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eBusiness-Process-Personalization using Neuro-Fuzzy Adaptive Control for Interactive Systems

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'Personalization', which was earlier recognized as the 5th 'P' of e-marketing , is now becoming a strategic success factor in the present customer-centric e-business environment. This paper proposes two changes in the current structure of personalization efforts in e-businesses. Firstly, a move towards business-process personalization instead of only website-content personalization and secondly use of an interactive adaptive scheme instead of the commonly employed algorithmic filtering approaches. These can be achieved by applying a neuro-intelligence model to web based real time interactive systems and by integrating it with converging internal and external e-business processes. This paper presents a framework, showing how it is possible to personalize e-business processes by adapting the interactive system to customer preferences. The proposed model applies Neuro-Fuzzy Adaptive Control for Interactive Systems (NFACIS) model to converging business processes to get the desired results.

Field of Research: Marketing, e-business

1. Introduction:

As Kasanoff (2001) mentioned, the ability to treat different people differently is the most fundamental form of human intelligence. "You talk differently to your boss than to your child, because you are smart enough to know what to say to each, and how to say it. But most companies lack this basic intelligence, and that's why they have trouble maintaining relationships". Personalization enables a business to match the right product or service to the right customer, for the right price, at the right time. This gives each customer a unique experience, enabling even the largest companies to achieve high levels of customer intimacy.
As businesses become more and more customer centric, personalization, which was earlier considered as a value-adding service, gradually came to be known as the 5th P of e-marketing. Its effective implementation has now become a strategic success factor in the e-marketplace. A lot has been done in recent years for gaining maximum benefit from it but most of the efforts have been directed towards website content personalization. Efficient systems exist for presenting targeted personalized information on the website, or so to say 'passive personalization', but when it comes to business processes, options cannot not be exercised due to the lack of integration between internal and external business processes, personalization systems and applications.

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We address this core issue by extending personalization to cover business processes too. As part of our proposed framework we advocate convergence of internal and external business processes necessary for applying the 'active' personalization. This would involve adaptation of large-scaled very complex structures with high number of unknown or badly estimated parameters in the real-time interactive environment. Thus a framework supporting the development of a system that is able to learn in dynamic, imprecise, and uncertain environments is needed. A visible trend of applying neuro-intelligence to business problems marks the recent e-business evolution process. Keeping up with the trend, we select an appropriate neuro-intelligence model for our problem and integrate it with the converging business processes framework to present our complete integrated model for Business-process-personalization. We present a framework showing how its possible to adapt the interactive business-process-personalization system using Neuro-fuzzy Adaptive Control for Interactive Systems (NFACIS-BPP).

We begin our argument by discussing the basic underlying technologies of personalization and neuro-intelligence , followed by the architecture of neuro-fuzzy control model used as the basis. Then we move on to describe what encompasses business-process personalization and propose our framework, followed by a critical discussion about its benefits and limitations.

2. Website content Personalization

The World Wide Web and the Internet architecture provide e-businesses a very suitable platform for implementing personalization and to monitor its effects on business performance in real time. For Internet based businesses Nunes and Kambil (2001) mention that delivering value for users means having the right content at the right time, and generating the right options, based on recommendations from interpretations of both personal and broader context information. In the eyes of customer, a highly personalized web site describes an efficient, flexible and customer-focused organization behind it, and so, significantly improves the business' brand image too. In fact, the more customers a business has, the richer the database of customer preferences, and the better the business can tailor its content to the unique needs of each customer.

The basic tool for implementing website-content personalization is building a customer profile, and using algorithmic filtering systems to match content to user preferences. Most personalization systems for the Web have fallen into three major categories: decision rule systems, collaborative filtering systems and content based filtering agents (Drogan, Hsu, 2004). Collaborative filtering systems typically take explicit information in the form of user ratings or preferences, and through correlation engine return information that is predicted to closely match the users' preferences. Content-based filtering approaches rely on content similarity of Web documents to personal profiles obtained explicitly or implicitly from users. Other techniques which have been put to use are simple agents, Bayesian networks, Cluster Analysis and online analytical processing systems.

