Utilsmart
Utilities solution for smart cities

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Abstract
In the last decades, governments from the entire world have implemented various digital solutions to increase public services eficency and transparency. Almost every government around the world now provides e-services to citizens and other stakeholders through websites and mobile applications. Living in the era of rapid digitization, emerging technologies such as Blockchain, Artificial Intelligence (AI) and advanced decision-making systems are essential for modernizing and streamlining interactions between institutions, citizens and businesses. Together, these technologies contribute to build an interconnected, secure and transparent digital ecosystem capable of transforming administrative and decision-making processes and facilitating a fast and reliable flow of information. One of the most important problems that both public institutions and citizens are facing is related to utilities distribution systems, from optimizing water, energy, gas consumption, or alternative energy sources, to distribution systems maintenance, issues with the network and much more. The aim of this paper is to present a proposal that solves all the previous aspects and put together all the stakeholders in a single solution. The application will consist of multiple components: utilities consumptions, single point of contracting, utilities distribution systems malfunction reporting, bonifications, rating mechanisms (for providers and citizens). The entire solution will be based on multiple technologies like Blockchain, AI, Serious Gaming or modern Decision Support Systems. The value of this proposal is obtained from unifying all the important actors (citizen, public administration and utilities providers) in one single place.

Keywords: Smart Cities, Blockchain, Decision Support Systems, Artificial Intelligence.

1. Introduction

The expansion of internet access has led countries worldwide to integrate digital technologies as tools for communication and service delivery between citizens and various entities. E-governance enables users to access online services directly from the comfort of their homes, eliminating the need to wait in long lines at public offices, thus saving time and transportation costs. At the same time, service providers can operate more efficiently, streamlining delivery processes [1].

Emerging technologies have become the main driver of global digital transformation, reshaping various sectors, from the economy and healthcare to education and public administration. Among these, blockchain, artificial intelligence (AI), and decision-making systems stand out for their potential to revolutionize how we manage data, make decisions, and interact at individual, organizational, and social levels.

Blockchain is a distributed ledger technology that enables the secure, transparent, and immutable storage and transfer of information. It eliminates the need for a trusted intermediary, providing a solid foundation for applications dealing with digital identity

management and data traceability. The adoption of blockchain pushes the boundaries of digitalization by enhancing trust and reducing risks associated with data manipulation.

Artificial intelligence refers to the development of systems and algorithms capable of performing tasks that require human intelligence, such as learning, reasoning, and natural language processing. AI is already integrated into daily life through applications like voice recognition, recommendation systems, and virtual assistants. Across various industries, it optimizes processes, reduces costs, and unlocks new possibilities, such as the development of autonomous vehicles or medical diagnostics based on big data.

Decision systems are technological tools that analyze complex data to support the decision-making process. They combine analytical algorithms, predictive models, and human expertise to generate effective solutions in complex situations. For instance, in the public sector, these systems can optimize resource allocation or aid in risk management during crises.

The interaction between blockchain, AI, and decision systems creates synergies that amplify the benefits of each technology individually. For example, blockchain can ensure the integrity of data used by AI algorithms, while AI can rapidly analyze information stored in blockchain ledgers to support informed decision-making. This convergence opens new avenues in areas such as digital governance, healthcare or finance.

These emerging technologies not only redefine how we work and live but also shape the future, with the potential to address global challenges more efficiently, transparently, and sustainable.

2. State of the art

E-governance involves the use of information and communication technologies to provide public services to citizens and organizations in an efficient, fast, and transparent manner. This field represents one of the most complex systems, requiring secure distribution, protection against unauthorized access, and the preservation of data confidentiality. Failures in these areas can have significant consequences, both economically and socially. Most current e-governance systems, such as official websites and electronic identity management platforms (eID), operate on centralized infrastructures based on servers and redundant databases. This type of architecture poses significant vulnerabilities, being exposed to the risk of single points of failure as well as cyberattacks, such as malware, or denial of service (DoS) attacks.

According to a United Nations study on e-governance [2] most governments worldwide now provide electronic services to citizens and other interested entities through websites and mobile applications.

