DESIGNING AND DEVELOPING SMART MANAGEMENT SYSTEMS LEVERAGING ON THE IOT OF CONTACTLESS CARDS

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

By 2050, more than 68% of the world's population will have moved to urban regions, predicts a computational and statistical data assessment conducted by the United Nations Department of Economic and Social Affairs (UNDESA) (United Nations, 2018). The pursuit of better living circumstances, contemporary amenities and lifestyles, as well as smart and connected assets (e.g. homes, cars, cities, etc.) are typical justifications for this change (Djabel, Doola, Muntean & Murphy, 2014). Yet, this quick movement in population toward cities may raise the possibility of pollution, flash floods, a lack of infrastructure for housing, or other social effects that have an impact on a citizen's standard of living. The "smart city" idea was presented by scientists and government officials to lessen such hazards. The definition of a smart city includes customer interaction in addition to technical advances and advancements implemented into the conventional city infrastructure. A smart city is an architectural concept that uses artificial intelligence (Kaur & Maheshwari, 2016), machine learning (Jiang, Zhang, Ly & Song, 2016; Sayghe, Hu, Zografopoulos, Liu, Dutta, Jin & Konstantinou, 2020), robotics, and automation techniques (Kaur & Maheshwari, 2016; Lam, Leung & Chu, 2014) to support the economic development of societies and offer better prospects for citizens while maintaining high standards for sustainability and mobility.

The move towards the implementation of smart cities was supported by technological advancements. Using scientific advances in areas like big data and the Internet of Things (IoT) can help cities build safe, cost-effective, and sustainable infrastructures while tackling the majority of the problems associated with urbanization. In addition to the previously mentioned benefits, contactless technology (CT) has recently experienced rapid popularity due to its useful and secure method of carrying out transactions (Lam, Leung & Chu, 2014; Naphade, Banavar, Harrison, Paraszczak & Morris, 2011; Lee, Guo, Choi & Zukerman, 2015). The COVID-19 epidemic has recently increased the demand for contactless technology in smart cities. Since roughly a decade ago, embedded chip-based technologies used for contactless payments, identification verification, attendance monitoring, etc. have been using contactless technology. Early in the year 2000, banking systems used magnetic stripe-based payments. Later, contactless technology payment techniques were created, enabling users to make payments at specialized embedded devices.

Due to the COVID-19 outburst and the recent major digital transition, businesses have been forced to change their business models. For additional information, see that nearly 68% of businesses now use digital technologies to maintain their clientele, deliver services, and do so with the least possible disruption to business operations. Notably, during the pandemic global crisis, technology-driven smart applications, including IoT devices (e.g., smartphones, computers, smartwatches, and sensors), improved citizen security and safety while keeping them socially isolated from the outside world to stop the virus's spread following the rules set forth by the government. The outbreak of COVID-19 has made contactless technology, or touchless technologies, the new norm. Everybody on the planet

has been impacted by the pandemic uncertainty. More cooperation between humans and artificial intelligence (AI) is now required than ever before due to the need for advancements and new technologies. Companies are already using novel ideas leveraging automated technologies like AI, cloud-based systems, and others to grow their businesses and mitigate the effects of the epidemic (Komninos, Philippou & Pitsillides, 2014; Lin, Yu, Zhang, Yang, Zhang & Zhao, 2017).

A ‘contactless card’ processes transactions using Near-Field Communication (NFC) and Radio Frequency Identification (RFID). One can just tap or hover a contactless card over a terminal to finish a transaction. When one visits a store or gas station, one can make a contactless payment, often known as a "no-touch" transaction, without having to swipe, insert your card, and in some situations, physically touch the terminal (Lee, 2021).

Due to their simplicity of use and transactional speed, contactless cards have grown in popularity for usage in a variety of payment and access control applications. The development of smart management systems that improve efficiency, security, and accessibility is now possible thanks to the Internet of Things (IoT) technologies. The Internet of Things (IoT) is a network of linked devices that exchange data and communicate with one another. The creation of smart systems for use in a variety of applications, including public transit, healthcare, security, and retail, is made possible by the integration of contactless cards into the Internet of Things (IoT).

A complete solution for administering and monitoring numerous applications is offered by smart management systems that take advantage of contactless cards' Internet of Things capabilities. For access control, payment, and monitoring, these systems use contactless cards, which boosts productivity and lowers expenses. According to earlier studies, adding

contactless cards to smart management systems can speed up transactions, increase security, and make them more accessible. In public transportation, for instance, the use of contactless cards has decreased wait times and enhanced the user experience. It is necessary to build a complete framework that combines numerous technologies, including sensors, cloud computing, and data analytics, to establish smart management systems that leverage the Internet of Things and contactless cards. The framework should consider several things, including interoperability, security, and privacy. These systems increase efficiency and cut expenses by using contactless cards for access control, payment, and monitoring.

1.2 PROBLEM STATEMENT

Smart management systems can profit from merging IoT and contactless cards, but there are still several issues that need to be resolved. The lack of a thorough framework and methodology for creating and developing smart management systems integrating IoT and contactless cards is one of the main obstacles. Ad hoc systems that are not scalable and lack system compatibility have resulted as a result of this.

The privacy and security of personal information stored on contactless cards is another issue. Identity theft and other fraudulent activities have increased as a result of the widespread use of contactless cards. Lack of adequate security measures can result in unlawful access to personal information on contactless cards, endangering people's privacy and causing financial losses.

In smart management systems that use the IoT of contactless cards, data management is another significant difficulty. To make sure that the massive amount of data generated by the systems is correct, current, and available when needed, it must be managed

appropriately. As various systems employing various protocols and standards need to connect, interoperability problems can appear.

These issues make it challenging to design and create comprehensive smart management systems that are effective, efficient, and secure employing IoT and contactless cards. To overcome these obstacles and enable the creation of scalable, interoperable, and secure smart management systems integrating IoT and contactless cards, a thorough framework and methodology must be created.

1.3 OBJECTIVES OF THE STUDY

The following are the objectives of this study:

- To evaluate the state of smart management systems already utilizing the IoT of contactless cards and to pinpoint the issues that must be solved.
- To examine how contactless cards can enable smart management systems in a variety of industries, including healthcare, transportation, and smart cities.
- To create and implement a comprehensive smart management system that makes use of contactless cards' IoT capabilities for resource management that is both efficient and effective.
- To compare the developed smart management system to more established management systems to assess its performance and efficacy.
- To determine potential future research areas and prospects for the creation and development of smart management systems utilizing contactless cards and the Internet of Things.

