Frameworkfor Pervasive Context Aware Pandemic Diseases Infected Person Identificationand Information Deliverywith Special Referenceto COVID-19 (The Caseof ETHIOPIA)

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Abstract:
Human history is observing an awfully strange time fighting an invisible enemy; the novel pandemic COVID-19 coronavirus. Initially observed within the Wuhan province of China, now fastly spreading around the world. An emerging area of great impact and significance is the application of pervasive computing technologies in healthcare; that specialize in enabling pervasive computing environment using mobile devices. Currently there are issues in home to home testing/investigation for corona virus infected peoples while they are migrating from place to place for testing, timeliness, opportunity missing due to anxiety, anywhere, anytime inaccessibility, dynamic and static reporting over small hand held devices like mobiles. This research aims to develop a framework for pervasive context aware pandemic diseases infected person identification and information delivery with special reference to COVID-19. The researcher followed an applied research design with empirical analysis. This is the mix of two main approaches (quantitative and qualitative). For primary data collection Survey, Interview and Practical observation of the researcher are used for collecting the relevant facts on researchability attributes, issues and challenges. Edraw-Max is used for designing the system framework and Google Form for Survey. The system framework consists of client server architecture in which citizens' and health care workers are the two sorts of clients and a server serves to both of them. The information's of infected people are delivered to the server either in PULL/PUSH mode then the server implicitly PUSH's the information to health care worker. In PULL mode, the system provides a listing of possible signs and symptoms for the user to explicitly pass his/her signs and symptoms to the server and the server analysing the user signs/symptoms and performs reasoning and decisions supported context data store in the context repository backend databases.Then, it delivers the relevant information to the health care workers. On the opposite hand, in PUSH mode, the server analysing the user's signs and symptoms based on the information from the user mobile device while they are using or opening by automatically measuring their temperature, the system pushes notification message to the health care workers.

Keywords: COVID-19, Framework, Pandemic, Pervasive environment, PULL, PUSH, Real time

1. Introduction

Ubiquitous computing technologies can play in medical care and analysis of health conditions to support preventive, hospital, and chronic care. Additionally, the ways within which many of these technologies are reinventing the trendy healthcare experience is examined. This broad area of research and practice is usually cited as pervasive health [1]. In current state of art home to home investigation is employed to identify the infected person with COVID-19, this home to home investigation will have many disadvantages like waste much money, spent much time, frustration, missing the opportunity to be tasted etc. the provision of real-time information helps to enhance the current home to home searching and helps to manage the Pandemic at early stage.

Mobile, pervasive, and ubiquitous computing technologies offer favourable solutions to documenting progress, diagnosing conditions, and treating and managing care in this patient-centred approach. Pervasive computing, ubiquitous computing, and ambient intelligence are concepts evolving from the development and deployment of pervasive applications, frequently in the healthcare domain and is most of the time mentioned in the healthcare context [2]. Initial visions of pervasive and ubiquitous computing describe environments furnished with computational artefacts that remain in the background and have intelligent capabilities to support user-centred activities[3] [4]. Pervasive health applications range from wearable and implanted sensors that support in self-care (e.g., [5], [6] to hospital environments boosted with pervasive computing technology[7].

Location is very important parameter in portable services. It is usually determined using a network of satellites Global Positioning System (GPS) or a network of antennas, either wide area Global System for mobile Communication (GSM) or local area (e.g. Bluetooth) [8] [9]. The most common mobile positioning methods are based on Cell Identification (Cell ID), Time of Arrival (ToA), Received Signal Strength (RSS), Time Difference of Arrival (TDoA), or Angle of Arrival (AOA) measurements determined from the MS signals received at the BSs. In this corresponds, the researcher focus on mobile positioning using Cell-Id and RSS information. Signal strength is an easy and low-cost method to implement in GSM, because it does not require any changes to the handset and existing network infrastructure. RSSI information is readily available to the user's applications on almost all GSM phones. Such systems have the potential of localizing 80-85% of today's cell phones [10] . For these reason, the researcher decided to use RSSI positioning method for identifying the user's location and using their IMEI code to implicitly send alert indicating the symptom. The MS continuously measures the signal strength from each base station and reports this information back to the serving base station. With this signal strength information, it is possible to calculate the position of the MS, by taking into consideration the fact where the received signal strength degrades as the distance between the transmitter and receiver increase. However, there are number of factors that limit the effectiveness of this method. Some of

them are the distance between MS and BTS, the characteristic of terrain between the transmitter and receiver, and the issue of indoor attenuation [11] [12] .

2. Problem under Investigation with Goal of the Research

In current state of art testing/investigation for peoples infected with corona virus is done manually migrating from place to place this way of investigation have the following major identified issues and challenges:-

- While migrating from one place to another place for testing COVID-19 will result in a lot of resource wastage and tiredness both on the government and health professionals and may be they are not able to get all persons in one place or home this may lead to the manual testing mechanism not addressable.
- In the current system practice identification of person infected with corona virus (COVID_19 positive) may be occur after he/ she transmitted the pandemic to many other peoples.
- The current system practices are very time consuming, cost consuming, tiresome, and boring.
- While searching for COVID-19 positive person during home to home investigation some peoples are intentionally hiding themselves due to fear to be tested for corona virus, this will lead to rapid transmission of the pandemic.
- The current state of art lacks technology supported real-time information delivery/dissemination both for the peoples and to the health care station, some peoples have no sufficient information/ awareness level about the symptoms and the treatment ways and also the health professionals are not able to get real-time information about peoples with COVID-19 positive to make early isolation.

