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DEPARTMENT OF BUSINESS ADMINISTRATION

PROGRAM OF DOCTORAL STUDIES

PhD THESIS

Cutting-edge Computational Systems and Emerging Technologies Applied to E-Government and Virtual Environments

Vasileios Yfantis

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Cutting-edge Computational Systems and Emerging Technologies Applied to E-Government and Virtual Environments

ΔΙΔΑΚΤΟΡΙΚΗ ΔΙΑΤΡΙΒΗ

Υπολογιστικά συστήματα αιχμής και αναδυόμενες τεχνολογίες που εφαρμόζονται στην ηλεκτρονική διακυβέρνηση και τα εικονικά περιβάλλοντα

Βασίλειος Υφαντής

ΕΠΙΒΛΕΠΩΝ ΚΑΘΗΓΗΤΗΣ: Κλήμης Νταλιάνης, Καθηγητής Τμ. Διοίκησης Επιχειρήσεων, ΠαΔΑ

ΤΡΙΜΕΛΗΣ ΕΠΙΤΡΟΠΗ ΠΑΡΑΚΟΛΟΥΘΗΣΗΣ:

Κλήμης Νταλιάνης, Καθηγητής Τμ. Διοίκησης Επιχειρήσεων, ΠαΔΑ
Ιωάννης Ψαρομήλιγκος, Καθηγητής Τμ. Διοίκησης Επιχειρήσεων, ΠαΔΑ
Νικόλαος Τσότσολας, Αναπληρωτής Καθηγητής Τμ. Διοίκησης Επιχειρήσεων, ΠαΔΑ

ΕΠΤΑΜΕΛΗΣ ΕΞΕΤΑΣΤΙΚΗ ΕΠΙΤΡΟΠΗ

Κλήμης Νταλιάνης, Καθηγητής Τμ. Διοίκησης Επιχειρήσεων, ΠαΔΑ
Ιωάννης Ψαρομήλιγκος, Καθηγητής Τμ. Διοίκησης Επιχειρήσεων, ΠαΔΑ
Νικόλαος Τσότσολας, Αναπληρωτής Καθηγητής Τμ. Διοίκησης Επιχειρήσεων, ΠαΔΑ
Δημήτριος Στράνης, Καθηγητής Τμ. Διοίκησης Επιχειρήσεων, ΠαΔΑ
Μαρία Τσιριντάνη, Καθηγήτρια Τμ. Διοίκησης Επιχειρήσεων, ΠαΔΑ
Ιωάννης Σαλμόν, Αναπληρωτής Καθηγητής Τμ. Διοίκησης Επιχειρήσεων, ΠαΔΑ
Χρήστος Κυτάγιας, Αναπληρωτής Καθηγητής Τμ. Διοίκησης Επιχειρήσεων, ΠαΔΑ

Ημερομηνία Εξέτασης 23/04/2024

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Vasileios Yfantis

SUPERVISOR: KLIMIS NTALIANIS, Professor Department of Business Administration, UniWA

THREE-MEMBER ADVISORY COMMITTEE:

Klimis Ntalianis, Professor, Dep. Business Administration, UniWA
Ioannis Psaromiligkos, Professor, Dep. Business Administration, UniWA
Nikolaos Tsotsolas, Associate Professor, Dep. Business Administration, UniWA

SEVEN MEMBER EXAMINATION COMMITTEE

Klimis Ntalianis, Professor, Dep. Business Administration, UniWA
Ioannis Psaromiligkos, Professor, Dep. Business Administration, UniWA
Nikolaos Tsotsolas, Associate Professor, Dep. Business Administration, UniWA
Dimitrios Stranis, Professor, Dep. Business Administration, UniWA
Maria Tsirintani, Professor, Dep. Business Administration, UniWA
Ioannis Salmon, Associate Professor, Dep. Business Administration, UniWA
Christos Kytagias, Associate Professor, Dep. Business Administration, UniWA

Examination Date 23/04/2024

Μέλη Τριμελούς Συμβουλευτικής Επιτροπής συμπεριλαμβανομένου και του Επιβλέποντα

Α/Α	ΟΝΟΜΑ ΕΠΩΝΥΜΟ	ΒΑΘΜΙΔΑ/ΙΔΙΟΤΗΤΑ/ΤΜΗΜΑ	ΨΗΦΙΑΚΗ ΥΠΟΓΡΑΦΗ
1	Κλήμης Νταλιάνης	Καθηγητής Τμ. Διοίκησης Επιχειρήσεων, ΠαΔΑ	Klimis Ntalianis Digitally signed by Klimis Ntalianis Date: 2024.05.09 11:34:49 +03'00'
2	Ιωάννης Ψαρομήλιγκος	Καθηγητής Τμ. Διοίκησης Επιχειρήσεων, ΠαΔΑ	Ioannis Psaromiligkos Digitally signed by Ioannis Psaromiligkos Date: 2024.05.10 11:44:01 +03'00'
3	Νικόλαος Τσότσολας	Αναπληρωτής Καθηγητής Τμ. Διοίκησης Επιχειρήσεων, ΠαΔΑ	Nikolaos Tsotsolas Digitally signed by Nikolaos Tsotsolas Date: 2024.05.16 00:57:11 +03'00'

Μέλη Επταμελούς Εξεταστικής Επιτροπής

Α/Α	ΟΝΟΜΑ ΕΠΩΝΥΜΟ	ΒΑΘΜΙΔΑ/ΙΔΙΟΤΗΤΑ/ΤΜΗΜΑ/ΣΧΟΛΗ/ΠΑΝΕΠΙΣΤΗΜΙΟ
1	**Κλήμης Νταλιάνης**	Καθηγητής Τμ. Διοίκησης Επιχειρήσεων, Σχολή Διοικητικών, Οικονομικών & Κοινωνικών Επιστημών, ΠαΔΑ
2	**Ιωάννης Ψαρομήλιγκος**	Καθηγητής Τμ. Διοίκησης Επιχειρήσεων, Σχολή Διοικητικών, Οικονομικών & Κοινωνικών Επιστημών, ΠαΔΑ
3	**Νικόλαος Τσότσολας**	Αναπληρωτής Καθηγητής Τμ. Διοίκησης Επιχειρήσεων, Σχολή Διοικητικών, Οικονομικών & Κοινωνικών Επιστημών, ΠαΔΑ
4	**Δημήτριος Στράνης**	Καθηγητής Τμ. Διοίκησης Επιχειρήσεων, Σχολή Διοικητικών, Οικονομικών & Κοινωνικών Επιστημών, ΠαΔΑ
5	**Μαρία Τσιριντάνη**	Καθηγήτρια Τμ. Διοίκησης Επιχειρήσεων, Σχολή Διοικητικών, Οικονομικών & Κοινωνικών Επιστημών, ΠαΔΑ
6	**Ιωάννης Σαλμόν**	Αναπληρωτής Καθηγητής Τμ. Διοίκησης Επιχειρήσεων, Σχολή Διοικητικών, Οικονομικών & Κοινωνικών Επιστημών, ΠαΔΑ
7	**Χρήστος Κυτάγιας**	Αναπληρωτής Καθηγητής Τμ. Διοίκησης Επιχειρήσεων, Σχολή Διοικητικών, Οικονομικών & Κοινωνικών Επιστημών, ΠαΔΑ

ΔΗΛΩΣΗ ΣΥΓΓΡΑΦΕΑ ΔΙΔΑΚΤΟΡΙΚΗΣ ΔΙΑΤΡΙΒΗΣ

Ο κάτωθι υπογεγραμμένος Βασίλειος Υφαντή του Αναστασίου, υποψήφιος διδάκτορας του Τμήματος Διοίκησης Επιχειρήσεων της Σχολής Διοικητικών, Οικονομικών & Κοινωνικών Επιστημών του Πανεπιστημίου Δυτικής Αττικής, δηλώνω ότι:

«Είμαι συγγραφέας και δικαιούχος των πνευματικών δικαιωμάτων επί της διατριβής και δεν προσβάλλω τα πνευματικά δικαιώματα τρίτων. Για τη συγγραφή της διδακτορικής μου διατριβής δεν χρησιμοποίησα ολόκληρο ή μέρος έργου άλλου δημιουργού ή τις ιδέες και αντιλήψεις άλλου δημιουργού χωρίς να γίνεται αναφορά στην πηγή προέλευσης (βιβλίο, άρθρο από εφημερίδα ή περιοδικό, ιστοσελίδα κ.λπ.). Επίσης, βεβαιώνω ότι αυτή η εργασία έχει συγγραφεί από μένα αποκλειστικά και αποτελεί προϊόν πνευματικής ιδιοκτησίας τόσο δικής μου, όσο και του Ιδρύματος.

Παράβαση της ανωτέρω ακαδημαϊκής μου ευθύνης αποτελεί ουσιώδη λόγο για την ανάκληση του διδακτορικού διπλώματος μου».

Ο/Η Δηλών/ούσα

Vasileios Yfantis

Digitally signed by Vasileios Yfantis
Date: 2024.05.08 10:25:31 +03'00'

Declaration

I thus certify that the contents and organization of this dissertation are my own original work and do not infringe on the rights of other parties, particularly those concerning the security of personal data.

Vasileios Yfantis

2024

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Abstract

This thesis delves into the intersection of innovative technologies and public service delivery, examining both business and technical dimensions inside the government. The study's main objective is to compare conventional approaches to obtaining public services, involving physical visits to government offices, and the utilization of cutting-edge technologies, particularly the Metaverse. Through a meticulous evaluation of key factors such as time efficiency, energy consumption, environmental impact (exhaust gases), and cost-effectiveness, the goal of this research is to offer a comprehensive grasp of the issues related to each method of delivering public services. This thorough analysis attempts to provide insights into the possible advantages and difficulties presented by the incorporation of cutting-edge technologies in the provision of public services. The results of this thesis provide policymakers with important new information by highlighting the benefits and drawbacks of implementing emerging technology in the public sector. As governments worldwide grapple with the task of modernizing service delivery, this research equips decision-makers with data-driven perspectives to inform strategic choices. In essence, the study serves as a critical resource for shaping policies that not only enhance the efficiency of public service provision but also align with broader societal goals, including sustainability and cost-effectiveness.

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1. Introduction

1.1 Background and Motivation

In recent times, governments throughout have been incorporating electronic systems and innovative technology to revolutionize their operations and service provision, under the banner of e-government (Epstein, 2022). The use of electronic communication technology to improve government services, administrative efficiency, and citizen involvement and participation is referred to as e-government (Fang, 2002). The rapid development of information and communication technologies (ICTs) has given governments new ways to improve administrative efficiency and offer citizens easily accessible services. (Yang & Rho, 2007). Online portals, digital document management, and electronic payment systems, for example, offer the potential to transform traditional bureaucratic operations by enabling faster processing, lowering paperwork, and boosting transparency. Furthermore, cutting-edge technologies such as artificial intelligence (AI), blockchain, the Internet of Things (IoT), and big data analytics have emerged as effective e-government tools (Long, Agrawal, & Trung, 2021). These technologies have tremendous potential for enhancing the effectiveness of public services, facilitating data-driven decision-making, and promoting a more inclusive and connected society.

Furthermore, the COVID-19 epidemic has brought attention to the need for e-government, reliable electronic systems, and innovative governance technologies (Amosun, et al., 2021). The global health crisis has hastened the shift to digital platforms and remote service delivery, emphasizing the importance of resilient and adaptive e-government frameworks. Governments all across the world have depended extensively on electronic systems and cutting-edge technologies to keep key services running, communicate information, and involve populations during lockdowns and social distancing measures (Poongodi, Malviya, Hamdi, & Rauf, 2021). The epidemic has also shown risks and shortcomings in current e-government infrastructures, emphasizing the importance of ongoing innovation, investment, and capacity building in this arena (Rozhkova, Rozhkova, & Blinova, 2021). This research aims to tackle these growing challenges and explore strategies for fortifying e-government frameworks to enhance their ability to handle upcoming crises and societal transformations.

The increasing significance of e-government in contemporary governance and the need to learn more about the potential advantages and drawbacks of utilizing cutting-edge technology and electronic systems in this setting are the driving forces behind this research. While several studies on e-government have been conducted (Palma, et al., 2023), the emphasis on the specific use of innovative technologies and their influence on government operations and citizen interactions has remained relatively limited. The goal of this initiative is to add to the body of knowledge already in existence and give policymakers important new information, government officials, and researchers by examining the interplay between electronic systems, innovative technologies, and e-government. Understanding the potential benefits, implementation problems, and best practices for leveraging electronic systems and innovative technology can help to design effective strategies for successful e-government programmes. Thus, the significance of e-government in advancing transparent governance, citizen-centered services, and good governance is acknowledged in this study. It recognizes the importance of governments constantly adapting to technological breakthroughs and changing citizen expectations in order to remain relevant in the digital age.

Finally, this study offers an overview of the context and reason for undertaking research on electronic systems and novel technologies used in e-government. This study intends to contribute to the growth of e-government practices by investigating the possible benefits, problems, and consequences of new technologies, ultimately supporting efficient and inclusive governance in the digital era. It contributes to the broader subject of electronic systems and novel technologies by focusing explicitly on their implementation in the context of e-government. It promotes understanding of how emerging technologies can revolutionize government operations, improve service delivery, and increase citizen involvement by offering empirical evidence and analysis. It contributes to the field of e-government and give significant insights for policymakers, practitioners, and scholars in this domain by addressing growing difficulties and investigating potential for development.

1.2 Goals of Research Objectives

This study's main objective is to investigate how innovative technologies and electronic systems are used and affect the e-government space. The following are the specific research objectives:

1. To investigate the existing landscape of electronic systems and emerging e-government technologies: To achieve this goal and gain a deeper understanding of the condition of electronic systems and new technologies utilized in e-government initiatives, a comprehensive literature analysis must be completed. It entails recognizing the technologies used, the amount to which they have been adopted, and the types of e-government services and procedures that they improve.

2. To evaluate the influence of information systems and advances technologies on government operations: This goal is to assess the impact of electronic systems and new technologies on the efficiency, effectiveness, and transparency of government processes. It entails studying case studies and actual data to assess how these technologies improve service delivery, administrative processes, and decision-making.

3. To look into the benefits and drawbacks of using new technology and electronic systems in e-government: This goal entails identifying and analyzing the benefits and drawbacks of adopting and implementing electronic systems and innovative technologies in e-government. It entails looking into the potential benefits for citizens, government agencies, and society as a whole, as well as the issues linked to privacy, security, the digital divide, and organizational structures.

4. To look at the elements that influence the successful implementation of electronic systems and new technologies in e-government: This goal seeks to identify the important aspects that influence the effective development and integration of electronic systems and innovative technologies in e-government efforts. It entails investigating organizational, technological, legal, and societal variables that influence technology uptake, scalability, and sustainability.

5. To assist policymakers and practitioners with recommendations for exploiting electronic systems and innovative technologies in e-government: This goal requires synthesizing research findings and providing practical conclusions for policymakers, government officials, and practitioners working in e-government efforts. It attempts to provide actionable advice and guidance for maximizing the benefits of electronic systems and innovative technologies in e-government while limiting the obstacles.

1.3 Research Questions

1. How does the implementation of cutting-edge technologies in e-government influence the required time for delivering public services?

The question seeks to examine how the application of specific technologies in the e-government context affects the required service time. Specifically, the question will provide details about the accurate required time to visit the public offices vs. the required time to receive public service through an innovative technology. Other variables that we will discuss for estimating the effect of technologies on the delivery time of public services include travel time, parking time, and employee service waiting time. The research question explores the complex relationship that exists between the time-efficient delivery of public services and the integration of cutting-edge technologies into e-government systems. This investigation requires a thorough examination of multiple aspects in order to fully comprehend the complex dynamics involved.

The research question highlights a dual comparison, highlighting the difference in time between using cutting-edge technologies to receive public services and physically visiting public offices. This comparison helps to clarify both the absolute time benefits of technology and its relative advantages over traditional approaches, providing a more complete view of how public service delivery is changing.

In order to arrive at a comprehensive understanding, the question broadens its focus to include a variety of elements that are involved in estimating how technologies affect service delivery time. The study will examine crucial auxiliary elements in addition to the simple comparison of visitor and technology-based service reception times. For instance, travel time is a crucial consideration since it accounts for both the time saved by utilizing remote services and the actual trip time to public offices.

Another important consideration that takes into account the realities of providing in-person services is parking time. The research is able to identify concrete time savings provided by technology-enabled service channels by accounting for the time spent locating parking and navigating office buildings. Concurrently, the duration required to receive staff services emerges as a crucial factor, providing valuable information on the efficiency improvements attained when technology reduces or eliminates lines and delays in service delivery.

The study topic's main objective is to obtain a deeper understanding of the long-term consequences of e-government's adoption of cutting-edge technologies. In order to provide a thorough and useful assessment of the transformative impact of technology on the temporal dynamics of public service provision, the study takes into account both the direct comparison of service delivery modes and the ancillary factors influencing overall time efficiency.

2. How does the implementation of cutting-edge technologies in e-government influence the consumption of energy for the completion of public service delivery?

In addition to human resources, public service delivery requires energy to be completed. This question explores the quantity of energy consumed in various forms (electricity, fuel) and draws a comparison about the cost-effective solution for sustainable public service delivery. The investigation of how e-government's cutting edge technologies affect how much energy is used to provide public services is a critical analysis that recognizes the wider environmental and economic implications of modernizing service delivery in addition to the human resources component.

The study topic essentially requires an analysis of the intricate relationship between energy consumption and technological advancements. The study intends to measure and analyze the energy footprint associated with the acceptance of cutting-edge technologies in the e-government domain by exploring the various forms of energy utilized, such as fuel and electricity. Examining the efficiency benefits and resource optimization made possible by technology-enabled service delivery is a crucial aspect of our investigation. Potential energy savings are identified and quantified by comparing the patterns of energy consumption between modern technology approaches and older ones. The relevance of this research increases with the global efforts of governments and companies to reduce their environmental effect and align their operations with sustainable standards.

Beyond only measuring energy use, the study topic also examines how cost-effectively various options may be used to provide sustainable public services. The long-term sustainability and operational efficiencies gained via technology integration must be considered along with the immediate energy costs when assessing the financial effects of using cutting-edge technologies. Educating administrators and legislators on the wider cost effects of switching to more sophisticated e-government technologies requires a comprehensive approach. By examining different energy sources, evaluating affordable options, and taking into account the wider sustainability implications, the research seeks to provide significant insights for developing practices and policies that balance environmental stewardship with financial responsibility in the field of public service delivery.

3. How does the implementation of cutting-edge technologies in e-government influence the consumption of exhaust fumes for the completion of public service delivery?

The research question explores the exhaust fumes as a factor that affects the cost of the public service delivery and its impact on environment. An important question at the nexus of technical innovation, economic viability, and environmental sustainability is how the use of advanced technology in e-government affects the amount of exhaust fumes used for public service delivery.

The environmental impact of traditional service delivery techniques, where the usage of machinery and cars adds to exhaust fume emissions, is recognized by this study question from the outset. The study intends to measure and assess the environmental impact of public service operations by concentrating on exhaust fumes as a particular factor, illuminating the ecological fallout from traditional methods. Examining the ways in which implementing state-of-the-art technologies can lessen or increase this effect offers important insights into the possible financial and operational benefits linked to creative thinking.

In summary, the investigation of this research question provides a means of deciphering the complex relationships among technology, environmental effects, and financial concerns in relation to providing public services. With exhaust fumes as a particular metric, the study hopes to advance knowledge of these interactions both theoretically and practically, helping to implement effective and sustainable e-government solutions that meet modern demands on both the environment and the economy.

4. How does the implementation of cutting-edge technologies in e-government influence the cost of public service delivery?

By estimating the consumption of energy, time, and exhaust fumes, it is easy to estimate the cost of public service delivery. In this question, mathematical calculations are applied to estimate the cost of public service delivery. The examination of how the use of cutting-edge technology in e-government affects the price at which public services are provided involves a quantitative analysis that uses mathematical computations to interpret the financial effects of technical developments. The adoption of novel technologies and the practical economic issues involved in delivering public services in a technologically advanced setting are crucially connected by this research question.

The main focus of this investigation is the thorough cost estimation that takes into account important factors like energy usage, time efficiency, and the effect on exhaust pollutants. The research attempts to offer a detailed understanding of the financial aspects of moving to cutting-edge technology within the e-government sector by combining various components into a single mathematical framework. A foundation for computing operating expenses is provided by taking time efficiency and energy consumption into account together. This entails calculating the costs related to gasoline, electricity, and other energy sources used in the delivery of governmental services through e-government. The temporal dynamics also enter the equation at the same time, enabling the evaluation of labor expenses, resource distribution, and possible savings via time optimization.

The incorporation of exhaust fumes as a consideration in cost estimate broadens the scope to encompass environmental effect externalities. This variable adds a more comprehensive socio-economic viewpoint by taking into consideration potential health-related expenditures and environmental cleanup charges related to conventional distribution systems, in addition to direct operational costs. This research question also promotes a forward-looking viewpoint by taking into account possible advances and cost-cutting strategies made possible by state-of-the-art technologies. Examining substitutes, like environmentally friendly forms of transportation or energy-saving procedures, advances our comprehensive knowledge of how technology might minimize present expenses while simultaneously promoting sustainable practices for public service delivery in the future. To have a thorough grasp of the entire financial implications of implementing cutting-edge technologies in e-government, this research topic essentially acts as a quantitative compass, navigating through the complex interactions of technology, time, energy, and environmental impact. With mathematical computations, the research aims to offer useful information for decision-makers in the public service sector who are trying to strike a balance between financial responsibility and technological advancement.

1.4 Scope and Limitations

The precise focus, aims, and methodology used in the study determine the scope of this research on electronic systems and novel technologies applied to e-government. This section describes the scope of the study, specifies the important topics of examination, and acknowledges the constraints that may affect the study's findings and generalizability.

This study looks at the use and impact of electronic systems and new technologies in the sector of e-government. It aims to investigate the various technologies used in e-government efforts, as well as the implications they have on government operations, efficiency, effectiveness, and transparency. The study's goal is to provide insights into the benefits and obstacles of using these technologies in e-government, as well as to identify the essential elements influencing their effective implementation. Furthermore, the study intends to provide policymakers and practitioners with concrete ideas for using electronic systems and innovative technologies in e-government.

The study will employ a mixed-methods approach that will include a full literature review, case study analysis, and simulation. The research will concentrate on specific e-government projects and electronic systems applied in various nations and industries. The research aims to offer a wider knowledge of the application and impact of electronic systems and new technologies in e-government by examining different situations and experiences. While this research aims to provide useful insights on electronic systems and novel technologies used in e-government, it is important to recognize the study's limitations. These constraints may have an impact on the findings' generalizability and scope. The following are the major constraints that have been identified:

Generalizability: The research's findings and suggestions may be limited to the unique situations and contexts researched. E-government projects differ among countries, regions, and industries, so the conclusions may not be directly applicable to all circumstances. As a result, caution should be used when extrapolating the findings to other contexts.

Data availability and accessibility: May differ among areas and jurisdictions in relation to e-government efforts, electronic systems, and innovative technology. Data availability and quality constraints may have an impact on the depth and breadth of the research.

Time constraints: The field of electronic systems and innovative technologies is rapidly expanding, with new technologies appearing and existing ones evolving. This study is a snapshot of current knowledge and may not reflect the most recent technological advances. As a result, the findings should be evaluated in the context of the study's technological landscape at the time. Constrained by time, resources, conducting data collection may provide practical difficulties. These limits may have an impact on sample size and data representativeness.

Ethical considerations: The research will adhere to ethical guidelines and precepts, including obtaining participants' informed consent and protecting the privacy and confidentiality of the collected data. However, ethical issues may impose restrictions on data gathering, processing, and reporting.

Despite these constraints, the goal of this research is to improve understanding of electronic systems and novel technologies in e-government. The study aims to provide significant insights into decision-making, policy formation and the deployment of electronic systems and innovative technologies in e-government efforts by recognising and overcoming these limitations.

1.5 The Methodology

This content discusses the methodology used in this study of electronic systems and innovative technologies in e-government. This study's research design employs simulation as a research tool. Simulation is a useful research approach for examining complicated systems and studying their behavior under various scenarios. It offers an organized and controlled environment for assessing the impact of electronic systems and novel technologies in e-government. Simulation allows academics to analyses and quantify the consequences of various technical interventions, policy changes, and implementation strategies by modelling various e-government processes and adding important elements and variables.

The procedure for gathering data for this study includes the collection of existing information, theories, and best practices linked to electronic systems and innovative technologies in e-government. This will serve as a theoretical framework for the following research activities. A detailed case study will be done to acquire insights into real-world implementations of electronic systems and novel e-government technologies. This case study will take into account differences in technology solutions, governance structures, and implementation tactics. Document analysis and direct observation of e-government procedures will be used to acquire data for the case studies. Moreover, simulation will be used as a research approach to collect quantitative data and assess the impact of electronic systems and novel technologies in e-government. This will entail creating simulation models based on real-world e-government scenarios, which will include key variables and parameters. The simulation models' data will be gathered from a variety of sources, including existing databases. The simulation models will be conducted under various scenarios to evaluate the effects of technology interventions, performance metrics, and potential areas for development.

We will employ thematic analysis to discover recurring themes, patterns, and insights from the data obtained from the literature review and the case study. This will provide a comprehensive grasp of the experiences, views, and issues related with electronic systems and emerging e-government technology. Statistics and visualization techniques will be used to analyses the quantitative data provided by simulation. Indicators of performance, such as efficiency, effectiveness, and transparency, will be monitored and compared across various situations and interventions. To give a full overview of the research questions and objectives, the findings will be integrated and synthesized. The outcomes of the research will be interpreted in light of current literature and theoretical frameworks, providing significant insights into the implementation and impact of electronic systems and novel technologies in e-government.

Simulation as a research tool has significant advantages in the study of electronic systems and innovative technologies used in e-government. Researchers can alter variables, test hypotheses, and observe effects without affecting actual e-government processes by constructing simulated environments that closely match real-world circumstances. This enables researchers to investigate multiple "what-if" situations, allowing them to assess the possible implications of various policy decisions, technological implementations, and process optimizations. Simulation can also be used to explore complex systems and their interconnections. E-government involves a large number of parties, complex workflows, and interrelated operations. Researchers can model these complex systems via simulation, representing the interactions between many components such as government agencies, citizens, and technology infrastructures. Simulation helps comprehension of e-government by capturing its dynamic character. Researchers can measure and compare important performance characteristics such as response times, resource utilization, and user satisfaction by running simulations under controlled conditions. This quantitative data provides empirical information to help decision-makers and policymakers in e-government. Scalability and reproducibility are also advantages of simulation. Researchers can repeat and redo simulations with varied parameter values, allowing for sensitivity studies and scenario exploration. Because of this scalability, it is possible to investigate both small-scale and large-scale e-government systems, taking into account varying population numbers, resource capacities, and implementation methodologies. The repeatability of simulations means that the research findings can be verified and validated, which increases the study's credibility and reliability.

However, it is critical to recognize simulation's limits as a research approach. The accuracy of the findings is based on the quality of the model and the underlying assumptions, and simulated environments may not convey the entire complexity of real-world e-government systems. The accuracy and availability of input data, which may add uncertainty and bias, also affect the validity of simulation results. Furthermore, the generalizability of simulation findings may be constrained by the simulation model's specific context and assumptions.

1.6 Contribution of the Thesis

The study's contribution is that it examines the financial and technological aspects of integrating cutting-edge technologies into e-government. Technically speaking, it examines emerging technologies like blockchain, cloud computing, and artificial intelligence from the standpoint of design. It explains how we could create a safe electronic voting system using blockchain, a clerkless public office using artificial intelligence; community cloud computing that provides services to other governmental organizations, how to use Metaverse in the government, and how to create a security outlook for Metaverse users.

Financially, as Metaverse is a virtual environment that might house the aforementioned technologies of artificial intelligence, blockchain, and cloud computing, it calculates the cost of integrating the revolutionary technologies by utilizing Metaverse as a case study. The financial section estimates the cost of using Metaverse to deliver public services in comparison to delivering public services in person by figuring out how much it costs for time, energy, exhaust gasses, and money resources. The comparative analysis facilitates the decision-makers' comprehension of the technology's quantitative worth and demonstrates its feasibility as an affordable solution.

Investigating the use of cutting-edge technologies in e-government from both a technical (design) and a business (cost of usage) standpoint may enable decision-makers to accurately plan the adoption of cutting-edge technologies in the public sector, preventing an investment that might not yield a beneficial outcome for the people and the government.

1.7 Thesis Organization

This thesis on electronic systems and novel technologies used in e-government is divided into chapters to give a logical and ordered flow of information. This section gives an overview of the thesis's organization, highlighting the important contents and contributions of each chapter.

Chapter 1: Introduction

The first chapter introduces the research issue by providing background, motivation, research objectives, research questions, scope, limits, and methods. It establishes the tone for the following chapters and provides a clear path for the remainder of the thesis.

Chapter 2: The Evolution of Government Electronic Systems

The second chapter performs a thorough analysis of the literature on electronic systems, novel technologies, and their applications in e-government. It investigates the field's existing theoretical frameworks, models, and best practices. The literature review critically examines current knowledge, identifies research gaps, and sets the groundwork for future study.

Chapter 3: Application of Innovative Technologies in E-Government

Chapter 3 discusses various applications of the emerging technologies in e-government. It explores these technologies from a theoretical perspective, including their advantages/disadvantages and impact on e-government. Moreover, it builds on the theoretical review to offer a potential application of the technologies in the e-government text. To that end, policymakers and decision-makers learn how to practically use these technologies for governmental purposes.

Chapter 4: Implementing Metaverse in E-government: Case Study and Comparison to State-of-Art

In Chapter 4, the potential implementation of the Metaverse technology in e-government is discussed from a business or technical point of view. The technology is explored as a potential solution in order to put public service delivery into practice, in contrast with service delivery through the visit of the citizen at the local public office. Factors such as cost, time, and energy are used as criteria for the comparison between the two chosen methods of service delivery (physical office visit vs. remote service through Metaverse). The case study provides a real-world example and insights into the practical application, problems, and benefits of the Metaverse in the context of e-government.

Chapter 5: Conclusions

The final chapter summarizes the research's main findings, contributions, and consequences. It considers the research questions, aims, and conclusions, emphasizing the study's importance in furthering knowledge in the subject of e-government. The chapter also examines the research's shortcomings, suggests future research directions, and closes the thesis.

In summary, this thesis is divided into five chapters, each of which addresses a different area of the research on electronic systems and novel technologies used in e-government. Starting with an introduction and a literature review, the chapters lead to the construction of conceptual frameworks and the presentation of case studies. The simulation approach is then outlined, which leads to simulation results analysis and integration with quantitative data. The thesis finishes with recommendations, a research reflection, and recommendations for future study areas.

The thesis attempts to give a cohesive and complete analysis of electronic systems and innovative technologies in e-government by adhering to this organizational structure. The study's research findings and recommendations have the potential to help policymakers, practitioners, and researchers use technological breakthroughs for better governance and citizen-centric services in the digital era.

2. The Evolution of Government Electronic Systems

In this section, we look at the evolution of government electronic systems, examining technological advances and their impact on the transformation of government operations and service delivery. Understanding the evolution of electronic systems over time provides useful insights into their current state and future possibilities in the field of e-government.

The history of electronic government systems may be traced back to the late twentieth century, when governments began to embrace computer technology for administrative work. Initially, electronic systems were designed to automate simple tasks like payroll management, record keeping, and data processing. These early systems relied on mainframe computers and batch processing techniques, which provided limited capabilities and access. Electronic systems began to incorporate increasingly complicated functionalities as technology advanced. The emergence of client-server architecture in the 1980s enabled data processing to be decentralized, allowing government agencies to have their own computing resources. This distributed computing approach enabled better data sharing and cooperation, as well as higher processing speeds.

The effective execution of e-government projects depends on the early acceptance of electronic systems. It entails making better use of digital platforms and cutting-edge technology to increase citizen participation, service delivery, and government process optimization. (Wikipedia, 2023). Enhanced efficiency is a major advantage of early e-government use of electronic systems (Hooda, Gupta, Jeyaraj, & Dwivedi, 2023). Governments may cut down on paperwork, get rid of unnecessary chores, and speed up service delivery by automating manual operations and integrating several systems (Team G. , 2023).

In addition to saving time, this lowers the expense of manual labour (Team G. , 2023). Furthermore, early use of technological systems helps governments to offer citizens better services (Awadhi, 2021). Citizens have anytime, anywhere access to government services via digital platforms and internet portals (Granicus, 2022). Transparency and accountability are encouraged while accessibility and convenience are improved (Esselimani, Sağsan, & Kıralp, 2021). Additionally, data-driven decision-making in e-government is facilitated by early adoption of electronic technology (Lu & Nguyen, 2016). Through the collection and analysis of data from multiple sources, governments can acquire significant insights into the needs, interests, and actions of their citizenry (Srinivasan, 2021).

2.1 Early Electronic System Adoption

A number of benefits that improve the efficacy and efficiency of public services arise from the early use of electronic technology in e-government (Samsor, 2020). Firstly, it improves accessibility since citizens can now obtain information and services without physically visiting government offices (Wikipedia, 2023). By doing this, time is saved and the strain on public resources is lessened (Sikaonga & Tembo, 2020). Secondly, by offering real-time updates on government operations, early use of electronic systems improves accountability and openness (Esselimani, Sağsan, & Kıralp, 2021).

Open and transparent governance is ensured by allowing citizens to follow the status of their applications or requests. Electronic systems also facilitate quicker and more precise data processing, which lowers errors and improves decision-making. Consequently, governments are better able to respond to the needs of their citizens and provide better services (Hooda, Gupta, Jeyaraj, & Dwivedi, 2023). Finally yet importantly, early adoption promotes innovation by helping to create new digital services that meet changing needs of the citizens (Lu & Nguyen, 2016).

2.1.1 Challenges and Considerations for Early Electronic System Adoption in E-Government

Several challenges and considerations need to be made while introducing early electronic technologies in e-government. To begin with, it is imperative to guarantee the accessibility of dependable and secure infrastructure, which encompasses strong internet connectivity and data centers that can manage substantial amounts of data (Zevenet, 2023). Because e-government systems entail the collecting and storage of sensitive citizen data, privacy and data protection are also major considerations (Domeyer, McCarthy, Pfeiffer, & Scherf, 2020).

Sufficient security measures need to be implemented to stop unwanted access or abuse (Pennsylvania Department of Human Services, 2023). Furthermore, early adoption of electronic systems in e-government is still hindered by the digital divide (United Nations, 2023). Equal access to technology and possession of the digital literacy abilities required for successful online platform navigation are not shared by all citizens (Apleni & Smuts, 2020). Through focused training initiatives and inclusive design methodologies, efforts must be made to close this gap. Additionally, for smooth integration and effective service delivery, systems from various government departments must be compatible with one another (Domeyer, McCarthy, Pfeiffer, & Scherf, 2020).

2.1.2 Successful Strategies for Implementing Early Electronic Systems in E-Government

Careful planning and execution are necessary when implementing early electronic systems in e-government (Al-Rahmi, et al., 2022). The subsequent tactics have demonstrated efficacy in guaranteeing a seamless shift towards digitalization (The Enterprisers Project, 2022):

1. Stakeholder Engagement: It is essential to involve all pertinent parties, such as citizens, government representatives, and IT specialists (Ramirez-Madrid et al., 2022). This makes sure that the system is widely accepted and can meet the needs of all users (U.S. Environmental Protection Agency, 2023).

2. Thorough Training: For adoption to be successful, government staff must get thorough training (Al-Shboul M. , Rababah, Al-Shboul, Ghnemat, & Al-Saqqa, 2014). Training in change management is also provided to assist staff in adjusting to new procedures, in addition to technical training on operating the electronic systems (Apleni & Smuts, 2020).

3. User-Centric Design: To increase adoption rates, it is important to put the user experience first and create user-friendly interfaces. System accessibility, usability, and group compatibility should all be prioritized (Ramirez-Madrid et al., 2022).

4. Incremental Implementation: Using a phased strategy makes it possible to introduce electronic systems gradually in various government agencies or services.

2.2 The Development of Online Service Delivery

A turning point in the development of electronic government systems came with the introduction of the internet in the 1990s. Governments realized the potential of the internet as a means of offering citizens direct services. As the idea of e-government gained traction, websites and online portals for service delivery were developed. In the current digital era, governments worldwide are adopting the concept of e-government, or the use of information and communication technologies (ICTs) to improve public service delivery (Granicus, 2022). Thanks to this shift, citizens can now access government information and services via digital platforms, a trend known as online service delivery. Due to its ability to provide citizens with ease, efficiency, and accessibility, online service delivery has completely transformed old bureaucratic institutions (Khoury R. , 2022).

Thanks to user-friendly websites, smartphone applications, and online portals, people may now easily communicate with government institutions from the convenience of their homes or places of business (Camilleri, 2019). The transition to digital platforms has resulted in expedited administrative procedures and increased citizen empowerment by giving them more authority over their interactions with the government (Energy E. C., 2023).

2.2.1 Evolution of Online Service Delivery in E-Government

Over time, e-government's online service delivery has made significant strides in its development (Ahmadi, 2017). At first, e-government services could only distribute basic information via static websites (Tola, 2020). Nonetheless, the introduction of Web 2.0 technology has made online service delivery more interactive and focused on the needs of citizens. In the first stage, the government's current services were digitalized and made available online (Team G. , 2023). This covered tasks including filing applications, paying taxes, and gaining computerized access to public documents (Srinivasan, 2021).

Under the second phase, citizens could complete all procedures online without having to visit government offices in person. This was known as transactional services (Dunleavy, 2023). Furthermore, the integration of mobile technologies has revolutionized the provision of e-government services (Yasser M. , 2023). Nowadays, a multitude of services is accessible at any time and from any location thanks to mobile applications (Carter, 2023). Furthermore, e-government services are now more effective and efficient because to the development of chatbots and artificial intelligence (AI) (Souter, 2022). Now, citizens may get individualized help and instant answers to their questions.

2.2.2 Benefits and Challenges of Online Service Delivery in E-Government

Various advantages to online service delivery in e-government improve accessibility and efficiency. First, it saves citizens time and effort by enabling quick, remote access to government services (Energy E. C., 2023). Furthermore, internet services can be accessed by residents whenever it is convenient for them, as they are available around-the-clock. Consumer satisfaction and experience are enhanced as a result (Gothmann, 2023). Additionally, through the elimination of paper records and labor-intensive procedures, e-government platforms facilitate the processing of requests and applications more quickly (House, 2021).

This results in cost savings by lessening the administrative load on both citizens and government workers (Energy E. C., 2023). However, there are drawbacks to online service delivery in e-government as well (Tola, 2020). The digital gap, which occurs when some societal groups do not have access to technology or the necessary digital literacy to make efficient use of internet services, is one of the main problems (GeeksforGeeks, 2023). Inequity and exclusion may follow from this (Souter, 2022). Furthermore, because sensitive citizen data is susceptible to hacking or data breaches, cybersecurity threats present a serious problem (Nabben, 2022).

2.2.3 Future Prospects and Potential Advancements in Online Service Delivery

Promising developments and future prospects exist for online service delivery within e-government (Carter, 2023). Governments can take advantage of new trends in technology as it develops to further improve services (Technology Innovators, 2023). One important area of development is the integration of machine learning algorithms and artificial intelligence (AI) into online service platforms (Carter, 2023). Governments may enhance user experience and cut response times by deploying AI chatbots or virtual assistants to assist citizens in a tailored and effective manner (Energy E. C., 2023).

Furthermore, the application of blockchain technology offers lots of promise for safe and open transactions in e-government services (Samsor, 2020). Governments can employ blockchain technology to safeguard data integrity and increase public confidence in their institutions (Open USA, 2022). Furthermore, future developments will be greatly aided by the implementation of mobile-first tactics (Energy E. C., 2023). Governments need to adapt their web services for mobile devices in order to attract a larger audience as smartphones become more and more commonplace globally (Camilleri, 2019).

2.3 Interoperability and Integration

The smooth transfer of data and services between various government agencies and systems, which promotes effective cooperation and streamlined procedures, is referred to as interoperability and integration in e-government (Paraskevopoulos, 2021). It entails the integration of diverse technologies, data, applications, and platforms to ensure e-government ecosystem compatibility, connectivity, and harmonization. The goal of interoperability is to create standardized interfaces and protocols that let disparate systems interact with each other seamlessly (Lewis S. , 2023).

This makes it possible for local, regional, and national government organizations to share information and services. In contrast, integration refers to the process of combining several systems into a single, cohesive system in order to reduce effort duplication and improve overall effectiveness (Ocampo, 2023). Governments can enhance the delivery of citizen services by facilitating easy access to information and services across many platforms through the achievement of interoperability and integration in e-government initiatives (UN.ESCAP, 2019). Furthermore, it encourages cooperation among government departments by promoting accountability, openness, and data-driven decision-making (UN.ESCAP, 2019).

2.3.1 Benefits of Interoperability and Integration in E-Government

Interoperability and integration in e-government offer a number of benefits that raise the effectiveness, efficiency, and general quality of public services (OECD, 2023). In the first place, it encourages smooth data sharing and exchange between various government entities, doing away with needless steps and effort duplication (Tammearu, 2022). This increased information flow allows for speedier decision-making, which leads to better service delivery for citizens (Cocoflo, 2023). Additionally, interoperability makes it easier to build integrated platforms that let users access a variety of services via a single entry point. This lessens the load on people looking for help or information from several sources and streamlines contacts with the government (Lewis S. , 2023). In addition, interoperability facilitates data-driven decision-making by offering thorough insights into the requirements and preferences of citizens across various services (Lo, et al., 2022). This confers authority upon governments to formulate focused policies and initiatives that efficaciously tackle particular social issues (Tammearu, 2022). Finally yet importantly, interoperability encourages cooperation amongst government agencies at different levels, allowing them to operate together harmoniously to achieve shared objectives (Thakur, 2023).

2.3.2 Challenges in Achieving Interoperability and Integration in E-Government

Several barriers in the context of e-government interoperability and integration impede the seamless exchange of information and services across government agencies (Rauscompass, 2023). First, effective communication between various systems is hampered by the absence of defined data formats and protocols (Wikipedia, 2023). Data exchange gets difficult and time-consuming in the absence of universal standards (Reisman, 2017). Second, a major obstacle is the existence of legacy systems in government organizations (Torab-Miandoab, Samad-Soltani, Jodati, & Rezaei-Hachesu, 2023). Integration attempts are costly and time-consuming because these antiquated systems frequently are not compatible with contemporary technologies (Nsaghurwe, et al., 2021).

Strong security and privacy measures are also necessary to prevent data breaches and illegal access when merging disparate systems that manage private citizen data (OECD, 2023). Moreover, organizational hurdles that exist between government departments may hamper measures for interoperability and integration. Opposition to change, disparate administrative structures, and differing agendas, which impede cooperative efforts, impedes the deployment of e-government. Finally, budgetary restrictions can prevent funding for interoperability infrastructure or training courses for public employees taking part in e-government projects (What When How, 2023).

Furthermore, measures against unwanted access and data breaches are necessary when integrating disparate systems that handle sensitive citizen data, as privacy and security concerns surface.

