Africa on Track Project

23A Fourth Avenue
Houghton Estate
Johannesburg
South Africal
enquiries@projectized.co.za
www.projectized.co.za

Document Control

Title	Africa on Track
Authors	Nokuthula Ndlovu on behalf of Projectized Management
Doc Ref	Africa on Track Project Proposal Version 1

23A Fourth Avenue
Houghton Estate
Johannesburg
South Africal
enquiries@projectized.co.za
www.projectized.co.za

23A Fourth Avenue
Houghton Estate
Johannesburg
South Africal
enquiries@projectized.co.za
www.projectized.co.za

Chapter 1

1.1. Introduction

This document outlines a proposed solution to assist health officials in Africa in the tracking and tracing of the COVID-19 virus spread via the process of community transmission. The current state of the art solutions in this problem space, in our opinion, do not fully address the real-world situations experienced by the majority of people living in Africa. The following Africa specific considerations were looked at as part of this proposal:

- High unemployment / poverty rates resulting in limited to no financial means directly affects access to mobile technology and importantly data / bandwidth to use for online resources. This is exacerbated by the high data costs in many African countries.
- Limited and / or unreliable telecommunication's infrastructure in certain African countries.
- Many informal dwelling types (villages, informal settlements etc.) that are not accurately recorded on any official addressing systems.
- High levels of missing demographic information in certain Africa countries.

Looking at the continent as a whole the high-level mobile technology penetration numbers are as follows:

Population on the African continent	1,216 Billion		
Number of cellular phones	650 Million		
Average number of persons per cellular phone	1.8		
Cellular phones by make and operating system	**Make**	**O/S**	**Percentage**
	Samsung	Android	33.57%
	Huawei	Android	17.61%
	Apple	IOS	13.19%
	Techno	Android	6.66%
	Infinix	Android	5.59%
	Oppa	Android	5.56%

Table 1: High-level mobile technology numbers for the African continent.

From Table 1 above roughly half of the people in Africa have access to a Cellular phone (high level insight not taking into account regional socio-economic factors). This number in reality is much better as the population numbers above to not take into account population age factors and one could safely assert that that the majority of the adult population has access either directly or indirectly to a cellular phone. The make and operating system percentages of the cellular phones in circulation are encouraging as they point to the fact that the majority of the 650 Million units in circulation are smart phones capable of running a custom-built application.

Having outlined the above and by taking into consideration the African limitations listed we fully believe that the mobile base application could greatly assist the health professionals in the various African countries in the fight against the COVID-19 virus from a track and trackability perspective. The

23A Fourth Avenue
Houghton Estate
Johannesburg
South Africal
enquiries@projectized.co.za
www.projectized.co.za

remainder of this document will outline our proposed solution, the technical design of the solution as well as the project plan and costing to build it.

Chapter 2 Epic description of solution

At a high level the solution will consist of a multi-tenant, cloud hosted, multi-platform smart phone application with the following justifications:

- Multi-tenant: Each country in Africa will need access and control of their own data and activity.
- Cloud hosted: Will allow for rapid scaling, ease of rollout and support. Support for public, private and local hosting will be a feature owing to the data jurisdiction laws certain African countries have in place.
- Multi-platform: Has to run on both IOS and Android operating system.
- Smart phone application: Most prevalent connect technology on the African continent.

Functionally, the solution will present 4 distinct interfaces to the users.

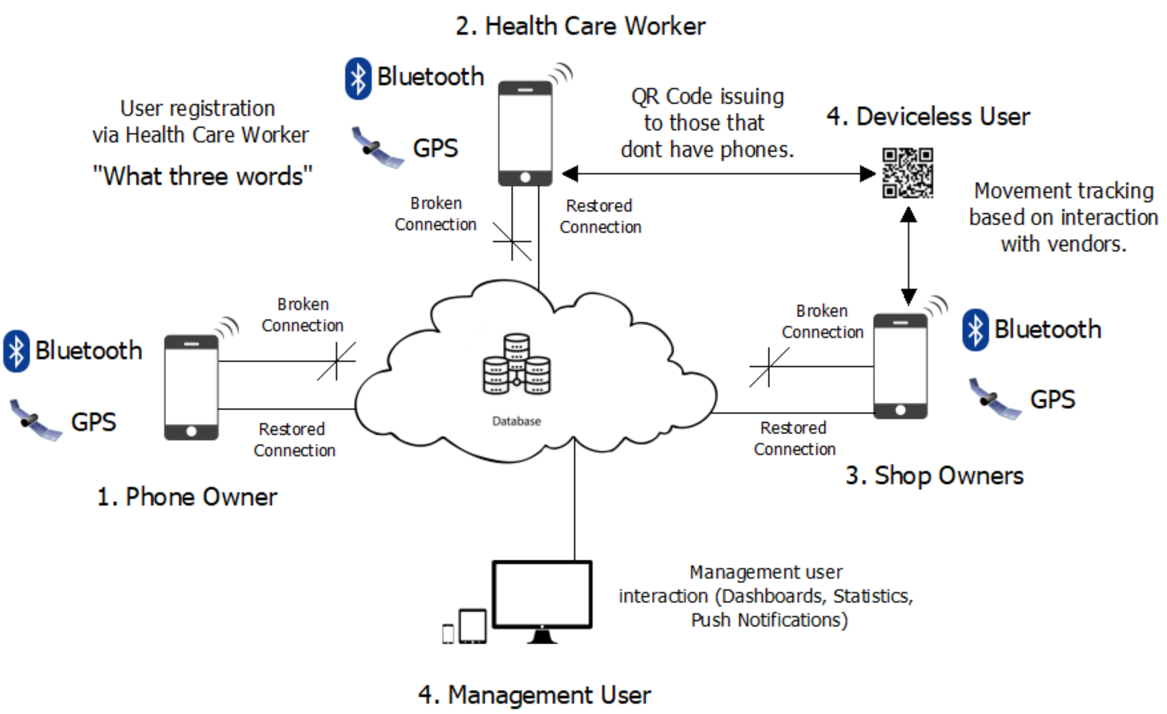


Figure 1: High level functional view of the solution.

2.1. Phone Owner / User

People with access to a cellular phone will download the mobile application from their respective application store. Upon first use the application will request the user to enroll specifying the following information:

- Country of residence
- Full name
- Local identification number
- Age
- Gender
- Location of primary residence (What3Words API)
- Current co-morbidities (multi-selection of Hypertension, HIV/AIDS, TB, Asthma, Diabetes, Cardiac disease)
- Smoking status
- Employment status
- Modes of transport
- Number of people staying in the same dwelling
- Cellular contact number
- Income / economic information
- Current COVID-19 status (assumed negative, only updatable by a registered health care professional)
- Picture of person taken via the device's camera
- Current mobility status (always at home, seldom leaves, attends school, works daily)

Once the above information has been captured the application will generate a QR code specific to the user that has just enrolled and link the QR code to the user's profile just created. The usage of the QR codes generated will be outlined shortly.