1.4 RESEARCH QUESTIONS AND HYPOTHESES

- What are the existing difficulties in creating smart management systems that rely on contactless cards' IoT?
- What role might contactless cards play in enabling smart management systems across a range of industries, including healthcare, transportation, and smart cities?
- What essential attributes and capabilities are needed for a complete smart management system that makes use of contactless cards' Internet of Things?
- When compared to conventional management systems, how effective and efficient is the smart management system that was designed?
- What are the future research directions and opportunities that could be pursued to develop and enhance smart management systems that rely on contactless cards' Internet of Things?

1.5 SIGNIFICANCE OF THE STUDY

Several important consequences come from the study of designing and creating smart management systems that use the IoT of contactless cards:

- By automating procedures and lowering the demand for human labour, the suggested system will increase the effectiveness of operations across a range of industries, including healthcare, transportation, and logistics. Businesses will save money as a result, and customers will receive services more quickly.
- By using contactless card technology to verify users, the system will improve security in a variety of situations, such as access management to buildings or sensitive regions. By doing this, the chance of fraud, illegal access, and other security breaches will be reduced.
- By suggesting a novel use for contactless cards as a method of data collection and real-time information delivery, the study will develop the Internet of Things (IoT) technology.

This will support the creation of more intelligent and networked systems across several industries.

- The study will add fresh perspectives and suggestions for more research to academic work in the fields of IoT and contactless card technologies.

1.6 SCOPE OF THE STUDY

The following will be covered in the study:

- The creation of a contactless card-based Internet of Things system for managing and collecting data automatically.
- The coupling of cloud-based systems for real-time data administration and analysis with the contactless card system.
- The creation of security mechanisms to guarantee the privacy, reliability, and accessibility of the data gathered by the system.
- The process of testing and validating a system in real-world situations to determine its efficacy and usability.

1.7 LIMITATIONS OF THE STUDY

- **Time Restraint**: The researcher combined this investigation with other academic activities at the same time. As a result, less time was spent on the research project.
- **Financial Constraints:** A researcher's ability to find relevant materials, literature, or information and collect data efficiently is often hindered by a lack of funding (internet, questionnaire and interview).

CHAPTER TWO

LITERATURE REVIEW

The COVID-19 pandemic (Roger, 2019) led to several banks raising their contactless payment thresholds (Brennan, 2019; Sheldon, 2020). In the UK, the ceiling was raised in March 2020 from £30 to £45 (UK Finance, 2020). Contrary to cash transactions and Chip and PIN card payments, contactless payments were advocated as being safer (Derin, 2020). Later, it was increased to £100 (UK Finance, 2021; Wikipedia contributors, 2023).

Hodson (2022) proposed that the continuous growth of IoT-enabled contactless payments is attributed to the increased adoption of wearable devices and high-bandwidth wireless communications. A Contactless Payment Market report published by Markets and Markets shows that the market size of contactless payments is anticipated to be 18 billion US dollars by 2025. By 2024, it's expected that contactless transactions would total more than $6 trillion, up 53% from the previous year. With the increased usage of smart devices like phones and wearables, cashless payments are more convenient and faster. Even if a completely cashless society may not realize soon, the payment card sector will undoubtedly be dominated by cashless transactions. He also proposed three ideal payment methods that may arise from the use of contactless cards.

- **One-Click/Instant Credit Transfer:**

Customers can quickly conduct transactions from one place to another via instant credit transfer, which leverages encrypted communication. Simply said, it indicates that two users who are located in various regions of the world can transfer and receive money in a matter of seconds. We can allow several IoT payment options by fusing rapid payments with open APIs.

- **Tokenization of Cards:**

Many multinational payment card systems have successfully implemented non-card payments thanks to tokenization. Near Field Communication (NFC), which has taken the place of Primary Account Number, is one of them (PAN). In addition, a smartphone application creates a different value each time a transaction is made to validate the card. Any IoT device can become a payment-capable device with the use of this tokenization.

- **Electronic/Digital Currency:**

The Internet of Things is supported by distributed ledger technology, which enables IoT devices to conduct transactions directly and independently of third parties. Due to regulatory concerns, the concept is still in its infancy, but once a regulated system is articulated for payments including digital currency, it can open up countless potentials.

The technology has the potential to transform management processes in a variety of industries, according to a survey of the literature on the topic of designing and creating smart management systems that use the IoT of contactless cards. Some of the major discoveries from the literature include the following:

(i) Technology for Contactless Cards:

Because it is quick and convenient, contactless card technology has been widely embraced in many industries. It makes identification, access control, and transactions quick and secure. The system enables a contactless connection between the card and the scanner using near-field communication (NFC) and radio frequency identification (RFID) technologies.

(ii) IoT Applications:

To enable automation, data collecting, and management, IoT applications have been embraced more widely across a range of industries. IoT-based systems have the potential to make management operations more cost-effective and efficient. Real-time data gathering, analysis, and administration may be made possible through the integration of contactless card technology with IoT systems.

(iii) Smart Management Systems:

To enable effective and efficient management operations, smart management systems take advantage of technology. Such systems can offer the ability to monitor, analyze, and make decisions in real time. Automation, data collecting, and management may be made possible by integrating contactless card technology with intelligent management systems.

(iv) Security:

In every system that handles sensitive data, security is a top priority. To ensure the confidentiality, integrity, and availability of the data gathered, contactless card technology must be integrated with IoT systems using strong security mechanisms.

Due to its convenience and quickness, contactless card technology has been widely embraced in a variety of industries. It supports identity, access control, and quick and secure transactions. The contactless connection between the card and the reader is made possible by the technology's use of Near Field Communication (NFC) and Radio Frequency Identification (RFID) technologies.

In Li (2021)'s 'Design of Smart Campus Management System based on Internet of Things,' he used IoT technologies, more especially contactless cards, to build and develop a smart campus security management system. At numerous gates and exits, contactless card readers are deployed as part of the system. These readers are connected to the campus network using IoT technology.

A sophisticated system that can identify anomalous behaviours like tailgating and unauthorized access processes the data obtained from contactless cards. The system also comes with a smartphone app for controlling and monitoring campus security in real time.

2.1 BASIC CONCEPTS

To understand the project title: **'Designing and Developing Smart Management Systems Leveraging on the IoT of Contactless Cards'** fully well, one would need to examine the basic concepts that make up the project's title.

2.1.1 SMART MANAGEMENT SYSTEMS

Wikipedia contributors (2022) and Akhras (2000) postulated that 'smart management systems' combined sensing, actuation, and control capabilities to describe and analyze a condition, make decisions that are predictive or adaptive, and take smart actions as a result. In most cases, the "smartness" of the system can be attributed to an autonomous operation based on closed-loop control, energy efficiency, and networking capabilities. Microsystems were the ancestors of many intelligent systems. They integrate microsystems technologies and elements-miniaturized electric, mechanical, optical, and fluidic devices—with other fields, such as biology, chemistry, nanoscience, or cognitive sciences.

