Binary Collaboration Models related to Manual Activities

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Abstract. The operational implications of manual activities in business processes lead to an interesting case study on binary collaborations in which situations of clashing interactions appear. This paper analyzes three situations involving manual activities and proposes three collaboration patterns to deal with them. These patterns are presented by means of a notation based on colored Petri nets in which most transitions are related to interactions. A solution to the problem of clashing interactions is illustrated as well.

1 Introduction

Collaboration models are meant to specify how a number of participants have to interact in order to achieve a common goal. Binary collaboration models are concerned with the interactions taking place between two participants and they can be the starting point for building multi-party collaboration models, as discussed in [1].

Various approaches and notations have been proposed, but they basically fall into two categories: 1) a collaboration model can be presented from the point of view of one participant (the point of view of the other participant being complementary), and hence it is made up of communication actions (i.e. sending actions and receiving ones); 2) or it can be formalized from a neutral perspective based on interactions. An interaction is a kind of abstract entity as in reality it encompasses a sending action on one side and a receiving action on the other side. Behavioral interfaces [2] belong to the first category, while UMM [3] and WS-CDL [4] fall in the second one.

In both cases a collaboration models consists of a number of communication entities (communication actions or interactions) placed in a suitable control structure. For this reason, in principle, the structure of collaboration models is similar to that of business processes and the results, such as the workflow patterns [5], obtained from the study of the latter can be applied to the former as well.

This paper analyzes the collaboration taking place between two major components of a process-driven information system, i.e. the Process Manager (PM) and the Task Manager (TM). A process-driven information system, also referred to as a PAIS (Process-Aware Information System [6]), is basically an information system equipped with business processes, which specify the order in which manual activities and automatic ones have to be performed. Business processes are formal descriptions to be interpreted by PM which, in fact, orchestrates their execution by calling the services of the underlying information system (for the automatic activities) and by interacting with TM for the manual activities. TM is in charge of mapping the manual activities,

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as seen by PM, to actual tasks, as seen by the users, and of notifying PM of the results provided by such tasks.

This paper analyzes three situations involving manual activities, from the point of view of the collaboration between PM and TM, and proposes three collaboration patterns addressing these situations. Such patterns are presented by means of a notation based on colored Petri nets [7], in which most transitions are related to interactions.

These patterns show circumstances in which two or more transitions are enabled and they refer to interactions in opposite directions; this means that the participants may take different paths and, as a consequence, they will produce clashing interactions. This paper presents an approach, based on priorities, which enables the participants to reconcile.

The organization of this paper is as follows: section 2 introduces the notation used for collaboration models and explains how to deal with clashing interactions; section 3 presents the collaboration patterns between PM and TM; section 4 makes a comparison with related work; section 5 presents the conclusion.

2 Modeling Binary Collaborations

This section introduces the notation used in this paper to represent binary collaborations.

A binary collaboration takes place between two participants (i.e. two business processes), which are abstractly referred to as the left participant (LP) and the right one (RP). The reason for these terms is that binary collaborations are usually exemplified by means of UML sequence diagrams having exactly two roles, one on the left and the other on the right.

The notation is based on a special kind of colored Petri nets [7], called i-nets, as shown in the examples presented in Figure 1. Transitions fall into two categories: regular transitions and interaction-oriented ones. In Figure 1, only interaction-oriented transitions appear. Interactions can be one-way or two-ways, although only the first category appears in this paper. A one-way interaction indicates the name of the message and its direction. For example, transition t1 contains interaction *a* followed by a right arrow (→): this indicates that the interaction is initiated by LP, which sends message *a* to RP. The left arrow (←) indicates that the interaction is initiated by RP. The description of messages is omitted for the sake of simplicity. The initial node is connected to the first transition.

Binary collaboration models can be interpreted as abstract behavioral models of the participants as far as the interactions are concerned. In fact, in the model shown in Figure 1.a, LP is assumed to send *a* and then wait for either *b* or *c*, while RP is assumed to receive *a* and then send either *b* or *c*. Therefore LP makes the first move (by sending *a*) and RP makes the second one (by sending *b* or *c*). Both participants follow the same path in the net and take the lead in turn.