3. Neural Intelligence in Business:

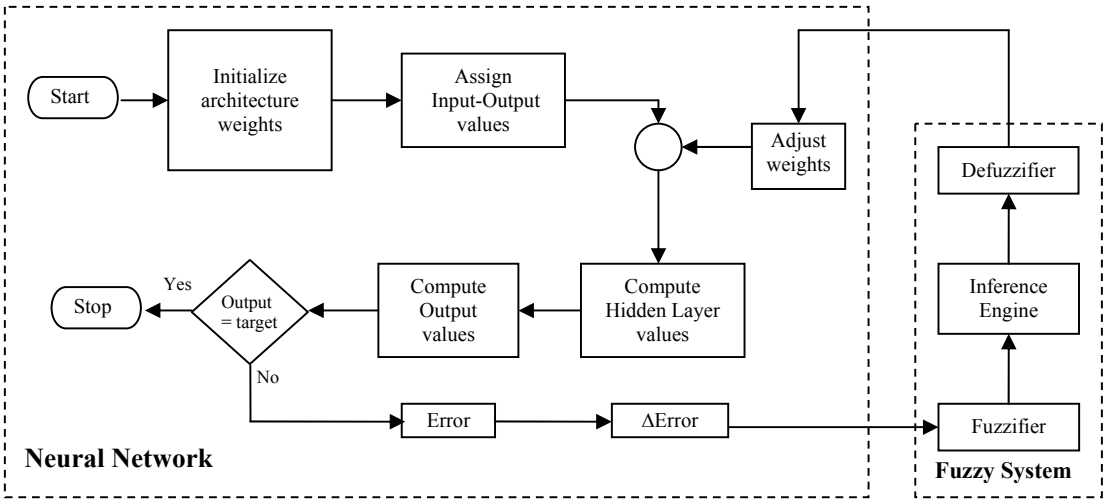
The evolution of neural intelligence in business decision making can be characterized by initial phases where individual productivity is enhanced , up to a point of total integration, where internal and external business processes can breed new process views. Neural intelligence models that have been put to use for personalization systems are neural networks, genetic algorithms, and fuzzy-logic systems. We chose a neuro-intelligence model that combines features of artificial neural networks, fuzzy logic and control theory.

3.1 Neuro-Fuzzy Systems

Fuzzy systems have been successfully applied to many decision making problems, as they provide an effective way to capture the approximate and inexact nature of the real world (Abraham, 2001). They are particularly useful when the processes are too complex for analysis by conventional quantitative techniques or when the available information from the processes is qualitative, inexact, or uncertain. Fuzzy rule-based systems are thus able to model the human thinking process rather well and, consequently can be used to automate many applications where human operators play an important role. The operator's expertise can be determined via interview and modeled in terms of rules that express his knowledge of both the domain in general and the specific decision problem. This method of design has some disadvantages too, firstly, the human expert might not be able to verbalize his or her knowledge and, secondly, translating this knowledge into formal control rules is difficult, even more so when the process is very complex. Thus, it would be useful to build an intelligent system that can not only perform just as well as (or better than) the operator but also learn the control law and express the acquired knowledge in understandable and reusable form.

Artificial Neural networks are precisely known for their ability to learn from example and their capability for generalization beyond the training data, as well as their inherent parallelism, with the drawback that the encoded knowledge is not accessible (Abraham, 2001). Fuzzy rule based systems, on the other hand, model the human (approximate) reasoning process very well, and offer a symbolic representation of the encoded knowledge. Integrating fuzzy logic rule-based system and neural networks to form a neuro-fuzzy system can yield the essential benefit of empowering a declarative knowledge representation with a learning and optimization mechanism (Buckley, Hayashi , 1994). The block diagram of a generic neuro-fuzzy system (Shapiro,2002) is depicted in Fig. 1.

