HINT project: a BPM teleconsultation and telemonitoring platform

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ABSTRACT

This paper describes a novel approach for teleconsultation and telemonitoring in healthcare domain. Teleconsulting for diagnostic images involves much more than merely transmitting images and information between two points called hub and spoke. It needs to accomplish a lot of tasks, among them: rapid access to radiological reports and second opinions, remote consulting among Physicians, improved patient care, access to complex tools for post processing and computer-aided diagnosis, support for research and training projects, ties between isolated healthcare providers and busier or more experienced providers, 24-h coverage.

The HINT project provides a real-time monitoring of the patient's clinical data and alerting in case of emergencies. The application is fully integrated with all IHE compliant RIS and PACS systems. The workflow management system, integrated in the platform, permits to manage a multiplicity of different scenarios in one application, allowing fast prototyping, process changing and reuse of subprocesses.

KEYWORDS

Teleconsultation, Telemonitoring, Business Process Management, HINT, Workflow management system

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1 INTRODUCTION

The American Telemedicine Association defines telemedicine as "the use of medical information exchanged from one site to another via electronic communications for the health and education of the patient or healthcare provider and for the purpose of patient care" (American Telemedicine Association, 2013).

The outcomes of telemedicine could be: accessibility to health-care in rural areas or developing countries; h24 diagnosis, also known as night-hawking; efficiency in delivery of care like tele-stroke scenario; cost savings; enhance collaboration between spe-cialists; lack of specialist [1].

There are two modes to provide a telemedicine service: synchro-nous or asynchronous. In the former case, the service establish an audio/video connection between the parties; in the latter, also known as store-and-forward, clinical data are stored and later trans-mitted to other participants.

Originally, since 1895 when Wilhelm Roentgen discovered X-ray radiation until 1980s when there were developed the first digital detectors, images were acquired and viewed on sheets of film that were placed on a light box for viewing and interpretation. In these years, the consultation can be done only using the physical medium.

Even if the first transmission of radiographic images dates back to 1947, modern telemedicine had its origins with the advent of the digital diagnostic images. In the subsequent years, Digital Imag-ing and Communications in Medicine (DICOM) was developed. DICOM is an internationally accepted standard for medical im-ages and metadata and deals with handling, storing, printing and transmitting images and medical metadata. Among the modality available for radiology we can cite:

- Radiography;
- Mammography;
- Computed Axial Tomography (CAT or CT);
- Magnetic resonance imaging (MRI);
- Ultrasound (US);
- Nuclear medicine (NM), SPECT or PET;

In this context, teleconsultation is now a routine part of the hospital procedures. An European survey [27] estimates that 65% of all radiologist currently use teleradiology, in particular for in-house image distribution and on-call readings from home. A similar survey conducted in the U.S. [18] estimates that over the 50% of American hospital use teleradiology for out of hours reporting.

Typically, every healthcare organization has a component in its information system called Picture Archiving and Communication System (PACS) that manages the various digital imaging informa-tion modalities. A well structured PACS include an acquisition imaging system and a secure network connecting the acquisition modalities captured through the radiology workstations (that can be on-site or off-site) with a centralized or a cloud based archive. The DICOM standard facilitates the interoperability of various de-vices in acquisition, transmission and saving phases. The Radiology

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Information System (RIS) is the part of the Hospital Information System (HIS) devoted to manage image workflows, diagnostic images, data, billing information and other general records. The diagnostic reports are sometimes inserted in the RIS domain and other times attached to the Electronic Medical Record (EMR) or the Electronic Health Record (EHR) of the patient that is stored in the HIS.

HL7 is an organization whose members are responsible for the standardisation of the exchange of electronic health informations. HL7 is responsible to define the interfaces used to exchange, inte-grate, share and retrieve EMR and other medical information. The focus of HL7 is on data communication and not on data storage. HL7 have defined in the past years a sequence of very popular standards as HL7 v2, v3 and the newest FHIR that use real-time RESTful interfaces.

IHE is a consortium of professionals and industries that have the goal to promote the adoption of international standards such as DICOM or HL7. IHE maintains a list of domains such as radiol-ogy, cardiology, Pharmacy, patient care, IT Infrastructure. In this context, it's worth noting to cite the Cross Enterprise Basic eRefer-ral Workflow Definition Profile (XBER-WD) that standardise the management of the workflow related to the eReferral. XBER-WD is based on a document type called Cross-Enterprise Document Workflow (XDW) in which are stored the tasks completed in the workflow, the inputs and the outputs of each task. The exchange of documents between organization can be done through Cross-Enterprise Document Sharing (XDS) repositories.

On the regulatory point of view, there is no specific EU law that regulates teleradiology or telemedicine. The teleconsultation borrows the existing laws in terms of healthcare, subcontracting, ionizing radiations and information technology infrastructure. In this context, any practice, intramural or extramural, that respect all the patient's right, guarantee the basic quality standards, ensure the identification and authorization of the involved actors, guarantee the traceability of the phases of the process and inform the patient, is legal. In particular, any teleradiology process fully consumed in the context of the same organization or company can be considered intramural and there is no difference with the general obligations applied to traditional radiology. On the other hand, if one or more tasks of the process are demanded to or subcontracted to another institution, i.e. we are talking about extramural teleconsultation, the General Data Protection Regulation (GDPR) imposes to sign a third party data access agreement between the Data Controller and the Data Processor.

