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A Hypergraph Structure Depicting Smart Hospital Management Fortified by Blockchain

Lalitha Pattabiraman[1], Madhumitha Mohan[2]
[1]Assistant Professor, Department of Mathematics, SRM IST, Chennai, Tamilnadu
[2]Undergraduate, Bachelor of Engineering and Technology, Department of Computer Science and Engineering, SRMIST, Chennai, Tamilnadu
[1]arthimohan2010@gmail.com[2]monamadhumohan14@gmail.com

Abstract: In this research work a Smart Hospital is scrutinized as a representative case study for broader IoT applications. The information and details regarding the patient is continuously monitored at home and sent to the doctor automatically without any human intervention. As a scientific mathematical instrument, hypergraphs can be implemented to simulate computer networks, biological networks, data structures, and various other systems. Hypergraphs are often used, to map the objects in the system and the complex relationships between them.Blockchain is defined as a data structure that contains transactional records, which also ensures security, transparency, and decentralization. It can be considered as a chain or records stored in the forms of blocks which are controlled by no single authority. Blockchain is completely open to everyone on the network as it is a distributed ledger. Once information is stored on a block chain, it is strenuous to change or alter it. Each transaction on a blockchain is fortified with a digital signature that proves its legitimacy.While transactions take place on a blockchain, there are nodes on the network that legalize these transactions. Due to the use of encryption and digital signatures, the data stored on the blockchain is tamper-proof and cannot be transformed. In blockchain, the nodes are called as miners and they use the concept of Proof-of-work, in order to process and authorize transactions on the network. In order for a transaction to be valid, each block must refer to the hash of its preceding block.
Keywords: Blockchain, hypergraph, Internet of Things (IoT), nodes, hyperedge, hospital

Introduction

For applications in IoT, a hypergraph-based multidimensional structure can be used to model the IoT device for efficient management and discovery of IoT objects. The proposed architecture is hierarchical, and consists of smart hospital, an overlay network and cloud storages coordinating data transactions with BC to provide privacy and security. Our design uses different types of BCs depending on where transaction occurs in the network hierarchy, and uses distributed trust methods to ensure a decentralized topology. These automated systems help in continuously monitoring and recording all the vital information of a particular subject by maintaining all the records. Quality check of the architecture is done under common threat models which highlight its effectiveness in providing security and privacy for IoTapplications.

The blockchain represents emerging technologies and upcoming techs. Being a decentralized infrastructure and distributed general ledger agreement, the block chain provides us with a revolutionary opening to launch data security and trust for automation and intelligence improvement in the Internet of Things (IoT) and it forms a new un-centralized programmable smart ecosystem.The transaction of data in Blockchain occurs only if the hash is accurate. If a hacker attempts to attack the network and convert the information of any specific block, the hash attached to the block will also get modified. The breach will be

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detected as the modified hash will not match with the original one. This ensures that the blockchain is unalterable because if any change is made to the chain of blocks, it will be reflected throughout the entire network and will be detected easily. Our research synthesizes and analyses; on blockchain-related perspectives which will potentially play a crucial role in sustainable development in the world.

Structure of Hypergraph

As a scientific mathematical instrument, hypergraphs can be implemented to simulate computer networks, biological networks, data structures, and various other systems. For applications in the IoT, a hypergraph-based multidimensional structure can be used to model the IoT device for efficient management and discovery of IoT objects. A hypergraph H denoted by H = (V; E) on a finite set V.E, is asubset of V called a hyperedge. Typically, V is a set of vertices and denoted by V(H) and E is a set of edges represented by E(H). If two vertices are in one hyperedge, they are called adjacent. The cardinality of a hyperedge symbolized by |ei| is the computation of vertexes in the hyperedge.

Two hyperedges in a hypergraph are adjacent if their intersection is not empty. The degree of a vertex is calculated as the count of hyperedges which accepts it. And the maximum degree is defined as the graph's degree. Hypergraph H in Figure 1 has five hyperedges (e_1 to e_5) and 11 vertices (V_1 to V_{11}).The cardinalities of each hyperedge are c(e1) = 4, c(e2) = 4, c(e3) = 2, c(e4) = 3 and c(e5) = 1. The rank r(H) = 4 (contributed by e1 and e2), and the co-rank cr (H) = 1 (contributed by e5). The degree of V1 is 2(because it is included by e1 and e4).

