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Performance of Distributed System

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Abstract

Many distributed systems are still too large to be handled. Thus, it's important to find techniques that can be used to extend the size of the systems that can be verified and analyzed. In this paper, we study the qualitative and quantitative performance of the distributed systems that can be interacting with each other by using Temporized Stochastic Petri Net (TSPN) [5]. We consider then the composition asynchronous operation for deducing properties of a global distributed system from the properties of its components [2, 9]. Introduction of a structured interface net allows us to preserve properties of components in the global system.

Keywords: *Distributed Systems, Temporized Stochastic Petri Net, Liveness, Boundedness and Interface Net.*

1. Introduction

Using a standard web browser, the user can access information stored on Web servers situated anywhere on the globe. This gives the illusion that all this information is situated locally on the user's computer. In reality, the Web represents a huge Distributed System (DS) that appears as a single resource to the user available at the click of a button. According to Leslie Lamport [10], a distributed system is defined as "one on which I cannot get any work done because some machine I have never heard of has crashed". This reflects the huge number of challenges faced by distributed system designers. Despite these challenges, the benefits of distributed systems and applications are many, making it worthwhile to pursue. Performance modeling and evaluation constitute an important aspect of the design of distributed systems. Performance models are mainly of two types : simulation and analytical. In this paper, we propose to use Temporized Stochastic Petri Nets (TSPNs) as an analytical models to study the conception and evaluation of performance of DS.

The paper is organized as follows : Section 2 outlines an introduction to TSPNs with an illustrative example. In section 3, we propose a composition of components via a structure of interface in order to facilitate the conception and performance evaluation of DS. Section 4 presents the preservation of qualitative and quantitative properties of the global system. Finally, Section 5 concludes the paper.

2. Temporized Stochastic Petri Net (TSPN)

Petri nets have emerged as a prominent modeling tool of concurrent systems. A class of timed Petri nets called Temporized stochastic Petri nets (TSPN) are well suited for performance modeling. In the framework of TSPN and Extended stochastic Petri nets, several features of distributed system such as concurrency, non-determinism and synchronization can be captured in an elegant way. Informally, any TSPN comprises a set of places, a set of transitions, a set of arcs, an initial marking; a random variable, and a time interval are assigned to transitions.

In the TSPN representation of a distributed system, places represent logical conditions or resources in the system; transitions represent events or activities; arcs represent interdependencies among places and transitions; initial marking refers to the initial state of the system; and the random variables model the durations of various activities in the system. The evolution of a TSPN in time constitutes a stochastic process called the marking process. The use of TSPN as an analytical model is based on a set state analysis of the marking process.

Example of TSPN:

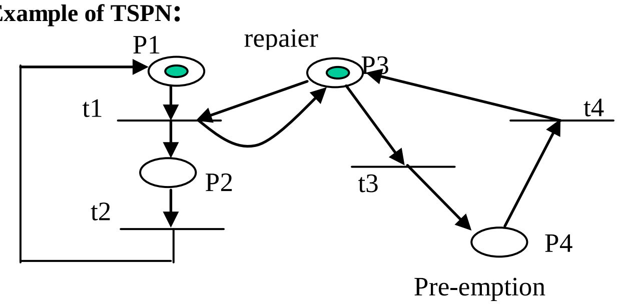


Fig1. Breakdown and pre-emption process.

Table 1: Distribution functions of example above

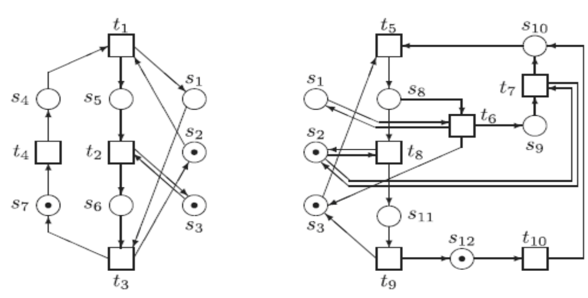
Transition	Density
t1	δ (x-10)
t2	(1/100)exp (-1/100)x
t3	δ (x-4)
t4	δ (x-5)

A Temporized Stochastic Petri Net is called event graph [4] if and only if each place has exactly one transition in input and one transition in output.

