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Conception and Development of a Digital Twin for the Control and Supervision of E-Government Services

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Dedication

Above all, I thank the **Great God**, who guiding us develop this modest work.

I dedicate my contribution to this work :

To my dear **parents** for their unwavering support at the most

And

To my three brothers **Tahar**, **Yahia**, and **Mustapha**

To my **friend** who contributed to the realization of this work: **Anouar**

To all my friends near and far

To my **teachers** who have informed my learning journey.

Abdeldjalil

Dedication

Above all, I thank the **Great God**, who guiding us develop this modest work.

I dedicate my contribution to this work :

To my dear **parents** for their unwavering support

And

To my **family** members who have been by my side

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To my **teachers** who have informed my learning journey.

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Abstract

The development of a digital twin for e-government services is of paramount importance for improving online service delivery and enhancing operational efficiency. By using SysML for modeling, Eclipse Ditto for remote monitoring, and integrating advanced technologies such as the Internet of Things and adaptive algorithms through a comprehensive web application, the project ensures effective service monitoring by utilizing an alert system that provides real-time notifications for proactive issue management, maintaining high service standards. The digital twin solution optimizes the delivery of e-government services in real-time, enhancing accessibility, transparency, and responsiveness in digital governance.

Keywords : Digital Twin, E-government services, IoT, Governance, SysML, Eclipse Ditto, Node-Red, Web Application,Supervised System, Alert System.

Résumé

Le développement d'un jumeau numérique pour les services de gouvernement électronique est d'une importance capitale pour améliorer la prestation des services en ligne et renforcer l'efficacité opérationnelle. En utilisant SysML pour la modélisation, Eclipse Ditto pour la surveillance à distance, et en intégrant des technologies avancées telles que l'Internet des objets et des algorithmes adaptatifs via une application web complète, le projet assure une surveillance efficace des services en utilisant une un système d'alerte qui fournit des notifications en temps réel pour une gestion proactive des problèmes, maintenant des normes de service élevées. La solution de jumeau numérique optimise la prestation des services de gouvernement électronique en temps réel, améliorant l'accessibilité, la transparence et la réactivité dans la gouvernance numérique.

Mots clés : Jumeau numérique, Services d'e-gouvernement, IoT, Gouvernance, SysML, Eclipse Ditto, Node-Red, Application Web, Système supervisé, Système d'alerte.

الملخص

يعد تطوير التوأم الرقمي لخدمات الحكومة الإلكترونية أمرًا بالغ الأهمية لتحسين تقديم الخدمات عبر الإنترنت وتعزيز الكفاءة التشغيلية. من خلال استخدام (SysML) للنمذجة، و (Eclipse Ditto) للمراقبة عن بعد، ودمج التقنيات المتقدمة مثل إنترنت الأشياء والخوارزميات التكيفية من خلال تطبيق ويب شامل، يضمن المشروع مراقبة فعالة للخدمات، وتوفر ميزة تنبيه النظام إشعارات في الوقت الفعلي لإدارة المشكلات بشكل استباقي، والحفاظ على مستوى عالٍ معايير الخدمة.
يعمل حل التوأم الرقمي على تحسين تقديم خدمات الحكومة الإلكترونية في الوقت الفعلي، وتحسين إمكانية الوصول والشفافية والاستجابة في الحوكمة االرقمية.

الكلمات المفتاحية: التوأم الرقمي، خدمات الحكومة الإلكترونية، إنترنت الأشياء، الحوكمة، تطبيق الويب،(SysML)،(Node-Red)،(EclipseDitto)، النظام الخاضع للإشراف، نظام التنبيه.

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List of Acronyms

IoT Internet of Things
DT Digital Twin
AR Augmented Reality
XR Extended Reality
AI Artificial Intelligence
DTD Digital Twin Data
ROI Return on Investment
ESG Environmental, Social, and Governance
RESTful Representational State Transfer
HTTP Hypertext Transfer Protocol
API Application Programming Interface
AMQP Advanced Message Queuing Protocol
MQTT Message Queuing Telemetry Transport
SysML Systems Modeling Language
BDD Block Definition Diagram
ICT Information and Communication Technology
G2G Government to Government
G2N Government to Non-government
G2B Government to Business
SME Small and Medium Enterprises
G2C Government to Consumer / Citizen
ESD Electronic Service Delivery
GTMI GovTech Maturity Index
NIN National Identification Number
EGDI E-Government Development Index
CNIBE National Biometric Electronic Identity Card
EMV Europay, Mastercard and Visa
BNA National Bank of Algeria
CIB InterBank Card
HTTP Hypertext Transfer Protocol
CSS Cascading Style Sheets
PHP Hypertext Preprocessor

General Introduction :

In today's fast-paced digital era, the integration of technology into governance processes has become imperative for efficient service delivery and enhanced citizen engagement. E-government services, which encompass a wide array of activities ranging from public service delivery to policy implementation, have increasingly relied on digital platforms to streamline operations and improve accessibility. As governments around the world endeavor to harness the potential of digitalization, the concept of a digital twin emerges as a promising paradigm for the control and supervision of different services.

A digital twin, originally popularized in the realm of manufacturing and engineering, refers to a virtual replica of a physical entity or system. [1]This virtual counterpart mirrors the physical system's behavior, allowing for real-time monitoring, analysis, and optimization without disrupting the actual operations. Applied to the domain of e-government services, a digital twin can serve as a powerful tool for policymakers and administrators to gain insights into the functioning of various government processes, anticipate potential bottlenecks, and enact data-driven decisions to enhance efficiency and efficacy.

The conception and development of a digital twin for the control and supervision of e-government services represent a significant advancement in the realm of governance technology. By leveraging data analytics, machine learning algorithms, and Internet-of-Things (IoT) devices, governments can create dynamic digital replicas of their service ecosystems, encompassing everything from administrative procedures to citizen interactions. This comprehensive digital representation enables governments to monitor service performance in real-time , identify areas for improvement, and adapt strategies accordingly to meet evolving citizen needs. the integration of a digital twin into e-government systems can foster transparency, accountability, and responsiveness.Citizens can gain greater visibility into government operations, track the status of their requests or applications, and provide feedback for continuous improvement. Additionally, policymakers can utilize the insights derived from the digital twin to design more responsive policies, allocate resources effectively, and address emerging challenges proactively.

However, the successful implementation of a digital twin for e-government services necessitates overcoming various challenges, including data privacy concerns, interoperability issues, and the need for robust cybersecurity measures. Moreover, ensuring the scalability and sustainability of such systems requires careful planning, collaboration across government agencies, and investment in technological infrastructure.

E-government services often face critical issues related to their service platforms or servers, leading to services not responding. This causes significant delays and dissatisfaction among citizens, hampering the efficiency of public service delivery and undermining trust in digital governance. Additionally, the complex and fragmented nature of these platforms results in data silos, making accurate and secure data management challenging across government departments and agencies.

To address these challenges, the platform aims to enhance citizen data exchange efficiency by implementing secure API connections, ensuring accurate data management through a centralized digital twin platform. It will improve public service responsiveness with a real-time alert system for quick issue resolution and maintain continuous service availability. By using insights from the digital twin, the platform will proactively manage and resolve disruptions, ensuring uninterrupted service delivery and a resilient e-government infrastructure.

The remainder of the document is structured as follow:

- **Chapter 1: Digital Twin**
  This chapter introduces the concept of the digital twin, exploring its origins, evolution, fundamental principles, key components, types, and enabling technologies,It delves into the connection between digital twins and the Internet of Things (IoT), examining communication protocols and platforms utilized in their development. with a focus on its applications and impact across various sectors including government, aerospace, healthcare, and manufacturing.

- **Chapter 2: E-Government Services**
  This chapter offers a comprehensive overview of e-government services, defining key concepts, categorizing different service types, outlining objectives and critical success factors, discussing implementation challenges and advantages, and providing examples from various countries.

- **Chapter 3: Conception**
  This chapter presents the conceptual framework for developing a digital twin for e-government services, detailing the overall architecture, API connections, service modeling, and digital twin entities, with illustrative use case, sequence, Class and Block diagrams.

- **Chapter 4: Implementation**
  This chapter addresses the practical aspects of implementing a digital twin for e-government services, covering detailed description of the various tools used,highlighting key component integration, and demonstrating the functionalities of the developed platform, and concludes with key insights and future directions.

Chapter 1: Digital Twin



1 Introduction :

Digital Twins emerge as a cutting-edge manifestation of advancements in technology, drawing from the realms of Industry 4.0[2] and the Internet of Things (IoT). This innovative digital representation technology strengthens the connection between the digital realm and reality, The advent of digital transformation has catalyzed significant changes across various sectors, including the public sector. aimed at enhancing accessibility, efficiency, and transparency, have become integral components of modern governance. However, ensuring optimal performance and seamless delivery of services pose unique challenges, including the need for real-time monitoring, predictive analysis, and adaptive management. In response to these challenges, the concept of the digital twin has emerged as a promising approach for controlling and supervising e-government services.

2 Internet of things(IoT) :

2.1 Internet of things (IoT) Definition :

The Internet of Things (IoT) plays a pivotal role in the development and operation of digital twins, serving as the primary source of data for virtual representations of physical devices, vehicles, appliances, and other physical objects that are embedded with sensors, software, and network connectivity [3] that collect real-time data from the physical entity, which is then ingested, processed, and analyzed within the digital twin environment allowing them to collect and share data.

IoT devices—also known as “smart objects”—can range from simple “smart home” devices like smart thermostats, to wearables like smartwatches and RFID-enabled clothing, to complex industrial machinery and transportation systems. Technologists are even envisioning entire “smart cities” predicated on IoT technologies[4]. IoT enables these smart devices to communicate with each other and with other internet-enabled devices. Like smartphones and gateways, creating a vast network of interconnected devices that can exchange data and perform various tasks autonomously.

2.2 IoT Architecture :

The Internet of Things (IoT) has emerged as a transformative technology paradigm with vast implications for various domains, including healthcare, transportation, agriculture, and smart cities. At the heart of IoT systems lies a sophisticated architecture comprised of distinct layers:

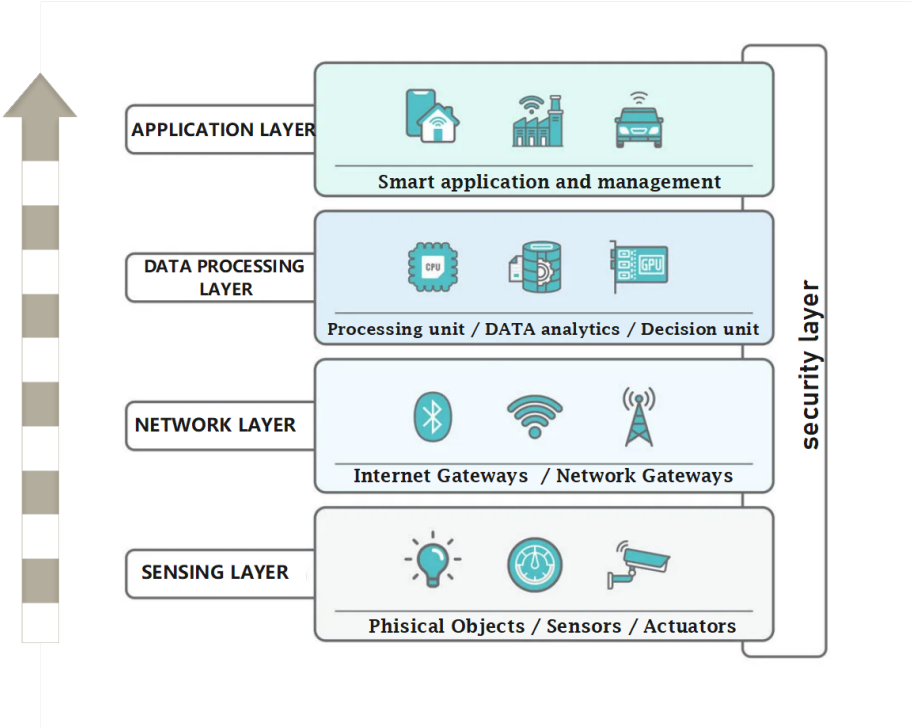


Figure 1: IoT Architecture.[5]

- **Sensing Layer :**The sensing layer encompasses various sensors and devices deployed across the service infrastructure to capture data pertaining to service delivery, resource utilization, and user interactions. These sensors, ranging from simple temperature and humidity sensors to advanced cameras and biometric scanners, measure specific physical quantities and convert them into electrical signals for IoT system processing. Ensuring data accuracy and reliability, often through calibration and data fusion techniques, this layer forms the foundation for analysis and decision-making in higher layers of the IoT architecture[6].

- **Network Layer :**The Network Layer serves as the backbone of the IoT architecture, facilitating seamless communication and data transfer between the sensors/devices in the Sensing Layer and the higher layers of the architecture. Utilizing robust communication protocols, such as MQTT or CoAP, this layer ensures reliable and secure transmission of data over wired or wireless networks, including LAN, WAN, and cloud-based infrastructures.
- **Data Processing Layer :**Upon receiving data from the Sensing Layer, the Data Processing Layer performs various tasks, including data aggregation, filtering, analysis, and storage. Advanced analytics techniques, such as machine learning algorithms, are employed to derive actionable insights from the voluminous data generated by the services. Additionally, this layer integrates with existing government databases and systems to enrich the collected data and facilitate cross-referencing.
- **Application Layer :**The Application Layer represents the interface through which stakeholders interact with the digital twin and leverage its capabilities for controlling and supervising. User-friendly dashboards, visualization tools, and mobile applications are developed to provide real-time status updates, performance metrics, and alerts. Moreover, this layer supports automation and decision-making processes based on predefined rules and policies.

2.3 IoT technologies :

Several technologies come together to make IoT possible :

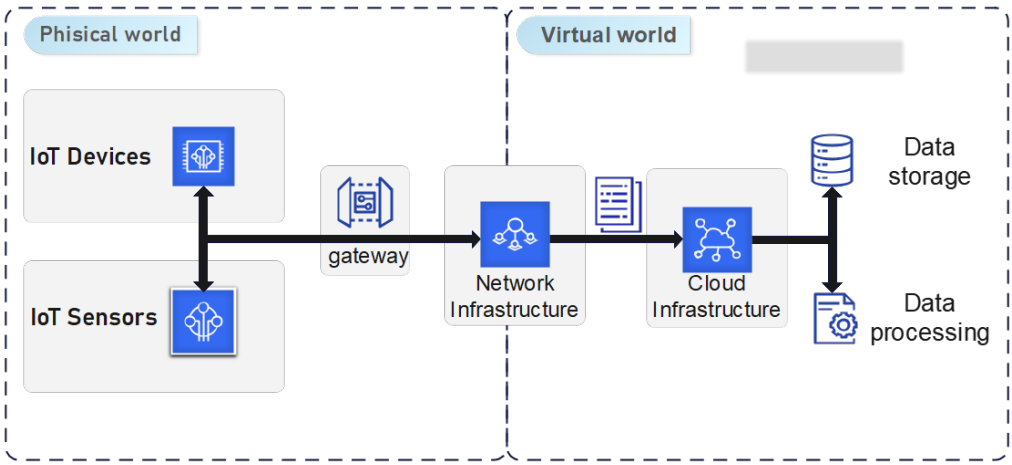


Figure 2: IoT Technologies[7]

- **Sensors and actuators:** Sensors are devices that can detect changes in the environment, such as temperature, humidity, light, motion, or pressure. Actuators are devices that can cause physical changes in the environment, such as opening or closing a valve or turning on a motor. These devices are at the heart of IoT, as they allow machines and devices to interact with the physical world. Automation is possible when sensors and actuators work to resolve issues without human intervention.
- **Connectivity technologies:** To transmit IoT data from sensors and actuators to the cloud, IoT devices need to be connected to the internet. There are several connectivity technologies that are used in IoT, including wifi, Bluetooth, cellular, Zigbee, and LoRaWAN.
- **Cloud computing:** The cloud is where the vast amounts of data that is generated by IoT devices are stored, processed, and analyzed. Cloud computing platforms provide the infrastructure and tools that are needed to store and analyze this data, as well as to build and deploy IoT applications.
- **Big data analytics:** To make sense of the vast amounts of data generated by IoT devices, businesses need to use advanced analytics tools to extract insights and identify patterns. These tools can include machine learning algorithms, data visualization tools and predictive analytics models.
- **Security and privacy technologies:** As IoT deployments become more widespread, IoT security and privacy become increasingly important. Technologies such as encryption, access controls and intrusion detection systems are used to protect IoT devices and the data they generate from cyberthreats.[3]

3 Digital twin :

3.1 Digital-twin technology :

A digital twin is a virtual representation of the real world, including physical objects, processes, relationships and behaviours.creating digital twins of the natural and built environments and uniquely integrates many types of digital models.[8]

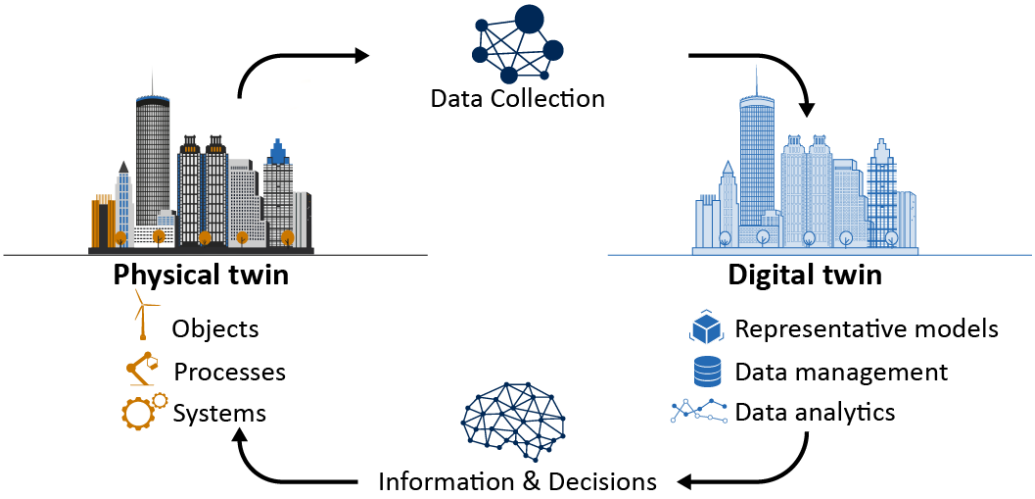


Figure 3: DT Concept[9]

The concept of the digital twin originates from the manufacturing industry, where it has been extensively used for product lifecycle management, predictive maintenance, and performance optimization. A digital twin refers to a virtual replica or representation of a physical entity, system, or process, synchronized in real-time. This virtual counterpart enables monitoring, analysis, and simulation of the corresponding physical entity, facilitating better decision-making and performance enhancement.
The evolution of digital twin technology has seen its application extend beyond traditional manufacturing contexts to diverse domains, including healthcare, transportation, and urban management and holds immense potential for enhancing service delivery, ensuring operational resilience, and improving citizen satisfaction.

3.2 Components of a digital twin :

A digital twin consists of various interconnected components spanning hardware, middleware, and software layers. These components work in tandem to create a virtual representation of a physical entity or system, enabling real-time monitoring, analysis, and optimization, the following components are essential for building a robust digital twin framework:[10]

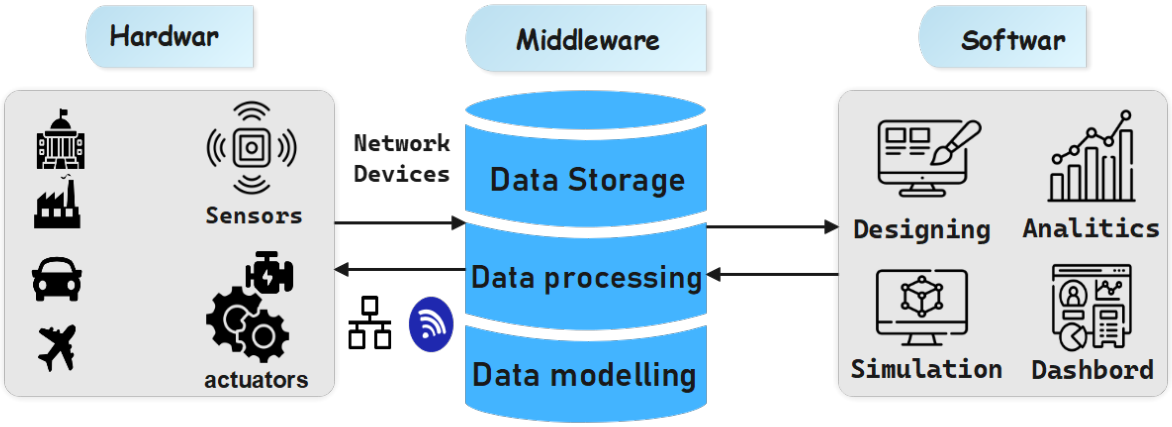


Figure 4: DT Components[11]

- **Hardware Components:** Hardware components form the physical infrastructure that supports the deployment and operation of digital twins. This includes sensors, actuators, IoT devices, edge computing devices, and communication networks. Sensors collect data from the physical environment, while actuators enable remote control and manipulation of physical assets. IoT devices serve as the interface between the physical world and digital twin environment, facilitating data acquisition, processing, and transmission. Robust and reliable hardware infrastructure is essential for capturing accurate and timely data for digital twin modeling and analysis.
- **Middleware Component:** The middleware component acts as the bridge between hardware and software layers, facilitating data integration, communication, and interoperability within the digital twin environment. Middleware components include IoT platforms, data brokers, message queues, and protocol converters. These components provide standardized interfaces and protocols for connecting heterogeneous devices and systems, ensuring seamless interoperability and data exchange. Middleware also enables data preprocessing, transformation, and routing, optimizing the flow of data between sensors, actuators, and software applications.
- **Software Components:** Software components form the core of the digital twin framework, encompassing applications, algorithms, and platforms for data processing, analytics, modeling, and visualization. Software components include digital twin platforms, simulation engines, analytics engines, and visualization tools. Digital twin platforms serve as the central hub for creating, managing, and interacting with digital twins, providing functionalities for data modeling, simulation, and analysis. Simulation engines enable the execution of virtual models that replicate the behavior of physical systems.

while analytics engines derive insights from data collected by sensors and IoT devices. Visualization tools provide intuitive interfaces for visualizing and interpreting digital twin data, enabling stakeholders to monitor performance, analyze trends, and make informed decisions.

3.3 Types of digital twins :

Digital twins can be categorized based on their scope, purpose, and level of abstraction. Understanding the different types of digital twins is essential for tailoring the framework to specific requirements and objectives. The following are common types of a DT :

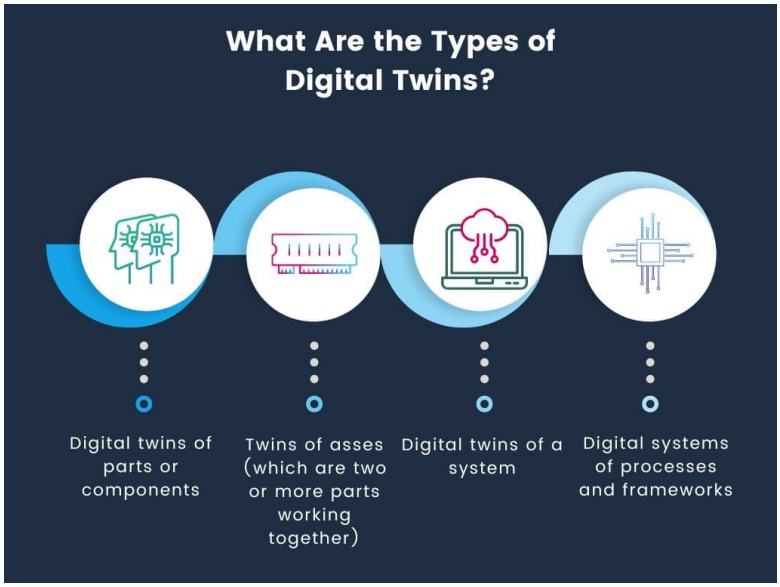


Figure 5: Types of DT[12]

- **Parts Twinning :**Parts twinning involves creating digital replicas of individual components or modules within a system. this type of digital twin can be utilized to monitor and assess the performance of discrete elements such as datacenters, servers, or databases. By modeling each part separately, parts twinning facilitates targeted analysis and troubleshooting, enabling administrators to identify and address potential issues before they escalate. Moreover, parts twinning allows for seamless integration with existing monitoring tools and infrastructure, making it a cost-effective solution for enhancing the reliability and efficiency.

- **Product Twinning :**Product twinning entails the creation of digital replicas of entire service offerings or applications. By encapsulating the entire service ecosystem within a virtual model, product twinning enables comprehensive monitoring and analysis of service performance, user interactions, and system dynamics. This type of digital twin facilitates holistic oversight of services, empowering administrators to identify trends, optimize resource allocation, and enhance user experience. Additionally, product twinning enables simulation-based testing and scenario analysis, allowing stakeholders to anticipate and mitigate potential challenges proactively.
- **System Twinning :**System twinning involves the creation of digital replicas of the entire infrastructure service, including hardware, software, and networking components. By modeling the interdependencies and interactions between different system elements, system twinning provides a holistic view of ecosystem, enabling administrators to optimize resource utilization, improve fault tolerance, and enhance scalability. This type of digital twin facilitates proactive maintenance and system upgrades, reducing downtime and enhancing service reliability. Moreover, system twinning enables real-time monitoring of system performance and security, enabling administrators to detect and respond to potential threats promptly.
- **Process Twinning :**Process twinning focuses on creating digital replicas of the workflows and processes associated with service delivery. By modeling the sequence of tasks, dependencies, and decision points within a process, process twinning enables administrators to streamline operations, identify bottlenecks, and optimize resource allocation. This type of digital twin facilitates continuous process improvement and automation, enhancing the efficiency and responsiveness of services. enables administrators to simulate alternative scenarios and evaluate the impact of process changes, empowering them to make informed decisions and adapt to evolving requirements.

