Business Process Modelling
P58: Scuola di Pittura

Jornea Ion [637765]
Lemma Ludovico [637757]

University of Pisa
A.Y. 2022/2023

Contents

List of Figures

1 Introduction

The proposed scenario is that of a painting 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 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 painting school. Within the painting school, a second distinction can be made between the teacher and what we have called the front office or desk. 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 BPMN.io[1] editor. The choice of the tool is justified by its user-friendliness and ease of use. Subsequently, we translated the diagrams into Petri nets and analysed them through the software WoPeD and Woflan.

2 BPMN diagram

The full choreography is presented in Figure 1. We have devised two separate pools: one for the student and one for the painting school. The second pool is then split into two lanes: one for the front desk and one for the teacher.

The start is triggered by a communication of the client (point of view of the following explanation) to the school: he/she contacts them in order to receive a list of courses to select from. Subsequently a newly appointed teacher triggers with a message the start of the negotiation of a date for the lesson, it is the client's choice (exclusive gateway) to accept the meeting proposal or refuse it to propose a different date and time, which in turn if it is not adherent to the teacher's needs (event-based gateway) it moves the negotiation back to the start.

The process moves to the receival of materials to study in advance of the lesson in order to be properly prepared for it. When the lesson starts the client follows the proposed instructions. It is up to him/her (XOR gateway) to then to ask for advice in case of doubts or wait for the teacher to explain the next step or end the lesson (event-based gateway). At the end of the lesson the client receives a proposal of a draft to be completed and it is up to him/her (exclusive gateway) to decide to accept or continue the negotiation until both are on common ground.

The last part of the diagram was the most difficult to model as we had a higher degree of freedom about the placing of the draft delivery. We discussed several possible solutions to model this part of the choreography, either using sequences or exclusion gateways or parallel gateways. The first two possibilities required us making more assumptions about the correct order of the payment, delivery and termination or continuation of the course, while the latter we opted for in the end required only the completion and delivery of the task to be in parallel with the payment. Furthermore we assumed an absolute obligation to complete the draft while also guessing this obligation would need to be fulfilled before the decision to continue or leave the course. We were not given any exact timing for the draft to be sent, but it was described just before the payment, so our final decision was to execute them in parallel.

[1] https://bpmn.io/

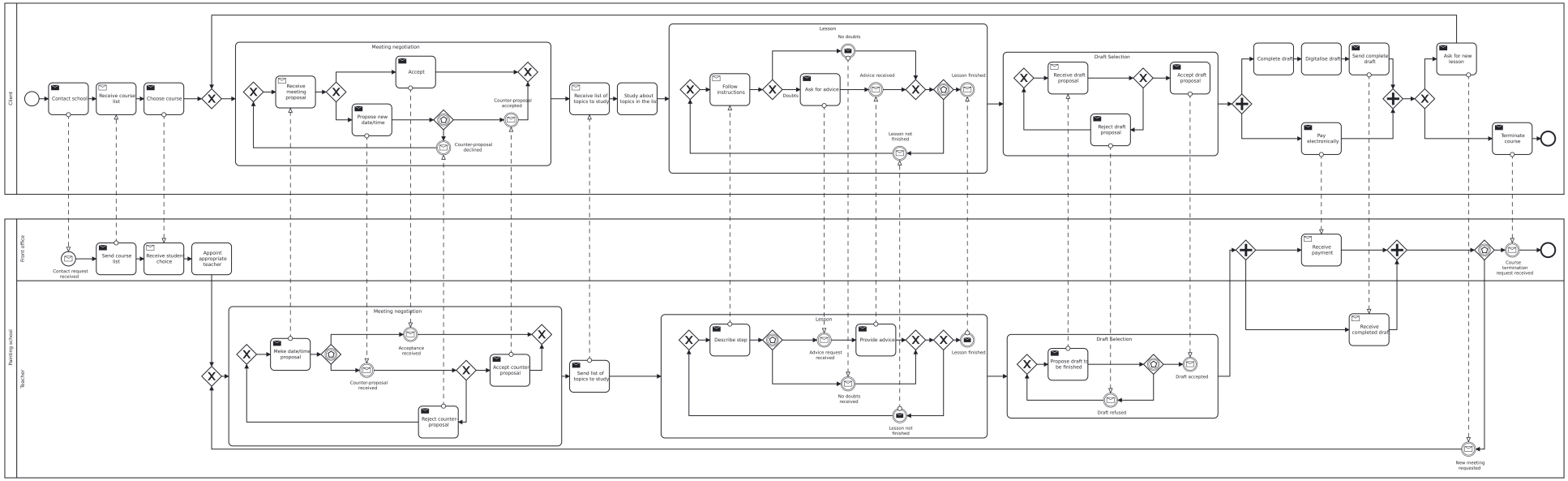


Figure 1: Complete BPMN diagram (original formulation)