They further elaborated on the three generations of smart management systems:

- **First-Generation Smart Management Systems:**

Object identification technology, driver status monitoring, and multipurpose surgical instruments are examples of first-generation smart management systems.

- **Second-Generation Smart Management Systems:**

Second-generation smart management systems include sophisticated energy management systems, environmental sensor networks, and active miniaturized artificial organs like cochlear implants or artificial pancreas.

- **Third-Generation Smart Management Systems:**

Third-generation smart management systems combine cognitive and technical "intelligence" to serve as a bridge between the virtual and physical worlds.

2.1.2 INTERNET OF THINGS (IOT)

Gillis (2022) defined 'The Internet of Things,' or 'IoT,' as *"a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction."* Of course, he went further to breakdown the terminology, 'thing' in the 'Internet of Things' and thought of it being *"a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile that has built-in sensors to alert the driver when tire pressure is low or any other natural or man-made object that can be assigned an Internet Protocol (IP) address and is able to transfer data over a network."*

The Internet of Things (IoT) ecosystem is made up of web-enabled smart devices that use embedded systems, such as processors, sensors, and communication gear, to gather, send, and act on the data they get from their surroundings. By connecting to an IoT gateway or other edge device, which either sends data to the cloud for analysis or analyzes it locally, IoT devices exchange the sensor data they collect. These gadgets converse with other similar devices on occasion, acting on the data they exchange. Although individuals can engage with the devices to set them up, give them instructions, or retrieve the data, the gadgets accomplish the majority of the job without their

help. These web-enabled devices' connectivity, networking, and communication protocols are heavily influenced by the particular IoT applications that have been implemented. IoT may also make use of machine learning and artificial intelligence (AI) to facilitate easier and more dynamic data collection methods.

Below is an illustration of the operation of an IoT system, from data collection to action:

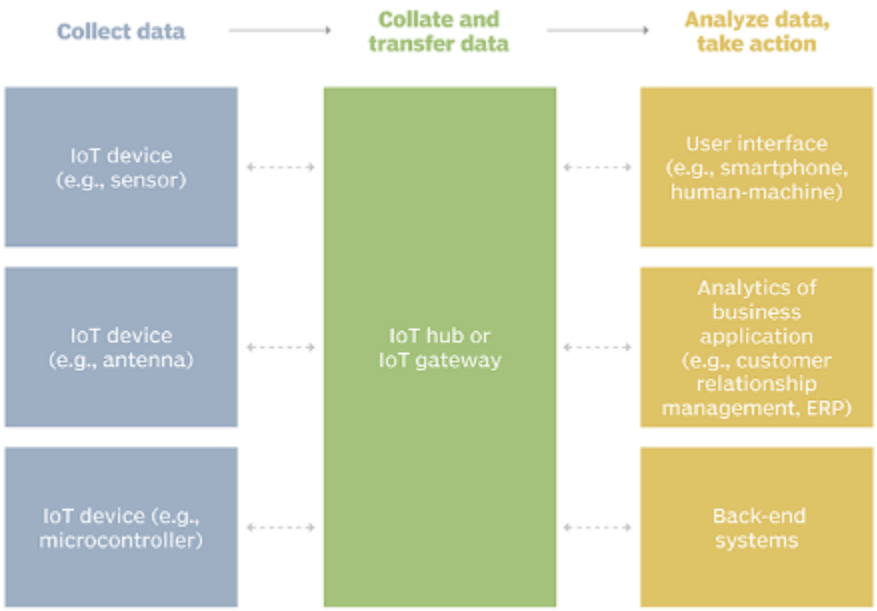

Fig. 1- (Gillis, 2022)

Source: https://www.techtarget.com/iotagenda/definition/Internet-of-Things-IoT

Brous, Janssen and Herder (2020) investigated and gave a summary of IoT's possible business benefits:

- Strategic insights into threats and opportunities in real-time and with more accuracy thanks to better forecasting and trend analysis.

- More effective management and maintenance planning.
- Cost reduction is brought on by the knowledge of operational inefficiencies.
- Services are delivered more quickly and effectively thanks to the availability of real-time information, and their reputation is improved according to greater degrees of client empowerment.
- The capacity to remotely monitor activities will lead to more effective controls.
- Insights into previously unknown product and service areas have created new revenue streams.
- Expanded uses due to increased service flexibility from linking multiple sources.

Although IoT can be so beneficial to all walks and spheres of life, but according to MicroAI (2022), below are the top six dangers now facing manufacturers, operators, and users of IoT devices:

- Insufficient regular updates and outdated software
- Using poor passwords
- Lack of knowledge
- Botnet assaults
- Unreliable deployment sites
- Data protection not enough/No encryption

2.1.3 CONTACTLESS CARDS

According to Alliance (2006), to communicate with a reader via a contactless Radio Frequency (RF) interface, contactless cards requires a secure microcontroller or similar intelligence, internal memory, and a tiny antenna built into the device. The applications of this technology are numerous. Contactless cards are being used to increase speed, convenience, and security in a variety of

applications, such as providing quick, secure transactions such as transit fare payment cards and securing personal information in government and business identification cards, electronic passports, and visas.

On the contactless cards in which they are embedded, contactless smart chips may securely manage, store, and grant access to data. They can carry out internal tasks (such as encryption) and communicate deftly with the contactless reader. One use for contactless cards is ‘contactless payments.’ Payments made using a consumer payment device that is not physically connected to a point-of-sale terminal are known as contactless payments. The use of payment methods now supported by American Express® (ExpressPay), MasterCard (MasterCard®, PayPass™), and Visa Contactless is referred to as ‘contactless payments’ in the United States. The ISO/IEC 14443 international standard for contactless cards serves as the foundation for all three products. Contactless cards can be read within 2 to 4 inches of a POS terminal. The security of the customer's data and the payment transaction is further protected by additional features included in contactless cards.

Fig. 2- (Lee, 2021)

Source: https://www.blackhawkbank.com/what-are-contactless-cards-and-how-do-they-work-

The contactless payments business has generated a lot of attention in recent months. In the United States, several card issuers have announced contactless card and device rollouts and subsequent issuance. With over 17 million cards issued since 2005, issuers have been significantly growing their market share (Alliance, 2006). The following are some mentions of contactless payment deployments:

- Credit and debit cards with a contactless ‘blink’ feature have been introduced by JPMorgan Chase in several significant cities, including Atlanta, Denver, Orlando, Philadelphia, and New York City. The contactless payment methods used by Visa and MasterCard are the foundation of the Chase Blink card. There have been more than 7 million "blink" Chase credit and debit cards issued.
- More than 2 million Blue Cards with ExpressPay contactless payment technology have been issued by American Express countrywide since they began issuing them in 2005.
- The affinity credit cards that Bank of America (via the acquisition of MBNA) issued are directed at particular sports venues in various locales. The card uses contactless MasterCard PayPass technology.
- Citibank is planning to issue 2.5 million contactless devices, including debit cards and key fobs, using MasterCard PayPass technology.
- KeyBank has replaced its entire debt portfolio with more than 2.5 million debit cards equipped with MasterCard PayPass.
- To new and existing clients, HSBC Bank is issuing more than 1 million new debit cards with MasterCard PayPass contactless payment technology.
- Debit cards featuring MasterCard PayPass contactless payment technology are being issued by Citizens Bank as replacements and new cards.

