An Improved Android Based Fertility Indicator and Antenatal Companion System

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Abstract
This paper presents an improved Android-based fertility indicator and antenatal companion system designed to assist women in monitoring their fertility cycles and providing personalized guidance throughout their pregnancy journey. The system leverages the power of modern technology to enhance the accuracy and convenience of fertility tracking and prenatal care.Furthermore, the antenatal companion aspect of the system offers expectant mothers personalized support and information throughout their pregnancy. The Android application provides a wealth of resources, including week-by-week and monthly developmental guides, nutritional recommendations, exercise routines, and relaxation techniques tailored to the specific stage of pregnancy. The system also offers regular reminders for prenatal appointments and medication intake, ensuring that the mother stays on track with her healthcare regimen.Preliminary user testing of the improved Android-based fertility indicator and antenatal companion system has shown promising results, demonstrating enhanced accuracy in fertility tracking and increased user satisfaction. The system has the potential to revolutionize the way women approach family planning and antenatal care, empowering them with actionable insights and personalized support.

Keywords: *Android, Android-based system, fertility indicator, antenatal companion, prenatal care, application*

Introduction

Access to the new information technologies over the past few decades has experienced rapid growth and has inspired a torrent of ingenious approaches to exploit these tools to tackle reproductive health challenges, including consumer behavior change, patient support, staff training, and management information and logistics systems. Due to the lack of previous communications infrastructure in low-resource areas, well-designed eHealth interventions could possibly have a much greater effect there than in developed areas with functioning phone, landlines and cable modems (Blaya et al, 2010). Nevertheless, Information and communication technology (ICT) plays vital roles in tackling issues of family planning, reproductive health, and various other health challenges such as; Human Immunodeficiency Virus/ Acquired Immunodeficiency Syndrome(HIV/AIDS), tuberculosis (TB), malaria, typhoid etc. ICT techniques can be used to educate and inform family planning/reproductive

health program planners, local clinic staff, community health workers, and other service providers, as well as clients/users. When efficiently applied, existing ICTs mainly mobile technologies have the capability to enhance access to family planning/reproductive health information and services for women, men, and the society at large. It can also maximize their opportunities to more efficiently engage in the economy, with the optimum potential to better both their health status and their quality of life. These technologies could also play a part in the general approach to handling gender inequities if adequate care is taken with every sense of purpose to sustain and encourage their use for women and by women. Despite the fact that technology is ever changing, the amazing tempo has led to many advances and innovations in the global health population (The AIDSTAR-Two Project, 2011).

Many observers now believe that planning for the new health care environments of the twenty-first century requires a deep understanding of the role that information technology plays in those environments. Health care organizations are discovering that they do not have systems in place that allow them to answer questions that are critically important for strategic planning and for their better understanding of how they compare with other provider groups in their local or regional competitive environments.

Furthermore, the inefficiencies and frustrations related with the use of paper-based medical records have become increasingly clear, especially when insufficient access to clinical information is one of the major barriers that clinicians meet when trying to increase their efficiency in order to meet productivity goals for their practices.

However, the method of family planning proposed in this work is the Fertility Awareness which uses a calendar based approach. This is a set of practices used to determine the fertile and infertile phases of a woman's menstrual cycle. It can be used to avoid pregnancy, to achieve pregnancy, or as a way to monitor gynecological health. (Trussell, 2011*)*

Fertility Awareness method using Android App

Fertility awareness-based methods, which require a woman to track her menstrual cycles and/or fertility symptoms but do not require a commodity or interaction with a provider, are the only methods that can be accessed entirely through a mobile app.

With these new technologies come new challenges. Currently, many smartphone apps have been developed that focus on women’s menstrual cycles. The majority of these apps are designed simply to track cycles or to assist in planning a pregnancy. Most are not appropriate for prevention of pregnancy, although, alarmingly, there is evidence that women are using these apps for this purpose (Moglia et al, 2016). Also, many of these apps are complex for couples and women to use and understand.

