ISSN No:-2456-2165

eGIF4DRC: E-Government Interoperability Framework for DRC

Joseph BIMBALA NGWABA
Senior lecturer and Researcher,
Department of computer science & Business Management,
University of Kinshasa
302, Lemba, Mont-Amba, 243,
The Republic Democratic of Congo

Frederick Kamba Kabangu
Teaching Assistant and Researcher,
Department of Computer Science & Business Management,
Institut Superieur de Commerce
259, libération, Gombe, Kinshasa,
The Republic Democratic of Congo

Etienne NGWABA
Senior Lecturer and Researcher,
Department of Mathematics and computer science, University of Kinshasa
302, Lemba, Mont-Amba, 243, Kinshasa, The Republic Democratic of Congo

Jacob NGWABA
Ministry of Post and Telecommunication (DR CONGO),
1009, boulevard du 30 Juin, kinshasa, The Republic Democratic of Congo

Vanessa BILONDA TSHINEMU
Information Technology expert,
Ministry of Digital (DR Congo), & University off Kinshasa.
68, Bd Colonel Tshatshi, Kinshasa, The Republic Democratic of Congo

Abstract:- The evolution of the Internet and Web has led governments to reshape traditional public services and supply the faster, better and more responsive access to public services to citizens called e-Government. E-Government is not only the electronic interactions between citizens and government agencies but also the co-operations among independent government affiliated agencies where exist different systems. These co-operations raise research challenges of heterogeneous interoperating environment in e-Government. This paper will examine the e-Government aspects and then identify the requirements in order to propose a G2G interoperability architecture based on microservices approach, the new trend of software architecture and distributed computing technologies, along with technical standards, maturity model, and some key actions meant to make the initiative implementable in real world and addresses some specific peculiarities and needs of developing countries, like DRC.

Keywords:- *ICT, developing countries, Democratic Republic of Congo, Interoperability, IT services, e-Government.*

I. INTRODUCTION

The unprecedented increase of Internet application demands and the recent COVID-19 pandemic crisis have forced government service delivery get converted to e-Government in many countries around the world. This mandatory transition has amplified the importance of digital technologies as essential tools for communication and collaboration between government and citizens and the private sector. E-Government has become indispensable to support the provision of basic public services and fundamental services in the health, education and security sectors, etc. [16].

Governments realize the transformational power of the Internet when it integrates with affiliated agencies – making public services immediate, accessible, relevant and flexible [9]. The paradigm shift to holistic adoption of e-Government across all public administration level can enhance public service delivery quality. The Government-to-Government (G2G) communication enables government departments, local governments including their related agencies to seamlessly exchange information. Interoperability means the capacity for systems to inter-link. It is opposed to “parallel” or “silos” system. It allows the integration of heterogeneous systems in one-stop portal. Most e-Government systems deployed in developing counties operate in 'silos' where the e-Government landscape is fragmented within and across ministries, departments and agencies making e-Government journey merely a delusion [9]. E-Government achieves its full potential when it can integrates with other agencies or between agencies and businesses systems regardless the heterogeneity of infrastructure including business rules, database systems, hardware or software architectures as well as programming languages. Each agency system may need to transact with other agency systems to use their services or exchange data (request or response). For example, taxation agency needs information of recorded businesses from trade institutions, commercial banks, the central bank, the pension contribution fund, etc. and judiciaries need criminal records from interior ministry to track the past behavior of a criminal etc.

When interoperability is achieved, it helps open up data and information silos and enable seamless exchange of information between services, better control and improved operational efficiency in information handling. The net outcome will be better-informed and timelier decision–making, reliable stats, improved cost efficiency and satisfaction with public service delivery.

ISSN No:-2456-2165

The aim of this paper is to propose a comprehensive and systematic approach to G2G interoperability in order to enhance vertical integration in public administration and foster relationships with affiliated agencies including the same level, higher or sub level in government hierarchy as well as cross-sectoral level in the Democratic Republic of the Congo.

The microservices architecture was used to enable a flexible, robust and scalable environment for communication among heterogeneous systems across public administration. The focus of this paper lies on inter-agency transactions based on existing systems. The paper examines challenges within some government services as a result of interoperability gap. Besides, future works for doing research and support actions for implementation of the system in the real world are proposed.

Most online repository of papers related to ICT case studies of DRC are more concerned about the development of software solution to business problems within public organizations. Hence, the following are benefits of the paper:

- It's among few papers that proposes e-Government interoperability framework for DRC (eGIF4DRC) context that can be implemented in the real world and yield an acceptable system.
- Serving as a blueprint, it will help DRC government in its endeavor to shift from a silos system to an integrated one as it outlines the broad picture of the implementation designing.
- It campaigns about digital service in public administration in order to stir up government authorities awareness as well as broadening their vision to comply with the new paradigm of public governance— 'the e-Government', to leapfrog the current disastrous governance model by reducing administrative burdens and improving service delivery to citizens.
- Last but not least, this paper gives insight to IT developers from all over the public administration agencies to become familiar with the current trend of software architecture and distributed computing technology of e-Government— the Microservices architecture.

II. RESEARCH METHODOLOGY

The study uses the analytical and descriptive methodology to analyze the existing e-Government system in DRC. The primary data used in this study was interview with some government officials in charge of IT. The interview helped assess the readiness of existing IT system based on the first stage of United Nations(UN) maturity model [12]. On top, the IT standard used was also investigated. Besides, officials from public institutions such ministry of interior and justice were interviewed to investigate the business process and challenges they encounter as a result "silos" system.

On the other hand, secondary data was collected from relevant institutions reports including United Nations, World Bank, International Telecommunication Union (ITU), Plan National Numérique (PNN)-horizon 2025 etc. as well as previous related works. The secondary data collected helped gain insight of the model to benchmark and come up with interoperability framework that can fit the context of DRC.