2 LITERATURE REVIEW

Teleradiology is implemented all around the world to address four main types of issues:

- After hour coverage using intramural services (at-home re-view)
- After hour coverage using extramural services
- Regional or rural hospital coverage
- Second opinion made by a sub-specialist

A survey [27] states that 44% of the European radiologists use at home review as alternative to on call referral. In many cases this modality doesn't include a structured hub and spoke architecture, but only the transmission of the diagnostic image to the radiologist that reports the referral to the referring doctor by phone or email (79% of the cases). The referring doctor is responsible to insert the referral document into the RIS. The case studies presented in [6] use business patterns to model collaborative processes in the public administration sector, which can be easily adopted in healthcare. Collaborative processes can be modelled using Human Process Management tools like the one described in [2] that allows knowledge users to examine the progress of the processes, the activities to be completed and the flow of communication.

Other hospitals, especially in the U.S., use the intramural or extramural teleconsultation to manage out-of-hour reporting. It's more appropriate in these cases to arrange a complete hub and spoke architecture that manages the entire process lifecycle. It's worth noting to cite the Kaiser Permanente hospital [14] that, during the out-of-hours, use only 2 radiologists to perform reporting for 11 different image acquisition sites, in place of having a dedicated radiologist for each hospital that is called when needed.

In the U.S., it is estimated that out-of-hours reporting or night-hawking is used by over than 50% of the hospitals [18]. It is possible to take advantage of the different time zones using extramural services located in daytime areas. For example in [11] radiologists from Sydney are used by an hospital located in Uppsala for emer-gency reporting, while in [16] an hospital in the U.S. calls Indian radiologists.

[21] reports back that radiological delays are shorter when tel-eradiology is used.

A well integrated hub and spoke architecture is necessary to provide to the external radiologist a complete context regarding the patient, including prior images, pathology review or patient's medical record. It is estimated that only 26% of the radiologist have access to the Electronic patient Record (EPR) and only 16% use dedicated teleradiology platform.

In the recent years, radiology is becoming more specialized. Many studies [10][30] report back the improvement associated to make a sub-specialist report in comparison to a general one. In this context, teleradiology can be used to access well trained radiologist in a given domain.

[23] states that fast wireless network and mobile technologies permit to evaluate diagnostic images with an accuracy comparable to PACS workstations. [17] design and develop a low cost web based platform for the referral of diagnostic images using web based technologies. Many PACS vendors offer similar features to their latest products. We refer the reader to [29] for a complete history of the applications in the field of teleradiology

It is possible to define home telemonitoring as an automated process that permits the transmission of data on the patient's health status from home to the respective health care setting. A survey [26] conducted on 65 studies in the field of telemonitoring for pulmonary, diabetes, hypertension and cardiovascular diseases reports back the maturity and reliability of remote monitoring technologies. In particular, in every study, the data were consistently reported to health care institutions. Telemonitoring has demonstrated the ability to identify early changes in patient conditions obtaining immediate intervention and avoiding complications. In diabetic patients, a decline in haemoglobin A1c and significant blood glucose have been reported by [7]. In patients affected by hypertension, [20] reports back a reduction of systolic and diastolic blood pressure.

All the studies report a high level of acceptance and satisfaction of telemonitoring processes [3][22][19].

Telemonitoring is associated with a significant decrease of hos-pital admissions for pulmonary and heart diseases [28][19].

Another important application field of telemonitoring is the control of elderly people [24].

We refer the reader to [12] for a complete review on telemedicine, including: telecardiology, telestroke, teleradiology, teleoncology, teledermatology, teleaudiology, telepathology and telemonitoring.

To the best of our knowledge and despite the large amount of scientific papers on this subject, no contribution were proposed in the last 20 years on business process management in telehealth, except for [15] that described two telemedicine processes, using Business Process Modelling Notation (BPMN) 2.0 process and their execution through the workflow management system Activity.