However, it is quiet easier to reach a wider range of woman due to that fact that many of them uses an Android smartphone and creating an Android app for Fertility Awareness Method will not be out of place. More so, the bulk of fertility apps are neither designed for avoiding pregnancy nor created on evidence-based FAMs. Numerous apps use their own algorithms, and these are not easy to assess because they have not been evaluated in peer-reviewed literature. Also, attractive apps are not necessarily effective while effective apps are not necessarily attractive. Apps that do not predict or calculate fertility days may also be useful for experienced FAM users to electronically record their data. Using FAMs

successfully depends on several factors, including the ability to accurately make and classify daily observations. Relying solely on an FAM app may not be sufficient to prevent pregnancy (Duane, et al, 2016).

Antenatal Care and Smartphone Apps

Antenatal Care apps are a kind of smartphone apps that offers prenatal care services and information aiming at pregnant and pre-pregnant women. It is a modern way guiding information and interpersonal interaction in the modern age of mobile technology which has been extensively accepted (Pan, 2014). Creation of an Android based mobile app for antenatal care in this contemporary era has become a necessity. The several existing apps in use by women and couple are found to be convenient and can also support their lifestyle adjustments during pregnancy. Nevertheless, several of these apps also included inaccurate or erroneous information that could cause unease and anxiety. There have also been expressions by some women who use the app on the need for developing an app containing evidence-based, well-informed, and customized health information to support them during pregnancy.

However, antenatal smartphone apps which are mostly android or iOS based are increasingly used by most women and there is need to further ensure adequate apps that can properly serve the needs of pregnant women.

Antenatal care (ANC) according to World Health Organization (2016), can be defined as the care given by health-care professionals and experts to pregnant women and adolescent girls so as to ensure the optimum state of health for both mother and baby during pregnancy. The elements of ANC comprise: risk identification, prevention and management of pregnancy-related or concurrent diseases, and health education and promotion.

Antenatal care (ANC) decreases maternal and postnatal morbidity and mortality both directly, through finding and treatment of pregnancy-related issues, and indirectly, through the identification of women and girls at high risk of developing complications during labour and delivery, consequently ensuring recommendation to a suitable level of care (Carroli et al, 2001). In addition, as indirect causes of maternal morbidity and mortality, such as malaria and HIV infections, contribute to around 25% of maternal deaths and close calls (Souza et al, 2013), ANC in addition provides a vital opportunity to avert and control diseases that affect concurrently through integrated service delivery.

Antenatal care (ANC) is the care a pregnant woman receives during her pregnancy through a series of consultations with trained health care workers such as midwives, nurses, and sometimes a doctor who specializes in pregnancy and birth (Federal Ministry of Health, 2013; National Population Commission, 2014).

Antenatal care which is also known as Prenatal care, is a form of preventive healthcare. Its aim is to offer regular check-ups that let doctors or midwives to treat and prevent potential health problems throughout the course of the pregnancy and to encourage healthy lifestyles that offer advantage to both mother and child. During check-ups, pregnant women are given medical information over maternal physiological changes in pregnancy, biological changes, and prenatal nutrition including prenatal vitamins.

Recommendations on management and healthy way of life changes are also made during regular check-ups. The availability of regular prenatal care, including prenatal screening and diagnosis, has played a role in minimizing the frequency of maternal death, miscarriages, birth defects, low birth weight, neonatal infections and other preventable health problems.

Effective Pregnancy with the Aid of Smartphone Apps

Smartphones, for instance Android phones and iPhones, are modern technology merging mobile communication and computers in a handheld device. By a simple touch of its keypad, users can easily perform several tasks, ranging from accessing online information to staying connected to people from around the world (Smith, 2016). Smartphone apps are currently developed for various tasks these days including apps for women who are pregnant and many more others.

The use of smartphone Android app or iOS app for pregnant women has effectively ensure that women easily monitor their pregnancy developmental stages by weeks, months or by trimesters and also calculate their Expected Due Date or Expected Date of Delivery (EDD). The apps can evidently ensure effective and healthy pregnancy.

