SMART CONTRACT FOR CALL INITIATION,TERMINATION,ROAMING AND BILLING UPDATE USING BLOCKCHAIN TECHNOLOGY

ABSTRACT:

With the advancement of technology in this fast-paced world, there has been an increase in demand for digitalisation of consumer appliances. Some of the many appliances that have been digitised are smartphones and a major component of smart phones is communication. Communication has changed vastly throughout the decades and has been made very convenient with the help of technology, but there is always a cost associated with convenience. The present practice of using the traditional centralised system of communication is insecure, i.e., the user data stored in such a system can be easily tampered with and pose a threat to the user's security. Also, the process of communication goes through various steps that require a centralised authority's intervention. This makes the entire activity tedious and difficult to work with. This study proposes a solution to this problem by introducing a smart contract which is a piece of code that gets automatically processed and is tamper-proof, developed using blockchain technology which is a kind of technology that decentralises the mechanism, which means that is no intervention of a centralised authority and makes sure that the user's security is kept safe. This article also simulates and considers real-life scenarios and provides a practical solution to the problems that are faced, which makes it efficient to be used in the telecommunication system. It ensures secure call initiation,termination, billing calculation and roaming checks. The smart contract is developed using solidity programming language on Ethereum network .It shows potential to eventually improve the security, transparency and efficiency of the telecommunication process.

1. INTRODUCTION:

The increasing use of digital devices in various fields, especially networking has increased its demand in the field of communication. There has been an exponential increase in the use of wireless devices such as smartphones which has led to a massive increase in wireless traffic in the mobile communication system .Traditional methods of communication which are mainly dependent on a centralised system, fail to provide the necessary security which has to be integrated into such a system, hence a revolutionary technology called blockchain technology has shown the potential to make this possible. Blockchain is a technology that enables users and applications with secure and private access to supply data to the system , without the intervention of a centrally controlled management system. All the participants can verify each transaction

and prevent disputes with the help of a mechanism called a consensus and it ensures that each partner is held accountable for any kind of role in the overall transactions which has to be recorded on an immutable ledger, the records and transactions are maintained using cryptography.Blockchain has received an overwhelming worldwide public attention as it enables the use of cryptocurrencies, which are digital records used to make transactions on a blockchain network. In 2008, Satoshi Nakamoto designed the first worldwide digital payment system known as Bitcoin, which used a combination of different cryptographic elements to make the transactions safe and secure. In recent years, blockchain has evolved from the original version in Bitcoin, to a number of upgraded versions, such as Ethereum and Hyperledger ,that support various complex programming execution.Blockchain's inherent qualities like transparency, anonymity, immutability and low cost has increased its popularity for use in a variety of innovative applications, such as in the world of telecommunications, Iot, healthcare and media. [1][2]

One of the many versions of blockchain, Ethereum is a decentralised global software platform.It uses a cryptocurrency called ether (ETH).Ethereum can be used by anyone to create any secured digital technology or develop smart contracts which are programs that are automatically executed once the terms of agreement among the members of the network, are met. It is designed to be scalable, programmable, secure, and decentralised. It is the blockchain of choice for developers and enterprises creating technology based upon it to change the way Industries using centralised systems work[3]

In this paper, we delve into the global telecommunication system and provide an alternative to the traditional system of mobile communication. In recent years, personal communication services (PCS), cellular communications, satellite communications, broadcasting, wireless LAN, Bluetooth, and other wireless applications have gained massive popularity and are in high demand for industries. The Global System for Mobile (GSM) paves the way of modern communication in the world of telecommunication system.It is a technology program that covers a wide range of digital radio channelling to carry out the functions of providing audio, transferring information, and other multimedia communication systems. In GSM, devices interact with it by looking for nearby cells, the cells are connected to a base station called a cell tower that collects some user data and transfers the information to the base station controller that consists of many base stations. After this, the call request is transferred to the mobile switching centre that verifies the identity of the person who has initiated the call request and validity of the phone number and decides whether the call will be initiated or not.

GSM, including other technological advances, has influenced the evolution of mobile

wireless telecommunication services. A GSM system manages communication between mobile stations, base stations, and switching systems.[4]

It is the first cellular system to specify digital modulation as well as network and service structures. GSM was originally introduced in Europe in 1991, and it is now the most widely used cellular technology. GSM is currently one of the most widely utilised digital cellular telecommunications technologies. As the number of mobile subscribers have grown, the demand for gsm technology has also increased as this is one of the most efficient working systems.[5]

In this paper we aim to provide a solution to the prevailing problems faced in the way that traditional centralised communication systems work with the help of blockchain and Ethereum networks by integrating these technologies in wireless communication and possibly change the present ways of handling communication. We first write about related works and discuss the abstract view of work and the output and existing problems. Then, we discuss our problem statement and then our contribution. After that, we describe the system architecture and further describe its components. Further, we describe the entire implemented program by using solidity language. We end the paper with a conclusion.

With growth and development of technology in the world of global telecommunication, the need for an efficient and secure way of handling the call communication process is increasing as voice calls remain a fundamental means of human communication among the diverse channels of communication. This research paper presents an alternative to dealing with the problems in communication by delving into the world of blockchain technology and developing a smart contact with the help of the Ethereum network, which eases the process.The core of this study revolves around decentralisation of the call communication process and ensuring transparency, security and immutability. With the help of a tamper-proof and automated smart contract, each call interaction is monitored and made secure.The subsequent sections of this paper explore the methodology, design, implementation and evaluation of the smart contract system. With decentralisation, we add to a broader understanding that a distributed and transparent system like blockchain can revolutionise real-world communication processes.

2. RELATED WORKS:

2.1 **Abstract view of work:** Using decentralised communication systems, this research work presents a solution in the form of a smart contract that is developed using solidity programming language, developed on ethereum network. This smart contract consists

of functions to handle the various processes involved in a call communication, namely, call initiation, call termination, roaming and billing update. Using this proposed smart contract, we aim to overcome the limitations of a centralised system. The following are the various implemented functions for the decentralised communication processes:

Call initiation: a user can invoke this function to start the process of call communication. This function helps to establish the call communication between the caller and receiver after verification of both participants.

Roaming: this function checks whether the user initiating the call request is trying to connect a call within the local network or to another network in an area outside the local area network, i.e. roaming and accordingly initiates the call.

Call termination: when the call is terminated, this function is invoked and the termination time is recorded by the system, this is done in a secure and seamless manner.

Billing update: The bill of the call is calculated by considering the call duration using this function, based on predetermined rates.

Decentralisation, transparency and security: The smart contract system using blockchain technology decentralises the process and ensures security and transparency in every step. This smart contract eliminates the need for a centralised system to keep a check on every step, making the process a lot shorter and convenient. Users engage directly with each other without relying on any authority

Output and existing problem: The proposed smart contract can be used to overcome the limitations of traditional centralised systems that are not tamper-proof by decentralising the entire mechanism of communication between users and making the entire process secure and transparent .The functions in the smart contract can be used to:

- Verify the caller's and receiver's identity and check whether their individual contact numbers are valid or not.
- Initiate or establish a call between two users.
- Check whether the user is within the local area or outside the local area, i.e. roaming.
- Terminate the call and record the call duration.
- Calculate the bill using the predefined rates, using the call duration.
- Send the bill of the call to the users.

Existing problem:

- The smart contract is confined to the telecommunication systems and may not be compatible with other networking systems.
- The smart contract is still under development and may not be adopted by a networking system due to its potential security risks.
- It may not be widely used in a networking system due to its complicated structure.

2.1 PROBLEM STATEMENT :

Traditional methods of handling call communication are centralised and inefficient as data stored or transferred through such systems can be easily tampered with as the security systems in such systems are weak and sometimes require intervention by a third party. This can be a threat to the security of users and hence, not be favourable. This research paper provides a solution to the problems mentioned earlier by completely decentralising the system and making the security system strong as the data entered in such a system is immutable and tamper proof. In blockchain, the need for intervention of a third party is completely diminished. Users can directly interact with each other. The proposed smart contract is a contract of agreement among the users which automatically gets executed when the terms of agreement are met, this ensures that data transferred is safe and secure.