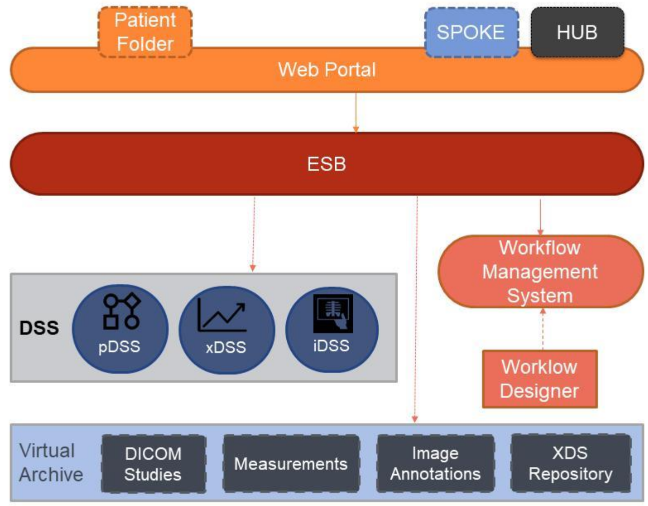
3 THE HINT PROJECT

The project aims at meeting the requirements for the implementa-tion of a network for clinical support both in cases requiring high specialization and covering areas with no specific skills. The project therefore provides the creation of a platform for the management of all the cases in which access to diagnostic images is provided, with the possibility of applying specific clinical skills even when physically not present in the site of images production. A distinctive feature of the project is the realization of technological solutions to optimize communication within the standardized processes im-plemented by teams of experts involved in a diagnostic case. The research activity also focuses on the definition of tools to improve the health information management and clinical data collection. Considerable innovations are now being pursued in systems to support clinical decisions based on the analysis of images achiev-ing individual objectives: improving the efficiency of the clinical workflow, the appropriateness of care and supporting the doctor in the decision-making process. The project aims at achieving a multi-target approach by integrating support to the Physician with the suggestion of diagnostic paths, based on a computational archi-tecture capable of handling large data sets and algorithms for deep learning and process mining. The potential benefits for end users are indicated below: for General Practitioners (GPs), a support in identifying the most suitable diagnostic process for the patient; for emergency/urgency interventions, guidance of the Specialist Consultant (SP) and preparation of the hospital; for public/private healthcare facilities, effective coverage of the largest number of clinical cases and homogeneity of the service offered through an enabling platform offering advanced services; for Specialist Physi-cians, extension of the catchment area and support in the diagnostic investigation through a platform offering advanced services; for pa-tients, availability of a greater number of specialist services within the process of hospital-territory care.

3.1 The HINT architecture

The project aims at developing a cloud platform with Hub and Spoke architecture for telemedicine based on imaging that supports international standards (DICOM, HL7, IHE, etc.) for the integra-tion of health data, processes and diagnostic images. In the cloud infrastructure, core components were developed, such as:

Figure 1: HINT project architecture



- User Interface Component: portal for the authentication of the actors, publishing data services and components for user interface design;
- Decision Support System (DSS): feature extraction, image classification and diagnostic support through a convolutional neural network (iDSS); analysis of diagnostic logs aimed at identifying diagnostic process models (pDSS); monitoring physiological data and reporting alerts (xDSS);
- Business Components including
  - Workflow Management System: system for defining mod-els and rules for diagnostic, telemedicine processes and models for the execution and workflows analysis;
  - Teleconsultation: components for the interaction between Hub and Spoke with the workflow engine through the Enterprise Service Bus (ESB);
- Integration Component: system for the interoperability of processes and the distribution and management of DICOM images;
- Virtual Archive: system for the anonymisation and secure storage of diagnostic images and clinical data.

Figure 1 shows the basic components of the platform which guarantee:

- user access to applications;
- the availability of record management services;
- access to integration services, which allow the conversion of messages into the standard formats used in the healthcare sector;
- standard access to storage services.

These components support the management of clinical cases by Physicians and healthcare professionals, allowing the authen-tication and authorization of the users, the management of the roles, the research and consultation of the patient lists, the visits management and the consultation of patient records, the opening of a clinical case, the data recording in the required formats and the starting and managing of predefined paths on diagnosis and treat-ment through the functionality of a Workflow Manager/Business Process Management System.

3.2 The BPM lifecycle

The business processes are “logically related tasks performed to achieve a defined business outcome” [8]. Business Process Manage-ment (BPM) is the set of methodologies and technologies which allow organizations to analyse, describe and optimize business processes. BPM can be defined as a structured approach based on methods, policies, implementations to define, continuously manage organization’s activities and processes in order to create an efficient and effective corporate business and maximize value for the cus-tomer [13]. BPM manages the life cycle of a process, starting from modelling to optimization so it can be seen as continuous cycle constituted by the following phases [9]:

- process analysis and modelling;
- process implementation;
- process execution;
- process monitoring.

In the first analysis phase, a business problem is posed and stud-ied, the relevant processes are identified and related to each other. The outcome of process identification is a new or updated process architecture that provides an overall view of the processes in an organization and their relationships. During the process modelling, the current state of the processes and the relative activities is de-signed and modelled through instruments and notations as BPMN, CMMN, DMN; subsequently, in the process implementation, the changes required to move from the as-is process to the to-be process are prepared and performed. Process implementation covers two aspects, organizational change management and process automa-tion. During the execution phase the process is run and tested. An amount of logs and measurements are collected in order to be used in the BPM lifecycle subsequent phase. Once the process is running, in the process monitoring and controlling phases, relevant data are collected and analysed in order to determine the performance of the process with respect to its Key Performance Indicators (KPI) and objectives.

In recent years some clinical organisations have started to use a technological approach based on Business Process Management (BPM) to achieve significant results and improvements in process management in the healthcare sector. In fact, when healthcare orga-nizations combine structured processes with their specific data and business rules, they obtain the ability to introduce operational visi-bility, support collaboration and strengthen governance structures. In turn, these features increase the quality and efficiency of the process and offer a better and more constant relationship with the patient. The use of Business Process Management (BPM) can help to support the implementation of medical practices by monitoring care processes, analysing and managing the clinical workflow and individual tasks. In this activity the analyst can be supported by a structured knowledge base for compliance with the company context [4][25]. Table 1 summarizes the phases concerning the life cycle of a telemedicine/teleconsulting process, and outlines the ac-tors involved (doctors, clinical specialists, developers, domain and process analysts), the clinical profiles and standards (i.e. IHE, HL7, DICOM), the notations for process modelling and rule management (i.e. BPMN,DMN) that can be used in the different BPM phases.