The capturing of the above information will assist health professionals in not only tracking and tracing community spread but also in the management of outbreaks and the modelling of the severity of outbreaks in specific communities. Examples of some of the benefits of obtaining this additional information upon registration are listed in Table 2 below. The principle being applied is that given the fact that people will be encouraged to download and use the application we might as well get additional information to assist in the management of the disease at the point of enrolment.

Age, gender, co-morbidities	Research has found direct correlations between certain co-morbidities, age and gender and the severity of COVID-19 infections in patients.
Modes of transport	Certain modes of transport present higher probabilities of community transmission i.e. high-density public transport.
Income / economic information	Can assist social workers in identifying persons / families in the greatest need of aid.

23A Fourth Avenue
Houghton Estate
Johannesburg
South Africal
enquiries@projectized.co.za
www.projectized.co.za

Number of people staying in the same dwelling	High density dwellings are prevalent across Africa increasing the risk of transmission.

Table 2: Data points and their implications in response modelling.

Post enrolment the phone user / owner will have the ability to specify their primary residence (when they are at the primary residence) via the What3Words API (www.What3Words.com). What3Words is a simple way of addressing locations on Earth that does not rely on complicated GPS co-ordinates. It does this by presenting a 3-word description that can uniquely identify each 3m square of the Earth's surface. These three words are available in 42 languages, human transferable i.e. can be easily communicated between people, and can solve a fundamental issue we have in Africa in which the majority of the informal settlements do not have a formal addressing system to uniquely identify a specific dwelling in the settlement. The final step of the enrolment will be a consent step in which the phone user / owner consents with regards to the application using Bluetooth and GPS information obtained by the device going forward. The manner in which the Bluetooth and GPS data will be use will be outlined in detail latter on in the document. To cater for the scenario in which a phone user / owner inhabits a dwelling with other people that might not have access to a cellular phone (spouse, children, grandparents etc.), the mobile application will allow the phone user / owner to enroll multiple people with the same information listed above on a single device. QR codes will be generated for each additional person enrolled. From a modelling perspective this will allow for the bucketing of people under the assumption that if a single person gets infected there is a high probability that others living in the same dwelling are also infected owing to the close proximity in which they live and the lack of PPE in use within private dwellings. Assumptions like this will need to be made in the African context and will help alleviate the constraints one would face modelling purely on individual cellular datapoints given than not everyone in Africa has access to a cellular phone.

Once enrolment is complete the mobile application will run in steady state. In steady state mode the application will collect Bluetooth and GPS data on trigger events. If the cellular phone has a built-in accelerometer and / or gyroscope, any phone movement will trigger a Bluetooth and GPS scan. The absence of motion detection hardware on the device will result in a time-based Bluetooth and GPS scan. Constantly scanning for Bluetooth devices in the phone owner's proximity will greatly reduce the battery life of cellular phone. Throughout the design of the solution we have paid special attention to not adversely affect the phone user / owner unnecessarily as this will undoubtedly result in an increase of non-compliancy in terms of application usage. The obtained GPS geospatial data will be periodically uploaded to the cloud / server infrastructure (see Technical Application Characteristics section) and will be used from a track and traceability perspective in the traditional sense regarding community spread. The first non-traditional approach we will employ relates to Bluetooth and is best described as follows:

1. Any Bluetooth device is constantly scanning for and identifying other Bluetooth devices in close proximity (accuracy at +-1.5 meters depending on the Bluetooth standard).
2. When a cellular phone running our application comes into range of another cellular phone running our application, a unique identifier (depersonalized) will be passed between the two cellular phones. Each cellular phone will sort a record of all the other cellular phones it has come in range of including the date and time of the interaction. This data will be periodically uploaded along with the GPS data as outlined above.

3. On the server side of the application we will be able to link the unique identifiers exchanged with registered profiles and determine that an interaction occurred between the respective phone users / owners. This will assist along with the obtained GPS data to effectively track and trace interactions between individuals and greatly assist health professional with contact tracing. We have also designed the mobile application with push notification functionality that can be used to send notifications to a specific phone user / owner or a general community / country. In the example above if one phone user / owner latter tests positive for COVID-19 we could pro-actively notify all the other phone users / owners that have come into contact with the infected user / owner in the last two weeks to self-isolate / quarantine.
4. The underlying premise of the above working effectively is that most / all of the phone users / owners will need to have Bluetooth enabled on their respective devices. From an application management perspective, we will be able to identify the phone users / owners that are not logging Bluetooth data and provide listing to authorities such that incentive models can be deployed to assist with driving the right behavior.

The second non-traditional approach will be the usage of QR codes. As mentioned above each phone user / owner along with any additional individuals enrolled per device will be given a unique QR code via the application. The mobile application running on the phone user / owner's device will have the ability to scan the QR code of any other phone user / owner. When scanned both devices will log the time, place and unique identifiers of the individuals involved. The applicability of this functionality will be highlighted in the next section that outlines how health care workers and deviceless individuals (non-cellular phone users / owners) will interact with the application and be facilitated respectively.

The mobile application will also contain a basic symptom checker whereby a phone user / owner can enter their symptoms and be guided on whether or not they should seek medical attention regarding addition care or COVID-19 testing. The symptom checker will be triggered on the known COVID-19 symptoms being high fever, dry cough, shortness of breath, sore throat and tiredness.

2.2. Health Care Worker

Health care workers will have the same functionality via the mobile application to enroll people and capture their respective information. Additionally, they will also have the following capabilities:

- Pull up the information of any person by entering their details / scanning their QR code.
- Update the COVID-19 status of any person.
- View an individual's contact history by entering their details / scanning their QR code.
- Associate a previously printed QR code with an enrolled individual.

The last point is of particular importance when it comes to deviceless users (people with no access to a cellular phone) as it will cater for the tracking and tracing of their interactions and movement. The idea behind this is that QR codes can be printed in bulk and assigned to deviceless individuals during an enrolment process. The bulk printing of QR codes can be done on mass at an attractive price point. Figure 2 below shows a possible bulk QR code implementation in the form of a wrist band. QR codes could also be printed on plastic cards or laminated paper depending on the funding available. This enrolment and QR code assignment capability can also be extended to Home Affairs officials, Financial Institutions, Pharmacies and other government institutions where needed.

Figure 2: QR code on a plastic wrist band.

Considering the above in combination with the fact that the mobile application can scan any individuals QR code associating then to a location and time opens up the possibility for the following:

- Deviceless users can be scanned when entering and existing public transport by designated officials.
- Deviceless users can be scanned when entering markets, public gatherings, places of worship and shopping facilities by designated officials / shop owners. Based on regulations in the respective jurisdiction's, entry could be denied if no QR code is presented driving to behavior for ensuring deviceless users make every effort to get registered.
- Phone users / owners can present the QR code on their device and would not need a physical QR code in the form of a band / card / etc.

