IEEE ComSoc
IEEE Communications Society
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e-Health Technical Committee NewsLetter

September-October, 2016

On behalf of the e-Health Technical Committee (TC) of the IEEE Communications Society (ComSoc), we wish our members a very instructive reading of this letter.
The contribution for this edition is by an author coming from Fortaleza, Brazil who is sharing his ideas and field experience in the area of Dengue disease mitigation in Brazil using ICT.
Members of the eHealth community are invited to contact the author for further information or collaborations.

We also welcome all our members to share their research activities and field experiences through this open newsletter and to open up new opportunities for discussions and collaborations.

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THE PREVENTION AND COMBAT OF THE DENGUE DISEASE BY A COMPUTATIONAL DSS WEB BASED SYSTEM.

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INTRODUCTION

The dengue fever and/or hemorrhagic dengue fever are systems of endemic diseases that occur in areas that conceal the vectors of the primary mosquitoes: *Aedes aegypti* and *Aedes albopictus*. As far as morbidity and mortality are concerned, dengue fever, hemorrhagic dengue fever (HDF) and the dengue shock syndrome (DSS) are considered to be the most important viral diseases transmitted by arthropods. That is why the World Health Organization (WHO) considers that it is necessary to make a global coordinated effort to bring the resources of modern science to bear on the control of ten major tropical diseases in the world, one of which is the dengue, [9], [15].

The Computational Framework based on a Logistical Planning Methodology, a Geographic Information System (GIS) and a Combinatorial Decision Support System (CDSS) allows the officials to have a better view of the dimension of the problem and helps coordinate the prevention and the combat of the diseases caused by zoonoses. This current study has an innovative character as the articulation of some specific techniques has never been used before to solve a public health problem, [12].

The WHO estimates that approximately 3.9 billion people live in risk areas over 128 countries and that there are 390 million cases of dengue infection, resulting in 2.5% of those affected die having some serious consequences on a rural economic sector or productive capability of an urban environment. It’s important to emphasize a significative proportion of human cases are children. But since effective dengue vaccines are not foreseen for the immediate future, the outbreak of zika and chikungunya infection in northest Brazilian region also transmited by the same mosquito, the government, health insurance companies and researchers must continue their efforts to understand the transmission dynamics associated with dengue, [15].

Considering the number of people who are infected annually by viral dengue, with more than 500,000 hospitalizations with severe dengue per year worldwide, there is a growth tendency, since the control measures of the dengue mosquito either fail or are not effectively implemented or regulated from a global scale point of view. For the eradication of dengue to succeed, the target populations must be quickly identified, so that large scale educational and biological control programs can be implemented immediately, [1], [7], [15].

In 2005, when this study began, there were 203,789 human cases of dengue notified in Brazil. From these total, 35.7% of the cases were concentrated in the months of March and April, with a tendency of reduction from May. When compared with the number of accumulated cases in the months of January and November from the same period in 2004 (108,480 cases), an increase of 84.4% in the number of notifications were reported. At the end of 2015 the number of notification in Brazil was 1.5 million human cases, 176% more than the previous year, [15].

There were 433 human cases of FDH in 2005, with 43 official deaths in Brazil. In the regional II, Fortaleza/CE, there were 1,004 classical cases reported and 26 human cases of FDH, 6% of the Brazilian number, [7]. In that year, Fortaleza reached 3.2k cases, although those numbers achieves 38k in 2011, 44k in 2012 and 42.2k cases in 2015. The children (≤9) represent 11.5-25.6% and older (≥60) 4.4-5.3% of the total, Table I. An understanding between human relationships, the environment and the disease systems, is crucial to reduce the morbidity and mortality rates associated to the epidemic and endemic dengue, zika and chikungunya transmission.

TABLE I
DENGUE ANNUAL NUMBERS IN FORTALEZA/CE - BRAZIL.

YEAR	HUMAN CASES	CHILDREN UNDER 9, OLD 60+
2007	13,673	3494 (25.6%), 648(4.7%)
2008	35,461	9076(25.6%), 1571(4.4)
2009	5,421	1211 (22.3%), 263(4.8%)
2010	5,778	1417(24.5%), 268(4.6%)
2011	38,237	7217 (18.8%),1932(5.1%)
2012	44,148	5212(11.8%), 2403(5.4%)
2013	17,182	2825(16.4%), 844(4.9%)
2014	10,696	1752(16.4%), 539(5.0%)
2015	42,203	4849 (11.5%), 2248(5.3%)

SOURCE: SINAN ONLINE (JUL/2016) - SIMDA

In order to avoid the introduction of the dengue fever in new areas and to reduce the incidence of epidemic dengue in endemic areas, studies must be carried out to identify the correlation between climatic variations, demographic changes, the increase of the incidence of dengue by taking attention of the Aedes territorial occupancy on time and the human cases on space-temporal metters, to have better forecasts of the disease growth based on more appropriate models, and to define logistical criteria to plan operations through agents and vehicles, that may facilitate and guarantee, in a broad manner, the coverage of the affected regions.

