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IMPLEMENTATION OF TRANSPARENT MID DAY MEAL PROGRAM USING BLOCKCHAIN TECHNOLOGY

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ABSTRACT

In an effort to combat malnutrition among younger generations attending educational institutions, the government and Non Governmental Organizations (NGO) have launched the noon meal programme. It has a huge budget and offers extensive food aid. Despite government officials' best efforts to make it a success, a number of issues are encountered, including poor food quality, meals not being served in accordance with regulations, and food not being delivered. If there is transparency in the system and proper power distribution from a select few to all parties involved in the process, the current implementation can be enhanced. These flaws can be fixed by blockchain, which has an immutable, shareable, and distributed ledger that is not under the jurisdiction of a single centralised authority. The suggested task By recording meal preparation and distribution data on an Ethereum-based permissioned blockchain, Nutri Chain has put the idea of a blockchain and Internet of Things (IoT)-based distribution network into practise. Every successful and unsuccessful transfer of a batch of meals from one stakeholder to another will be documented as a blockchain transaction. Each batch of meals will be identifiable by a unique identity. The IoT sensors capture the nutrient value of the meal along with the temperature, pictures, and weight as part of the IoT metrics score. Every meal's information is kept in a database, and its hash and overall IoT metrics score are kept as append-only blocks of transaction data on blockchain. The preliminary analysis points to the viability and promise of the blockchain- and IoT-based method in resolving the selected use case.

Key words: Internet of things, supply chain, and block chain.

1 INTRODUCTION:

He invention of bit coin, a crypto currency utilised in trading without the use of a centralised, dependable third party, is where the history of block chain begins. Block chain can be characterised as an append-only, unalterable digital database of blocks containing transactions that is intended to record nearly any valuable data, not only financial transactions. Every node in the network receives a new transaction as it is completed in order to update their ledgers. As a result, every node possesses a duplicate of the ledger; this degree of openness introduces the concept decentralised technology. In the blockchain, everything that occurs is a result of the network as a whole. As a result, it can prevent frauds or fraudulent transactions from occurring because it is not controlled by a single party or body, as is the case with centralised versions. The difficulties establishing midday meals, food assistance programmes, and further discussing the use of blockchain to enhance the current system are the main topics of this paper. The noon meal programme was established in India many years ago, but the difficulties it encountered from the start have still not been resolved. Accidents involving meals or managerial issues are occasionally resolved. Everything that happens in the blockchain is a result of the network as a whole. As a result, since it is not governed by a single entity, as is the case with centralised versions, frauds or fraudulent transactions can be avoided. The major subjects of this paper are the challenges of implementing midday meals, food aid programmes, and further discussing the usage of blockchain to improve the current system. The noon meal programme was started in India many years

ago, but the issues it ran into right away are still there today. Accidents involving food or administrative problems are infrequently fixed.
The motivation for this work is summarized below:
• The proposed work Nutri Chain implements the idea of an Ethereum-based permissioned blockchain and IoT-based distribution network to store meal preparation and distribute it to those who need it.
• This work highlights some of the previous work provided by researchers related to this field.
• Preliminary work shows that blockchain and IoT-based approaches, the selected use cases, should be feasible and promising.
The remainder of this article is organized as follows and discusses related work done by many researchers in this area. Additionally, presents details of the proposed work, among others, Blockchain Networks, IoT Sensors,

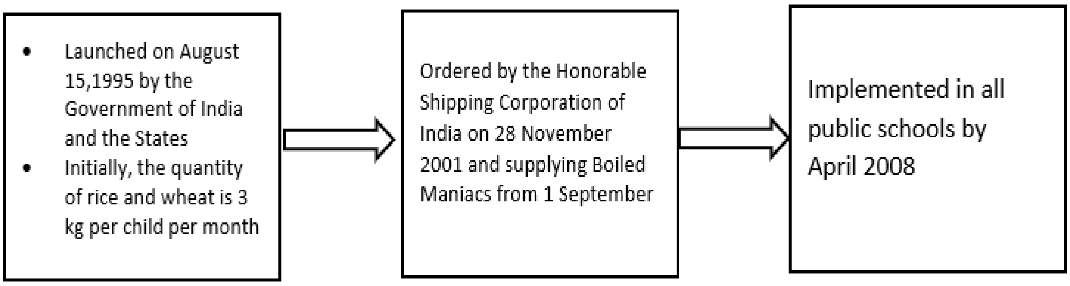

Fig .1 History of the lunch concept

Nutri Chain: Safe and transparent lunch
The creation of the different roles needed, and the preparation of the meal plus feedback via the flowchart are well defined. Additionally, auditing requirements and validation are explained. In addition, the performance analysis of the model is accentuated based on two properties, gas cost analysis and runtime analysis.
Finally, end with a conclusion

