USING WORKFLOW LANGUAGE FOR RAILWAY TECHNOLOGY MODELS

Michal Žarnay [1], Peter Britka

[1] Faculty of Management and Informatics, University of Žilina
e-mail: michal.zarnay@fri.uniza.sk, sosonbobo@gmail.com

Abstract

Paper shows a use of the YAWL workflow language for modelling of technological processes in railway stations. The processes are originally made in the form of network charts and are used in the simulation tool Villon. Comparing the network charts with workflow capabilities leads to a conclusion that benefits of the workflow language in this context are limited to the extent of need of specific technological processes involving wagon groups from multiple trains.

Keywords: *modelling, workflow, railway technology*

1 INTRODUCTION

Simulation models built with help of the Villon simulation tool use flowcharts (network charts for the Critical Path Method) for descriptions of processes undertaken on processed trains [1] [2]. The flowcharts are edge-oriented, i.e. elementary activities are represented by graph edges. From the network chart principle, there is no choice or conditional branching available, since the nodes of the network chart act as AND-nodes. This means that all activities represented by edges coming into a node must be finished before activities on edges going out of the node can start, and all activities related to edges in the flowchart must be performed.

Workflow methodology offers more construction elements and various additional capabilities for the modelling of routing and timing of activities than the described flowchart. Our motivation was to examine, whether a use of the elements can safe any work on the construction of the technological process models.

In the paper, we will use the following two terms: the *Villon approach* describes technological descriptions based on flowcharts used in the Villon simulation tool and the *YAWL approach* addresses studied workflow descriptions in YAWL.

The only criterion for a comparison of the approaches has been the number of elements used to describe the same technological processes – in the Villon approach and in the YAWL approach.

Related work includes that of Patras in [3] showing use of coloured Petri nets, another formal method for modelling technological processes, for synchronization of processing of transit trains exchanging wagon groups. The technological process discussed there corresponds to a technological description discussed in the section (namely model F) of this paper. Unlike there, we do not judge all modelling and analysing properties of the formal method used. Instead, we give an overview of modelling benefits of the YAWL approach on a wider spectrum of technological processes used in the Villon simulation models of railway operation.

The paper is organised as follows: the next section briefly introduces the workflow methodology via the YAWL workflow language. This is followed by a description of railway technological processes in the YAWL approach in the section , a short discussion on gained results from the analysis in the section and conclusions in the section .

2 YAWL WORKFLOW LANGUAGE

YAWL (Yet Another Workflow Language) is a workflow language that builds on the insights gained from the workflow patterns research and combines it with Petri nets [4]. Workflow patterns are characteristic sequences of activities that show how a business process operates. Activities in the YAWL language are represented by nodes. Flow relations between activities are represented by oriented edges leading from one node to another. Symbols used in YAWL are depicted at fig. 1.

Workflow patterns can be divided into 7 categories:

- *Basic control flow patterns* model sequential, parallel and conditional routing – they are available in most modelling languages,
- *Advanced branching and synchronization patterns* add advanced functions as split and join,
- *Structural patterns* produce a block structure identified by start and end points,
- *Patterns involving multiple instances* are used for modelling multiple enabling of parts of a process,
- *State-based patterns* add the ability to model states, e.g. milestone, and thus enhance the expressiveness of the language,
- *Cancelation patterns* used for events able to cancel other activities, in some cases this can cause a cancelation of the whole system,
- *New control flow patterns* further enhancing the formalism.

In [5], there are 43 different workflow patterns distinguished. However, only 20 of them are commonly used and the YAWL language supports 19 of them. The new workflow patterns have not been supported at the time of our work.

The YAWL language is based on the *Extended Workflow Nets* (EWF nets) that form a hierarchy (tree structure) of tasks (fig. 2). Tasks are either atomic or composite. Every composite task represents a unique EWF net on a lower level of the hierarchy. Atomic tasks are leaves of the tree structure. There is one net which does not represent any composite task. It is called *top level net* and represents the root of the tree.

