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A Context_Aware Workflow Model With Time Management

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Abstract. In the ambient intelligence field, workflow technology is gaining a lot of consideration. Ambient intelligence systems are composed of heterogeneous distributed devices. They are context-aware, and they can adapt to the contexts changes. Thus, context-aware workflow modeling is the main issue. Context-aware workflow management allows workflows to adapt dynamically to environmental changes; additionally, it depends heavily on time management. Generally, time violations require exception handling, which makes temporal constraint specification at design time a critical step. The method presented in this study for modeling context-aware workflows involves incorporating time-constraint information into the workflow specification. The main contribution is defining a formal spatio-temporal model that considers all feasible workflow executions. First, we specify the workflow using the algebraic language Time-AgLOTOS. Then, based on this specification, we build the corresponding labeled transition systems that illustrate the feasible executions. Finally, we give an example to demonstrate the usefulness of the research.

Keywords: Modeling Information in Smart Environments · Context Awareness · Ambient Intelligence · Formal Description· Workflow· Time Management· Formal Method

1 Introduction

Many studies are increasingly considering workflow technology for business process modeling and execution in ambient environments [1, 2]. An intriguing area of study is context-aware workflow, which enables workflows to adapt to contexts on-the-fly in a pervasive environment[3]. Time management is essential to workflow management, especially in this context. Time violations typically raise system costs because addressing exceptions would be necessary. It is imperative to describe time-related information in the workflow specification phase, such as temporal dependencies between activities, their durations, and consistency-checked deadlines [4].

The modeling of the time constraints linked to relationships between activities is the main focus of the material published thus far on workflow time management. A well-known method is workflow nets (TWF-nets) [5], and Time-BPMN [6], an extension of the Business Process Modeling Notation [7]. However, due to the rapid development of the Internet of Things (IoT) and the global demand for data [8]. Cloud computing alone can not handle this volume of data [9]. Fog computing has consequently gained popularity as a paradigm for data processing [10]; many studies discussed the use of scheduling algorithms considering time constraints of activities [11–13]. Therefore, workflow scheduling algorithms at the run time will carry out tasks according to the specification while attempting to meet the deadline to identify and change inconsistent execution to a consistent one. In the scheduling issue, a Task may have deadlines. When two tasks execute, we can compute their start and end times. A time model can be used to determine the possibility that the system will run without errors for a given time. Khennaoui et al. proved that AgLOTOS has a rich expressiveness when representing the workflow control semantics in an ambient environment[3]. AgLOTOS is a formal technique based on process algebra that allows the workflow description to be in consideration in the verification process[14].

In this paper, we suggest considering Time-AgLOTOS[15] for modeling workflows with time information within an ambient context to represent the remaining aspects, such as temporal constraints. The proposed model can be used in the verification process to check some contextual properties. First, we describe the workflow model we assume in this paper. Next, we demonstrate our design methodologies using a healthcare example.

2 Time-AgLOTOS for workflows

Van der Aalst defines workflow as business process automation during which documents, information, or tasks are passed from one participant to another according to a set of process rules [16]. The goal of the workflow system is to guarantee that activities execute within accurate periods. Therefore, consideration of temporal constraints should take place during the design phase. This paper proposes a model of workflow based on Temporal constraints using Time-AgLOTOS. In [3], the authors consider AgLOTOS to improve workflow specification; they model communication and mobility and include contextual information in workflow model states. In[15], the authors presented an extended version of AgLOTOS to enhance the notion of time; so that each action performs within a temporal domain. By associating specific timing constraints with behavior expressions. e.g. $a@t[SP]; E$, $\Delta^d E$. In this paper, we consider Time-AgLOTOS to handle temporal constraints for workflow. The timed AgLOTOS expressions are written by composing actions through the LOTOS operators [17]. Time Ag LOTOS is an algebraic language that describes temporal information such as deadlines and delays; this is beneficial in modeling context-aware workflow since they need to adapt on time to context changes. Context awareness necessitates time management, such as meeting task deadlines. Our approach allows modeling formal temporal workflow models based on mathematical methodologies used in the verification process. In the next section, we will give the syntax of Ag lotos and a brief definition of each operator.

Syntax of Time-AgLOTOS The general syntax of Time-AgLOTOS is defined as follows:

$$P ::= E$$

$$E ::= stop \mid exit\{d\} \quad (d \in \mathcal{T})$$

$$\mid \Delta^d E \mid E \odot E$$

$$\mid a@\,t[SP]; E \quad (a \in \partial)$$

$$\mid hide\, L\, in\, E$$

$$\mathcal{H} ::= move(l) \quad (\mathcal{H} \subset \partial, l \in \ominus)$$

$$\mid x!(v) \mid x?(v) \quad (x \in \mathcal{U}, v \in \mathcal{M})$$

$$\odot ::= \{ \mid [L] \mid, |||, \gg, [], \|, [>\}$$

For the detailed definition of each operator within the workflow context, please check [14, 15]. Where ∂ is a finite set of observable actions, L is a subset of ∂ and $\mathcal{H} \subset \partial$ is the set of Ambient Intelligence primitives that present mobility and communication; $\ominus$ is a set of spatial localities of the pervasive environment. $\mathcal{U}$ is a set of users, which can communicate, and $\mathcal{M}$ is the set of messages that can be sent or received. An essential component of a process definition is its behavior expression E A behavior expression can result by applying an operator to other behavior expressions. A behavior expression may include instantiations of processes. Termination: In Time-AgLOTOS, same as LOTOS, it is possible via the operator stop that indicates the inaction, while the exit operator expresses the successful termination. A=fail, A fails because of the dynamic context of the workflow. Prefix: the operator ; prefix a behavior expression with an action (actions are the elementary units executed by activities). Hiding: The expression hide L in E represents the explicit hiding of actions mentioned in L, making them unobservable. Respectively. The set $\odot$ represents the standard LOTOS operators [17]: Sequence: the sequential composition operator $\gg$ is used to describe the Sequence pattern (a loop in a process allows the repetitive execution of activities $P ::= E \gg P$. Choice: A [] B, activity A or B can run its execution. Disabling: During the activitys execution, it is possible to indicate its failure with the disabling operator '[>'. $A[> B$ activity B may disable A this interrupts the main flow and uses stop instead of exit. Parallelism: $A \mid [L] \mid B$ if the process is ready to execute an action at a synchronization gate, it has to wait until the process offers the same. Full synchronization $A \parallel B$: if L = ∂ the two composing activities must execute in complete synchrony. Pure interleaving: (operator'|||') if L= $\emptyset$, the absence of synchronization leads to the non-presence of interaction points among processes. The time specifications will constrain the actions and behaviors. Let E be an expression containing action a. $d \in \mathcal{D}$ be a time value. $\mathcal{D}$ is a domain of time ($\mathcal{Q}^{+} or \mathcal{R}^{+}$) attached to a. $a\{d\}$ means that a is a timed action whose starting interval is $[0, d]$, whereas $a@t[SP]; E$ $(a \in \partial)$ means $a@t[min < t < max]$ $SP = min \sim t \sim max$, such that $\sim \in \{<, \leq\}$, with $min, max \in \mathcal{D}$. Here, t records the time passed since enabling a and will be set to zero when a ends its execution. In other terms, a should be both started and achieved between the enabling moment, where a can begin; and the end moment, where a must terminates. The specification of E can be by $\Delta^{d}E$, which describes temporal delays. This operator means that no evolution of E is only possible after the elapse of a period equal to d.

3 Case study

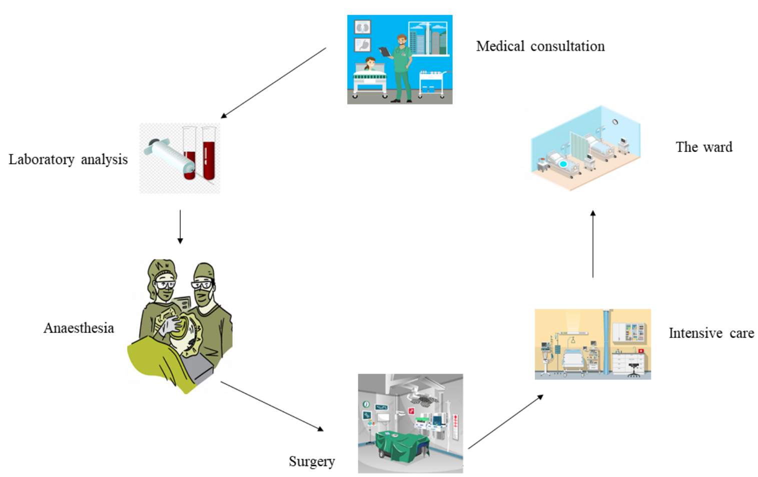


Fig. 1. A medical process

In this section, we present a formal contextual model with time information in the workflow specification of the medical process; each actor has a digital personnel assistant.

Fig. 1 describes the surgery process; the doctor examines the patient and can ask for tests, then schedule the patient for the surgery. The anesthesiologist is informed to go to the operating room at a specific time (the time of the surgery). After the anesthesia, the surgeon and the assisting nurses will run the medical operation; the patient will be first in the intensive care room and then the ward.

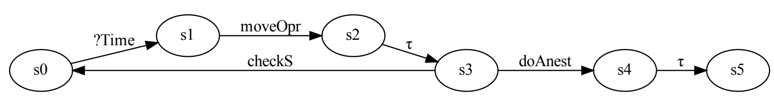
A set of sub-processes in parallel execution can describe the medical process, but we will consider only the anesthesiologist process.

Doctor ||| surgeon ||| patient|||anesthesiologist ||| nurses ||| laboratory-test

The Time-AgLOTOS description of the anesthesiologist is:

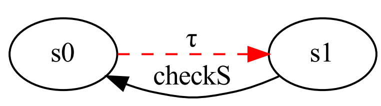
x?(timeofsurgery); move(operating-room)@t1[t1 $\leq$ 2];do anesthesia @t2[3 $-$ t1 $\leq$ t2 $\leq$4 $-$ t1]; exit;

The graph below illustrates the running example where nodes from s0 to s5 represent the system states, and the arcs are the transition (actions) as a labeled transition system.



That means that the action "move to the operating room" is carried out before the flow of two units of time which denotes the action's deadline; the same with the anesthesia action where its deadline is one unit. Otherwise, fail.

The resulting graph will be as shown below, Where the red label refers to the failure in carrying out the task.



4 Conclusion

Context awareness is the ability of workflows to react to environmental changes. Time management is a crucial aspect of workflow management. In this study, we presented an approach to model context-aware workflows; by incorporating time-related information in the workflow specification. We specified the workflow using the algebraic language Time-AgLOTOS, which allows a formal description of time information. The proposed model could be in use in the verification process. For future works, we aim to consider resource management.

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