2.3. Management Portal

The last interface component in the proposed solution will be a management web-based portal. This portal will be accessible to senior health officials / decision makers in the various countries. Based on the information the mobile application captures during the enrolment process as well as the geospatial information being streamed daily (GPS, Bluetooth) the following information (for example) at a regional / country level could be graphically displayed within the management portal:

- Co-morbidity rates per geographic area.
- Number of enrolled persons.
- COVID-19 infection rates per geographic area.
- Rate of COVID-19 spread.
- Low income / economic areas possible needing aid.
- Population density per geographic area.
- Population demographics.

23A Fourth Avenue
Houghton Estate
Johannesburg
South Africal
enquiries@projectized.co.za
www.projectized.co.za

Chapter 3 Technical Application Characteristics

3.1. Client-Server Communication

All communication taking place between the client (mobile application) will be compressed and encrypted in order to ensure efficient use of bandwidth resources and reduce the data cost for the end user. Carefully consideration will be given to the number of data points taken each day via GPS, Bluetooth etc. along with Edge computing (data will be transformed and aggregated on the mobile device itself before compression and transmission) will further reduce the data / network load.

3.2. Data Communication Efficiency

If a communication channel cannot be established between the client application and a server, the application will store the relevant information in an offline data store. When the applications connectivity is restored, the information will be transmitted to the server. This will ensure that no data points are lost during periods of no connectivity. Where the capacity of local networks and / or international bandwidth are an issue the mobile application will generate a random number (seeded with the devices MAC address, time of day generated and location of primary address). This random number will correlate to a time of day the application will upload its cached data. This will ensure that the load on the local networks and international bandwidth is distributed uniformly throughout the day and no surging occurs during peak mobility times of the day.

3.3. Globalization and Localization

The mobile application and the management portals will be developed with distribution across Africa in mind by catering for multiple language and localization requirements.

3.4. Performance and scalability

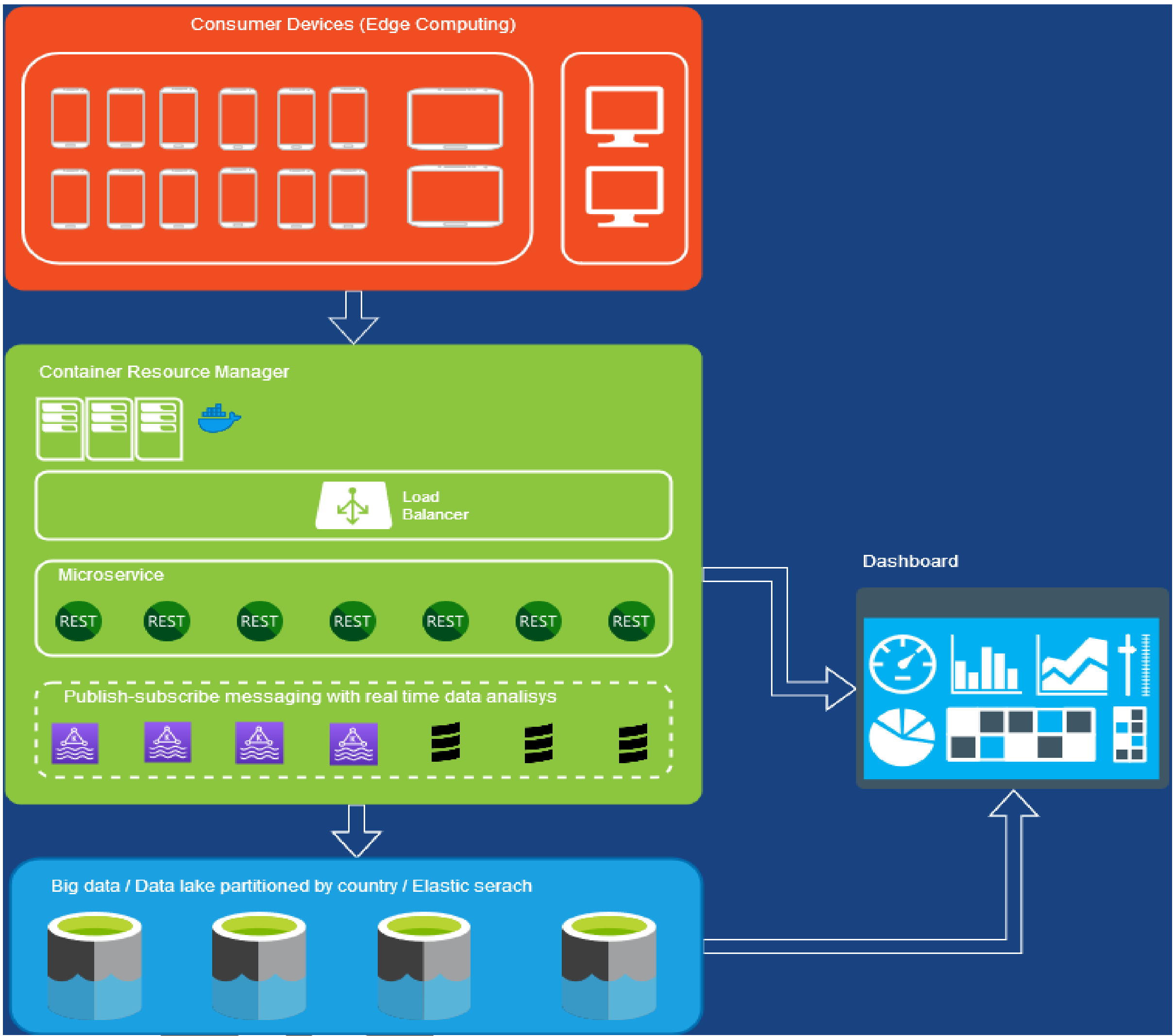
Covered in detail in the technical section of this proposal.

3.5. Security

As the mobile application / server components will be dealing with sensitive personal information all communication channels will be encrypted and secured. Best practice will be employed when designing and hosting the various solution components to ensure information security and integrity. All country specific data will be siloed in separate databases and the QR codes generated will only contain a unique identifier. No personal data will be encoded withing the QR code. No personal data will be exchanged in Bluetooth mode.

23A Fourth Avenue
Houghton Estate
Johannesburg
South Africal
enquiries@projectized.co.za
www.projectized.co.za

Chapter 4 High Level System Architecture



The figure above represents a high-level architecture that could be used to meet the requirements of the Contact Tracing application. It consists of four basic layers:

- **Consumer Devices (Edge Computing)**: This represents the various mobile and PC devices that can be used to interact with the application. For example, the mobile app used by citizens and field workers to register and enroll. A PC used to access the web portal of the application, to generate reports or view dashboards.
- **Application / Service Layer**: This layer is responsible for allowing the mobile application to submit registration information, track and tracing events, GPS or Bluetooth data etc.
- **Big Data**: A pipeline of data storage, transformation, and analysis, to allow for the storing of extremely large data sets and to facilitate in fast search and analysis of these large data sets. For example, analysis of all track and tracing events for each citizen, GPS and blue-tooth analysis etc. in order to quickly identity potential infection risks.