Every EWF net contains tasks (atomic or composite) and conditions that can be represented as places. Every EWF net has one input and one output condition. In contrast to Petri nets, it is possible to connect two tasks (transitions in the context of Place/Transition Petri nets) without the need of a condition (place) – this construction can be represented as a hidden (implicit) condition that is added to the direct connection.

Every task can have more than one instance. It is possible to specify high and low bound for the number of instances which are created after an initialization of a task. Also, it is possible to specify that a task ends after a certain number of instances has finished. When this condition is reached, all running instances are finished and the task ends. If no condition is specified, the task ends after all instances have finished.

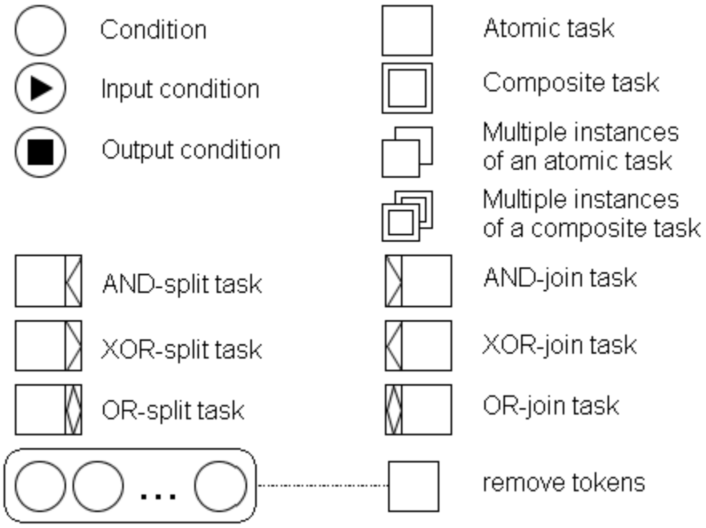

Figure 1 Symbols used in YAWL.

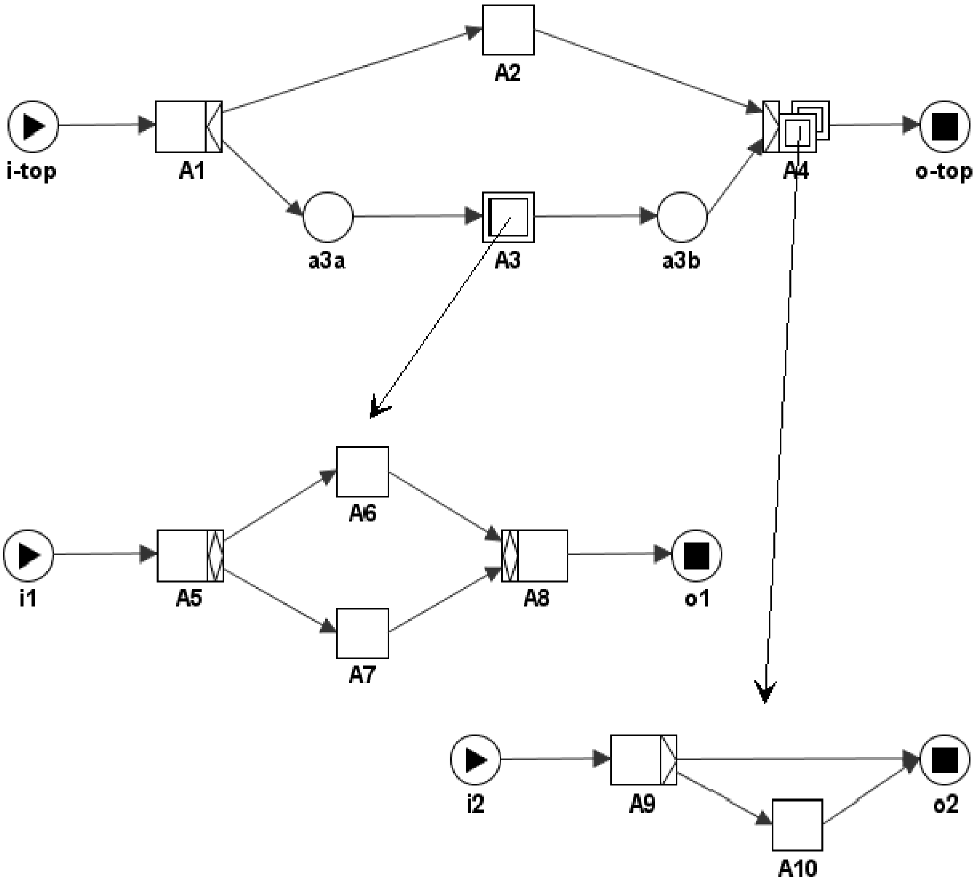

Figure 2 Hierarchy in Extended Workflow Nets.

