

Optimizing the Integration of the Patient Admission Process in a Swiss Rehabilitation Center with Multiple Parties

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Abstract: This paper explores challenges and solutions for the interoperability between Swiss hospitals, rehabilitation centers, and insurance companies with a focus on the patient admission process. It addresses issues such as inconsistent data formats, little to no structured interfaces between institutions, and limited trust in a central authority. The study proposes two alternative architectures: a centralized system with encrypted data and a decentralized system using public key infrastructure (PKI). The findings suggest a hybrid model combining centralized and decentralized features as a feasible solution to enhance collaboration, optimize admissions, and improve patient care.

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1. INTRODUCTION

The patient admission process in the observed rehabilitation center in Switzerland involves multiple parties that determine the flow of the patient in the process. Although the process only involves a few steps, dependencies and unknown factors make it complex. This paper focuses on the overarching process starting with the indicated need for rehabilitation of a patient at a hospital and ending with the patient arriving at the rehabilitation center. This overarching process faces several challenges, such as insufficient patient data or uninformed parties involved in the process. These challenges arise mostly due to the lack of standardized documents and processes in the Swiss healthcare industry.

Because of the close cooperation with the Swiss rehabilitation center, all aspects of the patient admission chain are taken into consideration for our study, which involves hospitals, rehabilitation centers, and insurance companies. The collaboration between the relevant parties and the observed rehabilitation center is primarily conducted via email and telephone. Although each institution has its own information system, the data is transferred in an unstructured manner. The process of extracting useful information from unstructured data and entering it into one's own systems is inherently prone to error due to the manual nature of the task.

The structure of the document follows the Design Science Research approach (Gregor and Zwikael, 2024). This study employs a case study approach, with a rehabilitation center in Switzerland as the primary contributor. The objective is to design a more efficient approach to patient admission across the entire chain, from the rehabilitation center's perspective with a focus on the interoperability between hospitals, rehabilitation centers, and insurance companies. First, the research methodology is defined and explained. Next, the

problem is described and connected to existing literature in related fields. Section 4 describes the observed inefficiencies and current situation of the patient admission process involving hospitals, rehabilitation centers, and insurance companies. In combination with an ongoing research project, a prototype is developed as an artifact. The design and architecture of this artifact are defined in the suggestion section. Findings and learnings from the project are discussed in the evaluation section.

2. LITERATURE REVIEW

The problem of data inconsistencies and barriers for sharing data in the health care industry is widely known. King et al. (2012) outlines the challenges of handling more elderly patients in health and social care systems. An important factor in this study was the capability of healthcare providers to provide the necessary IT infrastructure and knowledge to coordinate an inter-organizational system. Furthermore, the power dynamics between different institutions in the system lead to concerns about data confidentiality and control over information sharing.

A Swiss study found various challenges and potential for improvement of the patient admission process by conducting semi-structured interviews with eight health professionals (Röthlisberger et al., 2017). Information about the patient lies at the core of the process. The quality of this data impacts all identified challenges. Most challenges focus on the exchange of information and communication forms between medical institutions. Incomplete or outdated data can lead to wrong decisions in the planning process. Röthlisberger *et al.* (2017) recommend a common IT system for managing this process to facilitate communication and decision-making.

Many modern approaches for sharing patient data in the literature propose the use of blockchain technology (Abouali et al., 2021; Wang et al., 2019; Xiang et al., 2022; Yang et al., 2022; Zhang et al., 2023). One approach focuses on using blockchain for decentralized authentication and access control to protect medical data privacy and bolster system security against attacks (Xiang et al., 2022). Another approach involves using blockchain-based smart contracts, decentralized off-chain storage, and cryptographic protocols to enable secure and on-demand sharing of patient health records (Abouali et al., 2021). A common thread among these papers is the emphasis on data integrity, achieved by storing hash values of encrypted data on the blockchain to prevent tampering. Despite variations in the implementation, all the studies showcase the potential to transform patient data-sharing systems, enhance security, facilitate controlled data sharing, and ensure data integrity.

