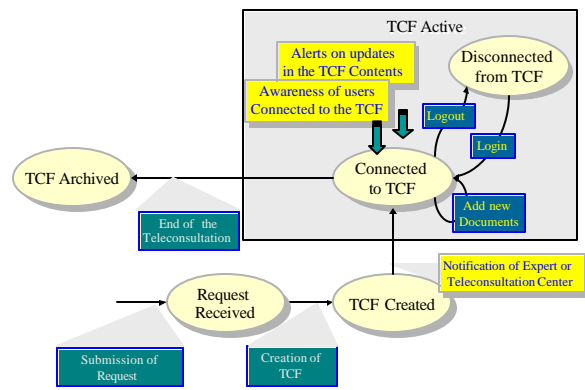


Figure 3: Workflow of a typical teleconsultation episode.

The design of the teleconsultation center has introduced a number of specialized WebOnCOLL components. These are customized workspaces and software agents. The *reception* shown in Figure 2 is a special workspace, which includes information on recent teleconsultation sessions. When a request for teleconsultation is submitted a new session object is created in the reception. This object includes the initial request as well as up-to-date information on the status of the teleconsultation. At any point in time, there are potentially multiple *active TCFs*, i.e. shared workspaces associated with active teleconsultation episodes.

The *request handler* is a software agent that handles incoming requests. Upon arrival of a new teleconsultation request, the reception handler validates the authenticity of the request, verifying its signature. Validation of the signature involves communication with the regional user directory service. The directory service provides the public key of the medical professional that allegedly signed the request. If the request is valid, the reception agent creates a new TCF with the medical data included in the request. Then, it updates the teleconsultation session object in the reception with the URI of the TCF

and changes its state, to inform the primary healthcare center that the request has been received and processed.

When the TCF is created, a specialized cardiologist on call is immediately notified. If another authorized cardiologist is explicitly requested, the *notification agent* takes into account the cardiologist's personal profile and the urgency of the request to select the most appropriate notification method. Notification is synchronous, using an audio signal transmitted through a personal computer, beeper, or mobile phone. When the medical expert responds to the request and connects to the associated TCF, the state of the session object in the reception changes to indicate that the TCF is active. A teleconsultation episode closes when the requesting GP inserts an outcome report. This typically occurs after the cardiologist has submitted a final consultation; the patient is transferred or discharged. The workflow of a typical teleconsultation session appears in Figure 3.

3. Teleconsultation protocols

Teleconsultation protocols including guidelines have been proposed in the literature [4-6], while clinical protocols and guidelines are common in various medical disciplines. The efficiency and effectiveness of teleconsultation services could benefit greatly from the incorporation of clinical protocols into teleconsultation guidelines.

Clinical protocols and guidelines include a great deal of information on the health data necessary to assess and treat a medical condition. If such information is incorporated in document templates customized for particular suspected medical problems, the overall efficiency of the teleconsultation will improve. Recently, XML technology has been applied successfully in this domain [7-10]. XML documents carry semantic content and stylesheets provide for flexible presentation [7].

On the other hand, this document-based approach requires extensive analysis and frequent revisions of the document templates. Furthermore, it requires robust document management to allow reuse, extensibility, and interoperability. For each suspected problem a set of documents are designed. Besides medical documents, the recording and viewing of ECGs is required in most cases. In some cases, additional examinations from radiology or cardiology are also required.

3.1. Acute myocardial infarction

In the case of suspected AMI, a working group of specialized cardiologists and GPs was formed to do the requirement analysis, model the exchange of information, and design the medical documents. For the specific teleconsultation problem, the requirements analysis showed that there was need for six document templates: the request, old ECGs, follow-up ECG, consultation, progress note, and outcome. For each form, an XML

DTD has been defined to specify a document template. The main goal of this process, which took several iterations and is still under revision, was to minimize data entry.

The teleconsultation request form consists of request-related administrative data, patient demographics, parts of the patient's medical history, clinical data such as pressure, laboratory data, comments of GP, and counter-indications for thrombolysis. The consultation forms include sample diagnoses and treatment plans for AMI. In the long run, reuse and refinement of these documents will lead to a rich knowledge infrastructure that will reduce the time required to support additional suspected medical problems.

