Università Di PISA

*Department of Computer Science*

*Master's in data science & business informatics*

**Business Process Modelling**

**PS 58: Art School**

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## 1. Introduction

The proposed scenario is that of a Art school aiming to manage its students' (hereinafter also called clients) requests. The main phases of the process consist in the selection of the course to be followed by the client, the arrangement of a meeting between the student and the teacher, the execution of the lesson, the selection of the draft to be completed, the payment, and the final choice of the student regarding whether to proceed with another lesson or to end the process. A second formulation (hereinafter referred to as a variant) of the problem offers the student the possibility of choosing a new course after terminating the lessons of a previous one.

The two identified actors are the student and the art school. Within the art school, a second distinction can be made between the teacher and what we have called the info office. The continuous interaction between the two agents sets up the stage for a collaboration diagram.

For the development of the process diagram, we adopted the Business Process Model and Notation (BPMN) since, unlike Event-driven Process Chain (EPC), it is suited to model choreographies. To this purpose we employed the online tools provided by the Camunda Modeler: BPMN Editor.

## 2. BPMN Diagrams

The full choreography is presented in Figure 1. The BPMN diagram represents the choreography between a student and an art school, which is divided into two pools. The first represent the **Pool 1: Student (Client) Perspective**, while the second pool represents the **Pool 2: Institute (Art school) Perspective** art school, further divided into two lanes: the info Office and the instructor. The process begins when the student contacts the school to request a list of available courses. Once the course options are provided, the student can proceed to select a suitable course.

Following course selection, the negotiation process for scheduling a lesson is initiated by the newly assigned teacher. The student can either accept the proposed date or suggest an alternative. If the suggested date does not align with the teacher's availability, the negotiation cycle restarts. After finalizing the schedule, the student receives study materials to prepare for the lesson. During the lesson, the student follows the instructions provided and can either ask for further clarification or proceed through the session based on the teacher's guidance.

After the lesson, the student receives a draft to complete. At this stage, they can either accept the proposal or enter further negotiations to refine it until both parties reach an agreement. The final steps of the process involve the submission of the completed draft and the payment for the course. These actions are executed in parallel to ensure efficiency in processing.

The most challenging aspect of the diagram was modeling the sequence of draft submission and payment. Several approaches were considered, including sequential execution, decision-based pathways, and parallel execution. Ultimately, the parallel execution approach was chosen to allow draft submission and payment to happen concurrently, ensuring that both are completed before making a final decision about continuing or terminating the course.

Overall, the BPMN diagram effectively models the interactions between the student and the art school, covering key processes such as course selection, lesson scheduling, lesson execution, and payment, while offering flexibility through negotiation loops and decision points.