The term Electronic Health Records (EHR) is often used in literature. It encompasses health data about patients in various formats and structures. Azarm, Meehan and Kuziemy (2023) use the term Personal Health Information (PHI) as a subset of EHRs with an emphasis on the ownership of the data and control over their personal information. Furthermore, they highlight a growing trend towards patient-centered information systems, where patients can actively manage their own health information. This allows them to share information with multiple institutions. Consequently, institutions with access to centralized data can retrieve information as soon as it is released by the patient without depending on another institution.

The adoption of HL7's Fast Healthcare Interoperability Resources (FHIR) standard has transformed data sharing between medical institutions by standardizing interoperability across electronic health record systems. Braunstein (2018) highlights its use of modern web technologies, such as RESTful APIs, enables real-time data exchange, improving care coordination and reducing delays.

Other approaches involve the creation of an ontology in the healthcare domain for better interoperability (Azarm and Peyton, 2018). Azarm, Meehan and Kuziemy (2023) expand on this research by introducing a new framework called System-level Record Sharing (SLRS). This system captures interesting aspects from commercial applications and governmental approaches to unify a solution. However, their findings show the need for governance and a shared ontology.

3. RESEARCH METHODOLOGY

Our study uses the design science research (DSR) approach (Gregor and Zwikael, 2024). As it is part of a practical research project, the DSR approach helps to find the link between the applied research and the practical implementations. DSR is composed of phases like in project management, where each phase builds up to the next phase. Finally, an artifact is created that can be evaluated. A full cycle of the DSR, commonly known as the Design Cycle, can be repeated until a satisfactory artifact is developed. This paper describes the first and second

cycles integrating valuable feedback from healthcare professionals.

The development of the artifact is described in section 5. It describes the first and the current version of the prototype. Section 6 evaluates and discusses the advantages and disadvantages of the different architectures and approaches.

4. AWARENESS PHASE

4.1 Interoperability between Institutions

The problem arises within the patient admission process in the rehabilitation centers. The current process involves several hospitals, rehabilitation centers, and insurance companies. One of the major problems identified at the rehabilitation center is communication between the different parties. Currently, the only communication channels used are email and telephone. Sometimes the email feed contains the full history of the patient registration process. However, it is often the case that emails are sent separately without reference. This leads to distributed communication channels and reduces the ability to track the current state of the process. Furthermore, the institution responsible for the patient must track multiple communication channels simultaneously for only one patient. Figure 1 depicts the situation if a patient is registered at three different rehabilitation centers and has two insurances.

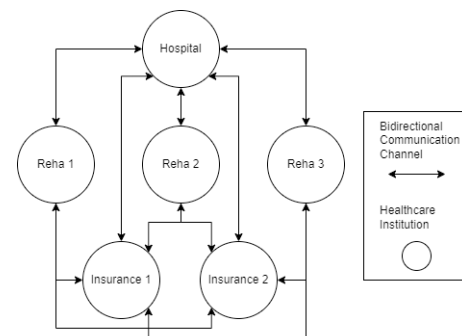


Figure 1: As-Is Communication Channels

In this scenario, the hospital registers the patient at three different rehabilitation centers and sends the request for a grant to the two insurances. Each rehabilitation center also sends a request to both insurance companies.

Now, several healthcare institutions in Switzerland usually have multiple employees in so-called Case Management teams. These teams are responsible for tracking those communication channels and managing the case of the patient. The involvement of numerous institutions that lack a unified communication interface creates additional effort to coordinate their activities. Furthermore, requests for grants from the insurance are multiplied because each institution sends another request without coordination.

Managing multiple communication channels and parties simultaneously increases the possibility of errors and outdated information. This is noticeable at the rehabilitation center by losing a previously registered patient whose plans have changed in the meantime. Consequently, it makes planning more challenging due to the uncertainty surrounding the quality and timeliness of the information.

4.2 Data Format

Another major challenge in this process is the format of the data for the registration. Using the data from the observed rehabilitation center, every hospital has a slightly different form for registering a patient for rehabilitation. Furthermore, some documents are digitally created and signed, while others are scanned. This makes it difficult to extract information from those documents in an efficient manner. All analyzed registration documents were received as PDF files. While modern programming languages have become better at extracting information from PDF files, it is a form of unstructured data and thus cannot be easily interpreted and transformed.

