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# METRIC GENETIC-FUZZY BASED CUSTOMER RELATIONSHIP MANAGEMENT HEALTH MODEL

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**ABSTRACT:** *Customer Relationship Management (CRM) is a model for managing a company's interactions with current and future customers. Most of the implemented CRM approaches are subjective in nature, in addition to the serious need to separate feelings of satisfaction or dissatisfaction with the services delivery. Metric Genetic-Fuzzy Based Customer Relationship Management Health Model (MGFBCRMHM) was initiated for these reasons. Unified Modeling Language was utilized for modeling the software system, depicting clearly the interaction between various components and the dynamic aspect of the system. The simulation results utilizing Matrix Laboratory (MATLAB) was satisfactory. This paper demonstrates the practical application of metric based soft computing techniques in the health sector in determining patient's satisfaction.*

**KEYWORDS:** CRM, Genetic Algorithm, Fuzzy Logic

## INTRODUCTION

The emerging customer-driven business trend is to be focused on the wants and needs of the customers (CISA, 2010). With the customers' expectations constantly increasing, these objectives are becoming more difficult to achieve emphasizing the importance of focusing on information relating to transaction data, preferences, purchase patterns, status, contact history, demographic information and services trends of customers rather than on products (CISA, 2010). All these factors lead to Customer Relationship Management (CRM), which is an optimum combination of strategy, tactics processes, skill sets and technology. CRM has become a strategic success factors for all types of business, and its proficiency has a significant impact on profitability (Russell, 2001).

The customer expectations are increasing tremendously which, in turn, raises the expectation of service levels. Therefore, the customer-centered applications focus on CRM processes emphasizing the customer, rather than marketing sales or any other function. CRM is a model for managing a company's interactions with current and future customers. It originated in the United States in the late 1990's, and, to date, has been accepted in a significant number of companies worldwide (Satoshi, 2006). It involves the integration of telephony, web and database technologies, and inter-enterprises integration capabilities (Paul and Jongbok, 2001). Also, this model spreads to the other business partners who can share information, communication and collaborate with the organization with the seamless integration of web-enabled applications and without bothering their local network and other configurations.

It is possible to distinguish between operational, analytical and collaborative CRM. Operational CRM is concerned with maximizing the utility of the customer's services experiences while also capturing useful data about the customer interaction. Analytical CRM seeks to analyze information captured by the organization about its customers and their interaction with the organization into information that allows greater values to be obtained from the customer base. Collaborative CRM deals with synchronization and integration of customer interaction and channels of communications like phone, email, fax, and web all geared toward referencing the customer in a consistent manner. The idea is not only to enhance the interactions between customers but also to increase and improve customer retention and liberty. Among the uses of analytical CRM; are increasing customer product holdings or "share of customer wallet", moving customers into higher margin products, moving customers to lower-cost service channels, increasing marketing success rates and making pricing decisions (Satoshi, 2006).

Most developed CRM models are private industry based exempting critical public Health service delivery. Implementing a Metric Genetic-Fuzzy Based Customer Relationship Management Health Model (MGFBCRMHM) is the focal point of this research paper utilizing fuzzy logic and genetic algorithm.

## REVIEW OF RELATED LITERATURES AND MATERIALS

According to Crow et al. (2003), Indirect Measures (IM) of satisfaction has been implemented in most Health centers which involve eliciting relevant healthcare experiences and based on these indicators inference is drawn pertaining to customer satisfaction. Crow et al. (2003) highlighted another approach which involves eliciting relevant information pertaining to healthcare delivery systems which were more useful for establishing trends over time and comparing across providing units. Although factual information is collected, its association with satisfaction has not necessarily been established. This depends on individuals' standards and expectations. For example a two hour wait in an accident and emergency department may be rated differently by a homeless person and a busy parent.

The theory of fuzzy logic provides a mathematical strength to capture the uncertainties associated with human cognitive processes, such as thinking and reasoning. In standard set theory, an object does or does not belong to a set. There is no middle ground. In such bivalent systems, an object cannot belong to both its set and its compliment set or to neither of them. This principle preserves the structure of the logic and avoids the contradiction of object that both is and is not a thing at the same time (Zadeh, 1965). However, fuzzy logic is highly abstract and employs heuristic (experiment) requiring human experts to discover rules about data relationship (Angel and Rocio, 2011).