Ineffective collaboration is a hindrance to the successful deployment of e-government due to disparate administrative structures, conflicting agendas, and reluctance to change. Finally, budgetary restrictions may prevent public workers working in e-government projects from receiving training or from investing in interoperable infrastructure (What When How, 2023).

2.3.3 Strategies for Promoting Interoperability and Integration in E-Government

As electronic systems developed in government, the necessity for integration and interoperability became clear. Government entities used their own segregated systems, which resulted in data silos and ineffective information sharing. To solve these issues, governments began prioritizing integration efforts, with the goal of establishing seamless communication and data interchange between various systems and departments. Adoption of standardized data formats, protocols, and interfaces was critical to system integration. Enterprise architecture frameworks, like the Federal Enterprise Architecture Framework (FEAF), were developed in the USA to provide guidelines and standards for the seamless integration of electronic systems among government agencies

1. Creating uniform standards: To guarantee interoperability and smooth data interchange across various e-government systems, governments should embrace and implement uniform technical standards. Standardized data formats, protocols, and interfaces are examples of this (Nanayakkara, 2023).

2. Establishing a solid infrastructure: To meet the interoperability needs of various e-government services, governments must make investments in the creation of a dependable and secure digital infrastructure (Wikipedia, 2023). This entails putting cloud-based solutions into place, developing scalable networks, and utilizing cutting-edge technologies like blockchain (Nato, 2023).

3. Promoting cooperation: To share best practices, exchange expertise, and jointly address interoperability difficulties, governments should promote cooperation

amongst diverse government entities on a national and worldwide scale (Puigarnau, 2017). Establishing interagency working groups or taking part in global forums on e-government interoperability are two ways to do this (Encora, 2023).

2.4 Mobile Technology and Pervasive Connectivity

The rapid advancement of mobile technology has resulted in a drastic shift in several industries, including e-government, in recent years (Yasser M. , 2023). The phrase "e-government" describes how governmental entities provide individuals with public services by using digital and electronic platforms (Simić, 2012). The increasing prevalence of mobile devices and ubiquitous connectivity is being utilized by governments globally to improve their service delivery methods (Eng, 2023).

Mobile technology makes it simple for citizens to access government services whenever and wherever they are, which offers numerous benefits for e-government (Simić, 2012). People can easily accomplish administrative duties on their tablets or smartphones, obtain information, and communicate with government entities through mobile applications (Shilton, 2011). Furthermore, ubiquitous connectivity makes it possible for governments to create channels of real-time communication with the public, improving openness and responsiveness (Impact, 2016).

2.4.1 Benefits of Mobile Technology in E-Government Services

Mobile technology has revolutionized the delivery of e-government services and provides governments and citizens with a number of benefits (Cocoflo, 2023). First off, people no longer need to physically visit the government or wait in line to get services from anywhere at any time. This is made possible by mobile technology (Eng, 2023). For both parties, this convenience results in significant time and resource savings (Alonso & Ambur, 2009). Second, mobile devices improve the user experience while dealing with e-government platforms by providing a customized and intuitive interface (Digital.gov, 2023).

On their mobile devices, citizens may simply browse through a variety of services, apply for jobs, make payments, and get real-time updates. Furthermore, mobile technology guarantees quick answers to questions or concerns by enabling speedier connection between citizens and government representatives via chatbots and instant messaging (contributors, Wikipedia, 2023). Furthermore, governments can ensure inclusivity and reach a larger audience by offering services to those who might not otherwise have access to traditional computers or the internet, thanks to the widespread usage of mobile technology.

2.4.2 Challenges and Implications of Pervasive Connectivity in E-Government

Data privacy and security for citizens is one of the main issues and consequences of ubiquitous connection in e-Government. The constant connectivity provided by mobile technology raises the possibility of hacking, illegal access, and data breaches (Atlan, 2023). In order to safeguard confidential data and uphold public confidence, governments need to make significant investments in strong cybersecurity protocols. Furthermore, worries about the digital divide are heightened by ubiquitous connectivity (Lyons-Burt, 2023).

Although mobile technology makes things more convenient and accessible, it also leaves out people who cannot afford smartphones or do not have access to dependable internet connections. Governments have an obligation to guarantee that all individuals, irrespective of their location or socioeconomic background, may utilize e-Government services (contributors, Wikipedia, 2023). Furthermore, because mobile technology is developing so quickly, governments must constantly update their infrastructure and processes (Apollo, 2023). In order to stay up to date with technical changes, government staff must undergo continuous training, which presents financial issues (Yasser M. , 2023).

2.4.3 Future Trends and Opportunities in Mobile Technology for E-Government

The expansion of mobile technologies, as well as the broad availability of high-speed internet connectivity, has further revolutionized government electronic systems. Individuals and representatives of the government can now access and interact with electronic systems while on the road, regardless of where they are physically located, thanks to mobile technology like smartphones and tablets. Governments began to create mobile applications and responsive websites in order to optimize their services for mobile devices. Mobile technologies enabled real-time information sharing, location-based services, and increased public participation. Citizens can now receive notifications, make requests, and access government services directly from their mobile devices, which improves ease and accessibility.

Future e-government using mobile technology has the potential to significantly alter citizen participation and public service delivery methods (Yasser M. , 2023).With the increasing proliferation of mobile devices and the growing pervasiveness of connection, governments can take use of these developments to improve their e-government activities (Eng, 2023). The use of artificial intelligence (AI) and machine learning in mobile applications is a notable advancement that enables customized and context-aware services (Campbell, 2018).

Because of this, governments will be able to offer citizens information and services that are customized to their needs, interests, and locations (Granicus, 2022). Furthermore, the development of 5G networks would transform e-government by offering dependable and quicker connectivity (Internet of Things Wi-Fi alliance, n.d.). This would make it possible for citizens and government agencies to exchange data in real time by providing seamless access to services from anywhere at any time (HandWiki, 2022). Moreover, with the increasing prevalence of linked devices, the Internet of Things (IoT) will be critical to e-government (Atske, 2020). Governments may enhance public safety, optimize resource allocation, and manage infrastructure better by utilizing IoT technologies (Yasser M. , 2023).

2.5 The Emergence of Novel Technologies

The way governments function globally has radically transformed as a result of the public sector's adoption of information and communication technology, or "e-government" (Yasser M. , 2023). The development of e-government may be traced back to government research in the 1980s on ICTs' potential to increase public participation and enhance service delivery. Over time, the advent of new technology has significantly shaped e-government by facilitating governments to improve transparency, expedite administrative processes, and encourage public involvement.

The growth of e-government will be covered in detail in this subtopic, from simple online service delivery to more sophisticated applications like big data analytics, blockchain, artificial intelligence (AI), and the Internet of Things (IoT). It will also look at how governance practices have been affected by these technological developments, leading to a digital transformation in public administration.

Among other advantages, the introduction of new technology in e-government has completely changed how governments interact with the public and provide services. (Almarabeh, Majdalawi, & Mohammad, 2016). A primary benefit is increased accessibility (Dias, 2023). Breaking down barriers of time and space, new technologies like online platforms and mobile applications have made government services more accessible to a larger populace (Gov.uk, 2023). There is no longer a requirement for citizens to physically attend government offices because they can now easily access government information and services from the comfort of their homes or while on the go (HandWiki, 2022).

These technologies have also increased service delivery efficiency (Nagware, 2022). Digital workflows and automated technologies simplify administrative labor and cut down on paperwork and red tape (Intellias, 2023). In addition to saving time, this reduces errors and improves accuracy for both citizens and government employees (Gov.uk, 2023). Furthermore, governments may now collect vast data about the interests, wants, and activities of their citizens thanks to innovative technologies (National Intelligence Council, 2021). With the use of this data-driven approach, governments may better comprehend societal issues and customize their services by making evidence-based policy decisions (Shepheard, 2022).

2.5.1 Challenges and Future Implications of Novel Technologies in E-Government

Innovative technology use in e-government is related with a number of new difficulties and long-term impacts (Marchant & Wallach, 2015). The requirement for governments to modify their procedures and infrastructure in order to integrate these new technologies is a significant obstacle (Digital.gov, 2023).

Funding, resources, and government employee training must be committed to this to a large extent (Al-Shboul M. , Rababah, Al-Shboul, Ghnemat, & Al-Saqqa, 2014). Furthermore, if some groups of people cannot use or do not have access to these innovative technology, there may be a risk of marginalization (Kavanagh, 2019). The expansion of government electronic systems has been accompanied by the advent of novel technologies with enormous promise for altering public service delivery. Among these technologies are:

Artificial intelligence (AI) (Ahn & Chen, 2020): has the potential to transform government electronic systems by enabling automated decision-making, natural language processing, and intelligent virtual assistants. AI-powered chatbots, for example, can deliver immediate solutions to citizen enquiries, enhancing customer service efficiency.

Big Data Analytics (Joseph & Johnson, 2013): As electronic systems create more data, governments have more opportunity to use big data analytics. Large dataset analysis can provide useful insights for policymaking, resource allocation, and finding trends and patterns. Governments may use big data analytics to make better decisions, improve service delivery, and save money.

Blockchain Technology (Alketbi, Nasir, & Talib, 2018): Government electronic systems could become more efficient, transparent, and secure thanks to blockchain technology.. Smart contracts can enable safe and tamper-proof transactions, expedite administrative processes, and improve data integrity and privacy.

Internet of Things (IoT) (Gil-Garcia, Pardo, & Gasco-Hernandez, 2020): Connecting tangible objects to the internet so they may exchange data and communicate with one another is known as the Internet of Things (IoT). In the context of government, IoT can be used for smart city initiatives, infrastructure monitoring and management, resource optimization, and public safety.

Cloud computing (Hashemi, Monfaredi, & Masdari, 2013) delivers scalable and flexible computing resources to governments, allowing them to store and process massive amounts of data, deliver services, and collaborate across agencies. It allows for cost savings, agility, and scalability while eliminating the need for on-premises infrastructure.

The integration of state-of-the-art technology with electronic systems has promise for revolutionizing government processes, enhancing service provision, and increasing citizen engagement. Governments are increasingly looking into how these technologies might be used in areas including healthcare, transportation, energy management, and environmental monitoring.

2.6 Citizen Experience and User-Centric Design

Modern governments are adopting digital platforms to improve services and communicate with residents more efficiently in an era of lightning-fast technology breakthroughs (Impact, 2016). Citizenship Experience (CX) and user-centric design are important aspects of e-government work (Ślusarczyk, 2023). CX highlights the need for smooth, customized experiences that are tailored to each individual's needs and refers to the general impression that citizens receive when dealing with government services online (Cocoflo, 2023).

When creating digital interfaces, user-centric design places individuals at the center of the process, taking into account their preferences, expectations, and skills (Schneider, 2023). The significance of user-centric design and CX in e-government is examined in this subtopic, which also shows how these methods can boost efficiency, build public confidence, and produce more inclusive and accessible digital services for all Americans (Mayotte, 2023).

2.6.1 Benefits of Prioritizing Citizen Experience in E-Government Services

Giving the citizen experience top priority in e-government services has several important advantages (Alonso & Ambur, 2009). First off, by offering simple, easy-to-use interfaces and efficient procedures, it raises user satisfaction and engagement (Schneider, 2023). As a result, people have more trust in governmental organizations and think better of public services (Digital Gov, 2021). Second, by designing e-government services to specifically address the requirements of the people, a citizen-centric strategy guarantees more efficient interactions and personalized experiences (Nabben, 2022).

Furthermore, emphasizing the citizen experience encourages inclusivity by ensuring that digital services are available to everyone, irrespective of their level of technological skill or any limitations (Khan, 2023). Citizens feel more empowered and engaged as a result, which improves their relationship with the government (Nookhao & Kiattisin, 2023). In the end, putting the citizen experience first in e-government services improves efficacy, efficiency, and transparency, which benefits governance as a whole (Urbanemu, 2023).

2.6.2 Key Principles of User-Centric Design in E-Government

1. Empathy: To create digital services that genuinely meet citizens' issues, one must have a thorough understanding of their needs, expectations, and habits (Cocoflo, 2023).

2. Accessibility: Make sure that all individuals, irrespective of their skills or level of technology proficiency, may utilize e-government systems (Mayotte, 2023).

3. Simplicity: Make e-government services easy to use and intuitive for citizens by streamlining complicated procedures and reducing the number of steps needed to access them (contributors, Wikipedia, 2023).

4. Transparency: To foster confidence and uphold transparency, give clear details about the methods used to gather, store, and utilize citizen data inside e-government platforms (Alonso & Ambur, 2009).

5. Personalization: Adapt digital services to the preferences of citizens, providing opportunities for personalization that improve user experience and address specific needs (Digital Gov, 2023).

2.6.3 Challenges and Considerations in Implementing User-Centric Design in E-Government

User-centric design implementation in e-government comes with a number of challenges and problems (Mayotte, 2023). First, it is imperative to get over government agencies' resistance to change (Congressional Research Service, 2007). Adopting user-centric design ideas may be hampered by conventional bureaucratic structures and procedures (HandWiki, 2022). Furthermore, a smooth citizen experience depends on providing interoperability and integration across various government platforms and systems (Digital.gov, 2023). Concerns about security and privacy also surface as important variables, necessitating creative solutions to safeguard private citizen data while preserving usability (Nookhao & Kiattisin, 2023).

Additionally, it is critical to guarantee that e-government services are inclusive by catering to the various needs of residents with varying degrees of technological access and digital competence (Nelson, 2023). Lastly, improving the general citizen experience in e-government projects requires the establishment of efficient feedback systems and ongoing design iterations based on user insights (Cocoflo, 2023).

2.6.4 Successful Examples of Citizen-Centric E-Government Initiatives

The Estonian e-residency program is a prime example of a citizen-centric e-government initiative that has been effective (contributors, Wikipedia, 2023). This initiative, which was started in 2014, enables non-residents of Estonia to acquire a digital identity and use numerous government services from a distance (Srinivas, 2023). Over 80,000 e-residents from all over the world have registered for the program thanks to its user-centric approach, which allows them to form and manage businesses online, access banking services, and even digitally sign documents (Belderbos, 2023).

Simplified online platforms, streamlined procedures, and safe digital signatures all contribute to a simpler user experience (Gov.uk, 2023). This program shows how a citizen-centric strategy can provide access to government services for people anywhere in the world without requiring physical presence or needless red tape (Khoury R. , 2022). It serves as an example of how, globally, user-centric design in e-government improves accessibility and convenience for citizens (Gawde , Godhwani, & Sabnis, 2023).

There has been a paradigm change in recent years towards user-centric design and an emphasis on improving citizen experience in electronic systems. Governments are realizing how important it is to personalize services, streamline intricate procedures, and provide straightforward, user-friendly interfaces in order to meet the various demands of citizens. Usability, accessibility, and inclusivity are prioritized in user-centric design concepts, ensuring that electronic systems are available to all individuals, regardless of their digital literacy or physical skills. Governments are investing in user research, user testing, and iterative design processes in order to produce systems that are intuitive, efficient, and tailored to the expectations of citizens.

2.7 Considerations for Security and Privacy

In the current digital era, governments everywhere are adopting electronic means of service delivery and citizen communication, giving rise to the concept of e-government (Finworks, 2023). E-government has various benefits, such as increased efficiency, cost savings, and improved citizen accessible (Center For Technology On Government, 2000). However, as more public services are provided online, it is important to make sure that robust security and privacy measures are in place. This subtopic looks at the security and privacy concerns of e-government. (OCIO, 2023).

It explores the particular difficulties governments encounter in protecting private data while offering their citizens smooth digital services (Alonso & Ambur, 2009). Data protection, safe authentication procedures, encryption techniques, cybersecurity frameworks, and privacy laws governing e-government operations are just a few of the topics that will be covered in the discussion (Van Rijmenam Csp, 2023). Effectively addressing these factors can help governments preserve the privacy, accuracy, and accessibility of vital information while also fostering citizen trust (Assiri, 2021).

2.7.1 Challenges and Risks in E-Government Security and Privacy

Both governments and citizens have benefited greatly from the implementation of e-government programs (contributors, Wikipedia, 2023). Nevertheless, it has also brought with it a number of concerns and difficulties pertaining to privacy and security (Goldberg). The susceptibility of e-government systems to cyberthreats, including denial-of-service assaults, hacking attempts, and data breaches, is one major problem (Assiri, 2021). These attacks have the potential to interfere with crucial government services in addition to compromising private citizen data (Vaidyanathan, 2023).

Unauthorized access to personal data kept in e-government databases poses a danger as well because it may result in identity theft or improper use of personal data (PrivacySense.net, 2023). Furthermore, governments are facing challenges in upholding individual privacy rights while sharing data among agencies in an increasingly interconnected world (González, 2016). Additionally, strong encryption methods that are impervious to manipulation or interception are necessary to guarantee the security of electronic transactions within e-government platforms (OCIO, 2023).

2.7.2 Strategies for Ensuring Security and Privacy in E-Government

1. Robust Authentication Mechanisms: By putting in place robust authentication measures like two-factor authentication or biometric verification, users gaining access to e-government services can have their identities verified, reducing the possibility of unwanted access (Grassi, 2020).

2. Encryption and Data Protection: To prevent interception or unauthorized disclosure, sensitive data must be encrypted both during transmission and storage (Wade, 2023). E-government systems are more secret when they use secure channels of communication and encryption methods (Hoven, 2019).

3. Regular Security Assessments: Regular security assessments aid in locating weaknesses in the apps and infrastructure of e-government. Frequent vulnerability scans, code reviews, and penetration tests might find possible vulnerabilities that should be fixed right away (Finworks, 2023).

4. User Awareness and Training: Preserving a secure e-government environment requires informing users about potential security threats, safe surfing techniques, and responsible data usage (Assiri, 2021).

2.7.3 Best Practices for Implementing Secure and Private E-Government Systems

1. Comprehensive Risk Assessment (E-Government Act, 2015): When performing a thorough review of any potential security and privacy vulnerabilities pertaining to the e-government system, keep in mind both external and internal threats.

2. Robust Authentication Techniques (Cloudian, 2023): Use strong authentication methods, such as multi-factor authentication, to ensure that only authorized users can access sensitive government data.

3. Encryption and Data Protection (Van Rijmenam Csp, 2023): Protect data while it is in transit and at rest by using strong encryption techniques to stop tampering or unwanted access.

4. Regular Security Audits (Google Cloud, 2023): To find vulnerabilities, evaluate adherence to security guidelines, and guarantee the efficiency of put in place security measures, conduct regular security audits.

5. Privacy by Design (OCIO, 2023): Make sure that personal data is gathered, kept, and processed in accordance with relevant privacy regulations by including privacy considerations into the system's architecture from the very beginning of development.

Governments must prioritize security and privacy protections as their reliance on electronic systems grows. Maintaining citizen trust in e-government programs requires ensuring the secrecy, integrity, and availability of data. Governments are putting in place extensive cybersecurity measures including encryption, access controls, and intrusion detection systems to protect electronic systems from cyber assaults. Privacy frameworks and laws are being designed to safeguard citizen data and guarantee its moral and responsible use.

2.8 Prospective Trends and Challenges in E-government

Governments all across the world are embracing technology in this quickly changing digital age to modernize their antiquated administrative procedures into effective, citizen-focused solutions (Khoury R. , 2022). A paradigm shift known as "e-government," or electronic government, makes use of digital technologies to enhance public services, promote transparency, and stimulate civic engagement (Yasser M. , 2023). Among the several initiatives that fall under the authority of e-government are platforms for participatory decision-making, open data sharing, digital identity management, and online service delivery (Scytl, 2022).

The importance of e-government cannot be overstated (OECD, 2023). By making information and services easily accessible at all times and locations, it gives citizens more control (Granicus, 2022). E-government lowers expenses while increasing public administration's efficacy and efficiency through the simplification of bureaucratic processes (Trigyn, 2023). Furthermore, it increases openness by enabling citizens to monitor government activities and hold officials accountable for their actions. (contributors, Wikipedia, 2023). Governments must take into account a number of impending trends and problems as they continue to adopt e-government technologies (United Nations, 2021).

2.8.1 Current Trends in E-Government Implementation

Recent years have seen tremendous progress in e-government, with a number of new trends influencing its use (Impact, 2016). The use of mobile technology, which makes it simple for residents to access government services via their smartphones or tablets, is one of the major developments (Team WalkMe, 2023). By reaching out to residents who might not have access to traditional desktop computers, this trend towards mobile e-government not only improves accessibility but also fosters inclusivity (Team, WalkMe, 2023).

The emphasis on evidence-based policy formation and data-driven decision-making is another trend (OECD, 2023). Governments are increasingly utilizing big data analytics and artificial intelligence to assess vast amounts of data collected from various sources, facilitating more informed and efficient decision-making procedures (Team, WalkMe, 2023). Additionally, it is becoming more and more crucial to improve cybersecurity protections in e-government systems (Center For Technology In Government, 2022). Governments are placing a higher priority on preserving sensitive citizen data and defending against cyber threats as a result of the growing reliance on digital platforms (Khoury R. , 2022).

2.8.2 Prospective Challenges in E-Government Development

Notwithstanding the potential advantages of e-government, its successful adoption will need addressing a number of issues (Al-Shboul M. , Rababah, Al-Shboul, Ghnemat, & Al-Saqqa, 2014). The problem of the "digital divide," in which some societal groups do not have access to technology or have low levels of digital literacy, is one of the main obstacles (Bertuzzi & Bertuzzi, 2021). It will take aggressive measures to close this gap by offering reasonably priced and easily available internet connection as well as training in digital skills (SDG Knowledge Hub, 2022). Another difficulty is guaranteeing the confidentiality and privacy of citizen data (CPS HR Consulting, 2022).

Because e-government depends on gathering and storing enormous volumes of personal data, safeguarding this information from online attacks becomes essential (Team, WalkMe, 2023). To keep the public's trust, governments must make significant investments in strong cybersecurity measures and impose strict data privacy laws (CPS HR Consulting, 2022). The issue of interoperability is another difficulty for e-government projects (Al-Shboul M. , Rababah, Al-Shboul, Ghnemat, & Al-Saqqa, 2014). Disparate databases and systems are frequently used by several government departments, making it difficult for people to share and collaborate on projects smoothly (Trigyn, 2023). The creation of uniform frameworks and standards for data exchange would improve interoperability between different government agencies.

2.8.3 Future Trends in E-Government Services

Future e-government service trends are expected to bring about significant advancements and changes in public administration (Redwerk, 2023). The key idea behind e-government systems is the integration of cutting-edge technologies like artificial intelligence (AI), machine learning, and big data analytics (Yasser M. , 2023). Artificial intelligence could enhance decision-making, automate tedious tasks, and provide citizens with customized services (Team, WalkMe, 2023). Governments can use machine learning algorithms to analyze vast amounts of data, identify patterns, and predict future trends in order to make well-informed policy decisions.

Another trend is the application of blockchain technology to enhance the security, transparency, and trust of e-government transactions (Yasser M. , 2023). Blockchain allows for decentralized governance models that do away with the requirement for middlemen and tamper-proof record-keeping (Krishna, 2013). Furthermore, citizen-centric services with an emphasis on user experience design are becoming more and more important (Bertrand, Bakshi, & McQueen, 2022). Governments are investing more in user-friendly interfaces, mobile applications, and configurable dashboards to make public services easier for citizens to access (Trigyn, 2023).

Governments must ensure that the benefits of electronic systems reach all individuals, including those in underserved neighborhoods and vulnerable groups, through digital inclusion. To prevent worsening existing disparities, it is critical to bridge the digital divide and promote digital inclusion. As government electronic systems advance, addressing these future trends and issues will be critical to maximizing their potential and ensuring their positive influence on e-government efforts.

Intelligent automation, augmented reality, responsible data use, and digital inclusion are major themes that will influence the future of government electronic systems. Addressing these trends and obstacles is critical to realizing the full potential of electronic systems and guaranteeing their positive impact on e-government efforts.

3. Application of Innovative Technologies in E-Government

Recently, e-government initiatives have been adopted by governments worldwide, leveraging state-of-the-art technologies to enhance public service delivery and increase citizen engagement (Bron, 2023). The swift progression of digital technology has fundamentally transformed the functioning of governments, permitting them to optimize administrative procedures, enhance transparency, and promote citizen engagement (Maitra, 2023). This subtopic examines the field of e-government and the numerous advantages that result from using cutting-edge technologies (Explore Tauranga, 2023).

Governments everywhere are using cutting-edge technologies in the present digital era to revolutionize the way they deliver services. The efficacy of e-government processes is being enhanced by these cutting-edge technologies, which include blockchain, data analytics, artificial intelligence (AI), and machine learning (Energy E. C., 2023). Governments may improve citizen happiness and reduce bureaucracy by automating time-consuming operations like document verification and form processing (Kurbalija, 2023).

Furthermore, real-time insights from advanced data analytics help policymakers make well-informed decisions that result in more efficient use of resources and execution of policies (Intellias, 2023). Moreover, the use of AI-driven chatbots allows governments to offer 24/7 support to residents, freeing up human resources for more intricate questions (Ghunaim, 2018).

In the context of e-government, citizen involvement and participation are crucial for enhancing governance. More transparency, inclusion, and cooperation are now possible because to innovative technologies that have completely changed how governments engage with their constituents. Through smartphone apps and internet resources, citizens may provide feedback on policies, actively engage in decision-making, and foster the development of their communities (Romero, 2023). Direct communication between citizens and government representatives is made possible by real-time communication channels, which guarantee prompt answers to questions or complaints (Maitra, 2023).

Social media platforms also give people the ability to participate in important conversations and express their thoughts on public topics (Scytl, 2022). Through the use of cutting-edge technologies, governments can improve communication between citizens and legislators (Center For Technology In Government, 2022).

As governments strive to improve services and boost citizen engagement, emerging technologies could have a big impact on how e-government evolves in the future (Yasser M. , 2023). It is anticipated that artificial intelligence (AI) would transform many facets of government by providing individualized services, automated decision-making, and citizen virtual assistants (DXC Technology, 2023). By facilitating safe and transparent transactions, blockchain technology has the ability to enhance document management security and expedite procurement processes (Explore Tauranga, 2023). Smart cities with interconnected infrastructure, maximizing resource use and improving urban services, can be made possible by the Internet of Things (IoT) (Trigyn, 2023). Furthermore, for evidence-based policymaking, Big Data analytics can offer priceless insights into citizen behavior and preferences (Yasser M. , 2023).

The following section of this thesis will look at the practical application of electronic systems in e-government efforts, looking at case studies and best practices from around the world. We can get significant insights into the successful deployment and utilization of electronic systems in many situations by analyzing real-world instances.

3.1 Mobile Government

The swift progressions in mobile technology have significantly affected several sectors, such as e-government, in the past few years. The phrase "e-government" refers to the process by which public services are delivered to citizens by government organizations via digital and electronic channels. The increasing prevalence of mobile devices and ubiquitous connectivity is being utilized by governments globally to improve their service delivery methods.

By giving citizens easy access to government services anywhere at any time, mobile technology has many advantages for e-government. People can use their smartphones or tablets to easily do administrative chores, access information, and communicate with government entities through mobile applications. Furthermore, ubiquitous connectivity makes it possible for governments to create channels of real-time communication with the public, improving openness and responsiveness.

Mobile technology has revolutionized the delivery of e-government services and provides governments and citizens with a number of benefits. First of all, people no longer need to physically visit the government or wait in line to get services from anywhere at any time. This is made possible by mobile technology. For both parties, this convenience results in significant time and resource savings. Second, mobile devices improve the user experience while dealing with e-government platforms by providing a customized and intuitive interface.

On their mobile devices, citizens may simply browse through a variety of services, apply for jobs, make payments, and get real-time updates. Furthermore, mobile technology guarantees quick answers to questions or concerns by enabling speedier connection between citizens and government representatives via chatbots and instant messaging. Furthermore, governments can ensure inclusivity and reach a larger audience by offering services to those who might not otherwise have access to traditional computers or the internet, thanks to the widespread usage of mobile technology.

3.1.1 Introduction to the Mobile Crowdsourcing

The inadequate financial and human resources are a fact that leads the organizations to find complementary ways of accomplishing their management goals. A popular idea in recent years has been to outsource the task of finding new ideas to the «crowd» (Palacios et al., 2016). The crowd could be an online community, the clients or the stakeholders of this organization. The whole process has been baptized "crowdsourcing" by the scholars. Crowdsourcing is the practice of assigning work that is normally done by staff to a group of people via an open call, according to Howe (Howe, 2006). Estelles-Arolas attempted to refine the definition of crowdsourcing based on existing definitions. This led to the definition being defined as a sort of participatory online activity where a person, an institution, a non-profit organization, or a company proposes, through a flexible open call, the voluntary undertaking of a task to a group of people with varying levels of knowledge, heterogeneity, and number (Estellés-Arolas & González-Ladrón-deGuevara, 2012).

In their discussion of the structure of crowdsourcing, Hazleen Aris and Marina Md Din list the following as its primary components: user, process, task, content, platform, and reward (Hazleen & Marina, 2016). Users may be the ones who design a task or who engage in it, according to Hazleen. There are two types of participants: active and passive. Active participants aid in the crowdsourcing process by giving the task creators relevant information that could help solve the problem. Usually, passive participants watch and take advantage of the information offered. The procedure covers every phase of crowdsourcing, from the start of the project to its conclusion. The suggested problem for solution is referred to as the "task" in this context. The kind of data that the engaged participants submit to finish the crowdsourcing process is called content.

The incentive may be extrinsic or intrinsic (Zhao & Zhu, 2014) and the latter may be classified as non-financial or financial. The medium that links the task creators and the participants is called the platform.

The rise in demand for mobile phone subscriptions and broadband connections established a new important medium for communication, the mobile medium. The ITU estimates that in 2016, there were 2,513 million active mobile phone subscriptions in poor nations and about 1,140 million active mobile phone subscriptions in affluent nations (ITU, 2016). Regionally, the Commonwealth of Independent States had the fewest active mobile broadband customers (150 million) and Asia & Pacific the largest (1,755 million).

Due to the increasing usage of mobile phones in scholarly crowdsourcing research, many authors have tried to define mobile crowdsourcing. Mobile crowdsourcing is defined by Daren C. Brabham, who describes it as an online, dispersed paradigm for production and problem-solving (Brabham, 2012). Mobile crowdsourcing, according to Yufeng and other academics, is the fusion of crowdsourcing with smartphone-based mobile technologies, which provides a great deal of flexibility and creates a new computing paradigm (Yufeng et al., 2016). According to Yufeng et al. (2016), task publishers, crowdworkers, and crowdsourcing platforms are the three parties involved in this notion. Therefore, a task publisher assigns a task to a crowdsourcing platform, and the crowdworkers use mobile devices as a medium to offer their feedback. This is how mobile crowdsourcing works.

The mobile medium features mobile crowdsourcing applications, and these are divided into applications that use human intelligence and human sensors (Yufeng et al., 2016).

Applications focused on human intelligence use human knowledge to tasks that prove challenging for computers to accomplish, such as natural language processing. The human sensor applications leverage mobile device owners' sensors to produce data that computers can process later (think smart transportation). Mahmud and Aris (2015) also studied the state of the art of mobile crowdsourcing applications and categorized them into the following groups based on their goals: social networking, weather, dictionaries, sound identification, traffic and navigation, 3D creation, translation, disaster reporting, and utilities. The categories with the greatest number of applications are traffic and navigation.

3.1.2 Crowdsourcing in the Public Administration: The Proposed Innovative Framework

The fact that crowdsourcing has a favorable impact on the public sector, as reported by a number of experts, is what spurs the investigation of crowdsourcing in this domain. Seltzer and Mahmoudi supported the argument that crowdsourcing enhances participation in planning and public policy making (Seltzer & Mahmoudi, 2013). Crowdsourcing, particularly through social media, has emerged as a tool for citizen-government interaction (Criado, Sandoval-Almazan, & Gil-Garcia, 2013). Carreras, Miorandi and Tamilin, consider that crowdsourcing has application in decision making and quality assessment campaigns of public services (Carreras, Miorandi, & Tamilin, 2013). According to Zambranno and Eymann, crowdsourcing at local public sector level can improve the decision-making and the effective allocation of the public resources (Zambrano & Eymann, 2014). Hilgers and Ihl discussed how collaboration and innovation between citizens and public administration, improve the citizen's participation and political decision-making (Hilgers & Ihl, 2010). Additionally, Bott and Young explored the impact of crowdsourcing on democratic governance (Bot & Young, 2012).

Public administration is defined by McKinney and Lawrence as the study of how decisions are made by the government, as well as the examination of the policies themselves, the different inputs that went into creating them, and the inputs required to create alternative policies (Lawrence and McKinney, 1998). According to Rosenbloom, the discipline of management appears to be another crucial component of public administration, requiring ideas and procedures related to politics, law, and management (Rosenbloom, 1986). Other academics who use the term "management" to describe public administration as the management of public programs are Robert and Janet Denhardt (Denhardt & Denhardt, 2009).

Applications are typically used in the use of crowdsourcing in public administration. Mobile crowdsourcing applications for public administration look at a number of topics related to critical indicators for enhancing citizens' daily lives, like criminal activity and the identification of public assets. Dhruv discusses "Project Jagriti," a mobile application that serves as a venue for reporting crimes, especially those involving assault against minors (Dhruv Chad, Sankaranarayanan and Sharma, 2014). This software was developed in order to help the government lower crime rates by encouraging people to report this kind of criminal activity anonymously. The issue facing the government in this instance is the small number of police officers who are implicated in crimes against minors. Because it encourages people to report crimes without raising the expense of hiring more police officers, this application offers a competitive edge. Afya Ya Barabara is a mobile crowdsourcing application that Njuguna and other academics created (Njuguna et al., 2014). In addition to receiving tweets from people pointing out issues with the road surface, the program visualizes statistics regarding the state of Nairobi's roads. The primary use of this program is to allow citizens to monitor public spaces, such as roadways, in situations where the government is unable to promptly identify and address emerging problems. Ouyang and other academics (Ouyang et al., 2013) discussed the usage of the iSee mobile crowdsourcing application, which targets and localizes illegal acts like smoking and graffiti in public settings.

3.1.3 Reading the Literature

To find out the present status of the study field, we start our investigation by searching well-known databases for relevant information. The selection of databases is generally determined by factors such as popularity and relevance to the research perspective. Three well-known databases that are often utilized by academics are included in our discussion of the topic from an IS perspective: Google Scholar, Scopus, and Web of Science. Table 1 shows the search parameters that were utilized for the literature research. The search for publications in the databases was carried out by filtering the findings.

Criteria types	Options	Argumentations.
Year Of Publication	1950 – Present	1950 represents the oldest year that SCOPUS could index a published work
Subject Area	Business, Computing	Subjects sections that reflect the various viewpoints on the subject.
Document Format	Journals, Conference Papers	Document kinds of significant scholarly weight.
Keywords	“Mobile Crowdsourcing” AND "government" OR "public administration" OR «public policy" OR “public governance” OR “public sector”	Keywords most pertinent to the subject.
Language	English	Due to the requirement for research data from academic works with international potential, the English language was chosen.
Databases	Scopus, Web Of Science, Google Scholar	As a meta-database, Scopus contains information from other databases. Google Scholar and Web of Science are two

		better-regarded databases among academics studying information technology.

Table 1 Criteria for literature research

The first total of records that satisfied the requirements came from the study done for scholarly publications on the popular databases. Not every record, though, had anything to do with the topic. The fact that this study addresses mobile crowdsourcing within the field of public administration rather than governance in general is particularly significant. Furthermore, mobile media was not the exclusive channel for crowdsourcing in a number of academic conclusions; that being said, we also included publications in which the author's research heavily relied on mobile media. Up until we arrived at the final number of records for additional analysis, the initial total of academic records was filtered. The procedure that was used was as follows:

1. Identification: Three duplicate records were eliminated after 330 records were found using the keywords.

2. Screening: Of the 327 records that were screened, 259 were discarded due to their non-compliance with the language and document type search parameters. Because Google Scholar suggested articles with academic content but sourced them from non-academic sources such websites, newspapers, and other sources, the majority of the results were eliminated.

3. Eligibility: Of the 68 full-text documents that were accessible, 46 were deemed irrelevant to the topic of my research and were so excluded.

4. Structuring: A total of 22 documents were kept and arranged into categories and themes in preparation for additional research.

3.1.4. Application Areas

The 22 documents that remained were categorized by segmenting the current bibliography according to the domains in which mobile crowdsourcing is employed in public administration. We concluded that the following public administration application areas had been identified after examining the literature: Infrastructure maintenance, environmental reporting, critical situation reporting, and crime watch reporting.

Information about a city's buildings, roads, and other assets is referred to as infrastructure maintenance. Information pertinent to an administrative area's green spaces and weather is deemed part of environmental reporting. The information that is discussed during emergent situations, such natural disasters and political crises, is known as critical situation reporting. Information about an area's safety and security can be found in the application area of crime watching. The findings are categorized in Table 2 according to the application area and content dimensions.

Academic Work	Type Of Application	Application area
(Harding et al., 2015)	Civic engagement in the design of a city maintenance system	Infrastructure maintenance
(You et al., 2016)	Citizen sourcing through the City Feed platform	Infrastructure maintenance
(Zeile, Memmel, & Exner, 2012)	Data accuracy on crowdsourcing for city maintenance	Infrastructure maintenance
(Santos, Rodrigues & Oliveira, 2013)	Presentation of city infrastructure maintenance applications	Infrastructure maintenance
(Njuguna et al., 2014)	Roads condition reporting	Infrastructure maintenance

(Aubry et. al., 2014)	Roads condition and safety	Infrastructure maintenance
(Balena, Bonifazi, & Mangialardi, 2013)	Urban utilities management	Infrastructure maintenance
(Barron et. al, 2014)	A mobile mapping and data hub platform to assist urban maintenance	Infrastructure maintenance
(Stevens & Hondt, 2010)	Noise pollution crowdsourcing	Environmental reporting
(Indris et al., 2016)	Ecotourism asset mapping	Environmental reporting
(Kanhere, 2011)	Data collection on environmental monitoring	Environmental reporting
(Wiwatwattana, Sangkhatad, & Srivatanakul, 2015)	Weather forecast verification	Environmental reporting
(Wakasa & Konomi, 2015)	A crowdsourcing process for green mapping	Environmental reporting
(Hupfer et al., 2016)	App presentation with scenario of critical situation use	Critical situation reporting
(Boulos et al., 2011)	Public health surveillance and crisis management crowdsourcing	Critical situation reporting
(Frommberger & Schmid, 2013)	Platform and task design on crowdsourcing for disaster report	Critical situation reporting
(Sweta, 2014)	Platform usability on crowdsourcing for disaster report	Critical situation reporting
(Liao et al., 2014)	Mobile framework for public safety in smart cities	Critical situation reporting
(Ariffin, Solemon and Bakar, 2015)	Evaluation of crime watch applications	Crime watch reporting
(Peuchaud , 2014)	Social media crowdsourcing for sexual harassment incidents	Crime watch reporting

(Shields & Stones, 2014)	Crowdsourcing for violence prevention	Crime watch reporting
(Huang et. al., 2015)	Academic campus safety reporting	Crime watch reporting

Table 2 Literature categorization

3.1.5 Infrastructure Maintenance

ICT design for civic participation and trust in the context of civic urban maintenance was the subject of a study written by Harding and other academics (Harding et al., 2015). The researchers address the infrastructure maintenance (I.M.) application type in this instance, which incorporates public opinions regarding the upkeep of an administrative region's infrastructure. Interviews with citizens and civic authorities—two stakeholders in civic engagement—were conducted as part of their hybrid research technique in the first phase. A prototype system was developed and tested as part of the experiment that comprised the second stage of the process. In addition to taking into account the needs of all stakeholders, this methodological approach is fair because it connects the first and second parts by using the survey results to develop the prototype system. The writers approach the topic from two paradigms of information systems research, behavior and design, from a research standpoint (Henver et al., 2004). Thus, from the perspective of crowdsourcing research, the authors add to the needs for an information system for crowdsourcing by recommending trust as a component that could be helpful in platform design. The primary conclusion of this article is that there is a lack of trust between the populace and the municipal authority. Both the public and civic authorities are concerned about lawsuits from the public and how the government is handling their personal data. This mistrust presents a research issue because crowdsourcing can be made better if researchers can determine what influences people's trust in a system.

You and other authors discuss another kind of I.M. application (You et al., 2016). They discuss CITY FEED, a smartphone platform that encourages community participation in municipal affairs. The authors mention four advantages of CITY FEED: 1. Citizen satisfaction is higher and service costs are lower. 2. The feed analysis is a task that can be accomplished with less human effort thanks to the platform mechanism. 3. It is possible to continuously enhance service performance. Access to open information might be a benefit to those involved in integrating value-added services. Using a case study approach, the researchers are able to examine the system primarily from the viewpoint of the person assigning the tasks. Nevertheless, I think the authors may supplement their study and look at the perspective of the task participants by using other resources, such a survey. Regarding crowdsourcing, the study undervalues the participant's perspective (citizen happiness, open information access) and emphasizes the work assigner's perspective (service cost, platform analysis method). This crowdsourcing effort is noteworthy for its analysis of the system's primary operations, including task publication, transaction, interaction, collaboration, and evaluation, in order to assess the system's maturity. In particular, identifying the benefits and drawbacks of the system may result from the examination of every procedure. As a result, the authors list the following research issues with relation to CITY FEED's crowdsourcing mechanism: enhancing the platform analysis mechanism, expanding the sources of information fed into the feed, and establishing the legitimacy of the crowdfeeds. In Harding's work, there is mistrust between the participants (citizens) and the task assigner (civic authority), which highlights the arguments of data credibility and trust. Regarding how the task assigner and participant interact, trust is noted as a crucial element of crowdsourcing in both publications. The lack of trust between the two parties indicates a risk for information security regarding each party's participation in the crowdsourcing implementation.

Zeile and other researchers are investigating the significance of location in infrastructure maintenance (Zeile, Memmel, & Exner, 2012). Zeile introduced the

RADAR SENSING app, which lets users use their smartphones to submit location-based data. The purpose of this program is to collect scientific data regarding city architecture and patterns. Through the creation of a mobile I.M. application and citizen testing, the researchers employed the experimental approach. While Harding employs a hybrid research style, Zeile and the other researchers choose their studies according on the caliber of the data that is submitted. The authors specifically point out a number of issues that are connected to the data that was contributed during the crowdsourcing campaign. Firstly, there is a risk of biased data because the crowdworkers are not a diverse population and their data contributions may appear similar. The second question raised by the authors is how to identify and remove inaccurate data that results from GPS problems. In terms of research, the writers support crowdsourcing by pointing out the homogeneous data issue, which raises questions about participant trust and task assigner confidence. This presents a research issue as well because other writers, such You (You et al., 2016), have previously brought up the subject of data accuracy in crowdsourcing. Therefore, additional researchers should consider the issues of data accuracy and trust in order to enhance the results of crowdsourcing.

In order to help the local government save money and manpower, Santos suggests an I.M. application that deals with municipal upkeep (Santos, Rodrigues, & Oliveira, 2013). The public can use a web browser or a mobile device to report on a number of non-urgent city issues. Santos employs an experimental methodology in the development of an application that leverages data compression technologies to minimize the volume of data sent. In contrast to the earlier writers who examined data accuracy in crowdsourcing, Santos's work advances the field by examining the volume of data that is provided. In a related endeavor, Santos investigates crowdsourcing from the perspective of usability, highlighting the significance of the application's colors and Android icons. In this instance, determining if the application's colors and icons influence how widely the mobile system is adopted is the study problem.

