Engineering Blockchain Enabling Win A Fortune Game among Novice through eAOM

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ABSTRACT

Blockchain application development has received much attention nowadays. As development is complex and challenging, a systematic approach is needed to improve the product, services, and process quality. Despite the introduction of techniques, there are still inadequate models for demonstrating the blockchain's internal architecture. Hence, there is a gap when developing the blockchain application, a gap in the modelling environment of a blockchain development application. This paper introduces a new insight into blockchain application development through extended Agent-Oriented Modelling (eAOM). eAOM is a methodology for complex socio-technical system development, and we believe that it can reduce the complexity of implementing the blockchain application. In this paper, the eAOM is used to model a blockchain-based "win a fortune" system, which includes smart contract development. It showcases the feasibility of adopting eAOM to model a blockchain enabling application. A usability survey among the novices has further validated the usability and benefits of eAOM in the blockchain enabling application development.

CCS CONCEPTS

• **Software Engineering**; • **Software Methodology**;

KEYWORDS

Blockchain application development, Model-driven Engineering, Agent Oriented Modelling, Ethereum Smart Contract

ACM Reference Format:
Michelle Libin Ten, Waishiang Cheah*, and Sim Yee Wai. 2022. Engineering Blockchain Enabling Win A Fortune Game among Novice through eAOM. In *14th ACM Web Science Conference 2022 (WebSci '22), June 26–29, 2022, Barcelona, Spain.* ACM, New York, NY, USA, 8 pages. https://doi.org/10.1145/3501247.3539018

1 INTRODUCTION

With the rapid growth of innovative technology, blockchain technology has received much attention nowadays. Satoshi Nakamoto found blockchain in 2008 [1]. It is a decentralized database distributed across a network of devices. It is known as a node. Blockchain provides a secure, trustworthy, and transparent environment for data transactions. Each transaction will generate a new block on the network and propagate to other nodes. The block consists of a current and previous block hash, and data are immutable once deployed to the network.

Aside from cryptocurrency, blockchain applications are growing in the most divergent fields. Regardless of the exponential surge in interest in Decentralized Applications (DApp), it currently lacks well-organized software development approaches [2]. The interest in Blockchain Technology has resulted in significant investment, generally in rapidly creating applications to be the first on the market, which has resulted in massive disasters, typically due to poor design and inadequate security practices [3]. Udokwu et al. [4] addressed blockchain technologies' limitations and common issues. For example, Blockchain Technology is facing complexity, usability, and architecture design issue. Hence, we have foreseen a gap in blockchain application development. Therefore, the primary purpose of this paper is to introduce an alternative methodology for blockchain application development from an Agent-Oriented Modelling perspective.

The primary research question is how Agent-Oriented Modelling Framework can support blockchain application development? The research question should answer that the agent-oriented modelling can capture blockchain characteristics and flow. Then, the sub-question is inferred based on the primary research question. What are modelling notations used to form the framework? How does the modelling notation in the framework relate to blockchain elements? What are the benefits of using the framework in the development of a blockchain enabling application? As blockchain is a complex system, extended Agent-Oriented Modelling (eAOM) can bridge the gap. eAOM is methodology that handles complex systems. With eAOM, we argue that it can aid the blockchain developers in identifying and analyze requirements, design and implement blockchain application.

This paper presents a case study where the blockchain is used to solve a "win a fortune" game system. We used the proposed methodology, eAOM, to trigger the blockchain application's functionality and potential. To evaluate the usefulness and completeness of the eAOM, we experiment with a group of novice users and compare the proposed methodology with Unified Modelling Language (UML) and AOM.

The remainder of the paper will be organized in the following manner: Section 2 presents the related works in engineering

WebSci '22, June 26–29, 2022, Barcelona, Spain

ACM ISBN 978-1-4503-9191-7/22/06…$15.00
https://doi.org/10.1145/3501247.3539018

blockchain 1applications. Section 3 presents a walkthrough example of how eAOM is adopted to blockchain based lottery mobile games. Section 4 presents the analysis and findings of the adoption of AOM and eAOM among novices in blockchain application development. Finally, the paper is concluded in Section 5.