Shriver (2017) defined pregnancy as the term used to describe the period in which a fetus develops inside a woman's womb or uterus. Pregnancy usually lasts about 40 weeks, or just over 9 months, as calculated from the last menstrual period to delivery. Health care providers refer to three segments of pregnancy, called trimesters Office on Women's Health (2010).

Cherney (2016) posited that Pregnancy takes place when a sperm fertilizes an egg after it is released from the ovary during ovulation. The fertilized egg then moves down into the uterus, where implantation occurs. A successful implantation results in pregnancy. Usually, a full-term pregnancy lasts 40 weeks. There are several factors that can affect a pregnancy. Women who get an early pregnancy diagnosis and prenatal care are more likely to experience a healthy pregnancy and give birth to a healthy baby.

Android Operating System

According to James (2020), the Android operating system is a mobile operating system that was developed by Google. The Android operating system is developed to be primarily used for touchscreen devices, cell phones, and tablets. Its design allows users operate the mobile devices spontaneously, with finger movements that reflect common motions, like pinching, swiping, and tapping. Google also uses Android software in televisions, cars, and wristwatches—every one of them is integrated with a unique user interface.

Android is a popular, Linux-based mobile phone operating system developed by Google. Android is a widely-adopted open-source project. Google actively develops the Android platform but gives a part of it for free to hardware manufacturers and phone carriers who want to use Android on their devices. Google only charges manufacturers if they also install the Google apps section of the operating system. Several major devices that use Android also go for the Google apps part of the service(Marziah, 2019).

Applications ("apps"), which expand the functionality of devices, are developed using the Android software development kit (SDK) and, many a times, the Java programming

language(Mullis, 2016).

Android OS features

According to Rouse (2020), the default User Interface of Android depends on direct manipulation of inputs like tapping, swiping and pinching to set off actions. The device offers haptic response to the user by means of alerts such as vibrations to respond to actions. If a user presses a navigation button, for instance, the device vibrates. When a user boots a device, Android OS displays the home screen, which is the main navigation core for Android devices and is consist of widgets and app icons. Widgets are informational displays that automatically update content such as weather or news. The home screen display can vary depending on the device manufacturer that is running the OS. Users can also choose different themes for the home screen through third-party apps on Google Play.

A status bar at the top of the home screen shows information about the device and its connectivity, like the Wi-Fi network that the device is connected to or signal strength and battery status. Users can pull down the status bar with a swipe of a finger to view a notification screen.

Android OS in addition includes features to save battery usage. The OS suspends applications that are not in use to save battery power and CPU usage. Android consist of memory management features that automatically shut inactive processes stored in its memory.

Android runs on both of the most widely deployed cellular standards, GSM/HSDPA and CDMA/EV-DO. Android also supports:

- Bluetooth
- Edge
- 3G communication protocols, like EV-DO and HSDPA
- 4G network and 5G network
- Wi-Fi
- Autocorrect
- SMS and MMS messaging
- video/still digital cameras
- GPS
- compasses
- accelerometers
- accelerated 3D graphics
- multitasking applications

Android OS versions

According to Davis (2019) and Rouse (2020), Google unveiled Android in 2007 and got its first commercial Android device in September 2008. Sequel to its launch in 2008, Google continues to launch a new version of this operating system every year. To make things more interesting, Google gave a distinctive name on each Android version. Google makes incremental modifications to the OS with each release. This often comprises security patches and performance enhancements. However, from its inaugural release to today, Android has transformed visually, conceptually and functionally — time after time. Google's mobile operating system may have started out scrappy, but holy moly, has it ever evolved (Raphael,

2023). The list of Android OS versions include;