Figure 1: An adaptive Neuro-Fuzzy System



By definition (Nauck, Nnberger, Kruse), a neuro-fuzzy system is a fuzzy system that uses a learning algorithm derived from or inspired by neural network theory to determine its parameters (fuzzy sets and fuzzy rules) by processing data samples. A Neuro-fuzzy system displays the following general properties (Nauck, Nnberger, Kruse) :

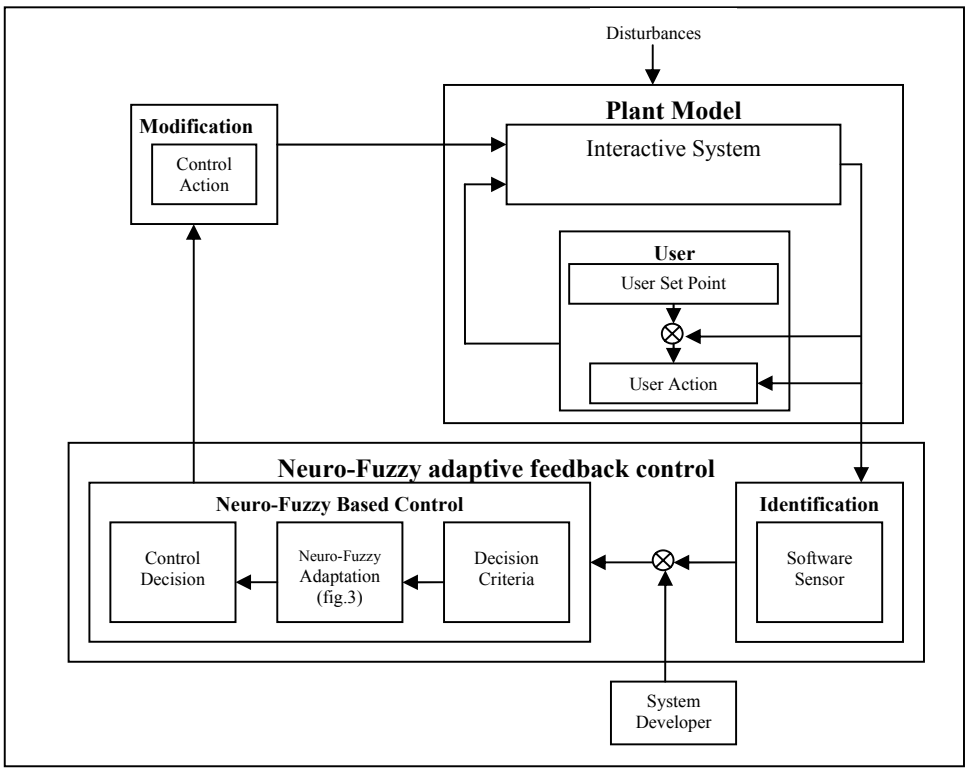
- It is based on a fuzzy system which is trained by a learning algorithm derived from neural network theory. The (heuristical) learning procedure operates on local information, and causes only local modifications in the underlying fuzzy system.
- It can be viewed as a layered feed-forward neural network. The first layer represents input variables, the middle (hidden) layers represent fuzzy rules and the last layer represents output variables. Fuzzy sets are encoded as (fuzzy) connection weights.
- It can be interpreted as a system of fuzzy rules.
- Its learning procedure system takes the semantical properties of the underlying fuzzy system into account resulting in constraints on the possible modifications applicable to the system parameters.