- Over 400,000 credit cards with Visa Contactless capabilities will be available on the market by the end of 2006, according to Wells Fargo Bank.
- Since last fall, Meijer Stores has integrated MasterCard PayPass technology into about 1 million Meijer cards.

2.2 APPLICATIONS OF THE IOT OF CONTACTLESS CARDS

Several industries have been transformed by the Internet of Things (IoT), and contactless smart cards are no exception. The use of contactless smart cards has gained appeal in many organizations, including educational institutions, hospitals, and financial institutions. These cards can be used for several things, including identity, payment, and access control. However, managing these cards can be difficult, particularly in companies with a big user base. The management issues with contactless smart cards have been addressed using smart management solutions. This literature study addresses the body of knowledge on the design and creation of smart management systems that make use of contactless cards and the Internet of Things.

Due to the simplicity and speed of transactions offered by contactless cards, their use has increased recently. The Internet of Things (IoT) and contactless card integration have the potential to produce smart management solutions that can boost productivity and security across a range of sectors. We will examine the present status of research on the application of IoT and contactless cards for smart management systems in this literature study.

The network of networked objects known as the ‘Internet of Things (IoT)’ is capable of data exchange and communication without the need for human involvement. On the other hand, ‘contactless cards’ are smart cards that communicate with card readers without making physical touch using Radio Frequency Identification (RFID) technology. By enabling real-time data

collecting and analysis, boosting security, and lowering costs, the IoT and contactless card combo has the potential to completely transform smart management systems.

IoT and contactless card usage have already shown encouraging outcomes in several businesses. Some of them are:

2.2.1 HEALTH-CARE

IoT-enabled contactless cards can be used in the healthcare industry to manage medical equipment, maintain prescription schedules, and monitor patient vitals. The healthcare sector can deploy IoT-based contactless cards for patient identification, monitoring, and medication management. These cards make it simpler for healthcare professionals to provide individualized care since they may contain patient information like medical history, allergies, and medication information. In healthcare contexts, contactless cards can be utilized to speed up patient check-in and check-out processes through the Internet of Things. Patients can sign in for appointments, get notifications for follow-up appointments, and make payments using their contactless cards. As a result, productivity increases, waiting times are decreased, and patients are more satisfied.

2.2.2 HOSPITALITY

In the hospitality sector, including hotels and resorts, contactless cards have also been used by the Internet of Things. Guests may simply access their rooms and other hotel amenities by using contactless cards as room keys. This increases both operational effectiveness for hotel workers and the overall guest experience.

2.2.3 TRANSPORTATION

Passengers could easily pay for their tickets using the system using contactless cards, such as NFC-enabled cards or mobile wallets, without having to physically engage with a ticketing machine or a human ticket agent. To detect passenger movements and keep an eye on the availability of seats and vehicles, the system might comprise sensors and Internet of Things (IoT) gadgets mounted on public vehicles as well as at bus stops and railway stations. Routes may be improved, wait times might be decreased, and overall efficiency could be increased using this data. A mobile app that enables users to quickly buy and reload contactless cards, watch real-time transit information, and get alerts about delays or interruptions could potentially be connected with the system. Transport systems like the metro, buses, and trains can also employ IoT-based contactless cards. These cards have RFID (Radio Frequency Identification) technology, which enables users to quickly access transportation services by scanning them at turnstiles or gates. The transportation sector has changed because of IoT contactless cards. For instance, commuters can use contactless payment cards to pay for transportation costs in locations like London and Hong Kong. As a result, there is no longer a need for paper tickets, and the lines at ticket machines are less crowded. Additionally, transit operators may use the information gathered from these contactless cards to better understand traveller behaviour, plan more efficient routes, and improve all aspects of the travel experience.

2.2.4 SECURITY

A smart home security system that employs contactless card technology to provide access control and monitoring capabilities could be one potential project topic for IoT and contactless cards. The technology might enable residents to access their houses without using physical keys by using contactless cards, such as NFC-enabled cards or mobile wallets. A smartphone app might be used to remotely operate and monitor IoT devices like smart locks and sensors that are part of the

system. Homeowners may unlock doors, deactivate alarm systems, and manage other linked gadgets in their houses using contactless cards. A security monitoring function that employs IoT gadgets like cameras and motion sensors to find and notify homeowners of any suspicious activity might also be part of the system. For instance, the system might send out an alarm and notify the homeowner via the mobile app if a door is opened without the usage of an authorized contactless card. IoT-based contactless cards can be utilized in employee identification or access control systems for buildings. Security systems can be made more effective and secure by using these cards, which can be configured to allow or restrict access to particular places or resources. Access control to buildings, events, and other secured venues can be managed with contactless cards. These cards can be configured to limit access to particular regions based on a person's level of authorization by utilizing the IoT. This enhances the tracking of people inside a place and promotes security.

2.2.5 CONTACTLESS PAYMENT

Contactless payments are the most typical use for IoT-based contactless cards. These cards enable customers to make payments without coming into direct touch with the payment terminal by utilizing near-field communication (NFC) technology. Retailers are also embracing contactless payment methods that leverage IoT-enabled contactless cards, such as Apple Pay and Google Wallet. Consumers with cell phones that are connected to their contactless cards can simply make transactions. This not only streamlines the payment process but also gives clients a safer way to pay.

2.2.6 INVENTORY MANAGEMENT

Inventory management systems can also make use of IoT-based contactless cards to track inventory levels, product movements, and supply chain activities in real time. To make sure that inventory levels are always optimum, these cards can be used to monitor products from the producer to the warehouse and finally to the retailer.

CHAPTER THREE

METHODOLOGY

Using Near-Field Communication (NFC) technology, a contactless card, such as a credit card or debit card, enables transactions without making direct touch with the payment terminal. Contactless cards can wirelessly communicate with a payment terminal that has an NFC reader thanks to an integrated chip that houses the account information of the cardholder.