Starting from the analysis proposed by [5], the authors has deepen the knowledge on some open source BPMS (Business Pro-cess Management System) as Bonita, JBPM, Camunda and Activity. It was decided to use JBPM as workflow engine. The comparison be-tween the selected platforms was based on different requirements: conformance to the notation for process modeling (BPMN) and de-cision making (DMN), use of forms, management of different tasks (service task, human task, script task), variables management, per-sistence, API, security, use of connectors, role management, deploy alternatives, execution and monitoring phases.

3.3 The implemented telemedicine scenarios

Three clinical processes have been identified and implemented in the project:

(1) NeuroRadiological Teleconsultation;
(2) Dermatological Diagnostic Support;
(3) Telemonitoring (Night apnoea).

The following paragraphs analyse the above-mentioned scenar-ios and identify the actors, the different processes, the data and application components that have been implemented in the Test Bed.

3.3.1 NeuroRadiological teleconsultation process. The process (fig-ure 2) involves the interaction between two actors, the requesting Physician and the clinical specialist, through the use of their own information systems organized in Hub and Spoke. Specialized hos-pitals (Hubs) work in conjunction with the local hospital (Spoke), where only basic hospital functions are provided.

The process is based on three steps:

- Creation of a Referral Request;
- Consultation Scheduling;
- Clinical data checks and specialist evaluation.

The HINT portal manages the first phases with patient admis-sion and his first clinical visits (MRI, PET, CT, diagnostic tests). The Spoke application starts the standardization of the neuroRadiologi-cal teleconsultation process with the request for a second opinion control through the workflow engine. The requesting Physician en-ters the data concerning the teleconsulting request to the available Hub. The inserted data are: patient personal data, type of request (e.g. neurological control), clinical history (e.g. suspected stroke, trauma), the level of urgency (time within the teleconsultation is rescheduled to another organization), reference list of past clinical studies. The "Scheduling" task generates a list of organizations that can take charge of the execution of the teleconsultation. A deci-sion table based on rules (such as time-sheet, modality type) will generate an ordered list of possible organizations that can take in charge the referral activity. A loop subprocess is repeated until the referral has been completed by one of the available hubs. At each loop iteration the workflow engine sends a notification message to the corresponding Hub organization. If the hub organization takes in charge the teleconsultation request, i.e. it claims the activity the specialist makes the consulting and submits the reference of the file containing the report and the diagnosis in text format. If the hub organization does not take over the request in the time

Table 1: Standards associated to clinical BPM lifecycle phases.

BPM Lifecycle	Actors	Standards
Business process analysis / modelling	Business/Process Analyst Experts in clinical domain (health manager, specialists, general practitioners)	BPMN CMMN DMN
Business process implementation	Process Developer IT Developer	CDA HL7 DICOM DSUB (IHE) XBeR-WD (IHE) XDS, XDS-I (IHE)
Business process execution	Physician and specialist Users RIS/PACS systems DSS UWB devices	DICOM XDW (IHE) FHIR
Business process monitoring	Clinical Risk Manager Clinical Data Analyst	AUDIT LOG XDW(IHE)

interval defined by the urgency of the request, it is passed to the next organization. The Spoke application that started the process receives a notification of completed diagnosis.

3.3.2 Dermatological Teleconsultation process. The basic process is the one described in the neuroRadiological teleconsultation, with the Request for referral, its scheduling and the remote consulting and clinical evaluation by the specialist. In this scenario, through the platform, the patient data and related images are acquired in order to make evaluations through a neural network as well as to provide predictions and statistics that can be used in the consultation of the specialist in order to make a more accurate diagnosis. The process (figure 3) uses a decision support system based on the analysis of annotated training images acquired in past diagnostic processes of melanoma. The iDSS is based on features extraction and images classification. A Physician (on the Spoke side) can initiate a clinical consultation or update a previous one. When a specialist consultation is required, the clinical data of the patient are acquired and predictions can be requested. At the end of the consultation (on the Hub side), the specialist uses the five most similar clinical cases that are displayed by the iDSS. Finally, He can draw up the report that will be sent to the Physician that requested the consultation.