Various neuro-fuzzy models like ANFIS(Adaptive Neuro Fuzzy Inference System) , FuN (Fuzzy Net) , Fuzzy RuleNet , GARIC (Generalized Approximate Reasoning based Intelligent Control), EFuNN (Evolving Fuzzy Neural Network) , NEFCLASS , NEFPROX and NEFCON, have been put to use in various business and engineering applications. All these models have differing characteristics e.g. The NEFCON model (NEuro Fuzzy CONtrol) supports the reinforcement learning using a fuzzy error measure that can be defined by the user. NEFCLASS (NEuro Fuzzy CLASSification) can learn classifications rules and suitable fuzzy sets from a set of training data for data analysis. NEFPROX is a model for NEuro Fuzzy

function approximation and learns a fuzzy system from training data to approximate the function given by the data samples.

3.2. Neuro-Fuzzy Adaptive Control for Interactive Systems

Figure 2: Neuro-Fuzzy Adaptive Control for Interactive Systems



Neuro Fuzzy Adaptive Control for Interactive Systems (NFACIS) was first introduced in 1999 (Nikov, Lindner, Georgiev) and then refined in 2001 (Lindner, Nikov, Georgiev) for adaptation and optimization of the interaction structure of interactive systems by application of the control theory principles to a neuro-fuzzy network and uses a self-tuning control system. The control theory is appropriate to model the structure and parameters of interactive systems and allows for on-line estimation of system parameters and self-tuning of the control algorithm. The synthesis of control algorithms is based on an adequate description of the plant of control (the underlying system) . It supports investigation and design of stable interactive systems and allows for optimization of system parameters.
We chose the Neuro Fuzzy Adaptive Control for Interactive Systems as an appropriate model for the problem in question i.e. for implementing Business process personalization due to the inherent interactive nature of the web platform and the need for real time adapted responses for active personalization.

3.3. NFACIS Architecture

The Neuro-Fuzzy Adaptive Control for Interactive Systems -NFACIS (Lindner, Nikov, Georgiev) consists of three main modules; the main plant of control, a neuro-fuzzy adaptive feedback control and modification module. A basic model is shown in figure. 2 and the functions of various blocks of the system are detailed below:

The *Plant Model* module represents the underlying model of interactive system , the user and the signal flow between them. The interactive system contains an adaptive controller that is responsible for the adaptation of the interactive systems and its interface. The user is modeled as controlled 'plant' that can be influenced by external disturbances or influences determining the changes of the user's behavior. The difference between goals and actual output actions as well as information is a part of the interactive system and an input of the adaptive control circuit.

Neuro-fuzzy adaptive feedback control module consists of the *Identification block* and the *Adaptive control*. The Identification" block has a *Software Sensor* which collects data from the goals' deviation as well as user input and output. It estimates parameters and performance, models the process online and keeps track of the log file data from a web-based interactive system. This block determines the transition matrices $\Omega^m = \{ \omega^m_{ij} \}$. Each element of these matrices ω^m_{ij} contains the frequencies of transitions between the different interaction points (i and j) during user's work with the interactive system. The following operator presents the software sensor as

$$\Phi s : L_f \rightarrow \Omega^m \qquad (1)$$

Where L_f is a set of log file data and Ω^m is the transition matrix.

The neuro-fuzzy-based Adaptive Control supports the learning process of neuro-fuzzy adaptation, determining the decision criteria and defining the control decision and consists of three sub-blocks: *Decision Criteria, Neuro-Fuzzy Adaptation* and *Control Decision*. The aim of this control algorithm is to adapt the interactive system based on user's work with it. The Decision Criteria block builds the training patterns for the Neuro-Fuzzy Adaptation block. The training patterns include the input and target values for learning neural network. The operator Φ_p describes the algorithm for building the training patterns,

$$\Phi_p : \Omega^m \rightarrow P_i^m \qquad (2)$$

Where P_i^m represents the i-th row of the training patterns matrix m.

