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FUZZY PETRI NET BASED E-COMMERCE SYSTEM DESIGN AND ANALYSIS

Suparna Karmakar[1], Tridib Chakraborty[2], Rajarshi Saha[3], Nirvik Roy[4]

Abstract- In today's daily life the online e-commerce based sites are gaining more importance for shopping purpose among more or less every human being. E-commerce based sites are more prone to suffer from various problems, such as lack of maintenance, products in availability, etc. And thus leads to the less profit in their business. In this work we have proposed an approach of handling products in availability by including an feedback mechanism to maintain the stock of products in all time basis. Also in this work we have included fuzzy constraints for maintenance of the web site. Modeling the total approach for handling all types of problems stated above we have used hierarchical modeling approach combined with the concept of Fuzzy Petri net model. Reachability analysis of this model also has been performed to ensure the liveliness or deadlock freeness of the designed model.
Keywords – Fuzzy Petri net, Hierarchical design, Fuzzy constrints, Reachability Analysis.

1. INTRODUCTION

In today's daily life all human beings are mainly motivated to do their shopping via online e-commerce based site. There are various kinds of online websites dealing with various products across all over the world. In website an user may find that a specific product according to his or her requirement is not available in the online E-commerce site. It may have possible that the websites are showing the product as unavailable or out of stock, which is a major problem for the customer across the globe. The excessive sale of a product sometimes can cause the eventual problem of unavailability of product. Excessive sale of any product mainly depends upon the demand of the product throughout the region where the service of online E-commerce site is available. It may happen that a product has been launched and it has gaining popularity . So depending on the quality the demand gets higher among the customers, which may eventually cause rapid sale in a given time period. This is also becoming a headache for the E-commerce organizations as time to time they are failing to fulfill the customers demand as they are having shortages of that specific product.

Besides the unavailable stock problem in any website there is another important problem of regular maintenance and regular updation in variety of products. As there are various systems all over the world such as windows, android, IOS and others. They are updating themselves to make the customer experiences better and better. So it is a burden for the online E-commerce websites that they should also be update themselves as well as for the betterment of the user and online vendor interacting system. As the time changes requirement of customers gets updated from the E-commerce website. But in case the updation takes a huge time which is not preferable for any customer. Hence the websites should update themselves to cope up with the requirement of customers. Maintenance of Ecommerce site is an important aspect for that we have proposed a solution in this work .

For handling the above mentioned problems associated with E-commerce website the Fuzzy petri net model has been used. Also the concept of Hierarchical designing method is applied in combination with Fuzzy petri net concept.

The rest of the paper is organized as follows. Related theory in section II. Proposed work and detailed modeling in section and Reachability analysis are given in section III.Concluding remarks are given in section IV.

2. RELATED CONCEPT

2.1. Fuzzy Petri Net:

Fuzzy Petri nets is a combination of Petri Net and fuzzy logic. Petri Nets are graphical, and mathematical modeling tool usually used for designing and analysis of discrete event systems. From [1], [2],[3],[4] it can be found that how the modeling techniques of Petri Net has been used in various fields such as computer science, automation and computer integration manufacture. The formalized definition can be found in [2], [3], [5].There are various types of Petri nets are available such as colour petri net, time petri net, Logical petri nets, Fuzzy petri net etc. In [6] the application of colored petri net, in [7] application of logical petri net, in [8] application of stochastic petri net cn be found. Now there are one interesting class of petri net is available called Fuzzy Petri net. The term "fuzzy logic" emerged in the development of the theory of fuzzy sets by

[1] Asst. Prof., Department of Information Technology, Guru Nanak Institute of Technology, Kolkata ,wb, India
[2] Asst. Prof., Department of Information Technology, Guru Nanak Institute of Technology, Kolkata ,wb, India
[3] Student, Department of Information Technology, Guru Nanak Institute of Technology, Kolkata ,wb, India
[4] Student, Department of Information Technology, Guru Nanak Institute of Technology, Kolkata ,wb, India