RELATED WORK:
Blockchain lessens the dangers of centralised control, single points of failure, and network-related assaults. There are strong security requirements and regulations included in the existing midday meal distribution practise, however their implementation and openness are problematic. The supply chain for the midday meal programme is shown in Figure 2. The use of blockchain to increase supply chain efficiency, transparency, and dependability was highlighted by Perboli et al. The focus of Kumar and Mallick was on IoT system problems and blockchain security. IoT device security and privacy challenges were covered by Qian et al., along with potential blockchain technology adoption solutions. In order to improve food safety, Tian proposed using blockchain throughout the whole food supply chain. According to Hofman et al., IBM, Nestle, and Walmart have created a consortium to research using blockchain to address food safety issues.

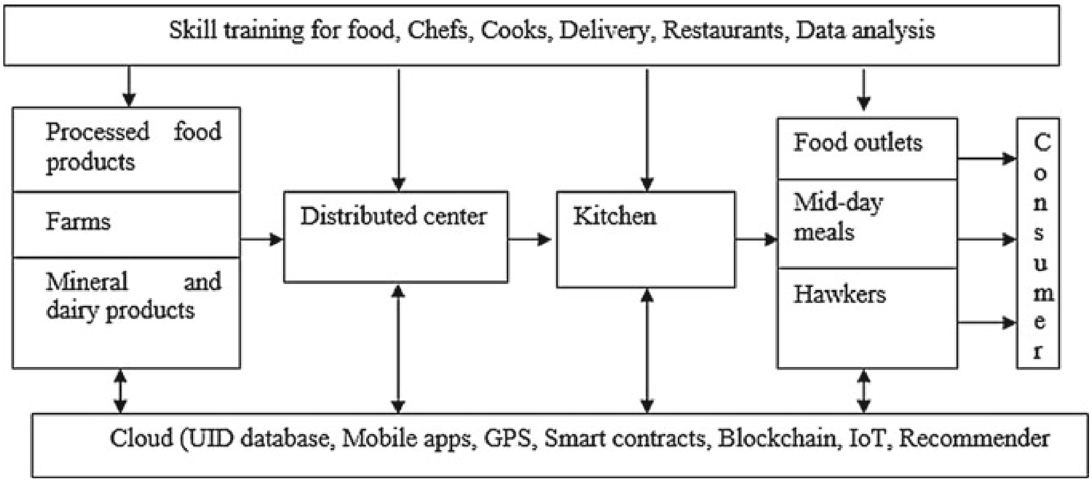

Fig.2 Supply chain for midday meal program

The core objective of this Work was being done to modernise their supply chain and optimise the cooking process. operations and projections for the future. The government's noontime meal programme is Serving kids from 16,956 schools in around 12 states and 2 union territories of India with the help of the Akshaya Patra Foundation, i.e., Every day, 1.9 million children. Our research focuses specifically on the noon meal. Program, by enabling all participants in the data capture and visibility.

3 PROPOSED WORK

This article suggests Nutri Chain as a dependable and open solution for midday meals. The solution's foundational technologies were IoT and blockchain. We created a food chain traceability system proof of concept (PoC) implementation and carried out additional tests and evaluations. The limitation of gas fee on Ethereum Main net is the biggest obstacle to implementing on-chain storage and tracking: executing a single smart contract command uses a set amount of gas, known as gas fee, with an average of around 10,000. The maximum amount of gas that can be utilised within a block in Ethereum is limited by a parameter called the block gas limit, which is typically around 10 million. To put it another way, the total gas fee for triggering a smart contract cannot exceed the block gas limit because only one block can contain the transaction in question, which means that the number of instructions cannot be greater than 10 million/10 thousand, or 1000. If it is, the transaction will be rejected.

