Simulation e-business applications using PNML

INES BROSSO
GRAÇA BRESSAN
WILSON VICENTE RUGGIERO
Computer Engineering and Digital Systems Department at the Polytechnic Scholl
University of São Paulo
Av. Prof. Luciano Gualberto, trav.3, n.158 CEP: 05508-900 São Paulo – SP
BRAZIL

Abstract : - This paper proposes the use of XML Petri Nets (PNML), a kind of high-level Petri Nets, for simulations Web-based systems, e-Activities like e-Business, Business-to-Business (B2B), e-Commerce and mobile applications wireless in the Web or ad-hoc networks.

The combination of Petri Nets and XML (Extensible Markup Language) files are emerging as an important approach for the specification of complex processing business tasks in distributed heterogeneous systems, allowing the follow-up of electronic business documents and data interchange process**.** In a Case Study, the proposed methodology is applied in the development of an e-business application, the customer surfs in the catalogue of products and adds desired items to its basket of purchases, the system verifies the authorization of the credit card and confirms the purchase immediately and soon sends an email to follow contends an identification code so that the customer follows its purchase.

Key-Words: - Petri nets, XML, Markov chains, Web-based systems, E-business, Simulation E-commerce, Distributed system

1 Introduction

E-business more and more tends to be each time used which had to the interfaces multiplatforms of integration with other technologies, using the resources of the Internet and e-mail to establish connection among the participants of the process. The applications in this environment must correlate the people to the businesses, with the necessary technologies to its optimization, that reflects the form wich that a group of people interacts to give course to a business process. Through the Internet, the software of e-business allow to integrate the business-oriented processes of a company with the world and its customers. From a personal computer in any place, an user can activate a process of business in the WEB which is generated in the instant where its URL will be referenced. Each user will be able to follow its processes being used to browser to surf in the Internet. With the increase of the necessity to develop electronic business-oriented applications in the more complex WEB each time, that possess mobility and interoperable, becomes necessary the evaluation of performance of these applications. For this, we will use a new kind of high level Petri Nets, the Petri Nets XML or Petri Net Markup Language (PNML), that besides keeping the mathematical formalism, the properties and the graphical representation of the Petri Nets, it uses language XML (Extensible Markup Language) to generate an archive with information of the Petri Nets, which could be integrated to other tools as MS VisualBasic, and systems managers of databases, to be used as database for a tool of simulation, analysis and visualization on the dynamic behavior of the modeling system, through the analysis of its properties and structural generalities.

The W3C (World Wide Web Consortium) recommends standards of XML in the exchanges of data in the E-Commerce (Electronic Commerce), for being an opened standard, the easiness to present information in browser (IE 5.0, Netscape and others), for the object representation and its properties and in databases to represent resulted of queries, etc. Two ways for XML document conversion exist: parsers and browsers. The Java language programming, is one of the most adopted in the implementation of parsers that analyze a XML document, converting it into a document HTML (Hyper Text Markup Language), thus its content can be visualized in environment WEB. [12]

2 XML Petri Nets applied to e-business

The most important characteristic of the PNML is the fact of being a mathematical formal model and to have a graphical representation that allows shape and study the characterized as asynchronous, distributed business-oriented systems, with high level of competition or parallelism, in discrete and/or random events, as in e-business, e-commerce and e-services.

A Petri Nets consists of places, transitions and arcs that connect them. The places can have marks, that indicate the current state of the system. The transitions are component assets, model the events that can occur, changing the state of the system and indicating if a transition is qualified or not. The transitions are qualified if all the conditions event will be fulfilled, the marks are removed and added in its exit places. The graphical structure of Petri Net are formed by a set of places *P*, a set of transitions *T*, a function of entrance *I* and an exit function *O* . The mapping is based on the theory of the multisets, having allowed that only one place (*P*), either considered as multiple entrances or exits of a transition (*tj*). Any model of Petri Nets, ordinary, place-transition, condition-event, Stochastic s, colorful, predicate-transition, the object oriented, interpreted, etc., can exist as XML Petri Nets (PNML), since that keeping its formalism and properties.[9] For business-oriented applications in such a way in the WEB as in ad-hoc mobile nets, it is preferable to work with Petri Nets of high level as the Stochastic s ones, colorful, predicate-transition or object oriented for possessing greater to be able of abstraction of the real world. Stochastic Petri Net is used in this work, for possessing the time condition that allows the construction of realistic models to evaluate discrete events systems for simulation. The use of Stochastic s Petri Nets allows to describe the mechanism watchdog and the construction of a graph of covering of the accessible states in simple cases where the ordinary Petri Net is limited, and the time intervals associates to the transitions are given under the whole number form. However, the size of the covering graph blows up quickly when the time intervals are very different and the description of the state of these nets must understand the secular information and the markings.