Fuzzy classification assumes the boundary between two neighboring classes as a continuous, overlapping area within which an object has partial membership in each class (Kuang; Ting-Hua and Ting-Cheng, 2011). Fuzzy logic highlights the significant of most applications in which categories have fuzzy boundaries, but also provides a simple representation of the potentially complex partition of the feature space. (Sun and Jang**,** 1993 and Ahmad, 2011) Conventional

approaches of pattern classification involve clustering training samples and associating clusters to given categories. The complexity and limitations of previous mechanisms are largely due to the lack of an effective way of defining the boundaries among clusters. This problem becomes more intractable when the number of features used for classification increases (Christos and Dimitros, 2008).

The Genetic Algorithm (GA) is a search and optimization technique based on the principles of genetics and natural selection. They represent processes in nature that are remarkably successful at optimizing natural phenomena. They are capable of solving other types of problems, using genetic operators abstracted from nature; they form a mechanism suitable for a variety of search problems. These algorithms encode a potential solution to a specific problem on a simple chromosome-like data structure and apply recombination operators to these structures so as to preserve critical information. Genetic algorithms are often viewed as function optimizer. The main idea is survival of the fittest (natural selection). Genetic algorithm is composed of three main genetic operators namely; **Selection:** is a way for the genetic algorithm to move toward promising regions in the search space. **Mutation:** is a genetic operator that changes one or more gene values in a chromosome. The mutation process helps to overcome trapping at local maxima.

**Crossover:** Exchanging Chromosomes portions of genetic materials.

According to Felica, (2013) and Jayshree and Faizn, (2013) healthcare customer relationship management determining factors for customer satisfaction includes; ***Timeliness, Proper Signage, Optima Human Touch, Accuracy HealthCare delivery, Responsiveness, Adequate Infrastructure and balance Health Care cost***.

## METHODOLOGY, DESIGN AND RESULT

From the review of CRM healthcare approaches, the following drawbacks has been elicited; most of the implemented approaches are subjective in nature therefore an objective approach is necessary. In addition there is a serious need to separate feelings of satisfaction or dissatisfaction with the services delivery or process of care from those related to the health care outcome.

### The Proposed Genetic-Fuzzy Model

The proposed model is an architectural framework which enhances the fuzzy (inexact) healthcare customer satisfaction based information prevalent within the health sector with the aim of establishing a conclusive boundary point. Unlike the current approaches, in which success or failure are based on the wills and experiences of relevant personnel designing and administrating the approach in other to elicit relevant customer health satisfaction points which could be expensive in terms of loss life, high cost incurred and loss of relevant employee personnel, in addition to relevant information loss. This model is artificial intelligence based; therefore success and failure are not dependent on human intuitions, but success, is closely linked within tuned-up approaches within the system components.

The Dataset present in Table 1, and which resides within the knowledgebase of our proposed model was obtained through a research survey, utilizing questionnaires as the research tool. The

quantitative and qualitative questionnaires comprises of two segments. The first phase contains demographic information's while the second phase comprises of customer relationship management health care questions with the aim of eliciting relevant customer satisfaction questions. A total of fifty questionnaires were constructed and distributed to various patients spread across several hospitals and medical centers within Nigeria. All questionnaires administrated were retrieved without mutilation. In other to generate a fuzzy linguistic variable membership function, all questionnaires responds were tuned utilizing the proposed equation at 3.1 (obi and Imainavan, 2013).

**Membership Function (MF) = $\sum$ (A, B, C, D, E)*X ... (3.1)**

**Where** *A, B, C, D and E = Picked Questionnaires Questions Options (PQQO), X (0.02) = Assigned Question Option Fuzzy Range Value (AQOFRV) and Unpicked options = 0.00*

***Table 1:*** *Data Set showing the Degree of membership Customer Relationship Management Health Model*

| **Parameters or Fuzzy sets For Customer Relationship Management Health Model** | **Codes** | **Membership Function for Customer Relationship Management Health Model** | | |
|---|---|---|---|---|
| | | **Cluster 1 ($C_1$)** | **Cluster 2 ($C_2$)** | **Cluster 3 ($C_3$)** |
| Timeliness | R01 | 0.50 | 0.15 | 0.35 |
| Proper Signage | R02 | 0.20 | 0.20 | 0.60 |
| Optima Human Touch | R03 | 0.10 | 0.80 | 0.10 |
| Accuracy Healthcare delivery | R04 | 0.20 | 0.10 | 0.70 |
| Responsiveness | R05 | 0.30 | 0.60 | 0.10 |
| Adequate infrastructures | R06 | 0.05 | 0.05 | 0.90 |
| Balance Healthcare cost | R07 | 0.00 | 0.50 | 0.50 |

Utilizing the Genetic Algorithm Procedures proposed by (obi and Imainavan, 2013), the generated membership function derived from our tuned questionnaires and tabularized in table 1 were optimized to obtain the fuzzy membership function boundary of 0.53 specified in table 2.