3.1 Blockchain Network

Ethereum has been selected as the blockchain technology to be used. The prototype was created using Geth in a private instance of the Ethereum network with a standard genesis block. Each time, a new block is created upon the receipt of 100 transactions, and this new block includes all outstanding transactions.

3.2 IoT Sensors

In order to prototype our concept, we employed temperature and GPS sensors. The Raspberry Pi is connected to the sensors, and REST APIs are used to process the data. IoT metrics score is determined using equations and ranges from 0 to 1. 1) and (2), as displayed below

$$\text{IoT Metrics Score} = 1 - \frac{\sum_{i=1}^{n} \Delta i}{n}, \quad (1)$$

$$\Delta i = \frac{\text{VE}_i - \text{VO}_i}{\text{VE}_i} \quad (2)$$

where VEi = Value expected from sensor I and VOi = Value observed from sensor I I = Deviation of observed value of sensor I from the predicted value, I [0, 1], n = total number of sensors utilised

3.3 Role Creations

Via web-based interfaces, Caterer Admin, Transporter Admin, and School Admin are registered and given distinctive Identities with the appropriate access rights. It is made possible by the creation of a database of meal Plans that Caterer Admin, Transporter Admin, and School Admin can use to coordinate the delivery of a batch of meals from a caterer to a school via a transporter. Each batch of food is given a distinct meal ID, a Caterer ID, meal Quantity, a Transporter ID, a School ID, and a reference Meal Code, the preferred Meal Code being assigned in accordance with the choice and the balanced meal plan for beneficiaries. Meal Plans' database is frequently checked and updated. The parties involved must gather information about the assigned meal and make appropriate plans

3.4 Meal Preparations, Transportations, and Feedback

At this step, the meal is produced, delivered to the final location, and served to the recipients in stages while receiving recorded beneficiary feedback. The method is explained in further detail.

3.4.2 Meal Handover to Transporter

The transporter Admin is provided a Web-based interface to view the shipments assigned to him for the next day, along with the assigned caterer, assigned school, and quantity to pick up from the meal Plans database. If the information provided in the interface matches, the actuals at the pickup site transporter submit the successful or unsuccessful pickup report through the web interface accordingly. For all successful pickups, meal Details submitted by caterer admin are hashed and concatenated with IoT metrics score to be submitted to the blockchain as a successful pickup transaction. Unsuccessful pickups are also submitted as transactions on the blockchain for recording purposes. All submitted transactions are appended to the ledger after mining, and TXHash is issued and stored as caterer T x Hash along with meal ID in the caterer Verification Hash off-chain database.

3.4.3 Meal Handover to School Admin

The school administrator is also provided a web-based interface to view the deliveries. assigned for the next day, along with the assigned transporter, quantity to be delivered, etc., from the meal Plans-database. The transporter ships the meals to the assigned school. If The information provided in the interface matches or mismatches with the actual batch. received through transporter, School Admin submits the successful/unsuccessful delivery report accordingly through the Web interface. For all successful deliveries, school Admin submits received meal Details and an updated IoT metrics score are calculated and stored along with the meal details in the school meal details off-chain database. a hash of the same data, after concatenating with mealID and updated IoT metrics score is submitted as a successful delivery transaction on blockchain. Unsuccessful deliveries are also submitted as transactions on the blockchain. for recording purposes. All submitted transactions are appended to the ledger after mining, and Tx Hash is issued and stored as a school TxHash along with mealID in theschool Verification hash off-chain database, and meals are served to beneficiaries.

3.4.4 Feedback Submission

For each batch of meals served, 10 percent of randomly selected beneficiaries submit Their feedback, in the range from 1 (lowest) to 10 (highest), about the meal served through the web-based interface after authentication. The same beneficiary is not allowed. To record feedback more than once in at least 7 and ideally 10 consecutive meal cycles, to ensure randomness. The school administrator is responsible for selecting random beneficiaries. in such a way to ensure that the above criteria are followed and any discrepancy can be detected, as beneficiaries are authenticated before submitting

feedback. The feedback is stored in a buffer storage on an off-chain database, and once adequate feed-back is NutriChain: Secure and Transparent Midday Meals …
received, an aggregated feedback score is calculated and is stored along with mealID on the ledger as a feedback submission transaction. Feedback is also aggregated in a range from 1 to 10 using formula in Eq. (3).

$$\text{Aggregated feedback} = \frac{\sum_{i=1}^{n} R_i}{n} \qquad (3)$$

where Ri = feedback rating by student i, Ri ∈ [1, 10] and n = total number of students eligible for submitting feedback. Feedback is aggregated for easy audit and verification, as the meal size and number of beneficiaries recording feedback can differ for every mealID. Submitted transaction is appended to the ledger after mining and Tx Hash is issued and stored as feedbackTxHash along with mealID in feedbackVerificationHash off-chain database.

