Testing approaches for blockchain enabled IoT system

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Abstract

IoT is reshaping the occupant business to keen industry included with information driven dynamic. Be that as it may, natural highlights of IoT bring about various difficulties, for example, decentralization, helpless interoperability, protection, and security weaknesses. Blockchain innovation gets the open doors tending to the difficulties of IoT. This paper presents in depth overview of Blockchain in IoT and talks about the bits of knowledge of this new worldview. Specifically, we present review of blockchain innovation and its testing approaches.

Keywords: Internet of Things, Blockchain, Software Testing

1. Introduction

The Internet of things (IoT) is an arising innovation, which goes about as an empowering agent to interconnect insightful and self-configurable gadgets "things" to build up a proficient also, dynamic stage for correspondence and joint effort [1], [2]. These gadgets are heterogeneous and resource constrained in term of capacity, force and calculation [3]. As per the ongoing examination distributed by Gartner, the number of associated gadgets will raise up to 20 billion by the year 2020 [4]. Presently, IoT partakes in nearly each field of life while there are a few IoT applications that mechanize day by day measures. These applications incorporate wise waste administration frameworks, insightful transportation frameworks, keen lattice, brilliant stopping, natural checking, traffic the board and various different applications [5],[6].

Formal check for the most part includes developing a theoretical numerical model of the framework's ideal conduct. From a legitimate point of view, the determination can be viewed as an assortment of properties that should hold for the framework, albeit regularly the detail isn't depicted straightforwardly in legitimate structure, yet rather utilizing different numerical displaying structures, for example, limited state machines [19],[50].When both the detail and the framework are prepared, the genuine check that the program fulfills the determination can be endeavored. On the off chance that fruitful, the check demonstrates that the properties of the determination are substantial for the program. This is an unmistakably more grounded result than what can be accomplished through testing, where the properties are just minded a couple of tests. Notwithstanding, full confirmation is difficult to accomplish consequently, and costly to do physically or intuitively[36].
Information respectability is considered as one of the key security issues about information stockpiling, which can either be cloud information capacity [7] or disseminated information stockpiling [18]. In this paper, we center just around distributed storage information respectability. We partition past writing about information uprightness into four classes: Storage Server Technologies, Protocols, Standards and Storage Architecture[6],[17]. There are mostly two most generally alluded trustworthiness confirmation methods falls into Storage Server Technologies, in particular RAID also, Check summing [4],[13]. In conventions classification, the most significant ones are Provable Data Possession [2] and Confirmations of Retrievability [8]. Both of the works were intending to check the uprightness of enormous information put away in semitrusted or untrusted workers without recovering the information. By embracing these methodologies, the I/O costs for information uprightness confirmation could be decreased, which helps increment the effectiveness of checking huge information. The fundamental thought behind the two recommendations are the equivalent: the information is isolated into blocks and each square is joined by a little bit of metadata for check.

The IoT envisions a completely associated world, where things are ready to impart estimated information and associate with one another[39]. This makes conceivable a computerized portrayal of this present reality, through which many savvy applications in an assortment of enterprises can be created. These include: Smart homes, Weareables, Smart urban communities, Healthcare, Automotive, Environment, Smart water, Smart framework, and so forth IoT arrangements are being conveyed in numerous territories, enhancing creation and digitizing ventures. IoT applications have unmistakable qualities, they produce enormous volumes of information what's more, require availability and force for significant stretch.

2. Outline of the Paper

Section 1 Description of Internet Of Things, Section 2 description about Blockchain, Section 3 presents the blockchain enabled IoT, Section 4 presents the different types of testing methods and Section 5 gives the representation of testing used in literature papers, Section 6 the survey summarizes the testing method of IoT system that was enabled by blockchain, Section 7 concludes the review and provides the guidance for future work.

3. Blockchain enabled IoT system

3.1. Internet of Things

The IoT connect the devices over the internet and over a wireless network it collects the data . IoT is the significant idea which is interesting and energizing [48]. The testin IoT is having secure biological system enveloping all structure square of IoT design. The IoT is a mammoth system of associated things and each individual which gather information about the manner in which they are utilized and about nature around them.

That incorporates a phenomenal number of objects of every kind – from shrewd microwaves, which naturally cook your nourishment for the correct time span, to self-
driving vehicles whose mind boggling sensors distinguish questions in their way, to wearable wellness gadgets that measure your pulse and the quantity of steps you've taken that day, at that point utilize that data to recommend practice plans custom fitted to you [47], [46]. There are even associated footballs that can follow how far and quick they are tossed and record those measurements through an application for future preparing purposes. The recent development of blockchain and IoT was mentioned in Figure 1.