2 RELATED WORKS

The next subsections provide instructions on how to insert figures, tables, and equations in your document. This section highlights current research on software development methodologies for blockchain applications. First, the existing study papers are sorted into a few categories: Software Development Life Cycle (SDLC), Agile Methodology, Agile Block Chain DApp Engineering (ABCDE), Model-Driven Methodology, Decentralized Agent-Oriented Modelling (DAOM), Action Design Research (ADR) Approach, Entity Relationship Diagram (ERD), Unified Modelling Language (UML), and Business Process Modelling Notation (BPMN).

Miraz and Ali [5] pointed out the limitations of the current methodology due to the blockchain characteristics: immutability behaviour, consensus mechanism, and gas cost during the transaction using a smart contract. Thus, Software Development Life Cycle (SDLC) models are challenging to fulfil, especially in the testing and maintenance phase.

Fridgen et al. [6] addressed that blockchain requires a technology-driven and systematic approach to design and develop potential blockchain use cases. The researchers apply the action design research (ADR) approach and situational method engineering (SME) to develop blockchain use cases. ADR consists of four steps: "problem formulation", "building, intervention, and evaluation", "reflection and learning", and "formalization of learning".

Researchers proposed adopting the Agile approach, a flexible, iterative, and adaptive methodology that involves gathering requirements, development, testing, and gathering feedback from users and enhancement. Agile methodology allows us to ensure software quality and usability. This methodology has been applied in various projects such as the Crypto-Trading project [7], smart cities project [8], Initial Coin Offering [9], and Supply Chain Operations [10]. Researchers proposed an Agile approach with a flexible, iterative, and adaptive methodology that involves gathering requirements, developing, testing, and gathering feedback from users and enhancement.

Since the year 2018, a team of researchers has made a great effort to propose an extension methodology from the agile approach, known as Agile Block Chain Development Engineering (ABCDE) [3], [11]. The idea behind using ABCDE is because the smart contract is complicated. Unlike traditional programming, smart contracts introduced new concepts such as the contract's address to perform a transaction; gas requires executing the contract and digital money transfer between two parties [11].

On the other hand, Model-driven engineering (MDE) is widely used in blockchain technology [12], [13], [14], and [15]. Model-Driven is convenient to design models and convert them to code by using tools. [14] pointed out that the code generation tools allowed us to apply best practices and well-tested building blocks.

The study in introduces decentralized agent-oriented modelling (DAOM) based on the model-driven framework. These models accommodate both technical and non-technical clients' communications. It is a three-step procedure for determining requirements and describing the architecture of a DApp. First, the AOM goal model is used in the initial stage to define the preliminary needs for dealing with the usability and complexity issues. The second stage involves connecting the UML component diagram to the project architecture. Finally, a UML sequence diagram is used to support the protocols and blockchain operations.

From the review, modelling is needed to model the complexity of blockchain enabling application development and to prevent bugs and errors. Furthermore, the smart contract will be implemented on various applications that handle sensitive data and money, so it is essential to have a formalized model for a systematic way to plan, implement, and design the blockchain application.

In order to fill this gap, Agent-Oriented Modelling (AOM) is proposed and used in our research. The benefits of using AOM are to document how the agent achieves the goal and how the agent behaves in a different situation, as elaborated in the following section. To date, AOM has been adopted in 3D simulation [16], video surveillance [17], emotion application [18], games [19].

3 MATERIAL AND METHODS

The eAOM consists of five phases before implementation, testing, and deployment, there are: requirement elicitation, conceptualization domain modelling, early identification of blockchain use case, platform independent design and modelling, and platform specific modelling.

Requirement elicitations are conducted using Human Oriented Method for Eliciting Requirement (HOMER) technique, it is to collects the needs of the domain experts and stakeholders through a series of question. This can be done through meeting, round table, interview, and self-examination to understand and analyze the problem.

Conceptualization domain modelling transform the HOMER answer into goal model, role model, organization model, and domain model. The models aid to obtain what expected of the system by describing the context in which it operates [20].

Early identification of blockchain use case adopt e3 value model to identify a potential and sustainable use case. E3 value model can fulfil the requirements of replacing middleman, a market structure that works in peer, and immutable transaction in a blockchain environment [21]. Agent role mapping are constructed to transform the actors from the previous model into dedicated agent.

