CC0007 Group Proposal (2)

Enhancing Healthcare Data Privacy in Singapore

Cluster	C
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Word Count	600 (excluding cover page, footnotes, figure captions, in-text citations, and references)

Introduction

With convenient access to data becoming a necessity, digitizing healthcare records appears to be a logical solution with its unparalleled accessibility. Yet, increased digitization engenders greater security concerns, as cybercriminals usually target healthcare data (Figure 1) for the amount of personal and financial information it contains (Koppel et al., 2019).

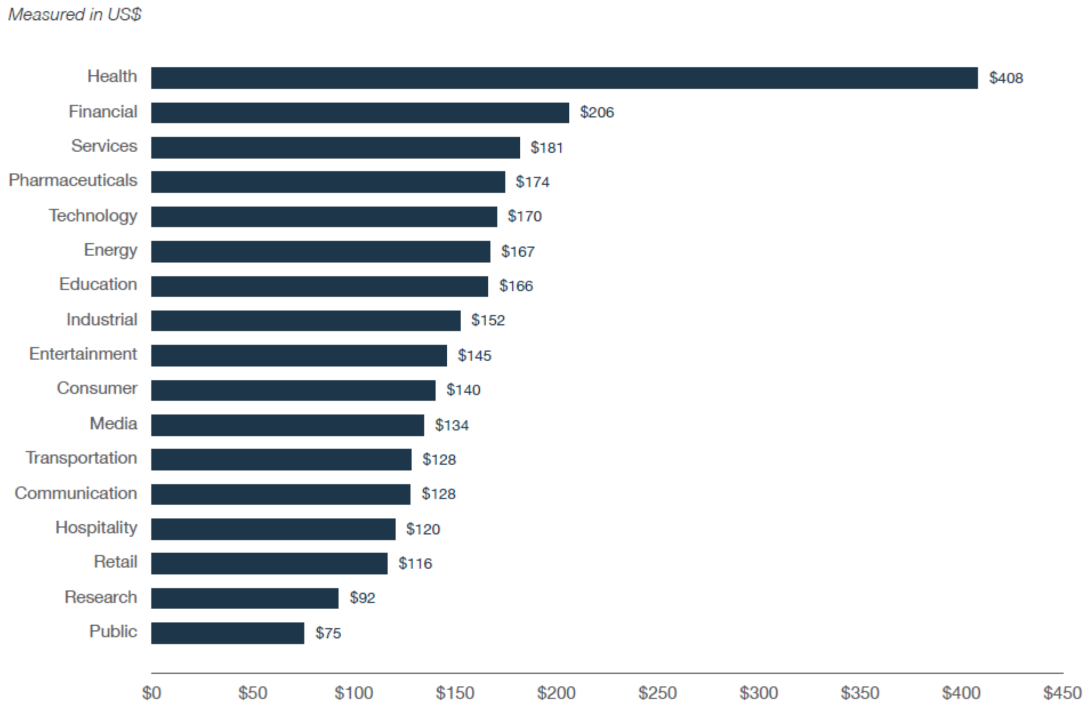


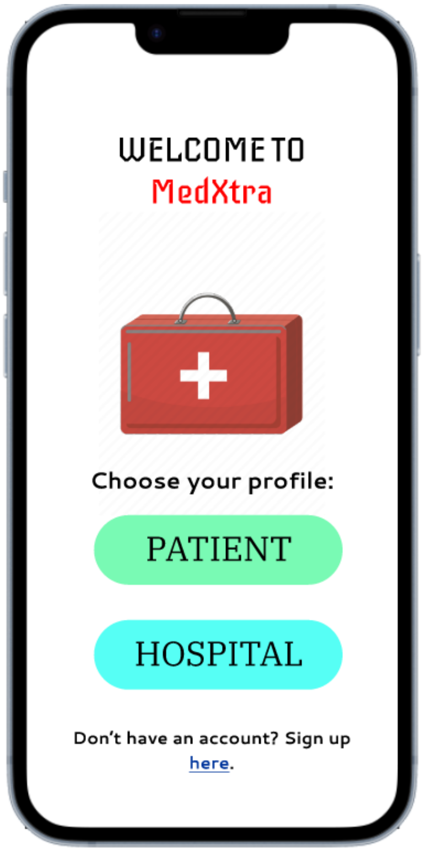
*Figure 1: Value Per Record of 17 Major Industries, with Healthcare Industry Being the Most Valuable (**$408** Per Record) (Imprivata, 2019)*

