An Integrated Framework for Business Process Re-engineering in Multi-agent Systems

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Abstract – ***Multi-agent Systems (MAS) technology provide general architecture for a multilayer feedforward neural network to structure, coordinate and to model nonlinearities common in an integrated social-technical-economical system. The paper proposes to model a re-engineering process in a complex system approached by means of Multi-agent Systems organization. The case study validates the effectiveness and suitability of methodology which evaluates a systems' performance in the multi-domain hierarchical environment encompassing economical, social and technical/operational fields.***

Keywords: ***multi-agent Systems; socio-technical-economical system (STES); real-time constraints; a multilayer feed forward neural network; nonlinear model.***

I. INTRODUCTION

An organization, regarded as an integrated socio-technical-economical system (STES), has to face external and internal market environment changes along with adapting its products/services to the consumers' needs and want, in the context of real-time and resources constraints. A STES, approached with multi-agent paradigm, is a dynamically changing set of autonomous, heterogeneous, collaborative agents.Each component of a complex system can be defined, design and operated as a sequence of interconnected agents. Handling the accumulated information provided by company's internal and external environment analysis, can be commanded and controlled a set of agents that fulfils same well-targeted goal.

The multi-agent abstraction allows the decomposition of complex system in interrelating components each represented by an agent, as self-organized, flexible and autonomous entity. Autonomous agents are computational systems that inhabit some complex dynamic environment, sense and act autonomously in this environment and by doing so realize a set of goals or tasks for which they are designed [1].

– The integration and cooperation between individual agents according the belief and goal of the agents, defined the collective agents which share the same goal or common task as a multi-agent system, thus:

– multi-agent environments provide an infrastructure specifying communication and interaction protocols;

– multi-agent environments are typically open and have no centralized designer;

– multi-agent environments contain agents that are autonomous and distributed, and may be self-interested or cooperative [4].

In multi-agent systems, the agents can function as intelligent application programs, active information resources, and will be knowledgeable about information resources that are local to them, and cooperate with other agents to provide global view of the particular management information.

Multi agent technology is applied by intelligent systems to solve the problems of analysis of complex systems and intelligent management activities. Intelligent Multi-agent Systems (MAS) based learning combine collection of information from their environment, recognition data, intelligent classification data and prediction future data, storage data, delivery data to knowledge management systems such as Decision Support System (DSS) and Management Information System (MIS) [5].

When adapting agent technology to complex system, the collaboration between agents integrates local knowledge, effective to obtain a broader basis for decision support. The uncertain and incomplete knowledge which comes from the complexity, instability, or unknown factors of the managed system and the dependency between the management components or correlated management events are aspects added to form a global view of the whole system.

II. TAXONOMY

An intelligent agent is a hardware or (more usually) software-based computer system that enjoys the following properties [2, 4, 5]:

– autonomy: agents operate without the direct intervention of humans or others, and have some kind of control over their actions and internal state;

– social ability: agents interact with other agents (and possibly humans) via some kind of agent communication language. IA has capability of interacting with other agents for negotiation and/or cooperation to satisfy their design objectives;

– reactivity: agents perceive their environment, (which may be the physical world, a user via a graphical user interface, a collection of other agents, or all of these combined), and respond in a timely fashion to changes that occur in it intelligent agents receive information of its environment by its sensors, changes internal design objectives of its structure and has suitable actions with feedback periodically;

– pro-activeness: agents do not simply act in response to their environment, they are able to exhibit goal directed behavour by taking the initiative intelligent agents can show goal directed behavior by taking the initiative, responding to changes in their environment in order to satisfy their design objectives;

– mobility: this refers to the agents' capability of transporting their execution between machines on a network. This form of moving can be physical, where the agent travels between machines on a network, or logical, where an agent which is running on a single machine is remotely accessed from other locations on the Internet;

– collaboration: collaboration among agents underpins the success of an operation or action in a timely manner. This can be achieved by being able to coordinate with other agents by sending and receiving messages using some form of agent communication language, and permits a high degree of collaboration, thus making social activities such as distributed problem solving and negotiation possible. Moreover, it is possible for agents to collaborate without actual communication taking place. The interaction of agents with resources and their environment may lead to the emergence of collaborative or competitive behavior;

– veracity: this refers to the agent's ability to deceive other agents via their messages or behavior. An agent can thus be truthful in failing to intentionally deceive other players. Moreover, an agent that is untruthful may try to deceive other agents, either by providing false information or by acting in a misleading way;

– disposition: this refers to the agent's "attitude" towards other agents, and its willingness to cooperate with them. An agent may always attempt to perform a task when asked to do so (benevolent), or may act in its own interests to collaborate with other agents only when it is convenient to do (self-interested), or it might try to harm other agents or destroy them in some way (malevolent).