A central problem is the individual storage and processing of patient data. During the last few years, there have been several approaches that try to standardize patient dossiers and use a common format (Tertulino et al., 2024). This would allow multiple institutions to share data without the need for any transformations of the data format. Christensen and Ellingsen (2016) evaluate the openEHR approach, which tries to decouple patient data from the medical institutions. The data is stored in a central hub, where processing institutions access and update the required data as needed. This allows multiple institutions to have access to the most up-to-date data about their patients.

However, the observed institutions are still using older formats or systems that do not support the new technologies. During meetings with other Swiss healthcare institutions, it was discovered that many institutions still use older technologies and have not upgraded yet to the newest approaches. Furthermore, some patients do not wish for a central patient dossier and can restrain the use of central storage. Consequently, medical institutions must store the data internally.

This situation contributes to the problem of data transmission. A rehabilitation center must have enough information about the patient to know if there is a bed available at the corresponding station. Furthermore, it must prepare the required therapies and schedules. Discussions with the staff from the rehabilitation center have shown that patient data is required to be present at the time of registration for a flawless procedure. If the rehabilitation center does not have enough data, it sends feedback to the hospital that they require more information which leads to further effort and error-prone communication.

5. SUGGESTION PHASE

5.1 Centralized Data Storage with Limited Access

During the research project, the first developed architecture featured a centralized approach to storing encrypted data objects that are transferred between the institutions. This allows each institution to access the newest information about the data object and share information in a central space enhancing the collaboration between healthcare institutions. The registering institution can define the target rehabilitation centers in this process, which shall be able to see and modify the data. Due to the sensitivity of patient information, it is crucial that the data is end-to-end encrypted by the institutions.

Therefore, the central platform would only store encrypted data objects. This architecture is visualized in Figure 2.

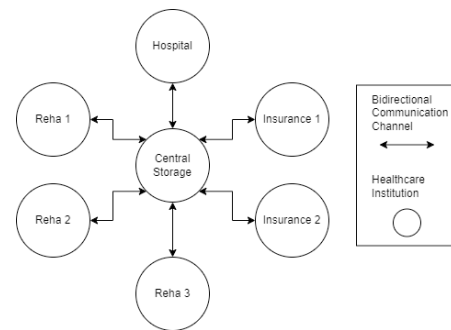


Figure 2: Centralized architecture

This approach reduces for every institution the number of communication channels to handle. All information concerning the registration of a patient for rehabilitation is stored in a centralized platform and accessible only to the institutions that possess a private key to decrypt the data. The organization and tracing of process steps becomes clear and transparent to all involved parties allowing for enhanced collaboration and simplified communication directly on the platform inside the registration data object.

5.2 Overarching Data Structure

Currently, every hospital has a slightly different form for registration. Our observations show that all registrations arrive in PDF format and sometimes the information is spread over multiple files containing patient information, diagnosis information, and the current health state of the patient. The rehabilitation center must manually transfer this information from the PDF files into their own information systems. This was indicated as a source of errors by the process owner because of the manual processing of the numerous PDF files. To put this into perspective, one registration on average contains 2 to 3 PDF files. Each PDF file contains on average one to three pages and is filled with information about the patient (first name, last name, birth date, etc.), medical registration details (diagnosis, reason for the rehabilitation, etc.), or current health state of the patient. This information can be extracted by copy and paste, if the document was digitally generated (or processed by optical character recognition), or by reading the information and rewriting it into the corresponding information system.

We propose an overarching data structure by utilizing already established Swiss healthcare standards and reengineering the creation of the registration files. This data structure shall be able to map registrations from any hospital to the requirements of the rehabilitation center. Consequently, new hospitals and rehabilitation centers could be integrated by mapping their current data structure to the overarching one. Finally, this allows all integrated institutions to exchange data easily.