Platform independent design and modelling presents the blockchain properties that design for the system. This phase consists of knowledge model, interaction model, scenario model, and behavior model.

Platform specific model consists of the transformation rules to map the design model to code. In this paper, Ethereum platform is selected to adopt the transformation rules.

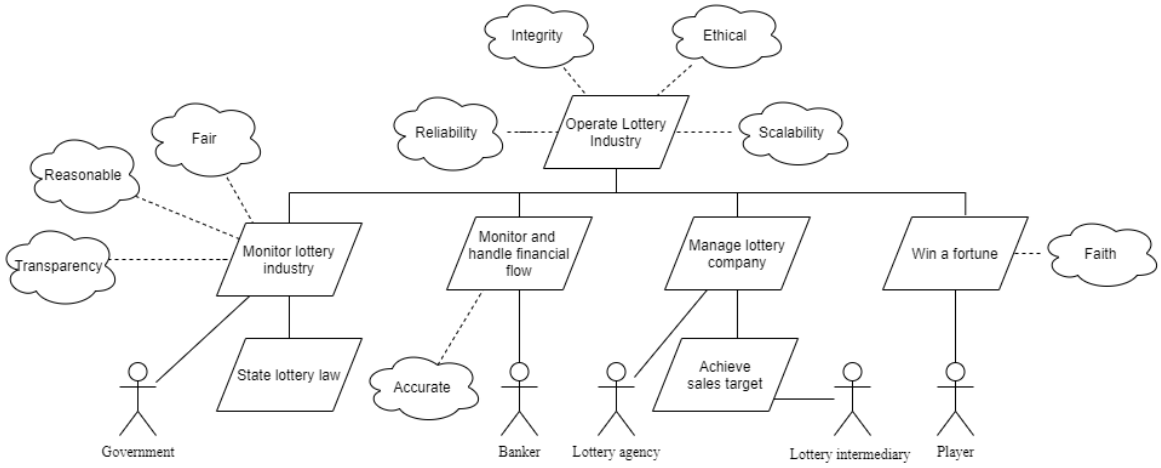

Figure 1: Goal model for win a fortune game case study

Table 1: Role Description of the Lottery Agency

Name	Lottery agency
Description	A department that manages the operation of the company.
Responsibility	Set, announce, and obey rules and regulations. Select a winner. Verify and validate the winning lottery ticket. Distribute the prize to the winner.
Constraint	Select winner based on the rules and regulations stated.

3.1 A Workthrough Case Study

This section elaborates the proposed methodology based on a walkthrough example of a blockchain enabled win a fortune game system. Win a fortune game is a type of game that provides players an opportunity to win big prizes. Win a fortune game is similar to lottery game but differ from gambling as it does not require any technique to win the game but luck. Although the current lottery industries have existed for more than decades, it is suffering from trust issues [22]. Hence, there are many blockchain based lottery application have been developed [22], [23]. Due to the popularity of the game, we present the blockchain based win a fortune game through eAOM. As early decision on blockchain is important prior system design and implementation, we introduce a walkthrough example of early decision which involve conceptualization domain modelling and early identification as described as following.

Figure 1 illustrates the main goal of operating a lottery industry which require integrity, ethical, reliability and scalability. The human agent involve in lottery industry are the government, banker, lottery agency, lottery intermediary, and player. To operate lottery industry, the government are responsible to monitor the industry by declare the law. Banker monitor and handle financial flow of the lottery industry. The lottery agency manages the company and achieve the sales target. Lastly the player with a goal of win a fortune.

Next is the role model that presents the role description, responsibility, and constraint. The role model could aid blockchain developers in understanding the roles before design the blockchain application. Table 1 and Table 2 shows the role models of the lottery agency and lottery intermediary.

The organizational model in Figure 2 shows the relationship between the government, banker, lottery agency, lottery intermediary, player, and winner. The government controls the lottery agency by using the law. The agency will cooperate with the banker to manage the financial flows of the company. Next, the lottery intermediaries are controlled by the lottery agency to obey the rules and regulations of the company. The lottery intermediaries know the player when the player buys tickets from the agent. Lastly, the winner is inherited from the players selected by the lottery agency.

