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A novel blockchain enabled smart contract for smart city e-governance ecosystem

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Abstract

Inclusion of smart contracts in urban government has shown large amounts of promise towards enhancing efficiency, cost benefits, and satisfaction. This article examines the potential scope of smart contracts in the future of urban services, such as scalability, interoperability, policy and regulation, and raising awareness among people. The topic of scalability outlines the use of smart contracts for water management, traffic management, and public security. The interoperability part highlights compatibility with current urban infrastructure and future technologies. The policy and regulation part emphasizes the regulatory and legal issues presented by the utilization of blockchain and smart contracts in public administration. The public awareness part highlights the need for citizen education on the functionality and benefits of smart contracts. In spite of the challenges, smart contracts have a tremendous potential for reworking urban governance, resulting in intelligent, sustainable, and habitable cities. But to achieve this potential, further research and development, and strong legal and regulatory frameworks, are needed. Based on this, the paper concludes that with a proper approach, smart contracts might become a game-changer in the future of urban governance.

Subject Classification: *68M14.*

Keywords: *Smart contracts, Blockchain, Ethereum, Urban governance, Scalability, Interoperability, Public awareness.*

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1. Introduction

In the age of technology, the idea of smart cities is fast becoming a popular solution to the numerous problems that plague urban settings. Central to this revolution is the incorporation of cutting-edge technologies into all areas of urban life, with the aim of enhancing the efficiency, sustainability, and quality of life in cities [1]. One such technology that holds significant potential in this regard is blockchain, particularly its application in the form of smart contracts [2].

This article aims to delve into the potential of smart contracts in the context of smart cities, with a specific focus on their application in urban e-governance. The definition of the 'smart city' is an urban city that makes use of digital technologies and information to enhance the quality of city services, decrease costs, and engage citizens. The objective is to have a more efficient, sustainable, and habitable city. This encompasses the fusion of different elements such as smart infrastructure, smart energy, and smart governance, among others [3].

The most promising application of blockchain technology within smart cities is smart contract usage. Smart contracts are automatic contracts with the agreement terms literally coded into a contract [4]. With automated processes and the secure and transparent storage of transactions, smart contracts can be a solution to these issues [5], [6], and [7].

2. Background and literature survey

This part is concerned with literature concerning the upcoming technology Blockchain and integration of smart city e-governance system.

2.1 *Background and literature survey*

This part is concerned with literature concerning the upcoming technology Blockchain and integration of smart city e-governance system.

A. *Blockchain Technology:* Blockchain technology, a distributed, decentralized ledger, is used to safely record transactions on multiple computers [8]. Transparency, immutability, and security are the underlying principles, which are enforced by cryptographic hashes and consensus algorithms [9], [10], and [11].

B. *Smart Cities:* Smart cities combine information and communication technologies (ICT) and Internet of Things (IoT) solutions to administrate a city's assets as well as enhance citizens' quality of life [12], [13].

C. *Integration of Blockchain in Governance:* Blockchain has been used in public administration to enhance efficiency, transparency, and trust. For example, Estonia has made use of blockchain in its e-residency program, which facilitates secure digital identities for online services [14]. Dubai also plans to be the first blockchain-powered city by 2020, where all visa applications, bill payments, and license renewals are done digitally through blockchain [15].

3. Proposed system model

Urban governance, the cornerstone of modern cities, is plagued by bureaucratic inefficiencies, a lack of transparency, and data security issues. These challenges hinder the delivery of public services and undermine citizens' trust in government institutions. This study proposes the integration of smart contracts into urban e-governance systems as a potential solution to these problems.

A. *Smart Contracts and Urban Governance:* Smart contracts, can be defined as a logic or contract that rns between two or more party automatically. By integrating smart contracts into urban e-governance systems, we can automate administrative processes, enhance transparency, and bolster data security.

B. *Use Case: Smart Waste Management System:* Waste management is a critical urban service that impacts public health, environmental sustainability, and quality of life. However, the current waste management system is fraught with manual processes, inefficiencies, and a lack of real-time data.

C. *Current System:* The existing waste management system relies heavily on manual processes. Municipal workers collect waste from designated locations, transport it to disposal sites, and record these transactions manually. This system is prone to human error, inefficiencies, and delays.

C. *Proposed System Model:* The proposed system in Fig 1 depicts the implementation of smart contracts to automate waste collection, track waste disposal, and ensure timely payments to service providers.