3.4 Digital twin technologies :

In the rapidly evolving digital landscape, the concept of Digital Twins has emerged as a groundbreaking technology[13], revolutionizing how we interact with physical objects and systems in the digital realm. At the heart of this transformation are four pivotal technologies, each contributing to the creation and management of digital twins. These technologies not only replicate physical entities in a digital format but also enhance our understanding and interaction with them in real-time. Let's delve into these core technologies and their roles in the digital twin ecosystem:[14]

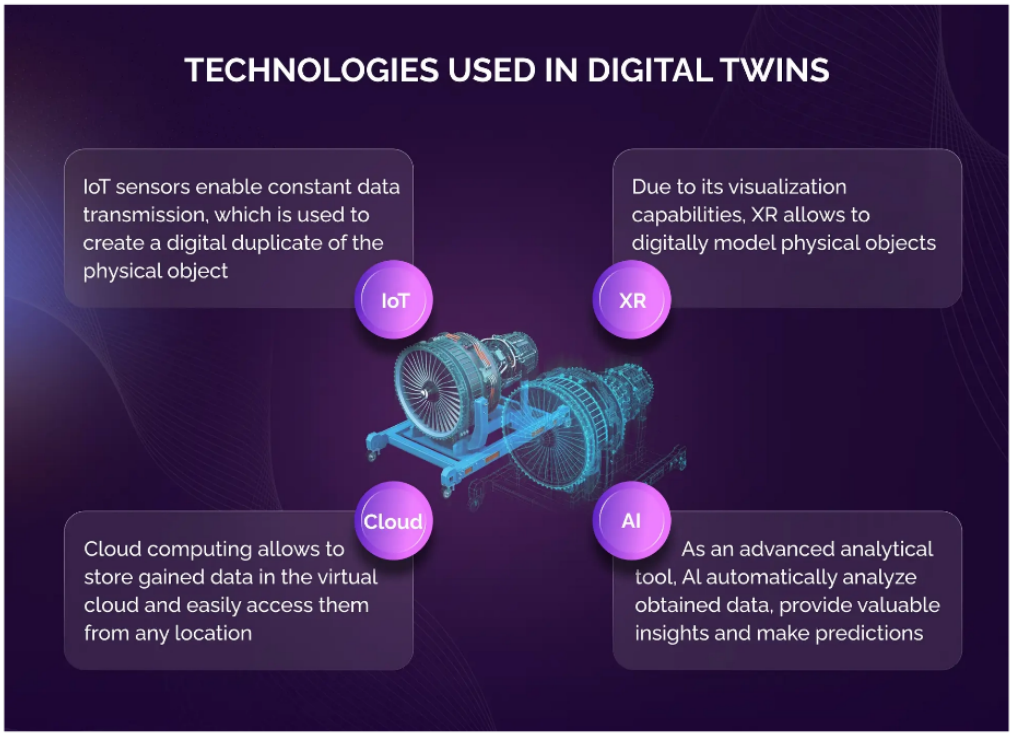


Figure 6: DT technologies[15]

- **Internet of Things (IoT) :** IoT technology equips physical objects and systems with sensors to collect real-time data across various parameters, such as temperature, pressure, humidity, and vibration. This vast array of data forms the foundation of a digital twin, mirroring the physical object's behaviors and conditions. Utilizing deep learning, a subset of machine learning that trains multi-layered neural networks, we can analyze this data intricately. Techniques like Keras early stopping are employed to fine-tune the learning process, preventing models from overfitting and ensuring they remain generalizable and efficient.
- **Cloud Storage and Retrieval Solutions :** The immense volumes of data generated by IoT sensors necessitate robust cloud storage and retrieval systems. These platforms not only securely house the data but also ensure it is readily accessible for the ongoing development and maintenance of digital twins. Furthermore, they incorporate automation capabilities for backups, data migrations, and scalability of storage resources, optimizing the management of digital twins in a cloud environment.

- **Extended, Augmented, and Mixed Reality (XR) :** Augmented Reality (AR) and its counterparts offer innovative ways to visualize and interact with digital twins within real-world settings. By superimposing digital twins over physical objects, AR provides a more intuitive and immersive experience. For instance, technicians can use AR devices to see a digital twin overlaid on actual machinery, simplifying the identification and troubleshooting of issues.
- **Artificial Intelligence (AI): Machine Learning and Deep Learning :** AI plays a crucial role in interpreting the data collected by IoT sensors, offering insights into the behavior and potential issues of physical objects or systems. Machine Learning, a branch of AI, focuses on developing models that can predict outcomes based on identified data patterns. Deep learning, known for handling complex tasks like image recognition, enhances digital twins with capabilities such as image annotation. This allows for the detailed labeling of images within digital twins, facilitating advanced analyses like equipment failure prediction and maintenance optimization.

3.5 Digital twin data methods :

Aligned with the complementary principle, data collection involves simultaneous acquisition from both physical and virtual realms to ensure comprehensive data coverage. Real-time interaction adheres to the timeliness principle, facilitating prompt transmission and adjustment of connection data. Conforming to the standardized principle, data storage entails the transformation of diverse formats, interfaces, and protocols into standardized formats. The association principle necessitates the extraction of various relationships between different DT components to support knowledge mining endeavors. Following the fusion principle, fusion data is synthesized by merging similar and complementary datasets for mutual validation and augmentation. The information growth principle guides the interpretation of progressive data evolution. Furthermore, in accordance with the on-demand principle, data-related resources are encapsulated into services tailored to diverse user needs. The detailed methods corresponding to each principle are elucidated below. in Figure 7 :

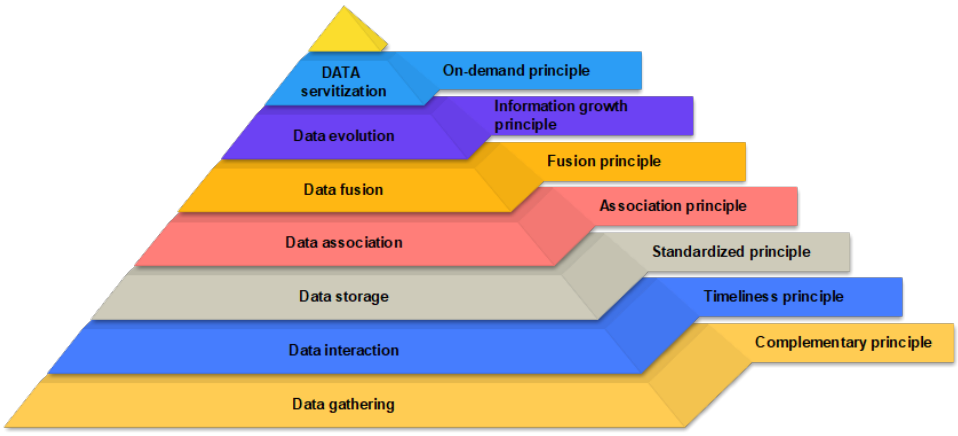


Figure 7: Methodology for digital twin data (DTD)[16]

The figure 8 represents the comprehensive framework for managing Digital Twin Data (DTD) across its entire lifecycle, from generation to servitization, through seven key technological and methodological domains.

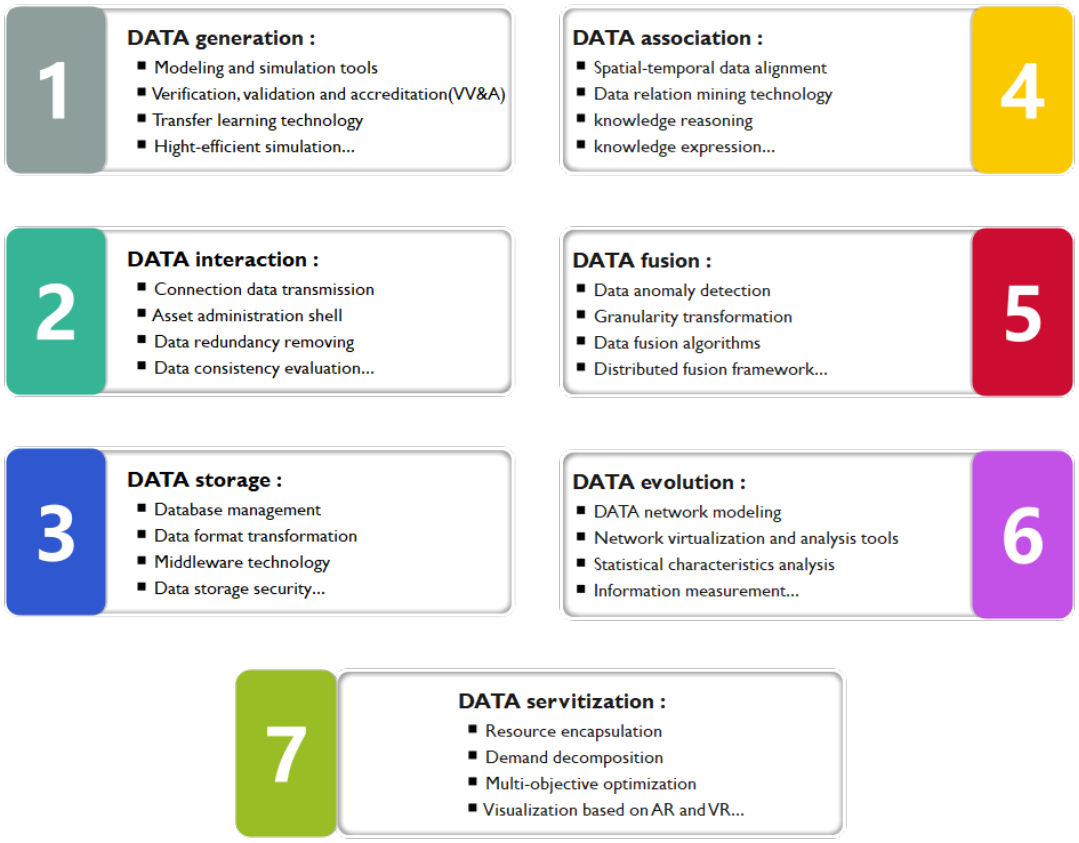


Figure 8: technologies for digital twin data (DTD)[16]

3.6 Application Areas of Digital Twins :

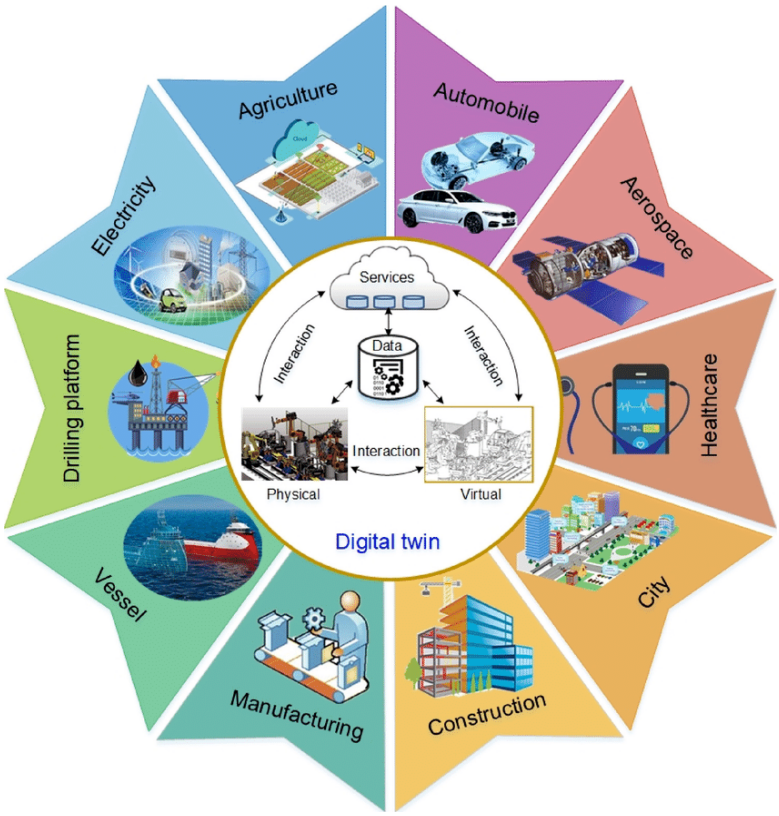


Figure 9: DT Application Areas[17]

Digital twins have versatile applications across various domains, ranging from manufacturing and healthcare to transportation and urban management. and offer unique opportunities for enhancing service delivery, improving operational efficiency, and fostering citizen engagement. The following are some key application areas of digital twins :

- **Incorporating New Data :** New data is added to the network, establishing association relations with historical data through preprocessing, alignment, and data mining algorithms. This creates new connections between new and existing data.
- **Automatic Fusion Mechanism :** An automatic fusion mechanism guides the process, reducing reliance on manual labor. Data correction and supplementation are achieved by fusing new data with similar or complementary relations.
- **Evaluation Using Information Entropy :** The effectiveness of data evolution is evaluated using information entropy. By comparing entropy before and after fusion, the gain or loss of information is assessed, informing the quality of the evolution process.

- **Analysis of Network Structure Changes :** Changes in the network structure after each fusion are analyzed, considering parameters like degree, edge betweenness, and clustering coefficient. These analyses provide insights into how data relationships evolve over time.
- **Mining Evolution Rules :** Over time, specific DTD evolution rules are mined, including rules for information transfer and the relationship between network structure and information distribution. These rules guide subsequent data fusions, informing the selection of fusion data and methods for iterative optimization and information growth.

3.7 Benefits of digital twins

Digital twin technology heralds transformative advantages for businesses across various industries. It equips organizations with the tools to enhance operations, mitigate risks, and innovate faster. Here's an integrated view of the significant advantages offered by digital twin technology, encompassing both immediate and long-term impacts:

- ✔ **Real-Time Performance Monitoring:** Digital twins excel in offering detailed insights into the performance and health of physical assets, enabling proactive issue resolution and maintenance, thus significantly enhancing operational reliability.[18]
- ✔ **Cost Reduction and Efficiency :** By predicting failures and reducing maintenance downtime, digital twins contribute to substantial cost savings. They streamline operations, minimize resource waste, and enhance the overall efficiency of business processes.
- ✔ **Informed Decision-Making :** Armed with comprehensive data on asset performance, businesses can make more strategic decisions. This insight leads to better resource allocation, improved product quality, and enhanced customer satisfaction.
- ✔ **Acceleration of Innovation :** Digital twins facilitate the rapid prototyping and testing of new products and services, allowing businesses to iterate quickly and bring innovations to market faster than ever before.[19]
- ✔ **Driving Revenue Growth :** By optimizing operations and improving processes, digital twins uncover potential defects early on and introduce efficiencies that can significantly boost revenue growth.
- ✔ **Operational Cost Reduction :** This technology proactively addresses maintenance needs and operational inefficiencies, leading to reduced operational expenses and enhancing the company's bottom line.
- ✔ **Productivity Enhancement :** Digital twins improve organizational productivity by streamlining operations and aiding in efficient decision-making. This technology helps in identifying and solving issues swiftly, reducing the need for trial-and-error approaches.[20]

- ✔ **Optimized Asset Utilization :** Through virtual simulations, digital twins allow for the maximum utilization of physical assets. This optimization leads to improved asset performance and operational fluency.
- ✔ **Safety and Training Efficacy :** Digital twins offer a safe, controlled environment for employee training and safety simulations, reducing workplace accidents and preparing employees effectively for their roles.
- ✔ **Risk Mitigation :** By simulating various scenarios, digital twins help in identifying and preventing potential risks, thereby safeguarding revenue and ensuring the safety of employees and assets.
- ✔ **Sustainability and ESG Contribution :** Supporting sustainability initiatives, digital twins assist in modeling and optimizing energy use, resource management, and waste reduction, aligning with Environmental, Social, and Governance (ESG) objectives.

The adoption of digital twin technology not only fosters operational excellence and innovation but also drives companies towards a more sustainable, efficient, and competitive future.

4 Technologies and tools used for twins:

The implementation of digital twins often involves the utilization of various technologies and tools for data management, integration, analytics, and deployment. selecting appropriate technologies is crucial for building scalable and efficient digital twin frameworks. these technologies use for digital twins deployment is :

4.1 Eclipse Ditto: IoT Data Orchestration :

Eclipse Ditto stands as an open-source framework designed to manage and orchestrate IoT data within the realm of digital twins. It encompasses functionalities for modeling digital twins, ingesting sensor data, managing device connections, and facilitating bidirectional communication with IoT devices. Leveraging a RESTful API, Eclipse Ditto facilitates seamless interaction with digital twins, allowing for effortless integration with existing IoT infrastructure and applications.

Functioning as a bridge between real-world IoT devices and their digital counterparts, Eclipse Ditto focuses on managing the state of digital twins rather than directly integrating the devices themselves. For device integration purposes, alternative options like Eclipse Hono are better suited. Eclipse Ditto prioritizes providing APIs tailored for web applications, mobile applications, or other backend services, supporting a range of protocols including WebSocket, AMQP 1.0, AMQP 0.9.1,[21] and HTTP. Additionally, recent enhancements have introduced connectivity via MQTT 3.1.1 Broker.

4.1.1 Eclipse DITTO architecture :

The architecture of a system using digital twins can be broken down into several key components, each serving a specific function that enhances the overall efficiency and functionality of IoT solutions:[22]

- **Policies :** This component manages the rules and permissions associated with digital twin interactions. It ensures that operations on the digital twins are performed in accordance with defined security guidelines and governance standards, regulating who can view or alter the digital twins.
- **Things :** The core of the digital twin architecture, this component represents the digital counterparts of physical devices. It maintains the state, metadata, and lifecycle of each digital twin, allowing systems to mirror the status of physical devices accurately and in real-time.
- **Things-Search :** This service provides enhanced search capabilities within the digital twin ecosystem. It allows users to query and retrieve digital twins based on attributes, status, or other criteria, facilitating quick access to the needed information and more efficient management of large-scale device environments.
- **Gateway :** Serving as the intermediary between the digital twins and the external world, the Gateway component handles all inbound and outbound communication. It processes and routes commands to the appropriate digital twins and aggregates data from the twins for external use, ensuring smooth data flow and integration with other systems.
- **Connectivity :** This component is crucial for integrating the digital twins with external systems and services. It manages connections to other IoT platforms, cloud services, and enterprise applications, supporting various protocols like MQTT, AMQP, and HTTP. This ensures that digital twins can communicate seamlessly across different networks and platforms, enhancing interoperability and data exchange.

The microservice architecture of Eclipse Ditto illustrates the interaction between microservices, external dependencies, and interfaces that are both exposed and consumed. represents in Figure 10 :

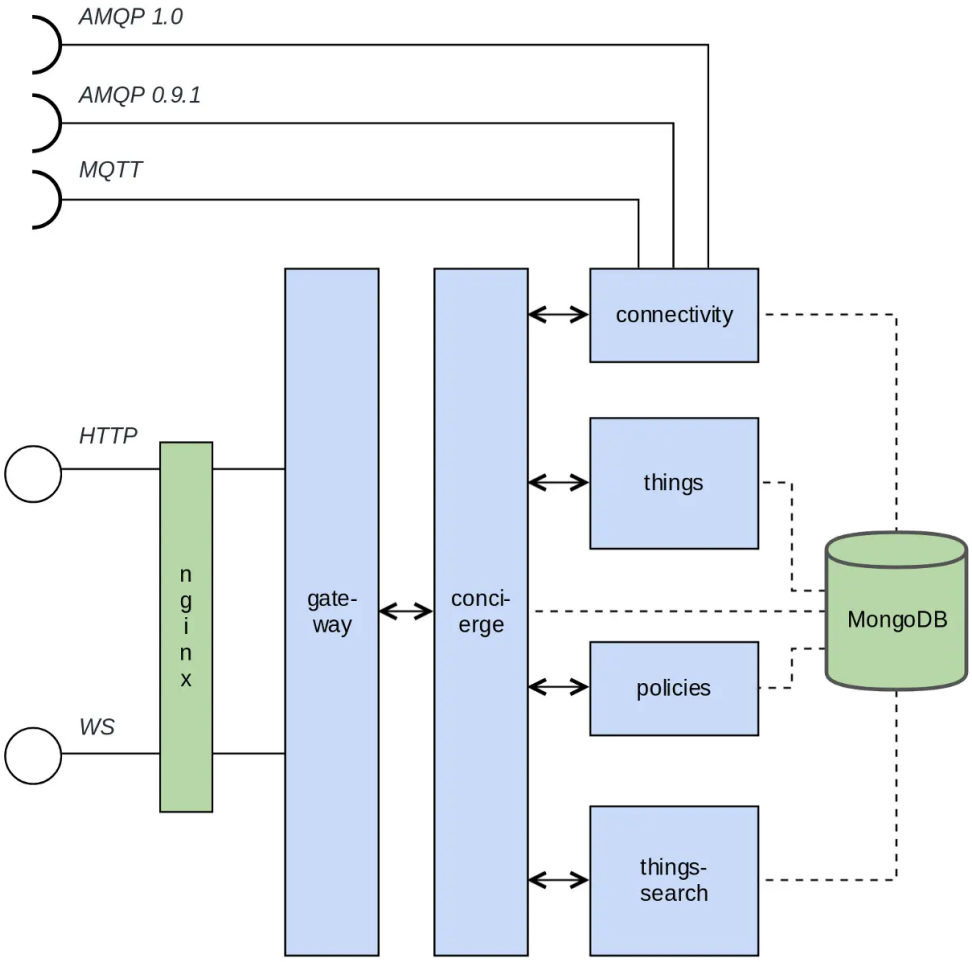


Figure 10: Eclipse Ditto architecture[23]

4.1.2 Eclipse DiTTo protocols :

Ditto facilitates seamless integration of digital twins into existing backend systems through the establishment of flexible connections to these foreign systems, leveraging its support for various protocols :

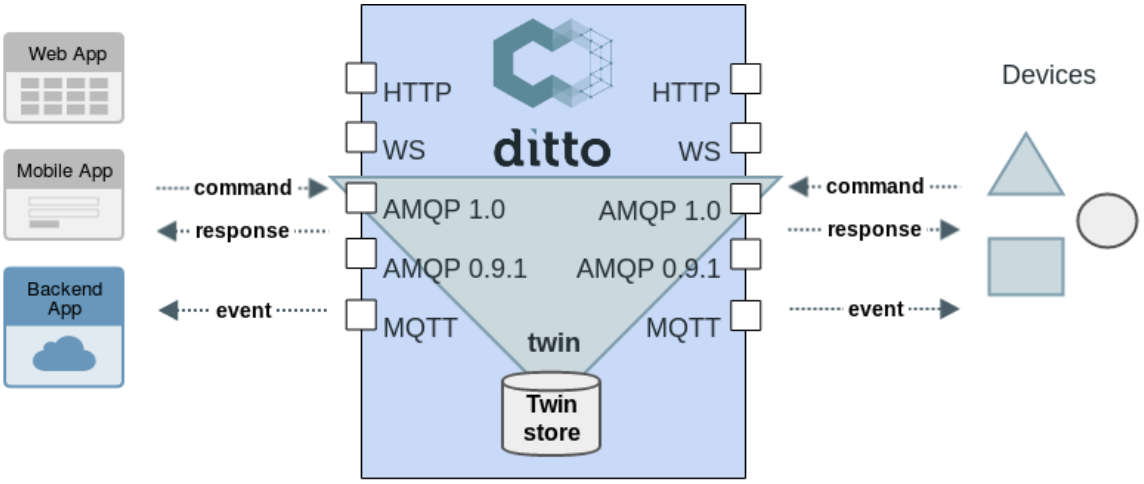


Figure 11: Protocols used by the Eclipse Ditto platform[24]

- **HTTP protocol :** The HTTP (HyperText Transfer Protocol) protocol, widely used since 1990, facilitates communication between clients and servers on the Internet. Initially designed for simple data transfer (as in HTML pages), it evolved to support message transfer with MIME-encoded headers in version 1.0. HTTP enables file transfer via URLs between browsers (clients) and Web servers. While HTTPS, a secure variant, is now preferred for encrypted exchanges, HTTP remains fundamental for accessing resources on Web servers, commonly via web browsers or other HTTP clients.

