A CASE STUDY

On Patient Empowerment and Integration of Telemedicine to National Healthcare Services

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Keywords: Telemedicine, Integration, Security policy, Shared medicine card, National healthcare services, Time-to-market, Small-medium size businesses, Presentation level integration, Decentralized access control.

Abstract: Patient empowerment in the digitalized healthcare can be supported by means of telemedicine. As opposed to Electronic Patient Records developed by a few large business suppliers for healthcare professionals, telemedical applications include innovative solutions of small-medium size suppliers and are targeted at specific groups of patients (e.g., hip operated or dermatology patients) and their care network. Based on an integration experiment we argue that in order to support the national visions for patient empowerment and connectedness of healthcare at the same time, it is necessary to achieve the integration of telemedicine to the national healthcare services on a business logic (functional) integration level. In this paper, (1) we identify the lack of business logic (functional) level integration opportunities for patient oriented telemedical applications with national healthcare services; (2) we summarize on processes, products and organizations which are part of the integration procedure and provide places for shortening the time-to-market of SMBs. (3) we identify the need of supporting telemedicine uptake by extending access rights policies of the confidential patient data to decentralized citizens level access control.

1 INTRODUCTION

"Telemedicine is the use of medical information exchanged from one site to another via electronic communications to improve patients' health status". (American Telemedicine Association)

There exist different telemedical applications, those that support professionals-to-professionals remote collaboration and those that support remote collaboration of a patient with his care network: family members, volunteers and professionals. We focus on the last type of telemedicine, as it allows patients to be proactive users of health care services i.e. through the use of remote patient monitoring technologies.

(Wartena, 2009) and (CDH, 2007) argue that patient monitoring systems promise to provide better care for patients and help solving resource challenges, such as limited human and financial resources.

Among IT health care services, on a national level, we take a look at Shared Medicine Card (SMC), or Fælles Medicin Kort (FMK) (Trifork SMC)(NSI) that allows citizens and health professionals share the same medication prescription of patients in Denmark.

It is important to note, that Shared Medicine Card, fully deployed for all counties in 2012, is the achievement of the lately established national organization, known as National Sundheds (Healthcare) IT (NSI), earlier known as Connected Digital Health of Denmark.

Among telemedical systems we take a look at stand alone Remote Rehabilitation Support (RRS) (Aarhus, 2011) for hip operated patients. It allows the patient and the care network: spouse, physiotherapist and hospital staff, to control and instruct treatment of the patient in the home. Among other things, RRS offers the following functionality for the patient: video conferencing, preview of XRays, viewing medical prescriptions, which can be extended to remind him about the medicine intake in time. In this paper, we focus on the integration of the last functionality of RRS, namely the medicine module, as it is explained below.

While RRS offers potential benefits for the hip operated patient and the hospital (e.g., video

Urazimbetova S..
A CASE STUDY - On Patient Empowerment and Integration of Telemedicine to National Healthcare Services.
DOI: 10.5220/0003870902630269
In *Proceedings of the International Conference on Health Informatics* (HEALTHINF-2012), pages 263-269
ISBN: 978-989-8425-88-1

conferencing, training and future extension to remind on medication), it is not adopted at any hospitals, because there is no cost-reduction evidence and it does not integrate with hospital EPRs. However, RRS can bring new valuable functionality for the patient and his family i.e., access to prescriptions and extension to remind on medicine intake. The interoperability of RRS with doctors' EPR is essential for RRS adoption. This is a common challenge for other telemedicine adoption, for example as pointed in a Norwegian CheckUp Care system (Larsen, 2011).

This paper approaches the integration problem of RRS to EPRs's medicine module at caregiver's site, by assuming that an EPR at the caregiver's site integrates to SMC. It is therefore only needed to integrate RRS medicine module, with SMC at patient site. The integration scenario will make RRS "transparent" for health professionals and allow for patient empowerment through RRS adoption.

Our hypothesis is therefore twofold:

(H1) it is possible to achieve integration of the patients' site of the medicine module of RRS to SMC in a reliable way

(H2) integration can be achieved without unnecessary expenditure of man hours.

