Soft Computing Approach for Measuring Business Process Agility in an Agile Environment

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ABSTRACT
Agile environment checks Organization's capacity or flexibility to accept the changes. Working in agile development needs to check their process, effect in the collaboration with other processes present in the enterprise solution. But agile environment is unpredictable. Hence to measure the process agileness, soft computing approach is used. In this paper, Hybrid Neuro-fuzzy approach is proposed to measure agility of business process with respect to the architectural level. This approach uses different weighting algorithm, for fully connected neural network evaluated on the basis of pairwise comparison of process type and architecture type. This method can be used to take check importance or effect of change of process used in the software solution used in the industry. In case of changing environment, this method will give a selection path to expert for selection of changes in the enterprise solution.

Keywords
Business Process Agility, Neural Network, Agile development

1. INTRODUCTION
An enterprise software solution may be made of a number of complex and interrelated applications. As per working style, applications can be classified into enterprise architectural levels. As per the changing environment, these applications are more prone to change as per stakeholder's requirement, process logic, or data. This paper shows soft computing techniques used for monitoring process agility using Neuro-fuzzy hybrid approach. Section I explains an architecture framework with different type of business processes. Section II shows proposed hybrid approach for measuring agility. This section focus on neural network structure used to find process criticality and fuzzy logic used to handle uncertainty of input data to find agility of the process. Section III shows real time case study working on agile methodology is analyzed with hybrid approach for monitoring business process agility.

2. ENTERPRISE SOLUTION WITH AGILE DEVELOPMENT
Enterprise solution is the software used in the organization as per the business requirement of the product. Following section gives details about the enterprise solution.

2.1 Agility in enterprise solution
[61] Enterprise solution is made of a sequence of simple or complex business process working as per business policy. Each business process may face challenges of changes based on techniques like flexibility or agility. Flexibility is defined as the general capacity to react to changes depending on the market changes, whereas agility can be defined as the speed in responding to changes depending on the market requirement. The flexibility and agility both depends on the ability of co-operating organizations to adapt. [12] Agility, but not the flexibility, is the important key to business process's ability to survive and succeed in the changing environment of the organization. [31] Currently used enterprise solutions are more process-centered, hence agile solution can be more optimized by furnishing resources and services. [6] Agility can be differentiated as operational agility, organizational agility, deployment agility, sustainability agility, acquisition agility, and conceptual agility. To measure agility, different techniques are used. These different techniques are As-Is strategy, Re-engineering of the process flow, structural complexity of the system, calculating ability of changes as per system requirement of enterprise solution.

2.2 Enterprise Architecture
Enterprise solution used in the organization can be classified into different architectural level. Architectural level also classifies its working processes based on its working. This process executes as per the business policy. [13] Enterprise architecture is a well-organized structure for analyzing, designing, and implementing software solution. Business architecture works as per the organization's mission and vision. Information architecture builds its knowledge pattern based on the working of applications. Data architecture builds and stores data as per application. Technology architecture gives a platform for storing and working in different hardware and software required for all above architectures. [3] [60] Business processes can be differentiated as Management, Core, Enabling and Enhancing process depending on its execution type. [50] [59] Management process represents business logic of an organization. Core process is mostly designed using management process logic for core working of the enterprise solution. Enhancing process is designed based on the core processes for improving quality of execution. Enabling process is designed for enhancing work of the core processes. Enabling and enhancing processes can be executed in parallel or in sequence for core processes or for management processes. [46] Management processes can be designed for information, data, application or technology levels. [19] [49] Core process can be designed at all levels for developing organizational logic. Enabling and enhancing processes can run in accordance with the core and management processes.