These potential issues and challenges inspired this research to design a “pervasive context aware Framework” to current platform for home to home investigation/searching with intelligent content. However, in Ethiopia; there is shortage of such frameworks which can provide a localized guideline to develop such systems to facilitate the real time information flow from "Citizens" to "Health care stations”. If they will get real time alert/information, the issues and challenges of the pandemic can be alleviated. This can help the health care workers to early isolate peoples with COVID-19 positive cases. Lack of such information system is a common phenomenon in the country. If such problem sustained for a long time without any technological enabled support and services then it will lead a significant increase in number of infected peoples in the country.

3. Review of Related Research Literature

In order to understand the contribution of different researchers; this study reviewed several research papers, dissertations, Journal papers and thesis documents. Some researches focus on using pervasive environment for different areas and A few research papers were found which are only focused to identify the transmission ways of the pandemic. Most of the papers

reviewed in this study did not cover the real-time based, using any device delivery and the use of pervasive environment for this new pandemic disease.

A research [13] Pervasive Computing in Healthcare Systems was developed to adopt pervasive computing in healthcare, based on EMR database that coordinates application services over network to form a service environment for medical and health-care. This work is relevant to the study. But the research paper focuses only on adopting pervasive environment in the health care centres in order to form service based environment generally without taking in consideration about the different context aware features and parameters. This work also lack some feature of pervasive computing. A research [14]was focused on Design and development of the context gathering framework which consists of sensor data model, messaging and communication protocol and software application programming interfaces. This study is also relevant to study. In this study these components form as one of the enabler to support the development of context aware mobile applications, but only limited on gathering the context information. Another research [15]Context Neighbour Recommender:Integrating contexts via neighbours for recommendations is developed for Design and development of the context gathering framework which consists of sensor data model, messaging and communication protocol and software application programming interfaces. This study is also relevant to study. In this study these components form as one of the enabler to support the development of context aware mobile applications, but only limited on gathering the context information. A review paper [16] on Mobile Context-Aware Systems: Technologies, Resources and Applications is done Reviewed existing work in context-aware systems. e.g., how to model context, and discusses further development of CAS and its potential applications by looking at available information, methods and technologies which is Relevant to the proposed study. But this study focuses only on comparison of the existing works in context aware system and existing information gathering only. This is a review paper and does not provide any significant system which resolves any selected problem

3.1Research design and approach

This paper followed an empirically applied research design strategy using mixed approach (quantitative and qualitative using survey questionnaire), Interview Questionnaire with qualitative approach along with practical observation of the researcher on the places home to home investigation is donefor collecting relevant primary data. Quantitative methods are used to examine the relationship between parameters i.e. (1) users Symptom, (2) Location, (3) Context, (4) Anywhere Anytime information. The research started from the understanding of how the current home to home investigation is done to identify COVID-19 positive peoples in Ethiopia using existing state of art systems.As a final outcome this study develops a new a Real Time Context based Pandemic diseases Infected Citizen Identification and Information Delivery System Framework in Pervasive Environment with Special Reference to COVID-19 based on context aware parameters.

3.2**Sampling design & primary fact finding**

The target population was selected from government and private organizations.The total citizens and healthcare workers population was 73.

This study used the purposive sampling technique, which is a non-probability sampling technique in which researchers rely on their own judgment when choosing elements/members of the population to participate in their study. It is also known as judgment sampling.

The research study collected data from both primary and secondary sources using the (1) questionnaire based semi-structured open indeed interview, (2) close ended questionnaire-based survey and (3) checklist based technical observations of the researcher. These data collection methods are summarized in figure 1.