2.2 CONTRIBUTION:

This paper proposes a solution to tackle the limitations faced in the real-world communication process by decentralising the entire process. It also makes the system tamper-proof, secure and convenient to use.

- This study provides a detailed description of the functions the proposed smart contract uses for the process.
- It provides a detailed description of blockchain technology, its applications, benefits, and potential in technological advancements.
- It provides a description of Ethereum technology powered by blockchain technology that was used to build the proposed smart contract.
- It describes the benefits of using a decentralised mechanism like ethereum network powered by blockchain technology over a centralised system.
- It incorporates real-world scenarios and aims to overcome the problems faced in the process.
- It proposes an alternate way to handle call initiation,termination,roaming and billing update, which, if handled in a centralised system can be insecure and

cumbersome.

- It evaluates the smart contract for its incorporation in real world communication.

3. SYSTEM ARCHITECTURE:

The GSM system for call communication has been implemented in this article and a hypothetical model using blockchain has been created on the mentioned system to decentralise the process and make it safe and secure. First, we will understand what the GSM system is. The GSM system which is an abbreviation for Global system for mobile communication, is a networking system that involves various processes to make a call connection possible. When a user makes a call request, it is received by a nearby cell tower called the base station (BS) that collects some user data and then transfers this data to the base station controller (BSC) which controls one or more base stations. Then, the request is forwarded to the Mobile switching centre (MSC) that has a number of components namely, Home location register (HLR), visitor location register (VLR), Authentication centre (AUC), equipment identity register (EIR), operation maintenance centre (OMC) and the public switched telephone network (PSTN). The user data received by the MSC is verified by the HLR and EIR which are databases that store subscriber data, if the call is made within the local area network and the call is initiated. If the caller initiates a call request while they are roaming, then the call request is sent to a BS in their proximity, after which it is transferred to BSC and then to the roaming area's MSC. The identity of the individual is verified by a request for verification which is sent by the MSC to the caller's HLR in their home network. If the information provided by the MSC is verified by the HLR, then an authentication key is sent back to the roaming network's VLR which then signals the MSC to initiate the call.

The process mentioned above is the way traditional centralised systems work on GSM.The entire process is long, goes through many steps and requires authentication at various levels, which makes it cumbersome and difficult to work with. Further, it is not secure. Therefore, the proposed hypothetical model uses blockchain technology that creates a smart contract that initiates a call, terminates it, checks whether a user is in a roaming network and calculates the bill. The smart contract gets automatically executed when the verification of the individual is completed with the help of the information stored in a blockchain, instead of storing it in traditional databases that are insecure.

PROPOSED MODEL:

Fig.1

HOME-ROAMING NETWORK CONNECTION

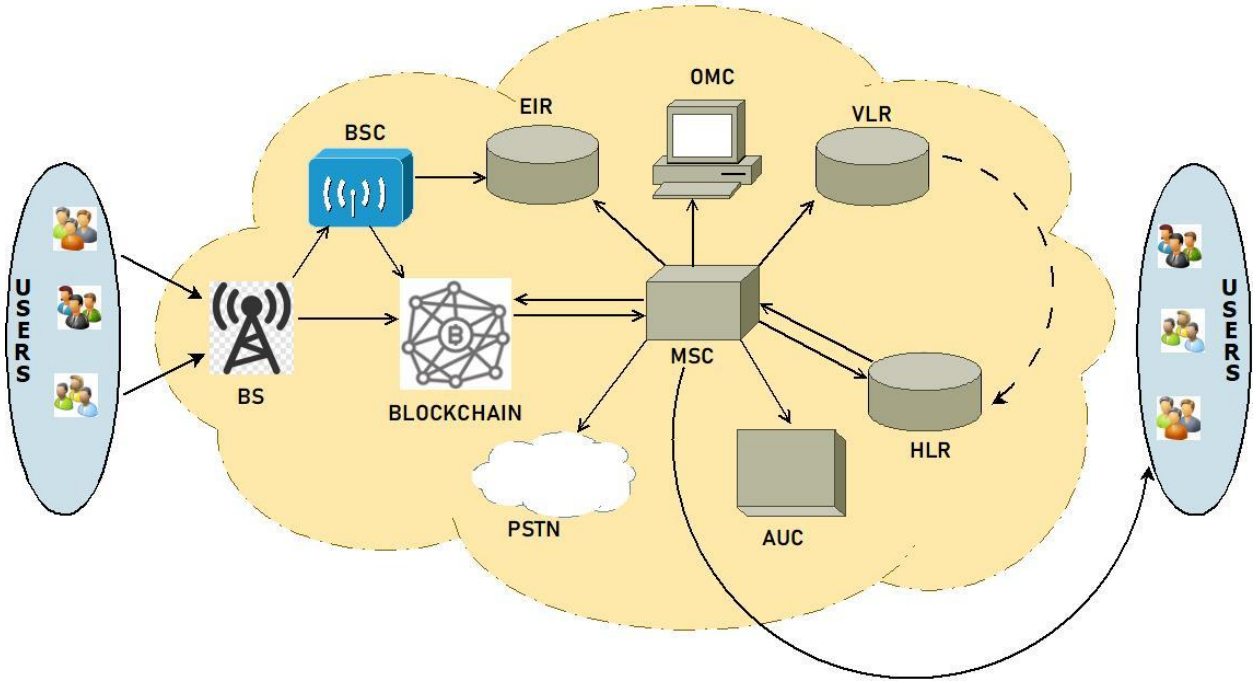


Fig.2

HOME NETWORK

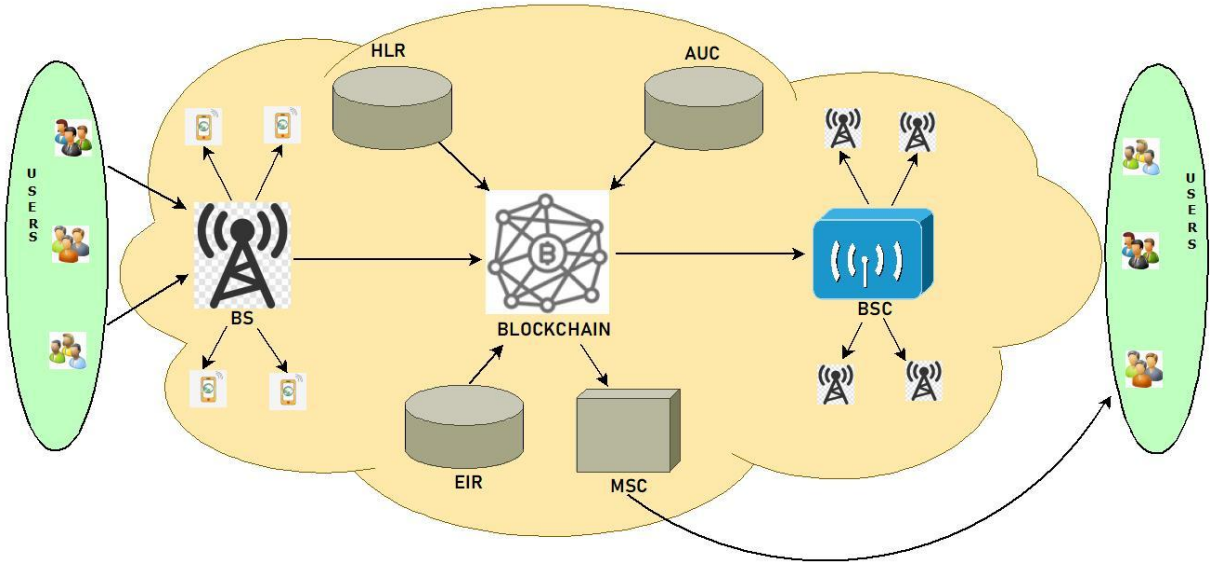
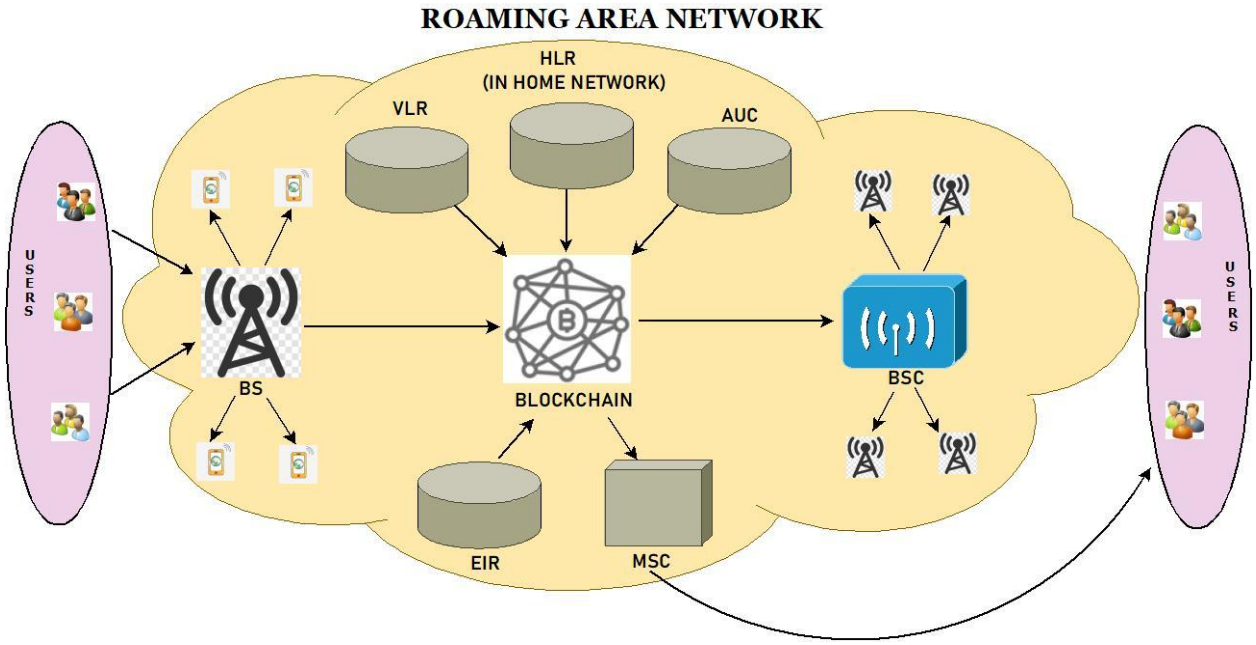


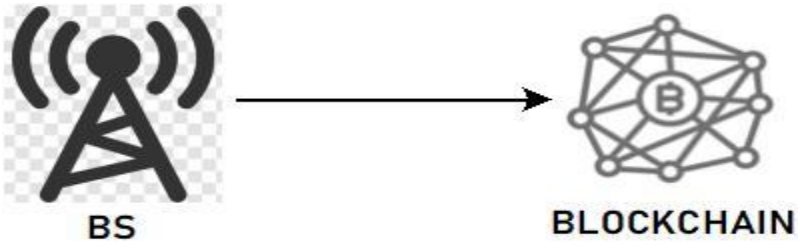
Fig.3



3.1 COMPONENTS OF ARCHITECTURE:

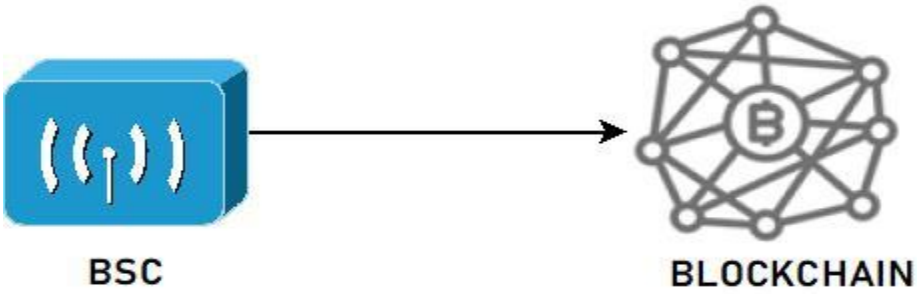
From Fig 1:

1.



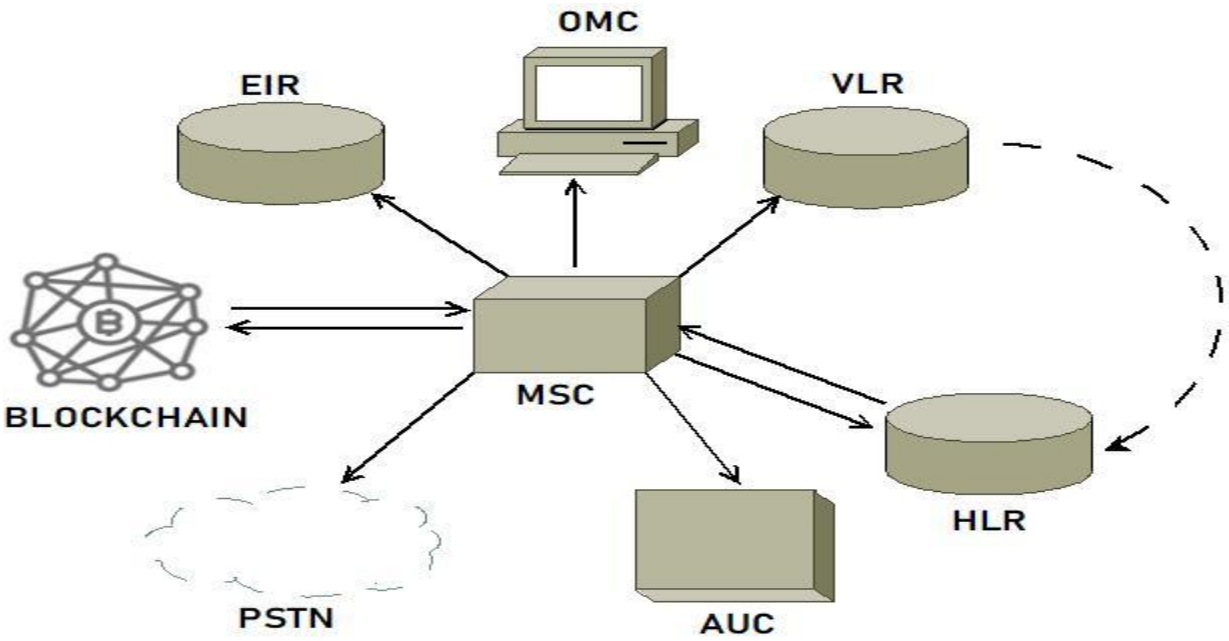
BS (base station): A base station works as the main communication point for one or more wireless mobile devices. It is a fixed transceiver capable of sending and receiving wireless signals via the radio frequency (RF) base station antennas to transmit RF signals to other devices. In the figure shown above, the user data that the base station collects like the identity, phone number, etc. is transferred to the blockchain.

2.



BSC (base station controller) : A base station controller (BSC) is a critical mobile network component that controls one or more base transceiver stations (BTS), also known as base stations or cell sites. Key BSC functions include radio network management (such as radio frequency control), BTS handover management and call setup.In the figure shown above, the base station controller collects the data stored in the blockchain and forwards the call request to the MSC.