2.3 Agile Environment
[61] Organization faces agile behaviors due to the growing demand in the market for resources, services, or products. [7] [36] Agility drivers are the parameter which is responsible for changes in the business environment. It also motivates the changes in the organizational strategy. Agile capabilities are the parameters which provide the ability for detecting patterns and adapting business processes as per the required events. Agile enablers are the parameters which creates a situation as per the changes so that changes can affect the working of the process. [7] Agile Manufacturing rules can be defined as statements, which can change very quickly. The agile product

life cycle is very short and response time is also short. Agile products are high level quality and wide-ranging services. Being constant or to update with changing parameters are the important objective of this research area. Hence this paper gives an opportunity to measure or to monitor the agile parameter of the business process present in the enterprise solution.

3. SOFT COMPUTING TECHNIQUES

[9] [28] In comparison to conventional AI techniques or hard computing, soft computing deals with precision, certainty and rigorous environment. [55] Soft computing is to achieve problems such as the tolerance for imprecision, uncertainty, robustness, and partial truth. [55] [11] [22] Soft computing is more oriented towards the analysis and design of intelligent systems working as per the uncertainty and imprecise environment. Soft computing can be used in many application areas such as process control, engineering design, financial trading, credit evaluation, medical diagnosis, and a cognitive simulation.

3.1 Neural Network

[32] [5] Neural network works as per the observations in the information systems. It generalizes the output by abstraction, Connection strengths between neurons, and memory used to store the knowledge. Training a neural network includes modifying the weights, adapting its connections to get the desired behavior for all input patterns. [17] Neural network can be used to learn new associations, new functional dependencies and new patterns from the same input data. In case of complex structure, input and output are dependent on each other depending on its connection type. [39] [4] Number of iterations for training algorithm and the convergence time for finding output will depend on the weight initialization within the neurons. [41] In a fully connected neural network structure all neurons are connected to each and every neuron. This structure is having high strength for fault tolerance. Applications of neural networks are pattern recognition, classification, data-mining, prediction systems, Sales forecasting, Industrial process control, Customer research, Data validation.

[44] [42] Advantages of neural networks are

- Its adaptivity to optimize their output behavior as a pattern recognizer, decision maker, system controller, predictor, etc. by automatically adjusting their weights.
- Neural networks are highly accurate for float values.
- Construction of neural network is very easy. Only need to remember connection nodes.
- Neural networks learn the relationship between independent variables and dependent variables.
- Neural networks work as a black box for classification or for pattern generation.
- It helps to minimize a quadratic error function.

Disadvantages of using neural networks are its lack of transparency due to assignment of weights. Its output knowledge or the pattern is difficult to understand due to threshold value or training pattern.

3.2 Fuzzy logic

[33] [7] [16] [1] Fuzzy logic is applied to decision making in uncertain and ambiguous situations. It decreases ambiguities and increases the effectiveness of decisions. [44] [10] In fuzzy logic, every input is working as a matter of degree range defined in the range of [0, 1]. [39] Fuzzy Logic represents undetermined, unknown, or intermediate truth-values. [35] [38] A fuzzy set can be represented by number of membership functions such as Triangular, Trapezoidal, Gaussian, and Polynomial. [8] α cut for membership function defines a selection of membership functions. Membership function needs to map for scale invariance, shift invariance, sign invariance and union invariance for specified range. A membership function is used to quantify a linguistic term from crisp term. A membership function determines each point in the given input space mapped using degree of membership value. [64] Overlapping of membership function improves classification and interpretability of calculated results. [36] [24] Defuzzifier combines the output sets corresponding to all fired rules in significant way to obtain only a single output set.

[14] Triangular fuzzy numbers are fuzzy numbers with a base value for lower, core, and upper values. Discourses of the specified variables which have a positive degree may fire at-least one rule as per specified range. A greater resolution is achieved with a high range of membership functions. The triangular approximation is reasonable for fuzzifying the input crisp value and provides fuzzy solutions with much smaller spread. [2] Selection of a triangular member function gives the simple way for fuzzification. Triangular method is a simple and easy for learning of the antecedent and consequent parts of the fuzzy IF-THEN rules. When number of rules decreases, it represents a lower computational complexity.

