ALL STAR CONSULTING GROUP

DIGITAL AGENDA & BUSINESS CASE

Using Blockchain to Revolutionize the Swedish Medical Record System

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Summary

In this report, a digital agenda and a business case devised by All Star Consulting Group is presented. The digital agenda untangles how the Swedish healthcare sector can create more value for its customers through digitalization. Customers are in this instance both tax payers and patients. At first, we suggest how to improve the *customer experience* when utilizing healthcare in Sweden. Thereafter, an investigation on how to enhance the power of core operations on a nationwide, county council, and local level is conducted. At the end of the digital agenda, our reinvented business model for the Swedish healthcare is presented.

In chapter two, business case, the possibility of revolutionizing the medical record system in Sweden by utilizing blockchain technology is explored. Currently, numerous different medical record systems are used at Swedish hospitals. In many cases, data is stored lacking proper redundancy precautions, as well as some data being stored locally on hard drives and in paper copies, altogether fragmenting the medical record data. Several cases have been recognized where different medical record systems are incompatible with each other, creating system malfunctions and risking patient safety. Moreover, data is stored using database technology not fully secure against intrusions and abuses of administrator rights. Meanwhile, blockchain, the technology ensuring secure transactions through the Bitcoin network, is applied to more and more areas, due to its advantageous properties.

Before introducing the proposed platform, a brief introduction to blockchain and formal requirements for a medical record system are given. The requirements are then closely followed by established problems with the current medical record system. The identified problems mainly concern incompatible systems being used, locally centralized data storage reducing redundancy and locally storing data on servers or paper copies fragmenting data. The proposed medical record system will be developed as a platform, which allows third party developers to create end user applications.

Following the description of the proposed solution to the problems, a cost savings analysis is given. The analysis presents the new system saving the health care sector 2.5B SEK yearly, concluding that an investment in the new platform results in a NPV of more than 5B SEK. After presenting the cost saving analysis, eventual risks linked to the project are conferred, followed by a project plan. The project plan shows how the system will be implemented in Sweden during approximately two and a half years, starting in Stockholm.

Contents

Chapter 1

Digital Agenda

Let's be clear: the public sector is a whole different beast compared to small startups and internet giants. This has a few implications when it comes to the driving factors and expectations of making changes in the way a publically owned organisation functions. In Swedish healthcare, the income does not come directly from the patients but from public funding in the form of taxes. Increasing revenue is therefore not a goal for the organisation – reducing costs is – which takes away a dimension from the long term strategy. This, combined with the bureaucracy and difficulty in encouraging innovation, makes the healthcare system slow in adapting to our ever-faster changing society.

New technology has the potential to save enormous amounts of tax payer money, but is hard to implement system-wide. A worrying trend has risen: new systems are implemented for each different purpose and in different regions, leading to a tangled mess of IT. Sweden is among the top countries when it comes to health expenditure per capita and the messy approach to digitalization is one of the reasons why. We at All Star Consulting Group believe in ripping that bandaid straight off, stripping local county councils off their IT systems and implementing a nationwide digital platform. More specifically, we have mapped out how digitalization can make Swedish healthcare a system that is appreciated by every Swede, ready for the future and delivers exactly what is expected of it.

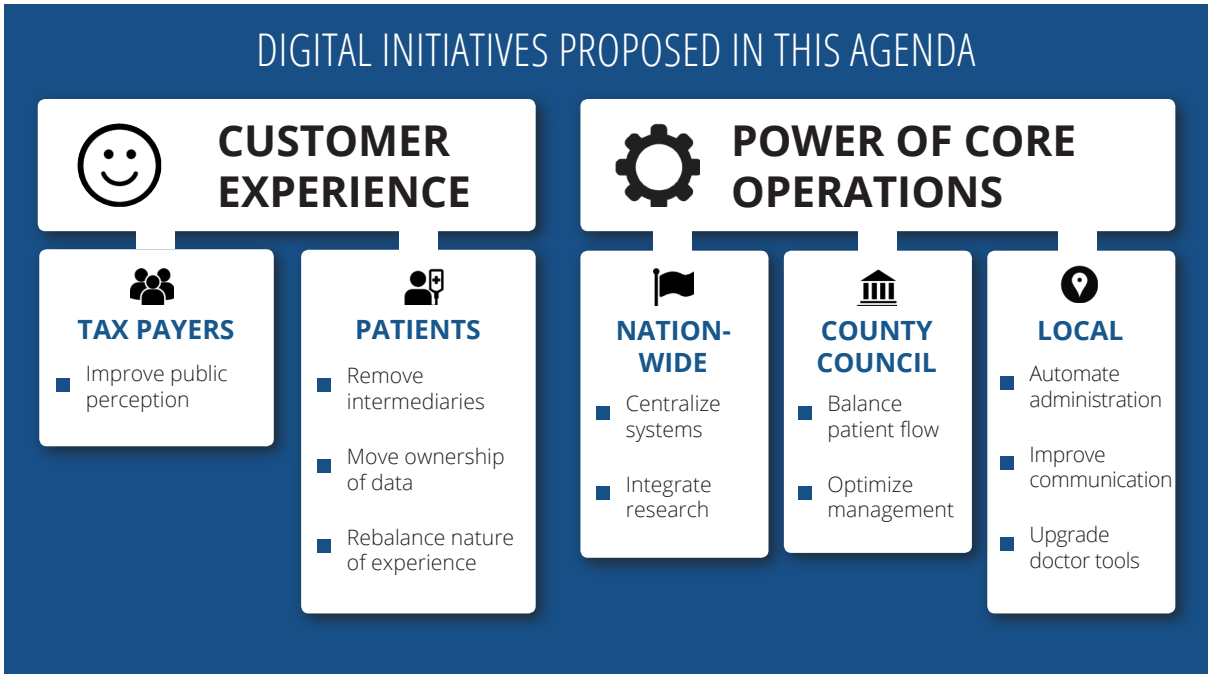

Figure 1.1: Map of initiatives in this Digital Agenda.

1.1 Creating a Compelling Customer Experience

As mentioned above, there are two ways of defining who or what the customer of a publically funded organisation is: the tax payers and the patients. In the sections below we will cover both of them.

1.1.1 The Tax Payers

Creating a compelling customer experience for the tax payers means to show them how their money is used in the best possible way. The entire society is taking advantage of public healthcare. For example, vaccinations remove harmful diseases from the population and proper pediatrics make sure there will be a healthy and capable workforce in the future. Despite this, the widespread effects of public healthcare make it hard for the public to understand what it is that it actually is paying for. Which leads to this proposed agenda's first initiative.

Improve the Public Perception of the Healthcare System

Data gathering, analyzing and presenting is more advanced today than ever before, and should be used to make the public aware of where their tax money is going. And even more importantly, why it's going there. By providing this information to the public in a transparent, credible, and easy to digest form our democracy becomes that much better. Politicians responsible for public health can use real data to influence policy changes, and voters who elect these politicians have more information when it comes to their choice. In the end, more people get involved in improving the system.

1.1.2 The Patients

In a way, the patient is also the product of the healthcare system. That's not how a patient wants to experience his or her doctor's visit, though. Today, there are several problem areas regarding a patient's connection to the healthcare system. In most areas, the waiting times to get an appointment are measured in months. The actual visit is as short as possible and continuity is hard to achieve. People moving across the country have problems getting their medical records to move with them. If you need immediate help, count on spending several hours in the emergency room first. Luckily, digitalization can put a significant dent in these issues by taking the following actions as pictured in 1.2 below.

