A business case for a blockchain based e-voting system for student union elections

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Abstract

E-voting is a controversial topic largely due to failed implementations in the past with questions surrounding usability issues, verification, reliance on trusted auditors and a high cost of ICT systems to enable e-voting. Some governments have successfully implemented a secure and functioning e-voting system with Estonia being a notable success story. Estonia first introduced e-voting in 2005 with Parliamentary elections having the facility in 2007 and has seen an increase in participation since the service was introduced, with 2023 being the first year a country with an e-voting system achieving more than 50% of total votes through the platform. The focus of this paper is to examine the current state of e-voting solutions and to explore the potential of developing a secure and robust e-voting system that is suitable for student union elections by utilising blockchain technology. In doing so this paper aims to address issues with the current e-voting systems by offering a solution that improves transparency, trust and accessibility.

Keywords

Blockchain, e-voting, digital democracy, education, student union

Chapter 1: Introduction

Since the COVID-19 pandemic remote learning has seen increased adoption as the platforms supporting students continue to mature. However, one aspect of student life that has fallen behind in this regard is representation within student unions, where elections almost exclusively require the electorate to be present on campus to cast their vote. E-voting solutions are beginning to gain traction in academia and professional societies, with UCC Students Union adopting an E-voting system from 2021, MSL (2021), NUIG implemented an e-voting system for their 2021 Academic Council Elections NUIG (2021) and the Law Society of Ireland passed a vote in 2022 to use an e-voting solution for their 2022 Council Election, LSOI (2022).

E-voting is a controversial topic largely due to failed implementations in the past with questions surrounding usability issues, verification, reliance on trusted auditors and a high cost of ICT systems to enable e-voting, McGaley (2008). Some governments have successfully implemented a secure and functioning e-voting system with Estonia being a notable success story. Estonia first introduced e-voting in 2005 with Parliamentary elections having the facility in 2007 and has seen an increase in participation since the service was introduced, *"Since its introduction, the amount of people using e-voting has continued to increase; in their 2019 parliamentary elections, 43.8% of participating voters chose to vote through their i-voting system, an increase of 13.3% from the last parliamentary election four years earlier."* Mozley (2021) and in 2023 over 50% of votes were cast using the e-voting platform Piirmets (2023).

1.2 Industry solutions

Membership Solutions Ltd (MSL) is a UK based company offering e-services to educational institutions including an e-voting system which was provided to University College Cork (UCC) in 2021. This service is hosted by MSL and there is the option to use an electronic polling booth alongside the online voting service. MSL provide real time metrics, polling booth invigilation to ensure that the voter ID is valid and audit trails.

Simply Voting Inc. is a US based e-voting provider, which has provided a solution to the Law Society of Ireland. They provide a fully hosted service which is based in a datacentre in the USA, the database is encrypted at rest with AES-256 encryption, extensive auditing features and the service can be managed by the client or by the service provider, SimplyVoting (n.d.).

Another option is to develop a blockchain based system using Hyperledger and Fabric protocols as the framework. There has been extensive research in this area in recent years and the consensus amongst academics is that blockchain technologies are suited to the requirements of an e-voting system, *"The features provided by blockchain such as distributed ledger, immutability and enhanced security makes it ideal for making a voting system."* Vidwans et al. (2022), *"We have shown that the blockchain technology offers a new possibility to overcome the limitations and adoption barriers of electronic voting systems"* Hjálmarsson et al. (2018) and *"benefits include improved efficiencies, lower costs, increased transparency, and an unchangeable record of all voting transactions"* Abuidris et al. (2019).

1.3 Technical Value

In 2013, a study was performed by Gritzalis (2002) to determine the principles and requirements of an e-voting system. They found that the constitutional requirements of a voting system were *"Generality, freedom, equality, secrecy and directness"* and Hussien & Aboelnaga (2013) in a similar study stated that *"Eligibility, secrecy, uniqueness, privacy and accuracy"* were key components of any electronic voting system. Another key feature that requires focus is usability and both Wang et al. (2017) and Budurushi et al. (2016) reference the ISO 9421-11 standard, *"Guidance on Usability"*. Other ISO standards that should be considered are ISO 27001 *"Information security management systems"*, Monev (2022), ISO 15408 *"Evaluation criteria for IT security"*, Pai & Mondal (2019) and ISO 25000 *"Software and data quality"*, Torre et al. (2022). When taking these technical requirements into account, a technical comparison can be performed.

1.4 Business value

Implementing an e-voting system in a university can bring several benefits such as increased participation, Taban et al. (2017) as a result of improved accessibility, Tsahkna (2013), cost-effectiveness *"the costs incurred initially can be amortized over the years in numerous elections"*, Agate et al. (2021) and real-time analytics, Pandey et al. (2019).