3 YAWL MODELS OF RAILWAY TECHNOLOGICAL PROCESSES

For the comparison, we have chosen a group of technological descriptions, based on experience with modelling technological processes in railway stations. They have been selected from several real simulation projects and accommodated for the analysis. They were created in the form of flowcharts in the Villon simulation tool. After their summary in the table 1 we introduce them in more details.

Label	Model description
A	Incoming freight train processing
B	Transiting freight train processing
C	Outgoing freight train processing
D	General re-grouping with 1 train in result
E	Re-grouping scenarios with 1 train in result
F	Re-grouping with multiple trains in result
G	Multiple activities

Table 1 Technological descriptions discussed in this paper.

Freight trains processing (A-C)

The first three technological descriptions are related to basic processing of freight trains in a marshalling yard. They differ in the origin and destination of the train. The *Incoming freight train processing* technology description is for trains coming from another station and finishing in the modelled marshalling yard. From railway activities, it includes a technical inspection, a goods inspection, a release of train locomotive and humping with shunting locomotive.

The *Transiting freight train processing* technology is for trains transiting the marshalling yard on their way between two other stations. It includes an exchange of train locomotives and a simple brake test.

The *Outgoing freight train processing* technology description is for trains originating in the modelled marshalling yard station and leaving it after their processing for another station. Main activities include coupling of wagons, one technical and one goods inspections and a full brake test.

All mentioned technology descriptions include allocations and releases of station personnel for activities with a suitable timing.

Compared to flowcharts, the created YAWL descriptions for all three technological processes are only a little simpler. The YAWL flowchart saves some nodes and edges due to the use of variables in the YAWL. They substitute some activities. The only workflow patterns used in the three descriptions are: sequence, parallel split and synchronization, i.e. basic control flow patterns.

Wagons Re-grouping (D-F)

We use the term *re-grouping* for technology descriptions where groups of wagons are moved among trains. Re-grouping schemes result in 1 train or more trains in the end. We have considered 3 different re-grouping descriptions from the Villon simulation tool resulting in models D, E (resulting in one train) and F (resulting in more than one train).

In the Villon approach, re-grouping is modelled on two levels of hierarchy (Figure 3). In train technology descriptions, there is at least one re-grouping activity determining, when in the course of processing of a train the re-grouping activities are to occur (after activity 1A for the train 1 and after 2A for train 2 in the example). The lower level of the hierarchy is the re-grouping description of other activities that are to be carried out in the particular re-grouping scheme.