- **WebSocket :** The WebSocket protocol, an advanced technology, facilitates bidirectional communication between a browser (client-side) and a server. Through this protocol, messages can be sent to a server and responses received event-drivenly, eliminating the need for continuous server polling. Leveraging TCP for reliability and efficiency, WebSocket establishes connections between communication endpoints known as sockets, enabling bidirectional data exchange across networks.
  Websites can be accessed in real-time through a dynamic call-up procedure, where the client simply initiates a connection to the server by sending the WebSocket protocol handshake, containing all necessary identification information. Once established, the open channel enables near-continuous communication, with the server autonomously sending data to the client. This principle powers push notifications on websites, wherein the server sends new information to the client without requiring specific requests from the client's end.[25] The Figure 12 shows the principle of communication between a web page and a web server:

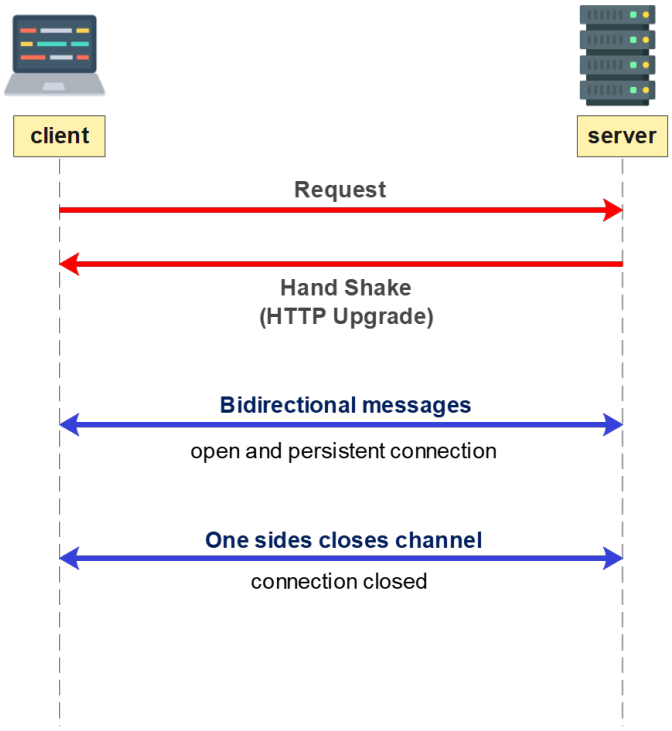


Figure 12: Websocket protocol

✤ **AMQP:** AMQP stands for Advanced Message Queuing Protocol. It is an open standard messaging protocol designed for exchanging messages between applications or systems. AMQP enables the communication between different components in a distributed architecture,the notion of publisher/subscriber is replaced by that of producer/consumer. supporting features such as message queuing, routing, and reliability.[26]

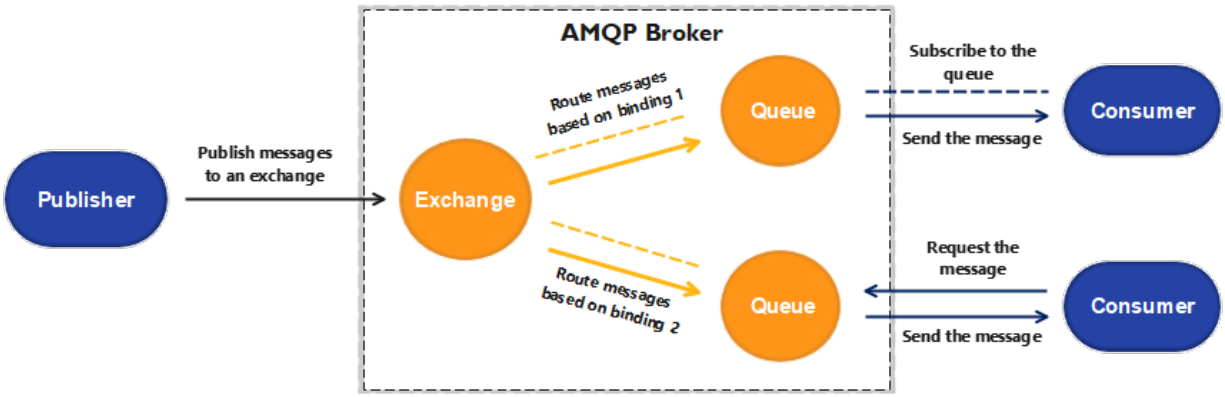


Figure 13: AMQP Broker[26]

✤ **MQTT:** MQTT 3.1.1 protocol binding[27] stands for Message Queuing Telemetry Transport. It is a lightweight messaging protocol designed for use in situations where network bandwidth is limited or unreliable. MQTT is commonly used in IoT applications for connecting devices and transmitting sensor data efficiently.[28]

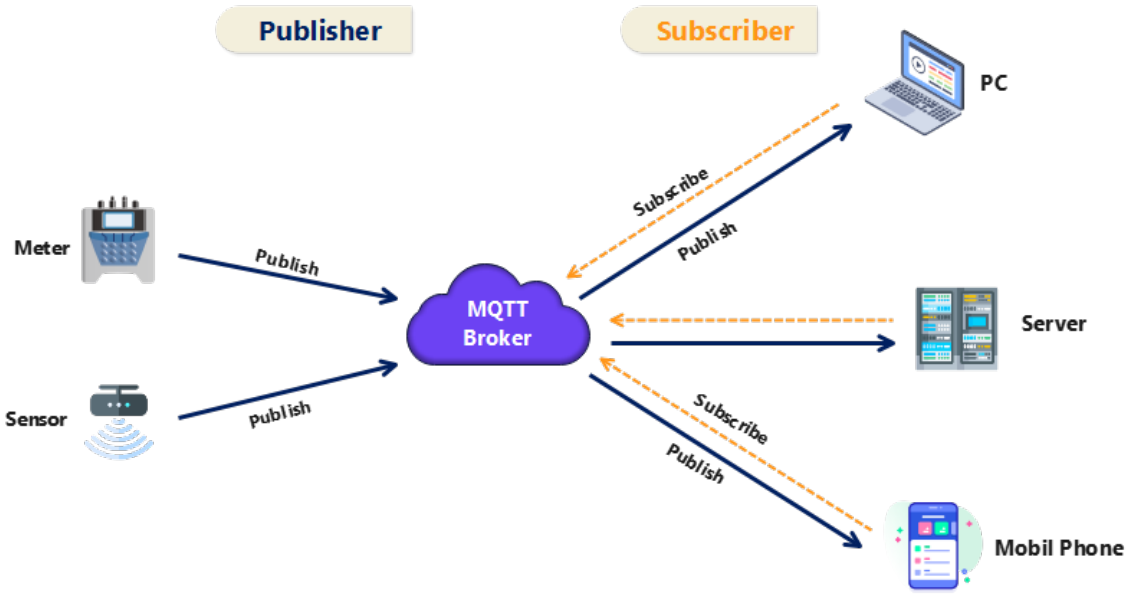


Figure 14: MQTT Broker[29]

✤ **API:** API stands for Application Programming Interface. It defines a set of rules and protocols that allow different software applications to communicate with each other. APIs specify how software components should interact, including the data formats, operations, and endpoints.

✤ **MongoDB:** MongoDB is a popular open-source NoSQL database management system. It uses a document-oriented data model, which means data is stored in flexible, JSON-like documents. MongoDB is known for its scalability, flexibility, and ease of use, making it a common choice for storing and managing data in modern applications.

Each of these communication protocols offers distinct advantages and may be preferred based on factors such as performance requirements, existing infrastructure, and compatibility with IoT devices or systems. Eclipse Ditto supports multiple protocols to cater to different use cases and integration scenarios.

Eclipse Ditto follows a modular structure. You only need the things service and the gateway service, as well as MongoDB, to have a minimal Eclipse Ditto runtime. If needed, the connectivity service (which can connect to AMQP 1.0, AMQP 0.9.1 or MQTT), a detailed policies service, or a search feature, can be added to Eclipse Ditto.

4.2 Node-red :

The implementation of digital twins requires the utilization of various technologies and tools for data integration, visualization, analytics, and simulation. In the context of e-government services, selecting appropriate technologies is crucial for building robust and scalable digital twin frameworks. One such technology that holds promise for developing digital twins is Node-RED.[30]

4.2.1 Node-RED: A Visual Programming Tool :

Node-RED[31] is an open-source, flow-based programming tool that simplifies the development of IoT applications and workflows. It provides a visual interface for connecting hardware devices, APIs, and online services, enabling rapid prototyping and deployment of IoT solutions. Node-RED utilizes a flow-based programming paradigm, where users can create and connect nodes representing different data sources, processing functions, and output endpoints.[32]

4.2.2 System architectur :

Node-RED supports seamless integration with a wide range of IoT devices and sensors, making it well-suited for building digital twins that rely on real-time data streams. Through its extensive library of nodes and connectors, Node-RED facilitates communication with sensors, actuators, and IoT platforms, enabling the ingestion of sensor data into the digital twin environment. This integration capability is essential for capturing real-world information and synchronizing it with the virtual representation in the digital twin.

Node-RED offers built-in functionality for data processing, transformation, and analytics, empowering users to manipulate and analyze sensor data within the digital twin environment. Through its extensive collection of pre-built nodes and functions, Node-RED supports tasks such as data filtering, aggregation, and anomaly detection. These capabilities enable users to derive meaningful insights from raw sensor data, facilitating real-time monitoring, analysis, and decision-making within the digital twin framework.

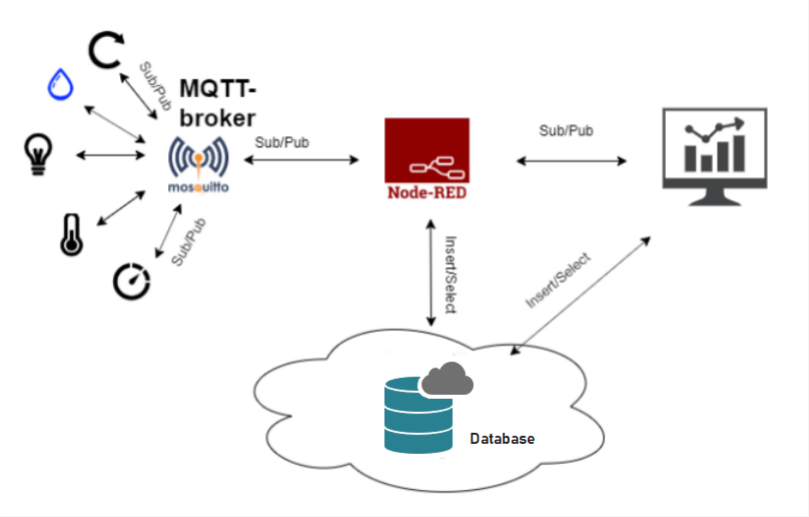


Figure 15: System architecture[33]

4.2.3 Visualization and User Interface Design :

Node-RED provides intuitive tools for creating interactive visualizations and user interfaces, allowing users to monitor and interact with digital twins in real-time. Its dashboard feature enables the design of customizable dashboards, charts, and widgets for visualizing sensor data and system metrics. Additionally, Node-RED supports integration with external visualization libraries and platforms, enhancing flexibility and customization options for designing immersive user experiences.

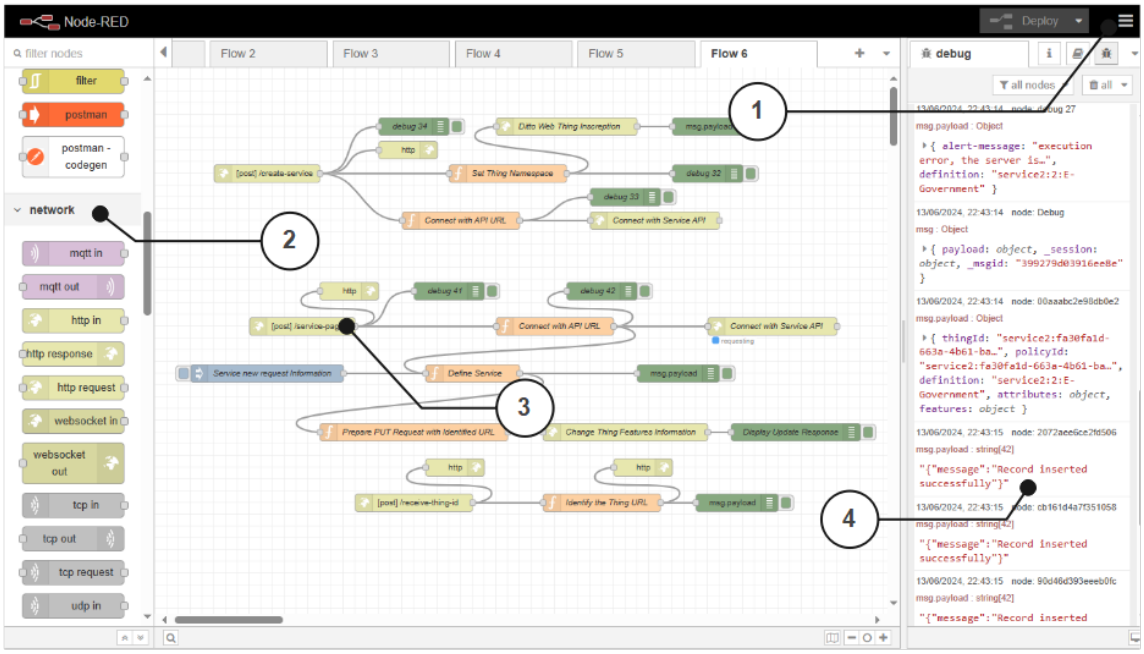


Figure 16: Node-RED Editor

1. The header at the top, containing the deployment button, Search window, the main menu with user authentication and user profile.
2. The left palette, containing the nodes available to use.
3. The main workspace in the middle, where the nods with there flows are created,these Function blocks allow you to create logical operations with JavaScript.
4. The sidebar on the right. All knots are explained clearly.

Node-RED stores flows in JSON format, facilitating easy import and export for sharing. Utilizing an online flow library, users can effortlessly share their top-notch flows with a global audience. To commence Node-RED, execute the ”node-red” command via the command prompt. Subsequently, access the Node-RED home page by navigating to http://localhost:1880 in a web browser.
In Industrial IoT and automation scenarios, various protocols are essential, with MQTT being a prominent one among the core nodes, the MQTT operates as a Client/Server protocol, where hardware devices, serving as clients, communicate with a server to send and/or receive messages. Crafting an MQTT flow is straightforward: simply drag an inject node (as input) and an MQTT node (as output), and connect these two nodes seamlessly.

4.3 Kafka as Digital Twin :

Kafka is a distributed streaming platform that is designed to handle real-time data streams efficiently. At its core, Kafka comprises four main components: producers, topics, brokers, and consumers. Producers are responsible for publishing data records to Kafka topics, which are essentially named channels or feeds. Brokers, which form the Kafka cluster, manage the storage and distribution of data across the system. Consumers, on the other hand, subscribe to topics and process the data records that are published to them.[34]

4.4 Kafka Characteristics of a Digital Twin :

One of Kafka’s key functionalities is its ability to handle large volumes of data while ensuring fault tolerance and scalability. This is achieved through the distributed nature of Kafka’s architecture, where data is partitioned and replicated across multiple brokers. Additionally, Kafka provides features such as data retention policies, which allow users to control how long data is stored within the system, and stream processing capabilities through Kafka Streams and other related frameworks. Let’s explore several architectural aspects while considering the five characteristics of Digital Twins and their relation to Kafka:[35]

- **Connectivity :** Kafka Connect stands out by offering seamless connectivity at scale in real-time, bridging various IoT interfaces, big data solutions, and cloud services. Notably, the Kafka ecosystem complements rather than competes with other Middleware and IoT Platforms, fostering interoperability and synergy across diverse technologies.
- **Homogenization :** Kafka excels in achieving true decoupling between clients, such as producers and consumers, a critical aspect for Digital Twins. Its robust schema management and enforcement capabilities, leveraging technologies like JSON Schema, Avro, and Protobuf, facilitate data awareness and standardization, ensuring consistency across heterogeneous environments.
- **Reprogrammable and Smart :** Renowned as the de facto standard for microservice architectures, Kafka enables reprogrammability and intelligence through its emphasis on separation of concerns and domain-driven design (DDD). This empowers the deployment of new decoupled applications, versioning, A/B testing, and canary releases, enhancing flexibility and agility in digital twin implementations.
- **Digital Traces :** Kafka's architecture as a distributed commit log makes it exceptionally suited for building digital traces for digital twins. With its ability to append events, store data indefinitely, and maintain immutability, Kafka offers an ideal foundation for constructing comprehensive and reliable digital traces, crucial for accurate representation and analysis in digital twin environments.
- **Modularity :** The modular and scalable nature of Kafka infrastructure, encompassing components like Kafka brokers, Connect, Schema Registry, REST Proxy, and client applications supporting multiple languages, empowers architects to design tailored Digital Twin architectures for diverse scenarios. Whether at the edge, in hybrid environments, or on a global scale, Kafka's modularity facilitates seamless integration with other IoT solutions, offering flexibility and adaptability to evolving requirements.[36]

4.4.1 Illustration of Real-Time Data Processing :

Kafka's support for real-time data streaming and event processing is highly relevant to the concept of digital twinning. Digital twins require timely and accurate data to reflect the current state of the physical system they represent. Kafka's capability to process data in real-time enables digital twins to react swiftly to changes in the environment and provide up-to-date insights and analytics.

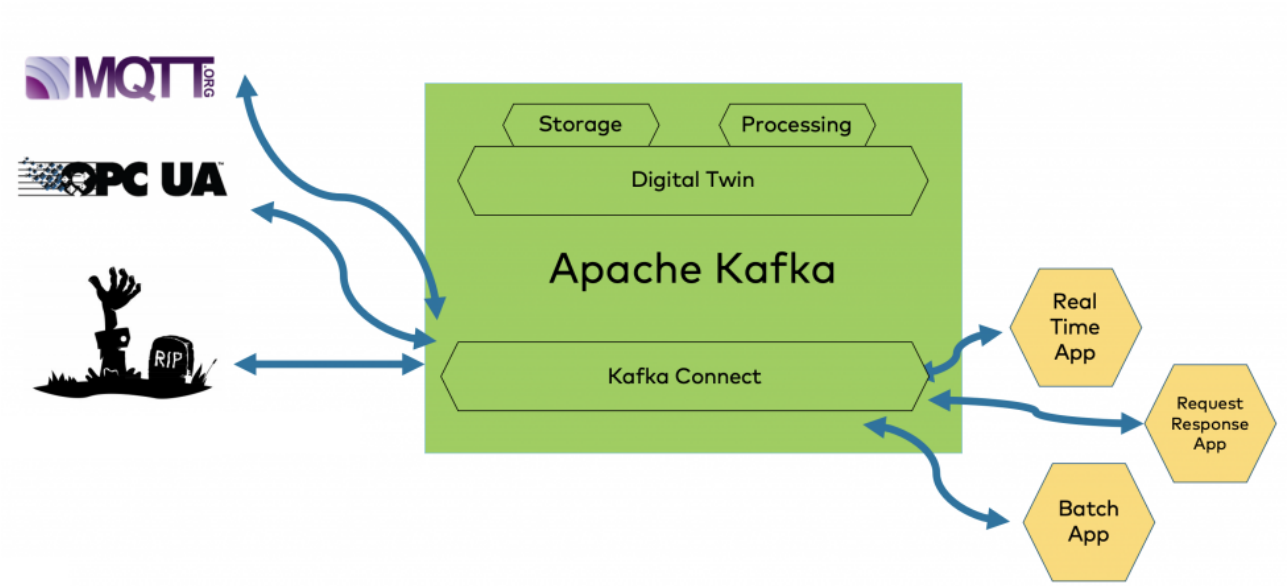


Figure 17: Kafka as Digital Twin[36]

Overall, Kafka's architecture, functionalities, and real-time data processing capabilities make it well-suited for supporting digital twin implementations across various domains, facilitating agile decision-making and enabling proactive management of complex systems.

5 Conclusion :

This chapter comprehensively explores digital twin technology within the Internet of Things (IoT) framework, detailing its architecture, components, and diverse applications across sectors like healthcare, aerospace, and manufacturing. It highlights essential tools and technologies like Eclipse Ditto and Kafka that facilitate real-time data orchestration and processing, critical to digital twin functionality. The broad applicability of digital twins is demonstrated in their capacity to enhance decision-making, optimize operations, and drive efficiency in various industries. Despite their extensive utility, the chapter also identifies gaps in research, particularly in data integration and system interoperability. Overall, digital twins emerge as pivotal tools in merging physical and digital realms, offering transformative potential across multiple domains.

Chapter 2:
E-government services

1 Introduction :

the evolution of e-government services has been propelled by advancements in information and communication technologies (ICTs) and a growing emphasis on enhancing government transparency, efficiency, and accessibility. Early e-government initiatives primarily focused on providing basic information online, such as static web pages with government contact details and forms. However, with the proliferation of digital platforms and the advent of Web 2.0 technologies, e-government services have transitioned towards interactive and transactional models, allowing citizens to complete various tasks online, from paying taxes to applying for permits and licenses.

2 Definition of Government, E-Government, and E-Governance:

2.1 Introduction to Government and Governance :

Government refers to the institution or group of individuals and agencies that hold the authority to govern an area or community, typically a state or nation. It is responsible for creating and enforcing laws, policies, and regulations that guide societal behavior, ensure public welfare, protect citizens' rights, and manage national affairs.

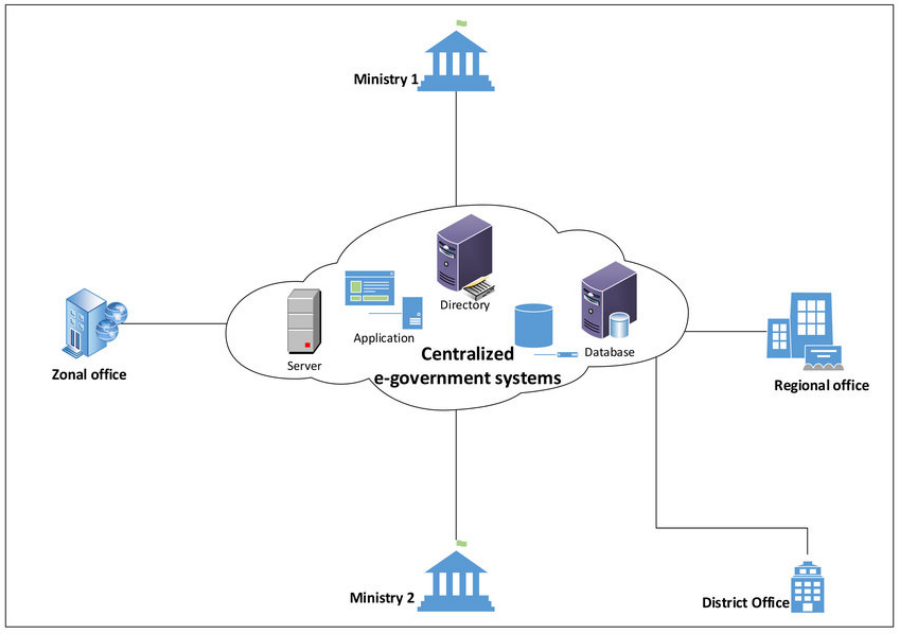


Figure 18: Integration of an e-government system for streamlined e-government services.[37]

Governance, on the other hand, encompasses the processes, systems, and practices through which power is exercised and decisions are made and implemented. It is broader than the government itself, involving various stakeholders including the private sector, civil society, and citizens in decision-making processes.[38]

2.2 E-Government: A Digital Transformation :

E-Government represents the use of information and communication technologies (ICTs) by government bodies to enhance the access and delivery of government services to citizens, businesses, and other government agencies. It involves the digitalization of public administration processes and services, aiming to make them more efficient, accessible, and transparent. The United Nations defines e-government as the employment of the internet and the world-wide-web for delivering government information and services to the citizens.

3 Services types of E-government :

In modern governance, various channels facilitate interactions between governments, businesses, and citizens. These channels serve as vital conduits for exchanging data, conducting transactions, and engaging in decision-making processes.
E-government services are directed towards four primary customer groups: citizens, the business community, government employees, and government agencies.[39] The objective of e-government is to streamline interactions not only with citizens, businesses, and government employees but also with government agencies and other governmental entities.
The relationship between these three groups (government, citizens and businesses) is presented in the following Figure 19 :

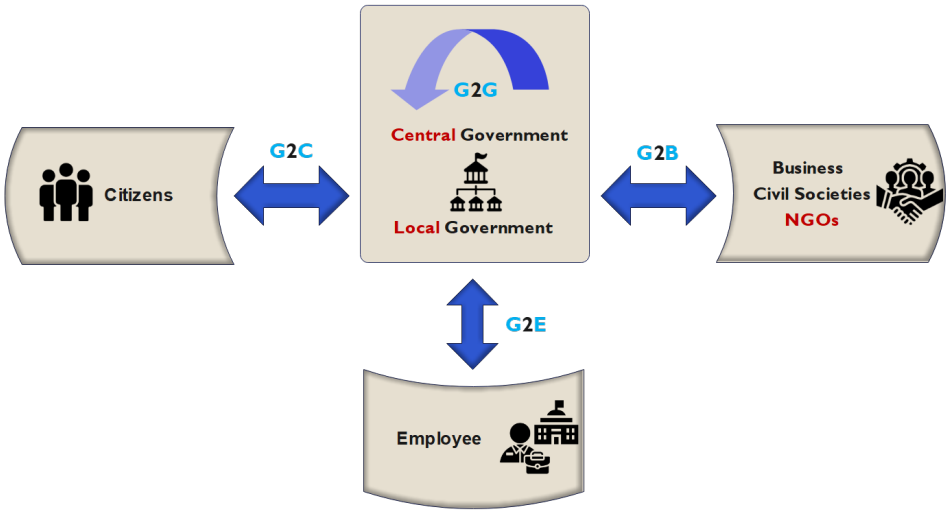


Figure 19: Interactions between the main groups in e-government

3.1 Government-to-Government (G2G) :

pertains to the sharing of data and conducting electronic exchanges among governmental entities. This encompasses both intra- and inter-agency exchanges at national levels, as well as interactions between national, provincial, and local authorities.
(G2G) services operate on both domestic and international levels. These services involve transactions between central/national and local governments, as well as between department-level entities and attached agencies and bureaus. Additionally, G2G services serve as a means of facilitating interactions between governments, serving as a tool for international relations and diplomacy.[40]

3.2 Government-to-Business (G2B) :

Government-to-business (G2B) transactions encompass a wide array of services shared between the government and the business community. These include the distribution of policies, memos, rules, and regulations. Businesses can access services such as acquiring up-to-date business information, downloading application forms, renewing licenses, registering businesses, obtaining permits, and fulfilling tax obligations. G2B transactions play a pivotal role in fostering business development, particularly for small and medium enterprises (SMEs). Streamlining application procedures to expedite the approval process for SME requests would serve as a catalyst for encouraging business growth.[41]

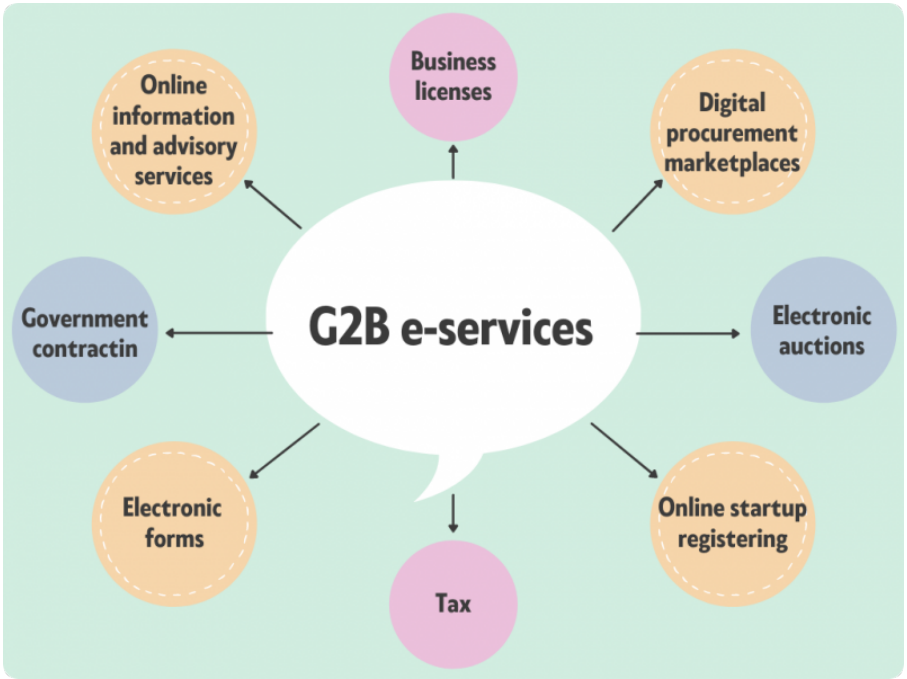


Figure 20: Government-to-Business (G2B)[42]

3.3 Government-to-employee (G2E)

This organization of services is responsible for maintaining the link between a government and its employees . Online learning is offered to staff members as part of a G2E service, aimed at helping workers improve their performance and enhance work efficiency. This also helps employees connect with each other. Employees have access, for their own use, to the rules governing social benefits and compensation . It is essential that G2E facilities focus on areas where state agents need to benefit from management and communication programs in order to establish an e-office and e-career.[43]

3.4 Government-to-Consumer / Citizen (G2C) :

initiatives aim to facilitate people's interaction with government as consumers of public services and as citizens. This involves interactions related to the delivery of public services and participation in consultation and decision-making processes.
(G2C) services encompass a range of offerings aimed at the public. These include disseminating information to citizens, facilitating essential services like license renewals, birth/death/marriage certificate requests, and income tax filing. Additionally, G2C services extend to providing assistance to citizens in accessing fundamental necessities such as education, healthcare, hospital information, libraries, and similar amenities.[44]

4 Objectives and Goals of E-Government

e-government has emerged as a transformative force, reshaping the relationship between governments and citizens. At its core, e-government aims to harness technology to enhance governance processes, improve service delivery, and foster citizen engagement. Understanding the objectives and goals of e-government is essential for comprehending its role in modernizing public administration and advancing democratic principles:[45]

❶ **Enhancing Access to Government Information :** Making government information accessible to all citizens in the public interest.