III. LITERATURE REVIEW

A. E-Government trends in the world and DRC

The united nations have recently released the r-Government Survey 2022 survey. The survey results highlight a remarkable improvement in the global E-Government Development Index (EGDI) average having increased overall [16]. The 10 leading countries with the highest rating in terms of the 2022 Survey results, with values ranging between 0.8943 and 0.9717 include Denmark, Finland, Republic of Korea, New Zealand, Sweden, Iceland, Australia, Estonia, Netherlands, United States of America. The United Kingdom is ranked eleventh and Japan fourteenth. Europe remains the global leader in e-Government development, with an average EGDI value of 0.8305, followed by Asia (0.6493), the Americas (0.6438), Oceania (0.5081) and Africa (0.4054).

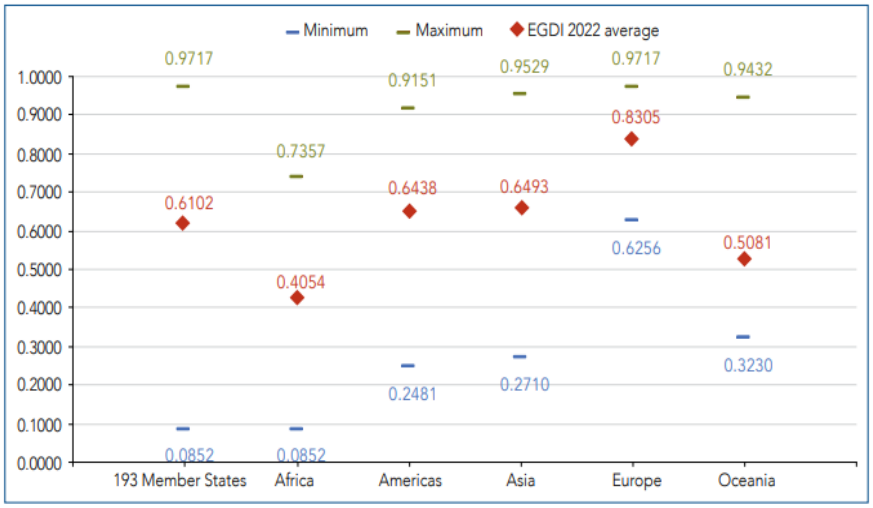


Fig. 1: Global and regional EGDI averages, 2022 [16]

ISSN No:-2456-2165

Africa is still underscoring, with rating below global average. Mauritius, Seychelles, South Africa and Tunisia are the only African countries appearing among the top 100 countries in the world in terms of overall EGDI rating above the global average of 0.6102. With an EGDI value of 0.7357, South Africa has become the regional front-runner in e-government in the continent. Yet, Mauritius scores the highest TII value in Africa (0.7588) and HCI value (0.7733).

Africa faces persistent challenges linked to inadequate investment in e-government development and ignorance of the potential of ICT in the modernization of public service delivry. Almost two thirds of the countries in Africa (59 per cent) have middle EGDI values, and close to a third (30 per cent) have high EGDI values. While there are no countries in Africa in the very high EGDI group, the declining trend in African representation in low and middle EGDI groups is encouraging.

However, this The 12th edition survey points DRC is still way behind most of the other African Countries, with the E-Government Development Index (EGDI) at 0.3057 in 2022, ranked 175 of 193 countries [16]. The E-Participation index is 0.2500, rank 135 of 193 countries. Similarly, the Online Services Index(OSI) stands at 0.2341 with Rwanda the regional leader with 0.7935. DRC's digital infrastructure is one of the most under-developed in Africa according UN(2022) scoring 0.1477 with the region leader Seychelles 0.8198.

Government of DRC has initiated several digitalization projects to roll upward by supporting a holistic approach to e-Government and expand digital public service delivery across all government entities for the development of the digital economy proposed through the PNN 2025. Yet, the implementation has not yield expected outcome due to weak government capacity and coordination [17]. Computerization projects initiated by different public entities do not align with e-agenda proposed through the PNN 2025. Different ministries and agencies are developing independently their information systems making the development of a holistic approach of e-Government a delusion exacerbated by lack of shared digital infrastructure and interoperability framework. The DRC has gained 8 seats since 2022, which is not significant at the global scale, but encouraging. The table 1 displays DRC's EGDI over the last 8 years.

Table 1: DRC's EGDI [16]

EGDI	2022	2020	2018	2016	2014
DRC(Rank)	175	184	176	180	183
DRC (Value)	0.30570	0.25800	0.26120	0.18761	0.15514

Interoperability is identified as one of key challenges for DRC to improving its ranking and enable fully functional and higher maturity level of e-Government in DRC. For examples out of 24 municipal investigated in Kinshasa— the capital city, it is discovered that the IT systems in place use legacy system that cannot integrate with other systems. This means e-Government systems in DRC exist in 'silos' lacking in system integration. They have been designed in such a way they do not communicate or exchange data and services with other agency systems. Citizens demand of public services often requires the aggregation of e-services simultaneously between institutions. The reliability of government services delivery is questionable as there is no coordination between government agencies causing service gap.

This situation hampers the establishment of the rule of law in DRC. The following public service business processes were investigated in other to unveil weaknesses behind silos system in public administration of DRC.

- *Case 1- Law case*

The interview with a lawyer revealed some public administration challenges they encounter when tracking criminal cases offenses. According to the lawyer, the lack of information coordination between government agencies throughout all level of hierarchy including ministries, municipality offices, the police stations, prosecutors and judiciaries etc., refrain the justice from achieving efficient rule of law as cases varies dynamically. For instance, it is difficult to track and coordinate criminal proceedings as the police often fail to respond to prosecutors' requests for evidences like criminal records or the full personal record of a person during the investigation process. As a result, criminal cases are investigated poorly and most of times criminals are released due to the lack of information.

- *Case-2 Delivery of certificate of criminal record*

In the same vein with lawyer testimony, criminal record office's business process was investigated. In fact, when applying for such a document, the receptionist loosely asked few yes/No questions to the applicants. The questions aim at investigating the applicant's past behaviors. The verbal information provided by the applicant is enough for the certificate delivery within 24 hours. The majority of certificate delivered, the Republic Prosecutor certified that the applicant is clean with no previous legal records. It is clear that cases are poorly screened and the evidence used to base the judgment remains questionable. As experiment, we recruited two young boys who had been to jail three times to apply for criminal record certificate. The applicants were delivered clean certificates, certifying the have no previous legal records. This highlights that the lack of coordination between police stations, judiciary institutions and other affiliated agencies is not in place to help deliver the truthful certificate of criminal records. This discovery sides with the lawyer's testimony and demonstrates the vulnerability of institutions operating in silos.