2.1 Blockchain and transparency in e-government

Blockchain technology enables the development of decentralized systems that offer enhanced security and privacy without relying on the control of third-party organizations. Through blockchain, new data and transaction outcomes are recorded in a distributed ledger

composed of blocks, ensuring both verifiability and immutability. Security and privacy are further strengthened by the encryption of data and its uniform distribution across the network [3].

E-governance systems manage a substantial amount of sensitive data related to citizens, employees, clients, products, research, financial situations, and more, through information technology. Typically, the compromise of this data results in the loss of user trust, opportunities, and financial benefits, among others [4]. It has been found that over 80% of e-governance websites worldwide exhibited vulnerabilities related to cross-site scripting (XSS) and SQL injection, due to the lack of proper authentication measures for validating user-inputted data [5].

Recently, many countries worldwide have been exposed to major threats due to denial of service (DoS) attacks and malware targeting their network infrastructures [6]. For example, in 2015, the U.S. government fell victim to a significant attack on its e-governance systems, resulting in a massive leak of confidential data, including information on over 4 million government employees, such as security clearances, Social Security numbers, identities, and passwords [7]. According to a report from [8], in 2016, the government of Tanzania was attacked by cyber actors, including hackers and tech spies, leading to financial losses of approximately 85 million U.S. dollars. Additionally, in 2014, Singapore's government platform was compromised, and hackers breached over 1,500 user accounts, gaining access to business creation processes and work permit applications [7].

Blockchain technology has been considered a promising solution for creating a decentralized and secure environment for data exchange [9] [10]. Initially developed for digital currency transactions, this technology has found applications in various fields focused on security and privacy, such as the Internet of Things (IoT) [11], smart homes [12], smart cities [1] , education [13], and the healthcare sector [14] Although governments worldwide have not yet widely implemented blockchain in the public sector, many countries have launched pilot projects to explore the potential of this technology in delivering public services to citizens [15]. Each project typically focuses on a specific service, such as e-residency, e-health, or land registry, and is still in the early stages. Today, there is no unified framework for integrating blockchain into e-governance [15]. Furthermore, each country is developing its own blockchain system, and this diversity in blockchain technologies may create communication barriers in international information exchange.

The integration of blockchain in e-governance represents a significant opportunity for improving security, transparency, and efficiency in the delivery of public services. The technology can eliminate risks associated with centralized systems by providing a decentralized and immutable framework for managing sensitive data. Although large-scale implementation is still in its early stages, and each country is exploring specific applications, blockchain can contribute to the creation of safer and more efficient governance systems, reducing the risks of cyberattacks and fraud. However, to maximize the benefits of this technology, the development of common legal and technical

frameworks is necessary to facilitate interoperability and information exchange between different countries and systems.

2.2 Artificial Intelligence and predictive analytics

Artificial Intelligence (AI) transforms nearly every aspect of modern life, from entertainment and commerce to healthcare. It is used to create personal profiles, which can be leveraged not only for behavioral analysis and personalized marketing but also for anticipating economic trends, political changes, and public opinions on a wide range of subjects [16].

Smart city initiatives are seen as major challenges for the global modernization of urban areas. The concept has various interpretations, with a smart city being defined more by its ability to optimize essential functions through the use of advanced technologies [17].

A smart city integrates a variety of e-governance services and benefits from a robust IT infrastructure, promoting transparent governance (smart governance). Its economy is based on e-commerce and digital businesses, while logistics and transportation activities are efficiently managed through IT solutions. Smart cities rely heavily on renewable energy sources, have digitally controlled energy networks, and feature eco-friendly buildings. They address pollution and monitor water and air quality (smart environment). Additionally, in such cities, citizens possess adequate digital skills, have access to education and continuous training, and services in healthcare, housing, culture, and social cohesion are well-developed [18].

