Predicate Logic System to Predict and Prevent Zika Virus using Cloud Computing

Sandeep Kaur
Assistant Professor, GNDU, RC, Gurdaspur, Punjab, India.

Abstract- Zika virus (ZIKV) is spreading at a rapid rate in various continents of the world. This most dangerous virus has already affected the lots of people around the world, i.e., Africa, Southeast Asia, and the Pacific Islands and further spreading day by day. Till date, no vaccine is available for the treatment of this ZIKV. Hence it becomes must alert nearby people to be aware of it because of its communicable behavior. This rapid spreading infection can be easily monitored and controlled with the help of 'Cloud computing' in a cost-effective and time-saving manner. In this study, a Predicate logic (PL) system is proposed that rapidly predict the ZIKV infection by available symptoms and subsequently inform the particular health care agencies for quick and timely action. This system gathers the information from the users with the help of Websites, Android App, IOS App and take necessary decisions and update that information in the medical database available on the Cloud Hosting. This purposed system provides the information of the infected individual along with updated user location to the nearest health care agencies/government agencies. The information is integrated into Google maps as a 'Red alert' area and accordingly infected user is provided with information of nearest hospital. By this information for infection rate as per area, pre-travel advice for travelers is available.

Keywords- Cloud computing, Big data, Internet of things, Google Maps.

I. INTRODUCTION

The biggest and most important challenge for any government about health care is to protect its citizens from the sudden disease outbreaks in which virus can spread from one citizen to another citizen via the medium of air [1]. Coronavirus, discovered in 2005 in South Korea, is an example of viruses that spread through the air and it caused a large number of casualties in humans and animals [2]. Zika Virus was traced in the 1948 and learned to be isolated from a monkey in the forest of Uganda, Africa [3-4]. Afterwards, it is witnessed that, as like dengue, yellow fever, Japanese encephalitis, West Nile, and Saint-Louis encephalitis viruses, Zika virus also belongs to the family of viruses called *Flaviviridae and genus flavivirus.* It can spread in humans by bites of the mosquito named *Aedes* [5]. Since then, it has been demonstrated from lab studies and virus isolations that this particular virus has wide geographic dispersion. Later on, another case of Zika virus was detected in Yap Island [6]. In this report, there were 49 confirmed and 59 probable cases of Zika virus found on Yap Island, Federated States of Micronesia. Furthermore, some cases were found in the travelers returning from Africa and South East Asia, few of them were sexually transmitted [7-8]. In December 2013, the largest outbreak of approximately 28,000 zika virus infections had been recorded, about 11% of the population of French Polynesia [9]. The most common symptoms of the Zika Virus are recorded as Fever, headache, Fatigue, Malaise, maculopapular rash, Arthritis and Arthralgia [10].The prominent issue in the arena of healthcare is to manage effectively the diseases which spread through the air also known as communicable diseases. Zika virus has been declared as the public health threat; so government and various agencies are on their toes to stop the further spread of this disease. To stop these outbreaks government can take following steps,

1. Either, they hire men who can visit manually in every village or town to check each person.

2. Or, they need to provide the location of nearest healthcare agencies to every individual for checkup against virus infections.

The first step needs large workforce for successful implementation that can be a very expensive move. Secondly, each will have to visit the nearest healthcare that may not be feasible regarding conveyance and can be time wasting for some of the people who might not be affected. Then, how to control it?

Cloud computing is an emerging field that can be the best alternative in this regard. Various healthcare agencies are adopting the Cloud computing in the field of healthcare to achieve maximum efficiency to curb various infections [11]. Cloud computing is the most effective and suitable method to provide the improved quality of healthcare services, because of large storage and ease of handling huge amount of patients data at very little cost. Nowadays, every government is dedicated to the budget on IT infrastructure. By using Information Technology (IT), one can design an efficient and a cost-effective system to provide instant healthcare services to every individual in any region.