- *Case 3- Electoral filing*

During the electoral processes in DRC, the electoral commission is challenged when it comes to data cleaning which consists of removing from the electoral list ineligible people such as dead people, soldiers, foreigners, teenagers who meet the voting age, etc.. The lack of coordination between the ministry of interior and its affiliated branches makes it difficult to provide with data to the electoral

ISSN No:-2456-2165

commission as a result of lack of transparency, electoral fraud and political unrest during and after elections.

➢ *Case 4- Police*

Police are challenged to track drivers who infringe traffic regulations. Reportedly, they advocate they are unable to link the car number to the owner as there is no coordination of business process between the police service and the agency in charge of car registration. The road case is poorly managed as a result of accrued traffic infringement. The police are unable to reach out the driver's address to deliver fine bill. This weakness pleads for the need to enable an integrated system between involved government agencies.

Considering the aforementioned weaknesses, it is clear that government lose control over the management of politico-administrative entities creating service gaps and inefficiency in public service delivery. The government is not responsive to provide with public data to help scrutinize the social or economical behavior of population to serve for social planning or economic projection etc. The holistic adoption of an integrated e-Government system model across all public administration level has the potential to make the process more efficient.

B. Requirements for inter-agency transactions

Obviously, each government agencies develops its own IT infrastructure including business process rules, hardware, programing language, etc. as there is no "one fits all" solution. Yet, systems are required to interoperate to achieve a mature, efficient and responsive governance. Some interoperability requirements are reviewed:

- **Service autarchy**: means the interoperation between systems participating in business is executed without a third party involvement [6].
- **Service extensibility**: implies the capacity of e-Government architecture to integrate new services as well as the possibility of quickly adapt and transparently switch from a service [16].
- **Flexibility and scalability**: involve the capacity of e-Government environment to adapt the changing of services rules.
- **Trust and security**: e-Government transaction environment should guarantee trust and security in full compliance with the relevant regulations, e.g., on privacy and data, to avoid attacking from malicious programs [8].
- **Inclusion and Accessibility**: The use of ICT should create equal opportunities for all citizens and businesses due to open, inclusive services that are publicly accessible without discrimination [7].
- **Openness**: Interoperability involves knowledge and information sharing between organisations which requires certain degree of openness.

C. Existing distributed technologies

Existing distributed technologies such as CORBA, COM/DCOM, Java RMI etc., are some of popular distributed object paradigms that provide distributed mechanisms to interoperate heterogeneous systems. However, they are strongly coupled with endpoints and therefore it is challenging to automate large-scale business processes between different technologies. Compatibility, scalability, portability and standards are setbacks for heterogeneous interchange system. Besides, it is challenging or impossible to develop applications that can communicate via the Internet environment insofar as these technologies cannot work via firewalls [11].

Common Object Request Broker Architecture (CORBA) requires compatible Object Request Broker (ORBs) to operates [7]. This means, it runs only on platform where a CORBA ORB is installed. Developers have to develop ad hoc strategies to instantiate all objects in the system because objects may depend on one another. This make implementation complicated and non-portable.

Java/RMI requires Java at each endpoint. It runs on any platform unless there is a Java Virtual Machine embedded in the platform. Since it relies heavily on Java Object Serialization, objects can only be coded in the Java language [9].

COM/DCOM requires a COM Service implementation for that platform in order to run. Besides, the complexity of implementation, dependence on the platform, search through the Active Directory service, the lack of the naming of services through URL make it inadequate for inter-agency system transaction [10].

The Service Oriented Architecture (SOA) bases on Web services technologies that are accessible via standard network protocols such as SOAP (Simple Object Access Protocol) over HTTP and standard technologies of WSDL, UDDI [10]. The SOA Web Services technology exploit XML and requires a sharing of codes or implementations.

D. Rationale of Microservices

Microservices often referred to as microservices architecture, is an architectural approach that involves dividing large applications into smaller, functional units capable of functioning and communicating independently. Because they are independently run, each service can be updated, deployed, and scaled to meet demand for specific functions of an application [3]. This approach arose in response to limitations of legacy approach – monolithic architecture. Monoliths are large containers holding all software components of an application, built as single unified systems [10]. They are severely limited: inflexible, unreliable, and often developed slowly.

Microservices architecture is a better way of implementing a service oriented architecture and has become a trend. Since they have become a critical component of modern application architecture, many companies and organizations are going microservices nowadays [10]. 73% of companies are using microservices as part of their architecture [5].

Microservices are lightweight, self-contained components, communicating with each other via a well-defined interface using lightweight APIs. The client can use the user interface to generate requests. At the same time, one or more microservices are commissioned through the API gateway to perform the requested task. There is no sharing of codes or functionality with other services. The use of well-

ISSN No:-2456-2165

defined APIs propagates communication between the program's various components. As a result, even larger complex problems that require a combination of microservices can be solved relatively easily [11].

With microservices, each unit is independently deployable and addresses an application's particular aspect and function but can communicate with each other when necessary.

A major advantage of microservices is that it enables continuous deployment and faster release cycles. It's also highly maintainable and testable and allows more flexibility in technology options [15].

The most vital advantages of microservices architecture can be summarized as follows**:**

- **Agility:** Microservices foster an organization of small, independent teams that take ownership of their services. Microservices architecture is agile and thus does not need a congressional act to modify the program by adding or changing a line of code or adding or eliminating features [5].
- **Improved scalability:** Since applications running on different Microservices architecture, they can handle large amounts of simultaneous requests in less time. This allows for faster and more efficient application performance. It is the standard technology behind many web giants like Facebook, Netflix, Amazon etc.[20]
- **Independent deployment:** microservices are granular in nature, development teams can work on one microservice, fix errors, then redeploying without redeploying the entire application [5].
- **Error isolation:** In monolithic applications, the failure of even a small component of the overall application can make it inaccessible. With microservices, isolating the problem-causing component is easy since the entire application is divided into standalone, fully functional software units. If errors occur, other non-related units will still continue to function [4].
- **Integration with various tech stacks:** With microservice, developers have the freedom to pick up the tech stack best suited for one particular microservice and its functions instead of opting for one standardized tech stack encompassing all of an application's functions [3].
- **Autonomous:** when each components of microservices is deployed or scaled, it cannot affect the functioning of other services [15].