5.3 Further Processing of Data Using Software

If the structure of the data is known, it can be exploited for faster processing within the target institutions. For example, a JSON object could be sent to an internal service recognizing

the described fields. Unstructured data is known to be difficult to process with traditional algorithms. Extracting information from PDF files requires the content to be standardized to a certain degree to have a repeating structure. This allows algorithms to match sequences and extract meaningful information directly from the file. However, if the data is already structured upon receipt, it can easily be imported by the information systems used in the rehabilitation center.

One part of the research project is the creation of a machine-learning prototype to categorize patients into predefined classes. However, this algorithm cannot run without the structured information of the registration. Consequently, there is a waiting time between the reception of the registration form and the possible categorization by trained models. Depending on the workload of the patient admission office, the further processing of the registration by software is estimated to be delayed by 20 minutes on average. To summarize, the structured arrival of data would immensely improve the flow of the registration in the admission process and allow for immediate subsequent processing utilizing the software.

5.4 Decentralized Architecture

A second architecture is proposed because of the limited trust for centralized infrastructure in Swiss healthcare institutions. This architecture utilizes a public key infrastructure (PKI) based communication network with whitelisted sender-target relationships. Each institution must install an interface that can transform the data into the overarching data structure and distribute the data objects to the defined targets. Figure 3 shows an overview of this approach.

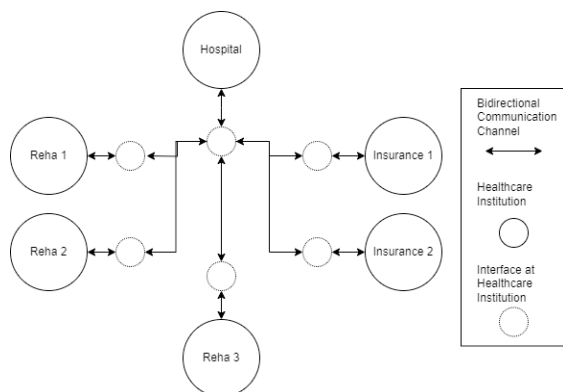


Figure 3: Decentralized architecture

Utilizing a decentralized approach, every institution is responsible for the correct handling of the data. Furthermore, it allows for a simple prototyping using RESTful APIs. It requires less technical overhead and expertise in the healthcare institution and enables each institution to control the whitelist of senders.

6. EVALUATION AND DISCUSSION

The first centralized approach was presented to three hospitals in Switzerland. Although the technical architecture was generally accepted as good, several concerns made the cooperation for a first prototype challenging.

One of the main concerns was the single point of failure at the centralized system. While technical architecture considers creating redundancy in this centralized service, the inability to find a company to support this product after the initial prototype raised skepticism. The healthcare industry in Switzerland is highly regulated and cyber security is a critical factor. The centralized architecture must comply with all regulations and be accepted by all participants of the network. This arose as a challenge, regarding the fact that many of the initial target participants already had different internal regulations. Therefore, finding a suitable solution that works holistically could prove challenging.

Centralized systems require considerable trust from the industry to make a project like this work. In Switzerland, there are some companies that are well established in the healthcare industry. SASIS AG is often referred to when processing information about insurance cards or checking details using the social security number of the patient. SASIS AG is working on the SHIP product, where they propose a framework with standardized procedures and services to be implemented by healthcare institutions.

Another established player is OPAN, which has made a name by connecting patients with further treatment services like nursing homes or home care. OPAN itself is currently trying to launch a similar platform that connects hospitals and rehabilitation centers for the registration process. Currently, they have some integrations into information systems by calling their URL with the information as parameters. However, this is critical due to the unencrypted nature of the URL. To summarize, there are some businesses in Switzerland that try to solve this problem with their own platform looking to make a profit from healthcare.

During discussions with the hospitals, it was noticed that it is sometimes difficult to work with services from businesses because access to their own data is limited or restricted. This may be due to the lack of expertise in the company and outsourcing of several information technology aspects. It opens opportunities for service providers to tackle challenges and provide paid services. The goal of this study is to create an alternative solution that is operable by the medical institutions and maintainable without much additional effort. It targets the wish of healthcare professionals to have full access to their data and knowledge about its processing.