❷ **Facilitating Citizen-Government Collaboration :** Establishing a cooperative relationship between the government and citizens, encouraging citizen engagement, and seeking public input to address citizen concerns effectively.

❸ **Promoting Citizen Participation :** Increasing and encouraging public involvement in the governance process, fostering a sense of ownership and responsibility among citizens.

❹ **Modernizing Information and Communication Technology (ICT) Infrastructure :** Improving the country's ICT infrastructure and leveraging electronic media to strengthen the economy and align government practices with modern standards.

❺ **Establishing Transparency and Accountability :** Building trust and confidence in the governance process by ensuring transparency, accountability, and integrity in government operations and decision-making.

❻ **Optimizing Government Expenditure :** Reducing costs associated with traditional government services through the efficient use of technology and digital platforms.

5 Application Areas of e-governance :

E-governance encompasses a broad spectrum of applications aimed at transforming traditional government processes and enhancing citizen engagement through digital technologies. These applications span various domains, facilitating interactions between government entities, citizens, businesses, and non-governmental organizations (NGOs). Understanding the diverse application areas of e-governance is crucial for comprehending its impact on service delivery, transparency, and public participation. This section explores key application areas of e-governance, outlining how digital platforms and initiatives are utilized to streamline government operations.

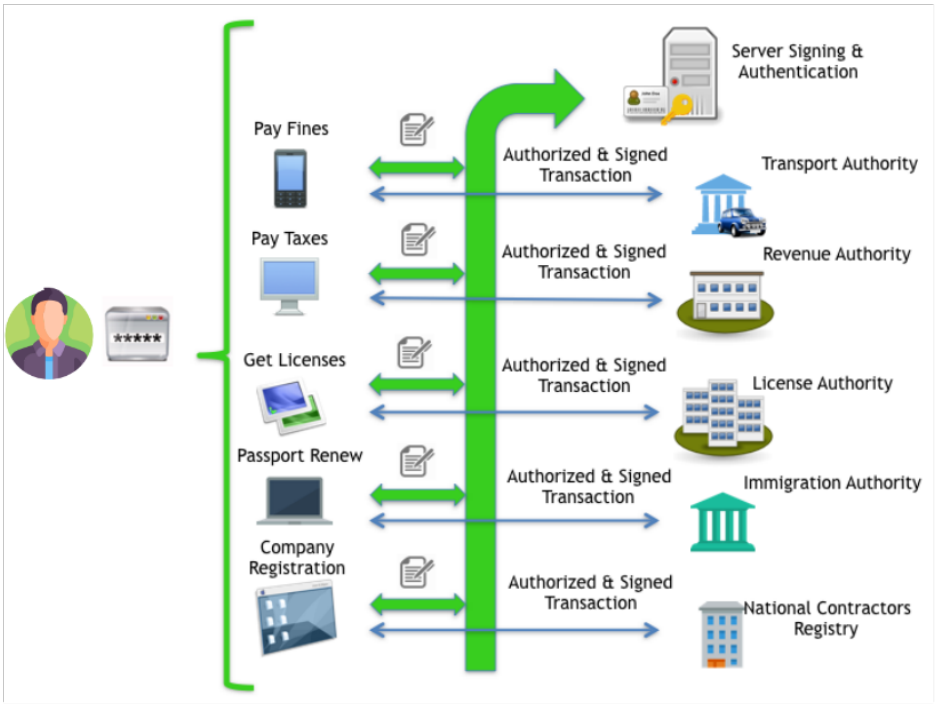


Figure 21: Centralized Authentication and Signing for E-Government.[46]

5.1 E-Commerce :

The term ”electronic commerce” refers to the practice of conducting commercial transactions through the use of electronic media, most commonly the Internet. E-commerce is defined as the process of buying and selling products and services via the Internet or the World Wide Web. It is evident from the variety of definitions proposed that the essential characteristics of e-commerce relate to all exchanges using technology between organizations and third parties. Additionally, various forms of electronic media are used at some point to facilitate these exchanges.[47][48]

5.2 E-Services :

Primarily considered as a front-end platform to enhance the delivery of public services to individuals, e-services involve the use of ICT to enable, execute, and process front-end services for consumers, including awareness, transactions, interactions, and distribution. Requests for official documents, applications for certificates and legal documents, and the issuance of licenses and permits are some examples of e-services. E-services, or electronic service delivery (ESD), refer to the information, programs, and government services accessible online ”24/7.”[49]

5.3 E-Administration :

The use of ICT to improve administrative procedures and internal operations of departments within an organization is also known as ”E-Management.” While e-services focus on what is known as ”front-office” relationships, e-administration pertains to ”back-office” organizational structures. E-government initiatives in this domain include email, integrated human resources and payroll systems, integrated financial management systems, collaborative web-based data resource platforms, electronic filing systems, electronic document management systems (EDMS), online recruitment, and enterprise resource planning.[50][51]

6 Examples of E-government :

6.1 E-government in Algeria :

The Algerian public service confronts challenges posed by complex modern technologies, necessitating the establishment of robust management systems. and identifying the primary obstacles impeding the success of e-government initiatives in Algeria, utilizing a comparative survey approach. It delves into the essential prerequisites for implementing a feasible e-government platform tailored to the Algerian context. The findings underscore the urgent requirement for investment in information and communication technologies.
The Algerian government has been actively progressing in the development of digital public platforms and has set ambitious targets in this domain. Collaborations with foreign companies and international organizations are facilitating the development of some e-services. Despite the considerable advancement in electronic public services in Algeria, there exists a lack of uniformity in platform design. Many platforms necessitate adjustments to effectively implement stated functionalities. For instance, the absence of a search function on the public procurement portal poses challenges in user interaction, while critical information regarding tender decisions and changes remains unpublished. Education and healthcare emerge as promising areas for cooperation with Algeria, particularly in the development and expansion of e-services and enhancing the functionality of existing services in these sectors.

Ultimately, the essence of e-government lies in digitally linking citizens, government bodies, businesses, and civil institutions through various electronic channels.

E-Government Development Index	2022	2020	2018	2016	2014	2012	2010	2008	2005	2004	2003
Algeria (Rank)	112	120	130	150	136	132	131	121	123	118	91
Algeria (Value)	0.56110	0.51730	0.42270	0.29991	0.31064	0.36077	0.31810	0.35150	0.32423	0.32476	0.36993

Table 1: E-Government Development Index in Algeria[52]

- In 2022, Algeria held the 112th position in the UN E-Government Survey, ranking 9th among African nations, with approximately 60% of its population having access to the Internet.
- According to the World Bank's GovTech Maturity Index report for the same year, Algeria advanced to group B, indicating a high level of e-Government development and a significant focus on GovTech, with a GTMI of 0.5, slightly below the global average of 0.55.

- The Algerian Prime Minister announced the development of a public services portal integrating 208 public services during a session of the National People's Assembly. However, as of April 2023, details regarding the current stage of implementation remain unavailable.
- Since its inception in 2017, the electronic medical card system known as Sihatic has been successfully integrated into Algeria's healthcare sector. Spearheaded by a private entity and backed by the Ministry of Health, this initiative has made significant strides. According to a study published on the Algerian Scientific Journal platform in June 2022 by M.A. Brahami and H.M. Dergal from the Algerian LAPAME Laboratory, 284 clinics and 16 medical institutions across Algeria have undergone digital transformation.

  For scheduling appointments with healthcare professionals, the SAHTI platform has been developed with support from the Ministry of Pharmaceutical Industry. However, while it currently serves as an informational hub providing contact details such as phone numbers, emails, and addresses of specialists or clinics, it does not yet offer an online appointment booking service.
- Implementation of the National Identification Number (NIN) project is currently underway in Algeria. Since 2021, a facial recognition service has been operational for pensioners, aimed at streamlining paper-based procedures. By 2019, approximately 17 million Biometric Cards (CNIBE) had been issued.
- The EDAHABIA Card, issued by ALGERIE POSTE, is an EMV-compliant debit card featuring the ALGERIE POSTE logo. It enables the cardholder to perform a variety of transactions, including cash withdrawals, self-service banking, and payments both at point-of-sale terminals and online.
- In terms of the national payment system, major Algerian banks such as BNA and Société Générale Algérie utilize the Algerian Interbank Card CIB, alongside the widespread usage of the Edahabia card from the Algerian Postal Service. Despite a total issuance of approximately 11.6 million cards, the figure represents only a fraction of Algeria's population of about 45 million, with 69% being over 14 years old.

Year	2013	2014	2015	2016	2017	2018	2019	1st Six Months 2020
Internet subscribers (fixed and phone)	1283420	1599538	2262259	2859551	3202505	3063835	3580456	367925
Internet subscribers (mobile and phone)	308019	8509053	16684697	25692619	31460534	39860900	36911428	36967783
Total Internet subscribers (fixed and mobile)	1591439	10108591	18946956	28552170	34663039	42924735	40491884	40643709

Table 2: Number of Internet Users in Algeria (2013–1st Six Months of 2020)[53]

From the above table, The number of internet users witnessed a significant surge during the first half of 2020, escalating from 15.91 million in 2013 to 40.64 million by the end of June 2020. This remarkable growth has been primarily fueled by a substantial increase in mobile internet subscribers, who numbered over 34.66 million by 2017. This surge underscores the growing recognition among Algerians of the pivotal role the internet plays in various facets of life, including education, the economy, social interaction, and culture.

6.2 E-goverment in Finland :

E-government digitalization in Finland and across Europe represents a concerted effort to modernize governance through digital means. In Finland, initiatives focus on providing seamless access to public services online, aiming to enhance citizen convenience and government efficiency. Similarly, across Europe, there is a shared commitment to leveraging technology to streamline bureaucratic processes and improve service delivery. Central to these efforts is the emphasis on digital inclusion, ensuring that all citizens, regardless of their background or location, can access and benefit from online services. Moreover, collaboration among EU member states facilitates the exchange of best practices, fostering harmonization and interoperability of digital solutions across borders.

Finland	2022	2020	2018	2016	2014	2012	2010	2008	2005	2004	2003
E-Government Development Index (Rank)	2	4	6	5	10	9	19	15	9	9	10
E-Government Development Index (Value)	0.95330	0.94520	0.88150	0.88168	0.84491	0.85052	0.69670	0.74880	0.82311	0.82389	0.76112
E-Participation Index (Rank)	6	14	1	8	24	11	30	45	15	16	20
E-Participation Index (Value)	0.95450	0.95240	1.00000	0.91525	0.70588	0.73680	0.41428	0.27272	0.55555	0.57377	0.44830

Table 3: E-Government Development & E-Participation Index in Finland[54]

The Table 3 represents the latest findings from the eGovernment Benchmark report, tracking the progress of eGovernment across Europe based on specific criteria. These criteria fall into four main categories:

- **User Centricity:** Reflects the extent to which services are available online and how users perceive them.
- **Transparency:** Measures the degree of openness in government responsibilities, service delivery processes, and handling of personal data.
- **Cross-Border Mobility:** Assesses the accessibility of online services for EU citizens and businesses in other countries.
- **Key Enablers:** Gauges the availability of technical prerequisites online, including eID, eDocuments, Authoritative Sources, and Digital Post, which facilitates electronic communication between governments and citizens.

The evaluation employs a life-events approach, such as mystery shopping, to measure these benchmarks. The overall eGovernment performance score is determined by eight life events. Four of these were assessed in 2013, 2015, and 2017, while the remaining four were evaluated in 2012, 2014, 2016, and 2018. Life events measured in 2017 included Regular business operations, Moving, Owning and driving a car, and Starting a small claims procedure. Those assessed in 2018 were Business start-up, Losing and finding a job, Family life, and Studying.



Figure 22: E-Government Benchmark Report of Finland and EUROPE[55]

This Figure 23 presents data from Finland across various years from 2003 to 2022, showcasing three key indices: the Online Service Index, the Telecommunication Infrastructure Index, and the Human Capital Index.

- **Online Service Index:** reflects the efficiency and accessibility of online services provided by the government or other entities. Higher values indicate better online service provision.
- **Telecommunication Infrastructure Index:** measures the quality and accessibility of telecommunication infrastructure within the country. Higher values suggest better telecommunication infrastructure.
- **Human Capital Index:** assesses the overall human capital development within the country, encompassing factors such as education, skills, and workforce readiness. Higher values indicate stronger human capital development.

Finland	2022	2020	2018	2016	2014	2012	2010	2008	2005	2004	2003
Online Service Index	0.98330	0.97060	0.96530	0.94203	0.77165	0.88235	0.47936	0.63210	0.82692	0.80694	0.60262
Telecommunication Infrastructure Index	0.91270	0.91010	0.72840	0.75903	0.85940	0.72250	0.62399	0.62456	0.65241	0.67473	0.69075
Human Capital Index	0.96400	0.95490	0.95090	0.94399	0.90370	0.94670	0.99333	0.99333	0.99000	0.99000	0.99000

Table 4: EGDI Sub-Components[54]

Delve into this section for a comprehensive glance at vital public services extended to citizens, influenced by the ethos of Your European online resource streamlining activities across European nations. Here, we expand beyond the confines of cross-border services, embracing a broader spectrum that encompasses both national and international realms. The categories outlined in this fact-sheet span various facets of citizen welfare, The groups of services for citizens are as follows:

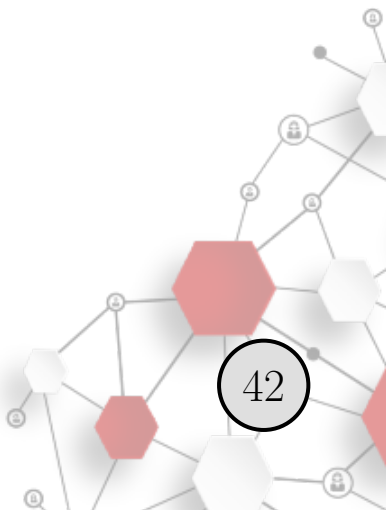
- **Travel:** Passport, Consumer protection of passengers, Assistance for disabled persons, Driving in Finland, Traveller entering Finland, Travel Information, Travel packages and consumer protection.
- **Work and retirement :** Job search services by labour offices, Job Market Finland, Tax cards, Recognition and international comparability of qualifications, Unemployment benefits, Income taxes: declaration; notification of assessment.
- **Vehicles:** Vehicle commissioning and decommissioning, Driver's licence, Unpaid vehicle tax, Car registration (new, used, imported cars).
- **Residence formalities:** Announcement of moving (change of address), Declaration to the police, Housing (building and housing, environment) – Report on construction, Moving to Finland to be with a family member, E-services, Documents, Licences, Voting in embassies in advance, Postal voting.
- **Health:** Kanta-serivces, My Kanta Pages, Patient Data Repository, Electronic prescription, Medical Helpline 116 117, Self-care health service, Medical costs (reimbursement or direct settlement), Medical treatment abroad, e-Prescriptions (cross-border), Finnish social security in international situations, Travel notification, Taxation while living abroad.

- **Education and youth :** Enrolment in higher education/university, Enrolment in higher education/university (Studyinfo – a portal to education), Study credit, degree and qualification service, Public libraries (availability of catalogues, search tools), Student grants, National register, Apprenticeships, Traineeships, Information and assistance to researchers, Public libraries (availability of catalogues, search tools), Research funding support, Volunteer work in Finland.
- **Family:** Child allowances I, Child allowances II, Child allowances III, Tax treatment of cross-border inheritance,
- **Consumers:** Consumer Advisory Services, Cancellation of a purchase, Communications, Consumer protection in the Financial Sector, Financial and debt counselling, Discrimination based on gender, Facing discrimination, Legal aid, Complaint to the Ombudsman, Comparison of energy prices, Complaint to the Consumer Disputes Board

7 Conclusion :

This chapter effectively describes e-government services and their transformative impact of digital technologies on governmental operations and citizen engagement. It delineates various types of e-government interactions, such as G2G, G2B, G2E, and G2C, demonstrating the scope and versatility of digital platforms in facilitating more efficient and accessible public services. The objectives and goals are clearly stated, aiming to enhance transparency, increase efficiency, and foster greater public participation in governance. Two examples of e-government initiatives in countries like Algeria and Finland provide concrete perspectives on the deployment of e-government services, highlighting the global and diverse nature of digital governance efforts.

Chapter 3: Conception



1 Introduction :

In light of the expanded digitization of government services in their various fields, , ranging from citizen services to economic and institutional domains, continual monitoring becomes imperative to identify challenges and drive ongoing improvements. A crucial tool for this endeavor is the utilization of digital twins, enabling real-time and perpetual monitoring of these services.

Within this chapter, we unveil a model solution designed to facilitate the seamless tracking and management of government services. This solution serves as a proactive measure against technical or software failures within server infrastructure, while concurrently enhancing monitoring capabilities. Its scope extends beyond mere troubleshooting to encompass the optimization of service performance, especially during critical government events with specific temporal demands. Additionally, it empowers administrators to oversee user engagement processes, ensuring a streamlined and efficient service delivery mechanism.

2 Overall Architecture :

The system architecture is devised through an extensive integration of all e-government services APIs within a digital twin model. In this section, we provide a concise overview of our proposed architecture, detailing its primary layers and components.

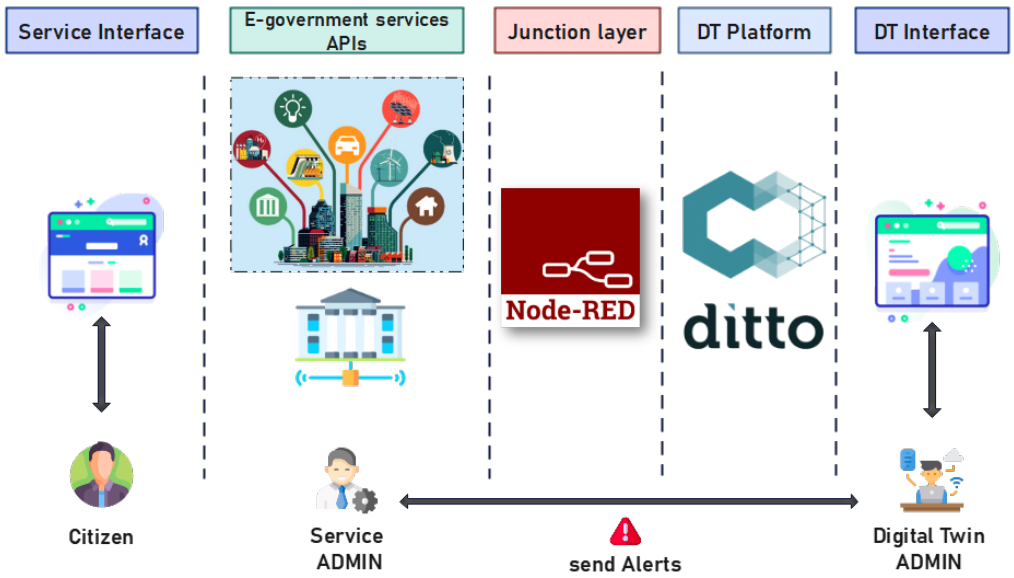


Figure 23: Overall Architecture

- **Service Platform (User Interface):** This component serves as the front-end through which users interact with e-government services. It is designed to be user-friendly, responsive, and accessible on multiple devices, providing a seamless experience for all citizens. The interface displays real-time data and updates from the digital twin, ensuring users have the latest information at their fingertips.
- **E-government Services APIs:** These APIs function as endpoints that facilitate the secure and efficient exchange of data between the e-government services and external applications. They ensure that all interactions are performed under strict security protocols, supporting the reliable delivery of services to the Digital twin and enhancing interdepartmental collaborations.
- **The Junction Layer (Node-RED):** Node-RED acts as the middleware in our architecture, orchestrating the flow of data between the APIs and the digital twin. This visual programming tool simplifies the creation and maintenance of integration flows, enabling real-time data processing and enhanced connectivity across different components of the system.
- **Digital Twin (Eclipse Ditto):** The digital twin, implemented using Eclipse Ditto, replicates the e-government ecosystem in a virtual environment. This allows for the testing and optimization of services in a controlled setting before they are rolled out to the public. The digital twin continuously updates to reflect changes in real-time, providing a dynamic tool for system management and decision support.
- **Digital Twin Platform (Admin Interface):** Specifically designed for administrators, this platform provides robust tools for managing and monitoring the digital twin. Administrators can access detailed analytics, manage system configurations, and respond to alerts, ensuring the stability and efficiency of the digital twin operations.
- **Alert Platform (Services Admins Interface):**This interface is crucial for services administrators, as it receives alerts from the Digital Twin Platform Administrator and supervises the services accordingly. It provides administrators with timely notifications about any issues or anomalies detected by the digital twin.

To effectively demonstrate the interactions among the system layers, actors, and external entities, we have constructed a visual diagram that encapsulates the various roles played by different actors within the system. This Figure: 23 serves to clarify their involvement in managing, controlling, and simulating E-govenment services, we outline the key actors in the system along with their designated responsibilities:

- **Service Administrator:** Responsible for overseeing the administration and maintenance of the e-government services platform, ensuring its smooth operation and resolving any technical issues that may arise.

- **Digital Twin Administrator:** Responsible for managing the digital twin services model, including creation, patching, and deletion. Monitors the digital twin's performance ensure it reflects real-world conditions accurately. and sends alerts to the Service Administrator regarding any anomalies or potential issues.
- **User:** Interacts with the e-government services platform, accessing various services and functionalities offered. Provides feedback on user experience and may submit requests or inquiries through the platform.

3 E-government Services APIs Connecting with DT :

The E-government Services API facilitates the seamless exchange of data between the e-government services platform and external applications. It acts as the conduit through which specific information is retrieved from service endpoints and integrated into the digital twin. This integration ensures the accurate representation of real-world data within the digital ecosystem. By establishing a unified model among e-government services, the API streamlines coordination and enhances interoperability. This enables efficient communication between different components of the system, fostering cohesion and synergy.

Additionally, the API enforces stringent security protocols to safeguard data integrity and confidentiality throughout the exchange process. Its role is pivotal in supporting the reliable and synchronized operation of e-government services.

In the context of this study, APIs encompass the services and user interactions within the system. The services platform acts as the primary interface connecting citizens with the digital twin model. Equipped with multiple servers, including those for visitors, server status, and user interaction, these services are responsible for gathering vital signs and other relevant data from citizens. This real-time data is critical for monitoring the services Without any problem occurring.

The services APIs are interconnected with the digital twin model through the junction layer, facilitating seamless connectivity and data exchange between the physical system and the digital twin. This layer aggregates data and transmits it to the digital twin model for analysis and monitoring.

To achieve this integration, the platform employs Node-RED, a versatile programming tool for linking hardware devices, APIs, and online services. Node-RED serves as the framework for constructing the junction layer and enabling smooth integration between these APIs and the digital twin.