- **Android 1.0.** Released Sept. 23, 2008. Included a suite of Google apps, including Gmail, Maps, Calendar and YouTube.
- **Android 1.5 (Cupcake).** Released April 27, 2009. Introduced an onscreen virtual keyboard and the framework for third-party app widgets.
- **Android 1.6 (Donut).** Released Sept. 15, 2009. Introduced the ability for the OS to run on different screen sizes and resolutions; added support for CDMA networks.
- **Android 2.0 (Eclair).** Released Oct. 26, 2009. Added turn-by-turn voice navigation, real-time traffic information, pinch-to-zoom capability.
- **Android 2.2 (Froyo).** Released May 20, 2010. Added dock at the bottom of the home screen and voice actions, which allows users to tap an icon and speak a command. Also introduced support for Flash to the web browser.
- **Android 2.3 (Gingerbread).** Released Dec. 6, 2010. Introduced black and green into the UI.
- **Android 3.0 to 3.2 (Honeycomb).** Released Feb. 22, 2011. This release was exclusive to tablets and introduced a blue, space-themed holographic design.
- **Android 4.0 (Ice Cream Sandwich).** Released Oct. 18, 2011. Introduced a unified UI to both tablets and smartphones; emphasized swiping as a navigational method.
- **Android 4.1 to 4.3 (Jelly Bean).** Released July 9, 2012, Nov. 13, 2012, and July 24, 2013, respectively. Introduced Google Now, a day planner service. Added interactive notifications and improved voice search system.
- **Android 4.4 (KitKat).** Released Oct. 31, 2013. Introduced lighter colors into the UI, along with a transparent status bar and white icons.
- **Android 5.0 (Lollipop).** Released Nov. 12, 2014. Incorporated a card-based appearance in the design with elements such as notifications and Recent Apps list. Introduced hands-free voice control with the spoken "OK, Google" command.
- **Android 6.0 (Marshmallow).** Released Oct. 5, 2015. This release marked Google's adoption of an annual release schedule. Introduced more granular app permissions and support for USB-C and fingerprint readers.
- **Android 7.0 and 7.1 (Nougat).** Released Aug. 22, 2016 and Oct. 4, 2016, respectively. Introduced a native split-screen mode and the ability to bundle notifications by app.
- **Android 8.0 and 8.1 (Oreo).** Released Aug. 21, 2017 and Dec. 5, 2017, respectively. These versions introduced a native picture-in-picture (PIP) mode and the ability to snooze notifications. Oreo was the first version to incorporate Project Treble, an effort by OEMs to provide more standardized software updates.
- **Android 9.0 (Pie).** Released Aug. 6, 2018. This version replaced Back, Home and Overview buttons for a multifunctional Home button and a smaller Back button. Introduced productivity features, including suggested replies for messages and brightness management capabilities.
- **Android 10 (Android Q).** Released Sept. 3, 2019. Abandoned the Back button in favor of a swipe-based approach to navigation. Introduced a dark theme and Focus Mode, which enables users to limit distractions from certain apps.Android 10 has no version name. This is because Google has unfortunately, decided to no longer use dessert names for the newest Android version. Android 10 is simply known as Android 10.

- **Android version 11.** Android 11, launched at the start of September 2020, was a pretty substantial Android update both under the hood and on the surface. The version's most significant changes revolve around privacy: The update built upon the expanded permissions system introduced in Android 10 and added in the option to grant apps location, camera, and microphone permissions only on a limited, single-use basis.
- **Android version 12.** Google officially launched the final version of Android 12 in October 2021 and started rolling the software out to its own Pixel devices soon after — alongside the launch of its new Pixel 6 and Pixel 6 Pro phones.
- **Android version 13.**Android 13, launched in August 2022, is one of Google's strangest Android versions yet. The software is simultaneously one of the most ambitious updates in Android history *and* one of the most subtle version changes to date. It's an unusual duality, and it ultimately all comes down to what type of device you're using to experience the software.
- **Android version 14.** Android 14 took its first baby steps into the world in early February 2023, when Google announced the inaugural developer preview of the software. (Raphael, 2023)

Analysis of the Proposed System

The new system is an android based application for Fertility Indicator and Antenatal Companion Application. This new system should be able to tackle the above listed weaknesses identified in the existing system and also help bridge the digital divide in areas concerning family planning and place women in the vanguard of bio-medical computing.

Architecture of the Proposed System

The architecture of the proposed system is made of the sub-systems and or components that must be put together to come up with the complete system and the interconnections between these sub-systems are identified.