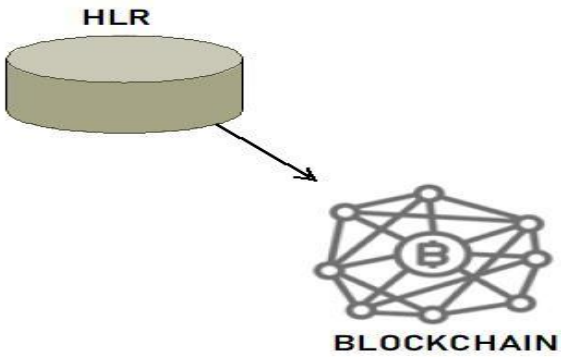
3.



MSC: (mobile switching centre) - The Mobile Switching Centre is a critical component in modern telecommunications networks. It is responsible for switching and routing of calls between different networks and devices, as well as providing services such as call forwarding, call barring and voice mail. It is the nerve centre of the mobile telecommunications system, connecting the user to a wide range of services, both within and outside the network. In addition, the MSC is responsible for controlling the resources of the network, managing the network's security, and providing billing and accounting services. With the continued growth of mobile networks, the MSC provides an essential link between the mobile user and the network. In the figure shown above, The MSC has six components, namely, EIR, OMC, VLR, HLR, PSTN, and AUC. All the previously mentioned components consist of user data that is transferred to the

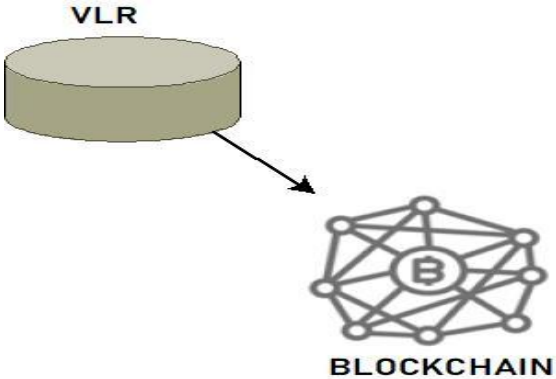
blockchain, the data is verified, after which the call can be established.

4.



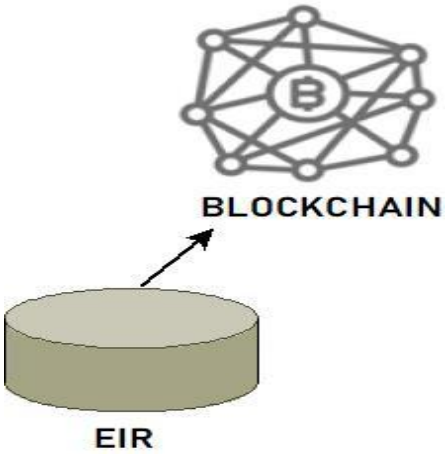
HLR: (home location register) - Home Location Register (HLR) is a database that contains data regarding authorised subscribers using a global system for mobile communication (GSM) core network. The home location register stores information ranging from phone numbers to current location of the subscriber. Some data contained in the home location register include the mobile Station International Subscriber Directory Number (MSISDN) which is a list of the telephone numbers used by the subscriber and the International Mobile Subscriber Identity (IMSI) which is a unique identifier of each subscriber identity module (SIM) and is the primary key for each HLR record of each subscriber. The HLR sends the previously mentioned data to be stored in the blockchain, as shown in the figure above (from Fig.2).

5.



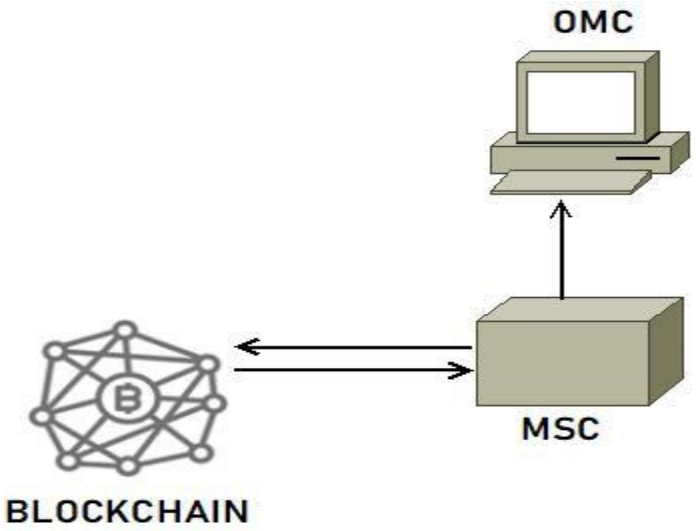
VLR: (visitor location register) - A visitor location register (VLR) is a database that contains information about the subscribers roaming within a mobile switching centre's (MSC) location area. The primary role of the VLR is to minimise the number of queries that MSCs have to make to the home location register (HLR), which holds permanent data regarding the cellular network's subscribers. In the figure shown above, the VLR

6.



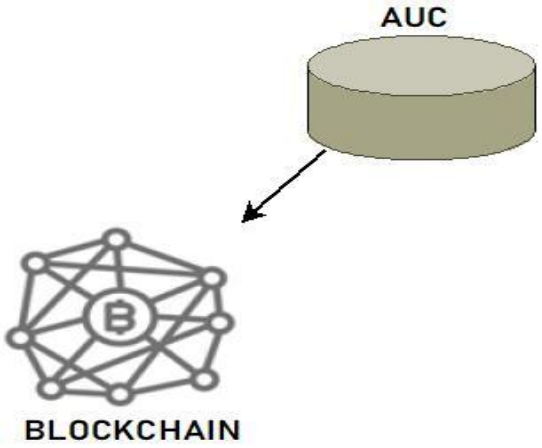
EIR: (equipment Identity Register) - is a key component in the architecture of a mobile network. It helps the network to identify and authenticate each mobile device that attempts to connect to the network. The EIR is constantly updated with information about the status of each device, such as whether it is authorised, barred, or reported as stolen. The network can then use this information to grant or deny access to the network for each device.

7.



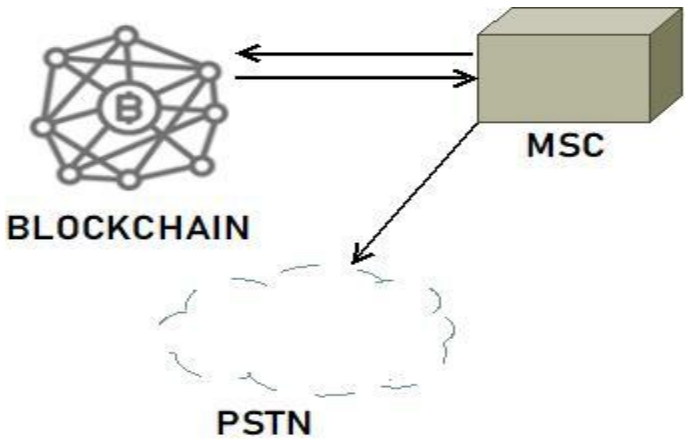
OMC: (operation maintenance centre) - Operation Maintenance Center (OMC) is used to monitor and maintain the performance of each Mobile Station (MS), Base Station (BS), Base Station Controller (BSC) and Mobile Switching Center (MSC) within a GSM system. The above figure (from Fig.2) shows how the OMC is connected to the MSC and blockchain.

8.