With a contactless card, the transaction is often completed in a matter of centimetres when the cardholder simply holds the card close to the payment terminal. Compared to conventional payment methods that call for inserting, swiping, or inputting a PIN code, this procedure is substantially quicker.

The use of contactless cards is spreading throughout the world as a result of their increased convenience and speed for both consumers and businesses. They are frequently used for low-value transactions, such as paying for coffee or bus tickets, but depending on the card issuer's regulations, they can also be used for higher-value transactions.

All the processes and procedures that simplify the customer shopping experience are included in the Internet of Things of contactless cards. For instance, a fantastic illustration of this technology is Amazon's "simply walk out" service. It streamlines the purchasing process by enabling clients to enter, take what they need, and then quickly exit. The items that customers put in their virtual shopping carts are tracked by the walkout technology. When customers finish shopping, their credit card is automatically paid for the things they bought and an email with their order receipt is sent to them (Babin & Zikmund, 2015).

Near Field Communication (NFC) makes it possible for two compatible devices to communicate using radio waves at predetermined frequencies. Devices with NFC capabilities can exchange data with minimal battery consumption (Tavakoli, Faghihinia & Kalhor, 2017). A lot of smartphones and smartwatches support NFC and make use of this technology to carry out numerous daily chores. NFC's 13.56-Megahertz transmission frequency allows for fast data transformation.

Near Field Communication (NFC) is present in devices to enable contactless communication, hence they are NFC-enabled devices. The diagram below is an overview as well as their applications.

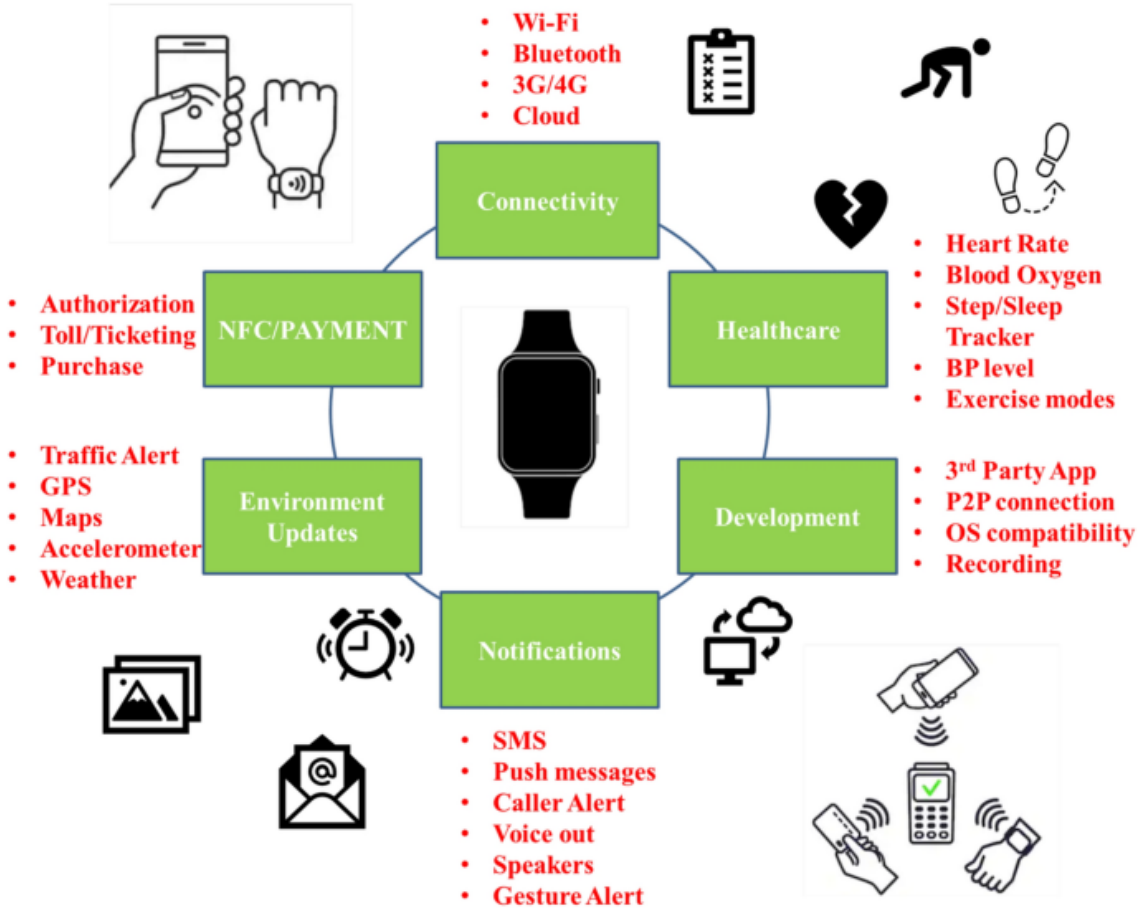

Fig. 3- (Manimuthu, Dharshini, Zografopoulos, Priyan, & Konstantinou, 2021)

Source: Contactless technologies for smart cities: big data, IoT, and cloud infrastructures.

According to Garnica, Chinga and Lin (2013); and Manimuthu, Dharshini, Zografopoulos, Priyan, and Konstantinou (2021), three operating modes are common for NFC-enabled devices:

(i) Reader/Writer Mode:

When in reader/writer mode, an NFC device acts as a reader for NFC tags, including RFID tags and contactless smart cards. It quickly detects a tag and has the option of reading or writing data to it.

(ii) Peer-to-Peer Mode:

Two NFC-enabled devices can exchange data in peer-to-peer mode. The model that Android Beam technology use is this.

(iii) Card-Imitating Mode:

An NFC gadget functions exactly like a contactless smart card while in card-imitating mode. In this mode, the smartphone uses the NFC to create RF rather than doing so on its own. However, it is necessary to adhere to the ISO/IEC 14443 standard standards for conventional contactless cards. Instead of using credit/debit cards, travel cards, access cards, or other forms of cards in this method, we can use our cell phones. As a result, NFC-enabled gadgets enable users to complete operations like making payments or purchasing tickets.

3.1 PROCESSES IN CONTACTLESS PAYMENT SERVICES USING NFC-ENABLED CONTACTLESS CARDS

Access to server resources and a database is made possible by cloud computing for contactless payments. It functions as a platform for the storage of user credentials and transactional information. The actions taken during contactless payments and purchases are described by the

operational sequence below: (Jiang, Zhang, Ly & Song, 2016; Manimuthu, Dharshini, Zografopoulos, Priyan & Konstantinou, 2021; Jabbar & Aluvalu, 2017; Sharifi & Khavarian-Garmsir, 2020).