***Table 2:*** *1st and 2nd Generation Table*

| **S/N** | **Selection** | **Chromosomes (Binary; 0 or 1)** | | | **Fitness function** |
|---|---|---|---|---|---|
| | | **Parent (1st Gen)** | **Crossover** | **Parent (2nd Gen)** | |
| 1 | 50 | 110010 | 1 & 6 | **110**101 | **53** |
| 2 | 46 | 101110 | 2 & 4 | **101**100 | **44** |
| 3 | 46 | 101110 | Mutation | 1011**0**0 | **44** |
| 4 | 44 | 101100 | 2 & 4 | **101**110 | **46** |
| 5 | 38 | 100110 | 5 & 7 | **100**010 | **34** |
| 6 | 37 | 100101 | 1 & 6 | **100**010 | **34** |

| | | | | | |
|---|---|---|---|---|---|
| 7 | 18 | 010010 | 5 & 7 | **010**110 | **22** |
| **Fuzzy membership Function Boundary** | | | | | **0.53** |

The model is made-up of four main components; as Figure1 presents

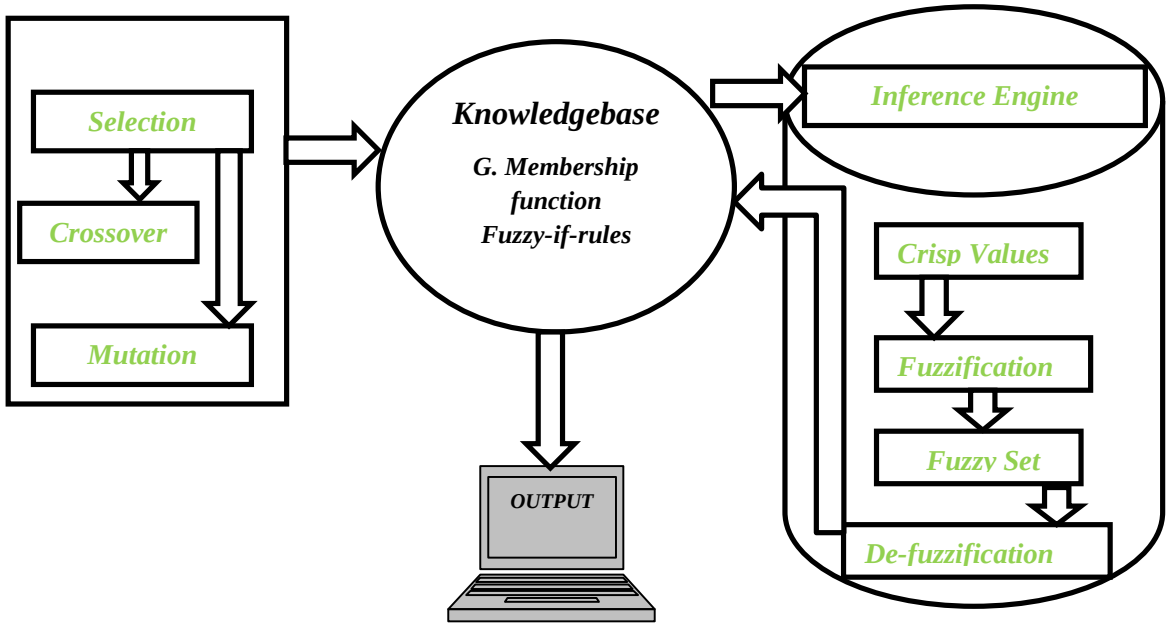


***Figure 1**: Metric Genetic-Fuzzy Based Customer Relationship Management Health Model*

a. The genetic optimizer help the model arrive at a universal boundary point for high and low membership function deductions utilizing the genetic operator selection, crossover and mutation in optimizing the generated membership function reside within the knowledgebase
b. The knowledgebase hold the health care satisfaction criteria's, the generated membership function elicited from relevant questionnaires distribution and tuning and the fuzzy –if –then rules.
c. The inference engine which is the heart of the model utilizing fuzzy operators; fuzzification and defuzzification to draw inference based on the generated membership function and fuzzy if then rules. There is a two-way interaction between the knowledge base and the inference engine enabling objective output to be obtained.
d. The output components display output results.