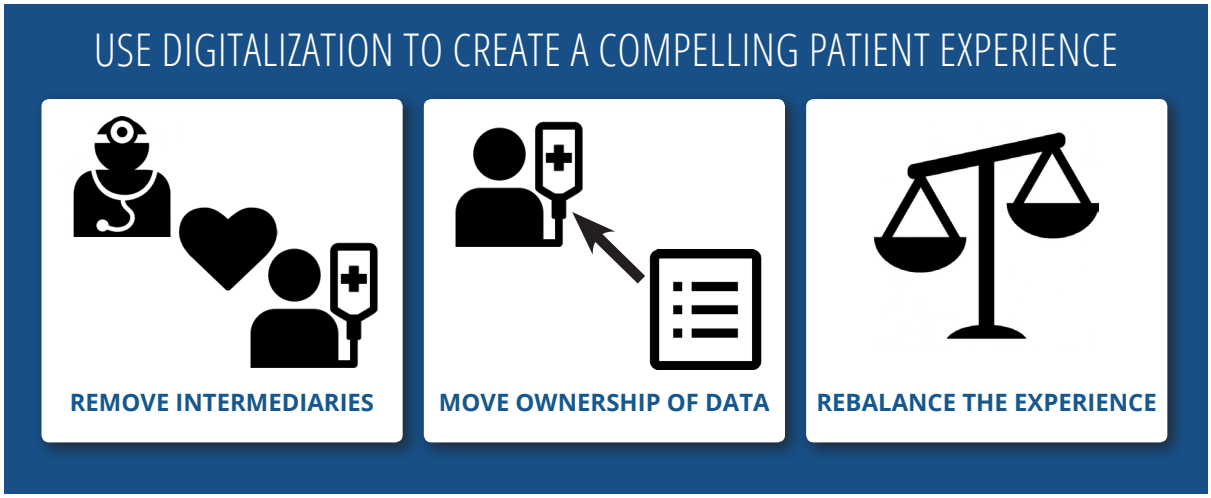

Figure 1.2: Initiatives related to the patient experience

Remove Intermediaries from the Patient-Doctor Relationship

Many of the obstacles in the healthcare experience for a patient can be resolved by using digitalization in order to remove unnecessary steps in the processes. Administration can largely be done automatically today, with improved communication channels patients can know more about their status and have a closer relationship to their doctors, and AI can be used to narrow down diagnosis. These implementations would lower the time from discovery of the first symptom to the start of the treatment and lower costs all raising patient satisfaction.

Move Ownership of Data to the Patient

Currently, huge costs are associated with the storage and management of patient data such as medical records and drug prescriptions. Different county councils use different systems which makes it extremely inconvenient for patients who move across the country to bring their data with them. Blockchain could be used to dramatically lower costs and merge all of the data into one platform. Read more about our proposal regarding the implementation of blockchain in our business case in chapter 2.

Rebalance the Physical and Digital Experiences

New technology makes us ask some questions about healthcare:

- Which types of doctor visits could just as well be performed digitally, without taking time out of your day to travel to the hospital? There are already a few initiatives running in this area, and we believe that more possibilities arise daily. By cutting the physical distance to the doctor, the patient can be brought closer to its care.
- Why do we have physical pharmacies for prescription medicine? A patient should be able to order his or her medicine digitally and receive it in the mail or at the local grocery store. Again, removing physical barriers and unnecessary steps.

1.2 Enhancing the Power of Core Operations

Digitalization can be utilized effectively to strengthen the Swedish healthcare system's operations. Different initiatives can be implemented on three levels of the organization: nationwide, county council and local, as listed below.

1.2.1 Nationwide Level

Sweden is a big country. Different county councils use different solutions for their healthcare problems, which leads to inconsistency and gaps between systems while enabling the risk of reinventing the wheel and duplicated work. Historically, this has been due to the physical distances making nationwide collaboration difficult or impossible, but digitalization enables standardization and orchestration on a nationwide level. We've identified two potential keys: centralization of digital systems and their integration with research, and they are explained below.

Digital Systems Move at the Speed of Light, so Centralize Them

There are clear economies of scale here: a single system for a single purpose nationwide will be cheaper, safer and more robust than a fragmentized infrastructure. The data will be easier to manage and analyze, and the implicated standardization removes unnecessary work. The physical distance doesn't have an effect in this case.

Improve Integration with Research

Medical research relies on data from the real world, and data from the centralized system mentioned above could be used to help research. Centralizing communication channels improves collaboration with and between researchers, and enables for quicker implementation of new breakthroughs. Our already world-class research structure will be empowered to unleash even more of its potential.

1.2.2 County Council Level

Many issues on the county council level today are related to balance. There are information gaps that result in patients visiting the suboptimal hospital or care center for their needs. Related to this, the physical resources available struggle to be utilized properly, why we propose the following initiatives:

- Balance patient inflow
- Optimize the management of physical resources

Both initiatives are more thouroughly explained below.

Balance Patient Inflow

Data analysis combined with upgraded communication channels help find the imbalances between available resources and patients needing help, which is why the patients know where to go for the fastest help. Attacking the problem from both directions stabilizes the load on hospitals and care centers while improving patient satisfaction, so we also propose a second initiative.

Optimize the Management of Physical Resources

With digital systems to manage employees, machines and rooms a possibility for optimization algorithms is created. Depending on workload and utilization, different resources can then be dynamically allocated between hospital and care centers. In the short term, extreme cases can be minimized and waste of time and space be avoided, in the long term investment and hiring planning can be heavily improved with the help of data.

1.2.3 Local Level

Locally, we can find the healthcare system's main interface towards the patients. Doctors and nurses are the essence of patient relationships and get paid by the public. Any change to the system affects these individuals the most, and today's huge workforce capacity issues make their time management a key factor. The physical disconnect with their patients creates gaps in continuity. Their time is limited and should therefore be used as best possible. They're also humans, and mistakes occur quite regularly. So what can we do to improve their daily life?

Automate Unnecessary Administration

Doctors and nurses are employed to work with actual patients, not to fight administration software and paperwork. Digitalization enables administration processes to be taken care of by automated algorithms. The employees can then focus their time on actual value creation in the form of helping patients.

Improve Information Flows

With new digital solutions doctors can receive more relevant information about their patients, and on a hospital/care center level real time data can be used for capacity planning. More information is always better, and digitalization makes it happen.

Improve the Doctors' Tools

AI and data analysis have the potential of becoming extremely important parts of a doctor's workflow. Many of the mistakes made in diagnosis or treatment are due to gaps in competence or relevant information. With digital tools capable of suggesting decisions and checking compatibility between different types of drugs and allergies, doctors no longer have to guess or assume and can instead rely on fast, accurate information in their decision making. Without incorrect diagnosis and prescriptions the patients avoid unneeded extra visits and an incredible amount of lives can be saved or improved.

1.3 Reinventing the Business Model

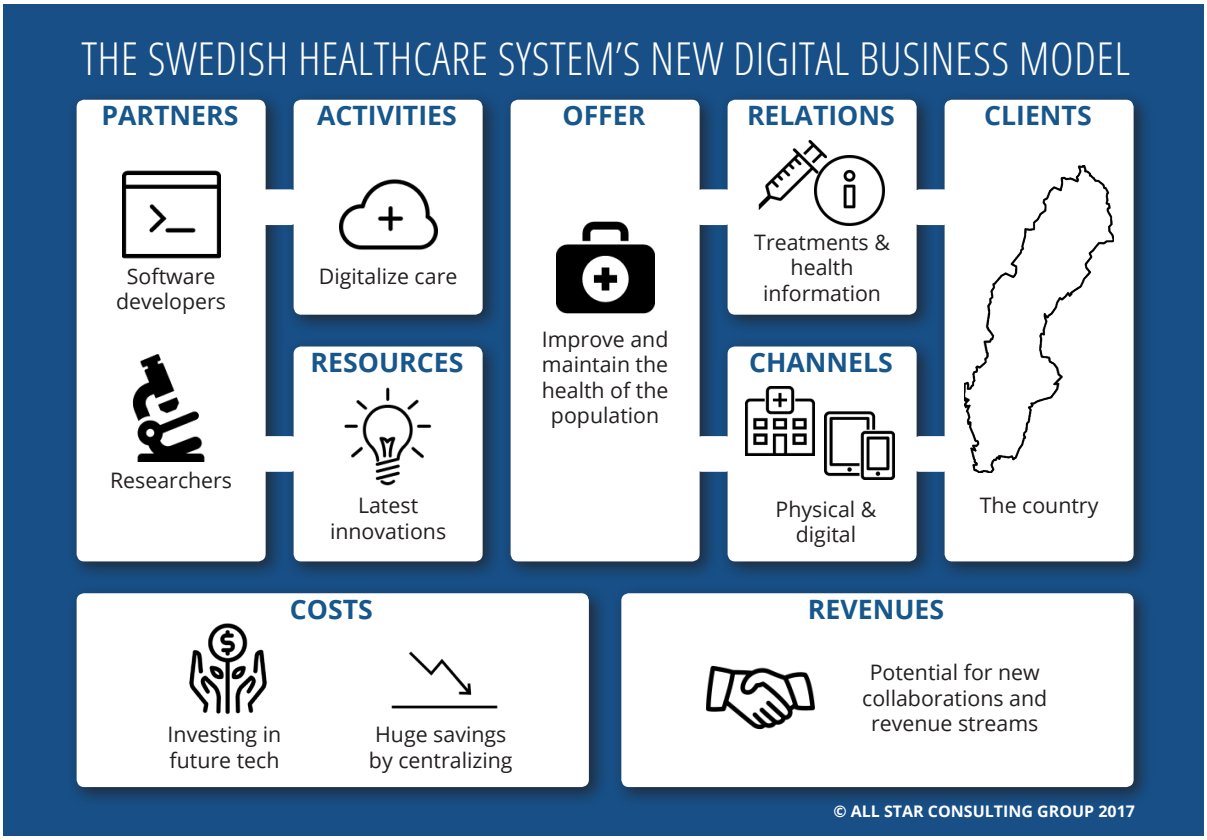

Figure 1.3: The Swedish healthcare system's new digital business model

The initiatives mapped out in figure 1.1 above combine into our proposal for a new digital business model for the Swedish healthcare system, as shown in figure 1.3. The model is designed with the goal to keep the value proposition right at the heart of operations: improve and maintain the health of the Swedish population.