In the proposed system there is a reduction in the cost of the workforce which a government needs to hire for a checkup of every individual, as stated above. It comprises of designing an app that can take initial decision for ZIKA virus detection according to symptoms. If the initial test is passed, then this system provides the nearest location of healthcare to the affected individual. This furthermore, helps in reducing congestions at healthcare as only those individuals are visiting the healthcare center that has passed the initial test of the system. This system makes use of GPS to track the location of the affected user and utilize Google maps to find the nearest location of the Healthcare agencies.

Nowadays, every individual has mobile phones and other electronic gadgets like iPad, laptop, and phablets. One can make use of these devices to capture the data from the user and update it on the cloud with the help of IoT. An Android app and IOS app thus created with graphical user interface ask questions from the user and analyses the situation and take decisions, accordingly. To provide the location services, Google Geocodes are embedded in the mobile application.

Various organizations like Amazon, Digital Ocean provided high computations, Storage and managed cloud hosting at pay-as-use model [12]. All the data is put on the cloud servers which is accessible at any location with the help of Internet connectivity and can be accessed from mobile phones and laptops. Because of IOT this data can be easily captured by the users and can be retrieved from the servers as per the need. By using these techniques effectively, the cost of healthcare services can be reduced with an increase in the quality of service [13].

Cloud computing is the latest technology which provides IT services over the internet without any large investment. Every day, new data records are saved in hospitals with rapid rate due to increasing number of patients. These records help doctors, Researchers, Hospitals and healthcare agencies for research and analyses of the Patients and take actions according to the situation. Nevertheless, it is very difficult to store this information at local hospitals or in manual notes. To overcome this problem, cloud computing with cloud storage is the best solution wherein, all the data can be stored on the cloud server and can be retrieved at any place in the world with the help of internet. Fast-spreading diseases like Zika virus can be down paced and controlled with the help of cloud computing. With the help of this technology, one can easily predict Zika virus at the initial stage and control its further spreading, and complete information of every infected person is stored in the cloud. That information is easily available for all the researchers, hospitals, Healthcare agencies, and Government. This helps them to find the solution for it. Furthermore, with suitable PL System, the government can predict infected person at the initial stage. Various goals of PL system are provided below:

- It can diagnose the infection at initial stage with the help of available symptoms.
- It can stop the further spread by alerting nearby people. With the help of GPS system and Pin code of the user, one can find the location and update it on Google maps and mark it Affected Area.
- If any individual is found infected with particular virus or disease, PL system can provide the nearest hospital location to the patient.
- Deadly viruses like Zika, adversely affect a pregnant woman and results in a poor delivery outcome. So with the help of PL system, prior knowledge of situation and location helps her to plan her baby accordingly. The woman will come to know about the location of infected area with the help of Google maps.
- All information is available at very low cost to various agencies, Government, Researchers, and hospitals.

So to achieve goals mentioned above a PL model has been proposed which can initially detect the stage of the virus. Android application for data capture has been used and connected with cloud storage. To save all information related to medical, a medical database is created. That database is easily available to the various agencies, Government, researchers, and hospitals. GPS is incorporated to capture the location of the user and geocoders are used to integrate the Google maps in the android app. When PL system detects that any patient is affected, it provides him nearest possible hospital location and this system decides with the help of predicate logic system by matching symptoms of ZIKA Fever. When the user is found infected in particular region, same is updated on the Google maps so that other people may be alerted to visit that location safely with precautions.

Rest of the paper is divided into the following section. Section II provides the related work to the ZIKA virus background, Symptoms, diagnosis, prevention and case study. Section III provides the proposed model, which is used to detect and control the zika virus.

II. RELATED WORK

In the early stages concerning the study of Zika virus, the sources of diseases are found, and till now there is no effective vaccination and is still under research. This section is divided into sub-sections that include the background of ZIKV

symptoms, diagnosis, and prevention. This section also includes the discussion about some of the case studies.

A. Background of ZIKV

Zika virus, spreading at a rapid pace and one of the most dangerous viruses, has already affected lots of people around the world including Africa, Southeast Asia, and the Pacific Islands. According to Wikipedia, Zika virus is a member of the family of viruses called *Flaviviridae and genus flavivirus*. It can spread in human by bites of the mosquito name *Aedes* and most importantly, it bites at daytime. An organization of America named as Pan American Health Organization (PAHO) announced alert in May 2015 about this virus worldwide, when they found some positive infected cases in Brazil.

