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Simplistic Graphic User Interface Design for Rendering Blockchain Data (A Case Study of Educational Administrative Domain)

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Abstract

Blockchain data is characterized by encryption which is usually aimed at securing the data itself from getting into wrong hands. However, this limits the readability of the data when there is a need to. Clarity and understanding are essential indicators of a usable system as a complex but functioning system is of no value to the user if the data are not presented in a simple readable format. A Graphic User Interface (GUI) with a simplistic design is presented to solve this problem by rendering only necessary blockchain data while considering supplementary details that are usually hidden. 5 blockchain scenarios are created for this purpose. The activities and potential data involved are clearly stated. The raw blockchain data on a high level are recorded in form of JavaScript Object Notification (JSON). Attention is given to supplementary details from the raw blockchain data while translating them into graphical form. Results were presented in three different forms (raw blockchain data, complex GUI, and the simplistic GUI) to different categories of users and their comments were compared and analyzed. Since human computer interaction is an essential factor in user's readability, the GUI rendered in this work is an enhancement to the blockchain technology as seen in the result which shows the simplistic GUI as the best understood interface even by a novice among the three.

Keywords: blockchain, Human Computer Interaction, educational administration, interface, JavaScript Object Notification

1. Introduction

Data management has evolved over the years. Central database that makes use of relational data structure is the most popular method where data are stored in a centralized server and client systems connect to this server to make use of the data (Manoj A. Thomas, Richard T. Redmond & H. Roland Weistroffer, 2009). In this case, clients only have controlled access given by the central server. In recent times, a distributed data structure has been employed to create a decentralized data management approach popularly known as the blockchain (Ping Zhang & Na Li, 2004; Antony Vigil, Prakarsh Pathak, Shubham Upadhyay, Deepankar Singh & Vaibhav Garg, 2018; Mohammad Jabed Morshed Chowdhury, Alan Colman, Muhammad Ashad Kabir, Jun Han & Paul Sarda, 2018). Cryptocurrency is the most trending application of the blockchain where financial transactions are the core actions that are happening. The idea with cryptocurrency was to take away financial control from central authorities and place it in the hands of the public while maintaining security and immutability at the same time.

Meanwhile, beyond cryptocurrency, other applications of the blockchain have surfaced such as supply chain, e-governance, identity management systems and tracking and monitoring systems among others (Uvini J. Munasinghe & Malka N. Halgamuge, 2023; Ibrahim Ramadan Abdelhamid, Islam Tharwat Abdel Halim, Abd El-Majeed Amin Ali & Ibrahim Abdelmoniem Ibrahim, 2023). In fact, recent research proposed the use of blockchain technology to detect counterfeit COVID-19 vaccines (Uvini J. Munasinghe & Malka N. Halgamuge,

2023). These applications, either cryptocurrency or otherwise, have struggled with designs for different reasons. Firstly, engineering a blockchain application is quite different from a regular server-client system because a medium such as Remote Procedure Call (RPC) is usually needed for convenient communication with the blockchain network, and this is why specific browsers or Decentralised applications (DAPP) are created for client interaction.

Also, since blockchain activities are available in the public domain, blockchain networks usually have a dedicated domain where all blockchain activities are available for viewing and sometimes interact with the smart contracts, examples are the Blockchain explorer for viewing bitcoin transactions (Satoshi Nakamoto, 2008), Etherscan for viewing Ethereum blockchain data (Vitalik Buterin, 2013) and Solscan for viewing Solana Blockchain data. However, these dedicated domains tend to be complex and difficult to navigate for an ordinary user. Many times, blockchain developers are the major users of these domains because a lot of attention is paid to displaying encrypted data. It is therefore extremely important that a simplistic design should be adopted for the design of blockchain applications and data explorers for ease of understanding and intuition.

Human computer interaction (HCI) is a field of computer science that focuses on how humans design and interact with information and actions that have to do with technology (Ping Zhang & Na Li, 2004). There is a bi-directional ripple effect between Advancement of Technology and HCI (Rajni Sharma, 2019). Also, blockchain has been pinpointed to be a promising technology that would change both government and industry (Ibrahim Ramadan Abdelhamid, Islam Tharwat Abdel Halim, Abd El-Majeed Amin Ali & Ibrahim Abdelmoniem Ibrahim, 2023). Hence, there is need to pay attention to the designs of blockchain-based applications so that landslide advancement can be experienced in the field of distributed systems as well as increase the rate of acceptance among everyday users. In fact, HCI does not only deal with improving usability but also provides new techniques for interaction especially around effectively accessing information (Aitham Suhas, 2020). Over the years, Graphic User Interface has proven to provide better solutions in the field of HCI.

Blockchain is undoubtedly a promising and trending technology. However, there is still a struggle in terms of the level of adoption, quite a few people are still skeptical about the usage. A recent study identified specific issues that lead to the low level of adoption and suggests potential solutions to these issues from a human-centered perspective. The motivation to change, the onboarding challenge, the usability problem and the feature problem were identified as issues. Suggestions include offering distinct user features, focus on learnability, convenient accessibility, and conversion of constraints into assets (Leonhard Glomann, Maximilian Schmid & Nika Kitajewa, 2019).

2. Literature Review

There are recent research activities that have been carried out in the past which are geared towards the creation and optimization of the design of blockchain application interfaces and design ideologies at large. In a recent paper examining the challenges that comes with the implementation of blockchain to govern shared resources, it was postulated that while the blockchain offers benefits like self-governance, transparency, and collaboration incentives, they also raise concerns regarding privacy and the role of individuals in decision-making processes. Focusing on tracking the use and contributions to the shared resources, managing the resources effectively, and negotiating the rules and rights associated with their use, the authors contributed to the field of human-computer interaction (HCI) by introducing a framework consisting of these three aspects and presenting six design dilemmas which help to strike a balance between conflicting values when designing local platforms for managing shared resources based on common ownership (Nazli Cila, Gabriele Ferri, Martijn de Waal, Inte Gloerich & Tara Karpinski, 2020).