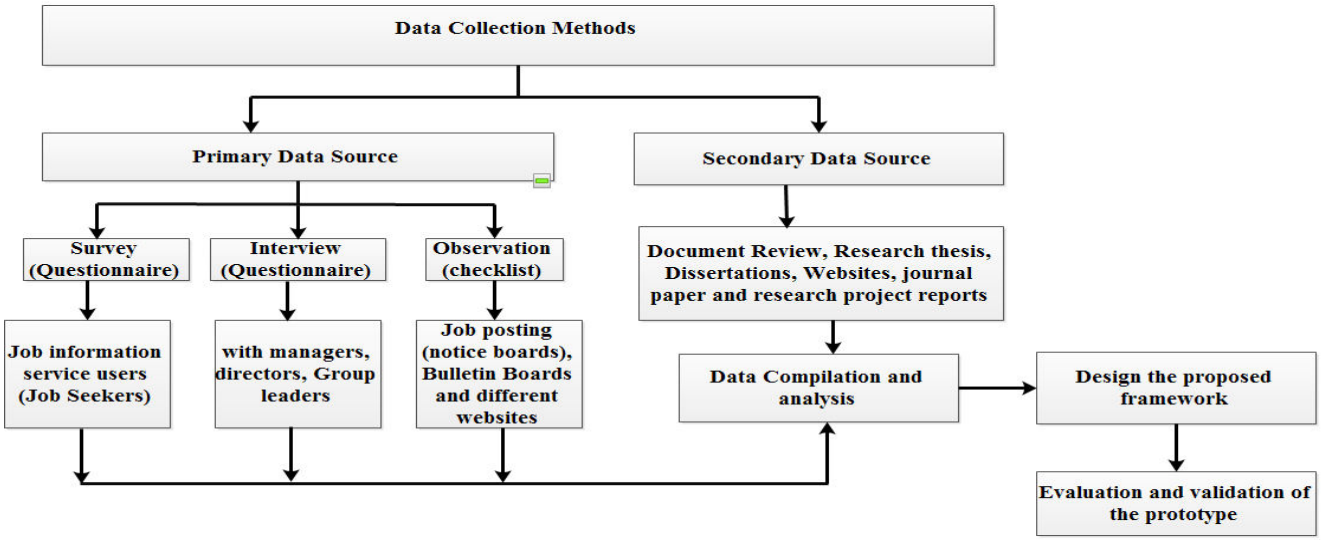

Figure 1: Data Collection Methods

3.3 Data analysis and discussion

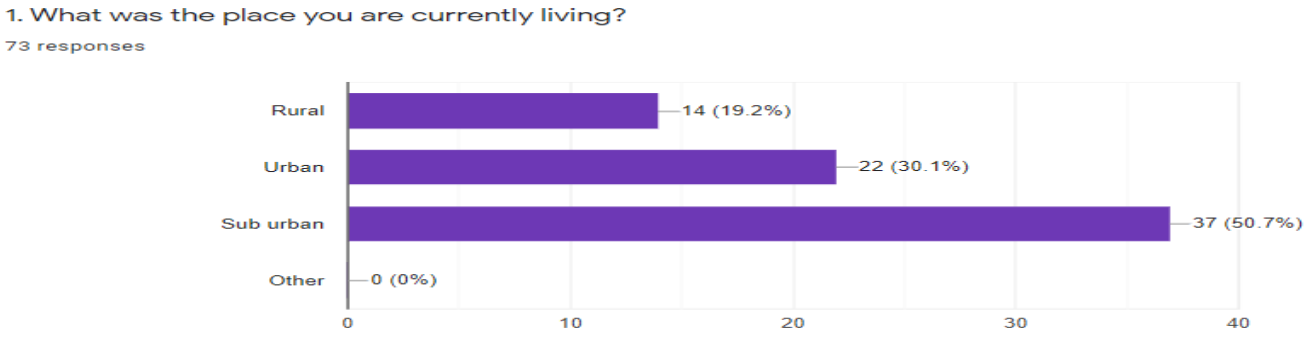

Figure 2: Current Place

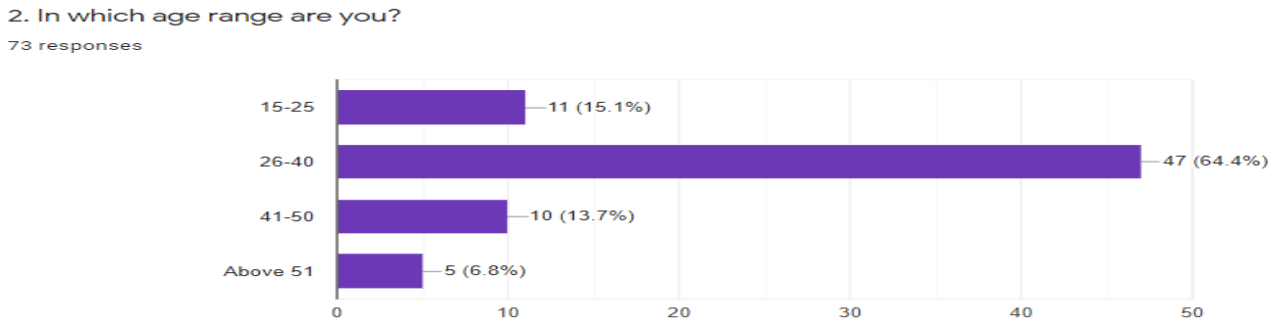

Figure 3: Age range

Inorder to get a deep understanding of the current situation in different places of the country peoples and health care professionals from different area 19% from rural area, 30.1% from urban area, and 50.7% from sub urban area as presented in figure (2) are interviewed, and also to know the understanding level of the pandemic diseases (COVID-19) interviewers at different age range are included as presented in figure (3)