3. Structure of interface between the components of DS Equations

3.1 Asynchronous composition of TSPN

Generally speaking, a composition operation of distributed systems combines two models into a single one whose behavior captures, in some sense, the interaction between that two models. There are two major ways of forming the composition of two models, synchronous and asynchronous, and for each of them different variants are known. In synchronous composition, the models run and synchronize on actions from a given set of actions. The main use of such an operation is for coupling a system with a tester which tests for the satisfaction of a given property. Opposite to the synchronous composition is the asynchronous composition, which does not assume any action synchronization but the systems may communicate via a set of shared variables (locations). The execution of such a system can be viewed as the interleaved execution of the components. For example of asynchronous composition of Temporized Stochastic Petri Net, we present Owicki–Lamport's Mutex algorithm [8] of composition of two models TSPN (reader and writer).



s_1 = writer involved
s_2 = writer detached
s_3 = reader detached
s_4 = prep1
s_5 = prep2
s_6 = writing
s_7 = producing
s_8 = pend2
s_9 = failed
s_{10} = pend1
s_{11} = reading
s_{12} = using

Fig 2. Tow components of TSPN.

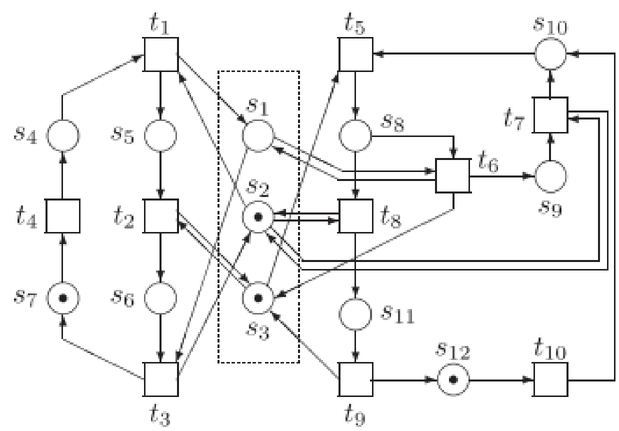


Fig 3. Composition of the two components above

It consists essentially of two sites: the writer and reader site, the first one to the left, and the second one to the right, of the dash box in figure. The net uses three flags: the flag writer detached (s2) signals to the reader that the writer is presently not striving to become writing, the flag reader detached (s3) likewise signals to the writer that the reader is presently not striving to become reading, and the flag writer involved (s1) is just the complement of writer detached (for a detailed discussion about this net model the reader is referred to [11]). These two sites of the net in Figure 3 are connected each other by means of s1, s2 and s3.

3.2 Structure of interface

In the case of asynchronous composition, the interface places are used by a component to interact with an environment [9]. During an execution, their content is updated by the system (component) or by the environment. The content of the internal places can be updated only by the component itself.
The aim of this section is to propose a new structure of interface between components in a distributed system that preserve some qualitative and quantitative properties in the global system.

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The interface is defined as follow:
Let N0 be a Temporized Stochastic Petri Net, with P0 and T0 the set of places and set of transitions respectively. T0 is the union of the sets of T01, T00 and T02. We say that N0 is a structure of interface S0 if and only if
a) (P0, T0) generate an event graph GE [4, 6].
b) $\Gamma(T0) \subseteq P0$; that means, P0 is the set of input and output places of T0.
c) For all Ωi, elementary circuit, of GE, the set of places of Ωi is S-Invariant (i.e the total of the tokens in Ωi remain invariant during the execution).

d) $\forall\, t\in T0/\, t^{*} \cap P0\neq\phi \Rightarrow f_{t}(x)=\delta(x)$, with t^{*} is the set of input places of the transition t, and f_{t} distribution fonction .