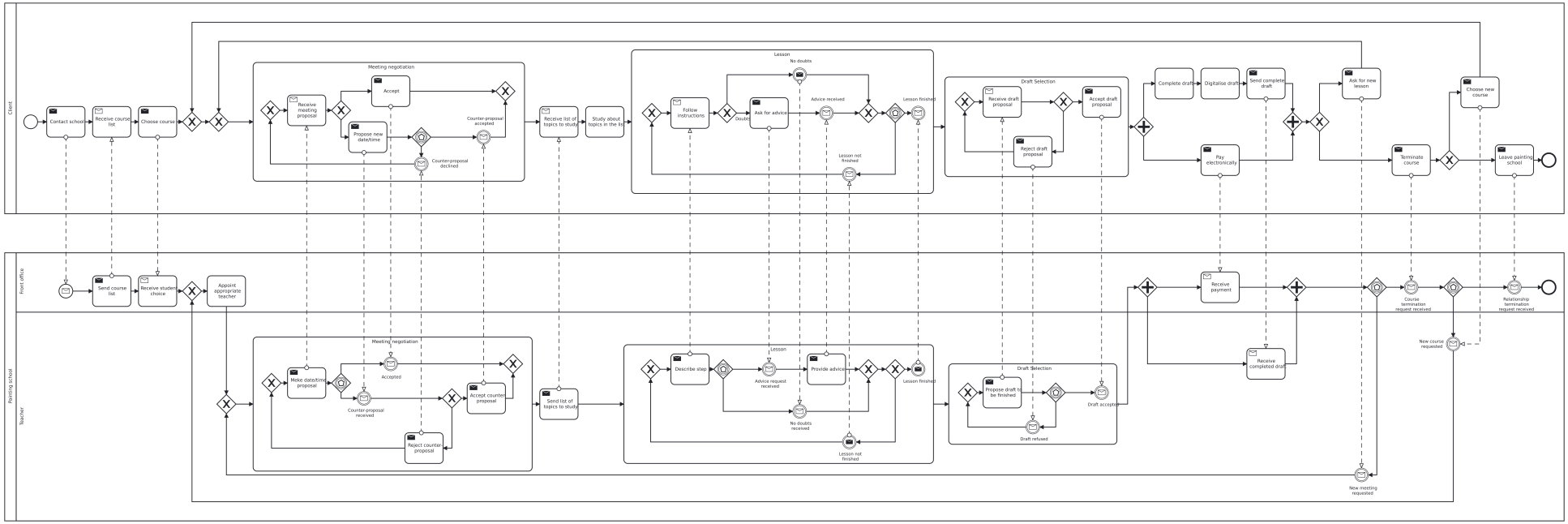


Figure 2: Complete BPMN diagram (variant)

2.1 Client

The pools of the client and that of the painting school are symmetric in general: the client has to follow just a small subset of non-symmetric extra tasks (namely the study of the materials and the completion of the draft). Either way we are going to systematically present the main processes the client meets during the choreography execution. Initial and/or final events may have been omitted inside subprocesses to favour compactness.

2.1.1 Meeting Negotiation

As it can be seen in Figure 3, for the client the meeting negotiation starts with the receival of a proposal from the teacher, then it proceeds with two mutually exclusive sending tasks: the client can accept the proposal or make one of their own. In the latter case, he/she waits for the response of the teacher (event-based gateway). The negotiation terminates upon either the immediate approval of the teachers' proposal by the student or the acceptance of the client's counter proposal by the teacher. If the teacher refuses, the negotiation goes back to the start.

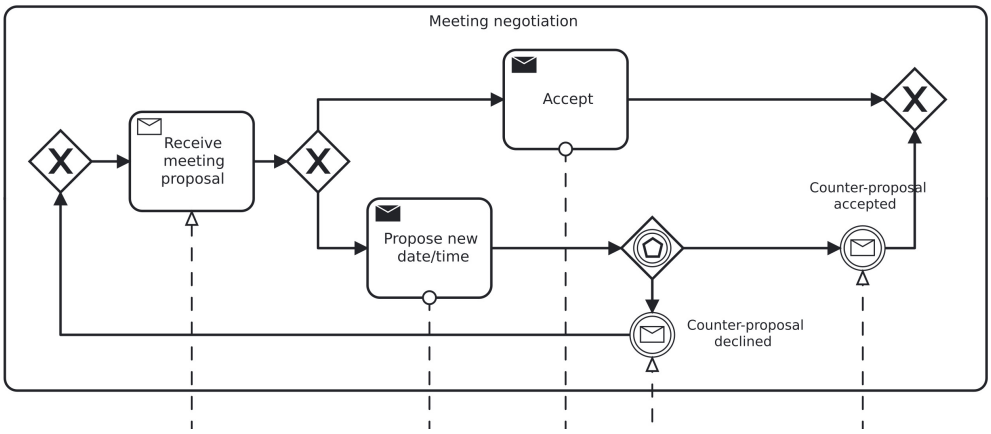


Figure 3: Client - Meeting Negotiation

2.1.2 Lesson

The lesson (Figure 4) starts with the client receiving instructions on the step to perform, then it is up to him/her to ask questions or not. Finally it is left to the teacher whether to conclude the process or restart it if other steps are yet to be covered in the current lesson.

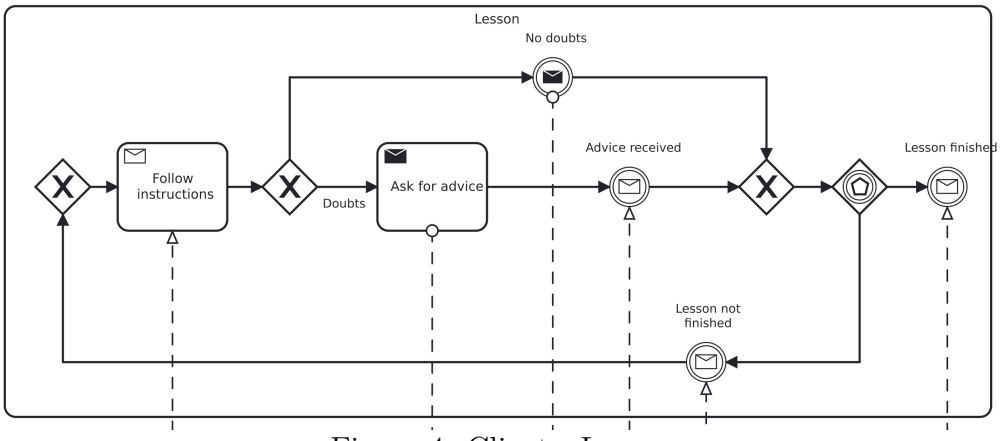


Figure 4: Client - Lesson

2.1.3 Draft Selection

As before the communication comes from the other pool at first (with a proposal of the draft to be completed, as in Figure 5) but here it is up to the client to end the process by accepting the proposal or to restart the process by refusing.