Figure 3 shows domain model that illustrates the relationship between the human agents and entities when an event occurs. In the entire cycle of lottery operation, the lottery agency must follow the law stated by the government. The government will monitor the lottery agency to prevent the agency breaks the law. Besides, the lottery agency, intermediary, players, and the winner must enforce the company's rules and regulations. The transaction will be done between the intermediary and the player by ticket trading. The lottery intermediaries will calculate the total sales and generate a report to the agency.

Then, the player will wait for the result announcement based on the time frame stated in the rules and regulations. Once the winner is announced, the winner can collect the prize at the official counter. However, the player needs to show the lottery ticket to the

Table 2: Role Description of the Lottery Intermediary

Name	Lottery intermediary
Description	The person who serves the lottery company and act as the middleman of manager and player.
Responsibility	Help the company sell a lottery ticket. Obey the rules and regulations set by the company. Calculate and report the number of tickets sold and total bets in a game. Boost company sales.
Constraint	The ticket must sell at the official lottery counter or platform. The report of tickets sold should be valid and immutable.

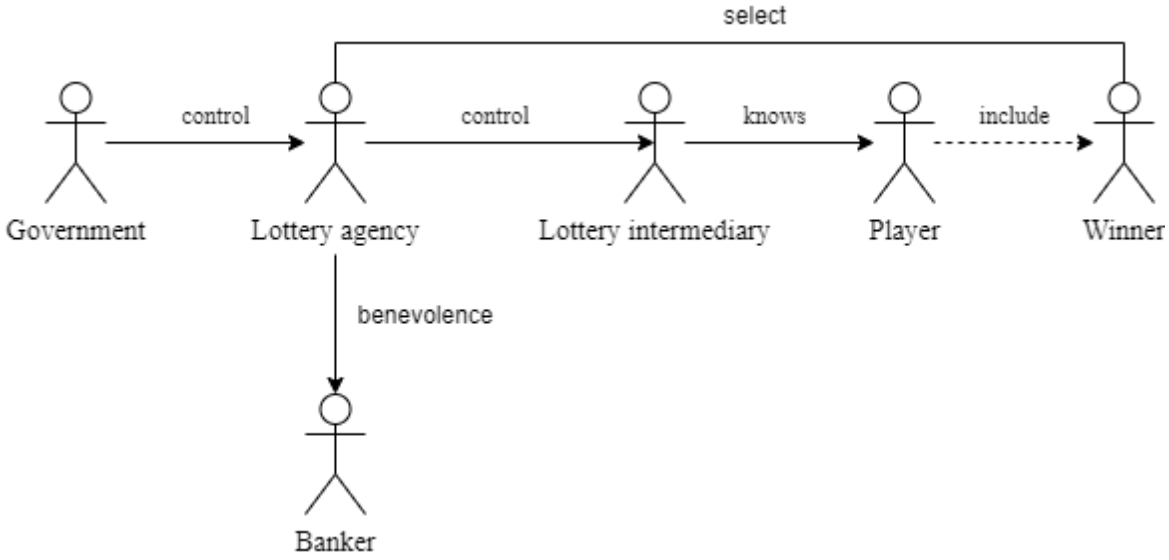

Figure 2: Organization model

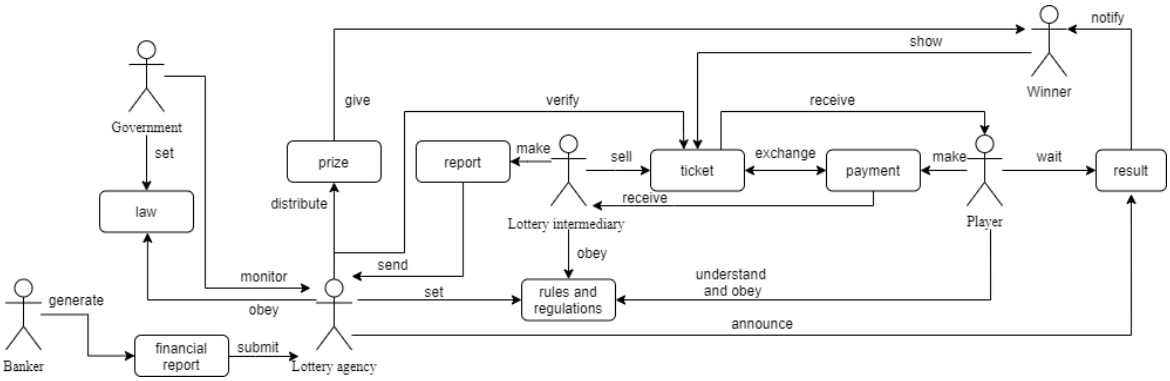

Figure 3: Domain model for win a fortune game case study

lottery agency as a proof. The agency is responsible for verifying and validating the ticket before handing the prize to the winner.

e3 value model is used for early identification of blockchain use case. Figure 4 shows the e3 value model of the lottery blockchain use case. The aggregator is a role that can be filled by any party like government or banker. In this case, government, banker, and lottery intermediary is replace by the aggregator and the e3 value shows the value exchange among the agents (player, winner, aggregator, and the lottery agency). Based on the requirements stated by [21], the e3 value model highlighted the following points:

1. Eliminate middleman: the aggregator acts as a middleman to handles the ticketing and transaction.

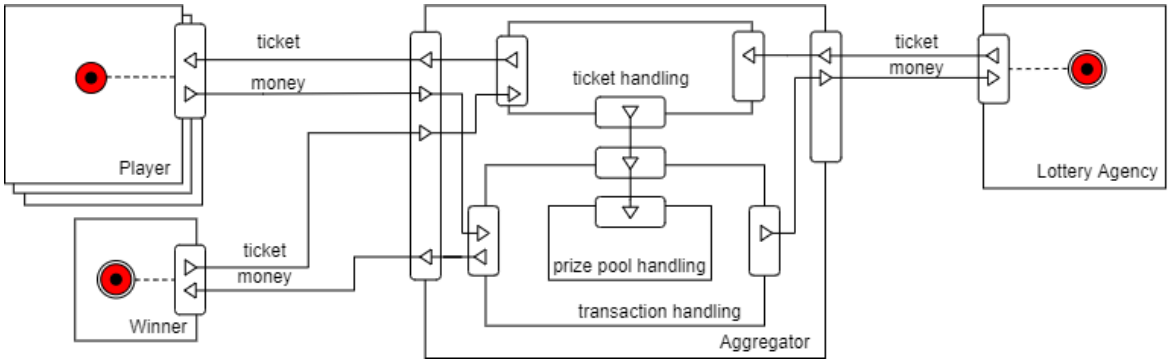

Figure 4: e3 value model for win a fortune game case study

Table 3: Scoring system for AOM and eAOM evaluation

Conceptual domain modelling		
No	Criteria	Point
1	Is the model at this layer able to show fairness issue?	1
2	Is the model at this layer able to show transparency issues?	1
3	Is the model at this layer able to show scalability issues?	1
4	Is the model at this layer able to show how bankers manage the issue?	1
5	Is the model at this layer able to show how intermediaries sell a ticket?	1
Early identification of blockchain use case		
No	Criteria	Point
1	Is the model at this layer able to eliminate the middleman?	1
2	Is the model at this layer able to show the transaction history?	1
3	Is the model at this layer able to show the peer market structure?	1
Platform independent design and modelling		
No	Criteria	Point
1	Is the model at this layer able to show how smart contracts solve fairness?	1
2	Is the model at this layer able to show how Blockchain provide transparency?	1
3	Is the model at this layer able to show the transaction made through a smart contract?	1
4	Is the model at this layer able to show how smart contracts arrange the player ticket?	1
5	Is the model at this layer able to show how data is store on the Blockchain?	1

2. Establish trust: There is a need to trust the parties to handle the ticket and transaction.
3. Immutable data history: The aggregator keeps track of the ticket and transaction.

4 RESULTS AND DICUSSION

This section presents the evaluation of the eAOM. The evaluation aimed to investigate the needs of AOM and eAOM for blockchain application development. The experiment is conducted among 140 novices from Faculty of Compute Science and Information Technology, University Malaysia Sarawak. The students have taken a course, Advance Software Engineering for a semester. The students undergo two experiments for this evaluation.