Through Node-RED, data from endpoints, server status monitors, is collected and processed. This collected data is then transmitted to the digital twin model, where it undergoes analysis and monitoring, providing insights into the services dashboard and server alert status.

3.1 Modeling services DT :

To model the services endpoints we chose the BDD diagram (block definition diagram) a SysML modeling diagram. The block definition diagram is a diagram that describes the structure of a system, subsystem, or component. A block is like a class, it can be composed of other blocks and can have relationships with other elements of the model (blocks, diagram, activities, etc.).A block is represented graphically by a rectangle with several compartments which contains details on the component (element) presented by the block.

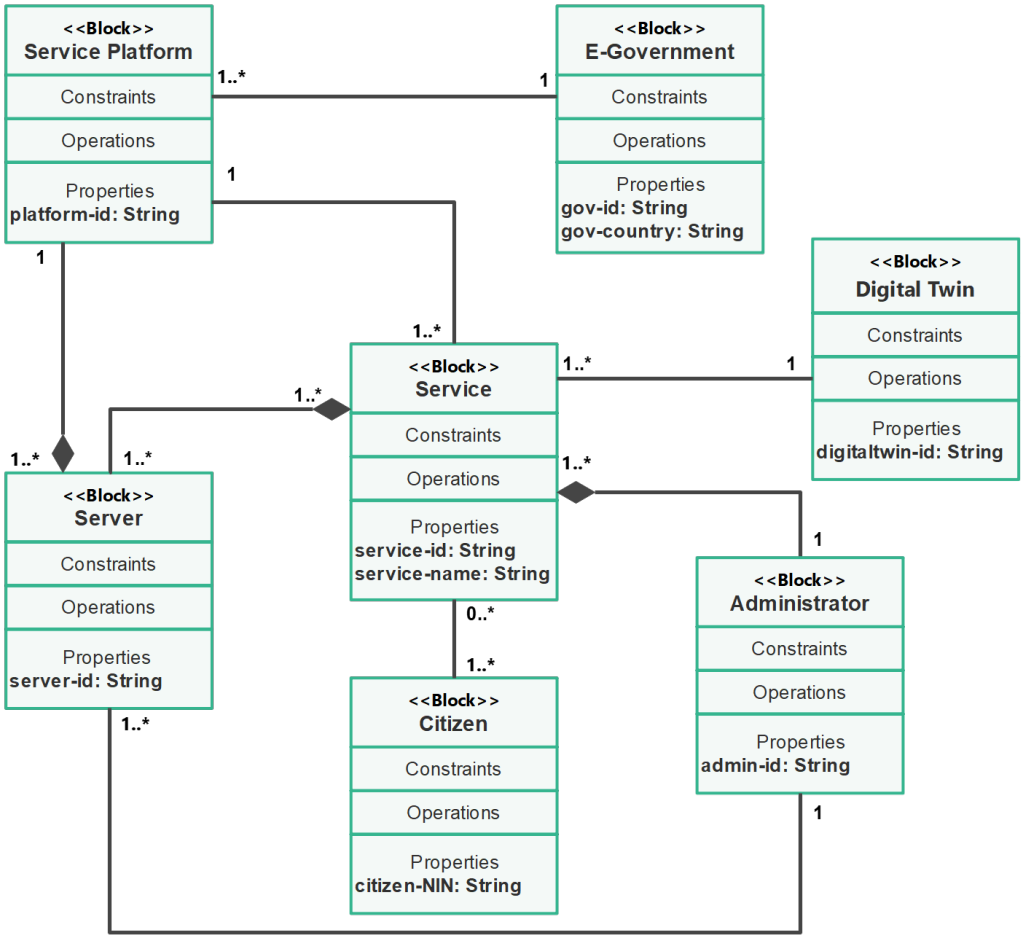


Figure 24: E-government Block Diagram

Modeling E-government services in this architecture involves defining the properties and relationships of each block to ensure seamless integration and operation. The Service Platform hosts multiple services that runs on servers. The Server block hosts services, while the Digital Twin represents digital counterparts of real-world entities, interacting with various services. Citizens use these services, and administrators manage them. This model ensures a clear and organized representation of how e-government services are structured and delivered, focusing on the interactions and dependencies between different components to provide a cohesive service delivery framework .

3.2 Modeling Digital Twin things :

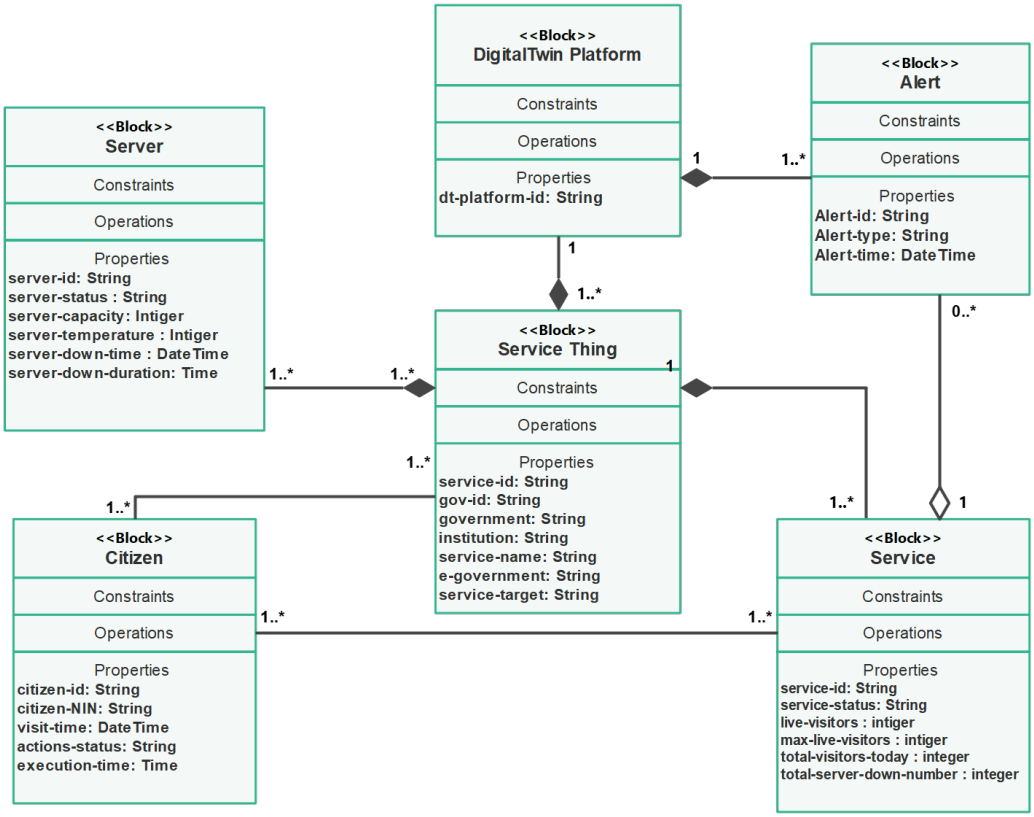


Figure 25: Digital Twin Block Diagram

The modeling of E-government services (DT) in this architecture focuses on defining the properties and relationships of each component to ensure seamless integration and real-time monitoring of e-government services. The Server hosts services that send API requests to service things. The Digital Twin Platform receive this data informations and interacts with service things for real-time data and manages alerts. The Alert block, with properties is linked to service things to generate notifications based on conditions. Service Thing blocks,

defined by properties , interact with the Digital Twin Platform that monitoring servers status, and citizens Informations and generate alerts. The Service block tracks and manages service performance metrics like live visitors and server downtimes. service things also monitoring Citizens informations that to access e-government services. This model ensures each component's properties and interactions are accurately represented, facilitating efficient service delivery and real-time monitoring within the DT framework.

4 Digital twin model :

The Digital Twin model for e-government services provides a comprehensive framework for digitally representing and managing various entities and their interactions within the e-government ecosystem. By creating a digital counterpart for real-world and virtual objects, this model enhances real-time monitoring, data analysis, and service delivery, ensuring that government services are efficient, transparent, and user-friendly.

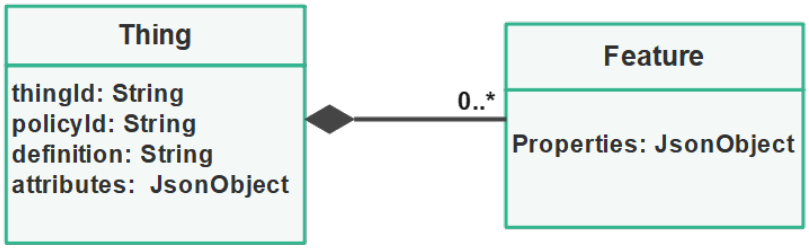


Figure 26: Class Diagram Concept of Digital Twin

4.1 Thing :

The Thing block is a versatile entity that serves as a handle for multiple features, representing a wide range of real-world and virtual objects. It is defined by several key attributes:

- **thingId:** A unique identifier for the thing.
- **policyId:** An identifier for the associated policy, which defines access control rules, specifying which authenticated subjects can read and write the thing or its parts.
- **definition:** A string describing the thing, which can also link to a model defining its capabilities and features, such as a valid HTTP(s) URL or other model references.
- **attributes:** A JSON object containing additional characteristics and metadata about the thing, typically used to describe static properties that do not change frequently.

In the context of e-government services, a Thing can represent a variety of entities such as servers, platforms, or service endpoints. These things are essential for the digital management and monitoring of public services, providing a digital counterpart to physical infrastructure and virtual entities involved in service delivery.

4.2 Feature :

The Feature block represents various features of the thing and is characterized by its properties stored in a JsonObject. A single thing can have multiple features associated with it, allowing for a comprehensive and detailed representation of its capabilities and behaviors. For example, a server might have features representing its current status, capacity, and operational metrics, while a digital service endpoint might include features related to user access and service performance.

4.3 Relationships :

The relationship between Thing and Feature is a one-to-many association, indicating that each thing can have numerous features. This structure supports robust tracking, management, and interaction within the Digital Twin framework, enabling a detailed and dynamic representation of real-world entities in a digital format.

4.4 Metadata :

Metadata refers to additional information associated with a Thing's attributes and features, serving to describe the meaning of the data or provide other useful insights about the data points within the twin.

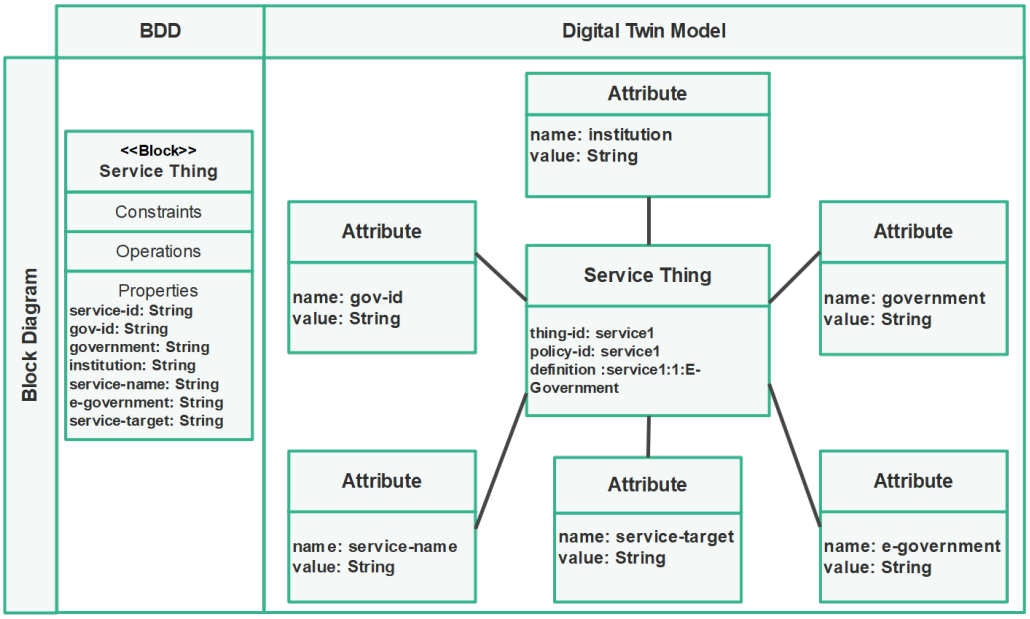


Figure 27: Thing BDD

The Figure 27 represent (BDD) Diagram for the DT model highlights the Service Thing block and its associated Attributes. The Service Thing block includes properties which define its unique identity and operational parameters.
Otherwise each Service Thing is linked to multiple Attribute blocks, each representing a specific characteristic, This structure enables a detailed and organized representation of the BDD of Service thing and its attributes in DT Model.

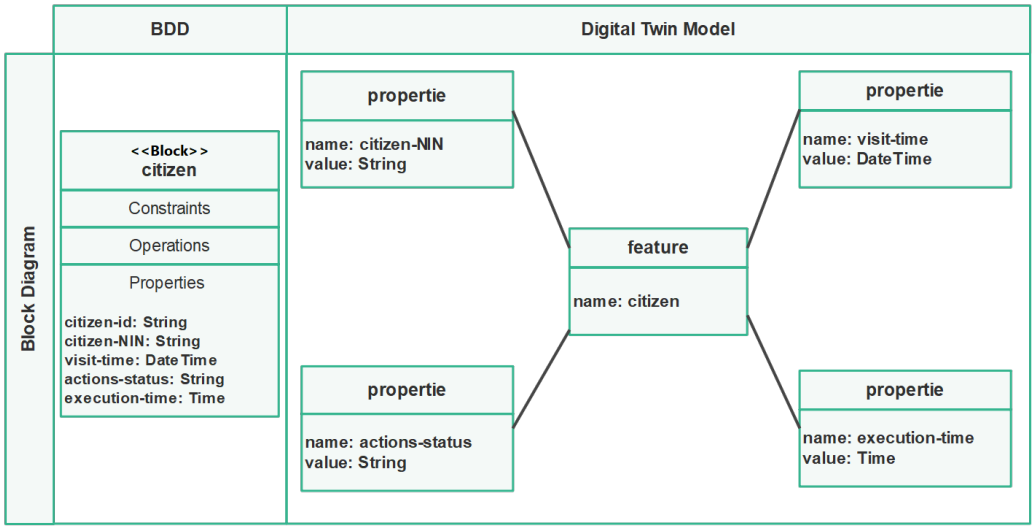


Figure 28: Proprieties of Feature BDD

The Figure 28 represent (BDD) Diagram for the Proprieties of DT thing features :Service, Server, reprisenting Citizen feature and its associated properties provide a detailed representation of the citizen's interactions within the e-government services. The Citizen feature in the Digital Twin model includes these properties, stored as propertie entries, which facilitate accurate tracking and management of citizen data. This structured approach ensures that every interaction and relevant detail is captured and available for real-time monitoring and analysis.

BDD for the Digital Twin model emphasizes the Service Thing and its detailed structure of associated Attributes and Features. Each Service Thing is identified by properties and it is enriched with multiple attributes providing a comprehensive description of the service.
The Features of a Service Thing, such as service, include dynamic properties which capture real-time operational data. This hierarchical and relational structure facilitates detailed in the Figure 29:

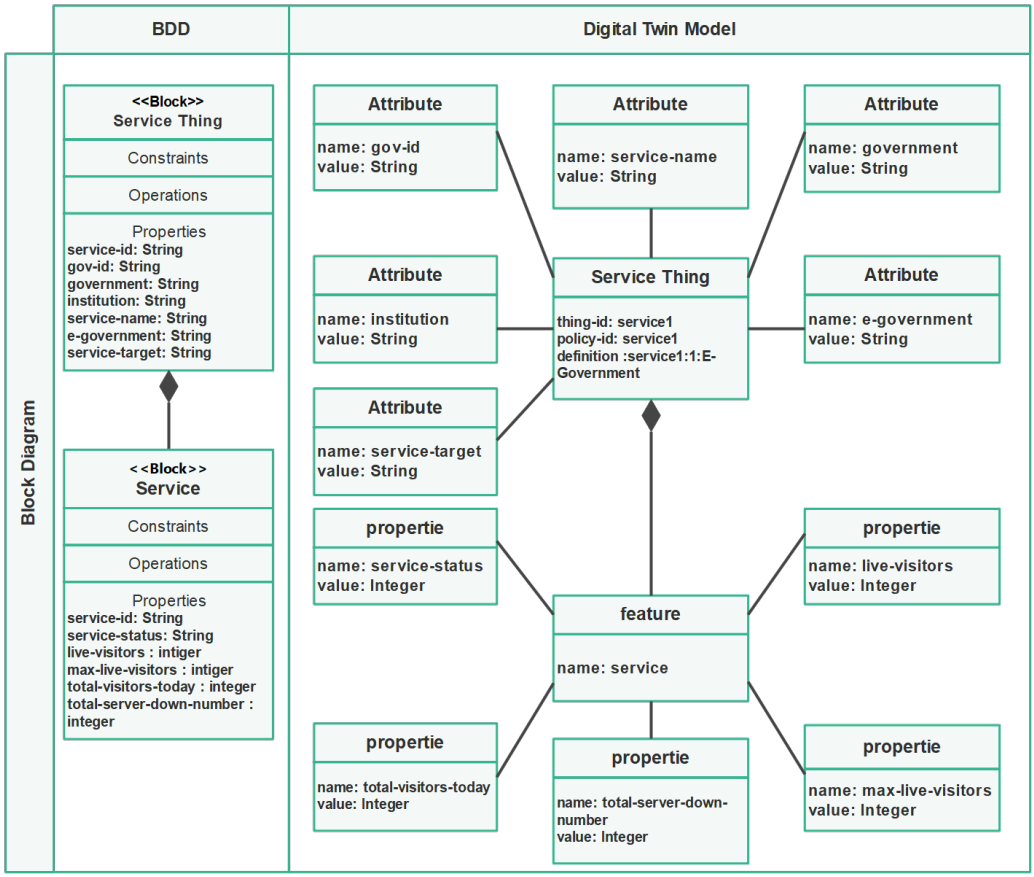


Figure 29: Features of Thing BDD

The Figure 30 illustrate Digital Twin Model Diagram provides a detailed visualization of the ”Service Thing” and its interconnected features and properties. Central to the model is the Service Thing, identified by a unique thing-id, policy-id, definition and defined by attributes , each stored as Attribute objects containing specific metadata. This Service Thing links to multiple features including citizen, service, and server.

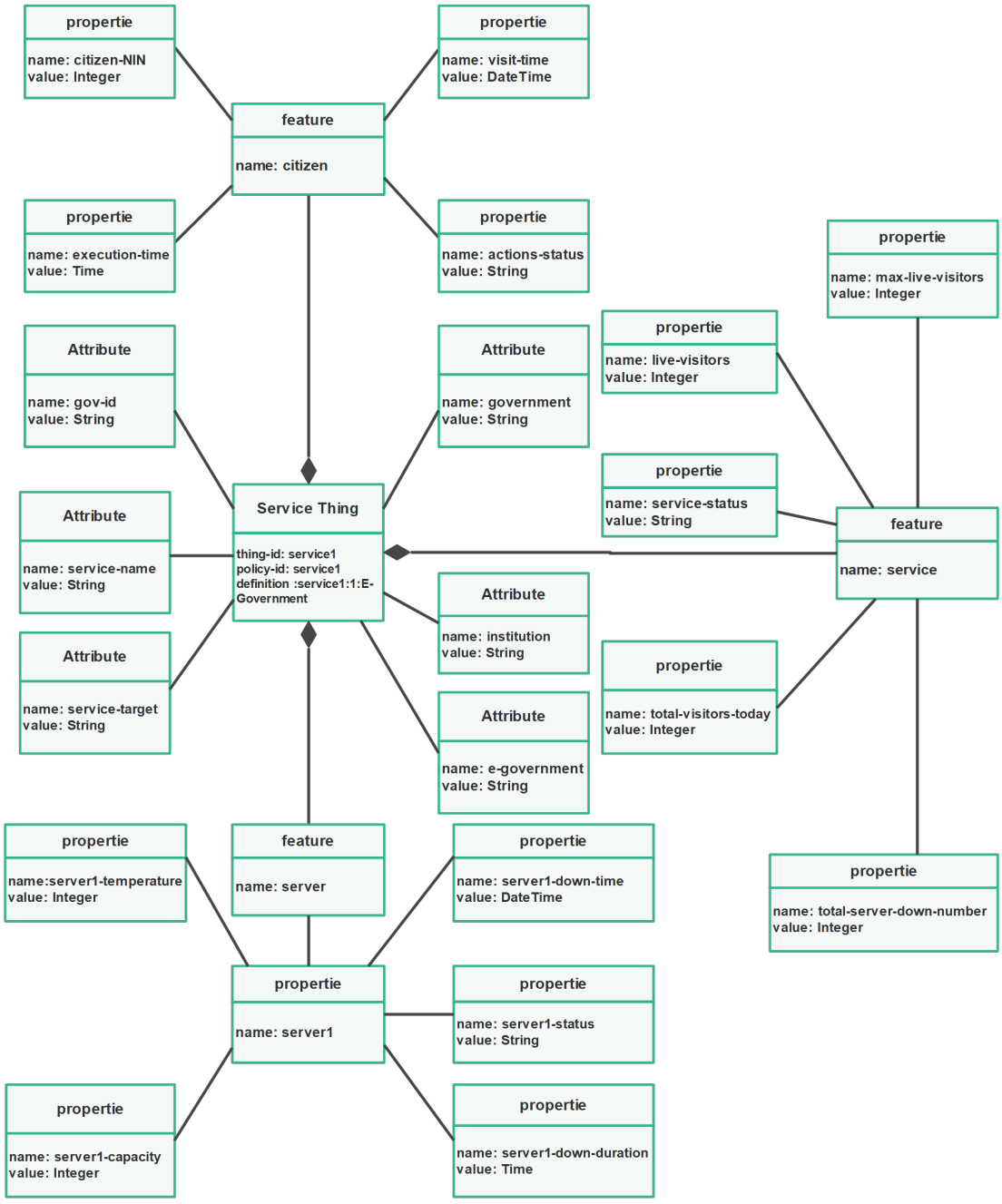


Figure 30: Digital Twin Model Diagram

Each with its own properties. The citizen feature tracks details that capturing vital interactions. The service feature monitors metrics, providing insights into service utilization and performance. The server feature includes properties ensuring thorough tracking of server health and operations. Together, these elements form a comprehensive digital representation of e-government services, facilitating real-time monitoring, management, and optimization.

Using the previous block diagram and the class diagram of Ditto, we present a JSON format of the digital twin, which must respect the hierarchy and decomposition of the concepts of the object; the figure defines the JSON form of the objects of E-government services:


```
{
    "definition": "service1:1:E-Government",
    "attributes": {
        "gov-id": "BICR",
        "government": "Algeria",
        "institution": "Municipal",
        "service-name": "Biometric Identity Card Registration service",
        "e-government": "E-Citizen",
        "service-target": "Government To Citizen"
    },
    "features": {
        "service": {
            "properties": {
                "service-status": "on",
                "live-visitors": 4,
                "max-live-visitors": 5000,
                "total-visitors": 24823,
                "total-visitors-today": 32,
                "total-server-down-number": 3
            }
        },
        "server": {
            "properties": {
                "server1": {
                    "properties": {
                        "server1-status": "on",
                        "server1-capacity": 2598,
                        "server1-temperature": 50,
                        "server1-down-time": "0000-00-00 00:00:00",
                        "server1-down-duration": "00:00:00"
                        }
                    },
                "server2": {
                    "properties": {
                        "server2-status": "off",
                        "server2-capacity": 2596,
                        "server2-temperature": 30,
                        "server2-down-time": "2024-02-20 13:25:26",
                        "server2-down-duration": "2338:50:26"
                    }
                }
            }
        },
        "citizen": {
            "properties": {
                "citizen-NIN": "109980931002650009",
                "visit-time": "2024-04-24 13:25:26",
                "actions-status": "success",
                "execution-time": "00:00:59"
            }
        }
    }
}
Line: 2  Column: 45
```


Figure 31: Digital Twin Model in JSON Format Example

5 Application Platform for supervising a digital twin :

5.1 Use case diagram :

The Digital Twin Use Case Diagram illustrates the various interactions between users and the system within the context of supervising a digital twin for e-government services. Central to this diagram is the DT System, which facilitates key functionalities such as User Management, Authentication, and the Creation and Management of Digital Twins for E-Government Services. The Service Thing Supervision use case is pivotal, encompassing both Service Thing Creation and Service Thing Monitoring, which are integral for maintaining the digital twins. Actors in the diagram include the DT Administrator, Service Administrator, and Citizen, each interacting with different parts of the system. The DT Administrator is primarily responsible for higher-level operations like User Management, Authentication, and overseeing the creation and management of digital twins. The Service Administrator focuses on Alert Management and receiving alerts related to the digital twins, ensuring prompt responses to any issues. The Citizen interacts with the system through activities such as Sending Data and Data Entry, providing essential input that keeps the digital twins up-to-date.