Lotfi Zadeh in 1965. Fuzzy logic is a set of methodologies that functions effectively in an environment of imprecision and/or uncertainty. Combination of these two gives a powerful tool to work efficiently in a real world system. Fuzzy Petri net [9] can be defined as 8-tuple(P,T,D,I,O,f, α,β), where

i. P : the finite set of places{p1,p2,…….}
ii. T : the finite set of transition {t1,t2,…….}
iii. D: a finite set of proposition {d1, d2,……}
iv. I: T→ P∞ is the input function mapping from transition to place of inputs.
v. O: P→ T∞ the output function mapping from transition to place of outputs.
vi. f: T→[0,1] is an association function, mapping each transition to a certainty factor,
vii. α : P→[0,1] is an association function, mapping each place to a truth value
viii. β: P→D is an association function, a bijective mapping from places to propositions

The techniques of modeling system using fuzzy petri net can also be found in [10], [11] and [12].

3. PROPOSED WORK

In e-commerce based system as we have identified different kinds of problems such as products in availability, lack of maintenance on a regular basis and as well as requirement to provide security about users data we are here to propose an fuzzy Petri net based approach. The model has been designed in an hierarchical approach. That is here starting with an identified process to handle a particular scenario, decomposition of a process into sub process has been done. The design has been performed in a top down approach. It is important that every sub processes are carried out successively, so that the overall process is maintained successfully.

When emergency situation occur, quick response should be given and also should be maintain to reduce huge amount of damage. For that reason a limited process can be maintained to overcome the emergency situation. The situation should be handled in such a way that the customers and the websites both remain consistent.

we are considering the E-commerce system conditions as the major concern of the fuzzy petri net model to handle the situation.

To find the solution of the above mentioned critical problem in E-commerce system we have included three major transitions- i) product sale(t1) ii) product demand(t2) iii) product quality(t3) are expected to occur simultaneously as shown in figure1 as its required for overcome the critical situation of E-commerce system. From the initial place (P1) we are having two transitions t1 (product sale) and t3(product quality). From transition t1 we are having place P2 which is the output of t1 and input of t2 (product demand) and P3 which is the output of t2.Thus the process of monitoring begins. Now in figure2 we are decomposing the transition t1,the product sale into subpart. Transition t1 has been decomposing into certain smaller parts as website maintenance (t11), product quality (t12) and feedback (t13).

Now the transition t11 has been broken down (as depicted in figure 3) into even smaller divisions of t11a (website server maintenance), t11b (website security maintenance (personal details)), t11c (website upgrade (easy to use)) and t11d (feedback), t11e (survey). Now after the decomposition we can see that the petri net model is having a survey which is checking whether the maintenance is required or not, after that a parallel transition of t11a, t11b, t11c whose output stored in the places respectively P1a, P1b and P1c. After coming to three places the result is going under the transition of t11d as a feedback and that has been stored into the place P11(as depicted in figure 3).