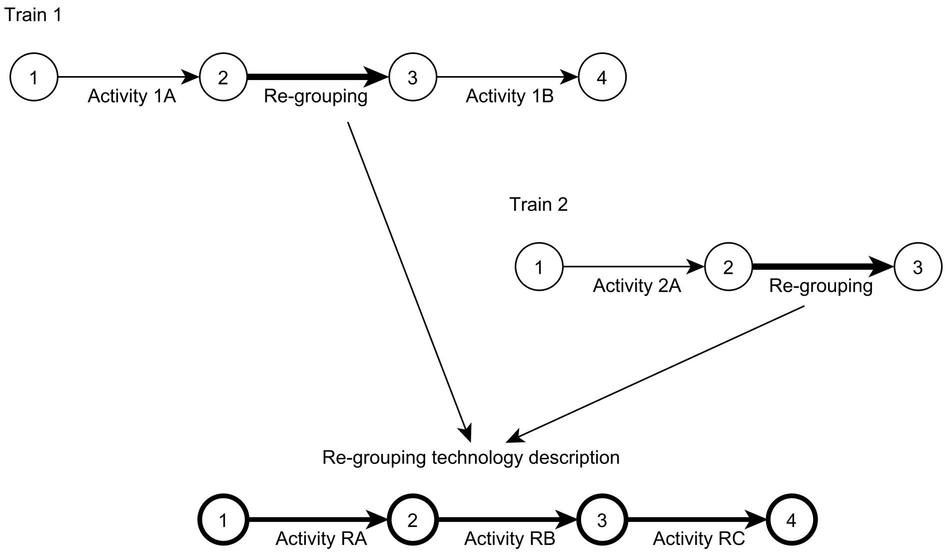

Figure 3 Activities for re-grouping in the Villon approach.

The Figure 3 depicts a general re-grouping technology description with one train in result, when all wagon groups occur (the model D). It is in the form of network flowcharts. When the processing of train groups 1 and 2 reaches the *Re-grouping* activity, the *Re-grouping technology* is started. In the end of it, only one train group exists, which continues by the *Activity 1B* in technological processing. The Figure 4 shows the proposed YAWL counterpart. In the top level net, trains involved in the *Re-grouping* scheme are recorded. Each train has its own workflow net containing one composite activity named *Re-grouping*. When the activity is enabled by all involved trains, the unfolded *Re-grouping technology* description is started. When it is finished, the respective train technological descriptions are finished. Since by that time, the two groups should compose one train, only one technology description contains activities after re-grouping (Train 1).

This model uses basic patterns sequence, parallel split and synchronization as well as a composite task. In the top level net also the *Structured synchronizing merge* pattern can be used in case that there may be cases, when not all the trains are involved in the re-grouping process each time. For modelling of the *Re-grouping* composite task, the *Milestone* pattern is to be used. It is because the activity cannot be triggered before all branches from all involved trains are enabled.

In a re-grouping model generally, there may be situations that not all train groups are present for the processing on a specific day (typical especially in freight trains transportation). In such a case, different scenarios must be defined: based on the present wagon groups, only one of them is valid, creating one train in the end of every case. This is reflected in the model E. Figure 5 depicts an example, when a resulting train can be composed from 3 different groups I, II and III. However, the groups II and III are not always present. This results in four scenarios: with all three groups present (I, II, III), with only two groups (I, II or I, III) and with only one group (I) present in the final train. In every case, the re-grouping technology description is slightly different in order to achieve the final train containing the wagon groups in the sequence III-I-II. In the description a shunting locomotive is used for collecting wagon groups in the yard and moving them to output track, where final processing before departure is carried out.

In the Villon approach, apart from flowcharts both on the train description and re-group description levels also an additional tree structure is used, making it all quite a complicated data structure. In the YAWL approach, we can combine all three structures into one hierarchic model with standard patterns. The YAWL model E includes only those parts of technological descriptions that are related to the differences among scenarios (i.e. activities common for all scenarios, like e.g. assignment and release of personnel or simple brake test are omitted). For the purpose of selection of the right scenario, the *Exclusive choice* or the *Deferred choice* patterns can be used. The former is for the case, when we know the presence of wagon groups in the system prior to the start of the whole technological process. The latter is for the case, when we know the information only at