B. Symptoms, Diagnosis, Prevention of ZIKV

1) Symptoms*:* The most common symptoms of Zika virus positive outcome is:

a. joint pain
b. Fever
c. Red Eyes and Rash
d. Poor pregnancy outcome

With mild illness, Individual needs to contact the nearby hospital. The proposed PL system can suggest nearby hospital also.

2) Diagnosis*:* Most of the symptoms of Zika virus are almost similar to Dengue and Chikungunya, and even mode of transmission (mosquito bite) is identical. If symptoms mentioned above appear, the PL system suggests the individual contact the nearby hospital. Health Care provider shall test blood for virus infections.

3) Prevention: Right now there is no vaccine available for treatment of Zika virus. But there are certain ways to prevent it by taking few intelligent steps.

e. Drink maximum water or fluids to prevent dehydration.
f. Get maximum rest.
g. Few medicines are available to control fever.
h. Consult nearby health care provider as soon as possible.

Case Study of ZIKV: This section highlights few cases of Zika Virus in various continents of the world.

1) Case 1: In Japan, 2014, a healthy man at the age of 20 years, came across some symptoms like fever, headache, and rashes for one day along with Arthralgia and was hospitalized. It was learned that recently he visited Bora-Bora island (Infected Area) in French Polynesia. He was diagnosed with Zika fever [14].

2) Case 2: A Japanese women at the age of 30 years, visited Bora-Bora island, where she stayed for ten days and told about mosquito bite she came across. After that, she suffered from fever, Joint pain, and Rash [14] and was hospitalized and was diagnosed with Zika Virus.

Predicate Logic System: In mathematical logic, predicate logic is the generic term for formal symbolic systems like first-order logic, second-order logic, many-sorted logic, or infinitely logic. This formal system is distinguished from other systems in that its formulae contain variables which can be quantified. Two common quantifiers are the existential ∃ ("there exists") and universal ∀ ("for all") quantifiers. The variables could be elements in the universe under discussion, or perhaps relations or functions over that universe. For instance, an existential quantifier over a function symbol would be interpreted as the modifier "there is a function."

Bioinformatics, cloud computing, and IoT: Cloud computing has a vital role in Bioinformatics; it is possible to access the data of biomedical database with the help of cloud. Doukas et al. [15] proposed a model of a mobile application which enables to store, share, and store and manipulate data related to healthcare with the help of the mobile application. The IoT has the great role in our system because we can connect our mobile phone, iPad or any device at which internet is accessible to the cloud medical database. That database is accessed on mobile, computers and any web-based system. To control the access of multiple devices a trust-aware access control system is proposed by Jorge [16] for the Internet of Things.

III. PROPOSED MODEL

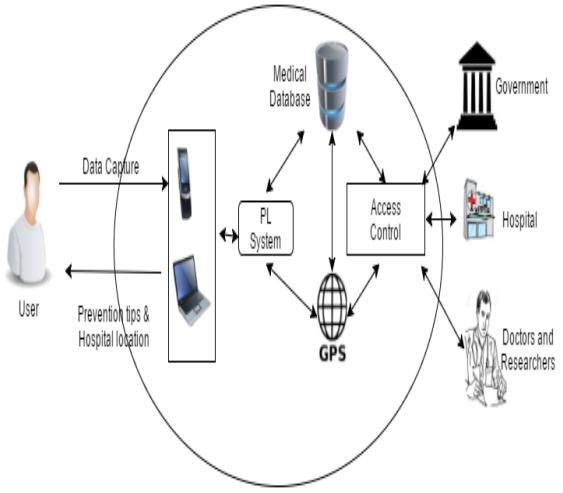

Fig.1. Proposed model.