Following sections present methodology of integration process in Sec 1; overview of Danish healthcare, the relevant Danish health initiatives and related work in Sec. 2; integration experiment and results in Sec. 3; experimental results, constrains of time-to-market of telemedicine in Sec. 4;

2 METHODOLOGY

This paper is original, in the sense that there have not been done any integration experiments of telemedical applications to SMC. Also, SMC is the first and so far the only representative of a family of national services that connect clinical patient data across Denmark. There is a plan to create "sister" services, like SMC, in the future, for shared data access (SDSD, 2009), e.g., to lab results.

The integration experiment is part of a larger project, Net4Care, initiated by Caretech Innovation (CI). The need for interoperability of telemedicine with national healthcare services (NHS) based on an example of RRS and SMC has already been published in (Hansen et al., 2011). This paper presents first results of the initiatives.

The project of integrating RRS to SMC has started in February 2011 and lasted for more than 6 month, including two month of implementation and experience gathering. During the project, we attended a technical, held by NSI, and a mixed clinical and technical organized by (AAU, 2011) workshops on Shared Medicine Card and a workshop on Continua Health Alliance, held at CI. To explore the possibilities of the security policy of healthcare services, there was held a seminar for the security research group at Aarhus University on the topic. Besides, several companies were contacted in order to gain better insight into different technologies. For example, suppliers of National Service Platform, Security Token Service Identity Provider, developers of SMC, Security group at Alexandra Institute and Lægemiddelstyrelsen for getting the permission to perform the integration experiment. The implementation aspects of integration were logged in a diary as follows: every day when the integration task started or ended (not including the breaks, meetings, emails, workshops) there was noted the amount of hours spent. Diary details are available in (Urazimbetova, 2011).

3 OVERVIEW

We start with a brief overview on facts of healthcare in Denmark, the lack of interoperability in healthcare, the initiatives on connecting patient data across the systems, which resulted in Shared Medicine Card service. We then present the related work and argue why experiment and results of this paper brings concrete places of improving current state of telemedicine in Denmark.

3.1 Lack of Interoperability

Danish healthcare is a public healthcare system primarily financed through general taxes. The responsibility of providing healthcare services lies usually with the county; there is free access to healthcare services for all 5.4 million citizens. Healthcare sector should be of high quality, efficient and allow for free choice of provider by users. It consists of primary care with self-employed general practitioners (GPs) and hospital care.

Healthcare IT systems, e.g., EPRs for hospitals, have been developed independently by different counties, delivered by different suppliers, without adoption of a common platform or standards, which resulted in non-interoperability of EPRs. The same holds for the standalone telemedical applications, like RRS or the adopted Cure4you communication system that integrate to some EPRs.

3.2 Connecting Digital Health

"It should be clear that integration is not only a technical problem. Rather, it also requires a good level of organization and management in order to be successful."(Ruh, 2001)

In order to develop interoperability in the public healthcare systems, there was created a new organization in 2007 called "Connecting Digital Health in Denmark" (CDH) now called National Sundheds IT (NSI), whose task was to create a new healthcare IT strategy, for digitalization of health services (Bruun-Rasmussen, 2008). The main strategic goals of the IT strategy 2008-2012 (CDH, 2007) are:

(1) digitalization that directly supports staff tasks and functions, thereby creating a basis for improving quality and efficiency; (2) digitalization aimed at improving the healthcare service level for citizens and patients

Table 1: Results of NSI initiatives.

Organiz.	Products
NSI Connectng digital health	-Shared Medicine Card (SMC):SOAP based web service and web client -National Service Platform (NSP) (Enterprise Service Bus, proxy to SMC, authentication service and future services.
MedCom Organization	-Den Gode Web Service (DGWS) or the Good Web Service Standard - Sundhedsdatanet closed Virtual Private Network of healthcare
Open Source	Service Oriented System Integration (Esben Dalsgaard, 2008)(SOSI). Imple ments DGWS & Security service STS

Some of the results of NSI are the products and standards presented in the table 1.

With the efforts of NSI, Denmark has achieved interoperability of citizens medicine prescriptions in EPRs, reducing the number of medication errors. In order to achieve the integration, with the "gluing" technology-SMC, suppliers of EPRs had to make use of the products and technologies depicted in table 1.

The following citation, presents strategic perspectives of IT Strategy 2008-2012 for telemedicine:

In addition to shared services making data available, it may be relevant to establish shared services making functionality available.

