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We, the undersigned members of the above Project Group, collectively and individually certify that the above Project Deliverable, as submitted, **is entirely our own work**, other than where explicitly indicated in the deliverable documentation.

INITIALS	SURNAME	GIVEN NAME	STUDENT NUMBER	SIGNATURE (IN-PERSON OR DIGITAL)
<i>FT</i>	<i>Tesoriero</i>	<i>Flynn</i>	<i>45621365</i>	<i>Flynn Tesoriero</i>
<i>SM</i>	<i>Mishra</i>	<i>Shivansh</i>	<i>45854319</i>	<i>S MISHRA</i>
<i>IL</i>	<i>Lee</i>	<i>Isaac</i>	<i>45526249</i>	<i>LZJ</i>
<i>MN</i>	<i>NAQVI</i>	<i>Maham</i>	<i>45559708</i>	<i>Maham Naqvi</i>
<i>SK</i>	<i>Kamath</i>	<i>Smriti</i>	<i>44489935</i>	<i>Smriti Kamath</i>
<i>MP</i>	<i>Pavlov</i>	<i>Mikhail</i>	<i>43659691</i>	<i>MikhailPavlov</i>

NB: please write all details clearly (if handwritten).

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List of tasks completed for the deliverable and activities since last deliverable certificate with totals for each individual team member and whole team *(copy individual total row for each member and copy pages if more pages needed)*

Performed by <i>(Student Names)</i>	Duration <i>(hrs)</i>	Comple xity <i>(L, M, H)</i>	Name of task	Checked by <i>(Initials)</i>
Everyone	2	M	Met with team (25th Feb)	SM
Everyone	2	M	Met with IBM (26th Feb)	SM
Everyone	2	M	Attended team training (4th March)	SM
Everyone	1.5	M	Met with IBM, discussed high level project info/goals (5th March)	SM
Everyone	1.5	M	Met with IBM, discussed UI & backend basics (9th March)	SM
Flynn Tesoriero	1	M	Created document skeleton, formatted content	SM
Flynn Tesoriero	2	H	Worked on Problem Identification Section	SM
Flynn Tesoriero	2	H	Worked on Opportunities Section	SM
Flynn Tesoriero, Mikhail Pavlov	1 0.5	H	Worked on Mandates Section	SM
Shivansh Mishra	1	H	Worked on Success Factors	FT
Shivansh Mishra	1	M	Worked on Current Situation	FT
Maham NAQVI	1	M	Worked on Introduction	FT
Maham NAQVI	1.5	H	Worked on Recommended Solution	FT
Maham NAQVI	1	M	Worked on References, Abbreviations and Assumptions	FT
Smriti Kamath	2	M	Worked on Benefits (Tangible)	FT
Smriti Kamath	2.5	M	Intangible benefits	SM
Smriti Kamath	0.5	L	Referencing	SM
Isaac Lee	1	M	Worked on Alternate Solutions	FT
Isaac Lee	3	M	Worked on the advantages and disadvantages on Alternate Solutions	FT
Isaac Lee	1	M	Worked on References, Abbreviations and Assumptions	FT
Maham NAQVI, Mikhail Pavlov	1.5 1.5	M	Edited, rephrased, and formatted different sections of the report to allow a uniform flow of ideas	SK
Flynn Tesoriero	2	H	Researched problem, opportunities and mandates	SM
Flynn Tesoriero	0.5	M	Ensured team tasks allocated and team communication	SM
<i>Isaac Lee Total</i>	14			
<i>Shivansh Mishra Total</i>	11			
<i>Flynn Tesoriero Total</i>	17.5			
<i>Mikhail Pavlov Total</i>	11			

<i>Maham Naqvi Total</i>	12	
<i>Smriti Kamath Total</i>	14	
Team Total	79.5	

Sankofa: A blockchain-based healthcare architecture platform

Feasibility Study

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1 - Introduction

The purpose of this Feasibility Study Report is to define the problem domain of the IBM Sankofa Healthcare Framework (SHF) project and to understand thoroughly all aspects of the proposed project. This study report will identify any potential problems that may occur while implementing the project and determine if, after considering all the significant factors like strategic, economic, technical, operational and planning factors, the project stands viable—that is, worth undertaking.