Gadgets and items with worked in sensors are associated with an Internet of Things stage, which coordinates information from the various gadgets and applies investigation to impart the most significant data to applications worked to address explicit needs [1]. These amazing IoT stages can pinpoint precisely what data is helpful and what can securely be overlooked. This data can be utilized to distinguish designs, make suggestions, and identify potential issues before they happen [35].

Web of Things is an environment of associated physical articles which are available through the web. The 'thing' in Iota could be an individual with a heart screen or a car with worked in sensors, for example objects which have been assigned an IP address and can gather and move information over a system without manual help or intercession [45]. The implanted innovation in the items causes them to connect with inward states or the outside condition, which thus influences the choices taken. Iota stages can assist associations with lessening cost through improved procedure effectiveness, resource use and profitability [44].

With improved following of gadgets/objects utilizing sensors they can make profit by knowledge and examination, which would assist them with settling on more astute choices. The development and intermingling of information, procedures and things on the web would make such associations progressively applicable and significant, making more open doors for individuals [43].

3.1. Blockchain

The records of information can be stored safely in the blockchain. It has two kinds of component: a) Transactions are the activities made by the members in the framework. b) Blocks record these exchange. Blockchain is the instrument that permits exchanges to be
verified by a gathering of inconsistent entertainers [40], [41]. It gives a dispersed, immutable, straightforward, secure and auditable record [42].

The blockchain can be counseled transparently and completely, permitting access to all transactions which have happened since the principal exchange of the framework, furthermore, can be checked and examined by any element whenever. The blockchain convention structures data in a chain of squares, where each square store a lot of Bitcoin exchanges performed at a given time. Squares are connected together by a reference to the past square; shaping a chain.

Blockchain is the instrument that permits exchanges to be verified by a gathering of inconsistent entertainers. It gives a dispersed, immutable, straightforward, secure and auditable record. The blockchain can be counseled transparently and completely, permitting access to all transactions which have happened since the principal exchange of the framework, furthermore it can be checked and examined by any element whenever. The blockchain convention structures data in a chain of squares, where each square store a lot of Bitcoin exchanges performed at a given time. Squares are connected together by a reference to the past square, shaping a chain.

3.3 Blockchain enabled IoT

Blockchain is missing to settle security and steadfast quality concerns in the IoT. It used to follow billions of related gadget, exchanges and correspondence between the gadgets[13],[14],[15],[16]. It sheds single point disappointment.

Traditional IoT systems are dependent on a concentrated plan. Information are sent from the device to the cloud where the data is readied using examination and subsequently sent back to the IoT contraptions. With billions of devices set to join IoT orchestrates in the coming years, this sort of united structure has compelled flexibility, revealed billions of feeble centers which deal arrange security and will end up being marvelously exorbitant and moderate if pariahs need to ceaselessly check and confirm each and every more modest scope trade between gadgets[17]. Portrayal of blockchain empowered IoT referenced in Figure 3.

![Figure 2: Benefits of using blockchain enabled IoT](image-url)
3.4. Challenges of blockchain in IoT

3.4.1. Scalability:
The ledger may lead to centralized due to over time. It required record management for future of blockchain technology.

3.4.2. Processing power:
The IoT ecosystem is very diverse and has different computing capabilities and it will run the same encryption algorithm at desired speed. It requires encryption algorithm for blockchain enabled IoT[18].

3.4.3. Storage:
Blockchain discards the server to store the transaction and server id. But the ledger stores the data by themselves it also increases the size when time[19] increases. The smart devices such as sensor have low storage.

3.5. Testing types

3.5.1. The combinatorial testing
Combinatorial testing is a strategy that can diminish cost and improve test viability fundamentally for some applications. This finding has significant ramifications for testing since it recommends that testing mixes of parameters can give profoundly successful issue identification. The key understanding hidden in this type of testing is that only one out of every odd parameter contributes to each disappointment, and observational information proposes that about all product disappointments are brought about by co-operations between generally hardly any parameters.