The Neuro-Fuzzy Adaptation block presents the kernel of adaptive control. Here a neural network is trained by a fuzzy system and so forming a neuro-fuzzy controller. The neural network structure is determined based on user's interaction with the interactive system. A fuzzy set P is defined on the space Z as a set of ordered pairs $(z, \mu_p(z))$, , where $\mu_p(z)$ denotes the value of the membership function $\mu_p(z) : 2^p : \rightarrow [0,1]$ at a given point $p \in Z$. The fuzzyfication operator (constructor of the fuzzy set) is presented as

$f_N(Z) : Z \rightarrow 2^z$ (3)

where 2^z denotes the set on all subsets of the set Z.

The neuro-fuzzy network can be defined as

$Z(i) = R_N(f_N(Z(i-1)), f_N(W(i)))$

$W(i) = R_L(Z(i), W(i), W(i-1))$ (4)

where Z(i) and Z(i-1) are fuzzy sets. W(i) presents network weights on the i–th learning step. Fuzzy relation R_N describes the activation function of the neurons and R_L is a fuzzy relation describing the learning algorithm.

The Control Decision block determines a new adapted interactive structure of the interactive system by an optimization algorithm using the trained weights of the neural network. The *Modification module* redesigns or synthesizes the controller. The change of interaction structure is carried out by *Control Action block* which sets the new adapted interactive structure of the system. This is done while paying attention to user expectations. The *System Developer* block presents the goals that guide the system's behavior from previous control structure. It provides Supervisor control of the parameters and the rules of the control algorithm and performs tuning of the control algorithm. The advantages of such a presentation are: investigation and design of optimal structure of adaptive interactive systems; selection and optimization of parameters of interactive systems; and investigation of stability of interactive systems and design of stable interactive systems.

4. Proposed Framework

4.1. Business Process Personalization:

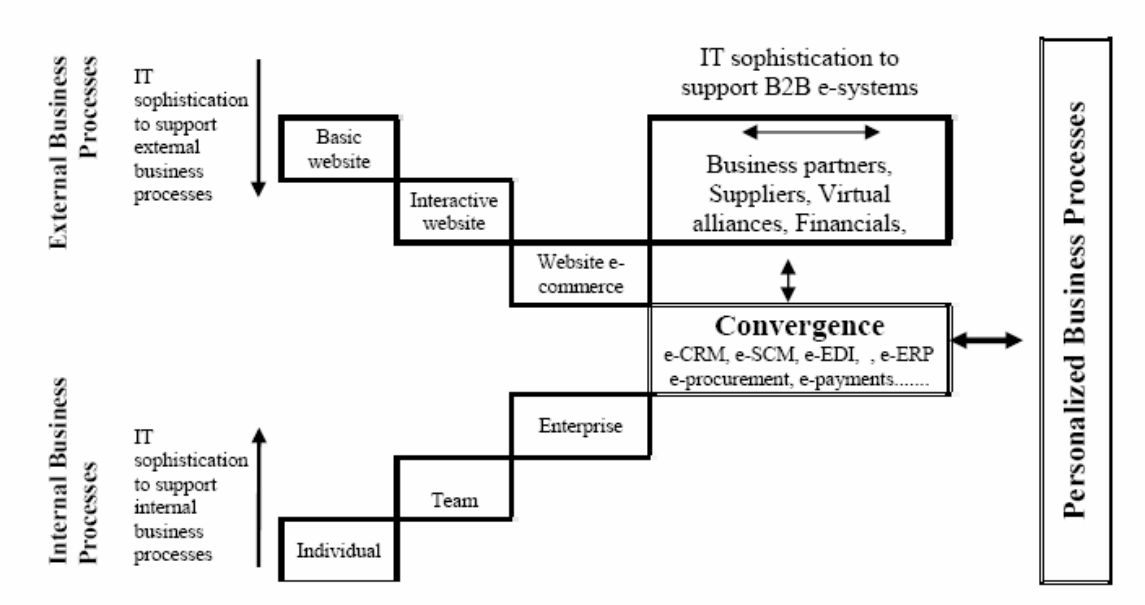
Most of the publications treat personalization as changes covering only the website structures and the main focus is on the several types of content filtering schemes for personalized interactions with the customers. We extend this abstraction to full personalization, which would represent the combination of website personalization as well as business-processes-personalization (BPP). Business process personalization is the customization and/or optimization done through the application of IT, influencing directly the core business processes.