Another paper focused on the creation of a layered hierarchy for upcoming blockchain applications (Chris Elsden, Arthi Manohar, Jo Briggs, Mike Harding, Chris Speed & John Vines, 2018). The authors identified the domains in which the blockchain applications were built as well as the features that made them unique. The paper established that Human computer interaction (HCI) has a major role in unifying the use case and design of blockchain applications with their respective human experience. It also identifies various important issues, concepts, and methodological challenges for HCI researchers.

Despite the vast attention that blockchain application is getting from the field of HCI, the involvement of non-specialists in the design process is still an issue. A paper focused on creating a prototype of a cryptocurrency platform called Geocoin and then giving participants the chance to experiment with it during a collaborative workshop (Bettina Nissen, Larissa Pschetz, Dave Murray-Rust, Hadi Mehrpouya, Shaune Oosthuizen & Chris Speed, 2018). The research created an avenue for creating diverse blockchain applications and therefore showed how a sample platform can promote collaboration and give regular people the opportunity to contribute to the design process.

There have been a lot of new introductions of new smart contract based blockchains in recent times. However,

the focus has only been mostly on Ethereum and Bitcoin. There are no established standards regarding the designs of these platforms. Most of the platforms make use of different patterns which have a huge impact on the usability of decentralized applications at large by end users. Hence, HCI has not been very successful in this regard. Therefore, a system was proposed for interface experimentations with different blockchain networks before deployment and the results were quite impressive (Michael Froehlich, Benjamin Moser, Florian Alt & Albrecht Schmidt, 2022). An experiment was conducted to make multichain more usable even for non-technical users by creating a GUI (Tani Hossain, Tasniah Mohiuddin, A M Shahed Hasan, Muhammad Nazrul Islam & Syed Akhter Hossain, 2021).

Another research introduced BlocKit, a physical kit that helps understand blockchain infrastructure. It uses cognitive theories and material-centered design to make it easier to grasp blockchain applications. The author suggested a new design approach, basic vocabulary, and design ideas to inspire HCI researchers in infrastructure design (Irni Eliana Khairuddin, Corina Sas & Chris Speed, 2019).

3. Methodology

The methodology for approaching this research begins with the creation and establishment of a scenario that depicts blockchain utilization. In this case, the administrative system of University of Ibadan Postgraduate College is chosen. This domain area requires the use of blockchain for promoting transparency and efficiency. After the scenarios from the administrative system have been identified, the specific blockchain data involved in each of the scenarios are extracted which are usually at high level. Normally, these data ought to be rendered directly for display, however, this research provides an intermediate stage of processing these data through an Application Program Interface (API). These APIs are in JSON format such that regardless of the blockchain programming language, the data is rendered independently. It is from the API processing stage that the simplistic GUI data rendering is developed as shown in Figure 1. Here, Supplementary data that are usually hidden in most blockchain explorers are prioritized for display while encrypted or encoded data are minimized on the display screen.