**RESULT**

Matrix Laboratory (MATLAB) serves as our simulation tool in achieving the our results because of its interactive environment for algorithm development, data visualization, data analysis, and numerical approach which was relevant to our numerical dataset which was more appropriate than with spreadsheets or traditional programming languages, such as C/C++ or Java. The generated results in table 3 were achieved utilizing 0.53 for determining high degree membership

function and low degree membership function. The fuzzy partition for each input feature consists of the parameters for assessing patient customer satisfaction. The fuzzy rules that can be generated from the initial fuzzy partitions for the classification of Customer Relationship Management are thus:

a. Not Satisfied (Class: $C_1$)
b. Moderately Satisfied (Class: $C_2$)
c. Satisfied (Class: $C_3$)

If the patient (P) experiences less than or equal to two ($P \leq 2$) of the parameters for assessing patient customer satisfaction *THEN* ($C_1$), If the patient (P) experiences three ($P = 3$) of the parameters for assessing patient customer satisfaction *THEN* ($C_2$) If the patient (P) experiences four ($P \geq 4$) or more parameters of the parameters for assessing patient customer satisfaction *THEN* ($C_3$).

***Table 3:*** *Data Set showing the Degree of membership Customer Relationship Management Health Model*

| **Parameters or Fuzzy sets For Customer Relationship Management Health Model** | **Codes** | **Membership Function for Customer Relationship Management Health Model** | | |
|---|---|---|---|---|
| | | **Cluster 1 ($C_1$)** | **Cluster 2 ($C_2$)** | **Cluster 3 ($C_3$)** |
| Timeliness | R01 | 0.50 | 0.15 | 0.35 |
| Proper Signage | R02 | 0.20 | 0.20 | 0.60 |
| Optima Human Touch | R03 | 0.10 | 0.80 | 0.10 |
| Accuracy Healthcare delivery | R04 | 0.20 | 0.10 | 0.70 |
| Responsiveness | R05 | 0.30 | 0.60 | 0.10 |
| Adequate infrastructures | R06 | 0.05 | 0.05 | 0.90 |
| Balance Healthcare cost | R07 | 0.00 | 0.50 | 0.50 |
| **Result** | | **Not Satisfied** | **Moderately Satisfied** | **Satisfied** |

Table 3 represents the degree of membership function for customer relationship management, for instance, R05 in cluster 1, we notice it has 0.30. In percentage, it can be represented as 30%, in cluster 2, 60%, in cluster 3, 10%. This means that the degree of membership function for health customer relationship management of P05 matches **30% of Not Satisfied, 60% of Moderately Satisfied** and **10% of Satisfied.** The Fuzzy clustering graphical distribution shown Figure 2 depicts one criterion with high degree of membership function for **Not Satisfied,** three criteria's with high degree of membership function of **Moderately Satisfied**, four criteria's with high degree of membership function of **Satisfied.**

