IoT Systems Internal Mapping using RTT with the integration of Blockchain technology

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***Abstract*— The degree to which innovators adopt Blockchain as a tool to create relevant and useful business solutions will determine how fast and far the platform moves into our daily lives. There are limitless opportunities for technology to define and shape future innovation. In a world dominated by digital technology, IoT plays a prominent role in our lives. It has created an ecosystem that links many systems to give smart performances in every task. The proliferation of the IoT has created a new evolution of cell phones, home and other embedded applications that are all connected to the internet. They have impeccably integrated human communication in ways we never expected before. Integrating blockchain and IOT will provide innovative technology. This integration will provide trustless, more secure, and more reliable IoT systems. The applications of this integration will be limitless. In this research, we will apply this concept in a simple game application. Bluetooth technology will be used to calculate the object's positions by using RTT and other data from mobile sensors and apply them in kinematics equations. This application allows building a map of objects positions relative to each other. Blockchain will be used to save this data and assure its accuracy and correctness. The Game application will be a simple proof of the concept, but its future application will be limitless.**

Keywords—Blockchain, RTT, Bluetooth, Ethereum, Android studio.

I. INTRODUCTION

Blockchain definition

The blockchain is a distributed database of records of all transactions or digital event that have been executed and shared among participating parties [1]. Each transaction verified by the majority of participants of the system. It contains every single record of each transaction. Blockchain Technology first became known when a person or group of individuals name 'Satoshi Nakamoto' published a white paper on "Bitcoin: A peer to peer electronic cash system" in 2008. Blockchain Technology Records Transaction in Digital Ledger, which is distributed over the network thus making it incorruptible [2].

Importance of Blockchain

- Immutability

The immutable factor in blockchain ensures that the data is not manipulated, replaced or falsified in any way, shape. Any agreed and shared transaction across the network is also nearly impossible to undo. This helps in situations where certain data needs to be tracked accurately and efficiently [2].

- Decentralization

The need for intermediaries and third parties is reduced with blockchain. This also helps to reduce costs by eliminating these middlemen. Efficiency is also increased as transactions are conducted between peers [3].

- Transparency

It is one of the positive attributes of why people prefer using Blockchain technology. The full transparencies in the network make it one of the most likeable technologies out of different technologies available in the market. The data is being shared among all the participants [2][3].

- Security

The need of security has risen but Blockchain has promised its users to provide robust security. Information is stored in blocks. Each block stash the information of the last block in it and making it fully interconnected with each other [4].

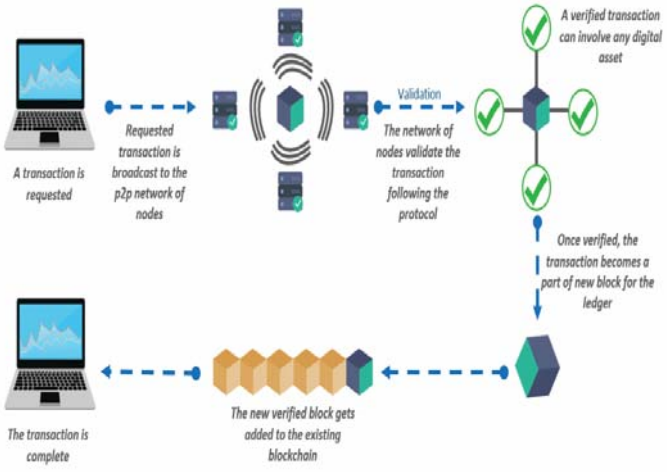

Figure 1. Blockchain architecture
Source: Adapted from [5]

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IOT definition

IOT is the extension of Internet connectivity into physical devices and everyday objects. Embedded with electronics, Internet connectivity, and other forms of hardware (such as sensors), these devices can communicate and interact with others over the Internet, and they can be remotely monitored and controlled [6] [7].

Literature review

With the rise of IoT lately, the need for automatic device for mapping raised. Thus, in the past few years a lot of research has been done on using Bluetooth for distance estimation. Distance estimation identifies the distance between two machines in wireless network. Researchers have been focusing on signal strength and Signal Strength Indication (RSSI) to calculate the distance. The characteristic of Bluetooth RSSI value is different as environments. A research done on 2016 has proved that RSSI is a poor distance estimator when using wireless sensor networks in buildings. Reflection, scattering and other physical properties have an extreme impact on RSSI measurement, which conclude that RSSI is a bad distance estimator [8] [9]. Another research stated that Some efforts have been made with purely signal strength based positioning, but indoor environments have shown to work unfavorably for these kinds of methods [10].