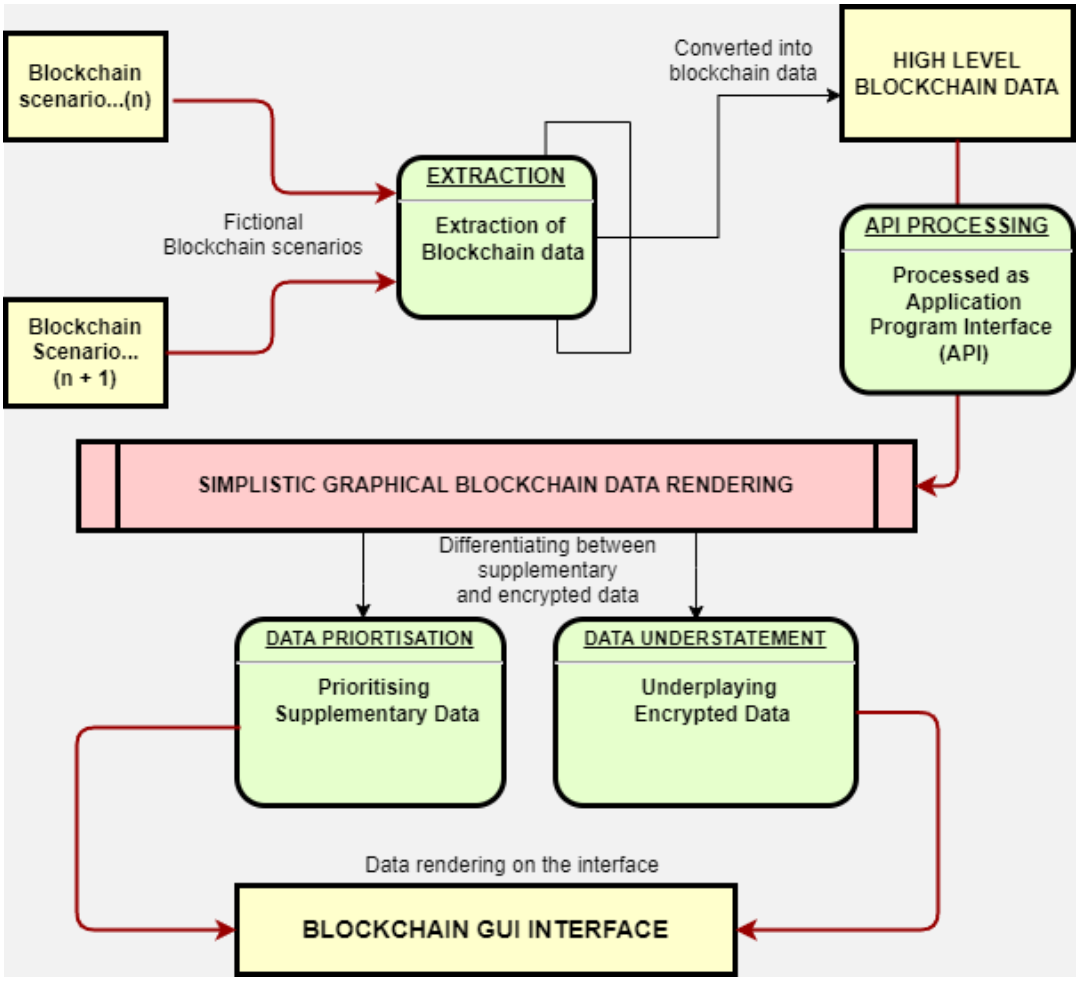

Figure 1. Simplistic Blockchain Data GUI Design

4. Blockchain Scenarios

These are the scenarios from the chosen Administrative System. They are basically scenarios that would play out in a blockchain explorer for a postgraduate college administrative system.

4.1 Scenario One: Displaying General Information

This scenario has to do with depicting general information on the administrative blockchain explorer. Here, the various sections within the Postgraduate Administrative system are requested. The result is basically a list of all the sections. The blockchain data involved here are Section names, Transaction hashes/Blockchain reference for each section added, Time stamps, Block numbers, Age, Encrypted address of performer of section adder, Encrypted address of section contract, Section contract name, Token value, Transaction fee, Transaction type, Nonce, Position in block, Current Method call, Preceding method call and Gas price.

4.2 Scenario Two: Displaying Document Trail

This scenario has to do with displaying an asset trail. The asset has been moving from one point to another on the blockchain and a level of provenance is needed to show the origin and history. In this case, the history of the asset is shown. The specific asset whose trail is requested for display in this scenario is Document RQ8765541. The blockchain data involved here includes Document id, Document type, Document location for each footprint, Block numbers for each footprint, Age of each footprint, Encrypted address of performer of footprint logger, Encrypted address of document trail contract, Document trail name, Token value, Transaction fee, Transaction type, Nonce, Position in block, Current Method call, Preceding method call, Gas price, Preceding method call, Entry time stamp for each footprint, Exit time stamp for each footprint, Transaction hash/blockchain reference for each footprint.

4.3 Scenario Three: Displaying Stakeholder Information

There are stakeholders within the administrative system. There is the need to display certain information about these stakeholders. This specific scenario gives rise to a request for displaying information about the identity of the Postgraduate Coordinator to the Department of Economics. The blockchain data here include Department name, Postgraduate coordinator name, Transaction hashes/Blockchain reference, Time stamp, Block number, Age, Encrypted address of performer of coordinator adder, Encrypted address of department contract, Department contract name, Token value, Transaction fee, Transaction type, Nonce, Position in block, Current Method call, Preceding method call and Gas price.

4.4 Scenario Four: Displaying System Activities

These are activities that take place within the system. This scenario displays a response to the request to outline all activities that are defined to happen within the context of the administrative system. The blockchain data include Activity name, Block numbers for each activity, Age of each activity, Encrypted address of performer of activity adder, Encrypted address of activity contract, Activity contract name, Token value, Transaction fee Transaction type, Nonce, Position in block, Current Method call, Preceding method call, Gas price, Time stamp for each activity, Transaction hash/blockchain reference for each activity.

4.5 Scenario Five: Displaying Event Data

This scenario shows how event data are depicted. This specifically depicts information about the performer of an event. The event in this case is the purchase of application form FM87866? Event name, Event ID, Event actor, Transaction hashes/Blockchain reference, Document ID, Time stamp, Block number, Age, Encrypted address of event contract, Event contract name, Token value, Transaction fee, Transaction type, Nonce, Position in block, Current Method call, Preceding method call, Gas price.

Each set of data from the blockchain scenarios is processed and returned through the JSON API with their respective values.

5. Data Prioritization and Minimization

Here, distinction is made between the data returned by the JSON API. Some of the data are prioritized and rendered while others are deemed less important and minimized into the background. Specifically, data that are encrypted and might pose confusion to the end users are in the minimized category while supplementary data with clear meaning are rendered on the interface for the end user to see. Usually, the full data returned by the API is displayed on the interface in most blockchain explorers. However, this paper is taking a simplistic approach to only display necessary information to the user. Table 1 shows the different data and the category they belong to as presented in this paper:

Table 1. Prioritized and Minimized data

PRIORITIZED DATA	MINIMIZED DATA
Section name [Scenario 1]	Age [All Scenarios]
Blockchain reference [All Scenarios]	Block number [All Scenarios]
Time stamp [All Scenarios]	Address Performer [All Scenarios]
Contract name [All Scenarios]	Address contract [All Scenarios]
Current method call [All Scenarios]	Token value [All Scenarios]
Preceding method call [All Scenarios]	Transaction fee [All Scenarios]
Document ID [Scenario 2, 5]	Transaction type [All Scenarios]
Time stamp in [Scenario 2]	Nonce [All Scenarios]
Time stamp out [Scenario 2]	Position in block [All Scenarios]
Document type [Scenario 2]	Gas price [All Scenarios]
Location [Scenario 2]	Age [All Scenarios]
Department [Scenario 3]	Block number [All Scenarios]
Activity name [Scenario 4]	Address Performer [All Scenarios]
Event name [Scenario 5]	Address contract [All Scenarios]
Actor [Scenario 5]	

6. Implementation of Interface Output

For this research, the prioritized data is rendered on a graphical user interface (GUI) compatible with a web browser on a local server that makes use of APACHE with source of data fetched directly from the API. Meanwhile, the full version of data is fed into the Ethereum virtual machine and rendered on the Ethereum blockchain data explorer which is later used as comparison purpose.