In 2018, a breach involving 1.5 million user records in the SingHealth database occurred in Singapore (Tham, 2018). By 2022, the number of such hacks exploded by 600%[1] (Embroker, 2022), further eroding patients' trust in Electronic Health Record (EHR) providers (Murphy, 2022). This resulted in worsened treatment outcomes for patients, as more chose to withhold health information due to a lack of trust in the EHR (Iott, 2020).

Hence, our proposed solution, MedXtra, aims to rethink the way healthcare data is stored, and foster trust in patients in an untrusting world prevalent with data breaches.

[1] This is mainly brought about by the COVID-19 pandemic from 2020 (Embroker, 2022), as many people transitioned from the usual face-to-face interactions in the past, to remote working, learning and interactions. This generated much more digital footprint than before, which can then be exploited by cybercriminals.

Proposed Innovation



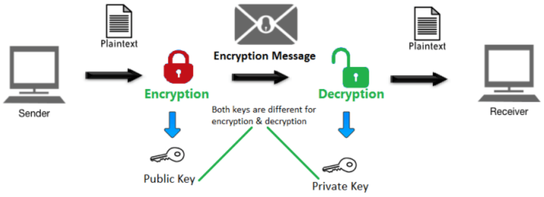
Don’t have an account? Sign up here.

Figure 2: MedXtra Splashscreen

MedXtra is a blockchain-based EHR application that leverages blockchain's decentralized nature[2] for storing patients’ health records. It addresses the issue of data breaches by building a secure protocol to facilitate sharing of data between a patient and doctors. With the removal of a central authority (and intermediary), MedXtra returns the ownership of medical data to the individual, granting them full control over access to their data.

[2] Given that blockchain is a “distributed ledger technology” that is based on a peer-to-peer network, there is no need for a central authority or administration to manage this, thereby giving rise to decentralization (Khatoon, 2020; Sharma, 2022).

Features

Feature	Benefit	Feasibility
Asymmetric encryption[3] (Figure 3) adopted for access to EHRs	1. It enhances data security by making decryption without the associated private key computationally infeasible. 2. Sense of security[4] in the encryption will encourage patients to be more transparent with healthcare providers[5] (Thilakanathan et al., 2016).  Plaintext Encryption Message Plaintext Sender Encryption Decryption Receiver Both keys are different for encryption & decryption Public Key Private Key *Figure 3: An Overview of Asymmetric Cryptography (Public-Key Encryption)*	1. Blockchain has become increasingly prevalent in healthcare management (Fusco et. al., 2020). 2. Asymmetric cryptography is usually used for transaction authentication in an untrusted environment (Shi et. al., 2020).
Single Source of Truth (SSOT) for healthcare providers	1. It improves treatment outcomes by facilitating continuity of care[6] (Rudolf et. al., 2017), and ensuring information flow to increase efficiency[7] (Ljungholm et al., 2022).	This no longer poses the risk of a single point of failure, despite being a central platform for data access, as each datapoint is individually encrypted[9].