To use the markovian analysis is necessary that the systems are without past memory, that is, if an event to produce a detonation of transition *t* and to transform the *M1* marking into *M2*, the future evolution of the transitions that were sensitized by *M1* before the detonation of *t* will have to be identical to that the transitions would suffer if they came to be sensetized by *M2*. In the Stochastic Petri Net the duration of sensitization associates to the transitions are defined by geometric distributions, that allows to construct a markovian process equivalent that makes possible to analyze the Petri Net behavior. The duration of sensitization is a variate of exponential distribution probability *f(x)=1-e-yj*, where the function *f(x)* describes the probability that the detonation of transition *t* happens before date *j* and, therefore, that the duration of sensitization is lower to this date. [4]

A Stochastic Petri Net is defined by a *6-upla*:

{ P, T, I, M, 0, L }, where:

P is a finite set of *m* places, with *m > 0;*

T is a finite set of *n* transitions, with *n > 0;*

I is the entrance function that identifies all the places of entrance of a transition;

O is the exit function that identifies all the places of exit of a transition;

M0 is a function defined in *P,* where *M(p) is* the number of marks in place P.

M:p->n where *N* is the set of the whole numbers including the zero;

L is a set of detonation taxes associates to the transitions of the Petri Nets that obey an exponential distribution, the detonation taxes can have its dependent value of the number of marks in the places of the net.

2.1 PNML Properties in e-Business

The verification of a business-oriented application with Stochastic s Petri Nets can be effected through the analysis of the properties of Petri Nets, which are extensible to the PNML. The properties of the Petri Nets applied in e-business are listed below:

. Limited: If the maximum number of markings in all places can not exceed the maximum number of marks that a place can contain in any marking.

. Alive: Through the vivacity property, we can verify if an application won't suffer stoppage for imperfection (deadlock) and if exists some state or sequence of states that never will be reached.

. Restart: It is possible, from any state *M* to return to the initial state *M0*. Through this property it is possible to observe the cyclical or repetitive behavior, or if the application is restarted after to reach one definitive state.

. Mutual Exclusion: In Petri Nets, two transitions are in mutual exclusion if they never be qualified simultaneously.

. Conserve: It is used when is needed to verify if the marks of a place increase or decrease, or if they remain constant.

. Contact (Overflow): This property verify if a transition cannot be gone off by the lack of legal capacity in some place.

. Conflict: The conflict implies in the existence of two or more possibilities, in case that one occurs, another one never will occur.

. Parallelism: It implies that all the activities could be executed at the same time.

3 PNML in e-business application performance

The development of a business-oriented application, demands of its developers to beyond the knowledge of the business considers the e-business application route definition, the logical way defined under specific rules, has the function to inside transfer the process information binding the activities. For our study, we will make the modeling of a fictitious e-business application, an abstraction of a real world, through the Stochastic s Petri Nets represented graphically in described Figure 1 and in Table 1.

"*With the page of purchases opened in the browser, the customer surfs in the catalogue of products and adds items desired to its basket of purchases. When the customer desire to pay, describes the delivery address, supplies the information of the credit card and confirms the purchase. The system verifies the authorization of the credit card and confirms the purchase immediately and soon sends an email to follow contends an identification code so that the customer follows its purchase.*

When the product will be available, the system will direct the product to the delivery company and will bring an up to date to the situation of the purchase. At any time the customer will be able to consult its purchase for the Web site."

Now, we will study the case through the following steps:

1.Step: Modeling the e-business Application through the Petri Nets

The Petri Net is composed by:

. One set of places *P={P1, p2, p3, p4, p5, p6 }* that represents business or activities.

. One set of transitions *T={t1, t2, t3, t31, t4, t5, t6 }* that represents events associates with the business, linked for arcs that connect places to transitions and transitions to places.

. *M={1,0,0,0,0,0}* is a set of initial marks in the places that together with the registrations in the arcs represent the application flow.

In e-business many business-oriented processes occur simultaneously and an application can be seen as a sequence of discrete events, the changes happen due to occurrence of an event.