In this Feasibility Study Report, we will discuss the issues that the project aims to address and rectify, the opportunities and the resources available, the requirements and constraints subject to the implementation of the project, and the expectations needed to be achieved in order to consider the project as a success. Recommended solutions and other alternative solutions are devised and suggested in light of their respective advantages and disadvantages in order to accomplish the objectives of the project and to make it feasible, cost-effective and profitable as desired.

1.1 - Problem Identification

Data security and privacy are critical and topical issues, especially in the healthcare space. Given the sensitive nature of healthcare data, it is essential that privacy and security can be guaranteed. Healthcare data can include any data related to patients, such as physician notes, diagnoses, immunisation history and other sensitive medical records.

A number of issues arise when trying to protect access to this data both inside and outside an organisation, as well as ensuring granular access control to the data. Traditionally, data sharing between healthcare organisations has been limited, resulting in data that has poor timeliness and may be redundant. Often healthcare providers maintain their own systems and infrastructure for storing patient information. This fragmentation of information and systems leads to a security risk, as each healthcare provider maintains its own security policies and systems, resulting in more attack vectors for software bugs and securities holes to compromise patient data privacy. This issue is compounded when data is shared between a number of parties, such as other healthcare providers, government healthcare systems, private practices and other organisations. Ensuring data security and controlling access to information between organisations and systems becomes a challenging task, as different systems and protocols must be linked together, exposing the systems to security holes. Further issues arise around validating the accuracy of healthcare data. A topical application of this problem is the tracking and verification of COVID-19 vaccinations.

The Sankofa Healthcare Framework (SHF) project seeks to solve these problems through a software product. At its core, the project seeks to provide a single framework for the secure sharing and storage of healthcare data between many parties. The project shall allow identity access management (IAM) with granular data access permissions to ensure that users can only view, change and delete the data they are permitted to. By leveraging blockchain technology, the project shall also be scalable and decentralised to ensure absolute reliability and resilience. By providing a platform for sensitive healthcare data to be shared, the project aims to promote greater transparency, security and ownership of data

between healthcare providers and their patients. Specifically, the SHF project has a focus on providing a means of tracking the COVID-19 vaccine rollout. By providing a secure and verifiable means of tracking who has received the vaccine, the project seeks to offer a system of verifying if a patient has received the vaccine.

By solving the problems identified above, the SHF project aims to overcome the fragmentation and security flaws of current healthcare information systems by providing a single source of information that is both open and transparent, as well as secure and resilient.

1.2 - Opportunities

A number of opportunities have converged that have given rise to this project. These opportunities include the development and rise of blockchain technology, the global demand for healthcare solutions especially amidst the current COVID-19 epidemic, and the network of partners that IBM possesses, in both business and academic circles.

A key opportunity available to the project is the use of blockchain technology. Blockchain is the core component of cryptocurrencies such as Bitcoin and is poised to make a profound impact on software development over the coming decade [1]. Bitcoin is an open and distributed ledger technology that allows transactions between two parties to be recorded in a way that is efficient, verifiable and permanent [2]. Blockchain is distributed across several locations or among multiple participants around the world, meaning no single party controls the information stored within the database. When new data (transaction) is to be recorded, the communication occurs directly between two parties before being verified and replicated across to the other nodes on the blockchain. Records on the blockchain are irreversible, meaning once they are created they cannot be deleted or altered. Furthermore, all transactions on the blockchain are visible to anyone with access to the system, which provides transparency and assurance to those on the network. Blockchain technology presents an opportunity for this project as it helps solve a number of issues identified in the *Problem Identification* section of this study. The technology helps solve the issue of intercommunication between many different parties, such as healthcare providers and the government, by providing a singular trusted protocol. Blockchain also solves the issues around ensuring data validity, trust and transparency through its transparent and distributed nature. As records in the blockchain must be verified by other nodes on the network, the integrity of the data is ensured. This is bolstered by the fact that data cannot be deleted or modified on the blockchain.

As a result of the COVID-19 global pandemic, the increased demand for secure, efficient and reliable healthcare information-sharing technology also presents an opportunity for the project. The pandemic has brought to light the difficulties in handling and sharing healthcare data between different parties, which has sparked demand and interest in solutions that can solve these problems. This particularly applies to tracking the rollout and recipients of the COVID-19 vaccine. Tracking the rollout and recipients of the vaccine carries a number of issues, such as:

- Ensuring the security of stored data,
- Checking the validity of entered data,

- Maintaining the security of the datastore,
- Verifying the accuracy of the data, and
- Allowing input of data from a number of sources and partners.