Furthermore, Artificial Intelligence (AI) and predictive analytics are transforming e-governance by enhancing the efficiency, transparency, and personalization of public services. Here's how these technologies are making an impact:

- Personalized Public Services: - AI can analyze large datasets to understand citizens' behaviors, preferences, and needs. By using this data, governments can tailor public services to individuals, improving the overall user experience. For instance, AI can suggest relevant services or information based on past interactions or demographic profiles.
- Predictive Analytics for Decision Making: - Predictive analytics uses historical data and AI algorithms to forecast future events or trends. In e-governance, predictive models can help public authorities anticipate issues and make proactive decisions
- Optimizing Resource Allocation: - AI helps governments optimize resource allocation by predicting demand and identifying inefficiencies. For example, predictive models can forecast the demand for public services such as healthcare, education, or infrastructure, enabling better planning and cost management.
- Enhanced Citizen Engagement and Interaction: - AI-driven chatbots and virtual assistants can provide real-time assistance to citizens, answering questions, processing requests, and guiding them through administrative procedures.
- Fraud Detection and Prevention: - AI and predictive analytics can be used to detect irregularities or fraudulent activities within public systems, such as tax evasion or welfare fraud. By analyzing patterns and identifying anomalies in transactions, AI can flag suspicious activities in real-time, allowing governments to act swiftly to prevent or mitigate fraud.

- Smart Cities and Infrastructure: - Predictive analytics and AI play a crucial role in managing urban infrastructure in smart cities. For example, sensors can collect data on energy usage, traffic, or air quality, and AI algorithms can predict future demand, optimize energy consumption, or reduce traffic congestion. This can improve overall sustainability, safety, and livability in urban environments.

AI and predictive analytics are revolutionizing e-governance by enabling smarter decision-making, personalized services, and more efficient public sector operations. As these technologies continue to evolve, they offer new opportunities for improving governance, transparency, and citizen engagement. However, careful attention must be paid to ethical considerations and the development of regulations that ensure these tools are used in a responsible and equitable manner.

2.3 E-government – the bridge to citizens

E-government, also known as electronic government, refers to the use of digital tools and technologies by government institutions to provide services, engage with citizens, and manage administrative processes efficiently. The core idea is to leverage technology to enhance the relationship between government bodies and the public, creating a more accessible, transparent, and responsive system.

E-government enables citizens to access a wide range of public services online, anytime and anywhere. This eliminates the need for physical visits to government offices, reducing barriers related to time, geography, and accessibility.

In the past, electronic governance (the first generation of e-government) was limited to the simple delivery of public services through electronic technologies. Later, E-gov 2.0 emerged, involving the integration of social networks and Web 2.0 technologies into government processes and the delivery of public services. As attention shifts towards larger-scale digital transformation initiatives, which include technologies such as artificial intelligence, blockchain, virtual reality, and augmented reality, the E-gov 3.0 generation is born [19]. Thus, the concept of e-government 3.0 is based on the foundations of e-government 2.0, but includes the use of emerging technologies (such as artificial intelligence and blockchain) to revolutionize public service delivery and improve the governance process.

E-government, powered by AI and blockchain, holds the potential to transform government operations, enhancing smart, efficient, and transparent governance, while also fostering a safer and more accountable environment for citizens. However, its success depends on the smooth integration of these emerging technologies into a global, sustainable, and equitable governmental framework.

2.4 Advanced decision systems and data-driven strategy

Technological progress has opened new possibilities for addressing the complex environmental and health issues we face. Artificial intelligence, by processing data at an advanced level, provides decision-makers with the tools necessary to assess and predict the impact of policies on the environment. This integrated approach represents a crucial step

toward a future where technology, science, and human responsibility work together to foster a healthier and more balanced environment. In the management of water resources, these decision-support systems bring both significant advantages and substantial challenges, as the need for effective management becomes increasingly urgent in the face of climate change and population growth.

A Decision Support System (DSS) [20] is an intelligent platform that processes data to facilitate complex decision-making. At the same time, water consumption is closely linked to economic growth.

An essential factor to consider is population growth, which creates an increased demand for water and necessitates the implementation of intelligent management solutions [21]. One increasingly used concept, with multiple benefits across various fields, is the Internet of Things (IoT) [22]. The integration of IoT into smart water management systems has brought significant improvements [23].

The study [24] involved researching and understanding the complex interactions between economic and technical factors within urban water management infrastructure. Its goal was to analyze models that illustrate how economic aspects can influence technical decisions and vice versa.