Advantages of Fuzzy logic are [42]

- It does not require specifying concrete values of properties depending on the current understanding of the problem.
- Fuzzy logic is viewed as a limiting case of approximate reasoning which is characterized by its exact reasoning.
- Fuzzy classifiers generate a list of if-then rules represented in linguistic forms which can be easily interpretable by users.
- If development capability, generalization, number of factors increases, calculating the uncertainty will be quite responsive and easy. [53]

Disadvantages of Fuzzy logic are defining as many rules as possible, and as per the degrees of acceptance. [15] Defuzzification works according to singleton output membership function.

[63] The fuzzy logic controller system is capable of approximating a compact set to arbitrary accuracy. It works as universal approximators. [21] There are two main types of controller system, defined as Mamdani fuzzy systems and Takagi–Sugeno fuzzy systems. A Sugeno fuzzy system is computationally efficient and works well with linear techniques. It works well with optimization and adaptive techniques. It is well suited to mathematical analysis. Mamdani fuzzy system is intuitive and has widespread acceptance. It is well suited to human input. [40] [62] To apply the fuzzy logic concept to a real time application, the following steps are used

- In fuzzification crisp data is converted into fuzzified data using selected Membership Functions.
- In Fuzzy Inference Process, membership functions combine fuzzified data using control rules to derive the fuzzified output.
- In defuzzification, defuzzification methods are used to calculate each associated output and put them into the memory.

3.3 Hybrid approach

[54] [65] [55] Intelligence techniques based on hybrid soft computing approach can develop decisions of the enterprise solution. Fuzzy logic gives the quality control. Neural networks as the capabilities of a supervised learning algorithm, performs the fine-granule local optimization. [56] Neural Networks has the capability of self-learning, while the fuzzy logic inference system is capable of dealing with fuzzy information and simulating decision making as that of the human brain. [4] Fuzzy logic rule sets can always be translated into easily understandable linguistic rules, but rules cannot be learnt in the same way as that of neural networks. Neuro-fuzzy approach can overcome their individual drawbacks if they are combined together. Neural network with their learning capabilities can be used to learn fuzzy decision rules. [11] A fusion of neural networks and fuzzy systems provides learning as well as readability of the changeable adaptive topologies of the fuzzy systems.

[26] [48] [47] Based on the training data, neural network and fuzzy logic system determines their properties as that of human's process information. During the training procedure, rule parameters for antecedent and consequent will be tuned to minimize computing error. [43] Neuro-fuzzy systems combine linguistic and numerical information. Fuzzy if-then rules with specified range are based on linguistic information supported by neural network.

4. PROPOSED SYSTEM TO FIND AGILITY OF THE PROCESS

Combining the features of hybrid system based on Neuro – fuzzy approach, this paper proposes a system to measure agility of the enterprise solution as shown in figure 1. In phase 1, neural network will find process criticality and in phase 2, fuzzy logic rule base will find the agility of the process. This incorporates the optimization of the problem using a hybrid solution approach. Input for neural network phase is process importance, parameter importance taken from the user and generates process criticality. In phase 2, fuzzy system generates business process agility as output based on the input provided for neural network. Rule base is constructed based on the criticality of the process and criticality of the parameter. This helps to find agility of the process with respect to the affected parameter.

4.1 Phase 1 - Neural Network system

The neural network system structure is of fully connected type. All the neurons present in the layers are connected to each other. Each connection is having weights assigned to each neuron. Input to the neural network is the process importance for finding process criticality and parameter importance for finding parameter criticality. Process importance and parameter importance is a value between {1...10} showing its importance from lower to higher scale. [57] Using saaty's method for pairwise comparison of architectural level and process type, weights are calculated for different architectural levels. Pairwise comparison is different for each organization; hence weight for each neuron will be different. Output is generated considering the importance of all nodes. Due to simplicity of the triangular function value for its component are taken from the user only.