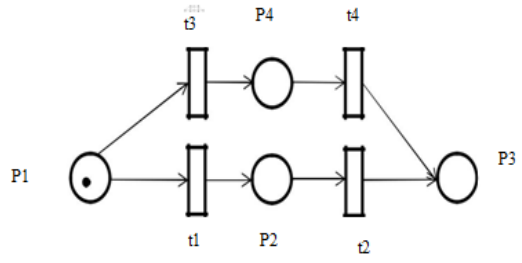

Figure1:Service Flow

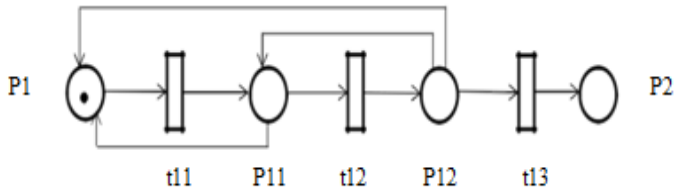

Figure2:Service Flow by decomposing t1

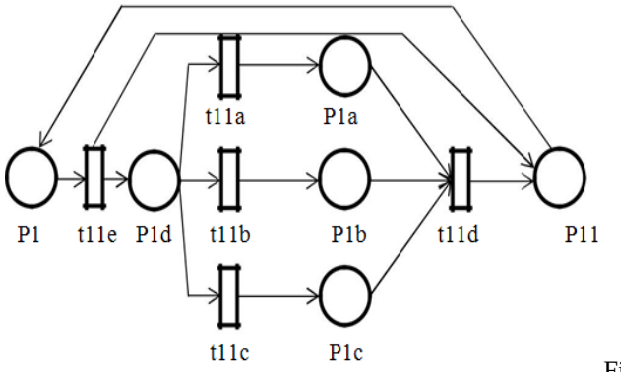

Figure3: Service flow decomposition of t11

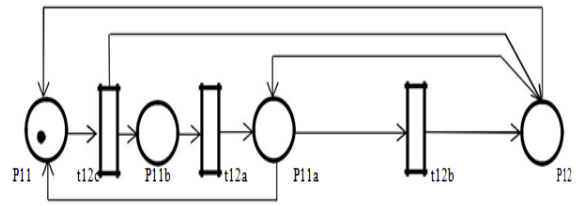

Figure4: Service flow by decomposing t12

Now the transition t12 has been decomposed(in figure4) into smaller transition as t12a (product material) and t12b (check for product quality user friendliness), t12c (survey) and we are having places P11a which is the input and output of t12b and t12a respectively and t12 which is output of transition t12b.

For the transition of t13 the decomposition has been done (depicted in figure5) as t13a (website feedback) and t13b (product feedback). Where t13a is the output and input of P12 and P12a and t13b is the output and input of the P12a and P2 respectively. To overcome the deadlock situation the arc of P2 needs to send to the Place P12a and place P12 according to the purpose of usages.

In figure 6 the decomposition has been made successively over the transitions t11, t12 and t13. In the first part we can see t11 has been decomposed into its smaller parts as t11a, t11b, t11c, t11d and t11e and the same has been applied to the other transitions also as we can see below.

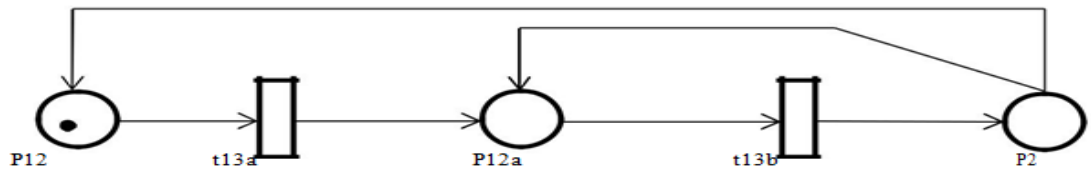

Figure5: Service flow by decomposing t13

Here t11e serves a pretty important aspect knowing as the survey or error checking. Here we are going to include some constraints (fuzzy rules):

If the transition is finding that the range of error is in between 0.4 to 1.0 then it will move forward for the other procedures which will work in parallel (t11a, t11b, t11c) as mentioned below and for a record will be accessed in t11d, hence if the error is in between 0 and 0.39 then it will automatically proceed for the next part of decomposition.

Now the feedback part will be stored in the place P11. As we can see the next transition t12 has been decomposed into smaller transition named as t12a, t12b and t12c. So the survey procedure will again come to play in here.

In this case t12c will be the decision making part whether to go through for the other checking procedures or not. Here we also using the passing range of 0.4 to 1.0 to check either to proceed for transition t12a and t12b or directly proceed for the next part i.e. P12.Here as we are talking about the part of t13, it's just about the part of website feedback and product feedback. At the end it will move further ahead for the transition t2(depicted in figure6)

