Using Formal Model Of Fuzzy For Performance Evaluation of Enterprise Architecture

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Abstract: Preparing enterprise architecture is complicated procedure which uses framework as structure regularity and style as the behavior director for controlling complexity. As in architecture behavior precedence over structure, for better diagnosis of a behavior than other behaviors, there is a need to evaluate the architecture performance. Enterprise architecture can not be organized without the benefit of the logical structure. Framework provides a logical structure for classifying architectural output. Between the common architectural framework, the C4ISR framework because the methodology of its production and the level of aggregation capability and minor revisions, considered appropriate. C4ISR framework, in three views and by using some documents which called product, describe the architecture. In this paper, for developing the systems and as the uncertainy in information systems because of the nature of the requirements it is avoidable, The new version of UML, called FUZZY-UML is used. This extended version include structure and behavior of the system. Due to the inability of UML in evaluation of systems the necessary of transforming real model (UML) to the formal model (fuzzy petri nets). become clear by providing an appropriate model of the system we can evaluate complex systems.

Key words: Evaluation of Enterprise Architecture • C4ISR framework • Fuzzy UML • Uncertain requirements • Fuzzy Petri Nets (FPN)

INTRODUCTION

In today’s world, developments in all areas, limit decisions time of managers and dear the expense of mistakes or even make it irreparable. In the new century, companies and organizations are working on providing better service which leads organizations to processes [1]. In addition, information technology, as well as the change agents in organizations, underlying factor [2]. For any production these issues make organization survey on information technology essential one provides the possibility to Several methods have been proposed for developing Several methods have been proposed for developing enterprise IT architecture (enterprise architecture). Architecture consists of a large number of documents which describe each part of the organization. The problem which rise is how we can pay attention and apply all of them?.

So for regularize and organizing architectural description, we need framework. Enterprise architecture’s framework is intended to provide focus on one aspect of the organization without losing the holistic approach for all stakeholders. These are different framework for enterprise architecture, but in this article, the C4ISR architecture’s framework due to its methodology of production in the framework and also features a component-level aggregation and minor revisions, is considered appropriate apply one model of a system, provides the possibility to Several methods have been proposed for developing Several methods have been proposed for developing information systems so that they can be classified as object-oriented and structured. The lake of a unified modeling language in a structured approach, cause the reduction readability and efficiency of these methods. The problem in
Problem definition

Implementation with UML diagrams

Convert UML diagrams to fuzzy UML diagrams with
linguistic variables

Building a sub profile from F-UML for modeling the enterprise architecture performance

Transforming the F-UML to formal model (fuzzy petri nets)

Using the analysis technique and simulation for solving the formal model

Fig. 1: Presented idea in this study

object-oriented methods rise by presenting UML language (unified modeling language). UML language as a powerful language can support object-oriented concepts, so today addition all to use of object-oriented methodology we use this language in database. Techniques which are used in UML can evaluate certain cases. In other hand, there is uncertainty in many information systems. By applying uncertainty in UML, new version of it which called FUZZY-UML represent that provide exploit of this language.

The products of enterprise architecture framework C4ISR, are described and illustrated by UML diagrams [2]. So far, many methods have been proposed for the assessment of enterprise architecture by converting C4ISR products which are shown with UML diagrams, to petri networks, we can evaluate enterprise architecture [3, 4]. Despite the importance of examine uncertainty in enterprise architecture, no action has been taken and exist approaches can’t describe uncertain cases.

In this article we want to do an assessment of enterprise architecture as fuzzy. the products of C4ISR enterprise architecture are classified into three categories: operational, systemic and technical, that in this paper, for evaluating the performance of enterprise architecture we focus more on systems products such as SV-4, SV-10 and SV-11. the proposed idea in this article is considered in Fig. 1.

The second part of this article evaluate the works which have done until now in enterprise architecture. In third section of the paper deals with fuzzy data. This section presents a class diagram with a fuzzy and by it enters uncertainty in the data structure and then by using diagrams for sequence cases mode and activity as fuzzy, we perform modeling fuzzy behavior. In forth section of this paper, diagrams obtained based on section, some algorithms are converted to colored fuzzy petri nets and evaluate it. The fifth section deals with an experiment on the system and, ultimately, section VI concludes and offers work for the proposed work.