23A Fourth Avenue
Houghton Estate
Johannesburg
South Africal
enquiries@projectized.co.za
www.projectized.co.za

- **Dashboards and Analytics**: Dashboards can be used to provide summarized information, such as number of registered users, number of tracing events etc. Advanced analytical queries will also be allowed.

This architecture is designed to meet enterprise-level requirements:

- **High Availability:** the application should always be available for use, if possible. It should be resilient to data center outages, power failures etc. In information technology (IT), a widely held but difficult-to-achieve standard of availability for a system or product is known as the "five 9s" (99.999 percent) availability. Citizens, fields workers and government officials should not have to worry about the application being available for use. This is achieved by deploying the application to multiple data centers and employing automated failover strategies.
- **Scalability:** the application needs to meet throughput demands without negatively affecting performance. For example, the application needs to able to scale to meet the throughput demands of a large country, such as Nigeria. Our approach to achieve this is to us a **micro-service architecture.** Micro-services can be quickly deployed to additional servers to meet increased demand by employing **container orchestration.** Container orchestration allows the application to be placed into containers and those containers can be automatically scaled or moved around to meet the demand.
- **Data Replication:** data must be replicated to multiple servers or regions to prevent any potential data loss that can occur from a data center outage or a power failure.
- **Security:** various industry-standard principles and tools will be employed to ensure the security of the application and the associated data. For example, the use of SSL to encrypt all web traffic between the mobile application and the application layer. The employment of protection tools to protected against DDoS (Distributed Denial of Service) attacks. Firewall systems to strictly control inbound and outbound traffic, as well as industry-standard authentication and authorization protocols to protect against unauthorized use of the application. Data can also be encrypted to prevent potential data snooping or data theft.
- **Big Data and Analytics:** the application will employ enterprise-grade big data services and frameworks to allow for fast processing and analysis of large data sets. For example, the process and analysis of all interaction and tracing events for each citizen in a country. Analysis of citizen location movements or GPS movements over time.

To meet all these requirements, we can implement the architecture on a **cloud platform** or by employing the **data centers** available in each country**.** Cloud platforms provide services such as high availability, scalability, security etc. as part of their service offering.

A conceptual architecture that makes use of either a cloud platform or data center will be discussed in section 4.1.

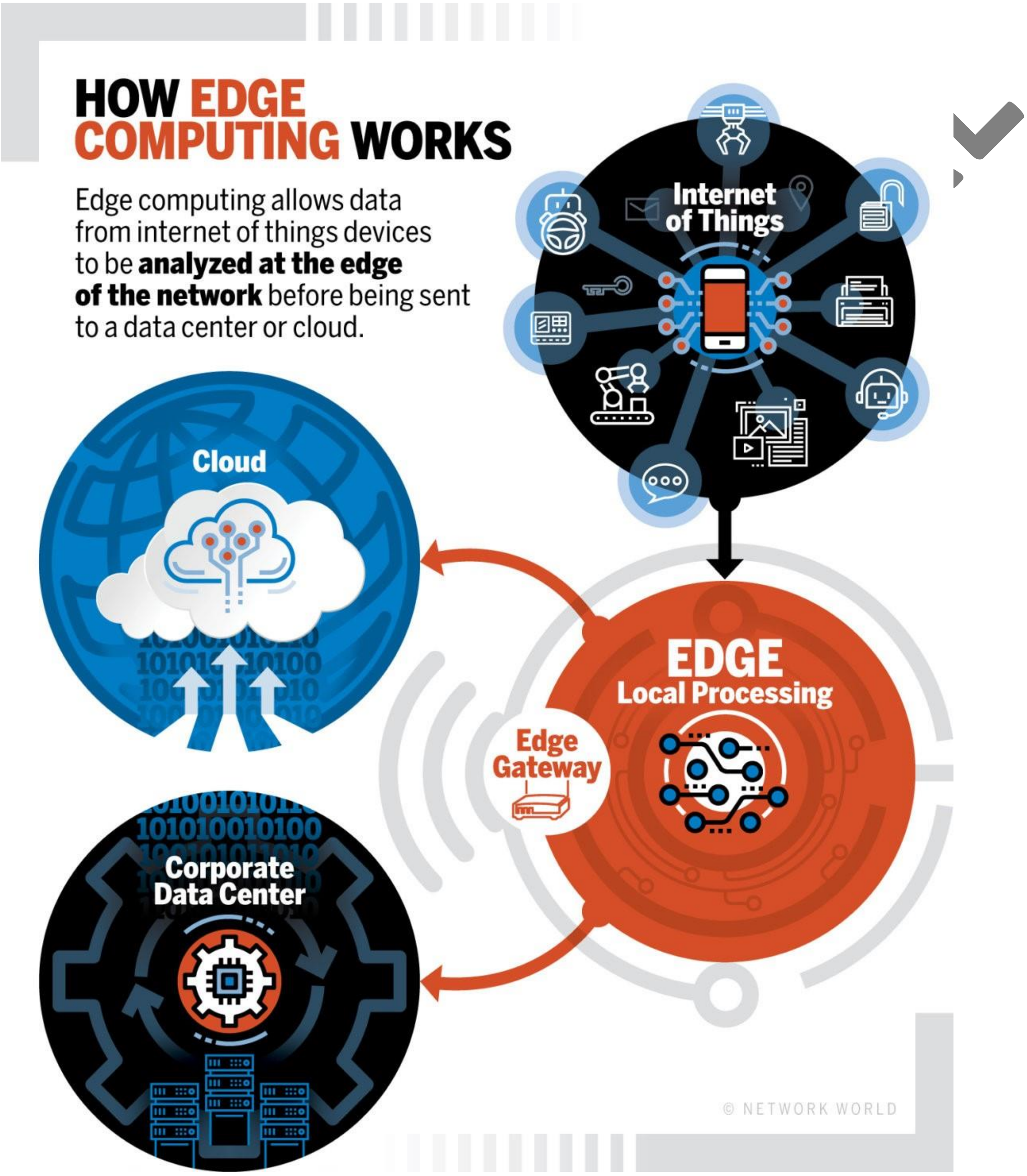
4.1. Edge Computing

Edge computing is a distributed, open IT architecture that features Decentralised processing power, enabling mobile computing and Internet of Things (IoT) technologies.

