How Does It Look? Exploring Meaningful Layout Features of Process Models

Vered Bernstein(✉) and Pnina Soffer

University of Haifa, Mount Carmel, 3498838 Haifa, Israel
vbernste@campus.haifa.ac.il, spnina@is.haifa.ac.il

Abstract. The layout of business process models has a substantial effect on their understandability. However, currently only few layout properties are well defined, thus appropriate support for creating well-laid-out models is limited. This position paper indicates the importance of developing a collection of layout features which will correspond to meaningful layout properties perceived by human. It reports an exploratory study for obtaining such a collection.

Keywords: Model layout · Understandability · Exploratory study · Cognitive load

1 Introduction

Business process models have been the subject of extensive research in the past decade. They serve different purposes and may have different forms along the life cycle of a business process. This paper focuses on business process models as conceptual models, facilitating understanding and communication among people.

For this purpose, model understandability is of crucial importance. Much research has been conducted in recent years on factors that impact the understandability of conceptual models in general (e.g., [4]) and process models in particular. Attention has mostly been given to visual properties of the modeling language [9], but some research also addressed properties of individual models. Examples include the influence of model complexity [7, 14], modularity [19], grammatical styles of labeling activities [8], and secondary notation [5, 15]. Obtained insights led to the development of empirically grounded guidelines for business process modeling [8], and for avoiding process model smells [18], such as unnecessarily complex process fragments [14] or edge crossings [8]. Yet, as far as we know, a systematic investigation of the effect of the layout of a model on its understandability has not been conducted.

Specific layout features have been discussed (e.g., line-crossing [8]). However, layout can be characterized by a variety of features. Currently, only a few are accurately defined [13]. Furthermore, there is no evidence that these features are the most relevant layout features in terms of human perception. We argue that a basic collection of well-defined layout features is essential for investigating the effect of model layout on its understandability. Moreover, a collection of well-defined and meaningful layout features can also be beneficial for gaining a better understanding of how individuals construct process models.

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This paper explores the layout features of a process model with the aim of identifying the features that are dominant in forming the human perception of the visual appearance of a process model. We report an exploratory study extracting a collection of layout features through questionnaires and interviews.

The remainder of the paper is organized as follows: following a motivating example, Sect. 3 discusses cognitive implications of model layout for model understanding and construction. The exploratory study and its findings are reported in Sect. 4. Finally, a concluding discussion and future directions are in Sect. 5.

2 Motivating Example

As a motivating example, consider the models in Fig. 1, both depicting the same process. The difference in their appearance is clear to the eye, but it is hard to clearly indicate what makes this difference. We currently lack precise concepts to verbalize or measure the appearance of the models and their differences. Our aim is to take a step towards filling this gap.

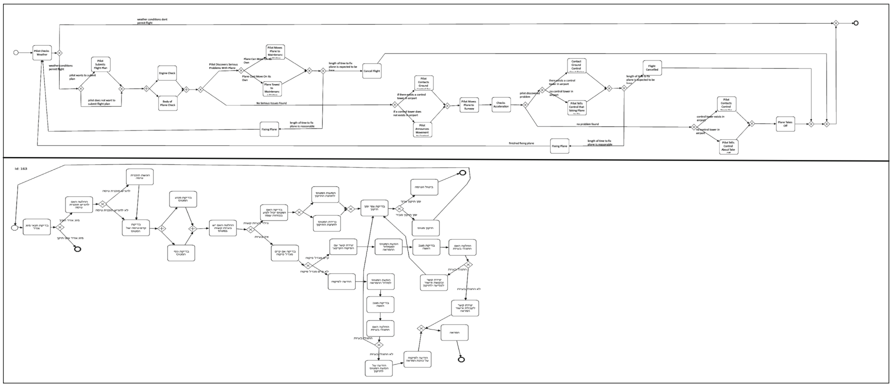

Fig. 1. Two models of the same process

3 Cognitive Considerations

This section discusses cognitive implication of layout features for model understanding and for model construction.