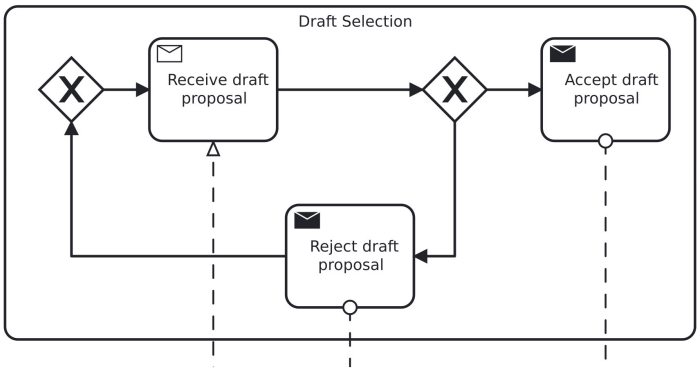


Figure 5: Client - Draft Selection

2.1.4 Payment, Restart or End

Here (Figure 6) the main actor is the client, almost all decisions depend on his/her choices. The payment and the completion of the draft are executed in parallel (this was an assumption on our part), then he/she can either leave the course or ask for a new lesson.

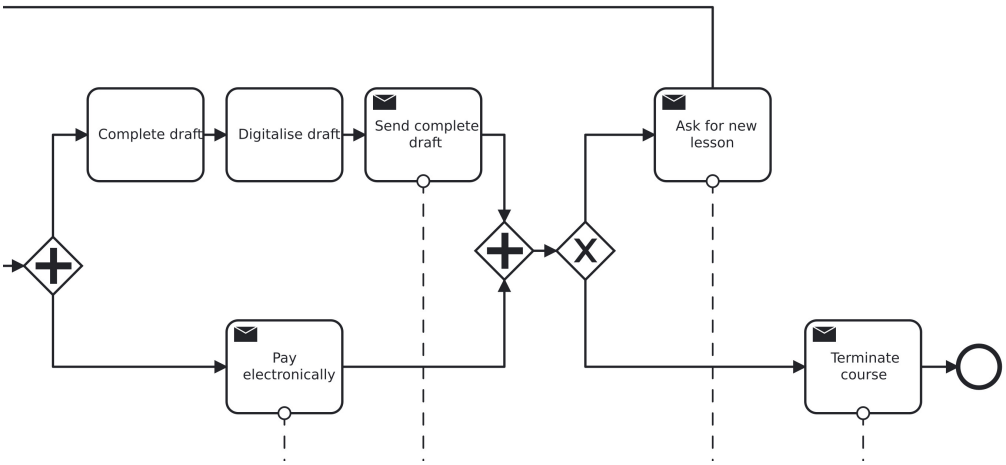


Figure 6: Client - Payment, Restart or End

2.2 Painting school

For the painting school, the activities, excluding the study of the materials and the completion of the draft, are practically the same, with mirrored receiving and sending tasks, and the reversal of the exclusion and event-based gateway roles. Furthermore, we now have two lanes, as some activities are performed by the front desk (such as initially interacting with the client, appointing the teacher, receiving payments) and the other by the teacher.

2.2.1 Meeting Negotiation

As visible in Figure 7, the meeting negotiation is initiated by the teacher, then the client answers with his preference. If the original proposal is declined, the decision goes back to the hands of the teacher, who can go with the alternative proposed by the client or give a new one of his/her own.

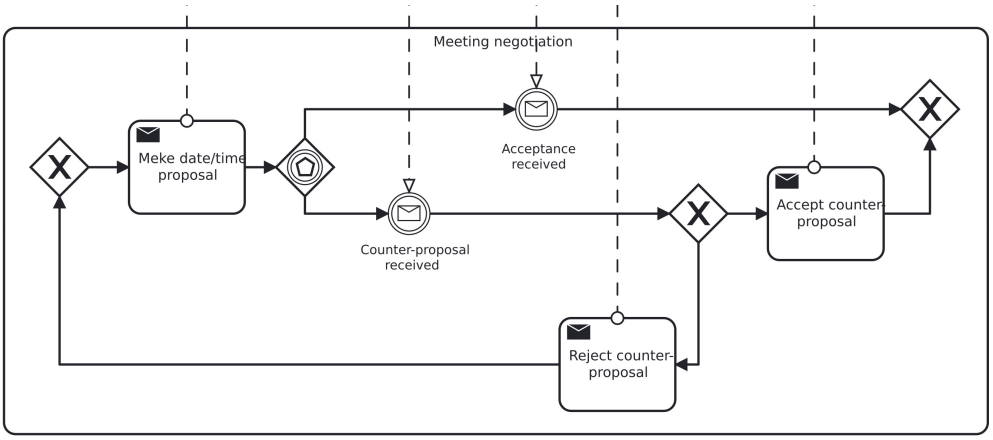


Figure 7: School - Meeting Negotiation

2.2.2 Lesson

Here (Figure 8), just as before, the teacher starts the process, then the event-based gateway signals the decision is made by the client (who can ask for advice or not). The final exclusion gateway shows that the teacher is the one deciding whether the lesson is over or more steps are to be performed.

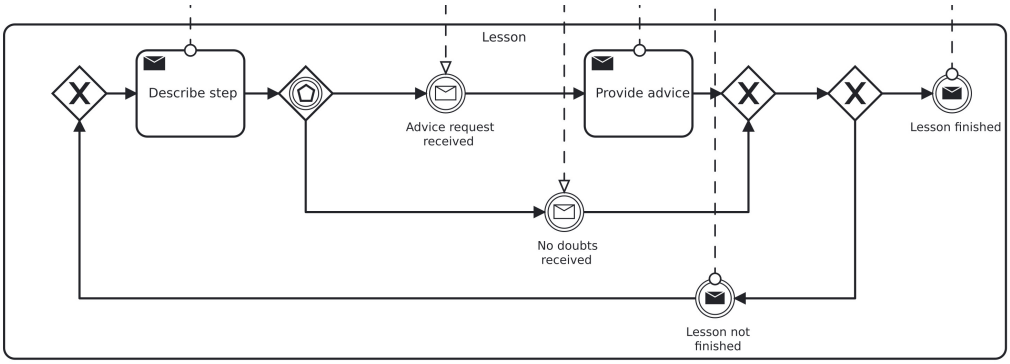


Figure 8: School - Lesson

2.2.3 Draft Selection

Here (Figure 9) the teacher starts again the process. After that the decision depends mainly on the client which may restart the negotiation or accept and continue to the payment.