The properties of an agent are summarized in the table 1 [3].

Table 1. Properties of agents

Property	Property	Meaning
Reactive	sensing and acting	responds in a timely fashion to changes in the environment
Autonomous		exercises control over its own actions
Goal-oriented	pro-active, purposeful	does not simply act in response to the environment
Temporally continuous		is a continuously running process
Communicative	socially able	communicates with other agents, perhaps including people
Learning	adaptive	changes its behavior based on its previous experience
Mobile		able to transport itself from one machine to another
Flexible		actions are not scripted
Character		believable "personality" and emotional state

Agents may be usefully classified according to the subset of these properties that they enjoy. Every agent. by our definition, satisfies the first four properties Adding other properties produces potentially useful classes of agents, for example, mobile, learning agents.

Agent refers to an entity that acts on behalf of other entities or organizations; and Multi-Agent System consists of several agents with capable of common interaction with selforganization. The structure of multi-agent system encompasses [6]:

Actions: Responsing of agent in front of environment events and changes,

Percepts: Accumulating information from the environment,

Events: Processing of updating beliefs and to operate actions,

Goals: Considering objectives of system to accomplish and can be updated,

Beliefs: Handling accumulated information about the environment,

Plans: Using plan library for handling events and achieve goals,

Messages: Necessary for agents to interact,

Protocols: Rules of interaction.

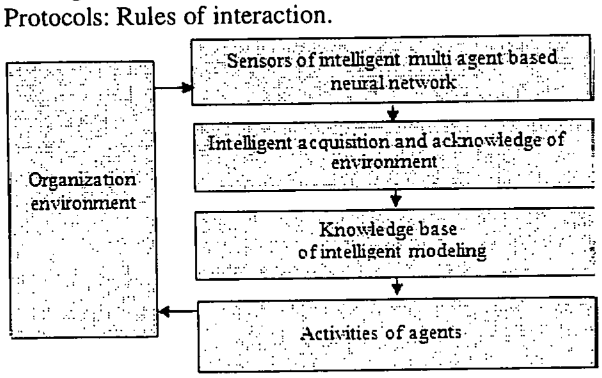

Fig.1. A multi-agent system model

II. STRUCTURE OF MULTI-LAYER NEURAL NETWORK

A generic artificial neural network can be defined as a computational system consisting of a set of highly interconnected processing elements [7]. The inputs received by a single processing element can be represented as an input vector $A = (a_1, a_2, \ldots a_n)$, where a_i is the signal from the i*th* input. A *weight* is associated with each connected pair of neurons. Hence weights connected to the j-*th* neuron can be represented as a weight vector of the form $W_j = (w_{1j}, w_{2j}, \ldots, w_{nj})$, where $w_{i\,j}$ represents the weight associated to the connection between the processing element a_i, and the processing element a_j. A neuron contains a threshold value that regulates its action potential. While action potential of a neuron is determined by the weights associated with the neuron's inputs a threshold modulates the response of a neuron to a particular stimulus confining such response to a pre-defined range of values factor is given by equation 1:

$$SUM = \sum_{i=1}^{n} x_i w_i \qquad (1)$$

The output y of a neuron as an activation function f of the weighted sum of $n+1$ inputs. These $n+1$ correspond to the n incoming signals. The threshold is incorporated into the equation as the input :

$$y = f\left(\sum_{i=0}^{n} x_i w_i\right) \qquad (2)$$

$$f(x) = \begin{cases} 1\ if\ \sum_{i=1}^{n} x_i w_i > 0 \\ 0\ if\ \sum_{i=1}^{n} x_i w_i \le 0 \end{cases} \qquad (3)$$

An artificial network performs in two different modes, learning (or training) and testing. During learning, a set of examples is presented to the network. At the beginning of the training process, the network deducts the output for each example. However, as training goes on, the network modifies internally until it reaches a stable stage at which the provided outputs are satisfactory. Learning is simply an adaptive process during which the weights associated to all the interconnected neurons change in order to provide the best possible response to all the observed stimuli. Neural networks can learn in two ways: supervised or unsupervised. The network is trained using a set of input-output pairs. The goal is to 'teach' the network to identify the given input with the desired output. For each example in the training set, the network receives an input and produces an actual output. After each trial, the network compares the actual with the desired output and corrects any difference by slightly adjusting all the weights in the network until the output produced is similar enough to the desired output, or the network cannot improve its performance any further.