Table 1: Technical comparison of e-voting solutions

	MSL	Simply Voting	blockchain solution
E-voting portal	Yes	Yes	Yes
Push notifications	No	Yes	Yes
Scalable	No	Yes	Yes
Variety of voting methods	Yes	Yes	Yes
Service desk	Yes	Yes	Yes
ISO compliant	No	No, Socs 2	Yes

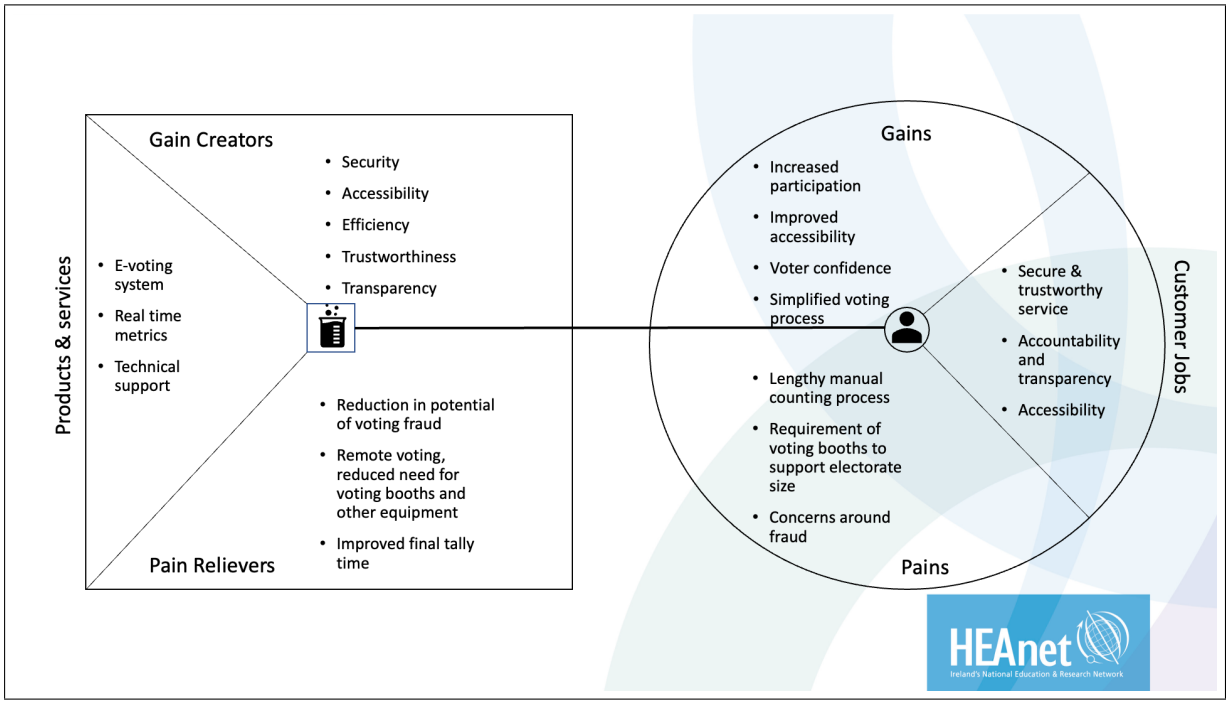

Figure 1: Value proposition canvas (Source: Author, 2023)

1.5 Financial modelling

While a financial investment is required from a client to implement an e-voting service, the return is not necessarily of a financial nature. Clients may want to measure the effect of implementing such a service by observing cost savings, greater accessibility, higher participation and gathering feedback from end users.

If the developer is a for-profit organisation they will perform a cost analysis to customise and deploy the e-voting service to each client and this analysis will influence the client cost. Developers in this space will have performed a business case analysis to determine the viability of the product and will help assess which financing models they offer, such as, licence agreements, pay-per-use or recurring subscription. For example, market sizing and analysis would provide these organisations with insights regarding potential client size, pricing models, market dynamics and potential revenue streams.

If the developer is a non-profit organisation they will be less concerned with financial return and have more focus on meeting customer requirements. Social return on investment (SROI) is a model that observes outcomes and the impact of projects to

measure if the expected outcome was achieved, *"The SROI methodology provides a platform to systematically account for broader outcomes of interventions and the value for money of such interventions."*, Banke-Thomas et al. (2015). SROI can be used to observe the expected outcomes of increased participation, improved accessibility and cost-effectiveness to justify the financial investment.

1.6 Evaluation

There are several solutions available for e-voting and these range from commercial closed source solutions to free open source self-hosted services, there are also blockchain backed commercial products in this space. One recurring issue with investigating these services is lack of documentation around ISO and GDPR standards, with many potentially falling short of the requirement. Costing is often on a case by case basis with Simply Voting the only service researched that provides a calculator for self administrated elections with managed elections also priced on a per-case basis.