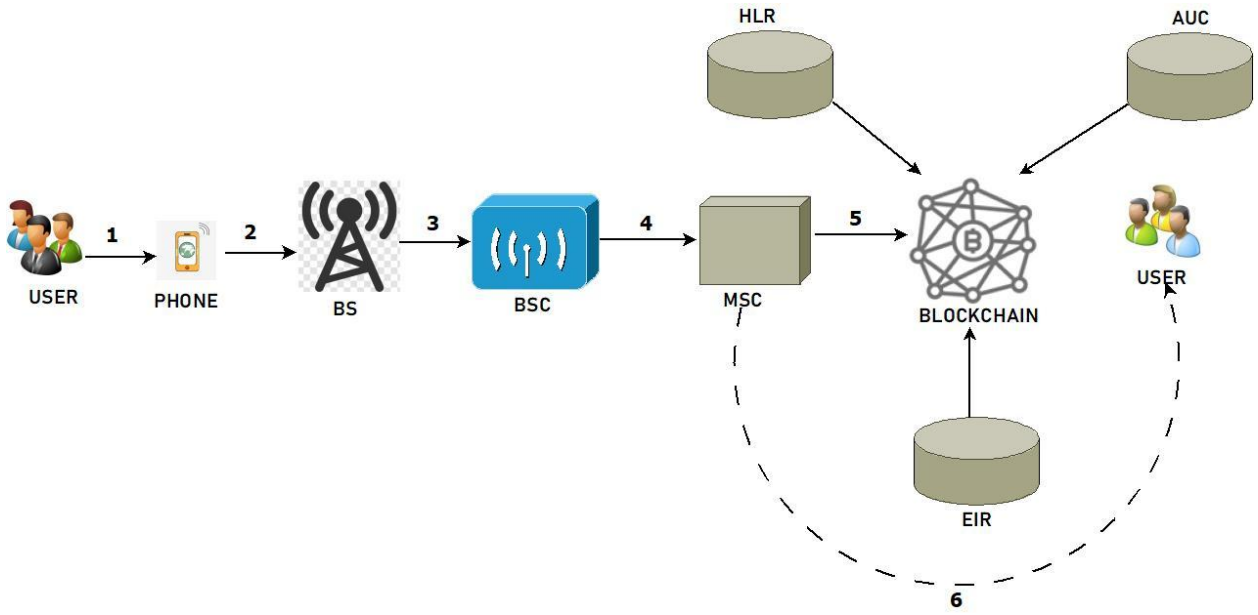
AUC: (authentication centre) - The authentication centre (AuC) is a key component of a global system for mobile communications (GSM) home locator register (HLR). The AUC validates any security information management (SIM) card attempting network connection when a phone has a live network signal.The AUC provides security to ensure that third parties are unable to use network subscriber services.This component of MSC transfers the data to the blockchain as shown in the picture (from Fig.2) above.

9.



PSTN: (public switched telephone network) - it is a collection of the world's phone systems that use traditional circuit-switched telephone networks for public communications. The telephone network is known by several names, such as PSTN, landlines, Plain Old Telephone Service (POTS), or fixed-line telephones. The picture shown above (from Fig.1) shows the connection of the PSTN with the blockchain.

3.2 CALL INITIATION:



1- The user requests a call.

2- The call request is received by the BS.

3- The BS forwards the call request to the BSC.

4- The BSC sends the call request to the MSC.

5- The MSC then verifies the information provided by the BSC with the data already stored by the HLR, EIR and AUC in the blockchain.

6- If the data received by the MSC matches the information stored in the blockchain then the MSC establishes the call.

ALGORITHM:

This algorithm is for the function for call initiation and call verification.

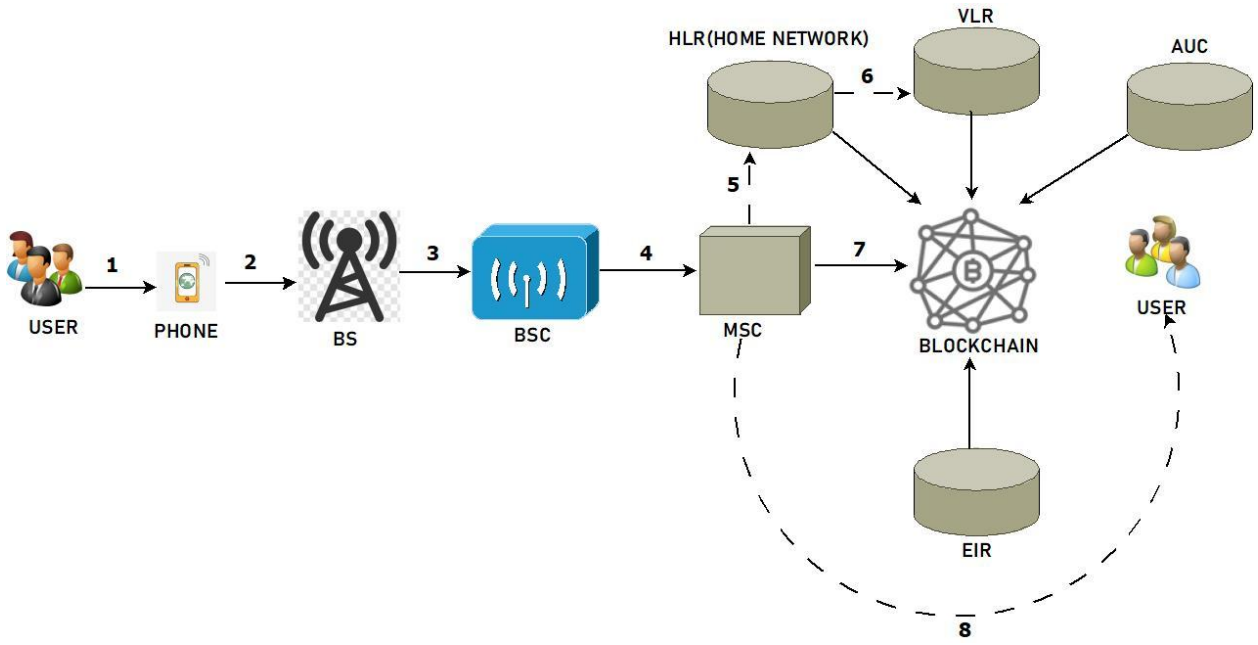
1-Invoke function call initiation(caller, receiver, location). Fetch the details of the caller.

2- Fetch the details of the receiver

3- Check validity of details, if ok connect call and start timer

4- If it is not ok, terminate the call.

3.3 ROAMING:



1- The user requests a call.

2- The call request is received by the BS.

3- The BS forwards the call request to the BSC.

4- The BSC sends the call request to the MSC.

5- The MSC then checks the location of both the caller and receiver. If they do not belong to the same location i.e then they are roaming. In this case, the MSC sends user data to the user's home network.

6- The HLR verifies the received data. If the data matches the data the HLR has stored in the blockchain, then it signals the VLR to go forward with the call initiation.The VLR, EIC and AUC store the rest of the user data in the blockchain.

7- The MSC verifies the data stored in the blockchain, if the details are valid then the call is established.

ALGORITHM:

This algorithm is for the function for roaming check:

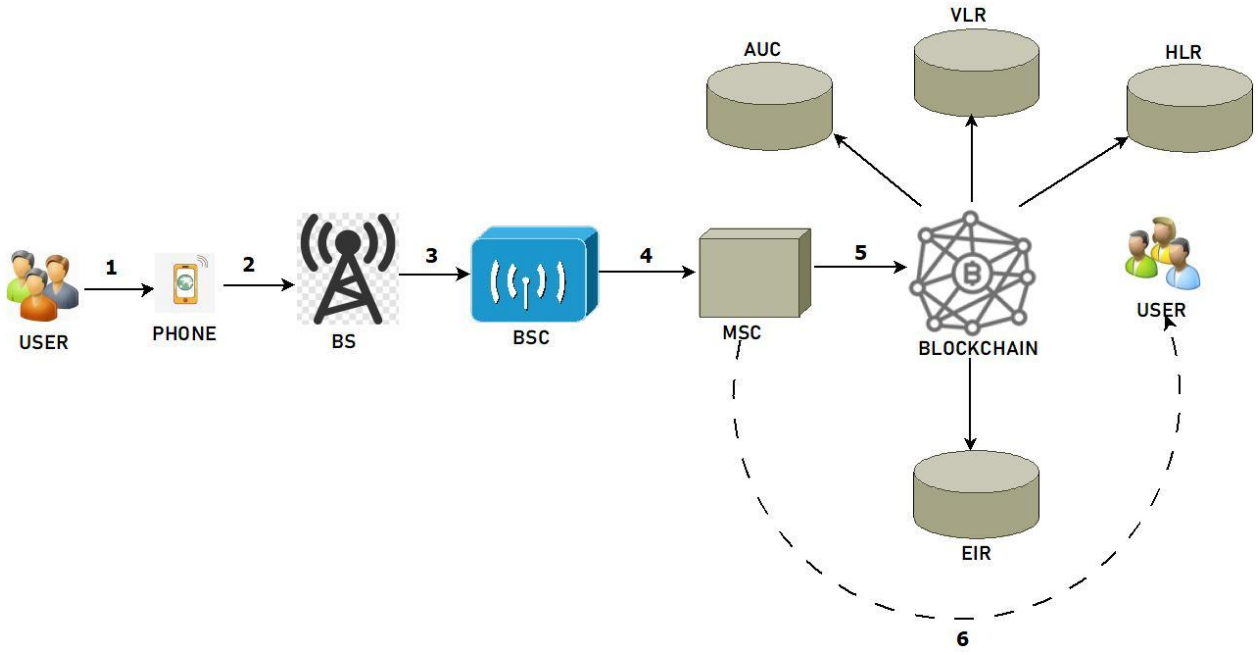
1- Invoke function roaming(caller, receiver, location). Check the location of the caller and receiver.

2- If both locations are different then invoke function call_initiation().

3- Connect the call.

4- Start the timer.

3.4 CALL TERMINATION AND BILLING UPDATE:



1- Either user requests for call termination.

2- The request is received by the BS.

3- The BS forwards the request to the BSC.

4- The BSC sends the request to the MSC.

5- The MSC then reallocates the data stored in the blockchain to the HLR, EIR ,VLR and AUC.

6- The MSC signals the user that the call has terminated.

ALGORITHM:

This algorithm is for the function for call termination and billing update:

1- Invoke function call_termination(caller, receiver). Stop the timer, get the timestamp. Get the duration of the call.

2- invoke function billingupdate(caller, receiver)

3- Fetch the details of the caller and calculate the money depending on the call duration.

IMPLEMENTATION:

The following screenshots show the implementation of the proposed smart contract using solidity programming language on Ethereum technology.

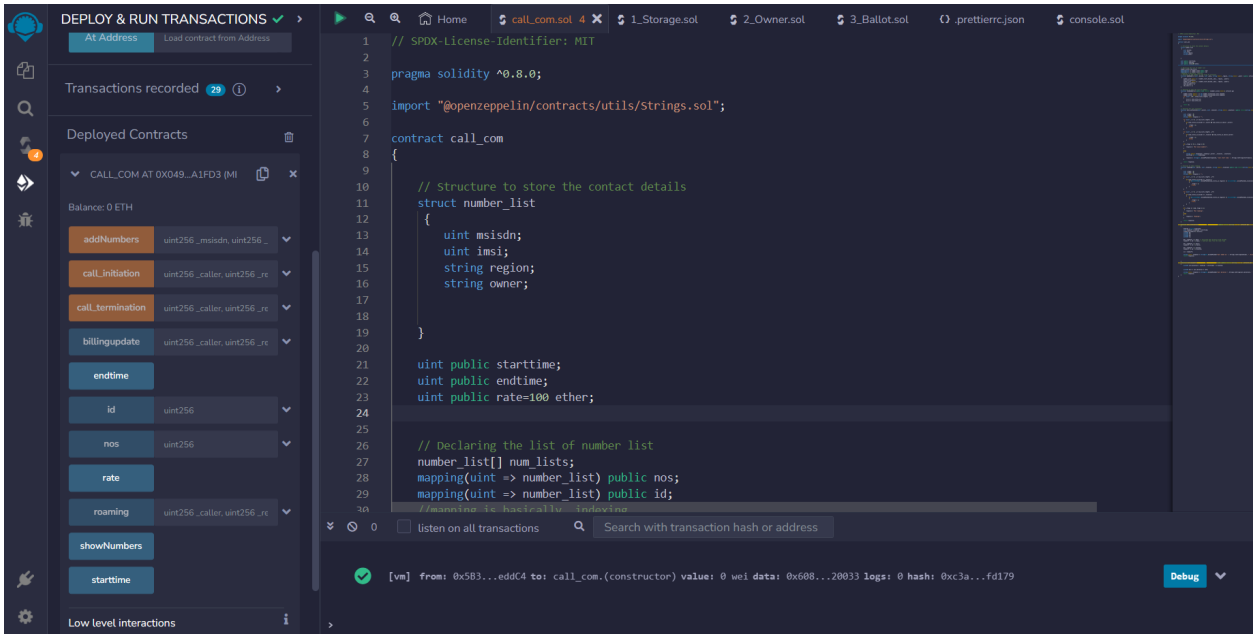


Fig.1 ***Creation of call repository***

1. In the screenshot above, we create a repository that stores the subscriber's number (msisdn), identity (imsi) , location and name of the subscriber. Then we declare a few public variables like starttime, endtime, to calculate the call's duration and another variable stores the predefined rate of one call which is 100 ether.

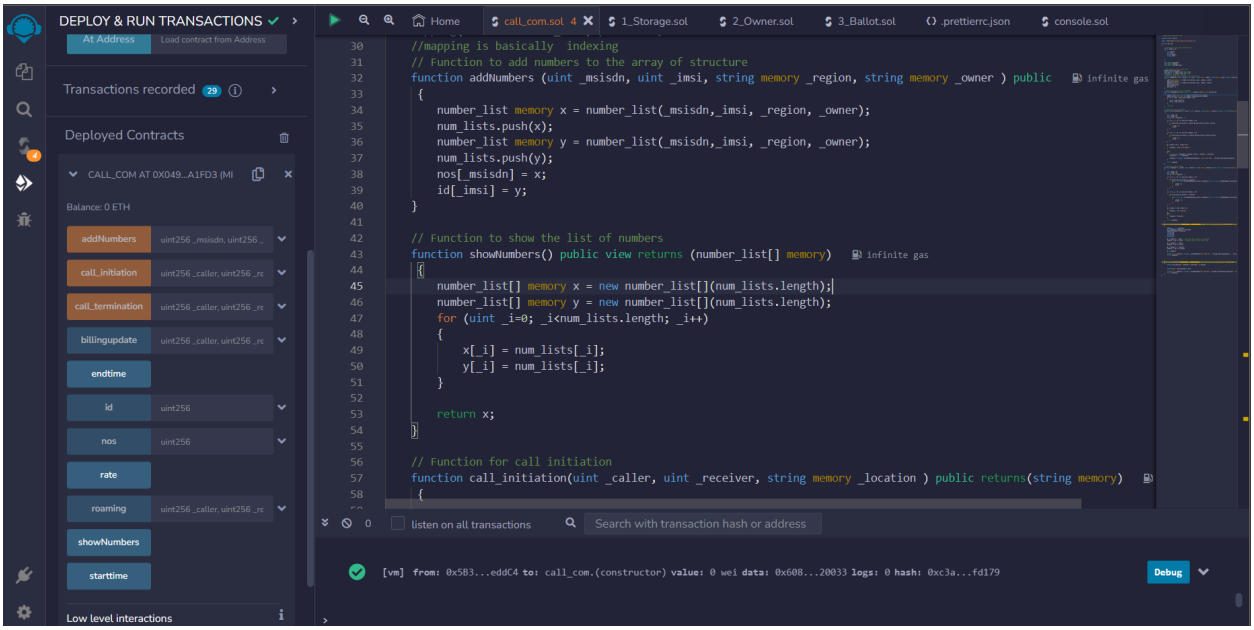


Fig.2 ***Creation of a function called addNumbers***

2. The screenshot above shows the creation of a function called addNumbers, with the help of which we store the phone numbers, identity and owners name, that are entities contained in HLR, VLR, and EIR.