3.3.3 Telemonitoring process. This scenario describes the telemonitoring process, based on non-invasive Ultra Wide Band (UWB) technology, of a patient's heart rate and night apnoea in order to diagnose Obstructive Sleep Apnoea Syndrome (OSAS) and its possible following monitoring in the future. The process (figure 4) is initiated by a Physician, at a local clinic, who requires the system to perform a sleep monitoring to deepen the analysis of the patient. Once the request has been initiated, the system assigns the task to a more appropriate Spoke operator, who takes charge of the activity and supervises the process to its conclusion (the production of the report by the Specialist). When the diagnosis has been completed, the Specialist may then decide to carry out a subsequent phase of telemonitoring in order to report in real time, episodes of the patient's sleep apnoea (figure 5). The sleep telemonitoring service can be provided both in a public hospital, in a private structure adhering to the project, or at the patient's home. Moreover, at home, the service can be provided in Integrated Home Care (IHC) mode. The monitoring system essentially consists of a device based on UWB technology, able to acquire, in a non-invasive and contactless way, data relating to the heart and respiratory rate of a patient during sleep time. A tablet is used as a gateway, which takes the data recorded by the UWB device and forwards them to the system via cellular data network. In the first phase of the scenario, the pre-diagnosis monitoring, the data collected for a specified time interval (heart rate and breath rate time-series) are stored locally in the monitoring system and are identified as the standard (or reference) pattern associated with the patient. After the monitoring phase, the data are forwarded to the Spoke and made available to the patient. From here, the Physician who initiated the telemonitor-ing request, can retrieve the patient monitoring data and analyse the pattern path, in order to diagnose any OSAS and produce the related reports which will be recorded in the system. In case the patient is affected by OSAS, or the Physician wants to deepen the analysis of the patient, he can decide to set up a process of tele-monitoring in the medium or long term in order to monitor the evolution of the clinical picture over time. In this case, a monitoring process is started, in which the data collected in real time by the patient's UWB device, together with the standard pattern data col-lected during the pre-diagnosis monitoring, are provided as input to the xDSS of the platform. The xDSS processes each piece of data in real-time, comparing it with the standard pattern of the patient and promptly generating an alert message in the system if there is a deviation from the standard pattern, such as a night apnoea episode in progress. The alert can be viewed by the concerned operators.

4 CONCLUSIONS

The main goal of the HINT project is to go beyond the traditional modality of teleconsultation, providing a complete and optimized framework based on workflow management systems. After a brief introduction and literature review about telemedicine, the authors

Figure 2: Neuroradiological process

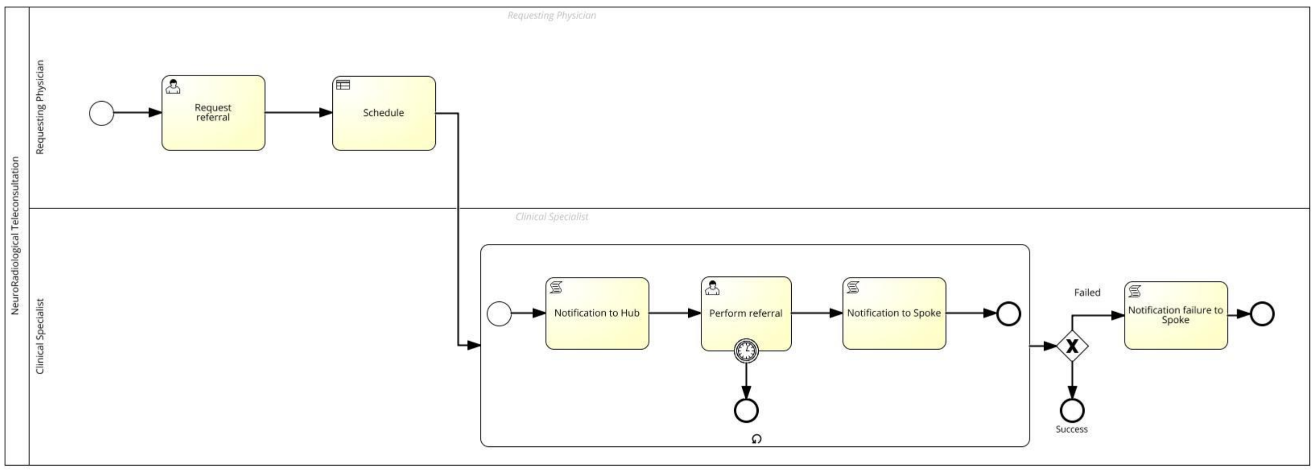
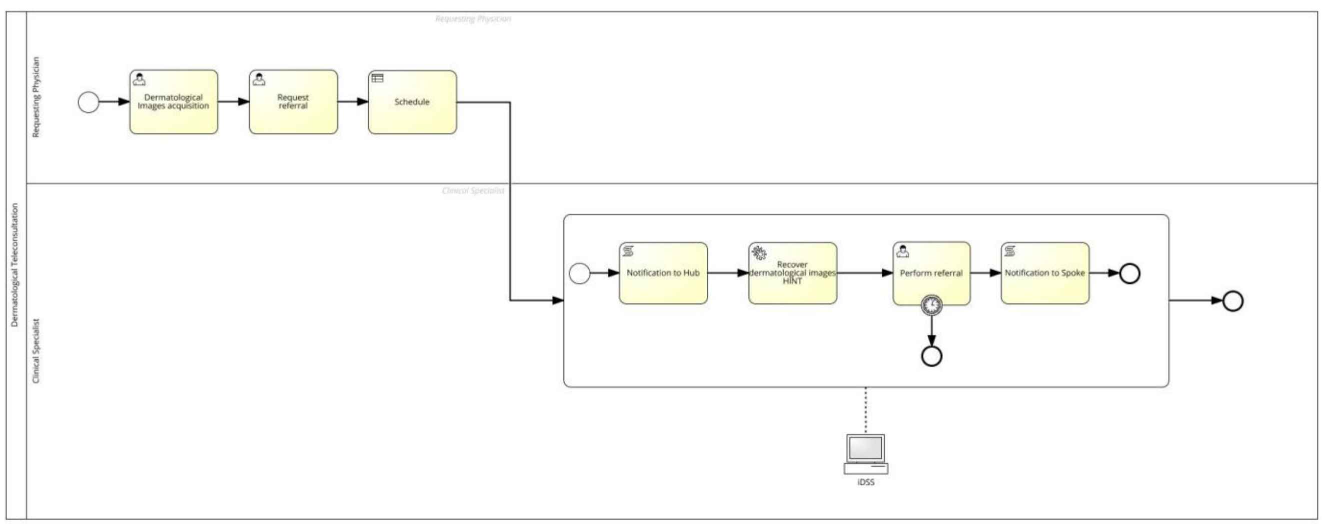