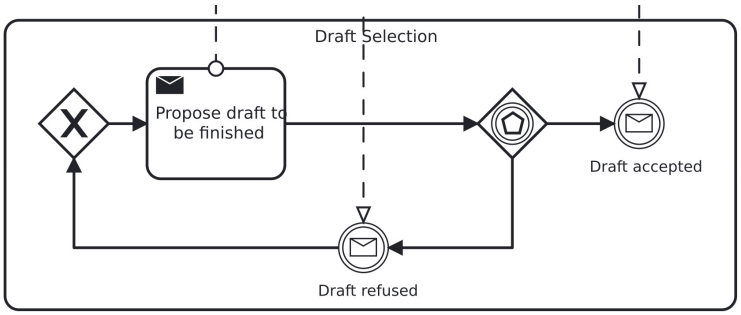


Figure 9: School - Draft Selection

2.2.4 Payment, Restart or End

In this final phase (Figure 10, with respect to the same block of the client, the school is just passive, here the front desk (which receives the payment) and the teacher (which receives the completed draft) both wait for the decision of the client to continue the lessons or leave the course.

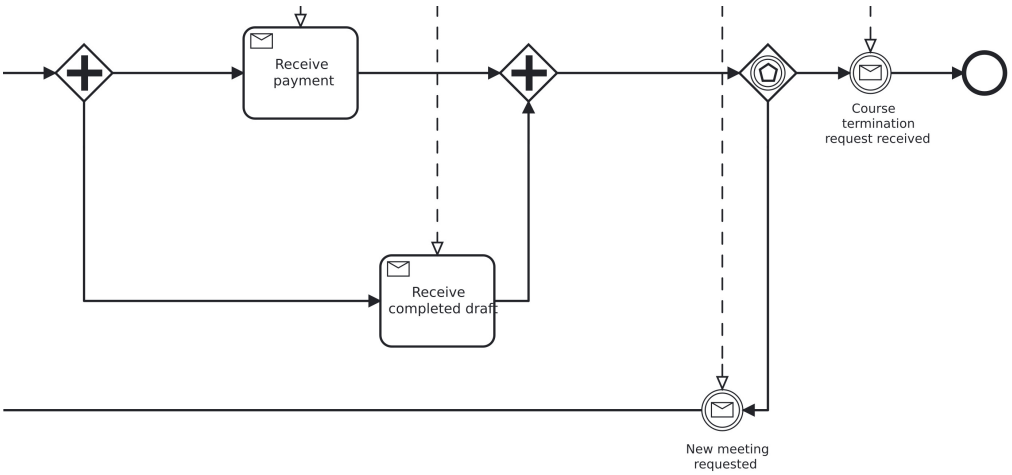


Figure 10: School - Payment, Restart or End

2.3 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 join 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 aforementioned gateway. In Figure 11 it can be seen how the new choice depends on the client and, after the gateways, there is the communication to the school of the choice made.

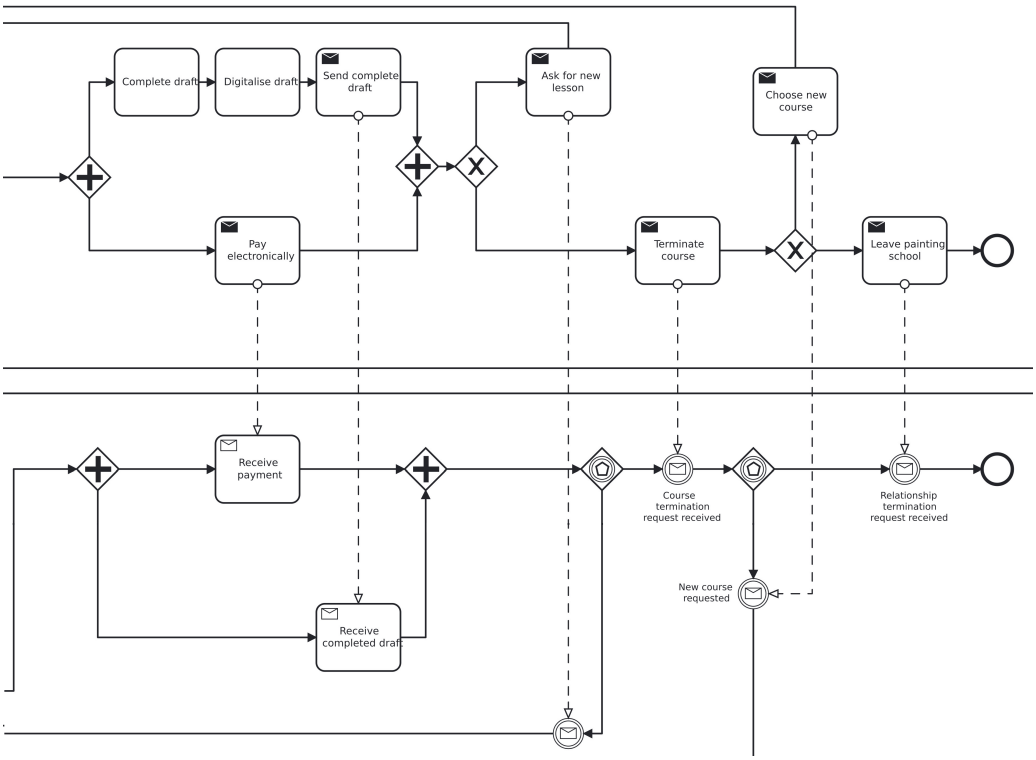


Figure 11: Variant - Main differences with original

3 Petri net

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

a. transforming every sequence flow into a place;
b. transforming every activity/event and XOR/AND split/join into a transition;
c. fusing places around event-based gateways;
d. 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. Woflan was used for preliminary soundness analysis, particularly on the Petri nets of the full process, as WoPeD was significantly more time-consuming in this case (taking from 3 up to 11 hours each time) 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 12. 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.