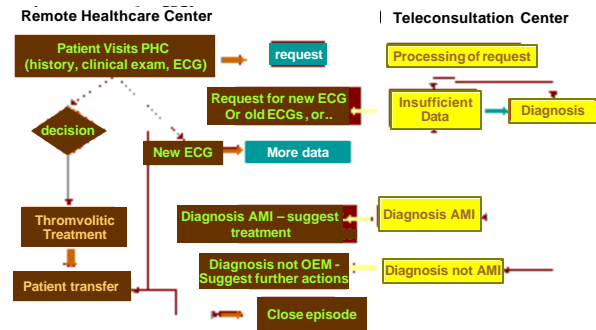


Figure 4: Part of the teleconsultation protocol for myocardial infarction

Part of the resulting teleconsultation protocol for suspected AMI appears in Figure 4. It is worth noting that the information included in the request form for suspected AMI is expected to be sufficient to assess the medical problem in 90% of cases. When a patient's presenting symptoms raise the suspicion of AMI, the GP in the primary healthcare center records the medical history of the patient in the health record, conducts a clinical examination, and records a resting ECG. If the GP would like a second interpretation of the ECG, an urgent teleconsultation with a specialized cardiologist may be requested. A request form that includes the recent clinical findings and the ECG is constructed, reviewed, and signed. The request is forwarded to the teleconsultation center and a cardiologist is notified. The cardiologist reviews the data in the TCF and provides an initial consultation. If the request data do not suffice to reach a diagnosis, additional data may be requested, such as a follow-up ECG after a specified period of time, or old ECGs of the same patient if available. Alternatively, if AMI is diagnosed, a recommendation that includes a prescription for thrombolysis may be returned. During the teleconsultation session, the doctors may engage in video or telephone conference. If the patient is given thrombolytic therapy, the cardiologist may request tele-monitoring of the patient so as to be alert for possible arrhythmias. In any case, the teleconsultation case is

closed once the patient is transferred to the ICU.

4. Integration issues

The term ‘integrated teleconsultation services’ mainly refers to interoperability of the teleconsultation with the health record system. At the level of the health care organization this applies to the local health record system, while on a regional scale it refers to the I-EHR.

A teleconsultation request may be completed interactively or semi-automatically. In the first case, the GP uses the teleconsultation application as standalone. The GP selects the suspected problem, records a resting ECG, fills out patient demographics and relevant health data, and submits the teleconsultation request to the teleconsultation center, all within the teleconsultation application. Alternatively, the GP may request teleconsultation from the environment of the health record. In this case, by selecting the suspected medical problem, relevant data are extracted from the current visit record of the patient to create the teleconsultation request form. The GP needs to fill out additional data that might not be present in the health record, review and sign the request.

Figure 5 shows the integration architecture that allows the automatic extraction of relevant data from the health record system. The retrieval of relevant data from the health record involves the processing of XML schema templates and the use of XML namespaces customised to the database schema of the health record system [12,14]. In addition, XSL and CSS stylesheets [13] are used to reflect the originating primary healthcare center.

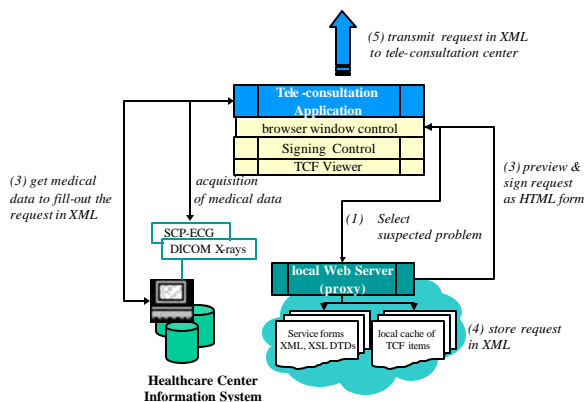


Figure 5: The integration architecture allows the extraction of data relevant to the suspected problem from the health record of the patient at the primary healthcare center.

5. Conclusions

The gradual acceptance of teleconsultation as part of the daily healthcare routine, combined with the creation

of the I-EHR at a regional level as a distributed collection of medical record segments, demands robust interoperability solutions. Terminology and communication standards, together with web technologies and XML, provide an elegant solution to interoperability problems and facilitate continuity of care.

Acknowledgements

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