This project is well suited to solve many of the issues listed above, presenting an opportunity to meet the demand for a secure, efficient and reliable healthcare information-sharing system.

Another opportunity available to the project is the huge network of professional contacts available to IBM. Through its years of experience and a convenient network of business partners, IBM can use the opportunity and resources to bring the tools, knowledge and trained technical people required to solve complex problems that might be faced throughout the project. The project can hence leverage this network and experience to achieve greater success and better solve the task at hand.

1.3 - Mandates

The project has been designed and pitched as an 'evolving' body of work, meaning that it will be released and continuously updated and improved by future teams and the open-source community as per the requirements. This is especially relevant as the project's goals are broad and ranging.

In spite of this, the current COVID-19 global pandemic and the subsequent vaccine rollout presents a key opportunity to apply the project in a specific manner. Nevertheless, there are no rigid mandates imposed on this project, especially given its evolving and broad scope.

However, the concept of COVID-19 vaccine-related restrictions are at the forefront of many businesses and governments around the world in efforts to restart activities safely. For example, airlines may make COVID-19 vaccinations mandatory for travellers looking to fly overseas and education bodies could enforce teachers to be vaccinated before re-entering the classroom.

The open-source, security centred nature of this project means that it is a viable candidate for fulfilling the role of being a vaccination passport that could be used to demonstrate having received the vaccine while also alleviating many of the concerns that arise if the platform that performs this role is closed source.

2 - Success Factors

There are a number of components that can result in the efficient implementation of the SHF COVID-19 Vaccine Tracker. These are listed below:

- 1) *Data Security*, which will be managed by the Security team. In order for this project to be a success, it is essential that the patients' data is stored safely and is only accessible through identity access control and management (IAM) which allows users to view and edit certain parts of the data, more importantly, only the parts they

are permitted access to. It is also necessary that only the trusted parties like the Hospitals, Schools, Immigration Departments, etc are able to access a patient's records and in order to achieve that, the patients will be needed to sign an agreement waiver that enlists those trusted corporations and asks for patients approval for sharing personal health records. This factor will need to be completed before the project is launched for the common public.

- 2) *Leadership and Management* of this project also plays a very important role in it being a success. This can be accomplished by nominating a leader from each of the six teams that can report directly to the mentors from IBM at the end of each week with all essential updates. This would facilitate effective communication with the vendor that will allow the project to be up to date with the required specifications and therefore be a success.
- 3) *Acceptance* towards the platform is a significant key to the project because organizations and common people are required to register themselves on the platform in order to be able to access the healthcare data. This can be achieved by creating a user-friendly application that is easily navigable and accessible to the user as it is well-integrated. The assigned UI team and the API team will be responsible and will need to work together to achieve this component before the application is officially launched.
- 4) *Support from Medical Institutions and Healthcare Organisations* is crucial to allow a hassle-free transfer of patient records between different parties. This can be achieved by establishing trust of the healthcare departments with the proposed system framework and by providing them with a secure, simple and well-integrated UI.
- 5) *Staying up-to-date with rapid technological development* is also significant to allow easy integration of the product. All members of the project will need to be well informed with the latest technologies in order to produce a platform that is credible, highly efficient and safe from any potential vulnerabilities. All six teams will need to work together to achieve the desired goals of the project well before the deadline (Week 10) in order to be able to test the system efficiently before submitting the product to the sponsor.
- 6) *The Scalability* of the system under development is also necessary as the SHF platform may need to be deployed across various locations around the world in order to address the global nature of the COVID-19 epidemic. A scalable system will also ensure that the framework developed can easily be utilised for all vaccinations needed to be tracked in future.
- 7) *High efficiency* of the system is mandatory to allow the project to be feasible. This will require the system to be accessible at all times when needed, with fast response times and a low system error rate. The system developed will need to be highly effective, have an intuitive UI, and a high storage capacity database.

3 - Current Situation

Currently, the world is fighting against a deadly COVID-19 epidemic that has lasted for over a year and has caused high death charts across the world. Many organisations and companies are now working diligently to develop an effective vaccine against the life-threatening virus that can help eradicate the global issue. With regard to these efforts, IBM has delegated a number of teams to work in collaboration and develop a framework that would help different organisations track and verify COVID-19 vaccinations. This project seeks to provide a system that can address the gaps in the intercommunication between Healthcare systems and provide varying levels of granular access to the sensitive medical data to various parties.

