

# Optimizing Smart City Waste Systems with Quantum Computing: Security Risks and Safeguards

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## ABSTRACT

Quantum computing is an emerging frontier in research, offering transformative capabilities across diverse domains such as data mining, cyber security, artificial intelligence, automation, and smart city development. Unlike classical computational approaches, quantum systems provide superior efficiency and advanced problem-solving potential. This paper explores the application of quantum computing in smart city waste management, highlighting how its unique processing power can optimize operations and decision-making. Additionally, it examines the cyber security challenges introduced by quantum technologies, particularly their impact on safeguarding digital infrastructures and communication networks in urban environments.

**Keywords:** Quantum computing, Cryptography, Encryption, Cyber Security, Classical Computers, Smart city, Graph theory, IoT

## 1. INTRODUCTION

Quantum computing is an advanced technology that harnesses the principles of quantum mechanics to perform complex computations. Unlike classical computers that rely on binary bits (0 or 1), quantum systems operate with qubits, which can exist in multiple states simultaneously. This property, known as quantum parallelism, enables faster and more efficient processing for intricate calculations.

In the realm of cyber security, quantum computing presents a dual impact. On one hand, it strengthens digital protection through innovations such as quantum-based encryption. On the other, it poses significant risks to current security frameworks, as existing cryptographic methods may become vulnerable to quantum attacks. On-going research is focused on building practical quantum machines and preparing defences against these emerging threats.

To safeguard modern infrastructures, organizations must adopt proactive strategies—emphasizing vigilance, preparedness, and resilience. Approaches like quantum cryptography and post-quantum cryptography, though still under development, hold promise in mitigating potential risks and ensuring secure communication in the future of smart devices and applications.

## 2. RELATED WORK

Abushgra A.A. in 2023 explained future of quantum computers, their advantages and disadvantages and probably cyber security problem face in the upcoming decade [1]. Gotarane R.V. et.al. in 2016 discussed about the need of quantum computation and advantages over classical computers. They also discussed about the challenges to Quantum computing [2]. Fisher G.A.K et. al in 2014 studied the computing on encrypted data and techniques. They also studied the cryptography techniques [3]. Peelan S.M et. al., in 2023 studied the relationship of quantum computing and IoT to improve accuracy, speed, and security in the field of quantum digital marketing, quantum-secured smart lock etc.[4]. Haart M. et. al. in 2019 described the overview and history of quantum computing. They also discussed its

algorithmic mechanisms, and explores its implications for cryptography, innovation, power structures, and day-to-day life [5]. Sharma N. et. al., in 2021 explained a concise overview of the basic elements of Quantum Computing, its fundamentals, and various key distribution schemes based on Quantum Computing. They also explained the applications of quantum computing in computational engineering [6]. Bova F., Goldfarb B. A. & Melko, R.G in 2021 though quantum scientists are banking on the many profits of quantum computers [7]. Castelvechi D. in 2022 explained that researchers are concerned about protecting the Internet from quantum hackers [8], Cornea A.A. & Obretin, A.M in 2002 explained that the beginning of quantum computers will make cybercrime unassailable [9], Grimes, R.A in 2019 described that some evangelists are warning to a quantum apocalypse [10], Schiffer, B.F in 2022 presented about an existential risk similar to that concerning artificial intelligence [11]. Quantum cryptography is one of the most promising application of communication systems and quantum key distribution. Over the optical fiber, its security is tested and has been experimentally tested over hundreds of kilometers [12]. For the detection of the intrusion/attacker in the network physical layer security is checked. For secure communication in different areas such as metro and regional networks quantum, optical cryptography is used [13].

### **3. Methodology:**

#### **3.1 Smart City Planning**

In smart city planning, Quantum computing produced high speed, optimal and accurate solutions in difficult problems. New development system it shows the optimal processing and quick communication and less time periods by using quantum based algorithm. Algorithm can be upgraded by using quantum computing.

#### **3.2 Classical Computation of Waste management**

We have done the Solid waste collection from the apartments using Graph theory and IoT. We have prepared a model and algorithm for collecting solid waste from the Apartment. We have calculated the shortest route. Selected route save the time and complete the waste collection with less effort. Using this model any one can find optimal locations for installation of solid waste container such that waste collection becomes efficient.

The following procedures are proved using Graph theory method. The steps are given below

- i. Information gathering
- ii. Present analysis for Waste collection in Apartments
- iii. Proper position waste containers and path of waste collection etc.