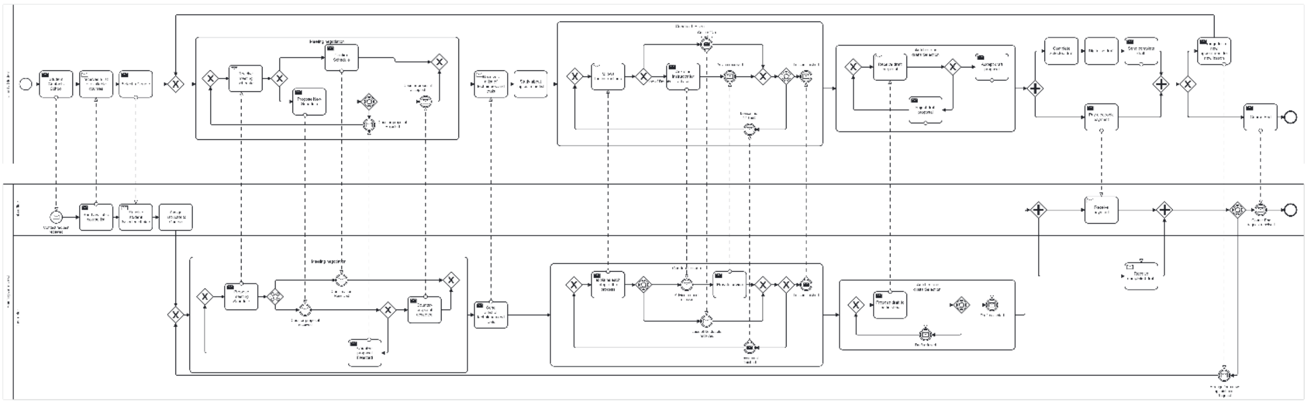


*Figure 1: Complete BPMN diagram (original formulation)*

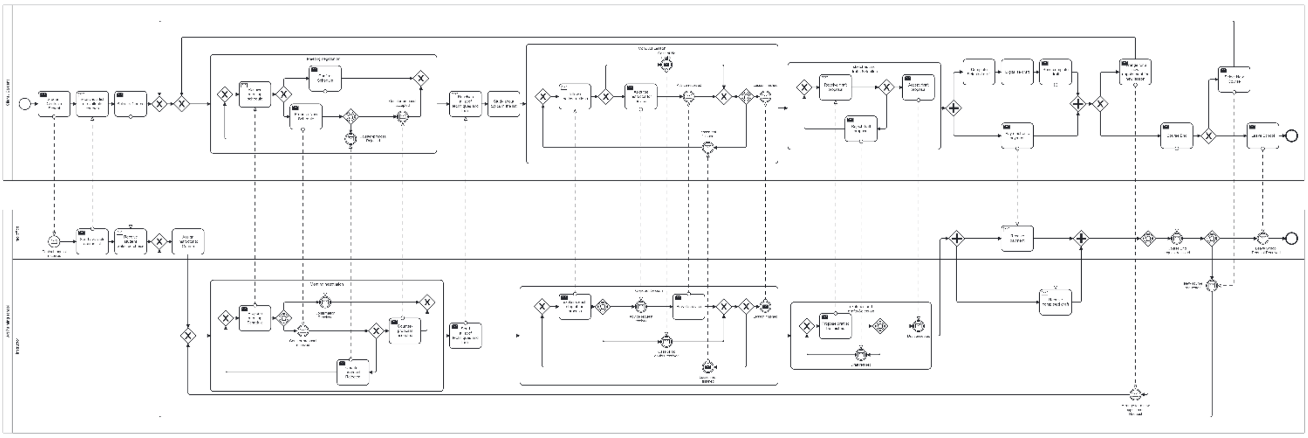


*Figure 2: Complete BPMN diagram (variant)*

## 2.1 Variant

The diagram of the variant is similar to the original up to the second-to-last block, up to that point the only change is the addition of an exclusive gateway joining to add the possibility to come back to just after the selection of the course by the client and just before the appointment of a teacher by the school.

The latest block we presented for both the client and the school presents instead some variations. Indeed, just after the parallel block, it is added the possibility for the client to choose another course and come back to the gateway. In Figure 3 it can be seen how the new choice depends on the client, and, after the gateways, there is communication to the school of the choice made.