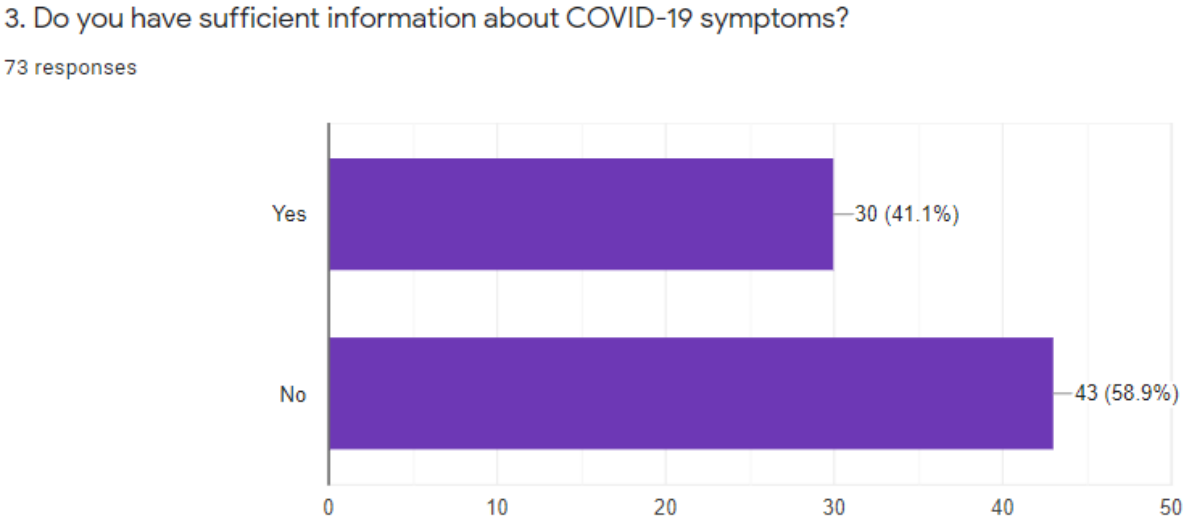

Figure 4: Information about COVID-19 symptom

When a question was raised to know the understanding level of corona virus (COVID-19) symptoms as presented in figure (4) 41.1% respondents responded YES (means they have sufficient information about the pandemic) and 58.9% respondents responded that NO they don't have information about COVID-19 symptoms, this result clearly shows that there is a need for new system to transmit the information at hand in real time fashion.