While free open source services can be manipulated and adapted to client needs, there are concerns around scaling and security. ConsulProject for example relies on a Postgres backend database which is in theory scalable but as time goes on, scaling further requires a significant amount of work to ensure data integrity and there is also the risk of DDOS to services built in this way.

By utilising blockchain technology as the backend for a self developed e-voting system there are benefits in terms of scaling, security and redundancy. There has been extensive research into e-voting systems using Hyperledger/Fabric protocols that cover a variety of methods to ensure voter secrecy, network security and anti-tampering, Kyazhin & Popov (2020), Díaz-Santiso & Fraga-Lamas (2021), Mukherjee et al. (2020) and Kirillov et al. (2019).

1.7 Best practice

To ensure an e-voting platform it is imperative that it is usable, trusted by the electorate, Mozley (2021), is secure and auditable while maintaining privacy, Hussien & Aboelnaga (2013). Ensuring the privacy of each voters decision is key in building trust with homomorphic encyrption methods often considered the most appropriate, Jabbar & Alsaad (2017), Chillotti et al. (2016), Shinde et al. (2013).

Chapter 2: Business case analysis

2.1 Data Collection

The source of data for client requirements is from the tender documents released by TU Dublin for the e-voting service. The author made several attempts to contact the relevant people within the student union with no success. Vendors were also unwilling to provide any information that was unavailable on their websites.

The tender document provides a comprehensive overview of what TU Dublin expect from the service and in a proposal with the only unclear requirement being *"collate and provide final results, in accordance with ISO accredited procedures"* where research was performed to suggest relevant ISO standards for this service. The tender includes schedules and appendices for pricing schedule, service specification, charges, service level agreements and data protection agreements which are to be agreed upon after a successful application.

2.2 Client Background

Technological University Dublin (TU Dublin) is a third level institution with a student population of around 28,500 across three campuses. TU Dublin is a recently formed institution as a result of merging IT Blanchardstown, IT Tallght and DIT and has a focus on expanding digital education capabilities.

2.3 Company Background

HEAnet is Irelands National Research and Education Network (NREN) providing networking and e-infrastructure services to educational institutions, schools and other state-sponsored bodies. HEAnet focuses on five core pillars to fulfil their strategic plans, which are Connectivity, Security, Identity, Brokerage and Research engagement. The strategic plan is created by collaborating with stakeholders and international peers within the NREN community. The company mission is *"Delivering common, repeatable and shareable solutions for all of education."*

2.4 Requirements

The TU Dublin tender for an e-voting system for student union elections includes a number of technical and design requirements. The relevant requirements are as follows;

- An intuitive e-voting portal with candidate material
- Ability to communicate with the electorate with voting instructions
- Be able to handle variants in the numbers voting at any given time during the polling period
- Exemplary security and personal data privacy
- Ability to facilitate proportional representation and first past the post
- Have a service desk available during elections for queries
- Collate and provide final results within 48 hours of polls closing and in accordance with ISO accredited procedures

2.5 Current position

Commercial e-voting systems are usually closed source services provided by private companies that often operate outside the EU, which could raise some concerns such as data protection, compliance and security along with the possibility of the company ceasing to operate. TU Dublin have representatives on the board of HEAnet and the two organisations have an established relationship. As a result of this relationship, HEAnet have an understanding of the people and culture within TU Dublin and is in an ideal position to propose a solution that not only meets the requirements laid out in the tender, but to also apply cutting edge technology and share this knowledge with the wider educational and research community.

2.6 Strategic alignment

This project is aligned with several HEAnet strategies; Connectivity, Security, Identity and Research. This is an opportunity to not only provide a service to TU Dublin, it also presents an opportunity to meet the company mission of *"Delivering common, repeatable and shareable solutions for all of education."* as the blockchain is a decentralised, distributed network which can be shared by many organisations without compromising the security of their data on the network.

2.7 Financial analysis

HEAnet operates as a non-profit organisation and as a result financial returns are not a key priority. The Project Managers Office analyse budget/expenditure and tracking spend activity within a project, for example monitoring if the project is running under budget or beginning to overspend. They also focus on time spent on a project since engineer time will have been estimated and allocated with a portion of project budget allocated for this. Research in this paper shows that SROI would also be a useful model in measuring returns for such a project.