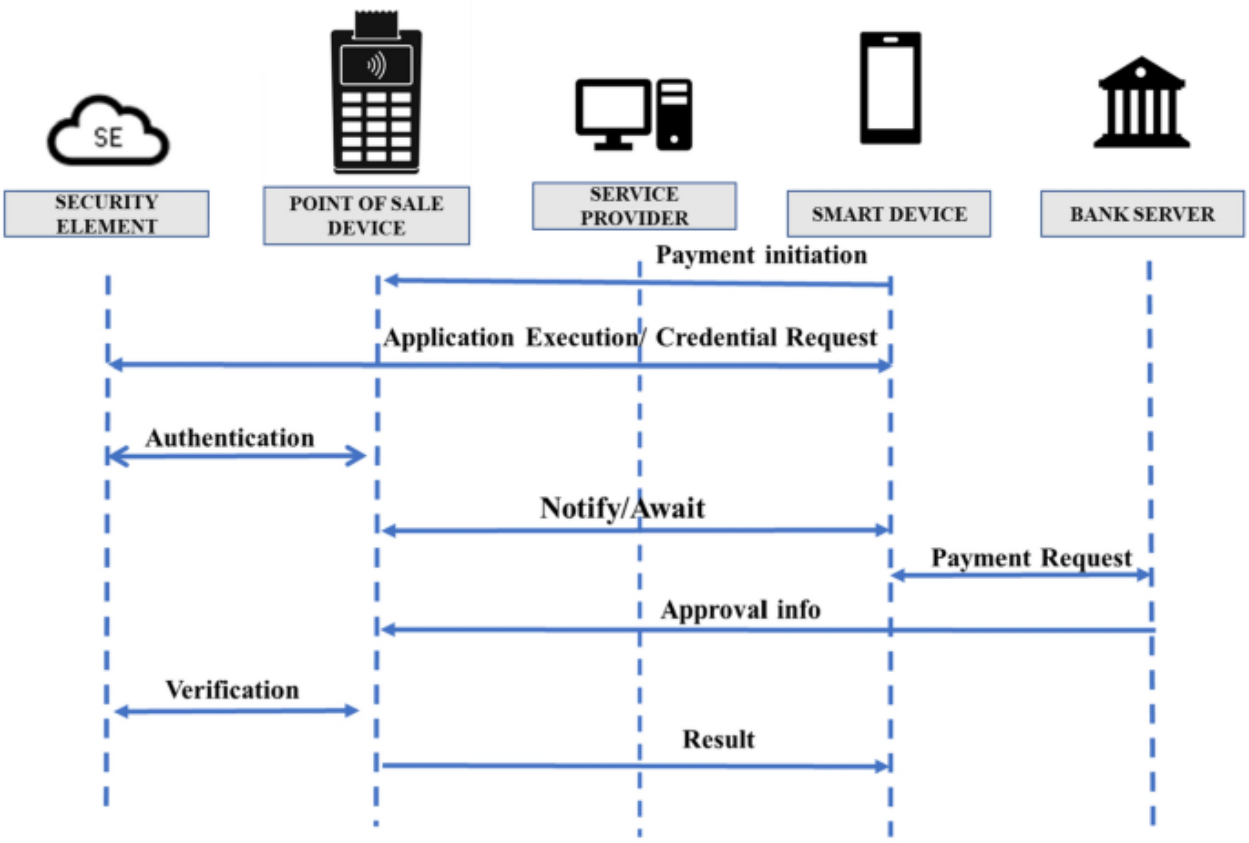

Fig. 4- (Manimuthu, Dharshini, Zografopoulos, Priyan, & Konstantinou, 2021)

Source: Contactless technologies for smart cities: big data, IoT, and cloud infrastructures.

(I) The contactless card is brought nearby the POS device to start the transaction.

(II) A payment link is sent from the cloud to the consumer device by the POS device.

(III) The POS contacts the client's banking network to validate the credit limit and obtain payment authorization.

(IV) The POS is permitted by the cloud network.

(V) Payment verification and data validation

(VI) If the client transaction is approved, the merchant POS synchronizes with the client's record.

(VII) After being accepted, the mobile application is sent to the banking network to complete the payment.

(VIII) The bank server validates the user's credentials and completes the transaction.

(IX) The bank server sends the POS terminal the proof of the transaction.

(X) The POS system completes the transaction and issues the payment status receipt.

The security element (SE) and NFC controller are the two primary parts of a contactless card. For the desired transactions, authentication is provided by the SE, a processing unit. The full duplex multi-cast handshake between a contactless card and a POS terminal is made possible by NFC controllers acting as a medium (Garnica, Chinga & Lin, 2013). Before beginning any application procedure, NFC and SE must be synced. So, using SE (cloud resources), which synchronizes with the banking network and establishes the communication channel for payment processing, customer information is verified. These are the transaction details: communication between contactless cards and POS devices, credential verification via SE and the bank network, and payment initiation between contactless cards and POS are the first three. To successfully verify, authorize, and control each step involved in consumer payment transactions, both NFC and SE are used.

3.2 HARDWARE AND SOFTWARE USED

Building smart management systems leveraging the IoT of contactless cards comprises a whole lot. For the sake of comprehension and easy projection, it was classified into two sections:

3.2.1 SOFTWARE

- **Operating System (OS):**

The OS to use is determined by the physical platform and the particular system needs. Linux, Windows, and Android are a few of the commonly used options.

- **Database Management System (DBMS):**

Data connected to the system is stored and managed using a database management system (DBMS). The system's specific requirements will determine which DBMS to use. A few well-known DBMS platforms are MySQL, Oracle, and MongoDB.

- **Middleware:**

Software that connects various software components and allows them to communicate with one another is known as middleware. Transaction management, security, and real-time component communication can all be accomplished with middleware.

- **Programming Language:**

The choice of a programming language is based on the particular system's needs. Java, C++, Python, and Ruby are some of the major programming languages utilized in creating intelligent systems.

- **Communication Protocols:**

To allow devices to communicate with one another, communication protocols are utilized. TCP/IP, HTTP, and MQTT are some popular protocols used in the development of intelligent systems.

- **Cloud Computing:**

The cloud can be utilized to give the smart system access to storage, processing power, and other resources. Analytics may be performed, data can be stored, and remote access to the system is all possible with cloud computing.

- **Data Analytics:**

From the data that the system has gathered, data analytics can be used to conclude. To find patterns, trends, and anomalies in the data, data analytics can be employed.

- **Mobile Applications:**

Mobile apps can be used to make payments in addition to contactless cards. Users of the app will be able to use their mobile devices to make payments thanks to the integration with the contactless card system.

- **Security Features:**

There may be a need for additional hardware and software components to secure the system's security. Data saved on the contactless card or transferred between the reader and the database, for instance, may be secured using encryption techniques. To stop unwanted access to the system, firewalls and intrusion detection systems may also be applied.

