Obtained results of effort and cost estimation for the goods dispatch BPMN model (Fig. 1) when considering the design stage ($x_s = 1$) and low complexity ($m = 2.4, n = 1.05$) are the following:

$$PE_s = 1 \cdot 152 \cdot 2.4 \cdot \left(\frac{19 \cdot 7}{1000}\right)^{1.05} = 61.96 \text{ peson} - \text{hours},$$
$$PC_s = 61.96 \cdot 45 = 2788.12 \text{ USD}.$$

The values obtained reflect the total effort and cost of business process modeling, including interviews and other techniques for extracting business process information.

Conclusion. The following tasks were completed in this study to solve the problem of business process modeling effort and cost estimation:

1) the approach for estimation of business process modeling effort and cost is proposed;
2) the software implementation of the proposed approach is developed;
3) the software is used to estimate business process modeling effort and cost.

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SOFTWARE TOOL FOR BPMN DIAGRAMS EVALUATION AGAINST MODELING RULES

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Abstract. Organizations may enhance their efficiency, minimize mistakes, and improve output quality by ensuring that all business process diagrams adhere to agreed modeling guidelines. The object of study is the process of business process diagrams evaluation against modeling rules. The subject of study is the software solution for business process diagrams evaluation against modeling rules. The goal of study is the improvement of business process diagrams in terms of correspondence to modeling rules by developing a respective software solution.

Problem statement. Business process modeling is a vital technique of the Business Process Management (BPM) methodology. It facilitates alignment between IT and business by promoting effective communication between business users, including CEOs, managers, and other stakeholders, and IT engineers responsible for developing and maintaining enterprise information systems. Graphical business process models, including Business Process Model and Notation (BPMN) and other notations, capture and analyze current workflows to identify opportunities for improvement. This can be achieved through upgrading existing IT systems or implementing new modules where required, especially for workflows that have not yet been automated. Captured business process models must be clear, well-organized, and free of uncertainties. Without these qualities, it would be impossible to conduct a proper analysis of current enterprise activities and recommend effective ways to improve them. Additionally,

inaccurate business process models could indicate flawed business processes, leading to modeling errors that reflect issues in the actual business process.

Study aim and tasks. The object of study is the process of business process diagrams evaluation against modeling rules. The subject of study is the software solution for business process diagrams evaluation against modeling rules. The goal of study is the improvement of business process diagrams in terms of correspondence to modeling rules by developing a respective software solution. Hence, to achieve the improvement of business process diagrams in terms of correspondence to modeling rules, in this study we focused on the following tasks:

1) analyze business process design anti-patterns and modeling rules;

2) develop the software tool to evaluate business process diagrams against the modeling rules;

3) demonstrate the developed software solution and analyze obtained results.

Research results. The results presented in [1] state that considered BPM tools (Adonis CE, ARIS Express, Bizagi Modeler, Bonita BPM, Camunda, IBM Blueworks Live, Microsoft Visio, Oracle BPM Studio, and Signavio) are able to detect all of the following Anti-Patterns (AP) occurred frequently in BPMN process models:

– anti-pattern 1 (AP-1): Activities in one pool are not connected;

– anti-pattern 2 (AP-2): Process does not contain an end event;

– anti-pattern 3 (AP-3): Sequence flow crosses sub-process boundary;

– anti-pattern 4 (AP-4): Sequence flow crosses pool boundary;

– anti-pattern 5 (AP-5): Gateway receives, evaluates or sends a message;

– anti-pattern 6 (AP-6): Intermediate events are placed on the edge of the pool;

– anti-pattern 7 (AP-7): Hanging intermediate events or activities;

– anti-pattern 8 (AP-8): Each lane in the pool contains start event;

– anti-pattern 9 (AP-9): Exception flow is not connected to the exception;

– anti-pattern 10 (AP-10): Message flow used inside the pool.

However, there are more different BPMN Modeling Guidelines (MG) exist, such as [2]:

– MG-1: A model should have a start event;

– MG-2: A model should have at least one end event;

– MG-3: Intermediate events should not start the business process flow;

– MG-4: Intermediate events should not end the business process flow;

– MG-5: Activities should not initiate the business process flow;

– MG-6: Activities should not terminate the business process flow;

– MG-7: A process flow should be branched only using split gateways.