![Figure 3: Representation of block chain enabled IoT](image)

This finding has significant ramifications for testing since it proposes that testing mixes of parameter can give exceptionally powerful deficiency location. This testing is cost effective [1].
3.5.2. The unit testing

Unit testing is a degree of programming testing where singular units/segments of a product are tried. The intention is to approve that every unit of the product proceeds as structured. A unit is the littlest testable piece of any product. It as a rule has one or a couple of information sources and typically a solitary yield. In procedural programming, a unit might be an individual program, work, methodology, and so on [4].

![Diagram of testing types]

Figure 4: Types of testing used in literature papers

3.5.3. The black box testing

Black box testing, otherwise called Behavioral Testing, is a product testing technique in which the inner structure/plan/execution of the thing being tried isn't known to the analyzer. These tests can be useful or non-utilitarian, however generally useful [10]. This technique is named so in light of the fact that the product program, according to the analyzer, resembles a black box; inside which one can't see. This strategy endeavors to discover mistakes in the accompanying categories: Incorrect or missing functions, Interface errors, Errors in information structures or outer database access, Behavior or execution errors, Initialization and end blunders.

3.5.4. The Repeated testing

Repeated testing of a previously tried program is done after alteration, to find any imperfections presented or revealed because of the adjustments in the product being tried or in another related or disconnected programming part.

3.5.5. The Property based testing

Property put together testing is undertaken with respect to properties. It watches that a capacity, program or whatever framework under test submits to a property. More often than not, properties don't need to go into an excessive amount of insights concerning the yield. They simply need to check for helpful qualities that must be found in the yield [7]. For testing types refer Figure 4.
3.5.6. The comparative testing

Comparative testing and reasonable testing are fundamentally same. Both expect you to control factors so as to help answer questions. What's more, both expect you to make examinations between various materials or articles. The focal points are Reduce Product Development Time, Increase Customer Confidence, Ensure Product, Quality and Reliability, Forecast Life Expectancy, Reduce Costs, Increment Profitability, Reduce after Sales Service. For percentage of testing usage refer in Figure 5.

4. Research Method

4.1. Research Questions

The objective of the survey is to distinguish the territory where further research is important and furthermore is characterize the current writing. The most significant angle is to recognize which variables and strategies/systems have been considered in the writing and which have not been utilized. The review questions are discussed in Table 1.

Table 1. Discussion of research questions

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<thead>
<tr>
<th>S.no</th>
<th>Review Questions</th>
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<tbody>
<tr>
<td>RQ1</td>
<td>What is the importance of Block chain enabled Iota?</td>
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<tr>
<td>RQ2</td>
<td>What types of research have been conducted?</td>
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<td>RQ3</td>
<td>Are the datasets available?</td>
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<td>RQ4</td>
<td>What are the testing types?</td>
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<td>RQ5</td>
<td>What are the testing techniques to test the Blockchain empowered IoT?</td>
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<tr>
<td>RQ6</td>
<td>What factors should be considered to measure the Performance?</td>
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</tbody>
</table>
Figure 6: Pipeline of the progress of in the past year

4.2. Search criteria

At first inquiry criteria includes the meaning of "Web of Things, Blockchain, distinctive Testing techniques". The overview centered testing techniques for blockchain of IoT frameworks in this manner, the terms blockchain and IoT are as often as possible utilized in the writing work[37],[38]. Figure 7 presents the pursuit way based on equivalent words and time of search. The broad hunt included papers from various diaries, articles and meetings. This hunt criteria gives a wide point of view of the overview. An endeavor has been made to distinguish the exploration papers and articles via looking physically with the changed watchwords like IoT, Blockchain and so on. For the search criteria refer Figure 7.

5.1. Sources of Information

5.1.1. Other Sources

Aside from the sources of data which have been examined above, specialized reports on blockchain empowered IoT, books, writing which are significant to the audit paper are incorporated.gives extra sources to accomplish the writing work all the more generally and offer completeness to this work.
5. Related Survey

Many authors have described various methods for testing the blockchain that was empowered with IoT. To debug the error the combinatorial testing is used. Alexander Chepurnoy, Mayank Rathee† Ergo Platform and IOHK Resea Sestroretsk, Russia. The error will occur when transaction of crypto currency is high. Si Chen, Jinyu Zhang, Rui Shi (&), Jiaqi Yan, and Qing Ke propose a comparative testing based on read or write data and process or record transaction of blockchain. The bottleneck problem can be easily identified [8]. Michael A. Walker, Abhishek Dubey, Aaron Laszka, and Douglas C. Schmidt [9].