With the current global issue at hand, this desired technology is certainly a mandatory need to allow the organisations to be able to verify and track if every person has been vaccinated or not. In the future, this system framework can be further rescaled to all kinds of vaccinations and programs, for example, educational institutions can use the system to check whether a student has been vaccinated before admitting them into the educational premises.

Throughout the discussion with the IBM sponsor team, it has been revealed that the six PACE teams will work in collaboration to develop the UI/UX, and the API, to mitigate the data breach vulnerabilities by deploying blockchain technology in the design and development of the proposed system.

4 - Benefits

4.1 - Tangible Benefits

- New products and services and who would benefit from them
 - Data security for transferring and storage of highly confidential and important health care data using blockchain and granular data access permissions with multiple users.
 - Benefits can include but are not limited to:
 - Universities will be able to operate smoothly and securely as they will have assurity that their information on a student is correct as it is coming directly from the source and a third party is verifying the information. Making it easier to conduct larger classes in a covid-safe environment.
 - Companies can potentially use the platform to streamline the process of planning their workplaces and managing expectations. Some organizations depending upon the legislation and internal ethical guide might choose to not allow members to be physically present until vaccinated. This simple, easy to use platform will securely deliver them the information they need to do the same.

- Time savings
 - The main benefit of this application would be to reduce the monumental amounts of time and engagement of multiple administrative workers being currently put into the transfer of information.
 - The app eliminates the middleman from a lot of transactions as it is allowing the individual to directly provide permission to the vaccination centre. The vaccination centre can then directly provide it to administer the data without having to interact much with each other. Making this is a much quicker process and reducing staff time.
- Cost savings
 - This project can lead to a substantial level of cost savings as the platform will integrate multiple processes into one simple place. Currently, there doesn't seem to be a process in place for organizations to verify that their employees have been vaccinated. This means multiple expensive HR team member hours internally will be spent on running these business processes, however, using Sankofa's platform can reduce or eliminate this.
 - Labor Reduction: with Sankofa's platform we will be able to eliminate a lot of unnecessary labour hours by reducing the number of people needed for securely transferring the information.
 - Reduced Operating Costs: Lesser internal operating costs as the process of getting the verification can be outsourced to the platform.

4.2 - Intangible Benefits

- Currency of information: With the platform, it will be much easier for vaccination centres to dispense the required information and organisations to receive the information with permissions from the individual. This will lead to having much more current information for all parties involved.
- Improved customer satisfaction: Current long wait times and unreliability of information/ lack of security can be controlled and in some cases eliminated. Leading to a much better user experience. As the platform will be easy to use, users will be inclined to ensure the correct and quick flow of information.
- Improved decision making: With the more current information efficient business decisions can be made. Funds can be redirected to other more strategic business decisions rather than administrative operating costs.
- Better internal and external communication: The app will allow the users to communicate with each other in a systematic professional manner where unnecessary details will not be shared yet secure and correct pragmatic data will be exchanged.
- Improved control environment: streamlining the process of transferring this confidential and important information will lead to organizations being able to establish stronger controls.

5 - Alternative Solutions

Having alternative solutions gives us a variety of advantages and disadvantages to decide which alternative is the most suitable way to tackle the problem. Since the IBM UI project is based on blockchain architecture, we are going to provide the facts of every solution and will decide on the Recommended Solution later.

5.1 - Alternative 1 - Using Carbon UI, React and JS technologies

5.1.1 - Advantages

Carbon UI is an open-source design system mainly used for product development and enhanced user experiences, which is developed by IBM itself [3]. With this system, everyone can create and develop user interfaces on their own contributions. In this way, the six different members of the team working on the UI / UX of the project can coordinate and collaborate more effectively in terms of code development and design of the user interface of the system [4]. Carbon UI provides efficient designing tools, human-computer interaction guidelines, functioning codes and other accessible resources such as the IBM library and online community forum which allows more flexibility when developing code and executing a program. Furthermore, it provides better consistency based on IBM's effective design system and components that can work together to ensure an excellent user experience. The Carbon design system is also highly accessible to all developers who are responsible for designing the UI allowing more effective communication between the team members.

React, also known as React JS, is an open-source JavaScript library mainly used for creating web interfaces on the Web [5]. This software technology allows team members to create reusable user interface components like resource files or codes for future projects. React is most likely centred to develop large corporate web applications due to its high scalability, performance and simplicity benefits. This JS library is extremely beneficial for software development team members as it is easy to learn and use and requires only basic knowledge of HTML and CSS. In addition, it can also be used to create interactive mobile applications.