Along with this, Njuguna and the other writers talk about a reporting application for the upkeep of the city, namely for Nairobi's roads (Njuguna et al., 2014). Njuguna creates the I.M. mobile application AYB, utilizing the experimental approach. By integrating the usage of social networks with the reporting application, the author addresses the topic of citizen engagement. Because Njuguna's work emphasizes the importance of social networks as a trustworthy source of information to enlighten the public and public servants, it contributes to the crowdsourcing movement. The primary element that Njuguna recommends for citizen participation in crowdsourcing is the application's social awareness functionality. That time, measuring the effect of social awareness on the adoption of mobile crowdsourcing was the research challenge. To improve their work, the authors could assess how widely users of social networks use the application. The I.M. application for road condition and safety that Aubry (Aubry et al., 2014) discusses is another one. Crowd Out is a mobile crowdsourcing service that Aubry recommends for city traffic safety. In actuality, this is a mobile application that lets users report issues with traffic, including poor road conditions and illegal parking. By testing the app in France, the writers investigate this I.M. application through an experimental methodology. The fact that both task designers and task participants can access the crowdsourcing data is one way that this technology contributes to crowdsourcing. As a result, both target groups are able to examine the data and provide recommendations for possible fixes for the traffic problems. The authors have identified data reliability, anonymity, and privacy as study challenges. Since the writers who were previously mentioned also look at this matter, it is clear that data reliability is once again a significant concern.

Barron (et al., 2014) and Balena (Balena, Bonifazi, and Mangialardi, 2013) have addressed other urban I.M. issues, aside from road conditions. By developing a mobile application, both writers talk about public areas and city maintenance.

Balena developed an internet-based mobile application and tested it in Italy as part of an experimental research technique. His writings mostly consist of a technical explanation of his method with applications to municipal maintenance. Balena's research challenge is that crowdsourcing adoption in public settings might be associated with a feeling of community within a virtual environment. It is possible that the variable "virtual belonging" has a favorable impact on crowdsourcing for public areas in this way. Additionally, Baron employs an experimental approach by creating a mobile application that facilitates citizen involvement and maintains public participation records. According to Baron, information exchange between the public and the government will strengthen links between them. He emphasizes on the platform's design and the NFC sensors' utility in reporting issues to the government from a crowdsourcing perspective. Enhancing the platform's data analysis as a means of streamlining the local government's logistical procedures presents Baron with a research challenge.

3.1.6 Environmental Reporting

Stevens talks about a smartphone application that lets people gather information regarding noise pollution (Stevens & Hondt, 2010). Due to the crowdsourced data's relevance to the physical environment of humans, this application falls under the category of environmental reporting (E.R.). In order to generate a noise map, the community is being given access to the specific data (noise measurements). Through the development of the NoiseTube mobile platform, the authors experiment to validate their beliefs. Because the experiment was not finished when the report was written, the authors' concerns on their study effort are multifaceted. By showing how crowdsourcing can be utilized to address a scientific problem without requiring individuals to have sophisticated skills, this study contributes to the field of crowdsourcing. The writers face a number of research obstacles, usability being one of them. Specifically, using a smartphone as a data collector has usability problems, especially when the phone is in a pocket. The problem of multimodality in crowdsourcing is brought up by the limitations of smartphones as a crowdsourcing tool. It appears that until a better medium is selected, mobile crowdsourcing falls short in terms of data quality. Another research topic that the authors address in their study is crowdsourcing coordination. The researchers are looking for a subsystem that gives consumers more flexibility regarding the location and timing of the noise gathering. The authors' third area of study concern is the crowdworkers' confidence and the quality control of their data contributions. Trust and data accuracy are also emphasized in Zeile et al.'s work (Zeile, Memmel, & Exner, 2012).

Indris talks about an additional E.R. use case for crowdsourcing: assessing citizen performance in order to create an ecotourism map (Indris et al., 2016). In particular, Indri uses structured observation as a study approach to assess the qualities of the mobile application's user interface. Because it looks at crowdsourcing from a sociotechnical standpoint, this methodology—, which is primarily utilized in social, research—certainly makes a contribution to the field of crowdsourcing research. Because usability is a component of crowdsourcing, Indri considers people to be a geo-crowdsourcing sensor. In addition, the writers address age and literacy levels in their discussion of the crowdsourcing campaign's success. These abilities present a research difficulty since the authors fervently contend that mandating instruction for task participants would be a wiser course of action than enhancing mobile device design. Accordingly, a recent study hypothesis proposes that age and education have a good impact on E.R. crowdsourcing.

Wakasa and Konomi (2015) propose a participatory green mapping and networking system in which community members map nearby parks and other green spaces. This E.R. application is based on the role of the citizens as task participants, and the task creator is proposed by the authors to be the local government of Kashiniwa. The platform that is being used is a multichannel one since the gathering of the content will be provided by using Google Street Images, existing data by the governments and a smartphone-based mobile crowdsourcing tool. Wakasa and Konomi’s method is an experiment because they have developed a prototype that gathers mobile requests. The authors' contribution to crowdsourcing is their attempt to increase citizens' active participation by using greenness continuity as a goal. The authors' research objective is to improve the crowdsourcing process's design and advocate for the common good (or "greenness") as a driving force behind system adoption.

Research on E.R. crowdsourcing is conducted by another scholar, Kanhere (2011). He talks about how citizens can contribute data by utilizing their mobile phones and how data can be shared for environmental monitoring through relevant statistics. In addition to contributing to crowdsourcing research by highlighting the significance of the device's sensor, Kanher discusses participatory sensing applications using an exploratory research technique. Furthermore, the authors discuss the first research issues of data quality and context of use. The crowdworkers are under no duty to report all available data because they provide their data voluntarily. Furthermore, as the setting—such as the weather—may have an impact on both users and mobile devices, the context of use throughout the crowdsourcing process may also have an impact on the research's findings. Trust and privacy present additional difficulties since users worry that their personal information will be disclosed and task assigners worry about putting their trust in volunteers who might provide harmful data.

Wiwatwattana employs citizens as an information hub to confirm weather conditions and investigates the use of mobile crowdsourcing for weather forecast verification (Wiwatwattana, Sangkhatad, & Srivatanakul, 2015). Because many academics emphasize technology but undervalue data verification, Wiwatwattana adopts a case study research methodology and contributes to crowdsourced research. In addition, the academics address the veracity of crowdsourcing data and wonder how we might embrace it in the name of a new fad rather than confirming its truth and worth. Thus, the research issue here is to balance the value of precise data with the adoption of a novel data collection method.

3.1.7 Critical Situation Reporting

In order to facilitate citizen participation in data collection and dissemination to scientists who would then map the data, Hupfer and his co-authors developed the MoCoMapps smartphone application (Hupfer et al., 2012). Emergency response is one application scenario where citizens are requested to submit critical situation reports (C.S.R.).The mobile application prototypes are used and tested by the writers as part of their experimentation process. The authors' discussion of the importance of communal design in a crowdsourcing system advances the field of crowdsourcing research. From a crowdsourcing perspective, collective design could be contingent upon the device's dimensions and unique characteristics, such color and screen resolution. Nevertheless, as was already said, Indris undervalued these technical limitations (Indris et al., 2016) and contends that education makes up for the technical shortcomings of the gadget. The technological characteristics of the gadget as a determining factor in the crowdsourcing system design presents this case's research problem.

Frommberger discusses at Mobile4D a system that consists of an Android application, a web front end, and a disaster management server (Frommberger & Schmid, 2013). The technical system’s scope is to gather information that citizens contribute to the reporting of disaster events, so this is another C.S.R. type of application. The work’s contribution to crowdsourcing is on a technical level because, as the scholars state, they research two important issues found in the current crowdsourcing systems: missing institutionalization and missing two-way communication. Therefore, the research challenges for the authors were in the areas of the system's usability and the visualization of the information.

Furthermore, a disaster management system that allows residents to report on the effects of a prospective disaster on their locality was described by Sweta in 2014 (Sweta, 2014). The platform is a mobile CSR system that may also be put on numerous free websites with a disaster theme. The mobile application is being developed and tested by the authors as part of their research technique, experimentation. In terms of crowdsourcing research, the writers concentrate on the platform's smooth operation that requires very little literacy. The platform's usability facilitates communication between participants and task assigners without the need for specialized technical knowledge. Accurate data is one of the research challenges. The question of whether GPS functionality may be made optional for task participants arises since GPS malfunction is a prevalent issue in crowdsourcing. The authors also note that social media presents a research problem because it provides a low-cost and simple means of sharing and verifying information through crowdsourcing. It would be intriguing for other academics to look into the production costs of social media crowdsourcing campaigns.

As a result, Liao (Liao, et al., 2014) investigates situation awareness in smart cities using the residents' smartphones' efficient operating systems. Liao uses experimentation as a methodology, creating and testing a C.S.R. mobile application that gives citizens sensing tasks to complete. Because the authors' method shortens the response time for crowdsourcing jobs, it makes a valuable contribution to the field of crowdsourcing research. The authors state that security and privacy present research obstacles, particularly in larger-scale trials. In this instance, developing a new heuristic algorithm may be able to reduce these hazards.

Hence, Boulos discusses theoretically C.S.R. applications of health surveillance and crisis management by performing an exploratory type of research (Boulos, et al., 2011). His contribution to crowdsourcing research is minimal, and mainly it is a state-of-the-art review without providing empirical data. Of course, the research challenge for the author would be to augment his work by gathering empirical data about citizen sensing and categorizing the application areas.

3.1.8 Crime Watch Reporting

The concept of keeping an eye on actions that may be connected to possible illegal conduct is the subject of a research topic called "crime watch reporting" (C.W.R.). Based on factors deemed significant to the system and its users, Ariffin assesses six mobile crowdsourcing apps for crime watch (Ariffin, Solemon, & Bakar, 2015). In order to perform an exploratory type of research, Ariffin reviews the literature in an unsystematic manner. The platform-centric assessment standards have no bearing on the other components of crowdsourcing, such task assigners and task participants. His research on crowdsourcing is valuable since it provides new readers with an overview of C.W.R. crowdsourcing. The author's study challenge is to conduct a systematic literature review, which will be used by other scholars to validate his application evaluation criteria and highlight the significance of C.W.R.

Peuchaud investigates social media as a substitute channel for information about sexual harassment episodes using a case study research methodology (Peuchaud, 2014). His primary input to crowdsourcing is that he details his investigation into a particular illicit practice: sexual harassment. Peuchaud's research could therefore be useful to the authorities who are hoping to lower this crime rate. While crime and other political situations are relatively new, are they always reported on via cell phone? The fact that alternative technologies might be helpful for crowdsourcing in an emergency appears to be the author's research challenge in this case. In C.W.R., crowdsourced research could therefore be expanded by considering the medium as well.

In Shields (Shields & Stones, 2014), the topic of using mobile phones as a crowdsourcing tool in times of political unrest is examined. Using a case study approach, he backs up the claim that people use mobile phones a lot for personal usage but not for providing information during political emergencies. Since Peuchard and Shields lack sufficient empirical evidence to address the topic of whether crowdworkers will utilize their mobile device in an emergency, the context of use appears to be the practical issue for both of them. The context of use (such as a hazardous circumstance) for mobile crowdsourcing presents a research difficulty in this instance.

Huang explored the willingness of the students to participate in crowdsourcing actions regarding the campus's safety (Huang et al., 2015). The authors used a methodology that included a lab experiment and an MTurk study to understand the different factors that affect a student's willingness to crowdsource through a mobile app. The overall findings indicated that the student's willingness to provide information for the safety report was influenced by location and crime type, but not by the time of day. While methodologically, a mix of methods can produce satisfactory research results, the authors refer to the risk of biased research results. The reason behind this is the fact that the students were given examples of crime incidents and asked how they would react on these occasions. As Huang states, in practice, they might not choose to react to these crime incidents because other factors might affect their decision.

The authors' work contributes to the level of crowdsourcing adoption by implying that crime type and incident location influence the user's intention to use C.W.R. crowdsourcing.

Therefore, the authors propose that the mobile application's design might benefit from the inclusion of time and location elements. The authors' task would be to compile all of these details (incident kind, time, and place) and create a conceptual model for the use of C.W.R. crowdsourcing. Scholars and authorities who wish to further C.W.R. could benefit from this paradigm.

3.1.9 Conclusions and Future Work

In the specialized field of public administration, mobile crowdsourcing is being investigated in contemporary academic work. Public administration has not used crowdsourcing as much as other fields, with most academics concentrating on the practice in the public sector as a whole. Public administration, which takes into account the implementation of government policy, is distinct from public governance in the field of public management. The bureaucratic obstacles that significant social actors create make it difficult for the public administration to implement public policy (Peters & Pierre, 1998). Hughes (Hughes, 2003) has also brought up the subject of bureaucracy in public administration, criticizing it as "an administration under the formal control of the political leadership, based on a strict hierarchical model of bureaucracy". If a first-hand policymaking study were conducted to determine the public policy's implementation technique, bureaucracy would be avoided.

Because it focuses on public workers who interact with administration and looks for ways to enhance their job performance, our study has a practical benefit. By examining the business potential for the current domains of public administration, the study will also be helpful to mobile service providers and decision-makers in public spending.

In the present research, mobile crowdsourcing is covered under four distinct themes. Eight items are related to infrastructure maintenance, five to environmental reporting, five to critical situation reporting, and four to crime watch reporting. The upkeep of the city's physical assets is related to the first area, which is infrastructure maintenance. Since the authors discuss data accuracy, one significant study difficulty is the caliber of user-submitted data (Zeile, Memmel, & Exner, 2012). Zeile backs up the claim that inaccurate data—, which arises from consumers entering data incorrectly or from a weak GPS, signal—is a problem. Financial loss due to inaccurate asset maintenance forecasts is a possible concern for city decision-makers. The lack of trust between task assigners and task participants is another challenge in research (Harding et al., 2015; You et al., 2016). Because they do not think the government is a reliable institution, the populace feels that civic engagement will be fruitless. Privacy concerns are still another problem (Aubry et al., 2014). Concerns over the substance of the photographs that the task participants submitted surfaced during the testing of Aubry's mobile application about traffic in the city.

Environmental reporting, which deals with the usage of mobile crowdsourcing in residents' physical environs, is the second application area. Trust (Stevens & Hondt, 2010) and data problems: frequent research challenges with infrastructure maintenance include data contribution (Stevens & Hondt, 2010), data quality (Kanhere, 2011), and data correctness (Wiwatwattana, Sangkhatad, & Srivatanakul, 2015).The data-driven obstacles associated with environmental reporting highlight the need for enhanced crowdsourcing research from a data standpoint. Nonetheless, the following are the latest crowdsourcing research challenges:

The context of usage (Kanhere, 2011), usability (Stevens & Hondt, 2010), and user literacy skills (Indris et al., 2016) The term "usability" describes a mobile phone's capacity to gather data, which occasionally varies depending on the kind of data. According to Stevens, users must be literate in order to take part in crowdsourcing. Furthermore, the context of use matters because a user's behavior towards crowdsourcing may be influenced by their surroundings.

Critical situation reporting, where citizens are asked to report on new situations like catastrophic events, is the third application area. In terms of crowdsourcing, the researchers offer feedback on the layout and functionality of their platform, addressing technological problems such the absence of two-way communication. In theory, the platform is crucial in emergency scenarios since crowdsourcing has the potential to save lives. Nonetheless, the majority of the writers refer to nontechnical elements and research obstacles that have already been discussed, including data accuracy (Sweta, 2014), privacy (Liao et al., 2014), and education (Hupfer et al., 2012). As such, compared to environmental reporting and infrastructure maintenance, there are either few or no new research issues in the critical situation report.

Crime watch reporting, where citizens report on criminal incidents, is the fourth application area. Similar to the third application area, this application area deals with crucial situations; however, it exclusively addresses incidents that are criminal in character from a legal perspective. Researchers mostly look at this field of study from the perspective of the crowdsourcing process, seeing mobile crowdsourcing as a substitute for traditional media or as a tool for political crises (Shields & Stones, 2014). (Peuchaud, 2014). Ariffin (Ariffin, Solemon, & Bakar, 2015) also discusses the technological aspects of the mediums as well as the participant's readiness to utilize their mobile device during a criminal incident (Peuchaud, 2014) (Shields & Stones, 2014). In this instance, the crowdsourcing technology and location present research problems. The latter poses a question about the characteristics of mobile crowdsourcing. Are smartphones appropriate for using in mobile crowdsourcing? What about employing wearable technology or tablets or other mobile devices?

Moving from classifying the crowdsourcing application areas to classifying the authors' research issues is an addition or a research challenge for the current study. First, it should be noted that the study difficulties encompass both non-technical (privacy, trust, education, and usability) and technical (primarily data-oriented) aspects. While the screening of the publications made this clear, it is nevertheless advisable to validate our findings using a systematic process. It is possible that a content analysis technique will identify every research challenge and its classification using keywords that carry extra weight.

According to Morschheuser's empirical research, gamification is an intriguing way to boost motivation and involvement in crowdsourcing (Morschheuser, Hamari, and Koivisto, 2016). The term "gamification" describes the application of components of game design in non-gaming environments (Huotari & Hamari, 2012). It can also be a novel idea in the public sector (Michaelides, 2016).

3.2 Artificial Intelligence (AI)

Artificial intelligence (AI) has great promise for e-government as a game-changing technology. Computer vision, natural language processing, and machine learning are some of the subfields that make up artificial intelligence. Governments are using AI in a number of ways to streamline administrative processes and enhance service delivery. Governments are utilizing AI-driven chatbots and virtual assistants to facilitate customer service interactions and provide prompt answers to public inquiries. These smart bots can assist citizens in navigating government services, understand natural language, and offer tailored advice.

Machine learning algorithms are used to analyze large datasets in order to identify trends, patterns, and anomalies. These insights can help governments adopt targeted policies, make data-driven decisions, and allocate resources more effectively. For instance, machine learning algorithms are able to anticipate citizen needs, optimize transit routes, and identify fraudulent behavior. AI technology aids in the automation of e-government as well. Repetitive and rule-based tasks are automated using RPA, giving government employees more time to concentrate on more difficult and strategic tasks. AI-powered solutions that automate data entry, workflow management, and document processing can increase productivity and decrease errors.

There are several benefits of using AI in e-government. Through personalized interactions, it improves user experience, speeds up and improves the accuracy of service delivery, and assists governments in making more informed decisions based on data insights. However, ethical concerns around the proper application of AI, privacy protection, and transparency need to be addressed in order to uphold public trust and eradicate any biases.

3.2.1 Adoption of Artificial Intelligence in the Government

Artificial intelligence is becoming more widely used in the business sector, but the public sector appears to be lagging behind. The use of this cutting-edge technology by people and public personnel is restricted for certain reasons. To demonstrate the benefits of artificial intelligence, this article first lists the advantages and possible obstacles to its application in the public sector. Subsequently, an Octalysis gamification framework is proposed as a means of influencing stakeholders' intent to utilize artificial intelligence. Octalysis is made up of eight basic drivers that characterize the kinds of incentives and game features that the perfect gamified system need to have. Lastly, the Octalysis paradigm is implemented on an active public sector chatbot that provides details about Dubai's public administration. The information system is rated according to how likely it is to become gamified through the use of Octalysis. Lastly, a few gaming components are recommended to raise the system's overall score and aid users in effectively utilizing artificial technology. This paper's practical significance comes from its recommendation of Octalysis and gamification as helpful tools for decision makers who want to implement this technology in public organizations. The next great thing in entertainment and assisting the public sector in utilizing new technologies may be games. The citizens will not be able to take advantage of all the advantages artificial intelligence (AI) has to offer the digital world if the public administration does not embrace this fascinating notion.

3.2.1.1 Introduction

The 1940s saw the start of the investigation into artificial intelligence (AI) (Bush, 1945; McCulloch & Pitts, 1943), and it continued into the 2010s (Kouziokas, 2017; Ayoub & Payne, 2016) and beyond. Artificial intelligence (AI) systems function autonomously, identifying and interpreting patterns to arrive at logical decisions (Čerka et al., 2016). In addition, artificial intelligence (AI) describes a device's capacity to reason by assessing its surroundings, evaluating data, and taking action to accomplish a desired outcome (Russell & Norvig, 2016). Artificial intelligence has been a hot issue for discussion among scientists and has been implemented in a number of fields. The public sector is among the last to implement AI, yet because of its potential, several nations have chosen to do so at this time (Boyd & Wilson, 2017).

The creation, modification, and use of the proper algorithms and technical techniques that result in the administration of public offices are all part of the public sector's adoption of AI. Two artificial intelligence (AI) technologies that help with massive data management are machine learning and deep learning. The handling of big data is advantageous to the public sector because it facilitates the discovery of patterns that guide decisions on resource reuse and cost savings. The quantity and quality of the recovered data that the AI system utilizes to identify patterns determines how effective AI technology is (Coglianese & Lehr, 2016). The AI system's output will be more effective the more data it collects.

The fact that public employees are not always able to oversee and supervise every transaction that takes place in the public domain defines the significance of artificial intelligence in the public sector. According to Haro-de-Rosario et al. (2018), the public administration generates many data from its use of social media that it may find beneficial. The amount of social media comments, the recognition of societal trends, and other elements are examples of data that artificial intelligence (AI) technology may process and use to guide decisions. Put another way, by keeping an eye on individuals' internet activity, artificial intelligence (AI) has the potential to play a major role in national governance.

Nearly all individuals who utilize the customer services offered by different companies are aware of the usage of artificial intelligence in the private sector. For example, when someone calls to report a technical issue with their home internet services, an AI contact agent is nearly always available to answer technical queries. Furthermore, virtual artificial intelligence (AI) bots that recognize trends in a customer's online shopping behavior can recommend the best commercial deals. Although commercial businesses have recognized the benefits of artificial intelligence in their interactions with the public, little is known about how AI is being used in government. This article aims to investigate the application of artificial intelligence in public administration by analyzing the industry's demands, impending trends, and obstacles. Using an exploratory research methodology, the key topics will be presented and examined from the standpoint of information management. This paper's contribution is that public decision makers will learn how to use artificial intelligence (AI) as a tool to enhance decision-making and implement this technology in government.

3.2.1.2 Application of AI in the Public Sector

Important government departments, like the health care system, have used artificial intelligence. A machine learning-based illness surveillance system was implemented in 2010 at a number of British hospitals (Mitchell, et al., 2016). The machine learning techniques were successfully adopted since the system was able to stop infections from spreading. AI has the potential to be a very useful tool in the medical field. Whether supervised or unsupervised learning algorithms are used by the researcher, intriguing outcomes are produced. The national safety sector of the government is another crucial area. The prediction of crime in metropolitan areas may result from the use of AI for security purposes. A California police force began using artificial intelligence (AI) in the early 2010s to identify potential crime scenes (Goldsmith, et al., 2014). The outcomes were remarkable because the AI's output reduced property crimes by up to 27%. A criminal activity's likelihood could be estimated by taking into account the possibility that another illegal activity has already occurred. By considering past information, the Baye's Theorem machine learning method determines the likelihood of a hypothesis (Joyce & Zalta, 2003). If we apply the Baye's Theorem algorithm in this situation, we might determine the likelihood that someone will behave unlawfully. Definition of Baye's Theorem (Shaw, 2019):

$$P(h|d)= (P(d|h)\ P(h)) / P(d)$$

- $P(h|d)$: The probability that hypothesis h is true, based on the data d.
- $(P(d|h)$: The probability of submitted data if hypothesis h is true.
- $P(h)$: The probability that hypothesis h is true (regardless of the data).
- $(P(d|)$: The probability of the data (regardless of the hypothesis).

For example, it is thought that all citizens who are involved in illicit activities belong to a certain financial category. It does not follow that a person with the same standing has a 100% risk of turning criminal. We feed data into the algorithm and get findings regarding the likelihood that someone with a given income will become a criminal based on the incidence rate (1/100000 and 1/10000 non-criminals people with the same financial status worldwide). The findings will assist law enforcement in tracking the yearly earnings of residents in a given area and forecasting their probable criminal history. As a result, the police could arrange for the right amount of staff to be needed to patrol the area.

Another intriguing instance of artificial intelligence being used in government was carried out in Australia. An AI bot that responds to inquiries from citizens on taxes was developed by the Australian government, which oversees tax services (Nuance Communications, 2016). First contact resolution rate increased to 80% as a result (Sun & Medaglia, 2019). Three components make up chatbot systems (Reshmi & Balakrishnan, 2016): An interpreter program that interacts with the UI, a knowledge base, and a chat engine interface. When a citizen submits a query, the system analyzes the data provided and searches the knowledge base for a possible response. Then, using artificial intelligence and natural language processing (NLP), the system presents a response. Of course, there are other examples of AI application in the public sector as well. However, by taking into account the advantages of the technology, it is important to find out about the challenges of the technology's implementation as well. The AI chatbot system's value stems from its ability to recognize trends in both human behavior and business data for a given corporate database. Both of those components assist the public since client service is information-driven and free from unforeseen human involvement issues. This system may be put physically in a real office, even though it is located remotely. The proposed solution would comprise an internet of things (IoT) system connected to a chatbot system housed within a vacant public office. The individual will answer questions, and various nearby sensors will take their temperature, blood pressure, and other vital signs. If the sensor detects that the person's blood pressure or pulse rate is elevated, it is likely a sign that they are upset about problems with the chatbot. This kind of data will be sent by the sensors to an administrator gadget, which will then contact an actual public servant to come into the office and respond to the inquiries.

3.2.1.3 Challenges of AI in the Public Sector

The first problem that the decision-makers must address is the use of AI technology in the public sector. Case studies substantiate the usefulness of AI in government. However, what exactly are the determinants of an effective AI deployment in the public sector? Scholars such as Catherine et al. (2018) and Thierer (2018) debate over the difficulty of implementing AI and the potential for failure.

One aspect that definitely influences the possibility of using AI technology is security. It is well known that an AI system picks up knowledge from a behavior and uses it to inform judgments. In the event if the system began acting negatively (Conn, 2017; Wirtz, et al., 2018), what would happen? This is a significant problem that has the potential to turn AI from a tool for prediction to one for devastation. As a result, the AI implementation should have a security system that identifies the appropriate behavior, whether positive or negative. Perhaps an intelligent ambient approach, or an Internet of Things approach that uses sensors to identify human conditions. Here, sensor signals indicating a potentially dangerous human state could activate a system that halts the AI process's execution.

The government's information technology staff should likewise be mindful of the privacy of citizens' data. Unauthorized access to the AI system may cause important data to be lost or altered. In particular, the deployment of AI surveillance systems that serve as a monitoring system for extremely sensitive data raises privacy concerns (Gasser & Almeida, 2017).

AI application in public administration may also be influenced by two other factors: the quantity and quality of data. The machine finds more patterns for analysis the more data it collects. The lack of data in industries like healthcare (Xie, 2017) reduces the effectiveness of AI. Because there should be a relationship between different types of data in the database, such as demographic and clinical data, data integration is important from the perspective of data quality (Suna & Medaglia, 2019).

The next element that will embrace AI adoption in the public sector is expertise. The individuals who will create and alter the AI system's characteristics will determine its worth. The rate at which artificial intelligence is developed in the public sector may be slowed down by a shortage of qualified data scientists. The government's human resources division ought to provide a competitive benefit in order to attract the experts.

Finally, but just as importantly, the moral dilemma of robots taking the place of people (Krausová, 2017) stimulates responses from workers and beyond. Is a knowledgeable employee more valuable than a clever machine? How many employees of the government will be let go? Given that, AI systems lack awareness and emotion in comparison to humans (Banerjee et al., 2018), it begs the question of how an emotionless entity could decide on an entity that possesses feelings.

The many issues raised here are topics of discussion for public decision makers who wish to implement AI in government. In addition, there are additional managerial implementation obstacles, such as organizational and financial adjustments. Since this research is ongoing, more information will be available in a subsequent paper that will classify and examine each unique difficulty.

3.2.1.4. Adoption of AI in the Public Sector

A strong framework that will encourage public workers and citizens to trust artificial intelligence is necessary for its adoption in the public sector. Using gamification, artificial intelligence (AI) may one day be implemented in public administration. According to Deterding et al. (2011), gamification is a technique for incorporating game features into non-gaming environments. A study by Sailer claims that gamification increases motivation by focusing on the mechanisms that drive motivation (Sailer et al., 2013). The public sector has effectively applied the concept of gamification (Fernandes & Junior, 2016), and the conversion of public services to a gamified setting is a topic of continuous discussion (Al-Yafi & El-Masri, 2016).

According to empirical study, gamification favorably influences users' intentions to use information systems, including mobile banking services (Baptista & Oliveira, 2017). Why not utilize gamification to influence potential users' intentions to use AI public information services? It already influences their desire to use a new technological framework (m-banking). Octalysis, a gamification model created by Yu-kai Chou, serves as the paper's suggested framework (Mohasses, 2019). Eight basic motivational drives are included in the model, and they are connected to aspects of games.

A. Epic Meaning & Calling

This is the primary motivation where the player believes he has been selected to carry out a heroic and daring deed. This kind of individual spends a lot of time creating things for the community because they enjoy giving back to it.

B. Development & Accomplishment

This inner drive characterizes an athlete who enjoys training and taking chances.

C. Empowerment of Creativity & Feedback

This kind of player looks for feedback on his actions and plans to resolve problems by applying his creative abilities.

D. Ownership & Possession

This core desire characterizes gamers who believe they ought to possess an actual or virtual asset.

E. Social Influence & Relatedness

The social aspects of the game that the player finds comfortable are part of its core. This urge, for example, is connected to aspects of games like rivalry, social reactions, and friendships.

F. Scarcity & Impatience

This basic motivation relates to the player's inability to obtain an asset instantly or whose access is exceedingly challenging.

G. Unpredictability & Curiosity

This is a gamification feature that motivates the player since he might stay logged in the game environment out of curiosity or because he has no idea what will happen next.

H. Loss & Avoidance

This is a primary motivation that motivates the player to be faithful to the game's system because he might lose something he values, like data, if he does not.

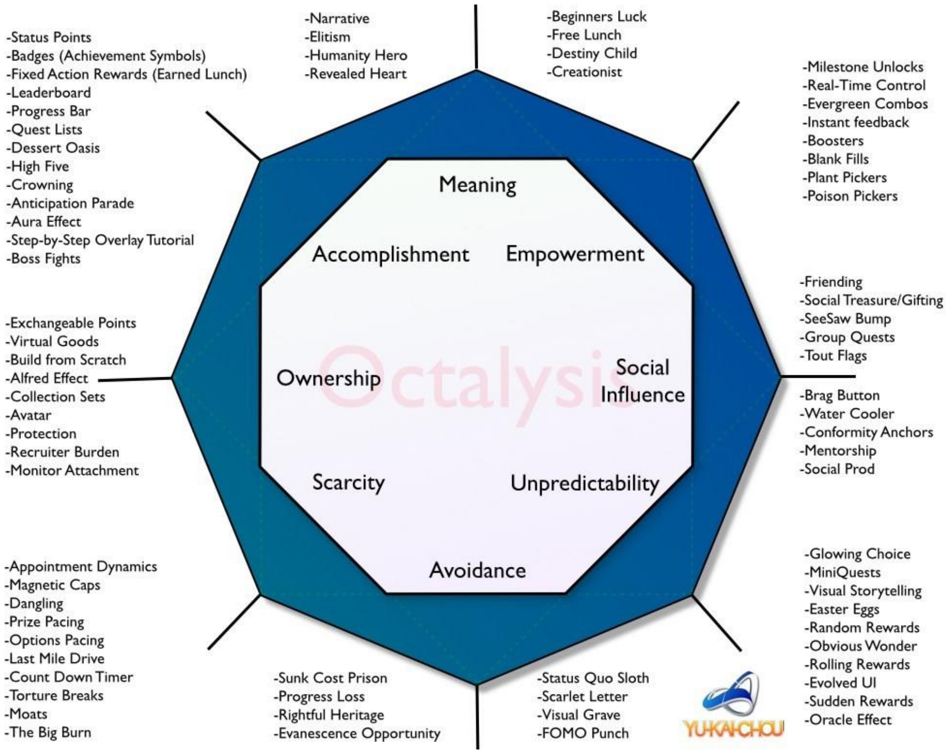

Figure 1 Octalysis Model

The usefulness of this model resides in the researcher's ability to assess how gamified a system is by using Octalysis. The evaluation of an AI system could indicate its merits and weaknesses in terms of its stakeholders' intention to utilize it, since gamification is essential for the adoption of new technologies. Several cities have implemented AI systems to provide public services; Dubai is one of them, having introduced the AI chatbot Rammas (Mohasses, 2019). The Dubai Electricity & Water Authority produced Rammas on January 17, 2017, and it can communicate in Arabic and English. The chatbot was developed and deployed on the Google AI platform. Its functions include receiving citizen inquiries, processing data, and making AI-based choices.

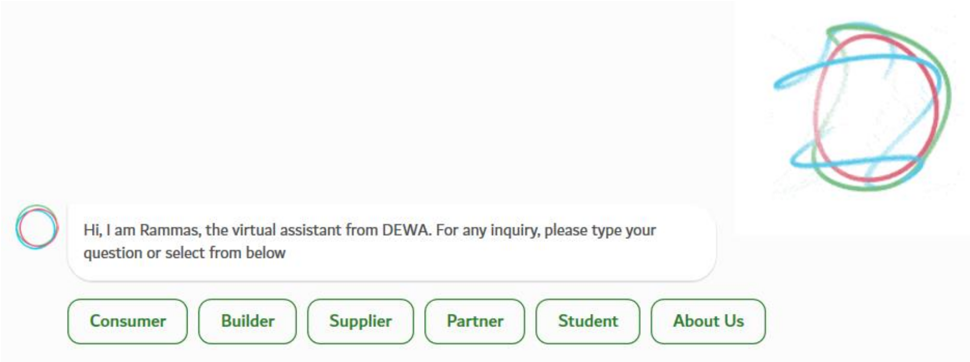

Figure 2 RAMMAS chatbot system of Dubai

In order to identify the gamified aspects of Rammas' chatbot, we tried interacting with it and making requests. The Octalysis online rating tool, which can be accessed at https://www.yukaichou.com/octalysis-tool/, is the instrument to score its performance on motivation level (8 Core Drives). After the chatbot was rated, it received a total score of 95. A few well regarded gamified elements, such Ownership & Possession and Scarcity & Impatience, appear to be present in Rammas. After reading Ramma's responses, the citizen believes he should be the owner of or have access to some of the advantages Dubai provides. Additionally, there are situations when the citizens' access to the knowledge is restricted, which raises the Scarcity score. The chatbot's overall experience is not gamified, and Octalysis's other primary motivations are somewhat restricted.

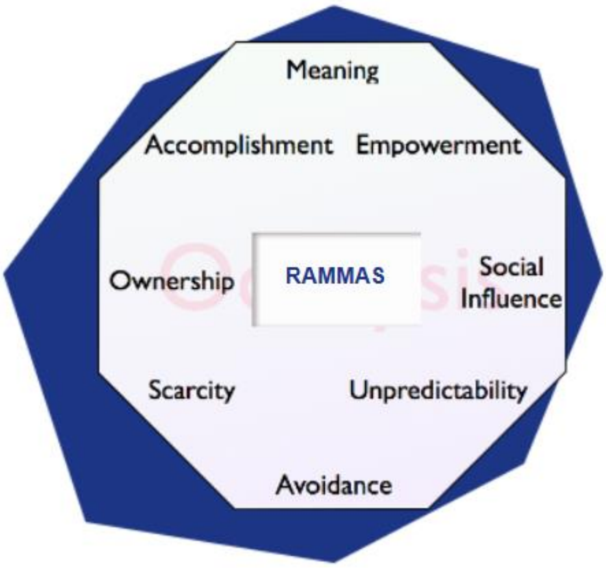

Figure 3 Applying Octalysis for the rating of RAMMAS chatbot system

Our suggestion is that the city of Dubai could add game elements such as milestone unlocks and boosters to foster the empowerment of the user. A powerful user could be a powerful citizen that will appreciate this gift from the government. On Social Influence level, it would be interesting for the Rammas to offer abilities for the user to share the received information on the social media. Friending and companionships are some other game elements that the chatbot could offer to the citizens. For instance, if there is a difficult question from the citizen then the system could display a virtual friend for helping the person. Unpredictability is another core drive, which the chatbot seems to have low performance. Game elements such as Easter Eggs could increase the rating of this core drive. For an example, while the citizen chats with Rammas, the system could offer an unpredictable opportunity for a live phone call with a real public servant!

3.2.1.5 Conclusion and Future Scope

This study examines the applications of artificial intelligence in the public sector, considering the difficulties associated with implementing new technologies. Our research indicates that the following present the biggest obstacles: acceptance of new technology, security, privacy, quantity and quality of data, competence, and ethical considerations. Through the identification of citizen behavior trends and the reuse of existing data assets, the prospective use of AI in the public sector will reduce the cost of public expenses.

Gamification is a strategy that needs to be carefully considered in order to encourage people to begin utilizing AI applications for their interactions with the government. Nonetheless, it is important for the governments to allocate resources and attention towards examining other gamification models like Octalysis. Octalysis has the benefit of being quickly adapted, even by those with little academic experience. Conversely, a new framework with fewer or more core drives will be developed if other academics attempt to demonstrate the academic worth of each core drive through empirical research.

Future technology advancements like blockchain and the internet of things should be on the study agenda for artificial intelligence's potential use in the public sector. The public sector's adoption of these technological developments is the solution to a myriad of problems, including a shortage of funding and the distribution of public spending on the purchase of new equipment to support government operations.

3.2.2 The Proposed Artificial Intelligence-Based Clerkless Public Office

The current state of artificial technology application in public administration is restricted because of many obstacles that prohibit decision makers from implementing it. In order to improve citizen service even in dire circumstances like pandemics and natural catastrophes, we present in this article the notion of clerkless public offices, where the idea of public administration is applied through a synergy of AI and other technologies. The proposed concept is an extension of the latest e-government state of the art and the cashierless Amazon Go store. In education, the same implementation is possible.

3.2.2.1 AI in the public sector

A data-oriented world was brought about by the digital revolution of the 2000s, as the majority of internet users broadcast their data on social media and other open platforms, creating online records. According to Brynjolfsson and McAfee (2017), the volume of these data led to a growth in the demand for computing processing services and the development of artificial intelligence technologies. The breakthrough technology known as artificial intelligence (AI) has found extensive use in the private sector. While there are many benefits to this kind of technology, its capacity to learn a behavior (based on data) and facilitate intelligent decision-making is by far the most significant.

The adoption of AI in public administration was brought about by the private sector's success, which also had an impact on the public sector. Critical facets of public administration, including health, security, education, and others, are being integrated with AI in the public sector (Capmegini, 2017; Business Insider, 2016). According to Gomes de Sousa et al. (2019), Sousa and colleagues discovered that the public sector employs eight distinct artificial intelligence (AI) techniques, with artificial neutral networks (ANN) being the most widely used. There are a lot of possible advantages to using AI in the public sector. The AI system's forecasts regarding public governance get better the more data it gets and evaluates. Researchers at Deloitte University specifically looked into cost reduction through the use of AI technologies. According to Eggers and other academics, the government will save between $3.3 billion to $41.1 billion by automating tasks

(Eggers et al., 2017). AI can be used to address the following six governmental concerns, according to Mehr's 2017 paper at Harvard and Androutsopoulou's subsequent research (Androutsopoulou et al., 2019):

1. Resource allocation
2. Large datasets
3. Experts shortage
4. Predictable scenarios
5. Procedural and repetitive tasks
6. Diverse data aggregation and summarization.

Even though AI is a suitable tool for resolving these problems, its adoption and application in the public sector are still lacking. The political establishment is hesitant to use AI in government for a number of reasons, including funding other initiatives that may have an impact on public opinion of the government (Van Deursen et al., 2006). Furthermore, as Liu and Kim noted in their 2018 study, there is currently a dearth of information regarding the application of AI in the public sector. Furthermore, there is always the risk that jobs would be lost because of automated tasks. It is clear that even while AI has the potential to be a fantastic tool for the public sector, government decision-makers need to be convinced of this. This paper's goal is to persuade government officials by outlining a creative use of artificial intelligence (AI) in the public sector that could work for the majority of governmental problems pertaining to the provision of public services. The idea of clerkless transactions (Seigel, 2003) has been modified for use in public administration operations. The suggested model is based on a conglomeration of AI technologies that have the potential to increase public sector productivity.

3.2.2.2 The issue of the unavailability of public services

There are a number of reasons why the quality and quantity of citizen services may be restricted. In the event of a pandemic, natural disaster, or other emergency, public employees may be unable to report to work. In less developed nations, this kind of scenario is fairly common, especially when the local infrastructure (such as the state of the roads) is impacted by the national economy. As a result, a public servant's performance may not always be at its best because of health issues that could limit the clerk's capacity for maximum productivity. Other factors include crime, which makes it difficult for citizens to visit public offices in large cities for fear of being the target of violent crime. Despite the fact that these issues exist, the government must continue to provide public services since they have an impact on the economy, even in dire circumstances. For example, inclement weather preventing the municipality's tax clerks from working could have an impact on the amount of money the municipality makes each day.

It will be disastrous if a local government chooses to punish the public employees and reduce their pay in order to resolve the issue. As retaliation, the staff unions may go on strike or the servants may do less well overall. The option that requires the fewest financial and human resources should be the one that is recommended. It is perhaps necessary to adopt a less dangerous medium, like technology, to combat this undesirable circumstance.

3.2.2.3 A hybrid AI solution

The culture of clerkless stores, particularly Amazon Go, served as an inspiration for the proposed solution (Polacco & Backes, 2018). In 2017, Amazon's first physical store without a worker debuted as a food store in Seattle, Washington. This business was unique since it was made for customers who dislike waiting in line and for the cashier to attend to their needs. Using a smartphone app they had downloaded, consumers check in when they visit the business. A complex fusion of AI technology tracks their movements as they browse the store and remove items from the shelf, identifying them as the product's purchasers. Even if a consumer changes his mind and returns the item to the shelf, the intelligent AI system can still comprehend human movements. In this instance, the product is shown as being available for purchase by other customers. The customer simply leaves the store without waiting for a salesperson to charge the items he purchased. Conversely, after the customer leaves the store, the AI system provides information about the items they bought to the mobile app. The customer's credit card or virtual wallet is linked to the mobile app, and he is billed for the items he buys. The same sensors, computer vision, and deep learning techniques used by self-driving cars (Amazon Go Editorial Staff, 2020) are used by Amazon to achieve this concept. The Amazon Go store caters to consumers who would rather not wait in line and would rather have all of their services handled automatically using digital technologies. If we modified this idea and used it in public administration, it would be intriguing. A public office without a clerk would be able to serve the public around-the-clock while keeping operating costs to a minimum. However, the local cultures and the degree of digital divide among the populace should be considered in the design and business model of the clerkless offices. For example, it would be pointless to deploy a mobile app concept to a nation where the populace lacks cellphones and is digitally separated. However, these obstacles can always be surmounted by employing a less innovative technology approach. Within the government's Amazon Go "store," citizens might transact using actual smart cards in place of a mobile app.