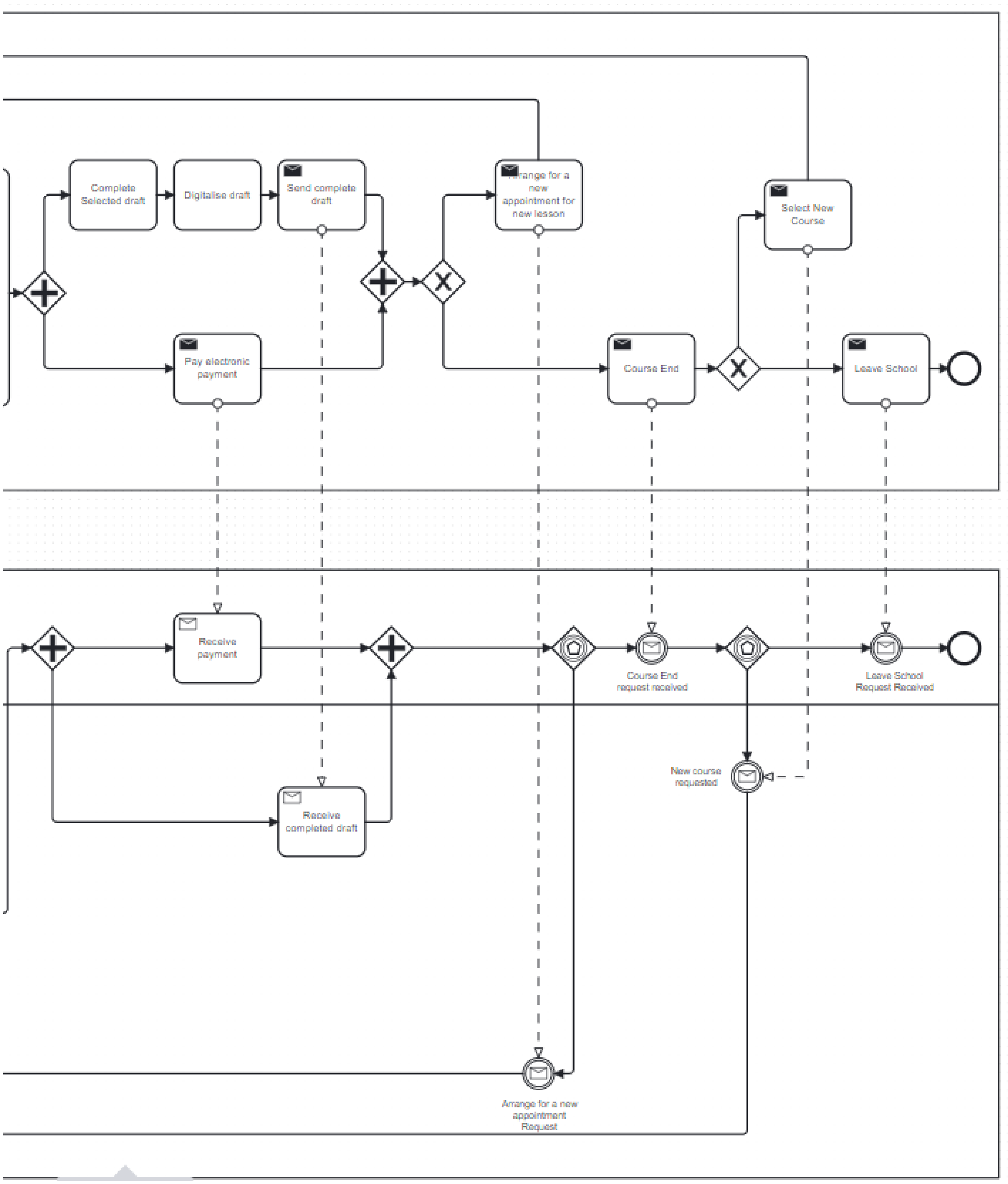



*Figure 3: Variant - Main differences with original*

## 3. Petri net

The BPMN diagrams displayed previously have then been translated into Petri nets. The steps performed to achieve such result include:

- Transforming every sequence flow into a place;
- Transforming every activity/event and XOR/AND split/join into a transition;

- Fusing places around event-based gateways.
- Desugarizing XOR splits/joins.

On the resulting nets we then conducted a structural and soundness analysis to verify their properties. The coverability graphs are also reported. We employed the WoPeD software for the semantic analysis and coverability graph generation. We try two software tools for the petri nets process but get success in Woflan, Woflan was used for preliminary soundness analysis, particularly on the Petri nets of the full process, as WoPeD was significantly more time-consuming and it was unfeasible to use it on a consistent basis. In the report we display only the complete Petri nets.

As a common characteristic, all following Petri nets are workflow nets, meaning they all respect the conditions of no dead task, option to complete, and proper completion. Furthermore, all nets are sound: in particular, all transitions are live (also implying freedom from deadlocks) and no place is unbounded

### 3.1 Client

The semantic analysis on the student Petri nets is summarised in Figure 4. For the original formulation we have a workflow net with 43 places and 47 transitions. In addition, the net is also free-choice, which, coupled with liveness and boundedness, implies that the net is S-coverable. In fact, all places belong to one of the two S-components in the net (the two components differ only in the parallel block related to the draft completion and payment). This also implies that at least one positive S-invariant exists.