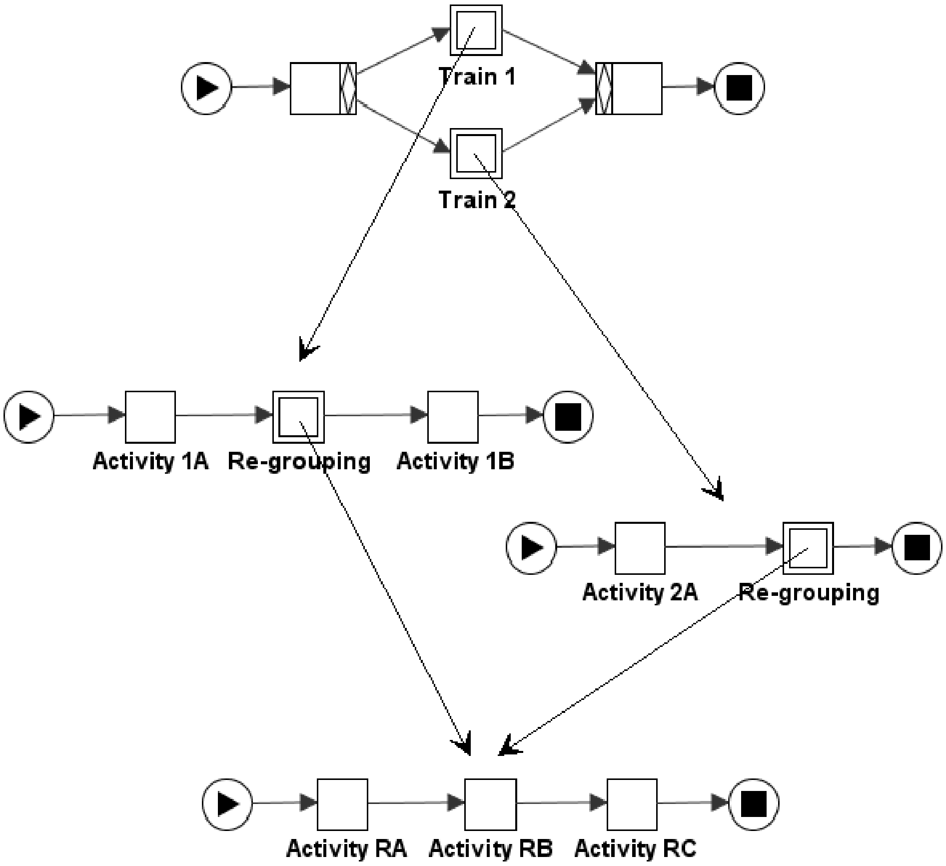

Figure 4 Hierarchy of YAWL nets for the model D.