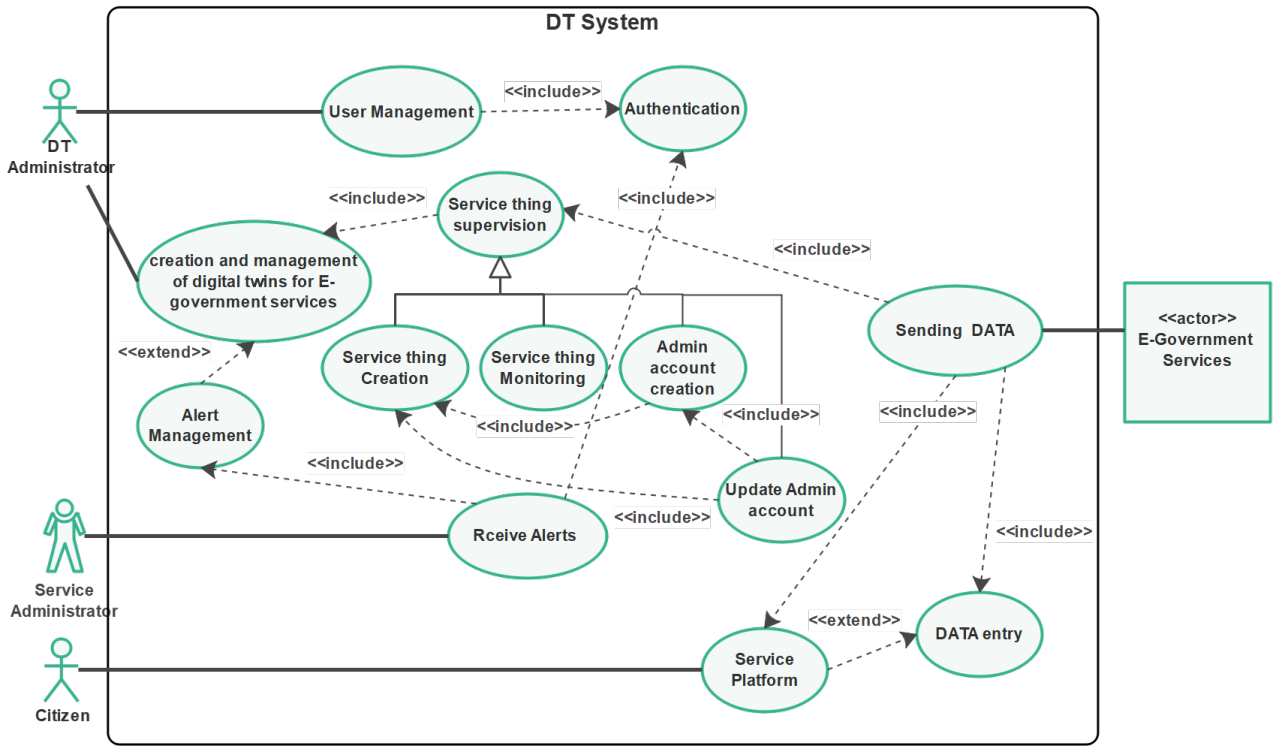


Figure 32: Digital Twin Use Case Diagram

Included within these primary use cases are various sub-functions, like Service Thing Supervision incorporating Service Thing Creation and Service Thing Monitoring, and Service Platform which is extended by Data Entry and includes Receiving Alerts. This structure highlights the comprehensive nature of the system, ensuring that all aspects of digital twin management, from data entry to alert management, are covered efficiently.

Overall, the diagram encapsulates the collaborative effort required to maintain and supervise digital twins within an e-government framework, ensuring robust, real-time management and interaction capabilities.

5.2 Sequence diagram :

The Sequence Diagram provides a detailed visual representation of the interactions and the chronological order of events between different components and actors within the digital twin system. The key actors involved in this sequence diagram are:

- DT Administrator: Responsible for overseeing the entire digital twin system, managing users, and ensuring the system's smooth operation.
- Application: Represents the front-end interface or software application through which users interact with the digital twin system.
- DT Platform: The core platform that hosts and manages the digital twins, handling their creation, monitoring, and supervision.
- Service: Refers to the specific e-government service being managed and monitored within the digital twin system.
- Citizen: The end-user who interacts with the e-government service, providing input data and receiving services.
- Service Administrator: Manages the specific e-government service, ensuring it runs effectively and addresses any issues that arise.

This diagram captures the sequence of interactions between these actors during various processes such as user management, service monitoring, data entry, and alert management, illustrating the flow of messages and operations that ensure the seamless functioning of the digital twin system in e-government applications.

5.2.1 Authentication :

In the authentication sequence, the DT Administrator initiates a login request by sending their credentials to the Application. The Application verifies these credentials against its database. Depending on the correctness of the provided credentials, the Application either grants access to the DT Administrator or prompts an error message for incorrect credentials, As shown in the following diagram:

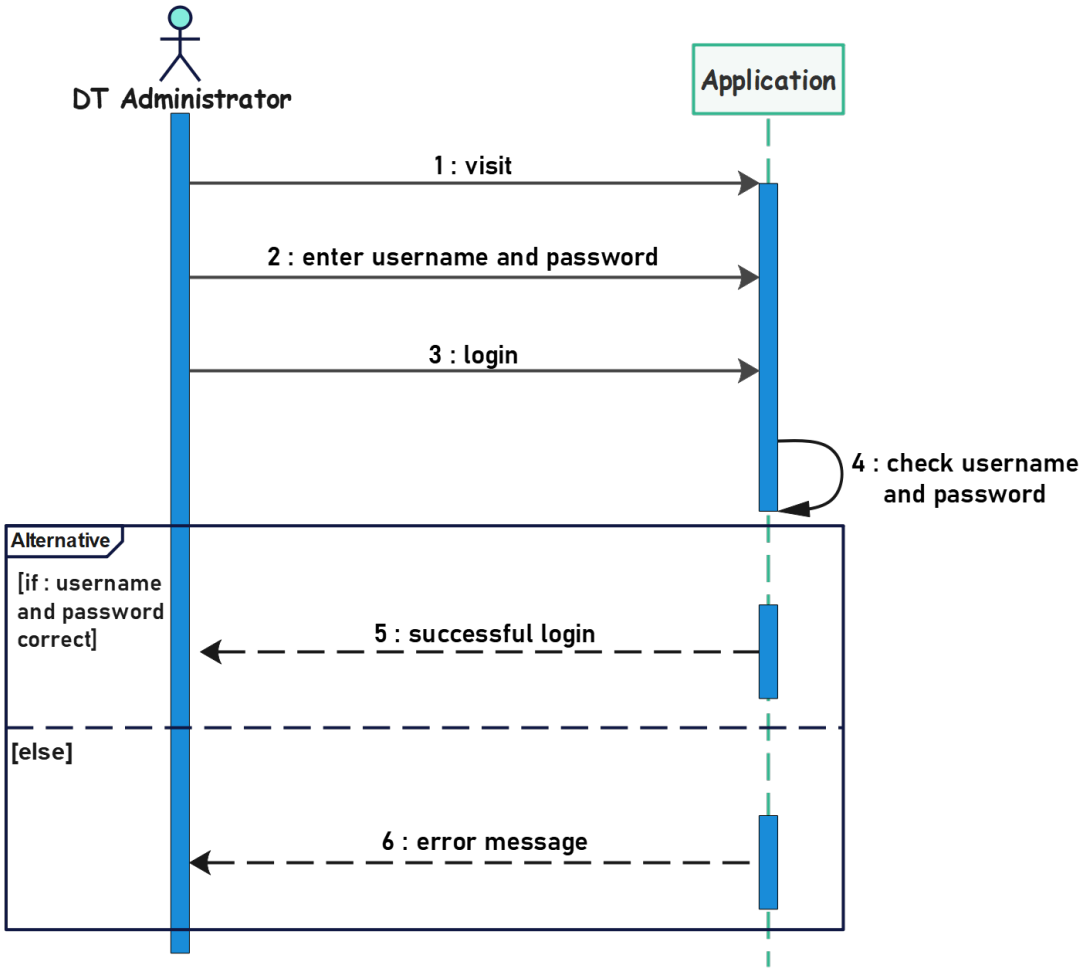


Figure 33: Authentication Sequence Diagram

5.2.2 Thing creation :

In the thing creation process, after successful authentication, the DT Administrator sends a request to create a new digital twin to the Application. The Application forwards this request to the DT Platform, which processes the creation of the new digital twin entity. Upon successful creation, the DT Platform returns a confirmation response back through the Application to the DT Administrator, As shown in the following diagram:

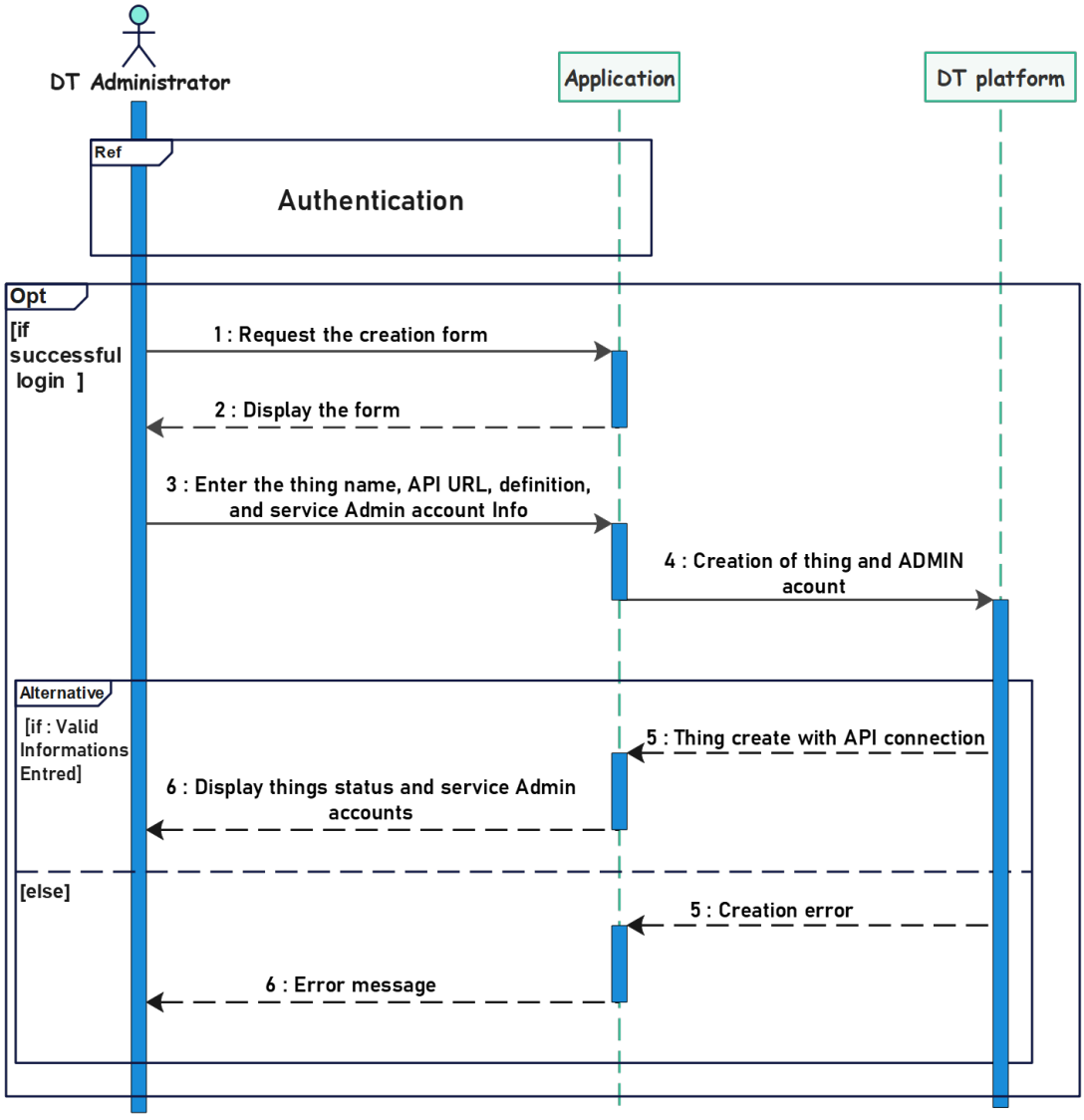


Figure 34: Thing Creation Sequence Diagram

5.2.3 E-government Services Supervision :

The DT Administrator initiates a request through the Application to supervise the current status of e-government services. The Application queries the DT Platform, which retrieves and processes real-time data on these services. This data is then sent back to the Application, which displays the current supervision status to the DT Administrator, enabling effective monitoring and management, As shown in the following diagram:

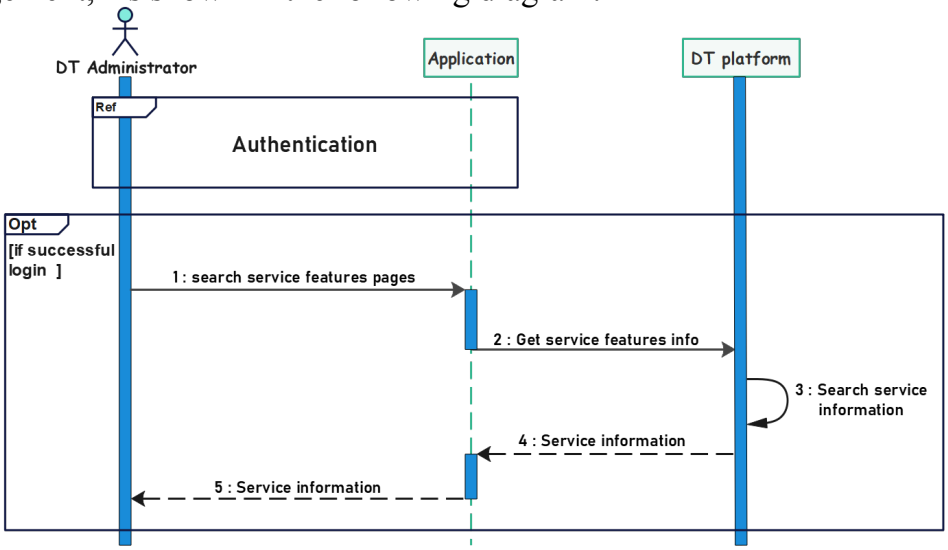


Figure 35: Display Current Supervision Sequence Diagram

The DT Administrator logs into the Application, which then enters a loop to continuously check for new service values. The Application sends requests to the DT Platform to fetch updated information from the Service. Upon receiving the new data, the DT Platform updates the Application, allowing the DT Administrator to supervise the latest information regarding e-government services in real-time, As shown in the following diagram:

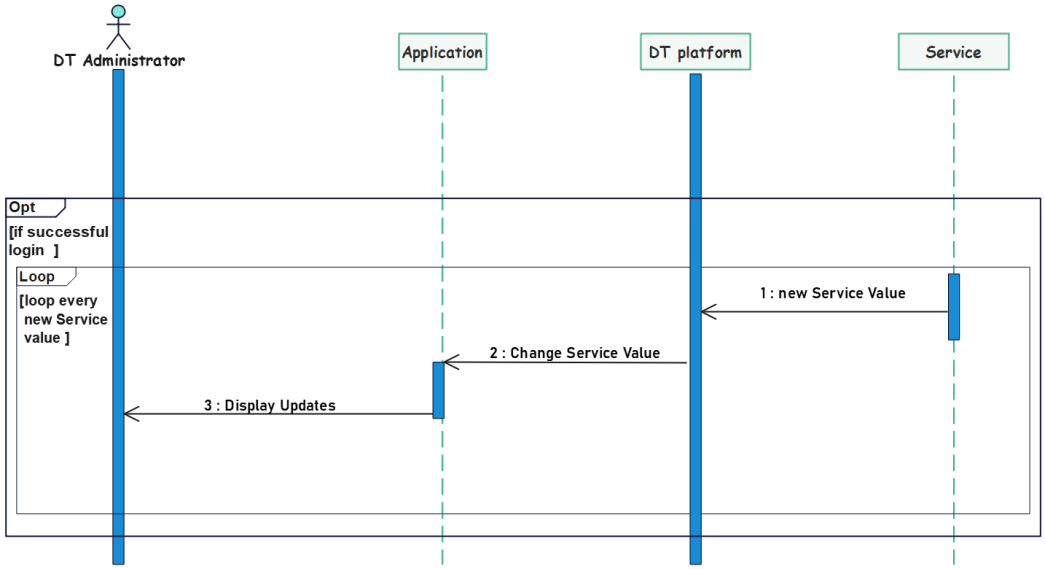


Figure 36: Display New Information Supervision Sequence Diagram

5.2.4 Alert management :

In the alert management process, the DT Administrator starts by logging into the Application, which triggers the DT Platform to monitor the status of various services. When a specific condition or threshold is detected, the DT Platform generates alerts and sends them to the Service. If the DT Platform detects a visiting error to the service or an execution error, it triggers the alert mechanism. The Service then responds to both the Citizen and the DT Platform simultaneously, notifying the Service Administrator of the alert. This allows for timely and appropriate actions to address any issues, ensuring that citizens are kept informed of any disruptions or important updates, promoting transparency and efficient resolution of problems, As shown in the following diagram:

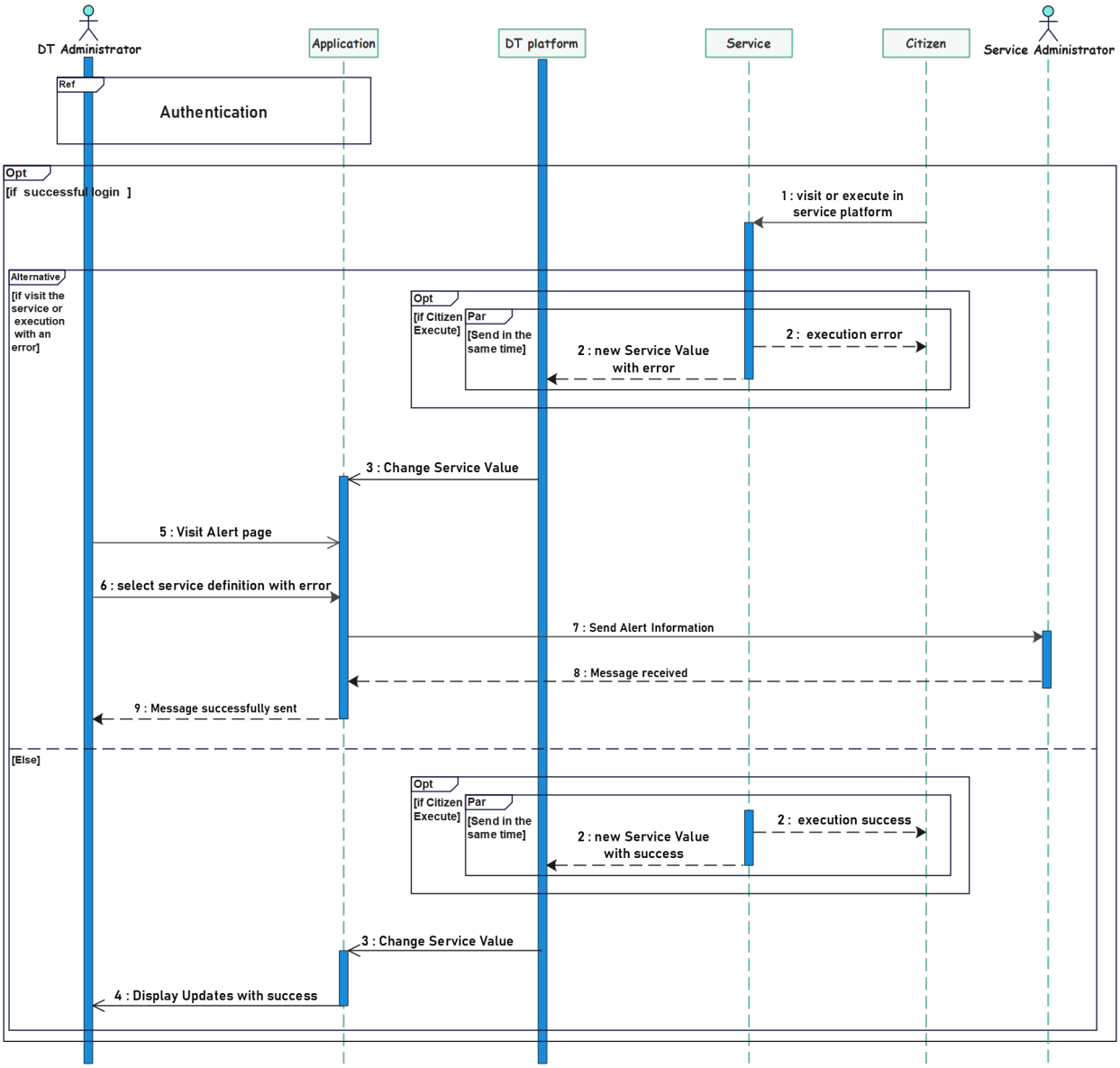


Figure 37: Alert System Sequence Diagram

6 Conclusion :

In this chapter, we have comprehensively examined the various processes and mechanisms involved in the digital transformation and e-government services supervision. Through detailed sequence diagrams, we elucidated the authentication procedures, thing creation, current supervision, new information supervision, and alert management processes. These steps illustrate the importance of a robust and transparent system for monitoring and managing e-government services, ensuring efficient communication between the DT platform, services, and citizens. By streamlining these processes, we can enhance service delivery, improve responsiveness to issues, and ultimately foster greater trust and satisfaction among citizens.

Chapter 4: Implementation

1 Introduction :

In this chapter, we delve into the practical aspects of implementing a comprehensive e-government services supervision system. The focus is on the digital tools and methodologies employed to create, monitor, and manage services effectively. We explore the Digital Twin API, the Node Red platform, and various web application interfaces designed to facilitate seamless interaction and oversight. By detailing the steps and components involved in this digital transformation, we aim to provide a clear understanding of the implementation process and its critical role in enhancing e-government services.

2 Integration of E-government Services in DT Platform :

The integration of e-government services into the Digital Twin (DT) platform is a critical step towards enhancing the efficiency and effectiveness of public service delivery. This integration involves connecting various e-government service servers to a central DT server through the Internet of Things (IoT). The DT server continuously monitors the status of these services, ensuring real-time data flow and management.

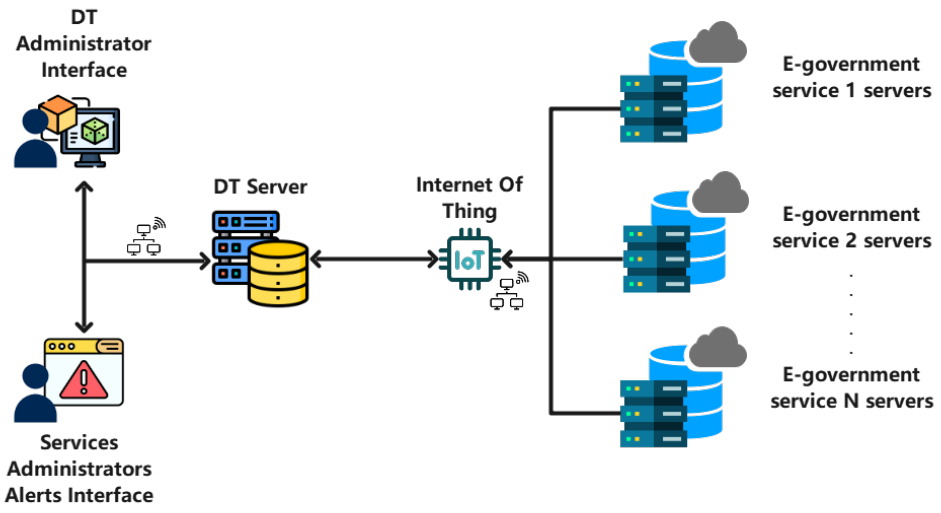


Figure 38: DT of e-govement services

In the depicted system architecture, e-government service servers are connected to the DT server via IoT, allowing for seamless communication and data exchange. The DT server communicates directly with the Services Administrators Alerts Interface, notifying service administrators through a dedicated interface. This setup ensures that administrators are promptly informed of any issues or disruptions, enabling them to take timely corrective actions.

The DT administrator interface allows administrators to manage and monitor the entire system effectively. By providing a centralized view of all e-government services, the DT platform enhances transparency, improves service reliability, and facilitates the proactive resolution of potential problems. This integration ultimately contributes to a more responsive and user-centric public service infrastructure.

3 Digital implementation :

In this section, we present the technical tools for implementing a Digital Twin (DT) platform for managing e-government services. The primary focus is on the integration and utilization of various digital tools and APIs that facilitate the creation, monitoring, and management of digital representations of physical systems. By leveraging these technologies.

3.1 Digital Twin API :

The Digital Twin API serves as the backbone of the DT platform, providing a set of standardized protocols and interfaces for interacting with digital twins. This API enables seamless communication between the DT platform and various e-government services, ensuring real-time data exchange and monitoring. The use of a robust and flexible API is crucial for the effective implementation and scalability of the DT platform.

3.1.1 DT Platform (Eclipse Ditto™ HTTP API):

The Eclipse Ditto™ HTTP API is a JSON-based, REST-like API designed for managing digital twins within the Eclipse Ditto platform. The API adheres to the HTTP status codes defined in RFC 7231 to indicate the success or failure of specific requests.