For example, shared services could make certain telemedicine solutions available to all relevant healthcare users. Such solutions will provide a number of opportunities for cooperation. They will enable faster and better diagnosing, less unnecessary transport, new opportunities to consult experts and support a seamless transfer of tasks and development of shared care, etc.

The above quotation is presented to support the hypothesis that telemedicine should be a connected part of digitalized Danish healthcare, just as it is the case with connected medicine prescription modules that integrate with EPRs.

3.3 Related Work

(Wartena, 2009) presents, The Continua Health Alliance (CHA) and guidelines. CHAs goal is to ensure interoperability of telemedical devices as well as interoperability of these with EPRs, by means of guidelines for standardisation. On international level CHA have similar visions as NSI. (Wartena, 2009) refers to Google Health, which is out of the market, since mid 2011 and the Microsoft HealthVault, as places for sharing Personal Health Records. However, telemedicine requires trusted and available services, which is achieved by implementation of SMC. The paper also presents the trends of patients being able to access EPR records (created by health professionals) from web portals, however, it does not raise questions of how confidential data will be accessed given their guidelines? In this paper, we do. Furthermore, interoperability of medication prescription, in our experiment is not achieved by use of HL7 protocol, as proposed by CHA, but by means of national standards. In this paper, we work our way out from the local to the national implementations and standards, and point out the places for improvements of national healthcare services to support telemedicine in a Danish context.

4 INTEGRATION EXPERIMENT

Below we present definitions of integration layers; the experimental results, which identify the integration levels, provided by SMC; present the technologies that integrators work with during integration; explain why H1 is a place for improvements of national healthcare services.

(Ruh et al., 2001) present three different layers of integration: presentation level integration, business logic (functional) level integration and data level integration and argue for pros and cons of the models quoted below:

1) "The presentation integration model is based on the concept of accessing the legacy application through its existing presentation logic. Each user

interaction, however, must ultimately map into the old presentations in order to integrate."

2) "Business logic is code written to perform required business functions in an application. It includes the processes and workflow as well as the data manipulation and interpretation rules. … that are required to properly interpret or construct the data and that are not always available through the presentation.

3) "Data integration model goes directly into the databases bypassing the presentation and business logic to create the integration".

Figure 1 depicts the three horizontal layers of integration and vertical columns for systems (from left to right): SMC; authentication service for citizens, known as NemID; authentication service for employees, known as Security Token Service (STS); National Service Provider (NSP) that acts as proxy to SMC and STS; an example of EPR integration for employees, and finally the RRS integration for patients and citizens.

Shared Medicine Card, architecture details in (Trifork SMC), consists of a database with medicine records of all 5.4 mio. of Danish citizens on a data level. The business logic implements the functionalities such as: medicine prescriptions mechanism, versioning and logging. The presentation layer allows citizens (and health professionals) access shared medicine card functionality through a web client and is generated by the business logic layer.

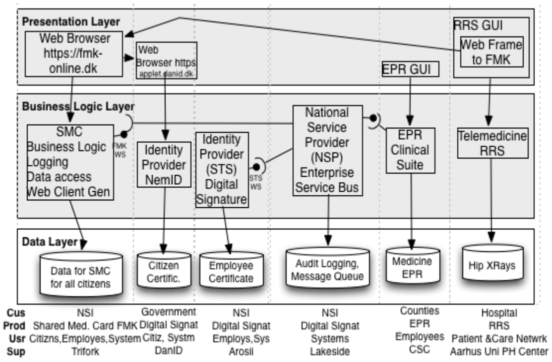

Figure 1: Levels of of integration for analyzed systems SMC allows for integration of RRS at presentation level.

The horizontal connections seen in business logic and presentation level integration show entry points for integration. From the drawing, we can see, that for an EPR system there is no way of establishing a database connection to SMC therefore we do not consider this level any further.

For example, at the business logic level, an EPR can access shared medicine card and its functionality by establishing SOAP based communication to its web service interface. Hence, Shared Medicine Card consists of a Web Service (WS) (Trifork software pilots). However, to achieve successful integration to SMC WS, an EPR system must be (1) part of the closed VPN connection (Sundehedsdatanet) and (2) the end users must be employees and own special employee certificates, all dictated by national web service standard, The Good Web Service (TGWS) 1.0 (MedCom, 2006). However, RRS on the patient's site does not fulfil these requirements and cannot achieve business level integration, because (1) RRS is not authorized as a member of the closed network and (2) patients are not employees and have no employee certificates, which TGWS asks for.