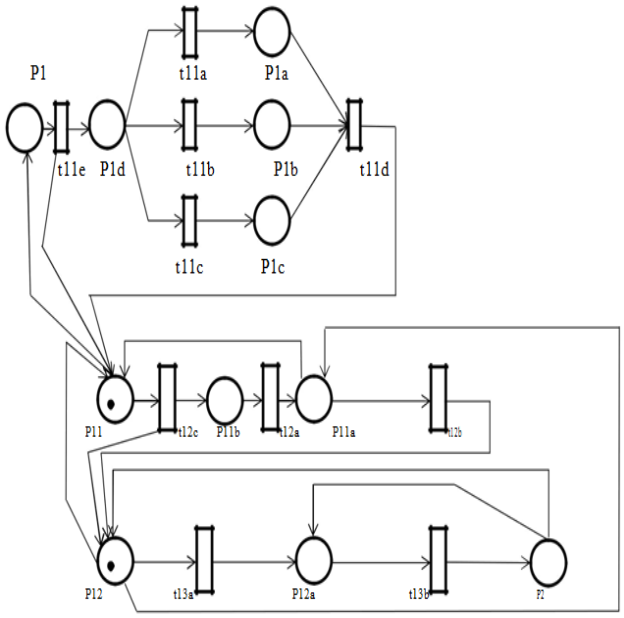

Figure6: combined service flow of all the decomposition of t1

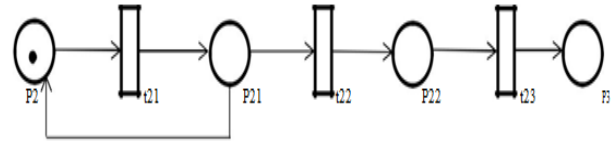

Figure7: Service flow by decomposing t2

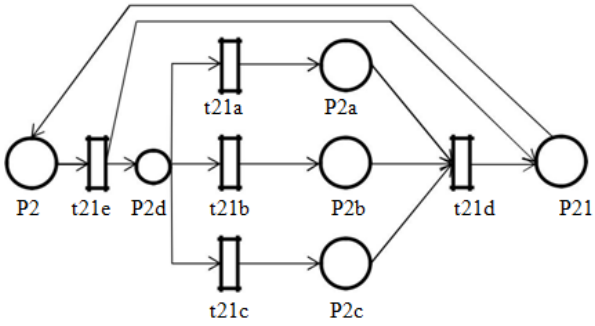

Figure8: Service flow by decomposing t21

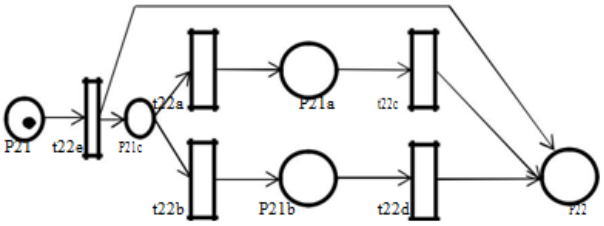

Figure9: Service flow by decomposing t22

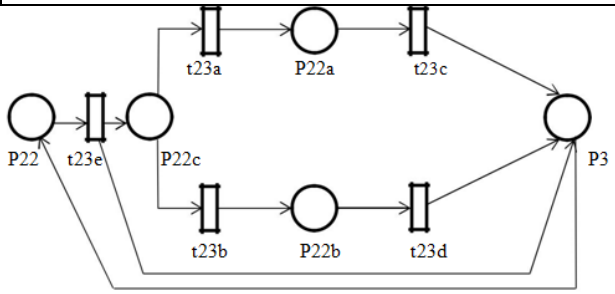

Figure10: Service flow by decomposing t23

Now we are decomposing the transition of t2 (as in figure 7) into smaller ones as t21 (product price), t22 (product specification and facility) and t23 (product lifeline). Here the arc of the place P2 is transiting through transition t21 and the output of the transition is stored in the place P21 and output arc again pass to the t22 and stored the output to the place P22, t23 is the transition process taking the input of place P22 and place P3 is output of the transition t23.

We are taking t21 which is here decomposed (as in figure 8) into four transitions as t21a (product material price), t21b (product production price), t21c (product market price), t21d (decision making) and t21e (survey). Here t21a, t21b and t21c is parallel transition taking input from place P2d and stored the output to the place P2a, P2b and P2c respectively. The final transition t21d taking the input from P2a, P2b and P2c and send output to the place P21. To prevent the deadlock situation the arc of P21 sends to the place P2.