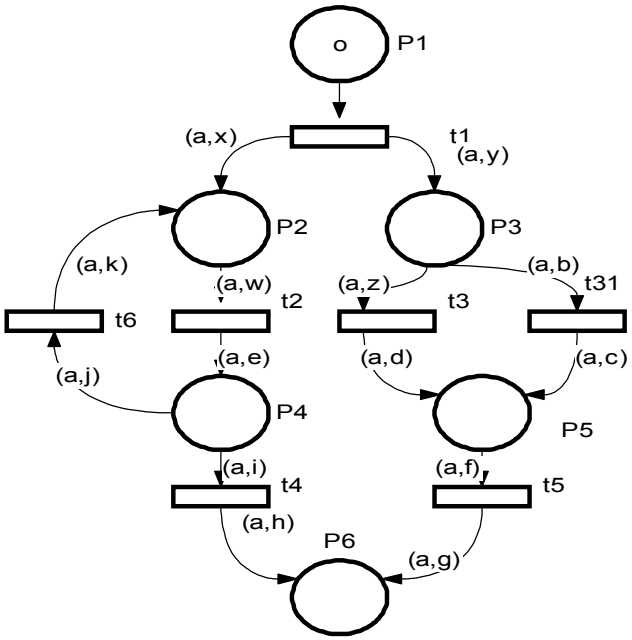

Fig.1 - Graphical Representation of the Petri Nets

Table 1 identifies the places and the transitions of the Petri Nets.

Place / Transaction	Interpretations
P1	Access the e-business application site to purchase by Internet
T1	Fulfilling the e-business electronic form fields
P2	Verify fulfilling the e-business electronic form fields
P3	Access database of the e-business system
T6	Verify the hierarchies APPROVAL identification
T2	Verify approval field (s/n)
T3	Electronic Form is sent to the responsible mail box
T31	Verify if there are the specified item in the warehouse
P4	the electronic form is directed to the Credit Card Company
T4	Consistency of the Credit Card
T5	Delivery the material to the customer
P6	There aren't the requested material in the warehouse

From a Stochastic s Petri Net we can build a Markov Chain, following the steps:

1) The Markov Chain corresponds to the set of accessible markings of the Petri Net with initial marking *M0*;

2) The state change tax *i* (associated with *Mi*) for state *j* (*Mj*) is $q_{ij} = \Sigma\, l_k$, for all pertaining *k* to the set of all the transitions qualified for marking *Mi*, whose detonation generates the *Mj* marking. The states are the accessible markings. The tree of accessible markings of the Stochastic s Petri Net is a Markovian Diagram, then exists a mathematical isonomy (1->1) between Stochastic s Petri Net and Markov Chain.

The matrix *M* of transition taxes is written directly from function *L*. the column *j* of *M* describes the evolution of the *Pj* probability of the *Mj* marking from *Mi*. Its value is negative therefore describes the transition tax that allows to abandon state *Mi*. The stationary regimen of the markovian process is given by the vector Π, solution of the equation $\Pi Q=0$ with $\Sigma\, \Pi i = 1$, that allows to calculate the average value of the number of marks in a place.

2.Step: To codify in XML the graphical representation of the Petri Nets

Observing Figure 1, we will make the e-business application codification with XML language, in the note block (NOTEPAD) of the Windows. All XML document is marked by "tags", the minor signal (<) and greater signal (>) are delimiters. Tag initial is < pnml xmlns.....> and indicates the root of XML document. The end of the document is defined by </pnml >. The same logic for the beginning and end of the document inside applies for each register and each field of exactly (in our case the Petri Nets information in Fig.1). The content properly said is after each tag of beginning and before tag of end. The structure of a XML document can become complex, with many fields, tables (information contained in the DTD) and Schemas (projects) for consistency of the data. [5]

To simplify we will show to only one part of the codification of the application e-business in XML, that is the representation of the Petri Nets.

```
<?xml version="1.0"?>
<pnml xmlns="htpp://www.larc.usp.br/ines/pnml.dtd">
<net id="p1" type="pnml">
 <nome>
   <value>rede de petri xml in e-business</value>
 </nome>
  <lugar id="p1">
   <nome>
     <arco><arco lugarp1 ="1"/></arco>
     <value>p1</value>
   </nome>
    <marcainicial>
    <arco><arco lugarp1 ="1"/></arco>
     <value>1</value>
    </marcainicial>
   </lugar>
<lugar id="p2">
   <nome>
    <arco><arco lugarp2 ="2"/></arco>
     <value>p2</value>
    </nome>
    <marcainicial>
    <arco><arco lugarp2 ="2"/></arco>
     <value>0</value>
    </marcainicial>
   </lugar>
<lugar id="p3">
   <nome>
    <arco><arco lugarp3 ="3"/></arco>
     <value>p3</value>
    </nome>
    <marcainicial>
    <arco><arco lugarp3 ="3"/></arco>
     <value>0</value>
    </marcainicial>
   </lugar>
<lugar id="p4">
   <nome>
    <arco><arco lugarp4 ="4"/></arco>
     <value>p4</value>
    </nome>
    <marcainicial>
    <arco><arco lugarp4 ="4"/></arco>
     <value>0</value>
    </marcainicial>
   </lugar>
<lugar id="p5">
   <nome>
    <arco><arco lugarp5 ="5"/></arco>
     <value>p5</value>
    </nome>
    <marcainicial>
    <arco><arco lugarp5 ="5"/></arco>
     <value>0</value>
.....
.....
.....
  </arco>
</net>
</pnml>
```

F ig.2 - Code of XML

3ºStep: To execute XML code in browser:

Lets elaborated XML code and execute it in browser, Internet Explorer, and observing it in the Fig.3.