With the help of above mentioned the proposed model, we can detect the Zika virus infection in the patient. In 'data capture,' we can get the data from the user with the help of websites or mobile application, i.e., android app, IOS app, etc. The user

interface should be provided to the users to interact with the system. In PL system we designed some predicate logic which can take an initial decision about Zika virus infection detected in patients. The medical database is used to store the information of the infected patients. First, PL system decides either patient is infected or not, after that, if the patient is found infected then we will update that information of the patient in the medical database. With the help of GPS, we will easily find the location of the user. We capture the ZIP Code of the user to detect the current location of the user. If patient fount infected, we will update the location of the user on the Google maps, which can help us to find the affected region on the Google maps. GPS will find the Longitude and Latitude of the patient location and update it in the medical database; we can retrieve those values to show the location of the affected area in the Google maps. As a result, one can easily find the Zika virus affected area from anywhere in the world with the access to the internet. Suppose, if anyone plans to travel in any particular country, he/she will be able to easily detect the region where Zika virus outbreak occurs. So, one can plan to travel accordingly. After that, all the information related to the affected patient is provided to the Government, healthcare agencies and doctors so that this information could be helpful to the government to control Zika outbreak. This information is made available on the cloud database. Doctors and researchers will use this information to analyse the patient's activity for research purpose and treatment purposes.

When any user found infected, our system will provide them the location of the nearest hospital. The location of nearest health care agencies can be found with the help of Dijkstra algorithm. In Fig. 2, some phases of the proposed model have been discussed.

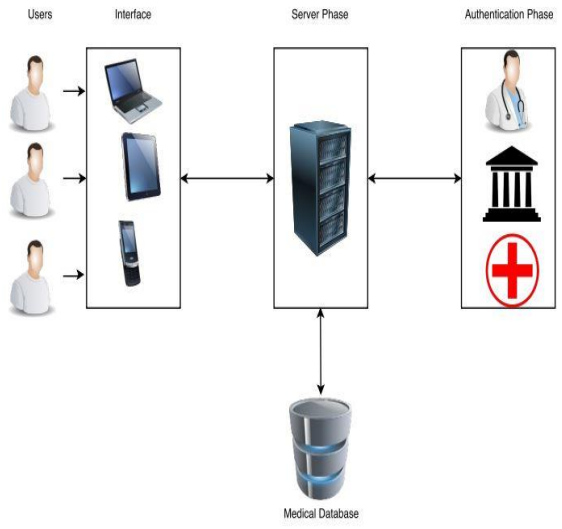

Fig.2: Phases in the proposed model.

1.Data flow Diagram: In figure 3, all the data flow is provided in the form of a tree. The various components of the tree can be divided into the three phases. In the first phase, we take input from the user and in the second phase, we can analyze that data, and in the third phase, we can provide access to the various agencies, hospitals, and government.

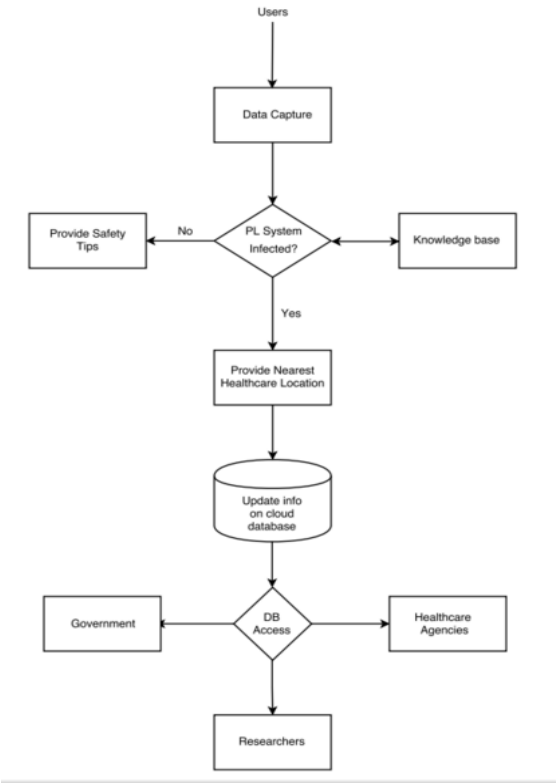

Fig. 3.Data flow diagram of proposed model

2.Interface: In the Interface various devices like Mobile phones, websites and Laptop interact with the user to capture data. The various fields represented in the Data capture components are provided below:

TABLE I. USER ATTRIBUTES FOR DATA CAPTURE

S.No	Attributes	Description
1.	Name	Enter username
2.	Age	Specify age in years
3.	Sex	Male/Female
4.	Address	Specify user address
5.	Zip Code	Zip code helps to identify area on GPS
6.	Contact Number	User telephone number
7.	Work	Occupation of user

If the user found positive with the Zika virus at the initial stage, then the PL system will suggest them nearest hospital

location. And in another case, if the user found normal then PL system will provide some prevention tips to the user. In the next phase, all the medical data of the user is stored in cloud along with the PL decision system. The PL System will decide whether the individual is infected or not. If Infected they can store all the information in the database and update location as infected area.

3. Server Phase /PL System: The PL system capture the information related to the appearance of symptoms in the form of YES/NO form with the help of table 2. After that, it analyses the user responses by Prepositions equivalences. The PL system is divided into three stages, i.e. Stage 1, 2 and 3. If all the responses of the user are in Yes or 1, then it is tautology at *stage 3*. If tautology results then the initial stage of Zika virus is confirmed. If the result of user responses is a contradiction then it is *stage 1* which shows no symptom is positive, so the user is safe. If the result of user responses is a contingency, it is *stage 2* then the user might have any other infection like Dengue or chikungunya.

TABLE II. SYMPTOMS APPEARANCE

S.No	Attributes	Appearance	Description
1.	Fever	Yes/No	Temperature of body
2.	A headache	Yes/No	Pain in head
3.	Fatigue	Yes/No	Feeling extreme tiredness
4.	Malaise	Yes/No	Feeling of discomfort
5.	Rash	Yes/No	Skin color change
6.	Joint pain	Yes/No	Pain in joints

Here the above Table II donates Fever = F, Headache = H, Fatigue = G, Malaise = M, Rash = R, Joint Pain = J. Now if (FHGMRJ) = False then it is an contradiction and it is Stage 1. And if (FHGMRJ) = True then it is stage 3 such as tautology with confirmation of initial test of Zika virus. The stages are shown in Fig. 4:

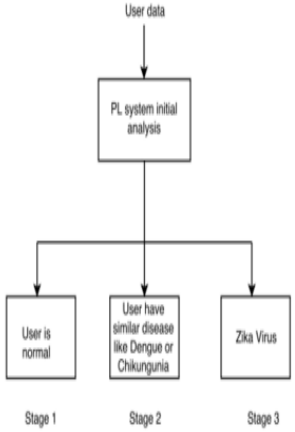

Fig. 4.Stages of PL system.

4. Authentication phase: In this phase, the access of data is provided to various Agencies/ Doctors and Hospitals. The data is scalable and secured by using SSL protocol and by using Attribute-Based Encryption, which provides the read and writes permission to the users according to their role. The concept of the internet of things is used to capture the data.

IV. IMPLEMENTATION

Right now, Zika virus is under research, that's why there is no database found on the internet to test our proposed model. It was tested by taking synthetic data. Implementation and experimental setup is divided into following stages.

a) Stage 1: Synthetic Data creation

b) Stage 2: Mobile application for Information capturing and display results

c) Stage 3: Testing and training of PL System

d) Stage 4: Performance analysis of the proposed system using Amazon EC2 cloud Server.

e) Stage 5: Google maps based affected Area region risk assessment.

Table III. Sample combination of ZIKA virus infections

S.No	F	H	FA	R	JP	M	D	Dia	ZV
1.	1	1	1	1	1	0	0	0	Y
2.	0	0	1	0	1	0	1	1	N
3.	1	1	0	1	1	1	0	0	Y
4.	1	1	1	1	1	1	1	1	Y
5.	1	1	0	0	0	0	0	1	N
6.	1	1	0	0	1	0	1	0	N
7.	0	0	1	0	1	0	1	0	N
8.	1	1	0	1	1	1	0	1	Y
9.	0	0	0	0	0	1	1	0	N
10.	1	1	0	0	0	0	0	1	N

Various abbreviations in the above table are F-Fever, H-Headache, FA- Fatigue, R-Rash, JP-Joint Pain, M-Malaise, D-Diabetic, Dia-Diarrhoea, ZV-Zika Virus, Y-Yes, and N-No.