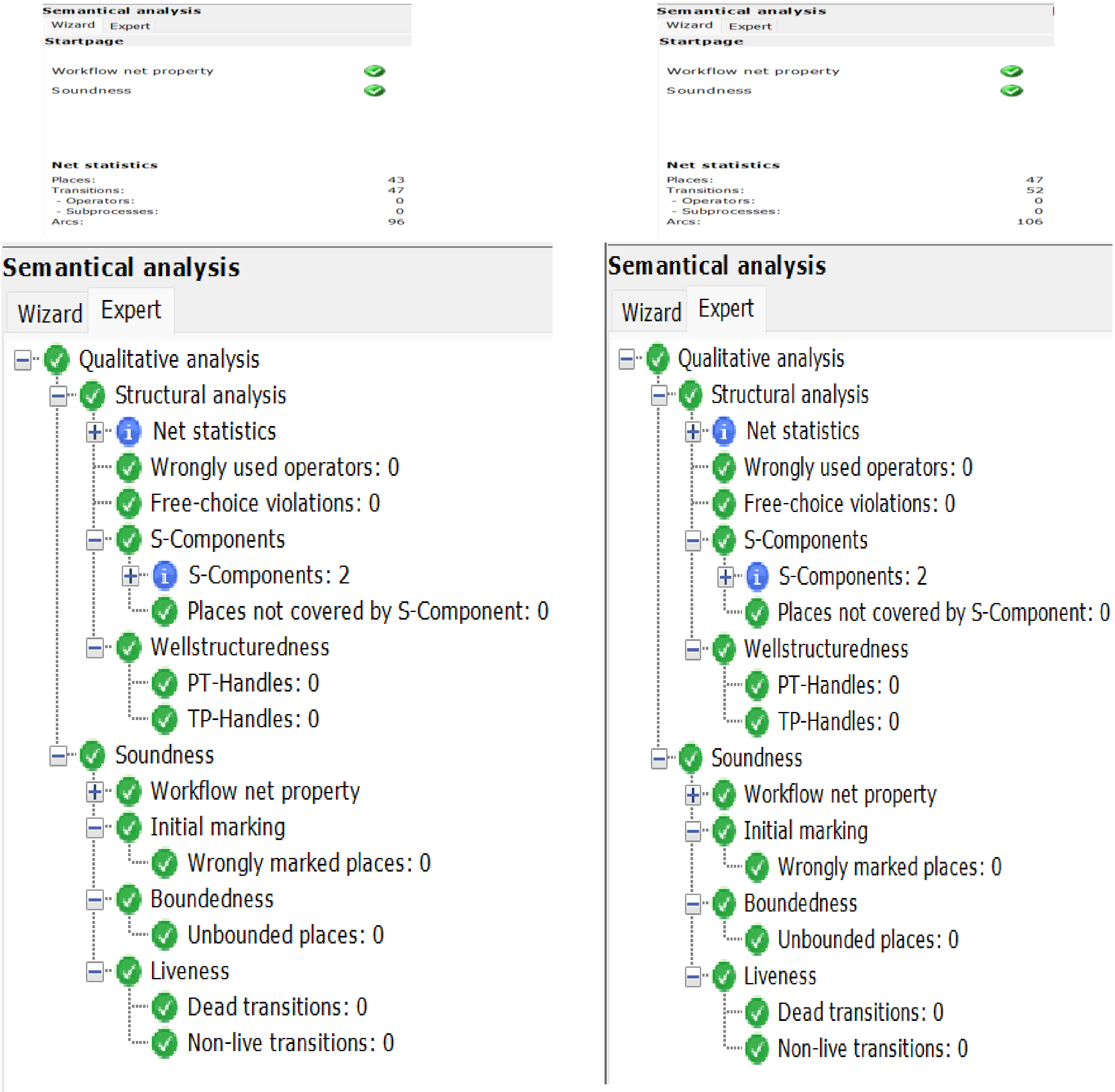
The net is well-structured, as no PT- or TP-handles are present. The net is not an S-net, given that the transitions representing the parallel block of draft completion and electronic payment have more than one incoming/outgoing arc. This implies that the amount of tokens present in the net is not an invariant under any sequence of firings: once we enter the parallel block we would go from 1 to 2 tokens, and then back to 1 when exiting the block. Consequently, the net is not safe. This could be adjusted by putting the activities in a sequential way, avoiding the parallel block. It is also not a T-net due to the presence of event-based gateways, which translate to a place having more than one outgoing arc.

The reachability graph is bounded and hence it corresponds to the coverability graph (Figure 6a), which presents 45 vertices and 53 edges. A few loops are also present.

Identical considerations can be made for the variant of the problem. The only notable changes are the increased number of places and transitions in the net and the presence additional loops in the coverability graph. Figures 4b and 6b provide the relevant information to this point.