The network is trained using input signals only. In response, the network organises internally to produce outputs that are consistent with a particular stimulus or group of similar stimuli. Inputs form clusters in the input space, where each cluster represents a set of elements of the real world with some common features. In both cases once the network has reached the desired performance, the learning stage is over and the associated weights are *frozen*. The final state of the network is preserved and it can be used to classify new, previously unseen inputs. At the testing stage, the network receives an input processes it to produce an output. If the network has correctly learnt, it should be able to *generalise*, and the actual output produced by the network should be almost as good as the ones produced in the learning stage for similar inputs.

Neural networks are typically arranged in layers. Each layer in a layered network is an array of processing elements or neurons. Information flows through each element in an input-output manner. In other words, each element receives an input signal, manipulates it and forwards an output signal to the other connected elements in the adjacent layer. A common example of such a network is *the Multilayer Perceptron* (MLP) (Fig. 3).

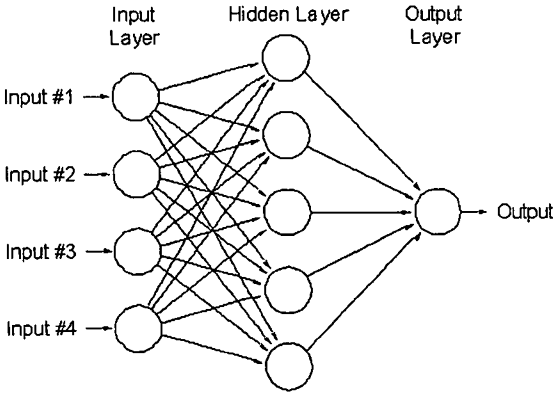

Fig.1. A feedforward artificial neural network model that maps sets of input data onto a set of appropriate output

MLP networks normally have three layers of processing elements with only one hidden layer, but there is no restriction on the number of hidden layers. The only task of the input layer is to receive the external stimuli and to propagate it to the next layer. The hidden layer receives the weighted sum of incoming signals sent by the input units (Eq. 1), and processes it by means of an activation function. The activation functions most commonly used are the sigmoid (Eq. 4):

$$f(x) = \frac{1}{1+e^{-x}} \qquad (4)$$

and hyperbolic tangent (Eq. 5) functions

$$f(x) = \frac{e^{x} - e^{-x}}{e^{x} + e^{-x}} \qquad (5)$$

The hidden units in turn send an output signal towards the neurons in the next layer. This adjacent layer could be either another hidden layer of arranged processing elements or the output layer. The units in the output layer receive the weighted sum of incoming signals and process it using an activation function. Information is propagated *forwards* until the network produces an output. network response to a presented input. The way in which these weights are adapted is specified by the learning rule. The most common rules are generalizations of the Least Mean Square Error (LMS) rule (Eq. 6) , being the generalised delta rule or backpropagation, the most frequently used for supervised learning in feedforward networks. In supervised learning, a feedforward neural network is trained with pairs of input-output examples. For each input, the network produces an output. The accuracy of the response is measured in terms of an error E defined as the difference between the current o_p and desired t_p output. Weights are changed to minimise the overall output error calculated by equation 7:

$$E = \frac{1}{2}\sum_{j}\left(t_{pj} - o_{pj}\right)^2 \qquad (7)$$

The error E is propagated backwards from the output to the input layer. Appropriate adjustments are made , by slightly changing the weights in the network by a proportion d of the overall error E. After weights have been adjusted, examples are presented all over again. Error is calculated, weights adjusted, and so on, until the current output is satisfactory, or the network cannot improve its performance any further. A summarized mathematical description of the backpropagation learning algorithm extracted from [9] has the following steps:

1. Present the input-output pair p and produce the current output o_p.
2. Calculate the output of the network.
3. Calculate the error d_{pj} for each output unit j for that particular pair p. The error is the difference between the desired t_{pj} and the current output o_{pj} times the derivative of the activation function $f'_j(net_{pj})$, which maps the total input to an output value:

$$\delta_{pj} = \left(t_{pj} - o_{pj}\right)f'\left(net_{pj}\right) \qquad (8)$$

4. Calculate the error by the recursive computation of d for each of the hidden units j in the current layer. Where w_{kj} are the weights in the k output connections of the hidden unit j, d_{pk} are the error signals from the k units in the next layer and $f'_j(net_{pj})$ is the derivative of the activation function. Propagate *backwards* the error signal through all the hidden layers until the input layer is reached:

$$\delta_{pj} = \sum_{k}\delta_{pk}w_{kj}f'\left(net_{pj}\right) \qquad (9)$$

II. RE-ENGINEERING PROCESS

Business Process Reengineering is a process-centric thinking attempted by many organizations that are looking for gains from the successful redesign of their processes. Re-engineering their processes, the firms faces the difficulty of integrating processes with management and organizational structures BPR, the high risk, time consuming activity with no guarantee of success. Business Process Reengineering (BPR) is a management approach aiming at improvements by means of elevating efficiency and effectiveness of the processes that exist within and across organizations. It is a fundamental and radical approach by either modifying or eliminating non-value adding activities [10].

Radical redesign means disregarding all existing structures and procedures, and inventing completely new ways of accomplishing work. Reengineering reinvent business, begins with no assumptions and takes nothing for granted.

Business Process Reengineering (BPR) is a management approach aiming at improvements by means of elevating efficiency and effectiveness of the processes that exist within and across organizations. It is a fundamental and radical approach by either modifying or eliminating non-value adding activities [10]. The Radical redesign imply ignoring all existing structures and procedures, and inventing completely new ways of accomplishing work. Reengineering reinvent a business, begins with no assumptions and takes nothing for granted, not looking for marginal or incremental improvements or modification.

Reengineering is driven by open markets and competition. No longer can we enjoy the protection of our own country's borders as we could in the past. Today, in a global economy, worldwide customers are more sophisticated and demanding [11]. Modern industrialization was based on theories of specialization with millions of workers doing dreary, monotonous jobs. It created departments, functions and business units governed by multiple layers of management, the necessary glue to control the fragmented workplace. In order to be successful in the future, the organization will have fewer layers of management and fewer, but more highly skilled workers who do more complex tasks. Information technology, used for the past 50 years to automate manual tasks, will be used to enable new work models. The successful organization will not be "technology driven;" rather it will be "technology enabled" [12].

Reengineering is about radical improvement, not incremental changes having the goal of dramatic improvements in performance. The integrated business process that eliminates wastes and provides real-time management in a complex system has the specific objectives that include:

– Analysis current business processes;
– Identify relationships and deficiencies within the current operating system;
– Develop a business process model that addresses the three key business processes: Front-end Sales, Opportunity Introduction, Order Fulfilment;
– Implement new operating systems and establish monitoring and review of the effectiveness of the business process model.

The methodology has to: explicitly define a business vision; define process objectives; identify processes that cover a high proportion of the business; extensively document and measure processes being redesigned prior to redesign; consider IT as a lever for new processes; have managers highly involved;consider and support employees [14].

To support the organizational, structural, functional and social behavior perspectives [5], requirements modeling process which is decomposed into two main activities:

Requirements definition and Requirements Specification, (fig.2).
The purpose of this model is to represent the different roles found in each sub-organization and to reason about their special relationships. The special relationships between roles can serve to identify the common properties between the roles in order to create a hierarchy of roles using inheritance relationships and the identification of the social behavior relationships between roles in different sub-organizations. In order to obtain a clear view of the models used, each of them is presented as follows. The *Mission Statement* is defined in natural language, with a recommended extension of one or two paragraphs. Since the *Mission Statement* identifies the overall goal within the organization as a whole, it provides us with information about the organizational and functional perspectives. The *Mission Statement* is the root of the *Refinement Tree*.