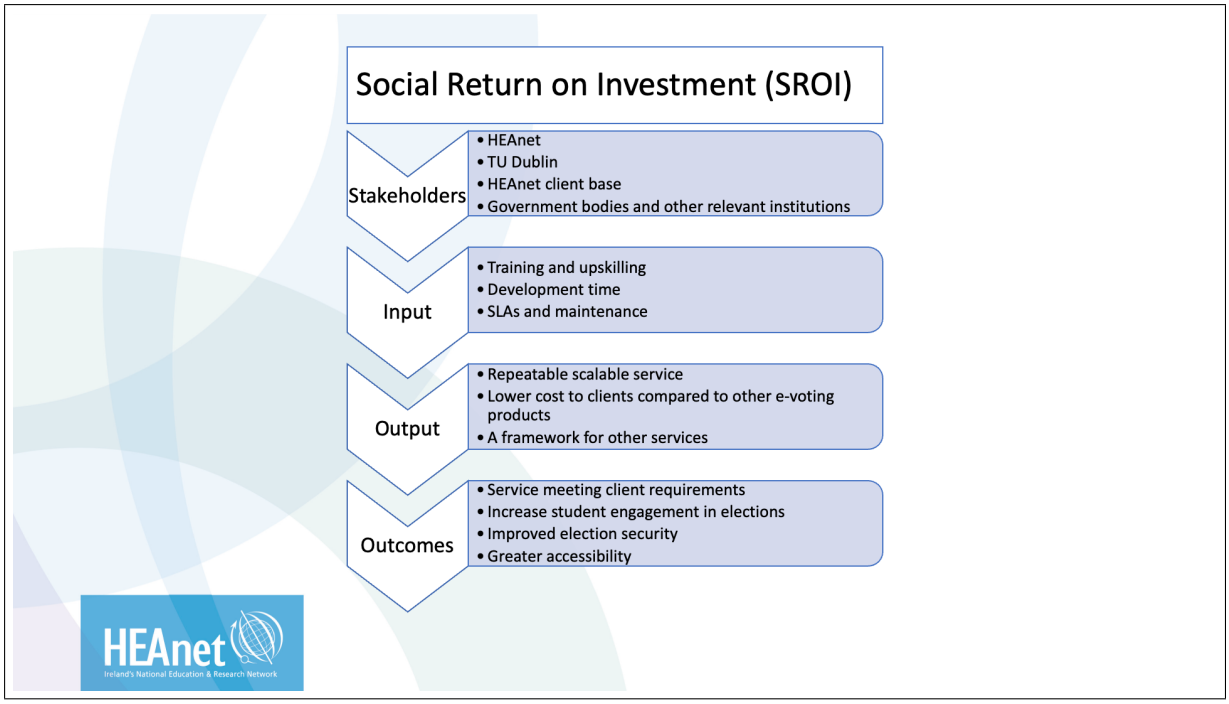

Figure 2: An overview of SROI (Source: Author, 2023)

2.8 Product/Vision

The recommended solution is to put forward a proposal for a blockchain based e-voting system, using European Blockchain Services Infrastructure (EBSI) which supports Hyperledger and Fabric protocols, EBSI (n.d.). The EBSI is a European Commission initiative, with all EU member states as stakeholders and is a blockchain built on Hyperledger/Fabric protocols available for use by suitable organisations within the EU.

The proposed product will be available both on mobile and desktop devices and built entirely on the Hyperledger framework. Voting will be encrypted while the count can decrypt the vote without revealing how a person voted. Accounts and registration will be created in the form of a wallet and tied to the student Active Directory account while the e-portal will be a dApp built on top of the EBSI blockchain.

