# UNIVERSITY OF NAIROBI

# COLLEGE OF BIOLOGICAL AND PHYSICAL SCIENCES

# SCHOOL OF COMPUTING AND INFORMATICS

# BIRTH NOTIFICATION SERVICE FOR CIVIL REGISTRATION

# IN KENYA – SOA MODEL

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## P53/79106/2015

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Submitted in partial fulfillment of the requirements of the Master of Science in Distributed Computer Technology

## Declaration

## Student

I hereby declare that this project is my own original work and has, to the best of my knowledge, not been submitted to any other institution of higher learning.

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This project has been submitted as a partial fulfillment of requirements for the degree of Master of Science in Distributed Computer Technology with my approval as the University supervisor.

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## Acknowledgement

# Table of Contents

# Abstract

The problem of birth notification and registration has limited the rights of children to education, health, recognition among other human rights. The challenge to sufficient registration of new born babies is traceable to the initial stage of notification.

The aim of this project was to investigate application of modern ICT technologies in solving birth notification problems in rural communities and the use of web services in sharing birth information with various stakeholders. The specific objectives that project sought to address include; investigation of current birth notification system in Kenya, the processes, finding the appropriateness of application of service oriented architecture in designing and developing a prototype for birth notification solution. The intention was to allow real time pre-notification of vital events by parents, verification of that information by local agents, and sharing of that data for use by other government agents. The events that take place in hospitals were also included in a broad solution.

In this project two approaches were used where case study of a remote Sub County of injara in Garissa County was used to study rural events and processes. Then IT product design and development was used to develop prototype based on service oriented methodology .This is an iterative and incremental process of transforming business processes to services until services are developed, deployed and can execute as expected.

The prototype in which parents and guardians would notify birth events as soon as they happen, using SMS, web portal or mobile application was developed. The registered birth data consumers could import data to their applications from the prototype using an API in desired platform. The testing and evaluation findings revealed that application of integrated services of SMS, Web application and Mobile application have positive implications in birth notification process. This was so through real time reporting of events. The evaluation of the system showed that the integrated services can improve birth notification experience both for rural events and hospital events as well as provide real time data for other consumers such as national health care insurers as well as statistical data consumers.

# List of Figures

# List of Tables

## Abbreviations

UN              United Nations

CR               civil registration

CRVS         civil registration and vital statistics

ICT              information and communication technology

MOVE IT      monitoring of vital events using information technology

VS               vital statistics

URI             uniform resource identifier

WHO          World Health Organization

API             Application Programmable Interface

SOA           Service oriented architecture

HIS             health information systems

CHWs        Community Health Worker (s)

NHIF          National Hospital Insurance Fund

WWW         World Wide Web

REST          Representation of State Transfer

# Definition of terms

**SOA**– it is an architectural style or paradigm where services are provided between  set of components, through a communication protocol over a network.

**Usability**- Making application easier to operate and matching it more closely to user needs and requirements.

 **Accessibility** – it is ease with which information can be input or retrieved regardless of the location where the user is located.

**User Interface**- It is the means in which a person controls and interacts with a software application or system.

# CHAPTER ONE: INTRODUCTION

Registration is a key milestone towards gaining belonging, acquiring rights and accessing services in any organization. When a child is born the first step towards recognition is usually naming, and thereafter entering the given name to a register. However this is not the case to many children in Kenya, whose existence is absent from any form of registration. A key human rights instrument includes but is not limited to Universal Declaration of Human Rights (UN General Assembly, 1948) states that "every person has the right to a nationality" and this depends on having each birth legally recorded. This was also reinforced in the Declaration of the Rights of the Child (UN General Assembly, 1959) that states that every child is entitled from birth to a name and nationality; and in the International Covenant on Civil and Political Rights (UN General Assembly, 1996) that also states that "every child shall be registered immediately after birth and shall have a name."

The problem of unregistered birth events in Kenya is as a result of various challenges that face different players. These problems and challenges include information gathering methods, transmission, processing procedures and legal structures. Some of the systems are outdated and may have difficulties in matching modern needs in data management and requirements.

In any organization information communication technology is a key tool and driver of doing business and should involve the embracing of best available practices. It's therefore to the interest of any organization to conduct business using the best ICT models and paradigms to stay profitable and relevant in the market.

In recent times service oriented architectures has become a great business paradigm of constructing and integrating systems for cohesion, granularity and reuse. SOA is a paradigm that provides strategies, principles and methods in which business processes, information and enterprise assets can in best practice be organized and deployed to provide and enable best business strategic plans. This results in productivity levels that are required by competitive business environments (Papazoglou 2003). In this manner, new business processes, components or services can consistently be added and mapped to service providers without affecting entire enterprise but providing ease of reuse and modifications.

## 1.1 Problem Statement

In developing countries there exist a number of challenges and opportunities for civil registration systems that include: scaling up, innovation, and integration of systems, business process streamlining and automation of CRVS processes. A key challenge experienced in Kenya according to (WHO, 2013) report is that only 57% of all births and 49% of all deaths were being registered. This clearly shows there is a problem when Kenyans undertake process of birth registration. The registration process which starts at the notification stage has several players who also have distinct roles and accompanying challenges.

This low coverage of birth events in Kenya is attributed mostly to the fact that the events that occur outside health facilities are rarely registered or numerated. This is a limitation to systems and structural processes of notification, information processing and legal structures of carrying out actual registration.

The registration officer in Kenya ideally relies on the office of the chief and medical institutions to carry out birth and death notifications. This is expected to be done accurately, timely and in a complete fashion. However this has not been attained after numerous attempts and the capture of birth events still remain low in rural communities. On the other hand in urban and semi urban communities not all the notified births events get into registration record.

Among the challenges that hinder adequate birth registration is the problem of initial data capture to the system, especially regarding the notification of community events which may occur in vast rural areas. In many areas across the country the systems are manual hence challenges in error management, accessibility, data sharing and transmission.

In developing countries there exist a number of challenges and opportunities for civil registration systems that include: scaling up, innovation, and integration of systems, business process streamlining and automation of CRVS processes.

## 1.2 Objectives

To design a system that can improve the birth notification process and hence increase the birth registration in Kenya, through a suitable service oriented architecture model for vital events notification which also can integrate with other systems.

**Specific objectives,**

1. To evaluate and investigate the existing birth notification process and registration systems.
2. To propose a system that can lead to timely notification of birth events, share data, and integrate well with other legacy systems in various agencies.
3. To design and build a prototype that can lead to acquisition of vital statistics for national planning and development in Kenya.
4. To test the prototype.

## 1.3 Significance of the system

The notification of births which is followed by registration and evidenced by issuance of a certificate of birth has wider range of implications (WHO, 2010). Apart from being the first legal acknowledgement of a child's existence and a ticket to citizenship and nationality, a certificate of birth is fundamental to the realization of a number of rights. The development of the system sought to provide solutions in notification of every birth occurrence. The developed system was able to provide services that can promote;

i)   The enrollment of children in school at the right age through provision of required data.
ii)  Protecting a child orphan from being disinherited by guardians/ relatives by providing parental information of all children.
iii) Effective counter measures to the problem of forced marriage for girls before they are legally  eligible, by providing data that can be used as proof of age.
iv)  Provision of the required data in educational, health and or insurance policy cover for children.
v)   Care for children in conflict areas by providing required data for special protection of children so that they are not treated practically as adults. (WHO, 2012)

The pre-notification service provided  population participation in notifying birth events remotely and also accelerate notification processes through involvement of communities hence a greater

opportunity in registration of birth events. The pre-notification service also provided important data essential in national planning and developments.

According to UNICEF, Plan international and WHO in Eastern pacific countries ministerial meeting of ministers on strengthening civil registration and vital statistics system (CRVSS) held on 24-28 November 2014, ICT has the potential to provide transformative improvements in CRVS systems based on its ability, among others, to ensure universal coverage (meaning no one is left behind), to standardize and streamline registration processes, to ensure system interoperability and provide secure storage. It is therefore important to carry out a study and build systems that can strengthen birth registration that should begin with universal notification service.

This therefore necessitates for appropriate designs of distributed ICT applications coupled with suitable structures so as to raise birth registration statistics. The modern technologies therefore should be proposed and systems constructed in order offer best solutions in birth registration.

# CHAPTER TWO: LITERATURE REVIEW

## 2.0 Introduction

This section is broken down into background of registration problems, background on service oriented architecture the registration process in Kenya, the existing solutions and the proposed solution.