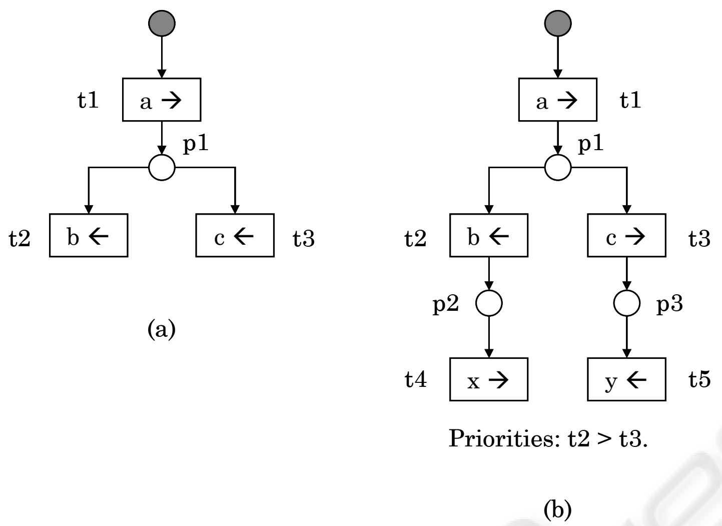


Fig. 1. Examples of collaboration models.

There are situations, however, in which the participants may take different paths at a fork and, as a consequence, they will produce clashing interactions.

A fork is a situation (more specifically, a marking in the net) in which two or more transitions are enabled. If they refer to interactions in the same direction (such as t2 and t3 in Figure 1.a), all of them are initiated by the same participant: this participant makes the choice, and the other one follows.

On the contrary, if there are two or more transitions enabled and they refer to interactions in different directions (such as t2 and t3 in Figure 1.b), both participants may initiate an interaction at the same time, thus taking different paths.

A way of reconciling the participants is needed; this is based on the priorities given to the clashing transitions, as discussed with the help of Figure 1.b. From place p1, the two participants may follow different paths: RP may decide to send *b* at the same time as LP is sending *c*.

The clash can be detected in several ways: for example, if each message is followed by an ack from the receiver, the clash is detected by RP, if it receives *c* instead of *ack(b)* after sending *b*, and by LP, if it receives *b* instead of *ack(c)* after sending *c*. If the priority is given to message *b*, as shown by means of annotation "t2 > t3", the right path is the one taken by RP, so LP is to abandon its path and accept interaction *b*. In this example, RP turns out to be the winner, while LP is the loser.

As to message *c*, which has actually been sent by LP and received by RP, there are two ways of handling it: it can be accepted anyway or it can be rejected. In the first case, RP is meant to process message *c*, while in the second case, RP will ignore message *c* and LP will undo the actions related to the production of *c*. The first behavior is the standard one; the second behavior is indicated by a "-" following the lower-priority transition. Therefore if the annotation in Figure 1.b were "t2 > t3-", message *c*, in case of clash, would be completely ignored.

The annotation must establish the priorities for all the clashing transitions in the net.

A particular function of colored tokens in i-nets is to manage the correlations among the messages, as follows. A collaboration model, such as the one in Figure 1.a, exists in several instances, in the sense that several collaborations of that kind can take place simultaneously between the same pair of parties. For example, at a given instant, party A has sent a number of messages *a* to party B, while no message *b* has been sent yet; this means that several transitions t1 have been performed and several tokens are in place p1. When party B replies with a message *b*, which *a* is this *b* a reply to?

The solution adopted in i-nets is based on correlation values carried with the messages. When a transition receives a message, it reads the correlation value from the message and sets the correlation attributes in the outgoing tokens. Therefore, when transition t1 receives a message *a*, it delivers a token to place p1 having its correlation attribute equal to the value read from message *a*. When transition t2 receives a message *b*, it matches the message with the proper input token on the basis of the correlation value of *b* and the correlation attributes of the tokens in p1, and removes that token from p1.

The standard color is called CC (correlation color): it has no additional attributes and is omitted from the models for the sake of simplicity.

