Framework for the Development of Business Intelligence Using Computational Intelligence and Service-Oriented Architecture

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Framework for the Development of Business Intelligence Using Computational Intelligence and Service-Oriented Architecture.

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Abstract — **The literature shows that scientific community is trying to predict or classifying some financial, economics and administrative problems with the use of computational intelligence and using frameworks to develop Business intelligence. For the reasons above, the main aim of this article is to propose a computational intelligence-based framework for the development of Business intelligence using service oriented architecture. The research method was an applied research. This paper presents the development of a framework for software development using computational intelligence. The results show that the proposed intelligent framework for Business Intelligence development systems can be considered as a tool for making business decisions.**

Keywords — Business Intelligence - BI, forecasting, BI framework, Computational intelligence.

I. INTRODUCTION

Currently, the process of decision making within organizations is supported on the use of information systems – ISs. Some of these, more elaborate than others, such as enterprise resource planners - ERP, customer relations managers - CRM, Supply chain managers - SCM among others, are on the agenda [1]. All of these systems, provide different or multiple data source for the decision making. Recently, some authors have been studied how to convert the raw data into information and this information in corporate knowledge [2]. This process is called Business Intelligence - BI [2].

According to Wu [1] numerous business intelligence tools (BI) thus have been developed to support decision making [3]. On this aspect, Computational intelligence - CI can be considered as a powerful tool because it is primarily concerned with using an analytical approach to making decisions based on prior data [4]. The power of the CI system derives from its ability to generalize from what it has seen in the past to make sensible judgments about new situations [4].

Cavalcante, et al. [5] state that financial markets play an important role in the economic and social organization of modern society. In this context, information is an invaluable asset. Actually, there is a huge number of scientific papers that investigate the use of computational intelligence techniques to solve financial market problems [6, 7], for the reasons above, the research team wanted to propose the framework explained in detail in the next sections.

The financial, economics and administrative market is considered a volatile environment due that the technologies evolve quickly and the information moves faster than previous years. For the reasons above, this paper proposes an agile methodology for the development of computational intelligence-based framework to develop Business Intelligence using service-oriented architecture. The proposed framework includes the SCRUM methodology [8] as a base for the development of all components of the mentioned framework.

The remainder of this paper is organized as follows. Section 2 discusses the theoretical background and related works. Section 3 discusses a computational intelligence-based framework for the development of an intelligent trading system (Business Intelligence). Section 4 provides a general discussion of the proposed framework. Section 5 provides the final conclusions of this paper.

II. BACKGROUND AND RELATED WORK

A. Business Intelligence - BI

The term Business Intelligence is not a new concept as it dates from the decade of the 90. Many authors have placed the

task of defining the concept, within them are the following: Eckerson [2] defines BI as "The processes, technologies, and tools needed to turn data into information, information into knowledge, and knowledge into plans that drive profitable business action. Business intelligence encompasses data warehousing, business analytic tools, and content/knowledge management".

B. Computational Intelligence - CI

Bezdek [9] was the first author who tried to propose and define the term. According to Venayagamoorthy [10] Computational intelligence (CI) is the study of adaptive mechanisms to enable or facilitate intelligent behavior in complex, uncertain and changing environments. CI was defined as the combination of fuzzy logic, neural networks, and genetic algorithms [11]. Computational intelligence uses experiential knowledge about the process that generally produces a model in terms of input/output behavior [12].

For the particular case of this work, Voges and Pope [4] state that these CI methods have been applied to many issues, such as marketing, e-commerce, financial management, decision making, classification, time series forecasting and optimization. The final system has the ability to learn and/or deal with new or unknown situations and is able to make predictions or decisions about future events [12].

The following are some main concepts within this field of study.

C. Fuzzy models

Aspects related to the difficulties encountered in analyzing large amounts of information and its complexity are found in the production of different systems. Therefore, there is a need to seek mathematical methodologies that incorporate specialist, subjective knowledge, enabling the simulation of situations for decision support [13]. Basically, these models are divided into two types: Mandani [14] and Sugeno types [15, 16]. There are some examples using this area in business: [17], [6], [18], among others.

D. Artificial neural networks

The neural networks are sets of mathematical algorithms used in processing elements (PEs) arranged to imitate the complexity of non-linear and parallel mechanisms involved in the interpretation of information by biological neural networks [19].

Generally, an artificial neural network is composed of multiple processing units called neurons, which have a fairly simple function [20].

According to Tkáč and Verner [21], most of the research in this field has aimed at financial distress and bankruptcy problems, stock price forecasting, and decision support, with special attention to classification tasks. There are some of the studies in this area: [22], [7], among others.