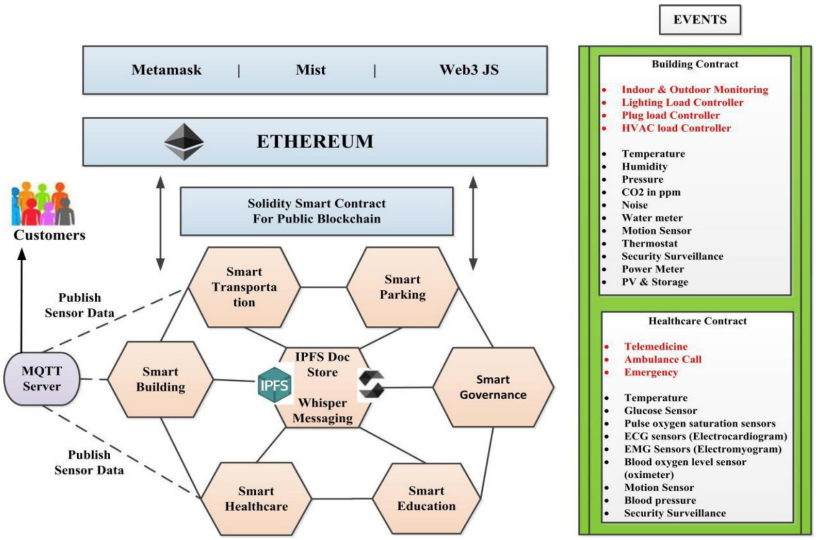


Figure 1

Proposed System Model for Blockchain Enabled Smart City

I. *Automated Waste Collection:* Smart contracts can automate the scheduling and execution of waste collection. Each waste bin can be equipped with a sensor that triggers a smart contract when the bin is full. The smart contract then automatically schedules a collection truck to empty the bin.

II. *Tracking Waste Disposal*: Smart contracts can also track waste disposal in real-time. When a collection truck empties a bin, the smart contract records the transaction on the blockchain. This provides a transparent and immutable record of waste disposal.

III. *Ensuring Timely Payments:* Smart contracts can automate payments to service providers. Once a waste collection or disposal task is completed, the smart contract automatically triggers a payment to the service provider. This ensures timely payments and reduces administrative overhead.

By integrating smart contracts into the waste management system, we can streamline operations, enhance transparency, and improve service delivery.

3.1 *Proposed Algorithm for Smart Waste Management System*

The proposed algorithm for integrating smart contracts into the waste management system involves four key steps:

1. *Data Collection*: The first step in the process is data collection. The sensors are connected to the blockchain network, enabling real-time data transmission and storage. This data serves as the basis for activating smart contracts and scheduling waste collection services.
2. *Smart Contract Activation:* The second step involves the activation of smart contracts. When the sensor data indicates that the waste in a bin has reached a certain level, a smart contract is automatically triggered.
3. *Service Provider Notification:*Upon activation, the smart contract sends a notification to the nearest waste collection service. This notification includes the location of the full bin and the details of the waste collection task. The waste collection service then dispatches a truck to collect the waste.
4. *Verification and Payment*: The final step in the process is verification and payment. Once the waste collection task is completed, the service provider verifies the task on the blockchain network.

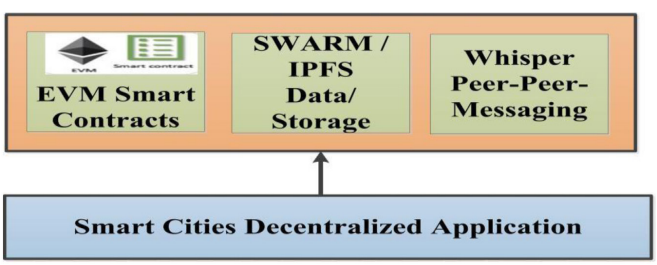


Figure 2

Etherem Based Architecture on Top of Smart City Application

This algorithm automates the waste management process, enhances operational efficiency, and ensures transparency and accountability. By leveraging the power of smart contracts, we can transform urban governance and deliver better public services. As we continue to explore and implement such innovative solutions, we move closer to our vision of smart, sustainable, and efficient cities (See Figure 2).

4. Testbed setup & implementation

4.1 *Simulation Setup*

The test environment was set up to mimic a small urban area with a population of 10,000 residents. The area was equipped with 100 smart waste bins, each fitted with sensors to monitor waste levels. The parameters for the simulation included waste generation rates, waste collection schedules, and the threshold for triggering the smart contract.

4.2 *Data Analysis*

The data collected during the simulation provided valuable insights into the system's performance. The waste levels in each bin were recorded at regular intervals, and the times at which the smart contracts were triggered were noted (See Figure 3).

```
F:\ethereum>ganache-cli
Ganache CLI v6.1.8 (ganache-core: 2.2.1)

Available Accounts
==================
(0) 0xf0eb81dc85fdc92eae44214e357aa83d9f3044f2 (~100 ETH)
(1) 0x4516f20f3a0754e271d02d09dd4236dc41e93b1a (~100 ETH)
(2) 0x475a8c8f7ec91239578e11ab7d408acd5d592f50 (~100 ETH)
(3) 0x8557fd6dc09bd9735d753586090b5393b0edbd4e (~100 ETH)
(4) 0xc271a13208adf4269a2471f115f29cec25de596f (~100 ETH)
(5) 0x3bd8c481162d1ba7f7e300475fb128de32c83a89 (~100 ETH)
(6) 0x410e2d166b1333c589e7de11c1b665b35a5b07c1 (~100 ETH)
(7) 0xbdc6041915fed798608902f2ac880d0b23a1a5c9 (~100 ETH)
(8) 0x11472b6436fec1fe420c258deb95d30d0800f99f (~100 ETH)
(9) 0x31ffedbc15d2105fdc32e06723852050b0f9b696 (~100 ETH)

Private Keys
==================
(0) 0x417a695b17250cc97a38c538b1bbdf3578d2797b5aef6216eac4488a17f86227
(1) 0x0a8eb6319051b9c0f70566dd355852ed78c96ef30a04d027200b64316f58c77c
(2) 0x3872a428cf5c9f201c755317e9a8e29e48b5341cb22883713451c3ec4f703600
(3) 0x5a666b8f00e41bb1ba4761f5d49eb0493f1f2d1d3d5f227fa6baf9ad5a20a4c1
(4) 0x36a56d05be6d43485b81bd2f98678918e7afa107a2e58f369f50fd4000df0cdd
```