Creating New Solutions

The latest digital innovations are used to digitalize care, with the help of researchers and software developers. New tools are created to provide opportunitites for the system to evolve.

Using them to Deliver Value

Value creation by proactive healthcare can be expanded further, to lower the amount of reactive care necessary and keep the population healthy. Digitalization could also move the value creation from hospitals and care centers closer to the patients, enabling a patient to seek care immediately after suspecting symptoms by, for example, using an app on his or her smartphone. This significantly shortens the time from first discovery of symptoms to the start of treatment and thereby creates more value to society.

Paying for It

Investments in new technology make sure that old and inefficient systems are phased out, creating long term savings. The creation of new revenue streams is also made possible through digitalization. Standardized medical record databases would allow a simplification of aggregation of data, which could be sold to universities conducting research in the significant areas. This is improving Swedish medical research at the same time as it is creating revenue streams to the healthcare sector.

1.4 In Conclusion

We've outlined some of the ways digitalization can help the Swedish health care system, focusing on customer experience, core operations, and its business model. Implementing these initiatives will greatly improve perception and functionality of the system, and reinstate Sweden in the forefront of digitalization.

Chapter 2

Business Case

2.1 Current Situation

In this section we will present a background to the blockchain technology and the Swedish medical records system, as well as identify problems with the current medical records system. First, a brief description of blockchain technology will be presented. Second, a brief description of medical records and current regulations will be presented. Lastly, problems with the current medical record system will be identified and analysed.

2.1.1 The Rise of Blockchain and Its Implications

Blockchain is a database technology that is distributed, public and encrypted. The concept of the technology was originally published in 2008 by an anonymous creator or group of creators under the name of Satoshi Nakamoto. The publication focuses primarily on the idea of a peer-to-peer encrypted electronic currency, a cryptocurrency, but blockchain has since then been proven useful in a wide range of contexts. The name of the cryptocurrency is bitcoin (BTC) and is today a global currency, which consists of one hundred million Satoshis. It has a total estimated value of 15B USD and more than 200M USD worth of transactions are made daily [12]. Bitcoin is entirely decentralized and therefore no institutions are vital for its existence. Furthermore, there can only be 21 million BTC in existence, which will eventually lead to a deflation in value [9].

Following up on bitcoin's success, different applications using the blockchain technology have been developed in areas like digital asset management, online identification and file storage. It is the versatility of the technology that enables many areas of application. The Canadian technology theorist William Mougayar defines blockchain in three dimensions: technical, business and legal [7].

Technical Aspect

Blockchain can be viewed as a back-end database that keeps an openly distributed ledger [7]. The technology stores transactions in blocks which can not be deleted. Each block contains a timestamp and a link to the previous one which thereby forms a chain. Only by solving a cryptographic puzzle, a block can be added to

the chain. The nodes connected to the network work together to solve the puzzle and are then rewarded for it. In order to change an already occured transaction, the block it is in and every following block have to be replaced. New blocks are added continuously which makes transactions practically immutable after a short period of time. The distributed nature of the chain, as seen in figure 2.1, means that it is extremely reliable. Every node stores the entire ledger. A power outage or server crash will therefore not bring the entire database down with it.

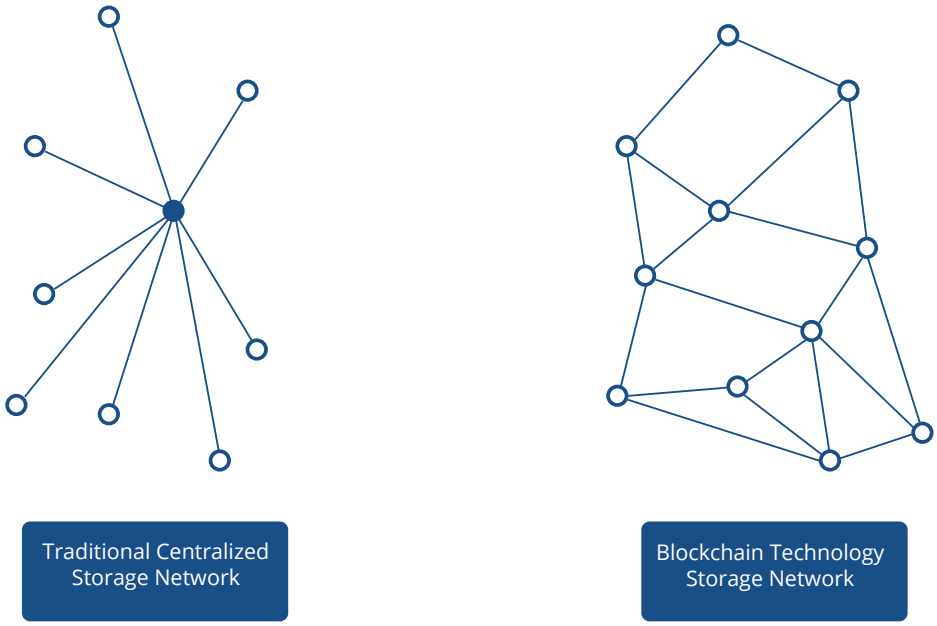

Figure 2.1: Centralised network vs blockchain network

Implementation of a blockchain can be done in different ways. The software is generally open source, but does not have to be in order for it to work. The content of the transactions can be encrypted in varying degrees. The existance of a transaction can be verified by anyone, but its contents can only be seen by those who have a key.

Business Aspect

Another way of looking at the blockchain technology is from the business aspect. Mougayar describes it as a network where exchange of value is possible [7]. A fundamental part of a blockchain is that no central institution is needed to make the transaction. Without intermediaries, a market can move freely, with lower costs and at a higher pace. The way old policies and modern companies, by being corporate, slows down market growth can thereby be avoided. For actors on the market this results in financial gain and less restrictions.

Legal Aspect

The legal aspect of the blockchain is all about the absence of need for trust. In today's society trust is expected between actors, which can be abused by intermediaries. A blockchain doesn't expect any trust from the actors. Instead, cryptographic proofs and decentralised databases are used to guarantee the integrity and security of the entire chain. It is practically impossible to fraud a blockchain due to actors having a bigger

incentive to help than to destroy. This makes a big blockchain network extremely trustworthy. The entire network validates every transaction, and thus an actor can trust any transaction that is on the chain.

Implications

In summary, the blockchain has five huge implications for the future of our society.

First of all, private rights of ownership can be protected through the use of immutable records. This means that individuals cannot be cheated out of their property and assets by corrupt intermediaries. Secondly, it enables an economy based on sharing. Today's "sharing" innovations such as Airbnb and Uber don't share their profits with the renters or drivers, they profit by aggregating. The aggregation services are not necessary on the blockchain and the profits go to the value creators.

The third implication is the end of profiting on transaction fees. Blockchains do have transaction fees, but these serve only the purpose of ensuring the security of the network. A transaction over the Bitcoin network, for example, costs orders less than the same transaction through Western Union. This leads on to the fourth implication. Creators of value are ensured compensation on the blockchain. Smart contracts can be created, and no middle men such as record labels are in control of a musicians' intellectual property, for example.

Finally, a blockchain enables citizens to own their data. The only way to access the contents of the transactions connected to you is by unlocking them with your private key. Therefore, you alone have control over who has access to your data. This ensures privacy for every individual actor. These benefits can be applied in areas where it has up until now been impossible, yet very important, to ensure privacy of individuals' data. One of these areas is the medical industry, where medical records and prescriptions must be private.

2.1.2 Medical Records

A medical record is a document where medical data, such as events, timestamps and notations, are stored. The purpose of medical records are to secure that the patient receives continuous care independent of where the patient is treated, as well as store information about which personnel have ordinated which treatment. [1].