3.2.2 HARDWARE

- Readers for contactless cards that are RFID or NFC compatible. The data on the contactless card is read by this piece of hardware. To verify the card and get the required data, it normally talks with the software component.

- The hardware and software elements of a POS system allow businesses to receive customer payments. A terminal, screen, and software that interfaces with the payment gateway are often included.
- Access points or gateways that link the readers to the backend system
- Databases and the backend system are hosted by servers or cloud infrastructure.
- Mobile devices like smartphones or tablets are used in enabling mobile apps to communicate with the smart system.
- Environmental data-gathering devices, such as temperature or occupancy sensors in a building.
- Cameras that record photos or video for security reasons.

3.3 FLOWCHART OF A SMART SYSTEM LEVERAGING ON THE IOT OF CONTACTLESS CARDS

Below is a typical flowchart that embeds the payment procedures used in a typical smart payment system that leverages cards, in this case, contactless cards.

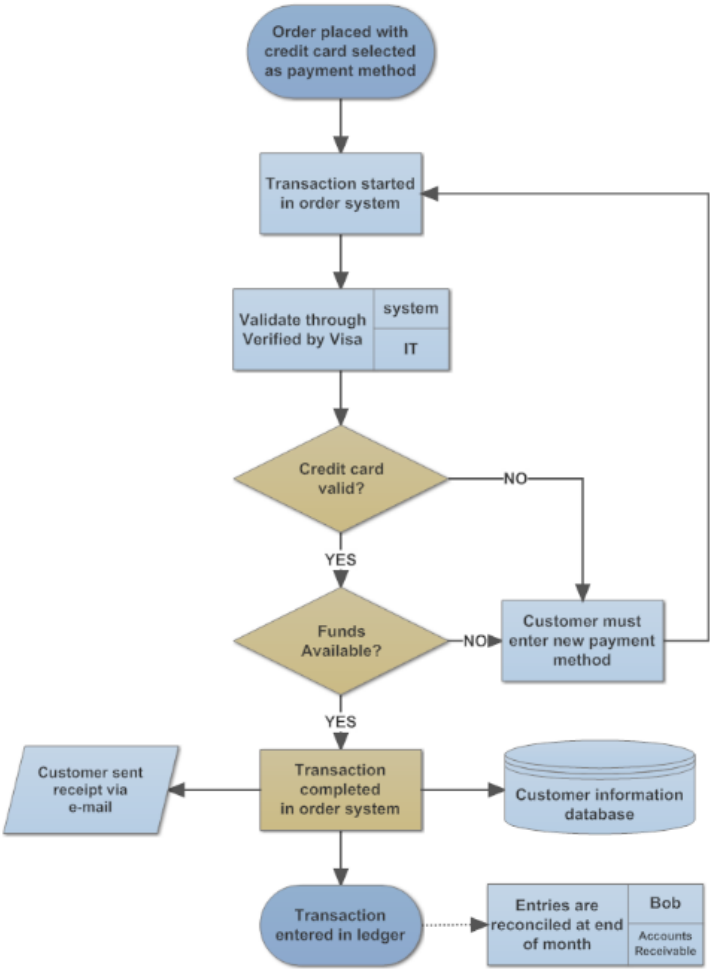

Fig. 5- (Dreh, n.d.)

Source: https://www.pinterest.com/pin/404549979007132011/

3.4 PYTHON CODE IMPLEMENTATION

A smart management system that leverages the IoT of contactless cards needs to be implemented using a complicated and secure method that incorporates several different elements, including databases, encryption, APIs, and more. The code for such a system would also differ based on the particular specifications and

technologies employed, in this case, the Internet of Things (IoT). However, below is a straightforward Python language payment processing program using the Stripe API.

```
import stripe

stripe.api_key = "YOUR_SECRET_KEY"

# Create a charge

charge = stripe.Charge.create(

    amount=1000,

    currency="usd",

    source="tok_visa", # This is an example token for a Visa card

    description="Example charge"

)

# Print the charge ID

print (charge.id)
```

The program above utilizes a test token and the Stripe API to generate a $10.00 charge to a Visa card. This is merely a straightforward illustration that would need to be modified to meet unique requirements and security demands.

CHAPTER FOUR

RESULTS AND DISCUSSION

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

Science and technology are now the primary forces behind the implementation of the smart city idea and fast urbanization. The COVID-19 pandemic's unpredictability opened the door for CT to spread internationally. In this work, we give a thorough analysis of BIC-based CT applications in smart cities. We next go over case studies from five smart cities in India that use CT and BIC for a variety of purposes. We provide a thorough study of the many smart city sectors affected by COVID-19's requirement for the usage of BIC. We aggregate the survey results and offer analysis on CT applications in different smart cities and how COVID-19 affects various industries. In our upcoming study, we intend to look at the difficulties of adopting CT in densely populated nations like India and show how successful BIC is at addressing open concerns and problems with smart city infrastructures through data collecting, processing, and analysis.

REFERENCES

Akhras, G. (2000). Smart materials and smart systems for the future. *Canadian Military Journal*, *1*(3), 25-31.

Alliance, S. C. (2006). The what, who and why of contactless payments. *Smart Card Alliance Paper, November*.

Babin, B. J., & Zikmund, W. G. (2015). *Exploring marketing research*. Cengage Learning.

Brennan, J. (2020, March 19). Increase in contactless payments limit may not be ready until April. *In The Irish Times.* Retrieved April 7, 2023, from https://www.irishtimes.com/business/financial-services/increase-in-contactless-payments-limit-may-not-be-ready-until-april-1.4207022

Brous, P., Janssen, M., & Herder, P. (2020). The dual effects of the Internet of Things (IoT): A systematic review of the benefits and risks of IoT adoption by organizations. *International Journal of Information Management*, *51*, 101952.

Catarinucci, L., De Donno, D., Mainetti, L., Palano, L., Patrono, L., Stefanizzi, M. L., & Tarricone, L. (2015). An IoT-aware architecture for smart healthcare systems. *IEEE Internet of things journal*, *2*(6), 515-526.

Clark, D. (2020, March 24). Contactless limit is set to rise to 45 pounds to help COVID-19. *In Money Facts.* Retrieved April 7, 2023, from https://moneyfactscompare.co.uk/news/money/contactless-limit-is-set-to-rise-to-45-pounds-to-help-fight-covid-19/#:~:text=While%20using%20contactless%20payment%20is,of%20payment%20are%20still%20available

Djahel, S., Doolan, R., Muntean, G. M., & Murphy, J. (2014). A communications-oriented perspective on traffic management systems for smart cities: Challenges and innovative approaches. *IEEE Communications Surveys & Tutorials*, *17*(1), 125-151.