### 3.2 Painting school

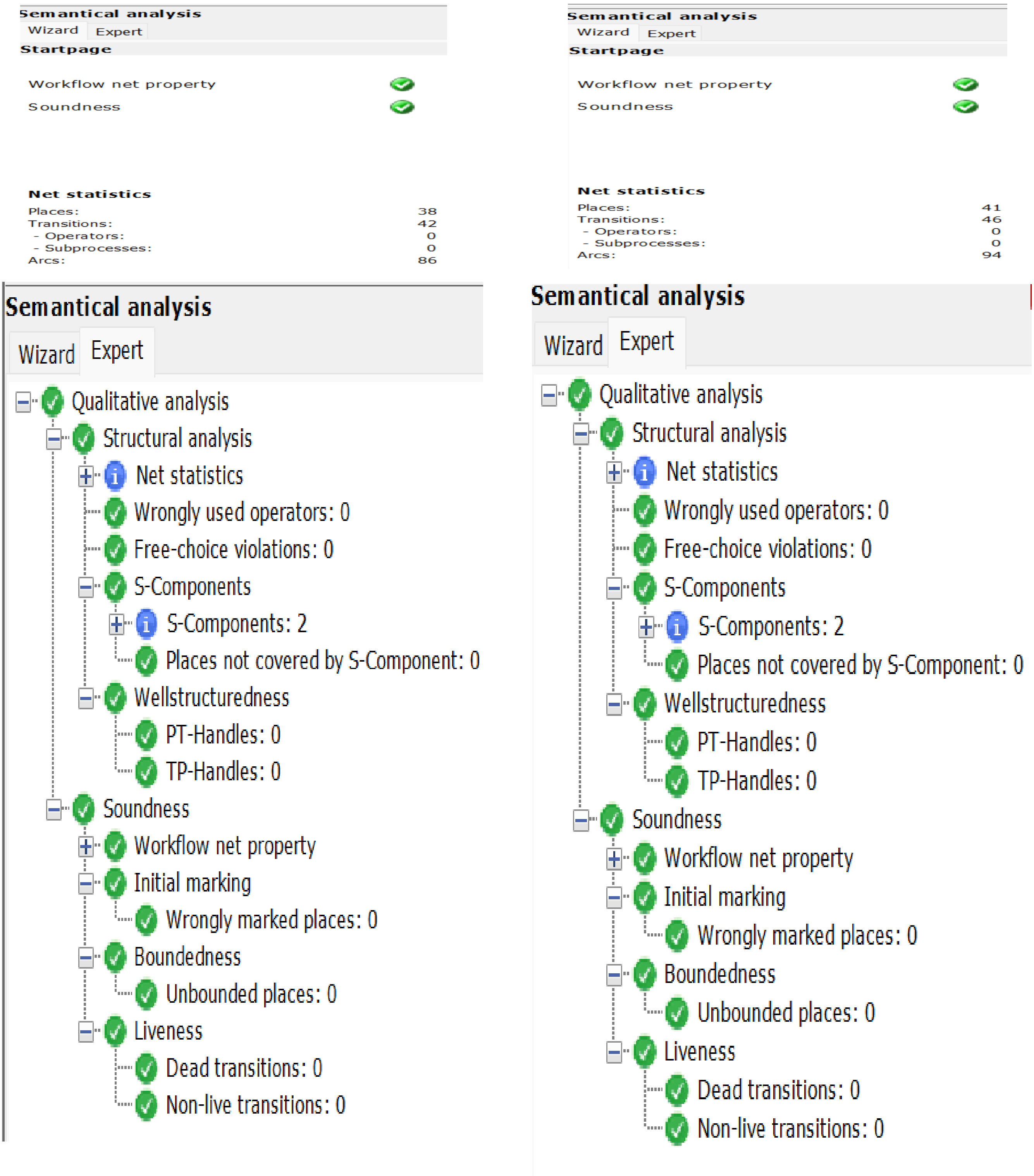
The analysis of the painting school Petri net is analogous to that of the student one and it is omitted for the sake of avoiding excessive redundancy. The differences lie in the number of places and transitions and elements of the coverability graph, which are less than before. Figures 5 and 7 provide an overview of the situation for both the original formulation and the variant.




*(a) Original formulation*

*(b) Variant formulation*

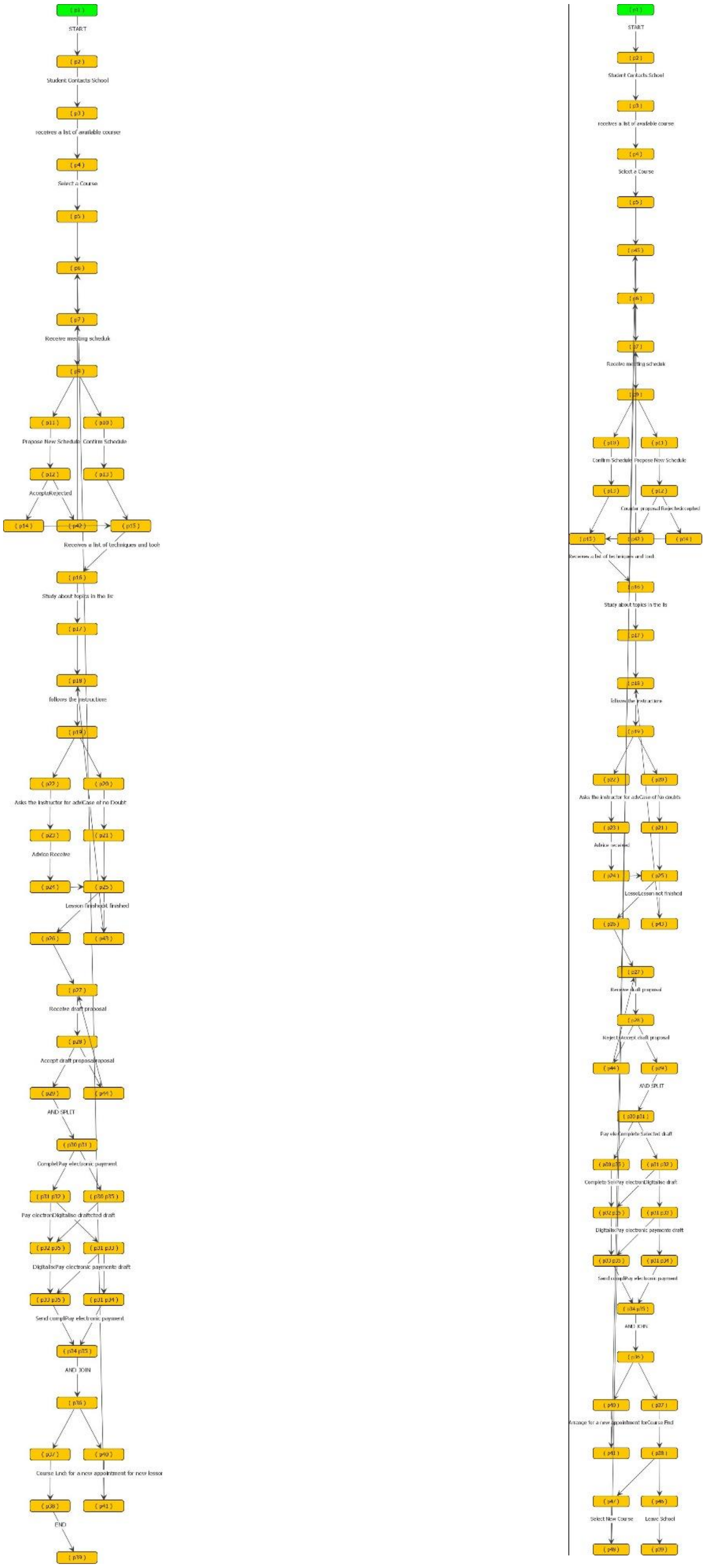
*Figure 4: Semantic analysis of the student Petri net*