Our solution is designed with the needs of the public in mind and is citizen-oriented. First and foremost, a public sector clerkless store needs to determine the real reason a citizen comes to the public office. An artificially intelligent chatbot that guides the citizen to the procedure is the recommended method for determining the citizen's needs. A chatbot is a piece of computer software that takes human input and applies natural processing, a type of artificial intelligence, to extract meaning and information. The user may input text, audio, or any other format that the computer can understand. For example, facial expressions can still be used to convey meaning and information when analyzed using machine vision techniques. The chatbot interprets the user's input to determine the purpose of the query and then provides the best possible response. The three primary components comprise the basic architecture of the chatbots:

1. Natural language understanding (NLU)
2. Dialogue manager (DM)
3. Natural language generator (NLG)

Every component has a distinct function within the chatbot. Natural language understanding (NLG) categorizes and deciphers user input to derive meaning. In particular, searches should produce language output that is suitable for the dialogue manager because they generate patterns and grammatical texts. In this instance, the user will input a question on a duty related to public administration, such paying taxes or obtaining a passport, among other things. This reality makes the NLG's access to a database containing data about public administration necessary.

The dialogue manager, which will get the information from the NLG, is the next component of the chatbot agent. The DM's job is to get the responses from the system ready to be transmitted to the natural language generator. According to Moataz and Mostafa (2020), the DM uses a rule-based, knowledge-based, or retrieval-based approach and has access to entity and intention templates. It selects the most appropriate template based on the strategy to create a relevant response. Neural network and online information retrieval components assess the user's input if it does not match any of the templates. While the online retrieval components search the internet (including social networks) for matching templates, the neural network components use deep learning and machine learning techniques.

The final component of the chatbot is the natural language generator. When there are more than two right responses, the NLG ranks and presents them according to an internal engagement ranking after filtering the response content. The answers are written down, but the final response will be spoken thanks to a text-to-speech tool. Speech may be the best method of response given that the general public may not be conversant with information and communication technologies.

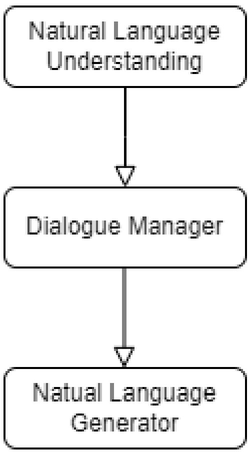

Figure 4 Data flow in chatbots.

Furthermore, if we move on to putting our design model into practice, a certain kind of hologram would be a good way to increase the AI chatbot agent's strength. A hologram is often a 3D animated representation that resembles a person and can communicate with other people. In this instance, the citizen user will see the chatbot agent as a hologram. In actuality, the hologram's primary function will be to acquaint the citizen with the human species—the chatbot will still handle input and output.

Depending on the holographic chatbot's instructions, the citizen enters the clerkless governmental store in the following step of the process. Every room in the clerkless store will be designed to accommodate the demands of different citizen groups. It would be helpful, for instance, to have a space for people with disabilities or a room with more sophisticated people who are carrying cellphones. The natural language generator's response will also specify which room the citizen will visit within the clerkless store. A smart card or a smartphone could be used as the admittance medium (for the less tech-savvy populace). The process inside the store, which serves as a collection point for new passports, is seen in the picture below. The passports are arranged on shelves similarly to the items at the Amazon Go store. Obtaining a new passport involves the following steps:

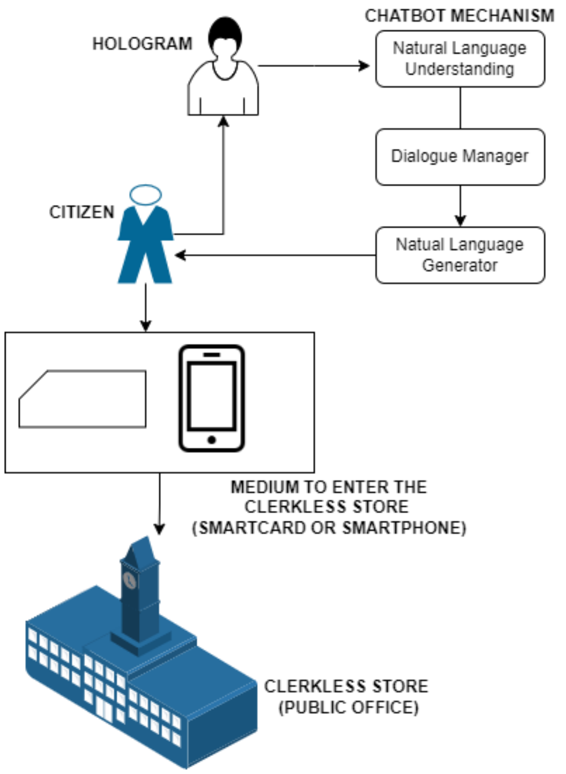

Figure 5 Chatbot communication and entrance to the clerkless store.

1. The citizen uses the smart card or the government's mobile app to authenticate himself or herself when they enter the store.

2. Following the chatbot's prior directions, the citizen goes to the shelf holding his passport.

3. As he pulls the passport off the shelf, a camera records a picture of him. His biometric data and the data on the new passport are matched by the camera's facial recognition technology.

4. The passport is taken from the shelf by the citizen.

5. The sensor, which is positioned on the shelf, recognizes the receipt of the passport and updates the central system's status.

6. The passport is correctly received by the machine when the citizen checks out using a smart card or a mobile app.

Deep learning algorithms are used on the system's backend to examine customer behavior within the store and train the system based on identified learning patterns. For example, how long does the citizen spend in front of the shelves and which shelf is ideal for placing the passport are useful pieces of information for the system to learn.

3.2.2.4 Conclusion

Because AI has the ability to extract powerful information from citizen data, it is the best instrument available to the government for providing public services. An artificial intelligence system that has received proper training can recognize learning patterns and make decisions quickly. It goes without saying that employment losses could result from the AI system's deployment. If the impacted employees take on a different function in the corporate setting, they may still be able to maintain their employment. Public employees have the potential to train the AI system by giving it more information about the services rendered to citizens by people. In this instance, they continue to work and train the AI public servants virtually. It is simple to comprehend how these approaches can be used in synchronous, asynchronous, and web-based education.

3.3 Blockchain Technology

Originally created for cryptocurrencies like Bitcoin, blockchain technology has grown in popularity due to its possible uses in electronic government. Distributed ledger technology, or blockchain, provides a decentralized, transparent, and safe way to record and validate transactions.

Governments are looking at using blockchain technology to enhance the efficiency, security, and transparency of several e-government operations. Some well-known sectors where blockchain technology can have a significant impact are as follows:

Identity Management: Secure, impenetrable identity verification and authentication might be provided via blockchain technology. Governments can create decentralized digital identity systems that provide people control over their personal information while protecting its confidentiality and integrity. Digital signatures, citizen registration, and access to government services can all be sped up with this.

Supply Chain Management: By enhancing supply chain traceability and transparency, blockchain can reduce fraud and counterfeiting. Blockchain technology can be used by governments to monitor goods movement, verify product origins, and ensure regulatory compliance. This technique holds great promise for applications in the pharmaceutical, food safety, and sustainable sourcing industries.

Elections and Voting: Blockchain technology has the ability to produce an open, safe, and transparent election platform. It might provide immutable and verifiable voting records, preserving the integrity of the political process and boosting public confidence. Blockchain-based voting systems can remove the possibility of vote manipulation and outcome manipulation.

Smart Contracts: Blockchain technology can be used to carry out self-executing contracts with predetermined conditions and regulations. Governments can utilize smart contracts to automate tasks like property registration, procurement, and contract management. This can decrease expenses, increase efficiency, and lessen conflict in dealings with the government.

Despite the many benefits of blockchain technology, certain issues need to be resolved before it can be applied effectively. Three technical challenges facing blockchain are energy consumption, interoperability, and scalability. Establishing legal and regulatory frameworks is also necessary for issues like privacy, data protection, and cross-border commerce.

3.3.1 New Development: Blockchain—A Revolutionary Tool for the Public Sector

The idea of blockchain is covered in this article along with how it can be used in public administration studies to boost public confidence in the government. This article's contribution is that it clearly outlines the benefits and drawbacks of blockchain technology, enabling users—citizens and public servants—as well as decision-makers—who plan to utilize this cutting-edge technology to improve transaction transparency in the public sector—to make well-informed decisions.

3.3.1.1 Impact

A difficulty that many countries are attempting to address is transparency in the public sector. Blockchain is a decentralized technology that secures transactions between untrusted parties, therefore reducing corruption. This article describes blockchain technology and the reasons public administrations ought to use it. The benefits and drawbacks of blockchain technology are discussed, along with real-world applications, to assist policymakers and public servants in appreciating the significance of this revolutionary technology and facilitating its widespread adoption.

3.3.1.2 Lack of trust in government

The successful operation of a government and the efficacy of public service delivery are significantly influenced by the issue of trust between the government and its population (Walle, 2018; Mehree et al., 2018; Parent et al., 2005). According to Miller and Listhaug (1990), political confidence in government is the extent to which political authorities and institutions behave in a way that meets the expectations of the public. Numerous researchers have discovered low levels of trust around the world (see, for instance, Wang & Van Wart, 2007; Morckel & Terzano, 2018). Similar findings have been drawn from official assessments that gauge public trust in the government. For example, a 2015 report from the Organization for Economic Co-operation and Development (OECD) revealed that public services are more trusted by the people than the government (OECD, 2015). Just 37% of people in OECD nations said in 2016 "they had an influence in what the government does" (OECD, 2019); in Italy and Slovenia, this percentage was 20%. OECD countries' average level of trust in their governments in 2018 was 45%, which is comparable to the percentage that existed in 2007 before to the financial crisis (OECD, 2019). The majority of respondents (52%) to a survey commissioned by the European Commission said they had little faith in their national government (European Commission, 2019).

Governments should focus on the following six areas, according to the OECD (OECD, 2015), in order to raise trust levels:

- Reliability
- Responsiveness

- Better regulation
- Integrity and fairness
- Inclusive policy-making
- Openness

The duty of a government to lessen corruption in the public sector is referred to as the area of reliability. The speed and efficacy with which a government responds to public demands is referred to as responsiveness. Governments must specify their guiding principles and directives for the planning and provision of public services in order to improve regulation. Public decision-making and the skillful handling of conflicts of interest in the conduct of public employees are linked to integrity and fairness. Creating public policies that are fair and accountable—free from any unfair political interests or outside influences—is the goal of inclusive policy-making. Lastly, the idea of openness addresses how citizens interact and participate in government information systems. Transparency in the budget is a component of open governance.

Targeting levels of trust is the goal of the openness and citizen engagement initiatives put in place by 61% of OECD nations (OECD, 2015). Studies examining the connection between government transparency and trust typically find that when a government releases factual information, public perceptions of that government tend to be more favorable (Buell & Norton, 2013; Mettler, 2011). A type of computing transparency is produced when government information is displayed using computer technology (Grimmelikhuijsen & Welch, 2012; Meijer, 2009). Government performance and openness can be enhanced by using computing networks, such the internet and digital media, to provide public services (like online prescriptions) (Andersen et al., 2010; Welch et al., 2005). According to Meier

(2009) and Porumbescu (2017), "computing mediated transparency" refers to the use of computer systems that let regulators and the public examine public entities.

3.3.1.3 Using blockchain to gain trust

The blockchain technology, which replaces institutional trust with technological trust, represents a significant advancement in government computer transparency (Franks, 2020). Blockchain is a decentralized public ledger technology that uses data blocks to store records and transactions. Every transaction that has been approved by the nodes of the blockchain network is appended to a block and inserted into a chain that links to earlier transactions. A block cannot be withdrawn from the blockchain after it has been added. At each node, a copy of the public ledger is kept. "Miners" are the network nodes that confirm the legitimacy of the transactions and the integrity of the data. In order to create a hash value that links the prior block to the current one, miners must solve a mathematical challenge known as the "proof-of-work" (PoW). In exchange for figuring out the mathematical puzzle and confirming the transaction's transparency, miners typically are paid in bitcoin. Blockchain technology is decentralized, meaning that no public or private body can administer it centrally. Instead, data blocks are dispersed throughout a completely secure blockchain network. There are other iterations of this original blockchain concept available, each with unique benefits and drawbacks, including scalability and transaction validation methods.

Blockchain is typically applied to transactions involving value transfer or access to digital products as a means of fostering trust between untrusted entities. Actually, what blockchain does is make sure that two or more strangers may trust one another. For example, it is clear that mistrust between the two parties may arise when the department of a public office wants to enter into a financial arrangement with another party (such as a vendor or foreign public office). To secure the agreement in this situation, a third party is called upon to draft a contract. But this reality results in additional expenses for them both. Instead, the "trusted third party" in the blockchain smart contract process is the technology itself, as it creates a virtual contract with computer coded stipulations. Only when the predetermined requirements are satisfied does the smart contract begin to be performed and safeguard the potential value or information transfer between the two parties (Zheng et al., 2020).

Two significant benefits of blockchain technologies are their non-immutability and sovereignty. Although names do not appear in the blockchain, the program that conducts the transactions can be tracked, and a public authority maintains the association of "wallets," the blockchain's identification unit, and its mapping with a real person. It is still possible, despite the fact that tracing back is extremely tough (far harder than tracing a conversation using a mobile phone).

Concerning complexities (as opposed to drawbacks), the two main ones are the expense of maintaining a node (which is advantageous as well, as it deters malevolent users from attacking the system) and the lack of a "forget" function, which implies that it is unsuitable for managing sensitive data. Every citizen of the EU has the right to request that a system that holds their personal data erase (forget) their data, in accordance with the EU's General Data Protection Regulation (GDPR). A feature like that goes against the core principles of blockchain technology.

Although blockchain technology is not a panacea for every problem facing contemporary governments, its transparency and security features may improve information exchanges between government departments. For example, when public institutions purchase services from vendors, the terms of the service level agreements (SLAs) between the two parties determine how the outgoing payments go. To save time searching for new vendors, it makes appropriate to share the vendor's performance data if other public agencies are working with the same vendor. Additionally, "smart" contracts built on blockchain technology may be used to construct agreements between vendors and agencies. When deliverables, timeliness, and service quality are met, among other contract criteria, smart contracts have the ability to automatically disburse money. Because citizens can track transactions in real time—especially if they can become miners and validate transactions—transparency in public spending can foster public trust in the government. The advantages of blockchain technology in the public sector extend well beyond financial transactions:

- Asset registry: implementing a blockchain solution that registers and manages every asset will drastically cut down on the amount of red tape and the accuracy of the data supplied for each item. The public sector would gain from participating in procedures that incur additional costs for the working hours of employees that handle the asset registration paperwork. The land title registry and real estate industry are suitable candidates for such a solution since their size supports the expenditure of implementing a blockchain-based system.
- Election voting could be made more dependable and safe.
- Aids and entitlements: A blockchain technology may potentially automate and record social security and medical assistance, for instance. For example, after enrolling on the national health system website, patients might use the blockchain's smart contracts to get their medicines online.

Identity identification is a significant factor in building confidence. Millions of people have had their identities altered without their consent or have had no records of them kept. The issue of identification and trust is widespread in business, according to Cofta (2007), since any business interaction should establish the identities of the individuals involved and progress toward mutual trust. Stated differently, when one party's identification is questioned, the transaction's validity is also called into doubt. Blockchain is crucial in this situation because distributed ledger technology gives citizens the ability to create a digital identity and manage the components that make up their ID. By using a safe, one-of-a-kind token from the blockchain system, citizens can participate in consultations like elections and referenda while also protecting their anonymity.

3.3.1.4. Conclusions

The potential for blockchain technology to transform public policy and expenditure decision-making makes it an attractive instrument. First, it must be more broadly comprehended from a technological and conceptual standpoint. Before introducing a technology that would completely alter the political and financial landscape, decision-makers must receive training. Additionally, there is a need to increase public knowledge of the use of this technology. However, there are numerous benefits to a government implementing blockchain technology, which might enhance the openness and efficiency of public sector organizations.

Stakeholders could have rapid access to information and the danger of utilizing unreliable systems reduced by using a standardized ecosystem of transactions like blockchain. Every transaction and record would be digital and accessible in real time, streamlining record-keeping and fostering intelligent decision-making.

Due to the decentralized nature of blockchain, it will also alter institutional philosophy and structure, resulting in a decentralized democracy. Decentralized democracy can be conceptualized as giving citizens access to a blockchain via public network nodes, so outsourcing public decision-making to them. This might change how public institutions are managed: fewer personnel would be required to carry out tasks, and most of them would be technical staff members who would be in charge of overseeing and maintaining the blockchain network and solution. For example, instead of administrative staff validating every incoming document from citizens, IT staff will need to construct the blockchain network in order to audit public sector transactions on medical e-services (such online prescriptions).

3.3.2 An Innovative Blockchain-Based Platform, Offering Intelligent Teaching Services

Depending on the student's academic background, there is a high level of digital literacy deficiency in the student body. It is evident that resources, such as funding or instructional time, are insufficient to address these changes, even though the skills gap can be closed by adding more staff that are academic and enhancing learning strategies. Our academic project suggests a student-maintained blockchain network that enables students to trade teaching responsibilities and impart digital skills to one another. As a reward, the students assume the roles of instructor or learner and are awarded reputation points. The platform is built using gamified blockchain technology, which enables a reliable and enjoyable way for students to trade teaching responsibilities with one another.

3.3.2.1 Introduction

A person who is sufficiently knowledgeable about information and communication technology, particularly in the workforce, is said to be digitally literate. In 1997, Paul Gilster gave the phrase its first definition. Gilster (1997) defines digital literacy as the astute application of digital technology and the retrieval of information within the framework of daily life. In 2019, the Department for Digital, Culture, Media, and Sport (DCMS) was tasked by the British government to conduct a study. The study's objectives were to identify the UK market for digital skills and then develop a skills policy. The figures were striking and showed how important digital abilities are. At least 82% of the UK's online job postings require digital skills, and employers who do so provide salaries that are 29% higher than those of non-digital skill organizations (Nania et al., 2019). It is clear that digital skills are necessary in this day and age, since the Covid-19 pandemic has forced most workers to acclimate to working remotely with the aid of ICT. The real competency of digital skills is low at the European Union level, despite the rising need for them. As per the findings of the Eurostat study from 2020, about 50% of the European population possesses basic or above basic digital abilities in 2019. Put differently, the other half of the EU population is being denied access to high-paying jobs because they lack digital skills. The shortage of digital skills among EU citizens presents an opportunity to create a platform for developing digital skills. Even though there are a lot of free digital skills platforms (like Coursera), most of them employ a mass teaching approach. The fact that such platforms aim to provide digital skills to as many learners as possible means that there is little room for personalized instructional services. Not all prospective students can afford the tailored learning services that are offered by platforms for digital skills; these services are often fee-based. This study aims to provide the conceptual design for a digital skills platform that provides a cost-effective and personalized learning experience.

3.3.2.2 The platform

Digital skills are taught by faculty members, lecturers, professors, and guest tutors in the higher education sector. Even if it appears that this is the official method of instruction, a number of problems occur and hinder the pupils' ability to acquire digital skills. For example, the majority of lectures are given at times when students may not be available. On the other hand, students who must work during their studies would find an on-demand lesson more appealing. Typically, the issue is that the institution does not finance this option or the instructors do not have the time to record their lectures on video. Creating a platform where students with the necessary expertise may teach each other digital skills is one way to address the issue. As a result, students will learn and get the desired experience of becoming virtual professors, while the university's official teaching staff will not be involved in the teaching process at all! Students from the same university will use the platform, allowing the system to validate their login credentials from their registration on the university's official system. The users will be able to instruct or learn, designating them as "student learners" or "student lecturers." After registering on the platform's system, the student learners will have the ability to request a series of private sessions from the student lecturers. Students' performance in an actual university will determine how well they can instruct a course. A student is eligible to teach this course on the platform as long as he has completed and passed a digital skills course in the actual academic program. In terms of the platform's infrastructure, we think that before using it, pupils need to have faith in it. Because of this, the platform's technology ought to be reliable, reducing the possibility of illegal access from outsiders. Our recommendation for this platform's development is to use safe technology that has features that encourage platform usage. The architecture of a blockchain platform with gamification features is then covered in this paper (Parizi & Dehghantanha, 2018).

From a technological standpoint, blockchain technology offers numerous benefits (Golosova & Romanovs, 2018; Yfantis et al., 2021). First off, according to Chen and Bellavitis (2020), this technology is decentralized, meaning it is not overseen by a single entity. The freedom to create a self-administered platform without the approval of university authorities makes this significant for the students. Furthermore, despite their lack of mutual trust, several stakeholders can work together on a project thanks to blockchain technology (Werbach, 2018). There is a chance of fraud throughout the transaction if a cooperative scenario involving organizations that are most likely unknown is implemented. The ideal option in this situation would be a blockchain technology, which provides a safe form of transaction based on cryptography (Raikwar et al., 2019). This fact lowers the possibility of a privacy violation, which promotes student collaboration.

The real user interaction on the platform is just as important to its long-term survival as the technology being deployed. A proper motivation schema is necessary for the students to interact with the platform's functionality. To keep the stakeholders engaged in the project, the providers of the educational services may be compensated with money or in kind. Massive open online courses, or MOOCs, are free and well-liked by academics, thus if money is the incentive, "student learners" will likely turn to them (Sanchez-Gordon & Luján-Mora, 2014). In addition, the financial incentive presents a problem since there may be mistrust regarding the amount of money awarded and the caliber of the services provided (teaching services) between the "student lecturers" and the "student learners."

As a result, we suggest a non-monetary reputation point reward system that has longer benefits for student lecturers. This is a gamified approach with components that will influence students' desire to utilize the app (Vanduhe et al., 2020). According to numerous academics, gamification—the application of game components in non-gaming contexts—positively influences users' intentions to adopt new systems (Aguiar-Castillo et al., 2020; Du et al., 2020). There are instances of its application in the public and private sectors (Yfantis et al., 2018). A few gamified components that may be employed are:

• A leaderboard featuring ratings for the community's top tutors.

• Unique insignia and reputation points that function as virtual currency.

• Easter eggs that provide access to extra learning sessions via virtual doors on the platform.

• Offering free courses as a way to thank new users for using the platform.

• Online competitions between the most well-liked tutors to increase their standing with students.

• Cartoon characters that give instructional services to the platform's passive users in an effort to get them to become more active.

Reputation points will be used by our platform as a virtual currency and payment for educational services. As a symbol of accomplishment and experience in becoming virtual lecturers, the student lecturers will be awarded virtual badges based on the quantity of reputation points they have accrued. A large number of points will be awarded to the most engaged users who have completed the most worthwhile tasks. The achievement of these points will result in the badges being defined. The relationship between the necessary acts, the number of reputation points, and the available badges is shown in table 3.

Actions	Reputation Points Earned
User registration in the system	20
Course registration in the system	30
Teaching 1 course	50
Teaching 10 courses	600
Suggesting an idea for the platform	1000

Table 3 Actions and Reputation points earned

In table 4, you can read the types of badges and the required reputation points.

Badges	Reputation Points Required
Participant	1-50
Supporter	51-200
Junior Lecturer	201-400

Super Lecturer	401-1000
VIP Lecturer	1001-2000
Influencer	2001- 5000

Table 4 Badges and required Reputation points system

In addition, holders of the academic badges would be eligible to get exclusive benefits within the actual university. For example, when it comes to MSc and PhD programs, VIP teachers will be given preference over other candidate students. Furthermore, Influencers will be given preference over other applicants for opportunities as teaching assistants in actual universities. In addition to the student lecturers, the gamified blockchain platform will also assist the student learners. They will not jeopardize their financial situation and will acquire new digital abilities, therefore they will engage in a low-risk atmosphere. Blockchain technology and gamification working together will produce a safe and enjoyable platform.

3.3.2.3 Smart contract's design

Ethereum (Tikhomirov, 2017), a program that mimics the creation of a permissionless blockchain, will be used for the platform's design (Miller, 2019). According to Dubovitskaya (2019), the primary characteristic of the permissionless blockchain is its ability to enable users to read and write on the system without requiring permission from a central authority. In this instance, going with a public blockchain seems like a smart decision, as it will encourage a lot of students to engage with the network and increase its popularity. The EVM (Ethereum Virtual Machine), a decentralized computational entity controlled by account creation, is a component of Ethereum. Their private keys will manage the externally owned accounts (EOA) of the students, both lecturers and learners. Both instructors and students might be able to be anonymous while yet having the ability to transmit messages in this scenario. The contract kind of account is an additional account type in the system. The creation of smart contracts is the only function of this autonomous account type, which is managed by the smart contract code (Mohanta, 2018). The majority of the business procedures and transactions on this blockchain platform might be created as a sequence of smart contracts.

The initial setup of Ethereum nodes, business services, and smart contract functionalities make up the structure of smart contracts (Karamitsos et al., 2018). On Ethereum, the following nodes are recommended:

- The student instructors who develop the smart contract and provide instructional services.

- Students who register for an Ethereum wallet in order to access blockchain nodes and take advantage of learning services.

The learning platform's business services include:

- Registration for users

- Registration for courses

- Training courses

- Making money (reputation points)

The following recommended smart contract functions are based on the smart contract's goal:

- Contract creation: The lecturer drafts the terms and conditions, which include the title of the course and the specifics of the lecturer and student.

- Beginning of the Contract: The student signs a contract committing to give the lecturer X reputation points.

- Smart contract: Upon the commencement of the lecture, the system runs a code that awards the lecturer with the predetermined number of reputation points.

- Contract termination: This indicates that the lecturer will no longer be accessible to provide the student with the remaining lessons. The learner gets their reputation point deposits refunded in this scenario. Figure 6 shows the platform's whole architectural layout.

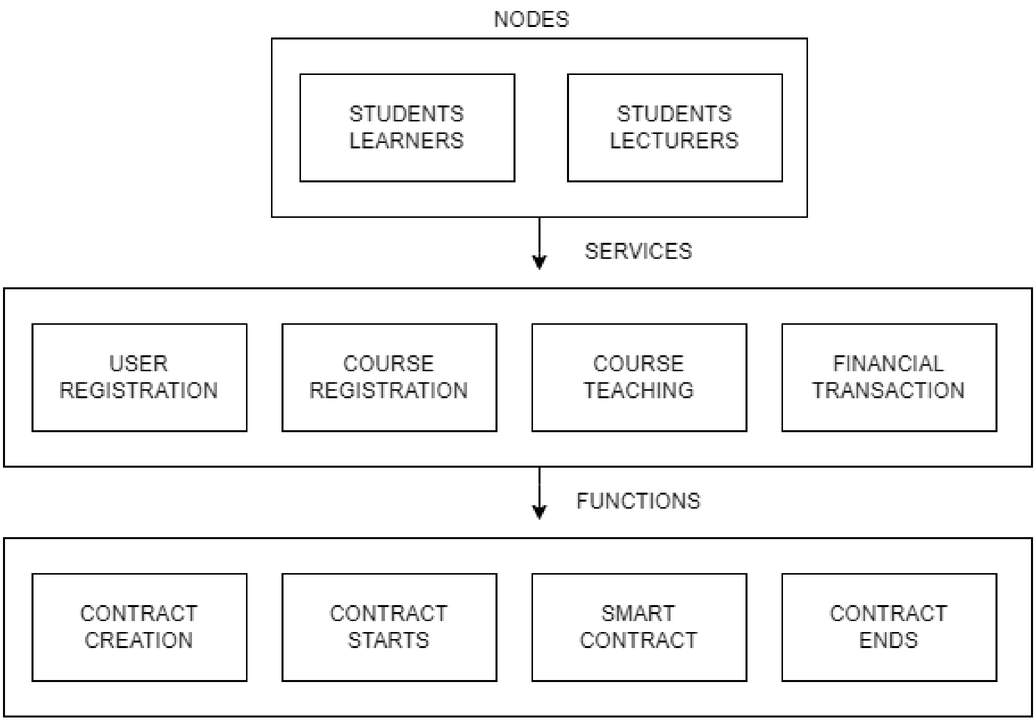

Figure 6 The structure of the Blockchain teaching platform

According to our needs, there are three types of smart contracts that could be used for the operation of the platform:

1. User Registration Smart Contract

2. Course Registration Smart Contract

3. Course Teaching and Financial Transaction Smart Contract

User Registration Smart Contract: The new users may only be fellow students at the same university. Students have been issued a set of public and private keys by the educational institution's officials, which they can use to sign up for new courses and digitally autograph exam papers. Upon registering on the blockchain platform with their public keys, new users can either be recognized and accepted as official students by the system or be allowed to browse the network as guests without having to participate as lecturers or learners.

Course Registration Smart Contract: Any registered student can add courses that they are qualified to teach and edit their course profile. The new user to add courses to their profile utilizes the public key that was provided for registration. Additionally, the registration for the university's official courses could be completed using the same public key. In this instance, the smart contract may be able to identify the public key that the student used after passing a university course on digital skills. Thus, the platform recognizes the user and permits them to add the course to their profile with the label "verified" if the student has successfully completed the university's course. If not, the smart contract permits him to add courses with the label "not verified" and refuses his request to add "verified" courses.

Course Teaching and Financial Transaction Smart Contract: The platform's users can impart or learn new skills. The user can schedule a new learning session with a lecturer based on his availability after finding him on the platform and selecting his favorite available courses. The student requests the lecturer's teaching services by using his public key to identify himself as a verified user of the system. The smart contract sets up the transfer of reputation points between the learner and the professor, provided the lecturer accept the terms of the agreement. An agreedupon number of reputation points that raise the lecturer's standing are awarded as compensation. Students get more recognition from the community and are eligible for exclusive privileges the more badges they have earned from teaching services.

3.3.2.3 Conclusion

The idea of a student-run teaching platform is not too unlike from reality. The existing quo of reality is dissolving on rare occasions like the Covid-19 incident, and communities must rethink their programs. As long as transactions are transparent, a student-centered educational approach may be able to convince them to take part and accept it. Blockchain technology lowers the possibility of potential disputes between untrusted entities and enhances transparency. Furthermore, using gamification to motivate users to use the system will increase their intention to use it. A collaborative effort with other communities to provide an enhanced operation is the research challenge for platform improvement. For instance, the capacity of the student lecturers to impart digital skills to users registered on other blockchain platforms under their own management. The creation of a multi-chained blockchain and a significant amount of processing power for its operations would be necessary to achieve this action's purpose.

3.3.3 A Novel Gamification Approach to Address the Adoption of Blockchain Technology in the Public Sector, with a Focus on Education

Blockchain technology, which provides data immutability and transparency, is one creative technology that could help address the growing problem of corruption in the public sector. We outline the potential applications of blockchain technology in public education transactions as well as a theoretical framework for University of West Attica staff members to use this technology. Because we also recommend gaming elements for the primary public sectors, our research has practical implications for public sector IT managers who want to incorporate blockchain into their businesses.

The public sector is made up of a number of organizations that manage the requests of multiple groups that make different types of requests for public activities in different ways (Lane, 2000). It appears that the United Nations Classification of Functions of Government, which divides up governmental activities into groups based on their purposes, has become the de facto international standard for the many public sector kinds (Roness, 2017). The following 10 main categories of activity (United Nations, 1991) are listed:

1) general public services;

2) defence;

3) public order and safety;

4) economic affairs;

5) environmental protection;

6) housing and community amenities;

7) health;

8) recreation, culture, and religion;

9) education;

10) social protection.

The primary components of the public transaction systems in use today are central third parties for operation authentication and trustworthy institutions like governments. This renders them as isolated points of failure in the event of a cyberattack, natural disaster, or possibly another kind of disruption. The sustainability of the provision of public services and the records they maintain is seriously threatened by this fact. With some of its alleged problems, blockchain technology might be able to help the public sector in this area. The development of automated and decentralized transaction systems that guarantee authenticity and transparency without the need for centralized governmental bodies is the benefit and future promise of blockchain technology. Furthermore, because digital data cannot be changed inside the blockchain network without clearly leaving a sign of the previous activity, the history of transactions and information is immutable.

In general, blockchain has the following crucial characteristics (Batubara et al., 2018):

Decentralization: Every node in the network has a copy of the ledger and is able to authenticate transactions, in contrast to traditional transactions, which are verified by a central, trustworthy organization (Kshetri, 2017).

Security: Inaccurate transactions are prohibited by the use of a consensus mechanism, a timestamp, and a cryptographic mark. Additionally, it is now difficult to add, erase, or duplicate transactions that have already been recorded in the blockchain (Peck, 2017).

Anonymity: Blockchain-based interactions take place between two people who conceal their identities using public-key cryptography.

Auditability: Every action on a blockchain is recorded in a chronological manner, together with the hashes of the most recent block and the preceding block, which are presumably used to connect the newly formed block to the previous one.

Governmental bodies for the storage of highly secure identities and other sensitive data, such as land registry records (Themistocleous, 2018) and customs statements

(Belu, 2020) are already investigating Blockchain technology. Furthermore, the application of blockchain opens up new avenues for data sharing with citizens and even between different institutions.

3.3.3.1. Gamification and Blockchain Adoption

As per a global survey carried out by the esteemed consulting firm BDO, which involved participants from the public sector, 43% of the respondents are investigating use cases related to blockchain technology, 35% are testing the possibility of implementing blockchain technology, and merely 8% are putting blockchain applications into practice within their public institutions (BDO, 2020). It is crucial to manage the concept of "change" among staff members in preparation for the possible adoption of new technology, as it may alter their business or financial situation. Finding a technique to influence consumers' motivation to adopt blockchain technology is one strategy to address the issue of technology adoption. According to Ryan and Deci (2000), there are two types of motivation: intrinsic and extrinsic. The intention of someone to carry out an action because they believe it will be joyful is referred to as intrinsic motivation. On the other hand, acting because of outside forces is known as extrinsic motivation (Mekler, 2015).

The use of game plan elements, such as points, badges, missions, etc., to draw people in non-gaming contexts is known as gamification (Huotari & Hamari, 2017). The notion of "gamification" incorporates components like badges, points, and other incentives (Muntean, 2011) with the primary goal of promoting motivation (McGonigal, 2011). This applies to both types of motivation (Richter et al., 2015). An illustration of what gamification looks like in action is shown below (Figure 7).

The "Memrise" software is a gamified language learning tool that teaches languages using a range of gamified techniques, such as a gamified graphical user interface. The user of this app is an astronaut who is going on a language-learning expedition. Game levels rise as the user gains greater proficiency in the new language, and a number of ancillary virtual characters—as cartoon aliens—evolve in tandem with the user's language learning.

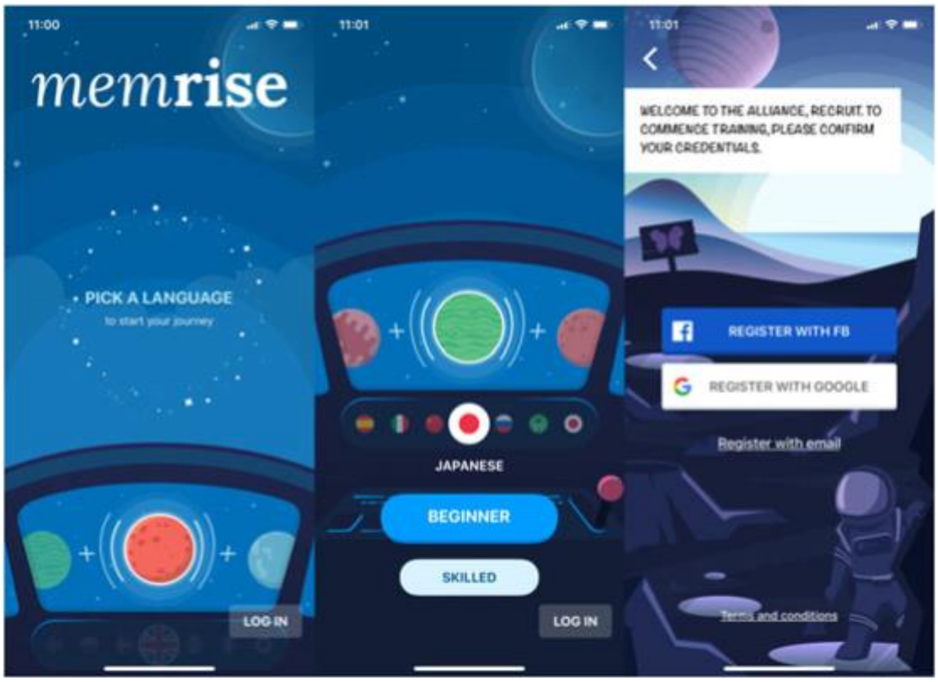

Figure 7 Example of gamification in Memrise app

Gamification has been included into the electronic government of many countries. Australia, Great Britain, Singapore (Yen et al., 2019; Pluntke & Prabhakar, 2013), and Spain (Garcia et al., 2019) are a few examples of industrialized countries that seem to have the majority of governments (Purwandari et al., 2019). However, it also happened in developing countries like Malaysia (Wei & Anwar, 2017) and Indonesia (Rahayu et al., 2017). By placing participants in a lottery pool sponsored by drivers who had received traffic citations, people who drove within the speed limit in Stockholm were encouraged to drive more safely. Over the course of the three-day experiment, there was a 22% decrease in traffic speed (UNDESA, 2016). Because of the associated difficulties, the public sector has not fully embraced gamification as a tool (Tolmie et al., 2014). Applying gaming to government services is a significant challenge, for example, because turning an activity into a game makes it harder to access (Mahnic, 2014). However, actual study data shows that playing engagement games increases political participation and government confidence (Hassan, 2017; Kahne et al., 2009). After analyzing these data, we conclude that in order to encourage public employees to use blockchain technology, a framework for game design is necessary.

Blockchain adoption needs to be gamified, and this calls for an appropriate design framework. Scholar Mora conducted a literature review and penned a paper discussing the various design frameworks for gaming (Mora et al., 2015). The authors' method involved identifying 21 design frameworks before coming up with 18 frameworks. Five dimensions were the main focus of the discussion of the final 18 frameworks:

1) economic;

2) logic;

3) measurement;

4) psychology;

5) interaction.

3.3.3.2 Design of the Gamification Framework

We selected education as the industry and the verification of academic credentials as the primary problem to address in order to explore the possibilities of gamification as a means of promoting blockchain adoption in the public sphere. Our focus is specifically on the falsification of academic records. Academic record falsification is widespread and commonplace. According to Accredited Online Colleges (Accredited Online Colleges, 2020), more than 100,000 degrees are simply purchased each year in the US; this may include more than 50% of PhDs

(Ezell & Bear, 2012). The biggest benefit of blockchain technology in education is that it is a shared, unique version of the truth. Blockchain's integrated smart contract and authentication capabilities may enable automation of activities related to university administration, academic record transfers, credential equivalency development, and credential transfers (OECD, 2021). Blockchain technologies confirm a credential's origin (i.e., the institution that issued it) and the authorized recipient by combining state-of-the-art encryption with digital signatures (OECD, 2021).

Out of the eighteen design frameworks, that Mora proposed (Mora et al., 2015); we selected a motivation-oriented design framework for gamification since research has demonstrated that motivation increases information system adoption and trust (Akhlaq & Ahmed, 2013; Alalwan et al., 2015). In this instance, the gamification element may increase public employees' trust and affect their decision to utilize blockchain technology. As a result, Yu-kai Chou's Octalysis design framework was selected because it is motivation-oriented (Chou, 2019). Octalysis is a framework for gaming that incorporates all of the gaming features that are present in games into actual information systems. From a design standpoint, Octalysis has eight core drives, according to Yu-kai Chou.

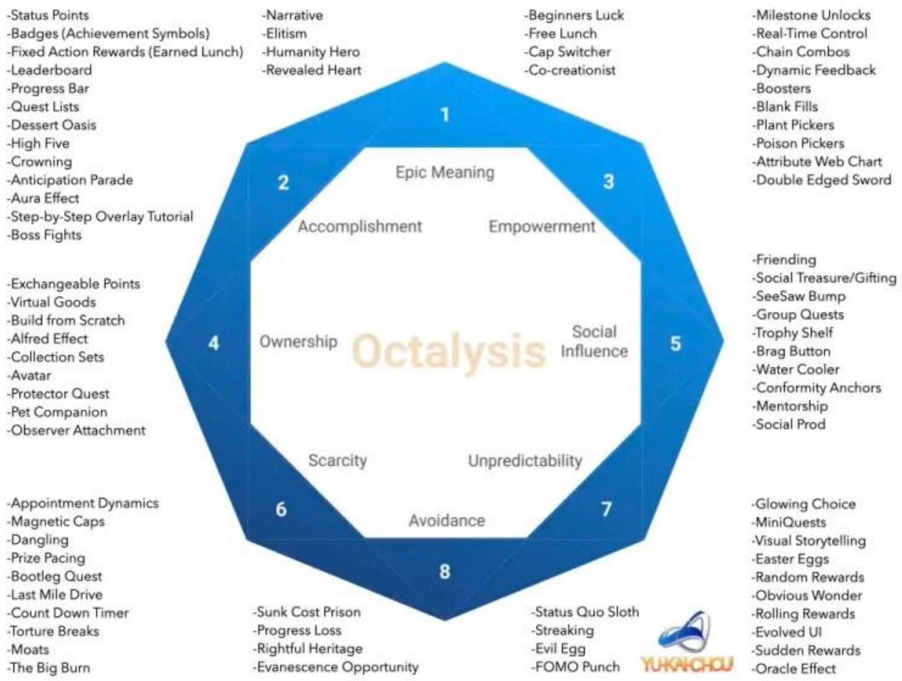

Figure 8 Octalysis gamification framework

1) Epic Meaning: This is the main motivation, when the player believes he has been chosen to carry out a significant task.

2) Accomplishment: This is the main motivation, where the player hopes to develop skills, overcome obstacles, and move forward.

3) Empowerment: Players must exercise creativity when attempting to resolve problems through the application of a varied blend of knowledge, as this is their primary motivation.

4) Ownership: This fundamental motivation stems from the participants' sense of ownership and ability to better what they have.

5) Social Influence: The social aspects of the game that affect the player, such as rivalry, camaraderie, and social emotions, are all included in this basic drive.

6) Scarcity: The gamers are driven by this core desire when they need something but cannot currently get their hands on it.

7) Unpredictability: The main motivation for the user to remain focused on the system's advancement is that he or she has no idea what will happen next.

8) Avoidance: The primary motivation, avoidance refers to avoiding a bad situation. The system user can be afraid of losing data, unless he takes immediate action in response to a specific problem.

Finding a way to apply the Octalysis framework to actual systems is the next stage. The creator of the Octalysis model, Yu-kai Chou, asserts that at least one of the eight core drives is typically present in a successful system. There are two phases to the Octalysis implementation:

1) The evaluation of the current system in light of the eight core drives' capacity. Either each edge of the Octagon will grow or contract based on how strong these gaming components are.

2) The system's customization through the addition or deletion of gaming elements in accordance with the strength or weakness of the Octalysis core drives.

3.3.3.3 Existing System's Assessment

To evaluate the blockchain's applicability at the University of West Attica (UNIWA), we chose to integrate the Octalysis framework into our system and encourage users to embrace blockchain. In order to determine the benefits and drawbacks of the system prior to its actual use, the Octalysis was applied in a learning environment. To begin with, we conducted an anonymous evaluation of the current system by asking 20 employees of the UNIWA Information Technology Department to rate it based on whether or not Octalysis core drives are now present in it. In the conclusion, we produced Figure 9, which shows the UNIWA system's capacity in connection to the Octalysis paradigm.

