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Research and Application of Time Workflow Model Based on Timing Constraint Petri Nets

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Abstract

In order to visualize time information of the complex workflow system, time parameter concept is firstly introduced to workflow model, and then a new modeling and time parameters calculating method for the practical business process system are proposed based on timing constraint Petri Nets(TCPN). Finally, an insurance claim process is modeled based on TCPN workflow model, which suggests that it is effective and consistent with the specification of the system requirement.

Keywords: Workflow; time workflow model; timing constraints Petri Nets; insurance claim.

1. Introduction

Workflow management technologies have attracted great attention from researchers around the world in recent years. Time information modeling, verification and analysis are the most basic and core problems in Workflow Management System (WFMS)[1]. Time violations in WFMS can often lead to some negative influences such as increasing cost, unexpected delays and resource wasting, or even cause catastrophic breakdowns within business processes.

A workflow model is used to capture a process abstraction and includes an activity structure and information exchange among activities in a workflow, exception handling, activity duration, and priority

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attributes[2]. However, there exists no standard for the temporal behavior of workflow modeling. In time modeling of workflow processes, Ling and Schmidt[3] provided a time interval extension of WF-nets for the purpose of modeling and analyzing time constraint of workflow systems. They emphasized on checking the soundness of workflow process definitions, and endowed an interval for each transition. Eder et al. determined timing inconsistencies at model time and found the optimal workflow execution resources at run time using the time information generated[4]. Marjanovic assigned a time interval to individual workflow tasks as duration constraints, checked various temporal requirements and inconsistencies of workflow systems by using their proposed verification algorithms [5, 6].

However, Most of the existing work on time Petri nets have focused on using random variables to describe uncertainty of the workflow time information, or just introduces local time concept, and moreover, most of them do not present the calculation method for the token's time parameters. Therefore, a time constrained workflow model for describing time information of the complex workflow system is presented, and the calculation method for time parameters of TCPN is put forwarded. Finally, a study case is used to illustrate its feasibility.

2. Basic concepts of TCPN

Petri Nets originated from the early work of Car Adam Petri[7] has the advantages such as formal semantics, local state-based system description, and abundant analysis techniques[8~10]. Its use as a mathematical foundation for the formal analysis of workflow models is also very attractive. The following concepts will be applied in this paper.

Definition 1. Timing Constraint Petri Nets (TCPN) is defined as a 6-tuple (P, T, F, TC, D, M): where

P denotes a finite set of places**,** i.e., $P=\{p_1, p_2, \ldots, p_m\}$.

T denotes a finite set of transitions**,** i.e., $T=\{t_1, t_2, \ldots, t_n\}$ and $P \bigcap T = \varnothing$, $P \bigcup T \neq \varnothing$.

$F \subseteq P \times T \bigcup T \times P$, denotes a directed arcs of connecting places and transitions.

TC: $P \bigcup T \rightarrow R^+ \times R^+$ denotes a set of integer pairs related with places and transitions, remarked by $[TC_{\min}(p), TC_{\max}(p)]$ and $[TC_{\min}(t), TC_{\max}(t)]$ respectively.

D denotes a set of execution durations of transition, remarked by $T_d(t)$.

M is a set of marking with m-vector for describing system state, $\{M(p_1), \ldots, M(p_j), \ldots, M(p_m)\}$, where $M(p_j)$ denotes the numbers of token in place p_j, M_0 denotes the initial marking.

In general, the time pairs associated with transitions are referred to as transition time pairs and those associated with places are referred to as place time pairs. For the duration times which are associated with transitions like timed Petri nets do, we say they are transition durations. For those places and transitions without explicit timing constraints, the default values of place time pairs or transition time pairs are (zero, infinity) and the default value of transition duration is zero.

Definition 2. Workflow model is a set of activities abstracted from actual business process, which is often used to define concrete workflow. It includes all kinds of information needed by workflow when being executed.

Definition 3. A Petri-net $PN=(P, T, F)$ is called a WorkFlow net(WF-net) if:

(1) PN has two special places: i and o. Place i is a source place, namely $\bullet i = \varnothing$. Place o is a sink place, namely $o\bullet = \varnothing$.

(2) If we add a transition t^* to PN so that $\bullet t^* = \{o\}$ and $t^* \bullet = \{i\}$, then the resulting Petri-net is strongly connected.

To specify the timing constraints, WF-net is extended with time information, leading to Timing Constraint WorkFlow net(TCWF-net). Here, two kinds of timing constraints should mainly be discussed: internal and external ones as shown in the following.