Figure 2.2: Example of a physical medical record

The national patient overview (*sammanhållen journalföring*) allows any relevant medical personnel to access data regarding a patient's previous medical history. The medical data is only accessible by medical staff with a personal patient relationship wherein the healthcare staff personnel has been given full or part access by the caretaker.

Regulations of the Medical Records

What is being stored in medical records is in Sweden regulated by the law *patientdatalagen*. The law includes requirements on what information must be stored in the medical records as well as demands on how the data should physically be stored to ensure the patient's safety and integrity.

Patientdatalagen states that a medical record has to include the following:

- A way to identify the patient, usually name and social security number
- Notes on why the patient received care
- Notes about which diagnoses have been determined, descriptions of diseases as well as what examinations and treatments have been offered to the patient
- Notes about what information has been given to the patient, such as offered options regarding treatments and possibilities of new medical evaluations
- Notes on what medical staff personnel made the notes and when the notes were made
- Notes on the patient's medication and prescriptions.

The law also prohibits any personnel from altering or deleting data. An implication of the law is if a user makes an error in a medical record, the misinformation should not be deleted but noted as faulty and supplemented with the correct information.

The Patient's Rights

In general, it is within a caretakers rights to access its personal medical record. There are however exceptions, such as cases regarding specific categories of mental illness. In addition, the patient has the right to hide or delete parts or the entirety of the personal medical record by contacting the authority IVO, *Inspektionen för Vård och Omsorg*. When hiding information it still exists in the medical record and can be accessed by caregivers in case of an emergency. To delete the medical record the patient has to give specific reasons for the deletion as well as motivation as to why the medical record is not needed for future care.

Every time a caregiver accesses a medical record the patient has a right to be notified. The caregiver is responsible to regularly verify that only authorized personnel with legitimate reasons have accessed the medical record [14].

2.1.3 Problems with the Current Medical Record System

All Star Consulting Group has identified and analysed four problems, displayed in figure 2.3, and their main causes, with and within the current medical record systems. They are in no order of significance listed below.

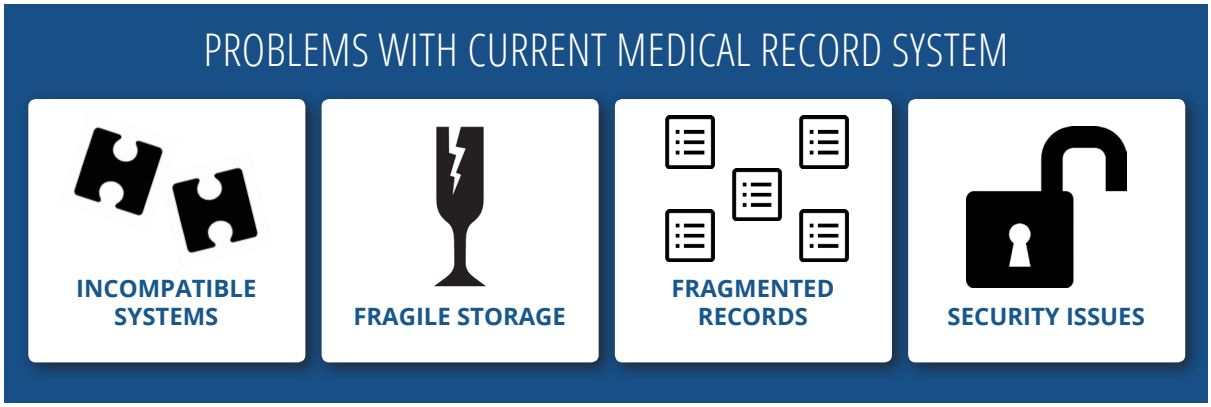

Figure 2.3: The problems with the current medical record system

Incompatible Systems

Some systems within the healthcare sector that are meant to communicate, have been found incompatible with each other. The reason is found to be deficient system engineering and expansion [13].

As well as incompability, the vast amount of the different systems, all with unique functionality, leads to a lot of time being spent on administration, e.g. finding the right system and migrating the right information at the right time. To exemplify, in Stockholm's administrative healthcare system there are as many as around

1600 different healthcare systems with different or sometimes overlapping functionality [5].

A larger number of connected systems within a single area of work also perpetuates fragmentation of data which can lead to data being forgotten within the different systems. Excessive abundance of discrete systems also entails lower redundancy and a bigger opportunity for system dysfunctionality [6].

Fragile Data Storage

There have been numerous cases where a centralized system has been proven highly vulnerable for disturbances [2] [8]. These disturbances often inhibit medical personnel from accessing vital patient information within the medical record systems. The system downtime also hinders the updating of patients' medical records, which greatly raises the risk of vital information not being properly recorded[11]. If one central server malfunctions, data could be corrupted or even destroyed[3]. Centralised systems also affect data management. If, or when, a patient wants to hide or delete certain information from his or her medical record, he or she has to contact every medical facility that stores his or her medical information [1].

Fragmented Data Records

In some instances, paper based medical records are still used today. These paper records are hard to track and keep updated. *Västra Götaland* county council describes how patient safety problems arise when further medical data records exists but are not known or found during treatment [10]. Keeping data at discrete and separated locations may lead to problems regarding updating information, i.e. information may expire because it is not updated properly. Locally storing medical record also makes information is less accessible by external parts, e.g. if a different clinic needs specific data from another medical facility. Even though *sammanhållen patientföring* aims to create a platform for sharing medical records between medical facilities, current systems using local storage of data vastly hinders and decelerates the rate of development. The slow and lacking accessibility of medical records are often cited as a significant patient security risk. Users often describe an *information gap* between data stored locally in paper records and data stored in a digital medical record system [10].

Security Issues

A common problem with nearly every database is its vulnerability against misuse from personnel of trust, such as administrators or super users. Misusing administration rights might enable a user to access, copy or alter information within the data storing systems. A few instances have been observed where medical records have been sold by users exploiting security deficiencies or system rights [4].

2.2 Solution

In this section we will describe how the problems identified in section 2.1.3 will be solved by implementing a blockchain based platform. First, the platform and its API will be described in detail. Second, analysis on how this solution solves the identified problems will be presented.

2.2.1 Proposed Solution

With the established problems regarding current medical record systems in mind, All Star Consulting Group proposes a solution based on introducing an platform using an API, *Application Programming Interface*, utilizing blockchain technology. The API will work as an interface towards which third party developers can create end user applications accessing and adding medical data stored on the blockchain. Users and the platform on which the medical record systems will be based on is pictured below in figure 2.4. Due to the end user applications being based on a closed API, it allows for continuous update and improvement of the platform. The technology also enables customers to successively actualize the platform by gradually implementing and adding current databases to the blockchain. The highlighted blue area in figure 2.4 marks what All Star Consulting Group will develop before implementation, while end user applications for medical records, accessible by healthcare staff personnel and patients, will be developed by a combination of All Star Consulting Group and third party developers.