6. Challenges for testing the Blockchain enabled IoT

Testing has a ton of difficulties both in a Manual just as in Automation. This isn't the situation continually. Testing the total application, Misunderstanding of organization forms, Relationship with Developers, [34] Lack of Skilled Testers undergo testing under specific time Constraint. The rest of the challenges are discussed in Figure 8.

7. Classification of testing methods

The testing types can be comprehensively named static testing and dynamic testing. In the static testing, the product venture reports are checked on to distinguish the mistakes [33], [23]. The survey can be casual audit, formal survey or investigation, specialized audit, or an audit during walk through meeting. Casual survey can be led by a QA examiner whenever during the task. It is a cheap method for testing and the advantages rely upon the product analyzer. Formal survey or examination is arranged and constrained by the mediator. The
QA experts survey the product venture records doled out, before the audit meeting. During the audit meeting, blunders are talked about; copyist (a job appointed to one of the analyzers during survey meeting) records the conversation. The commentators submit survey report to arbitrator toward the finish of audit meeting [45].

In the dynamic testing, programming is tried during the process. This testing can be either white box testing or discovery testing. The two kinds of white box testing are unit trying and joining testing. The white box testing is likewise called as basic testing [30], [31], and [32]. Unit testing or the part testing will be trying each program segment in disengagement. Joining testing is to test the interfaces between the program parts. The designers lead the white box testing utilizing apparatuses in the improvement condition. The other sort of unique testing is discovery trying and it is additionally named as determination based testing [25].

The framework testing and client acknowledgment testing (UAT) are ordered under the discovery testing. The framework testing on the product is led by a free group of QA examiners to build up the nature of the product. Both the useful and non-useful qualities of the product are tried by the QA group. The framework testing is performed utilizing different distinctive Software Testing devices, in the test condition. After the framework testing, clients can test the convenience of the product in User acknowledgment testing [21], [22].

The QA investigators may help the clients in the UAT. The clients can play out the UAT in IT condition and it is called as Alpha testing. In the event of the product being tried by the clients in the genuine or pre-creation condition then it tends to be called as Beta testing. Programming testing must be done at various degrees of the product advancement with a particular goal at each level. There is wide assortment of programming testing types to test the different highlights of programming picked dependent on the task situation[24],[25].

In any case, the product testing can either be a manual testing or computerization testing [41], [34]. Here are associations with the physical condition that may require correspondence with sensors as well as actuators. Management undertakings[33],[38],[49].
Figure 8: Challenges for testing blockchain enabled IoT

Table 2. Comparison of our survey with the other related surveys

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In any case, the product testing can either be a manual testing or computerization testing [41], [34]. Analyzers know about the different kinds of Software Testing, for example, Functional Testing, Non-Functional Testing, Automation Testing, Agile Testing, and their sub-types, and so forth. Every one of us would have gone over a few kinds of testing in our testing venture [24], [25]. We may have heard a few and we may have chipped away at a few, however not every person knows about all the testing type. Here are associations with the physical condition that may require correspondence with sensors as well as actuators. Management undertakings [33], [38], [49].

8. Testing analysis of Blockchain empowered IoT system

The clarification of this is huge in light of the fact that it portrays the regular structure target of language [26], [27]. Non-Turing understanding vernaculars are less difficult to analyze and anticipate run-time direct, results, and expected lacks. Besides, there are blockchain/appropriated record frameworks [24], [20].

For example, Hyperledger Fabric which doesn’t give a particular open blockchain to utilize, however rather gives devices to creating adaptable blockchain/disseminated record applications or usage separately. Generally during a similar time as the development of blockchain, the expanded multiplication of IoT gadgets persuaded the requirement for value-based uprightness because of the progress of IoT gadgets from simply being keen sensors to being dynamic members that sway their condition by means of correspondence, dynamism, and physical in-citation.

These capacities require value-based trustworthiness to give evaluation of activities made by conceivably untrustworthy organized outsider IoT gadgets [28]. The interest for value-based uprightness in IoT gadgets which at the same time influence blockchain highlights, (for example, decentralization, cryptographic security, and unchanging nature) has persuaded us to inquire about making trans active IoT blockchain applications[10].

8.1. Shortcoming in testing IoT and Blockchain

The zeroed in on proper confirmation of shrewd agreements [14], [11], [12], [13], and how to compose brilliant agreements "protectively" to evade special cases when various agreements connect [15]. The present status of-the-workmanship as for testing, nonetheless, is missing in light of the fact that blockchains are inconsistently tried at scale in an orderly and repeatable way, so we center on that underneath.