Related Works: In enterprise architecture, much work has been done. Rezaei in [5] described the ways of evaluating the process of enterprise architecture. His article focus on the extraction of basic components, including enterprise architecture that we can sign to architecture of current desired situation and transition strategy. Javanbakht in [6], according to the architecture of exist situation as the origin, draws architecture of optimal situation. One of the methods which are used for breeding and development of enterprise architecture, is assessment of enterprise architecture maturity, but maybe the architecture of an organization doesn't have enough talent for improvement. In this paper, a method to measure whether they have enough talent to improve has been presented.

Javadpour in [7], presents a model for evaluating the performance of enterprise structure. In this study, at first he converts products of C4ISR framework enterprise structure to UML diagrams, then by proposing an algorithm, convert the UML diagrams to petri net graphs and finally by using the petri nets, measure the performance of enterprise architecture.

Also mozafari in [8], at first describe a way to verify the behavior of enterprise architecture and then by using an algorithm converts the products of enterprise architecture to petri nets diagrams and evaluate them. In the research provide by the levis, the framework of C4ISR enterprise architecture is used. In this study, he used integrated modeling language UML for describing enterprise architecture. Then levis offers an algorithm for converting UML diagrams to petri nets diagrams and then use them for evaluating the performance of enterprise architecture. All works cited by the researchers, focus on certain aspects of systems. Considering that in most real systems requirements describe uncertainty, these algorithms would not be efficient in these systems. What distinguishes this paper from other papers is the focus on uncertain aspects of system that fuzzy logic is used for this work.
Modeling Fuzzy Data and Describing C4ISR Products for Evaluating Performance by Linguistic Variables:

As we said in the previous section, the framework of C4ISR enterprise architecture has lot of products [2-8]. But for performance evaluation it just needs to investigate some of its products. These products include: SV-4, SV-10, SV-11. Each of these products for their expression use one or more of the UML diagrams. To model the product SV-4 (describing function of system) we use the activity diagram, for product SV-10 state and sequence diagram and for SV-11 (physical data model) the class diagram is used. So at first we must convert these diagrams to fuzzy diagrams by using linguistic variables.

Data Model of Fuzzy-UML: For modeling fuzzy data, the UML diagrams are used. Class diagram in UML are logical model which describe the main structure for the system. The classes and relation between them, are elements of class diagram. By enter the uncertainty to these elements FUZZY-UML data model is created. Based on data extracted from [9-14], there are three levels of the fuzzy system as follows: making fuzzy structure that in class, the data model apply according its contents in section as fuzzy characters. Fuzzy modeling in a way that some objects, specimens are desired?

Even assuming a class structure is certain and some objects with dependent level belonging to the class [0,1]. the third level of fuzzy modeling are applied an class subsection levels. An attribute in a class is described on a range that assumed for its slope attribute or class name must express with the words “ WITH MEM DEGREE” where 0=<MEM=<1 this show. The degree to which this attribute belongs to the class or class belong data to model. In third level, a key word fuzzy appears in front of the attribute. In the second level on fuzzy modeling, we should represent the degree of dependence one class sample to the class. For this purpose, an additional attribute in the class define to show the degree to which the sample belongs to the class and its slope is [0,1], we have a special attribute is denoted with µ.

“Z.Ma” in 2011 has provided an example about the bank account that fuzzy concepts are used in it. In Class shown in Figure 1, credit can be adjective consists of fuzzy values (third level of fuzzy modeling). In other words, credit adjective is a language variable that its scope include fuzzy sets (eg low/high). Type of class represent membership degree of credit adjective to the class (the first level of fuzzy modeling):

Fuzzy Sequence: When a service is presented as definitive, fuzzy use case become clear. After determining the definitive and indecisive cases, we draw the diagram of use case in UML, for applying use cases, we use sequence diagrams. If the use case is uncertain, the sequence diagram is uncertain too. A sequence diagram includes the operating, system and the message, that each message will include events and circumstances for the event. This diagram uses fuzzy rules for transforming from one object mode to another that fuzzy rules can be written as follow:

RULE= if <condition list> then <event list>

According to [11], uncertainty in method, including two stage fuzzy modeling : 1)the method membership degree choose. 2) decision logic. Figure 2 shows a sample fuzzy concept that object a with membership function µa(x) transform message of C to B object and B object with membership function µb(x) transform message of D to A object.