## 2.1 The Background of Birth Registration in Kenya

Analysis of the organization of the civil registration processes and functions requires mapping all the authorities and organizations with a role in civil registration, in a model that allows smooth integration and collaboration of services. During notification process in Kenya for instance local administration are part of notification process and so are health workers but actual registration and issuance of certificate is done by department of civil registration. The problems in notification process arise from various fundamental issues which are attributed to technical, legal and policy mechanisms (WHO, 2013)

```
┌─────────────┐      ┌─────────────┐      ┌─────────────┐      ┌──────────────────┐
│ Birth event │ ───▶ │ Notify birth│ ───▶ │  Register   │ ───▶ │ Issue certificate /│
│   occurs    │      │    event    │      │ birth event │      │   share data      │
└─────────────┘      └─────────────┘      └─────────────┘      └──────────────────┘
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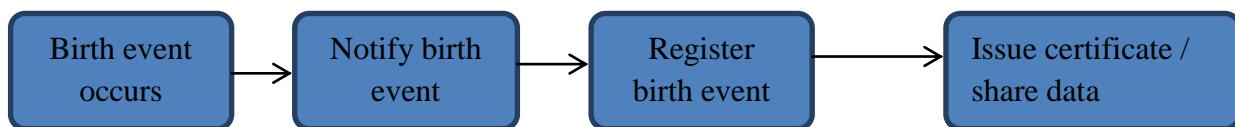
**Figure 1: Steps in birth registration process**

## 2.2 Limitations in birth notification system

The local registration agents are the first authorized points of contact that provide legal witness and notification of the birth occurrences and events. The CRO are reliant on the assistant chiefs and medical institutions to carry out birth notifications in an accurate, timely and complete fashion. The registration officers in Kenya mainly wait for these agents to supply the notification data which is the key for any registration to take place (UNICEF, 2013).

The assistant chief works for the Office of the President and are not employees of the CRD, they are therefore not directly supervised by or responsible to the civil registration department. Where the local registration agents do not or cannot perform notification tasks adequately, it is less

likely that there is any corrective measure or sanctions that can be taken if they remain passive on notification process. This leaves the community in a big problem of registration since some agents (assistant chiefs) are not housed in offices which are known or accessible.

The Assistant chiefs carry out a wide range of administrative tasks for the Office of the President in a sub-location. The task of birth notification may not be among the priority responsibilities and therefore they may not see the need to be involved proactively in notifying events; they may not even avail themselves to carry out notification process when sought. More so if there are higher priority issues in the sub-location, they may be overwhelmed by numerous issues they handle.

However some chiefs may be working hard to carry out notification of these vital events, but some sub-locations are very large geographically and not easily reachable by the assistant chief to investigate where new events has occurred. In some communities also the style of livelihood is nomadic which complicates not only administration processes but also access and reachability for recording and registration purposes. In such scenarios solution to the process should be tailored to suit their way of life but still providing the needed information within significant time lines.

There exist chances where two assistant chiefs could, in theory, notify the same event, for example, in the place of event occurrence and again at the place of residence of given individuals. This in practice leads to duplicate records. This is especially the case for births if parents initiate the process at the place of occurrence and then again at the place of residence. There is a need for active mechanisms to curb against duplicate notifications and registrations in most registration centers in Kenya. The integration with ICT mechanisms should be incorporated at earliest stage of registration process, which is notification to enhance credibility of information captured.

An integrated system would be an ideal solution to this notification complexity if it can rely on various sources of notification and consistently record the events. A service which is client focused and that can minimize duplicate registrations by facilitating the search capabilities, and an alert if duplicate information is entered among other capabilities, would enhance availability of valid process and data.

The importance of the informant lies in the fact that, the registrar can legally record a vital event only on the basis of a legally designated informant's declaration, either verbally or in writing. The informant must be able not only to supply the accurate information necessary for registration, e.g., for legal purposes, but also the particulars required for statistical purposes, (UNICEF, 2013).

Some single parents may fear questions of paternity during notification through chief or community agents. Therefore due to such reasons as stigmatization, culture and religious settings they choose to stay with unregistered children. Other scenarios still are underage girls who are in dire needs of assistance but due to fear of stigma and discrimination by community they will not come out to report or notify about birth to chief. In community some people may not be in good relationship with the chiefs and thus may be unwilling to report any matter to them whatsoever. An innovation solution that can be designed to notify birth events within existing legal structures would be an asset not only in the process of registering every birth but also rendering of maternal care and services to such under privileged.

The notification of birth may reach the agents and record it down for onward transmission to CRO. However in that process it may get lost or damaged if recorded manually before it get to the CRO for registration or even further get there beyond acceptable set time. In most parts of the country the unregistered populations reside in the rural areas. These area mainly lack in good road network and reliable transport means to registration centers. Rural and remote folk also have challenge with transport fees to the centers and in most cases immediate returns of birth notification or registration are not visible.

According to the United Nations children fund, the ability of the civil registration service to function is highly affected by certain special circumstances, such as natural disasters and conflict. Nationals may need to flee from emergency situations, and vital events among refugees and displaced people may go unregistered, (UNICEF 2013). During civil war or unrest certain areas of a country may be inaccessible or unsafe for government officials such as civil registrars. Similar challenges can also apply in countries with large numbers of refugees and migrants. Therefore innovative ICT solutions in vital events registration should have wide scope to cover such circumstances and work toward availing dependable information under strenuous circumstances. In Kenya we have had a wide share of problems brought by refugees trying to

register as citizens or neighboring countries acquiring citizenship illegally. This is majorly to be blamed on weak birth notification and registration system which does not capture those details early enough in life.

## 2.3 Background on Service Oriented Architecture

SOA is an approach of solving problems where technical capabilities are organized in standardized principles that can enable elastic performance of continuously shifting requirements and demands. Services are envisioned as capabilities performed by one component for another to accomplish the expected outcomes and goals. SOA institutes services as the mechanism by which needs, capabilities and solutions are tied together. Its orientation implies that its capabilities are autonomous and self-governing so that several services can be connected together to solve various business challenges. SOA therefore seeks to standardize the interface so as to support enable seamless communication of various actors.
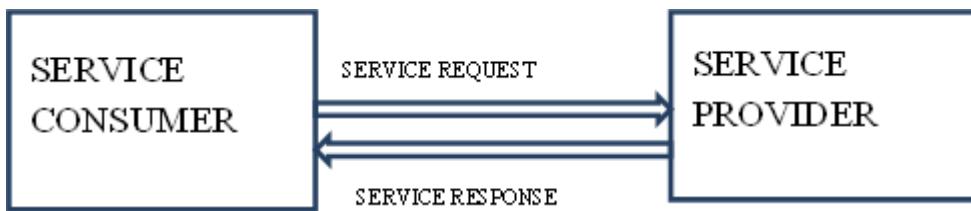


Figure 2: interactions between service requester and service provider in SOA model

Most Enterprises are made up of a set of business processes that can be broken down into simpler discrete building blocks known as services.

Service-oriented architecture defines how to integrate widely disparate applications for a Web-based environment in electronic business and uses multiple implementation platforms. Rather than defining an application integration pattern for extended enterprise, Service-oriented architecture defines the interface in terms of protocols for electronic business and functionality, (Papozoglou,2006) .This creates avenues for disparate organizations to share data and communicate irrespective of heterogeneity of their hardware and software platforms. The service providers advertise their services where they can be discovered by requesting clients.

## 2.3.1 SOA Implementations

Different application needs may require different SOA patterns and designs in software construction in order to realize the best outcome and performance. In SOA implementations we have web services based on SOAP, which are reliant of three standards namely SOAP protocol, WSDL and the UDDI. The other implementation is based on RESTful services which majorly utilizes the HTTP protocol.

I.    SOAP Web Services

This implementation is mainly leveraged on existing applications, where XSD (xml schema) is usually constructed. The XML is the payload in the SOAP protocol message which enables access to the service. The service contract WSDL, web service description language is developed to govern service consumption. This contract binds the parties; the service provider and service requestor, on how to provide and how to utilize a given service respectively. The service provider then publishes the service with all required terms, in a place it found by the service requestors, usually in a UDDI (universal data discovery and integration). UDDI is a registry for publishing, maintaining and the management of web services. This is a standard promoted by WWW (World Wide Web) consortium and it is better than REST in respect to security in distributed systems (Yong, 2008). SOAP offers libraries which make it easier to create services for various businesses or organizations. However SOAP requestors are required to understand all activities implied in a given service, this therefore makes a large number of operations required to be defined per each message transacted. This increases the load and constraints in transactions that involve context-aware applications hence higher network load.

II.    Restful services

The components here are uniquely identified through a hypermedia link (URI). The restful services implementation uses HTTP which is stateless protocol. In computing, a stateless protocol is a communications protocol that treats each request as an independent communication and that it is unrelated to any previous request (Fielding, 2000). In REST the URL is made available to the client who in turn gets the resource in a specified format. The request must contain all the required information by the server so as to have a complete