Therefore, to analyze the coverage of BPMN modeling guidelines by the most of well-known BPM tools (Adonis CE, ARIS Express, Bizagi Modeler, Bonita BPM, Camunda, IBM Blueworks Live, Microsoft Visio, Oracle BPM Studio, and Signavio [1]), let us build the correspondence matrix of anti-patterns and guidelines (Fig. 1).

Figure 1 – The correspondence matrix for BPMN APs and MGs

As can be seen from Fig. 1, considered modeling anti-patterns AP-1 – AP-10 [1] and guidelines MG-1 – MG-7 [2] have partial coverage. However, the most important is that all modeling guidelines,

except MG-7 "A process flow should be branched only using split gateways", are covered by anti-patterns and, thus, are followed by considered BPM tools (Adonis CE, ARIS Express, Bizagi Modeler, Bonita BPM, Camunda, IBM Blueworks Live, Microsoft Visio, Oracle BPM Studio, and Signavio [1]). The guideline MG-7 "A process flow should be branched only using split gateways" is not covered by the considered anti-patterns AP-1 – AP-10 [1] and, thus, by BPM tools. However, this guideline is important for high-quality business process diagrams – split gateways can explicitly demonstrate different process scenarios, such as parallel, inclusive or exclusive paths. This approach is much understandable than conditional flows, that can mislead readers of business process models.

Therefore, in this study we propose to design and develop a software solution for business process diagrams evaluation against modeling rules.

An efficient and effective software solution for evaluating business process diagrams against modeling rules may be provided by combining the MySQL database management system, Java, JSP (Java Server Pages) and Servlets, and CSS (Cascading Style Sheets) [3].

The set of analyzed BPMN models is taken from the public GitHub repository [4] that contains a lot of business process models for research and experiments. These models belong to different domains and describe various business processes, such as goods dispatch, credit scoring, insurance recourse, and self-service restaurant operations.

The BPMN model analysis page of the software solution for business process diagrams evaluation against modeling rules is demonstrated in Fig. 2. According to Fig. 2, the business process model named "Banking_example…" represents the credit scoring process, however, it has several warnings produced by the developed algorithm and software:

– W-1: the activity "Send scoring level 1" should have a single outgoing flow;
– W-2: the activity "Sending result" should have a single outgoing flow;
– W-3: the process should begin with a single start event;
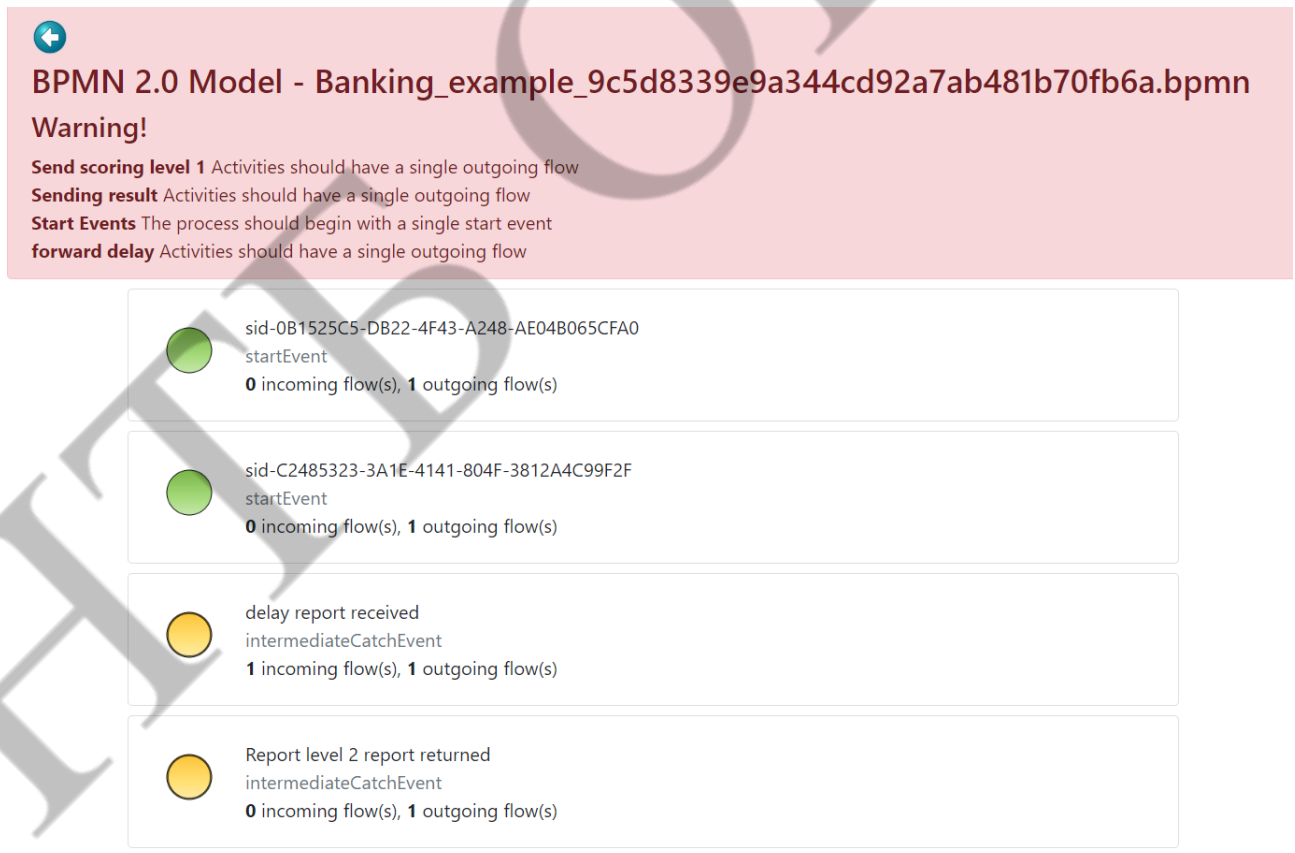– W-4: the activity "forward delay" should have a single outgoing flow.

Figure 2 – The BPMN model analysis web page of the developed software solution

According to Fig. 2, we have warnings W-1, W-2, and W-3 classified as True-Negative (TN), warning W-3 classified as False-Negative (FN), whereas the absence of at least one End Event in the "Credit protection agency" was not reflected by the software, so this situation can be classified as the

False-Positive (FP). Hence, the accuracy of 75% should be improved in the further study in the field of business process diagrams evaluation against modeling rules.

Conclusion. In this paper, the relevant engineering problem for improving the modeling rule conformance of business process diagrams has been solved by developing an appropriate software solution. Improving conformance to modeling standards in business process diagrams is critical because it promotes uniformity and consistency in the representation of business processes, making them easier to understand, analyze, and communicate. Adherence to modeling standards improves clarity, minimizes ambiguity, and enables more effective collaboration among stakeholders, resulting in better decision making, process optimization, and overall operational efficiency.

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SOFTWARE TOOL FOR BUSINESS PROCESS MODEL COMPREHENSIBILITY ASSESSMENT

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Abstract. *This study addresses the important engineering problem of business process models comprehensibility improvement. Improvement of the of business process models comprehensibility is critical since it has a direct influence on an organization's performance and efficiency. Hence, the object of this study is the process of business process models comprehensibility assessment. The subject of the study is the software for business process models comprehensibility assessment. The study aims to improve the business process models comprehensibility by developing a software tool for its assessment.*

Problem statement. Many organizations today use conceptual models to capture their business processes. These models provide a framework for activities related to the business process life cycle, such as process analysis, process redesign, process evaluation, and so on [1]. Hundreds of models have been created by designers with different backgrounds as a result of various modeling projects for these processes. Inadequate quality assurance is one of the major barriers to more effective implementation of these process models. This paper lays the groundwork for the development of automated analysis approaches that can provide such quality assurance.

In fact, a large number of business process models suffer from quality problems, with reliability issues affecting 5% to 30% of models. At least some of these are motivated by the increasing number of business process modeling projects. Such inadequate development leads to problems at the model design and maintenance stages as well. Employees are increasingly involved in the modeling activity. Because many of these inexperienced architects lack modeling expertise and training, the newly created models aren't always of high quality.