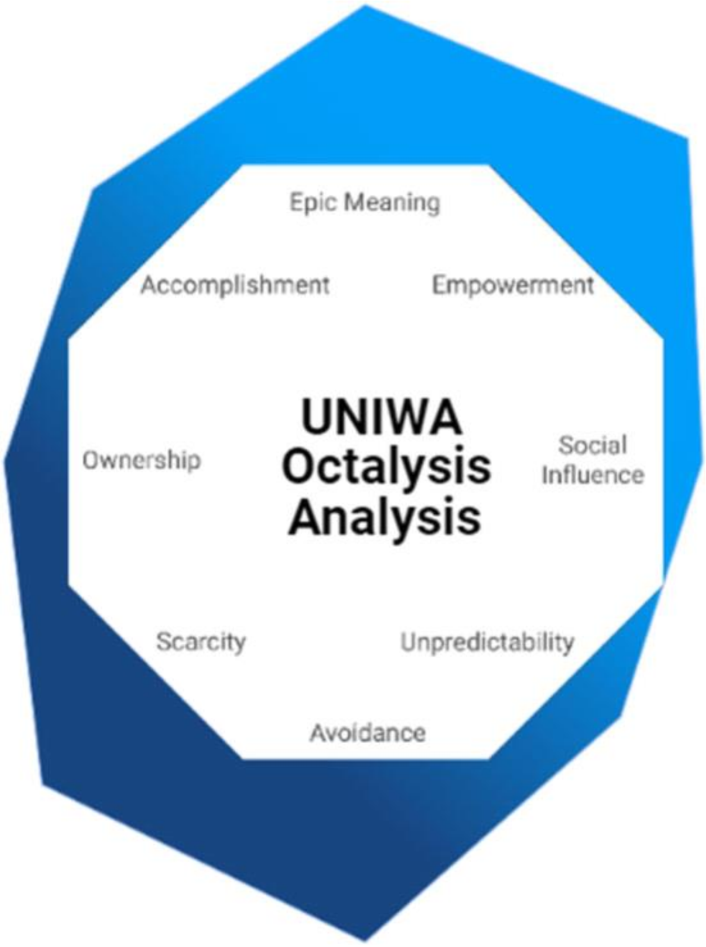

Figure 9 UNIWA's Octalysis analysis.

The outcome shows a healthy balance between the right and left sides of the octagon, representing intrinsic and extrinsic motivation. This indicates that the university's information system has gamification elements that may affect users' overall motivation to use it. On the other hand, we observe an expansion of the boundaries of the bottom core drives (unpredictability, avoidance, and scarcity). According to Yu-kai Chou, bottom core drives are also known as black hat gaming or negative motivators since they influence users' behavior negatively (e.g., making them act as though they are afraid of losing something). Our goal was to get consumers to adopt the new idea, and since adopting technology is linked to "positive" motivation (Parapanos & Michopoulou, 2022), we made the decision to incorporate more positive motivators into the new design and decrease negative ones. Consequently, we eliminated gaming elements from our current design, such "progress loss," "countdown timer," and "dangling," and included more positive incentives, like "badges."

3.3.3.4 New System's Testing Implementation

There has been little use of this paradigm in the public sector, although some study (Kenta et al., 2021; Treiblmaier & Zeinzinger, 2018) on the use of gamification to encourage the adoption of blockchain technology (Carrasqueiro & Monteiro, 2019). Siassiakos and other researchers have proposed an intriguing method to gamification and blockchain adoption in Greece: combining blockchain, gamification, and data analytics (Siassiakos et al., 2020). Motivated by this effort, we made the decision to develop and evaluate a prototype for a gamification strategy to implement blockchain at UNIWA. The concept resulted in the development of a smartphone application that makes the job of staff members validating a graduate student's degree more enjoyable. Put another way, getting a degree from a university is regarded as a blockchain transaction that needs to be confirmed by the government employees who work as miners.

Using a survey, the UNIWA staff's adoption of the gamified blockchain environment was evaluated. Specifically, a questionnaire grounded in the Unified Theory of Acceptance and Use of Technology (UTAUT) model was utilized to assess the application. Eight of the most important research theories on how people accept information technology are combined in the UTAUT model, which was created by Venkatesh and other researchers. These theories are all based on social cognition theory (Venkatesh et al., 2003). We modified our model to arrive at the form that is shown in Figure 10 because the influence of gaming is what we are primarily interested in.

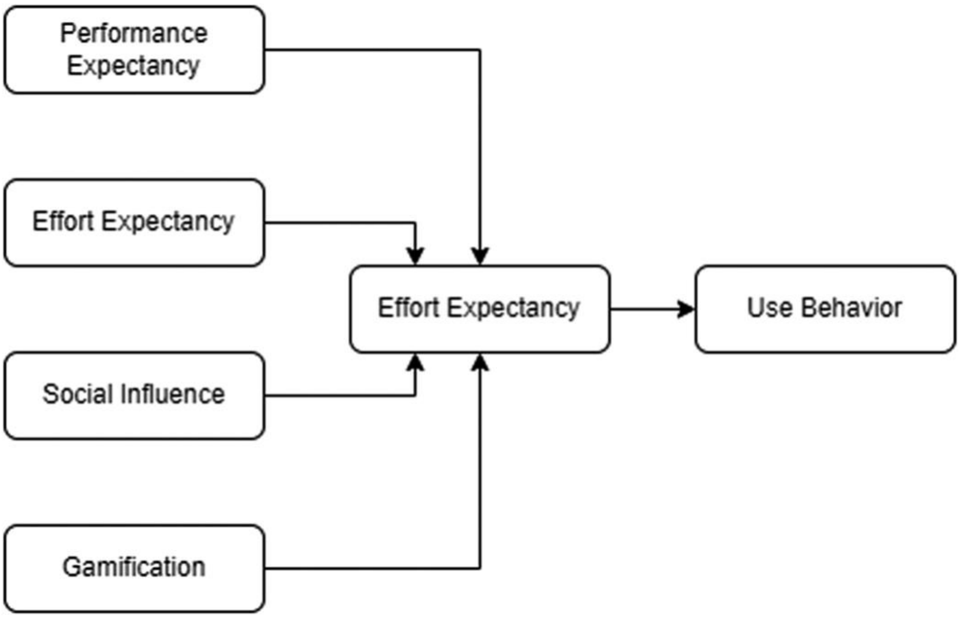

Figure 10 UTAUT model of gamified blockchain acceptance.

We distributed an anonymous survey to thirty employees of the university, and we hired statisticians to do the analysis. After making the Likert scale results of the poll more readable for decision makers, we prepared Table 5, which lists the variables influencing blockchain adoption.

The survey's successful results demonstrated that gaming is the most significant media that has the potential to affect blockchain technology adoption. Naturally, the social factor's great significance also highlights how difficult it is to include social components into the system because of privacy concerns. Most likely, we will test including Octalysis social gaming elements like "group quests" in the upcoming iteration of the system.

Factor	Percentage of influence
Performance expectancy	75.7%
Effort expectancy	74.3%
Social influence	76.2%
Gamification	77.5%

Table 5 Degree of Intention to Use the Gamified Blockchain.

3.3.3.5 Epilogue

The government's aims cannot be met with dedicated finances if public officials lack loyalty and acceptability, which is a prerequisite for the successful adoption of blockchain in public organizations. The focus of our scholarly work is to propose a conceptual design framework for gamification that influences technology adoption motivation.

Using the Octalysis schema, we tried a gamified blockchain system at UNIWA, and staff members responded well. However, we only used a tiny sample size and a small scale for our testing. We intend to test our model more thoroughly and use more Octalysis features before the gamified blockchain system is really put to use. In light of this, we intend to extend our research in subsequent articles, and this work serves as a first step toward the public sector's adoption of gamified blockchain.

We used our research on the blockchain's acceptance in the public education sector. With respect to the introduction of gamified blockchain (via Octalysis) into additional public domains, we propose the ensuing central initiatives, which are shown as follows.

1) Public sector: General public services

Suggested core drive: Accomplishment

Reasoning: Since this industry provides broad services, providing hurdles will also force employees to come up with innovative solutions.

2) Public sector: Defence

Suggested core drive: Epic meaning

Reasoning: Given the significance of the industry's content, gaming features that elevate staff members' sense of importance are essential.

3) Public sector: Public order and safety

Suggested core drive: Epic meaning

Reasoning: For the same rationale outlined in the section on "Defence."

4) Public sector: Economic affairs

Suggested core drive: Ownership

Reasoning: Since economics is a field where financial loss is possible, we draw consumers in by providing game characteristics like virtual money.

5) Public sector: Environmental protection

Suggested core drive: Epic meaning

Reasoning: For the same rationale outlined in the section on "Defence."

6) Public sector: Housing and community amenities

Suggested core drive: Social influence

Reasoning: Social gaming elements would be necessary to encourage blockchain adoption among users due to the community-based nature of housing services.

7) Public sector: Health

Suggested core drive: Epic meaning

Reasoning: For the same rationale outlined in the section on "Defence."

8) Public sector: Recreation, culture, and religion

Suggested core drive: Avoidance

Reasoning: Because this industry is mostly recreational, it needs gaming elements to keep public employees from getting sidetracked.

9) Public sector: Social protection

Suggested core drive: Social influence

Reasoning: For the same rationale as outlined in the section on "Housing and Community Amenities."

Though these are merely conceptual recommendations, we firmly feel that the public sectors should utilize gamification as a means of introducing cutting-edge technologies because of its motivating nature.

Regarding the Octalysis schema, there are a lot of game characteristics that are beneficial for adoption; in fact, the more gaming technology advances, the more features become available.

3.3.4 Designing a Blockchain Prototype for Governmental Elections

3.3.4.1 Introduction to the Blockchain

A trustworthy financial institution is not necessary for financial transactions to take place thanks to the architecture of an online peer-to-peer information system known as blockchain, which was first proposed by Satoshi Nakamoto in 2008 (Nakamoto, 2008). According to Segendorf (2014), Bitcoin was the first use of blockchain technology. It is a digital money that is exchanged online and is safe because it is based on cryptographic principles. Any industry that involves the transfer of value, including money, real estate, and other digital information, can benefit from the application of blockchain technology.

Blockchain uses time-stamped transactional data, which is stored in blocks connected by cryptographic hashes. The Secure Hash Algorithm (SHA-256) is the hash algorithm in use, and it generates a 256-bit hash (Barker, 2002). Any size of plain text can be fed into the SHA-256 algorithm, which converts it into 256-bit data. SHA-256 hashes are mathematical operations that generate a 256-bit hash code by splitting the original data into 512-bit chunks. A one-way hash algorithm, SHA-256 can produce a hash code from any kind of data, but it is unable to construct the data itself. Comparing the two hash codes is all that is required to compare two different kinds of plain texts that have been encrypted using SHA-256.

An example of using the SHA-256 hash function is the following, which displays the initial form of the plain text and the output of the hash code.

1. Plain text: Elections

Hash code (output of the hash function):

56ac9256e35acf7b7f72788785dfbe9525b73e93ec97963a0d363c54419529f2

2. Plain text: Election

Hash code (output of the hash function):

4e5c805d417e4c1e722e5d2646e249b52da27fb11071276c8b8a3e33f2175301

If we compare the two hash codes of the words "Elections" and "Election," we realize that we end up with two different hash codes, although the words are almost similar. This means that SHA-256 is a secure way to encrypt any type of information.

The Genesis block, which is the first in the chain, contains generic data for the whole chain. As new blocks and transactions are added on a constant basis, the chain of blocks also keeps increasing. Depending on the type of blockchain, the blockchain is a distributed ledger that can be accessed privately or publicly. It houses all of the transactions and allows all parties involved to examine them. A large number of validators, known as miners, examine each transaction to ensure that it is legitimate. In exchange for their efforts, the miners typically get paid. Miners will add a new block to the blockchain and permit the parties involved to complete this transaction if it is valid.

The structure of the Blockchain in each Block consists of the Header and the Body section. The Header section includes:

Time Stamp: A sum of unique data, which includes information about the exact date and time that the Block was added to the Blockchain.

Nonce: A random, unique number (32-bit field) that increases during the hash calculations and is the initial numeric value that the miners have to find before adding a block to the Blockchain.

Hash of the previous block: The hash algorithm of the previous inserted block (parent block) is used to link each block to the one before it.

Merkle Tree Root: A block of the Blockchain's hash value that combines the hash values of each transaction on the block.

The total of all transactions (Transaction1, Transaction2, Transaction3, etc.) and a transaction counter that approximates the quantity of archived transactions are included in the Body section.

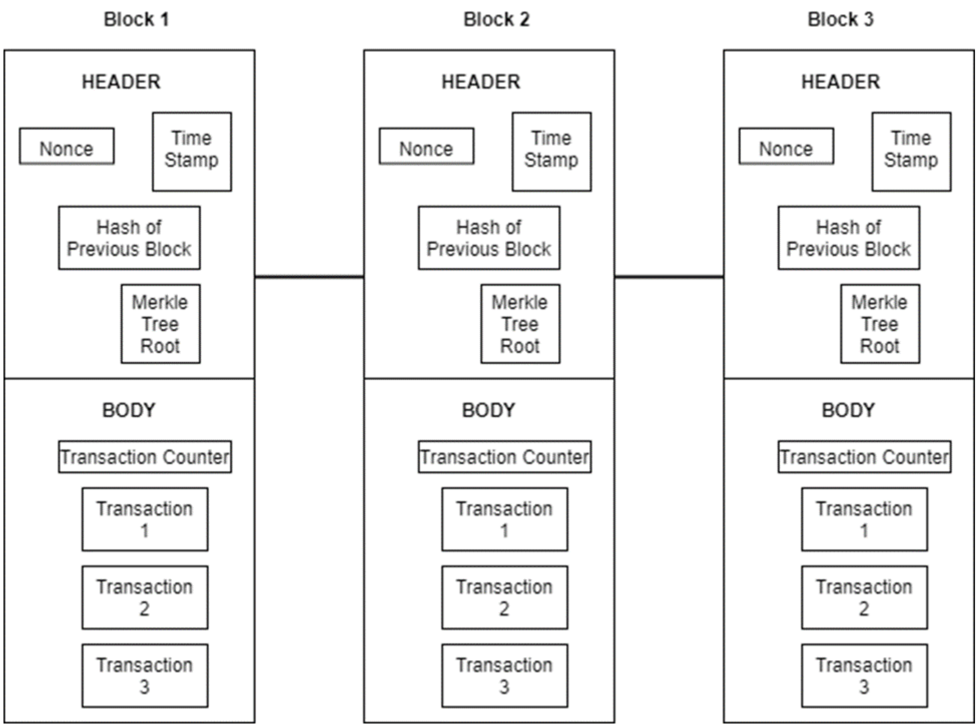

Figure 11 Blockchain structure

The nodes to validate the transactions, lowering the possibility of fraud by identifying legitimate transactions and guaranteeing that each node has an authenticated copy of the distributed ledger that is up to date, use a consensus process. Consensus methods come in several forms, and each has benefits and drawbacks. These are the key consensus processes that are used to verify transactions and add new blocks to the Blockchain.

3.3.4.2 Types of Consensus Algorithms

1. Proof of Work (PoW): This algorithm was first used for bitcoin and introduced by Nakamoto, the founder of Blockchain. With the PoW method (Gervais et al., 2016), the miners are trying to solve a mathematical puzzle by using their computers to implement various computations. Specifically, the computers (nodes) participating in the PoW competition calculate the hash values of the block's header in order to find the exact value of the hash that meets some predefined criteria (Bamakan, Motavali, & Bondarti, 2020). The first node that finds the expected hash value is the one that will add the block to the Blockchain and receive a reward. The advantage of PoW is its decentralised character, since miners are not predefined under specific criteria; however, the problem is that the mining process requires a lot of time and energy for the nodes to perform the calculations. Time and energy are crucial factors that prevent engineers from using it for large datasets and the validation of many transactions (Alsunaidi & Alhaidari, 2019). Due to the criticism received from other scholars (Ullrich, Stifter, Judmayer, Dabrowski, & Weippl, 2018) (Zhang & Chan, 2020), recent research has focused on replacing the electrical energy of the nodes with solar energy from solar panels (Rishabh & Dogra, 2019) to save money and make the algorithm energy efficient.

2. Proof of Stake (PoS): The PoS algorithm does not depend on the computing power of the miner; on the contrary, it depends on the financial power (stake) of the miner (Nguyen et al., 2019). All the participating miners are selected randomly, and the only obligation for them is to own over a specific amount of digital currency to participate in the mining process. On the contrary, with the PoW method, this one requires a deduced amount of computing power. However, the problem is that the asset based selection policy creates a private blockchain "by default" and creates a lobby of miners with centralized decision power. Moreover, the miners receive no reward for their mining services, except the transaction fees, which offer no motivation for them to deliver their services responsibly.

3. Delegated Proof of Stake (DPoS): The DPoS (Saad & Radzi, 2020) is an improved version of the PoS algorithm. The new element is that the miners who validate the transactions are elected from all the participating nodes on the Blockchain. Moreover, if a miner is delaying the mining process, the other miners have the right to replace him. This is an energy-efficient method, but it transforms the system into a centralized one with fraud potential since the voters are able to choose the miners who will satisfy their needs.

4. Proof of Elapsed Time (PoET): The PoET algorithm (Chen, et al., 2017) was developed by Intel and is almost similar to the PoW since each miner is called to solve a mathematical puzzle. The miners are entering the network, and then the algorithm generates random sessions of waiting time for each miner. The miner with the shortest amount of waiting time is the one that will validate the first transaction and consequently add a new block. The advantage compared with the PoW method is that it requires less computing energy because the nodes who join the network could sleep until their time session comes for the transaction's validation.

5. Proof of Activity (PoA): The algorithm's operation combines elements from both PoW and PoS. The implementation of the PoA (Bentov, Lee, Mizrahi, & Rosenfeld, 2014) initializes with the validation of the first transaction as a PoW system, and then for the mining of the second transaction, the system will use the PoS method. The advantages of the PoA algorithm are that the PoW part of the process makes it difficult for the hackers to identify the participating nodes, and the PoS part reduces the required energy for the miners.

6. Proof of Importance (PoI): This algorithm proceeds by choosing the miners who validate the transactions on the Blockchain, depending on the importance of the nodes. The system specifically performs a graph analysis by estimating each node's transaction quantities and hash computation before prioritizing each node for block addition based on his overall performance score (Tasatanattakool & Techapanupreeda, 2018).The higher the number of past block additions to the Blockchain, the higher the importance of the node and its potentiality to become an active node again. The disadvantage of this algorithm is that it prevents miners from spending their cryptocurrency in order to remain "rich" and participate in the selection process for the mining process of the new Blockchain.

7. Proof of Luck (PoL): The PoL algorithm (Milutinovic, He, Wu, & Kanwal, 2016) depends on the node with the highest luck. Each participating node selects a random number, and the one with the highest number is chosen to validate the transaction and add the next block. The advantage of this algorithm is that it reduces energy consumption because only the chosen node consumes energy for the transaction's validation. Moreover, it is a secure algorithm because an attacker will find it difficult to predict who the luckiest node to add the block is, and it requires a lot of computing power to gain access and control all the participating nodes.

8. Proof of Weight (PoWeight): This algorithm is based on the Algorand (Buntinx, 2018) consensus method and chooses the participating nodes to validate the transactions depending on the weight assigned to each node. It is almost similar with the PoS because one important criterion for the weight's assignment is how much cryptocurrency the nodes hold. However, there are other additional factors for the weight, such as the quantity of data that each node stores. The PoWeight algorithm is efficient in terms of energy consumption; however, the fact that the miners do not receive an award may prevent them from participating on the Blockchain.

9. Proof of Burn (PoB): This algorithm is based on the theory that the nodes that become miners, do not have to waste computing energy but cryptocurrencies (Kiayias & Zindros, 2020). The obligation of the miners is to "burn" part of their savings in cryptocurrency by sending them to a publicly verifiable address that holds them and prevents anyone from spending them. The more cryptocurrency the node burns, the more likely it is that he will become a miner. The cryptocurrencies sent to this address are not actually destroyed, but are becoming inaccessible to anyone and cannot be spent.

10. Proof of Capacity (PoC): The PoC (or Proof of Space) algorithm's theory supports the argument that the potential miners have to dedicate a part of their hard disc capacity for the mining process (Dziembowski, Faust, Kolmogorov, & Pietrzak, 2015). Instead of spending computing power, such as in PoW or currency, such as in PoS, the miners with the largest hard disc space allocated for mining, have the better options to add the block to the Blockchain. Beforehand, the nodes allocate hard disc space on their sides and store potential solutions that include hash values that might match the hash value that the algorithm will define. Consequently, the node that stores the most hash values, is the one with the best chance of being chosen to add the block. The advantage of this algorithm is its low energy consumption, but the hard disc capacity requirement may raise node costs by requiring nodes to purchase expensive hardware or rent cloud storage resources.

11. Directed acyclic graphs (DAGs): A DAG is a data structure in which a set of entities are related to one another and the flow of information in a network can pass through a defined direction without reaching the same nodes more than once (Benčić & Žarko, 2018). The creation of distributed ledgers (such as Blockchain) is an implementation of DAGs, with the difference that no blocks are required and transactions are verified very quickly because the nodes act in parallel.

12. Practical Byzantine Fault Tolerance (PBFT): A problem related to the validity of the transactions on the Blockchain is the fact that malicious nodes might affect the chain's operation. The PBFT method (Gao, Yu, Zhu, & Cai, 2019) is an answer to this problem because the theory suggests that all nodes participated in transaction validation, and the block is added only when two-thirds of the network agrees on transaction validation. The advantage of this method is energy efficiency because all the participating nodes, equally offer the computing power needed to validate the transaction. On the other hand, the problems are that there is no reward for the nodes, and there is a time delay until all the miners agree on the validity of the transaction.

13. Delegated Byzantine Fault Tolerance (DBFL): The DBFL algorithm operates in the same way as the PBFT, however, the main difference is that not all the nodes are participating in the mining process (Hongfei & Zhang, 2021). On the contrary, a number of nodes are selected based on pre-defined criteria, who add the blocks to the Blockchain. The main advantage of this algorithm is its energy efficiency; the disadvantage is that the delegates are elected publicly and there is no anonymity mechanism that prevents them from becoming victims of malicious attacks.

14. Raft: This is a distributed consensus algorithm, and it was first designed to achieve consensus on a server system over a shared state (Ongaro & Ousterhout, 2014). According to Raft, each node in a multiple server system can acquire each of the following roles: 1. Leader, Candidate, Follower. The Leader is elected and interacts with the client, the Candidate asks for votes to become Leader and the Follower only responds (not issues) requests. The Raft system divides time into randomized time terms, and during each term, an election is initiated, resulting in random Leaders at the end of the process due to the random duration of the elections. The advantage of the system is that each time a random miner adds a block to the Blockchain, this fact alone cannot ensure that this node is not a malicious one.

By comparing all the mentioned algorithms based on the works of several scholars (Bamakan, Motavali, & Bondarti, 2020) (Alsunaidi & Alhaidari, 2019) (Sharma & Lal, 2020) (Kaur, Chaturvedi, Sharma, & Kar, 2021) (Azbeg, Ouchetto, Jai Andaloussi, & Fetjah, 2021), table 6 was created, which includes the comparison of five important features:

1. Decentralization: The term refers to the degree to which one or a few entities control the process of mining and decide upon the selection of nodes and the process/duration of mining.

2. Energy efficiency: The term refers to the degree of computing energy savings by using an efficient method to tackle the issue.

3. Security (51% Attacks): A 51% attack is one of the most common attacks on the Blockchain (Sayeed & Marco-Gisbert, 2019) and refers to the capability of selected miners to control 51% of the computing power or the harsh rate of the network.

4. Speed (Block creation): The term refers to the speed of adding a block to the Blockchain after the validation of the transactions.

5. Scalability: This phrase describes the capacity of a consensus method to handle an increasing volume of transactions for Blockchain validation without crashing the network.

Algorithms	Decentralization	Energy Efficiency	Security (51% Attacks)	Speed (Block Creation)	Scalability
Proof of Work (PoW)	Strong	Low	Vulnerable	Slow	Strong
Proof of Stake (PoS)	Strong	High	Vulnerable	Fast	Strong

Delegated Proof of Stake (DPoS)	Strong	High	Vulnerable	Fast	Strong
Proof of Elapsed Time (PoET)	Strong	High	Safe	Fast	Strong
Proof of Activity (PoA)	Strong	Low	Vulnerable	Medium	Strong
Proof of Importance (PoI)	Strong	Low	Safe	Fast	Strong
Proof of Luck (PoL)	Strong	Low	Safe	Fast	Strong
Proof of Weight (PoWeight)	*Weak*	High	Vulnerable	Fast	Strong
Proof of Burn (PoB)	Strong	High	Vulnerable	Fast	Medium
Proof of Capacity (PoC)	Strong	Medium	Vulnerable	Slow	Strong
Directed Acyclic Graphs (DAG)	Strong	Low	Safe	Fast	Strong
Practical Byzantine Fault Tolerance (PBFT)	Weak	Medium	Vulnerable	Slow	Weak
Delegated Byzantine Fault Tolerance (DBFL)	Weak	Medium	Vulnerable	Fast	Medium
Raft	Weak	High	Safe	Fast	Weak

Table 6 Comparison of Blockchain consensus algorithms

3.3.4.3 Types of Blockchain

Furthermore, there are various types of blockchain networks based on their privacy. According to Korpela and other scholars, the Blockchain is classified into three categories (Korpela, Hallikas, & Dahlberg, 2017):

1. Public Blockchain: The Public Blockchain is an open system that enables all users with access to the internet to validate transactions and add blocks (Lai & Chuen, 2018). Bitcoin and Ethereum are several popular examples of the Public Blockchain system.

2. Consortium Blockchain: The Consortium Blockchain is also an open system with information available to all participants; however, the nodes are predefined and only trustworthy participants are accepted for transaction validation (Dib, Brousmiche, Durand, Thea, & Haminda, 2018).

3. Private Blockchain: The private Blockchain is a private network where not all the nodes have permission rights to the information throughput and the validation of the transactions (Kwak, Kong, Cho, Phuong, & Gim, 2019). Usually, a centralized entity authorizes the users of the network for further actions on the Blockchain.

For a better understanding of each type of Blockchain, here is a comparison based on three features of the network:

1. Decentralization: This is the degree to which the Blockchain network is not controlled by a central authority. On the Public Blockchain, the network is completely open, and no one controls it. On the Consortium level, there are usually a few authorities that control the whole network, and on Private Blockchain level, there is always an authority that controls the network.

2. Participation of nodes: This is the number of nodes that participate in the mining process of the Blockchain. On the Public Blockchain, all nodes are

able to participate in the validation of the transactions and the addition of the block to the Blockchain. On the Consortium Blockchain level, there is a small team of nodes who are authorized for the mining. Lastly, on Private Blockchain level, there are strictly selected nodes that participate in mining.

3. Access to information: This is the degree to which one or more nodes of the network have access to the information stored on the Blockchain. On the Blockchain level, all the participants have reading rights and can access the information stored on the network. On Consortium and Private Blockchains, access to information could be public or limited, depending on the decision of the authorities who control the network.

	Public	Consortium	Private
Decentralization	Yes	Partially	No
Participation of nodes	All nodes	Few nodes	Selected nodes
Access to information	Public	Public or limited	Public or limited

Table 7 Comparison of Blockchain Types

E-voting is a type of digital information that could be transferred through the use of the Blockchain.

3.3.4.4 E-voting system's components

By constructing a voting system that reduces the possibility of corruption, the proposed electronic voting system seeks to improve voting transactions' openness and boost public confidence in the government. Other objectives include developing a quick voting system, which will slow down the release of election results, and cutting down on the expense of Greece's current electoral system.

The e-voting system that we are going to implement should be user friendly and meet the following requirements (Qadah & Taha, 2007):

1. Authenticity: Only citizens who are registered in the national polling database by using a unique username and password could cast a vote in the elections. In our case, the citizens will use the same login details that they use for the Greek taxation system.

2. Accuracy: Only the valid votes from the e-voting system should be counted.

3. Privacy: During and after the voting process, the voter's identity must remain concealed, so no one will be able to connect the voter's choice to his or her true identity.

4. Security: During the voting process, the vote cannot be accessed by anyone.

5. Democracy: All the registered persons should be eligible to vote.

The e-voting system includes a Blockchain system embedded in a client-server architecture. The system consists of the following components (Shah, Kanchwala, & Mi, 2017):

1. Voter (VR)

2. Voting device (UI)

3. Authentication server (AS)

4. Blockchain server (BS)

5. Blockchain system (BSM)

Voter is a citizen who is eligible to vote in the national elections according to the Greek legal framework.

Voting device is the device that the citizen uses to access the appropriate web page to vote through the e-voting system. The voting devices could be personal computers/laptops, tablets, or voting machines provided by the government for those who have no access to a personal computer. The required technical features of the devices include large internal memory, processing power, a large screen size, and web browsers installed. If the citizens decide to not use their personal devices, then they have to visit the physical public offices and use the offices' gear for voting.

Authentication server is a web server connected to a database of the Greek tax registration system, which includes information for all the citizens eligible for voting. The role of the server is to authenticate the eligible voters and create accounts for them in the Blockchain system.

Blockchain server is a server that sends the votes to Blockchain nodes for verification and provides a key to the citizens to use for the encryption of the voting message.

Blockchain system is the system used for the voting of the citizens. One of the specialized nodes receives the votes cast by the public in order to verify the results. The integrated smart contract is used by the node to verify the vote's legitimacy. The node adds a block to the Blockchain after confirming the vote. The blockchain-based electronic voting system is made up of multiple interconnected blocks. The first block, dubbed Genesis, contains all the election metadata, such as candidate names, election duration, details about valid votes, and other data needed to carry out the election process. The voter's ID, vote, vote signature, timestamp, and hash value from the previous block are among the other blocks (Haibo, 2019). The architecture of the Blockchain is depicted in Figure 12.

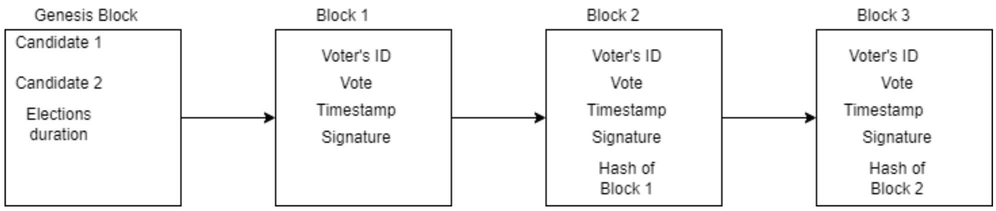

Figure 12 Blockchain architecture

3.3.4.5 E-voting system's processes

The e-voting process consists of four stages:

1. Initialization
2. Registration
3. Voting
4. Counting of the votes from the governmental staff

3.3.4.5.1 Initialization

During the initialization stage, the rules of the elections are defined in a smart contract, including the duration of the election's process, the stages of the process, and the citizens who are eligible to vote. All of this data will be used to create the genesis block, the first block of the blockchain that will be stored on the chain. The genesis block includes all the metadata that is useful for the implementation of the e-voting process. The genesis block includes the names of the candidates and their addresses on the Blockchain, the duration of the elections, and the validation public keys for the elections. Table 8 displays an excerpt of the smart contract for the poll creation.

```
contract NewEkloges {

 //creates the poll (Kalpi in Greek)
 struct Kalpi {
  address owner;
  string title;
  string options;
  uint deadline;
  bool status;
  uint numVotes;
 }

 // event of recording all votes
 event NewVote(string votechoice);

 // declare a private poll called k
 Poll private k;

 //function that stores the required initial poll information
 function NewKalpi(string _options, string _title, uint _deadline) {
  p.owner = msg.sender;
  p.options = _options;
  p.title = _title;
  p.deadline = _deadline;
  p.status = true;
  p.numVotes = 0;
 }
```

Table 8 Smart contract for the Poll creation

3.3.4.5.2 Registration

The **registration** stage is the phase in which the citizens are authenticated through the Greek tax registration system. The registration of citizens could be done in either an offline or online setting. The offline process allows those who do not own a polling device to visit the local polling office and use the appropriate computing devices. The visiting citizens show their passport/identification card to the person in charge, who records the person's details to prevent unauthorized people from attempting to cause damage to the polling gear. If the citizens choose the online process, then everything is implemented on their side by using their own registration device (computer, smartphone, tablet, etc.).

Users can register online by going to the website gov.gr and clicking on the link "Greek Elections." They are entering their credentials, and the website sends the http request to the website of AADE (Greek tax registration service), which is gsis.gr. The system of gsis.gr tries to match the credentials with the credentials stored in the database of AADE because, according to Greek national law, all the citizens registered with AADE, are the citizens who are eligible to vote in the Greek elections. If the citizen is registered with AADE, then the process continues; otherwise, the request is rejected and the system displays to the user an error page displaying "User not found, please try again." If the voter is finally registered, the voter's client side will generate a pair of public and private keys. The public key will be used as a "hidden identity" of the voter and will verify his signature; the process is depicted in Figure 13.

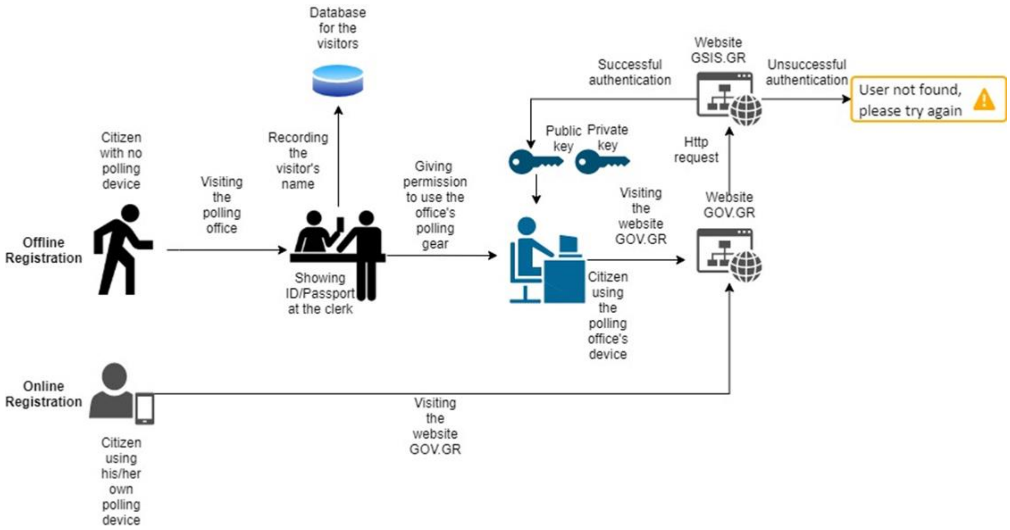

Figure 13 The online and offline registration stage

3.3.4.5.3 Voting

Voting is defined as a series of subprocesses, all of which are depicted in Figure 14 and refers to the broadcasting of the vote to the blockchain network. The voting stage includes the log-in of the citizen to the authentication server **(subprocess 1), and** after the successful authentication of the user, a public key is generated on his side and sent to the authentication server **(subprocess 2)**. The key creates an account for the user on the Blockchain system, and a sum of the Ether currency is added to his account on Blockchain **(subprocess 3)**. The authentication server sends back a token session for the user **(subprocess 4a)** and the user sends it to the Blockchain server **(subprocess 4b)**, who verifies it from the authentication server **(subprocess 4c)**. Then, the Blockchain server sends to the citizen the public key of the Blockchain node that will receive the citizen's vote **(subprocess 5)**. The citizen uses this public key to encrypt his vote and send it to the Blockchain server **(subprocess 6a)** who sends it to the node in charge of the voting process **(subprocess 6b)**. The Blockchain code is managed by miners who verify the transaction by using the mechanism of the proof of Luck (PoL) since it uses a consensus algorithm that is strongly decentralized, consumes less energy, is fast in terms of block creation, and has strong scalability, preventing the system from instantly collapsing. After the validation of the transaction, the Blockchain node sends the vote to a Smart contract to check if it is valid and finally adds the vote as block to the network (**subprocess 7a**). Then the node, encrypts the message with a private key and sends the Ether of the citizen to the Blockchain account **(subprocess 7b)** of the candidates (the candidates have also set up Blockchain accounts before the election process).

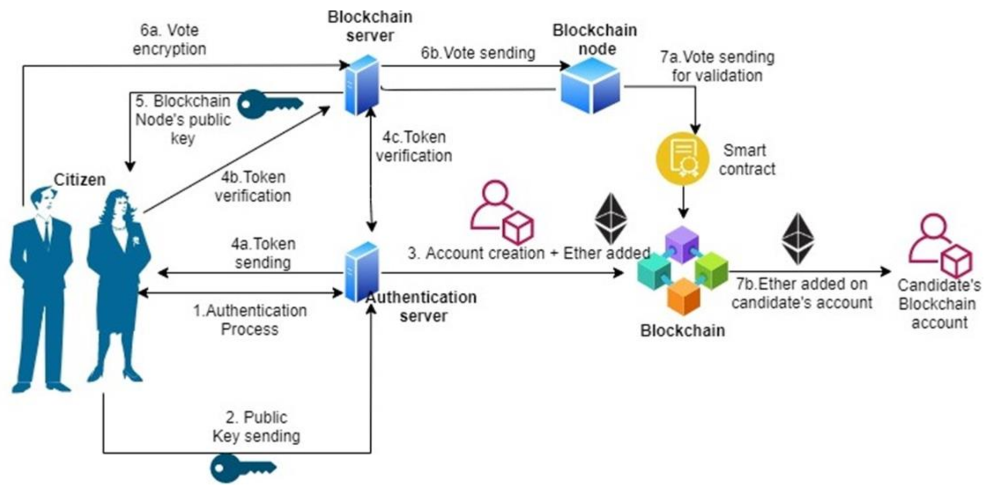

Figure 14 The voting stage with its subprocesses

Voting protocol

In order to ensure that the voting process satisfies the requirements of fairness, eligibility, privacy, verifiability, and alteration, the **voting protocol's** scope is described as follows (Hardwick, Akram, & Markantonakis, E-Voting With Blockchain: An E-Voting Protocol with Decentralization and Voter Privacy, 2018). The assurance that no one would obtain access to the election results prior to the process' conclusion is referred to as fairness. Only eligible voters are allowed to cast a single ballot following the completion of the prior authentication procedure. The "voting choice" of a citizen to prohibit unauthorized access is known as privacy. Verifiability is the guarantee that every vote has been cast and the option for voters to confirm this information. Alteration is the process by which a voter modifies their vote after it has been cast but before the election deadline passes. The following components make up the voting protocol, and they are shown at the table 9:

Voting element	Description
V	Voter
V_{pubk}	Voter's public key
Vc	Voter's choice
Do_V	Voter's digital obligation
CH	Choice
Do	Digital obligation
Etv	Valid token for voting
VA	Verification authority
DS	Digital signature
V_{pvk}	Voter's private key
M	Message
VTID	Vote
B_V	Ballot
AB_V	Alter ballot
VL	Value of the digital obligation

Table 9 Voting Protocol's elements and description

Voting Protocol's Functions

A. Voter: A voter (V) is a person who is eligible to vote according to the national laws and has the right to vote for one of the candidates. The voter owns a public key (Vpubk) and can make a voting choice (Vc) for one of the candidates or even cast an invalid vote as a symbol of protest. Therefore, the voter will adopt a digital obligation (DoV) about his/her voting choice (Vc) that will make it known only during the counting process of the votes.

The voter has to send both the digital obligation (DoV) and the public key (Vpubk) to the verification authority for it to sign them. The client will use a blind signature to protect the privacy of the user and will use a blind function for the message (including the public key and the digital obligation) to the verification authority, which will sign the message and send it back. The client will receive the message and unblind it, and this would be the required and valid token Etv for voting. Here is our Python code for the blind signature, which is a modification of the computing code, originally created by Robert Durst (Durst, 2017):

```
import cryptomath, random, hashlib



class SigningPerson:



    def __init__(self):

        self.publicKey, self.privateKey = (self.generateInformation())



    def getInformation(self):

        # The signing authority creates public and private keys and stores them.

        p = cryptomath.getPrime()

        q = cryptomath.getPrime()

        phi = (p - 1)*(q - 1)

        n = p*q
```

```
        foundEncryptionKey = False
        while not foundEncryptionKey:
            e = random.randint(2, phi - 1)
            if cryptomath.gcd(e, phi) == 1:
                foundEncryptionKey = True

        d = cryptomath.findModInverse(e, phi)


        publicInfo = {"n" : n, "e": e}
        privateInfo = {"n" : n, "d": d}


        return[(publicInfo),(privateInfo)]


    def retrievePublicKey(self):
        return self.publicKey


    def signMessage(self, message, eligible):
        if eligible == "y":
```

```
        return pow(message, self.privateKey['d'], self.publicKey['n'])

      else:

        return None



  def confirmVoter(self, eligible):

    pass




class Voter:

  def __init__(self, n, eligible):

    self.eligible = eligible



    foundR = False

    while not foundR:

      self.r = random.randint(2, n - 1)

      if cryptomath.gcd(self.r, n) == 1:

        foundR = True



  def blindMessage(self, m, n, e):



    blindMessage = (m * pow(self.r,e,n)) % n
```

```
        return blindMessage



    def unwrapSignature(self, signedBlindMessage, n):
# The voter unwraps the blinding of the ballot.
        rInv = cryptomath.findModInverse(self.r, n)


        return ((signedBlindMessage * rInv) % n)



    def getEligibility(self):
# The voter is eligible to vote.
        return self.eligible



def verifySignature(message, randNum, signature, publicE, publicN):
    return (int(hashlib.sha256(str(message) + str(randNum)).hexdigest(),16) ==
pow(signature, publicE, publicN))
```

Table 10 Python Code

To test and implement the blind signature's code, we are using the command-line operation of the Windows operating system and the technical instructions by Subariah Ibrahim and other scholars (Subariah, 2021).

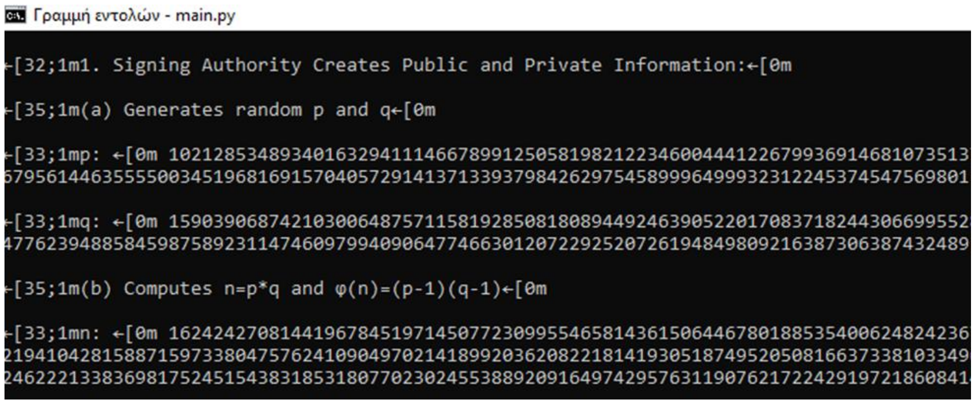

Figure 15 creating Blind Signature by using Python

B. Verification authority: The role of the verification authority (VA) is to act as a central authority and verify that only eligible voters will vote for the candidates. The verification authority for the Greek voters is the Greek Tax registration Agency (AADE) which will authenticate the users through the gov.gr website by checking the validity of the credentials that the citizens use to enter the Greek Tax Registration System. After successful authentication by the agency, the citizens receive a token that proves their eligibility as voters and enables them to vote. The token Etv is a digital signature over a message (DS) and embeds a private key (V_{pvk}) and a digital obligation. The representation of the eligibility token in mathematical symbols is the following:

$$Et_V = DS(V_{pvk} I\ Do_V)_{VA} \tag{3.1}$$

C. Vote: The vote is a unique message (M) that includes a ballot and a successful transaction on the Blockchain network. The vote is symbolised as a $VTID_M$.