JavaScript is a well-known programming language famous amongst developers and programmers for its simplicity and ability to enhance web-pages or web-based applications by incorporating interactive elements in them [6]. It can allow developers to implement complex features on web pages that can help engage users. Furthermore, it reduces server workload time which means it may not essentially require a server to run. JS can also be used in combination with other programming languages like HTML and CSS that are often used on the Web platform allowing more effectiveness. Lastly, JavaScript allows extremely fast execution of the program since it operates on the client-side instead of the server-side.

5.1.2 - Disadvantages

Carbon UI may not be the best for those who have better creative ideas of the design of the product than the primary designers and developers as it has limited options [7]. The system does not reflect if the developers designed the user interface with bugs in the system. As a result, it could lead to biases instead of options for discovering other methods. Additionally, the design system can become inflexible over time as new technologies, methods or implementations arise.

Developing user interfaces with React may lead to poor documentation as it updates continuously with any changes made. This may lead to complications during deployment in the long term. In addition, it can only be applied to the front-end development, bringing no use to the back-end side of the system. The React environment also changes really fast meaning the developers need to learn new methods and adopt new technologies frequently. Therefore, in order to use React, the designated team members will need to keep themselves updated with new skills and technologies.

The drawback of JavaScript is that it can be used to write malicious code in order to exploit unnoticeable bugs on web applications leading to potential security breaches on the client-side. This means that hackers may inject harmful code on the websites in order to gain access to sensitive information such as patients' medical history, and other personal information. JavaScript may also interpret differently on different web browsers like Google Chrome, Mozilla Firefox, Safari and Internet Explorer, as some of these browsers may not have certain functionality to run the required code properly. Therefore, when using JS for web development, it is best to ask the clients for their preferences in terms of which browser they would like to use. Whilst most web-based applications use multiple inheritances, JavaScript also does not support it, which limits the programs that require it. In terms of data types, if JavaScript handles complex data, it requires more time to convert due to the operator and conversion which is only 32 bit whereas JavaScript stores 64 bit.

5.2 - Alternative 2 - Using Bootstrap and Angular

5.2.1 - Advantages

[Bootstrap](#) is a frontend UI framework similar to Carbon UI. Bootstrap has a number of advantages over Carbon UI, such as having a more expansive library of components, a more active developer support community, a robust responsive grid system and a number of plugins and examples [8]. Bootstrap has been actively developed for over 10 years and was initially developed by Twitter for its web application. Over the past decade, the library has been continuously updated. This has given rise to a large number of components to choose from and a high level of customizability, making the library very useful for rapidly building web applications. As Bootstrap is used by an expansive list of companies, there is a highly active developer support community, making problem-solving easier than comparatively less popular UI frameworks such as Carbon UI [9]. Bootstrap has a highly customisable responsive grid system, making it easy to control how website layouts display on many different devices and screen sizes, such as large desktop displays, laptops, tablets and smartphones. This is especially important given how many users access websites from their mobile devices now. Further, many developers using Bootstrap have developed plugins and

extensions that expand the functionality of Bootstrap, such as integrating it with frontend JavaScript frameworks such as React and Angular. Bootstrap also supports a wide variety of web browsers as well, meaning users browsing with older browsers will still be able to use the web application.

Angular is a front-end application framework similar to React. Using a framework such as Angular makes web app development easier by handling lower-level functions such as DOM manipulation, state management, and data storage and validation [10]. Angular is the primary competing framework to React and differs in terms of its approach to web application development. Although it has a steeper learning curve than React, Angular takes much of the decision-making process away from the developer, creating a rigid consistency throughout the application, which can lead to performance and documentation gains. This also means that future developers working on the project who know how to use Angular will be able to rapidly start work.

5.2.2 - Disadvantages

A drawback of Bootstrap that there will be similarities in terms of the design [11]. Even though you want to change the design by overriding the code or style, it will still remain the same, because it's in the same framework. If you want changes to be made in order to have a unique web page, it requires more overriding files. Therefore, it is common that most websites that use bootstrap will have similarities in terms of appearance and UX.

Team members take time to learn how Bootstrap works by knowing the classes well, including the components' functionalities in order to test whether it fits the grid system or not. This will consume a lot of time if one of the members can't keep up when the newer version comes in.