*(a) Original formulation*

*(b) Variant formulation*

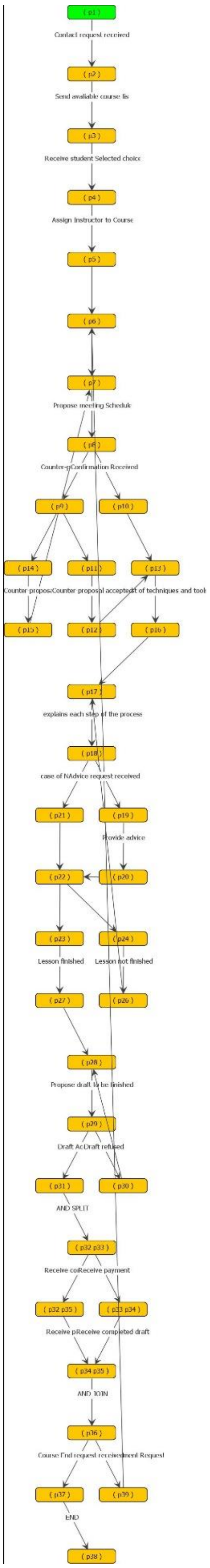
*Figure 5: Semantic analysis of the Art school Petri net*



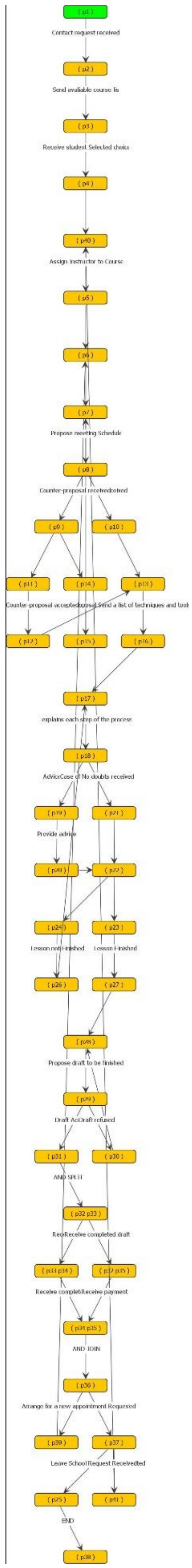
(a) Original formulation

(b) Variant formulation

Figure 6: Coverability graph of the student Petri net



*(a) Original formulation*



*(b) Variant formulation*

*Figure 7: Coverability graph of the Art school Petri net*

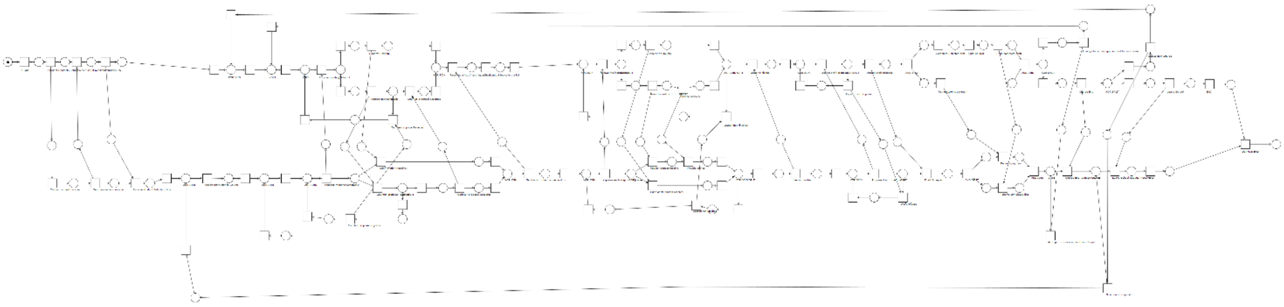


Figure 8: Complete Petri net (original formulation)