E. Neuro-fuzzy networks

Neuro-fuzzy networks take advantage of the learning ability of neural networks and use fuzzy systems to process the knowledge clearly. The final solution of a neuro-fuzzy network can be interpreted as a Sugeno-type fuzzy inference system. Basically, the operation of this type of system, is the same as that of neural networks, except that when a neural network "learns", it modifies the sets and rules of the fuzzy inference system (membership functions). There are some works about the area: [7], [23] among others.

F. Genetic algorithms

The genetic algorithm – GA is considered a robust method, used primarily to solve problems in numerical research, optimization functions and machine learning, among other areas [24]. For solving problems with the use of genetic algorithms is assumed that in a population each individual is a candidate for solving the problem. The optimization function is the environment in which the initial population lies. The application of genetic algorithm is highlighted in data classifier systems [25]. Genetic algorithms are extremely efficient in sweeping large search spaces, giving them the authority to use as optimizers of neural networks and fuzzy logic parameters among other possible techniques [26]. There are some examples of the research area in the field of Business: [22], [27], among others.

G. Genetic-fuzzy algorithms

A Genetic Fuzzy System – GFS, is basically a fuzzy system augmented by a learning process based on evolutionary computation, which includes genetic algorithms, genetic programming, and evolutionary strategies, among other evolutionary algorithms [28]. In the case of Fuzzy Rules-Based Systems - FRBS, a priori knowledge can be in the form of linguistic variables, fuzzy membership function parameters, fuzzy rules, the number of rules, etc. [29]. For the author, to apply the genetic algorithm in a fuzzy environment, we need to define the appropriate genetic coding, the objective function, and genetic operators. There are some examples from the research area in business: [30], among others.

H. Service-Oriented Architecture - SOA

This concept can be explained by The Open Group SOA Working Group [31] which defines SOA as "an architectural style that supports service orientation, and service orientation is a way of thinking in terms of services and service-based development and the outcomes of services". There are some examples from the research area in business: [32], [33], among others.

About the related works, we found the works made by Liyang, et al. [3] who proposed a business intelligence as a Service framework (SaaS BI), Wu, et al. [34] used service-oriented architecture for business intelligence and Wu [1] who proposed a framework based on CI techniques using them as optimizer, classifier and predictors. There are other related works, however, the pages' number limitation doesn't allow to put all of them in this section.

- III. METHODOLOGY

A. A computational intelligence-based framework for the development of business intelligence.

The aim of this paper is to integrate the computational intelligence approaches in BI systems design through the development of a framework with the goal of assisting in the collection of and pre-information and its dissemination, to assist managers in the decision-making process. For the development of the framework, key definitions of BI, Enterprise Architecture – EA, CI and related concepts were considered.

B. Enterprise Architecture - EA

The first component to describe is the enterprise architecture – EA. According to Zachman [35], EA is a set of descriptive representations relevant for describing an enterprise so that it can realize management requirements and be maintained over the period of its useful life. In this case, this is an important item, because the concept of business intelligence lies about one layer (data layer), but it impacts in all the other layers [36]. In the next section, it will be described each layer from the proposed enterprise architecture. (Fig.1).

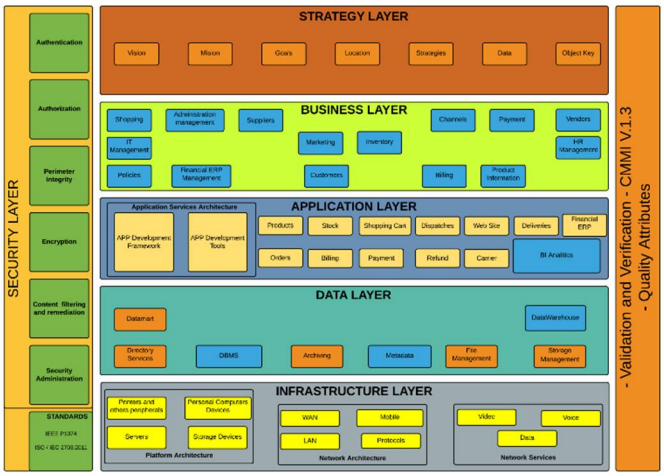

Fig. 1. Enterprise Architecture Framework.