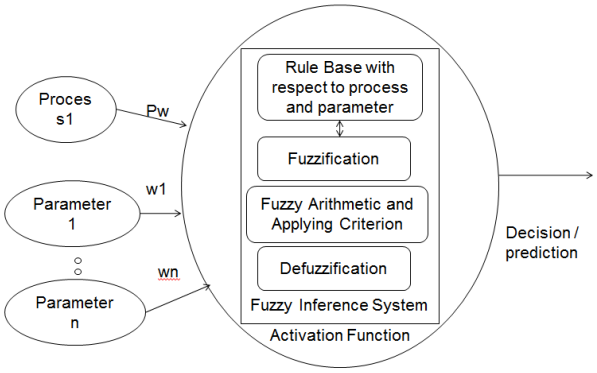

Fig. 1: Proposed hybrid soft computing Approach

In the proposed system, two neural networks structures are considered. One for finding process criticality and another for finding parameter criticality. Depending on the type of neural network system, it will have hidden layers defined for architectural level, process type and parameter type. [49] As shown in the figure 2, process criticality is calculated by fully connected neural network based on hidden layers for architecture type and process type. The formula used for finding process criticality is as shown in equation 1. In the same way, parameter criticality is calculated using formula as shown in equation 2. Parameter criticality is calculated by fully connected neural network based on hidden layers for architecture type, process type and parameter type. Based on the organizational business policy, process importance and parameter importance value ranging from 1 to 10 is taken from user.

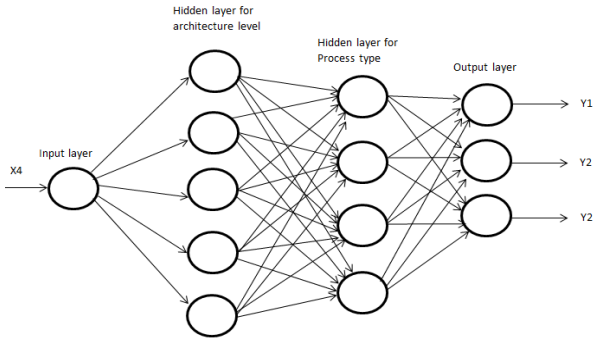

Fig. 2: Fully connected Neural Network for Parameter Type

Criticality of Process = Process importance * Weight of Process at specified architectural level * weight of process at specified process type ---------- (1)

Criticality of Parameter = Parameter importance * Weight of Process at specified architectural level * weight of process at specified process type * weight of parameter type ---------- (2)

For fully connected neural network, connectivity weights are calculated based on different algorithms. This algorithm calculates the eigen vector, for input pairwise comparison matrix as per saaty's method of calculation. Following are the suggested weighting algorithm

1. Geometric Average Approximation (GA): GA is an arithmetic mean calculation method. It gives an average mean of the input matrix. This method works on the rate of return concept that connects the starting and ending values of range, if it is considered in all periods of calculation. It works on relative measure of the data.

2. Exact Linear Algebra Calculation (EA): EA computes an exact solution of a problem calculating a solution of linear equations with input as precise value, integers modulo, a prime number, or residues modulo a minimum polynomial. [18]
3. Successive Matrix Squaring (SMS): [34] SMS works on the policy for displacement rank with given specified ranges. [29] Parallel matrix generated at the end of each calculation, changes the elements of the original matrix. [51] SMS shows a deterministic iterative algorithm based on a repetitive matrix squaring scheme.
4. Analytical Hierarchical Processing (AHP): [20] [57] AHP considers the problem divided into a hierarchy of sub problems which is subjectively evaluated. This makes the problem easy to solve and for calculation as per sub problems. Normalized eigenvector of this matrix are the relative weight of input vector.

4.2 Phase 2- fuzzy logic System

[25] Fuzzy logic works in uncertain environment, working as per the linguistic nature. In phase 2, triangular membership function is used for Fuzzification. Crisp value is converted into fuzzified value using the triangular membership function. [41] In proposed method, fuzzy logic develops a rule base comparing process type with parameter type. This rule base shows relation between the process and parameter as per organization policy. [10]

[45] [10] [58] Rule base is constructed with the help of business expert's view for the architectural level to the process type and for the process type to the parameter type. Rule base maps process criticality with [30] [23] Table 1 shows an example of the rule base created for fuzzified value of process and parameter criticality. This table may have different values for different organization based on organizational business policy.