Blockchain technology has many advantages and is constantly being explored for further applications. Since 2008, blockchain had different applications in different fields [11]. Despite the importance of IoT applications, Integrating IoT system with blockchain is still a not solved problem.

This paper will present a real life application of integrating blockchain technology with IoT systems, and shows how this integration will add a valuable impact on IoT technology. Throughout the methodology, we will introduce more efficient way for indoor mapping using RTT.

This paper will discuss the steps of integrating IoT with blockchain technology in a simple game application in section II, then section III will show the application testing results, section IV will discuss the results, section V will show some limitation and recommendation for future research, and finally section VI will conclude the work done and explained in this paper.

II. Methodology

Android studio was used to create the application for reading sensors' data, and calculate the relative positions for different devices, as well as, sharing the data in the blockchain. Each device will represent a player in the game, and if the player knows the positions for other players, he will be able to shoot them as targets to win points. The scoring record will be evaluated by a smart contract on Ethereum to check its reliability. The steps for application creation is as follows:

A. Connecting devices using Bluetooth

A connection socket is opened for Bluetooth connection allowing sharing data between the devices. Once the devices are paired, they will be able to send and receive packets.

B. Calculating RTT

RTT calculation will be the starting point to calculate the distance between two devices. Packets will be sent cautiously to update the distance. This distance will be used later to evaluate positions using kinematics equations.

RTT will be calculated with two scenarios to compare the results between both of them. The first scenario shown in figure 1 shows that there will be a processing delay for including t_1 and t_2 in the packet. This delay will affect time accuracy, which will affect the distance accuracy.

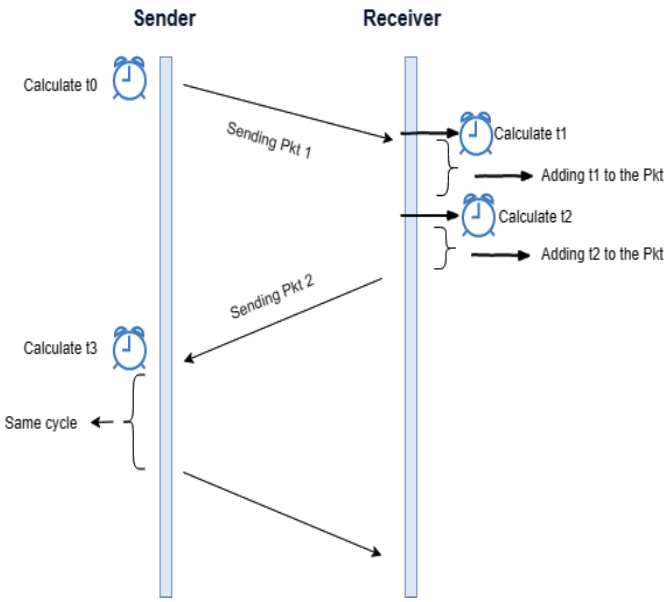

Figure 2: Scenario 1 for RTT

The second scenario will surpass the processing delay that affects the values for t_1 and t_2 but will delay the calculation with one cycle. We expect that this delay will not affect the accuracy significantly, as the human rate in changing their speed will be bigger than the timing of the cycle.

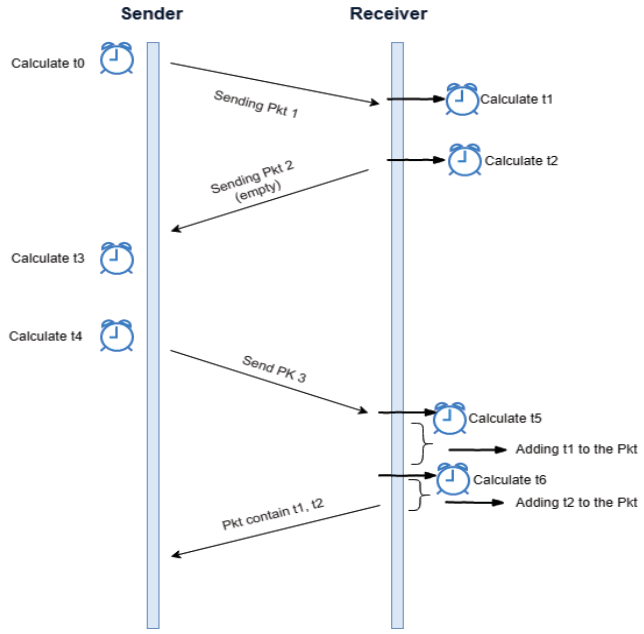

Figure. 3 Senario 2 for RTT

C. *Calculating velocities*

Using the accelerometer sensor, the device will get the values for its acceleration. Using the kinematic equation:

$$v = v_0 + at \quad (1)$$

Knowing the calculated time, we will be able to calculate the velocity from equation 1 supposing that the initial velocity is zero.