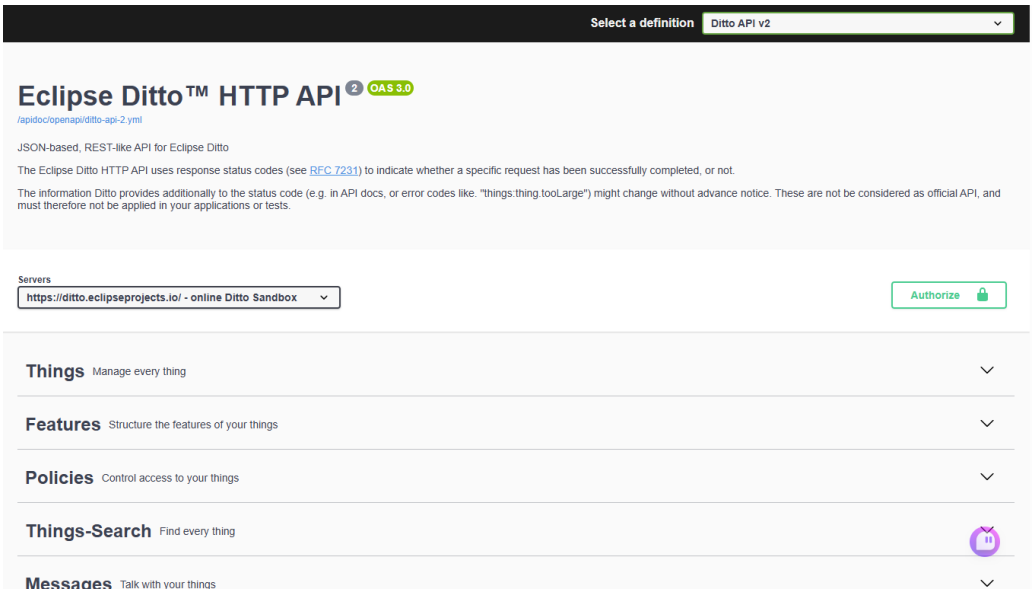


Figure 39: Eclipse Ditto™ HTTP API[56]

The main interface of the Eclipse Ditto™ HTTP API documentation. The key features include:

- Servers: The dropdown menu allows the selection of different servers, with the current selection being the ”online Ditto Sandbox”.
- Things: This section is dedicated to managing every ”thing” (or digital twin) within the platform.
- Features: This section allows for the structuring of various features of the digital twins.
- Policies: This section provides controls for access management to the digital twins.
- Things-Search: This section enables searching for specific digital twins.
- Messages: This section facilitates communication with your digital twins through messages.
- CloudEvents: This section handles the processing of CloudEvents in Ditto, which is crucial for event-driven interactions and notifications.
- Connections: This section manages the connections to various data sources and sinks, ensuring that the DT platform can interact with external systems effectively.
- DevOps: This section includes APIs to manage log levels and configurations at runtime and to send piggyback commands, enhancing operational control and flexibility.

The API documentation is structured to provide comprehensive details on each of these functionalities, ensuring that developers can effectively implement and manage digital twins within the Eclipse Ditto platform. The authorization button ensures secure access to the API, which is essential for maintaining the integrity and security of the data and services managed through the DT platform.

3.1.2 Things Interface :

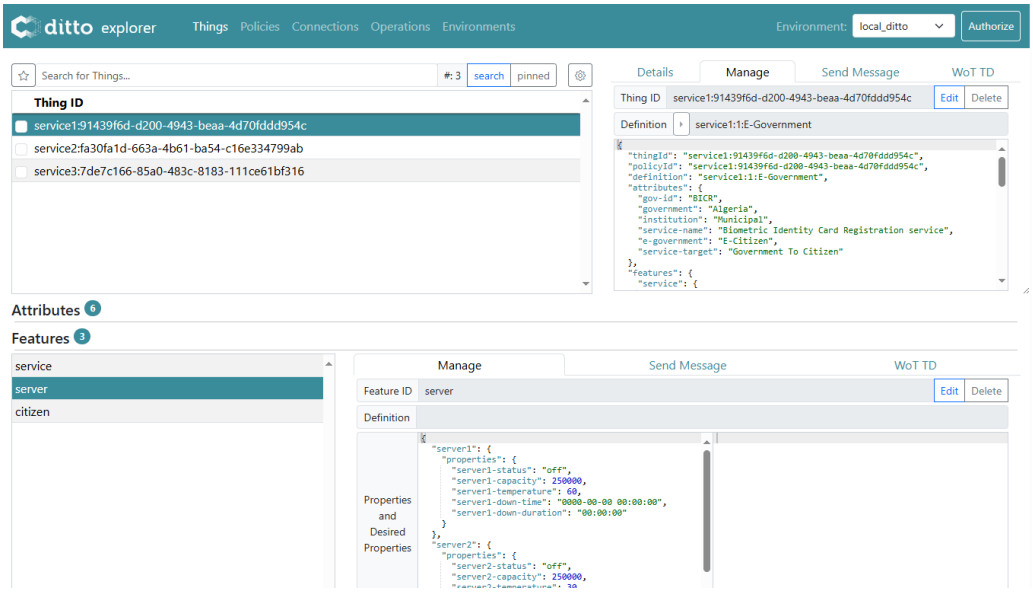


Figure 40: Eclipse Ditto™ explorer

The Things Interface in Eclipse Ditto™ serves as the central hub for managing digital twins, referred to as ”things.” This interface allows users to view and edit detailed attributes and features associated with each digital twin, facilitating comprehensive oversight and control. As shown, users can manage attributes such as government ID, institution, and specific service names, while also handling features related to service performance, server status, and citizen interactions. This robust interface supports the seamless integration and monitoring of various e-government services, ensuring that each digital twin is accurately represented and maintained within the platform.

3.2 Node Red :

Node-RED is a flow-based development tool for visual programming, ideal for wiring together hardware devices, APIs, and online services. In the context of digital twin implementation, Node-RED plays a crucial role in automating workflows, integrating services, and managing data flows between different systems. This section delves into the practical application of Node-RED for creating and managing service things in a digital twin environment, it employed in this implementation to create and manage workflows that interact with the Eclipse Ditto platform, ensuring that all components work together seamlessly.

3.2.1 Service Thing Creation Flux:

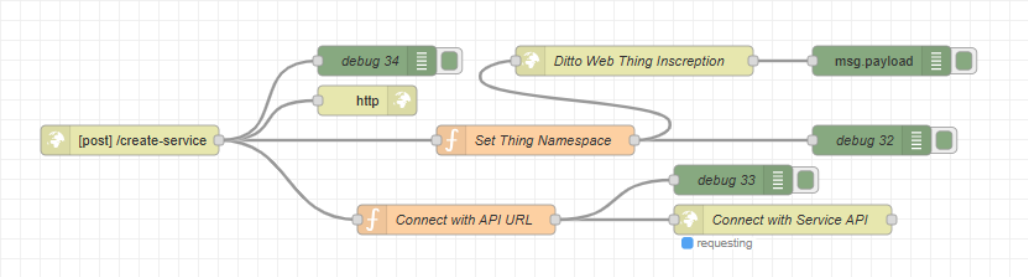


Figure 41: Create Things Nodes

The Service Thing Creation Flux in Node-RED outlines the workflow for creating digital twin representations of e-government services. As shown in the provided images, this flow starts with an HTTP POST request to create a service. Subsequent nodes handle various tasks such as setting the namespace, connecting with the API URL, and inscribing the service into the Ditto Web Thing. Debug nodes are included to monitor the process, ensuring that each step is executed correctly.

3.2.2 Monitoring Flux:

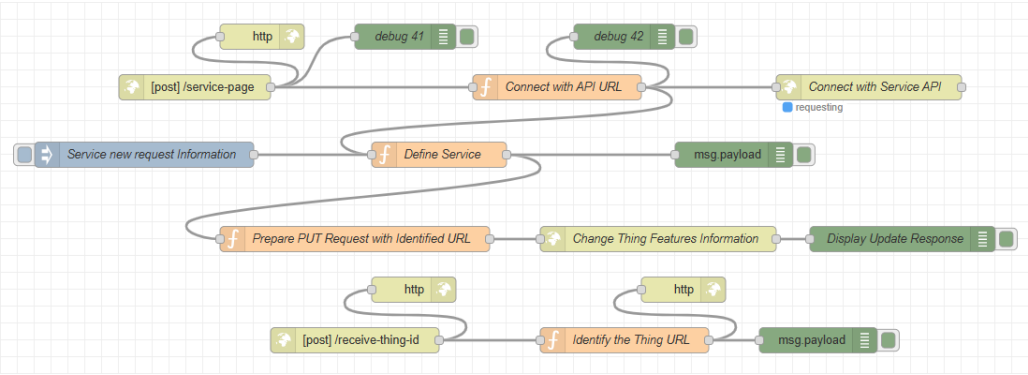


Figure 42: Service Things Monitoring Nodes

The flowchart of Figure 42 details a process where the system first enters the service page and connects with the Service API to receive the thingid and definition for the selected service. It then defines the service thing with the selected service definition, using the identified thing URL that include the thingid. The system prepares a PUT request with the identified URL to change the service's features. Finally, it sends the PUT request to update the specific service's features and displays the response, ensuring the service is correctly updated and monitored.

3.2.3 Notifying and Sending Alerts Flux:

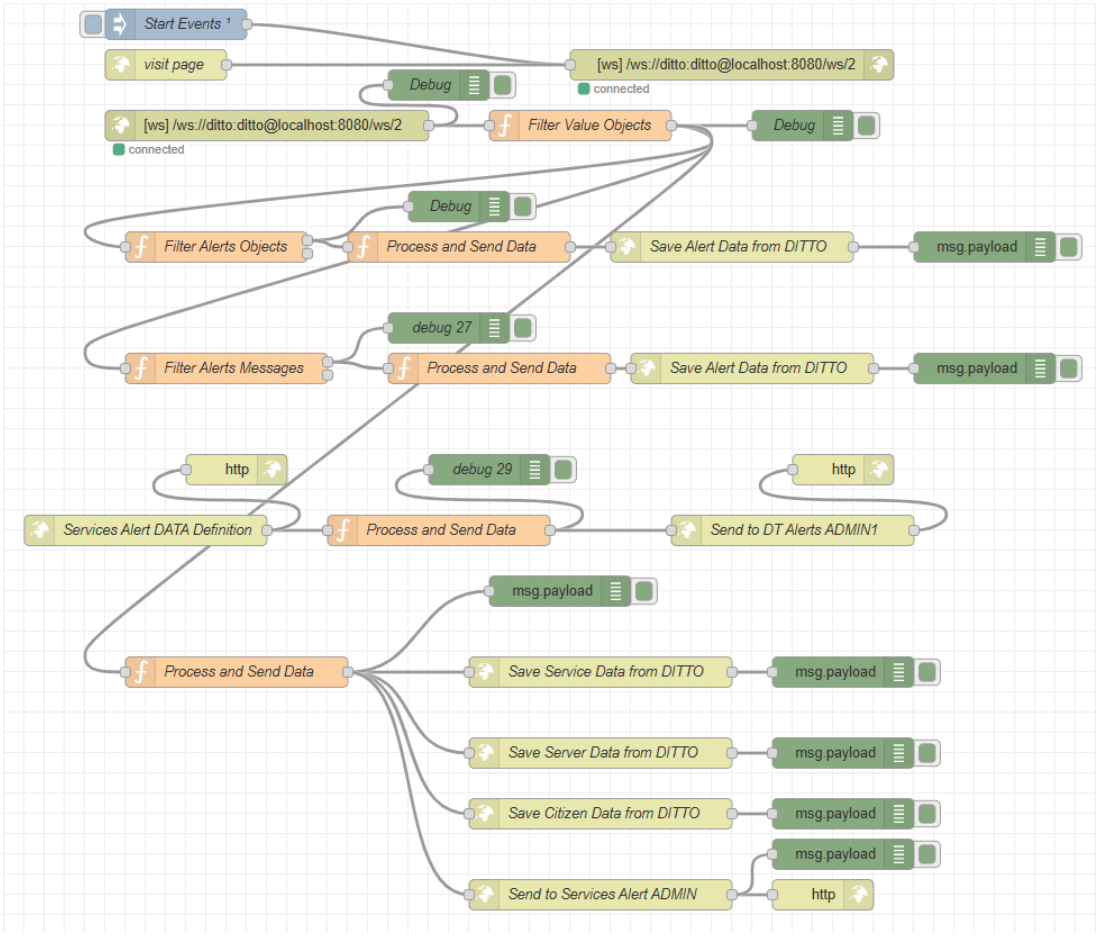


Figure 43: Alerts Nodes

The Figure 43: Alerts Nodes represent a Node-RED flow that manages alert data. The process begins with a trigger node that activates upon a page visit, sending a message payload START-SEND-EVENTS that subscribes to the Ditto WebSocket. A WebSocket node listens for messages from a local Ditto server endpoint (/ws/:ditto:ditto@localhost:8080/ws/2), informing any new information sent to the Things from services. The incoming data is filtered through various function nodes, such as ”Filter Value Objects” and ”Filter Alerts Objects,” to isolate relevant alert objects and messages. Debug nodes are strategically placed to display the flow of messages for monitoring purposes. The filtered alert data is processed and saved using nodes like ”Process and Send Data” and ”Save Alert Data from DITTO,” with the data stored in msg.payload. various types of data such as service, server, and citizen data are saved from DITTO and sent to the services alert administrator.

The second Flow, an HTTP node fetches alert data definitions from a Services Alerts page, which are then processed and sent to the DT Alerts Admin endpoint. The entire flow ensures that alerts are filtered, processed, and transmitted to the appropriate destinations for further action.

4 Web Application :

This section outlines the various interfaces and functionalities of the web application designed to support and enhance e-government services through the integration of Digital Twin technology. Each subsection provides a detailed look at specific components of the application, including the initial interface, authentication process, service dashboards, and various monitoring interfaces. For development, we employed technologies such as HTML, CSS, and JavaScript for creating the static components of the web pages, while PHP was utilized to generate dynamic pages and handle HTTP requests in JSON format.

4.1 First Interface :



Figure 44: Home Page

The first interface of the web application serves as the landing page for the Digital Twin platform, aimed at enhancing e-government services through advanced technology. It features a clear and bold headline introducing the platform, accompanied by an illustrative image showcasing the interconnected nature of digital services. The page includes two prominent buttons, ”DT Login” and ”Alert Login,” which direct users to the respective login interfaces for accessing the Digital Twin system or services alerts management functionalities, while the navigation bar provides quick links to the Home, About, and Contact pages.

4.2 Authentication Interface :

The Authentication Interface for E-government services is crucial for ensuring secure and seamless access to various digital services offered by the government. This section highlights the login interfaces designed for the E-government services Digital Twin (DT) and Alerts, showcasing their user-friendly design and functionality aimed at providing a secure authentication process.

4.2.1 E-government services DT LogIn :



Figure 45: E-government services DT LogIn Interface

The Figure 45 illustrates the login interface for E-government services Digital Twin (DT). It features a clean and simple design with fields for Username and Password, a checkbox to remember the device, The interface is straightforward, ensuring users can easily log in to access their digital twin services.

4.2.2 E-government services Alerts LogIn :

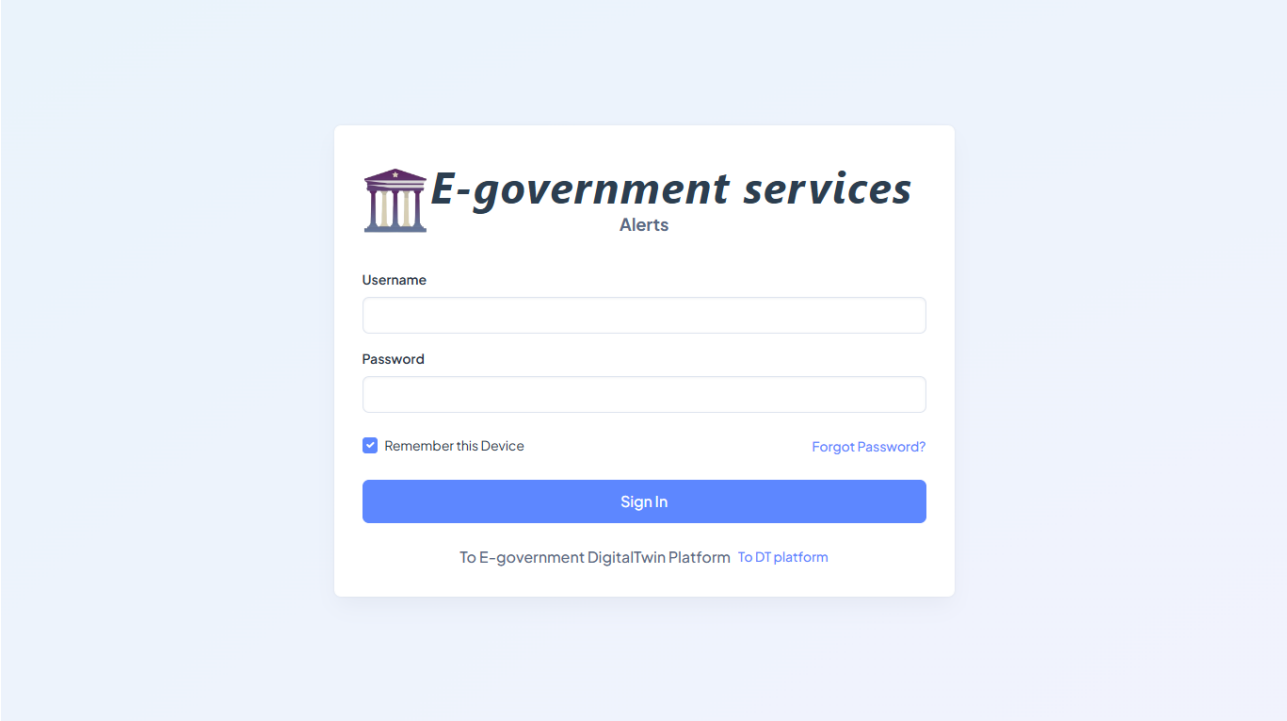


Figure 46: E-government services Alerts LogIn Interface

The Figure 46 presents the login interface for E-government services Alerts. Similar in design to the DT login, it includes fields for Username and Password, along with options to remember the device. This interface ensures that users can securely access the alert services, highlighting its tailored purpose for alert-related functionalities.

4.3 Create service thing :

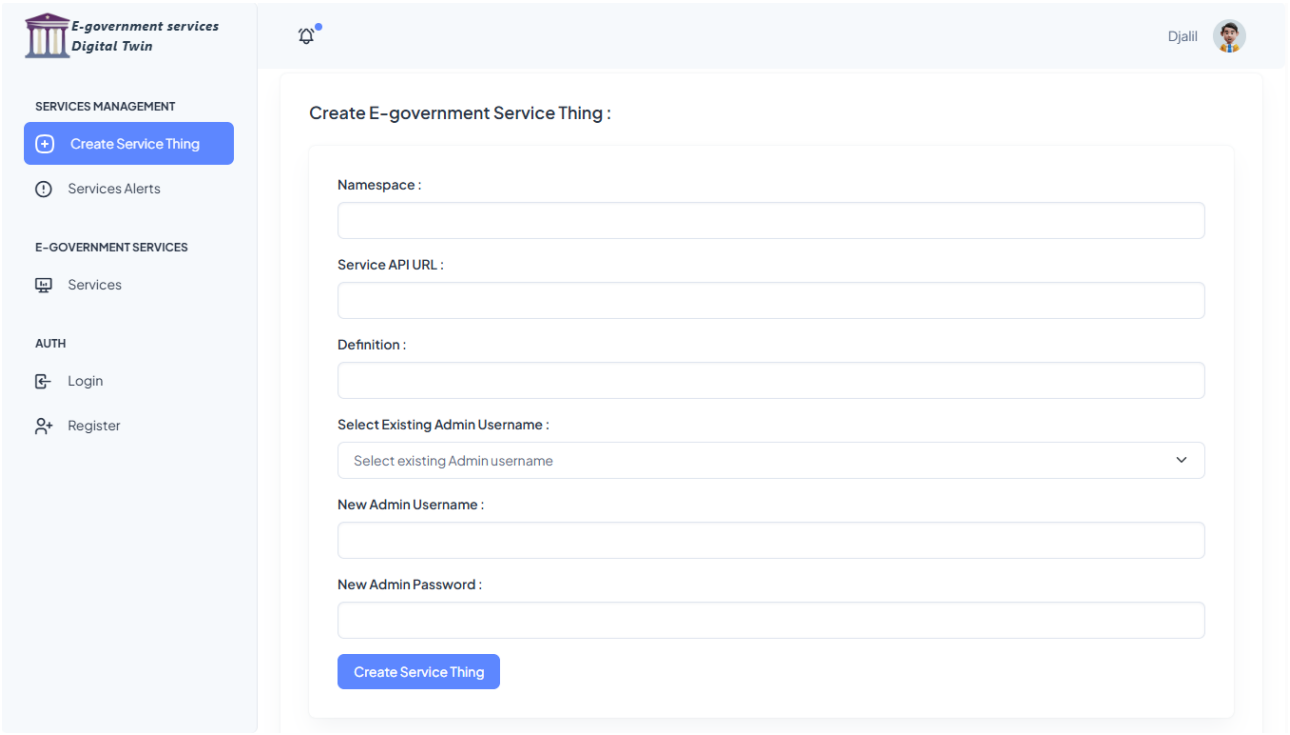


Figure 47: Create Service Things

The Figure 47 illustrates the ”Create E-government Service Thing” interface, where administrators can add new services. The form requires inputs for Namespace, Service API URL, Definition, The form also allows selecting an existing admin username or creating a new admin username with a corresponding password. ensuring that all necessary information for the new service is provided. Located in the ”Services Management” section, this interface is accessible via the ”Create Service Thing” option in the sidebar. The user-friendly design simplifies the process of creating new service entries, promoting ease of use and efficiency. Finally, the form’s submission button, labeled ”Create Service Thing,” allows administrators to finalize and add the new service to the system.

4.4 Supervise service things :

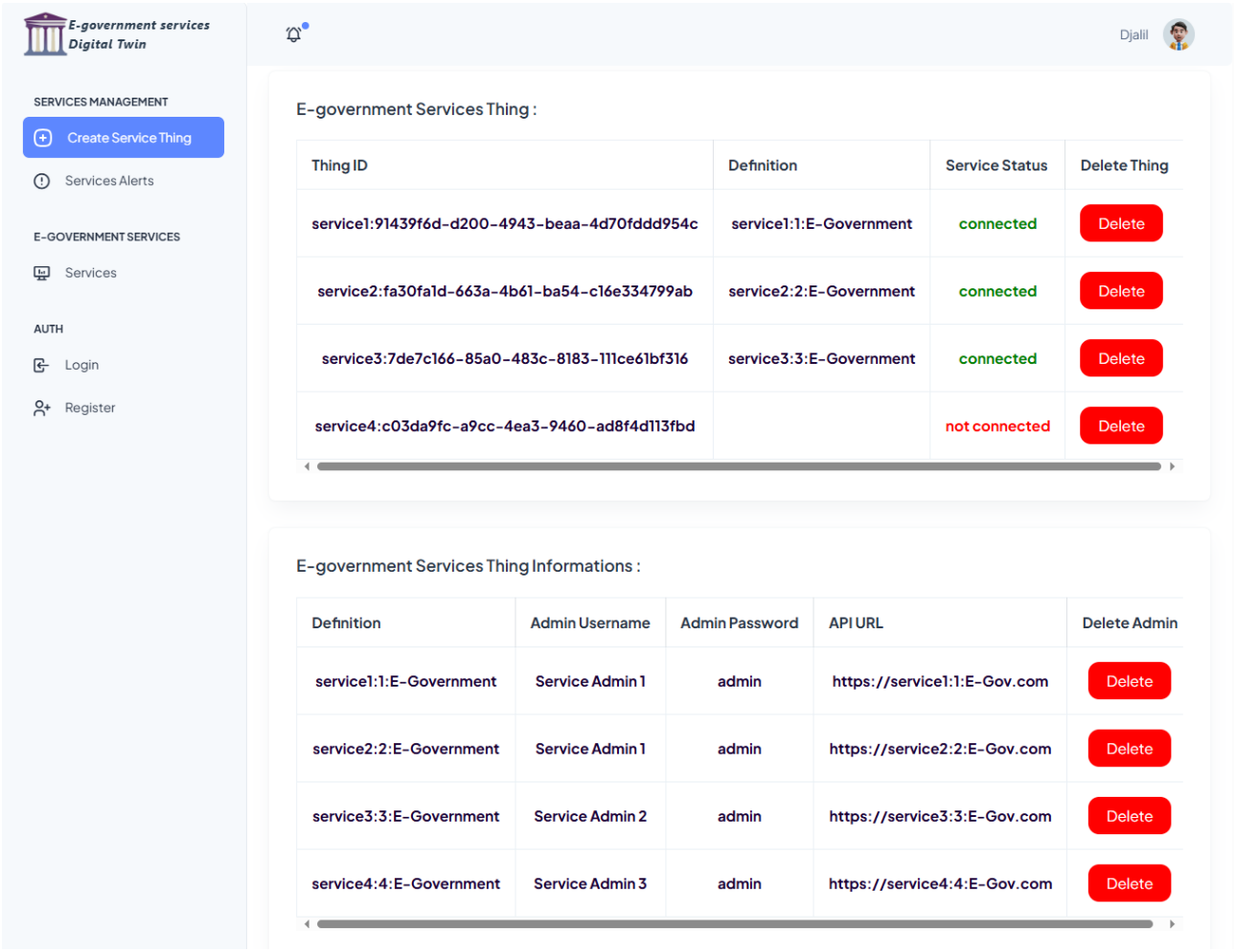


Figure 48: Supervise Service Things

The Figure 48 depicts the supervision interface for "E-government Services Thing." It shows a list of existing service things with details like Thing ID, Definition, Service Status, and an option to delete each service. There are connected and not connected statuses that identified by service definition indicated by green and red labels, respectively. Below this list, another table provides additional information about each service, including Definition, Admin Username, Admin Password, and API URL. The interface is designed to offer comprehensive monitoring and management capabilities for administrators, ensuring efficient oversight of all registered service things.