23A Fourth Avenue
Houghton Estate
Johannesburg
South Africal
enquiries@projectized.co.za
www.projectized.co.za

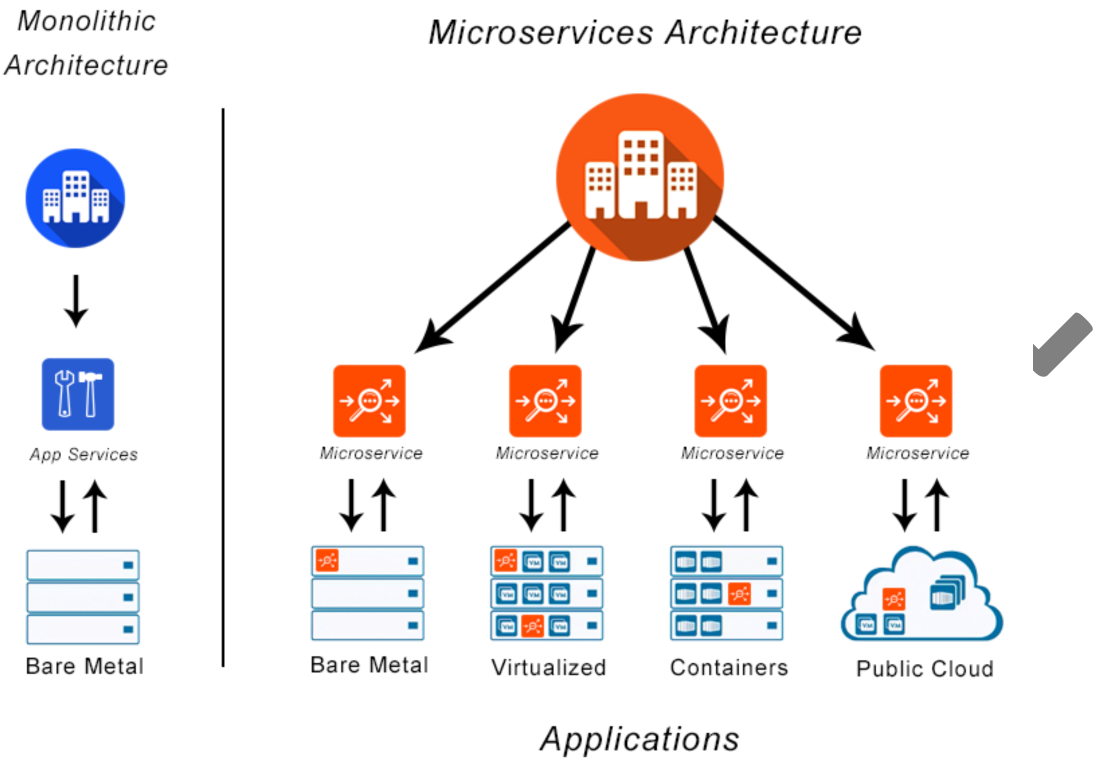
This distributed form of processing can allow data to be processed and analyzed at various region, state or provincial **"edge"** nodes / devices before the data is sent to the central data platform or data center. This allows for faster processing and analysis of data at the central level.

For example, if each region, state, or province performs some pre-processing and analysis of data, such as location and tracing data points, user registration etc., this will reduce the amount of work required by the central data platform.



4.2. Micro-service Architecture

The application / service layer will be implemented using a micro-service architecture.



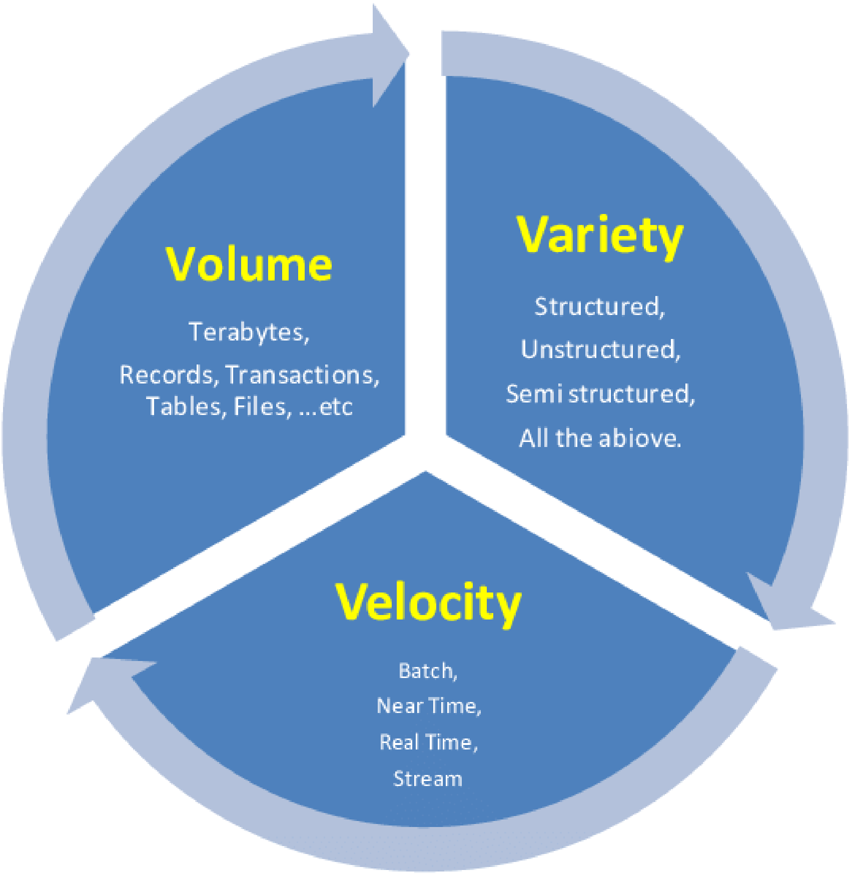
The micros-service architecture allows you to divide the application into small services or applications, which each represent a feature of the overall application.

This has the following advantages:

- **Distributed processing:** Each micro-service provides a feature or service of the application. This allows for better throughput and performance. For example, let us say that citizen registration is implemented as a micro-service and users are complaining that registration is slow or unresponsive. We can then start up multiple instances of the "citizen registration" micro-service to increase performance.
- **Horizontal Scaling:** The isolated nature of micro-services allows them to be hosted and deployed to multiple servers at a time to provide better throughput performance.
- **Fine-grained Security:** Each micro-service can be configured with their own set of security and authorization rules. For example, citizens using the mobile app will only be allowed to interact with the micro-services they are allowed. Government officials would have access to private or sensitive micro-services.
- **Change Isolation:** The isolated nature of micro-services means that we can change or update a micro-service without affecting the rest of the micro-services.
- **Integration Points:** External or government systems will be able to integrate with the application via consumption of the micro-services.

4.3. Big Data

Big data refers to the large, diverse sets of information that grow at ever-increasing rates.



It considers data from three perspectives:

- **Volume:** the size and source of data for consideration.
- **Variety:** the different data formats and schemas in which data can appear.
- **Velocity:** the rate or speed at which new data arrives at the Big Data pipeline and the rate or speed at which the data is processed and analyzed.