The devices will share their velocities with other devices along with their direction calculated using the device's compass. This shared data will allow each device to locate the other devices.

D. *Scoring*

Knowing the positions for other devices, any player will direct his device to the right position and shoot on target to win points. He will share his score among all the players. Each player will have a record for all the scores.

E. *Sharing data on Blockchain*

At the end of the game, each player will share the scoring record on the blockchain. An Ethereum smart contract was implemented to compare the data of each player. If the players' scores are similar among more than 51% of the players then the scores will be considered true and will be verified on the blockchain. This will prevent any player from manipulating the data, or it will be excluded. Besides, blockchain will save the data securely without any future manipulation.

III. RESULTS

Applying scenario 1 on calculating the RTT, there was a time delay, as expected, varying approximately between 1 to 3 seconds. This time delay resulted in not accurate relative positions with a maximum error of 7 meters. Testing the methodology 60 times shows the following results in table (1).

TABLE I. PROBABILITIES OF DIFFERENT ERROR RANGES

Error	Probability
Less than 3 meters	0.4
3 to 5 meters	0.5
6 or more meters	0.1

The probability of getting less than 3 meters error range of the relative position was 0.4, the probability of getting the error in the range of 3 to 5 meters was 0.5, and the probability of getting the error of 6 meters or higher was 0.1. Due to these errors of distance, unexpected errors found in calculating relative velocity. As stated above relative velocity is calculated as the change of distance over time. With this big deviation in error, velocity rarely is calculated correctly. As relative velocity values are strongly damaged, it was hard to calculate the angle from it. Because of these errors, this algorithm is not efficient in building internal maps over low powered Bluetooth (Bluetooth 4.2 was used only) in regular cell phones. Calculating self-velocity and analyzing it on the compass directions by a background daemon seems to have an acceptable error range. Accurate error calculations will be easier when the relative velocity and angle are will be calculated.

IV. DISCUSSION

This research was built on the hypothesis that internal mapping for objects communicating through an IoT system could be implemented using RTT calculation, which with simple kinematics could give relative positions of the objects. The data of the mapped IoT system will then be verified and saved on blockchain to guarantee high reliability and security. To test the hypothesis, the two scenarios explained should be done and test the accuracy of each. Scenario 1 was expected to give a time delay, which will result in an error range on relative positions on the objects. As expected the results showed a maximum error of 7 meters. Scenario 2 results are not included in this paper, but the results are expected to give high accuracy, as the time delay of scenario 1 will be surpassed. Although we applied the test on a game application, this research could be applied on different applications such as warehouses, self-driving cars or any other applications that have objects needs to communicate with each other knowing the relative positions of each other.

V. LIMITATIONS &RECOMMENDATIONS

Due to time constraints, the results of testing scenario 2 (shown in figure 2) have been not conclusive yet. These results could do a major change in proving the concept of using RTT for calculating relative positions to create an internal map of objects. Besides, the lack of resources limited the testing to be

done on only four different mobile devices with the same version of Bluetooth but different processing speeds, although, trying different versions of Bluetooth with different processing speeds could drive conclusion on how changing the devices could affect the accuracy. To overcome those constraints, we recommend those who are attentive to continue working on this topic to firstly, conclude the results of scenario 2 and compare the results of the two scenarios. Secondly, to calculate RTT using multithreaded application and take the average of the calculated time on each thread to increase the accuracy. We also recommend creating private blockchain developed to save and process the data of this application with high transaction speeds and zero cost. Using Ethereum was to test the concept, but its relatively low speed and high cost may cause problems in real-life applications.

VI. Conclusion

Internet of Things (IoT) is paving the way for a world, where many of our daily objects will be interconnected and will interact with their environment to collect information and automate certain tasks. Sharing IOT data requires a secure, fast, and reliable network and this is what blockchain technology could offer. Blockchain in 2010 was a peer-to-peer network for sharing ledger, but now the blockchain technology expanded to share data for different applications. We expanded the use of blockchain for sharing IoT data. To conclude, a shooting game was developed to present the concept of using blockchain technology for the internet of things. The devices were able to connect through the Bluetooth connection and join the game session. The live data of the game, which determines the winner, was captured using device sensors then moved to the smart contract to be processed using a secure blockchain network to be accessed easily with the right people through an inner-product proxy re-encryption scheme that ensures an efficient and secured data access to IoT data is presented.

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