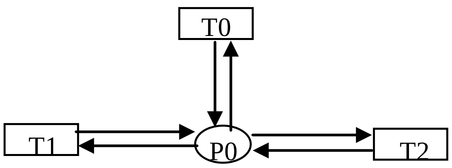

Fig 4. Interface S0

In figure 5 below, the chanel representes the interface S0 between the producter (P) and consumer(C) with T0 null.

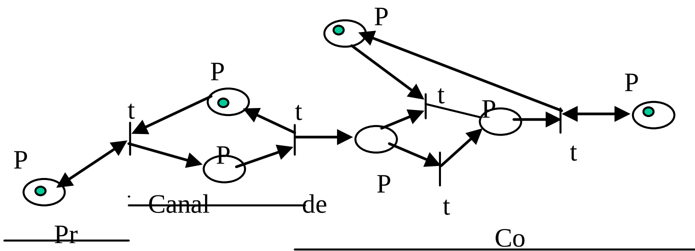

Fig 5. Canal de transmission as S1

4. Preservation of properties by the composition of components via S0

The goal of this paragraph is to deduce the properties of the global system from those of its components.

4.1 Qualitative properties

We are interested here by the livness and boundedness properties.
The first property liveness permits to control the dysfunction of the distributed system. We say that a transition ***t*** is live if from any reachable marking, there is a reachable marking enabling ***t***. If we expect that the activity modeled by ***t*** can always take place from any state, ***t*** shoud be live.

We take into account that we consider in our study of Temporized Stochastic Petri Net the case of the memory of trajectory [5].

Proposition

Let N1 and N2 two Temporized Stochastic Petri Net. The composition of N1 and N2 via the interface S0 generates a Temporized Stochastic Petri Net N. Then, N1 and N2 are live $\Rightarrow$ N is live. In otherwise, the composition via the interface S0 preserves the property liveness. This means that associate many components of the distributed system which are live via interface S0 guaranties that the whole system is also live.

Proof: For each marking M in the N then M/Pi is a marking of Ni ; where M/Pi is a projection of M to Ni and Pi the set of places of Ni. Also, for each marking Mi of Ni there is a marking M in the N such that M/Pi=Mi. This result is deduced from 3.2 c). This remark is the main idea for proving the result looked for.

The second qualitative property is the boundedness which ensures that each place of the net is bounded (for example, there is no overflow in storage areas).

Proposition

Let N1 and N2 two Temporized Stochastic Petri Net. The composition of N1 and N2 via the interface S0 generates a Temporized Stochastic Petri Net N. Then, N1 and N2 are bounded $\Rightarrow$ N is bounded.

Proof: Let p be a place of N, Mi a marking of Ni and k an integer such that Mi (p) <=k. For each marking M in the N, M/Pi (p) <=k since the number of tokens is not changed in the Ni, then M (p)<=k. This is deduced from 3.2 c).

4.2 Quantitative property

Execution path is a quantitative property which can be defined as (Ei,σ,Ef); where Ei is the initial state and Ef is a final, and σ a transition sequence from Ei to Ef.

Proposition: Let N1 and N2 two Temporized Stochastic Petri Net. The composition of N1 and N2 via the interface S0 generates a Temporized Stochastic Petri Net N. Then, if (Ei, σ, Ef) is a path execution of N1(or N2), then (Ei, σ,Ef) is an execution path of N.

Proof: The proof is deduced from the fact that, for any transitions' sequence σ in N, the projection of this transition' sequence σ/Ti is a transitions' sequence of Ni.

5. Conclusions

In this paper we've shown that the complexity of distributed system can be dressed by studing its components. By using the composition of Temporized Stochastic Petri Net, we have introduced a new structure of interface wich preserve the qualitative and quantitative

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properties of components in the global system. In the perspective, we shall present new structures of interface that will preserve other properties.

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