- The infrastructure layer: Federal CIO-Council [37] describes this layer as Architecture technology and network architecture connectivity, among others terms. In this layer, the main responsibility is to characterize the business through modeling, designing Infrastructure Architecture, the modeling of the physical distribution business, the design of the physical layout of the business, the deployment of physical distribution business and extended physical distribution Design Business-Networking Extend [38]. According to the same authors, all models, and designs mentioned above are the responsibility of the infrastructure architect.

- Data layer: Nieto Bernal and Luna Amaya [38] state that this layer is composed of a set of models to display the organization infrastructure integrated information. This phase initiates with the conceptual models up to reach the physical design of the database, data warehouses and repositories of information. From this layer, the most important characteristics for the successful implementation of the framework, are Data base management system – DBMS, metadata and Data warehouse – DW.

- Application layer: For Nieto Bernal and Luna Amaya [38], this layer is composed of a set of models to display conceptual models up to reach physical model implementation level, in models this layer describes: high-level components, component models and detailed model of services, applications and software components, the integrated model and extended system design or distributed. All these models are from enterprise architect's responsibility. From this layer, the most important characteristic for the framework successful implementation is the BI analytics, because it is the main core of this work.

- Business layer: The business architecture allows an in-depth view of the system context and on this basis to establish the principles that guide the development of the following layers of the business information architecture [38, 39].

- Strategy layer: This layer represents the business strategic platform. The layer provides the context for large-scale (vision), high-impact architecture decisions (goals, object key), priority setting (mission) and budget allocation, among other aspects.

- Security layer: This layer is a parallel view which is responsible for identifying the risks architecture, define security policies, organization security architecture, identify the security architecture users, authentication, authorization, among other aspects. All this responsibility lies with the security engineer [39].

- Governance and quality attributes layer: According to Nieto Bernal and Luna Amaya [39] this layer is represented by the business and Information Technologies - IT architects. On one hand, the business architect defines and applies requirements for taxonomy, standards, guidelines, procedures, templates and tools, and provides a linkage for these components. On the other hand, the IT architect has the responsibility to identify, describe the Quality attributes to stakeholders: Performance, security, modifiability, reliability, usability, calibrates ability, availability, throughput, configurability, Subset ability and reusability [39]. For this case, the research team propose to insert the concepts of validation and verification proposed by Capability Maturity Model Implementation – CMMI in software quality attributes [8].

C. The proposed computational intelligence-based Framework.

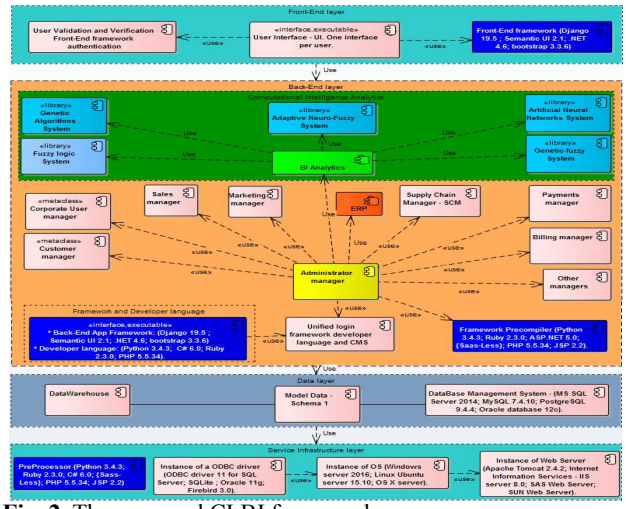

Fig. 2. The proposed CI-BI framework

These layers are conceptualized below:

- Service Infrastructure layer: This layer belongs to the enterprise architecture infrastructure layer proposed in the section III.B. It is composed of all instances of Operating systems - OS, Web services - WS, Open Data Base Connectivity - ODBC drivers and preprocessors.

- Data layer: This layer belongs to the enterprise architecture data layer. In this, the enterprise architect, information and IT architect build the set of the model described in section III.B.2. At this part, they must choose which Data Base Management System - DBMS are going to work. They must choose the specification of the Data Warehouse – DW establish the data model and their metadata.

- Back-End or applications layer**:** This layer belongs to EA applications layer. It is composed of all individual application systems to be deployed. All the applications must have a relationship with the core business processes of the organization. As mentioned above (section III.B), the main core of this work is to propose business intelligence software development using computational intelligence as a base. In this section, the authors propose the methodology below:

The first step is knowing the organization multiple data sources. It means that the IT and information architect must know which are the possible source of the data, in this case, the authors suppose that exist different sources like: Spreadsheets, Data Bases - DBs, Comma-Separated Values - CSV, Enterprise Resource Planning - ERP, Customer Relationship Managers - CRM, Material Requirements Planning – MRP, among others.