3 Collaboration Patterns

A business process is a collection of interrelated activities which fall into three major categories: manual activities, automatic activities and control-flow ones.

A manual activity is carried out by a specific (human) user with the help of a suitable GUI (graphical user interface). The "task" term is often used to denote a manual activity as perceived by the user in charge of it. A task encompasses all the low-level interactions a user has to carry out through the GUI (e.g. entering textual information, selecting items from lists, giving commands) in order to achieve a particular purpose, such as placing an order.

Automatic activities are carried out without human intervention. Control-flow activities are special automatic activities which control the flow of action; decision nodes, merge nodes, fork nodes and join ones are common examples.

There are several notations and XML-based languages addressing business processes: the former include BPMN [8], while the latter include XPDL [9].

In traditional information systems (i.e. those in which processes are not explicitly defined) a user can select the task to carry out through a menu showing all the possible tasks compatible with his/her role. In a process-driven information system, there is a new category of tasks, called process-driven tasks, corresponding to the manual activities defined in the business processes. Such tasks are usually presented to the user in a list, called to-do list showing the name of the task as well as some specific information.

From a logical point of view, three major software components are involved in the operation of a process-driven information system: the Process Manager (PM), the Task Manager (TM) and the Enterprise Information System (EIS). PM interprets the business processes (e.g. their XML representations) and orchestrates them by interacting with TM and EIS. EIS is a conceptual entity encompassing all the software components needed to operate on the underlying business objects. In order to perform an automatic activity, PM requests a service of EIS, since a business process has limited processing capabilities. When a manual activity has to be carried out, PM requires a service of TM, so as to include the task description in the performer's to-do list.

Manual activities indicate the rule for selecting the performer (i.e. the user appointed to fulfil the task). In most cases, the performer is selected among the users playing a certain role, often on the basis of a load-balancing criterion. However, there are situations in which the selection depends on the information flow: for example, the performer of task "accept order" is the account manager of the client organization that issued the order to be examined. The resource patterns presented in [10] provide a number of techniques for the selection of the performer.

This section analyzes three situations involving manual activities, from the point of view of the collaboration between PM and TM, and proposes three collaboration patterns addressing these situations.

In the models below, PM is the left participant and TM the right one.

Pattern SASR (Single Activity – Single Result)

This is the most frequent case, in which a manual activity corresponds to a single task. For example, activity "accept order" brings about a task for a single performer (i.e. the account manager of the client organization that issued the order).

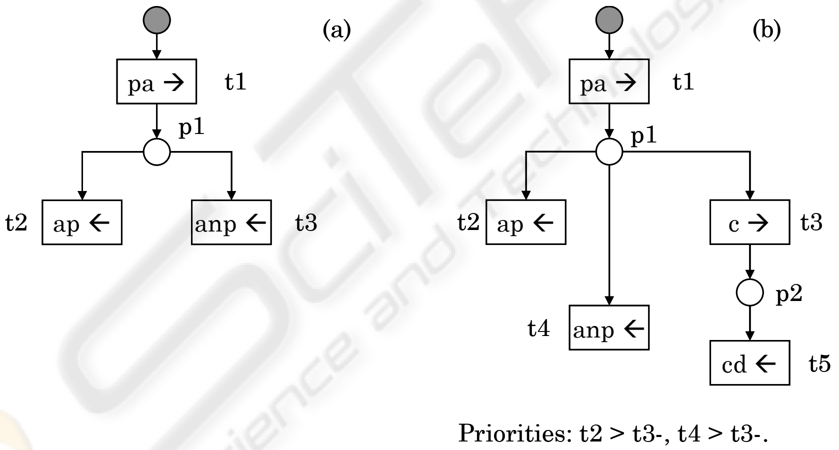


Fig. 2. Collaboration pattern SASR.

Two models are shown in Figure 2, the first is the basic one, and the second exhibits clashing transitions due to cancellation message *c*.