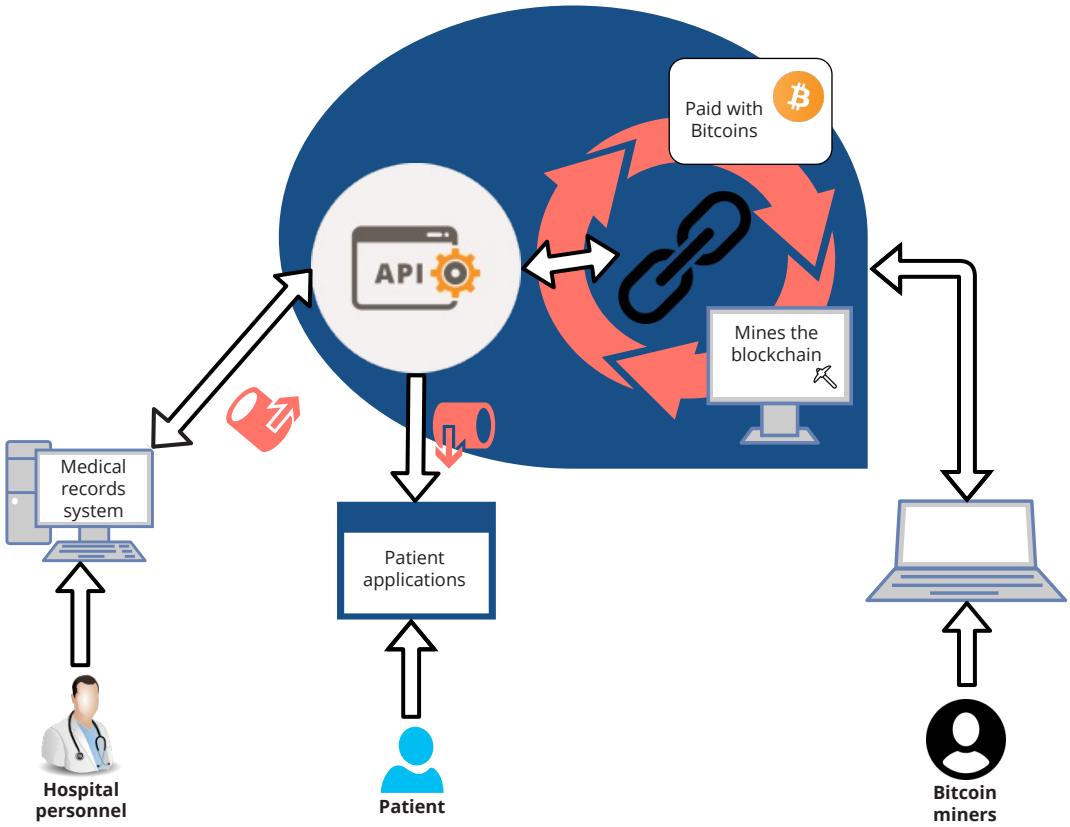

Figure 2.4: Chart describing the finished system's functionality.

The medical record database will utilize the same network as bitcoin. While using an *altchain* is a viable option, it requires a separate framework and infrastructure for mining the blockchain. Since using the Bitcoin blockchain enables the platform to utilize current mining infrastructure, it ensures higher level of security and lower implementation barriers. A consequence of adopting the Bitcoin blockchain is its transaction costs. These costs are reviewed in section 2.3.2.

The API will implement a framework for continuous monitoring and logging of all database access, enabling the patient to make sure no unauthorised personnel or individual views his or her's medical record. Having the API based on blockchain technology also makes sure all personal data is anonymized until the proper private key is used.

As the Swedish law *Patientdatalagen* dictates, no medical record data is permitted to at any point be deleted or edited. As a result of the way a blockchain is constructed, no information can possibly be edited or deleted, which is in accordance with law and guidelines. *Patientdatalagen* also states that certain information within a medical record can, at the request from the patient, be hidden or deleted from medical staff personnel. Even if information technically cannot be edited or deleted from the blockchain, data can be hidden or seemingly deleted by either granting a patient a new personal key, or by making an equal but opposite transaction removing its content. This way, the data is still stored in the blockchain but not accessible by default. Because the hiding process still requires a transaction, its existence is, unlike with normal databases, always documented and accessible in the blockchain.

2.2.2 Problems Solved by our Solution

Incompatible Systems

With all patient data storage systems using the same API, they can communicate using the same protocols and thusly problems with incompatibility are more easily averted. Despite many different third party developers will develop the end user applications, they will be more cohesive due to common architecture. This enables healthcare providers to create a more lean and communicative information ecosystem, reducing the amount of systems in use. In turn, a more efficient information system reduces user confusion and provides time reduction. Fewer integrated systems are also beneficial due to less cross platform dependency, thusly lowering the risk of incompatibility.

Fragile Data Storage

Using blockchain technology, data is stored and verified on all computers within the network rather than just one server. This collective storage and verification means if one computer in the network malfunctions, the data is not affected or corrupted. Even though personal data will be stored on all network nodes it will at all times be anonymized, and thereby the caretaker's integrity will be preserved.

Furthermore, using decentralised and collective data storing and verification means information will be available and directly distributed to all connected parts. This practically entails a patient only has to contact one connected part to access or revise all relevant personal data.

Fragmented Data Records

Since the data will be stored on the blockchain, it neither requires nor encourages any sort of physical storage. Moving away from physical storage solutions helps in regards to instant data updating (no risk of data expiring), more aggregated instantly accessible data and overall making the personal data records more accessible to caregivers.

Security Issues

Due to the platform being based on blockchain technology, information cannot be altered or deleted unless more than half of the accumulated network computing power decides to. Accumulating more than half of the computing power of the entire Bitcoin network is impossible. This also prohibits administrator or super user rights from being used against the protocol in damaging purposes. Albeit deletion restrictions, information can be hidden in accordance to current patient data record laws by creating new personal keys or using reverse transactions as described above.

2.3 Financial and Risk Analysis

The following section will describe the financial implications of the project as well as potential risks and recommendations on how to manage these. First, potential costs savings will be calculated. Second, costs related to the platform will be calculated. Third, development of costs and savings over time will be presented. Fourth, potential risks and their impacts will be identified and valued. Fifth, recommendations on how to manage these risks will be presented.

2.3.1 Cost Saving Analysis

Figure 2.5 below is taken from a McKinsey report named *The value of digital technology in Swedish healthcare*. What the chart illustrates is how cost savings in the Swedish healthcare sector could be realized by investing in different types of digitalization areas.

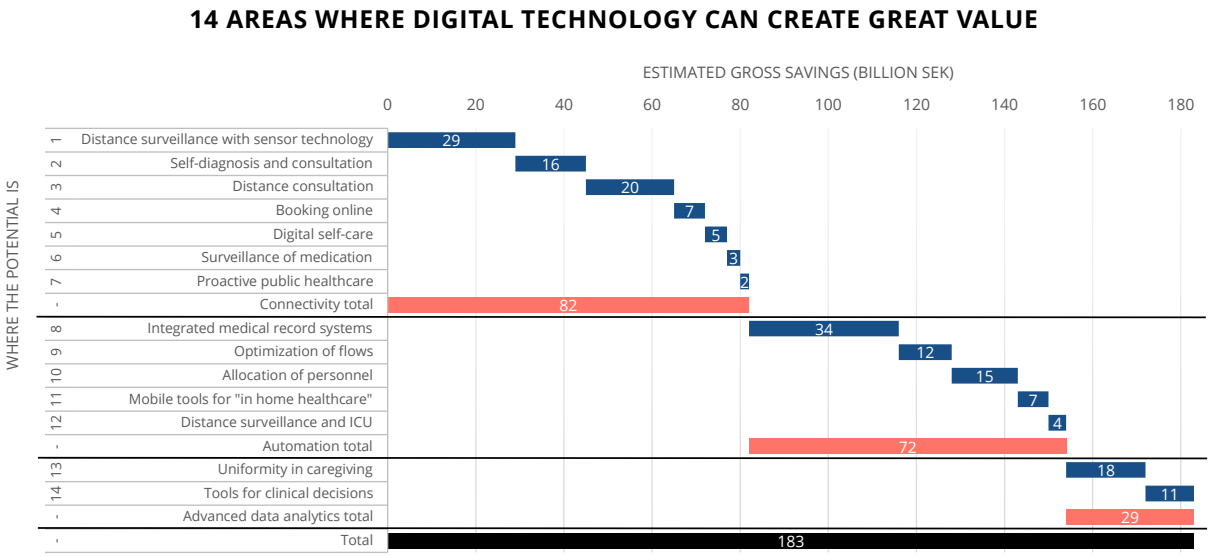

Figure 2.5: Chart showing potential cost savings over ten years in the healthcare sector.

McKinsey identifies *Integrated medical record systems*, number 8 in figure 2.5, as the factor with the highest level of possible cost reduction, specifically 3.4B SEK per year over the next ten years. The findings in this report correlate well with the problems and solutions All Star Consulting Group proposes. The proposed solution also manages problems found in number 6, *Surveillance of medication*, where McKinsey identifies fragmented medical records as the major cause of medication errors and costs related to mismanagement. Independent studies performed by the Swedish government also strengthen McKinsey's claims, approximating cost savings regarding *Surveillance of medication* to 0.5B SEK instead of 0.3B SEK mentioned in the report from McKinsey.

Due to the fact that the platform along with any medical record application directly addresses these issues, it is estimated the proposed blockchain solution will generate cost savings of 50 to 60 percent of the costs related to 6 and 8 in figure 2.5. The estimation equals cost savings between 1.9B SEK to 2.2B SEK per year,

leaving between 1.5B SEK to 1.9B SEK to be realized by third party applications.

In addition, the solutions also provide the basis needed to realize number 11, *Mobile tools for "in home healthcare"*, due to its requirement of accessible, digitized medical records. We calculate savings of around 25 percent of the 0.7B SEK per year in area 11. The rest of the cost reduction will be realized by third party applications. As a result, our blockchain solution creates 175M SEK per year in savings and a potential 525M SEK by third party applications.