The second step is the Extraction, Transformation and Load - ETL process. This process allows organizations to move data from multiple sources (mentioned above), reformat and clean them, and load them into another database, data mart or data warehouse -DW for posterior analysis.

The third step according to the methodology proposed by Palit and Popovic [40] and modified by Cavalcante, et al. [5] is the Data Preparation - DP. This phase means that the data stored in the DW must be preprocessed [5]. The first part on this phase is to define the input and output variables to be used for modelling financial asset. The preprocessing is a procedure where datasets (input(s) and output(s)) are prepared to be processed by the computational intelligence techniques. For do that, exist in the literature some preprocessing mechanisms used to improve the prediction or classification performance, among these, we can found: Feature Selection [41]. Feature Extraction [42]. De-noising and outlier detection [43]. Time series segmentation [44]. Clustering: [45]. Continuing with the process of Data Preparation, datasets must be normalized and structured. After that, the developer team must choose or define the respective algorithms to implement according to the user stories (product backlog). They must choose predictor and configure architecture of the computational intelligence.

The next step is training the technique (Genetic algorithms - GA, artificial neural networks - ANN, adaptive neural fuzzy inference system – ANFIS). Here, the developers must define the algorithm, adjust parameters and perform training.

The following step is the forecasting evaluation, it means defining metrics, evaluate accuracy. After this, the team must have risk control about the accuracy evaluated, because the techniques have pros and cons, this part should be considered in the decision-making process.

Another important part is the rules to enter and exit (which technique is appropriated or not). The last step is to define measures and evaluate profits according the decisions took. Once the developers team have done all the above-mentioned process, the subsequent step is trying to exploit the individual results of each technique, and depending on the results of the accuracy evaluated in the above process, will be given a weighted weight to each technique used to the development of sprint (user story developed) and eventually these results could return combining these techniques (if the user chooses two (2) or more techniques to support their decisions). This process is known as ensemble techniques, which allows exploring additional information and the consensus among individuals that compose the ensemble with the goal of improving the generalization performance when compared with an individual learning method [5]. The last step on this layer is preparing the data and results for the visualization in the next layer.

An important note for the developer's team when working in this layer, is the insertion of quality attributes like functionality, reliability, usability, efficiency, maintainability, portability and quality of use [46] and validation and verification, the choice of platforms, techniques, tools and / or frameworks must be coincident, must be developed with the same developer language. In the case of choice of frameworks in the back and front-end, they should be equal also, avoiding violating any of the quality attributes mentioned above. Another aspect to consider is the compatibility between the ODBC and the DBMS.

- Front-End layer: This layer belongs to the EA applications layer too. Within this, is showed the user interface according to the role of the final user. The main objective of this layer is to interact with the back-end layer (training and test or techniques uses). The user who makes decisions about some topic, will interact with the user interface where put the input variables and will show the result either through the choice of one or more computational intelligence techniques (if possible). It is noteworthy that each user will have a graphical user interface - GUI.

IV. CASE STUDY

A case study was developed, which applied the proposed framework. An agricultural company conducted a monitored for physiological variables in Holstein cows based on two input variables (dry bulb temperature and relative humidity), from the experiment were observed the output variable thermal comfort index (TCI). Considering the observed variables over a period of six (6) years the company requested the realization of an intelligent system to predict whether or not the animals were in thermal comfort. Thermal comfort is estimated from the TCI index, which is calculated based on the input variables dry bulb temperature (tbs - ° C) and relative humidity (%). The functional requirement was that the system will generate an alert

to "On" or "Off" ventilation systems and/or cooling of the confinement barns. This measure optimizes the use of the same thermo-regulatory mechanisms in animals. In heat discomfort spend their energies on maintaining their homeothermy, thus wasting that energy for reproduction and/or increased productivity (milk production, increased body mass) among other aspects [47].

Following the methodology outlined in the proposed framework, as a first step for the development of the requested system, the product backlog was generated from user stories, giving rise to the realization of three sprints that consisted of:

1) Three computational intelligence techniques were implemented, which would allow the system to suggest actions to be taken on the cooling system as accurately as possible. An artificial neural network of two layers, with 700 and 1 neurons per layer, using Levenberg-Marquardt Backpropagation learning was implemented. An ANFIS network and a fuzzy inference system also was implemented. The three techniques were implemented in Matlab 2012 and their respective dll libraries were generated to be used in the following sprints.