Throughout this course, the students completed an assignment by research and review the existing blockchain technology, attended a blockchain lecture given by Dr. Alexander Norta and a workshop to understand the eAOM on blockchain application. After attending the talk and workshop, the students shared a similar grasp of the blockchain concept. Then, a case study is given to the students to model the blockchain based Win a Fortune game by using AOM and eAOM. The students' models were graded based on the scoring system as shown in Table 3. The first experiment is to evaluate the usability of AOM, thus the scoring for experiment 1 are mainly focus on conceptual domain modelling and platform independent design and modelling; while second experiment evaluate the usability of eAOM, the scoring system focus on conceptual domain modelling, early identification of blockchain use case, and platform independent design and modelling.

The results of the students are then filtered based on their attendance of the blockchain lecture and workshop to ensure consistency. A total 45 students' result are calculated and tabulated as shown in Figure 5. Based on the results, approximately over half of the students could model and analyze at least three lottery industry problems in the conceptual domain modelling. Most of the students failed to model the blockchain element in the platform independent

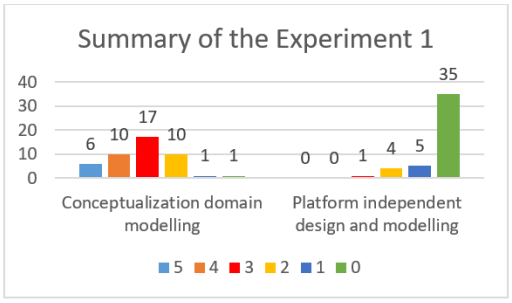

Figure 5: Result for experiment 1 (AOM)

design and modelling. 22.22% of the students were able to model the minor blockchain element at the design specification.

From the findings, we can foresee the gaps when modelling the blockchain application through AOM in details. The students then to mix up the problem analysis and technology design even though the AOM stated the problem and technology design in two different layers. For example, most of the students included the blockchain technology at the conceptual domain modelling even though they knew the conceptual domain modelling is for problem analysis, On the other hand, the students failed to identify the elicited answers based on the case study given. This led to missing blockchain elements during the modelling process.

Although the students learned AOM and obtained blockchain knowledge through lectures and assignments, most of the students still could not understand the different abstractions of AOM. It is also apparent that blockchain properties are hard to be defined in the AOM. Nevertheless, the AOM is too general that it makes it difficult to trigger the blockchain requirement without the extension of AOM.

Thus, experiment 2 was conducted to test the usability of eAOM for blockchain application development. From the findings in Figure 6, the eAOM helps to derive more potential blockchain criteria. The eAOM provides more complete steps to help the students in identifying the blockchain requirement in phase 3 of early identification of blockchain use case.

Based on the result, the blockchain design is much complete in the platform independent design and modelling. The result at the conceptual domain modelling phase is as similar as Experiment 1. However, the students adopt the correct concept of the conceptualization domain modelling and examine the problem in the case study. In early identification of blockchain use case, most of the students could capture the needs of Blockchain, such as eliminating intermediaries, presenting the market structure, and the value exchange between the agents. Significantly, over half of the students were able to model at least three blockchain criteria. 44.44% of the students achieved 4 points and above, 15.55% of the students scored 3 points, 28.89% students got 2 points, and only 11.11% of the students got 1 point and below.

With the eAOM, the results in the platform independent design and modelling phase have improved significantly. The students were able to understand how blockchain may handle fairness and transparency. For example, a smart contract could execute the select winner mechanism to achieve fairness. Some of the students allowed

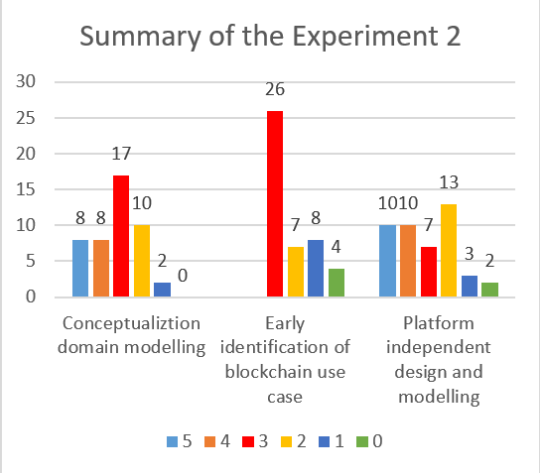

Figure 6: Result for experiment 2 (eAOM)