4.5 Service Dashboard :

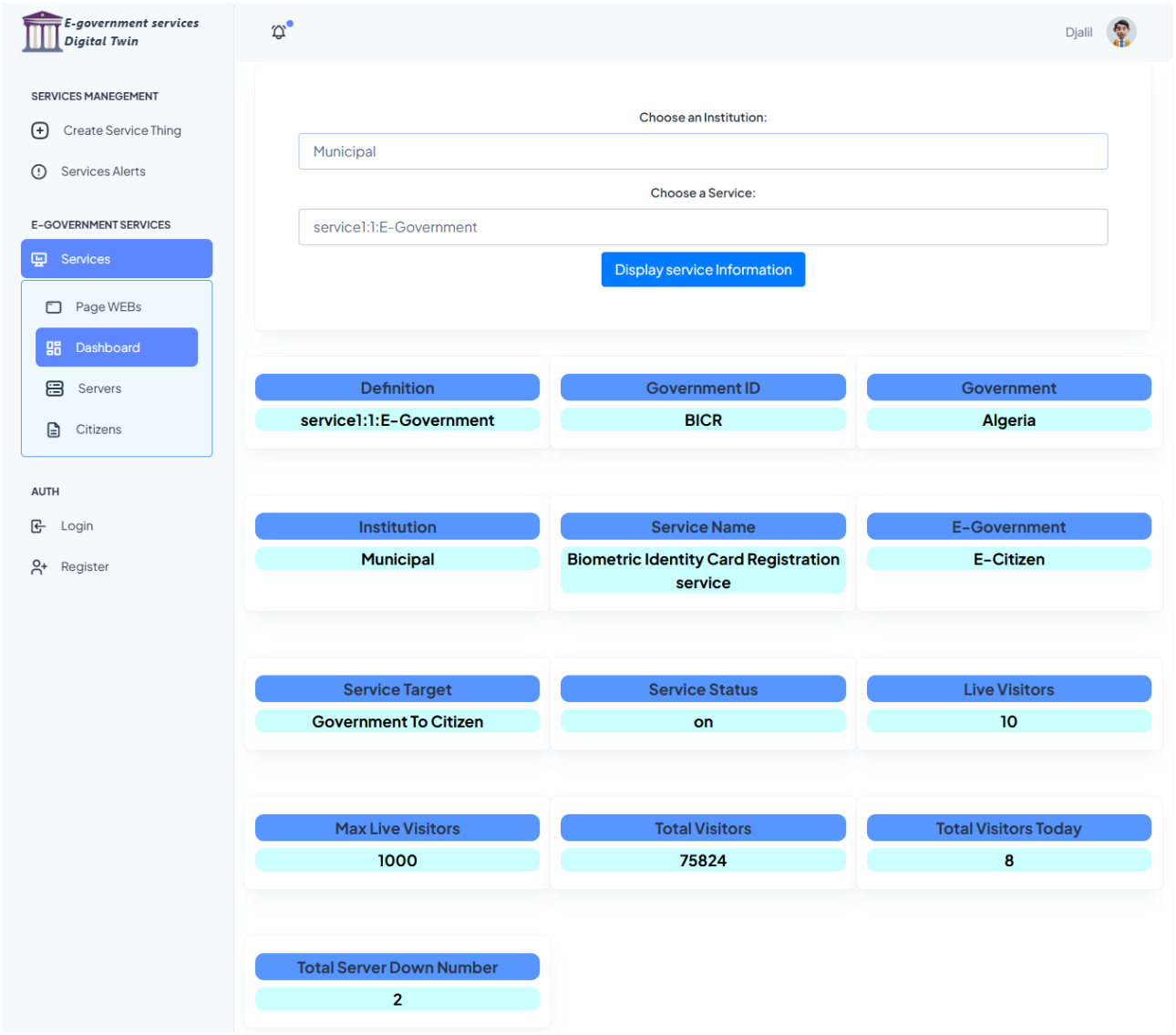


Figure 49: Service Dashboard Interface

The Service Dashboard page provides a comprehensive overview of the Biometric Identity Card Registration service, highlighting key details and metrics.It shows detailed information for a selected service with a specific institution then service identifier such as Definition, along with essential information like Government ID, Government (Algeria), and Institution (Municipal). The dashboard also includes service-specific data such as Service Name, E-Government type, and Service Target, alongside real-time statistics like Service Status, Live Visitors, and Total Visitors, ensuring administrators have immediate access to critical service performance indicators.

4.6 Servers Monitoring interface :

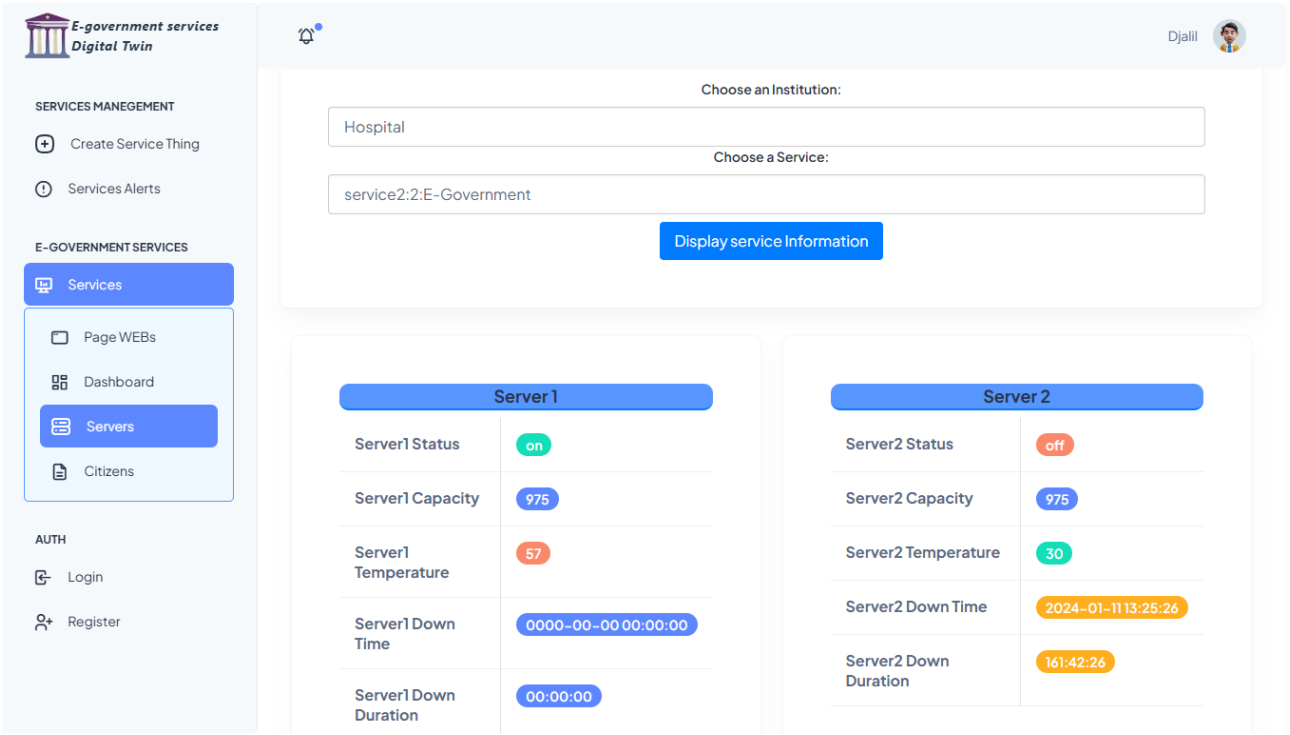


Figure 50: Service Servers Interface

The Servers Monitoring Interface provides detailed real-time information about the status and performance of two servers for the selected service, by selecting specific institution then service identifier, associated with the Biometric Identity Card Registration service. For Server 1, it shows the server's status as "on," its capacity at 975, temperature at 52 degrees, and zero downtime, indicating optimal performance. Server 2, however, is marked as "off," with the same capacity but a lower temperature of 28 degrees, and it includes specific details on its downtime and duration, highlighting an ongoing issue that requires attention. This interface allows administrators to quickly assess server health and address any issues to ensure continuous service availability.

4.7 Citizens Monitoring interface :

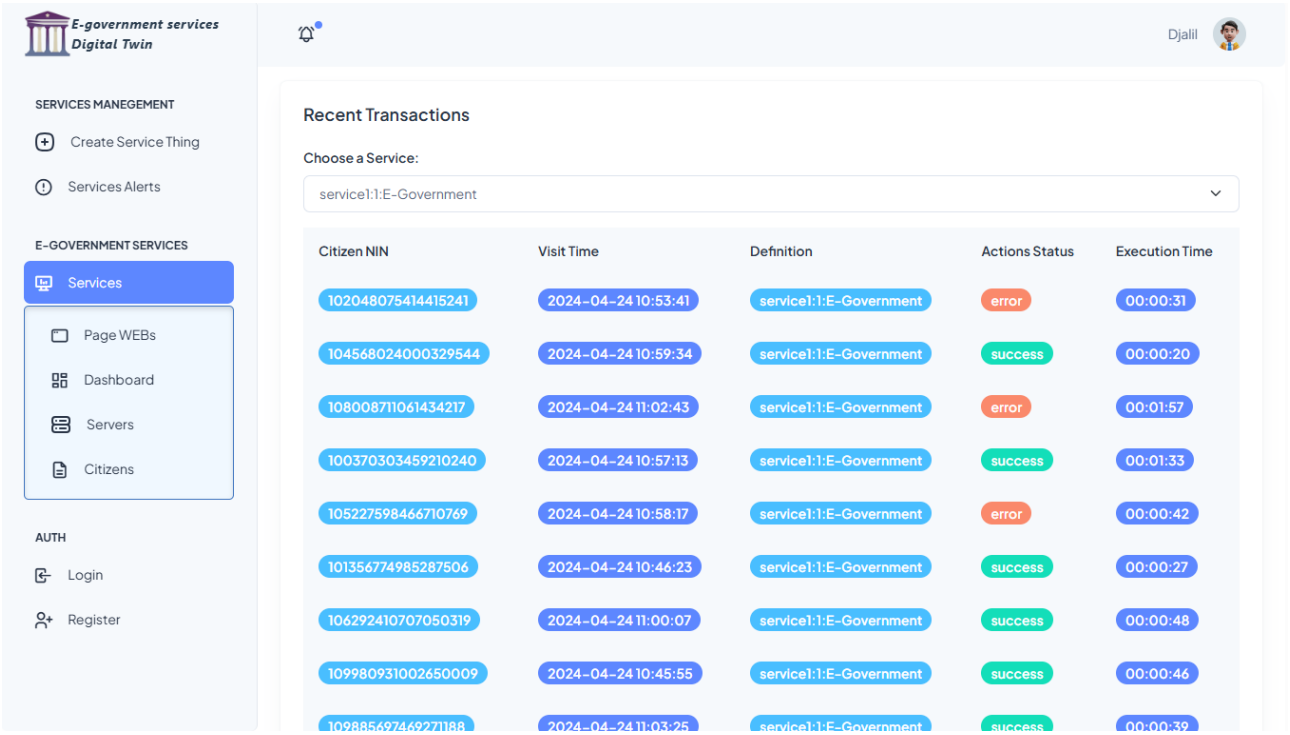


Figure 51: Service Citizens Interface

The Citizens Monitoring Interface provides a detailed overview of recent transactions involving citizens interacting with the Biometric Identity Card Registration service., by selecting specific service identifier. Each entry lists the citizen's National Identification Number (NIN), the exact visit time, the status of the action (success or error), and the execution time for each transaction. This interface allows administrators to monitor and analyze citizen interactions in real-time, identify any errors quickly, and ensure efficient service delivery by tracking the performance and response times of the system.

4.8 Services Alerts Management:

The Services Alerts Management interface allows administrators to monitor and manage alerts for various e-government services. It provides detailed information on alert messages, including the alert time, service definition, citizen NIN, service status, and action taken. Administrators can view and respond to alerts to ensure that issues are promptly addressed.

4.8.1 DT Administrator Alerts Interface:

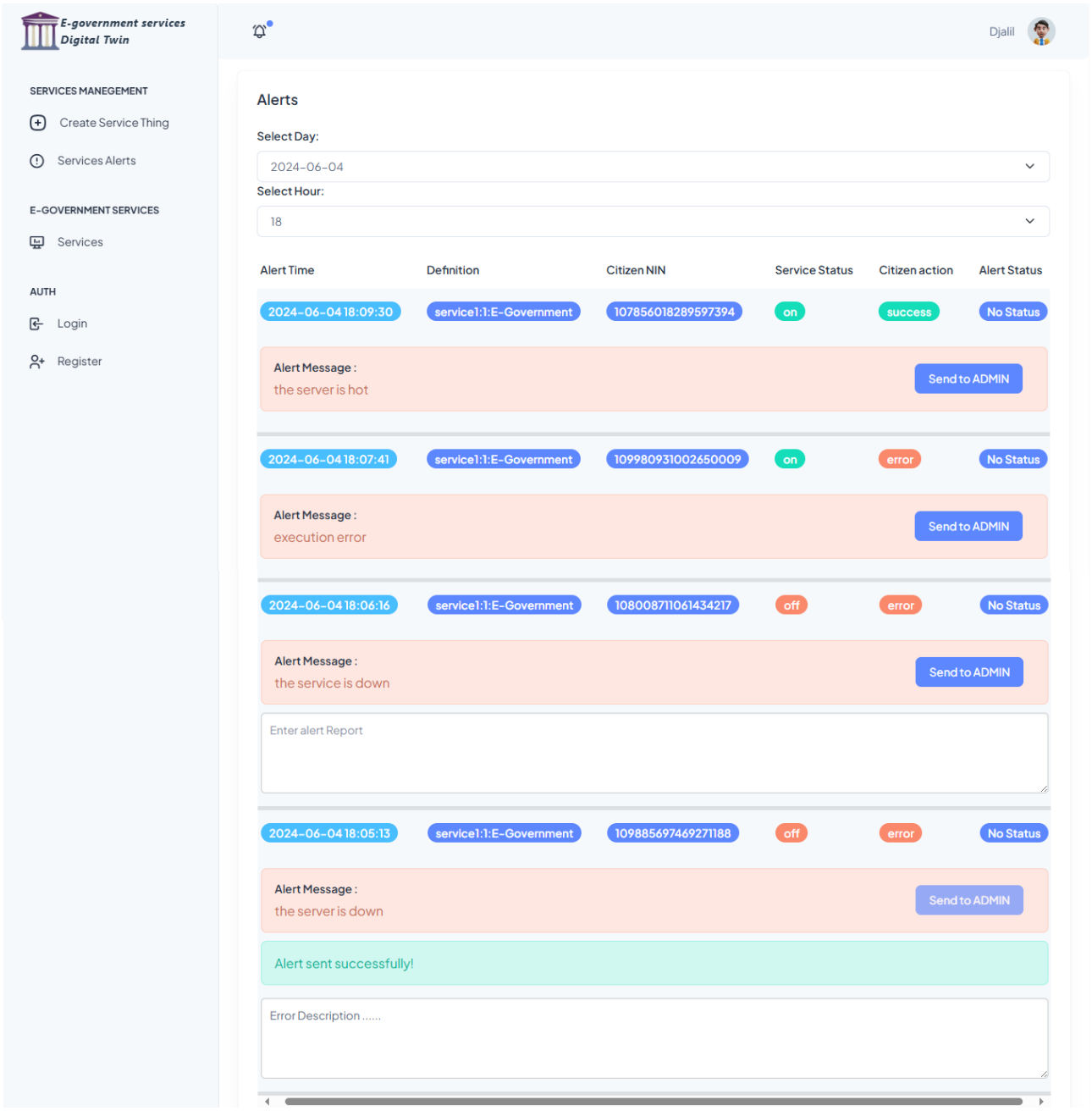


Figure 52: Services Alerts

The Services Alerts Management interface presents a list of recent alerts for e-government services, with detailed information for each alert. The alerts are categorized by time, service definition, and status, helping administrators quickly identify and address issues. When an administrator selecting specific date and hours and clicks on a row of an alert, a text area appears to enter alert reports, and there is functionality to send alerts to the appropriate administrators.



Figure 53: Service Alerts Sent

Once an alert is successfully sent, the corresponding button becomes deactivated to indicate the alert has been addressed.

4.8.2 Services Administrators Alerts Interface:

The Services Administrators Alerts Interface displays a list of alerts for e-government services, showing the alert time, service definition, and alert message. This interface is designed to help service administrators monitor and manage service issues efficiently. Each alert entry includes a description area where administrators can provide additional details about the issue.

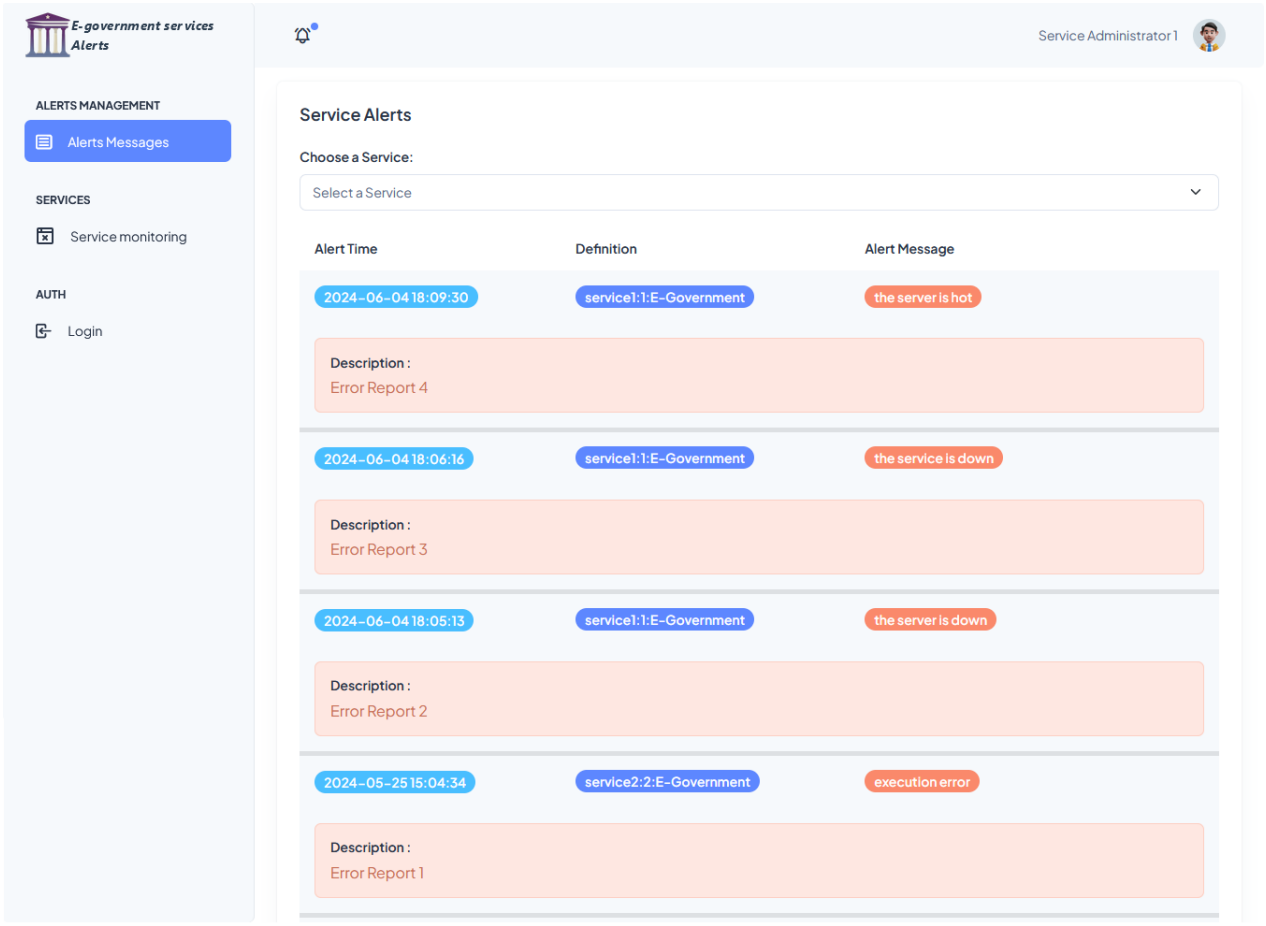


Figure 54: Receive Services Alerts

4.9 Services Administrators Supervising Interface:

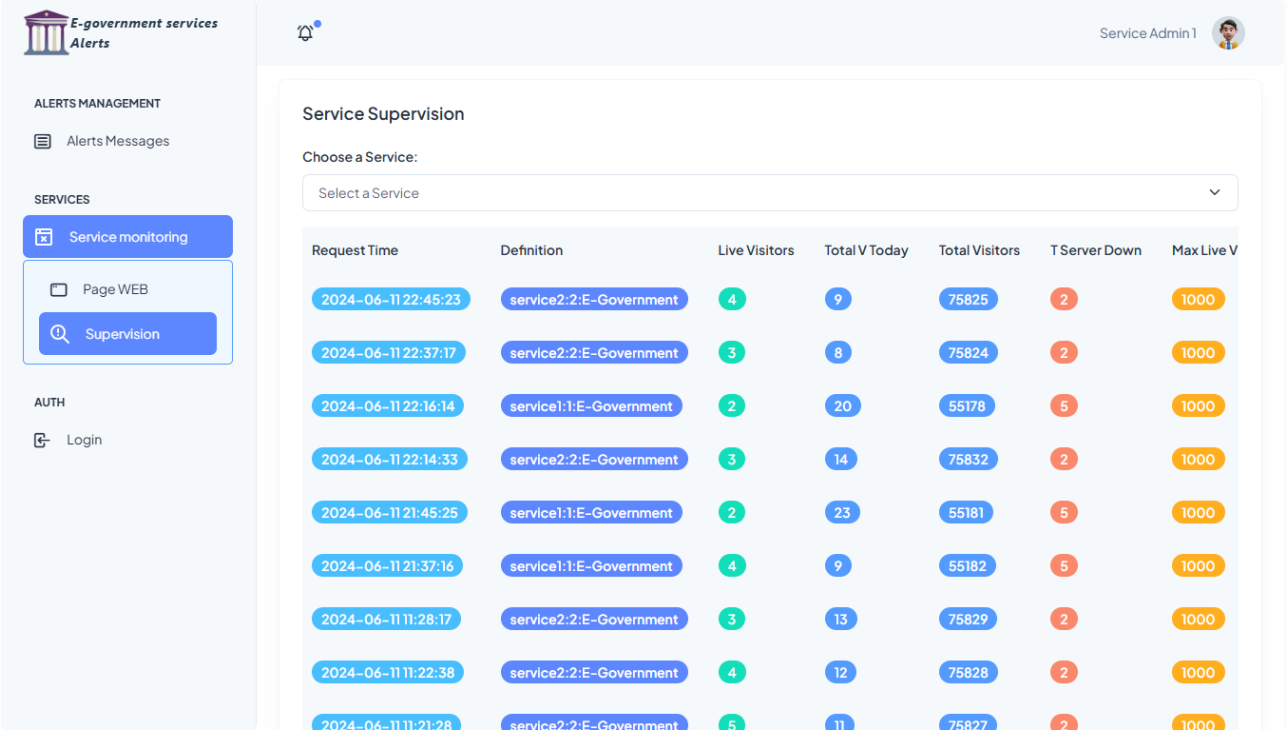


Figure 55: Services Alerts Supervision

This interface provides a detailed overview of the real-time status of e-government services. It displays important metrics of a selected service from their spicific administrator such as request time, service definition, the number of live visitors, total visitors today, total visitors overall, server downtime, and maximum live visitors allowed. This comprehensive dashboard enables administrators to effectively monitor service performance and quickly address any issues to maintain service reliability.

5 Conclusion :

In conclusion, the interfaces presented in this chapter are crucial for the efficient management and supervision of e-government services. They provide administrators with the necessary tools to create, monitor, and respond to service alerts, ensuring that the digital services remain functional and responsive to citizen needs. The detailed metrics and alert systems enhance the administrators' ability to maintain high service standards and promptly resolve any emerging issues.

General Conclusion

General Conclusion :

The integration of Digital Twin (DT) technology within the realm of e-government services presents a transformative approach to enhancing the efficiency, reliability, and responsiveness of public sector operations. This memory Project explored the multifaceted relationship between Digital Twin technology and e-government services, delineating the conceptual frameworks, implementation strategies, and the tangible benefits such integration can offer.

The research began with a detailed examination of Digital Twin technology,represent a virtual model of physical entities, enabling real-time monitoring, analysis, and optimization. The Project detailed various components, types, and technologies, emphasizing their applicability across multiple sectors, including government, aerospace, healthcare, and manufacturing.

E-government, on the other hand, was dissected to understand its role in modernizing governmental functions and services. The types of e-government services—ranging from (G2G, G2C, G2E, G2N and G2B) were discussed in depth, along with the objectives, and critical success factors necessary for effective deployment. The advantages and challenges of e-government implementation were scrutinized, providing a balanced view of its potential and limitations.

The conception phase of the project envisioned a unified architecture. The detailed architectural design and modeling of services and digital twin entities laid the groundwork for a robust integration framework. This model aimed to facilitate real-time supervision and management of e-government services, for more responsive and adaptive public administration.

A robust framework was proposed for integrating Digital Twin technology into e-government services. This included the overall architecture with modeling services, API connections, and the creation of a Digital Twin model. Key tools and platforms such as Eclipse Ditto, Node-RED, and Kafka were explored for their roles in facilitating this integration.

The implementation phase translated these conceptual models into a practical digital platform. Leveraging tools such as Eclipse Ditto and Node-RED, the project demonstrated the feasibility of creating a responsive DT platform. Key functionalities included real-time monitoring, alert management, and a comprehensive dashboard for various stakeholders, ensuring effective oversight and management of e-government services.it detailed through a series of interfaces designed for various administrative roles. The real-time data processing capabilities of Digital Twins ensure that administrators can effectively supervise and respond to service-related issues, thereby maintaining high standards of service delivery.

The architecture offers benefits such as enhanced operational efficiency, improved service reliability, and better decision-making capabilities. However, the project also acknowledges challenges like the need for robust infrastructure, data privacy concerns, and the necessity of continuous updates and maintenance.

As a perspective on what can be achieved, it is important to rigorously evaluate the potential impact of this integration, incorporating AI-based predictive capabilities. AI learning models will be developed to predict server downtimes by anticipating surges in the number of live visitors, allowing preemptive actions to be taken to mitigate service disruptions.
Additionally, AI will be used to enable the system to scale resources dynamically and maintain optimal performance during peak times.

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