6.1 Index Interface

Figure 2 is the index page of the interface for the simplistic GUI blockchain design:

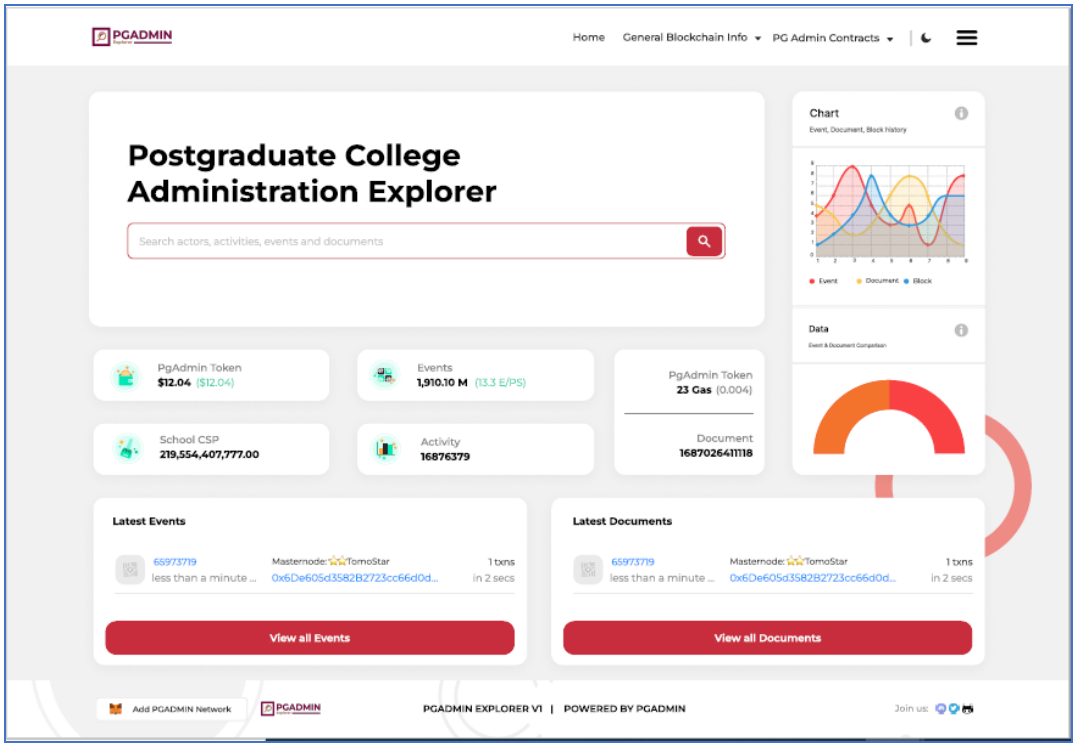

Figure 2. Index Page of Simplistic Blockchain GUI Data Rendering

6.2 Interface 1

Page description: This interface shows the sections that are within the system. Table 2 shows the Data result for scenario 1 while Figure 3 shows its respective GUI design.

Page name: General Information

Contract name: PgAdminSection{}

Method call: GetAllSection()

Table 2. Data result for Scenario 1

SECTION NAME	TIME STAMP	ADDED BY	PREVIOUS METHOD	BLOCKCHAIN REFERENCE
Admission Section	21st January 2023	Admin 06543	Add_Section()	Adx07654
Audit Section	21st January 2023	Admin 06543	Add_Section()	Adx07655
Committee Section	21st January 2023	Admin 06543	Add_Section()	Adx07651
Examination Section	21st January 2023	Admin 06543	Add_Section()	Adx07652
Finance Section	21st January 2023	Admin 06543	Add_Section()	Adx07653
Ict Section	21st January 2023	Admin 06543	Add_Section()	Adx07656
Information Section	21st January 2023	Admin 06543	Add_Section()	Adx07659
Record Section	21st January 2023	Admin 06543	Add_Section()	Adx07658