Fuzzy Petri Nets: In 2006, based on motameni, fuzzy petri networks can be apply to model the fuzzy rules, which is defined as follow [15,16]:

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\((P, P_s, P_c, T, TF, TRTF, A, I, O, TT, TTF, AEF, PR, PPM, TV)\)

\(P\) is a finite set of places. Each location is expressed by the following features:

- \(P_s \subset P\): a finite set of input places for primary events.
- \(P_c \subset P\): a set of output places for operations or the results.
- \(T\): is a finite set of fuzzy transitions. This places use the values of input places and produce values for output places.
- \(TF\): is a finite set of transition functions.
- \(TRTF\): \(T \rightarrow TF\) is a transition function that mapped every membership \(T\) to a member function of \(TF\).
- \(A \subset (P \times T \times P)\): a finite set of connections between places and transitions. The connections between input and transition sites \((P \times T)\) and the connections between transitions and output places \((T \times P)\) are expressed by them. So:
  - \(I: P \rightarrow T\) is an input mapping.
  - \(O: T \rightarrow P\) is an output mapping.
- \(TT\): is a finite set of fuzzy token type. Each token is linguistic variable (eg “low, high or medium”), which are expressed by a membership function.
- \(TTF: T \rightarrow P\) is the function of token type that mapping each fuzzy place of member \(P\) to fuzzy token type of member \(TT\).
- \(AEF\): Arc–Expression is a phrase function that mapping each connection to a phrase that holds the information.
- \(PR\): is a finite set of transitions that operate correspond to an event, condition, or operations.
- \(PPM: P \rightarrow [0, 1]\) is a fuzzy location for mapping transition where: \(|pr| = |p|\).
- \(TV: P \rightarrow [0, 1]\) the correct amount of tokens that mapping to table to the locations and express membership degree of a token to special location.

**Fuzzy-Uml Conversion Algorithm to Fuzzy Petri Nets:**
Due to the inability of UML in evaluation software systems, the necessary of converting real model (UML) to the formal model (FUZZY petri networks) is observed. Note that in this article for expression one of the products (SV-10) we used fuzzy sequence diagram, here we give an algorithm that convert this diagram into colored petri networks [17]. The algorithm is as follow:

**STEP1)** for each message in sequence diagram, all the events and circumstances should be specified. The events and conditions calculated for the dream activity is represented in Table 1.

**Table 1: Events and condition for dream activity**

<table>
<thead>
<tr>
<th>Rule</th>
<th>Event</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>E is E1</td>
<td>C1</td>
</tr>
<tr>
<td>R2</td>
<td>E is E2</td>
<td>C2</td>
</tr>
</tbody>
</table>

**Fig. 4:** Facing with more than one condition (OR)

**Fig. 5:** Facing with more than one condition (AND)

**Fig. 6:** Modeling consequent of fuzzy rule with aggregation

**STEP2)** the right conditions must be investigated. Therefore, we need to map it. For each condition we should put a transition that is responsible for validation of results. This means that the token can be expressed with a fuzzy value and its value is between 0 and 1. The complete analysis of the condition \(c\), which would be a fuzzy value that depends on condition. But must of the times we are facing with more than one condition. These conditions can be expressed as follows:

- \(OR = \mu_{AB}(x) = \text{Max}[\mu_A(x), \mu_B(x)]\) \hspace{1cm} (4)
- \(AND = \mu_{AB}(x) = \text{Min}[\mu_A(x), \mu_B(x)]\) \hspace{1cm} (5)

In Figure 8, Figure 9, two different common cases are depicted:

**STEP3)** events run if conditions are established. Fuzzy value calculated for evaluation results are used. Here’s for applying correct previous amount the result membership function is used. Aggregation occurs here as in figure 10. Finally, as the final output of a fuzzy system should be a certain value, you must convert the fuzzy value to a certain amount. This operation is based on COG test is done as follow:
Table 2: Fuzzy Rules For Weather System Online