Parameter || Process	Low critical	Avg. critical	High Criticality
Low critical	Not Agile	Less Agile	Avg. Agile
Avg. critical	Less Agile	Avg. Agile	More Agile
High Critical	Avg. Agile	More Agile	High Agile

Table 1: Rule base for Fuzzy logic

Process agility is the defuzzified output value using the centroid method. In Centroid defuzzification method, the area of each resulting set is multiplied by the domain values passing through its center. Phase 2 gives an output showing agility of the process with respect to the parameter. The output of each processor can be aggregated using the centroid defuzzifier to obtain a crisp value as agility. [52] The agility value of a parameter with respect to the process shows its agility within the process. This value shows the percentage that parameter may change or may be volatile with respect to the process. Calculated agility value shows the relationship of agile parameter with respective architectural level and as per process type. This agility value of the process may help in taking decisions related to agility constraints. It helps for finding the impact of change with respect to the process for respective architecture level. [27]

5. CASE STUDY FOR BUSINESS PROCESS AGILITY

5.1 ABC Company for Health Fidelity System

ABC Company works in an agile development mode. It works in agile mode for accepting the changes in technology or in process execution. ABC Company works for Health Fidelity system (HF) where input health data is changing as per organizational environment. Client requirement makes system agile for execution of certain process. HF System works on Natural Language Processing technology and suggest platform to analyze vast amounts of unstructured data in order to provide clinical and financial insights. This system works for finding risk analytics of people based on their health history.

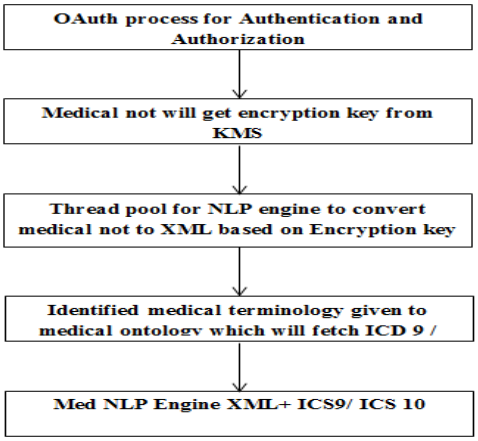

Fig. 3: Working of MedNLP Engine

This system predicates an insurance to be issued to a user based on the predictions made. MedNLP Engine – HF System is a core module for converting medical history into XML format. This conversion is done by NLP engine. This application helps for the payer and provider of organizations to address risk and quality in the value-based payment models. This application is designed using real-world workflow for input from authenticated health plan, a key development partner and strategic investor. HF is used for transforming risk adjustment. This application offer a combination of technology and expertise that enable Medicaid health plans to transform manual risk adjustment process into an integrated workflow. With HF, user will gain better visibility, control and predictability into user plan's risk adjustment activities for user's operational, compliance, and financial performance. HF process flow is as showing in figure 3.

5.2 Agile Environment for HF system

HF system's working analysis is done as shown in table 2. This table shows each process working as per management, core, enabling and enhancing with respect to each architectural level. This relation shows processes working at different architecture level along with agile parameter. From this table, it is observed that for HF system, most of the processes from application level are agile. Application level works on PAAS and web services technology. Web services work on reusability and responsiveness. Applications with agile parameter also effect on the speed of execution. Client changes health data or working style of the process which may affect agility. Hence, most agile architecture is

application architecture as compared to the other architecture level.

Agility drivers are the parameter from users or administrator affecting the health plan requirement. This data may be changing as per user. The administrator will also change health plan as per the business policy. For user, data attributes are working style of user, gender, Location etc. For administer, attributes are terms of the health plan, waiver in the health plan. This attribute may changes as per the change in the business policy.