The second transition of the decomposition (as in figure 9) of transition t2 is t22. Transition t22 also can be decomposed into t22a (facility according to cost), t22b (facility according to demand), t22c (feedback for cost of facility), t22d (feedback for demand of facility) and t22e (survey). In this decomposition model t22a, t22c and t22b, t22d are parallel transition where t22a taking the input from place P21c and throw the output to the place P21a and again the arc of P21a pass through the transition t22c and store to the place P22.In the other side t22b taking the input from P21c and store to the P21b and pass the arc for further process to transition t22d and finally the output arc store to the P22.

The third transition of the decomposition (as in figure 10) of transition t2 is t23. Transition t23 again decomposed into four transition t23a (price based lifeline), t23b (material based lifeline), t23c (decision making (price based lifeline)), t23d (decision making (material based lifeline)) and t23e (survey). In this model we use a parallel transition of t23a, t23c and t23b, t23d. Transition t23a taking the arc input from the place P22c and send to the place P22a and pass to the transition t23c and the output stored into place P3. Again t23b taking the input from the P22c store the output into place P22b and the output arc of the place P22b pass through the transition t23d and finally output of that transition t23d stored in the place P3.

Now in the figure 11 we can see the full decomposition of transition t2 where it's respectively broken into smaller transitions named as t21, t22 and t23. In the first part transition t21 is again been broken into smaller transitions named as t21a, t21b,

t21c, t21d and t21e where t21a, t21b and t21c are working in parallel position. . Here t21e serves a pretty important aspect knowing as the survey or error checking.

Now the fuzzy constraints which is included is as follows:

If the transition is finding that the range of error is in between 0.4 to 1.0 then it will move forward for the other procedures which will work in parallel (t21a, t21b, t21c) as mentioned below and for a record will be accessed in t11d, hence if the error is in between 0 and 0.39 then it will automatically proceed for the next part of decomposition. Now the feedback part will be stored in the place P21. As we can see the next transition t22 has been decomposed into smaller transition named as t22a, t22b, t22c, t22d and t22e. So the survey procedure will again come to play in here. In this case t22e will be the decision making part whether to go through for the other checking procedures or not. Here we also using the passing range of 0.4 to 1.0 to check either to proceed for transition t22a, t22b, t22c and t22d or directly proceed for the next part i.e. t23 which is again decomposed into smaller parts named as t23a, t23b, t23c, t23d and t23e. The survey procedure will again come to play in here. In this case t23e will be the decision making part whether to go through for the other checking procedures or not. Here we also using the passing range of 0.4 to 1.0 to check either to proceed for transition t23a, t23b, t23c and t23d or directly proceed for the next part i.e. next place.

Now t3 has been decomposed(as in figure 12) into four transitions as t31 (in stock), t32 (out of stock), t33 (feedback) and t34 (feedback (send message to the vendor)), t35 (survey). It's also a parallel transition between t31, t33 and t32, t34. t31 and t32 getting the input from place P33 and P34 respectively and throw the output to the place P31 and P32 respectively. P31 and P32 send the arc through the transition t33 and t34 and place P4 stores the output from t33, t34.

The first transition of decomposition t3 is t31 has been demonstrated in figure 13. Transition t31 again has been decomposed into six transitions in figure 13 as t31a (excess stock), t31b (purchase failure), t31c (market demand), t31d (report for excess stock), t31e (report for purchase failure) and t31f (report for market demand). t31a, t31b, t31c taking the input from the place P33 and also the output of those transition proceed through t31d, t31e and t31f respectively for further process. Finally the outputs send to the place P31 simultaneously from t31d, t31e and t31f .

The transition of decomposition t31 is t31b. Transition t31b has been decomposed (in figure 14) into six transitions as t31ba (non-user friendly), t31b2 (product price low/high), t31b3(non-trustable), t31b4 (feedback for non-user friendly), t31b5 (feedback for product price low/high) and t31b6 (feedback for non-trustable website). In this model t31b1, t31b4 and t31b2, t31b5 and t31b3, t31b6 goes on parallel transition taking the input from place P33 and stored all feedbacks to the place P3b.