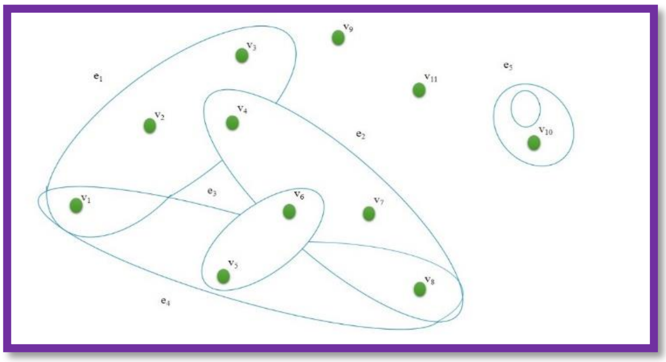

Figure 1.*Hypergraph*

Smart Hospital Designing

In this paper, a system for 24x7 human health monitoring is designed and implemented. In this system, the Arduino Uno board is used for collecting and processing all data. Various sensors are used for measuring specified/required parameters. All this data is uploaded to thing speak for remoteanalysis.AnESP8266moduleisusedforconnectingtotheinternet.

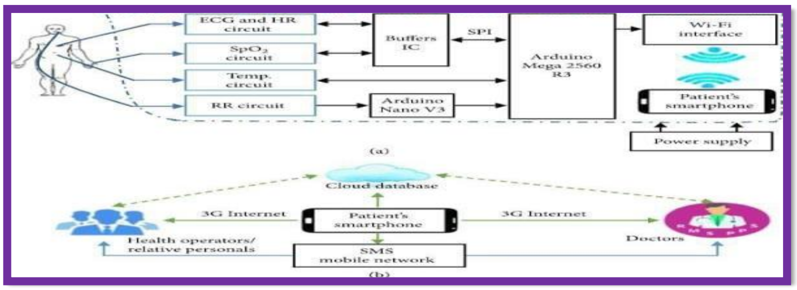

Figure 2. *Smart Hospital Design*

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In this model, the nodes in the blockchain network are distributed into several bunches, each with the same transaction record chain. Due to the dynamic nature of the blockchain network, such as in the IoT environment, it is tenacious to formulate in a static manner. The nodes that record the transactions appear in the blockchain network as anonymously as possible due to security and privacy considerations. A mathematical model of the structural design is provided by the hypergraph theory.

Nodes: A node is a device with storage capability in a blockchain network. Each node in the network belongs to at least one hyperedge and can also belong to multiple hyperedges simultaneously.

Miners: Miners are devices for calculating encryption block hash keys in blockchain network, which is similar to ordinary miners. However, in the designed architecture, miners also undertake the task of calculating the linear independence matrix in the network, which is mainly used for the control of transaction data.

Hyper edge: A hyper edge is a set of nodes. All nodes on the same hyperedge have the same vector encoding that is independent of other hyperedges, and they have synchrony when storing transaction data.

The blockchain network is mapped to a hypergraph, where the devices are nodes in the graph, and each hyperedge corresponds to a set of devices. A device belongs to two or more hyperedges at the same time in this model. For example, Node6 belongs to hyperedge e_2 and also belongs to hyperedge e_5. The probability of devices that belong to the same hyperedge appearing in the same local network, either as nodes or as miners is likely.

The Automated System Architecture

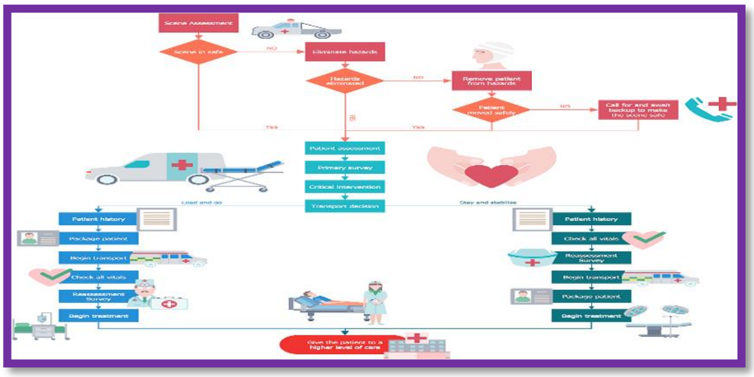

Figure 3. System Architecture

SystemFactors

The nodes in the same hyper edge are synchronized in the transaction record storage process. The degree of each node in the specified network must be N. A transaction record is documented by nodes in a hyperedge in the planned design. The working mechanism of the blockchain network is different from the original based on the proposed architecture. Thus, the data structure of the node in the hypergraph and the storage function is essential to be redesigned. In this case, if the original blockchain structure is adopted, the data blocks in the nodes will no longer be the alike. When the current block is complete and must be encrypted, the hash values calculated by each node are always altered.