Figure 3: Dermatological process



focused on the description of the HINT project (architecture, BPM and scenarios). Three scenarios were described: neuroradiological teleconsultation, dermatological teleconsultation and telemonitor-ing for night apnoea.

In the neuroradiological teleconsultation the HINT platform sup-ports two components called Hub and Spoke to create a specialist referral of diagnostic images. In the dermatological teleconsulta-tion, a DSS, implemented through a deep learning algorithm, is used by the dermatologist in the referral phase with the purpose of reducing the error probability and early skin cancer detection. The telemonitoring for OSAS detection provides the remote collection and transmission of important clinical signals to be analysed by the DSS and the specialist aiming at early detection of the pathology.

In the context of specialistic diagnosis, telemedicine applications provide consulting and real-time monitoring of the patient con-ditions. It has been proved that telemedicine is associated with a significant decrease of hospital admissions for different categories of diseases and these practices are completely accepted by the pa-tients.

In the context of the HINT project, research institutes and soft-ware houses working in the healthcare business collaborate to cre-ate a flexible workflow centric teleconsultation and telemonitoring platform. The design of the platform has been completed and the architecture components are in the development phase. Afterwords, health organizations will be involved to test the application.

Figure 4: Telemonitoring process - scenario 1

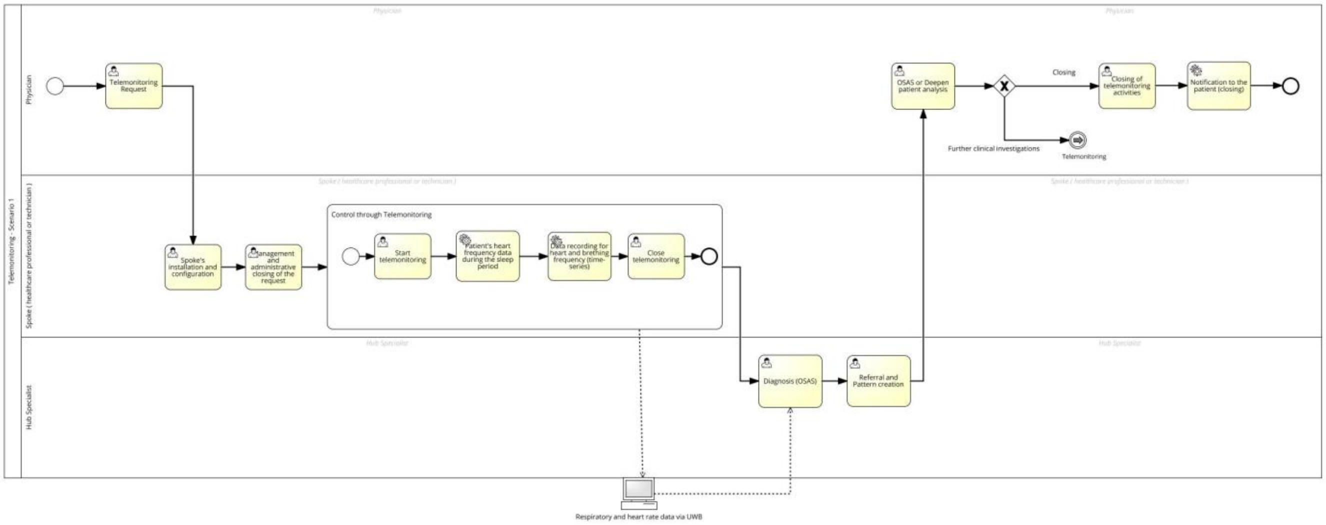
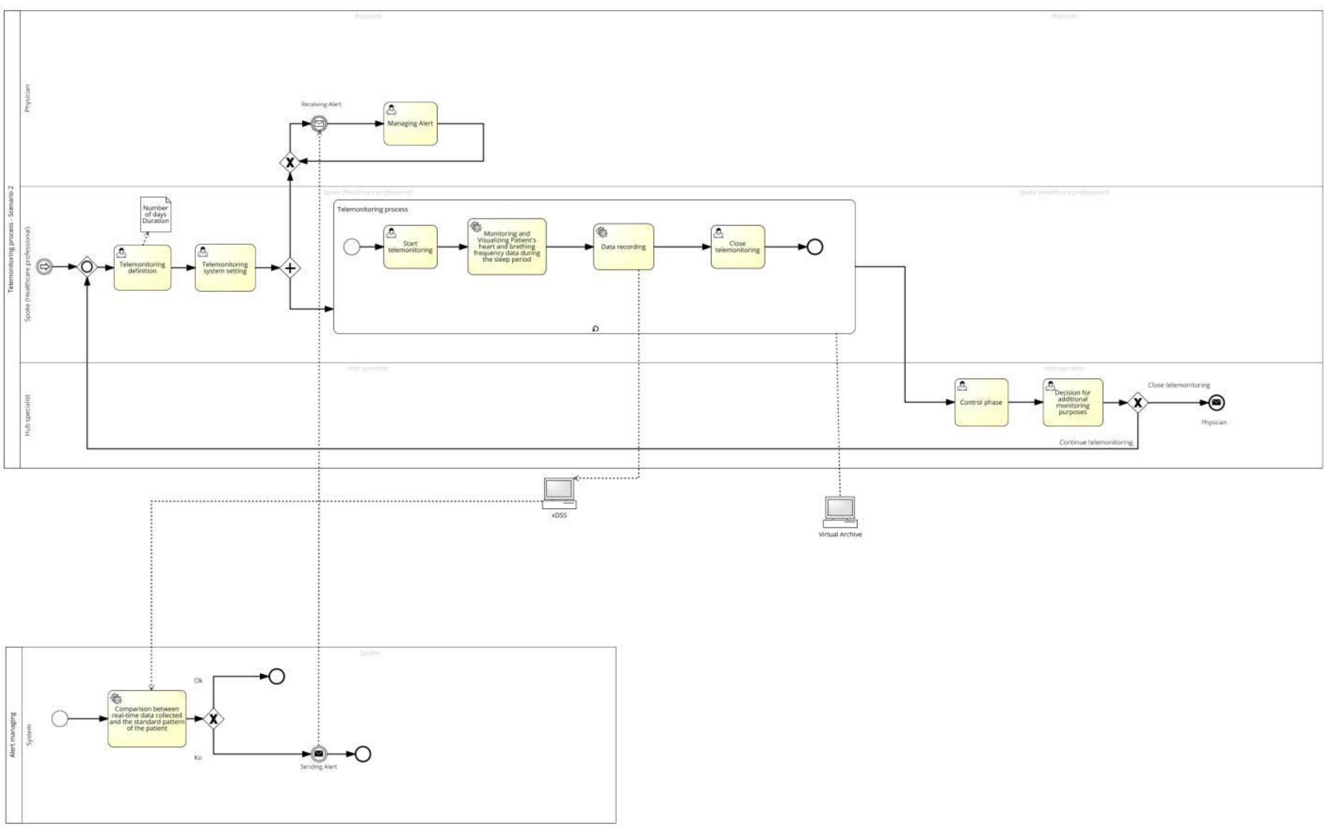


Figure 5: Telemonitoring process - scenario 2



REFERENCES