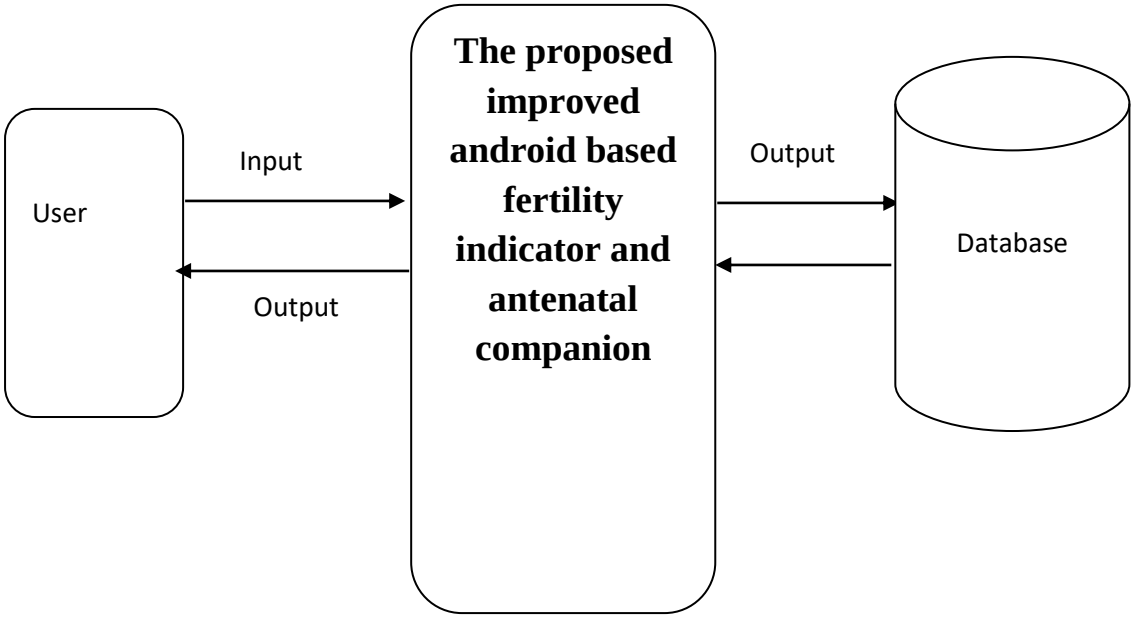

Figure 1: Architecture of the Proposed System

Object Oriented Diagram Showing Interaction within the System

This shows how the system interacts and communicates with other systems and users is pointed out here.