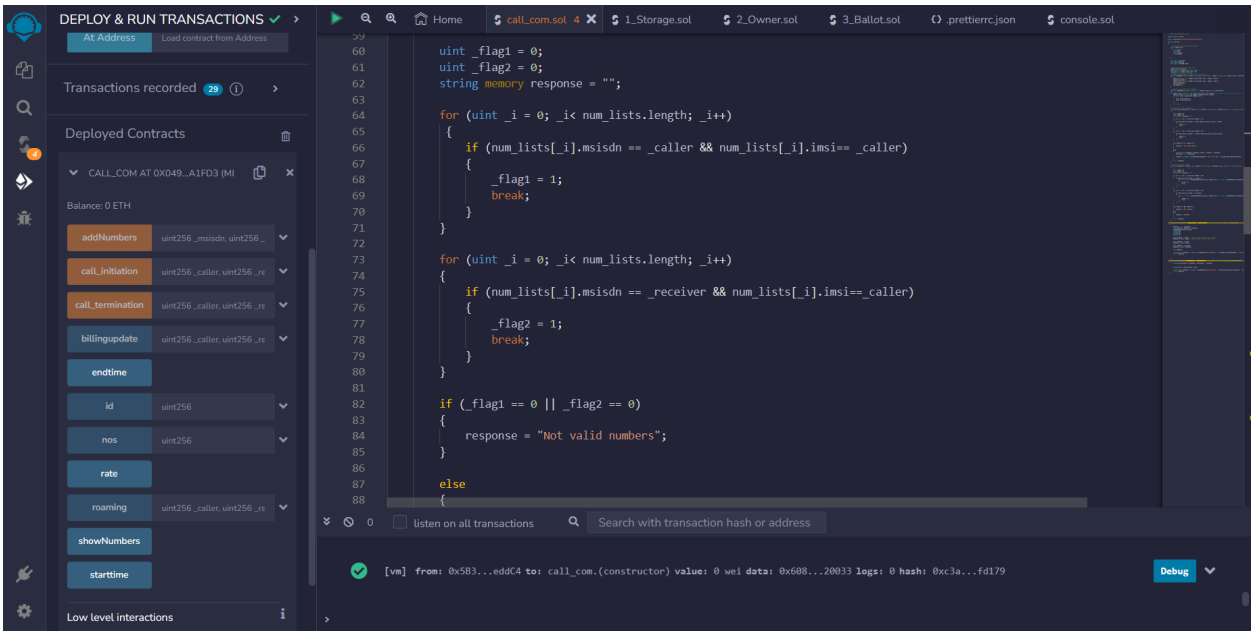


Fig.3 ***Checking the validity of numbers***

3. The validity and identity of each subscriber is checked from the existing information present in the repository and the call is initiated between the subscribers with the

function call_initiation if the identity and numbers are valid.

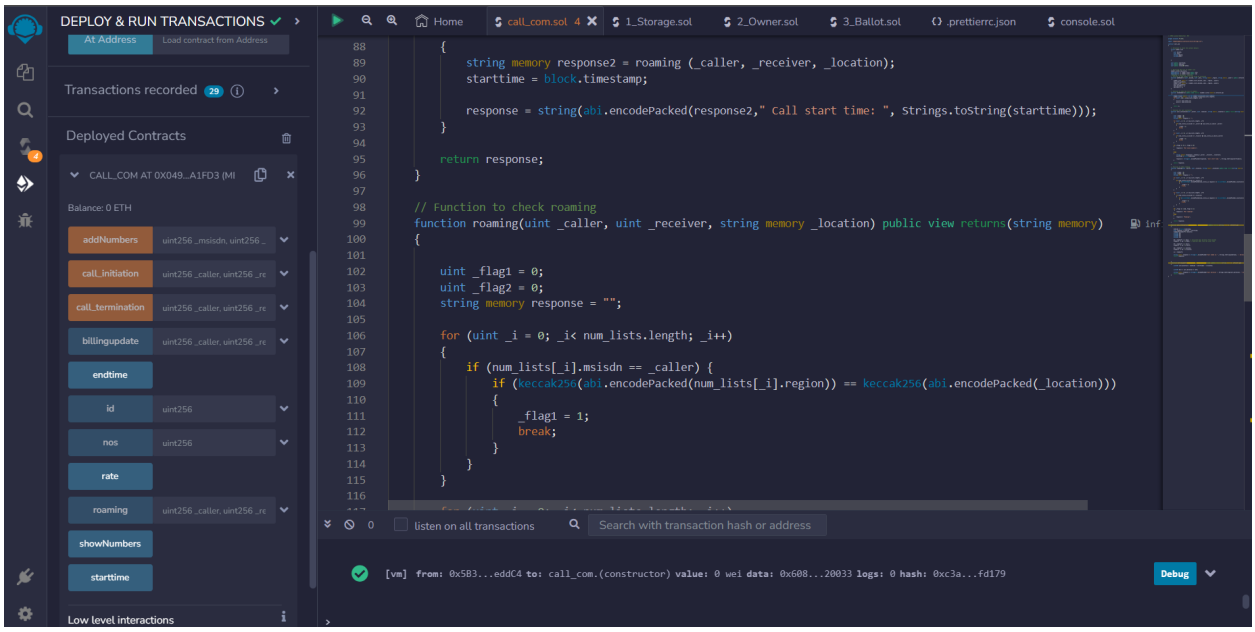


Fig.4 ***Creating a function called roaming***

4. A function roaming is created to check whether the subscriber is from the home location or from a location that is outside the local area network, i.e. roaming.

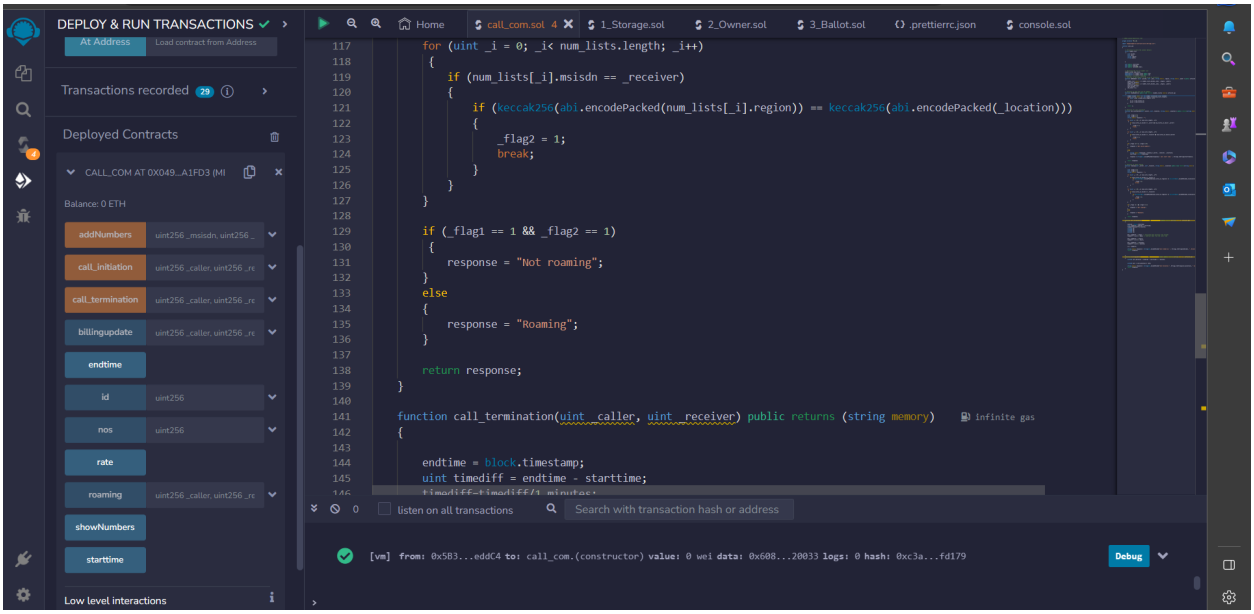


Fig.5 ***Creating a function called call_termination***

5. A function call_termination is created to terminate the call. The timestamp of the time when the call ends is recorded and the duration of the call is calculated.