The problem of centrality is tackled by changing the technical architecture and removing the need for trust in a central authority. While the initial architecture relied on a central communication service, which kept track of all encrypted data objects, the new proposal integrates the option to have the communication service hosted by healthcare institutions. The decentralized architecture, described in section 5.4 can be envisioned as a mailbox utilizing structured messages. The message contains the data object and is sent to each target individually on every update. The volume of these interactions is rather small, which makes the replication of data not critical.

Required information and data objects must be defined. While this initiating process requires expertise, once the data object has been defined and mapped to the overarching data structure,

it can be used immediately. Defined data objects shall be visible for the hospitals that want to be integrated into the network. The overarching data structure provides a mapping for all integrated data objects and allows for a new hospital to link its own type of data with the overarching data structure. It then can send the data to all rehabilitation centers that are correctly integrated into the network.

The internal system could further be used to automatically load the registration object into medical systems like clinical information systems, insurance management systems, or enterprise resource planning systems. The rehabilitation center involved in the research project aims to seamlessly integrate the incoming registrations with their enterprise resource planning system and the bed planning system. This enables the patient administration team to reduce the manual processing of registrations to a minimum. Furthermore, due to the structured nature of the arriving data, it can be fed directly into the machine learning pipeline for categorizing the class of the patient. This enables faster planning for the bed allocation of the patient. Additionally, insurance companies could leverage their existing information systems by importing the received data. Instead of multiple requests per email, the insurance companies can have central management for cases.

One challenge of the decentralized solution is the additional effort for all IT departments in the healthcare institutions because they must take care of their interfaces. Furthermore, small institutions may not have the manpower or expertise to support this. This could be tackled by mixing the two proposed architectures, where smaller institutions could leverage a centralized storage approach by trusting a third-party provider to handle this interface. Nevertheless, the system is expected to reduce workload for workers and increase productivity because of the elimination of redundant information retrieval through phone calls or emails.

The interface installed at each institution manages the distribution and receipt of messages. It serves as a central system for all messages within this closed network. Due to the flexibility of this interface, it is possible to increase the complexity and add multiple bucket-like structures that could collect data objects by categories and forward or process them according to rules assigned to the bucket. Consequently, this interface could be enhanced with further data structures and establish more inter-organizational connections. Having feasible entry requirements enables fast and secure connections for the near future. Whereas other solutions try to standardize the full healthcare process landscape, our approach focuses on providing a minimal solution for fast and simple interoperability between organizations.

While this study focuses primarily on Switzerland, we estimate that the system could also be integrated into other countries. Most certainly, the data structures used for patient information and patient admission, or transmission, are different and must be standardized into a holistic overarching data structure. However, after this initial effort, this system can reliably share data between institutions and make information readily available as a service. Consequently, certain information requests can be automatically handled and do not require human processing. Furthermore, the proposed architecture is

expandable to other processes that require the sharing of data between organizations.

CONCLUSION

Our observations show that the standardization of the whole healthcare industry in Switzerland is challenging and requires substantial time. Furthermore, institutions are hesitant to comply with systems they have no control over. Establishing a standard that works for everyone seems highly complex and might prolong the optimization of the patient admission process. Our study is hoping to create an open-source solution where healthcare institutions can integrate this system using simple tools and little maintenance requirements. This enables institutions to act now to implement a more efficient solution. As processes become more efficient in the healthcare industry, the workforce has more time to focus on the patients and their well-being.

Standardization over the whole healthcare industry is complex, requires time, and the acceptance of all actors. However, creating a standard for a specific process, like the patient admission process, is feasible and can contribute to the research project. There are many common denominators in the patient admission process among the Swiss rehabilitation centers. Required information seems to be almost identical, enabling the creation of a common standard that can be used for interoperability. The implementation of interfaces at each institution contributes to the bigger picture of allowing seamless data transformation between all integrated members.

FUTURE WORK

As described in section 3, this is only the second cycle of the design science research process. Future work includes the implementation of a working prototype between healthcare institutions to observe the change in efficiency over the process. Furthermore, this architecture may be adapted and used in other domains to enhance interoperability between organizations. This system shall enable companies to work together relying on a secure and controllable service.

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