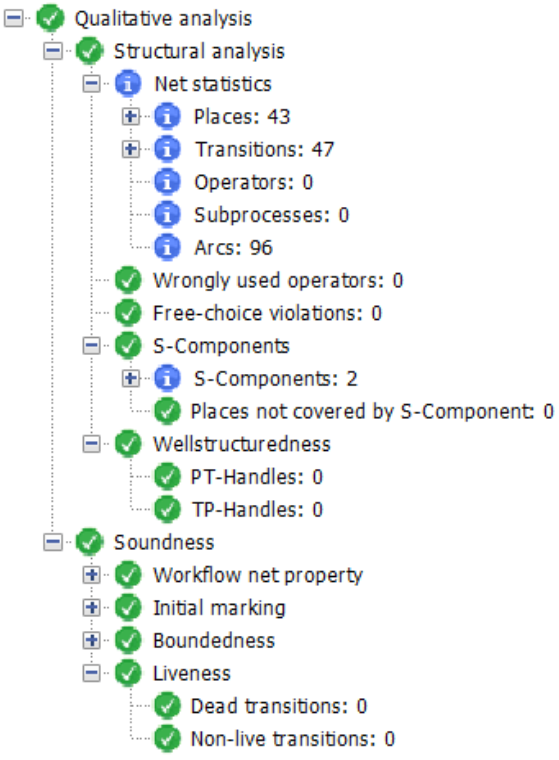
The net is well-structured, as no PT- or TP-handles are present. The net is not an S-net, given that the transitions representing the parallel block of draft completion and electronic payment have more than one incoming/outgoing arc. This implies that the amount of tokens present in the net is not an 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 14a), which presents 45 vertices and 53 edges. A few loops are also present.

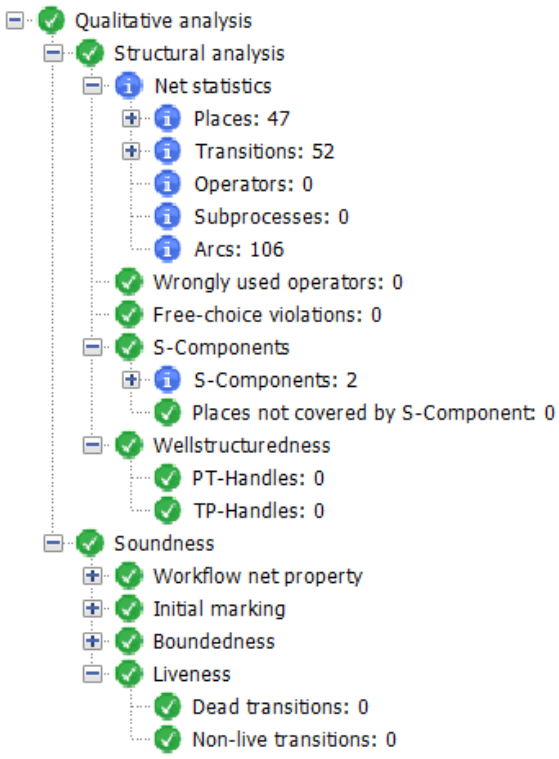
Identical considerations can be made for the variant of the problem. The only notable changes are the increased number of places and transitions in the net and the presence additional loops in the coverability graph. Figures 12b and 14b provide the relevant information to this point.

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 13 and 15 provide an overview of the situation for both the original formulation and the variant.