We can observe that before each element a signal of less(or more) exists that can be used to inside diminish (or to expand) a level of the hierarchy attributed to archive XML. To have access the data generated in archive XML, it is enough to use a XML Parser, that is an interpreter how to read archives XML, there are some XML Parsers, in this work we opted to use Microsoft XML DOM (Document Object Model), that is an API to work with XML documents. There are some API's to work with XML documents. The basic types are Tree-Based (based in trees) or Event-Based (based in events). The API's based in tree creates a structure of data in the memory, representing the data of archive XML, this type of API allows fortuitously to have access any knot inside of the document, exactly because the data are after processed the shipment in the memory.

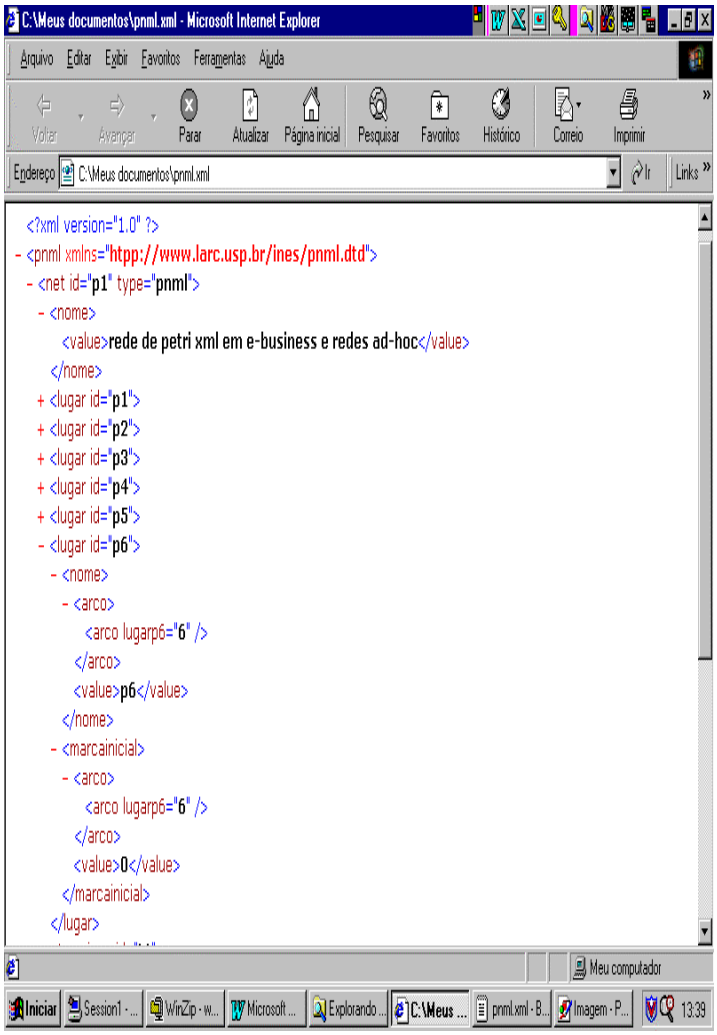

Fig.3 – XML in Web browser

The DOM is part of this type. The API's based in events is focused in the action of interpretation of XML document and allows to execute action when loading any knot of the document, when using this type of API, the code offers a sequential access to the data, the code will process knot-the-knot, example of this API is the SAX (Simple API will be XML).