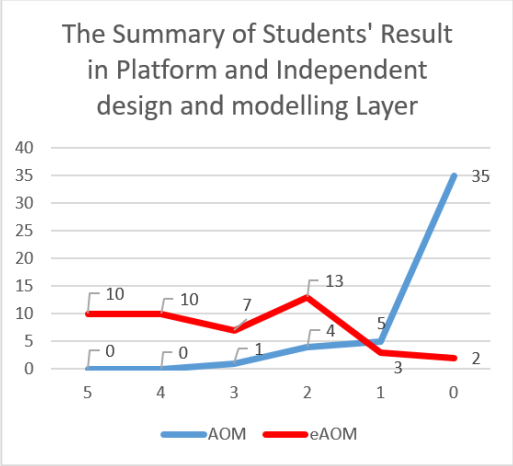

Figure 7: The Overview of the Platform Independent Design and Modelling Layer Result

the smart contract to generate random numbers, and some let the system choose a winner randomly.

The graph in Figure 7 shows a clear trend in which the students could completely utilize blockchain technology to solve the problem by extracting more blockchain properties. There are 60% of the students able to model at least three blockchain elements using the eAOM, whereas only 2.22% of the students achieve this score. The mean score for AOM and eAOM is tabulated in Table 5. Significantly, the mean score of platform and independent design and modelling phase for eAOM is 2.755 higher than the standard AOM. This finding confirms the usefulness of the eAOM. This concurs well with the objectives of the research.

Based on the mean result in Table 5, the experiments showed that the eAOM could aid to design a better blockchain application than AOM. Equation 1 is used to prove the hypothesis.

$$H_2: \mu_{extended\ AOM} > \mu_{AOM} \quad (1)$$

Table 4: Comparison of Experiment 1 and Experiment 2 in Percentage

	5	4	3	2	1	0
Experiment 1	0.00	0.00	2.22	8.88	11.11	77.78
Experiment 2	22.22	22.22	15.56	28.89	6.66	4.44

Table 5: Mean Score for AOM and eAOM

Modelling Technique	AOM	eAOM
Mean	0.356	3.111

In sum, the findings in Experiments reveals that the eAOM could help a beginner design a blockchain application by starting with problem analysis. The eAOM outperforms the AOM in terms of investigating identifying blockchain needs using the e3 value model. There are several threats to validity that should be acknowledged in this study. The students learned blockchain knowledge through lectures. The students that attended the lecture shared a similar grasp of the Blockchain concept. They used their understanding of blockchain technology to apply to the AOM and eAOM. However, the ability of each student to model the case study is different.
Even though students were given blockchain-related assignments and lectures, they may require additional blockchain expertise to reduce threats. To strengthen the blockchain knowledge of the students, Dr Alexander was invited to give a talk on Blockchain topic. Then the eAOM was introduced through the workshop to stimulate potential blockchain features to the use case.
Besides, the perspective of each student is different, which may cause threats to validity. The test was given in a blind test mode to reduce the bias of the experiment. Next, the time constraint for the final was insufficient, and the case study was only part of the exam. Thus, the students might take the least time to complete the case study without going into details.

5 CONCLUSION

This paper has provided new insight on the blockchain development approach. In doing so, the state of art on blockchain technology is studied and summarize to examine the gap. Then, eAOM is introduced and validated by using win a fortune game case study. Besides, eAOM is evaluated among students through experiments. The experiments require the students to model the case study by using AOM and eAOM. The result of the experiment is collected and analyzed. The analysis revealed that the eAOM successfully helps the novices to elicit blockchain requirements along the way from analyze the problem and identify the needs of blockchain. Concerning the security aspect of the blockchain application, we can also expect to improve the methodology by generate test case based on the model.

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