Hence the final decomposition (as in figure 15) of t3 is t32. It's a liner transition decomposed into two parts t32a (product availability) and t32b (alert message send). Transition t32a taking the arc as input from place P34 and throw the arc as output to the place P3A. Arc of P3A send to the transition t32b for further processing and stored to the place P32.

Here in the diagram 16 we can see the full decomposition of transition t3 where it's respectively broken into smaller transitions named as t31, t32, t33, t34 and t35. Here is t35 is the main decision making part where it declares whether the product is in stock or the product is out of stock. Following fuzzy constraints are going to be checked:

In this transition if the range is from 0.2 to 1.0 then it will go for the transition t31 or if the range is from 0 to 0.19 it will go for the transition t32 and it will send a message to the vendor regarding the situation.

If the transition t31 has been committed then it will go through other smaller transitions i.e. t31a, t31b, t31c, t31d, t31e and t31f. If purchase failure takes place then it will go through other sub transition given as t31b1, t31b2, t31b3, t31b4, t31b5 and t31b6 and at the end it will be landing on next place and perform the last transitions t32a and t32b.

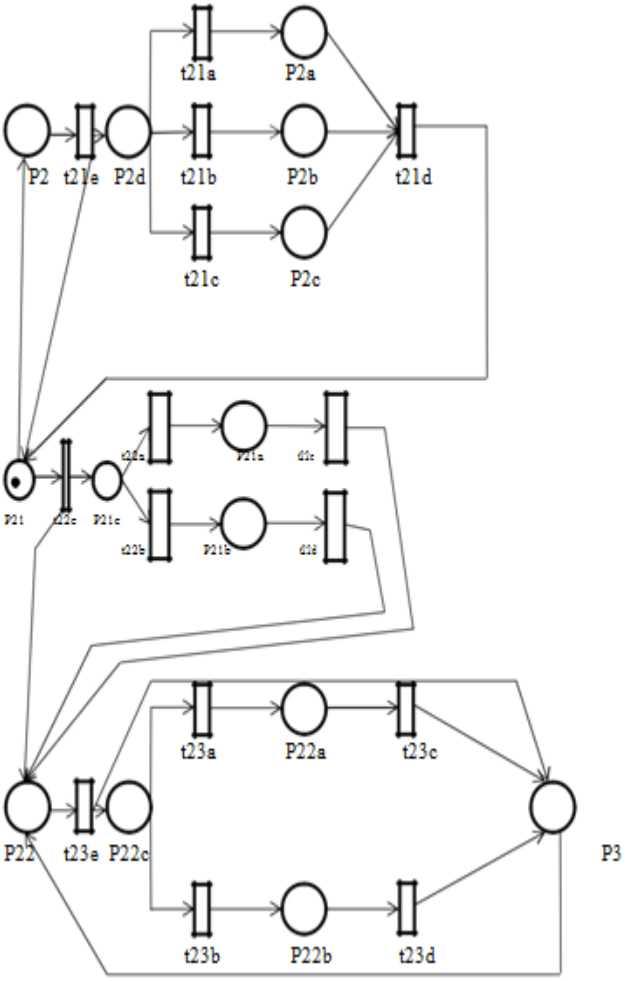

Figure:11: service flow by decomposing t2

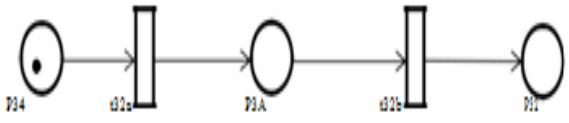

Figure15: Service flow by decomposing t32