3.1 Implications for Process Model Understanding

When reading a process model for the purpose of performing a certain task, the individual uses the limited capacity of her short-term memory. According to the cognitive load theory [16], three types of cognitive load are involved: intrinsic load, which stems from the task, extraneous load, which relates to the information representation (in our context, the visual appearance of the model), and germane load, relating to the integration of the current information with long-term memory knowledge. Many researches (e.g., [1]) indicate that effective task performance can be achieved when extraneous load is minimized, releasing more capacity for intrinsic load. Indeed, based on cognitive load considerations, Mayer [6] has indicated that even a small representation manipulation can yield significant differences in task performance results. A recent study that used eye-tracking technology [3] has measured eye movements between different parts of the display, reflecting an effort devoted to integrating information that was scattered in different places. It was found that for display configurations which required less integration effort (thus less extraneous cognitive load), higher learning performance was achieved. Considering process models, the layout of a model determines the extent to which information integration efforts would be required. If elements that closely relate to each other are located separately in the model, the reader spends more effort integrating this information, thus extraneous cognitive load increases. Note that some layout constraints can be imposed by the modeling language. As an example, consider the swimlanes that denote roles in BPMN. Using these constructs, activities performed by one role are visually located in one lane, making their integration easier. On the other hand, tracking the sequence of activities might be challenging if it moves among different roles, since information from different lanes needs to be integrated.

It follows that further investigation of the impact of different layout configurations on model understandability is needed. We believe that identifying a meaningful set of layout features would allow targeted investigation of their effect on process model understandability and advance the construction of more understandable models.

3.2 Implications for Process Model Construction

When constructing a process model, the modeler determines its layout. In addition to affecting the understandability of the resulting models, recent studies indicate that extensive dealing with the layout during model creation can result in a long and unfocused model construction process [10]. Reference [11] suggested that the modeling style is affected by four groups of factors – individual interface preferences, cognitive properties of the modeler, intrinsic and extraneous task properties. In particular, individual preferences are reflected in the layout of the resulting model. Consider, for example, the two models given in Fig. 2. These are models of different processes, constructed by the same modeler. While some visual similarity is clear to the eye, we currently lack an appropriate set of concepts for expressing this similarity.

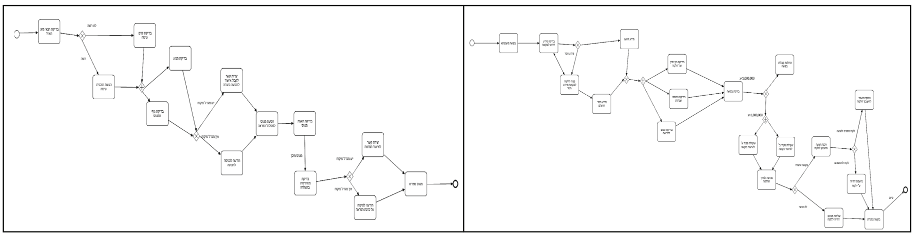

Fig. 2. Two models of different processes constructed by the same modeler

4 Exploratory Study

4.1 Setting and Data Analysis

This section reports an exploratory study aimed at extracting a set of visual layout features that are meaningful to the human perception. The study used questionnaires and interviews with the participation of 22 Information Systems students. 15 undergraduate students answered the questionnaire and 7 graduate students were interviewed, using the questionnaire as a basis for the interview. The questionnaires included 5 pairs of process models, to prompt the indication of features through comparison of models. The models were made small to fit a single page, yet their structure was clear visually. Any label in the model elements or on the edges was blurred in order to have participants address only the visual aspect of the model. Examples of such pairs can be seen in Figs. 1 and 2. Considering each pair, participants were asked to rate the similarity of the models using a 7 points Likert scale and to indicate three different aspects and three similar aspects in the models. In the interviews more detailed information was prompted using additional questions. In particular, the questions related to features that support or hamper the understandability of the models in order to encourage participants to engage in the specific appearance features. All participants had basic knowledge of process modeling. Participation in the study was voluntary.