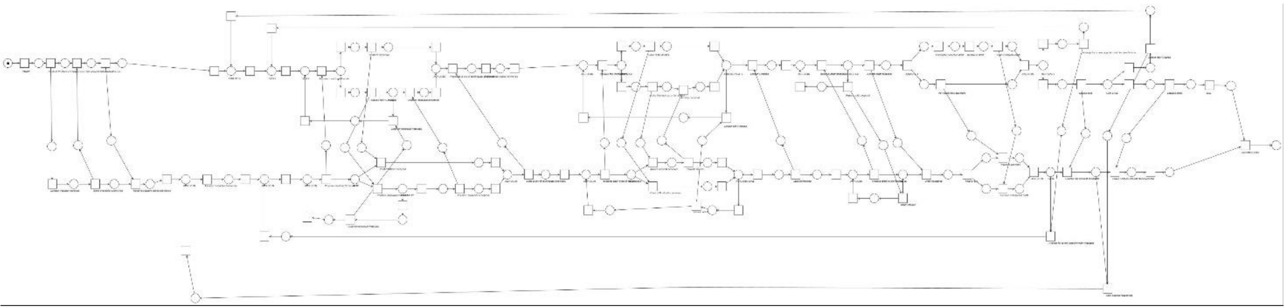


Figure 9: Complete Petri net (Variant formulation)

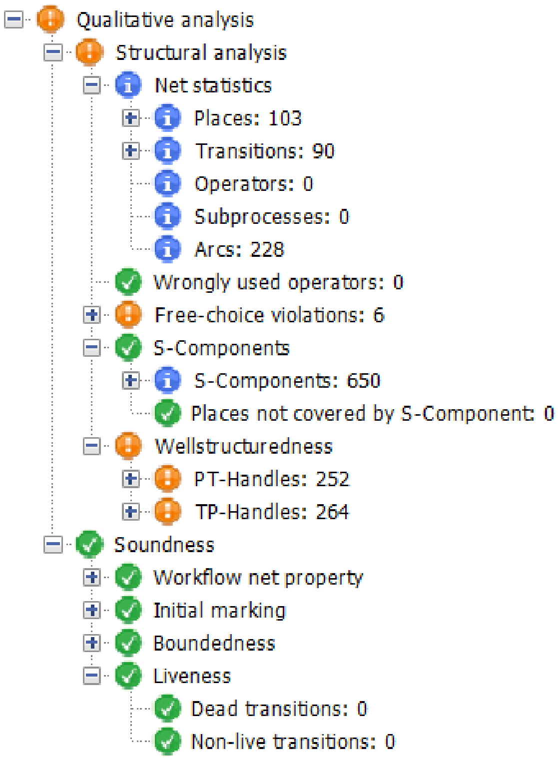
### 3.3 Full scenario

The merging of the workflow nets of the two agents into a single module required some adjustments: we added a common ending place, which we connected through an AND join and we translated the message flows by adding additional places and connecting the respective transitions. The common starting point is represented by the starting point of the client, as he/she is the one who starts the process as a whole. The complete Petri nets are displayed in Figures 8 and 9.

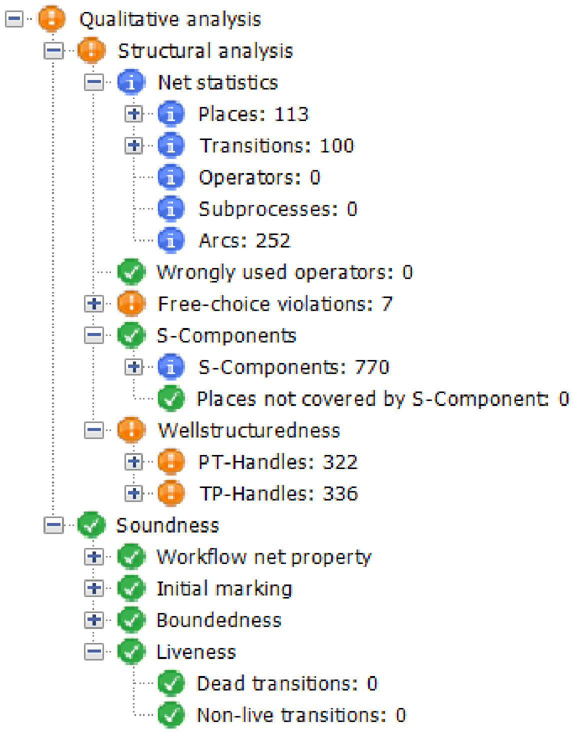
As visible in Figure 10a, the resulting workflow net maintains the soundness property, but it is not free choice anymore. This is due to the event-based gateways, which, in the full scenario, introduce pairs of transitions whose pre-sets are neither strictly equal nor disjoint. We have in fact 6 free-choice violations, corresponding to the 6 event-based gateways. The net is now not well-structured, as a conspicuous number of PT- and TP-handles are present (over 250 each). Another notable difference is the number of S-components, which increases drastically to 650. Nevertheless, the net is still S-coverable, so that at least one positive S-invariant exists.