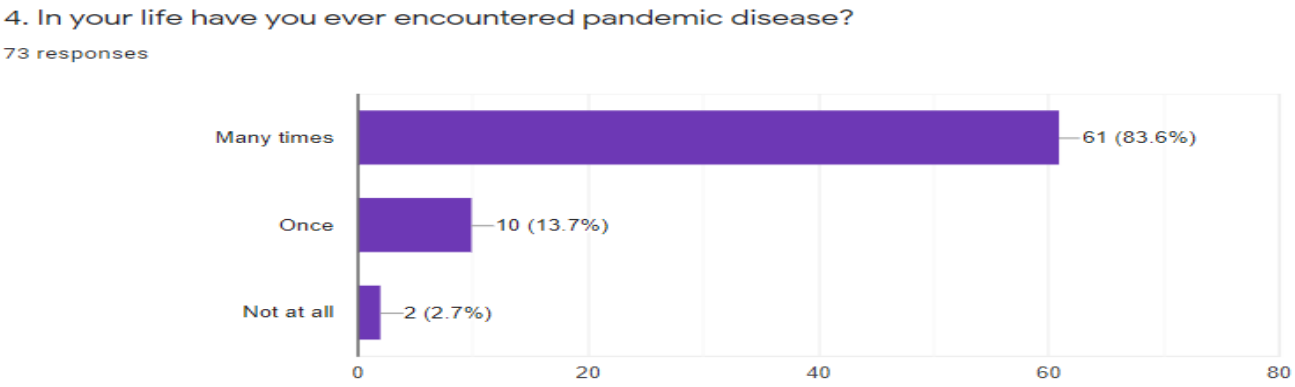

Figure 5: Occurrence of pandemic disease

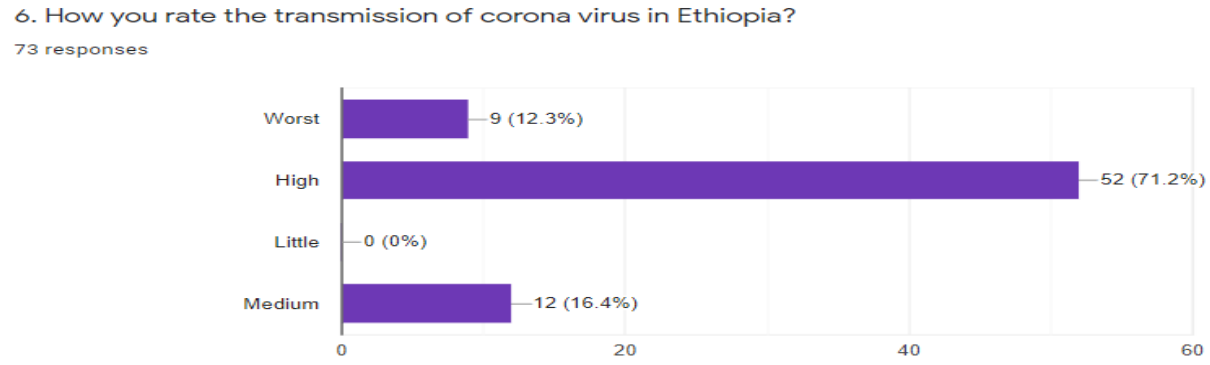

Figure 6: COVID-19 transmission rate in Ethiopia

Another question was asked to know the continuous trendy of pandemic disease as presented in figure (5) 83.6% of respondents responded that they encountered the occurrence of pandemic diseases many times, 13.7% responded they faced once regarding the occurrence of pandemic diseases and the remaining 2.7% respondents responded they don't have experienced any pandemic disease, further a question was asked to rate the transmission of corona virus in Ethiopia as presented in figure (6) 12.3% of respondents responded Worst, 71.2% of respondents responded highly spreading , 16.4% of respondents responded Medium and 0% responded little. This result clearly showed that there is a strong need for a system to control the pandemic at early stage same question where asked for health professionals and proved the strong need of alternative system.

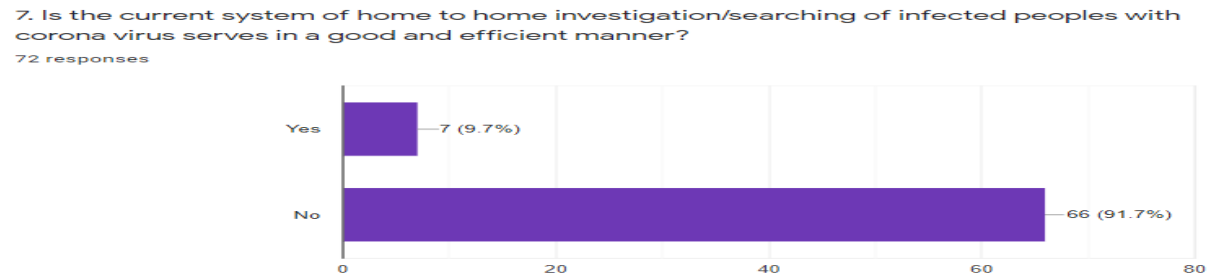

Figure 7: The efficiency of current system

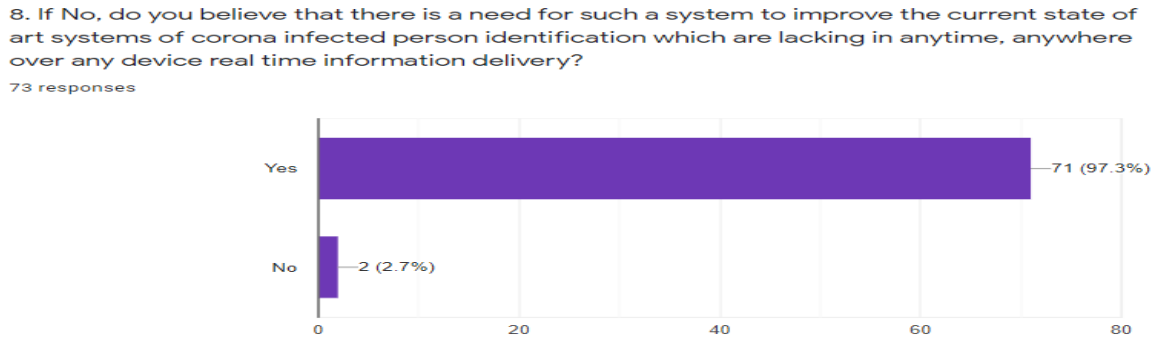

Figure 8: Current system improvement

Another question was asked to know the efficiency of current system of home to home investigation to isolate peoples with corona virus (COVID-19) as presented in figure (7) only 9.7% of respondents respondedYES it serves in a good and efficient manner, the remaining 91.7% respondents totally argue on the efficiency of the current system while searching for peoples infected with corona virus (COVID-19). Further the question was asked to know the need of new system to improve the current home to home testing by addressing the feature of anywhere, any time and over any mobile device as presented in figure (8) 97.3% respondents responded YES and only 2.7% of respondents responded NO, same question was asked to health care professionals and same result was obtained and clearly revealed that the current system practice lacks real-time information dissemination, anywhere any time reporting and using of technological features.