Number 13, *uniformity in caregiving*, and 14, *tools for clinical decision support*, both require extensive data about patients on an aggregate level. McKinsey mentions a required big data analysis, made difficult in the current defragmented medical records systems. Our solution provides the potential to execute the aggregated analysis. As a result, 7 to 13 percent of the potential savings in these areas could be realized. From the aggregate of *Total of advanced data analytics*, calculated to 2.9B SEK per year savings, it is estimated the proposed solution would realize between 203M SEK to 377M SEK per year, leaving between 2.3B SEK to 2.8B SEK to third party applications.

As seen in figure 2.6, these areas of cost reduction result in an aggregate of between 2.2B to 2.8B SEK directly related to the blockchain platform. Plus an additional aggregate of between 4.5B to 5.1B SEK from third party applications, depending on how much value is created directly by the platform.

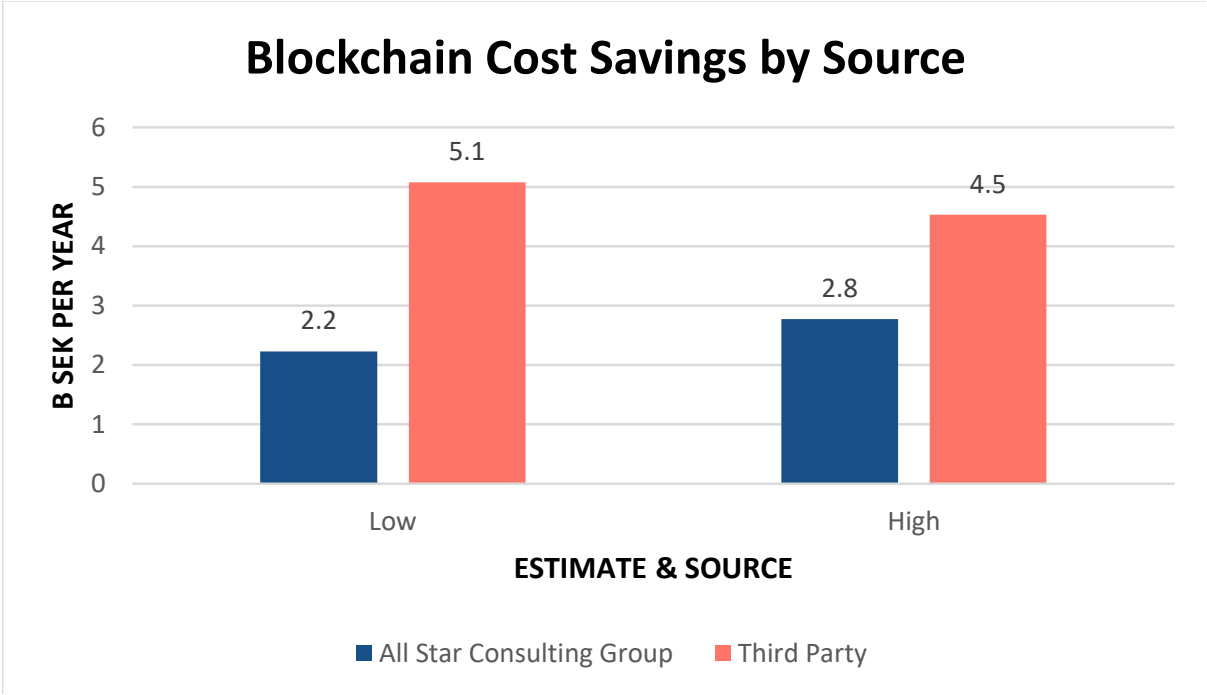

Figure 2.6: Chart showing aggregate cost savings made possible by blockchain.

It is highly plausible that our solution also provides a good basis for third party developers to solve more problems than those discussed in this report. It is likely that we could relate some of those savings to our platform, although we estimate that the effects would be negligible.

2.3.2 Cost Analysis

The majority of costs established by the project are related to transaction costs on the Bitcoin network. Every transaction registered on the Bitcoin network and confirmed by miners requires energy in order to be performed. As a compensation for the energy cost, the miners receives an amount of newly created, mined, bitcoins, as well as capital from transaction costs. As the number of bitcoins approaches the fixed *bitcoin limit*, an increasingly larger part of the reward comes from transaction costs.

Every time medical personnel accesses or updates a medical record, a transaction is performed, and thereby a transaction cost arises. The transaction cost is thus a result of two conjoined factors:

1. Number of times a medical record is updated
2. Transaction cost of each transaction on the Bitcoin network

The transaction cost can in turn be derived from the following factors:

1. BTC to SEK exchange rate
2. Current strain on the network
3. The size of the transaction (in bits)

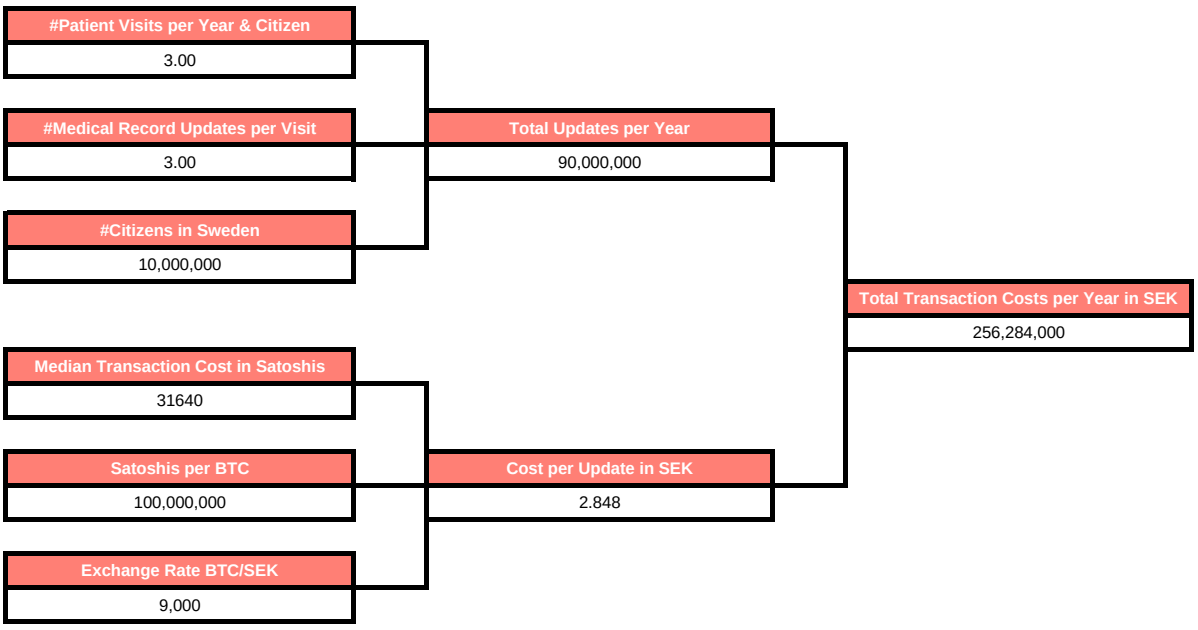

Figure 2.7: Estimated transaction costs on the network

As shown in the calculations from figure 2.7, the cost of a transaction will increase in proportion to the number of users adapting to the platform. Assuming the current 3 medical visits per citizen and year remains stable, and our estimate of 3 medical record updates per visit are correct, transaction costs will increase to roughly 256M SEK per year, at current exchange rates.

Costs related to implementation and switching to the new platform are expected to be approximately 300M SEK in the first year, including costs related to development of the platform. As the growth of the platform is expected to be very high during the consecutive two years, predicted implementation costs reach its peak in 2019, ensuing decay to solely maintenance costs by 2022.

Maintenance of the system is expected to start as soon as the project launches and increase rather slowly with adaptation to the new platform until it reaches approximately 100M SEK per year.

2.3.3 Project Financial Impact

Determined by the cost and cost savings analysis presented above, a net cost savings analysis is presented below.