The following table lists certain features of SOA and Microservice, bringing out the importance of using microservice over SOA.

Table 1: difference between SOA and Microservices[11]

Component	SOA	Microservice
Design pattern	SOA is a design paradigm for computer software, where software components are exposed to the outer world for usage in the form of services.	Micro Service is a part of SOA. It is a specialized implementation of SOA.
Dependency	Business units are dependent on each other.	All business units are independent of each other.
Size	Software size is bigger than the conventional software.	Software size is small.
Technology	Technology stack is less than Microservice.	Microservice is heterogeneous in nature as exact technologies are used to perform a specific task. Microservices can be considered as a conglomerate of many technologies.
Autonomous and Focus	SOA applications are built to perform multiple business tasks.	Microservice applications are built to perform a single business task.
Nature	Monolithic in nature.	Full stack in nature.
Deployment	Deployment is time-consuming.	Deployment is very easy. Hence, it will be less time-consuming.
Cost-effectiveness	More cost-effective.	Less cost-effective.
Scalability	Less compared to Microservices.	Fully scaled.

Microservices architecture bases on web services technologies that can be applied into heterogeneous system like inter-agency communication [5]. It enables connection of heterogonous applications to conduct business on Internet platforms. These features overcome the weaknesses of many distributed technologies that are hardware, language and platform dependent. This is suitable for government applications insofar as it enables extensibility, flexibility and scalability. besides, it supports security-enhanced environment and identity management, so it can guarantee trust and security for inter-agency transactions by any backend system [11].

IV. THE EGIF4DRC ARCHITECTURE

A. Micro service-based eGIF4DRC

Micro services approach to e-Government system can satisfy requirements, particularly in inter-agency context in flexible, scalable, extensible manner. The figure 1 describes the eGIF4DRC service architecture acting as the blueprint for data, systems, and processes integration.

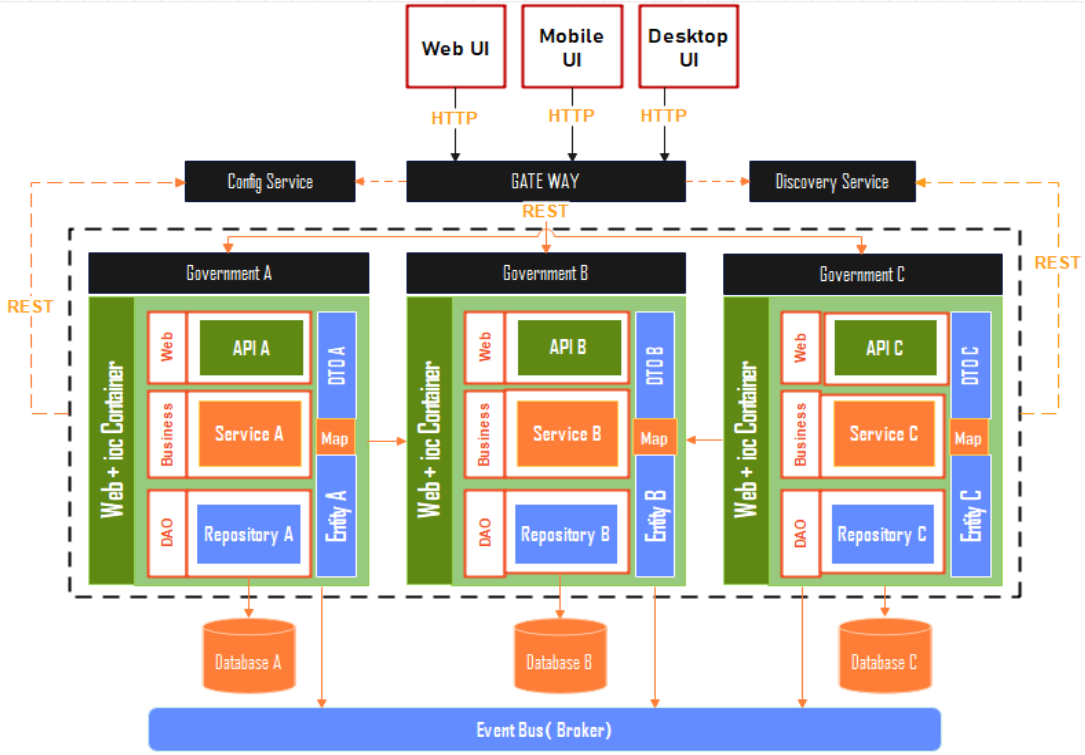


Fig. 1: Microservices-based eGIF4DRC(adapted from [20])

➢ *User interface*

The client can use the user interface to generate HTTP requests. The front end include web, mobile, and desktop.

➢ *Web layer*

The web layer serves as the client interface to exploit the service of the application. There are many frameworks used for front end such as Angular, React, Flutter etc.

➢ *Business layer*

The web layer calls for the business layer where functional specifications are developed.

➢ *DAO layer*

In the Data Access Object layer, there are repositories that will manage data persistence. Standards like JPA, Hibernate, Spring data are often used.

➢ *APIs*

The APIs propagates communication between the program's various components. Besides, services no longer need to share code or implementation with other services. The communication happens via well-defined APIs.

➢ *DTO*

The Data Transfer Object will store data from persistent entities, hence object-object mapping. Mapstruct and Jmapper are the most used framework for this purpose.

➢ *Brokers*

Brokers are messaging tools that enable microservices to communicate both internally and externally. They are handlers that allow both to publish and catch events (messages) but also process them. Each broker operates differently. Rabbit MQ and Apache KAFKA are some examples of brokers. The figure 2 depicts how a broker operates in general.