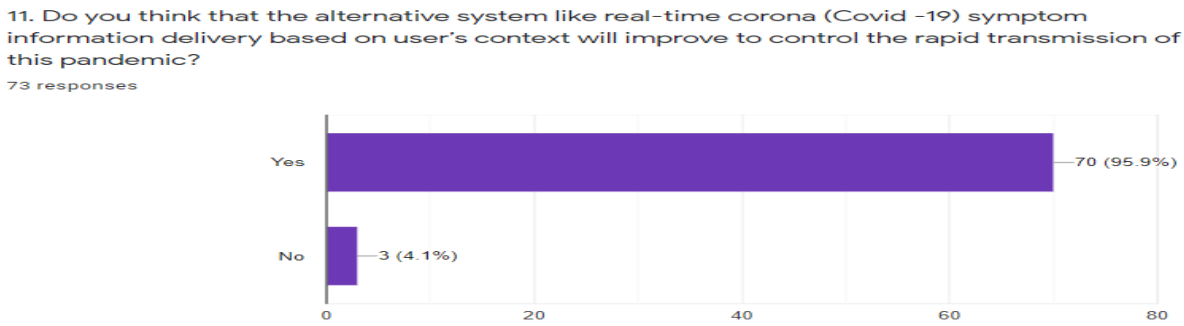

Figure 9: New system efficiency in controlling the pandemic

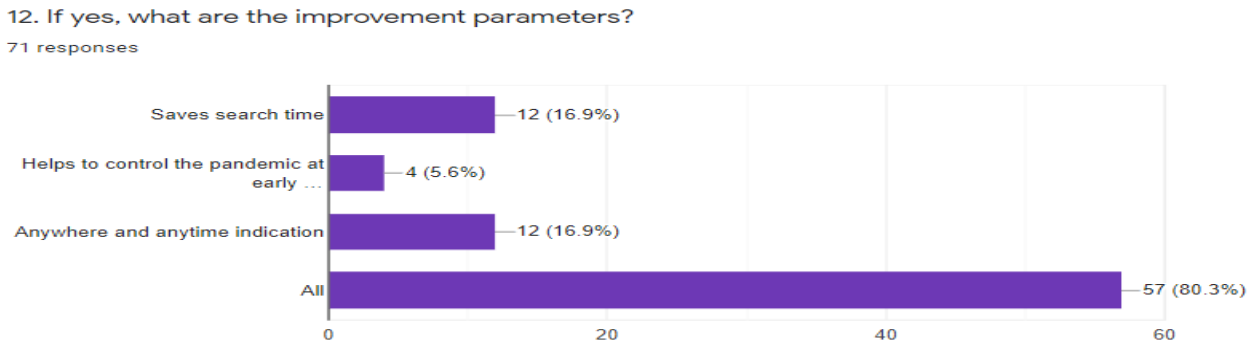

Figure 10: Improvement parameters

When, another question where asked regarding the new system framework efficiency in controlling the rapid transmission of corona virus (COVID-19) as presented in figure (9)95.9% of respondents responded YES the new real time context based information delivery framework greatly helps to control the rapid transmission of pandemic, 4.1% respondents responded NO it doesn't help to control the rapid transmission , further a question where asked to know the improvement parameter as presented in figure (10) 16.9% of respondents responded the new system frame work saves search time compared to the existing system, 5.6% respondents responded Helps to control the pandemic at early stage, 16.9% respondents responded the new real-time system framework have anywhere any time indication of the infected person with corona virus (COVID-19), and the reaming 80.3% of respondents responded all improvement parameters are mandatory for the new real-time corona virus infected citizens identification and reporting system framework.

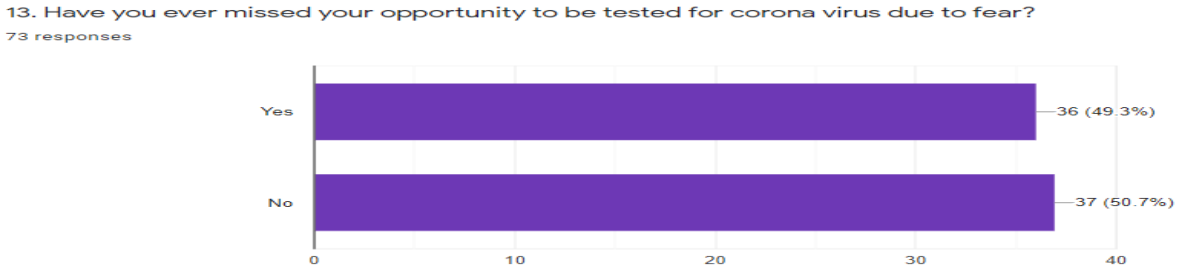

Figure 11: Opportunity missing to be tested due to fear

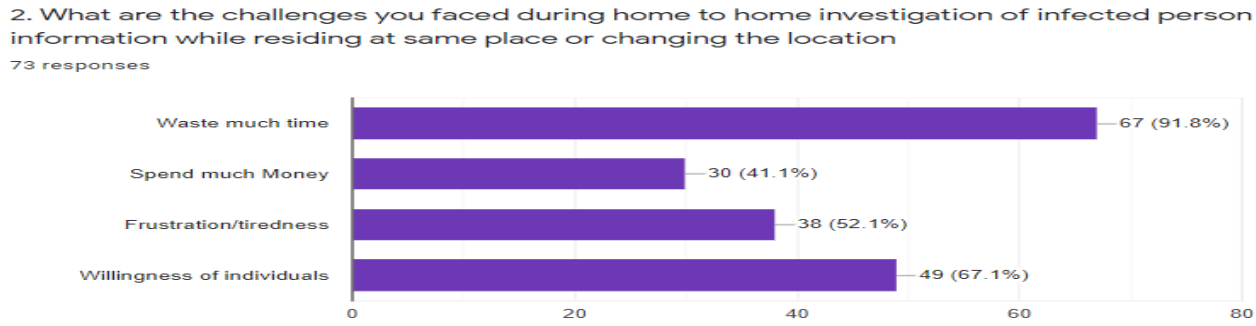

Figure 12: Challenges during Home to Home Investigation/Testing

Another question was asked to know opportunity missing to be tested for corona virus due to fear as presented in figure (10) 49.3% of respondents missed the opportunity to be tested for corona virus due to fear and 50 % respondents responded they didn't miss the opportunity this result showed that the virus is rapidly transmitting, because many peoples are hiding themselves to be tested for virus. When a question was asked to know the challenges health care workers face while they are doing home to home investigation of information while residing at the same place or changing location as presented in figure (11) 91.8% respondents responded waste much time, 41.1 respondents responded spend much money, 52.1%

respondents responded frustration/tiredness and 67.1% respondents responded willingness of individually are the major identified challenges in the current system practice.