A) Stage 1: Synthetic data Creation

Synthetic data is created according to different possible symptoms of user/patient to implement PL system. Few sample cases are created which is shown in Table III. There are total $2^8 = 256$ possible cases. And these cases are divided into three categories based upon their probability of occurrence, as listed in Table IV. To capture the data, a mobile

application is developed with the help of android programming.

Table IV. Division of all possible ZIKA Virus combinations.

Stages	Probability	Description	Count
Stage 1	$p \leq 0.15$	Rare possible combination	49
Stage 2	$0.15 < p \leq 0.40$	Possible combination	109
Stage 3	$p > 0.40$	Most possible combination	98

B) Stage 2: Mobile application for Information capturing and display results

For the implementation of the proposed model, an android application is developed which captures data from the user also the PL system is implemented in the mobile application. The Fig. 5 shows the main activity of the application.

Fig. 5.User attributes to captures information

After capturing the details of the user the next activity is created which is shown in Fig 6, where the user can enter their symptoms. These symptoms will decide whether the user is infected or not. Radio buttons are used to convert values in the True or False form.

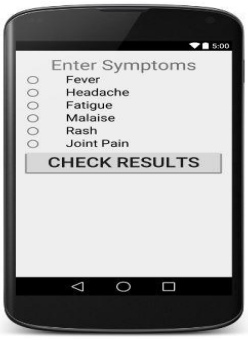

Fig. 6.Symptoms which are experienced by the user

After getting the information from the user about appearances of the symptoms the PL system will take decisions and shows the results in the next activity, which is shown as a screenshot of the infected person in Fig 7.

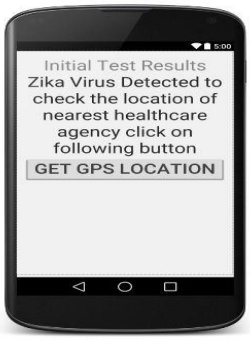

Fig. 7.Results of PL system in android app.

After calculating the results proposed system will provide the location of the nearest healthcare agency with the help of Google maps. Then, the proposed system finds the shortest path between the user and nearest healthcare agency. User location is tracked with the help of ZIP code updated in the database shown in Fig. 8.

Fig.8. User Location Tracking

The application will store and retrieve information from the Amazon cloud storage. Cloud services will be available to all doctors, researchers and healthcare agencies. In the next phase analyses for the accuracy of the PL system and the performance of Amazon cloud server with our android application.

C) Stage 3: Testing and training of PL System

When stage 1 symptoms appear that case has very less probability of infection. When stage 1, 2 and 3 appears together, then there are maximum chances of Zika Virus infection, so we tested high probability 500 cases. We created a decision tree for stage 1, 2 and three symptoms and matches that data of the user with the available synthetic dataset. If the record is already available in the dataset, then decide according to the probability of occurrence. The data of 500

users at every stage according to different probabilities available in the provided table V.

Table V. Shows accuracy percentage using Weka tool 3.7

Number of Stages	Correctly identified	Incorrectly identified	Accuracy (%)
Stage 1	497	3	99.4 %
Stage 2	455	45	91%
Stage 3	425	75	85%

D. Performance analysis of the proposed system using Amazon EC2 cloud Server

In PL system Zika virus application user data are stored in EC2 cloud storage provided by Amazon. Cloud storage is optimized by technique Storage-optimized i2 xlarge. Available data can be accessed by doctors, users, healthcare departments, and the governmental agencies. The operation performed on the server is Update, Delete, Insert and search data. We connected the mobile application with the cloud server to make requests. Application is installed on LG Nexus 5X smartphone for testing purpose. Apart from this JavaScript code is used make frontend application for the web. We tested response time as per the number of requests made in one second. We increased 100 requests in every second and measured the response time of the Amazon EC2 server. Fig. 8(a) shows resource utilization when we increase the number of users concerning time. A number of requests responsible for more number of transactions so need more resources. Similarly when the number of requests increases, the response time is shown in Fig 8(b) also increases. The lower number of requests uses fewer transactions and responsible for higher response time because of lower resource utilization. The accuracy of the algorithm with the number of requests also shown in Fig. 8(c), with a large number of requests the accuracy of system decreases. It is because the system needs to handle a number of database transactions so failure rate increases. In Fig. 9; we show PLS (PL system) performance compare to another available algorithms.