Another approach [25] involved developing effective strategies for monitoring and analyzing water consumption patterns of urban residents. The criteria used included factors such as days of the week, times of day, and long-term trends. The goal was to collect accurate and relevant data to support informed decision-making in water resource management.

Another paper focused on identifying and developing profiling methods and techniques to gain a deeper understanding of consumer behavior regarding water usage. These methods provide a detailed insight into the individual habits and preferences of consumers, enabling the efficient modeling of consumption patterns to support the development of a sustainable water network infrastructure [26].

In [27], strategies were developed to support consumer decisions, promoting the responsible and efficient use of water in households. These strategies were based on personalized recommendation systems that integrated profiling data and the consumption habits of each user.

A new direction focused on integrating emerging technologies, such as blockchain and serious games, to develop an advanced and complex water resource management system. This system uses blockchain to ensure data transparency and security, while serious games are incorporated to educate and motivate users to adopt responsible water usage behaviors [28].

Each highlighted approach aimed to analyze data and develop solutions to optimize the management of urban water infrastructure. By continuously collecting and closely

monitoring precise data, a detailed understanding of consumer behavior and their specific needs can be achieved. This information has been crucial in creating strategies to increase consumer awareness of the importance of responsible water use and promote effective water conservation practices.

Additionally, the integration of emerging technologies such as blockchain and serious games into water resource management systems was designed to bring innovation and efficiency to their management. Blockchain was used to ensure data protection and transparency, essential aspects for effective water resource management, while serious games were implemented to educate and motivate consumers to adopt responsible water usage behaviors.

3. Proposed solution

Emerging technologies become more and more popular in e-government solutions, bringing innovation, easier ways to design complex sistems, trust and security.

As presented in [29], these technologies can be integrated together in order to create complex solutions for water management in the context of smart cities.

3.1 Solution overview

Starting from that solution [29] we aim to extend the functionality and design a fully integrated architecture that includes all the stakeholders for all the utilities that citizens need to interact with. The following figure presents an initial overview of these extension.

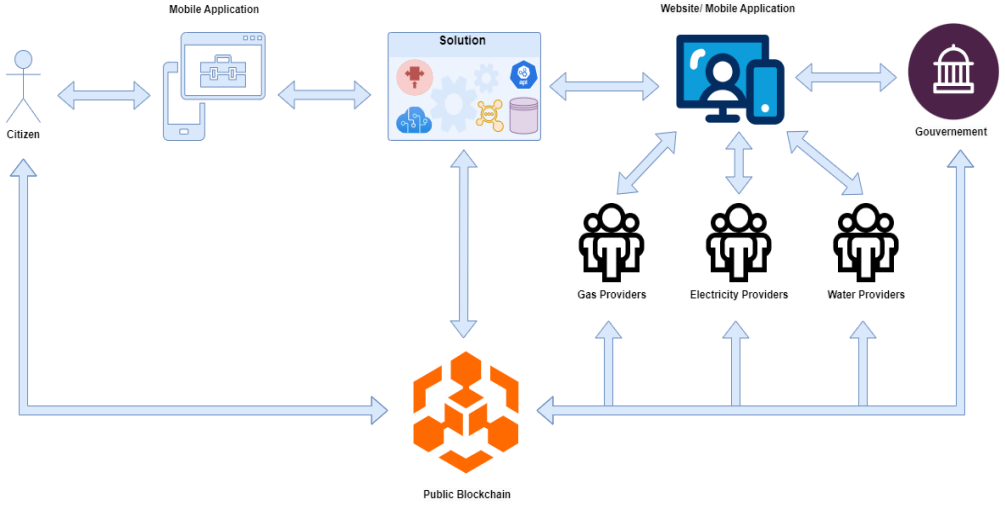

Fig. 1. - Solution Overview

From the technical point of view, the ecosystem will consist of a core (named generic “Solution” – who will handle all the services, database infrastructure or API endpoinds), a mobile app (used by citizens) , that will call the Solution Core in order to retrieve data and perform desired actions, a mobile app/website or desktop application used for both utilities providers on one side (to administrate their contracts, validate the incidents or make any decisions) and government (to supervise the entire process, audit the contracts and

suppliers and maintain the equity, transparency in the relationship between resource poviders and citizens). Last, but not least, the technology that links all the parts, consists of a public blockchain that will be used both through the application, but can also separately, by each individual/institution using public wallets.