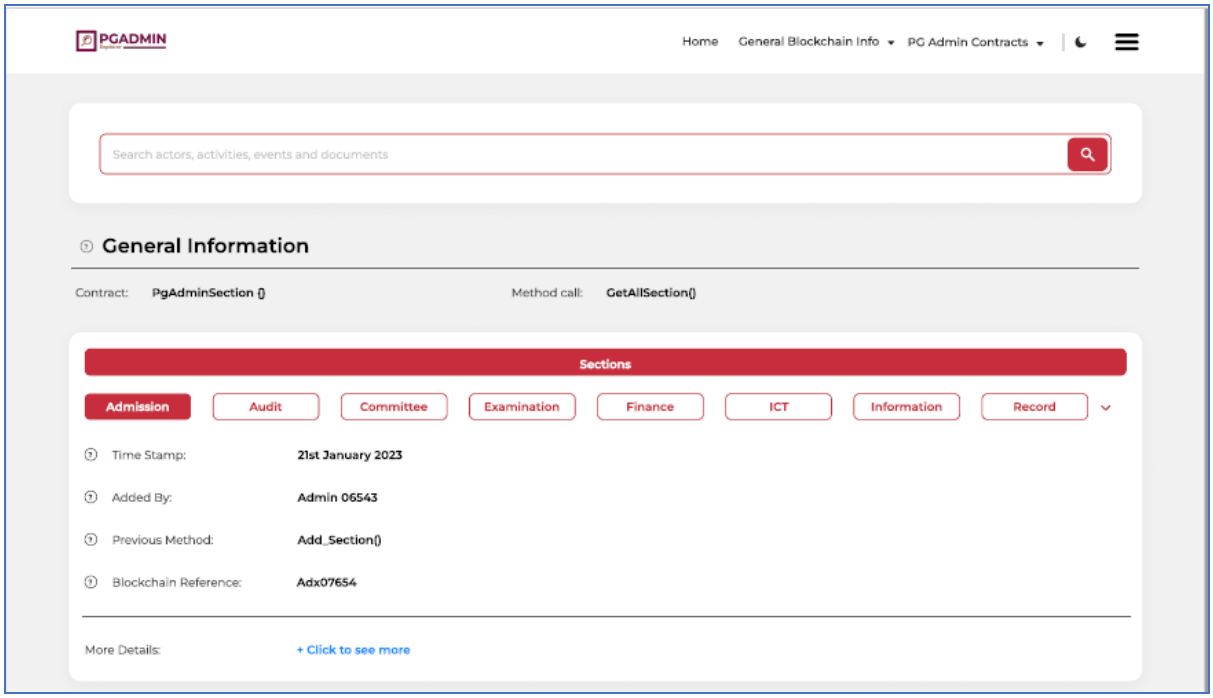

Figure 3. GUI Design result for Scenario 1

6.3 Interface 2

Page description: This screen shows a trail of Document RQ8765541. Table 3 shows the Data result for scenario 2 while Figure 4 shows its respective GUI design.

Page name: Documents

Contract name: PgAdminDocument{}

Method call: GetDocumentTrail(RQ8765541)

Table 3. Data Result for Scenario 2

DOCUMENT	TYPE	LOCATION	PREVIOUS METHOD	TIME STAMP IN	TIME STAMP OUT	BLOCKCHAIN REFERENCE
RQ8765541	REQUEST	Admission Section	Log_Trail()	21st January 2023	22nd January 2023	Adx0765211
RQ8765541	REQUEST	ICT Section	Log_Trail()	23rd January 2023	24th January 2023	Adx0765212
RQ8765541	REQUEST	Finance Section	Log_Trail()	25th January 2023	26th January 2023	Adx0765213
RQ8765541	REQUEST	Registry Section	Log_Trail()	27th January 2023	28th January 2023	Adx0765214

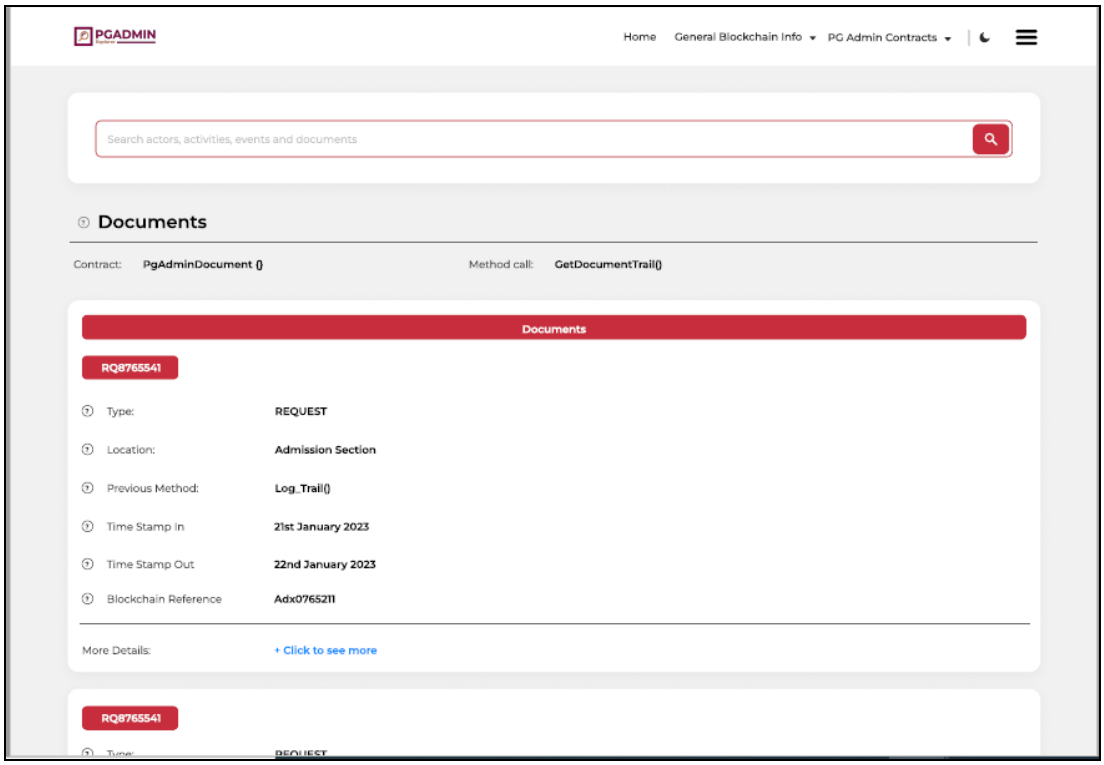

Figure 4. GUI Design Result for Scenario 2

6.4 Interface 3

Page description: This screen displays information about stakeholders. Specifically, the Postgraduate Coordinator to the Department of Economics. Table 4 shows the Data result for scenario 3 while Figure 5 shows its respective GUI design.