For RRS it is possible to integrate on presentation level (once, an Open Source Component, Smart Framing is released (Trifork Software Pilots). The idea is based on the older idea of web frames, where RRS can act as a host to the guest fmk-online.dk web client. This is like a redirect to fmk-online.dk web client from RRS. Citizens from fmk-online.dk can authenticate with a citizens digital signature, called NemID.

We can now argue, that given presentation level integration possibility of SMC for patient oriented RRS, we cannot satisfy H1, as quoted earlier in 2).

To support the argument we provide an example: Assume, patient site RRS acts as a host application to fmk-online.dk web client. RRS wishes to deliver new medicine reminder functionality to the patient: "intake 2 pills of a medicine 4 times a day" via presentation level integration. RRS uses Smart Framing to get PDF document of medicine prescription of patient. The PDF document, or (HTML of web client) does not contain the semantics (meaning) of medicine data. Technically it is possible that developer of RRS can guess the meaning of values. However, the guessing of the meaning and the fact that SMC user interface can change with time, makes the new reminder functionality of RRS not appropriate for ensuring patient safety and software reliability.

5 CONSTRAINS AND TIME-TO-MARKET OF TELEMEDICINE

This section presents the general constrains on the time-to-market of RRS adoption on top of the NHS. The constraints include the ones connected to the integration process and the centralized access control of the patient data. We start by testing the boundaries of the integration process of H2, by measuring the process in man-days and provide the method used for analysis, using a tree based process analysis. Thereafter, we summarize on other issues that hold SMBs from creating new functionalities for citizens and patients.

5.1 Integration Process

It is important to clarify the preconditions of the hypothesis: assumptions made, products and documents given to integrator; experience with technologies. These preconditions impact the volume (number of all paths) of integration process tree, as described below.

The tree in figure 2 has the root, which is the hypothesis H1, with its preconditions. The intermediate nodes are the intermediate integration activities that were identified as being important by integrator. Only one integration path from the root to the leaf is defined as a correct integration process and results in the task completion (in our case partial completion, details in next sec.) i.e., the correct path for our hypothesis is the left most path that leads to the leaf, called "Finish 1". The tree in fig. 2 shows all processes that integrator performed, before the correct path towards integration completion was discovered. The preconditions of the integration process are lack of documentation and tutorials. For example, integrator was given an executable machine image, called NSP-in-a-box. The installation guideline for installing and running the image on a virtual machine, examples of http requests one could execute on NSP-in-a-box; a white-box architecture drawing with numerous unexplained abbreviations as ones of table 1. All these were questions to answer and things to learn and influence the time-to-market, as argued below.

5.2 Man Days of the Integration Process Tree

Getting back to the H2, our results show that integration process takes 84,5 hours and could be reduced to 43,5 hours to achieve a partial integration. It is called partial because integration on the business logic level cannot be achieved as stated in sec. 4.3 (or achieved with employee signature which patients don't have) and RRS cannot provide new functionality for patients in a reliable way.

Figure 3, gives an overview of the integration subtasks. The tasks of the chart are mapped to the tasks of the integration process tree, where (T3) stands for a path from "Start of Task 3" in the tree to its completion leaf, "Finish 3" and so on.