Agile capabilities are the parameters which get affected and hence propagate to impact further changes. In case of user's data, it may provide the ability for detecting patterns and adapting business processes as per the events. Plan may include an exception for certain user data. They incorporate the changes, but with the substitution. E.g. user now affected with diseases and still he can continue with existing plan. Administer may make certain changes in the execution of the plan. Group plan for health may include floating value options as per changes.

Agile enablers are the parameters which capture and bring it in visibility to support efficient development and delivery of future changes. This parameter affects agile manufacturing rules. E.g. Infrastructure or environment can be the agile enablers for the user's health. [7] Agile Manufacturing rules can be defined as statements, which can change very quickly. The agile product life cycle is very short and the time delay in response is also short. It can be unpredictable. Agile products are with very high levels of quality and wide-ranging services.

5.3 Process Management Tool Based on Neuro – Fuzzy approach

Process Management tool is based on Neuro-fuzzy based hybrid approach. This tool helps to measure agility value of business process. This tool is made using JAVA programming language with back end as MySql. The following pages are made in the process management tool.

- Add process page: This page will take process information like working architectural level, type of process and process importance of application. Here the user will select weighting algorithm to calculate process criticality.
- Add parameter page: Here a user needs to give information as type of parameter and parameter importance for the selected process type.
- Assign membership values for process / parameter: This page is used for assigning linguistic values using the triangular membership function to process and parameter. For triangular function values for low, average or high is taken from the user based on the intuition method of Fuzzification given by the expert of the system.
- Assign Rule base page: Rule base pairwise relation for process criticality and parameter criticality may be different as per Company's requirement for all types of combination of process type with parameter type along with different architectural level.
- Assign weight for process and parameter: This page is used for adding pairwise comparison for architectural level, process type, and parameter type.
- View agility: This page gives results as the agility of the process based on the parameters. This page shows, agility constraint, framework relation selected for that process.

5.4 Case study for process Plogin

Process management tool is used for measuring business process agility for single process named Login. In order to check more agile architectural level or more agile process type only one process information is applied to all architectural levels and all process types for all combinations of the parameter type. Architectural level with one business process helps to find behavior of all architecture w.r.t to one perspective.

Abbreviation used: Management Process: MP, Core process: CP, Enabling process: EP and Enhancing process: EEP

Architectural Level: ArL, Process type: PT, weighting type: WT, Agility Value: AV

Process Information : Process name = Login, Process importance = 10 Input Parameter name = puname, Input parameter importance = 10 Output parameter name = ploginss, Output parameter importance = 10							
ArL	PT	WT	AV	ArL	PT	WT	AV
BL	MP	GA	0.021	AL	MP	GA	0.739
		ELA	0.029			ELA	0.647
		SSM	0.023			SSM	0.730
		AHP	0.013			AHP	0.627
	CP	GA	0.351		CP	GA	0.190
		ELA	0.289			ELA	0.200
		SSM	0.326			SSM	0.192
		AHP	0.249			AHP	0.180
	EP	GA	0.082		EP	GA	0.082
		ELA	0.088			ELA	0.120
		SSM	0.098			SSM	0.088
		AHP	0.078			AHP	0.080
	EEP	GA	0.044		EEP	GA	0.034
		ELA	0.079			ELA	0.039
		SSM	0.044			SSM	0.035
		AHP	0.039			AHP	0.029
IL	MP	GA	0.182	DL	MP	GA	0.003
		ELA	0.183			ELA	0.004
		SSM	0.186			SSM	0.003
		AHP	0.173			AHP	0.002
	CP	GA	0.067		CP	GA	0.046
		ELA	0.073			ELA	0.046
		SSM	0.067			SSM	0.047
		AHP	0.063			AHP	0.036
	EP	GA	0.026		EP	GA	0.022
		ELA	0.033			ELA	0.023
		SSM	0.027			SSM	0.022
		AHP	0.023			AHP	0.020
	EEP	GA	0.010		EEP	GA	0.007
		ELA	0.012			ELA	0.009
		SSM	0.011			SSM	0.007
		AHP	0.009			AHP	0.006
TL	MP	GA	0.011	TL	EP	GA	0.041
		ELA	0.012			ELA	0.044
		SSM	0.010			SSM	0.042
		AHP	0.009			AHP	0.034
	CP	GA	0.091		EEP	GA	0.015
		ELA	0.089			ELA	0.020
		SSM	0.088			SSM	0.015
		AHP	0.084			AHP	0.014