Page name: Stakeholders

Contract name: UniversityDepartment{}

Method call: GetPgCoordinator('Economics')

Table 4. Data result for Scenario 3

DEPARTMENT	POSTGRADUATE COORDINATOR	TIME STAMP	PREVIOUS METHOD	BLOCKCHAIN REFERENCE
Department of Economics	Dr Dora Harris	27th January 2023	Add_Coordinator()	Adx07652141

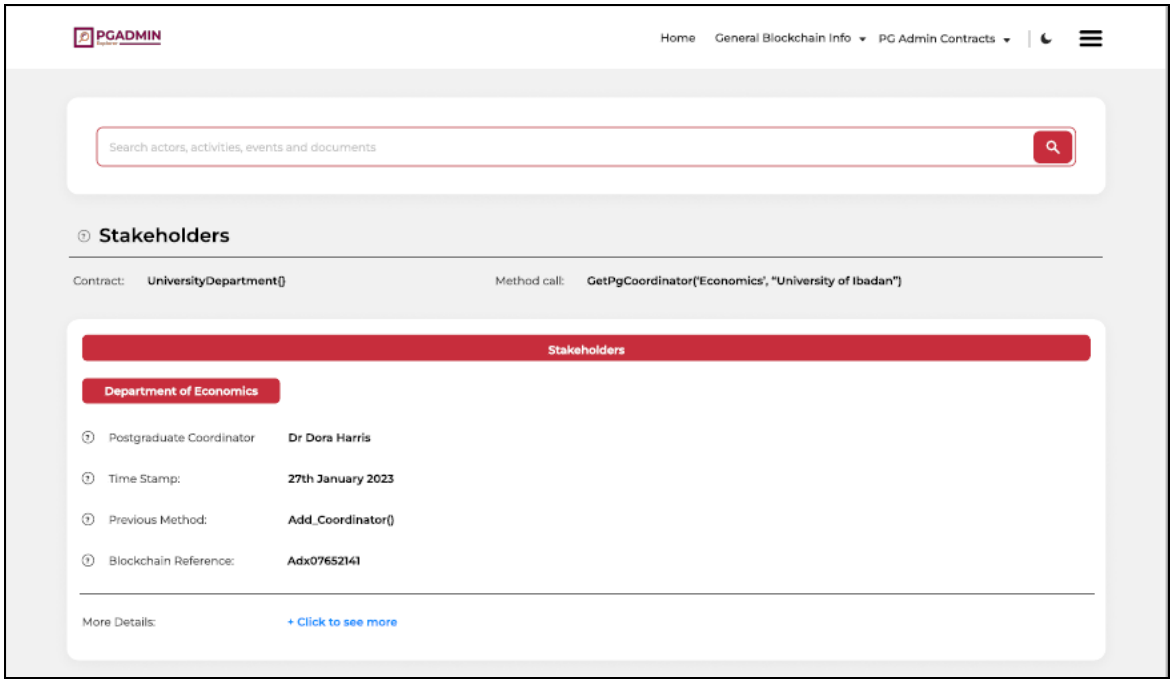

Figure 5. GUI Design Result for Scenario 3

6.5 Interface 4

Page description: This screen display system activity. Outline all activities that are defined to happen within the context of Postgraduate Administration Ontology. Table 5 shows the Data result for scenario 4 while Figure 6 shows its respective GUI design.

Page name: Activity

Contract name: PgAdminActivity {}

Method call: GetAllActivity() Table 1. Competency Questions for validating

Table 5. Data Result for Scenario 4

Activity	Time stamp	Added by	Previous method	Blockchain reference
Admission Process	27th January 2023	Admin 06543	Add_Activity()	Adx0765233301
Application Process	27th January 2023	Admin 06543	Add_Activity()	Adx0765233302
Billing Process	27th January 2023	Admin 06543	Add_Activity()	Adx0765233303
Certificate Process	27th January 2023	Admin 06543	Add_Activity()	Adx0765233304
Complaint Process	27th January 2023	Admin 06543	Add_Activity()	Adx0765233305
Program Deferment Process	27th January 2023	Admin 06543	Add_Activity()	Adx0765233306
Program Reactivation Process	27th January 2023	Admin 06543	Add_Activity()	Adx0765233307
Student Clearance Process	27th January 2023	Admin 06543	Add_Activity()	Adx0765233308
Student Registration Process	27th January 2023	Admin 06543	Add_Activity()	Adx0765233309

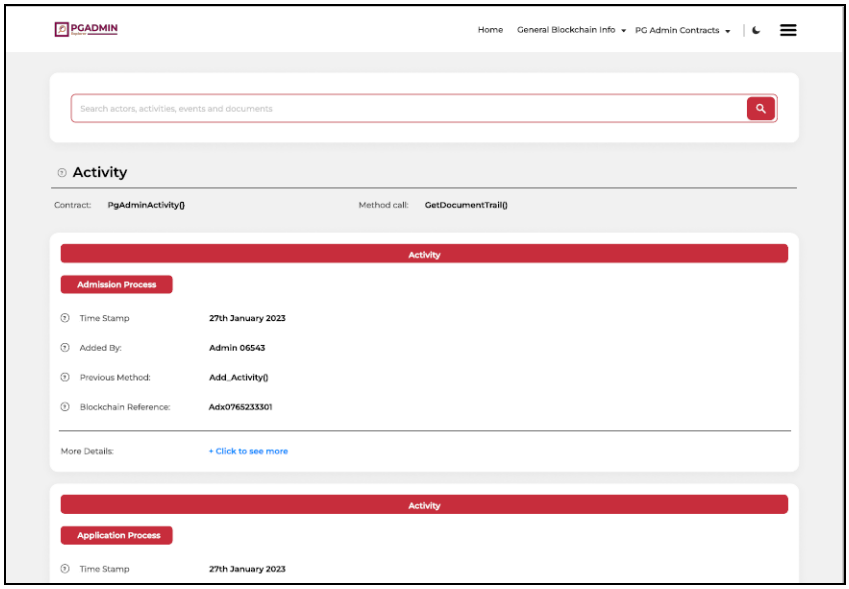

Figure 6. GUI Design result for Scenario 4

6.6 Interface 5

Page description: This screen displays event related data. Who is the performer of the event involving the purchase of application form FM87866? Table 6 shows the Data result for scenario 5 while Figure 7 shows its respective GUI design.