[3] Based on a public-key encryption architecture (Figure 3) (Cyware Hacker News, 2019)

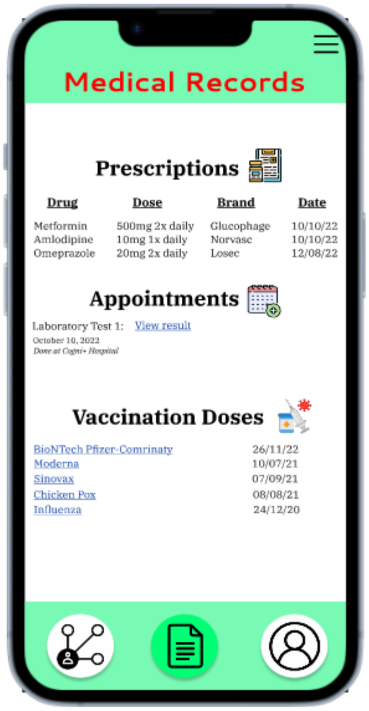
[4] Asymmetric cryptography provides authenticity, immutability and non-repudiation, on top of confidentiality, unlike symmetric cryptography which only offers confidentiality (Geeks For Geeks, 2022).

[5] This leads to more accurate medical diagnoses.

[6] An important factor in the quality of care

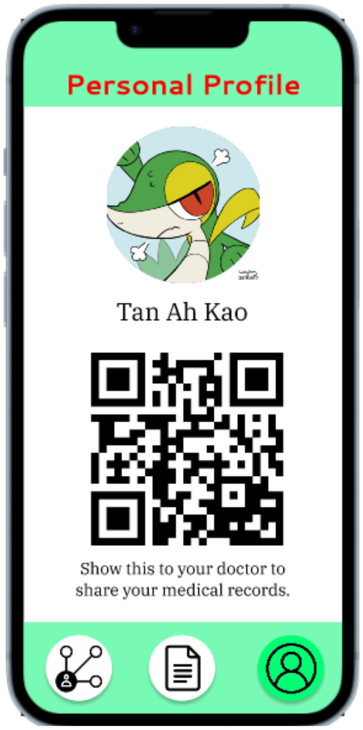
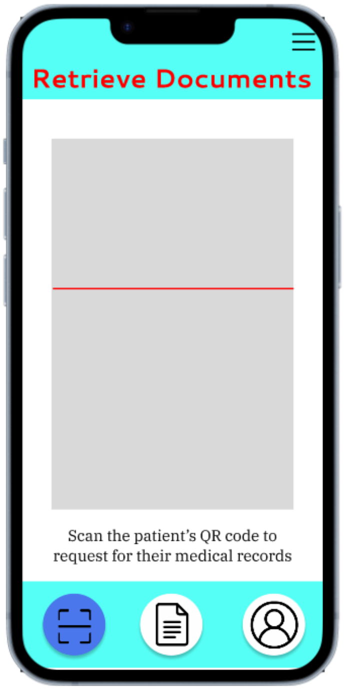
[7] With the traditional system, critical information regarding the patient's condition may not be effectively transmitted between doctors in full, resulting in redundant (and duplicate) clinical tests being conducted (Rudolf et al., 2017).

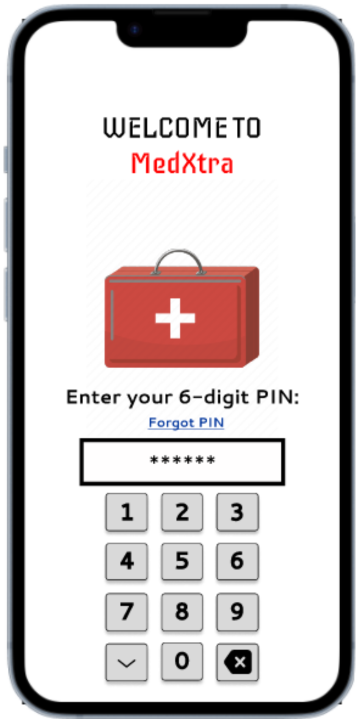
[9] The breach of 1 patient's data will no longer constitute the breach of the entire "database", thereby mitigating the risk of a Single Point of Failure occurring.