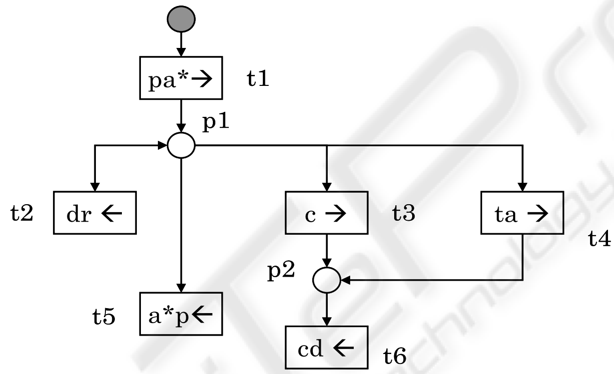
In the first model, shown in Figure 2.a, PM starts the collaboration by sending message *pa* (perform activity), then waits for either message *ap* (activity performed) or message *anp* (activity not performed) to come.

The parameters of message *pa* include: the name of the task, the performer, the business objects to be acted on, and the deadline. The parameters of the other messages are omitted for the sake of simplicity. The meaning of message *ap* is that the activity required has been successfully performed and a result has been produced: the information on the result is returned in the message. Message *anp* returns the reason why the task has not been performed (e.g. deadline elapsed or user's refusal).

In the second model, shown in Figure 2.b, PM can send cancellation message *c* so as to make TM cancel the task, and TM replies with message *cd* (cancellation done). However TM may be sending message *ap* (or message *anp*) at the same time as PM is sending message *c*, so a clash may happen. In this case, as the annotation gives priority to messages *ap* and *anp*, the cancellation message is ignored and the collaboration ends normally.

Pattern SAMR (Single Activity – Multiple Results)

As an example, manual activity "review paper" is meant to make a conference paper reviewed by a number of reviewers (those associated with the paper). TM will produce several actual tasks, one for each reviewer involved, and will notify PM of each review produced.



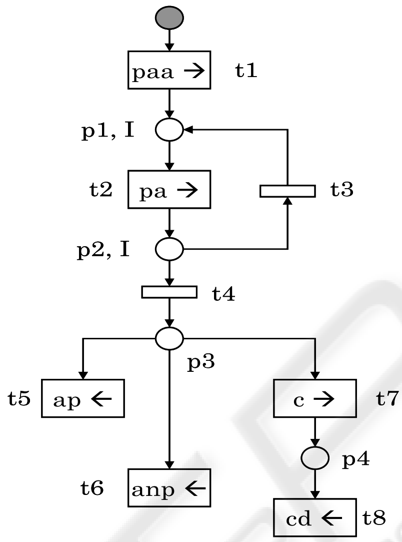
Priorities: t3 > t2, t4 > t2, t5 > t3-, t5 > t4-.

Fig. 3. Collaboration pattern SAMR.

The model presented in Figure 3 shows that the collaboration is started by message *pa** (perform activity with multiple results) and is normally followed by a number of messages *dr* (deliver result) and one final message *a*p* (activity performed). However, at any time, PM can decide to cancel the whole activity or only the remaining tasks (if it does not want to receive any more results): in the first case it will send message *c*, in the second case message *ta* (terminate activity). On the basis of the priorities presented in Figure 3, if a clash occurs between message *dr* and messages *c* or *ta*, *dr* is accepted by PM, but TM follows the path chosen by PM and replies with message *cd*; on the other hand, if a clash occurs between message *a*p* and messages *c* or *ta*, message *a*p* prevails and the collaboration ends normally.

Pattern AASR (Alternative Activities – Single Result)

This pattern addresses situations in which several activities are possible, but as soon as one is started, the others are disabled. For example, if the activity of charging an expense, such as a travel expense, to a project is being performed, the activity of closing the project has to be disabled and vice versa. Such situations are also known as deferred choices [5].



Priorities: t5 > t7-, t6 > t7-.

Fig. 4. Collaboration pattern AASR.

The collaboration is started by message *paa* (perform alternative activities) and is followed by a number of messages *pa*, one for each alternative activity. Places p1 and p2 are colored and color I includes an integer value counting the number of messages *pa* to be transmitted. Transitions t3 and t4 are regular transitions and the inscriptions on their arcs are omitted. The subnet originating from place p3 is similar to the one originating from place p1 in Figure 2 and therefore they have similar interpretations.