[1] Julian Adler, Chris Yu, and Mineesh Datta. The changing face of radiology: From local practice to global network. Medical Journal of Australia, 190(1):20–23, 2009.

[2] Ugo Barchetti, Antonio Capodieci, Anna Lisa Guido, and Luca Mainetti. In-formation systems for knowledge workers: the kpeople enterprise 2.0 tool. In International Conference on Web Information Systems Engineering, pages 804–807. Springer, 2012.

[3] Riccardo Bellazzi, Cristiana Larizza, Stefania Montani, Alberto Riva, Mario Ste-fanelli, Giuseppe d'Annunzio, Renata Lorini, Enrique J Gómez, E Hernando, Eulalia Brugués, et al. A telemedicine support for diabetes management: the t-iddm project. Computer methods and programs in biomedicine, 69(2):147–161, 2002.

[4] Adriana Caione, Anna Lisa Guido, Angelo Martella, Roberto Paiano, and Andrea Pandurino. Knowledge base support for dynamic information system manage-ment. Information Systems and e-Business Management, 14(3):533–576, Aug 2016.

[5] Adriana Caione, Anna Lisa Guido, Roberto Paiano, and Andrea Pandurino. A survey of open source workflow management systems. International Journal of Emerging Trends and Technology in Computer Science (IJETTCS), 4:22–26, Set 2015.

[6] Antonio Capodieci, Giuseppe Del Fiore, and Luca Mainetti. Adopting collabo-rative business processes to prevent the loss of information in public adminis-tration organisations. World Academy of Science, Engineering and Technology, International Science Index 89, International Journal of Social, Human Science and Engineering, 8(5):54–62, 2014.

[7] Stephanie Crossen, Nicole Glaser, Hadley Sauers-Ford, Shelby Chen, Victoria Tran, and James Marcin. Home-based video visits for pediatric patients with poorly controlled type 1 diabetes. Journal of telemedicine and telecare, page 1357633X19828173, 2019.

[8] Thomas H Davenport and James E Short. The new industrial engineering: information technology and business process redesign. 1990.