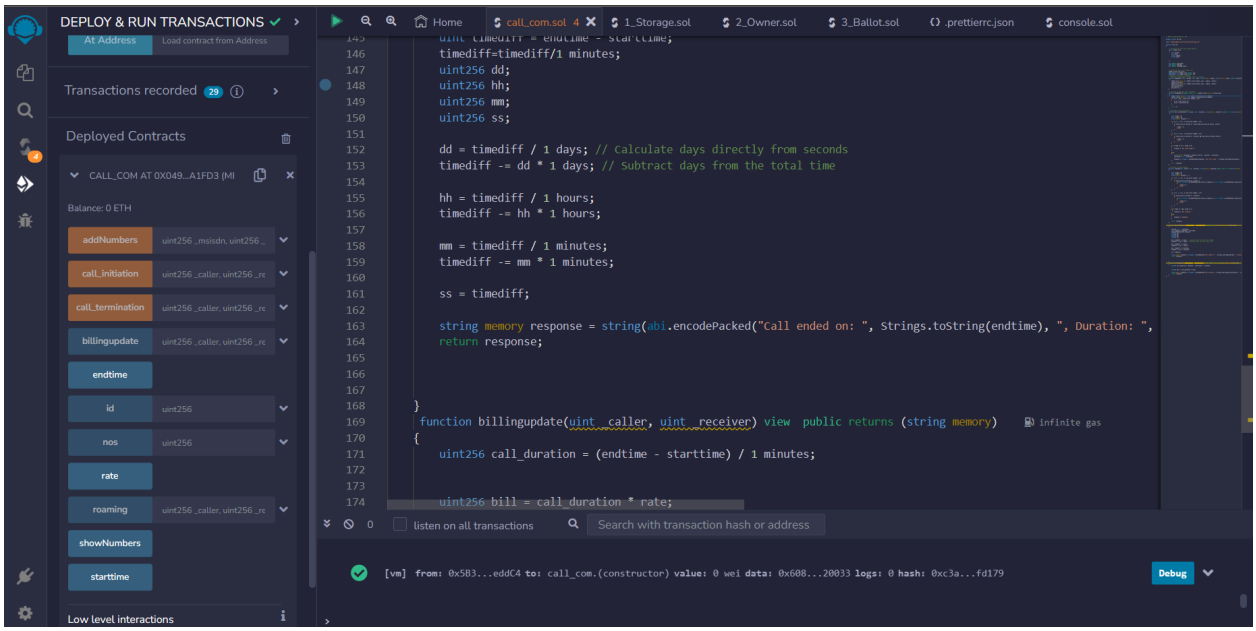


Fig.6 ***Creating a function called billingupdate***

6. A function billingupdate is created to calculate the bill of the call between the users, using the duration of the call calculated earlier and the predefined rates which are 100 ethers.

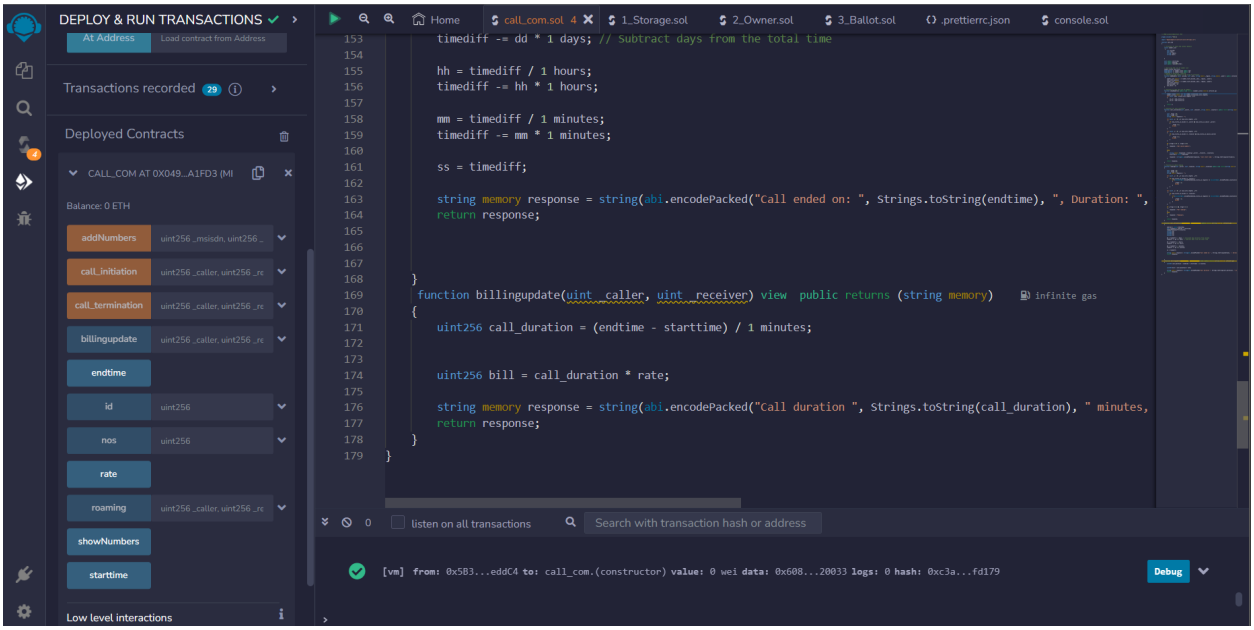


Fig.7 Creating a function called billingupdate

7. The bill is calculated and sent back to the user along with the call duration.

IMPLEMENTATION, RESULT AND DISCUSSION:

The implementation of the smart contract involved rigorous testing, evaluation and incorporating real-life scenarios. Solidity programming language was used for coding this contract and Remix IDE was the platform used to deploy it.

The functions used to implement the call communication process are:

IMPLEMENTATION:

Call initiation: This function is used to establish the call connection between the caller and receiver after verifying the user's name, identity, phone number and location. The smart contract makes sure that security of both the parties is not compromised during the call interaction.

Call termination: This function is invoked when either participant terminates the call. The call termination time is recorded with the help of a timestamp and the call duration

is calculated.

Roaming: This function is used to check the locations of both the caller and receiver involved, i.e. whether they belong to the same geographical location or they are in different places.

Billing update: The bill of the call is calculated using the call duration that was recorded earlier. it is calculated using predefined rates and sent back to the user.

RESULTS AND DISCUSSION:

The smart contract underwent thorough testing and showed promising results. The transaction times for each of the functions of the call process, namely, call initiation, call termination, roaming and billing were significantly reduced.There is security and transparency of the information provided by the users. The performance of the smart contract is enhanced with the help of roaming checks. The smart contract proved that a decentralised system is more time efficient and secure than the traditional centralised systems. It is also more cost-effective as it consumes less gas. Accurate calculation of the bill shows the precision of the smart contract. This smart contract shows potential to revolutionise future technologies by decentralising many other systems like the telecommunication system. It also displays numerous benefits that can improve the functioning of various sectors.

CONCLUSION:

In conclusion, this paper shows an approach to revolutionise call communication with the incorporation of blockchain technology into the development of a smart contract. This decentralised system provides a solution to the limitations of traditional call management systems while taking into consideration transparency, security and immutability.Thorough testing proved the efficiency of the proposed system in handling the entire call communication process by reducing the time taken in transactions, optimization of resources and overcoming the traditional methods of involving a centralised system. With the help of the evolving and diverse blockchain technology, this proposed system is aimed at providing a revolutionary way of handling the telecommunication process and potentially other centralised systems as well.

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