D. Ballot: The ballot (BV) is the digital representation of the paper made document that displays the choice of a citizen over a candidate of the elections. If the value (VL) of the digital obligation of the voter has been made public, then the ballot is considered open, otherwise, it is considered sealed. Moreover, each ballot also includes the public key of the citizen.

$$AB_V = V_{pvk}IDo_VIEt_v \quad (3.2)$$

The ballot becomes alter ballot (ABV) when the voter changes his choice and casts a new vote to replace the previous one. The alter ballot embeds the following elements: a) A statement that the voter with a specific ID will cancel his/her voting choice; b) The voter's public key; c) The new digital obligation of the voter, including the new voting choice.

$$B_V = Cancel(VTID_M)IV_{pvk}IDo_VI\ DS(Cancel(VTID_M)IV_{pvk}IDo_V)V \quad (3.3)$$

Counting

The **counting phase** is the one during which the voters' voting choices are revealed. Particularly, the voters are broadcasting a ballot message including their vote unique message, the initial value of their digital obligation and a signature for both values. The **counting of the votes** is estimated by measuring the sum of the Ether currency that each candidate has received. The candidate with the highest sum of Ether is the winner of the elections because it means that he/she received the highest number of votes. In case of a recount of the votes, there should be a website displaying all the public keys participating in the Blockchain transactions. If the number of the public keys matches the accounts created on the authentication server, since each public key is associated with an account on the authentication server and an account (wallet) on the Blockchain.

Epilogue

The way things are currently done, especially with regard to electronic technologies, gives voters a lack of traceability and transparency, which makes them less confident that the vote they cast matches the one that poll workers record. We suggest using technology advancements to improve election structures rather than going back to antiquated offline methods. In this paper, we investigate the possibility of implementing Blockchain technology to address those cost and transparency concerns.

There are major benefits to the proposed system over the existing ones. Very significantly, it provides increased transparency by having an official voter database while maintaining the confidentiality of participants. It is a much more secure environment since it involves consensus from the randomly chosen nodes for a process to be executed. An attacker should have access to all nodes within the network in an attempt to change the outcome of elections. With a large sufficient amount of nodes and a degree of randomness in the selection of the nodes, this attack might become incredibly difficult. Moreover, the fact that there is no need for competition among the miners, just like with other consensus algorithms, offers the following advantages for the elections: Speedy voting transactions (low latency), less voting confirmation time, a small amount of computing energy required, and wisely distributed mining.

The chosen consensus method for the implementation of the mining process, Proof of Luck, is a consensus method that achieves reduced transaction latency while requiring the least amount of energy and computing power (He, Guan, Lv, & Yi, 2018). It is built on the usage of a trusted execution environment (TEE), which creates a random number generator. A trusted execution environment (TEE) (e.g., Intel SGX) is a section of a device's primary processor that is isolated from the main operating system (OS) (Sabt, Achemlal, & Bouabdallah, 2015). It guarantees that data is stored, processed, and preserved in a safe manner. By providing an isolated, encrypted mechanical framework and enabling end-to-end security, TEE secures any connected entity, such as a connected trusted application. A TEE is supposed to be safer than a standard processing environment since it operates in parallel with the operating system and uses combined hardware and software. Despite the fact that a TEE is separated from the rest of the device, trusted code running in a TEE will usually have complete access to the processor and memory of the device. The main function of the Proof of luck consensus is that nodes ask TEE for a random number (luck), and the node with the greatest luck is chosen to validate a block.

For the calculation of the speed/performance of our voting system, which is based on the Ethereum blockchain platform, we use the experimentation paradigm of Rouhani and Deters (Rouhani & Deters, 2017). The researchers ran an Ethereum blockchain, executed by a Geth client with a system configuration of 24 GB of RAM and a Core i7-6700 CPU. The experiment resulted in an estimation of the required time for processing 2,000 transactions, which is 198.9125 milliseconds. In our case, the total number of transactions required for implementing the Greek elections is approximately 9,828,523 transactions since this is the official number of all the Greek registered voters according to the Greek Ministry of Interior (Interior, 2022).

If 2,000 transactions = 198.9125 milliseconds of required time

Then 9,828,523 transactions = 977,508.0406 milliseconds.

977,508 milliseconds = 16.2918 min

This means that according to our estimation, the required time for the system to proceed with all the votes is only approximately 16 minutes, which proves the speed of our suggested voting system.

Except for transparency and speed, cost is another advantage of our suggested voting system. According to the Greek Ministry of Interior, the total cost of the Greek elections is estimated at about 75,000,000 Euros (Pagenews Team, 2022). The cost of our voting system is estimated by assuming that we will use the standard Blockchain hosting packages offered by famous companies such as IBM and Amazon.

Particularly according to the Amazon Web Services price calculator for hosting a Blockchain solution displayed at Table 11 (https://calculator.aws/#/createCalculator/ManagedBlockchain), the Total cost for Ethereum (monthly) is 3,048,858.50 USD (approximately 2,840,035.99 Euros) which is much cheaper than the 75,000,000 Euros spent by the Greek government for the elections in 2019.

	Blockchain's cost Estimation
1	50 instance x 1.229 USD hourly x 730 hours in a month = 44,858.50 USD total monthly cost for on-demand instance
2	50 instance x 800 GB x 0.10 USD = 4,000.00 USD total monthly cost for storage
3	0.000003 USD per request x 1,000,000 unit multiplier = 3.00 USD per million requests
4	1,000,000 million x 3.00 USD per million = 3,000,000.00 USD total monthly cost for requests
5	44,858.50 USD + 4,000.00 USD + 3,000,000.00 USD = 3,048,858.50 USD total monthly cost
6	Total cost for Ethereum (monthly): 3,048,858.50 USD (approximately 2,840,035.99 Euros)

Table 11 Blockchain's cost estimation

3.4 Cloud Computing

The way governments handle, store, and analyze data and apps has changed dramatically as a result of the cloud. Cloud computing is the provision of computer resources—such as storage, processing power, and software—through the internet. Cloud computing is increasingly being used by governments in e-government to provide flexibility, scalability, and cost-efficiency. Cloud services enable governments to store and access data from any location, allowing for remote work, collaboration, and data exchange among many departments. Cloud-based solutions also make it easier to design and implement e-government services. Governments to host and distribute web portals, apps, and databases, assuring high availability and reliability for citizens, can use cloud infrastructure.

Moreover, cloud computing offers governments significant cost savings. The pay-as-you-go nature of cloud computing allows governments to avoid investing in expensive on-premises equipment by only paying for the services they actually utilize. This reduces the need for initial capital investments and allows governments to build infrastructure in response to demand. Furthermore, cloud computing offers data integration and interoperability among many government systems. Governments can combine their data and applications by shifting to the cloud, boosting data sharing, collaboration, and efficiency across agencies. This improves procedures including citizen data access, interagency collaboration, and data analytics.

However, using cloud computing for e-government means that security, privacy, and regulatory compliance must be carefully considered. Governments must ensure that appropriate security measures, like encryption, access controls, and regular audits, are in place to secure sensitive data kept in the cloud. The privacy of citizens must be protected by adhering to data protection laws like GDPR. In order to guarantee ongoing service delivery, governments must also evaluate the availability and dependability of cloud service providers. Disaster recovery plans and service-level agreements (SLAs) should be put into place to reduce risks and ensure operations continue.

3.4.1 The Exploration of Government as a Service through the Community Cloud Computing

In the current paper, the idea of government as a service—managed from a public community, like the residents of a municipality—is discussed using cloud computing. A possible design for a gamified community cloud computing system is proposed in an effort to make managing cloud computing interesting and worthwhile. A community will be developed on-site, and the infrastructure for community cloud computing will be outsourced, according to the architecture. The potential of cloud computing as a tool for the successful functioning of a self-governing community is also covered in more detail in this article.

3.4.1.1 Introduction

Because the services are provided in both physical and virtual formats, public offices are a part of a public organization that functions in both modes. Every physical resource and procedure that the government manages is part of the public organization's physical infrastructure. As a result, the public organization's virtual structure ought to have at least the fundamental components of a virtual organization. A virtual organization is defined as "a security and collaboration context not exclusively associated with anyone physical organization" by Lee and other academics (Lee, 2014). Put another way, a virtual organization might be seen as existing apart from a real organization. Citizens may become confused if a virtual public organization is not connected to a real organization. However, the public organization's virtual entity is able to provide services that its physical one is unable to. For example, a virtual organization can provide digital signature and virtual authentication services around-the-clock. It is evident that the government becomes a collection of electronic services when it becomes a virtual public entity.

Government as a Service is a phrase that specifies a governance paradigm where cloud computing (Ostermann, 2002) is a significant part in the operation of the public sector. The ideals of service orientation are emphasized by contemporary society as the cornerstones of the world economy's future. Software as a Service is one promising idea that is being used (SaaS). Cloud computing is the platform that is being used to implement it.

3.4.1.2 Governance as a Gamified Cloud Computing Service

To enhance Government as a Service, we are examining the idea of community in this section. The idea behind cloud computing and community cloud computing is the same: they share hardware, software, and application resources among users. A high degree of political freedom allows citizens to engage in the political process more openly and actively, which in turn reduces corruption by enabling them to keep an eye on how the government is exercising its authority, according to Manion (2004). On a local level, it implies that individuals can contribute to the decrease of corruption if they engage in the electronic governance of their community. This is a compelling cause to investigate the autonomous community's real involvement in electronic governance. There are two forms of community cloud computing that depend on the administration of the server side components (Badger, 2011):

a. On-site community cloud: Community members are in charge of managing and maintaining the server.

b. Outsourced community cloud: A private company is responsible for managing and maintaining the server.

These two forms of community cloud computing in different ways when it comes to implementation and dissemination will affect governance. The instance of autonomous communities, like tiny towns or villages, is the most intriguing one. One could categorize users into two groups: those who behave solely as citizens and those who assume the administrator position and oversee the server's operations. The administration of the server and other associated duties take a lot of time, which may deter residents from joining the volunteer crew that oversees the cloud. To stay engaged and committed in this situation, they require either intrinsic or extrinsic motivation (Ryan & Deci, 2000). Intrinsic motivation is the word used to describe the reasoning behind an action taken because the person performing it finds it rewarding. Consequently, an activity that is motivated by extrinsic elements, such as a monetary incentive or some kind of external reason, is referred to as having extrinsic motivation (Mekler, 2015). According to McGonigal (2011) and Kapp (2012), gamification is a methodology that has a good impact on the idea of motivation, particularly on the two categories of motivation (Richter, Raban, & Rafaeli, 2015). According to Huotari and Hamari (2012), the usage of game aspects in a non-gaming study domain defines the concept of gamification. Badges, leaderboards, points, quests, and other aspects typically found in video games are among the gameplay elements. Intra-organizational systems (Farzan & Brusilovsky, 2011), work (Flatla, Gutwin, Nacke, Bateman, & Mandryk, 2011), and innovation (Jung, Schneider, & Valacich, 2010) are among the industries where gamification has been successfully applied. Nevertheless, there is little research on the topic of gamification's use in cloud computing maintenance. Shahri is now conducting research on who might volunteer to take over cloud administration responsibilities using a gamification approach (Shahri, 2014). Although this fact has not yet been empirically proven, the scholar's work suggests a connection between the various types of cloud users and the game features. The research for the current paper might benefit from this kind of information since it might enable the creation of a unique user interface with gaming components. Meanwhile, figure 16 shows the proposed architecture for the community cloud.

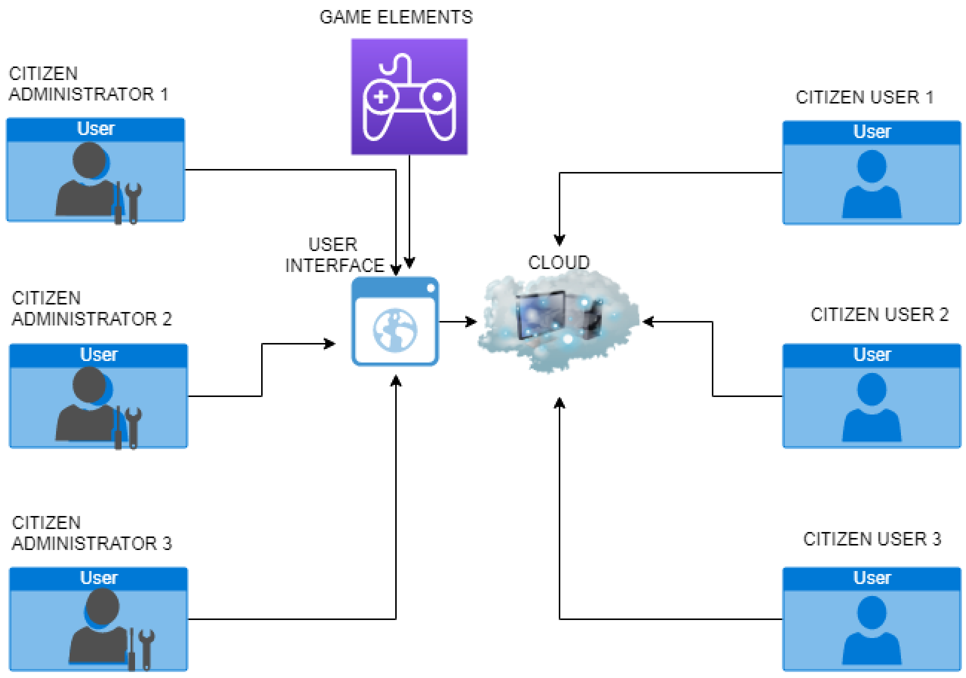

Figure 16 On-site community cloud computing.

The schema states that everyone can take advantage of the citizen services since the IT literal members will manage the cloud and handle technical duties, with some members helping with regular technical operations. In order to add a fun element to the responsibility of cloud management, the user interface for citizens acting as administrators will include gaming features like badges and status points. As long as each member concentrates on the community's governance objective and behaves appropriately, the community's relationship will remain strong. The appropriate use of citizens' rights will be prompted by the community's responsible behavior. Accordingly, members will appreciate the public sector more the more they respect the community. Governments, aware of this, will make an effort to educate and train the next generation of responsible citizens through educational school programs.

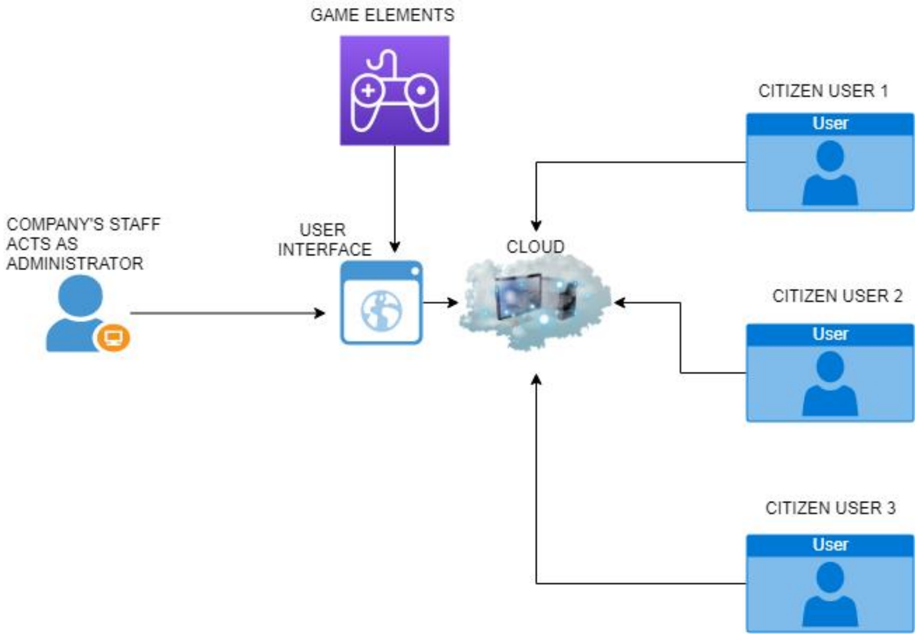

Figure 17 Outsourced community cloud computing.

The residents gain more independence when they use the outsourced communal cloud concept. The community members will concentrate on upholding citizen rights responsibly and cooperating with other communities; a business model could be created to grant other communities access to their best practices for governance in exchange for a subscription. The server's maintenance will be contracted out to an outside company. The company's employees, who may be encouraged to be more productive because they will find it pleasant, will also, use the gamified user interface.

The governments require the utilization of various apps and a substantial quantity of processing power. By using less costly software and hardware, community clouds enable citizens to share resources and save money. Not to mention, communities will be able to charge other communities for a portion of their computing resources.

Each community adopts a unique cloud computing system that meets their specific computing demands because they all share a common mission and set of needs.

Like any other community, the community of citizens has the following traits (Anderson, 2008):

a) Access: To use the community's resources, each member must have permission to do so.

b) Communication: Interaction among community members is necessary.

c) Presence: The community's members need to build ties with one another.

d) Involvement: Each community member is required to take part in community activities.

According to Gerald Briscoe and Alexandros Marinos, a community cloud computing has the following characteristics (Briscoe, 2009):

a) Openness: Since the main cloud computing companies do not impose any limitations, the notion is open source (Krutz, 2010).

b) Community: The social structure and the technological infrastructures have similar traits.

c) Graceful Failures: Since no one firm owns the cloud, there is less chance of a failure. Since each node in the community cloud runs independently, the failure of a node would be "graceful" since the system will continue to function and gradually recover, essentially removing any downtime (Birman, 2012).

d) Convenience and control: Since both are equitably dispersed throughout the society, there is no contradiction between the two.

e) Community currency: To utilize the service, community members might choose their own money. This currency could be cash aid or a voluntary technical effort (Soder, 2008).

f) Environmental Sustainability: Community cloud computing is an eco-friendly solution. To maintain the scalability of the available resources, each member of the community utilizes precisely the amount of energy required to meet its needs (Wang, 2011).

The following qualities of a communal service are conferred onto citizen action by the adoption of community cloud computing in the community:

Citizen community’s access and community cloud computing: By reducing access limitations, the open design of mobile cloud computing facilitates public document access. The members are aware of what to anticipate from their involvement in this community because they have similar requirements and a shared civic objective.

Citizen community’s communication and community cloud computing: Information about new rules or policies is primarily shared among community members through communication. Exchange of new public documents may also result from the community members' convenience and control over file sharing provided by community cloud computing.

Citizen community’s presence and community cloud computing: One of the most crucial virtues in both interpersonal and commercial interactions in human civilization is trust. In a community of citizens, file sharing among members may inspire them to plan conferences, get-togethers, and other political events centered on shared interests. Users can be "friendly" with other members thanks to the community cloud computing's framework, which strengthens social ties.

Citizen community’s involvement and community cloud computing: To increase the number and caliber of shared public documents inside a community, each member must take an active role. The community cloud computing's graceful failures serve as a reminder to its contributing members to become involved fully in order to prevent disaster.

Anything that improves the functioning of the citizen community may serve as the community cloud computing's money. This implies that if citizens volunteer to perform technical tasks, they will be able to reduce their financial commitments to the government. Teams from the community will be formed, and each team will work on a technical task. Examples of tasks that each team may have include testing applications, maintaining servers, and performing backup duties. This is a great feature of the community cloud that will increase community involvement.

Because the cloud operates using community resources, it does not need expensive hardware or significant power consumption to work. These eco-friendly methods may attract potential customers who are concerned about these kinds of things.

3.4.1.3 Future Research Directions

Web 2.0 consumers are accustomed to exchanging data. On the other hand, individuals searching for the next big thing have already witnessed the rise of the semantic web, or Web 3.0 era (Allemang, 2011). How will Web 3.0 society be incorporated into Government as a Service?

The semantic web defines simasia, or meaningful value, to the content of websites so that modalities can predictably reuse them to meet human needs. Currently, a web search engine performing a "keyword search" will return results that contain the keywords but do not match the user's query. For example, current web intelligence is not capable of providing an efficient answer to a question like "which is the fastest administrative act regarding the family status?" Humans must examine and assess the results, omit options, and refine their search parameters. With the use of semantic web mining engines, questions can have their simasia removed and compared against simasia taken from RDF structured information.

Semantic mining can be applied by developing ontologies that determine meaning. The semantic web mining technique results to increased satisfaction among the members of a cloud community that will inspire more requests for the public services. More community members result from increased satisfaction and a reduction in the time required for the release of public documents; the greater the number of members, the greater the computer resources available to serve user needs. Communities will begin to lend each other computing resources and prepare to respond to queries along the lines of "lend me the appropriate computing resources to efficiently provide the x documents to my members for k weeks." A portion of the preceding query relates to the computational resources that must be estimated and made available to a different community. We foresee a semantic mining engine that can help us with these kinds of inquiries. This might be the evolution of the post-semantic web.

The following traits are shared by semantic web research projects (Stumme, 2006):

a) Standard syntax for phrases focused on machine language

b) A shared lexicon

c) A standard language for logic

d) The use of the language for proof-exchange

While developing a search engine, the majority of academics these days concentrate on the meaning of the web page's contents; a post-semantic web will also be able to determine the necessary computing resources. For example, in addition to providing answers to queries like "which is the fastest administrative act regarding the X process?" and "what is the required bandwidth for the issuing of the document in real time for forty users," a post-semantic web engine will also be able to answer queries like "which is the fastest administrative act of the X process?" The key to sustaining information sharing in an advanced web is the creation of a hybrid semantic engine that can look up a specific public document or combine public data with the processing power required to support it. To put such a hybrid semantic engine into practice, an appropriate ontology-driven language is needed.

In addition to the direction of technical research, using community cloud computing in the public sector raises legal questions (Winkler, 2011). The fact that citizen data is kept on the cloud rather than on a local system presents legal questions regarding who is authorized to see and alter this data. Establishing a suitable agreement between the government and the cloud computing provider is crucial from the government's perspective to guarantee data protection. The terms and conditions of the agreement must guarantee a specified service level from the vendor's end and should make clear who has power over each party's data pertaining to citizens. Regarding security, there need to be a procedure established by the vendor to alert the authorities in the event that hackers get illegal access to the data or foreign governments request access to the data (Snooks, 2012). In terms of confidentiality level, each collection of data has a different level of secrecy, which the vendor must know in order to handle the data properly.

3.4.1.4 Conclusions

The idea of cloud governance needs to be modified to meet the emerging information technology issues. The use of cloud computing to implement e-government in autonomous communities can lessen corruption and strengthen ties among community members. However, communities must utilize cloud computing's benefits in an ethical manner. It is a tragic fact that ISIS was recently found to be employing a network of PlayStation devices for terrorist communication. It's critical to ascertain whether a communal cloud computing network could serve as a potent tool in the terrorists' arsenal. Here, the questions to ask are: What is the purpose of a community cloud network, and how secure is it? Nevertheless, if the Government as a Service model is created from the perspective of the citizenry, the problems of illegal access to private data and website hacking will be minimized. Citizens will likely become more responsible and respectful of public policies as long as there is no political incentive. The suggested strategy encourages people to participate and share more in their communities while teaching them to respect political systems and governments.

3.5 Metaverse

The concept of the metaverse—a virtual world where users can interact in real time with digital objects and each other—has attracted a lot of attention in recent years. Advancements in technology such as augmented reality (AR) and virtual reality (VR) have opened up new avenues for interaction and accessibility inside the metaverse. Though it gained popularity first in the gaming and entertainment industries, it is not limited to leisure activities.

In the area of e-government, the metaverse offers great possibilities to transform citizen involvement and governmental services. The construction of metaverse virtual government spaces allows residents to effortlessly access a multitude of services from the comfort of their homes or enterprises. Examples of this include applications for obtaining official papers, participating in virtual town hall meetings, and even virtually visiting government offices to obtain assistance. The metaverse offers a unique platform for enhancing the usability, efficacy, and transparency of e-government services.

The integration of the metaverse with e-government services offers several benefits that could transform public service delivery and citizen-government relations. It first enhances accessibility by providing a virtual environment where citizens can engage with government services whenever and from anywhere, doing away with physical barriers and the need for face-to-face encounters. Second, it boosts productivity by streamlining bureaucratic procedures through automation and digitization. Both citizens and government employees benefit from quicker service delivery and less administrative labor as a result.

Furthermore, real-time information sharing made possible by the metaverse promotes transparency by giving citizens a clear understanding of government actions and decisions. Furthermore, the metaverse facilitates more inclusive participation in decision-making processes by providing immersive experiences like virtual town hall meetings and interactive consultations. In general, citizens are given more convenience, efficiency, transparency, and involvement in their contacts with government entities when the metaverse is integrated into e-government services.

3.5.1 Proposing and Analyzing the Adoption of Metaverse in E-Government

The science fiction book Snow Crash by Neal Stephenson, published in 1992, is when the word "Metaverse" first appeared (Stephenson, 1992). Digital environments that conflate real and virtual space are referred to as the "Metaverse" (Dionisio et al., 2013). Divergent viewpoints exist inside the Metaverse. One vision is of a long-term, privately managed, centrally planned system in which massive corporations, like Facebook's "Meta," determine how people "socialize, learn, collaborate, and play" (Facebook, 2020). On October 28, 2021, Facebook CEO Mark Zuckerberg announced the company was renaming to "Meta." Part of the new strategy was to develop the "Metaverse," a three-dimensional virtual and augmented reality depiction. According to Sascha et al. (2022), the rebranding of social media seems to be a game-changer, primarily affecting a company's whole business strategy.

According to a different interpretation of the Metaverse, distributed, mission-driven communities known as "Decentralized Autonomous Organizations" (or DAOs) build their own surroundings through distributed technical design, such as blockchain-based Internet infrastructure (Nabben, 2022). These communities, which are typically independent cryptocurrency communities, embrace a virtual form of government that allows them to work together to negotiate, finance, build, maintain, and regenerate without depending on outside resources (Foresight Institute, 2021).

The company claims that the Metaverse will be a three-dimensional reflection of reality or a blend of today's online social interactions (Meta, 2021). By catering to the senses of sight, sound, touch, and smell and enabling movement and touch-based interactions, this cutting-edge medium as a technology has the potential to significantly change user-platform connections (Studen & Tiberius, 2020). Entrepreneur and writer Matthew Ball asserts that the Metaverse has the potential to generate up to $30 trillion in profits over the next ten years (Knight, 2021).

The Metaverse's architecture is made up of both material and immaterial components. Our understanding of the architecture is based on Jon Radoff's Metaverse Value-Chain (Radoff, 2021). The seven elements of the Metaverse are:

1. Perception: The virtualization of physical space, distance, and objects is linked to the Metaverse, and it is immensely powerful. Users of the metaverse create material based on their connections in their virtual communities.

2. Exploration: The act of exploring is the means via which individuals are introduced to novel perspectives. As we virtualize actual reality, the metaverse is exposing digital social systems and encouraging users to explore it. Static social networking activities centered on a small number of centralized services defined earlier Web phases. However, a decentralized ecosystem of virtual experiences

could return power to the users and drive them toward collective experiences and collective intelligence.

3. Hardware: As per Park & Kim (2022), this component comprises all of the material technology that creators frequently employ to create experiences for Metaverse consumers:

• Head-Mounted Displays (HMD): These devices project images onto a screen and emit sound via speakers. The visuals on the screen could either overlay the virtual environment (augmented reality) or fill the full screen (virtual reality).

• Hand-Based Input Device (HBID): The purpose of Hand-Based Input Devices (HBIDs) is to give users a tactile sensation while they are in the Metaverse. These gadgets offer two different kinds of tactile features: an active haptic generates virtual pressure to simulate interacting with objects, while a passive haptic gives the sensation of actual objects.

• Non-Hand Input Device: These gadgets provide voice input capabilities, head tracking, eye tracking, and additional input choices. For example, the eye-tracking feature modifies the user's viewpoint when it detects eye movement without head movement.

4. Software: This group comprises programs that aid in our comprehension, exploration, and information retrieval from three-dimensional environments. 3D engines for the visualization of animation, geographic mapping, object identification, voice, and gesture detection are a few software categories in use.

5. Decentralization: When distributed computing is used, a decentralized ecosystem of users is formed, free from the oversight of a central authority. Numerous virtual worlds are created, and each one develops unique features and security protocols to prevent the Metaverse from collapsing completely in the event that an unauthorized

party attacks one of the virtual worlds. Furthermore, decentralization thanks to technologies like blockchain improves the virtual world's transparency. This technology permits the exchange of digital values among entities in real time by requesting authorization for the realization of the exchange from the members of a computing network.

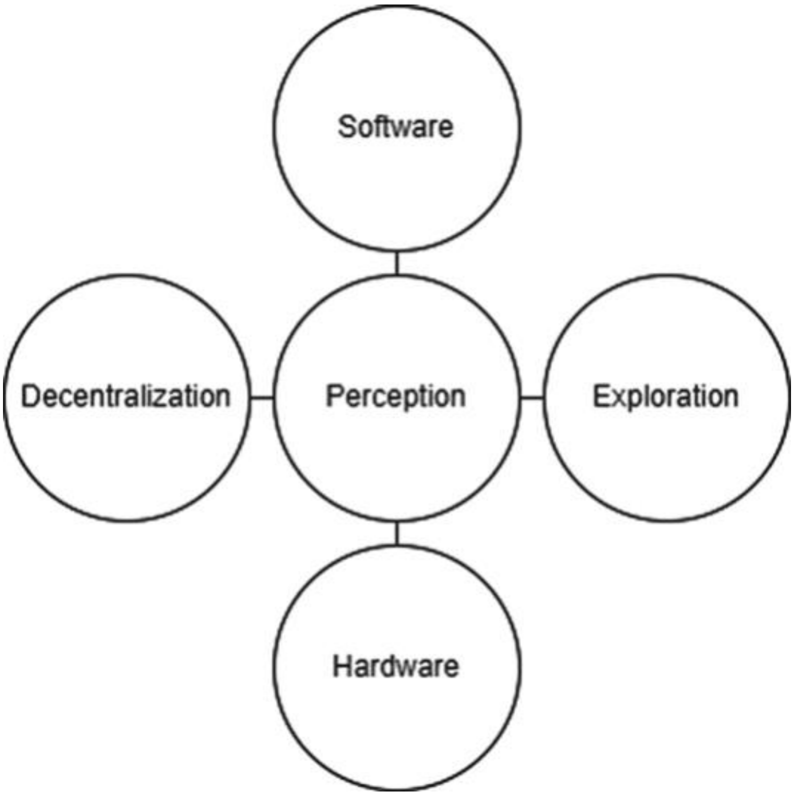

Figure 18 The Metaverse's architecture

All of the aforementioned components are included in the architecture of the Metaverse, which is shown in Fig. 18.

3.5.1.1 Metaverse Integration in Government

Nearly half of adult residents in 29 nations feel familiar with the Metaverse, according to a survey conducted by Ipsos on behalf of the World Economic Forum (WeForum, 2022). Developing countries see the Metaverse's future more favorably, but most participants expect Metaverse-based apps to change people's daily lives in the next ten years. The survey was conducted from April to May of

2022, and more than 21,000 adult respondents answered it. Table 12 presents a number of the most significant findings in response to the query on citizens' acquaintance with associated technology.

Type of technology	Percentage of feeling familiar	Country with the highest percentage	Country with the lowest percentage
Virtual Reality	80%	Turkey 94%	France 46%
Augmented Reality	61%	Turkey 84%	Belgium 36%
The Metaverse	52%	Turkey 86%	Poland 27%

Table 12 Familiarity with the Metaverse

Numerous cities worldwide have adopted the Metaverse as a result of their residents' familiarity with it. Seoul, South Korea, is getting ready to launch "Metaverse Seoul," a Metaverse environment that will serve the entire municipal administration (Kit, 2022). The action plan combines cooperation, virtual reality (VR), and digital twins to improve management, virtual tourism, and municipal services. Approximately e2.8 billion has been invested in the project by the South Korean city as part of Mayor Oh Se-Hoon's SeoulVision 2030 plan.

The United States' cities are likewise in favor of implementing metaverse. Representatives from towns, cities, and communities make up the National League of Cities (NLC), an organization dedicated to improving the lives of present and future inhabitants. As per the findings of a recently released analysis (Geraghty et al., 2022), the NLC envisions a future where American residents would be able to easily and swiftly access public meetings and city services through the Metaverse, compared to other digital platforms. People with physical limitations or time constraints may find services more accessible as a result of this.

Furthermore, Barbados, a little island nation in the West Indies' Lesser Antilles, chose to establish an embassy in Decentraland, which is the Metaverse as it exists now (Bloomberg, 2021). The Barbados' digital envoy, Gabriel Abed, said at Bloomberg (Bloomberg, 2021) that "we recognize that we are a 166-square mile island—we are tiny—but in the Metaverse we are as large as America or Germany." Abed also serves as Barbados' ambassador to the United Arab Emirates.

President of the Republic of Indonesia, Joko Widodo, has publicly acknowledged that his country must be prepared to take part in the Metaverse (Ifdil et al., 2022). In Indonesia, steps to embrace Metaverse innovation have already been taken into consideration. In 2022, Jakarta's governor, Anies Baswedan, made the decision to form a collaboration with WIR Group, a well-known augmented reality technology company in Southeast Asia (AsiaOne, 2022). According to Michael Budi, President and Director of WIR Group, Jakarta will receive help from the company through this partnership as they lead the implementation of interaction in the Metaverse.

Numerous governmental entities have showed interest in adopting Metaverse since the launch of Meta (formerly Facebook). It is crucial to highlight the substantial opportunities and difficulties associated with implementing the Metaverse since, despite the recent trend toward the virtual world; the government does not yet employ any significant Metaverse applications.

3.5.1.2 To Find Innovative Ways to Communicate with the Citizens

When the majority of citizens gained access to the Internet, face-to-face conversation was largely displaced by Web communication. Because it draws in residents, the virtual world appears to be the next big thing for the new era of connection with them. The precursor to the Metaverse, Second Life, began as a virtual environment in 2003 and offers a setting where social interactions create meaning between the virtual and real worlds (Boellstorff, 2015). In Second Life, users can communicate through a variety of channels, such as online chat, co-visiting places, playing multiplayer games, and making, buying, and selling virtual goods. The virtual world online experience is very compelling, even if the number of visitors to the U.S. National Oceanic and Atmospheric Administration's (NOAA) Second Life website is a fraction of those to the organization's main portal. For example, users of the NOAA's Second Life Island spend ten times longer there than users of the organization's other web services, according to official statistics (Wyld, 2008). Because residents would be able to visit the virtual locations of public offices and conduct all of their transactions with the government exactly as they would in the real world, the Metaverse, a virtual world, may open up new avenues for innovative citizen-government communication. Avatars and citizens will have the same virtual presence in public spaces as real people as long as they use a virtual passport or identity card.

3.5.1.3 To Establish Team Working Operation Inside the Workplace

One benefit of the Metaverse is that it might make employees feel as though they are working alongside someone else. The online persona and the ability to engage with the environment and virtual components from many angles, including the third-person perspective, shape the psychological impression of being in the same place as someone else (Mystakidis, 2019). The following are some benefits of holding meetings virtually: (1) Eliminate employee alienation from remote locations; (2) Reduce the number of people who must travel for meetings or conferences. Employee teamwork and creative collaboration will be improved by having public servants coexist as avatars in the workplace.

3.5.1.4 To Find New Employees

When it comes to using virtual worlds as a recruiting tool, the US Army is an acknowledged leader. "America's Army" is recognized as the first instance of the US government utilizing gaming technology and virtual worlds on a large scale for efficient communication and recruitment. Additionally, it is the first instance of gaming software being used to aid in US Army recruiting (America's Army, 2022). The ability to use the Metaverse as a monitoring tool for candidates' behavioral and digital literacy skills makes it an advantageous recruiting tool. Although candidates' digital literacy (i.e., IT abilities) could be assessed by a range of written exams, it is difficult to forecast how a prospective employee will behave in the workplace. The candidates may be required to join a genuine working team and spend a day in the real working environment, as Metaverse will serve as the actual workplace. The executives in charge of human resources might then keep an eye on and verify the candidates' behavioral competencies in connection to their work at the office.

3.5.1.5 To Develop a New Economy

The rebranding of the government's business model with the introduction of the Metaverse for both administrative and tourism operations is another crucial situation that warrants more investigation. If a government's public office is situated on a virtual island in the Metaverse, its residents can also take advantage of the island's virtual beach, buy souvenirs from government shops, go on paid vacations with other residents, and other amenities. The government may be able to obtain new funding sources from the Metaverse, which offers citizens a novel experience. To learn more about the virtual world, several governments have opened virtual embassies in Second Life, most notably the Maldives. In May 2007, the Maldives made history by being the first country in Second Life to open a "virtual embassy" on the Diplomatic Quarter of Diplomacy Island. The beach-themed virtual embassy provides information and links to official government offices, along with tourism-related goods and services (Diplomacy, 2022). The Metaverse may serve as the heart of a new economy that presents chances for increased government revenue through novel tourism-related goods and services, provided that governments reconsider the function of citizen service centers and public offices.

3.5.1.6 Metaverse Challenges

Notwithstanding the benefits of the Metaverse that have already been discussed, policymakers must consider a number of significant obstacles while making the shift from the real world to the virtual one. We will talk about topics related to the possible challenges in putting the public sector's operations in the Metaverse into practice in this study area.

• Security: Privacy and security are crucial issues since Metaverse collects data on behavior that is more insightful than transactions and browsing patterns. Since data privacy is crucial, we should exercise greater caution in the event of unforeseen crimes in the Metaverse. Furthermore, tracking activities suggest that organizations like the army and police are required because of the increase in users. In the Metaverse, respectable real-life people may occasionally break the law because of their anonymity online.

• Health: There are also health problems and adverse effects (including fatigue, headaches, and movement injuries). Furthermore, user focus disturbance in some augmented reality systems has led to severe risk, including unintentional accidents. Another barrier to extended usage is head or neck pain brought on by the weight of virtual reality headsets. According to Slater et al. (2020), prolonged usage of virtual reality can also result in physical discomfort, social alienation, Internet addiction, and isolation from real-world activities.

• Staff: While autonomous avatars can greet visitors to a virtual world straight away, it is advisable for an organization to have a virtual avatar in charge of overseeing its virtual world. This virtual avatar should be able to answer visitor inquiries and direct them to the appropriate offices. It would be necessary to fill the post of virtual public worker with multiple real employees, especially during regular business hours. If the Metaverse public office is open around-the-clock, then shift labor by more actual public servants is required.

• Ethical Issues: Unauthorized growth and truth deception into preconceived notions are ethical dilemmas. Participants in the Metaverse may create users' physiological psychographics based on their feelings about their data (Metaverse Wiki, 2022). These elements might be used to start making unintentional psychological evaluations that support prejudice. Toxic behavior in virtual social environments, including anxiety, cyberbullying, and verbal harassment, is another well-known disadvantage. Furthermore, situations in virtual worlds might be distressing. Artificial intelligence techniques and deep learning algorithms are linked to online morality and can be used to perpetrate identity theft.

3.5.1.7 Epilogue

The future of the new framework for providing public services is being shaped by the opportunities and challenges associated with implementing the Metaverse in government. The ideal approach for the government to address the current issue is to investigate the ways in which each individual component (opportunity or difficulty) aligns with each component of the Metaverse (decentralization, hardware, software, perception, and exploration). Subsequently, Leigh (2009) suggests conducting a SWOT analysis to assist decision-makers in determining how to proceed to the next phase of Metaverse adoption. Figure 19 shows a schema with all the necessary data for applying the SWOT analysis, which will disclose the public organization's present state of adoption of the Metaverse.

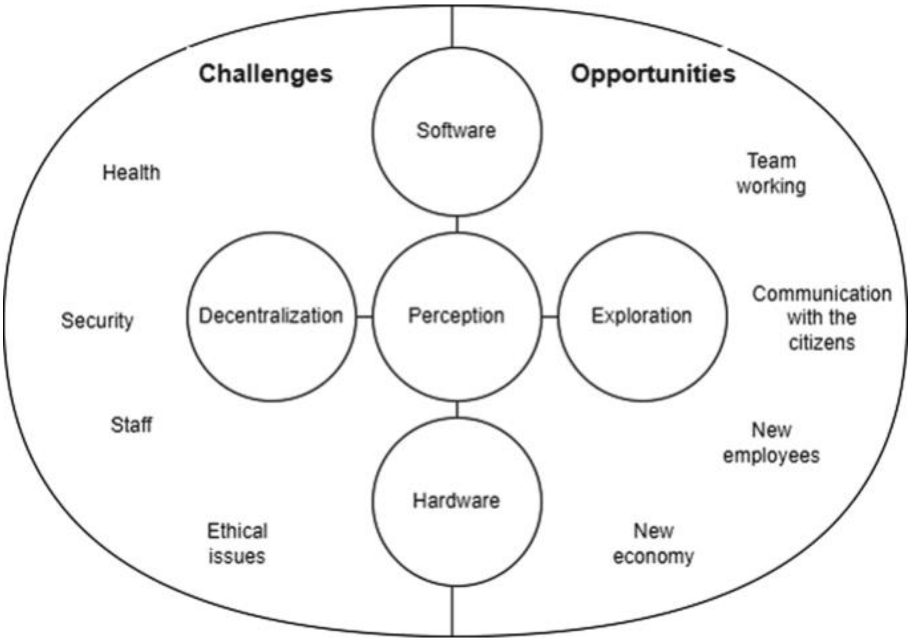

Figure 19 Challenges, opportunities, and elements of the Metaverse

The government's choice to concentrate on the Metaverse positions it as a cutting-edge, very promising new technology. Because less hardware will be needed because of virtualization, operating expenses for government agencies could soon be reduced.

The government has already established the most important business processes in terms of operations, so while Metaverse would be a new setting to house the administrative transactions, the heart of the business would not alter significantly. Government employees will therefore need to focus on increasing service efficiency rather than completely reimagining services from the ground up. Activities that will need additional development include citizen-oriented projects that are necessary for novel forms of interaction or data security topics that are not crucial in the workplace today but are predicted to become more and more popular in the future.

The Metaverse's realization has not yet happened, despite the fact that government agencies have long employed and accepted ideas like "virtual worlds" and "extended reality." Training prospective new hires on how to adapt the citizen service culture to the new Metaverse framework is the most crucial prerequisite for the adoption of Metaverse. It will be helpful to educate the staff about the potential of the virtual world and how to influence residents' motivation to adopt this novel environment through virtual world techniques like gamification (Yfantis et al., 2018). Other technologies, like cloud computing (Yfantis et al., 2020), blockchain (Yfantis et al., 2021), and artificial intelligence (Yfantis et al., 2020), may be helpful for public servant training as tools to improve the delivery of public services by lowering the cost of the necessary resources.