Given these major problems, the GRAPHVS Ltda team, researchers from the State University of Ceará (UECE), the Federal University of Rio de Janeiro (UFRJ) and Universitè de Avignon (FR), joined to design and implement a complex information system which manages a huge volume of information coming from the fields concerning the presence of breeding sites, of vector in the different real estate unit breeding sites (buildings), the occurrence of human cases, the realization of interventions on the larva and adult forms of the vector, and on educational interventions to reduce and eliminate breeding sites.

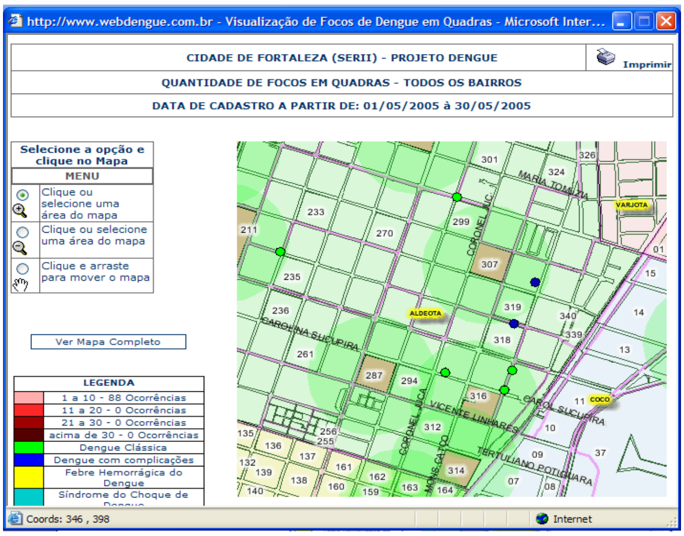
The objective of which is to speed up the arrangement of information and consequently to turn the decision making process of health officials easier.

Just to have an idea, the information about where the mosquitoes are (focuses) is registered daily by the 1,700 sanitary agents working on both sites of Sobral (147 thousand inhabitants) and Fortaleza (2.5 million inhabitants) in the state of Ceará, Brazil. It means more then 45,000 registers per day for these cities, around 4,000 sheets of paper full of information to be processed, nowadays still transferred by hand to the federal systems: FAD and SINAN.

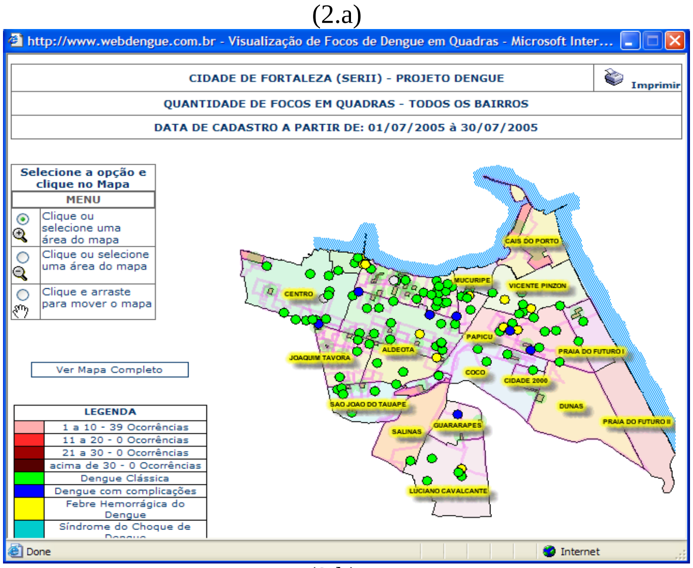
THE COMPUTATIONAL FRAMEWORK

The Framework consists in a set of computational systems integrated which was successful tested in all of its parts in mainly in Fortaleza/CE. Figure 1 shows its components and integration, [12].

FIGURE 1: COMPUTATIONAL FRAMEWORK FOR DENGUE DISEASE CONTROL AND COMBAT.



(2.a)



(2.b)

FIGURE 2
(A) PRESENCE OF FOCUS AND CASES CLOSED TO EACH OTHER IN REGIONAL II - FORTALEZA/CE, HUMAN RISK EVALUATION OF FOCUS PRESENCE; (B) PRESENCE OF FOCUS AND CASES OVER THE REGIONS (FORTALEZA/CE)

WebDengue system is basically used to improve the information gathering (cases and focuses) coming from the health units and sanitary agents on the field.

The major tools WebDengue brings are: remote and dynamic cases actualization by laboratories, hospitals and medical clinics; remote and dynamic actualization of focus confirmation from central zoonoses laboratories; health management risk status in multiple city maps for the principal responsible on managing operational and epidemiologic factors (the health secretary), Figure 1; The human disease risk related to the presence of focus in the city blocks, viewing the focus influencing the existence of disease cases in the same time-window, Figure 2.