execution. These formats may be XML, HTML or JSON. The services in REST are accessed using operations HTTP GET, POST, PUT or DELETE.

The RESTful SOA architecture is tiered, and data can be cached at any layer thus improving performance in the clients' rich applications. It also improves the performance of the applications because there is no need to look up contracts in web service registry. The functional process logic, data access, computer data storage and user interface are developed and maintained as independent units on separate platforms.

The application of service oriented technology has overall multiple advantages in development of modern solutions in various fields;

I. Loose Coupling

The use of SOA principles means that your business infrastructure and architecture are split up into various services. This makes it pretty easy to write software that tends to be loosely coupled (less interdependent). This is not the case with traditional systems where many applications are tied to specific architecture and platforms.

II. Flexibility

In the SOA the developers, software engineers and the organizations are given flexibility to design various components of the architecture in whatever language and platform they choose to. So this means, you can write the client facing side in a more dynamic and productive language like Python/Ruby/Javascript etc. and write the performance critical components in lower level languages like Java or C.

III. Easier Testing and Debugging

Having all your components isolated into various services makes it easy to test and debug each of them individually. Many organizations have separate teams to develop, test and maintain these components, while others share data with other agencies thus various platforms exists. To test and upload such systems require flexible, isolatable and semi-autonomous components.

IV. Scalability

Having separate components makes it simpler and easier to scale up the architecture. This could easily scale up a particular component or service and test it in isolation, without affecting the other components. This makes it easy to add in servers, services or infrastructure components without facing any downtime. Since various components are built out separately, it becomes much easier to reuse them later.

## 2.4 Related work

### 2.4.1 The Existing Solutions in Kenya

In Kenya manual notification of birth events is still highly used. The event is recorded by an agent and family issued with duplicate slip. To follow up on registration is by going to the nearest registration center. Some hospitals have been installed with system for filling vital events. This system is still being rolled out in the country. It is expected to capture vital events into databases. These solutions still require improvement because, one, not every birth event occurs in the hospital and two they don't offer participatory of people served, in notifying and following up birth registration through distributed system access. These are the areas that this project intends to evaluate and propose suitable solution.

### 2.4.2 Mobile phones to Improve Registration of Births and Deaths in Kenya.

WHO Country Office, Kenya; and the Millennium Development Goal (MDG) Central, East and Southern Africa, embarked on a project named: Introduction of mobile phone technology to speed up and improve the registration of births and deaths (WHO 2013).

The main objective was to integrate Mhealth (mobile technology for health) within the existing civil registration system to demonstrate that infrastructural barriers that impede the registration of births and deaths could be overcome by the use of mobile phones and transmission of data over phone lines allowing real time reporting and monitoring of events. The solution was based on RapidSMS platform within an automated System for notifying of births and deaths by community health agents and local authorities.

One lesson learned using mobile phone technology was that notifying the assistant chief with an SMS did not necessarily result in the event getting legally registered through the civil registration officers. This is because the solution focused singular notification but not entire architecture of notification and other legal processes.

Their solution was tested in comparison to manual systems and was found to be better for health workers to send notifications they capture on "real time" to centralized systems. The process did not explore on how parents and guardians can be part of notification process as crucial source of that data and the need to involve them in their project. Solutions therefore need to be expanded

within current and future legal frameworks to involve those who have the vital events to be part of notification process using technology.

The other limitation of that system was their "real time" capture of vital data could only apply to events within health facilities which are easily recorded. The events that happen outside medical centers have highest probability of missing on registration. These events can be captured on real time if system allows participation of local population or individual families which actually form the greatest statistic of unregistered civil data. One of the aims of this project is to find prudent avenue using services and notify each birth as soon as it happens (real time).

## 2.4.3 Use of Mobile Applications to Improve Flow of Birth in Tanzania and Malawi.

This project centered on finding methods for improvement of birth registration in communities by facilitating communication of birth information between community health workers (CHWs) in their communities, the health facility workers and district health officials in the republic of Tanzania and Malawi (Ngoma et.al. 2011).

Their findings revealed there were viable opportunities in use of mobile phones in improving the communication of health information systems that would greatly augment provision of reliable and timely supportive supervision and significant feedback. They noted this would help in improving the collection, recording and transmission of birth information. The Provision of support was observed as one of the key factors for motivating CHWs to improve on their duties and performance. In that sense, a mobile phone could therefore be adopted as a tool to strengthen the structure in the HIS. This in turn would motivate the CHWs to collect and report accurate and complete information timely .This project therefore was a milestone in digitization and transmission of collected data departing from manual systems.

The limitation of this project is that it bordered on improving working conditions for the CHWs and their motivations without exploring a solution for rural communities to participate in notification and registration process. The community health workers learning of new events which they could report was not also addressed by this system. The transmission of noted events to district registrars also does not give the served person avenues of following up their registration process remotely. These are the gaps this project seeks to address in the process of developing solution for counting every event.

## 2.4.4 Mobile Birth Registration in Sub-Saharan Africa

In Senegal, an NGO called (Aide & Action) whose activities focused on facilitating access to education, had already identified the comparative lack of birth certificates as a barrier to education, and was working to improve registration efficiency by raising awareness amongst village chiefs. It appeared that the best way to improve registration rates was to make it easier for village chiefs to inform regional and national registration offices about new births. The solution was deployed by Orange where mobile phones were equipped with specific java software. They were then distributed to 30 village chiefs. The chiefs are responsible for capturing information regarding births in their village, and transferring that information to the Senegal State Registrar (Ngoma et.al. 2011).

The registration office is equipped with a mobile phone in order to receive the information sent by village chiefs. Once received, this information is checked and the birth is registered both physically in the registry, and electronically in a database. A registration number is then sent back to the village chief, who communicates it to the parents. This registration number means that the child has been registered. Using this number, parents can collect a birth certificate from the registration office at any time, provided that they pay the corresponding fee.

In Uganda, a dual solution was rolled out to:

a) Hospitals are equipped with a 3G connection (when necessary) to access a web-based application to register births.

b) Registration agents (village chiefs, regional administrators) are given SIM cards mapped to their names, so as to be able to send USSD codes to register births occurring locally.

In Uganda Telecom used USSD codes on mobile phones, and a web-based application on computers. USSD may be less "user-friendly" than a customized Java applet, but has the advantage that it can work on any phone; this is according to (GSMA Mobile Identity Team 2016).

Limitations of the solutions in Senegal and Uganda were:

I. The solutions were based on specific mobile networks thus limiting users of other network or forcing users to have multiple SIM cards. This creates an issue of interoperability with other mobile networks and also with legacy systems.

II. The solution required creation of unified database of all network providers for the registration birth events, with subscribers of any and all networks being able to use the system, this is a difficult task to attain.

III. The solution also did not focus on local population being active participant except through local chiefs which creates a disjoint in real time notification of vital events.

These are the gaps that the proposed project wants to look into by proposing a system that can allow individuals irrespective of system architecture or platform to access the services.

### 2.4.5 Mobile-Based Child-Birth Registration System in Nigeria

The project carried out by Olusola, et. al. (2016) was aimed at addressing the challenges facing families in the area of child registering by using mobile technology for child-birth registration. The work relied on use of mobile-based child-birth registration system to increase accessibility, reduce cost and keep the records for future use. The work focused on the registration part in civil registration process and did not go to the details notification process. This project has identified notification process as the key impediment to sufficient registration. This project intends to go a step further in proposed solution to incorporate broad based mobile solutions in notification of events. It is also important to note that legal processes and requirements in each country are unique and therefore solutions must be tailored to fit within legal contexts which are not amended overnight.