2) Three web services were implemented based on the libraries developed in the sprint 1. Each web service encapsulates the respective dll; thus, a service that recommends actions on the cooling system based on the output of the neural network from the input pair (temperature, humidity) was developed. Similarly, a service based on the network ANFIS dll was developed and a service based on the dll of the fuzzy inference system was implemented.

3) A recommendation system was developed based on the web services developed in the sprint 2. This recommendation system makes an ensemble of the classifiers (computational intelligence techniques implemented) contained in the services. To perform the assembly, weights were assigned to the classifiers, according to the evaluated accuracy of each against the other. Table 1 summarizes the weights assigned to the classifiers in the ensemble developed in the recommendation system:

Table 1. Assigned weights to the classifiers according to the composition or assembly

Assigned Weight per classifier	ANN	ANFIS	FUZZY
ANN – ANFIS – FUZZY	0,4	0,3	0,3
ANN – ANFIS	0,6	0,4	0
ANN – FUZZY	0,6	0	0,4
ANFIS – FUZZY	0	0,5	0,5
ANN	1	0	0
ANFIS	0	1	0
FUZZY	0	0	1

ANN: Artificial Neural Network; ANFIS: Adaptive Neuro-Fuzzy Inference System.

Since the recommendation system lets the user select the classifiers techniques used in analyzing the input data to the suggestion actions on the cooling system, the above table of values was constructed. The table shows the weight assigned to each classifier according to user selected techniques. The system response is calculated according to the equation 1

$$ICT = \sum_{i=1}^{3} w_i r_i \quad (1)$$

where w_i represents weight set to i-th technique r_i, being r_1 = ANN response, r_2 = ANFI response, r_3 = Fuzzy response. The weight $w_i = 0$ indicates that the technique i-th was not selected. For example, when the user wants to know the recommendation system response for a given couple input (temperature, humidity), using all the techniques, internally the system calls each web service with the values of temperature and humidity supplied and it generates as response to the user the weighted sum of each technique, as follows:

$$ICT = 0.4rANN + 0.3rANFI + 0.3rFuzzy. \quad (2)$$

4.2. Architecture

Under the proposed framework, the implemented system architecture is SOA type, as illustrates figure 3.

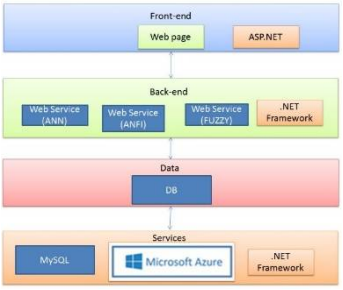

Fig. 3 System architecutre

- V. DISCUSSION

In this paper, several details about the description of a computational intelligence-based framework for the development of Business Intelligence software were given above. Comparing the proposed framework with other related works found in the literature, the reader can see that this paper shows a complete solution for this topic, because the framework expresses the direct relationship with the enterprise architecture through that interconnections of their layers (service infrastructure, data and applications layers).

In Wu [1] the framework proposed by the authors work over several CI techniques using them as optimizer, classifier and predictors. The difference between this framework and our proposed framework lies on the numerous of computational intelligence techniques used for prediction, classification and optimization processes. Other significant difference between the two works lies on the characterization of the methodology proposed by the research team to develop business intelligence development software, the authors previously quoted, did not mention a methodology for the development of the framework.

In Wu, et al. [34] used service-oriented architecture for business intelligence. In this work, the authors proposed a similar conceptual architecture for BI with our proposed methodology. One difference between this work and the proposed framework developed by the research team is the lack of the Enterprise architecture integration and the methodology for implementation of the Service-oriented architecture.

In Liyang, et al. [3] the authors proposed a business intelligence as a Service framework (SaaS BI). They structured their framework in unified five (5) layers. The authors used data mining tasks algorithms. The authors also provide different interfaces to access BI application via web portal, desktop or mobile clients. The main difference between this work and our proposed framework lies in the wide range about the Enterprise Architecture given in this paper. Other difference lies on the non-presentation of a case study in the mentioned work. Neither is presented a development software methodology to develop or implement their proposed framework.

- V. CONCLUSIONS

The proposed computational intelligence-based framework for the development of business intelligence using Service-oriented architecture can be considered as a tool for making business decisions as shown in the case study presented in this paper. The system may have the potential to solve some specific financial, economics and administrative problems such as demand forecasting and

classification, because it makes possible a seamless integration of technologies into a coherent business intelligence environment, through to the integration of the different layers of the Enterprise Architecture. Future works can apply the proposed CI-based framework to develop real business intelligence. Other future work includes trying to test the performance of the proposed framework in every architecture mentioned in section III.C.

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