Page name: Event

Contract name: PgAdminEvent{}

Method call: GetEventWithDocument (FM87866) Table 2. Competency Questions for validating

Table 6. Data Result for Scenario 5

Event	Event id	Actor	Document	Time stamp	Previous method	Blockchain reference
Application Form Purchase	EVMM654	Mr Jaime Chase	FM87866	27th January 2023	Log_event()	Adx07652133

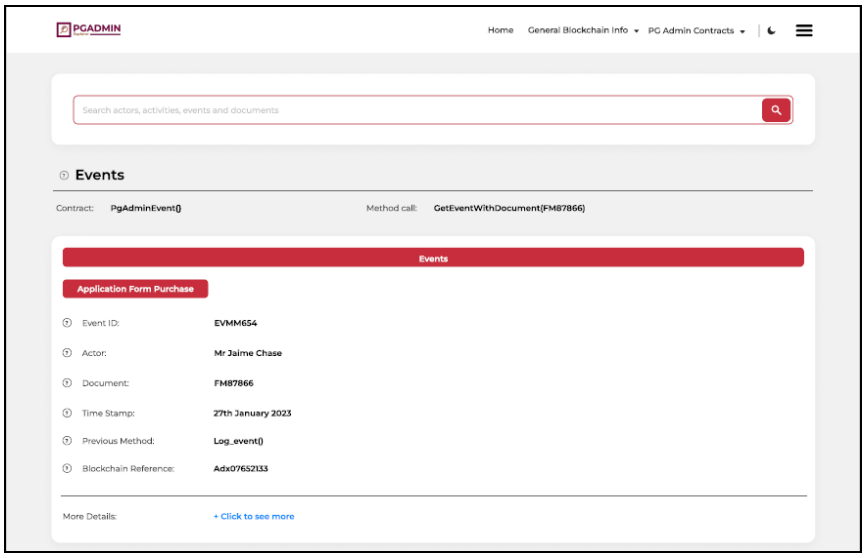

Figure 7. GUI Design result for Scenario 5

7. Users' Observations

Three categories of end users are chosen as subjects for observations to interpret the GUI and their observations are recorded, they are:

Domain Expert End Users

This consists of 20 participants. These are users who are professionals in the domain used for the case study. They have firsthand knowledge about the blockchain scenarios that are used.

Technical End Users

This consists of 20 participants as well. These are users who understand the nitty gritty of the blockchain system and the kind of data that are involved. Some of them are system developers, analysts, programmers etc.

Novice End Users

This also consists of 20 participants. These users do not have any prior knowledge about the domain neither do they have technical knowledge. They are everyday users who make use of computer devices and interact with applications for basic purposes.

Each of these categories are shown in three kinds of interfaces as follows:

- The raw application program interface (API) in form of JSON
- The full data version in the Ethereum explorer GUI interface
- The minimized data rendering in the simplistic blockchain GUI

The participants are given 15 – 20 minutes each for each of the interfaces and record their level of understanding. Hence, observation is made whether they had excellent understanding of the interface, partial understanding, or no understanding at all.

Tables 7-9 below show the result of the various user observations by the kind of interface.

7.1 JSON API Rendering

This refers to the data collected from the three categories of users while observing the JSON response.

Table 7. Users' Observation of JSON API Response

Participant category	Number of participants	Excellent understanding	Partial understanding	No understanding
Domain experts	20	8	7	5
Technical users	20	12	5	3
Novice users	20	0	3	17
Total	60	20	15	25

7.2 Full Data Rendering

This refers to the data collected from the three categories of users while observing the GUI from a full data perspective.

Table 8. Users' Observation of Full Data GUI Design

Participant category	Number of participants	Excellent understanding	Partial understanding	No understanding
Domain experts	20	9	9	2
Technical users	20	14	3	3
Novice users	20	3	6	11
Total	60	26	18	16

7.3 Simplistic Blockchain GUI Rendering

This refers to the data collected from the three categories of users while observing the simplistic GUI design.

Table 9. Users' Observation of Simplistic GUI Design

Participant category	Number of participants	Excellent understanding	Partial understanding	No understanding
Domain experts	20	18	1	1
Technical users	20	19	1	0
Novice users	20	16	3	1
Total	60	43	5	2

8. Discussion of Results

Figure 8 shows the JSON API response observation by the three categories of users. It shows that 33% of all users have an excellent understanding of the API response, none of these was a novice user. 25% of all users have a partial understanding of the JSON API response with the highest number from Domain experts. The highest number with no understanding of the JSON response is from Novice users. 85% of the novice users do not understand JSON responses.