3.5.2 Exploring Privacy Measures in the Community Metaverse

People's interactions with the physical world are changing more and more as a result of recent technology advances. Consequently, our digital and online identities are tracked and used to expose personal information about us. One of the many major causes endangering this information is social manipulation (Krombholz et al., 2015). Individuals, companies, and governmental entities can employ web sensors to identify artificial and natural elements in any given location. Virtualized storage may be used to keep such records for a number of purposes. Among the methods for gathering and evaluating the data are security cameras. Other methods include trend identification, consolidation, and analysis of movement and position.

We refer to an “avatar” (or “agent”) as a visible character who abides by the rules of the community metaverse. The community metaverse (Falchuk et al., 2018):

- Is provided by a system that contains the computing frameworks for every element of the environment such as designs, networking, synchronization, and so forth. The security and long-term durability of the metaverse is entirely under the control of the system including avatars that are unable to disappear from the system (which may attempt to track or analyze avatar behavior), and they are unable to carry out tasks that are not supported by metaverse APIs.

- Is adaptable in the sense that avatars could affect the virtual space (e.g., adding or removing digital entities).

The ability of some avatars to utilize the digital world's resources in a conceivable way may offer them the chance to become hostile. We believe that this has created a need for conditions for privacy standards for conflicts within the community metaverse. Even though it may seem like not much is at risk right now, it is vital to keep in mind that a significant portion of our life could very well occur in these social metaverses in the future.

The main contribution of this article is to suggest an innovative strategy to overcome privacy issues in the community metaverse by utilizing a combination of digital twin concepts, and the parallel metaverse. The structure of this work includes an introduction to the theme of privacy in the community metaverse, and afterwards, it argues about the use of digital copies (or avatars as clones of the original avatars) in effort to confuse potential intruders of the metaverse. Then, the article explores the idea of the parallel metaverse as a sanctuary for avatars who wish to hide their real presence in the community metaverse.

3.5.2.1 Privacy in community metaverse

In a community metaverse where all avatars essentially have the same digital skills, we could expect a new framework of rules that ensure balanced privacy. However, despite this expectation, it is still conceivable for morally repugnant, unpleasant, and hostile behaviors to manifest. Considering the possibility that another avatar might: a) persistently follow you, and/or b) harass you with involvement in your daily routine. These are our suggested measures for reducing these kinds of undesirable effects. The main objective of our suggestions is to assist in protecting privacy without completely defeating the advantages of interacting in the metaverse. We advise implementing the following:

1. Digital twin avatars: According to this strategy, the system generates one or more digital twins of the user's avatar that look the same as the original. Digital twins are digital copies of the original avatars that also interact inside the metaverse, but they are controlled externally by an administrator. The administrator manages the behavior of a unique avatar that is generated by a software, and each move the software avatar makes, it is also repeated by the twin avatar acting inside the metaverse. Therefore, in effect, this would be one way to confuse the hostile avatars about the identity of the victim avatar. A major drawback of this strategy is that additional costs and time to install and maintain the avatars would be necessary for implementation. However, the metaverse community could secure these resources by crowdsourcing so that each community metaverse member could contribute funds for the benefit of the whole community.

2. Parallel metaverse: This procedure allows the user to ask to temporarily enter a parallel metaverse, similarly, to how Neo, the protagonist in the science fiction film "The Matrix," enters a parallel universe (Constable, 2006). The metaverse user enters the parallel world by using public key cryptography and a blind signature (Pointcheval & Stern, 2000) to request to entry into the new, virtual world. The parallel metaverse includes all the elements of the real metaverse. However, to ensure that the transactions inside the parallel metaverse are transparent, the transactions of the parallel world are stored in blockchain networks (Yfantis et al, 2021). In this way, we confirm the traceability of the actions occurring in the parallel metaverse. As part of an extended framework of privacy measures, metaverse users could combine both measures in an innovative way:

a) When a user chooses to join a Parallel Metaverse in association with Digital Twin Avatars, his avatar disappears from the original metaverse and re-appears as a digital twin avatar in the parallel metaverse. In doing so, other avatars trying to keep track of the user in the original metaverse, and following him in the parallel metaverse, will not be able to realize the user's true identity, and will therefore be unable to track his interactions in the parallel metaverse.

b) A user can choose to combine the Digital Twin Avatars plan with Parallel Metaverses so that when the digital twin avatar appears in the real metaverse, the user's true avatar simultaneously moves to a parallel metaverse and relaxes without performing any actions that may have an effect in the real world.

c) A user decides to combine digital twin avatars with parallel metaverses so that when the avatar is transported to a parallel metaverse, a digital copy of that parallel metaverse is generated. If the victim avatar was followed in the new metaverse by hostile avatars, they would not be able to tell whether they were in the real parallel metaverse or its digital copy. Additionally, because the parallel metaverse's actions are recorded in a blockchain network, it is possible to keep an eye on the bad avatars' behaviors for later analysis, as well as to monitor the development of attack scenarios for the metaverse's information technology staff.

3.5.2.2 Conclusion

This article explores measures and theoretical foundations that will aid users in protecting their privacy when interacting with other avatars. The community metaverse's capacity for a large number of avatars, and the unpredicted intention of using their digital skills, pose a challenge for creating a safe and trustful environment. Due to user privacy concerns and the potential of personal information being exposed in the metaverse, such a scenario would likely be unpleasant, if not harmful, to the entire avatar community.

Our list of recommendations offers a variety of technologies and methods by which a metaverse user can protect his privacy and avoid being seen by others. Our measures include:

- Provide a user of the metaverse the option to mislead malicious avatars with fake information, including fake identity and fake virtual worlds.
- Enable the metaverse user to spend some time in a parallel virtual world.
- Training the future IT personnel of the metaverse in information security matters by letting them examine the suspicious behavior of malicious avatars that are located in a deceptive virtual world.
- Provide transparency to the metaverse community by using blockchain technology to record the transactions in the parallel metaverse.
- Provide extra privacy to the avatars of the virtual world by using cryptography to encrypt their transactions in the parallel metaverse.

It is crucial to first apply these technologies in a test environment to evaluate their advantages and disadvantages. Our next efforts will be to further investigate the numerous additional difficulties that arise with successfully implementing such technologies and measures. The additional costs for the operation of the digital twin avatars, as well as the users' intention to adopt the metaverse system, are potential obstacles and limitations of the strategy. A potential way to influence the user's intention to adopt these measures is by using gamified features (Seaborn & Fels, 2015) (e.g., considering parallel worlds as secret stages of a video game). Since gamification may affect the user's adoption of a new information system (Yfantis et al., 2018), it is possible to encourage them to adopt a new set of measures.

4. Implementing Metaverse in E-government: Case Study and Comparison to State-of-Art

There is a lot of potential for e-government technologies to improve citizen involvement and government services, implementing these technologies is not without challenges. While blockchain, AI, cloud computing, mobile government, and other technologies have specialized applications, the metaverse can enhance these technologies by offering a comprehensive and immersive user experience. The Metaverse presents unique challenges, both technically and in terms of public perception. Exploring the costs associated with the potential usage of Metaverse in government in comparison with the current situation can provide valuable insights for governments considering the adoption of Metaverse. The public offices that could potentially enter the Metaverse are mainly the Citizen Service Centers, the universities, the offices of the municipalities, the tax authorities, the urban planning authorities, and the social security offices. Our case study deals with the social security offices.

4.1 Facts and Figures

1) In the USA, social security agencies have offices in about 1200 locations (SSA.gov, 2023)

2) In the USA, about 430 million people visit the social security offices annually (Ennis, 2020).

3) In the USA, social security offices operate 260 days a year. Consequently, on average about 1,650,000 citizens visit the offices daily

4) USA has an area of 9,629,091 square kilometers and a population of 336,997,624. That is (if it was circular), it would have a radius of 1,750 kilometers.

5) Considering that the offices are distributed symmetrically throughout the USA (in the whole circle), we fill the circle with smaller circles. Each circle has an area of about 6,362 square kilometers, i.e. a radius of about 45 kilometers. The circle contains 1,178 smaller non-covering equal circles (The Engineering Toolbox, 2023). These circles cover 7,494,436 square kilometers. 9,629,091 – 7,494,436 = 2,134,655 square kilometers not covered. We can assume that this area is forested, deserted, etc. and is evenly distributed. Every circle could be a city.

6) We consider that the social security offices are located in the center of every city

7) Consider that in each city lives the same number of people i.e. 336,997,624/1,178 = 286,076 inhabitants

8) Every day, in each city (circle), an average of 1,400 people visit the local social security office

9) Each person and every employee use a computer that consumes 170 watts per hour

10) Each social security office has 40 people staff

11) The hour (lost time) for each citizen costs on average 10 Euro (someone will have to leave his job to go to the social security office)

12) On average, it takes 12 minutes to park the car and walk to the social security office

In our experiment, the proposed scheme is compared to state-of-art methods. In particular, the following 3 methods are considered:

a) H-Scheme (Homogenous Scheme): the inhabitants live homogeneously throughout the cycle. Then on average they will have to travel 22.5 kilometers to go and 22.5 km to return from the social security office (some people live next to the office = 0 kilometers, while others live on the edge of the circle = 45 kilometers from the office). In total, they travel an average of 45 kilometers to be served

b) C-Scheme (Compact Scheme): each circle operates as a compact city (Duany & Steuteville, 2021). In these cities all the inhabitants live at a distance of up to 2.5 kilometers from the center. On average they'll have to walk 2.5 kilometers (roundtrip). We will consider that only 10% use electric vehicles for this transportation, 20% go by bicycle and 70% go on foot.

c) P-Scheme (Proposed Scheme): our proposed method

4.2. Research Questions and Results

Question 1: Total time required to move in each circle/city

Question 2: Total time needed to move across USA

Question 3: Total time to service in each city

Question 4: Total time until service time begins across USA

Question 5: Total energy spent in each cycle/city

Question 6: Total energy spent throughout USA

Question 7: Total gases emitted in each cycle/city

Question 8: Total gases emitted throughout USA

Question 9: Total money spent per city

Question 10: Total money spent throughout USA

4.2.1 Total Time Required to Move in each Circle/City

H-Scheme (Homogenous Scheme):

260 days a year (days when the social security offices are open) 1,400 people visit the offices. On average, they are travelling 45 kilometers.

The cities of the simulation experiment have a population of 286,076 inhabitants. The city of St. Louis has a population of 301,578 inhabitants and resembles demographically the cities of the simulation experiment. Similar results can be produced for any other city. According to St. Louis traffic report (Tom Tom, 2023) to travel 10 kilometers takes an average of 10 minutes and 20 seconds.

Because the cities of the simulation experiment are slightly smaller, we assume that for 10 kilometers it takes 10 minutes (600 seconds or 60 seconds for each kilometre).

Therefore, the travel time of each person in each such city is:

$$45 \text{ km} * 60 \text{ seconds/km} = 2{,}700 \text{ seconds (per person, per move)} \quad (4.1)$$

A total of 1,400 people move daily. So the total daily time for all individuals is:

$$1{,}400 \text{ people} * 2{,}700 \text{ seconds/person} = 3{,}780{,}000 \text{ seconds (per day)} \quad (4.2)$$

Movements take place 260 days a year. So the total time is:

260 days * 3,780,000 seconds/day = 982,800,000 seconds (all year) = 273,000 hours = 11,375 days (4.3)

The parking time and the walk to the social security office should be added at this point. We assume that the walking and parking times add up to 12 minutes (720 seconds) every move. This is totally reasonable, since according to a report by Inrix (Spot Hero, 2017), US drivers spend an average time of 9.7 minutes to find parking space in USA:

Parking Search Time

City	On-street search time (mins per trip)	Off-street search time (mins per trip)	Parking trips (per week)
New York City	15	13	10
San Francisco	12	11	9
Los Angeles	12	11	9
Washington D.C.	10	9	9
Chicago	9	8	8
Seattle	9	8	9
Boston	8	8	8
Atlanta	8	8	8
Dallas	8	8	8
Detroit	6	6	7

SOURCE: INRIX

Figure 20 Parking Search Time

Thus 9.7 minutes for finding parking space and 2.3 minutes to walk from the parking to the social security office, in total: 12 minutes.

So the total daily time is estimated as:

720 seconds/motion * 1,400 moves = 1,008,000 seconds (daily) (4.4)

And for the 260 travel days we have:

260 days * 1,008,000 seconds/day = 262,080,000 seconds (all year round). (4.5)

So the total time spent annually in a city is:

982,800,000 + 262,080,000 = 1,244,880,000 seconds = 345,800 hours = 14,408.33 days (4.6)

C-Scheme (Compact Scheme):

It is a compact and at the same time ecological city which does not implement Metaverse.

260 days a year (days when the social security offices are open) 1,400 people move to the offices.

On average, they are travelling 2.5 kilometers.

It is assumed that 10% of people use an electric vehicle for this movement, 20% go by bicycle and 70% go on foot.

According to St. Louistraffic report moving 10 kilometers takes an average of 10 minutes and 20 seconds. But because only 10% use an electric car in this city and therefore have no traffic (the rest travel by bicycle and on foot), we consider that it takes only 40 seconds on average to move 1 km.

We also consider that cyclists move at an average speed of 20 kilometers per hour and pedestrians move at a average rate of 4 kilometres per hour.

Therefore, car traveling time is estimated as:

Car: 2.5 km * 40 seconds /km = 100 seconds (4.7)

Bicycle: travels 2.5 kilometers in 450 seconds

Pedestrian: travels 2.5 kilometers in 2,250 seconds

Car Time per Day:

140 people * 100 seconds/person = 14,000 seconds (4.8)

Cycling Time per Day:

280 people * 450 seconds/person = 126,000 seconds (4.9)

Walking Time per Day:

980 people * 2,250 seconds/person = 2,205,000 seconds (4.10)

Car Time per Year:

260 days * 14,000 seconds/day = 3,640,000 seconds (4.11)

Bicycle Time per Year:

260 days * 126,000 seconds/day = 32,760,000 seconds (4.12)

Walking Time per Year:

260 days * 2,205,000 seconds/day = 573,300,000 seconds (4.13)

At the above estimated times we also add the parking time and the walk to the social security office. We consider that the parking time and the walking time for electric cars is equal to 3 minutes per move (180 seconds). That is 1⁄4 of the time compared to a homogeneous city (H-Scheme). This is justified, as a compact city does not require much time to park, as traffic is only 10% compared to the homogeneous city.

For bicycles and pedestrians we consider that parking time and walking time is zero.

So we have for cars:

140 people * 180 seconds/person = 25,200 seconds (per day) (4.14)

260 days * 25,200 seconds/day = 6,552,000 seconds (a year) (4.15)

So the total time spent annually in such a compact and ecological city is:

3,640,000 + 32,760,000 + 573,300,000 + 6,552,000 = 616,252,000 seconds = 171,181 hours = 7,132 days (4.16)

P-Scheme (ProposedScheme):

No moves are required.

Total travel time + parking + transfer to the social security office = 0 seconds (4.17)

4.2.2 Total Time to Move across USA

H-Scheme: 14,408.33 days/city * 1,178 cities = 16,973,012.74 days (4.18)

C-Scheme: 7,132 days/city * 1,178 cities = 8,401,496 days (4.19)

P-Scheme: 0 days /city (no physical commuting) * 1,178 cities= 0 days (4.20)

4.2.3 Total Time to Service in each Cycle/City

H-Scheme (Homogenous Scheme):

As mentioned above, the sum of travel time, parking time and walking time is equal to 1,244,880,000 seconds. At this time we should also add the time until the employee service begins.

According to the Customer Wait Times in the Social Security Administration's Field Offices (Stone, 2018), visitors who scheduled an appointment at the US Social Security offices waited an average of 4 minutes to get serviced by the public servants. Moreover, visitors who did not have an appointment waited an average of 28 minutes to get serviced by the public servants.

Based on the above, there are 2 cases. In the first case (best case), all citizens are served on an appointment. In the second case (worst case), all citizens are served without an appointment.

So we have for each city:

Best case: 1,400 people * 240 seconds/person = 336,000 seconds (per day) (4.21)

Worst case: 1,400 people * 1,680 seconds/person = 2,352,000 seconds (per day) (4.22)

Movements take place 260 days a year. So the total annual time for each city is:

Best case: 336,000 seconds (per day) * 260 days = 87,360,000 seconds per year (4.23)

Worst case: 2,352,000 seconds (per day) * 260 days = 611,520,000 seconds per year (4.24)

So the total time until service is as follows:

Best case: 87,360,000 seconds a year + 1,244,880,000 seconds per year = 1,332,240,000 seconds annually (or 5,124,000 seconds a day)	(4.25)
Worst case: 611,520,000 seconds a year + 1,244,880,000 seconds per year = 1,856,400,000 seconds annually (or 7,140,000 seconds daily)	(4.26)

C-Scheme (Compact Scheme):

As mentioned above, the travel time, parking time and walking time is equal to 616,252,000 seconds. At this time we should also add the time until the employee service begins.

The waiting times until service are the same as the H-Scheme.

So the total time until service is as follows:

Best case: 87,360,000 seconds per year + 616,252,000 seconds per annum = 703,612,000 seconds a year (or 2,706,200 seconds per day)	(4.27)
Worst case: 611.520.000 seconds per year + 616,252,000 seconds per Year = 1,227,772,000 second per year (or 4,722,200 seconds per day)	(4.28)

P-Scheme (Proposed Scheme):

As mentioned above the sum of travel time, parking time and walking time is equal to 0 seconds. At this time we should also add the time until the employee service begins.

The waiting times until service are the same as the H-Scheme.

So the total time until service is as follows:

Best case: 87,360,000 seconds per year + 0 seconds per annum = 87,360,000 seconds a year (or 336,000 seconds per day) (4.29)

Worst case: 611,520,000 seconds per year + 0 seconds per annum = 611,520,000 second per year (or 2,352,000 seconds per day) (4.30)

4.2.4 Total Time until Service Time Begins across USA

H-Scheme

The best case/worst case are estimated as:

Best case: 1,332,240,000 seconds per year/city * 1,178 cities = 1,569,378,720,000 seconds (4.31)

Worst case: 1,856,400,000 seconds per year /city * 1,178 cities = 2,186,839,200,000 seconds (4.32)

C-Scheme

The best case/worst case are estimated as:

Best case: 703,612,000 seconds per year/city * 1,178 cities = 828,854,936,000 seconds (4.33)

Worst case: 1,227,772,000 seconds per year /city * 1,178 cities = 1,446,315,416,000 seconds (4.34)

P-Scheme

The best case/worst case are estimated as:

Best case: 87,360,000 seconds per year/city * 1,178 cities = 102,910,080,000 seconds (4.35)

Worst case: 611,520,000 seconds per year /city * 1,178 cities = 720,370,560,000 seconds (4.36)

4.2.5 Total Energy Spent in each Cycle/City

The total energy spent includes the fuel used by conventional cars (oil, gasoline) for travel, the electricity used by electric cars for traveling, the electrical energy used by citizens' computers. People also spend energy (calories) to ride a bicycle or walk. These experiments do not take into account the energy consumed by humans. Employees' computers also use energy in serving citizens. But in these experiments we do not look at the time of service, but the time until the service of each citizen (Time of waiting until the citizen is served. During the waiting time, the employee serves another citizen).

To calculate the fuel of conventional cars we need to know the kilometers travelled in each Scheme as well as the travel time.

To calculate the electricity of electric cars we need to know the kilometers travelled in each Scheme as well as the travel time.

Computers are used by citizens only in the P-Scheme. Therefore, the electricity consumed by citizens' computers is calculated on the basis of the waiting time until they are served by an employee.

The calculations are presented below for each Scheme.

H-Scheme

As mentioned in a previous question, the travel time by car is:

2,700 seconds (per person, per move) + 582 seconds (9.7 minutes per person per parking lot).

There are also a total of 1,400 people travelling every day, traveling 45 kilometers. We consider that the move is made only for the social security office (i.e. the citizen does not travel for other tasks)

In total, they travel daily:

$$1{,}400 \text{ people} * 45 \text{ km/person} = 63{,}000 \text{ km} \tag{4.37}$$

In total, they are held annually:

$$63{,}000 \text{ km/day} * 260 \text{ days} = 16{,}380{,}000 \text{ km} \tag{4.38}$$

According to the US Bureau of Transportation Statistics (Chambers & Schmitt, 2015), we consider that the citizen uses a passenger car for his transportation.

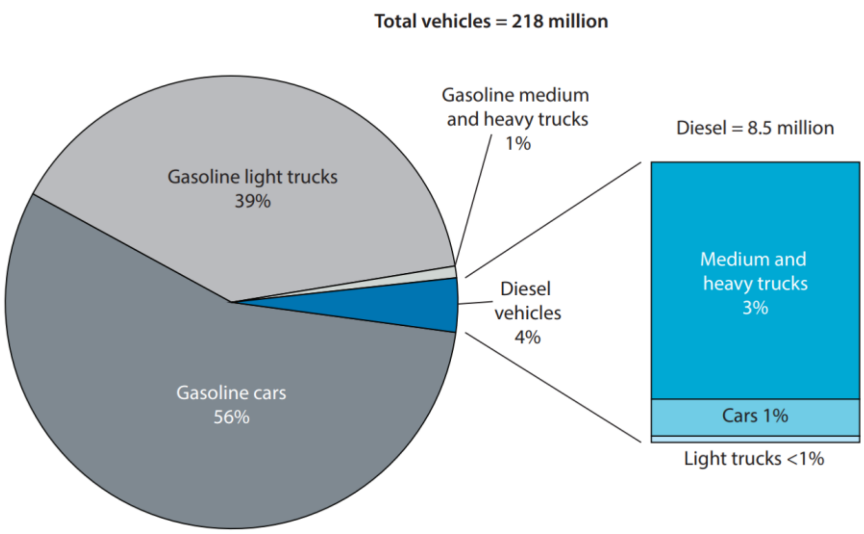

Figure 21 Composition of Diesel and Non-Diesel Fleet: 2014

According to Reuters (Cage & Granados, 2022), Less than 1% of the 250 million cars, SUVs and light-duty trucks on the road in the United States are electric.

Based on the above, we consider that 96% of travel takes place with a petrol car, 3% with a diesel car and 1% with an electric car.

Therefore, the traveling distances are estimated as:

16,380,000 km * 96% = 15,724,800 km passed by petrol engines (4.39)

16,380,000 kilometers * 3% = 491,400 kilometers driven by diesel vehicles (4.40)

16,380,000 kilometers * 1% = 163,800 kilometers traveled by electric vehicles (4.41)

According to the US Department of Energy (US Department of Energy, 2020):

Gasoline engines travel on average 24.2 miles with 1 gallon of gasoline.

1 gallon is 3.79 liters. 1 mile is 1.61 kilometers

So gas-powered cars travel on average 38.96 kilometers with 3.79 liters or otherwise consume 0.097 liters per kilometer.

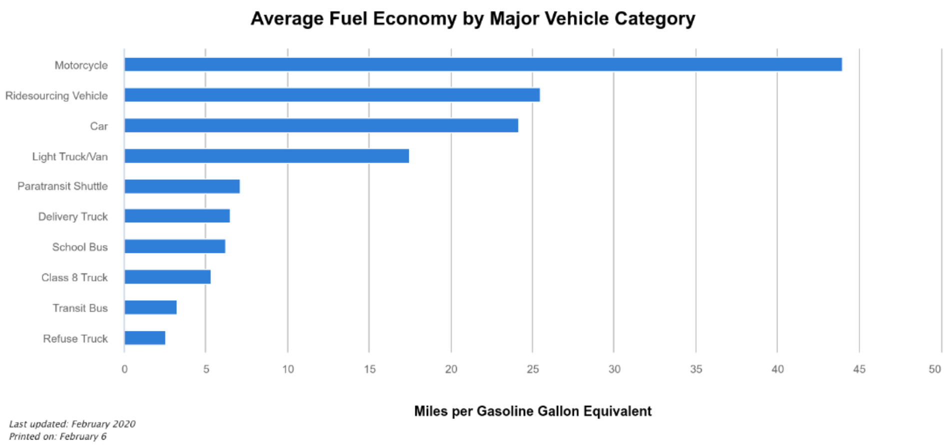

Figure 22 Miles per Gasoline Gallon Equivalent

According to a research (Hearst Autos Research, 2022) Diesel engines consume 24 – 29% less fuel than gasoline engines. Considering that on average they consume 26.5% less fuel, this means they consume 0.071 liters per kilometer.

According to a research (Eco Cost Savings, 2022): Electric cars consume 0.346 kWh per mile. That means they need 0.215 KWh per kilometer.

Based on the above, the liters spent annually are:

15,724,800 kilometers (run by petrol engines) * 0.097 liters per kilometer = 1,525,305.6 liters of gasoline (4.42)

491,400 kilometers (run by diesel vehicles) * 0.071 liters per kilometer = 34,889.4 liters of oil (4.43)

In addition, the energy consumed by electric vehicles are:

163,800 kilometers (electrically driven) * 0.215 KWh per kilometer = 35,217 KWh (4.44)

C-Scheme

In compact ecological city, daily use electric vehicle 140 people, travelling an average of 2.5 kilometers.

Therefore, daily travel by electric vehicle is:

140 people * 2.5 km/person = 350 km (4.45)

And all year round, an electric vehicle travels:

350 km/day * 260 days = 91,000 km (4.46)

So the total energy consumed is:

91,000 kilometers (traveled by electrically driven vehicles) * 0.215 KWh per kilometer = 19,565 KWh (4.47)

P-Scheme

In the proposed model, citizens are not moving. But their computer is consuming energy.

According to a research (Open Genus, 2023), the CPU and Desktop monitor consumes around 170 Watt per hour (= 0.17 KWh) of Electricity when actively used.

Again we have 2 cases: with an appointment (4 minutes) and with no appointment (28 minutes). So the total number of seconds per year is:

Best case: 336,000 seconds (per day) * 260 days = 87,360,000 seconds per year = 24,266.7 hours per year (4.48)

Worst case: 2,352,000 seconds (per day) * 260 days = 611,520,000 seconds per year = 169,866.7 hours per year (4.49)

Based on the following, we have annual consumption:

Best case: 24,266.7 hours per year * 0.17 KWh = 4,125.3 KWh per year (4.50)

Worst case: 169,866.7 hours per year * 0.17 KWh = 28,877.3 KWh per year (4.51)

4.2.6 Total Energy Spent throughout USA

H-Scheme

In total for the 1,178 cities of USA we have:

1.525,305.6 litres of gasoline/city * 1,178 cities = 1,796,809,996.8 litres (4.52)

34,889.4 litres of oil /city * 1,178 cities = 41,099,713.2 litres (4.53)

35,217 KWh/city * 1,178 cities = 41,485,626 KWh (4.54)

C-Scheme

In total for the 1,178 cities of the USA we have:

19,565 KWh/city * 1,178 cities = 23,047,570 KWh (4.55)

P-Scheme

In total for the 1,178 cities of the USA, we have:

Best case: 4,125.3 KWh/city * 1,178 cities = 4,859,603.4 KWh (4.56)
Worst case: 28,877.3 KWh/city* 1,178 cities = 34,017,459.4 KWh (4.57)

4.2.7 Total Gases Emitted in each Cycle/City

H-Scheme

According to our previously found data (question 5), the total energy consumed per year is:

- Vehicles using gasoline: 1,525,305.6 liters gasoline
- Vehicles using petrol: 34,889.4 liters petrol
- Vehicles using electricity: 35,217 KWh

According to the Autolexicon (Auto Lexicon, 2023):

- 1 liter of petrol (gasoline) produces 2.39 kg of Carbon Dioxide (CO_2).
- 1 liter of diesel (oil) produces 2.64 kg of Carbon Dioxide (CO_2).

Vehicles using gasoline (Gasoline-powered passenger vehicles):

1,525,305.6 litres gasoline * 2.39 kg/lt = 3,645,480.38 kg of Carbon Dioxide (CO_2) (4.58)

Vehicles using oil:

34,889.4 litres oil * 2.64 kg/lt = 92,108.02 kg of Carbon Dioxide (CO_2) (4.59)

According to US Energy Information Administration (U.S. Energy Information Administration, 2023) in 2021 (U.S.A.), the production of 1 kWh leads to 0.855 pounds of CO_2 emissions.

Thus:

1 kWh produces 0.39 kg of Carbon Dioxide (CO_2).

Vehicles using electricity (Kilowatt-hours used):

$$35{,}217 \text{ KWh} * 0.39 \text{ kg/kWh} = 13{,}734.63 \text{ kg of Carbon Dioxide } (CO_2) \quad (4.60)$$

C-Scheme

According to our previously found data (question 5), the total energy consumed per year is:

Vehicles using electricity: 19,565 KWh

1 kWh produces 0.39 kg of Carbon Dioxide (CO_2).

19,565 KWh * 0.39 kg/kWh = 7,630.35 kg of Carbon Dioxide (CO_2)

P-Scheme

According to our previously found data (question 5), the total energy consumed per year is:

- Best case (citizens with an appointment): 4,125.3 KWh
- Worst case (citizens without an appointment): 28,877.3 KWh

Best case (citizens with an appointment):

$$4{,}125.3 \text{ KWh} * 0.39 \text{ kg/kWh} = 1{,}608.87 \text{ kg of Carbon Dioxide } (CO_2) \quad (4.61)$$

Worst case (citizens without an appointment):

$$28{,}877.3 \text{ KWh} * 0.39 \text{ kg/kWh} = 11{,}262.15 \text{ kg of Carbon Dioxide } (CO_2) \quad (4.62)$$

4.2.8 Total Gases Emitted throughout USA

USA includes 1,178 cities /cycles.

H-Scheme

Vehicles using gasoline: 1,178 * 3,645,480.38 kg = 4,294,375,887.64 kg of Carbon Dioxide (CO2) (4.63)

Vehicles using petrol: 1,178 * 92,108.02 kg = 108,503,247.56 kg of Carbon Dioxide (CO2) (4.64)

Vehicles using electricity: 1,178 * 13,734.63 kg = 16,179,394.14 kg of Carbon Dioxide (CO2) (4.65)

Overall, H-Scheme produces:

1,178 * 3,645,480.38 kg + 1,178 * 92,108.02 kg +1,178 * 13,734.63 kg = 4,419,058,529.34 kg of Carbon Dioxide (CO2) (4.66)

C-Scheme

Vehicles using electricity produce:

1,178 * 7,630.35 kg = 8,988,552.3 kg of Carbon Dioxide (CO2) (4.67)

P-Scheme

Overall, H-Scheme produces:

Best case (citizens with an appointment): 1,178 * 1,608.87 kg = 1,895,248.86 kg of Carbon Dioxide (CO_2) (4.68)

Worst case (citizens without an appointment): 1,178 * 11,262.15 kg = 13,266,812.7 kg of Carbon Dioxide (CO_2) (4.69)

4.2.9 Total Money Spent per City

H-Scheme

Cost of Lost Time (according to results of the question 3)

- Best case: 1,332,240,000 seconds per year
- Worst case: 1,856,400,000 seconds per year

According to our data, the cost of 1 lost hour per citizen is 10 Euros (about 11.06 USD according to the xe.com conversion on July 24, 2023).

The best case provides 1,332,240,000 seconds per year (370,066.7 hours per year) which leads to the following cost:

$$370{,}066.7 \text{ h} * 10 \text{ Euro/h} = 3{,}700{,}667 \text{ Euro} \tag{4.70}$$

The worst case provides 1,856,400,000 seconds per year (515,666.7 hours per year) which leads to the following cost:

$$515{,}666.7 \text{ hrs} * 10 \text{ Euro/h} = 5{,}156{,}667 \text{ Euro} \tag{4.71}$$

Cost of Electricity & Fuels

Cars using gasoline: 1,525,305.6 liters gasoline (according to results of the question 5). According to USA Gasoline prices (Global Petrol Prices, 2023), 1 liter of gasoline = 1.027 USD = 0.93 Euro

$$1{,}525{,}305.6 * 0.93 \text{ Euro/lt} = 1{,}418{,}534.2 \text{ Euro} \tag{4.72}$$

Cars using petrol: 34,889.4 liters petrol (according to results of the question 5). According to CheckPetrolPrice.com (CheckPetrolPrice.com, 2023), 1 liter of petrol = 1.04 USD = 0.94 Euro

34,889.4 * 0.94 Euro/lt = 32,796.03 Euro (4.73)

Cars using electricity = 35,217 KWh (according to results of the question 5) According to the US Bureau of Labor Statistics (Department of Labor Logo United States Department , 2023), 1 KWh = 0.17 USD (June 2023) = 0.15 Euro

35,217 * 0.15 Euro = 5,282.55 Euro (4.74)

Total Cost

Best case:

3,700,667 Euro + 1,525,305.6 * 0.93 Euro/lt + 34,889.4 * 0.94 Euro/lt + 35,217 * 0.15 Euro= 5,157,279.78 Euro (4.75)

Worst case:

5,156,667 Euro + 1,525,305.6 * 0.93 Euro/lt + 34,889.4 * 0.94 Euro/lt + 35,217 * 0.15 Euro = 6,613,279.78 Euro (4.76)

C-Scheme

Cost of Lost Time (according to results of the question 3)

- Best case: 703,612,000 seconds per year
- Worst case: 1,227,772,000 seconds per year

According to our data, the cost of 1 lost hour per citizen is 10 Euros (about 11.06 USD according to the xe.com conversion on July 24, 2023)

- Best case: 703,612,000 seconds per year = 195,447.7 hrs * 10 Euro/h = 1,954,477 Euro
- Worst case: 1,227,772,000 seconds per year = 341,047.7 hrs * 10 Euro/h = 3,410,477 Euro

Cost of Electricity (Citizens use only electric vehicles)

Cars using electricity: 19,565 KWh (according to results of the question 5). According to the US Bureau of Labor Statistics, 1 KWh = 0.17 USD (June 2023) = 0.15 Euro

$$19{,}565 * 0.15 \text{ Euro/kWh} = 2934.75 \text{ Euro} \quad (4.77)$$

Total Cost

Best case

$$1{,}954{,}477 \text{ Euro} + 19{,}565 * 0.15 \text{ Euro/kWh} = 1{,}957{,}411.75 \text{ Euro} \quad (4.78)$$

Worst case

$$3{,}410{,}477 \text{ Euro} + 19{,}565 * 0.15 \text{ Euro/kWh} = 3{,}413{,}411.75 \text{ Euro} \quad (4.79)$$

P-Scheme

Cost of Lost Time (according to results of the question 3)

- Best case: = 87,360,000 seconds per year
- Worst case: = 611,520,000 seconds per year

According to our assumption, the cost of 1 lost hour per citizen is 10 Euros (about 11.06 USD according to the xe.com conversion on July 24, 2023). The cost for best case/worst case is:

Best case: = 87,360,000 seconds per year = 24,266.7 hrs * 10 Euro/h = 242,667 Euro (4.80)

Worst case: = 611,520,000 seconds per year = 169,866.7 hrs * 10 Euro/h = 1,698,667 Euro (4.81)

Cost of Electricity (Citizens use only electric devices)

Best case: 4,125.3 KWh per year (according to results of the question 5). According to the US Bureau of Labor Statistics, 1 KWh = 0.17 USD (June 2023) = 0.15 Euro

4,125.3 * 0.15 Euro/kWh = 618,795 Euro (4.82)

Worst case: = 28,877.3 KWh per year (according to results of the question 5). According to the US Bureau of Labor Statistics, 1 KWh = 0.17 USD (June 2023)

28,877.3 * 0.15 Euro/h = 4,331.59 Euro (4.83)

Total Cost

Best case:

242,667 Euro + 4,125.3 * 0.15 Euro/kWh =243,285.79 Euro (4.84)

Worst case:

1,698,667 Euro + 28,877.3 * 0.15 Euro/h = 1,702,998.59 Euro (4.85)

4.2.10 Total Money Spent throughout USA

H-Scheme

Best case:

1,178* (3,700,667 Euro + 1,525,305.6 * 0.93 Euro/lt + 34,889.4 * 0.94 Euro/lt + 35,217 * 0.15 Euro) = 6,075,275,580.84 Euro (4.86)

Worst case:

1,178* (5,156,667 Euro + 1,525,305.6 * 0.93 Euro/lt + 34,889.4 * 0.94 Euro/lt + 35,217 * 0.15 Euro) = 7,790,443,580.84 Euro (4.87)

C-Scheme

Best case

1,178* (1,954,477 Euro + 19,565 * 0.15 Euro/kWh) = 2,305,831,041.5 Euro (4.88)

Worst case

1,178* (3,410,477 Euro + 19,565 * 0.15 Euro/kWh) = 4,020,999,041.5 Euro (4.89)

P-Scheme

Best case:

1,178* (242,667 Euro + 4,125.3 * 0.15 Euro/kWh) = 286,590,666.51 Euro (4.90)

Worst case:

1,178* (1,698,667 Euro + 28,877.3 * 0.15 Euro/h) = 2,006,132,344.91 Euro (4.91)

4.3 Diagrams and Observations

4.3.1 Diagrams and Observations Regarding Total Time to Service in each Cycle/City

Diagram 1 is derived from Question 3: ***Total time to service in each cycle/city***

H-Scheme (Homogenous Scheme):

As mentioned above, the total time to service in each city is equal to:

Best case: 87,360,000 seconds a year + 1,244,880,000 seconds a year = 1,332,240,000 seconds per year (or 5,124,000 seconds a day = 1423.33 hours a day)

Worst case: 611,520,000 seconds a year + 1,244,880,000 seconds per year = 1,856,400,000 seconds annually (or 7,140,000 seconds daily = 1983.33 hours per day)

C-Scheme (Compact Scheme):

As mentioned above, the total time to service in each city is equal to:

Best case: 87,360,000 seconds per year + 616,252,000 seconds per annum = 703,612,000 seconds a year (or 2,706,200 seconds per day = 751.72 hours per day)

Worst case: 611,520,000 seconds per year + 616,252,000 seconds per annum = 1,227,772,000 second per year (or 4,722,200 seconds per day= 1311.72 hours per day)

P-Scheme (Proposed Scheme):

As mentioned above, the total time to service in each city is equal to:

Best case: 87,360,000 seconds per year + 0 seconds per annum = 87,360,000 seconds a year (or 336,000 seconds per day= 93.33 hours per day)

Worst case: 611,520,000 seconds per year + 0 seconds per annum = 611,520,000 second per year (or 2,352,000 seconds per day= 653.33 hours per day)

So,

H-Scheme (Homogenous Scheme):

Best case: 1423.33 hours per day

Worst case: 1983.33 hours per day

C-Scheme (Compact Scheme):

Best case: 751.72 hours per day

Worst case: 1311.72 hours per day

P-Scheme (Proposed Scheme):

Best case: 93.33 hours per day

Worst case: 653.33 hours per day

The above-mentioned hours per day are not fixed. They are valid on average.

So for example in City A of H-Scheme (Homogenous Scheme) and in the case of best case, citizens on 25/08/2023 may have taken 1377.15 hours to serve. Accordingly, in City B of H-Scheme (Homogenous Scheme) and in the case of Best case, citizens on 25/08/2023 may have taken 1439.28 hours to serve. All cities with the H-Scheme (Homogenous Scheme) and in the case of best case will have to give an average of 1423,33 hours per day.

To create the chart, we assume that in all cities and for all cases there is a fluctuation of +/- 20%, while keeping the average constant.

In this case and for a period of 30 days we get the following measurements (simulated results) (b: best case, w: worst case):

Day#	H-Scheme/b	H-Scheme/w	C-Scheme/b	C-Scheme/w	P-Scheme/b	P-Scheme/w
1	1,619.71	2,021.93	626.55	1,162.98	102.98	707.78
2	1,671.45	2,337.41	767.5	1,057.08	80.66	615.31

3	1,156.58	1,703.34	789.62	1,436.12	79.02	679.52
4	1,475.93	1,665.86	661.43	1,268.27	97.06	576.63
5	1,535.05	2,374.03	739.21	1109.6	76	680.54
6	1,550.6	2,216.17	689.67	1,437.25	100.41	611.25
7	1,273.35	1,716.43	699.94	1,182.16	99.84	723.3
8	1,223.83	2,337.64	825.76	1,082.34	85.85	755.05
9	1,309.86	2,272.89	685.17	1,075.73	77.63	564.62
10	1,547.28	2,074.29	746.15	1,233.45	79.86	537.91
11	1,173.13	1,960.83	785.79	1,488.46	91.66	607.47
12	1,560.3	2,202.17	630.97	1,296.36	82.28	710.37
13	1,173.63	1,907.99	721.88	1,472.69	83.79	698.51
14	1,378.8	1,788.43	685.17	1,286.14	104.04	689.68
15	1,364.11	1,922.11	860.46	1,140.37	107.92	643.02
16	1,440.39	2,000.28	814.27	1,258.09	92.22	754.11
17	1,477.58	1,630.21	620.28	1,507.92	87.35	584.39
18	1,183.83	1,683.7	743.5	1,286.71	111.39	753.63
19	1,597.9	1,748.05	847.28	1,349.18	75.38	529.61
20	1,706.87	2,300.62	826.32	1,174.8	111.09	595.06

21	1,497.73	1,841.94	657.99	1,333.9	102.41	749.89
22	1,684.52	1,634.64	658.74	1,245.27	99.21	651.22
23	1,162.79	2,233.84	863.87	1,092.23	100.45	549.64
24	1,608.82	2,331.37	716.91	1,484.66	90.74	599.73
25	1,154.78	2,279.02	679.69	1,485.82	94.77	598.31
26	1,641.99	2,300.5	887.26	1,508.75	107.09	525.78
27	1,411.92	1,796.23	881.51	1,548.69	77.02	743.88
28	1,249.26	1,681.49	814.43	1,346.91	101.34	754.07
29	1,618.12	1,772.16	732.99	1,497.66	89.86	719.45
30	1,249.85	1,764.36	891.19	1,501.91	110.43	690.09
Aver	**1,423.33**	**1,983.33**	**751.72**	**1,311.72**	**93.33**	**653.33**

Table 13 Simulated results for 30 days

Diagram 1 contains 6 curves (H-Scheme/b, H-Scheme/w, C-Scheme/b, C-Scheme/w, P-Scheme/b, P-Scheme/w). The x-axis represents days (1,2,..., 30). The y-axis represents the total time until service based on the data from the above table (e.g. on day 1 H-Scheme/b requires a total time of 1,619.71 hours, on day 4 C-Scheme/w requires an overall time of 1,268.27 hours, etc.)