An example of **volume** would be the amount of citizen logging and tracing events generated each day by the mobile application. A large country, such as Nigeria, could generate hundreds of millions of these data points each day. This could mean that terabytes of data need to be stored and processed each day.

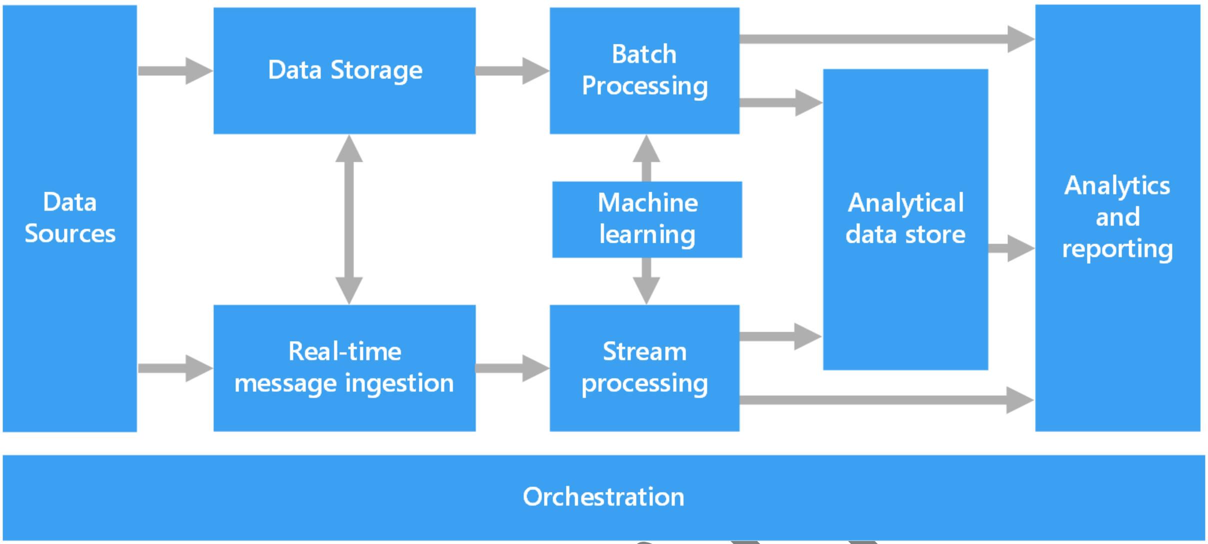
An example of **variety** would be the movement data captured by citizens using the mobile application, data captured by field workers, GPS data, Bluetooth data, geospatial data.

An example of **velocity** would be thousands or tens of thousands of data points entering the system each second, due to citizens across the country using the mobile application to capture their daily movement entries.

23A Fourth Avenue
Houghton Estate
Johannesburg
South Africal
enquiries@projectized.co.za
www.projectized.co.za

4.4. Big Data Pipeline

Below is the general architecture for a Big Data pipeline.



This pipeline can be used in the context of Contact Tracing as follows:

- **Data Sources:** data captured by citizens, field workers, GPS and Bluetooth data enter the pipeline.
- **Data Processing:** depending on the nature of the data entering the pipeline, it can be either be processed in real-time **(Real-time message ingestion)** or in batches **(Batch Processing)**:
    - **Batch Processing:** used to process data in batches. This is generally more accurate than real-time processing but has a delay due to complexity of the analytic processing. For example, average number of contacts events for each citizen in the country. Full history of contact events for each citizen
    - **Real-time / Stream Processing:** data is streamed and analyzed in real-time. For example, a citizen with Covid-19 interacted with seven other citizens in the last hour and those citizens need to be alerted of the exposure.
- **Machine Learning:** processed data can be fed through machine learning algorithms to extract additional data patterns relating to citizens.
- **Analytical Data Store:** processed and analyzed data can be stored in storage engines specifically designed for analysis and search.
- **Analytics and Reporting:** analytics and reporting tools to get an overall picture of contact tracing. For example, dashboards to show regional behavior of contact tracing within the country. Plotting of GPS or location data onto a map with a timescale etc.

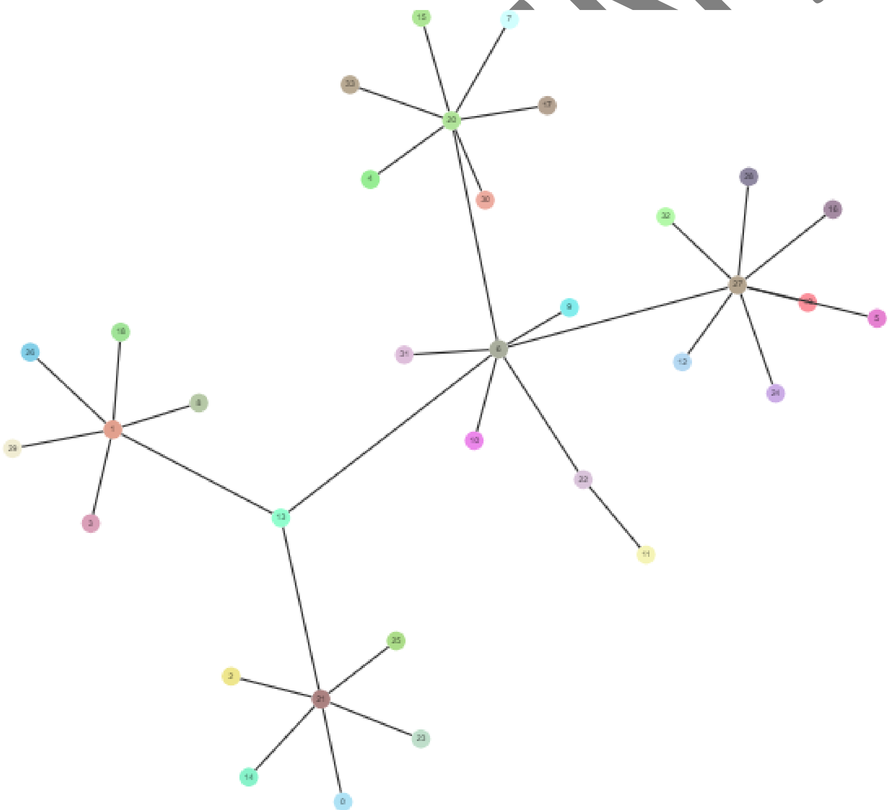
4.5. Examples of Analytics provided by Big Data

Below are some of examples of how analytics provided by Big Data can be used for analysis.

23A Fourth Avenue
Houghton Estate
Johannesburg
South Africal
enquiries@projectized.co.za
www.projectized.co.za

Example 1 – Citizen contact and movement over time.