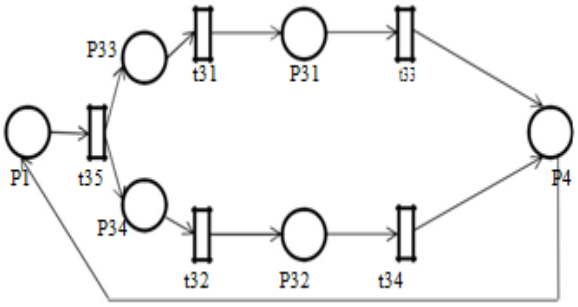

Figure12: Service flow by decomposing t3

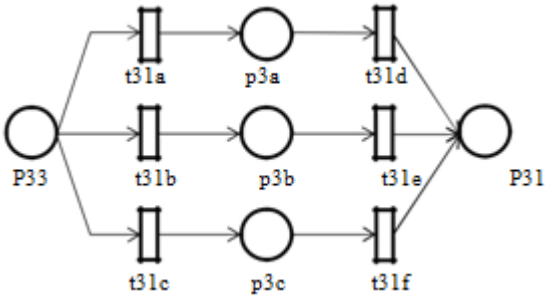

Figure13: Service flow by decomposing t31

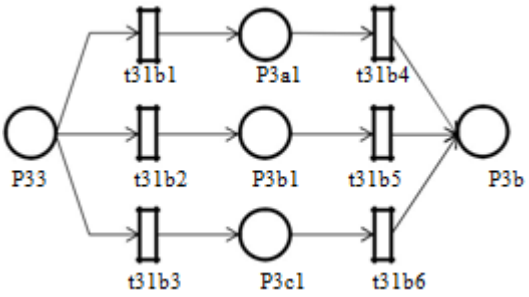

Figure14: Service flow by decomposing t31b

Now we can have the combined diagram as in figure 17 by joining all the decomposition of transition t1 using the following equation available in [13].

Composition operation of Petrinet:

Sharing Composition operation : Suppose that a net system is defined as Ni=(Si,Ti,Fi), where , i=1,2.

If S1 ∩ S2≠ ø & T1 ∩ T2= ø, then we call N=(S1US2 , T1UT2 , F1UF2) , is the sharing composition net[3] of net N1 and net N2, which is represented by N=N1 Cs N2.

The composite initial marking M0(s) for the composed net is represented as

$$M0(s) = \begin{cases} M0i(s),\ s \in Si - (S1\text{-}S2),(i=1,2) \quad \text{(where, M0i(s) is the initial marking of the ith Net)} \end{cases}$$

M01(s) + M02(s) -1, s Є S1∩ S2.

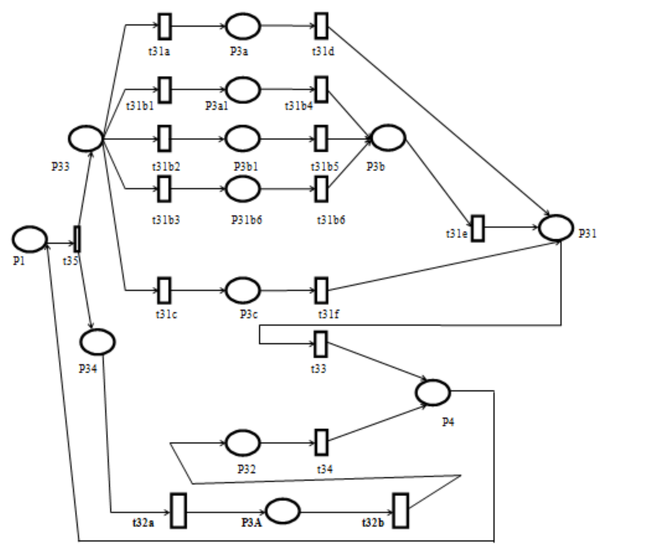

Figure16: Service flow by decomposing t3

Synchronous composition operation:
Suppose that a net system is defined as Ni=(Si,Ti,Fi) , where i=1,2 .
If S1∩S2=ø & T1∩T2≠ø, then we call N=(S1US2 , T1UT2 , F1UF2) is the synchronous composition net [3]of net N1 and net N2.
The composite initial marking M0(s) for the composed net is represented as

M0(s) = { M0i(s), s Є Si – (S1-S2) ,(i=1, 2) (where, M0i(s) is the initial marking of the ith Net)
M01(s) + M02(s) -1 , s Є S1∩ S2.