### 2.5 Envisioned Solution

This project envisioned a mobile; web and SMS based solution where individuals are active part of notification process. Instead of physically looking for the agents, they can be a part of multi-level service oriented notification and registration service which can also be integrated with various vital data consumers. In the intended solution a multi-stage verification was proposed, players (chiefs, hospitals, reporting parents) are notified and records are validated.

## 2.6 Conceptual Design

The following diagram shows the actors in the conceptualized model.
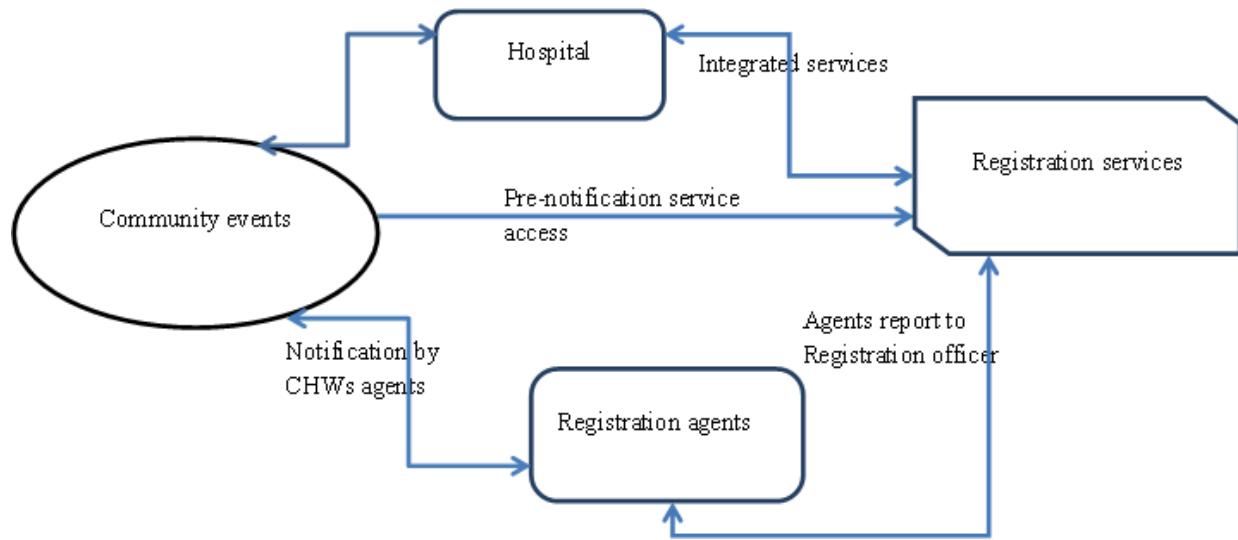


Figure 3: Conceptual Model Design

The diagram represents how birth occurrences (events) are reported or forwarded to the registration officer in the office of birth registrar. The events that occur at homes (community events) are registered through registration agents (chiefs through notification by CHWS). The events that occur in hospitals are notified by hospital staff to the registration office.

The envisioned solution has a pre-notification service where birth events or occurrences at home and in the community would notify the registration office using the system. Once pre-notification is done, probably in real time, registration agents and hospitals can then help in confirming the notification using the system.

The system is also has capability of sharing data between hospitals and registration offices for various uses and this may include maternal health.

# Chapter 3 : METHODOLOGY

## 3.1 Overview

This chapter entails the methodology used and various steps taken in achieving the objectives of the project. The service oriented methodology proposed by Papazoglou (2006) was used. This is outlined in seven iterative phases.

## 3.2 IT Product Design and Development Methodology

In service design and development, it advocates for the identification of the right services, organize them into convenient order of composite services, choreographing them together to support business processes. The business services or processes can be made up of smaller or finer services that have to be sustained by infrastructural services and management services such as provision technical utilities. These include services such as logging into a given system to use it, security attributes or features, authentication of processes, and other system modules that control the resources.

According to (Papazoglou, 2006) service-oriented design and development is based on an iterative and incremental process that comprises one preparatory and eight distinct main phases that concentrate on business processes and can be carried out iteratively. These are planning, analysis and design (A&D), construction and testing, provisioning, deployment, execution and monitoring.

**Planning phase** - this phase comprise of carrying out the preliminary study, understanding business processes in an organization. At this stage the activities includes analyzing the business needs and requirements in measurable goals, reviewing of the current technology landscape and systems.

**Analysis and design -** this follows application of the gathered requirements in designing components of the required system services. It also involves further analysis of best methods to meet the requirements. The conceptualizing of the requirements of the new environment and its effects on existing systems then mapping them to a new solution or modifying available implementations

**Construction and testing** - this is a phase where components are coded using appropriate tools. The various services are constructed and appropriate interfaces are defined.

**Provisioning phase** - Service provisioning comprises of technical and business characteristics for supporting services and client activities. This may involve choices for service governance, service certification, and service access and billing.

**Deployment** – This includes the publication of the service interface and service implementation descriptions on how applications and users can consume or find the services.

**Execution and monitoring** - During the execution phase, Web services are fully deployed and operational. During this stage of the lifecycle, a service requester can find the service definition and invoke all defined service operations.
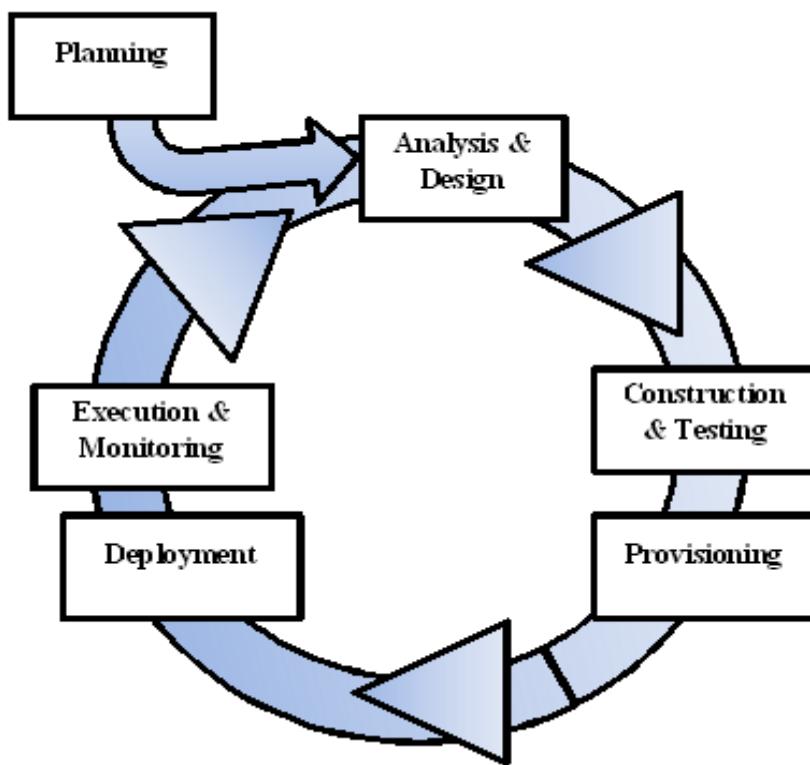


**Figure 4: Phases in the service-oriented design and development methodology (Papazoglou, 2006)**

### 3.2.1 Planning phase

The planning phase in this project was concerned with the feasibility study, nature and scope of service-solutions in the context of the birth notification and registration and also in the integration with various services and agencies. The key requirement in this phase is therefore to

understand the business environment and to ensure that all necessary aspects of the system are incorporated and considered in the design of the proposed solution.

The planning phase includes location selection, feasibility study and listing business needs fine grained concepts.

### 3.2.1.1 Location and scope

One segment of this project aimed at understanding and describing what parents and guardians go through in notification and registration process. What improvements can be done to give them best services during this process and increase overall registration? To gather such information the project relied on multiple designs to meet the objectives. A case study design was be carried out in rural selected area to analyze and evaluate the notification process in rural setting which is also closer to border region. In this case Injara Sub County in Garissa County is selected for studying the rural events in birth registration. This design is seen by the researcher as a crucial in studying the operations of civil registration department. The study was also carried out in key institutions of interest that include; civil registration department (CRD), health facilities and birth data consumers like NHIF (National Hospital Insurance Fund). This was geared towards evaluating the current systems of notification and registration, and data sharing mechanisms. This brought better understanding to requirements of proposed solution.

3.2.1.2 Feasibility study

This is the summary of the cost and benefit analysis of this project. It is the initial investigation that was carried out and confirmed throughout construction of the system.

| Feasibility | Outcome of the study |
|---|---|
| Operational | a) It was found out that system would work after deployment.<br>b) System was evaluated and was according to initial plan |
| Technical | a) It was found there are resources to develop, purchase, install, and operate the system in full production.<br>c) Supporting infrastructure for the system is sufficient for deployment in Kenya, there was good mobile coverage. |
| Economic | Financial benefits of the system outweigh costs since it would benefit many citizens as per system requirements analysis. |
| Schedule | a) Initial project schedule worked well and time was enough.<br>b) This project was carried out in set of three milestones |
| Political | a) Existing structures would support the system deployment<br>b) Users would be able to use the system<br>c) There would be minimal changes to structures in places of work |
| Legal | a) System would work well within existing laws CAP 149 and Kenyan constitution.<br>b) Enacting of new laws also would improve on some operations.<br>c) Project processes adhered to human rights and public relations.<br>d) The data received was properly coded and presented to protect individuals or institutions.<br>e) Data gathered was confidentially used only for intended or requested purposes. |

### 3.2.1.3 Population

The project relied on various methods and instruments to collect data. These instruments include interviews, face to face interviews, telephone interviews and questionnaires. The key stakeholders in the CRD, medical information officers and the data consumer agencies were interviewed. This is because their input was significant in describing the aspects of the system.

The interview format was face to face interview for this group. These interviews were geared towards providing insight on current systems in use, on aspects of notification and registration processes. The interviewees in this category were;

a.      Interview the District Registration Officers.

b.      Interview ICT officers in CRD.

c.      Interview users of current system in CRD

d.      Interview medical records and information officer.

e.      Interview ICT Officers in NHIF

Those who carry out notification on the ground, chiefs were interviewed to provide details of current registration system hurdles. Interviewing chiefs in remote districts helped the researcher in gathering qualitative data on current situation. Interviews were chosen because feedback would be immediate and it allows interviewee describe all possible angles of the challenges or the situation. The researcher employed focused interview so as to get as much information as possible. This also granted interviewees freedom to answer question broadly. Individuals who have vital statistics were interviewed using a structured interview.  This instrument was chosen because a number of individual's in the targeted rural population may not be able to read and write or fill questionnaire appropriately. In some sampled areas where accessibility is a challenge researcher employed telephone interview instead of face to face interview. Acquiring information from district registration officers the study used telephone interview.

**3.2.1.4 Requirement Analysis**

As earlier described in section 3.212, requirement analysis is an important step in understanding business processes and environment. The following were the references for this project;

1. Survey was conducted in Injara Sub County between $16^{th}$ June and June $30^{th}$ 2016

2. Oral interviews for senior ICT Officer Civil registration Department, $2^{nd}$ floor Hass Plaza upper hill area $15^{th}$ July 2016

3. Interview medical data records officer Masalani hospital 18th July 2016

4. Telephone interview for sampled CRO in remote Districts in August 2016

5. Interview National Hospital Insurance Fund (NHIF) ICT officer BuruBuru office.

These informed the business processes and services as listed below.

i.   Notifying the event

ii.  Physical confirmation of the event

iii. Recording the event in official record

iv.  Issuance of the notification slip

v.   Compiling the notification events by chiefs / hospitals

vi.  Registering the event

vii. parents presenting requests

viii. paying requisite fee

ix.  processing the requests

x.   Issuance of certificates

xi.  Dissemination of data to various agencies

xii. Verification requests from external users

The analysis gathered that current system is manual with no real time system for acquisition of birth events from various notification agents and hospitals. The agents perform monthly returns from which then full registration can be carried out.

The CRD department is in process of digitizing previous records which now appear to take more time than expected. The department hopes maternal health can help increase coverage of the children fully registered, but challenge remains not all events will take place in hospitals.