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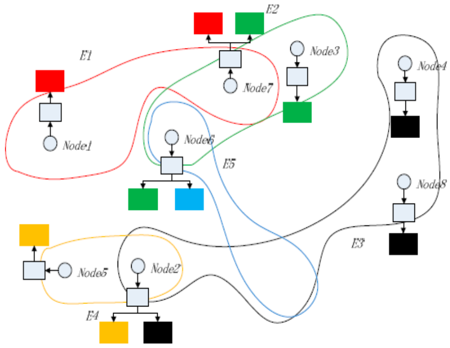
The data structure in each node is designed individually to avoid failure of process. The structure of storage in each node is planned with two parts: the blockchain head and SubBlockchains. The count of subblockchains and the degree of the node is of same quantity.A subblockchain is a kind of blockchain with a head, in which there is an N-dimensional vector known as hyperedge of the subblockchain stores synchronous transaction records separately in the hyperedge, whose feature vector is the same as the vector in the subblockchain head. Therefore, the nodes in the same hyperedge must have a same subblockchain.

Figure 4. *Advanced Hypergraph Network*



Functioningof Smart Hospital
Once a transaction ensues, the source node constructs a record that includes the following Information: timestamp, the selected linearly independent vector (an integer N-dimensional vector) and the common information, such as the parties to the transaction, transaction content, needed in. Initially, when a transaction happens, all nodes in the network receive the declaration and search for linked records in their subblockchains. The nodes which kept the latest transaction information of the source node obtain the arbitration right. A message that the transaction is legal is sent by the arbitration nodes to the network, if the transaction made is verified as legal; otherwise, a message will be sent that the transaction is illegal.
In our model, the verification is done by only the nodes, which have gained the arbitration rights. The particular node process and sends the result to others. After receiving the verification messages, the nodes in the network can judge the legitimacy of transactions based on the relationship of the average cardinality and the number of messages received, as well as the ratio between the legal certificate and the count of illegal certifications. Basically, for a given threshold, if the legal message count exceeds the threshold, the transaction is considered legal. A secret key system guarantees the security of messages.
When a transaction occurs, comparison takes place between Nodes in the blockchain network and recorded feature vector, with the vectors in its own subblockchain head. If matched and the transaction is verified to be legal, the record is inserted to the current block of corresponding subblockchain. When the current block in a certain subblockchain of a certain node is full, according to block chain working principle, the data of the current full block, previous block hash value and other information will be published to the network. All miners will get these data and calculate an encryption hash value competitively. If the result is acceptable, the block will be encrypted and stored, otherwise the outcome will be deleted and the calculation will be continued.

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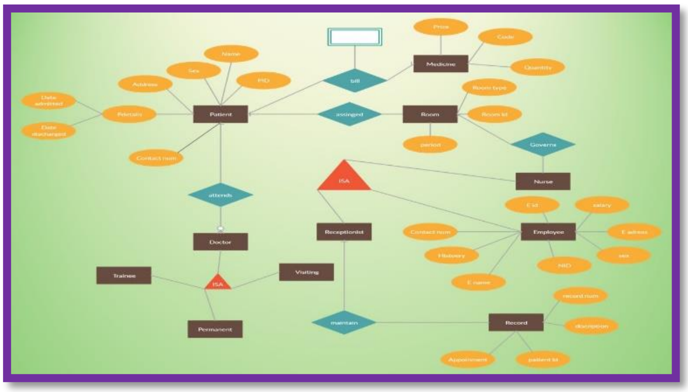

Figure 5. *Functioning*

Implementation

Algorithm

Mathematically, it is set of independent paths through the graph diagram.
The Code complexity of the program can be defined using theformula:

V (G) = E – N + 2

where,

E - Number of edges

N - Number ofNodes

V(G) = P+1

where,

P = Number of Predicate Nodes (Node that contains condition)

Conclusion

Therefore, the Smart Hospital App for regularly monitoring one's health has been constructed. A developed and simulated model for a health monitoring system for patients in remote areas using body sensors and mobile devices that havea connection to the Internet through the GPRS network, health information system and medical specialist. A working solution to the problem of distance in health care provision for people living in rural locations away from Medical Specialist is provided.

Furthermore, the work if properly optimized is a viable option for mobile healthcare provision for patients with hypertension that require frequent monitoring to reduce the incidence sudden heart failure and avoidable health disaster. Future research work on this could be done around the issue of sensor power consumption, medical information routing protocol, security, and interoperability with different body area sensor networks.A hypergraph-based blockchain model is proposed due to the less energy and memory of most IoT devices.

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