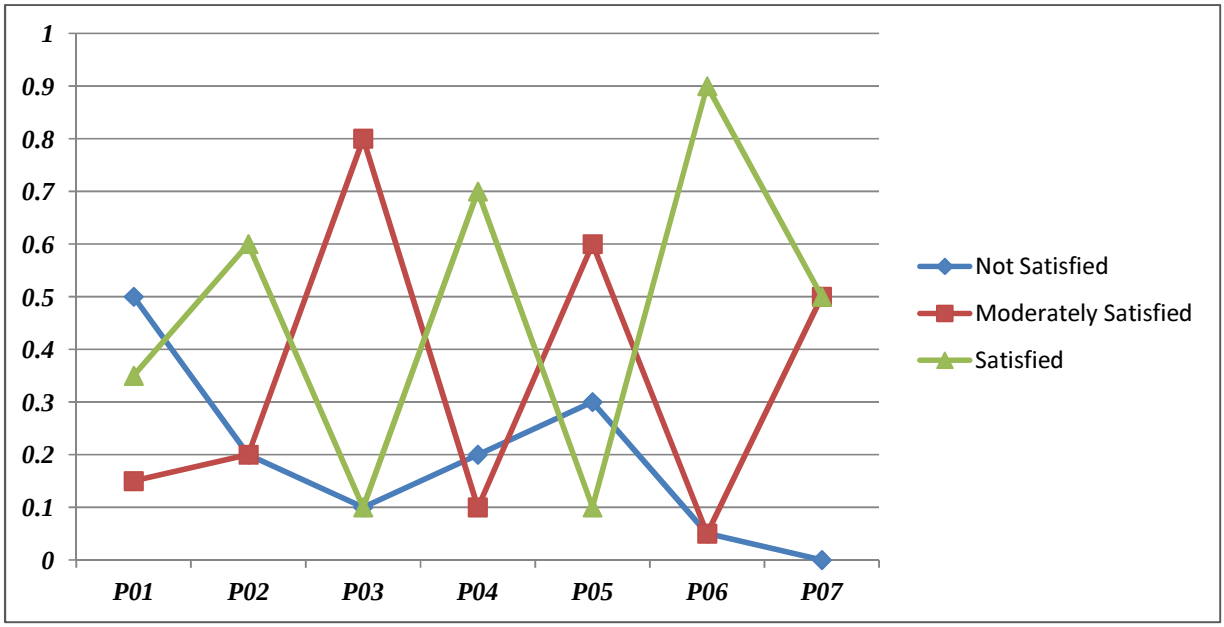


***Fig. 2:*** *Graphical Representation highlighting the Degree of Membership Function*

***Design***

Unified modeling language (UML) is a standard modeling language used for modeling software systems. It provides a number of graphical tools that can be used to visualize a system from different viewpoints. The multiple views (user, structural, behavior, implementation and environment) of the system that is represented by using diagrams together depict the model of the system (Philippe, 2000 and Chris, 2000). The views typically used are The *User view;* represents the goal and objectives of the system form user's viewpoint. The *structured view;* represent the static or idle state of the system. The *behavioral view;* represents the dynamic or changing aspect of the system. The *implementation view;* represents the distribution of the logical elements, such as source code structure, runtime implementation structure of the system. The *environment view;* represents the distribution of the physical elements of the system.

The user view of our system is modeled utilizing use case diagram on figure 3

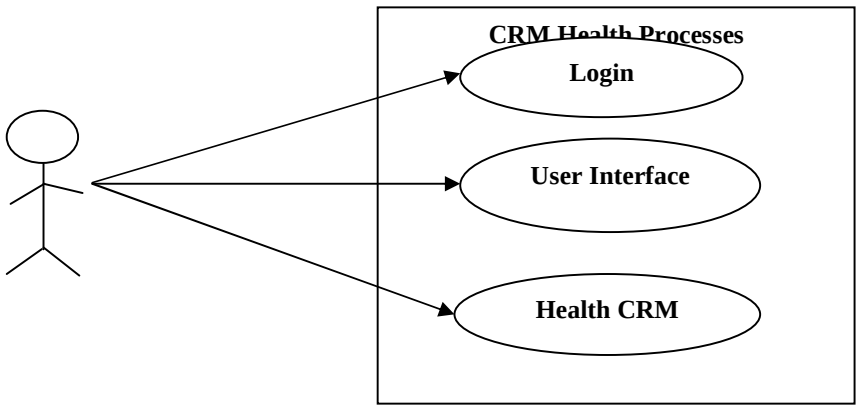

***Figure 3:*** *Use case diagram modeling CRM Health Processes*

The static view of our system is modeled utilizing class diagram on figure 4

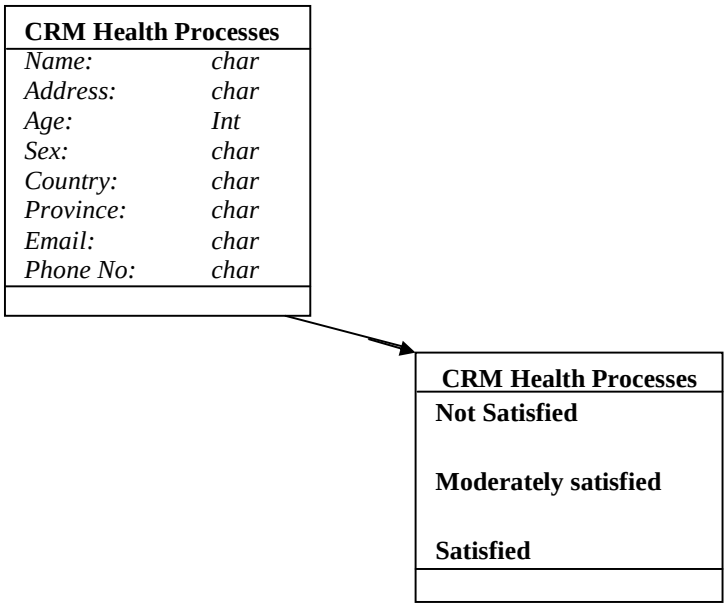


***Figure 4:*** *Class diagram modeling CRM Health Processes*

The behavioral view of our system is modeled utilizing sequence diagram on figure 5