The challenges to integration include infrastructure, generation of suitable data, and digitization of current data and security of data if published to consumers. This therefore implies that, if at inception data captured in digital form, it may lead to acquiring of information that is easy to share and in ready for use by various agencies.

### 3.2.1.5 Data Collection and Analysis

The views and inputs of stakeholders were collected from parents, community health workers, CRO, chiefs, and the officials in civil registration department and hospital as the key participants in notification and registration process, as well as NHIF as a data consumer.

The data collected and analyzed, results of that process directed the major requirements of the system.

### *3.2.1.5.1 Analysis of Responses from Community Agents*

The local chiefs are officers charged with legally reporting the events that take place within their jurisdiction that occur outside hospital facilities. The tasks in analysis of their work involved to find their experiences, challenges, views in the process of improving their work and general views to matters on this project. The first question was trying to find out the experience chiefs have in finding birth events that have taken place in their community.

Table 1.chief experiences in finding birth events

| Choice | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| Easy | 9 | 31.03 | 31.03 |
| Very Easy | 2 | 6.90 | 37.93 |
| Difficult | 15 | 51.72 | 89.65 |
| Very Difficult | 3 | 10.34 | 99.99 |
| Total | 29 | 99 | 100 |

Out of 29 respondents, 31.35% of them said that finding out birth events that have occurred was easy. 6.97% said that it was very easy. Another 52.25% said that it was difficult and the last

10.45% said that it was very difficult. From this study we can see that the majority of respondents (sum of difficult and very difficult responses, 62.7%) found it difficult to learn about the birth events in their communities.

The second question was trying to find out the major challenges that chiefs undergo when trying to learn about new birth events in their location

**Table 2 chiefs' major challenges in finding birth event**

| Choice | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| Parents failure to report | 3 | 20 | 20 |
| distance to cover while investigating the birth events | 6 | 40 | 60 |
| lack of technology in the notification process | 6 | 40 | 100 |
| Other | 0 | 0 | 100 |
| Total | 15 | 100 | 100 |

Out of 15 respondents, 20% of the respondents said that parents' failure to report was the major challenge that chiefs undergo in trying to learn about new birth events in their location. 40 % of the respondents said that the distance to cover while investigating was the major challenge. Another 20% said that the lack of technology was the challenge. From the table above, it is evident that the major challenges that the chiefs undergo when trying to learn about new birth experiences is a long distance to cover and lack of technology in the notification process.

The question was also posed to investigate how the use of pre notification system to inform the chiefs about the occurrences of births would be helpful and responses were as below.

**Table 3 the chiefs' thought on pre-notification service**

| Choice | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| Little Help | 10 | 35.71 | 35.71 |
| Helpful | 7 | 25.00 | 60.71 |
| Very Helpful | 7 | 25.00 | 85.71 |
| Am Not Sure | 4 | 14.29 | 100 |
| Total | 28 | 100.00 | |

Out of a total of 28 responses, 35.71% of the respondents said that it would be of little help. 25% said that it would be helpful. A further 25% said that it would be very helpful while 14.29% of the population was not sure if it would be helpful or not. This indicates that if a pre-notification system was used in notification process, half of the chiefs would find it helpful.

We also asked the respondents whether if their community was to be given several technologies to use in birth pre-notification immediately birth occurs, prior to birth registration, which method they thought would be more suitable.

**Table 4 chiefs thought on most suitable technology for the community**

| Choice | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| Mobile Application | 6 | 18.75 | 18.75 |
| Web Application | 3 | 9.38 | 28.13 |
| SMS | 17 | 53.13 | 81.26 |
| Call | 2 | 6.25 | 87.51 |
| Am Not Sure | 4 | 12.50 | 100 |
| total | 32 | 100.00 | 100 |

Out of 32 responses, 18.75% of the respondents preferred a mobile application as the most suitable method. Another 9.38% preferred a web application. Respondents who preferred SMS were 53.13% against 6.25% who preferred a voice call. 6.25% of the respondents were not sure. So we can conclude that the preferred mode of pre-notification was SMS.

We also tried to find out whether if they received a pre-notification message of a birth occurrence from CRO, how fast they thought it would take them to carry out the actual physical confirmation in their communities.

24

**Table 5.how long it would take chiefs to do actual confirmation after an alert**

| Choice | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| A day | 10 | 32.26 | 32.26 |
| Week | 12 | 38.71 | 70.97 |
| A month | 9 | 29.03 | 100.00 |
| Other | 0 | 0.00 | 100.00 |
| total | 31 | 100.00 | 100 |

From the 31, respondents, 32.2% of them said that it would take them a day. 38.71% of them said that it would take them a week. 29.03% of them said that it would take them a month. This means that 71% of the chiefs said it would take them a week to issue an actual confirmation of birth after pre-notification.

We tried to know if such a system would increase the level of birth notification in their community. The responses were as follows:

**Table 6. view on system intervention to increase registration level**

| Choice | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| Yes | 19 | 63.33 | 63.33 |
| No | 4 | 13.33 | 76.66 |
| Maybe | 7 | 23.33 | 99.99 |
| total | 30 | 99.99 | 99.99 |

Out of the 30 responses we got, 63.33% responded yes to this issue. 13.33% responded no and another 23.34% were not sure. From this data, we can conclude that most of them thought that a prior message would increase the level of birth notifications in their area and thus this system is a noble course.

### 3.2.1.5.2 Analysis of Parents Inputs in Requirement and Use Analysis

We were also able to interview some parents. Below are the responses by the parents.

The first question was to know the age bracket of the parent. Below are the responses.

**Table 7 The age brackets of the parent respondents**

| Choice | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| <18 years | 7 | 6.42 | 6.42 |
| BETWEEN 18 & 25 YEARS | 35 | 32.11 | 38.53 |
| BETWEEN 25 & 35 YEARS | 35 | 32.11 | 70.64 |
| ABOVE 35 YEARS | 32 | 29.36 | 100.00 |
| Total | 109 | 100.00 | 100 |

From the 109 responses we got, it was found out that 6.42% of the respondents were parents below the age of 18 years. Another 32.11% of the population was between the age of 18 and 25 years. 32.11% were between the age of 25 and 35, while the remaining 29.36% were over 35 years. This shows that most of our respondents were either between the age of 18-25 and 25-35 while those below the age of 18 were the least. This shows that most of the respondents are within age bracket that can use or learn how to use ICT tools.

We also tried to find out where the children were born. The table below shows the results.

**Table 8 The place of birth for respondents' children**

| Choice | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| At home | 31 | 28.44 | 28.44 |
| In hospital | 74 | 67.89 | 96.33 |
| Other | 4 | 3.67 | 100.00 |
| Total | 109 | 100.00 | 100 |

From the table, we can see that 28.44% of the respondents gave birth at home. Another 67.89% of the population gave birth in hospital. The remaining 3.67% neither gave birth at home or in hospital. From this we can see that most of the parents gave birth in hospitals. Children born in hospital are assumed to be automatically registered once returns are filed. The 32.11% of respondents who did not give birth in hospital form the statistic of those who may never be registered at all. The system development was hoping to capture this into registration bracket.

On the issue of having birth certificates, the responses were as follows.

**Table 9  The level of those whose children have birth certificates**

| Choice | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| Yes | 59 | 57.28 | 57.28 |
| No | 44 | 42.72 | 100.00 |
| Total | 103 | 100.00 | 100 |

57.28% of the respondents had birth certificates against 42.72% who didn't have that certificate. We inquired the reason why they did not possess birth certificates, in case they did not have and the response was as follows.

**Table 10 Responses on reasons why they find it hard to get birth certificates**

| Choice | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| Distance to the office | 21 | 42.86 | 42.86 |
| The process is tedious | 11 | 22.45 | 65.31 |
| I feel no need | 4 | 8.16 | 73.47 |
| I don't know the process | 13 | 26.53 | 100.00 |
| Total | 49 | 100.00 | 100 |

From the above table, out of the 49 respondents who had not taken birth certificates, 42.86% of the respondents said that the distance to the place that the birth certificate was to be taken was too far. A further 22.45% of the respondents thought that the process was tedious.  Another 8.16% felt no need of having a certificate of birth and 26.53% didn't know the process and process to follow. This indicates that most people did not have the certificates because the distance from the registration office was long. The study shows an intervention that may be used remotely can help in birth registration.

We tried to find out how the respondents rated the birth notification process.

**Table 11 parents perception on the current notification process**

| Choice | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| Easy | 44 | 40.37 | 40.37 |
| Not easy | 20 | 18.35 | 58.72 |
| difficult | 21 | 19.27 | 77.99 |
| Very difficult | 24 | 22.02 | 100.00 |
| Total | 109 | 100.00 | 100 |

27

From the 109 respondents, 40.37% said that the process was easy. 18.35% said that the process was not quite easy. Another 19.27% said that the process was difficult while the remaining 22.12% said that the process is very complicated. We can see that most of the respondents found the birth notification process to be easy and the least number of respondents found it tedious.

We inquired if the respondents could consider the use of a mobile phone to notify the birth of their child. The response was as follows

**Table 12 How the respondents would consider using mobile phone in notification**

| Choice | Frequency | Percentage | Cumulative Percentage |
|--------|-----------|------------|-----------------------|
| Yes | 109 | 100.00 | 100.00 |
| No | 0 | 0.00 | 100.00 |
| Total | 109 | 100.00 | 100 |

All the respondents said that they would consider the use of a mobile phone.

We inquired for the method they are likely to use in a mobile phone and the responses were as follows.

**Table 13 Response on use of mobile technology**

| Choice | Frequency | Percentage | Cumulative Percentage |
|--------|-----------|------------|------------------------|
| SMS | 53 | 48.6 | 48.6 |
| Mobile Application | 4 | 3.7 | 52.3 |