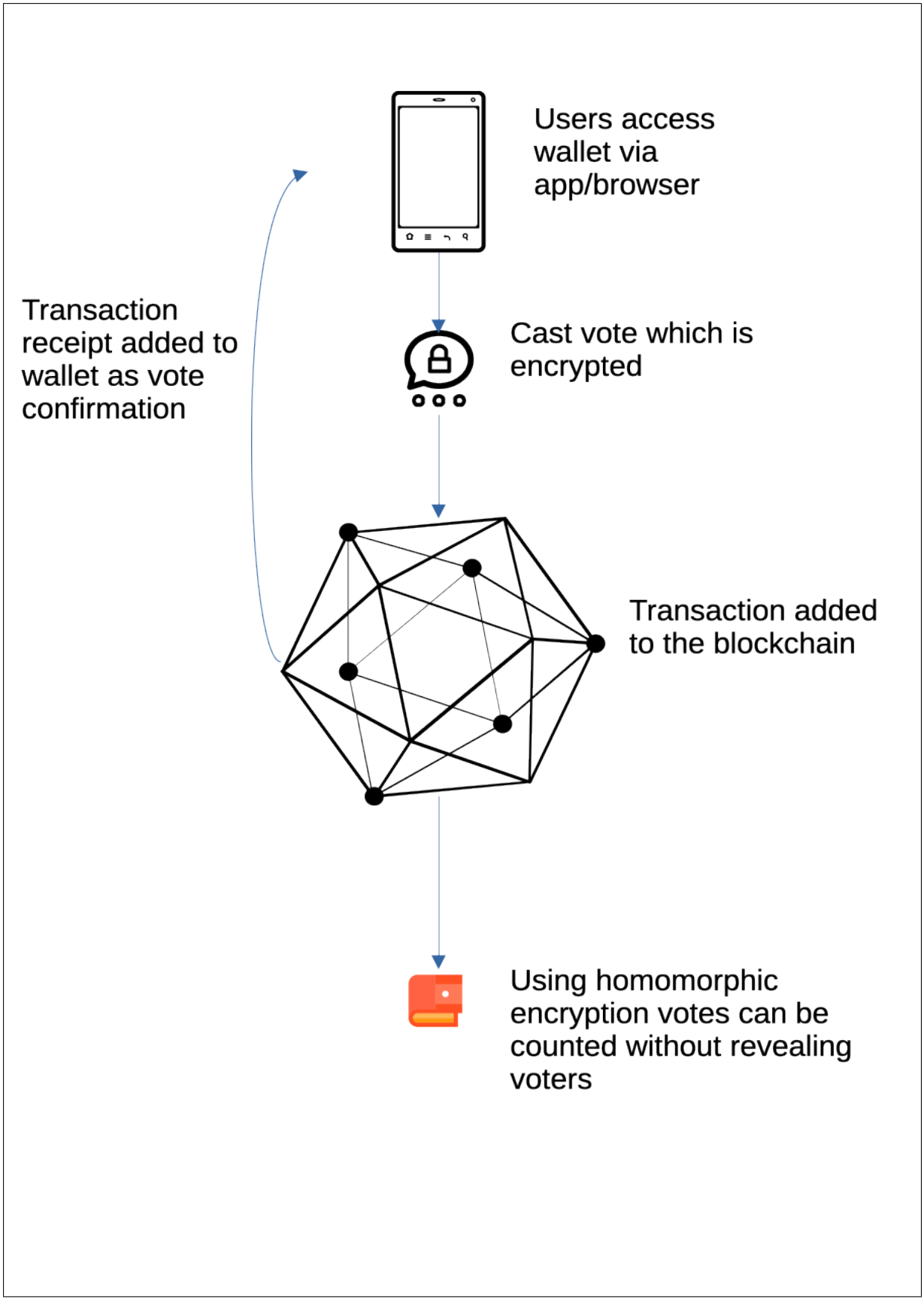

Figure 3: Basic service diagram (Source: Author, 2023)

2.9 Risk analysis

There are risks associated with proceeding with the proposed solution, such as exceeding the allocated budget and time for the project. To manage these risks there should be assistance from the internal HEAnet PMO team, who can provide support by providing feedback to stakeholders, interacting with any external vendors and ensuring the team has the resources required to meet milestones and deadlines. The service should also operate in a hybrid model, allowing administrators to assign a receipt onto the blockchain for anyone who provided a paper vote. Paper votes will still be required as some people may prefer this method or not have access to a device that is compatible with the service.

Chapter 3: Business case development

3.1 Future position

The initial goal of this proposal is to provide TU Dublin with a modern, secure e-voting solution that meets the requirements set out in the tender. There is a great opportunity to provide this service to other clients and suitable organisations along with providing valuable tooling and research to the community.

There is also the potential for developing a service that allows institutions to issue diplomas to graduates on the blockchain, providing a verifiable digital record of their achievements.

HEAnet is already an Identity provider (IDP) for many educational and research institutions in Ireland and blockchain technology has potential as a framework to build identity services on.

3.2 Resource Requirements

This project will require training as there is a lack of knowledge within HEAnet regarding Hyperledger/Fabric and infrastructure costing will fall within the standard operating costs. Training should be made available to developers, system administrators and any other support staff and is estimated to take between 1-9 days depending on the level of knowledge required by different team members and at a cost of approximately €25,000. This would provide training for several team members and would be provided in an online classroom by NobleProg (2023) covering the following topics;

- Hyperledger for Beginners
- Hyperledger Indy for Identity Management
- Hyperledger Composer for Building a Network
- Hyperledger Iroha for Mobile Applications

A team consisting of 2 service architects/developers and 2 system administrators should be capable of building a service on the EBSI framework in 18 months including time allocated for training. As of April 2023, according to Glassdoor (2023) the average annual salary of a senior software engineer in Ireland is €78,000 and the average annual salary for a senior systems administrator is €64,000. Taking these figures into account and considering the project will require 2 of each of these roles to reach production, the cost would be €426,000 over 18 months. There will be other salaries to be considered as other teams will be engaged on an ad hoc basis throughout the project. The estimated cost of training, developing and deploying this service is in the region of €500,000 over the course of 18 months.