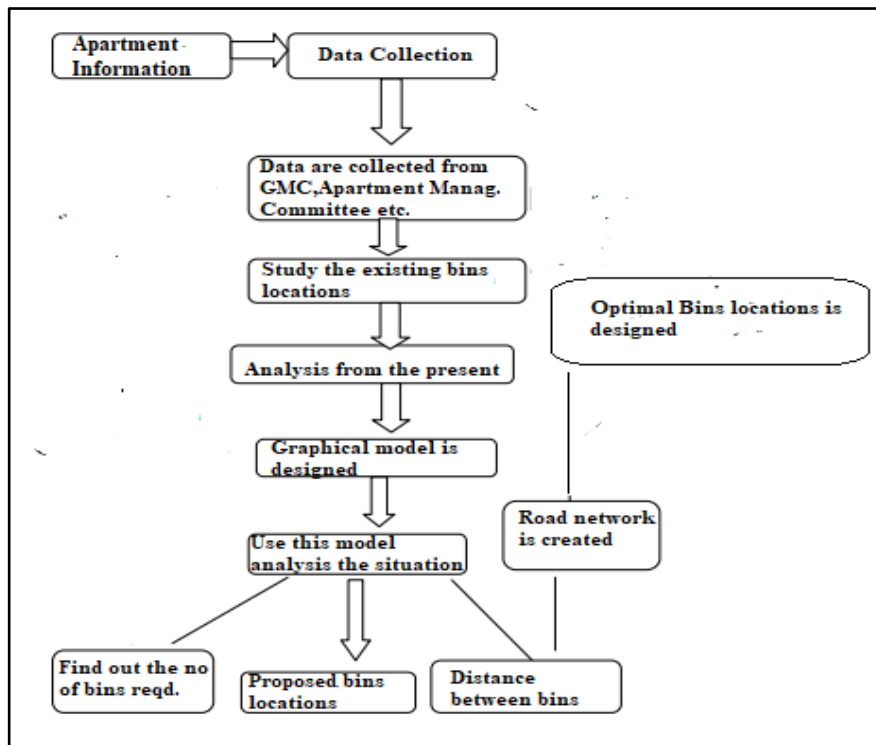


Figure 1: Methodology of proposed SW collection

### 3.2.1 Model:

We have **designed** a Model for Solid waste collection from the apartments.

Using this model resolves the problem of waste collection from the apartment with Shortest Route which saves Time and requires less effort.

- Author has taken each vertex of a graph as one garbage container.
- Considering that each apartment has one or more blocks.
- Author has taken that each block has route from each other.

Graphical model for waste collection way from starting location to final and once the collection container full back to the starting point to make empty the container (shown in the figure 2). Author considered different factors-distance, speed of collection and time

where:

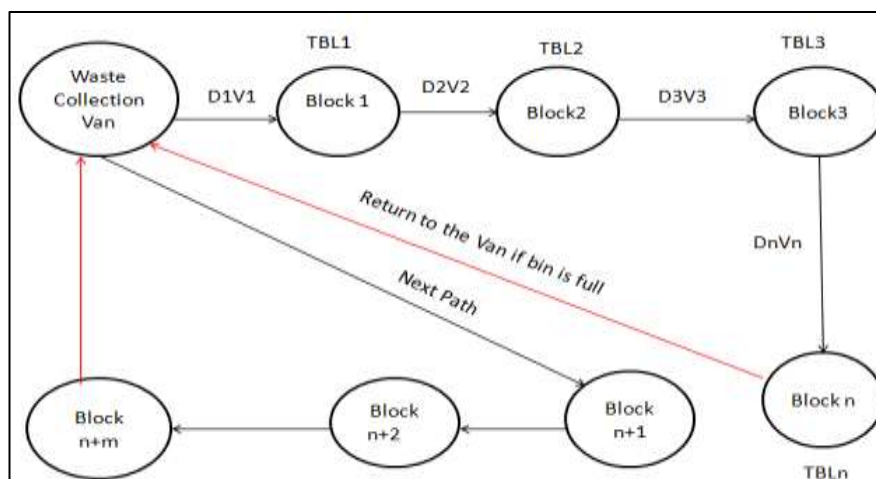


Figure 2: Graphical representation of waste collection and transport paths

Step1: Waste Gatherer go from Garbage Van to 1<sup>st</sup> Apartment

Step2: In unfilled state speed is  $V1 = \pm 20$  km/h and distance= $D1$  and time required= $TBL1$  is computed

Step3: After Block1, move to collect from Block2. New speed  $V2 = 5$  km/h, distance=  $D2$  and time= $TBL2$  is calculated

Step4: Waste collected from all the Blocks up to Blockn waste collection

Condition: Capacity of container is full then Waste Gatherer back to the Van  
 $V3 = 3$  km/hours in the full condition

Step5: Waste Gatherer goes to the next Apartment.