Example 2 – Citizen contact/interaction analysis

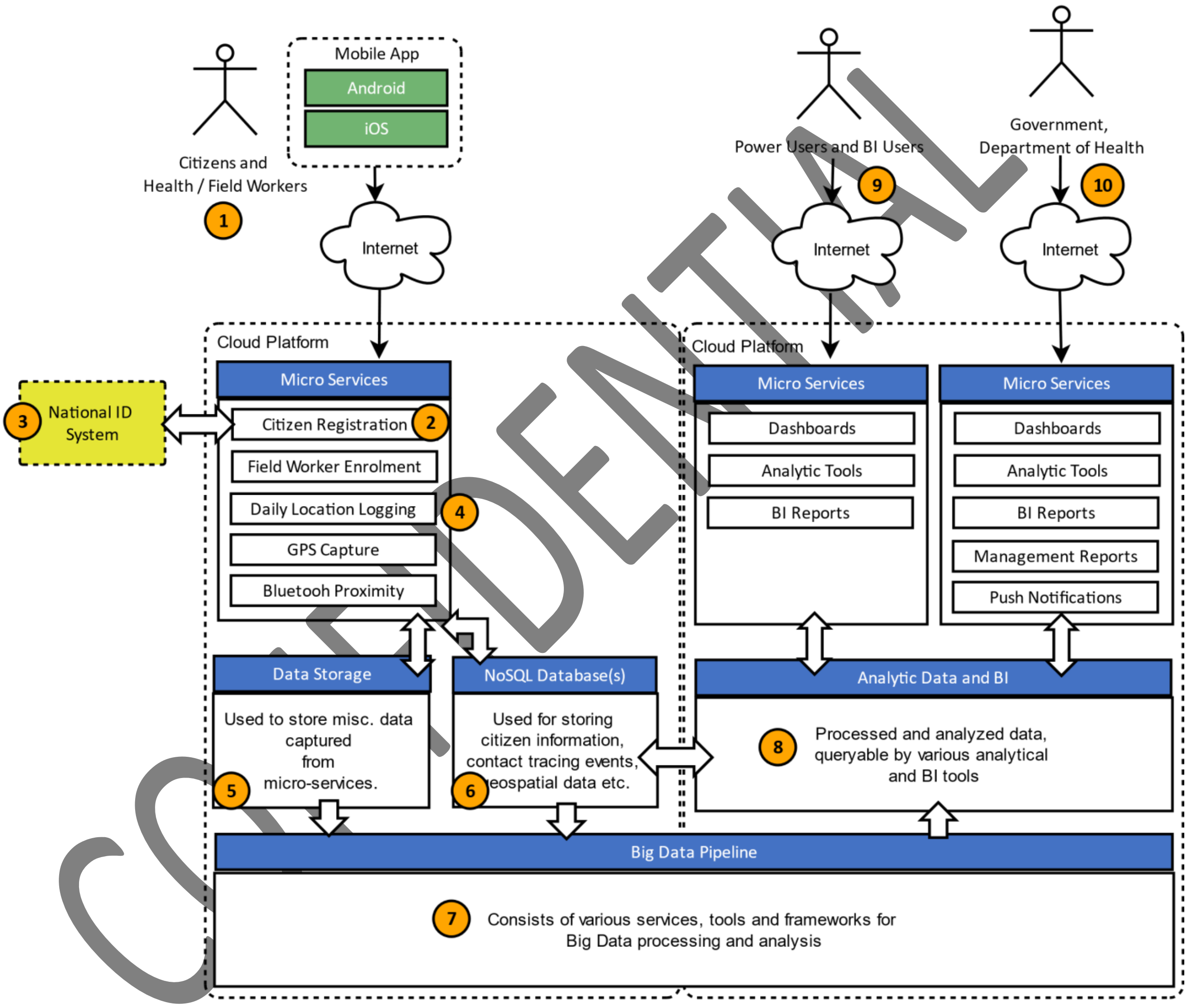


23A Fourth Avenue
Houghton Estate
Johannesburg
South Africal
enquiries@projectized.co.za
www.projectized.co.za

4.6. Proposed System Architecture

The application will need to be hosted on a cloud platform or on the data centers of each country to realize the requirements of the application.

Below is a simplified diagram of how the application can be hosted and used by various users of the application.



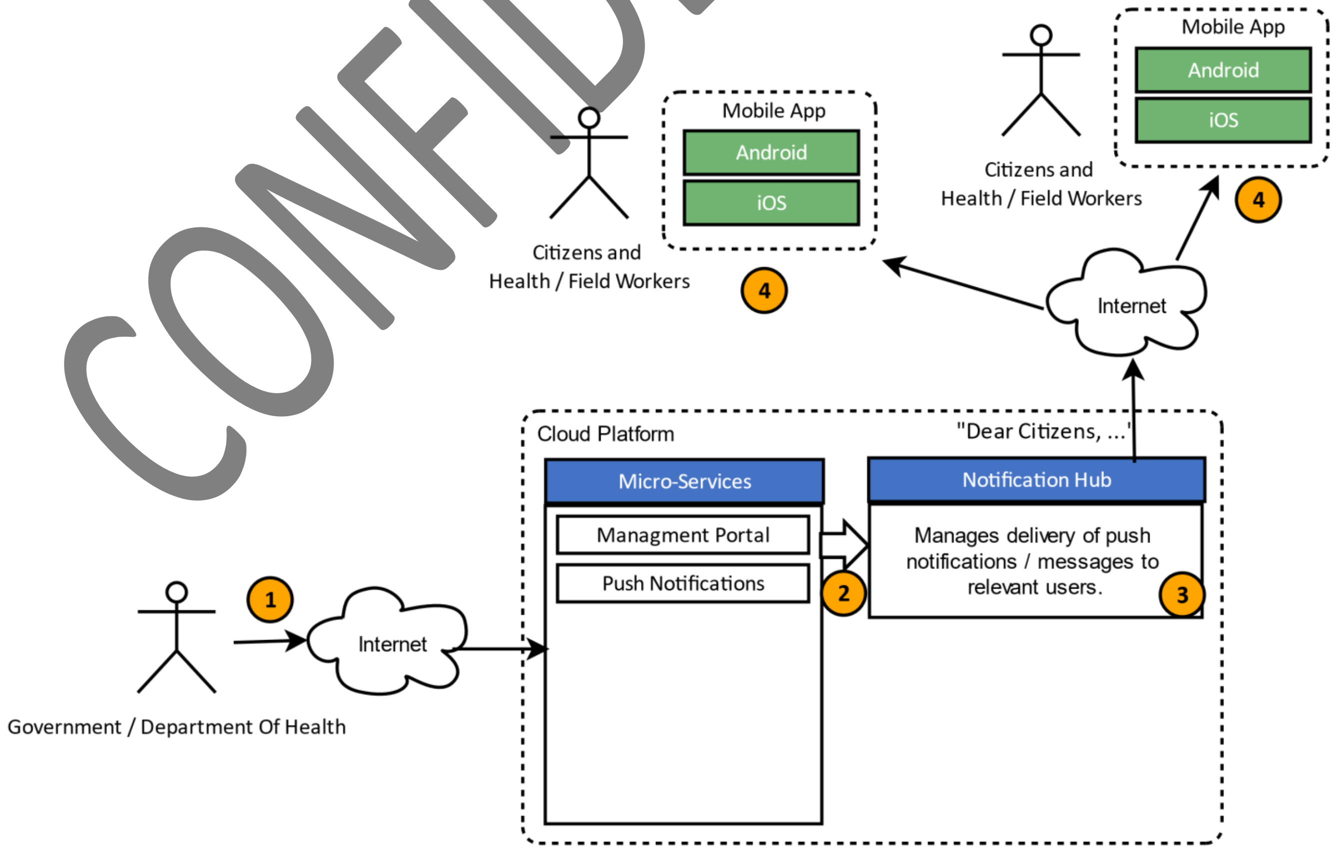
1. A citizen or field worker can download the mobile application to either register themselves or to enroll other people.
2. The 'Citizen Registration' micro-service will process the registration request.
3. (Optional) If the country has an existing National ID System that can be queried by the application, then the registration process will be simplified. The user can just capture their ID details and the remaining details will be retrieved from the National ID System.