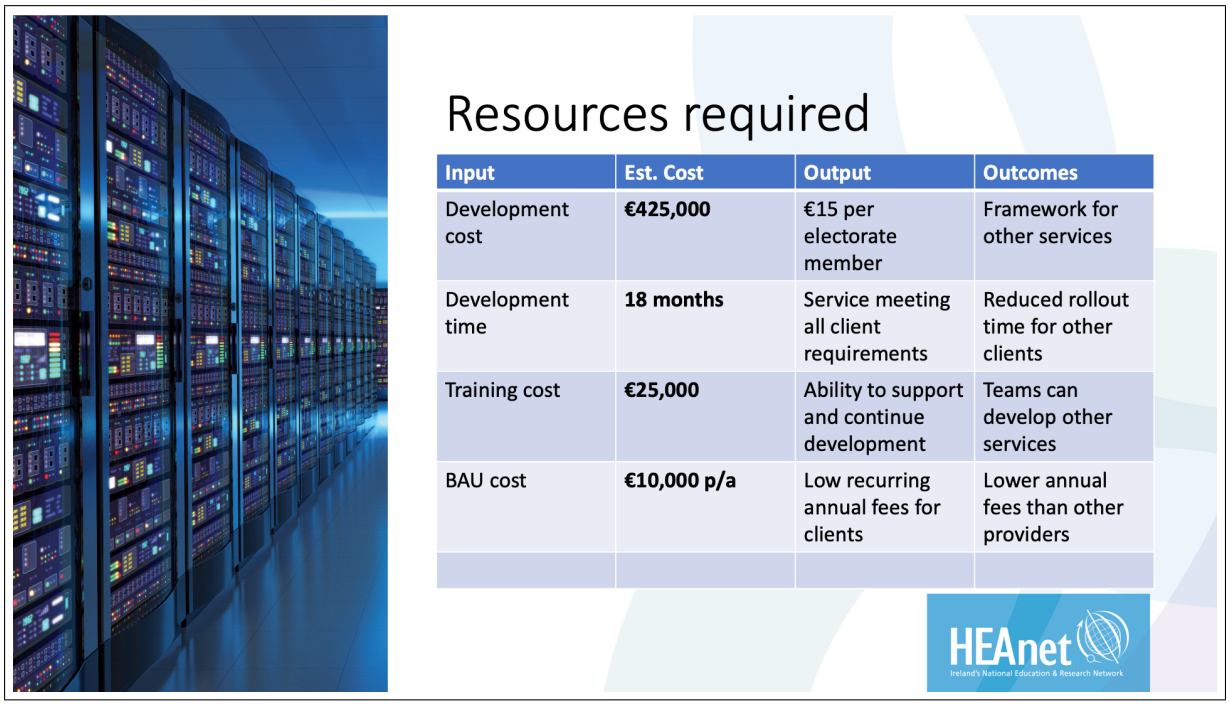

Figure 4: An example of measuring costs, output and impact (Source: Author, 2023)

3.4 Change management and governance

This project will follow Agile methodology which includes processes for change management such as making use of a product roadmap and Kanban boards as these allow the development team to both visualise their workload but also provides project representation to the wider organisation. Development will be incremental and continuously improving as a result of feedback and reviews of previous sprints. The assigned project manager will be the main point of contact between the team, client, other stakeholders and SMEs within the company who will be consulted regularly to ensure the project is conforming to ISO, GDPR and security standards throughout development. Change control will be handled on a review and test basis, where new code or features will be reviewed before being committed and built in a GitLab CI/CD pipeline, tested and deployed to the testnet for further testing and upon successfully passing this stage the development team can decide to deploy changes into the main production environment.

Roles and responsibilities within the project will be clearly defined from stakeholders to the development team to ensure decision-making is efficient and there is clarity for accountability for everyone involved in the project. HEAnet hosts a monthly company meeting where teams can provide feedback on how their projects are progressing and members of the development team should use this as a valuable time to provide visibility to the organisation. Documentation will be maintained in the form of issue tracking in GitLab making use of epics, milestones, tagging and merge requests as a form of both code review and historical code reference.