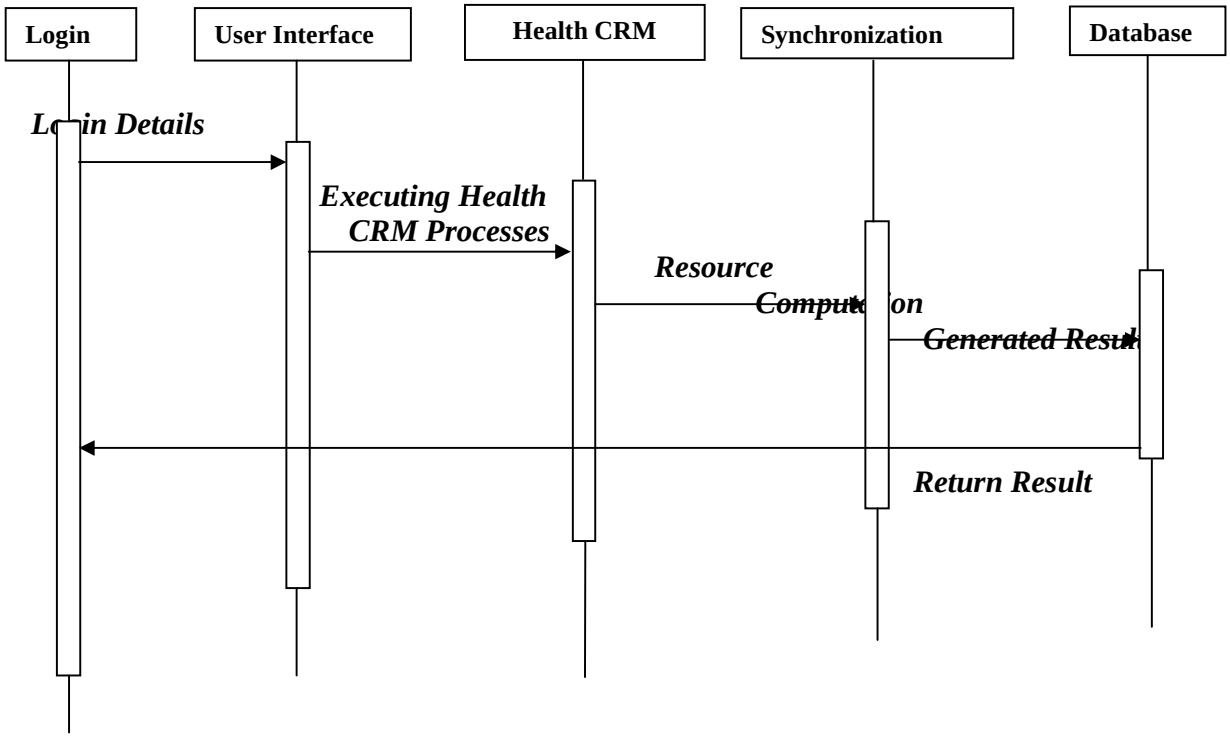

***Figure 5:*** *Sequence Diagram modeling CRM Health Processes*

## DISCUSSION

The Metric Genetic-Fuzzy Based Customer Relationship Management Health Model provides an interactive framework of determining patient satisfaction objectively as opposed to the subjective questionnaire based approach. This is achievable utilizing our model which is an hybrid approach in nature handling imprecision associated with criteria's for identifying customer satisfaction and optimizing these criteria's to pinpoint a central base for determining linguistic variables membership function in achieving our fuzzy middle-ground ("Moderately satisfied") from "Not Satisfied" and "Satisfied". This approach has help solved the problem associated previously approaches.

## CONCLUSIONS

Customer satisfaction is an integral factor within any organization which determines not only organization survival but also determines the level of granted revenue. Most of the approaches previously implemented have been subjective in nature and disentangling customer satisfaction and dissatisfaction has been handled holistically. This paper has demonstrates the practical application of metric based soft computing in the health sector in determining patient's satisfaction. This model which uses a set of fuzzified data set incorporated and optimized by genetic algorithm is more precise than the traditional system. The system designed is an interactive system which specifies patient ranges of satisfaction and dissatisfaction.

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