4. REACHABILITY ANALYSIS:

From the figure 17 we can assure that in every places there will be maximum of one token and hence the designed model is bounded. In figure 18 reachability graph for the figure 17 has been designed. The initial marking of this graph is M0 (1,0,0,0,0,0,0,0.0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0), where only place P1 is having token.And after firing t35 marking M1 will be (0,1,0,0,0,0,0,0,0.0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0) , i.e. P33 and P34 will have tokens. By following this approach it can be found that all the places are reachable and system is deadlock free.

5.CONCLUSION

In this work some problems associated with e-commerce site has been considered. To prevent this problem a fuzzy petrinet based model has been designed with some fuzzy constraints. As fuzzy petri net is a dynamic and marked graphical tool to handle fuzzy reasoning problems , the authors has used the fuzzy petri net to design and analyse the system. The reachability tree is also have been designed to ensure whether the designed model is deadlock free or not

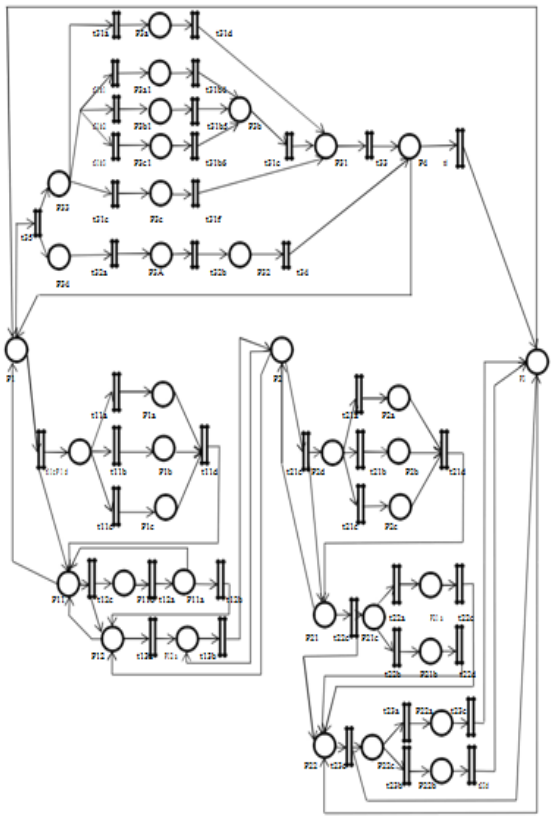

Figure17: Fuzzy Petri net model by combining all the decomposing

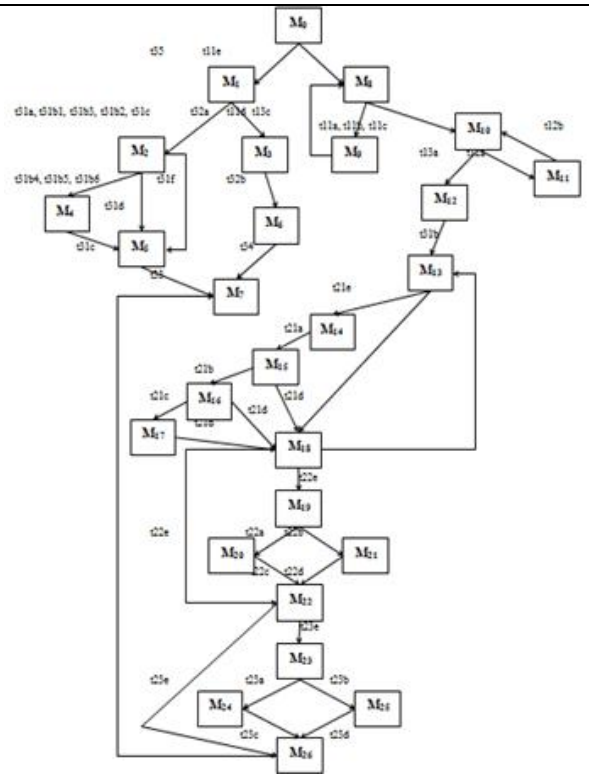

Figure 18:Reachability Tree

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