This personalization pattern promises powerful impacts on the e-business and can result in new business opportunities to emerge. With personalization integrated throughout the company, knowledge of a customer's preferences can be integrated into the complete business process model. This integrated approach makes it possible for the success factors to be met at any of the touch points where the customer interacts with the business. Keeping the importance of customer satisfaction and loyalty in mind, "customer insight" is to be introduced, which creates a unified interaction paradigm that spans marketing, sales and service and reaches across other business processes like procurement, production, distribution, payments etc. In order to create a true one to one personalized relationship

with a particular customer, the back end of a business (the production and service delivery parts etc.) have to come through based on what the front end (the sales, marketing, or customer service parts) have learned about this particular customer.

For an e-business this means that Internal and External businesses process need to be integrated electronically. When the internal and external business processes converge at some point, new processes can arise that can support full personalization inside e-business systems. The level up to which such personalization can be achieved depends on the extent of convergence of business processes and consequently on the IT sophistication level of the internal and external business processes. This can be represented by figure 3.

Figure 3: Convergence of Internal and External business processes for Business Process Personalization
(adapted and refined from (Odorico, Garcia)



Business Process personalization can be achieved when the organization reaches a required level of convergence, i.e. when core business processes like procurement, supply chain, customer services, sales, financials are integrated with the e-business model and become accessible and customizable through website operations (Coner, 2003). The information on business processes is stored in a central repository which is also used for storing and analyzing information from customer interactions. A suitable technology applied to this repository and extending it to converging business processes can achieve business-process-personalization.

4.2. Leveraging NFACIS for Business Process Personalization

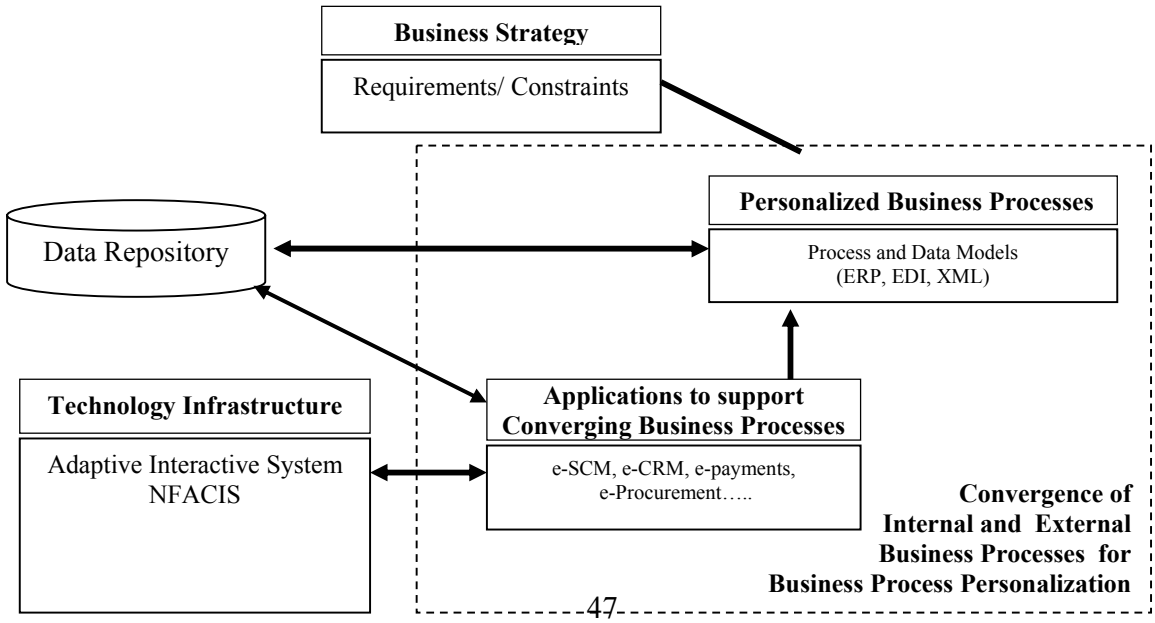
We apply the NFACIS model as the technical tool for adapting business processes based on interactions with the user. The central data repository is used as a data integrating hub storing business process information as well as data generated through interactions with the customer in real time. The user interacts with the system through the Adaptive Interactive