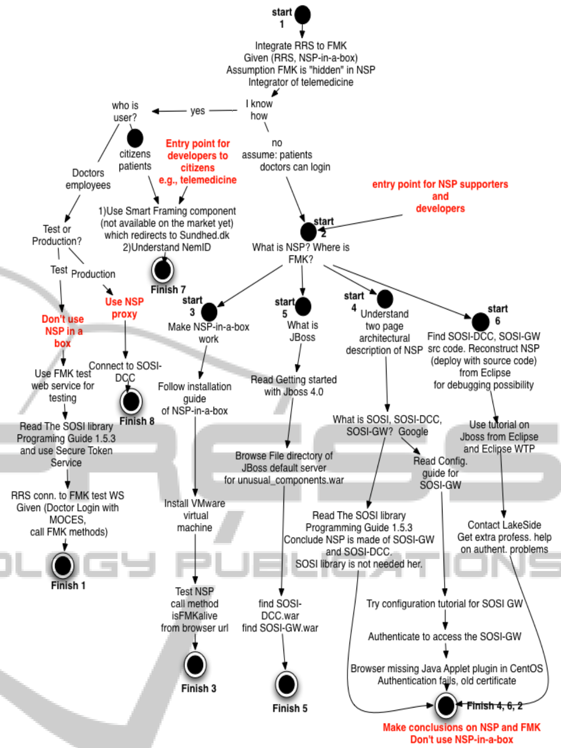

Figure 2: Execution of the "wrong" right sub tree is a result of e.g., lack of experience with tbl. 1. Path to "Finish 1" is partially correct.

Having got the tree and the chart it is easy to calculate: How many man-days could be saved if the integrator knew the right integration path? As we can see in the chart, the activities connected to solving the correct path problem, from bar 4 (from left) to bar 2 (from right) would be estimated to take: 43,5 hours. Thus to achieve integration to national health services, without unnecessary expenditure of man hours, NSI may want to provide better documentation, source code snippets, the right entry points for integration, like in drawing in fig.1 and fig. 2. Next section adds further constrains and maybe most noticeable constraints on time-to-market for telemedicine.

5.3 Security and Access Rights

As a result of the experiment following significant barriers for telemedicine integration to national healthcare services identified. First, the centralized way of controlling access permission to the confidential patient data of 5.4 mio. citizens of

Denmark. Second, is the existence of the web service standard that restricts the way web services should be implemented in Danish healthcare and includes employee signatures and excludes citizens signatures.

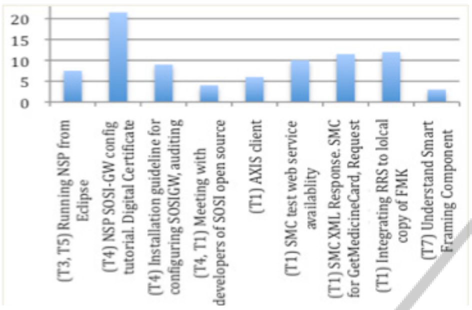

Figure 3: Hours spent on the integration H1.

Allowing EPR suppliers to operate on SMC data that contain confidential medicine information of 5.4 mio. citizens in a closed healthcare network, Sundhedsdatanet, require that EPRs systems behave well with respect to all data. Due to the fact that EPR systems are the main actors and contributors and have operated on most population data before SMC was established, MedCom has to give access to these systems. Current solution for access rights to national services follow the concept “all or nothing”. Hence, RRS with current security model may have difficulties at getting access to the confidential data for few hip operated patients.

The access problem can be solved on the business logic level, by extending the centralized “all-or-nothing” policy to a decentralized on individuals based access control. For example, by creating an SMC web service, where individuals can authenticate with private NemID and give permission for telemedical applications to operate on their confidential data. For example, RRS would prompt a confirmation window to a patient, where patient would permit the application to access and operate on medicine prescriptions. This model might in turn require that 3rd party applications, like RRS, can not i.e., steal the data from the patient site for evil purposes and are reviewed on a code bases by trusted organizations and approved to behave well with respect to the confidential data, for each new system version.

6 CONCLUSIONS

This paper presents issues of improvements of NHS to better support development of telemedicine:

First, national healthcare services, like SMC should support integration of patient oriented telemedicine on a functional integration level. Presentation level integration is not purposed for creating new valuable functionalities in a reliable way, which may keep third party developers from innovating services for patients and care network.

Second, the time-to-market will depend on the experience of a developer with applied domain specific technologies. Though, we demonstrate that in theory, it is possible to reduce the integration expanses, measured in man-hours, by factor 2 by providing better integration documentation for SMB.

Third, to support national visions for patient empowerment by telemedicine, the standard TGWS should be revised to include individuals’ authentication. Security constraints in the deployment of solutions create harsh conditions to SMBs and long calendar time from idea to production. Therefore the centralized access control should be extended to decentralized access control.

It is interesting to analyze possible business and organizational models that would best support criteria’s for NHS and telemedicine.

ACKNOWLEDGEMENTS

Morten Kyng, Henrik Blunk, Michael Christensen, Thomas Hohn, Klaus Hansen, Henrik Christensen, NSI, Security group at AI, Lakeside, Trifork & Lars

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