Table 3: Database for process agility as per Architectural Level, Process Type and Weighting Algorithm

5.5 Observation for process Plogin

Applying same process information to all architectural levels with possible combination of process type and parameter type; it is observed that the value of agility for application architecture is low compared to the other architectural level. Low value indicates the application level is more prone to changes.

- Process value is getting affected because of comparison values given by experts for pairwise comparison of architectural level with process type. ABC Company works on agile methodology; hence processes used here are quite changing compared to fixed processes
- In phase 1, four different weighting algorithms are evaluated for calculating weight matrix. These weight matrices are compared for their performance for same process key point indicator as time, complexity, accuracy and the use of memory. Out of 4 different weighting algorithms, it is found that the Analytical hierarchical processing algorithm is having more preference for complexity and accuracy. It gives less output value for changes. AHP check the pairwise comparison for its relative index. Output of the phase 1, is criticality of the process and parameter using different mathematical model.
- Rule base for process criticality and parameter criticality gives better understanding in relation to the process importance with respect to the parameter importance.
- Using centroid method as defuzzification method, crisp values for agility are calculated. The centroid method finds the center of the calculated sum of agility value using the center of sum formula.
- Same process value when applied to all architectural level different values are outputted. It is observed that agility value depends on process importance given by the user.
- This company works in an agile environment, hence expert given values are more affective for application architecture. Less value as output, gives an architectural level as a most agile level. This shows that application architecture is highly agile compared to other level's agility.

6. CONCLUSION

Due to the agile behavior of the market, enterprises have increased in their complexity of working. Finding the effect of change of process agility in enterprise solutions, may help to find the effect of process in decision making. Neural network approach increases speed of execution and Fuzzy logic approach gives an approximately correct answer due to use of linguistic variable in the human thinking manner. Using hybrid approach, it is possible to take advantage of both the approach in one intelligent system. Checking agility for one process at all levels, it shows the application level is more sensible compared to other levels. Soft computing approach helps to handle human thinking, behavior to measure business process agility. A different organization will have different results based on their own mapping for different process type to different architectural level. As a result this concept will work as a generalized concept for all types of organization handling complex and agile enterprise solution. This concept can be enhanced to check the impact of architectural agility to more different type of applications. This research can be validated with different type of processes working in different domain to suggest agile architecture level. In the same manner, Neuro-Fuzzy approach can be replaced with other soft computing approach.

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8. APPENDIX

Type of Architecture || Business Process	Business	Information	Application	Data	Technology Infrastructure
Management	Vision , Mission, Goal of the HF for stakeholders	XML Analysis based on HIPPA compliance	Defining business component based on PAAS	.Enterprise Data Model for user management and for ontology services	Technology parallel working Docker Qubernatives
Core	To understand G-XML for medical note To use NLP Engine to generate ICT 9 code	Preprocessing for medical note, format for input and output	NLP engine as pool of services, REST based web services, KMS for encryption key	IDM GUID for user management ER diagram for IDM NLP Engine TBR algorithm for generation of key	
Enabling	Web services for Throughput logic based on TO BE strategy, Authorization, Authentication used for user management	User GUID, generation of encryption key for security,	OAuth process for security Thread Pool for NLP Engine	Data Quality for GUID, symmetric key	
Enhancing	Performance Analysis model based on batch processing	SFTP account for batch processing	Queuing System based on HDFS and Map reduce	Pingfederate for OAuth, Medical notes are stored in HDFS. MapReduce for parallel requests to Reveal server	

Table 2: HF System – As Per Architectural level and process type relationship proposed in the research paper