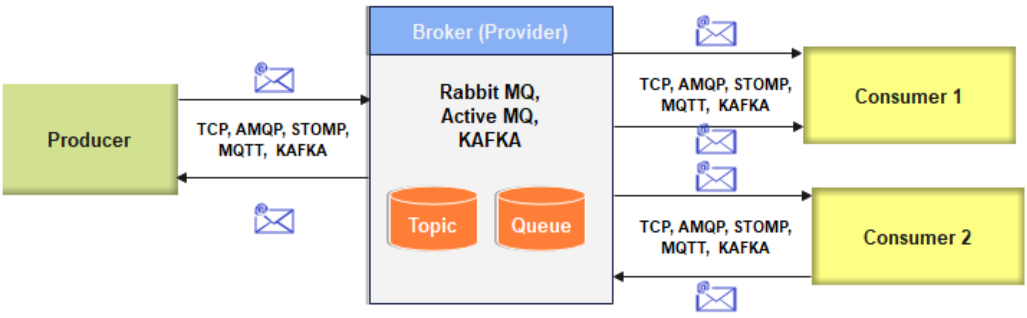


Fig. 2: Broker communication [20]

The producer (can be an affiliated organization or service) produces a message, that will be stored in a queue. In order to consume the service, the consumer needs to subscribe to the topic or the queue. A topic is a letter box where messages (events) are published. Each topic can have 0 or many subscribers [19]. The figure 3 depicts the asynchronous communication process between microservices through a broker.

ISSN No:-2456-2165

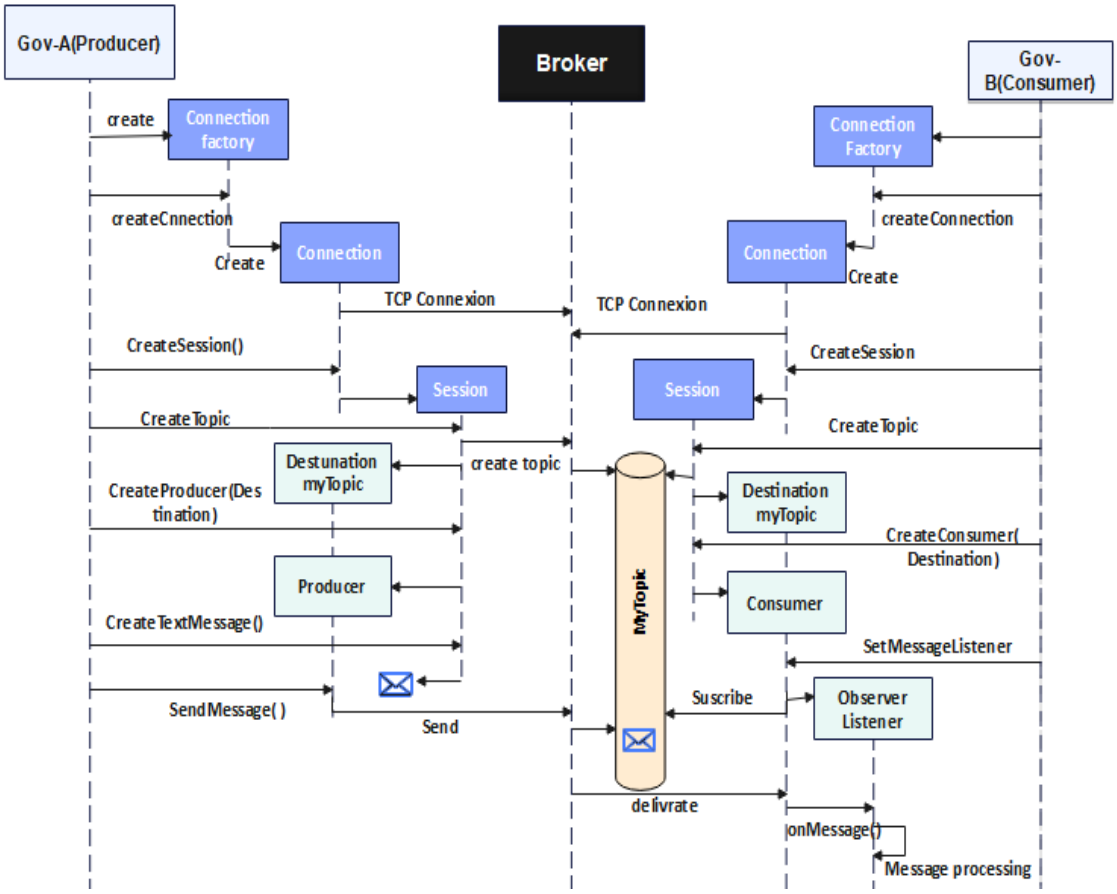


Fig. 3: UML sequence diagram of Communication model between microservices

➢ *Configuration service*

Configuration service centralizes the configuration properties of all microservices in the architecture in order to avoid redundancy. The idea is to use versioning system so that each microservices that boots connects first to the registration service to collect its configuration properties. REST communication enables hot boot in this case.

➢ *Registration service*

The registration service is a microservice that stores the location of each microservice this includes the name of the microservice, the IP address and the port address [20]. When a microservice boots, it first collects its configuration properties from the configuration service then publish its location in the registration service.

➢ *Gateway or proxy*

The gateway service provides an optimal way for executing services. It enables transformation, routing, and common processing across all the services. The gateway collects clients requests then redirects them to the service. Clients do not interact directly with the microservices as they do not know the location [19]. In addition, the gateway acts like a load balancer for the synchronization of database instances. It can be blocking or non-blocking. The non-blocking gateway is more appropriate for microservices architecture. The figure 4 presents the consultation service via gateway.