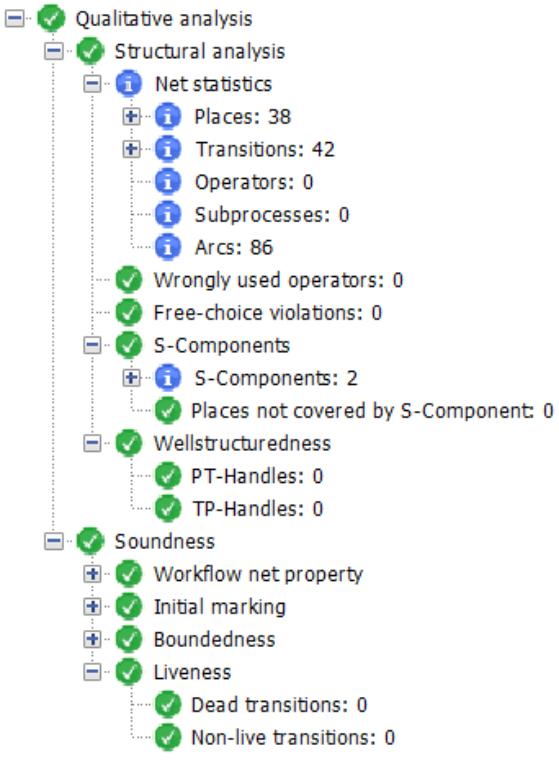


(a) Original formulation

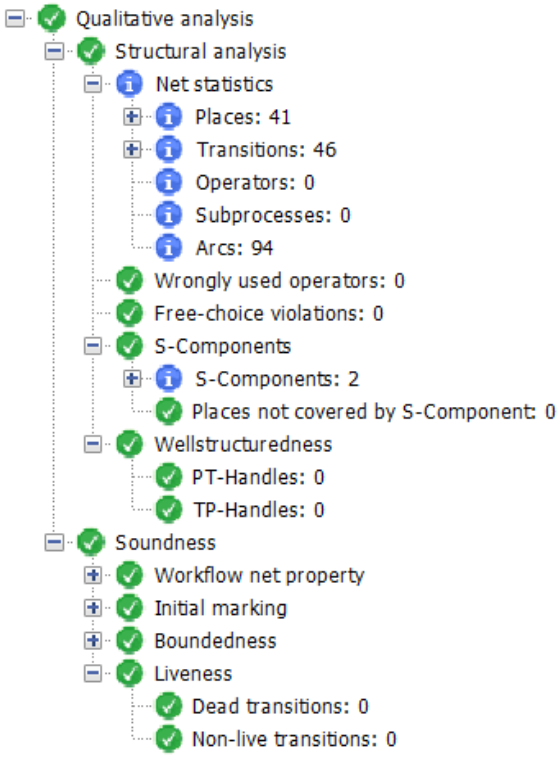


(b) Variant

Figure 12: Semantic analysis of the student Petri net

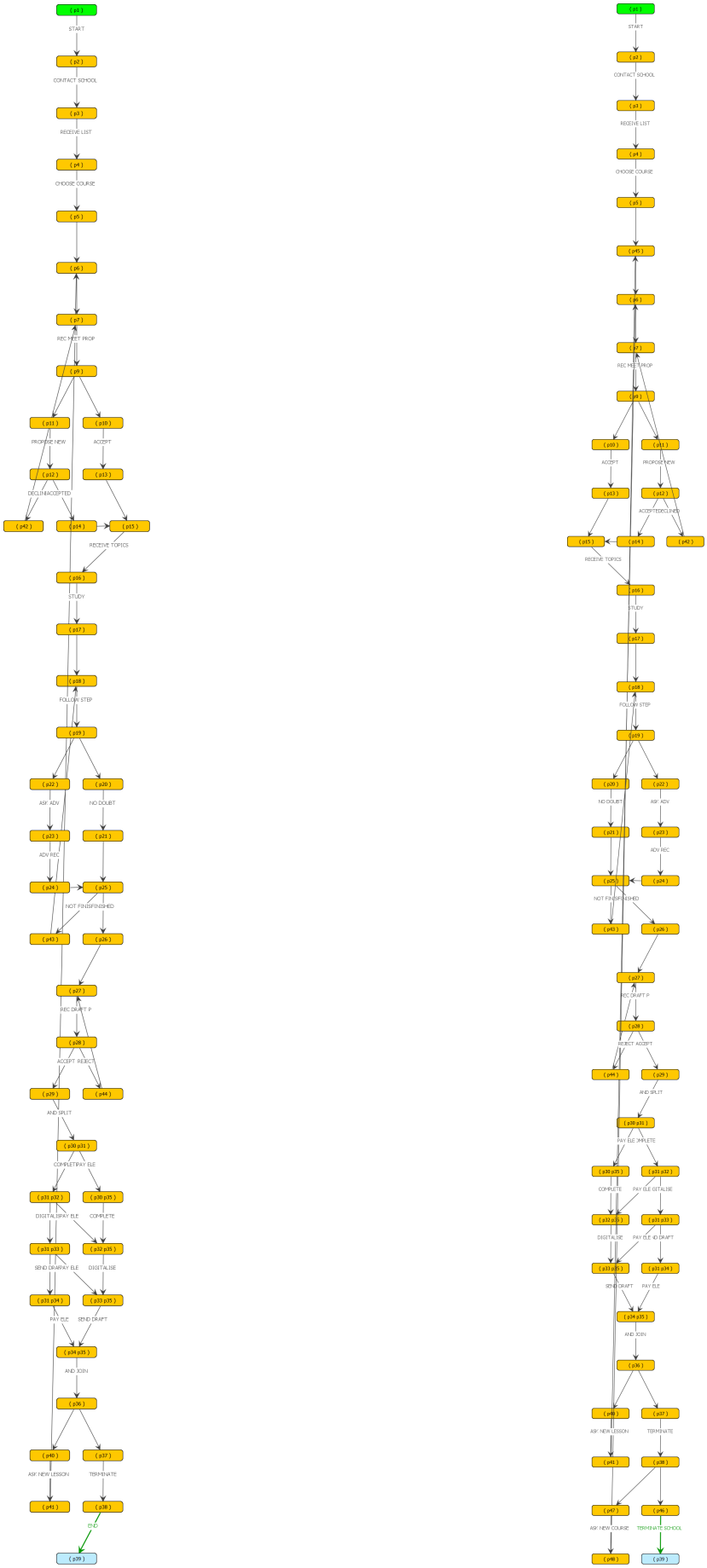


(a) Original formulation



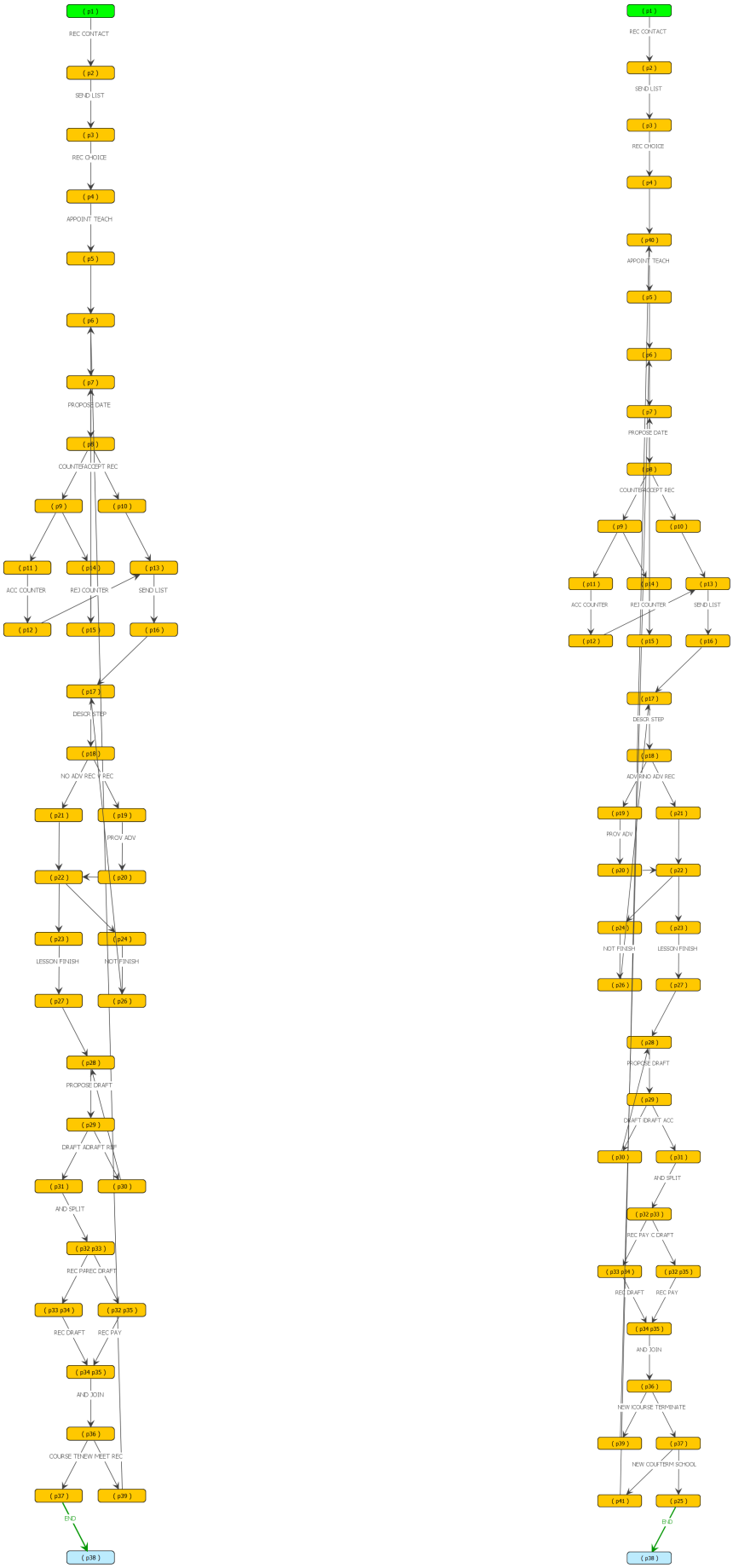
(b) Variant

Figure 13: Semantic analysis of the painting school Petri net