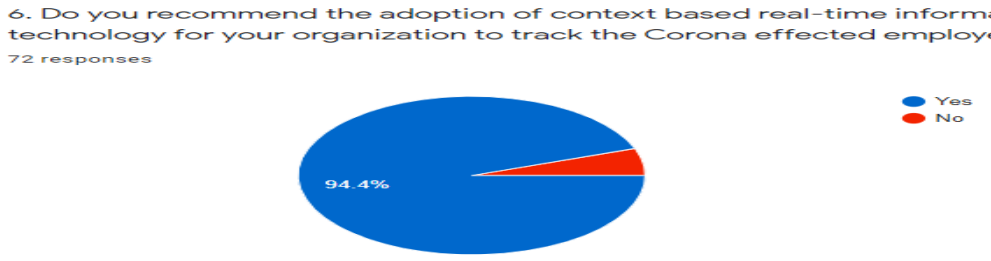

Figure 14: Adoption of context based real time information delivery of COVID-19 Positive person reporting to health care center

Further when the question was asked to know the health care organization interest in adopting this new technology for identification of pandemic disease, the result was amazing as presented in figure (14) 94.4% of respondents responded yes.

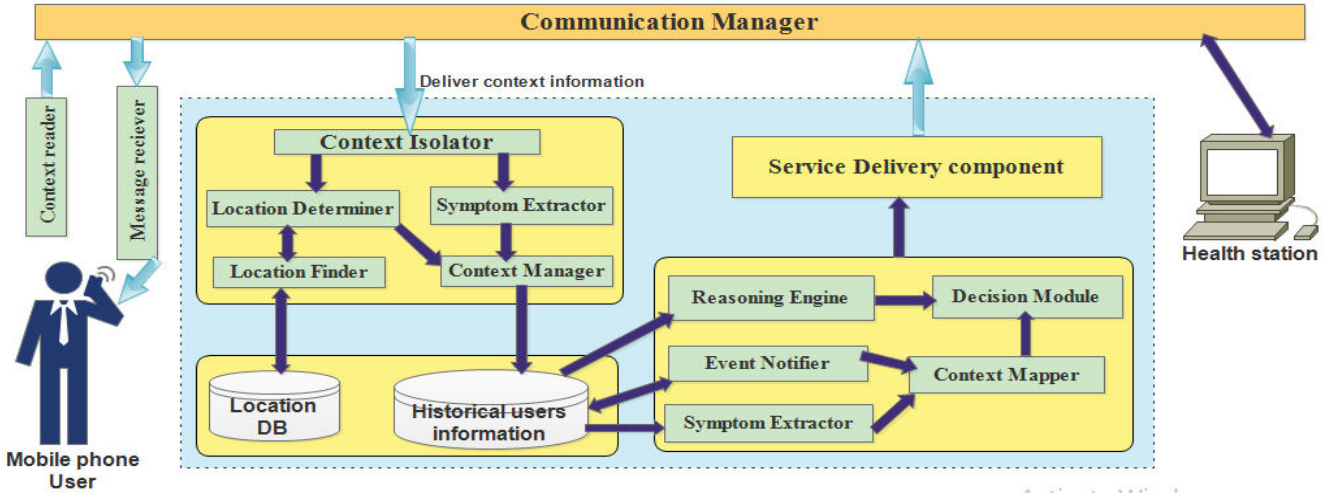

Figure 15: A Pervasive context aware COVID-19 infected peoples reporting Framework

4. Proposed Framework and its Functionality

The proposed framework consists of six major layers that reside on either on the server-side and/or the client-side. These layers communicate via the Internet (TCP/IP). These layers are Context Data Acquisition, Communication Manager, Context Analysing, Reasoning and Decision, Context Data Repository, and Service Delivery presented in figure (15). These components co-operate and communicate for effective assistance to the health care centre in getting the relevant information at the right time.

4.1 Context acquisition component

This component as presented in the figure (15) resides on the user side. Its main responsibility is to capture and submit raw context data to the server as requested. This

component is consists of two sub components/modules is described in the following subsections.

4.1.1 Context reader

It is responsible for reading implicitly raw context data (such location, symptom and time) from the user mobile device through APIs. This module as presented in the figure (15) forwards this context data to the Communication manager to be sent to the server to provide localized computation.

4.1.2 Message receiver

This module as presented in the figure (15) is responsible for accepting all the incoming messages about the symptom of COVID-19 and treatment methods, which holds the context information that is sent by the server.