4 Comparison with related Work

Collaborations are based on interactions (either one-way interactions or two-way ones). The RosettaNet consortium [11] provides a rich catalog of (business) interactions including the specification of the business documents to be exchanged and of the quality of service requirements.

Collaboration models include control-flow elements, besides the interactions. The UMM [3] modeling methodology represent collaboration models, called business collaboration protocols, as UML activity diagrams and provides four control-flow elements: decision, merge, fork and join. Well known XML representations based on interactions are the Business Process Specification Schema (BPSS) [12] and WS-CDL [4].

A recent notation, "Let's Dance" [13], proposes an original control-flow structure based on three binary relationships, called precedence, weak precedence and inhibition.

None of the above mentioned notations and languages tackles the issue of clashing interactions.

The Language Action perspective [14] criticizes the interactions, as conceived by the above mentioned notations and languages, for being too rigid and adds a conversational structure enabling the parties to communicate in search of mutual agreement.

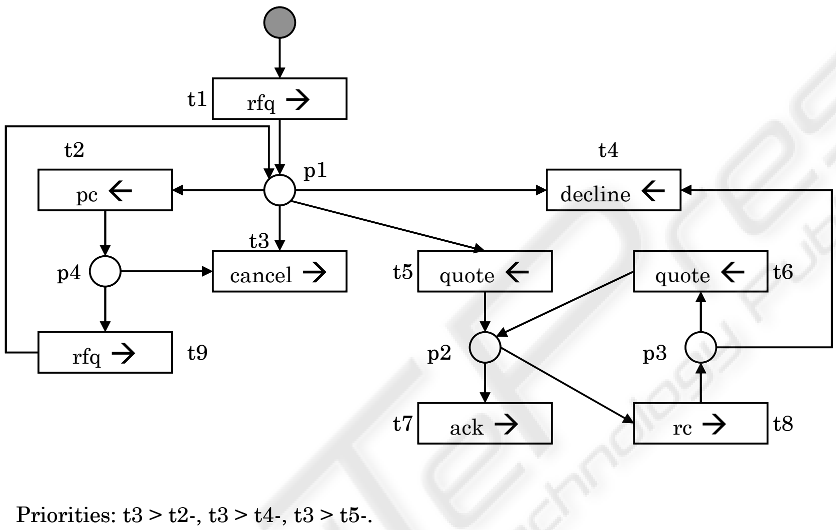


Fig.5. A conversational model based on i-nets.

The "conversation for action" approach [15], based on speech act theory [16], represents a conversation as a state model between two roles, referred to as the requester and the provider.

An example of conversational state model is shown in Figure 5 with i-nets.

The requester initially sends a request for quote (*rfq*) and then the provider may decline, or reply with a quote or request a clarification (*pc*). In the last case, the requester can provide a new *rfq* or terminate the conversation (*cancel*); the new *rfq* is assumed to contain the reply to the clarification request. After receiving a quote, the requester can acknowledge it (*ack*), or request a clarification (*rc*); in the latter case, the provider may send a new quote or decline; the new quote is assumed to contain the reply to the clarification request. Before receiving the first quote, the requester may terminate the conversation (*cancel*), and this implies a situation of clashing interactions as shown in Figure 5.

The annotation gives priority to message *cancel* which prevails over messages *pc* and *decline* in case of a clash.

5 Conclusion

This paper has presented a notation (i-nets) based on colored Petri nets in order to cope with the collaboration needed between two major components of a process-driven information system, i.e. the Process Manager (PM) and the Task Manager (TM).

Three collaboration patterns, related to the implementation of manual activities, have been presented. These patterns show circumstances in which two or more transitions are enabled and they refer to interactions in opposite directions; this means that the participants may take different paths and, as a consequence, they will produce clashing interactions. This paper has presented an approach, based on priorities, which enables the participants to reconcile.

Current work is being devoted to taking advantage of the expressive power of i-nets in order to extend the interactions presented in this paper with conversational features, on the basis of the Language Action perspective.

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