3.2 Citizen interaction

The citizen will be the main actor in the entire ecosystem and will provide valuable input for resource suppliers that will be extremely important in the process of resources and costs optimization. From the citizens point of view, the application will provide the following functionalities:

- Resources distribution systems incident reporting;
- UtilSmart token reword after incident reporting;
- UtilSmart token trading;
- UtilSmart token donation;
- Contract negotiation and discounts;
- Digital Contract Discounts
- Single point of administration for all the contracts with all providers (water, gas, electricity)
- User ratings

The following figure will illustrate the interactions between citizens and developed solution:

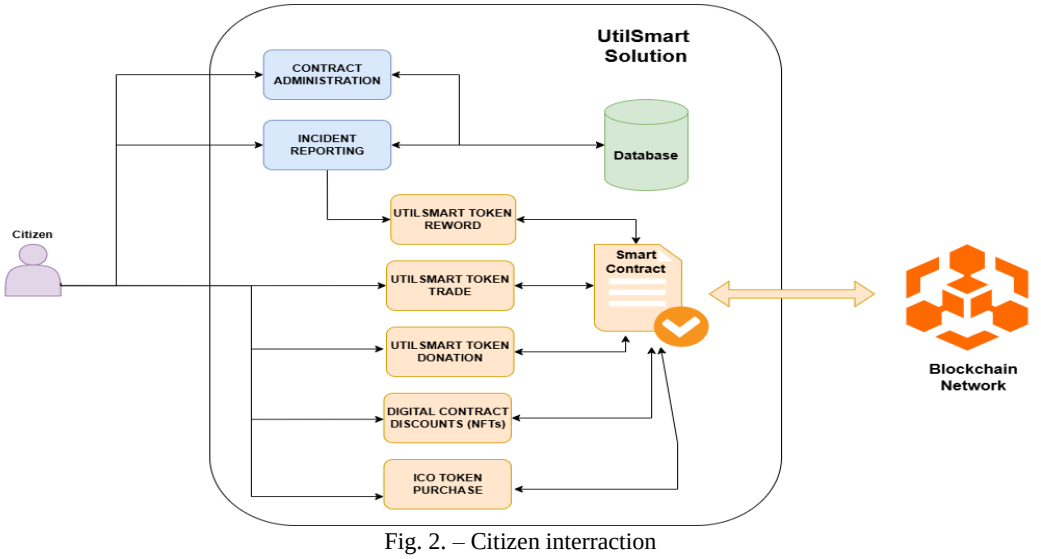

Fig. 2. – Citizen interraction

In order to increase the awareness about this solution, before release, any person will be able to purchase SmartUtil native token. The token will be used in the future to purchase utilities contract discounts or can be saved as digital money and traded on the secondary markets. The Initial Coin Offer will be open for a limited period of time and will allow users to buy token on lower prices that the price of which it will be listed.

One of the most important aspects that the solution brings is the possibility to raise citizen awareness and implication. Any citizen will be able to raise an incident using UtilSmart platform. Even if is a water distribution network issue, an energy distribution network issue, or more worring, a gas distribution network issue, the citizen will use the same application to raise it. The application will provide an easy-to-use map with the current location of the user, but also will allow users to report an incident in another location. In order the incident to be valid, the following data will be required:

- Small Title describing the incident;
- Detailed description;
- Relevant images/videos;

After raising the incident, the citizen will be notified that the record was created and will be verified by a validator. When a human validator or an artificial intelligence tool will approve the record, automatically, the citizen will receive UtilSmart token reword. Each valid reported issue will generate digital income in citizen digital wallet.

As mentioned before, the obtained token (by ICO participation, trading or incidents reporting) will be stored in digital personal wallets, or in wallets generated by UtilSmart solution and can be sell on any time in scope of obtaining profits. Another way in which the token can be used is to buy digital discounts for utilities contracts. The contracts discounts will be available as Non-Functional Tokens or Multi-Tokens and can also be traded on secondary markets. An important thing to mention is that also the purchased discounts can be traded on the secondary markets. The discounts will be automatically removed and the contract will be updated if the citizen chooses to sell the discount token on secondary markets.