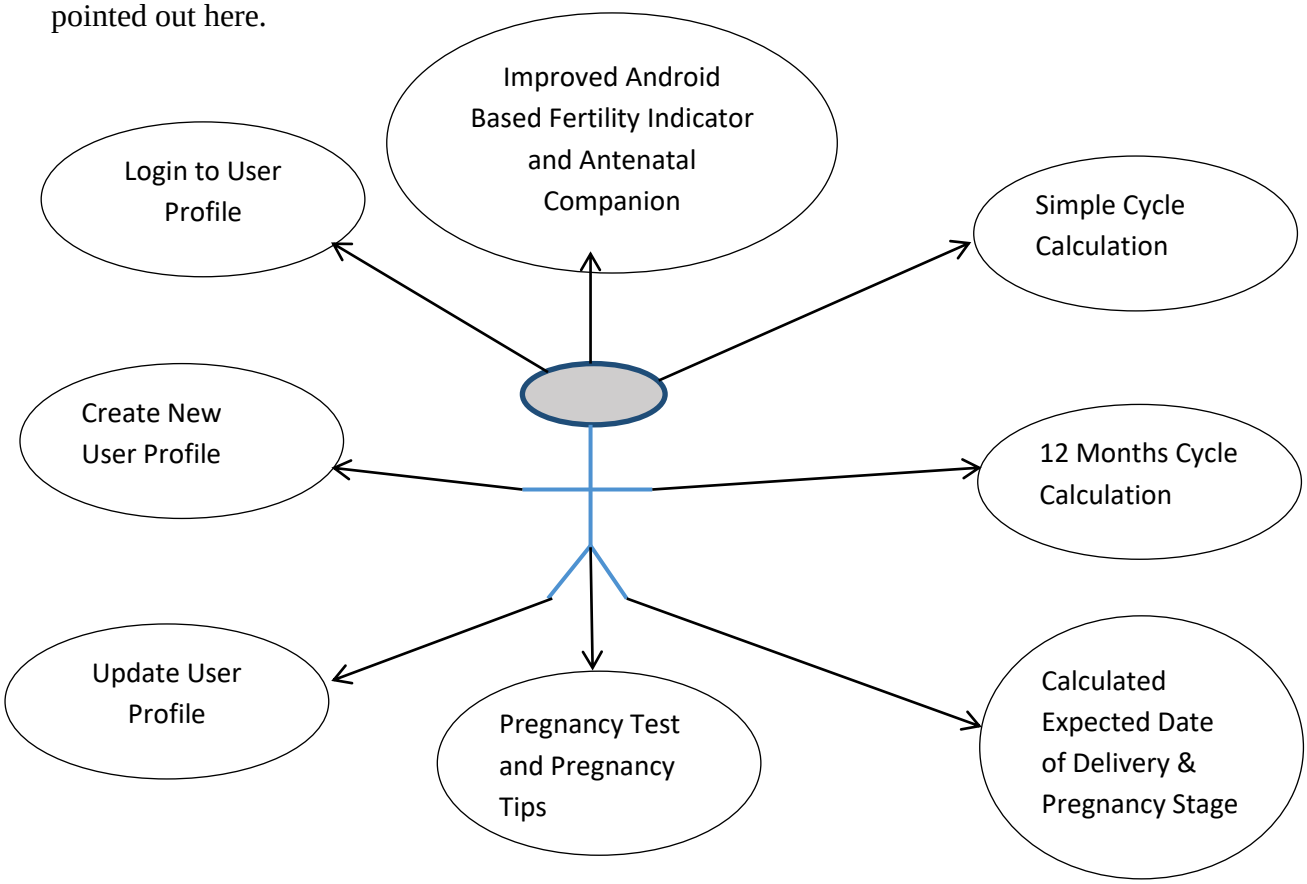

Figure 2: Fertility Indicator and Antenatal Companion Use Case Diagram.

The user logs in to the application using a smartphone. The user can update user's profile, run calculations on the simple cycle calculation, 12 months cycle calculation, check Expected Date of Delivery (EDD) and pregnancy stage, pregnancy test and pregnancy care/tips.

Test Results Evaluation and Discussion

The application was tested using different Smartphones that run of on android platform to make certain the communicability and operability of the application across smartphones. The result showed that precise and accurate calculations on fertility cycles and pregnancy stages are achieved.

The participants for the testing include android smartphone users. The participants were tasked to install and use the application to accessthe features and functionalities. This tends to yield accurate result on how the app will work on different android phones. A discovery was made on the screen size with a recommendation for a maximum screen size of 720 by 420 for better display.

The application was properly tested to measure level of success recorded in its development in regard to achieving the set objectives. In order to identify acceptability of the android based fertility indicator and antenatal companion system, two different questions were designed that reflect the users which are women of reproductive age.

Conclusion

The major research problem expressed in the start of the project was to develop an application that will enable and enhance efficient family planning by enabling women to make precise and accurate calculations on their fertility cycles, pregnancy stages and expected date of delivery using any smartphone that runs on the android platform. Therefore, an android based fertility indicator and antenatal companion app was developed to deal with the issues concerning family planning. The application was developed using NativeScriptframework of which JavaScript was used as the programming language and the user interface was designed using Vue.js which is a JavaScript framework for building user interfaces and single-page applications (SPA).The application was designed based on the study carried out in the early stage of the project as well as on the advice of women of reproductive ages and couples. Implementation of the application was done based on the designed model.

The application was tested in the final stage of the project although the time period for testing was very short. Time limit might have affected to show significant results but the response from the involved users was quite remarkable. According to users, the application was very successful in carrying out its intended task. Also, the user interface was very interactive and the users were quiet satisfied with the application in general.

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