This is not suitable for larger projects because it gives slower load time and has to manually delete certain things if needed. Therefore, it will have no use for the framework since the architecture is quite hard to maintain in the long term.

As Angular enforces a strict style to development, meaning there is an increased learning curve for developers who have not used Angular before. This also means that there is less flexibility in terms of which other tools to use. In contrast, React is simply a frontend framework and allows developers to select which libraries they would like to use for state management and other functions of a web app. This leads to more flexibility and customisation when using React over Angular.

5.3 - Alternative 3 - Taking No Action

5.3.1 - Advantages

An alternative to building the project is simply taking no action. Taking no action is the simplest alternative, as it involves no additional work, meaning resources such as time and capital could be used on other projects. There is also no cost associated with taking no action, meaning the client would not have to fund the development of the system. There are

also no constraints to take into consideration and no need to train staff on how to use a new system. Training on a new system may result in lost productivity in the short term, so this is another benefit of taking no action.

5.3.2 - Disadvantages

Although taking no action involves some advantages, these are certainly short-term advantages that result in a net loss in the long run. Taking no action means the problems and issues that the project seeks to solve will go unsolved. This is a critical disadvantage, as healthcare providers and patients will continue to experience the issues identified in Section 1. This not only leads to lost productivity and revenue for healthcare providers but also exposes patients and organisations to security issues around privacy and data breaches as a result of using old and outdated systems. Not taking any action also means that there will be no solution to the COVID-19 vaccine rollout tracking component of the project. This will make the process of tracking the rollout as well as recording and tracking vaccinations increasingly hard and prone to both error and security breaches.

6 - Recommended Solution

In light of all the alternative solutions available to tackle the problem identified, the best solution to adopt in the development of the SHF project will be to deploy Carbon UI, React and JS software technologies for the implementation of the vaccine tracking system. This choice can be justified with various reasons that are listed below:

- Carbon UI is an IBM product that will work most efficiently in order to meet the requirements and expectations of the IBM team that will be sponsoring this project. This also ensures that the designed product will meet the needs of the global market of IBM corporation including its various business partners and users.
- Carbon is also modular and provides maximum flexibility allowing different components to work seamlessly with each other, in whatever combination suits the needs of the user. This is especially important considering the evolving nature and broad scope of the project.
- React is best suited for web applications, web-pages and mobile applications. This provides the opportunity to deploy various platforms in order to meet the maximum audience. Since one of the primary goals of this project is scalability to allow tracking and verification of the extensive vaccinations, React will certainly work the best on par with other technologies available.
- React JS is also really easy to use with high-performance capability meaning that it can help build rich user interfaces in the least time needed. This is especially useful considering the novel capability of the team members designated and the strict time frame of deadlines allowing maximum profitability and efficiency over the course of the project.

- React JS is currently also used by many fortune 500 companies and stands out from other front-end development frameworks meaning it is highly trusted and valued across the globe. This ensures that the SHF UI platform built with React JS will be widely accepted by users and other organisations with ease and comfort.
- JavaScript has been used widely for over many years by Web and software development companies. It still stands as the best programming language for UI/UX development despite other options available because of its simplicity, interoperability with other programming languages and excellent speed.
- JS will ensure that the designed system is highly accessible with fast response times due to the reduced demand of the website server. This will increase its accessibility and reliability meeting the needs of the proposed system.

7 - References, Abbreviations & Assumptions

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Assumptions

Term	Definition
SHF	Sankofa Healthcare Framework is a proposed system under development that can address the gaps in the intercommunication between Healthcare systems and provide secured granular access to data using Blockchain Technology.
IBM	International Business Machines Corporation is the sponsor of the SHF project

	under development
COVID-19	Contagious Coronavirus that can be transmitted through close contact or droplets
IAM	Identity and Access Management is a business framework that facilitates the management of electronic or digital identities.
UI	User Interface is the space where interactions between humans and digital devices occur.
UX	User Experience is about how a user interacts with, or experiences, a particular product or system.
API	Application Programming Interface is a software intermediary that allows two applications to talk to each other.
PACE	Professional and Community Engagement (PACE) program available at Macquarie University that provides students with industry-valued practical experience in Australia and overseas.
JS	JavaScript is a text-based programming language that is used on both front-end and back-end development that allows building interactive web pages.

Assumptions

- The team will have access to IBM Cloud to build the various components
- The team will meet with IBM weekly to discuss project progress
- The project will be built on and improved by future teams