3.5 Audit and Verification

For verification and audit requirements, an application is developed with a user-friendly interface wherein anyone can search for mealIDs by filtering from schools and caterers and verify the midday meal details by entering the mealID. The detailed verifying and auditing process can be further defined using the following steps:

• Search for mealID: A search for mealID can be done by filtering through the school ID and/or caterer ID. The application displays all mealIDs associated with the respective school ID and/or caterer ID entered. Individual details of meals served can be searched with the obtained mealID, as discussed below.

• Search by mealID: Anyone can audit, verify, or view all the details of meals served to beneficiaries by entering the respective mealID.

• Verification of caterer Submitted meal Details: meal Details submitted by caterer and caterer TxHash are fetched through mealID from the caterer Meal Details and caterer Verification Hash databases, respectively. From caterer x Hash, the caterer's data hash and IoT metrics score can be fetched from the blockchain ledger. Caterer from the off-chain database are hashed again and compared to the caterer's data hash fetched from blockchain. If matches are found, caterer meal Details are displayed, along with the fetched IoT metrics score verifying the integrity of the off-chain caterers submitted meal Detail.

• Verification of Feedback: The feedback verification hash is fetched from the feedback verification hash database by the submitted meal ID. From feedback TxHash, the feedback rating of the respective mealID is directly fetched from blockchain and displayed.

Table 1: Average gas used and execution time in milliseconds for all processes and actions generating transactions

Action	Average gas used	Average time in milliseconds
Caterer Meal Details Submit To Ledger	53,309	1246
School Meal Details Submit To Ledger	50,247	1508
Feedback Data Submit To Ledger	28,963	652
Verify by Meal ID	Null	1287

4 PERFORMANCE ANALYSIS

The prototype was tested using Geth implementation of Ethereum-based private blockchain. Analysis was done on 25 complete cycles of meal distribution, wherein each cycle constituted meal preparation, meal shipment, meal distribution, and feedback submission. For performance analysis, 5 schools, 2 caterers, and 3 transporters were registered, and a total of 5 meals were shipped to each registered school, with different combinations of caterer and transporter assigned. We sent a total of 75 transactions, for 25 cycles of distribution. The transactions were mined after every 5 min to include them in the new block

4.1 Gas-Cost Analysis

The prototype is developed using a private instance of Ethereum, using Geth. An analysis of the average amount of gas used per operation is presented below. For verification or During auditing, no gas cost was incurred as we performed only read operations on the ledger.

4.2 Execution Time Analysis

Table 1 outlines the timing analysis measurements for tasks in the NutriChain. Execution time is calculated for each of the processes listed in Table 1, excluding manual data entry time, i.e., the only time taken between a function call and a function execution considered.

5 CONCLUSION

This proposed idea is to secure midday meals and food assistance programs by storing IoT metrics, feedback, and hashes of meal details on a distributed and shared ledger to bring transparency and trust to the public distribution system (PDS). NutriChain: Secure and Transparent Midday Meals... Mining distributes the power from a handful to many and ensures the participation of all the stakeholders involved. In this work, we have proposed and implemented NutriChain, which uses the application of blockchain and IoT to store real-time sensor-captured data along with meal details entered by all stakeholders from preparation to the endpoint of delivery on an immutable and distributed ledger. This ensures proper accountability in the system, and any discrepancy can be detected instantly. The feedback mechanism ensures the fair working of the program. The proposed idea can be secured further by integrating biometric sensors and replacing manual login with biometric login. The model can be trained by supervised learning to detect the meal type instead of manually entering meal Code. Manual data entry can be completely digitized to avoid possible human errors while submitting meal details. The current prototype is working on a private blockchain with limited sensors, but the end goal is to shift to a permissioned blockchain with the addition of sufficient sensing devices.

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