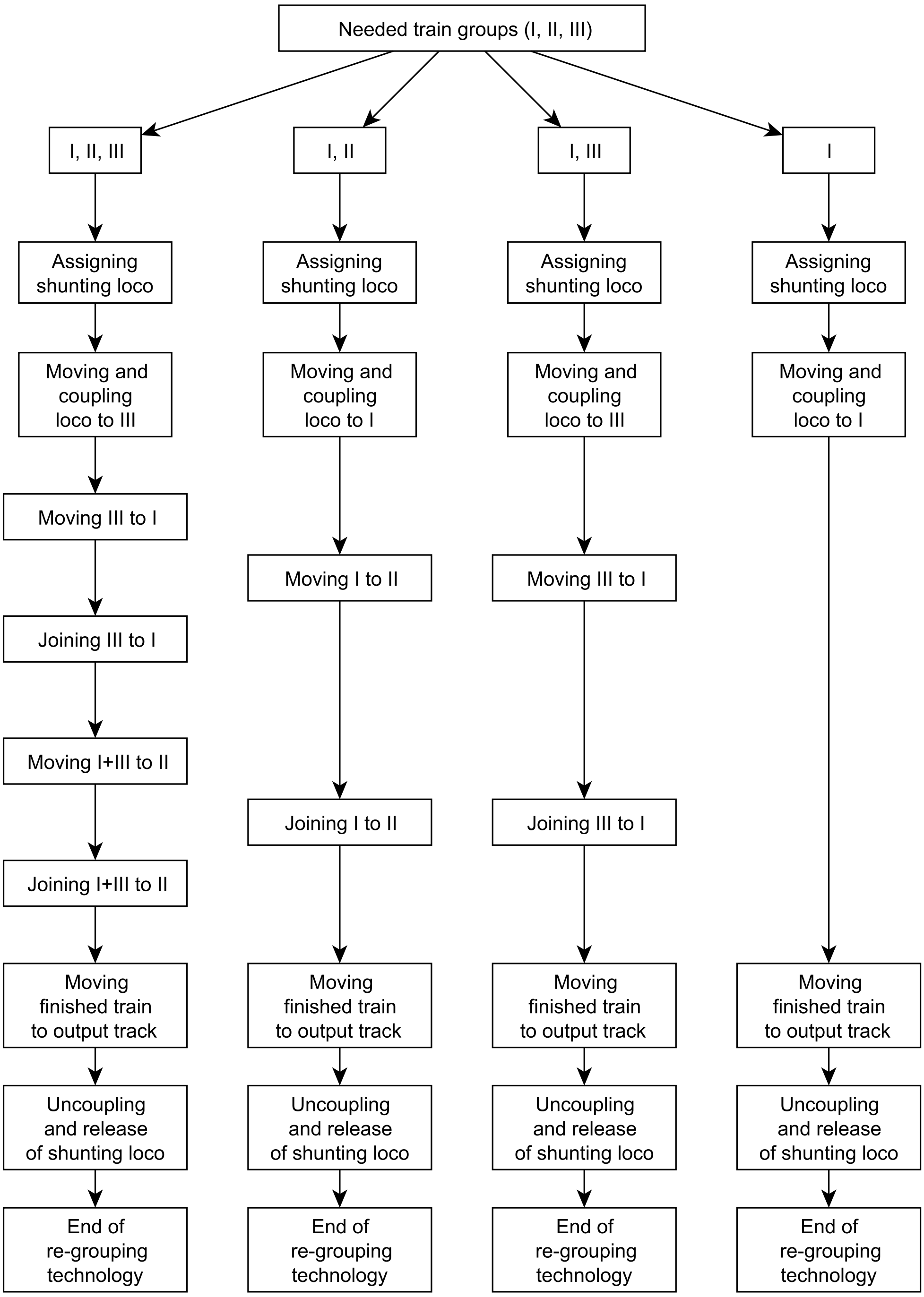

Figure 5 Re-grouping - model E - Villon approach.