Costs and Savings (MSEK)												R=20
	TREND	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Total
Cost savings through 8 and 6		150.00	375.00	1312.50	2122.00	2150.00	2170.00	2180.00	2190.00	2195.00	2220.00	17064.50
Cost savings through 11		0.00	10.00	19.00	36.10	68.59	130.32	175.00	175.00	175.00	175.00	964.01
Cost savings through 13 and 14		0.00	22.00	46.20	97.02	203.74	377.00	377.00	377.00	377.00	377.00	2253.96
Transaction costs on the network		-17.32	-43.30	-151.55	-256.30	-256.30	-256.30	-256.30	-256.30	-256.30	-256.30	-2006.27
Implementation and switching costs		-300.00	-456.00	-500.00	-310.00	-192.20	0.00	0.00	0.00	0.00	0.00	-1758.20
Maintenence		-50.00	-50.00	-75.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-875.00
Net savings		**-217.32**	**-142.30**	**651.15**	**1588.82**	**1873.83**	**2321.02**	**2375.70**	**2385.70**	**2390.70**	**2415.70**	**15643.00**
NPV		**-217.32**	**-118.58**	**452.19**	**919.46**	**903.66**	**932.77**	**795.62**	**665.81**	**556.00**	**468.18**	**5357.77**

Figure 2.8: Net savings related to the platform.

According to our projections, the project will result in net savings of 15.6B SEK over a ten year period and a net present value of 5.4B SEK, assuming a discount rate of 20 percent.

We expect savings related to areas 8, *Integrated medical record systems*, and 6, *surveillance of medication*, to be realized initially as they are directly and immediately achieved by adopting the platform. These savings

will keep growing as new caregivers adapt the platform. Ultimately, the savings are estimated to grow by 250 percent from 150M SEK in 2017 to 375M SEK in 2018 as early adopters adapt the platform. The mainstream caregivers are estimated to begin adaptation roughly 1.5 years after launch with a 350 percent growth in 2019 and a 61 percent growth in 2020. The laggards, in this case smaller care centers, are expected to realize cost savings approaching the maximum expected savings of 2.2B SEK in 2026, 10 years after launch.

Savings related to 11, *mobile tools for in home healthcare*, are expected to begin realization in 2018 as innovative firms develop third party applications using our platform. Growth in the area is relatively uncertain but estimated to 90 percent per year as demand rises within the public. We estimate the savings related to our platform to cap out at an estimated 175M SEK per year in 2023, 5 years after launch.

Cost savings related to 13, *uniformity in caregiving*, and 14, *tools for clinical decision support*, are related to the use of data analysis tools on the platform. These are expected to start occurring as enough data is transferred to the platform. Our estimation is in 2018. We predict that the savings related to our platform in areas 13 and 14 will steadily double every year as further data analysts adapt to the platform. The cost savings related to implementation of our database are expected to stagnate after five years as the majority of patients by then are predicted to be registered on the platform.

Costs and Savings from Third Parties (MSEK)											R=20
	TREND	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Total
Cost savings through 8 and 6		100.00	250.00	875.00	1414.67	1433.33	1446.67	1453.33	1460.00	1463.33	1480.00	11501.33
Cost savings through 11		0.00	30.00	57.00	108.30	205.77	390.96	525.00	525.00	525.00	525.00	3010.03
Cost savings through 13 and 14		0.00	147.23	309.18	649.29	1363.50	2523.00	2523.00	2523.00	2523.00	2523.00	15157.21
Development		-100.00	-200.00	-300.00	-500.00	-400.00	-350.00	0.00	0.00	0.00	0.00	-1751.00
Maintenance		-20.00	-40.00	-50.00	-60.00	-100.00	-150.00	-150.00	-150.00	-150.00	-150.00	-917.00
Net savings		**-20.00**	**187.23**	**891.18**	**1612.25**	**2502.61**	**3860.63**	**4351.33**	**4358.00**	**4361.33**	**4378.00**	**27000.57**
NPV		**-20.00**	**156.03**	**618.88**	**933.02**	**1206.89**	**1551.50**	**1457.25**	**1216.24**	**1014.31**	**848.49**	**8982.60**

Figure 2.9: Cost savings related to third party applications.

The table in figure 2.9 displays the estimated cost savings within the healthcare industry in Sweden from third party applications adapting to the platform. The third party cost savings are derived in similar practice to the cost savings related directly to our platform. We predict the project will result in net savings of 27B SEK over a ten year period and a net present value of 9.0B SEK related to third party applications.

In conclusion, the project is by our estimations valued at a NPV of 5.4B SEK directly through our platform and an additional 9B SEK through third party applications. Altogether resulting in a total NPV of 14.4B SEK. Net savings through our platform are estimated at 15.6B SEK as well as an additional 27.0B SEK from third party applications, collectively resulting in total net savings of 42.6B SEK over a ten year period.

2.3.4 Risk Analysis

As these calculations contains predictions on future growth and costs, numerous risk elements arise. Figure 2.10 illustrates how changes in costs, savings or discount rate affects the NPV and pay back time of the project.

Potential Outcome in Different Scenarios		
Scenario	**NPV in M SEK**	**Payback Time in Years**
Prognosis	5357.77	2
Doubled Costs	2864.18	3
Half the Savings	1432.09	3
Double Discount Rate	2332.36	2
Worst case	-1390.91	4

Figure 2.10: Risk analysis for various scenarios regarding the project

The *doubled costs* in the analysis presented in figure 2.10 are achieved when doubling the cost of implementation, maintenance and transaction. The cost increase could, for instance, illustrate a collapse in the SEK/BTC exchange rate in combination with implementation delays. Such events would cause a double whammy where both transaction costs and implementation costs may double simultaneously. The risk of the two events in occurring simultaneously is by our accounts minute, but still a justified risk factor. Uncertainties around the SEK/BTC exchange rate could possible lead to the government, in order to reserve costs for transactions, purchasing the amount of BTC required for the accumulated transaction costs of the entire period at the current exchange rates. Such action could hedge the risk of ever increasing exchanges rate away.

The risk of only being able to realize half of the estimated savings may occur if the fore-casted savings estimates from the Swedish government and McKinsey are fundamentally over-exaggerated. Another risk cause could be due to slower adoption to the platform than anticipated. The resulting effects would greatly affect the projected NPV but still provide sufficient positive returns to be an attractive investment.

By accounting for unanticipated risks and adjusting the discount rate to 40 percent the NPV is roughly halved. Despite this, the project is ultimately still an attractive investment. In the event of all three risk factors impacting the project simultaneously, the project would not be profitable and yield a negative NPV of 1.3B SEK. While improbable, the mentioned risk scenario still has to be considered. However, since costs related to transaction costs and maintenance grow in proportion to the savings, a cancellation of the project could be made at any point in time if negative indications start to show, limiting the negative effects.

In conclusion, the proposed project is an attractive investment in all scenarios but under conditions of extreme cost increases and savings reductions. If such improbable event would occur, early indications would enable the project to cancel without further implications. Worth noting is that the risk analysis do not include value or savings from third party applications. These factors have an accumulated potential of 5B SEK in annual savings. Accounting for the third party savings and value, the project emerges as a profitable investment even under *worst case* conditions. All things considered, we firmly consider the project an exceptionally lucrative investment.

2.3.5 Managing the Risk

In order to manage risk, a *probability/impact* matrix is devised. The matrix aims to identify probabilities of risks and their respective consequences. On one axis, the probability of an occurring event ranges from low to high. On the other axis, the impact of the probable event ranges from low to high. With an event nearing the top left, more action is required in order to control the risk.

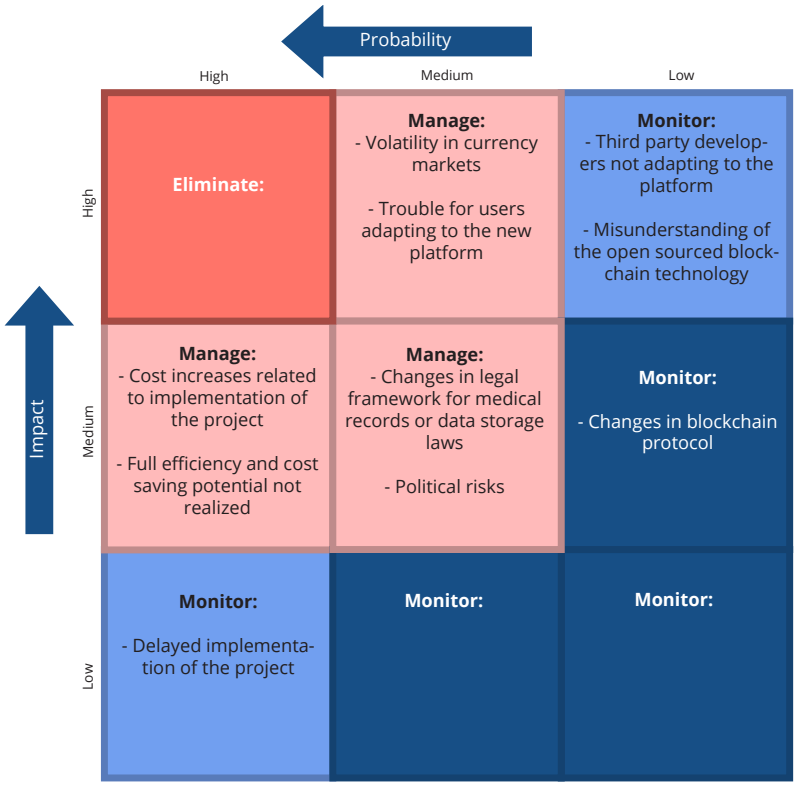

Figure 2.11: Risk matrix displaying potential threats for the project

Since the risks regarding costs and savings potential found in the lower left boxes in figure 2.11 are handled in section 2.3.4, further analysis on these are superfluous. Further explanation on the remaining risks in the figure are presented below.