WebDengue also includes tools to verify the relation with the pluviometric seasons (month pluviometer measures, relative air humidity, wind velocity) with the increasing number of focus of *Aedes* and reported human cases, a tool to forecast the numbers human cases of dengue and *Aedes* in a specific level of observed region. This tool is included to perform better prediction models, time between rain, growth of focus and cases, to optimize the decision process of prevention and combat the disease. Recently it is integrated to the web part a new tool using dynamic graphs (Dynagraph) that model and follow the space-temporal aspects of human cases evolution and *Aedes* presence, this tool is the initial step to process dynamic clustering procedures to identify natural groups and preview epidemic systems in the monitored area, [1],[3],[4],[6], [9],[14].

Manager system is a decision-making support tool based on optimization models. It helps officials of zoonoses centers to take decision on the number of sanitary agents, the scheduling of services, the itinerary of the agents, of the spraying vehicles, the quantity of poison used and other resources. Once the services are defined, the system updates the data of the mobile units of the stuff that control the focus of *Aedes* - supervisors and agents, considering the hieralchical process. Once a new focus or a human case is reported all the integrated systems can update in seconds the information as a WIFI/3-4G is available.

In 2009 the group introduced "the TRAP placement" tool, also a combinatorial tool that uses state-of-the art methodology to locate traps to attract and capture mosquito females, considering spatial occupancy or borougth limits, [12].

These operational processes use a state-of-the-art dynamic scheduling methodology that maximizes the distance between agents while they all cover the total district they are assigned to complete. It is also included constrained and unconstrained state-of-the-art clustering methods that performs over a hundred of thousands street blocks in few minutes, [2], [11], [16]. As a combinatorial decision making tool the manager system permits that the user reshape the schedules, clusters, and see the "what if" questions related to the operational design process. GeoGraphvs system is used as a production system to geo-reference residences, businesses and other buildings (edition of map which will serve to locate precisely focuses by the agent on the field).

The national information systems on such diseases SINAN, National System for Accompanying the Cases of Dengue and FAD, National System for Accompanying the Focuses of Yellow Fever and Dengue, are automatically fed by the system using ETL. Thus information is distributed and the data about the exact place, period and day of the presence of the *Aedes* mosquitos are registered, [12].

In this context it is very important to be able to cross information and detail them for the managers of health and tropical diseases, thus they will be able to note the growth and to act accordingly.

OPERATIONS RESEARCH FOR LOGISTIC PROBLEMS: PREVENTION AND COMBAT OF DENGUE

Logistic problems gather both the use of sanitary agents (prevention step) and spraying vehicles in large scale within the regions affected by mosquitoes (combat level). Operational Research (OR) methods seem to be the most adapted to solve those logistical problems, thus for each task a model and a methodology is applied.

The planning process for the sanitary agent tasks corresponds to the coverage division of the city by the groups of agents with capacity constraints and the division of the agent work within each coverage area, [2], [11].

The first division must be done in such a way that each partition is covered by the same group of agents throughout the visiting cycle. New techniques proposed by Xavier (2010) and Batista et al (2015) solve this problem using the Uncostrained and/or Capacitated Centred Clustering Problem. Those are already incorporated and used by the framework, [2], [11], [16].

For the sub-division, our interest is to distribute the agents by 'macro-region', in such a way that a representative sample of the total coverage of the city is explored each day. For that reason, we consider that agents must be as scattered as possible. This problem of scattering the agents has not yet been addressed but will be solved using Constraint Programming.

If an epidemic outbreak occurs, it is then necessary to send some spraying vehicles to eliminate the mosquitoes in the infested area. Note that, the same area has to be sprayed about every eight days since the larvae become mosquitoes within eight days. The planning process of the periodical tasks (spraying a given area) consists in dividing the periodical tasks between spraying vehicles which, most of the time, are in limited amount. Therefore, since the spraying phase is very important, we have to solve an accurate periodical scheduling problem with the objective of minimizing the number of machines.

Once the periodical scheduling problem has been solved, the problem of the itinerary of the spraying vehicles will be solved using similar techniques to the ones used for the Rural Postman Problem (RPP) and the Capacitated Arc Routing Problem (CARP), [5], [8].

We have been applying methods that have been developed to approach the problem of the prevention and the combat of dengue with a high level of reliability.

CONCLUSION

This work partially answers the WHO's concern about making the data of this disease accessible to researchers and public health officials, so that new methods for combating the disease can be available.

The computational Framework has been tested and evaluated in both cities of Sobral and Fortaleza. Our recent efforts are in the direction of showing the space-temporal relations of *Aedes* and human cases by applying dynamic clustering tools. The next step will be applying the Operational Research (OR) resources to prevent new cases of dengue and be prepared for a new epidemic situation.

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