control (NFACIS) and at each interaction, the neuro-fuzzy controller comes into play . The data is fed to the neuro-fuzzy control network, which clusters the input, identifies fuzzy variables, and extracts a fuzzy rule base. The rule generation aspect of neural networks is utilized to extract more natural rules for adapting responses. This rule base is used to successfully personalize and adapt the corresponding next interaction, based on the data in the repository and the interactive user responses. This is not just restricted to web-site content customization, the system is also able to access and personalize internal and external business processes through the converging applications.

4.3. Discussion:

The framework comprises of a judicious integration of the merits of neuro-fuzzy and business process convergence approaches, enabling one to build a more intelligent and adaptive personalization system. This incorporates the advantages of artificial neural networks of massive parallelism, robustness, and learning in data-rich environment into the system and modeling of imprecise and qualitative knowledge in natural/linguistic terms as well as the transmission of uncertainty through the use of fuzzy logic. By adapting business processes to the individual preferences of each customer, customer satisfaction increases and the businesses will experience a higher percentage of returning customers, which means increased customer loyalty and retention. The customer profile used for personalized services becomes more accurate over time and the system becomes more intelligent with time. The customer profile maintained is an excellent source of information for understanding more about the needs of not only that individual consumer, but also other consumers with similar preferences. When a corporation has committed itself to personalization as a way of doing business, what was formerly a narrow band of utility suddenly becomes a broad band of precision tuning throughout the organization.

Figure 4: E-Business Process Personalization using Neuro-Fuzzy Adaptive Control for Interactive Systems NFACIS-BPP



4.4. Pros and Cons of the Proposed NFACIS-BPP Model

Some of the benefits that the proposed NFACIS-BPP model promises to an e-business are:

- One-to-one interactions are based on the needs and preferences of each user e.g. interactive dialogs and personalized recommendations based on a user's goals.
- Business process personalization incorporates a company's way of doing business and treating its customers in every aspect of business operations including automated policies, practices, and procedures.
- Adaptive system can respond in real time to changing competition, internal business practices, government regulations, and customer behaviors to provide the most appropriate and effective treatment of each customer transaction.

Some of the limitations associated with the model are:

- As the model has not been tested on any software platform as yet, it yet has to be seen, how well the model can be implemented and how well it moulds to the requirements and constraints of efficient software development.
- Any automated personalization of core business processes can pose a significant threat to Enterprise consistency , i.e. maintaining the same business methodologies no matter how, when, or where customers, employees, suppliers or partners interact with the enterprise.
- The model is incomplete without incorporating data and transaction security which must be an integral part of the framework.
- Lack of adherence to common intra–enterprise standards makes convergence of external business processes quite far-sighted.

5. Conclusions:

The concept of personalization has been extended to incorporate business-process personalization along with website content personalization. This involves integrating core front-end and back-end business processes into the e-business model and their convergence for applying personalization. The self organizing capabilities of the neural network, the adaptability of the fuzzy rule-based system, and the applicability of the combined system to implement such a personalization has been demonstrated using the Neuro Fuzzy Adaptive Control for Interactive Systems(NFACIS).

6. Further research directions:

The proposed system does have some limitations and can give a direction for future research in refining the system. Effective convergence of external business processes is an issue and so is secure but limited accessibility and adaptation of external data repositories. An effective and efficient software implementation can be a challenge considering the complexity of the framework.

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