

# Control-Flow Representation of Business Processes – An Empirical Comparison of Connectors vs. Token Game

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**Abstract:** A number of process modelling notations use connectors for the representation of the control-flow while others apply the token game. There are number of good arguments in favour as well as against each to these two ways of representing the control-flow. This contribution describes the results of an empirical comparison of these two approaches from the end-used perspective. The overall outcome of the experiment supports the assumption that notations applying connectors are superior to the token game-based notations in terms of end-user comprehension at the conceptual modelling level.

## 1 Introduction

A common way of dealing with the complexity of business processes at the conceptual level is to define distinctive perspectives, clarify the contents of each perspective and describe within a framework how these perspectives interrelate to each other [Sc98]. One of the perspectives of business processes is the control-flow. It describes the execution order of tasks through constructors which permits the flow of execution control [KHA03]. Comparing different business process modelling notations indicate that there are two different approaches to the representation of the control-flow. The connector-based approach is based on the idea to provide a number of distinctive language primitives while each stands for a specific control-flow situation. Some modelling notations that use this approach are Event-driven Process Chain (EPC) [KNS92], Business Process Modelling Notation (BPMN) [OMG04a] and UML Activity Diagram [OMG04b]. The token game-based approach follows a different way of representing the control-flow. Here, the execution of tasks is controlled by token which represents the fulfilment of their pre and post conditions. An example of a notation which use the token game is the Condition/Event net (C/E net). It consists of conditions presented by circles and events or tasks presented by rectangles as well as black tokens representing the fulfilment of a condition.

There are number of good arguments in favour as well as against each to these two ways of representing the control-flow. One can argue that using connectors is more intuitive for end-users. However, using connectors also means an increased number language primitives which need to be precisely understood and memorized by end-users in order to understand a business process model using the connectors. For instance the EPC which include the basic AND, XOR, OR split and joint connectors and has been extended by a number of additional connectors like OR<sub>1</sub> and ET [Ro95], SEQ [Pr95] and Empty-connector [MNN05] as well as the multi-level connector as a shortcut for proceeding join and split connectors. In contrast, the token game-based approach is based on a limited number of language primitives. End-users need to understand only the token game in order to comprehend all kinds of basic and advanced control-flows. This contribution intends to investigate on the comparison of these two approaches by a laboratory experiment.

## 2 Empirical findings and interpretation

A laboratory experiment including 50 participants was conducted with a two-group, post-test only experimental design which was adapted and modified from [Mo02]. For further details regarding the research design we refer to [SDL05]. The summary of the findings of the experiment is represented by table 1.

Hypothesis		Supported
<b>H1</b>	The EPC connectors are better comprehended by end-user than C/E net representations with respect to AND-type situation (H1a) and XOR-type situation (H1b).	H1a: No H1b: Yes (significant)
<b>H2</b>	The EPC multi-level AND/XOR-connectors are comprehended by end-users as good as AND-connectors and XOR-connectors.	Yes (significant)
<b>H3</b>	The EPC OR-connectors are comprehended by end-users as good as AND-connectors and XOR-connectors.	No (significant)
<b>H4</b>	The overall end-user comprehension of the control-flow of an EPC model is higher than an equivalent C/E net model.	Yes (significant)
<b>H5</b>	The perceived ease-of-use of the EPC control-flow is higher than C/E net.	-
<b>H6</b>	The perceived ease-of-use of the EPC notation is higher than C/E net.	Yes (tendency)
<b>H7</b>	The intention of end-user to use the EPC is higher than C/E net.	Yes (tendency)

Table 1: Summary of findings

The implications of these outcomes are following issues:

- In terms of end-user comprehension the control-flow representation of a business processes is superior to token game. This finding has implications for the process modelling research: it refuses the use of C/E net or other token-game based notations for the representation of the control-flow for conceptual modelling as long as end-user are involved.
- The non-local semantic of OR-connectors is not only unfavourable to formalization issues of EPC models, but also clearly has negative impacts on end-user comprehension. While using OR-connectors in business processes, one should keep in mind that they are a source of ambiguity with negative impacts not only on accomplishing formal analysis of the processes due to the non-local behaviours of the connector, but also on end-user comprehension of the process models.
- One can use the XOR/AND multi-level connectors as a shortcut to XOR and AND-connector within a business process without being afraid of negative impacts of end-user comprehension.

### **3 Limitations and Future Work**

The results and the implications of the empirical study have to be treated cautiously and considered in the context of several limitations regarding external and internal validity. Regarding external validity, the use of students as subjects clearly limits the generalisability of the results. The behavior of students, their learning style and motivation might not be representative for the population of end-users in practice even though the use of student as subjects is a well-established practice of experimental studies. A further aspect is that the experimental task consisted of only one business process of a given complexity which limits the generalization of the results to more or less complex models. Additionally, the sample size used for the experiments can be considered as small. In order to ensure internal validity of the results, all variables except the independent variable had to be held constant between groups. Even if participants were separated randomly it was unavoidable that some individual difference between the participants of the two groups occurred. An increased training of the participants with some additional examples of the application of the notations could have lead to a completely different outcome.

However, this research shows that indeed the control-flow representation affects the process comprehension. To verify this conclusion more research need to be conducted in the future. Some researches need to be done in order to overcome the limitations of this study which were mentioned in the previous section. The next step is to repeat the study with the same research design with an increased number of participants or use professionals rather than students. But even by answering the general question on which of the two control-flow approaches are more appropriate and favorable, we are still at the beginning of this research area. We still don't know much about the influence of the number of language primitives, their shape, color and size etc. on the overall end-user comprehensibility (if there are any). And having in mind that the control-flow is only one perspective of a business process among others leaves room for further research on similar questions regarding the resource and the case perspective. Moreover, this research could be extended to end-user modeling tasks rather than model comprehension.

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