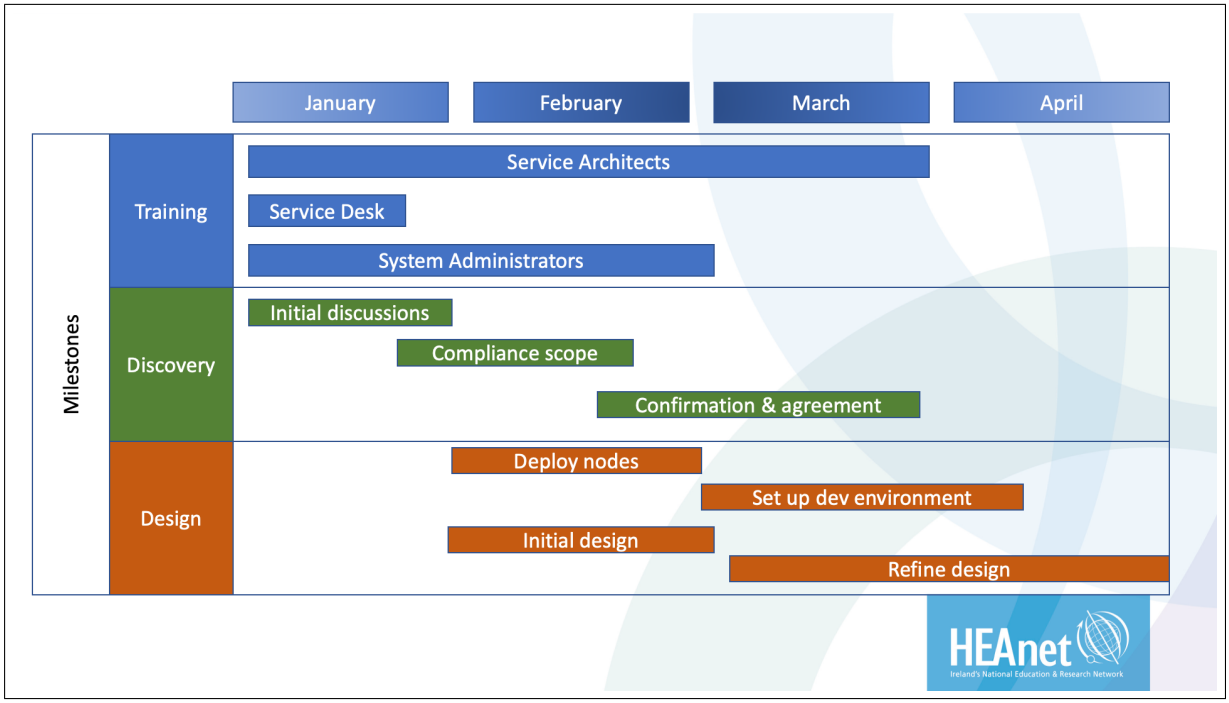

Figure 5: Example of a product roadmap for the first quarter (Source: Author, 2023)

3.5 Project schedule

The project will take approximately 18 months to complete taking into account training, requirement discovery, design, development, testing and deployment.

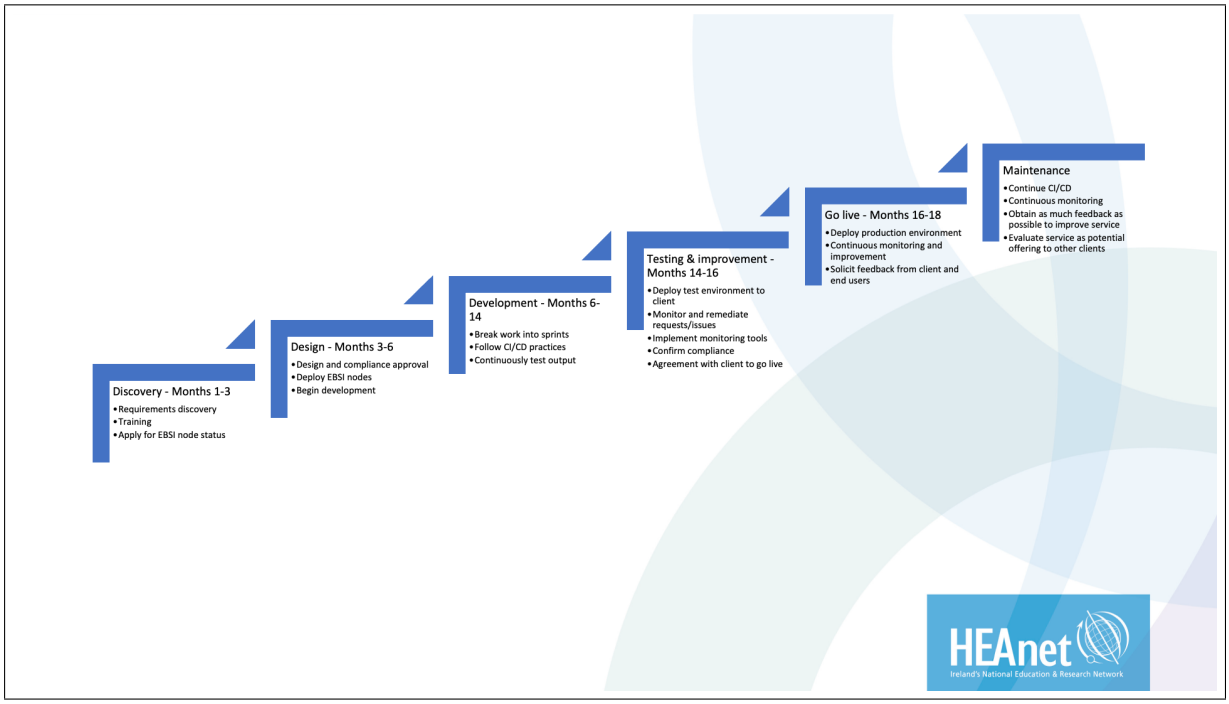

Figure 6: Project timeline with milestones (Source: Author, 2023)

3.6 Multi-annual business plan

This project is projected to take 18 months to reach completion by the end of 3 years there will be a product that has matured and is available as a service to the HEAnet client base.