4.2 Communication manager

This module as presented in the figure (15) resides outside the skirt of all components and manages the communication between the client and the main server over Internet gateway.

4.3 Context analyzing component

In this module several modules are interrelated (work together) to analyse the context data. Finally, they send the analysed context information to the Reasoning and Decision Making Component. This component as presented in the figure (15) consists of five modules that are presented in the following subsections.

4.3.1 Context isolator

This module as presented in the figure (15) accepts the context raw data from the communication manager and separates location data from other context data. Afterward, it passes location data to the Location Determiner Module for the identification of the user's location. And other context data to symptom Extractor to identify user's symptoms.

4.3.2 Location determiner

The main task of this module is to determine the location of the user while using the mobile phone. This module as presented in the figure (15) executes mobile location determination algorithm.

4.3.3 Location finder

This module as presented in the figure (15) is used to acquire the actual geographical location of a user through look up the Location database.

4.3.4 Symptom extractor

The main responsibility of this module is to extract the user's symptom from the raw context data that is received from the context filter module. It passes the identified user's symptom to the context manager module for further process.

4.3.5Context manager

The Context Manager (CM) is the module in charge of storing the user's symptom information in the historical users DB and delivering analysed context data to the Reasoning and Decision Making component for further processing and response.

4.4 Reasoning and decision component

The main responsibility of this component is to make decisions by examining contextual information or user symptom against the existing context instance of data in the context repository as presented in figure (15). The component comprises five modules as presented in Figure (15). (1) Reasoning Engine, (2) Event Notifier, (3) Decision module, (4) Preference Identifier, and (5) Context Mapper. The combination of these all the modules are able to carry on the context reasoning process.

4.4.1 Reasoning engine

This is the core module of the Reasoning and Decision Making component. The main responsibility of this module is to infer the suitable information to be dispatched to the health care station either in PULL or in PUSH mode.

4.4.2 Event notifier

This module of the system framework is responsible to notify the occurrence of a new event based on the monitored context and any new change on the parameters.

4.4.3 Symptom identifier

This module of the system framework is responsible to analyse and dispatch the user's symptoms either based on the occurred event that accept from Context Manager module, or through periodically navigate the users (citizens) profile histories from the User Profile database.

4.4.4 Context mapper

This module of the system framework performs its tasks based on two cases- 1) one is during Event Notifier modules notifies the occurrence of a special event, 2) Preference Discovery module submits context information to be dispatched to a user (citizens) based on his/her profile history.

4.4.5 Context data repository

The Context Data Repository component of the system framework is responsible to store context data instances into a responsible backend database for future references.

4.4.5.1 Memory-base repository manager

This module of the system framework is responsible for managing the interaction of other components with the backend databases. It is also responsible for analysing and dispatching the context data to Persistence Layer to be stored into a responsible backend database based on the received context from other components.

4.4.5.2 Persistence repository manager

This module of the system framework is responsible for managing the data store and access to the underlying relational database system and provides an abstraction for data access and retrieving operations.

4.5 Service delivery

This is one of the main module of the system framework. The main responsibility of this module is to submit the received context information from Reasoning and Decision Making Component to the Communication Manager Component in the form of message either in PULL or PUSH situation.

4.6 Health station

This module resides on the second user side (health station), responsible for receiving users information from service delivery component via communication manager and sends the symptom and treatment ways of information regarding COVID-19 to the user.

5. Conclusion

This research proposes aReal Time Context based Pandemic diseases Infected Citizen Identification and Information Delivery System Framework in Pervasive Environment with Special Reference to COVID-19. This is done by collecting local context information data from citizen's smart phone while using their mobile devices. Unlike other related researches, this research study uses an approach in which the following three component activities are incorporated: 1) firstly, the researcher collects primary input data from citizens in different place, age, and institution, healthcare workers, experts and researcher self for the real-time information delivery on any communication device in anywhere and anytime manners to the targeted health care organization, 2) Secondly, the researcher describes how the intended services are delivered to the end users (citizens and health care workers) using the two basic delivery modes the PULL and PUSH. This situation is described in the proposed framework and 3) finally, an algorithm that is used to identify the user's (citizens) location from the fetched cell-ID and RSSI information from the user mobile phone is used. The proposed system framework was built using 'E-Draw max tool'. Usability of the system can be greatly enhanced by utilizing contextual factors to display only the needed information and to provide optimized COVID-19 information in accordance with the user preference and interest in anytime, anywhere over any device manners.

6. Recommendations

Pervasive computing is still in its early stages of implementation or usage in developing countries like Ethiopia and therefore numerous researches need to be done in the area. The proof of concept demonstration was done on one of the popular tools with a limited performance and resource to address all features. So, the researcher recommends to use the better deployment platform or high performing machine to test the framework to the fullest potential and for better performance.

Besides this, the usability of the service increases, if the multilingualcapability is incorporated in the service, because in Ethiopia there is diversity of languages. Incorporating the multilingual capability helps the users, especially rural job seekers to access the service in their own languages.

The future research studies can include different features like GPS location, ordinary cell phone's advanced features or the Tablets. The researcher suggests the full implementation and evaluation of the framework

8. Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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