| Web Application | 8 | 7.3 | 59.6 |
| Call | 26 | 23.9 | 83.5 |
| Combination of choices | 18 | 16.5 | 100.0 |
| Total | 109 | 100 | 100 |

Out of the 109 respondents, 48.3% of them preferred the use of SMS. Another 3.7% preferred the use of a mobile application. 7.3 % preferred the use of a web application, 23.9 would want to use of a voice call, while the remaining preferred combination of choices. From this, we can see that SMS was their preferred mode. The least was a mobile application, and probably the reason being they are not used in use of mobile applications. The pie chart below illustrates the responses of the respondents

We asked if they thought that mobile notification systems in birth registration can help in registering their child more easily. Below is the response we received.

**Table 14 Responses on views if mobile can help register children easily.**

| Choice | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| Yes | 92 | 84.40 | 84.40 |
| No | 0 | 0.00 | 84.40 |
| Not Sure | 17 | 15.60 | 100.00 |
| total | 109 | 100.00 | 100 |

Out of the 109 respondents, 84.40% agreed while 15.60% were not sure. Most of the respondents thought that this could help in registering their children more easily.

We asked the respondents if they felt mobile interactions prior to visiting the chief would ease notification and registration process. The responses were as follows:

**Table 15 Respondents' views on alerts to chief on easing overall notification and registration**

| Choice | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| Yes | 75 | 68.81 | 68.81 |
| No | 0 | 0.00 | 68.81 |
| Maybe | 25 | 22.94 | 109.75 |
| Am not sure | 9 | 8.26 | 100.00 |
| Total | 109 | 100.00 | 100 |

We had 109 responses in this issue. 68.81% of the respondents felt that the mobile interactions would ease notifications hence. None of the respondents said no. 22.94% of the respondents said maybe and the remaining 8.26% were not sure. So we can see that if mobile interactions were used, most of them thought that it would ease the registration and notification process.

And finally we asked the respondents which communication method they would prefer in notification process. They responded as follows.

**Table 16 The respondents most preferable method of pre-notification**

| Choice | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| SMS | 48 | 44.86 | 44.86 |
| Mobile Application | 8 | 7.48 | 52.34 |
| Web application | 4 | 3.74 | 56.08 |
| Call | 12 | 11.21 | 67.29 |
| Combined choices | 35 | 32.71 | 100.00 |
| total | 107 | 100 | 100 |

Of the 107 responses, 44.86% would prefer SMS, 7.48% would prefer a mobile application. Another 3.74% would prefer a web application, 16.67% saw that a phone call was the best option and the remaining 32.71% preferred combined choices. So the most popular mode was SMS, since most of the respondents preferred it.

### 3.2.1.5.3 Analysis of Implementation Inputs from Civil Registration

The current notification system has its share of challenges that include loss of manual registers, late returns by local administration agents, its manual hence cumbersome and some records are reported incomplete thus in usable. The solution to these problems is a system that can enable timely reporting, reduce paper work, lead to automation of a number of functions and that can enhance delivery of services.

### 3.2.1.5.4 Analysis of External Users Inputs in Requirement Analysis

Credibility of the data and document presented sometimes poses the challenge to consumers of the birth data which in turn calls for further verification and validation. When internal verification of data or document for the case of NHIF is required, it may take a day and up to one week when requirement is from another branch. If the verification requires attention of civil registration department, it may take up to a month depending with the location request is being made. Integrated birth data sharing would improve efficiency of their services, accuracy and authentication process.

### 3.2.2 Analysis and design phase

System analysis and design is the process of collecting the actual data, reviewing and studying the processes involved, identifying the problems and recommending appropriate solutions that can be undertaken and detailing steps in the construction of proposed solution to the system. It

also involved the study of real business processes, operation procedures and the information flow so as to design solution aligned to core organization goals. It involved subdivision of complex tasks or processes into manageable smaller units that enable easy data identification and management of processes.

The thinking behind the system analysis and design is to find best solutions to each of the business process. What are the processes? How are things done? How are things linked? What are the inputs and outputs? What can be improved? This demand for insight and creativity from the analyst in development of solution that can settle the current challenges and that can allow future developments and growth.

### 3.2.2.1 Business Modeling and Transformations

In Service-Oriented Architecture is a business- driven IT architecture approach that supports integrating your business as linked, repeatable business tasks, or services. SOA helps today's business innovate by ensuring that IT systems can adapt quickly, easily and economically to support rapidly changing business needs. SOA helps customers increase the flexibility of their business processes, strengthen their underlying IT infrastructure and reuse their existing IT investments by creating connections among disparate applications and information sources. (Source: IBM)

### 3.2.2.2 Services Decomposition as Per Analysis

1. Reporting services as a request
   a. Pre-notification of birth occurrence
   b. Reporting birth occurrences by local agents / hospitals
   c. Sending acknowledgements of received requests
   d. Receiving feedback on reported births via email, SMS
2. verification services
   a. verification of users ( chiefs, hospitals)
   b. Approving and rejecting pre-notified events from parents
   c. Viewing reports on reported  and registered births for various use
   d. Generating the notification slip
3. Data Consumer services
   a. Viewing records on reported births

31

b. Using data from the database to validate their records

c. Exporting  data for use in other applications and agencies

4. Administrator Services

a. Registering chiefs and hospitals users

b. Registering data consumers user

c. Registering locations in counties

d. Viewing reports on approved births, rejected births and pending births

5. Integration services

Communication with other applications

### 3.2.2.3 The system architecture

The design of the system used the client-server architecture; the client was a mobile device, SMS requests and web application and on server side used a PHP Script and MySQL database. Architectural Design is the process of defining hardware and software components and their interfaces and establishing their framework for the computer system.
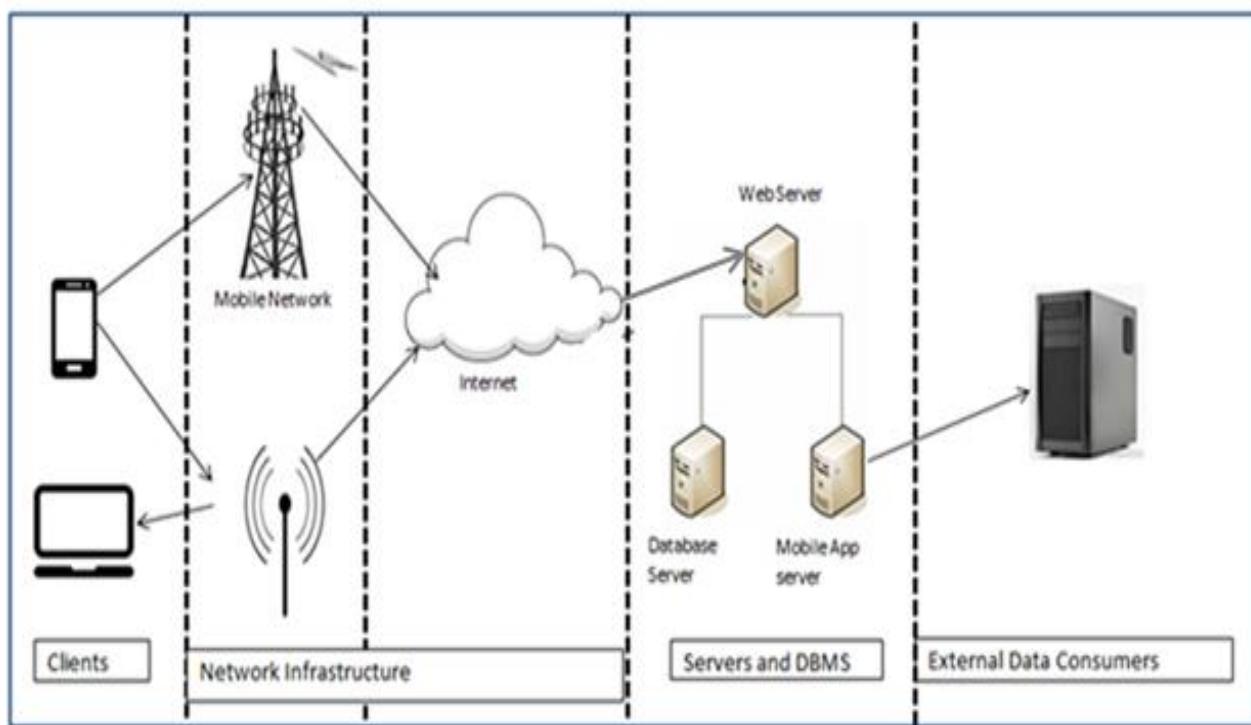


**Figure 5: System architecture diagram**

### 3.2.2.4 Clients Infrastructure

The infrastructure for access is as follows:

1. An internet enabled PC which is used by the clients, which are the parents, guardians, chiefs and hospitals to report births. The chief and hospitals are also able to view reported births and verify or disapprove the births after confirmation.

2. An internet enabled Smartphone which was used by the clients, which included the parents, guardians, chiefs and hospital officers to report births. The chief and hospitals are also able to view reported births and verify or disapprove the births events using the system.

3. A mobile phone which is can send and receive SMS. This was used by the parents to receive births verification updates. It was also to enable chiefs and hospitals to receive notifications on reported births.

### 3.2.2.5 Servers and DBMs

Apache server was used to host the web application and the central database. The SMS system was able to interact with the web application system through SMS gateway. The SMS server was used to receive and route messages appropriately.

# 1. Birth Notification Process flowchart
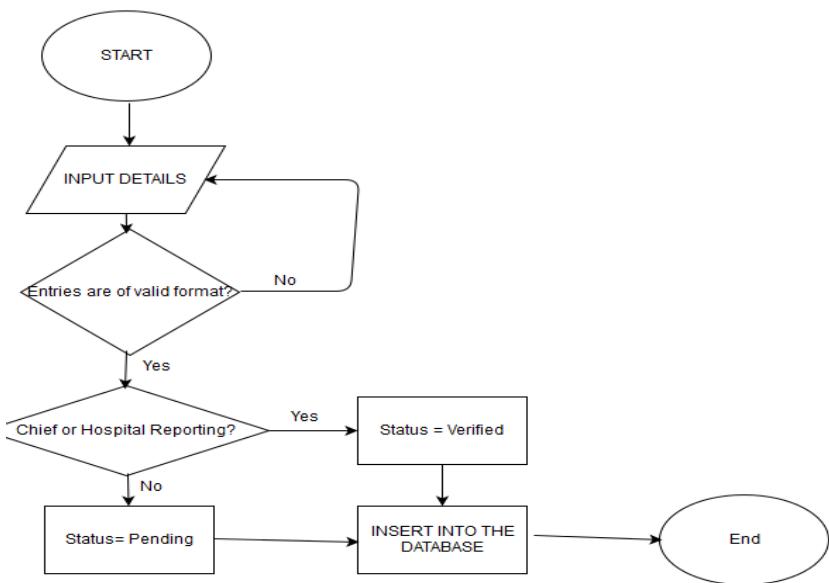


**Figure 6 : Birth Notification Process flowchart**

# 2. Birth event verification process
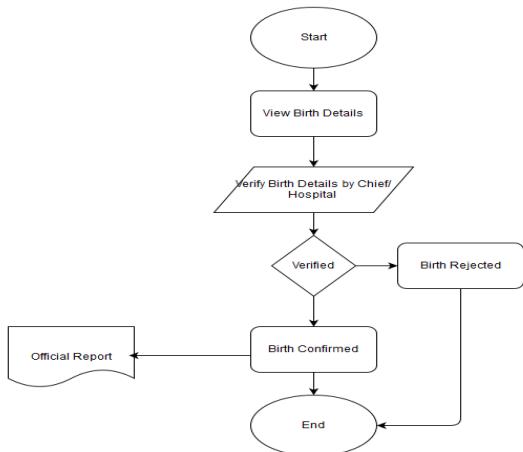


**Figure 7: Birth event verification process**

# 3. Use Case Model
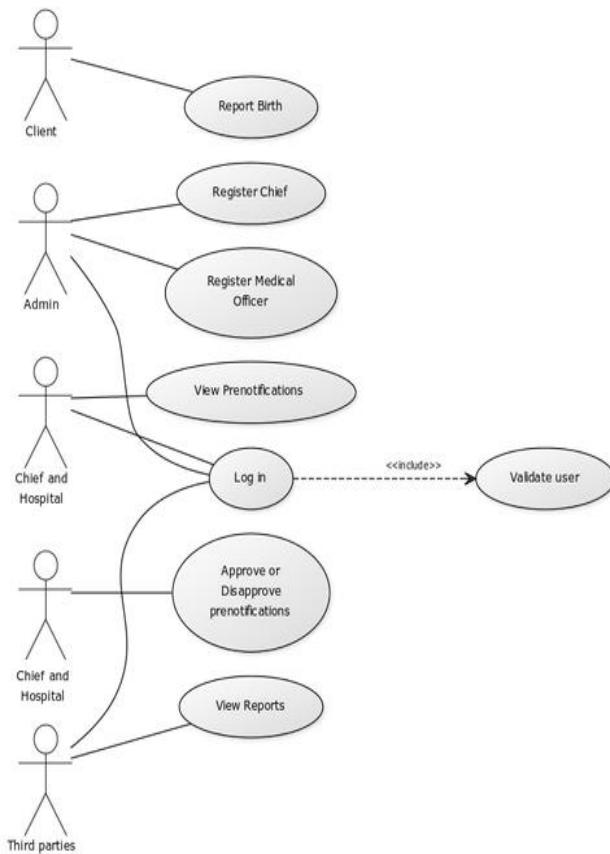


**Figure 8: Use Case Model**

## Class Diagram
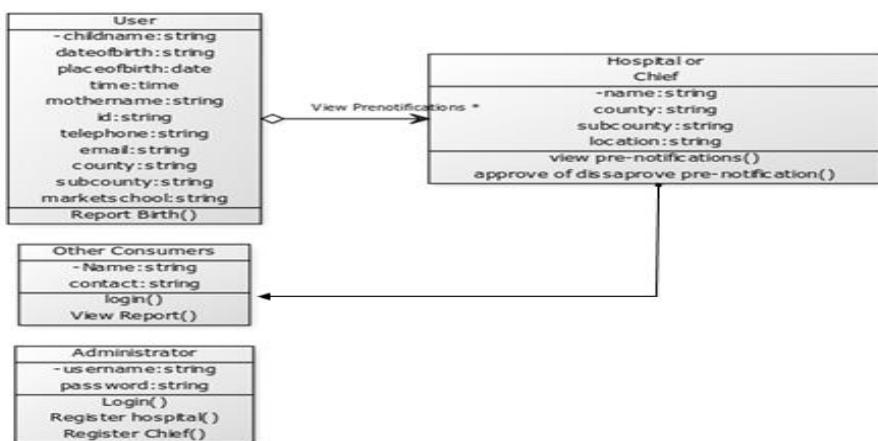


**Figure 9: Class Diagram**

### 3.2.2.6 Description of the system components

A Web server is the internet server that responds to HTTP requests or SOAP messages to deliver content and services. A database server is a computer program that provides database services to other computer programs or computers defined by the client – server model.it was used to service clients and external consumers' requests. The parents, chiefs and hospital staff used the mobile phones or computing devices that would access the web and (or) send mobile messages. These devices offered services through appropriate interfaces that the end users used to interact with the system. The SMS system also enabled the parents and other registration agents to report births. The other options were through mobile application was downloadable and installable in a mobile device. A web application for birth notification was constructed. The mobile network known as a cellular network was a crucial component in the system design. The mobile applications used the cellular network to access services from the system. The mobile coverage in the country based on communication authority of Kenya (CA) first quarterly report of 2015/2016 had put the penetration at 88.1% was a great asset for this project.

### 3.2.3 The service construction phase

According to (Rosenberg, 2010) a service that obeys the principles of service-orientation is an autonomous, loosely coupled, and stateless unit of functionality that is made available by a formally defined interface. The functionality provided by a service is discoverable by other applications that use the service. In other words, services expose their functionality via interfaces that other applications and services can read and learn how to use or interact with them. In the construction phase therefore it included development of the web services implementation, the definition of the service interfaces, description and the definition of the service implementation artifacts that define processes.

### 3.2.3.1 The Services Architecture
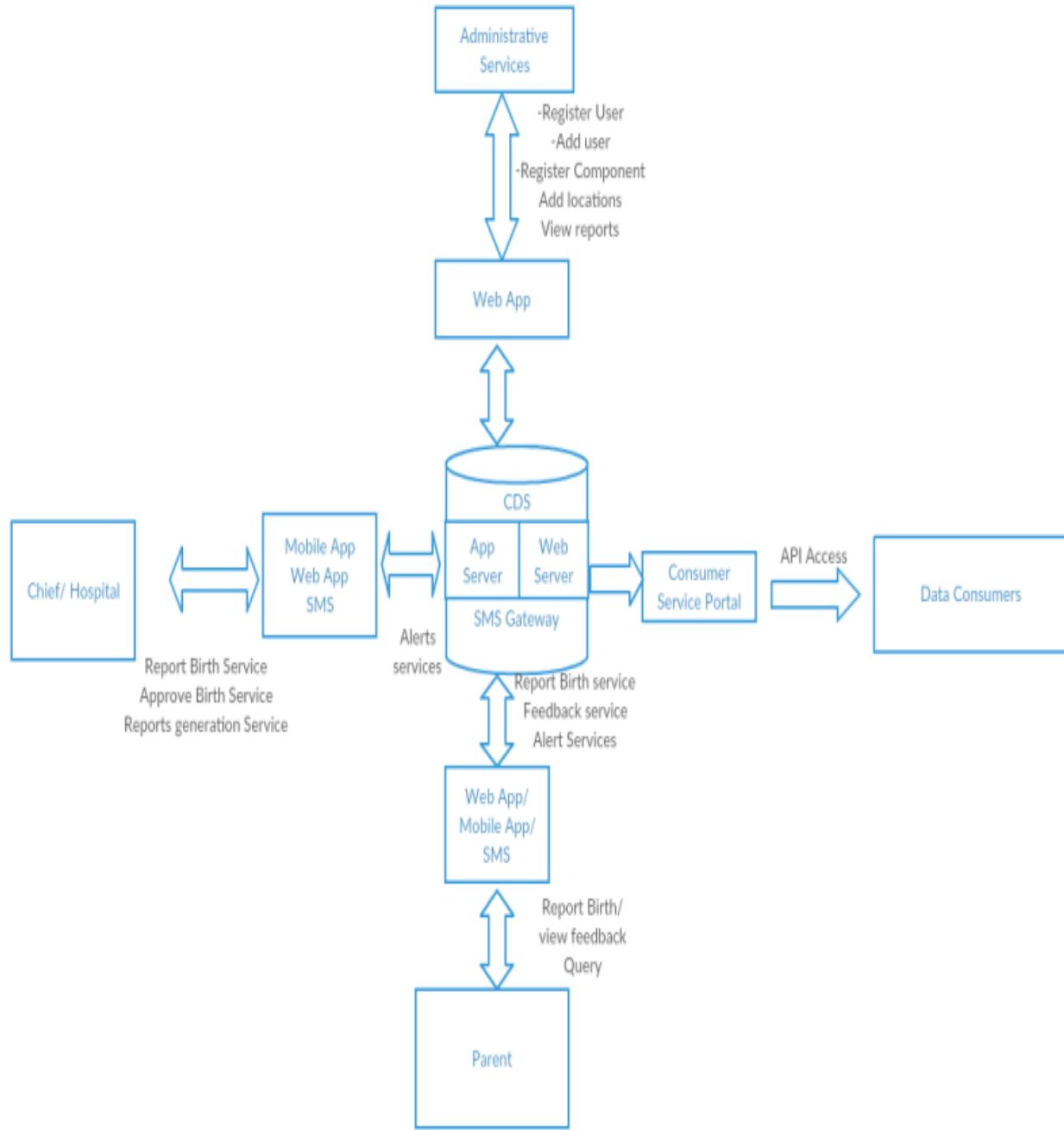


**Figure 10: The Services Architecture model**

## 3.2.3.2 Services use description

The clients interacted with the system through a three-tier model consisting of a mobile app, a web application and an SMS gateway. The parent gets feedback on reported births via the same