### 3.2.2 Waste collection Frequency Calculation

Author has designed a formula for frequency calculation. Author has considered weekly frequency (6 working days) and capacity of the container author has considered 20kg. Total waste generated per person per day 0.91 kg. (weekly  $6 \times 0.91$  kg). Each floor has one bin. Therefore the frequency of waste collection from the apartment is calculated using following formula

$$CF = (6 * TW) / (20 * NC) \dots\dots\dots (1)$$

Where

CF: Number of times waste are collected from the apartment weekly.

TW: Amount of garbage created. (Kg)

(An individual can generate 0.91 kg/ individual)

NC: total collection bins

$$[CF = (6 * TW) / (20 * NC)]$$

$TW = 0.91 \times 4 = 3.64 = 4$  kg (approx.) per day each house (average 4 members)

$NC = 1$  number of container for each house

$CF = 6 \times 4 / (20 \times 1) = 24 / 20 = 1.2 \approx$  twice a week

(Approximately twice a week)]

### Number of Bins required:

Author has used following equation to calculate the number of bins

$$NC = TW / (CW * SB * AF * NT) \dots\dots\dots (2)$$

Where NC = required garbage containers

TW = amount of garbage daily (Kg)

CW = Concentration of garbage (Kg/m<sup>3</sup>)

SB = Capacity of the garbage containers ( m<sup>3</sup>)

AF = Usual amount of filling waste bin. (Generally 80 %)

NT = Number of time waste are collected

To avoid scenarios of waste overflow IoT enabled waste bins are designed with Sensors. Internets of Thing make the procedure efficient and inform the collector about the level of garbage which prevents the overflow of garbage and also unnecessary movement of collector. Sensors are connected with bins to inform the level of garbage to the collector or van driver's device and according collector come for collection of garbage .Global position system help to detect the location of bins for both collector and users.



Figure3: Classical Sensor

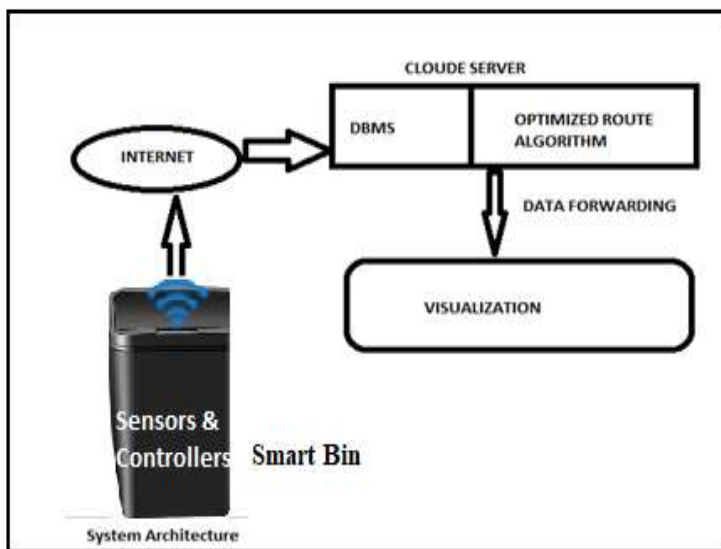


Figure4: Block Diagram of Smart Bin Classical Method

### 3.3 New Proposed Method

#### 3.3.1 Smart Waste Management using Quantum Computing

Quantum computing can also optimize algorithms in Bin Wise, a smart waste management system, to further modernize waste management and tracking features. Quantum computing facilitates decision-making and real-time data analysis in waste management. By processing huge amounts of data, quantum computers can analyze real-time sensor data from waste bins like waste composition and fill levels to optimize the waste collection. Quantum computers analyze and simulate complex systems by considering different factors, including waste generation rate etc.



Figure5: Quantum Sensor

Quantum sensors have the potential to significantly enhance the performance of IoT systems and create new and innovative solutions for various applications. Quantum mechanics is used in Quantum sensors and its give accurate result. Quantum sensors differ from classical sensors because quantum sensors use network entanglement manipulation and qubit superposition. This makes quantum sensors ideal for applications that require high-precision measurements, such as navigation of waste bin locations, Waste level monitoring etc. Quantum sensors' ability to calculate different parameters to give accurate values to monitor processes and waste bin, providing data in real-time that can be used to enhance control and efficiency. This can result in reduced downtime, avoid scenarios of waste overflow.