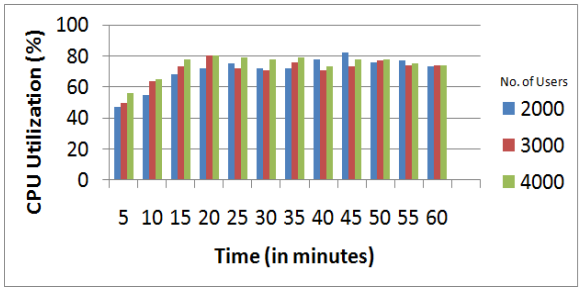

Fig. 8(a).Resource utilization

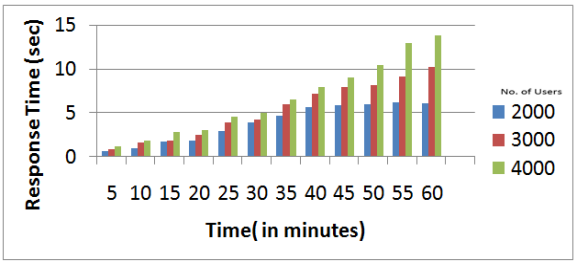

Fig. 8(b).Response time of server

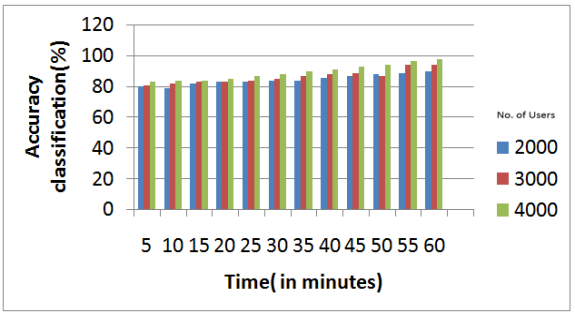

Fig. 8(c).Users accuracy of classification

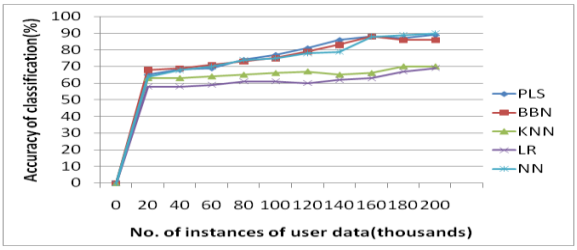

Fig. 9.Comparisons with other available algorithm performance

E. Google maps based affected Area region risk assessment

PL System provides a location to the nearest hospital to the users if they found infected. If the user found positive, then the region is updated on the Google maps. All the regions which are affected by the Zika virus should be shown on the Google maps. Fig. 10 shows affected region with Zika virus in Brazil.

Fig. 10.Location of the affected region on Google maps.

V. CONCLUSION

Information technology and cloud computing can help to control this virus outbreak at very low cost. So in this paper, PL system is implemented to control the Zika virus outbreak in various regions of the country. This proposed system will update the location of the affected area on the Google maps and provide the nearest location of the healthcare agency to the user with the help of GPS. The proposed PL system uses cloud computing and IoT such as smart devices to detect the Zika virus. It will also provide access to the authorized agencies such as government, doctors, and researchers. The proposed system is implemented on the Amazon EC2 cloud server with 84% accuracy. The future will include the smart wearable devices such as smartwatches and sensors to detect the Zika virus with the contact of the human body.

VI.ACKNOWLEDGMENT

The information relevant to the proposed system for predicting Zika virus is referred from few research journals like Trans RSoc Trop Med Hyg., and Future Gener Comput Syst .So I am thankful for proving relevant information.

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