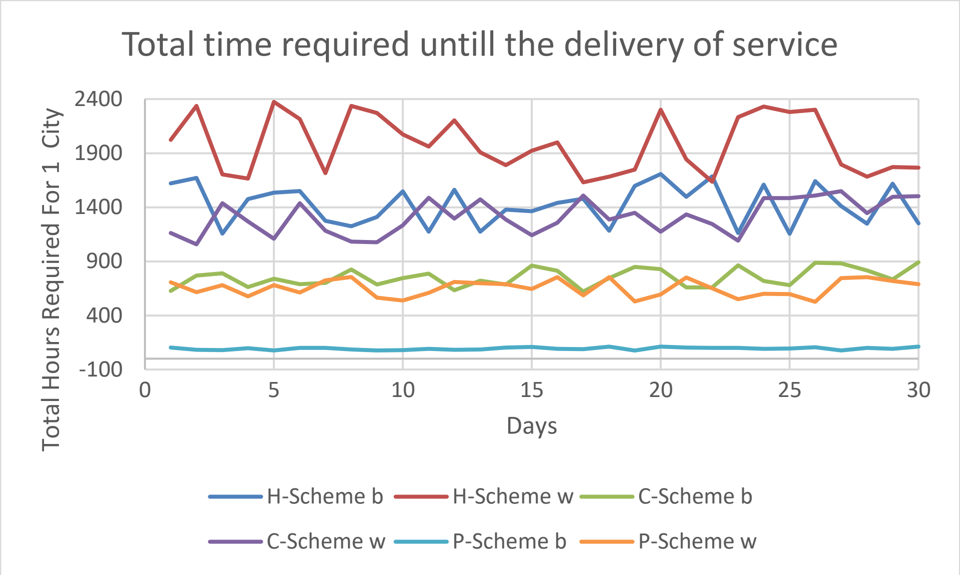

Figure 23 Diagram of total hours required for 1 city

Key Observations:

1. **H-Scheme vs. C-Scheme vs. P-Scheme:**

   - In the H-Scheme (Homogeneous Scheme), both the best-case and worst-case times are relatively high, with an average of approximately 1,619.71 and 2,021.93 for best and worst cases, respectively.
   - In the C-Scheme (Compact Scheme), the best-case times are lower than in the H-Scheme, indicating more efficient service, with an average of approximately 626.55. The worst-case times, however, are still relatively high, averaging around 1,162.98.
   - The P-Scheme (Proposed Scheme) demonstrates the best performance in terms of both best-case and worst-case times, with averages of approximately 102.98 and 707.78, respectively.

2. P-Scheme w vs C-Scheme/b

Let us draw a comparison between C-Scheme/b and P-Scheme/w for the 30 days, and then find the average values for both schemes. We will also identify instances where one scheme is better than the other.

Here's a comparison of C-Scheme/b and P-Scheme/w for each day:

Day#	C-Scheme/b	P-Scheme/w	Better Scheme
1	626.55	707.78	C-Scheme/b
2	767.5	615.31	P-Scheme/w
3	789.62	679.52	P-Scheme/w
4	6,614.3	576.63	P-Scheme/w
5	739.21	680.54	P-Scheme/w
6	6,896.7	611.25	P-Scheme/w
7	699.94	723.3	C-Scheme/b
8	825.76	755.05	P-Scheme/w
9	685.17	564.62	P-Scheme/w
10	746.15	537.91	P-Scheme/w
11	785.79	607.47	P-Scheme/w
12	630.97	710.37	C-Scheme/b
13	721.88	698.51	P-Scheme/w

14	685.17	689.68	C-Scheme/b
15	860.46	643.02	P-Scheme/w
16	814.27	754.11	P-Scheme/w
17	620.28	584.39	P-Scheme/w
18	743.5	753.63	C-Scheme/b
19	847.28	529.61	P-Scheme/w
20	826.32	595.06	P-Scheme/w
21	657.99	749.89	C-Scheme/b
22	658.74	651.22	P-Scheme/w
23	863.87	549.64	P-Scheme/w
24	716.91	599.73	P-Scheme/w
25	679.69	598.31	P-Scheme/w
26	887.26	525.78	P-Scheme/w
27	881.51	743.88	P-Scheme/w
28	814.43	754.07	P-Scheme/w
29	732.99	719.45	P-Scheme/w
30	891.19	690.09	P-Scheme/w

Aver	**751.72**	**653.33**	**P-Scheme/w**

Table 14 comparison of C-Scheme/b and P-Scheme/w for each day

The average service time between P-Scheme/w and C-Scheme/b over the 30-day period is:

(Average P-Scheme/w + Average C-Scheme/b) / 2

$$(653.33 \text{ hours} + 751.72 \text{ hours}) / 2 = 702.53 \text{ hours} \quad (4.92)$$

Therefore, the average service time between the two schemes is approximately 702.53 hours.

On average, P-Scheme/w has shorter service times (lower values) compared to C-Scheme/b. P-Scheme/w is better than C-Scheme/b on average over the 30-day period. There are 24 instances where P-Scheme/w is better and 6 instances where C-Scheme/b is better.

3. C-scheme/w vs. H-scheme/b

Let's draw a comparison between C-Scheme/w and H-Scheme/b for the 30 days, and then find the average values for both schemes. We will also identify instances where one scheme is better than the other.

Here is a comparison of C-Scheme/w and H-Scheme/b for each day:

Day#	C-Scheme/w	H-Scheme/b	Better Scheme
1	1,162.98	1,619.71	C-Scheme/w

2	1,057.08	1,671.45	C-Scheme/w
3	1,436.12	1,156.58	H-Scheme/b
4	1,268.27	1,475.93	C-Scheme/w
5	1,109.6	1,535.05	C-Scheme/w
6	1,437.25	1,550.6	C-Scheme/w
7	1,182.16	1,273.35	C-Scheme/w
8	1,082.34	1,223.83	C-Scheme/w
9	1,075.73	1,309.86	C-Scheme/w
10	1,233.45	1,5472.8	C-Scheme/w
11	1,488.46	1,173.13	H-Scheme/b
12	1,296.36	1,560.3	C-Scheme/w
13	1,472.69	1,173.63	H-Scheme/b
14	1,286.14	1,378.8	C-Scheme/w
15	1,140.37	1,364.11	C-Scheme/w
16	1,258.09	1,440.39	C-Scheme/w
17	1,507.92	1,477.58	H-Scheme/b
18	1,286.71	1,183.83	H-Scheme/b

19	1,349.18	1,597.9	C-Scheme/w
20	1,174.8	1,706.87	C-Scheme/w
21	1,333.9	1,497.73	C-Scheme/w
22	1,245.27	1,684.52	C-Scheme/w
23	1,092.23	1,162.79	C-Scheme/w
24	1,484.66	1,608.82	C-Scheme/w
25	1,485.82	1,154.78	H-Scheme/b
26	1,508.75	1,641.99	C-Scheme/w
27	1,548.69	1,411.92	H-Scheme/b
28	1,346.91	1,249.26	H-Scheme/b
29	1,497.66	1,618.12	C-Scheme/w
30	1,501.91	1,249.85	H-Scheme/b
Aver	**1,311.72**	**1,423.33**	**C-Scheme/w**

Table 15 comparison of C-Scheme/w and H-Scheme/b for each day

The average service time between C-Scheme/w and H-Scheme/b over the 30-day period is:

(Average C-Scheme/w + Average H-Scheme/b) / 2

(1,311.72 + 1,423.33 hours) / 2 = 1367.52 hours (4.93)

So, the average service time between the two schemes is approximately 1,367.52 hours.

On average, C-Scheme/w has shorter service times (lower values) compared to H-Scheme/b. C-Scheme/w is better than H-Scheme/b on average over the 30-day period. There are 21 instances where C-Scheme/w is better and 9 instances where H-Scheme/b is better.

4. **Daily Variations:**

   - There are significant daily variations in all three schemes. For example, in the H-Scheme, the best-case time ranges from 1,156.58 to 1,671.45, while the worst-case time varies from 1,665.86 to 2,374.03.
   - The C-Scheme also exhibits daily fluctuations, with best-case times ranging from 620.28 to 889.87 and worst-case times varying from 1,057.08 to 1,508.75.
   - The P-Scheme generally maintains consistent performance with relatively small daily variations.

Trends and Patterns:

1. **H-Scheme Trends:**

   - The H-Scheme experiences relatively consistent worst-case times throughout the month, indicating a uniform level of service quality.
   - The best-case times in the H-Scheme show fluctuations, possibly due to factors like traffic conditions.

2. **C-Scheme Trends:**

- The C-Scheme's best-case times are lower than the H-Scheme's, but the worst-case times are still relatively high. This suggests that while the C-Scheme provides quicker service on average, there are instances where citizens experience delays.
- There is no clear trend in the daily variations for the C-Scheme, indicating potential unpredictability in service times.

3. **P-Scheme Trends:**

- The P-Scheme consistently outperforms the other schemes in terms of both best-case and worst-case times.
- Daily variations in the P-Scheme are minimal, indicating a high level of predictability and efficiency in service.

Policy Implications:

1. **Improving Transportation Infrastructure:** The data suggests that the H-Scheme, where citizens have to travel longer distances, results in longer service times. Investing in improved transportation infrastructure could reduce travel times and enhance service quality.
2. **Promoting Alternative Transportation:** Encouraging the use of alternative transportation methods such as walking, biking, or electric vehicles, as seen in the C-Scheme, can help reduce travel times and ease traffic congestion.
3. **Digital Transformation:** The P-Scheme, which leverages digital solutions like the metaverse for service delivery, demonstrates the potential for efficient and convenient services. Governments should explore innovative digital approaches to streamline citizen services.

4. **Data-Driven Decision Making:** Continuously monitoring and analyzing service times can help identify trends and areas for improvement in social security offices. Data-driven decision-making can lead to more efficient resource allocation and service optimization.
5. **Service Quality Assurance:** While the C-Scheme offers better best-case times, efforts should be made to reduce worst-case times to ensure consistent service quality for all citizens.

4.3.2 Diagram and Observations Regarding Total Energy Spent in each Cycle/City

Diagram 2 is derived from Question 5: ***Total energy spent in each cycle/city.***

H-Scheme (Homogenous Scheme):

As mentioned above, the total energy spent in each city is equal to:

15,724,800 kilometers (drived by petrol engines) * 0.097 liters per kilometer = 1,525,305.6 liters of petrol per year = 5,866.56 litres of gasoline per day

491,400 kilometres (drived by diesel vehicles) * 0.071 litres per kilometre = 34,889.4 litres of oil per year= 134.19 liters of petroleum per day

163,800 kilometers (electrically driven) * 0.215 KWh per kilometer = 35,217 KWh annually= 135.45 KWh daily

C-Scheme (Compact Scheme):

As mentioned above, the total energy spent in each city is equal to:

91,000 kilometers (electrically driven) * 0.215 KWh per kilometer = 19,565 KWh annually = 75.25 KWh daily

P-Scheme (Proposed Scheme):

As mentioned above, the total energy spent in each city is equal to:

Best case: 24,266.7 hours a year * 0.17 KWh = 4,125.3 KWh a year = 15.87 KWh per day

Worst case: 169,866.7 hours a year * 0.17 KWh = 28,877.3 KWh a year = 111.07 KWh per day

So,

H-Scheme (Homogenous Scheme):

5,866.56 litres of gasoline per day

134.19 liters of oil per day

135.45 KWh per day

One litre of gasoline contains the energy equivalent to 8.9 kWh of electricity (Natural Resources Canada, 2023)

One litre of diesel fuel (auto) has an energy content of approximately 38 MJ – which approximates to 10 kWh (Sustainability Exchange, 2023)

Based on these data, we have for the H-Scheme:

$$5{,}866.56 * 8.9 + 134.19 * 10 + 135.45 = 53{,}689.73 \text{ KWh per day} \qquad (4.94)$$

C-Scheme (Compact Scheme):

75.25 KWh per day

P-Scheme (Proposed Scheme):

Best case: 15.87 KWh per day

Worst case: 111.07 KWh per day

The aforementioned daily energy consumption is not accurate. The values are valid on average.

So for example in City A of H-Scheme (Homogenous Scheme) the energy consumption on 25/08/2023 may have been 58,377.33 hours. Accordingly, in City B of H-Scheme (Homogenous Scheme) the energy consumption at 25/08/2023 was 43,197.17 hours. All cities with the H-Scheme (Homogenous Scheme) will have to reach an average value of 53,689.73 KWh per day.

To create the chart, we assume that in all cities and for all cases there is a fluctuation of +/- 20%, while keeping the average constant.

In this case and for a period of 30 days we get the following measurements (simulated results):

Day#	H-Scheme	C-Scheme	P-Scheme/b	P-Scheme/w
1	50,733.15	90.29	18.38	98.42

2	62,824.81	85.72	13.91	100.08
3	64,329.43	73.39	12.8	131.19
4	62,951.7	82.7	14.45	112.38
5	50,972.72	76.23	16.33	93.01
6	51,670.1	82.15	16.21	129.87
7	50,638.95	73.95	16.48	95.46
8	50,921.42	89.59	17.99	121.45
9	60,445.39	63.95	13.35	98.34
10	49,880.44	63.7	15.52	108.68
11	56,928.33	68.06	15.85	104.83
12	57,678.99	77.94	18.3	106.95
13	51,082.8	74.94	17.07	125.48
14	59,708.35	65.52	15.59	130.67
15	43,937.35	84.32	17.87	123.64
16	48,068.16	75.33	13.12	100.99
17	44,780.89	84.82	15.11	113.75
18	50,653.89	82.05	15.88	97.08
19	49,286.3	64.09	14.98	113.33

20	53,282.67	79.64	17.85	117.17
21	54,572.6	66.97	16.9	99.96
22	47,819.86	66.06	15.59	128.1
23	49,057.68	79.35	12.77	90.33
24	63,002.65	65.86	17.56	108.5
25	47,029.6	79.19	16.57	92.18
26	59,528.95	67.69	17.97	107.42
27	54,387.33	62.12	14.66	124.27
28	46,561.72	81.54	17.74	119.01
29	54,104.91	65.51	12.89	125.45
30	63,850.68	84.69	16.35	113.97
Aver	**53,689.73**	**75.25**	**15.87**	**111.07**

Table 16 Daily energy consumption

Because H-Scheme gives much higher values than the rest, logarithmic scale should be used in order to visualize. Therefore the following table is made (for all the values of the table above the log10 has been calculated (logarithm based on 10):

Day#	H-Scheme	C-Scheme	P-Scheme/b	P-Scheme/w
1	4.71	1.96	1.26	1.99

2	4.8	1.93	1.14	2
3	4.81	1.87	1.11	2.12
4	4.8	1.92	1.16	2.05
5	4.71	1.88	1.21	1.97
6	4.71	1.91	1.21	2.11
7	4.7	1.87	1.22	1.98
8	4.71	1.95	1.26	2.08
9	4.78	1.81	1.13	1.99
10	4.7	1.8	1.19	2.04
11	4.76	1.83	1.2	2.02
12	4.76	1.89	1.26	2.03
13	4.71	1.87	1.23	2.1
14	4.78	1.82	1.19	2.12
15	4.64	1.93	1.25	2.09
16	4.68	1.88	1.12	2
17	4.65	1.93	1.18	2.06
18	4.7	1.91	1.2	1.99
19	4.69	1.81	1.18	2.05

20	4.73	1.9	1.25	2.07
21	4.74	1.83	1.23	2
22	4.68	1.82	1.19	2.11
23	4.69	1.9	1.11	1.96
24	4.8	1.82	1.24	2.04
25	4.67	1.9	1.22	1.96
26	4.77	1.83	1.25	2.03
27	4.74	1.79	1.17	2.09
28	4.67	1.91	1.25	2.08
29	4.73	1.82	1.11	2.1
30	4.81	1.93	1.21	2.06
Aver	4.73	1.87	1.2	2.04

Table 17 Daily energy consumption (logarithm based on 10):

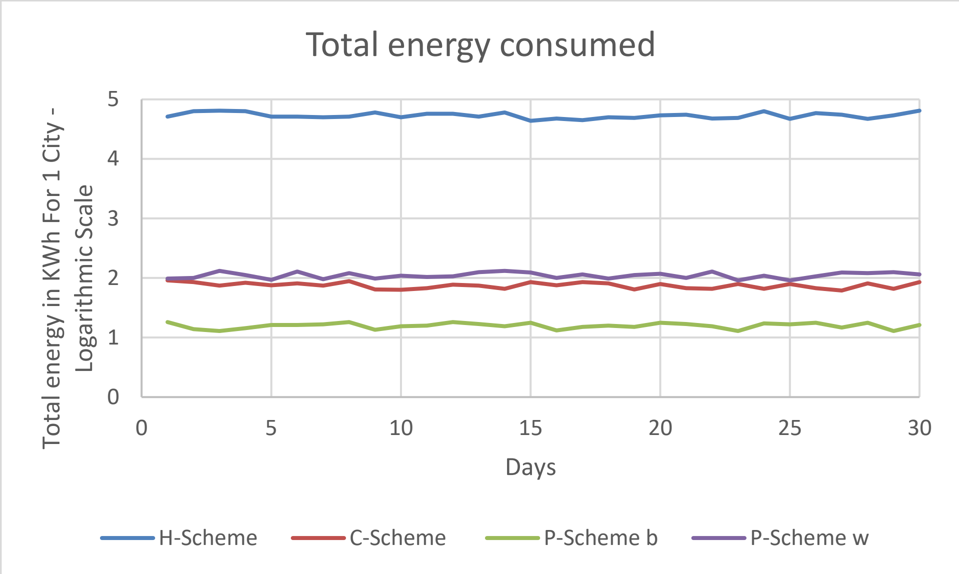

Figure 24 Diagram of total energy in KWh for 1 city

Key Observations:

1. **Energy Consumption in Schemes:**
   - In the H-Scheme, the energy consumption is the highest among all schemes, with an average of approximately 53,689.73 KWh. This may be attributed to the longer travel distances.
   - The C-Scheme consumes significantly less energy, with an average of approximately 75.25 KWh, indicating the benefits of compact city planning.
   - The P-Scheme's energy consumption falls in between, with best-case and worst-case values of approximately 15.87 KWh and 111.07 KWh, respectively.
2. **Daily Variations:**
   - Energy consumption varies daily in all schemes, suggesting fluctuations in demand or usage patterns.
   - The H-Scheme demonstrates the most significant daily variations in energy consumption.

Trends and Patterns:

1. **H-Scheme Trends:**
    - The H-Scheme consistently consumes the most energy daily, which correlates with the longer travel distances required for service.
2. **C-Scheme Trends:**
    - The C-Scheme exhibits relatively stable and lower energy consumption throughout the month, reflecting the advantages of compact city planning. In the second diagram, C-Scheme is always better than P-Scheme w. This means that a compact city is preferable to a Metaverse city (proposed) if citizen appointments are not predefined, and citizens have to wait in the queue to be served.
3. **P-Scheme Trends:**
    - The P-Scheme's energy consumption is moderate, suggesting that digital solutions like the metaverse may have moderate energy requirements.
    - Daily variations in the P-Scheme's energy consumption are relatively consistent, indicating stable demand patterns.

Policy Implications:

1. **Energy Efficiency:** Promoting compact city planning, as seen in the C-Scheme, can significantly reduce energy consumption associated with citizen services. This aligns with sustainability goals and reduces the carbon footprint.
2. **Digital Solutions:** The moderate energy consumption in the P-Scheme suggests that digital solutions, when implemented efficiently, can provide services with a reasonable energy footprint.

3. **Energy Management:** Governments should consider energy management strategies to optimize energy use in social security offices, especially in scenarios with high energy consumption like the H-Scheme.
4. **Data Monitoring:** Continuously monitoring energy consumption patterns can help governments make informed decisions about energy-efficient service delivery and identify areas for improvement.

4.3.3 Diagram and Observations Regarding Total Money Spent per City

Diagram 9 is derived from Question 9: *Total money spent per city*

H-Scheme

As we calculated above the total annual cost in each city is:

Best case:

5,157,279.78 Euro per year => 19,835.69 Euro per day

Worst case:

6,613,279.78 Euro per year => 25,435.69 Euro per day

C-Scheme

Best case

1,957,411.75 Euro per year =>7,528.51 Euro per day

Worst case

3,413,411.75 Euro per year =>13,128.51 Euro per day

P-Scheme

Best case:

243,285.79 Euro per year =>935.71 Euro per day

Worst case:

1,702,998.59 Euro per year =>6,549.99 Euro per day

The above-mentioned costs are not fixed every day. They are valid on average.

So for example in City A of H-Scheme (Homogenous Scheme) and in the case of Best case the total cost at 25/08/2023 could have been 18,942.76 Euro. Accordingly in City B of H-Scheme (Homogenous Scheme) and in the case of Best case the total cost at 25/08/2023 could have been 20,111.31 Euro. All cities with the H-Scheme (Homogenous Scheme) will have to give on average 19,835.69 Euro per day.

In diagrams 1 and 2 we compared different cities per day, so that as much diversity as possible is shown, taking into account a large number of cities. Diagram 3 shows the average (dayly) of all cities for 30 days. In this case: (a) it can be considered that the fluctuation is normalized to +/- 5% (other cities give higher costs and others lower. But overall they do not disappear from 5% of the average) (b) it can also be assumed that all models behave in the corresponding way every day, with some slight deviation (~ +/- 1%) (i.e. if on Day#5 the cost is reduced in H-Scheme/b, it will be reduced respectively in all other models (H- Scheme/w, C-Scheme/b, C –Scheme/w, P-Scheme/b, P –Scheme/w) taking into account the slight variation (~ +/- 1%)

In this case and for a period of 30 days we get the following measurements (simulated results):

Day#	H-Scheme b	H-Scheme/w	C-Scheme/b	C-Scheme/w	P-Scheme/b	P-Scheme/w
1	19,650.36	25,200.03	7,533.87	12,951.98	935.4	6,498.91
2	20,701.69	26,423.48	7,912.07	13,795.35	978.09	6,858.42
3	198,314.9	25,348.27	7,567.61	13,213.59	935.68	6,506.28
4	19,787.15	25,438.45	7,543.69	13,086.47	934.12	6,532.46
5	19,702.93	25,166.68	7,505.76	13,083.98	928.55	6,516.12
6	19,794.76	25,389.4	7,519.11	13,173.02	938.84	6,480.2
7	20,339.86	26,089.53	7,719.71	13,425.98	952.83	6,760.14
8	19,373.47	24,785.64	7,409.55	12,789.44	917.03	6,397.68
9	19,652.97	25,257.22	7,493.85	13,077.19	928.85	6,539.09
10	19,863.31	25,404.58	7,616.74	13,152.91	932.16	6,565.08
11	18,891.03	24,305.84	7,095.22	12,564.93	884.06	6,209,48
12	19,508.64	25,101.33	7,410.53	13,006.75	921.62	6,497.23
13	20,629.39	26,410.27	7618	13,588.4	967.99	6,757.49
14	19,536.88	25,148.37	7505.7	12,947.39	922.36	6,515.29
15	20,455.24	26,261.16	7,618.38	13,587,02	956.09	6,699.93
16	19,925.06	25,588.32	7,660.11	13,105.3	934.68	6,580.7

17	20,410.85	26,180.79	7,694.58	13,510.35	963.2	6,710.49
18	18,944.29	24,283.18	7,238.93	12,621.56	899.61	6,296.39
19	19,372	24,778.83	7,259.82	12,878.89	917.35	6,423.46
20	20,210.45	25,994.32	7,589.01	13,367.64	948.28	6,722.48
21	20,379.08	26,117.74	7,730.29	1,355.331	958.82	6,700.46
22	19,287.51	24,768.19	7,221.21	12,734.68	913.42	6,361.79
23	19,458.86	24,888.22	7,420.59	12,953.08	919.7	6,448.89
24	18,962.11	24,351.36	7,239.01	12,476.18	899.3	6,240.07
25	19,748	25,348.08	7,489.78	12,974.98	937.97	6,493.88
26	19,325.41	24,726.63	7,340.72	12,868.72	915.58	6,334.93
27	20,542.92	26,298.71	7,784.13	13,270.11	965	6,833.74
28	20,511.02	26,386.45	7,771.18	134,771.6	959.37	6,720.88
29	20,155.48	25,851.31	7,735.6	13,396.33	957.45	6,704.92
30	20,118.4	25,778.35	7,610.62	13,222.72	947.83	6,592.92
Aver	19,835.69	25,435.69	7,528.51	13,128.51	935.71	6,549.99

Table 18 Average (daily) consumption of all cities for 30 days

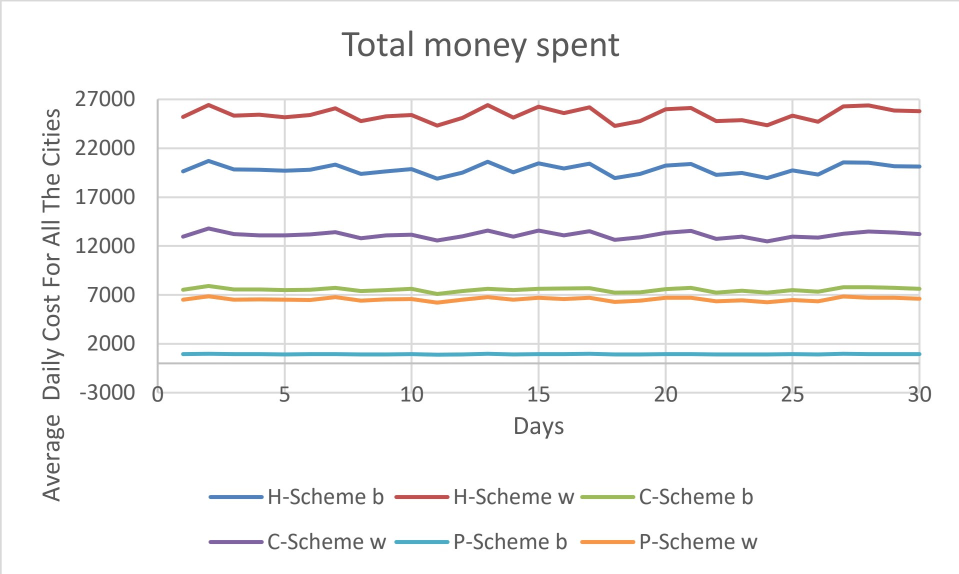

Figure 25 Diagram of average daily cost for all the cities

Key Observations:

H-Scheme (Best and Worst Case):

- The H-Scheme exhibits the highest daily monetary expenditure, indicating that it may be the costliest scheme in terms of monetary resources.
- The worst-case scenario in the H-Scheme is consistently more expensive than the best case, with notable differences.

C-Scheme (Best and Worst Case):

- The C-Scheme has substantially lower daily monetary costs compared to the H-Scheme, reflecting the efficiency of compact city planning.
- Similar to the H-Scheme, the worst-case scenario in the C-Scheme is consistently more expensive than the best case.

P-Scheme (Best and Worst Case):

- The P-Scheme's monetary expenditure is notably lower compared to the H-Scheme, suggesting that digital solutions and metaverse-based service delivery may be cost-effective.
- Both the best and worst-case scenarios in the P-Scheme show relatively consistent daily costs.

Daily Variations:

- All schemes show daily variations in monetary expenditures, indicating that the cost of servicing citizens fluctuates throughout the month.
- The H-Scheme has the highest daily variability, while the C-Scheme exhibits more stability in daily costs.

Policy Implications:

1. **Cost Management:** Policymakers should consider strategies to manage the costs associated with the H-Scheme, especially in worst-case scenarios, to ensure efficient resource allocation.
2. **Compact City Planning:** Promoting compact city planning, as seen in the C-Scheme, can significantly reduce daily monetary expenditures, making it an economically efficient option.
3. **Digital Solutions:** The P-Scheme's cost-effectiveness suggests that digital solutions and metaverse-based service delivery may offer financial benefits to governments.
4. **Budget Allocation:** Governments should allocate budgets considering the daily variations in costs to ensure stable and sustainable service delivery.

5. **Appointment scheduling:** In diagram 3, C-Scheme/b becomes comparable to P-Scheme/w. This means that in this scenario, we can see that a Metaverse city always operates better than a compact city. However, for it to function fully efficiently, the Metaverse city also requires appointment scheduling. Otherwise, it does not offer significant differences compared to the compact city, which has appointment scheduling.

5. Conclusions

The following chapter refers to the final remarks considering this research in e-government. Particularly, we will discuss the main contributions of this thesis to e-government research and how these contributions will help decision-makers and policymakers implement innovative technologies in the public sector and benefit from their advantages. Moreover, we will address both the objectives and research questions that were discussed in the early parts of this thesis. At last, but not least, we will share our final thoughts considering future work that could be implemented by the government and research community towards implementing cutting-edge technologies in the government.

5.1 Addressing the Research Objectives

1. *To investigate the existing landscape of electronic systems and emerging e-government technologies*: Our research explores the current landscape of electronic systems and emerging technologies by discussing the evolution of government electronic systems in Chapter 2 and presenting some of the most innovative technologies in Chapter 3.

2. *To evaluate the influence of information systems and advances technologies on government operations:* In Chapter 2 and through the other chapters we discuss how the usage of innovative technologies affects public service delivery, the privacy of data, and other government operations.

3. *To look into the benefits and drawbacks of using new technology and electronic systems in e-government*: In Chapter 2 and throughout the other sections, we discuss the benefits and the challenges of electronic government systems, including trust, privacy, user satisfaction, etc.

4. *To look at the elements that influence the successful implementation of electronic systems and new technologies in e-government*: In Chapter 4, our research explores and estimates the influence of time, energy, exhaust gases, and financial resources as elements for the implementation of e-government.

5. *To assist policymakers and practitioners with recommendations for exploiting electronic systems and innovative technologies in e-government*: The discussion about the application of innovative technologies in e-government (Chapter 3) and the case study of implementing Metaverse in the government (Chapter 4) suggest new ways to exploit these technologies by designing new systems and estimating the cost of their implementation.

5.2 Addressing the Research Questions

1. *How does the implementation of cutting-edge technologies in e-government influence the required time for delivering public services*?

The estimation of the total time (including travel time and parking time) to move in each city and in the whole country (USA) by using the Metaverse or visiting the public servants in person is the author's answer to the research question.

2. *How does the implementation of cutting-edge technologies in e-government influence the consumption of energy for the completion of public service delivery*?

The estimation of the total energy (fuel & electricity) consumed by the citizens who receive public services by visiting a social security office or by using the Metaverse, answers the research question and helps out policy makers for the implementation of the technologies in e-government.

3. *How does the implementation of cutting-edge technologies in e-government influence the consumption of exhaust fumes for the completion of public service delivery*?

The question is answered with precise numerical data by the estimation of the total exhaust gases emitted in each city and throughout the nation for the provision of public services, which can be done by visiting a local office or by using the Metaverse.

4. *How does the implementation of cutting-edge technologies in e-government influence the cost of public service delivery*?

The estimation of the total cost (lost time & energy) for each move required to receive public services by visiting a local office or using the Metaverse, provides accurate numerical data about this research question.

5.3 Final Thoughts – Future Work

Many studies have been conducted to investigate the influence of e-government projects on government performance, service delivery, and public happiness. E-government, for example, has been demonstrated in studies to improve efficiency by streamlining administrative operations, eliminating paperwork, and enhancing information flow across government organizations. It has also been discovered to help reduce costs through automation, digitization, and online service delivery.

Additionally, research has been done to find out how e-government affects public participation and involvement. The results imply that e-government can encourage increased accountability, openness, and public involvement in decision-making.

The ability for citizens to obtain information, offer suggestions, and take part in online consultations increases their engagement with government operations.

Even while earlier study has shed light on the impact of e-government, there are still unanswered questions. To evaluate the long-term advantages of e-government on government performance metrics like cost savings, process efficiency, and service quality, for instance, further empirical research is required. Additionally, greater investigation should be done into the ways that e-government enhances public participation and involvement as well as the elements that affect citizen acceptance and satisfaction with e-government services.

5.3.1 Evaluation and Measurement of E-Government Success

E-government initiatives must be evaluated for success in order to determine their impact and potential areas for improvement. A number of studies have offered methods and frameworks for evaluating the effectiveness of e-government, taking into account factors including citizen happiness, societal impact, usability, effectiveness, and efficiency.

Additionally, studies have examined the use of benchmarking and key performance indicators (KPIs) to evaluate and compare the effectiveness of e-government initiatives across nations and regions. These studies offer helpful insights into the metrics and evaluation process applied to determine how successful e-government is.

Nevertheless, in order to assess and gauge the effectiveness of e-government, several research gaps need to be addressed. First things first, standardized and tried-and-true assessment methods that can capture the complex character of successful e-government initiatives are required. Enhancing the rigor and comparability of evaluation studies can be achieved by developing robust frameworks and indicators for assessment that consider the unique features and objectives of e-government efforts.

Furthermore, research should concentrate on the long-term viability and scalability of e-government efforts. While short-term impact assessments are useful, it is critical to understand the elements that contribute to the long-term success and scalability of e-government projects. Examining concerns like, as funding systems, technical obsolescence, and the ability to respond to changing public requirements and expectations are all part of this.

5.3.2 Emerging Trends and Future Directions

Academic attention should be paid to the emerging trends and future directions in e-government. These include experimenting with cutting-edge strategies like open data, co-creation, and smart city initiatives, as well as integrating cutting-edge technologies like blockchain, artificial intelligence, and the Internet of Things into e-government platforms.

Research should focus on comprehending the possible advantages, issues, and consequences of these new trends for the implementation of e-government. Policymakers and practitioners can make judgments that are more informed on how to integrate new technology into e-government efforts by researching the possible benefits and risks of doing so.

Additionally, studies on the impact of e-government on the SDGs and social welfare ought to be carried out. Gaining knowledge on how e-government can contribute to the accomplishment of Sustainable Development Goals (SDGs) such as reducing inequality, promoting diversity, and guaranteeing access to basic services can shed light on the innovative potential of e-government in addressing social issues.

In conclusion, earlier research has provided useful insights into numerous areas of e-government deployment. However, research gaps exist, presenting potential for additional exploration. More empirical studies on the impact of e-government are needed, as is a deeper understanding of user acceptance and adoption, exploration of governance and policy challenges, improved evaluation and measurement of e-government success, and research on emerging trends and future directions. We can increase our knowledge by filling these research gaps.

Innovative technologies are critical to the progress of e-government efforts. They provide advantages such as better service delivery, increased efficiency, data-driven decision making, more transparency, citizen participation, and cost savings. However, its implementation is fraught with difficulties due to technological complexity, interoperability, data privacy and security, the digital divide, opposition to change, and ethical concerns. Governments may exploit the promise of innovative technology to enhance their e-government services and improve governance results by comprehending these difficulties and identifying significant applications. While novel technologies provide several benefits, their application in e-government efforts is fraught with difficulties. Among the major challenges are:

- Complexity of Technology: Innovative technologies frequently necessitate specialized knowledge and skills for implementation and upkeep. Governments may confront difficulties hiring and keeping the technical knowledge required to successfully install and operate these technologies.
- Change Resistance: Implementing innovative technology in e-government may encounter opposition from a variety of stakeholders, including government employees, citizens, and enterprises. Concerns about employment displacement, privacy concerns, or a lack of experience with new technologies can all contribute to resistance. Governments must address these issues by implementing effective change management strategies, engaging stakeholders, and launching capacity-building efforts.

- Ethical and Legal Considerations: There are moral and legal issues with using cutting edge technologies like data analytics and artificial intelligence. Governments are required to ensure that these technologies are used in an ethical and responsible manner, that prejudice and discrimination are avoided, and that the relevant laws and policies pertaining to data privacy and protection are observed.

5.3.3 Future Directions for Research on the Implementation of Metaverse in E-Government

There are a number of important issues that need more research as the metaverse concept develops popularity and its potential applications in numerous sectors, including e-government, become more evident. First and foremost, studies ought to concentrate on comprehending how metaverse technology might improve public involvement and participation in governmental processes. This can entail looking at creative methods to integrate augmented reality (AR) and virtual reality (VR) components into e-government platforms so that people can engage with public servants electronically and take part in decision-making.

Examining the possible difficulties and moral dilemmas posed by integrating metaverse technology with e-government is also necessary. It is important to conduct research on topics like data security and privacy, as well as potential digital divides brought on by unequal access to metaverse platforms.

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Appendix - Published Works

Mr. Yfantis Vasileios is a Ph.D. candidate at the University of West Attica. He holds a Bachelor in Marketing (Technological Institute of Athens), an MSc in Information Technology with Web Technology (University of the West of Scotland, UK), and an MSc in Information Security (Luleå University of Technology, Sweden). Vasileios is currently working at the University of West Attica in the administrative department of Laboratory Teaching Staff (E.D.I.P.), Special Technical Laboratory Staff (E.T.E.P.), and Other Staff. As a researcher, he has presented conference papers in both Europe and Africa. The main areas of his research interests are E-Government, Information Security, E-Tourism, and Music Industry.

<u>Research Experience</u>

Participation in International Projects

- (2022 – Present) Erasmus + program, Youth Wiki Greece: Project administrator and author of content discussing the youth policies of Greece.
- (2022 – 2022) WeVote EU Proposal: Authoring and submitting a proposal at the European Union regarding regaining political trust in public institutions through the creation of the Gamified Metaverse.
- (2022 – 2023) Erasmus + program Feelit, an innovative training program for designing tourism experiences for deaf persons: Author of content and translator.

Scholarships

• (July –August 2014) Scholarship from the Danish government for a short-term visit in Odense, Denmark for the Language and Culture Summer Course of Tietgen.

• (June 2014 – June 2014) Scholarship from the Greek Ministry of Education for a short-term research in the country of Armenia regarding the factors that influence the mobile government adoption.

Conference Papers

a. V. Yfantis, A. Usoro and D. Tseles, “Reducing the digital divide in the music industry,” in Proceedings of the eRA 6 international scientific conference, Athens, Greece, September 2011.

b. V. Yfantis, P. Kalagiakos and P. Karampelas, “MaaS Reloaded - Music as a Service: The community cloud approach,” (accepted poster paper), CISTI'2012, 7th Iberian Conference on Information Systems and Technologies, Madrid, Spain, June 2012.

c. V. Yfantis, P. Kalagiakos, C. Kouloumperi and P. Karampelas, “The contribution of quick response codes in E-learning”, ICEELI 2012, Interactive collaborative learning conference, Sousse, Tunisia, July 2012.

d. V. Yfantis, P. Kalagiakos and P. Karampelas, “The reduction of the digital divide by improving the appropriateness of the web content”, ITHET 2012, Information Technology based higher education and training conference, Istanbul, Turkey, June, 2012.

e. V. Yfantis, C. Kouloumperi, P. Kalagiakos, P. Karampelas, “A conceptual model of improving the collaborative information seeking groups”, (accepted full

paper), ICL 2012, International Collaborative Learning conference, Villach, Austria, September 2012.

f. V.Yfantis, K. Vassilopoulou, A. Pateli, A. Usoro, "The Influential Factors of M-Government's Adoption in the Developing Countries", MobiWIS 2013, The 10th International Conference on Mobile Web Information Systems, Paphos, Cyprus, August 2013.

g. V. Yfantis and D. Tseles, "The Impact Of Privacy On Wearable Computing Adoption," in Proceedings of the NETTIES international scientific conference, Athens, Greece, May 2017.

h. V. Yfantis and D. Tseles, "Exploring Gamification In The Public Sector Through The Octalysis Conceptual Model," in Proceedings of the Era 12 international scientific conference, Athens, Greece, October 2017.

i. V. Yfantis, P. Xuereb and L. Garg, "Exploring Mobile Crowdsourcing in the Public Administration," in Proceedings of the ISMS International Conference on Information Systems and Management Science, Msida, Malta, February 2018.

j. V. Yfantis, K. Ntalianis, F. Ntalianis and I. Salmon, "A systematic literature review of the crowdsourcing in the public sector," in Proceedings of the ICQSBEI2020, 4rth International Conference On Quantitative ,Social, Biomedical And Economic Issues , Athens, Greece, 10 -11 July 2020

Book Chapters

k. V. Yfantis, D.Tseles, A. Usoro, "Digital Divide and Disadvantaged Populations in E-Tourism" in Leveraging Developing Economies with the Use of Information Technology: Trends and Tools, IGI Global, pp 15 - 28, 2012.

l. V. Yfantis, D.Tseles, A. Usoro, “The conceptualization of a research model for the measurement of e-government 2.0 readiness in the developing countries” in Cases on Web 2.0 in Developing Countries: Studies on Implementation, Application and Use, IGI Global, pp 61 -75, 2012.

m. V. Yfantis, R. Kervenoael, “Articulating Wider Smartphone Emerging Security Issues in the Case of M-Government in Turkey” in Digital Public Administration and E-Government in Developing Nations: Policy and Practice, IGI Global, pp 177 – 205, 2014.

n. V. Yfantis, K. Vassilopoulou, A. Pateli, “Government as a Service in communities” in Encyclopedia of Information Science and Technology, (3rd Ed) Edited by Mehdi Khosrow-Pour, DBA, IGI Global, pp 3236 – 3244, 2015.

o. V. Yfantis, D. Tseles, A. Usoro, “A Conceptual Model for the Measurement of E-Government 2.0 Adoption by Developing Countries” in Digital Solutions for Contemporary Democracy and Government, IGI Global, pp 239-251, 2015.

p. V. Yfantis, , “Cloud Governance at the Local Communities” in Encyclopedia of Information Science and Technology, (4th Ed) Edited by Mehdi Khosrow-Pour, DBA, IGI Global, pp 1033 – 1039, 2017.

q. Yfantis, V., Ntalianis, K. (2023). Exploring the Potential Adoption of Metaverse in Government. In: Jacob, I.J., Kolandapalayam Shanmugam, S., Izonin, I. (eds) Data Intelligence and Cognitive Informatics. Algorithms for Intelligent Systems. Springer, Singapore. https://doi.org/10.1007/978-981-19-6004-8_61

Self-Published Books

r. V. Yfantis, “The Commercial Exploitation Of Color As A Consumer Stimulus” (Greek Edition), Amazon.com, 2013.

s. V. Yfantis, “The Lost Lyrics” (Greek Edition), Amazon.com, 2013.

t. V. Yfantis, “Punk Goes Science: The Academic Punk Bibliography”,CreateSpace, 2014.

u. V. Yfantis, “Disadvantaged Populations And Technology In Music”,CreateSpace, 2017.

v. V. Yfantis, “Metal Goes Science: The Academic Metal Bibliography”,CreateSpace, 2017.

w. V. Yfantis, “City Streets Of Europe,”Amazon.com, 2017.

x. V. Yfantis, “Disadvantaged Populations And Technology In Music,”Amazon.com, 2017.

y. V. Yfantis, “Hip Hop Goes Science: Volume I,”Amazon.com, 2019.

z. V. Yfantis, “Hip Hop Goes Science: Volume I (Extended Version),”Amazon.com, 2020.

aa. V. Yfantis, “Is Prog Rock Really Progressive?,” Amazon.com, 2020.

bb. V. Yfantis, “Power Ballads And The Stories Behind,” Amazon.com, 2021.

Public Lectures

cc. V. Yfantis, (2015) Exploring the digital divide in the music industry,{ Public Lecture}The Aesthetics of Music and Sound: More Than Meets the Ear. University Of The Southern Denmark. 12 November.

Journal Articles

dd. Yfantis, V., Ntalianis, K., Xuereb, P. A., & Garg, L. (2018). Motivating the Citizens to Transact with the Government Through a Gamified Experience. International Journal of Economics and Statistics, 81-86.

ee. Yfantis, V., Ntalianis, K., & Mastorakis, N. (2019). Exploring the Use of Mobile Crowdsourcing by the Public Administration. WSEAS Transactions on Communications, ISSN / E-ISSN: 1109-2742 / 2224-2864, Volume 18, 2019, Art. #3, pp. 17-24.

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gg. Yfantis, V., Ntalianis, K. (2020). The exploration of Government as a Service through the community cloud computing. International Journal of Hyperconnectivity and the Internet of Things, Volume 4, Issue 2, pp. 58-67.

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