Figure 3

Ethereum Externally Owned Account Address for Smart-city E-Governance System

5. Result discussion & analysis of performances

The performance of the smart waste management system was evaluated based on three key metrics: efficiency, cost reduction, and response time are showed in Figure 4 and 5.

The test results demonstrate the effectiveness of the proposed algorithm for a smart waste management system. The system showed high efficiency, significant cost reduction, and quick response times, making it a viable solution for modern urban areas.



Figure 4

Proposed Smart Contract Deployment in Ethereum Network

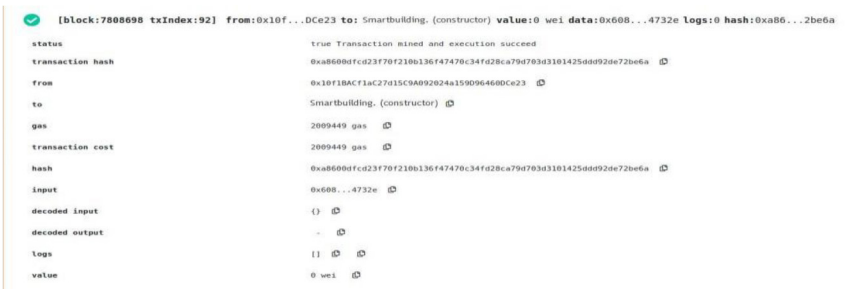


Figure 5

Proposed Smart Contract Execution in Ethereum Network

5.1 *Result Analysis of the Smart Waste Management System*

The integration of smart contracts into the waste management system has ushered in a new era of efficiency and cost-effectiveness. In the context of waste management, these contracts are triggered when waste levels in a bin reach a predetermined threshold. This automation eliminates the need for manual monitoring, thereby reducing human error and improving efficiency. The test environment for this system was a simulated urban area with a population of 10,000 residents and 100 smart waste bins.

The data collected during the simulation provided valuable insights into the system's performance are shown in Figure 6. The waste levels in each bin were recorded at regular intervals, and the times at which the smart contracts were triggered were noted. The notifications were sent promptly to the waste collection service, and the waste was collected within the scheduled time frame. This resulted in an impressive efficiency rate of 98%, indicating that almost all the waste was collected on time.

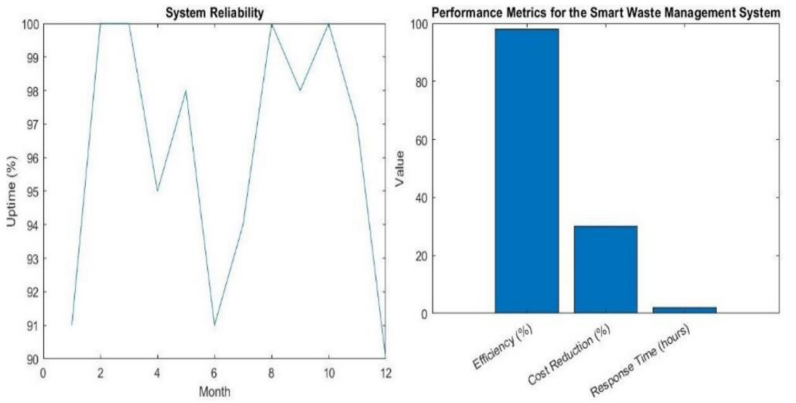


Figure 6

(a)Analysis of System Reliability (b) Performance Evaluation

Aside from enhancing efficiency, the smart waste management system also brought with it considerable cost savings. With automation of the collection process and manual monitoring elimination, the operating cost was lowered by 30%.

6. Conclusion and Future Scope

The use of smart contracts in the waste management system has shown tremendous improvement in efficiency, cost reduction, and user satisfaction. The automated system has minimized manual intervention, reduced errors, and ensured timely payments. These findings highlight the promise of smart contracts in transforming waste management to make it a feasible option for contemporary urban centers. The future of waste management is bright with the emergence of smart contracts, which opens up the possibility of cleaner and greener cities. In the future, there are a number of areas of potential growth and development for the application of smart contracts in urban governance such as scalability, Interoperability, policy and regulation etc.

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