The DOM is a standard that defines an object model, becoming possible to interpret and to create given way programs. The DOM represents an established hierarchy of us in tree. To each level below of the top (except when existing an only knot), we they can have children (a knot son is that one that is tied with one another one), relatives and brothers. They can also contain we of commentaries and us of processing instructions. To read the information in XML, a project in Visual MS beginner's all-purpose symbolic instruction code must be created, first, must be instance Microsoft XML in Visual MS beginner's all-purpose symbolic instruction code, the Project-References menu, the item Microsoft XML. After to make this, must be created a module for reading of archive XML. To work with a XML document an instance of the DOMDocument object must be created. To load the information of archive XML or an 0 variable, method LOAD is used and to load an 0 variable string of the memory, uses the LoadXML method. In both the cases a True value is returned if the data will be loaded or Falsify if some error occurred. Microsoft XML loads the data without synchronization , for standard. This makes with that a return of reception of data to the server is passed, very useful in an application customer-server. In the server, the return alone must be sent when the processing to finish, must be used an instruction stops to define the shipment way without tunning. To load data XML of an archive, one uses the instructions: 1º Me.txtXML that is a control that stores the content of archive XML 2º strFile that it is the way and the name of archive XML. To load data XML of an 0 variable string that it is in the memory, uses the following instructions: 1º strXML that it is an 0 variable that has content XML. With these commands, it is possible to visualize any archive or content XML.

3.3 E-business application Performance Analysis

The e-business application was shaped with the Stochastic s Petri Net and codified in XML language, the semantic ones they had been express in terms of Petri Nets. XML document executed being generated an archive text with information of the PNML. With the result of generated XML archive it can be analyzed, to validate, to simulate the application e-business, to verify

the behavior in the net and make the verification of the properties of Petri Net, being worked the data can be made the reached trees (map of the markings you reached).

4 Conclusion

It is verified that the PNML is an open standard. The complexity of the data that if wants to store in a XML document will grow proportionally to the complexity of the application business-oriented and the Petri Nets. Tools as language ASP, MS VisualBasic and data bases managers could be used in the simulation and analysis of the application, using the data generated for XML document. Other native tools of the XML, as DTD and Schema also can be used to validate the data of the XML. The group "Brics" of the University of Aarhus, together with the AT&T, developed a language Schema DSD (Document Structure Description), that uses boolean logic and regular expressions to describe the trees and to improve the XML extensibile, and appears as option to the use of native DTD and Schemas of the XML. As suggestion for future works, to intensify the study of protocols and standardizations that are appearing in the area of Wireless, in order to improve the mobility of business-oriented applications with the technology wireless.

References:

[1] AALST, W.M.P.van der; "Inheritance of Interorganizational e-business: How to agree and disagree without loosing control" In Proceedings of the Second International Conference on Telecommunications and Electronic Commerce, october/1999

[2] BOLCER, Gregory Alan
"Magi: Architecture for mobile and disconnected Workflow" IEEE Internet Computing - May/June 2000 pp.46-54

[3] BRUNO,R.
"WLAN Technologies for Mobile ad hoc Networks" Consiglio Nazionale delle Riecerche Instituto CNUCE, Pisa. Italy e Proceedings of 34TH Annual Hawaii International Conference on System Sciences Jan/2001.

[4] CARDOSO, Janette; VALETTE, R.
"Redes de Petri" Editora UFSC, 1997

[5] DSD: A Schema Language for XML
<URL:http://www.brics.dk/DSD/dsd.html>

[6] FREY, Georg; LITZ, Lothar
"XML based Interchanges format for Petri Nets-A Control Engineers Point of View" position paper 19/5/2000University of kaiserslautern , Department of Computer Science, Germany

[7] HAYES, James G.; PEYROVIAN,E.; SARIN S.
"E-business Interoperability Standards for the Internet "IEEE Internet Computing - May/June 2000 pp.37-45

[8]JAIN, Raj; The Art of Computer System Performance Analysis :Techniques for Experimental Design, Measurement, Simulation and Modeling" John Wiley & Sons, INC., 1991

[9] JUNGEL, Mathias; KINDLER, Ekkart; WEBER Michae , "The Petri Net Markup Language" ,Workshop AWPN, Koblenz, Germany ,October/2000

[10] KIM, Yeongho; KANG, Suk-Ho
"WW-Flow: Web based e-business management with runtime encapsulation" IEEE Internet Computing - May/June 2000 pp.55

[11] KUMMER, Olaf; WIENBERG Frank, MOLDT, University of Hamburg , Department of Computer Science- 2000

[12] LENZ,K.
"Modeling Interorganizational e-businesss with XML Nets"Proceedings of 34TH Annual Hawaii International Conference on System SciencesJan/2001.

[13] MAURER, Frank; DELLEN Barbara
"Merging Project planning and Web-Enabled Dynamic e-business technologies" IEEE Internet Computing - May/June 2000 pp.65-74

[14] PEHA,John M.
"Wireless Communications and Coexistence for Smart Environments"IEEE Personal Communications - October 2000 pp.66-68

[15] PURVIS,M. e LEMALU,S.
"A Framework for distributed e-business system"
Proceedings of 34TH Annual Hawaii International Conference on System Sciences Jan/2001.