The data analysis considered the text of the written questionnaires and the interviews text. Using qualitative methods [17], textual segments were first coded by the model(s) they referred to and classified to categories of features. Saturation of the categories was reached by the 4th interview. Second, the identified categories were aggregated to higher-level categories of layout features.

4.2 Findings

The identified layout feature categories relate to the general structure of the model, its direction, its ending points, properties of the edges and the angles between them, alignment of the elements, and symmetry of blocks. Below we explain each category and list the lower-level categories it includes.

Model structure – this includes the model's general *shape* (e.g., horizontally or vertically rectangular, square) and the model *size* – the space used on the canvas. This category relates to a coarse-grained view of the model and its boundaries, indicated in statements like "the size of the models is different".

Ending points – the *number of ending points*, while reflecting the process itself, affects the flow viewed by the model reader. The ending points form an anchor while reading the model, thus a model with multiple ending points is more difficult to read than a model with a single ending point.

Direction – includes several features. The *general direction* of the model, which can be horizontal (left to right or right to left) or vertical (top-bottom or bottom-top). A typical statement concerning the direction: "Both models are vertical". The *placement of ending point(s)* – in case of a single ending point it clearly marks the direction of the model; otherwise if ending points are placed apart from each other the direction might be unclear. *Branching off* is a situation where different branches of the model go in opposite directions (without forming a loop), blurring the direction of the model, as said "It then goes in many directions". *Change in direction* – when the general flow of the model changes its direction, usually in attempt to fit a large model into one page. This feature was highly indicated, e.g., "this model looks like a stair case".

Edges – many sub-categories relate to the edges of the model. The *length of the edges* may vary, creating a "messy" model. Alternatively, very short edges form a dense model, while long ones result in a widely spread one. *"Broken" edges* that include bending points bothered some of the participants ("Need to straighten all the broken edges"). *Crossing edges* are a long recognized feature whose avoidance was recommended [6]. Our participants indicated "…there are edges here that just go one on top of the other". *Text on edges* – annotations that are not necessarily related to branching conditions were also indicated as reducing the readability of the model.

Angles – the angles between edges can affect the general look of the model and how "neat" it appears. Specifically, 90° angles, sometimes referred to as "Manhattan layout", result in an easy to read model (as said: "90° angles gives a cleaner look").

Alignment – when the elements of the model are aligned, forming a straight line, the impression is of a tidy and clear model. A typical statement: "This model is clearer and very aesthetic"

Symmetry – symmetry of the placed elements in the structured blocks appears aesthetic and makes the model easy to read.

5 Concluding Discussion

The collection of layout features identified in the exploratory study provides an initial terminology with which the layout of a model can be characterized. Yet, these are qualitative terms rather than measurable properties. To this end, their quantification to a set of metrics is in process.

We note that quantitative layout metrics already exist [12] and are used as a basis for automatic layout functionality, which is available in process modeling tools (e.g., [2]). Nevertheless, these metrics are not anchored in any theory or evidence of what humans perceive as meaningful. Rather, they include properties which seemed important enough and possible to implement. The most comprehensive set of metrics we are aware of has been suggested by [13], relating to graphs in general. It includes metrics for the following features: edge crossing, bends ("broken" edges), symmetry, minimum angle between edges, orthogonality of edges and of nodes (alignment), upward flow (consistent direction of edges), and width of layout. All these features are included in the collection obtained in our study, which includes 7 additional ones.

We consider a set of layout metrics to be important for several purposes. First, they can be used in future studies for gaining a deep understanding of the effect of model layout on its understandability. Second, they can serve in future studies of individual preferences and layout decisions in the construction process of a model. Third, they can serve for modeling guidelines and for enhancing the automatic layout functionality in modeling tools. Thus, eventually, the understandability of the created process models will be promoted.

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