mode. Upon pre-notification by parents the local agent/administrator registered in the system were notified via SMS alert and email. The nearest hospital facility to the parents' location was also notified about the birth event through email. The local agents (chiefs) or hospital agents (community health workers) would physically confirm the birth event, then using cross platform mobile application or web portal, approve or reject the birth. The chiefs also received SMS notifications of birth occurrences in their area that need their attention. The chiefs were able to report birth occurrences that they learnt of via a mobile app or a web portal. The system administrator was in the office of civil registration department was able to register chiefs, hospitals and data consumers as well as define locations in the system. This was done through a web application that was accessible through administration portal via web browser. Registered data consumers were capable of accessing data or reports via a web portal in designated Jason format which exported to their applications for various use.

### 3.2.3.3 Service Interfaces

Interface provides point of interaction between the users of the systems. The interfaces are used to expose the functional components of the systems. Interfaces were designed as follows.

**The Index Page**
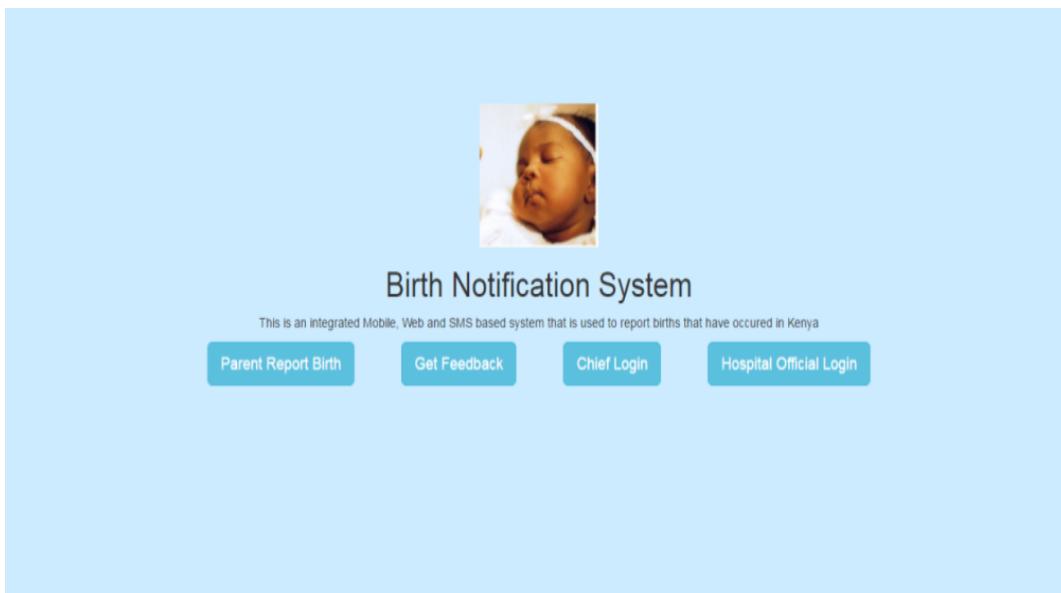


Figure 11: The Index Page

**The Mobile App interface**
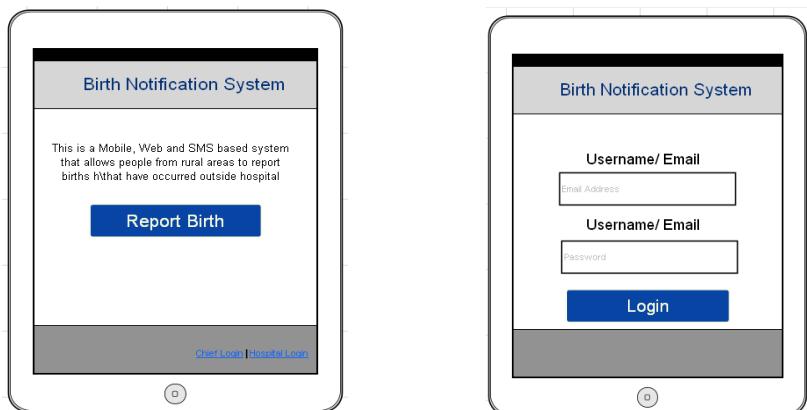


Figure 12: The mobile application interface


The SMS Service Interface Design
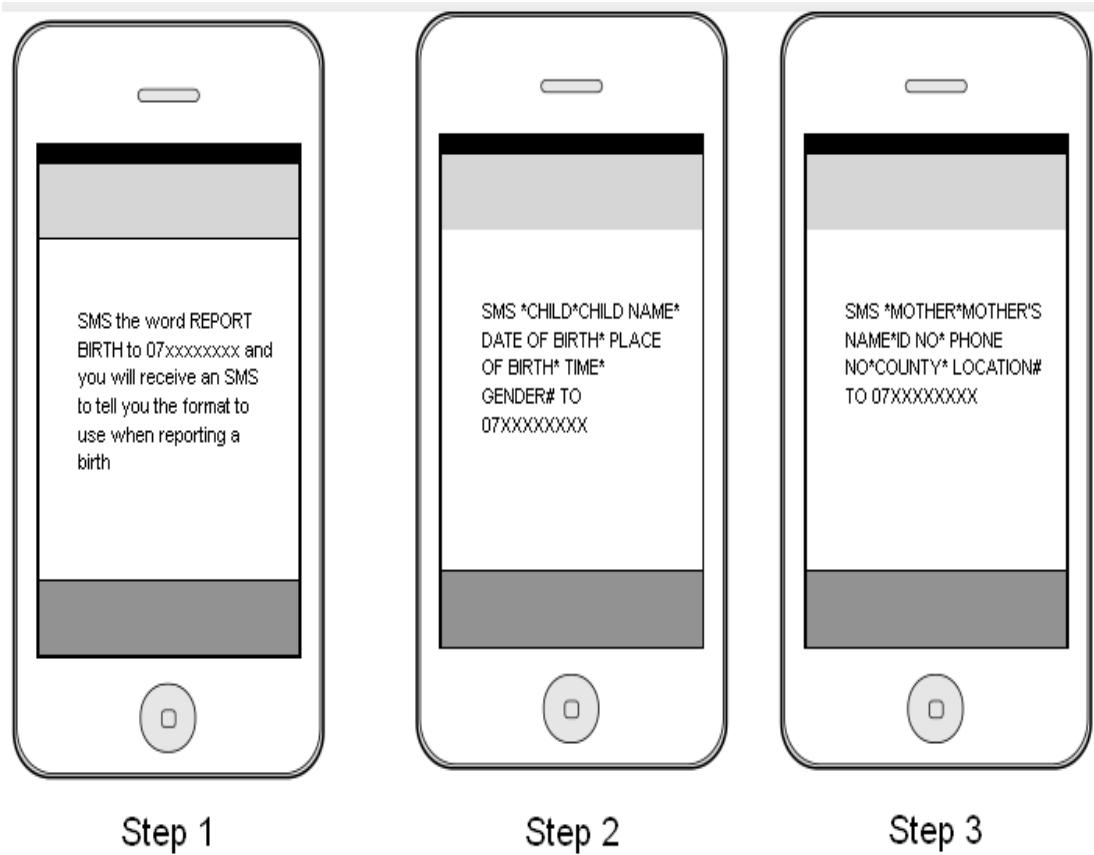


Figure 13: The SMS interaction system

### 3.2.3.4 Construction tools

#### 3.2.3.4.1 Hardware Resources

1. Laptop

2. Modems

3. phones

#### 3.2.3.4.2 Software Resources

The success of this project relies on several software applications.

1. **Adobe Dreamweaver CS6 -** This is a development framework used in developing websites and web applications in various fields and applications.

2. **Bootstrap** – it is open-source front-end application used in constructing websites and web applications.

3. **PHP** (Hypertext Preprocessor) is a server-side scripting language designed for web development but also used as a general-purpose programming language.

4. **Javascript** It is a small and lightweight web scripting language.

5. **Ajax** is an application for creating fast and dynamic web pages. AJAX allows web pages to be updated asynchronously by exchanging small amounts of data with the server behind the scenes. This means that it is possible to update parts of a web page, without reloading the whole page.

6. **Jquery Mobile** this is a cross platform mobile framework fo constructing mobile applications through integrating various standards so as to get robust, sustainable and organized applications.

7. **Cordova/Phonegap** application for packaging a web application to be a native application, installable in a mobile phone. It helps to create cross platform mobile applications.

8. **JSON**, or JavaScript Object Notation, is a minimal, readable format for structuring data. It is used primarily to transmit data between a server and web application, as an alternative to XML. In this project it is used to export data to external data consumers and between applications.

9. **Ozeki SMS Gateway -** The Ozeki Message Server is a gateway of integrating SMS in various applications and routing messages to email or mobile message centers.

10. **Apache -** this is an open source Web server.

11. **MySQL Database -** this a popular database with web developers used in various web applications, it is an open-source software.

## 3.2.3.5 System testing

### *1. Validation Tests*

The fields in the data entry forms were validated using JavaScript to ensure data integrity. The data types were specified. One could not be allowed to enter invalid data types. There is an appropriate error message displayed if wrong data was typed in the fields and the wrong data was not inserted into the database.

### *2. Unit Testing*

Each unit was tested individually starting from the web application, the mobile app them the SMS based system. This was to ensure that each module was working accurately as required as unit. The result of the test showed that all the modules were working as required.

### *3. Access Tests*

The system users with other roles than just reporting are authenticated before gaining access to the system. The authentication was done as follows: the users entered their usernames and passwords before gaining access to the system. If the username and password matched the ones in the database, the user was granted access to the system. If the two did not match, there was an error message that was given and the user was given another chance to try to login again.

### *4. Data Entry Tests*

Test data was entered into the fields to ensure that the system was able to capture data and save it into the database.

Below is the message from this test. If the data is not entered into the database, an error is displayed. If the data is entered, a success message is displayed.
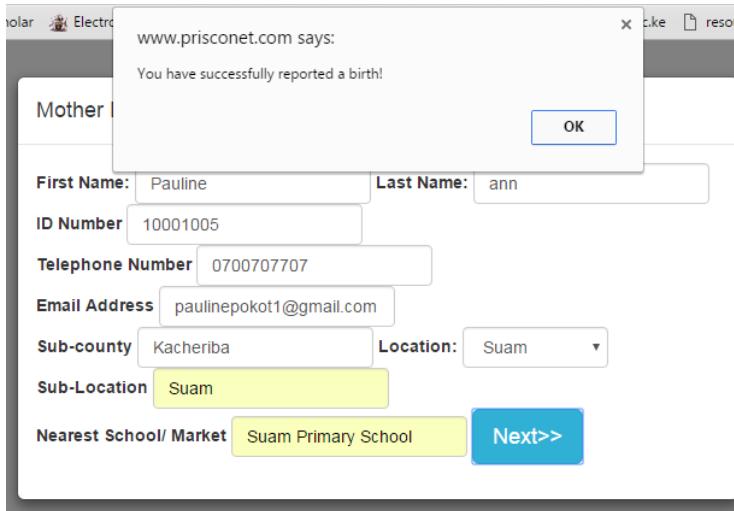
**Figure 14: Data entry test**

## 5. *External User Services Test.*

We also tested the ability of the consumer to get access to the data from the system. First the logging in was tested, then the system ability to generate data for the consumer to use was tested. The user simply enters the URL that is generated by the system and he/she is able to access data from the database.

## 6. *Service Integration Tests*

Then integration tests were done by viewing the feedback and effect of one service action on another service through service request and response messages (or) actions.

**Table 17: integration of services tests**

| Service requestor / action | Service response | Other service messages to parents | Other service actions |
|---|---|---|---|
| Parent mobile app | Child notification done | Sms, email confirmation | Chief/ hospital alerted |
| Parent SMS | Child notification done | Sms, email confirmation | Chief/ hospital alerted |
| Parent Web App | Child notification done | Sms, email confirmation | Chief/ hospital alerted |
| Chief verification | Birth event verified | Sms, email confirmation | Pdf generated |

| | | | notification card |
|---|---|---|---|
| Chief notification | Event notified | Parent receives SMS / email alert | Pdf generated notification card |
| Hospital notify | Event notified | Parent receives SMS / email alert | Pdf card generated |
| Report services | View reports | - | Print / export reports |
| External data users | Generate reports | - | Export Jason format |

Service request from parent through any of the three services lend to alerting the local chief and hospital about the birth event. The integration execution was therefore successful.

### *3.2.4 The service provisioning phase*

Service provisioning is a complex mixture of technical and business aspects for supporting client service and activities. This involves choices for service governance, service certification, and service enrolment, service auditing, metering, billing and managing operations that control the behavior of a service during its use. The system controls access by authenticating the users.

In this regard, only the registered consumers with civil registration were able to access system and perform functions like import data to their applications.

### 3.2.5 The Service Deployment Phase

The tasks associated with this phase of the Web service development includes, the publication of the service interface and service implementation definition. The publication was done using RESTful services.

### 3.2.5.1 Publication of Consumer Services

Services were implemented using RESTful services architectural style (Fielding 2006). The RESTful style was chosen because of less overhead while dealing with mobile applications. All the components of the system (mobile, web and SMS) communicates through interfaces, which have clearly defined methods and dynamic code. This means that the communication consists of independent pairs of request and responses. Thus each module or component of the system platform (mobile, web and SMS) was treated independently though the three modules were integrated.

*Service Dependencies*

The integration of services is dependent of level of dependencies in data and processes. In the realization this, the data consumption by external consumers is dependent on verification by administrative agents. The birth event also becomes registered after verification by hospitals or chiefs. Data consumers such as NHIF, MOH and KBS would be able to receive reports from the system of birth events which have been reported and verified.

### *Services Orchestration*

The services were orchestrated in a manner that various applications would consume and interact almost seamlessly. A report done using the mobile application, SMS and web application are well mediated in enterprise service bus. This can give tightly coupled endpoint integration as well as the intelligent routing, protocol mediation and other mechanisms provided by enterprise service bus. The external data consumers were registered and would export data in Jason format to their applications.

### *3.2.7.1 Services Integration and Data Sharing*

Web server runs a web application by returning HTML, Soap messages or XML files over an HTTP connection to a given endpoint. In an integrated service a server responds to HTTP requests to deliver content and services, in seamless interaction between various functional components is key requirement. This call for a well mediated process so as to realize all capabilities of SOA. In this project it was made possible through integrating SMS server with the web server so as to route the messages to mobile carriers.

Data integration was possible through use of Jquery mobile, HTML 5 and CSS standards which enabled data to be carried across different mobile platforms and devices.

Business to business integration was realized through use of Json data format to export data to external user APIs (application programmable interfaces) who would use it in their applications.

### 3.2.6 The service execution phase

During the execution phase, Web services are fully deployed and operational. During this stage of the lifecycle, a service requester can find the service definition and invoke all defined service operations. This can be confirmed in this project through generation of a birth notification slip.

The system was reviewed to ensure that it produced correct output from the services modules. This was done by viewing the reports that were generated by the system and it was confirmed that the correct execution as per the requirement analysis. .

1. Sample birth notification report.



REPUBLIC OF KENYA

THE BIRTHS AND DEATHS REGISTRATION ACT (Cap. 149)
**ACKNOWLEDGEMENT OF BIRTH NOTIFICATION (FOR PARENTS)**

Serial No. **151605092016**

1. NAME: **Mary  Ann**      2. DATE OF BIRTH: **24/08/2016**

3. SEX: **female**      4. TYPE OF BIRTH:  **Single Child**      5. NATURE OF BIRTH: **Alive**

7. PLACE OF BIRTH      COUNTY **West Pokot**      LOCATION **Suam**

8. NAME OF MOTHER Jane  Kamau

NOTIFICATION ISSUED TO **Jane  Kamau**      ID NUMBER **12345678**
*Note- To obtain a birth certificate, present this notification to the Sub-County Registrar of Births where this birth occured*