It breaks down the process into smaller components and man- ages the flow of their outputs and integrates them to get segmentation results [29]. In the following sections, a categorization of the segmentation frameworks is presented followed by discussion for each of the framework components with the review of related work in literature.

8.2. Testing Selection

In the acquisition of the testing for the blockchain, Iota various testing can be generated. Each of the testing sequence provides information about the testing Specific stage. The
progress of each testing can be visualized in block chain enabled IoT systems. The testing that should be selected by increasing the performance and within less time [30].

8.3. Functionality of testing IoT and Blockchain

At the beginning at the most effectively attainable but getting dynamically is: Unit Testing, Integration, Test Driven Development, and Fully Automated Test-Driven Development.

Be that as it may, contract dialects don't generally incorporate default unit-testing capacity in the language or default fabricates condition. In any case, the biggest usage for various classes of Blockchain arrangements to be viewed as creation level prepared [18]. Past unit testing, the following degree of wanted testing of ITBAs is reconciliation trying. Mix testing of simply programming based circulated frameworks gives a novel test because of coordination of various examples, organizing and run-time design, and so on[10]. In this way, similar to unit testing, we propose considering any framework that doesn't yet give consistent joining support by means of help libraries, instruments, and so forth to be non-creation level prepared [46].

8.4. Testing Methods

Table 2 presents a survey on the area of segmentation of testing blockchain and IoT, databases and also the testing techniques which vary widely in the literature.

![Diagram of various components of Blockchain enabled IoT](image)

**Figure 9: Study of various components of Blockchain enabled IoT**
9. Evaluation Measures

Various evaluation measures are described to evaluate the error detection which have been used in the literature are shown in Fig 9. All the measures are based on comparing the result of testing with the data set which is annotated by an expert. Data set can be compared by each testing methods. Therefore testing in both the blockchain and IoT can be classified based on different testing techniques.

10. Comparative study of testing methods and future direction

The information, methodology, parameters/evaluation measures are given. It likewise gives the subjective outcomes and future bearings acquired by the best in class draws near. A quantitative assessment among these methodologies is a troublesome assignment because of the changeability in the dataset and the parameters utilized. The most ordinarily utilized parameters are Blockchain, IoT, testing.

11. Result and discussion

In unit Testing, Problematic advances consistently produce incredible debate. Although there are numerous depreciate of virtual monetary standards, it appears evident that the innovation that continues them is a significant mechanical insurgency [45]. Blockchain is staying put. Be that as it may, adjusting the innovation without satisfactorily ensuring its activity or applying it to situations where the expense doesn't compensate the improvement of IoT ought to be examined cautiously and taken with alert [34].

It is normal that blockchain will reform the IoT. The combination of these two innovations ought to be tended to taking into account the difficulties recognized right now. The selection of guidelines is vital to the consideration of blockchain and the IoT as a feature of government frameworks. This reception would speed up the communication between residents [30].

This paper has given an investigation of the primary difficulties that blockchain and IoT must address with the end goal for them to effectively cooperate. We have recognized the key focuses where blockchain innovation can help improve IoT applications. An assessment has additionally been given to demonstrate the practicality of utilizing blockchain hubs on IoT gadgets movement of attractive quality for investigation of testing progress. Existing stages and applications have likewise been inspected to complete the examination, offering a total review of the association between blockchain innovation and the IoT worldview [22].

The following degree of wanted testing ITBA frameworks is consistent incorporation. Consistent coordination, similar to unit testing and reconciliation testing, is typical in programming advancement now. In this way, similar to unit testing, we propose considering any framework that doesn't yet give consistent joining support by means of help libraries, instruments, and so forth to be non-creation level prepared [46].
12. Conclusion

Different testing strategies were executed for Scorex structure. The suite comprises of 59 tests checking various properties of a blockchain framework. To run the suite against a solid blockchain convention customer, engineers of the customer need to give generators to irregular articles utilized by the convention. The suite is checking the presentation against the execution by utilizing irregular examples. We utilized Twinscoin execution gave Scorex for instance of a solid blockchain utilizing our testing unit. In this paper we gave numerous instances of the test as expert. Data set can be compared by each testing methods. Therefore test in both the blockchain and IoT can be classified based on different testing techniques.

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