### 3.4 Enhancing the Cyber Security in IoT Enable Waste Management

By combining quantum sensors with IoT systems, it is possible to create secure communication networks that are highly resistant to cyber threats. This is due to the inherent security of quantum systems, which makes it extremely difficult to eavesdrop on or interfere with quantum communications. This can lead to more secure and reliable communication networks, particularly in financial transactions used in the payment of waste management process, Waste Management infrastructure, and data communications among Server, Waste Bins and Waste Collectors.

The regulating and policy-making organizations are presently concentrating fully on special type of cryptography called Quantum-resistant (QR) to fight against quantum power. Last five records review showed that 90% of the QR method failed [14, 15]. These organizations can take decision of using Quantum Computing Service Provider (QCSP) for using quantum technology. Protecting from hacker QCSP is more suitable than QR

### 3.5 Safeguarding Quantum Computing Service Provider (QCSP) System

Both the cloud server classic and quantum are similar. To access the system user used secure software i.e. 3SoC from Quantum Computing Service Provider (QCSP) System. Only correct and actual request from the client will allow to access 3SoC server. Therefore hacker are failed to access the server. Hence the intranet of 3SoC is much secured.

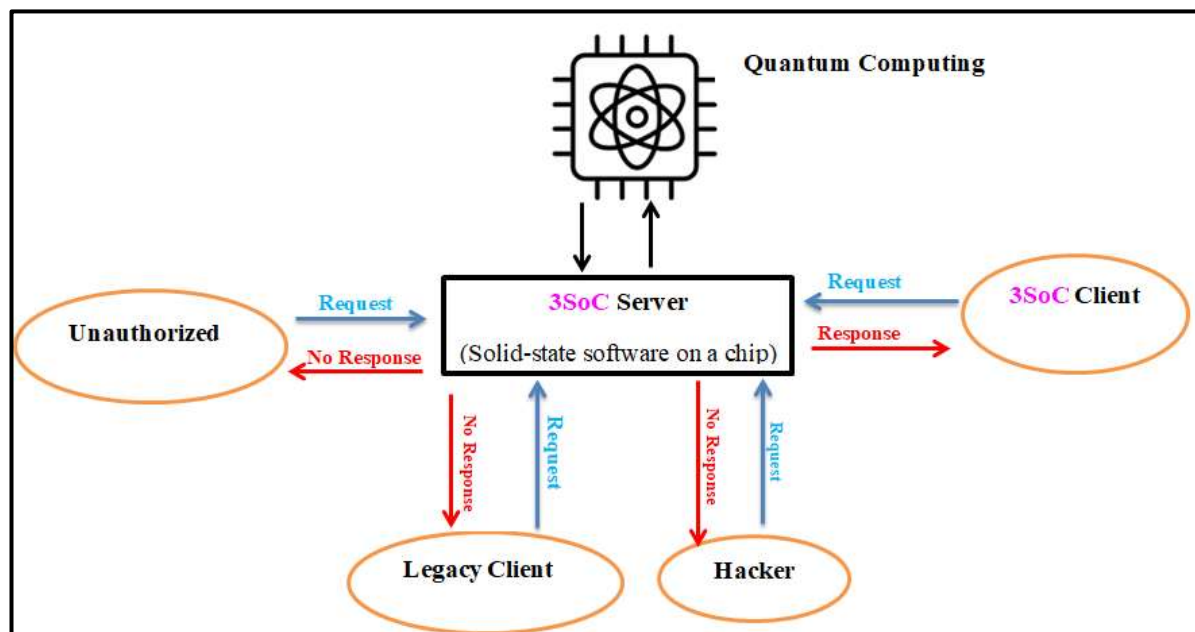


Figure 6: Using 3SoC network and QCSP giving Quantum computing service

## 4. Future Prospects

Different Smart City Problems like Bio toilets, Energy efficient street lighting, and Smart parking Ensuring safety with CCTV monitoring etc. works we may plan to solve optimally in future works. Even if the 3SoC system is under

research it will give an alternative way to protect from the damage of different attacks including cybercrime and quantum computing hackers. It also gives a new way to protect from the failure of QR.

## 5. Conclusion

Researchers are putting much effort into figuring out the many unresolved issues surrounding quantum computing. Both the cyber security and increasing cybercrime can be done by Quantum computing. By using QR technique security system should be prepared to protect their database. Secure method like 3SoC is trying to use in internet to make the network secure.

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