Dreh, M. (n.d.). Credit Card Order Process Flowchart. *In Pinterest.* Retrieved April 17, 2023, from https://www.pinterest.com/pin/404549979007132011/

Garnica, J., Chinga, R. A., & Lin, J. (2013). Wireless power transmission: From far field to near field. *Proceedings of the IEEE*, *101*(6), 1321-1331.

Gillis, A. S., (2022, March). What is the Internet of Things (IoT)? *TechTarget.* Retrieved April 7, 2023, from https://www.techtarget.com/iotagenda/definition/Internet-of-Things-IoT

Hodson, S. (2022, September 2). What is the Current State of Contactless Payments and the IoT? *AxiomQ.* Retrieved March 30, 2023, from https://axiomq.com/blog/what-is-the-current-state-of-contactless-payments-and-the-iot/

Jabbar, M. A., & Aluvalu, R. (2017, August). Smart Cities in India: Are we smart enough? In *2017 International Conference on Smart Technologies for Smart Nation (SmartTechCon)* (pp. 1023-1026). IEEE.

Jiang, D., Zhang, P., Lv, Z., & Song, H. (2016). Energy-efficient multi-constraint routing algorithm with load balancing for smart city applications. *IEEE Internet of Things Journal*, *3*(6), 1437-1447.

Kagan, J. (2020, October 10). Contactless Payment: History, Advantages and Types. Retrieved March 30, 2023, from https://www.investopedia.com/terms/c/contactless-

payment.asp#:~:text=Contactless%20payment%20allows%20consumers%20to,or%20sign%20for%20a%20transaction

Kaur, M. J., & Maheshwari, P. (2016, March). Building smart cities applications using IoT and cloud-based architectures. In *2016 International Conference on Industrial Informatics and Computer Systems (CIICS)* (pp. 1-5). IEEE.

Khan, M. M. (2020). An IoT-Based Smart Water Monitoring System for Fish Firming in Bangladesh.

Komninos, N., Philippou, E., & Pitsillides, A. (2014). Survey in smart grid and smart home security: Issues, challenges and countermeasures. *IEEE Communications Surveys & Tutorials*, *16*(4), 1933-1954.

Lam, A. Y., Leung, Y. W., & Chu, X. (2014). Electric vehicle charging station placement: Formulation, complexity, and solutions. *IEEE Transactions on Smart Grid*, *5*(6), 2846-2856.

Lee, J., Guo, J., Choi, J. K., & Zukerman, M. (2015). Distributed energy trading in microgrids: A game-theoretic model and its equilibrium analysis. *IEEE Transactions on Industrial Electronics*, *62*(6), 3524-3533.

Lee Sarah. (2021, June 15). What are Contactless Cards and How Do They Work? *Blackhawk Bank.* Retrieved March 30, 2023, from https://www.blackhawkbank.com/what-are-contactless-cards-and-how-do-they-work-

Li, W. (2021). Design of smart campus management system based on Internet of Things technology. *Journal of Intelligent & Fuzzy Systems*, *40*(2), 3159-3168.

Lin, J., Yu, W., Zhang, N., Yang, X., Zhang, H., & Zhao, W. (2017). A survey on Internet of things: Architecture, enabling technologies, security and privacy, and applications. *IEEE Internet of things journal*, *4*(5), 1125-1142.

Manimuthu, A., Dharshini, V., Zografopoulos, I., Priyan, M. K., & Konstantinou, C. (2021). Contactless technologies for smart cities: big data, IoT, and cloud infrastructures. *SN computer science*, *2*(4), 334.

MicroAI (2022). IoT Security – The Top Six Risks. *Micro.ai*. Retrieved April 17, 2023, from https://micro.ai/blog/iot-security-the-top-six-risks

Naphade, M., Banavar, G., Harrison, C., Paraszczak, J., & Morris, R. (2011). Smarter cities and their innovation challenges. *Computer*, *44*(6), 32-39.

Roger, H. (2019). WHO Encourages Use of Contactless Payments Due to COVID-19 *Forbes.* Retrieved April 17, 2023, from https://www.forbes.com/sites/rogerhuang/2020/03/09/who-encourages-use-of-digital-payments-due-to-covid-19/?sh=5e8cee8941eb

Sayghe, A., Hu, Y., Zografopoulos, I., Liu, X., Dutta, R. G., Jin, Y., & Konstantinou, C. (2020). Survey of machine learning methods for detecting false data injection attacks in power systems. *IET Smart Grid*, *3*(5), 581-595.

Sharifi, A., & Khavarian-Garmsir, A. R. (2020). The COVID-19 pandemic: Impacts on cities and major lessons for urban planning, design, and management. *Science of the total environment*, *749*, 142391.

Sheldon, J. (2020, March 24). Contactless card payment limit to change in emergency move amid coronavirus pandemic. *In Express.* Retrieved April 17, 2023, from

https://www.express.co.uk/finance/personalfinance/1259308/contactless-card-payment-limit-coronavirus-uk-money-lockdown-latest-news

Tavakoli, A., Faghihinia, A., & Kalhor, A. (2017). An innovative test bed for verification of attitude control system. *IEEE Aerospace and Electronic Systems Magazine*, *32*(6), 16-22.

UK Finance. (2020). Contactless Limit in UK to be increased to 45 Pounds. *In UK Finance.* Retrieved April 17, 2023, from https://www.ukfinance.org.uk/press/press-releases/contactless-limit-uk-be-increased-45

UK Finance. (2021). Contactless Limit to Increase to 100 Pounds from 15 October. *In UK Finance.* Retrieved April 17, 2023, from https://www.ukfinance.org.uk/press/press-releases/contactless-limit-increase-100-15-october

United Nations. (2018, May 16). 68% of the world population projected to live in urban areas by 2050, says UN. United Nations Department of Economic and Social Affairs. Retrieved April 17, 2023, from https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

Wikipedia contributors. (2022, December 24). Smart system. *In Wikipedia.* Retrieved April 7, 2022, from https://en.wikipedia.org/wiki/Smart_system

Wikipedia contributors. (2023, April 2). Contactless Payment. *In Wikipedia.* Retrieved April 17, 2023, from https://en.wikipedia.org/wiki/Contactless_payment#cite_note-35

Xia, Z., Wang, X., Zhang, L., Qin, Z., Sun, X., & Ren, K. (2016). A privacy-preserving and copy-deterrence content-based image retrieval scheme in cloud computing. *IEEE Transactions on information forensics and Security*, *11*(11), 2594-2608.

Yu, W., Liang, F., He, X., Hatcher, W. G., Lu, C., Lin, J., & Yang, X. (2017). A survey on the edge computing for the Internet of Things. *IEEE Access*, *6*, 6900-6919.