[9] Marlon Dumas, Marcello La Rosa, Jan Mendling, Hajo A Reijers, et al. Funda-mentals of business process management, volume 1. Springer, 2013.

[10] Christopher Eakins, Wendy D Ellis, Sumit Pruthi, David P Johnson, Marta Hernanz-Schulman, Chang Yu, and J Herman Kan. Second opinion interpreta-tions by specialty radiologists at a pediatric hospital: rate of disagreement and clinical implications. American Journal of Roentgenology, 199(4):916–920, 2012.

[11] Hampus Eklöf, Eva Radecka, and Per Liss. Teleradiology uppsala–sydney for nighttime emergencies: preliminary experience. Acta Radiologica, 48(8):851–853, 2007.

[12] Halit Eren and John G Webster. Telemedicine and Electronic Medicine. CRC Press, 2015.

[13] Paul Harmon and Business Process Trends. Business process change: A guide for business managers and BPM and Six Sigma professionals. Elsevier, 2010.

[14] Bruce Horn, Danny Chang, Julian Bendelstein, and Jo Carol Hiatt. Implementation of a teleradiology system to improve after-hours radiology services in kaiser permanente southern california. The Permanente Journal, 10(1):47, 2006.

[15] Latifa Ilahi, Sonia Ayachi Ghannouchi, and Ricardo Martinho. Healthcare in-formation systems promotion: from an improved management of telemedicine processes to home healthcare processes. In Proceedings of the Second International Conference on Technological Ecosystems for Enhancing Multiculturality, pages 333–338. ACM, 2014.

[16] Arjun Kalyanpur, Joy Weinberg, Vladimir Neklesa, James A Brink, and Howard P Forman. Emergency radiology coverage: technical and clinical feasibility of an international teleradiology model. Emergency radiology, 10(3):115–118, 2003.

[17] Ferdinand J Kammerer, Matthias Hammon, Philipp M Schlechtweg, Michael Uder, and Siegfried A Schwab. A web based cross-platform application for teleconsultation in radiology. Journal of telemedicine and telecare, 21(6):355–363, 2015.

[18] Rebecca S Lewis, Jonathan H Sunshine, and Mythreyi Bhargavan. Radiology practices' use of external off-hours teleradiology services in 2007 and changes since 2003. American Journal of Roentgenology, 193(5):1333–1339, 2009.

[19] Carmela Maiolo, Ehab I Mohamed, Cesare M Fiorani, and Antonino De Lorenzo. Home telemonitoring for patients with severe respiratory illness: the italian experience. Journal of Telemedicine and Telecare, 9(2):67–71, 2003.

[20] Karen L Margolis, Stephen E Asche, Anna R Bergdall, Steven P Dehmer, Sarah E Groen, Holly M Kadrmas, Tessa J Kerby, Krissa J Klotzle, Michael V Maciosek, Ryan D Michels, et al. Effect of home blood pressure telemonitoring and pharma-cist management on blood pressure control: a cluster randomized clinical trial. Jama, 310(1):46–56, 2013.

[21] A Martinon, MA Le Pogam, N Boublay, C Ganne, A Ben Cheikh, C Buron, V Thom-son, Y Berthezène, and C Journé. Teleradiology saves times in cases of vital emer-gencies: A comparative study with on-call radiology in two urban medium-sized french hospitals. European Research in Telemedicine/La Recherche Européenne en Télémédecine, 3(4):151–160, 2014.

[22] Birgit Morlion, Christiane Knoop, Manuel Paiva, and Marc Estenne. Internet-based home monitoring of pulmonary function after lung transplantation. Amer-ican journal of respiratory and critical care medicine, 165(5):694–697, 2002.

[23] GA Naqvi, M Daly, A Dawood, A Kurkuri, and S Kutty. Smart consultation for musculoskeletal trauma: accuracy of using smart phones for fracture diagnosis. The Surgeon, 12(1):32–34, 2014.

[24] World Health Organization, World Health Organization. Ageing, and Life Course Unit. WHO global report on falls prevention in older age. World Health Organiza-tion, 2008.

[25] Roberto Paiano and Adriana Caione. A knowledge base guided approach for process modeling in complex business domain. In ICSOFT-EA, pages 169–176, 2016.

[26] Guy Paré, Mirou Jaana, and Claude Sicotte. Systematic review of home telemoni-toring for chronic diseases: the evidence base. Journal of the American Medical Informatics Association, 14(3):269–277, 2007.

[27] ER Ranschaert and FH Barneveld Binkhuysen. European teleradiology now and in the future: results of an online survey. Insights into imaging, 4(1):93–102, 2013.

[28] Nihir B Shah, Elaine Der, Chris Ruggerio, Paul A Heidenreich, and Barry M Massie. Prevention of hospitalizations for heart failure with an interactive home monitoring program. American heart journal, 135(3):373–378, 1998.

[29] James H Thrall. Teleradiology part i. history and clinical applications. Radiology, 243(3):613–617, 2007.

[30] Elcin Zan, David M Yousem, Marco Carone, and Jonathan S Lewin. Second-opinion consultations in neuroradiology. Radiology, 255(1):135–141, 2010.