Volatility in Currency Markets

Since the transaction costs are dependant on the BTC exchange rate, variations in face value have a significant financial impact on the value of the project. To counter this, we recommend having the government hedging the risk by buying enough BTC to cover at least five years of transaction costs. The purchase would result in an initial investment of roughly 1B SEK, justifiable given the value volatility of bitcoin.

Trouble for Users Adapting to the New Platform

Launching a new platform with complimentary new end user interfaces always introduces the risk that the user face trouble navigating and using the new systems and applications. To minimize the risk, it is crucial that developers handles feedback and testing on real healthcare staff personnel correctly. This way, the risk of launching a superfluous platform is significantly reduced.

Third Party Developers not Adapting to the Platform

With third party development of end user interfaces, the risk of developers not wanting to adopt our platform to store data when designing new applications arise. We consider such a risk to be comparatively small due to the total added value of being part of the platform. To further motivation for third party developers, it is crucial that our development team respects third party developer needs and demands, creating a healthy platform with symbiosis between back-end and front-end developers.

Misunderstanding of the Open Source Blockchain Technology

Although utilizing the Bitcoin blockchain to store data is very secure, it may seem counter-intuitive and uncertain to unfamiliar individuals. Since the code and protocol is *open source*, i.e. available for everyone, and the bitcoin in some regards is considered as a safe haven for criminals, public opinion may be somewhat unfavorable for the technology. Despite this, we consider the risk considerably minute as nowadays trends show both bitcoin and blockchain technology has become increasingly accepted. For instance, the technology is already in use by many financial institutions. While the trends are moving in the right direction, it is still important that the benefits of blockchain technology is communicated properly to the public to avoid misunderstandings and determent.

Changes in Legal Framework and Political Risk

Due to the medical and medicine sector being highly managed by strict laws and regulations, it is important that the platform keeps up with current laws and guidelines and manage these with good example. The risks of changes in laws and regulations are considered fairly predictable and the platform will most likely be able to adapt accordingly.

Changes in Blockchain Protocol

The blockchain protocol is always evolving and it is important that the platform stay up to date with forthcoming changes. This is also a fairly predictable risk and adaptation, if needed, is considered to be relatively simple as long as it is monitored carefully.

RISKS WITH DOING NOTHING

If the Swedish healthcare sector decides not to update its medical data record practice, billions SEK of tax-payer money will go to waste every year due to inefficiency and alternative costs. Using old storage practises proven vulnerable for user error and technical failures also significantly heightens risking patients health and lives. Due to both the monetary and patient safety gains from implementing our platform, it ought to be considered a high priority.

2.4 Project Plan

In this section, a detailed description of the implementation process of the platform is presented. First, pre-implementation will be described. Second, actual implementation will be described along with a proposed employment schedule.

2.4.1 Pre-Implementation

Platform Specification

As specified in section 2.2.1, *Proposed Solution*, the initial step of actualizing the project is consulting with experienced medical staff regarding possible missing or misinterpreted functionality. The step is crucial, ensuring highest quality possible is delivered to the medical staff personnel utilizing the system. Platform requirements from end users could favorably be detailed through workshops with experienced medical staff, as well as follow-up studies.

Development

When project requirements have been specified, development of the platform can be initialized. The blockchain and the API will be tested by the developing team continuously during the development to secure errorless and expected functionality. The end user applications developed using the API are mainly meant to be developed by third party developers. To guarantee essential day one functionality, selected end user applications will developed in-house. These first party applications will also be used to test, evaluate and demo the platform.

During finalization stages, the platform and a few end user applications will be piloted at two to three selected hospitals and care centers. This way, platform functionality is confirmed to work as intended before full scale implementation. Testing the platform at two or three medical institutions is required in order to evaluate parallel usage as well as integration between different institutions. If bugs are found or functionality is missing, the software will be updated and the new version will be assessed. This process, called *beta testing*, will continue iteratively until the platform matches the specification. During the beta testing, the new platform will run in parallel with the old medical record system.

2.4.2 Implementation

After the beta testing is completed, a full scale implementation can be initialized at all hospitals and health centers in Sweden, starting in Stockholm's county council. This stage of the project intends to make the transition from the old databases and interfaces into the new one as seamless as possible. The steady transition also ensure no data is lost during the process. The transition process for each hospital or care center is planned to require four weeks. Platform integration at hospitals is estimated to on average require ten consultants while implementation at care centres on average requires two consultants. To avoid loss of data, both the old systems and the new platform will run in parallel for a projected two weeks. During the two weeks the

new platform will be installed and the users will be educated using it. Training of the users will be performed by consultants from All Star Consulting Group and the experienced medical staff personnel who participated in designing the platform in the initial workshop. The cooperation setup intends to reduce the medical staff's dependency on the consulting firm and at the same time facilitate training jointly with experienced medical staff. After the two weeks of implementation, the new platform will *go live* and replace the old ones. All Star Consulting will monitor the platform's performance for an additional two weeks, while also functioning as a resource for further training.

All Star Consulting Group currently employ approximately 100 consultants. In Stockholm county council there are nearly 250 care centers and 33 hospitals. In summary, implementation in Stockholm county council will last 9 months, as seen in figure 2.12. After implementation in Stockholm county council is completed, implementation in Västra Götaland county council will initialize, approximately lasting 5 months. The third implementation push aims to implement the platform in Skåne county council, lasting 4 months. Thereafter implementation in the remains of Sweden begins, lasting 14 months.

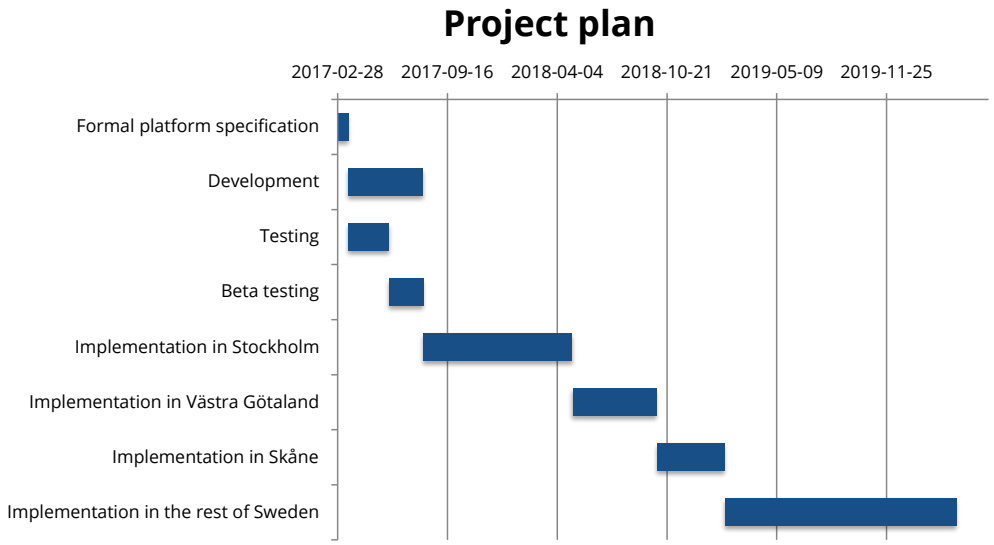

Figure 2.12: Gantt chart for the project.

Figure 2.12 describes the duration of each phase with respect to the time dimension of the project. The chart enables the project managers at All Star Consulting Group to make sure the project is unfolding as planned, but also allows the customer an insight to the project planning. Formal platform specification will last an estimated three weeks, including workshops with experienced users and the result analytics and translation. The development phase, including testing and beta testing, is estimated to last five months, ensuring the delivery of a fully functioning system. After the platform is completed, it will be implemented in all of Sweden, starting in Stockholm, Västra Götaland and Skåne.

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