(a) Original formulation (b) Variant

Figure 14: Coverability graph of the student Petri net



(a) Original formulation (b) Variant

Figure 15: Coverability graph of the school Petri net

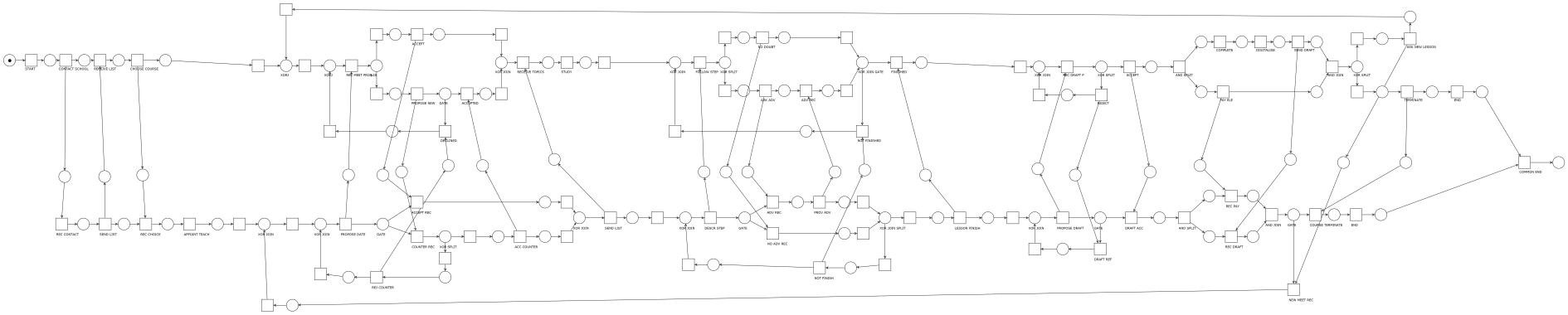


Figure 16: Complete Petri net (original formulation)

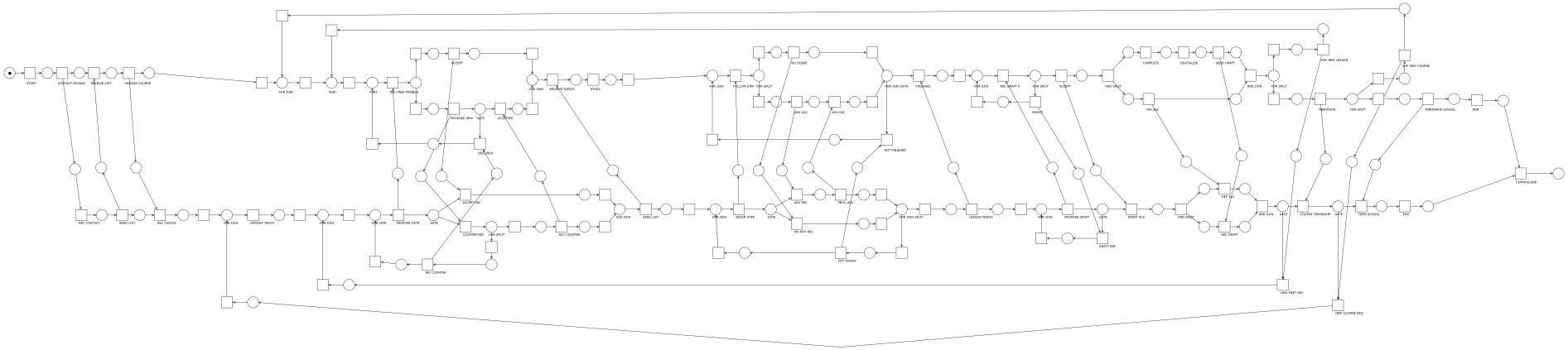


Figure 17: Complete Petri net (variant)