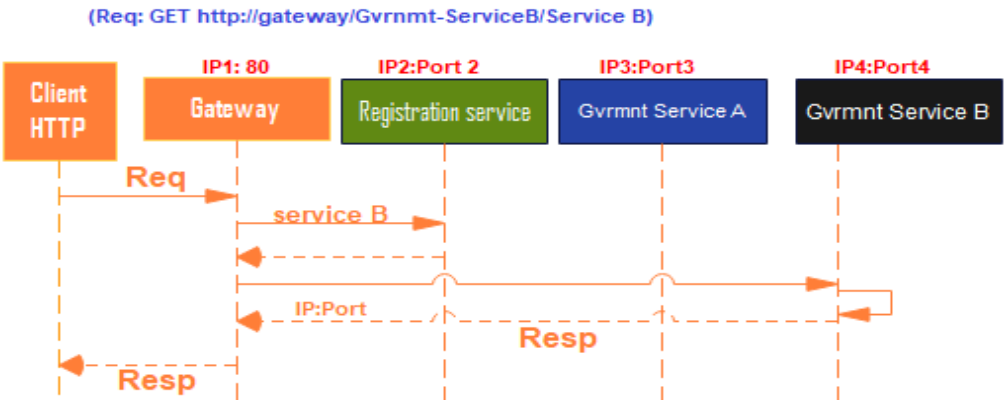


Fig. 4: UML sequence diagram of Gateway and registration service

ISSN No:-2456-2165

➢ *Authentication model*

There are two types of authentication model including stateful and stateless. Unlike stateful model used in monolith application, stateless authentication model is best suited for microservices architectures. It stores sessions in a token using a JavaScript Object Notation (JSON) format. The session credentials includes the user name, password and role. The token is digitally signed using existing cryptography methods such as PKI.

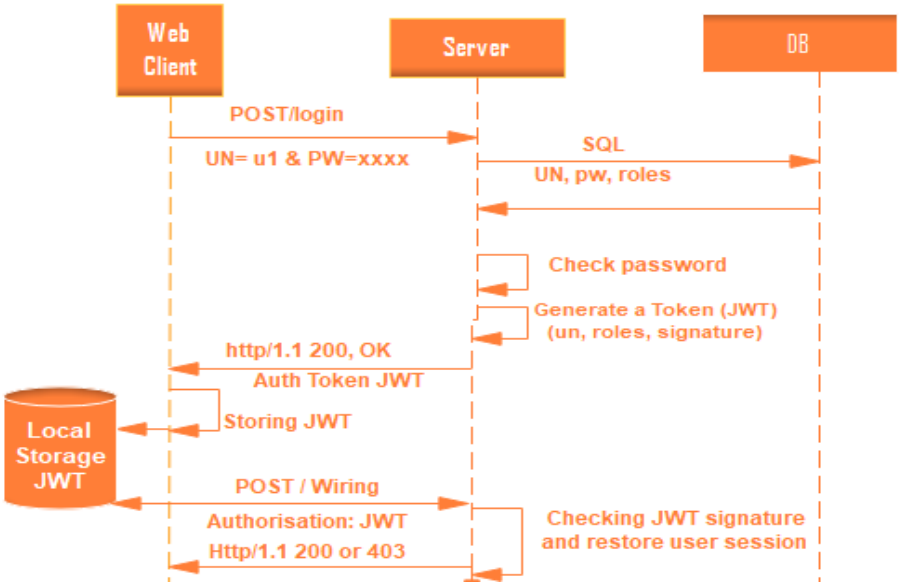


Fig 5: UML sequence diagram of Stateless authentication

➢ *Microservice Orchestration*

The microservice runs in a web container that take charge of control inversion and dependence injection. A container is a set of executables, codes, libraries, and files necessary to run a microservice [1]. Container orchestration tools provide a framework to manage and optimize containers within microservices architecture systems. The table 2 presents some frameworks and technologies for Microservices implementation.

Table 2: Microservices standards and technologies from [15]

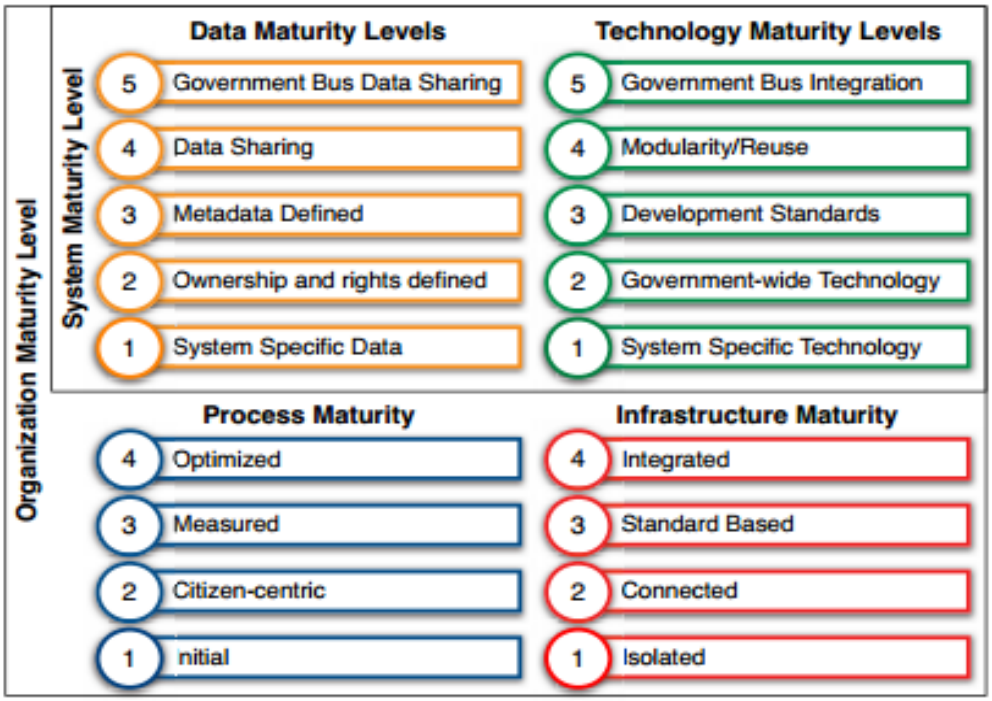
Operating system	Linux	Ubuntu	Windows
Programming languages	Java	Golang	Python, Node JS
API management & testing tools	API Fortress	Postman	Tyk
Messaging tools	Amazon Simple Queue Service (SQS)	Apache Kafka	Google Cloud Pub/Sub
Toolkits	Fabric8	Google Cloud Functions	Seneca
Architectural frameworks	Helidon	Quarkus	Molecular
Orchestration Tools	Kubernetes	Azure Kubernetes Service (AKS)	Conductore
Monitoring tool	Logstash	Middleware	Elastic Stack
Serverless tools	Claudia	Apache Openwhisk	Kubeless