The coverability graph (Figure 19a) is once again bounded and corresponds to the reachability graph, presenting a total of 237 vertices and 408 edges.

The variant formulation (Figures 18b and 19b) leads to an additional free-choice violation (given by the possibility of choosing a new course at the end) and an additional number of PT and TP-handles, as well as a larger coverability graph (314 vertices and 561 edges).

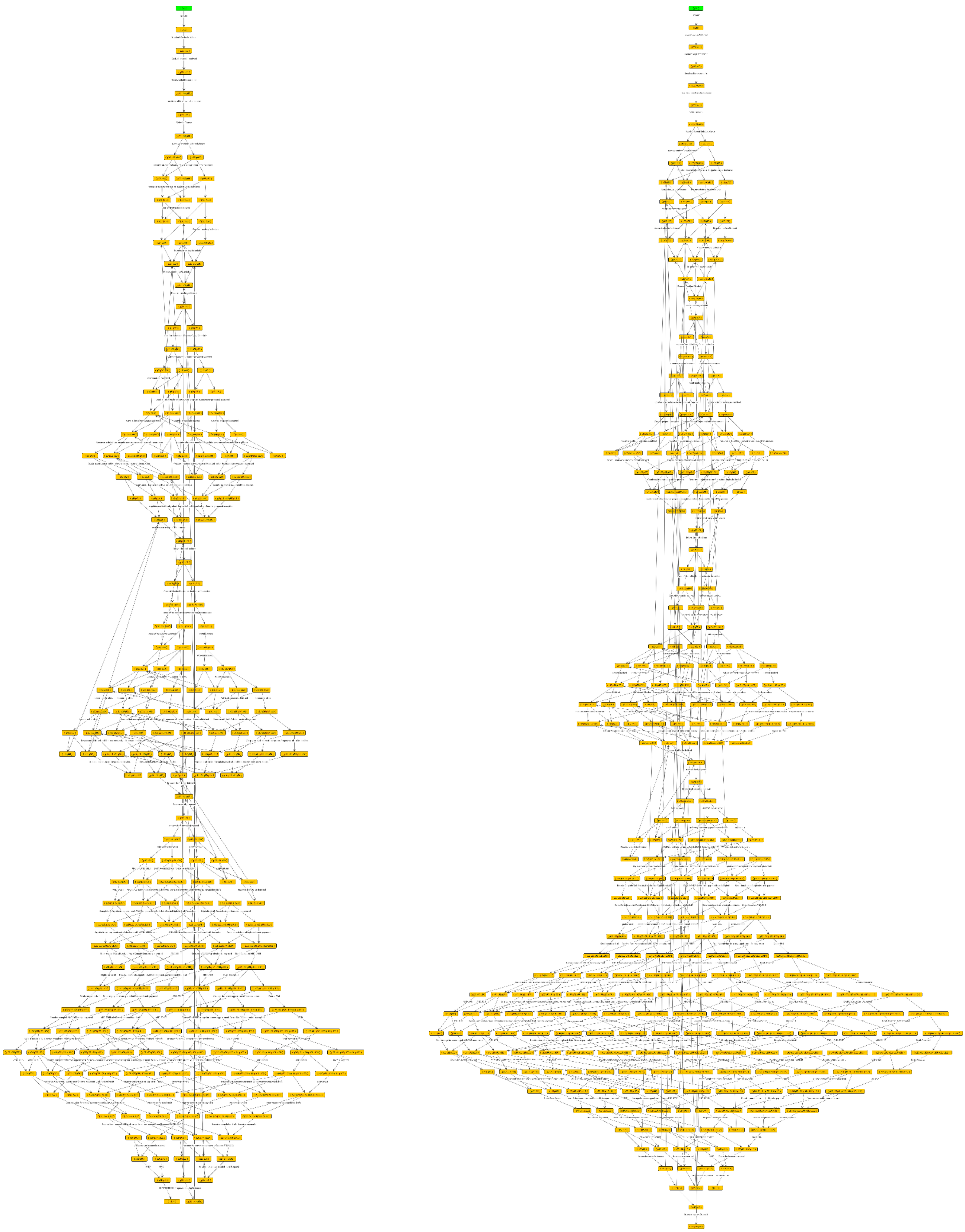



*(a) Original formulation*




*(b) Variant*

*Figure 10: Semantic analysis of the complete process Petri net*



(a) Original formulation

(b) Variant formulation

*Figure 9: Full Coverability graph*