**Figure 15: Sample birth notification slip report from prototype**

### 3.2.7 The service monitoring phase

The service monitoring phase concerns itself with service level measurement and monitoring is the continuous and closed-loop procedure of measuring, monitoring, reporting and improving the quality of service of systems and applications delivered by service-oriented solutions. Service level monitoring is a disciplined methodology for establishing acceptable levels of service that address business objectives, processes and costs.

This ensures that services are delivered as expected to consumers, in correct standards and timely. It also ensures services are armed with mechanisms to report noncompliance on qualities associated with each service module.

### 3.2.7.1 System acceptance

The system acceptance testing was done on a sample of users so as to analyze how user requirements were met directly in verifiable way. Some of the users were disguised as parents, others as local administrators (chiefs) and others as hospital officials. The core objective was to

test success in use of prototype in a user environment, identify problems which unit or integration tests might have missed, and then provide a complete overview on how "done" the system is.

**Table 18.The summary of parents' ability to perform actions in the integrated system**

|            | SMS use | Web portal | Mobile App | Feedback |
|------------|---------|------------|------------|----------|
| Success    | 4       | 4          | 4          | 12       |
| Failed test | 2      | 0          | 1          | 3        |
|            |         |            |            |          |
| % Success  | 66%     | 100%       | 80%        | 80%      |

The problem faced by some of the parents was remembering the mobile number to send the message to, thus typing the number wrongly in their phone. There was a case of also failing to format the message as described in section 4.733.

**Table 19. The summary of chiefs' ability to use the system**

|            | Web portal | Mobile App | Feedback |
|------------|------------|------------|----------|
| Success    | 5          | 4          | 5        |
| Failed test | 0         | 1          | 0        |
|            |            |            |          |
| % Success  | 100%       | 80%        | 100%     |

The problem encountered by the chief users was the use of the mobile application with little training.

### 3.2.7.2 System Evaluation

This was done to get the perspective and views of the users on various aspects of the system and how they rate the system. The key elements for this test were on interface designs, ease of use, and ease of navigation, connecting to the system and feedback from the system. A sample used in acceptance testing was given the chance to rate the system and other ten people who are developers were involved.

**Table 20. System Evaluation**

|  | Excellent | Good | Poor | Very poor |
|---|---|---|---|---|
| User Interface | 21 | 8 | 1 | 0 |
| Navigation | 12 | 16 | 2 | 0 |
| Feedback time | 8 | 19 | 2 | 1 |
| General Rating | 16 | 11 | 2 | 0 |
|  |  |  |  |  |
| Overall rating % | 47.50% | 45.00% | 5.83% | 0.83% |

From the sample, 47.5% of the users thought the system was excellent, 45% thought the system was good. Another 5.83% thought that the system was poor and 0.83% of the users thought that the system was very poor. Therefore the evaluation of the system revealed that 92.5% of the overall sample believed that system was good intervention.

# CHAPTER FOUR: RESULTS, RECOMMENDATIONS AND CONCLUSION

## 4.1 Achievements

The first objective was to evaluate and investigate the existing birth notification process and registration systems. This objective was achieved and we managed to evaluate and investigate the existing birth notification process and registration systems. The review of the current systems revealed that business processes are manual and does not support electronic sharing of data. The project also probed the effect pre-notification service would have on improving the entire registration process. The results from this project revealed that over 84% believed introduction of ICT technologies at earliest stage of notification would make registration more convenient. The consumers of birth data revealed that access to real time shareable data would make them meet their organizational goals more effectively.

The second objective was to propose a service oriented model that can lead to timely notification of birth events, share data, and integrate well with other legacy systems in various agencies. The model that was proposed includes parents and guardians in a pre-notification phase that creates raw data for authorities. The raw data is then validated by chiefs or hospital officials to get a notification properly registered. The model also allows mapping of registered events to shareable data formats. The shared data can then be used by various agencies that consume birth information and are registered in the consumers' register.

The third objective was to design and build a prototype that can lead to acquisition of vital statistics for national planning and development in Kenya. The prototype was designed, built and tested. The birth notification service was found to be working well; consisting of integrated SMS module, mobile application and web portal. Evaluation of its applicability and usability revealed that it can accelerate birth registration in Kenya. The aggregated data in central database system can then be shared with relevant agencies in portable formats to their applications. Service oriented architecture proved to be a good methodology of constructing the prototype because; decomposition of processes into services and development of independent units that can communicate was made possible.

## 4.2 Recommendations

The introduction of distributed birth notification service for civil registration is a solution that would greatly improve data and information capturing, processing and sharing.

Further study should also focus on integration of captured birth information to other individual data and family data held by the state departments and institutions. The future study should also explore methods that can be used to increase services on the prototype such as online generation of secure birth certificates from reported birth events on real time, real time reporting of death events and integration of other civil data. This would help the country get relatively complete statistic of almost all individuals who are alive in specified period of time and hence facilitate planning and forecasting in national policies.

## 4.3 Limitations

1. The study had challenges in rural data collection which spanned a large geographical area, thus wide scope in requirement analysis in SOA model design and implementation.

2. Bureaucracy in carrying research in some government institutions and individuals was also overwhelming difficult task.

3. Some tools which were required in development of prototype were valid freely for short period of time thus posing serious development challenges.

## 4.4 Conclusion

The findings from the project showed that the current systems and processes are not sufficient to capture all rural or community events effectively. The study also revealed that the introduction of ICT technologies based on service architecture model would improve birth events notification, registration and also enable data sharing for planning and national development. The model also provided means of providing services on different platforms which ensures resilience while offering birth notification services.

The prototype testing revealed that the use of loosely coupled services that are integrated is a good model for birth notifications registration. This is because other services can be added and scaled without affecting the existing services. The development of prototype also demonstrated there is shortened period in notification and registration of birth event since it could happen in almost real time which under current system takes about a month to get the notification slip.

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## Appendices

## Parents Questionnaire Form

**1. If you are a parent, what is your age bracket?**

- ☐ <18 years
- ☐ between 18years and 25 years
- ☐ between 25 years and 35 years
- ☐ above 35 years

**If you have children where were your children born?**
- ☐ At home
- ☐ in hospital
- ☐ Other specify……………………………

**2. Do your children have birth certificates?**
- ☐ Yes
- ☐ No

**if No, what could be the reason?**
- ☐ Distance to the registration office
- ☐ the process is tedious
- ☐ I feel no need
- ☐ I don't know the process
- ☐ Other......................................................................

**If Yes, whom did you notify the birth event of your children for registration?**
- ☐ Chief
- ☐ Hospital
- ☐ A friend did it for me

**3. How long after birth did you take to get birth certificate{s}?**
- ☐ less than six months
- ☐ between six months and one year
- ☐ over one year
- ☐ Other specify..........................................................

**4. How would you rate the current birth notification and registration process?**
- ☐ Easy
- ☐ not quite easy
- ☐ difficult
- ☐ very difficult

**5. Would you consider use of a mobile phone to notify the birth of your child if the means is made available?**
- ☐ Yes
- ☐ No
- ☐

**if yes, which method are u likely to use**

- ☐ SMS
- ☐ Mobile application
- ☐ Web Application
- ☐ Call

**6. Do you think mobile notification in birth registration can help you register your child more easily?**
- ☐ Yes
- ☐ No
- ☐ Not sure

**7. How effective do you find it, looking for chief physically to notify birth to him /her?**
- ☐ Not effective
- ☐ slightly effective
- ☐ effective
- ☐ very effective

**8. How would you rate chief's effectiveness in issuing birth notification in case of a birth event?**

- ☐ poor
- ☐ Fair
- ☐ Good
- ☐ Excellent

**9. Do you feel mobile interactions prior to visiting the chief would ease notification and registration process?**
- ☐ Yes
- ☐ No
- ☐ may be
- ☐ am not sure

**10. If communication methods of birth notification listed below are available choose the most preferred method(s).**

- ☐ SMS
- ☐ Mobile application
- ☐ Web Application
- ☐ Call

## Sample code snippet for the connection to Ozeki Server

```php
<?php
require'db.inc.php';
  $sender = $_GET['sender'];
  $message = $_GET['msgdata'];
  $str = ltrim($sender, '+');
echo $message;
  //trim the last # in the message
  $message=rtrim($message, "#");
if ($sender!='') {
    # Save incoming messages
    $fp = fopen("receivelog.txt","a");
fputs($fp,"$sender $message\n");
fclose($fp)
        $responsetext="Congratulations. The child's Details have successfully been inserted into the database. You can now enter the mother's details in the format *Mother*Firstname*Lastname*County*Location#";
    }
<?php
        //Open the connection
        $conn = mysql_connect("localhost", "priscone_admin", "admin");
        if (!$conn)
                {
                        die('Could not connect. We are working on fixing the problem' .mysql_error());                                                }
// Pick the databse
mysql_select_db("priscone_birth", $conn);
?>
```