ISSN No:-2456-2165

B. E-Govornment Maturity model

There are many maturity models for e-government implementation including ,levels of Conceptual Interoperability Model(LCIM), Organizational Interoperability Maturity Model(OIM), Enterprise Interoperability Maturity Model(EIMM), Levels of Information System Interoperability(LISI). The work in [9] provided a more comprehensive picture of interoperability framework that goes beyond technical reference as it is based on an adaptation and combination of various previous works models. The model was sized according to the needs of Mozambique, a developing country like DRC. It is hypothesized that most developing countries meet similar challenges, that why this paper leverages the maturity model described in the table 3.

Table 3: E-government interoperability Maturity model [9]



V. SUPPORTING ACTIONS

For effective implementation of interoperability framework policy, central government needs to place e-Government agenda in the wider context of other public agendas and reform programs to help ensure the effective alignment and coherence of the various policy areas [7]. The following are priority actions to be taken to achieve an interoperable e-Government in DRC:

A. Broadening the vision of the public sector

The political leaders shall not deem e-government investment as a threat to their regime or counterproductive. E-government will improve public service delivery and decision making quality when it is implemented effectively and efficiently. Without the support of the highest authorities, any effort to facilitate and deploy e-Government would be in vain. The development of e-Government is resource intensive and demanding even for mature e-Government countries like USA, Germany or South Korea. The involvement and support at the political level would provide visible sponsorship and a more direct connection to national priorities to make cross governmental co-operation work better [10]. The central commitment would ensure co-ordination of action to support integration, the security and privacy protection bound within a legal framework.

B. Alignment with national strategic goals

Interoperability business processes should be driven along with national vision and the whole government e-agenda to service delivery, policy development and program management. This would foster a strong and coherence governance system that reflects a strategic vision of the whole government development and implementation approach and drive an enhanced sharing of information and integration [3].

C. Elaborating e-Government roadmap

Assigning clear perspectives to embed e-Government and innovation in the strategic goals and foster the reconciliation approaches in terms of efficiency and innovation through a set of initiatives and projects is critical. Hence, the interoperability implementation should be part of national e-agenda, aligning with national strategic goals following an action plan within timeframes [2].

D. Strengthening the sub-national level

Mapping local government business processes in relation to interoperability initiatives could foster the public insight into the municipalities and affiliated agencies performance and increase their accountability and transparency. This could make it easier to facilitate a re-assessment of the role of the local government in relation to electronic service delivery and to the development of a joint channel strategy [11].

E. Improving the cross-governmental collaboration

Concrete activities and projects need to be implemented in order to speed up the development of joint solutions in all across government levels that would in return help break down the siloed approach and foster greater collaboration [9].

F. Foster Public sector capacity

There is the need to foster standardization of data and improve the workflow of public governance business within and across all levels of government in order to enhance cross-governmental interoperation by interfacing the primary holder of core data as well as the requirements for access or reuse by other parties(other government agencies, businesses etc.). in addition, there is a need to develop core capacities and nurturing IT experts in a systematic and practical manner to create policies and to support the growing demand for project and program management [17]. Furthermore, it is worth sharing experiences in the ICT field as well as raising mutual understanding with developed countries so as to form an effective partnership.

G. Reinforcing the organization of the public sector

Reinforcing the existing IT infrastructure across different levels of government by providing with the necessary inputs to make them ready for cross-governmental collaboration and co-ordination is critical in this endeavor. This will include re-designing administrative and workflows within and between government departments [10]. It consist in Mapping existing processes, identifying the gap analysis and improving the performance of the processes. Besides it will enable debureaucratization processes and ensure that e-Government is perceived as a core component among other programs [7]. Thereby delivering the maximum value to the government, businesses and the common citizen.

H. Building national data center

DRC is one late adopters of national datacenter. Till date, government agencies and businesses including SMEs hold their own data centers. With interoperability, a data center may have a significant impact on cost savings, scalability, upgrade possibilities, and sustainability of integrated infrastructure convergence.

I. Standardization

Commitment to agreed standards, frameworks, guidelines, reference models is required [14]. To reap the full potential of interoperability, EGIF4DRC must adopt the consistent approach with common standards and agreed governance arrangements to business process management.

J. Stakeholders synergy

Consultation with internal and external stakeholders is one of the building blocks of successful policy implementation. Stakeholders include sectorial ministries—the ministry of digital, Autorité de Régulation de Poste et de Télécommunication(ARPT), ministry of finance, and ministry of planning as well as business managers, civil society, academics and other bureaus at the center of government that have special roles to play in ICT policy implementations. They shall be distinctly identified, gathered and clearly and mutually understand their attributions and roles so that policies are implemented based on common consensus [16]. On the other hand, there are IT industries including Telecommunication services vendors, Cloud services vendors, Software-as-service providers, e-Service providers, Cloud services vendors, standardization organizations to name just a few.

K. Consider cultural resistance to change factors

Recognizing that people and culture are keys to successful change is critical, especially in developing countries. To successfully achieve ICT awareness and usage, the process of interoperability is required to meet people and mindsets as much as it relates to systems and processes [7].

L. Building ICT Centre of Excellence

Serving as a shared service centre, the Centre of Excellence model could assess a level of proficiency as well as the availability of experts within the entire public sector according to needs and thus balance the demand and reliance on external expertise[13].

M. Improving information and data management

It is critical to nominate leading agencies responsible for managing and retaining data that will enable a greater reuse across all the politico-administrative sectors government be that for citizens, businesses, ONGs etc.[12]. In addition, it would enable the public sector to set apart between services and data ownership (e.g. supporting shared services - for hospitals). In another way, this means that the re-use of information could be promoted and applied increasingly prevent redundancy of unnecessary storage of data across different government institutions.