All citizen contracts with resource providers will be managed by citizen in one single place in a dedicated section of the application.

Even if this proposed flow doesn`t need the citizen interaction it is important to mention that each citizen that reports incidents will have an associated rating given buy human validators or an artificial intelligence solution each time when an issue is raised.

Last, but not least, all the application users that have UtilSmart token in their digital wallets will be able to donate amount of token to friends or other persons that also have digital wallets.

3.3 Suppliers interaction

One of the issues that both citizens and resourse suppliers are facing these days is related to the bad communication between parties and non-standardization of the relationships. Also, the lack of citizen involvement in their communities tends to lead to more and more isolated individuals, creating barriers between citizens and government, public institutions and commercial institutions in the same time.
The proposed solution tends to solve these problems by linking together all the stakeholders in one single environment.

From the suppliers point on view, one of the most important win of using this initiative will be to have all the target group in one single place, on a sigle platform, administrated by the government. The design solution will allow suppliers or entities that administrate distribution networks to perform the following actions:

- UtilSmart token purchasing using ICO or normal trading on secondary markets;
- Contract negotiation with clients
- Incident validation
- Asign ratings to citizen for each raised incident
- Incident management
- Special Discounts Token minting
- Administrate fidelity campaigns for specific clients
- UtilSmart token donations (to other sub-institutions/charity scope)

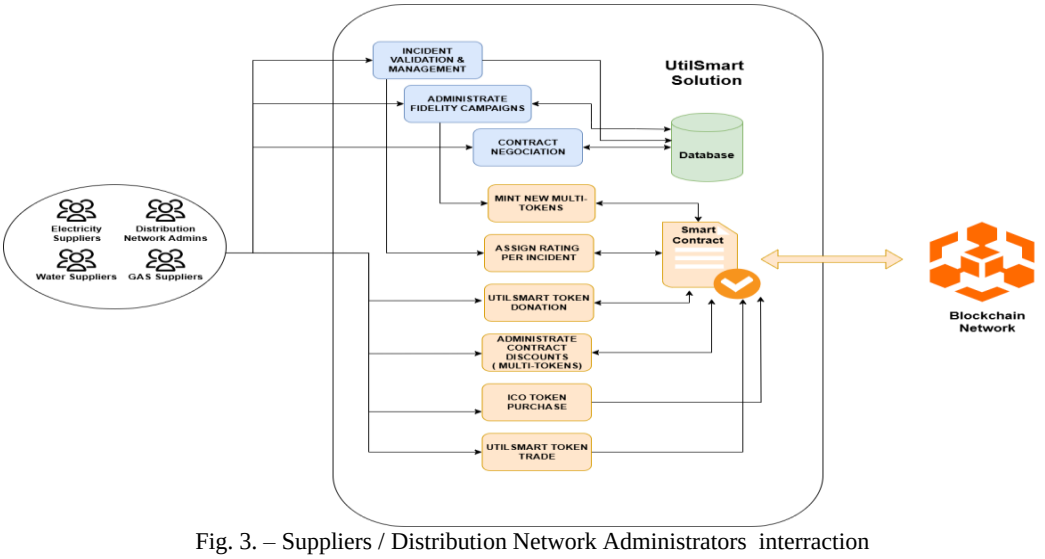

Fig. 3. – Suppliers / Distribution Network Administrators interraction

Fig. 3 presents all the actions that can be performed for both suppliers and distribution network administrators. As well as citizen, suppliers have the possibility to participate in ICO for purchasing the UtilSmart token, trade utilsmart token on secondary markets or donate UtilSmart token to contracted services. From the administrare point of view suppliers will have the possibility to negotiate contracts with citizen through the application, create campaigns for these contracts and administrate these campaigns. During the campaigns, suppliers will have the possibility to mint new types of contract discounts or extend the existing ones.

From the issue reporting point of view, suppliers/network distribution admins will receive incidents raised by citizen and will be able to approve or deny these incidents, assign ratings for the reported issue, rating that will be associated with the reporter and contact the network distribution administrators to fix the reported issue.