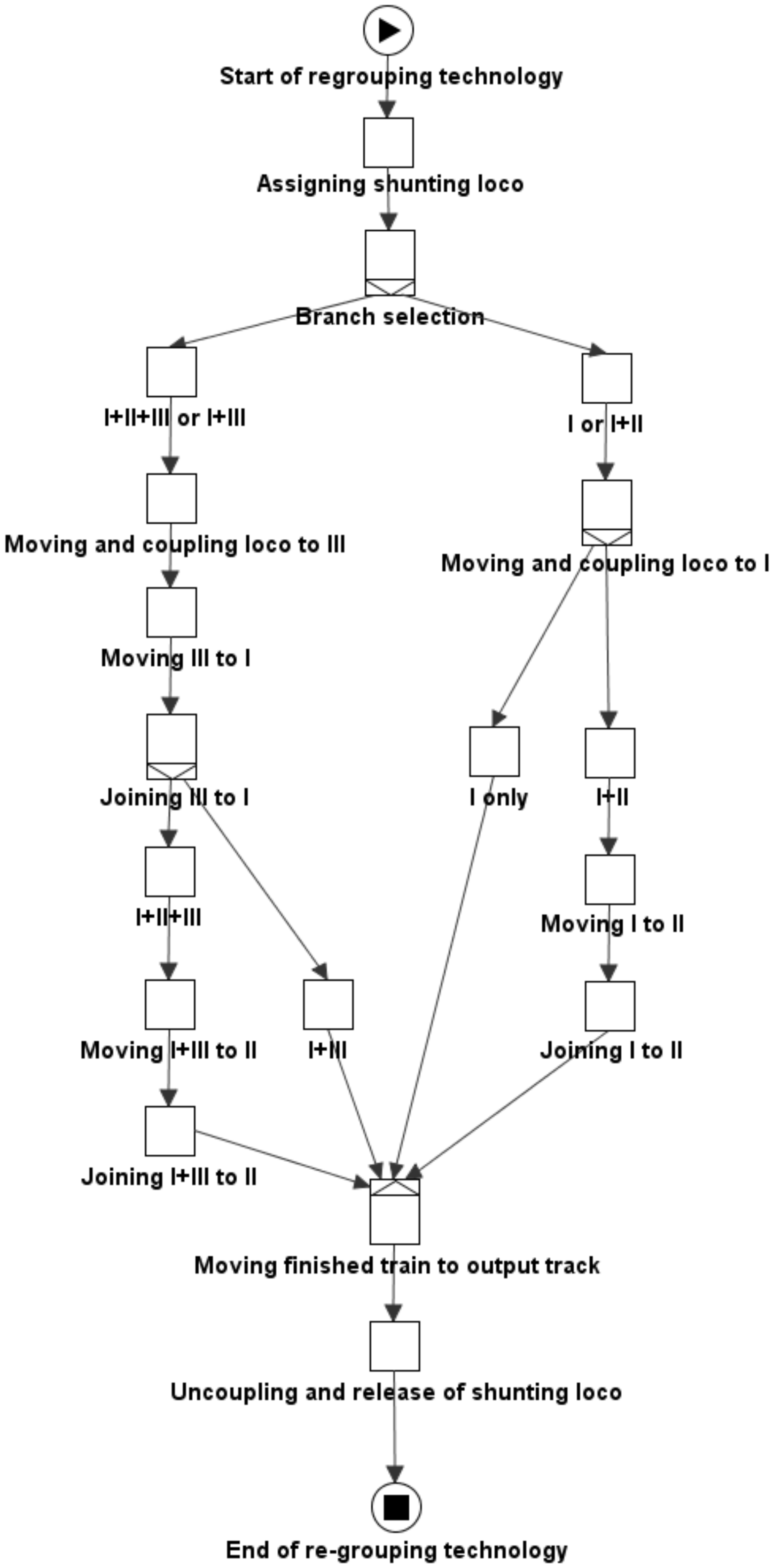

Figure 6 Re-grouping - model E - YAWL approach.

run-time of the technological process simulation. Thanks to the inclusion of all scenarios in one flowchart, identical sequences of activities from several (or even all) scenarios can be merged into common sequences and the description thus becomes simpler.

Re-grouping resulting in multiple trains (technology description F) is a case of trains that exchange groups of wagons from multiple origins to multiple destinations. Let's explain it on a simple example: two trains from origins P and Q to destinations R and S. Train 1, coming from origin P and heading to destination R, has wagons also for destination S, i.e. there are 2 wagon groups: P-R and P-S. Train 2, coming from origin Q and heading to destination S, has wagon groups Q-R and Q-S. When they meet in a common station on their different travel routes, they exchange the wagon groups P-S and Q-R using the regrouping technology, so the train 1 continues with groups P-R and Q-R and train 2 with groups P-S and Q-S.

The model in YAWL approach did not bring any significant benefits in modelling this particular technology description. Only the basic patterns were used: sequence, parallel split and synchronization. However, if we take into account different scenarios on different days, we may make an advantage of patterns specific to the YAWL approach analogically with the description discussed above.

Multiple activities (G)

Some technological operations are repeated more times on a number of units, typically on individual wagons or groups of wagons. Such an activity is for example technical inspection of wagons. In the Villon approach, this is modelled by one activity which lasts until the last wagon has been reviewed (activity B at the Figure 7). In the YAWL approach, it is possible to use the *Multiple instances with a priori run-time knowledge* pattern to model the cyclic character of the activity.

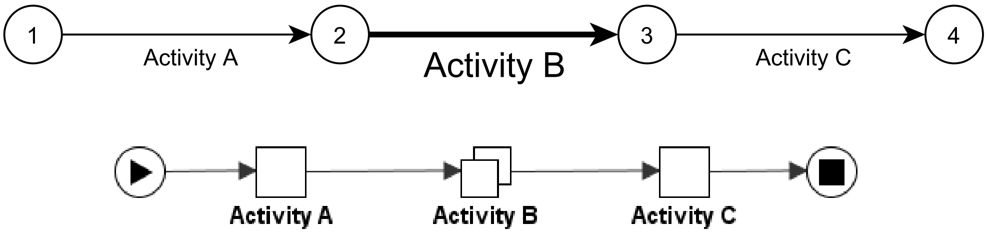

Figure 7 Activity B modeling repeated operation on units in the Villon approach (above) and in the YAWL approach.