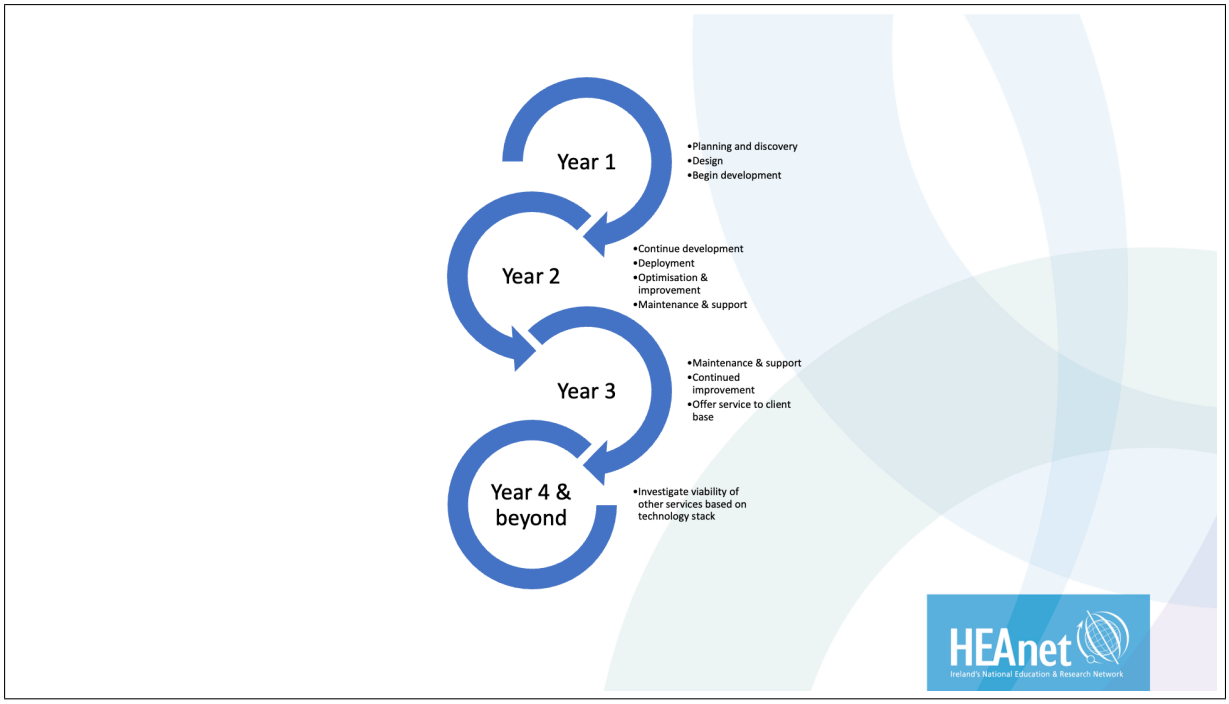

Figure 7: Multi-year project timline (Source: Author, 2023)

3.7 Evaluation

Based on the information gathered in the secondary research section of this paper a service design can be composed for submission to tender. Taking into considerations the key features required by TU Dublin, blockchain is a suitable platform to build a service to meet their needs. The inherent security features of blockchain technology provide network resilience, auditability and anti-tampering features while the cryptographic nature of the technology supports concepts such as homomorphic encryption to ensure the votes remain anonymous. Having full control of the development process also ensures that the product meets all ISO/GDPR requirements as the research performed showed that there was a lack of information from providers, many of whom were unwilling to discuss financing or mechanisms in place to meet the required compliance standards. Hyperledger Fabric uses chaincode which is a form of smart contract that exists on other blockchains, the function of chaincode would be to handle voter eligility, the voting process and result calculation. Since it is a form of contract and only the actions agreed within the contract are actioned then voting mechanisms can be customised for each election.

Chapter 4: Conclusion

HEAnet are in a position to provide not only TU Dublin with an e-voting service but their entire client base and with the training and knowledge obtained in doing so opens opportunities in developing other services based on the EBSI framework. In the past e-voting has been unsuccessful due to lack of oversight, understanding or financial will, however, as new technologies emerge then it is not unreasonable to continue to strive for a voting platform that provides security, trust, mobility and privacy. Estonia

has shown that elections at all levels of government can be successfully conducted using digital methods and the fact that there have been consistent increases in uptake shows that there is demand for such a service. Blockchain technology provides a platform for e-voting services that is cost-effective, secure, accessible, tamper-proof and auditable.

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Appendix

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