As an extension of the presented flows, an additional component will be implemented to enhance the issue reporting – issue approval – rating assigning: Based on an artificial intelligence software, each incident will be analized and its validity will be evaluated. A rating between 1 and 5 stars will be assigned per incident and will be associated to the reporter. After performing this action, the validator will be informed about the incidents that passed the AI validation and can be passed to technical team that will fix the problem on the field. The rating will be also saved on blockchain and will be used in the feature
Based on the previous ratings assigned by AI software, when a new incident raised by the same user comes, the AI software will be able to make a decision faster: If the reporter has 1 start rating, the incident will be automatically rejected. If the reporter has 5 start rating, this means that that he is a reponsable and well-intentioned citizen and the incident will be directly passed to final validator. If the reporter has a rating between 2 and 4, the AI tool does its analysis and pass the output to validator.

In this manner, a decisions support system, based on the proposed aritificial intelligence tool will speed up the decisions that need to be taken by validators.

3.4 Government interaction

One of the main benefits of UtilSmart solution is the fact that it brings together the citizens with resource suppliers and government in one single place. The entire ecosystem will be managed by the government. The following figure presents a high level view of the actions that government can take:

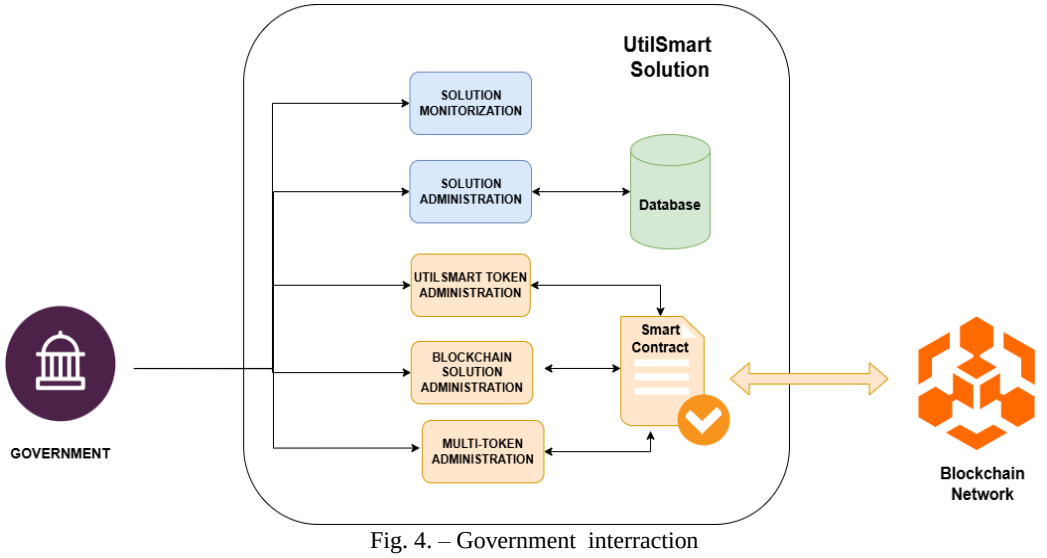

Fig. 4. – Government interraction

The government will be able to administrate the entire developed solution and will be the entity that will mint UtilSmart Token, with full rights on the token. The government will have the possibility to administrate all the blockchain related components and will be responsible for the entire solution. During application usage, government will monitorize the solution and all the corresponding flows.

4. Discussion

In the presented proposal, we managed to bring all the actors (citizen, distributors, suppliers and government) in a single platform. The entire solution is based on both citizen interaction but also cutting edge technologies, combined together in order to improve citizen interaction with resource suppliers and simplify their life on the context of smart cities. By combining technologies like blockchain, artificial intelligence and decision support systems, innovative government ecosystems can be created in orde to place the citizen in the center of processes. Blockchain ensures a trustworthy environment, artificial inteligence automates and optimizes processes, and decision-making systems integrate all these components to facilitate smart governance. In the future we are thinking to start designing low level architecture for each component, define database tables and implement a proof-of-concept on the blockchain side.

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