4. All other data capture operations will be handled by the relevant micro-services. For example, the 'Field Worker Enrolment' micro-service with provider the functionality for field workers to enroll citizens who do not have phones.
5. Miscellaneous data, such as photos or documents, will be stored.
6. Database entries for citizen information, tracing events, movement logging etc. will be created or updated.
7. Captured data will be pushed to the Big Data Pipeline for processing and analysis.
8. Big Data that been processed and analyzed will be pushed to the analytical data stores.
9. Power users and BI users can logon to a web portal to view dashboards, perform analytics and generate BI reports.
10. Government ministers and departments, such as the Department of Health, can logon to a web portal to view dashboards, perform analytics and generate BI reports. They can also perform analysis not available to power users, as well perform additional management functions such as sending out push notifications.

4.7. Push Notifications

There may be scenarios where members of government, such as the Department of Health, may want to send messages or notifications to all citizens of the mobile application and other registered users, or to send a notification to a specific citizen or group of citizens.

This can be achieved as follows:



1. Members of government logon to a web-based management portal.
2. They configure and submit the push notifications / messages. The 'Push Notification' micro-service will push the notification / message to the notification hub.
3. The notification hub starts the process of delivering the message to the relevant users or citizens of the application.

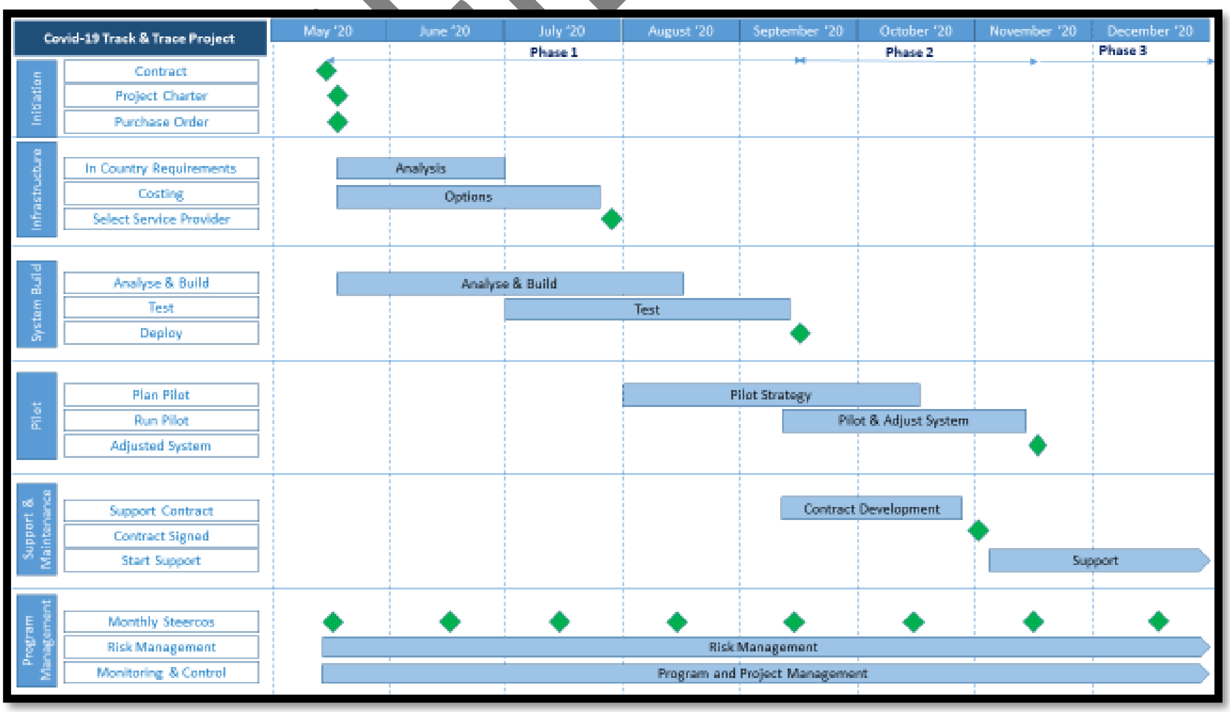
Citizens and field workers receive the notification message on their mobile device.

Chapter 5 - Timelines

5.1. High Level Flight Plan

The flight plan below is proposed for consideration by the client. It provides an end to end view that encompasses system development, Piloting though to Support and Maintenance for the year 2020.

In a nutshell, assuming a start date of 11 May 2020, we can have a system for piloting in the middle of September. We propose a 2 month piloting period in the countries planned for piloting with different languages. Following adjustments made to the system as a result of inputs from piloting, we foresee a roll out to the rest of the countries in Africa whilst system support and maintenance kicks in for the system in the pilot countries.



23A Fourth Avenue
Houghton Estate
Johannesburg
South Africal
enquiries@projectized.co.za
www.projectized.co.za

5.2. Project Plan

The flight plan above is supported by a detailed project plan attached as Appendix 1.

5.3. Flight and Project Plan Assumptions

The following assumptions are made with regards to the timelines proposed in this proposal.

- Contract and PO finalized by the 18th May 2020
- Agreement on the Architecture Design proposed for the solution
- Agreement on the cloud services to be used
- Contract between client and hosting services is in place
- Agreement on data management / restriction policies across countries

23A Fourth Avenue
Houghton Estate
Johannesburg
South Africal
enquiries@projectized.co.za
www.projectized.co.za

Chapter 6 - Conclusion

In view of this unfortunate situation facing the world today, we have chosen to be a part of the solution and use our expertise and skills to help save the lives of many people. As an African company that understands the context and hardships faced by many of Africa's citizens, we would value the opportunity as to build the solution for Africa. Through our solution, we hope to change the lives of our brothers and sisters across the continent not only in this pandemic, but to deal with many other health and poverty issues in Africa. For this opportunity, we would like to thank you.