<table>
<thead>
<tr>
<th>Rule</th>
<th>Condition</th>
<th>Table state</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>If(temperature is high &amp; pressure is low &amp; cloudy is unstable &amp; humidity is medium &amp; windy is strong)</td>
<td>Weather is storm</td>
</tr>
<tr>
<td>R2</td>
<td>If(temperature is low &amp; pressure is high &amp; humidity is high or humidity is medium)</td>
<td>Weather is Hail</td>
</tr>
<tr>
<td>R3</td>
<td>if(temperature is medium &amp; cloudy is unstable &amp; windy is strong or moderate)</td>
<td>Weather is rainy</td>
</tr>
<tr>
<td>R4</td>
<td>If(cloudy is stable &amp; humidity is high &amp; windy is calm)</td>
<td>Weather is snow</td>
</tr>
<tr>
<td>R5</td>
<td>If(pressure is low &amp; humidity is low &amp; windy is calm)</td>
<td>Weather is fog</td>
</tr>
<tr>
<td>R6</td>
<td>If(temperature is medium &amp; pressure is low &amp; humidity is high or medium)</td>
<td>Weather is shower</td>
</tr>
</tbody>
</table>

Case Study: In this section we evaluate the performance of an organization. Organization that we’ve chosen for our case study, the meteorological agency [18]. This is the organization for describing climate. Suppose that this organization wants to use an online system. For expressing climate, such the people enter to this and it report the weather base on weather conditions announced by the meteorological agency. Since weather conditions which are expressed uncertain (e.g. air pressure up or down “), the FUZZY UML is used to express how we use this system. According to the products listed in C4ISR framework, for expressing SV-10 products we use sequence diagram as our system is non-deterministic system. For describing the performance of this system, we use the following fuzzy sequence diagram:

For example, linguistic variables of temperature (high, medium, low) convert to crisp value by using membership function as below:

Since most parameters are declared by the meteorological agency with linguistic variables, FUZZY rules’ table of weather system is as follows:

The after drawing fuzzy sequence diagram of weather online systems, according to the proposed algorithm, we converted it to colored fuzzy petri nets. The obtained diagram is as follow:

In this section, we evaluate the performing model from the stakeholders perspective in architecture. For simulation petri diagrams, the software CPN/TOOLS and SHOW FLOW used.
Fig. 9: Fuzzy petri nets for weather system online

Fig. 10: Performance parameters diagram

**Response Time:** Response time is equal to the time that person or agent spent to receive service in the organization uses that this time includes the waiting time in queue and the spend for receiving time service.

**Processing Time:** Processing time is equal to the time interval between the beginning and the end of a process for the specific input. This time equal to the total time spent waiting in queue and the time spend for receiving services.

**Queue Length:** Queue length is equal to the number of vertebrae in the queue whenever the queue is removed from the vertebral or nut to be put in the queue.

**Performance Amount:** Operational efficiency is the percentage of time that a resource is busy.

Given the above description, we assume an exponential distribution with parameter time entry system is 0.1. Also, if the service time of each server to the client is an exponential distribution with parameter 0.5 And the second server is in the existing system and also out of people is an exponential distribution with parameter 0.3. Due to the mentioned parameters, the average queue length, the average percentage of busy server 1 and server 2, the number of inputs to the system and also the number of server to server 1 and 2 is plotted in the graph below:
CONCLUSION

In this paper, we describe an algorithm for evaluating the performance of C4ISR enterprise architecture framework’s products to do this. At first by using FUZZY-UML charts we modeled products for performance evaluation. But since UML is disabled in the evaluation of software systems, we transformed these charts to fuzzy petri networks by using an algorithm. Since the most requirements of real systems are inconsistent, in our proposed model to cover this issue, we used the fuzzy logic. Considering that in most software systems, certain parameters are used to evaluate performance, in this article, we tried to examine almost all performance parameters from perspective of system’s stakeholders.

REFERENCES


5. Reza Rezaei and Fereidoon Shams, 2009. Providing a comprehensive method for developing and evaluating enterprise architecture plan, the first Conf. on Enterprise Architecture in Practice, Isfahan, Iran, August.