4 COMPARING WORKFLOW CHARTS AND SIMPLE FLOWCHARTS

Summarizing the whole analysis in the previous section, we come to the following conclusions. From 43 available workflow patterns, only 8 were identified to be useful for modelling of technological processes in railway station. The used patterns are:

- the basic control flow patterns *Sequence*, *Parallel Split*, *Synchronization* and *Exclusive Choice*,
- the advanced control flow pattern *Structured Synchronizing Merge*,
- the state-based patterns *Deferred Choice*, *Milestone*, and
- the pattern *Multiple Instances with a Priori Run-Time Knowledge*.

Overview of patterns used in individual technological descriptions is in the table 2.

Pattern	A	B	C	D	E	F	G
Sequence	X	X	X	X	X	X	X
Parallel Split	X	X	X	X	X	X	X
Synchronization	X	X	X	X	X	X	X
Structured Synchronizing Merge				X			
Exclusive Choice					X		
Deferred Choice					X		
Milestone				X			
Mult. Inst. with a Priori Run-Time Knowl.							X

Table 2 Use of patterns in technological descriptions.

Since the first three patterns (*Sequence*, *Parallel Split* and *Synchronization*) are natural for network flowcharts in the Villon approach, we analyze only the remaining five patterns. All of them are included in the Villon approach in different forms than in flowcharts, either in additional data structures or in the application logic. As the table shows, the additional patterns are useful only for re-grouping technological processes, where hierarchy, different scenarios and synchronization through milestones can be useful. However, implementation of the last two patterns *Milestone* and *Multiple Instances with a Priori Run-Time Knowledge* requires use of XQuery language, associated with YAWL modelling formalism, i.e. for simulation of models with these patterns some additional programming to the workflow model is needed anyway.

Number of elements as a comparison criterion in the respective pairs of technological descriptions in the Villon and YAWL approaches appears to be not as expressive as it seemed to be in the beginning. The reason lies in the fact that number of elements used for modelling of some technological details (for instance assignment of presonnel resources) in both approaches is not the same.

The only evident saving in this criterion is visible by the E model dealing with different scenarios by re-grouping of wagon groups to form one train. When counting used elements on the respective models (fig. 5 and 6), the YAWL version contains 20 elements compared to 33 of the Villon version.

5 CONCLUSION

Our overall conclusion lies in the fact that the larger portfolio of modelling patterns in the workflow management compared to basic network flowchart is useful mainly by re-grouping activities. These compose usually only a minor part in technological descriptions in simulation models built with help of the Villon tool. However, there are sometimes models with high share of re-grouping activities, where the advantages of the YAWL approach could be greatly used. Thus the benefit from using workflow management tools in this domain is limited to the extent of technological processes requiring re-grouping processes.

However, we must keep in mind that the technological descriptions were built with the available tools and this could have influenced thinking of their designers. If they had had a wider palette of tools available as the workflow patterns offer, the definition of the technological processes could be different – richer in terms of used patterns. Further research in this area can be done in the detailed implementation of a whole simulation model of technology in a railway station by means of YAWL approach. This would bring more detailed modelling of patterns requiring XQuery language and involvement of model designers from the railway industry in use of the workflow patterns.

REFERENCES

[1] Adamko, N., Klima, V.: Definition of operating procedures in generic agent based simulation model of transportation logistic terminals. Proceedings of the European Simulation and Modelling Conference ESM 2008, Eurosis, Le Havre (2008) 312–316 ISBN 978-90-77381-44-1.

[2] Adamko, N., Sadloň, Ľ.: Aplikácia sieťových grafov v simulačných modeloch železničných uzlov [application of network flowcharts in simulation models of railway nodes]. Proceedings of the Infotrans 2003 conference, Pardubice (2003)

[3] Patras, V.: Formalizace technologie obsluhy tranzitních vlaků a jejich vzájemná synchronizace pomocí petriho sítí [formalization of transit trains service technology

and their mutual synchronization with help of petri nets]. Proceedings of the Žel 2007 conference, Žilina **3** (2007) 28–33 ISBN 978-80-8070-682-1.

[4] YAWL: Yet another workflow language. Available at: <http://yawlfoundation.org/index.php>(online)

[5] Initiative, W.P.: Workflow patterns, control-flow patterns. Available at: <http://www.workflowpatterns.com/patterns/control/index.php>(online)

Acknowledgement

This work has been supported by the institutional grant FRI 7/2007.