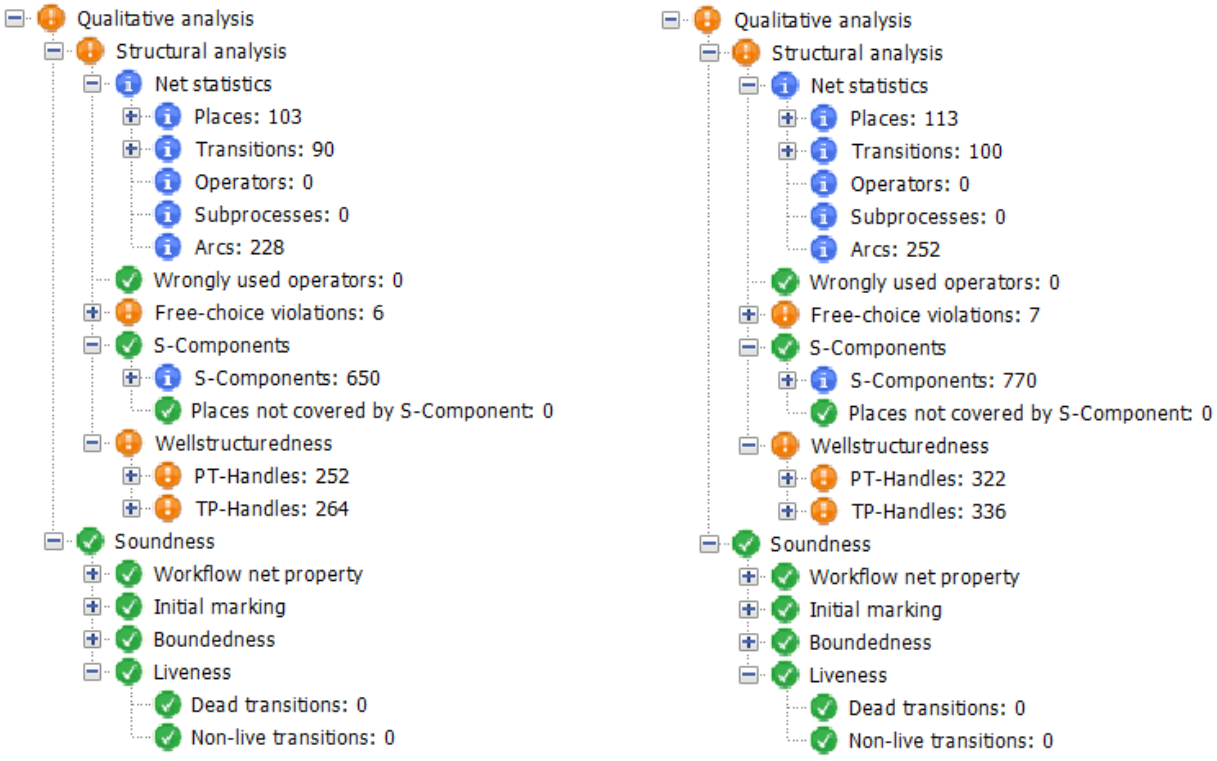
3.3 Full scenario

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 16 and 17.

As visible in Figure 18a, 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.

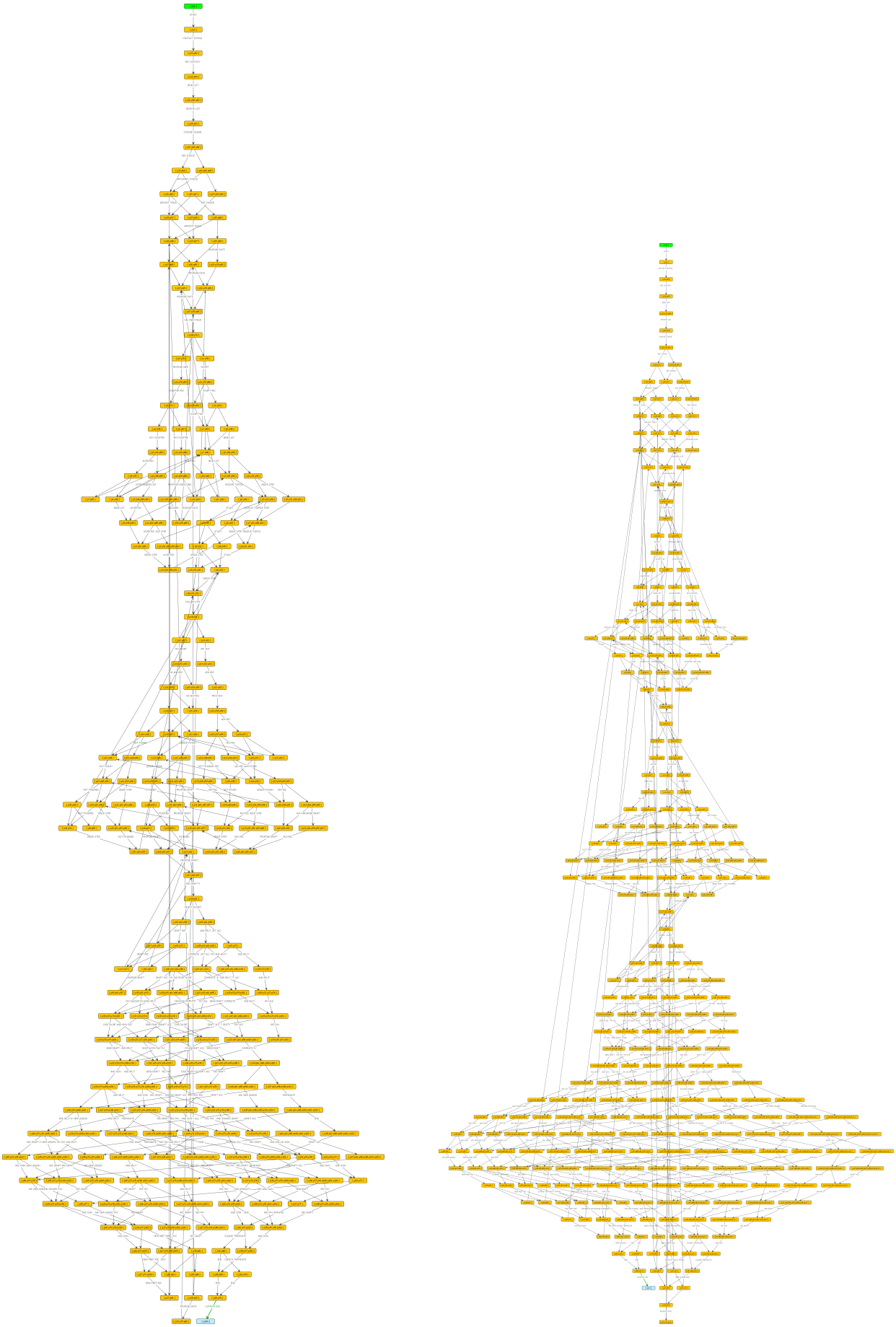
The coverability graph (Figure 19a) is once again bounded and corresponds to the reachability graph, presenting a total of 237 vertices and 408 edges.

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 18: Semantic analysis of the complete process Petri net



(a) Original formulation (b) Variant

Figure 19: Coverability graph of the complete process Petri net