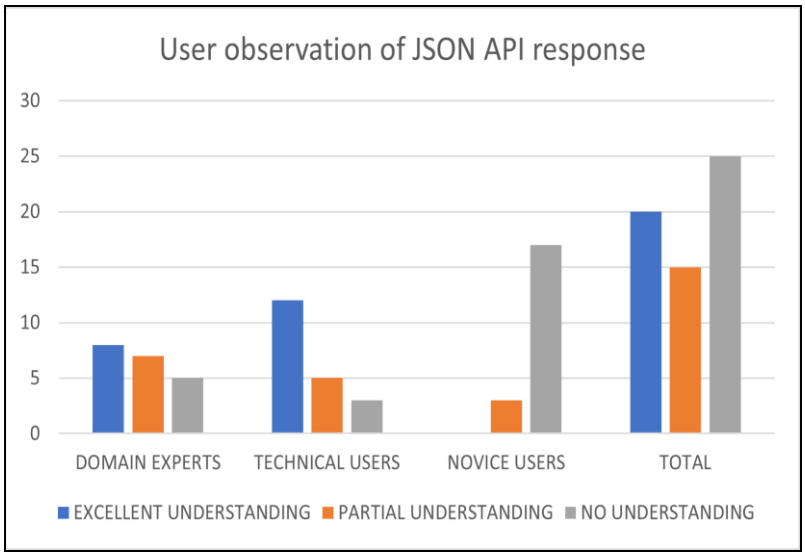

Figure 8. Graph showing Users' Observation of JSON API response

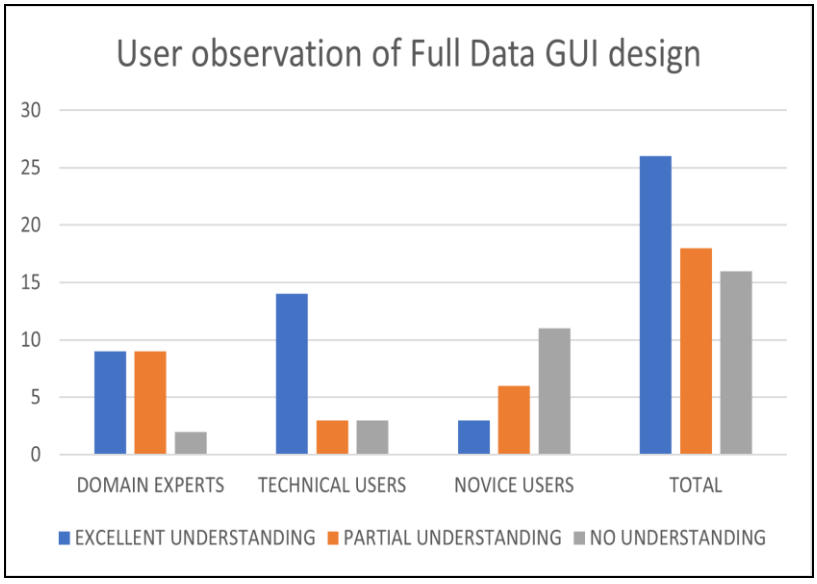

Figure 9. Graph showing Users' Observation of Full Data GUI rendering

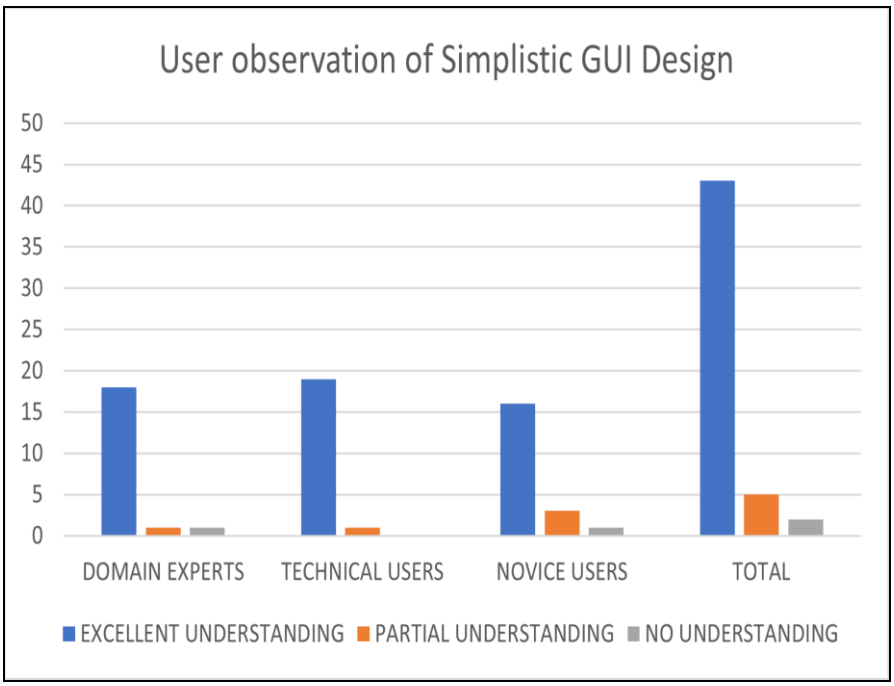

Figure 10. Graph showing Users' Observation of Simplistic GUI Rendering

Figure 9 shows the full data GUI rendering. Here, the novice users also had the highest number of observers who do not understand the data on the interface with 55%. Technical users have the highest number of observers with excellent understanding, they have 70%. Domain expert observers have good numbers of observers fairly distributed between excellent and partial understanding. 43% of all users have an excellent understanding of the full data design.

Figure 10 shows the simplistic blockchain GUI rendering where Novice users recorded the highest number of excellent understandings compared to the three other interfaces. The number of observers for the partial and no understanding category for the simplistic design was very negligible. A record of 71% of observers had an excellent understanding of the Simplistic design.

9. Conclusion

In summary, this research paper has introduced a streamlined interface design method within the context of blockchain technology. By creating blockchain scenarios and generating corresponding design outputs, user observations were conducted to assess their perception of this approach compared to existing interfaces. Firstly, it became evident that prioritizing minimal data display on the user screen aligns with user-centric design principles. This finding strongly supports the notion that a simplistic design approach is most effective for blockchain interfaces. Secondly, this research activity also revealed that complex and comprehensive data rendering primarily benefits technical users and domain experts. Novice users, on the other hand, tend to experience more confusion when presented with encrypted and intricate information.

The implications of these findings are significant as they contribute to the field of Human-Computer Interaction (HCI) and Blockchain technology by illuminating the relationship between simplicity and usability. While blockchain is inherently complex, abstracting intricate details from users enhances their understanding and improves the likelihood of widespread adoption. By focusing on user-centric design principles and incorporating simplicity into blockchain interfaces, we can bridge the gap between users and the intricacies of this technology, ultimately fostering greater acceptance and usability.

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