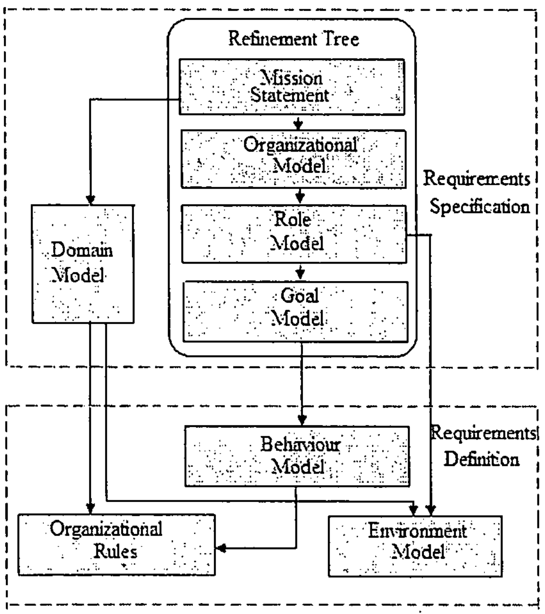

Fig.2. Model of re-engineering process

The first step in the analysis of current business processes is SWOT analysis is a tool used for identifying the company's internal and external environment by focussing on key issues. The SWOT acronym stands for strengths, weaknesses, opportunities, and threats. Strengths and weaknesses are internal factors; opportunities and threats are external factors. The SWOT analysis helps identify relevant internal and external factors regarding a complex system and how to actively improve the company by turning weaknesses into strengths and threats into opportunities. It will make it easier for managers to communicate and share their understanding to stakeholders through the display of the SWOT analysis. This will enable identifying the relevant measures which need to be taken in order to make the company more efficient and effective. SWOT analysis was applied to a firm that want to re-engineering its processes. The firm (Romanian firm) consists of four divisions under a central managing director at the head office The firm has approximately 100 employees. During the 2000's electronic supply industry became market oriented. The firm responded by changing its structure to align itself more with how products were sold rather than the type of product. The firm subsequently split into three strategic business units (SBU's), and later acquired a fourth (Electronics) the company became increasingly inefficient. As the managing director stated "processes do not remain static, and thus inefficiency grows." Within the divisions, profitability was declining and employees were consistently inundated with work The SWOT analysis resulting is summarized in table 2.

Table 2. SWOT analysis

STRENGHTS	High quality products; Continuous improvement process; It has flexible logistics; User friendly website; Social responsible and protecting the environment by reducing wastage; It is an important marketing tool for suppliers; All primary business are listed to the IT system; Includes suppliers in their projects; Employees are self-motivated; Internal solution finding; Experience on the market; Operating deliveries; Guaranteed next day delivery
WEAKNESSES	High prices compared with competitors; High minimal value; High order value; Cannot prove the quality of the products; Concentrated in only 1 market
OPPORTUNITIES	Globalization; New technology; Widening the range of products; Mergers, joint ventures or strategic alliances; Moving into new market segments that offer improved profits; An international market; Free trade
THREATS	Market increases only 1%; New competitors; Only 38% of the population have internet at home; Small percentage use electronic shopping; Price wars with competitors; A competitor has a new, innovative product or service. Competitors have superior access to channels of distribution; Taxation is introduced on products or services; It relies too much on its IT infrastructure

II. CASE STUDY

Supervised Multi-layer Neural Network models need suitable data pre-processing techniques to find input values while pre-training techniques to find desirable weights that in turn will reduce the training process. Without preprocessing, the classification process will be very slow and it may not even complete. Potential Weights Linear Analysis is technique for reducing training process and fast classification in new Supervised Multi-layer Neural Network model with high accuracy. The first Potential Weights Linear Analysis normalizes input values as data preprocessing and then uses normalized values for pre-training, at last reduces dimension of normalized input values by using their potential weights. Supervised Multi-layer Neural Network models can change to new models by using Potential Weights Linear Analysis [6]. All agents of system can apply the outputs of Potential Weights Linear Analysis technique and new Supervised Multi-layer Neural Network model. first define the decomposition of the system in a hierarchy of sub-organizations, thus representing the Organizational Model. It is successively refined to identify the goals of the system to be represented as leaf nodes in the tree.

VII. CONCLUSIONS

The study shows there is a correlation between increased efficiency and business process re-engineering, suggesting that it is often a combination of initiatives which when implemented alongside business process re-engineering helps to make the real difference. The contributory initiatives identified include: changing organisational structures, improving performance management, improving stakeholder management, replacing IT systems, training and providing guidance to staff.

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