	2. Doctors can access essential information on patients with ease (Rudolf et al., 2017)[8].	
Digital wallet for EHR's (Figure 4)	Patients can track their medical records for free, given that requesting medical records currently comes with a cost (HealthHub, n.d.).  Medical Records Prescriptions Drug · Dose · Brand · Date Metformin · 500mg 2x daily · Glucophage · 10/10/22 Amlodipine · 10mg 1x daily · Norvasc · 10/10/22 Omeprazole · 20mg 2x daily · Losec · 12/08/22 Appointments Laboratory Test 1: View result October 10, 2022 *Done at Cogni+ Hospital* Vaccination Doses BioNTech Pfizer-Comrinaty 26/11/22 Moderna 10/07/21 Sinovax 07/09/21 Chicken Pox 08/08/21 Influenza 24/12/20 *Figure 4: Patient's Point Of View (POV): Medical Records of a Patient*	HealthHub has recently rolled out a similar implementation, which was well-received.
Data access approval process (Figures 5, 6 & 7)	1. Patients have complete control over their health data. 2. The similarity to commonly used processes (ie. SingPass) will lower patients' barriers to adoption.	SingPass is widely used by Singaporeans in approving personal data access requests[10] (GovTech, 2022).

[8] With full access (upon approval) to patient data, doctors are now able to avoid duplicate tests and treatments (Rudolf et al., 2017), even when patients jump between doctors.

[10] SingPass is currently used by Singaporeans to access more than 2000 government agencies and private sector services (GovTech, 2022).

	 Personal Profile Tan Ah Kao Show this to your doctor to share your medical records. *Figure 5: Patient's POV: QR Code for Doctors to Seek Patient's Consent in Retrieving their Health Data, Similar to SingPass*  Retrieve Documents Scan the patient's QR code to request for their medical records *Figure 6: Doctor's POV: QR Scanner for Doctors to Retrieve Patient's Health Data, Given Patient's Consent, Similar to SingPass*	

	 WELCOME TO MedXtra Enter your 6-digit PIN: Forgot PIN ****** 1 2 3 4 5 6 7 8 9 0 *Figure 7: Log-In Page, Similar to SingPass*	
Decentralized storage of EHR's	1. Removing the middlemen will give patients full control over their health data[11]. 2. This mitigates the impact of hacks[12], since each datapoint is individually encrypted.	Blockchain is widely used in the Crypto[13] industry (Statista, 2022), proving the robustness of its architecture.

[11] 75% of patients surveyed by Savvy Cooperative preferred prior approval for access to their data (Kelly, 2022).

[12] Patient data has become an increasingly tempting target for hackers due to the wealth of personal information it holds. Thus far, most (if not all) hacks were due to database breaches, which were a result of a Single Point of Failure – with access to admin credentials, one could view the entire database with relative impunity (Higgins, 2008). This is quite costly.

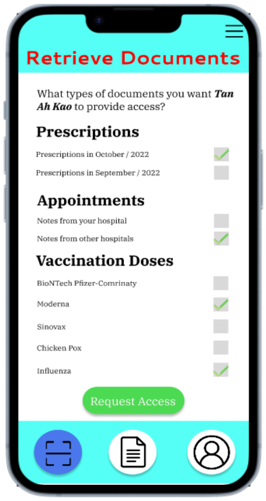
[13] The Crypto industry is valued at US$972b (Statista, 2022).

Considerations

Accessibility

Despite the benefits, skepticism regarding the adoption of MedXtra may exist. Hence informative campaigns targeting the younger generation will be conducted, allowing them to assist the older generation.

Additionally, technicalities of the application will be hidden[14], leaving a clean interface and a streamlined user experience (Figures 8, 9, 10 & 11) to drive higher adoption rates.



Retrieve Documents

What types of documents you want ***Tan Ah Kao*** to provide access?