N. Legal interoperability framework

Interoperability implies new channels of communication, including data exchange between organizations which will require regulations governing public information management in order to make the system integration legally binding.

VI. CONCLUSION AND FUTURE WORK

The contribution of this paper is to identify interoperability challenges gap in public service delivery of DRC and an implementable inter-agency transactions framework requirements that foster cross-governmental interoperation integration despite heterogeneous IT application platforms. Twelve municipalities systems were investigated based on two criteria including interoperation with other agencies and system standard. The finding helped underpinned the relevancy of the contribution of this work. With proposed architecture microservices Architecture, inter-agency transactions in e-Government can reach the needed interoperability requirements. It can be considered as the next generation of distributed programming paradigm that can overcome the weaknesses of existing distributed computing technologies [11]. The microservices architecture enables data exchanges via handlers without sharing any of their code or implementation with other services. Besides, this paper have discussed the main actions to guide decision making for the implementation of e-government interoperability in DRC and propose policy for effective implementation at the same time, allowing for a certain independence in the choice and development of ICT solutions among across all government

services. The next steps of this work is to examine and investigate in integrating security model so that such model can be deployed in real world.

REFERENCES

[1.] Casalicchio, E. (2016)Autonomic orchestration of containers: problem definition and research challenges," inProceedings of the 10th EAI International Conference on Performance Evaluation Methodologies and Tools, Taormina, Italy.

[2.] Charalabidis, Yannis & Asko, Dimitris (2008). Interoperability Registries in e-Government. The 41st Annual Hawaii International Conference on System Sciences -Waikoloa, HI, USA (2008.1.7- 2008.1.10)] Proceedings of the 41st Annual Hawaii International Conference.

[3.] Chen, R., Li, S. & Li, Z.(2017). From monolith to microservices: a dataflow-driven approach, in Proceedings of the 24th Asia Pacific Software Engineering Conference (APSEC), pp. 466–475..

[4.] Dragoni, N, Giallorenzo, S., & Lafuente A. (2017). Microservices: yesterday, today, and tomorrow, in Present and Ulterior Software Engineering, pp. 195–216, Springer, Berlin, Germany.

[5.] Gavin, C.(2021). 6 overlooked facts of microservices. Retrieved from Redhat: https://www.redhat.com/architect/microservices-overlooked-facts

[6.] Gopala K., Behara, Vishnu Vardhan, V. & Madhusudhana, R. (2009). SOA for E-Governance Service Oriented Architecture f or E-Governance. International Journal of Education Development, Vol.31. pp.126-148

[7.] Marcucci, L., Kluzer, S., Nicolini, A., & Cimander, R. (2006). ICAR - a system for e- enabled cooperation among regional, local and national administrations in Italy. European Commission (2006), Retrieved from IOP: http://www.egoviop.ifib.de/downloads/GPC_ICAR_Italy.pdf

[8.] Mustafa O. & J. Marx G.(2017). Optimizing economics of microservices by planning for granularity level, in Proceedings of the ProWeb Programming Technology for the Future Web, Brussels Belgium.

[9.] Pavel S., Adolfo V., RoZorer, Lourino, C., Jussi, H.(2017). eGIF4M: eGovernment Interoperability Framework for Mozambique. Retrieved from Researchgate: https://www.researchgate.net/publication/221561150

[10.] PNN-Horizon 2025: Projet du Plan National du Numérique (2019).

[11.] Rademacher, F., S. Sachweh, S. & Z¨undorf, A. (2017). Differences between model-driven development of service-oriented and microservice architecture, in Proceedings of the IEEE International Conference on Software Architecture Workshops (ICSAW), pp. 38–45, Gothenburg, Sweden.

[12.] Unitted Nations (2010). E-government survey: Leveraging E-government at a Time of Financial and Economic Crisis, UN Technical Repot. Retrieved from UN: https://publicadministration.un.org/egovkb/en-us/reports/un-e-government-survey-2010

[13.] United Nations (2018). E-government survey: Gearing e-government to support transformation Towards sustainable and resilient societies, UN Technical Report. Retrieved from https://publicadministration.un.org/egovkb/en-us/reports/un-e-government-survey-2018.

[14.] Yannis, C & Dimistris, A.,(2008). Interoperability Registries in eGovernment: Developing a Semantically Rich Repository for Electronic Services and Documents of the new Public Administration, Proceedings of the 41st Hawaii International Conference on System Sciences

[15.] Yu, H., & Sundaram, M.,(2016). A microservice based reference architecture model in the context of enterprise architecture, in Proceedings of the IEEE Advanced Information Management, Communicates, Electronic and Automation Control Conference, pp. 1856–1860, Xi'an, China, October 2016.

[16.] United Nations(2022). UN E-Government knowledgebase Retrieved from UN:: https://publicadministration.un.org/egovkb/enus/Data/Country-Information/id/47-Democratic-Republic-of-the-Congo.

[17.] The World Bank Group (2020). Washington Democratic Republic of Congo Digital Economy Assessment.

[18.] Yousfi, M.(2016). A New Efficient Distributed Computing Middleware based on Cloud Micro-Services for HPC. Conference Paper · October 2016 DOI: 10.1109/ICMCS.2016.7905644

[19.] Yousfi, M.(2019). Part 1 Mise en oeuvre d'une architecture distribuée basée sur Micro Services avec Spring Cloud. [Video]. Youtube. https://youtu.be/b_qdY2IsV4o. ADRIA, ENSET.

[20.] Yousfi, M.(2022). Part 1 - Bonnes Pratiques et Challenges des Architectures Distribuées basées sur les Micro-Services [Video]. Youtube. https://www.youtube.com/watch?v=tpCIvZ5QSAs&t=6s, ADRIA, ENSET.

[21.] Zuhoor, A., & Nasser, A., Naoufel K.,(2014). Developing A Service Oriented E-Government Architecture Towards Achieving E-Government Interoperability, Vol.8 No.5