Prescriptions

Prescriptions in October / 2022 ☑
Prescriptions in September / 2022 □

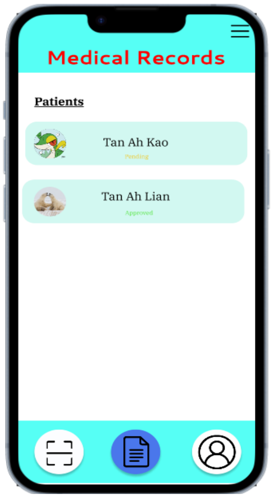
Appointments

Notes from your hospital □
Notes from other hospitals ☑

Vaccination Doses

BioNTech Pfizer-Comrinaty □
Moderna ☑
Sinovax □
Chicken Pox □
Influenza ☑

Figure 8: Doctor's POV: Requesting Documents from patients



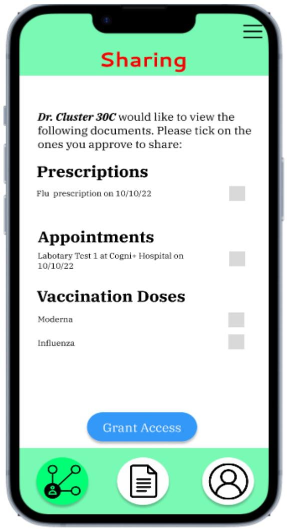
Medical Records

Patients

Tan Ah Kao
Pending

Tan Ah Lian
Approved

Figure 9: Doctor's POV: Medical History of Patients



Sharing

Dr. Cluster 30C would like to view the following documents. Please tick on the ones you approve to share:

Prescriptions

Flu prescription on 10/10/22 □

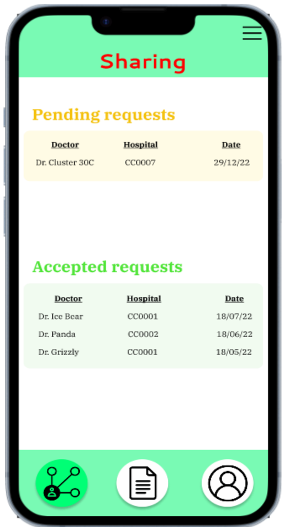
Appointments

Labotary Test 1 at Cogni+ Hospital on 10/10/22 □

Vaccination Doses

Moderna □
Influenza □

Figure 10: Patient's POV: Approving Requests From Doctors



Sharing

Pending requests

Doctor	Hospital	Date
Dr. Cluster 30C	CC0007	29/12/22

Accepted requests

Doctor	Hospital	Date
Dr. Ice Bear	CC0001	18/07/22
Dr. Panda	CC0002	18/06/22
Dr. Grizzly	CC0001	18/05/22

Figure 11: Patient's POV History of Sharing Requests

[14] "Under the hood"

Patient's Incapacity

The patient may be unable to provide the consent to access necessary health data during medical emergencies.

Thus, we can leverage smart contracts[15] and integrate with Apple and Android health apps, allowing doctors to access their health records during emergencies. Additionally, the user will have an emergency key saved with trusted contacts, which can be used to retrieve patients' data.

Blockchain Immutability

While blockchain's immutability ensures data integrity, such unchanging nature makes stored patients' health data impossible to remove (OECD, 2020).

However, this can be mitigated by deleting the private key, as data encrypted by the deleted key will be rendered useless due to the computational infeasibility of decryption without the associated private key (Poston, 2020)[16].

[15] Smart contracts will automatically decrypt the data when an emergency is triggered via the device's health app.

[16] Asymmetric decryption by unauthorized actors has a worst case time complexity of **$O(2^n)$** (Poston, 2020). Thus, the assumption that any decryption of data encrypted through asymmetric encryption without the private key will, more likely than not, occur well beyond the years of the patient's lifespan.

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