Università di Pisa

Business Process Modelling
2024/2025 project report

[P35] Ricerca

Professor:

Roberto Bruni

Cascone Lorenzo 581465

Neri Erica 682010

M.Sc. in Data Science and Business Informatics

Contents

1 Introduction **2**

2 BPMN Modelling **3**

2.1 Coordinator 4

2.2 Site Manager 5

2.3 Electronic evaluation system 5

3 Workflow Net **6**

3.1 Coordinator 6

3.2 Site Managers 7

3.3 Electronic evaluating system 7

3.4 Total Evaluation 8

4 Variant **10**

A Appendix **13**

A.1 Some other BPMN images 13

A.2 Some other Workflow Net images 14

A.2.1 Workflow nets analysis 14

A.2.2 Workflow nets coverability graphs 14

A.3 Some other Variant images 15

A.3.1 Coordinator 15

A.3.2 Site Manager 16

A.3.3 Collaboration analysis 16

Chapter 1

Introduction

Lo scopo di questo progetto è modellare lo scenario della sottomissione di un progetto di ricerca per ottenere un finanziamento. Il coordinatore del progetto contatta due responsabili di sede con cui collaborare alla stesura del progetto, inviando loro una bozza iniziale della proposta. Se accettano di collaborare, i responsabili di sede devono inviare al coordinatore le loro modifiche e integrazioni alla proposta. Il coordinatore prepara una nuova bozza che invia ai responsabili e il procedimento viene iterato fino a quando i responsabili non hanno piu‘ modifiche da richiedere oppure rifiutano di collaborare. Se viene raggiunta una proposta condivisa, il coordinatore inserisce il testo della proposta e tutte le informazioni necessarie nel sistema elettronico di valutazione che contatta i responsabili per avere conferma della loro partecipazione. L'esito della valutazione, quando disponibile, viene comunicato al coor- dinatore che provvede a informare i responsabili di sede. In ogni momento il coordinatore pu‘o decidere di ritirare la proposta. Progettare opportuni processi che rispecchino fedelmente lo scenario sopra descritto e siano compatibili. Modificare i processi in modo che, quando la proposta viene rifiutata, il coordinatore possa tentare di sottomettere un nuovo progetto assieme agli stessi collaboratori.

The decision was taken to utilise BPMN notation to model the scenario under consideration, employing the online editor BPMN.io. The decision to utilise BPMN.io was motivated by the intricacies inherent in the problem's structure, particularly the necessity to analyse the manner in which various entities interact in a collaborative environment.

Chapter 2

BPMN Modelling

The initial phase of the investigation involved the identification of three primary actors: the coordinator, the site manager and the electronic evaluation system, which are represented by three distinct pools. The communication dynamics between these actors are depicted by a message flow, transitioning from an orchestration model to a *collaborative* model.

The process, in its fundamental form, is illustrated in Figure 2.1 below. It is important to note that the coordinator and the electronic evaluation system are one, while there are two site managers. In instances where the coordinator or the evaluation system must interface with both managers through tasks executed concurrently, this is denoted by the three vertical lines in the corresponding activities.

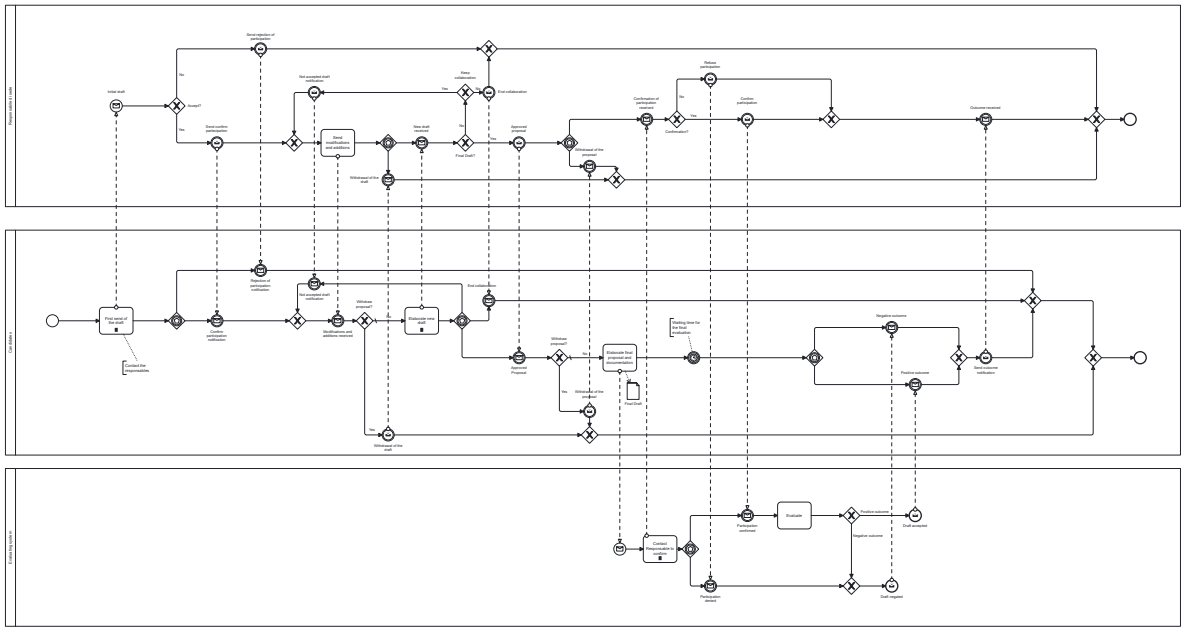


Figure 2.1: BPMN basic version

2.1 Coordinator

The process begins in the coordinator pool (see Figure A1), where an initial task is initiated. This task involves the coordinator contacting the site managers and providing them with a preliminary version of the proposal. Subsequently, the coordinator awaits their response, which may be positive or negative, signifying their participation in the project's drafting process. This scenario is modelled by an event-based gateway that depends on external information, represented by an intermediate catching event. In the event of a refusal to participate in the proposal, the process is terminated, and the other flows are joined with XOR joins, resulting in the end event. Conversely, in the event of confirmation of participation, subsequent to an XOR join (utilised for the purpose of joining the disparate streams), the coordinator is guaranteed to receive alterations or additions to the proposal from the designated individuals.

The coordinator reserves the right to withdraw the proposal at any time. This has been modelled using split XOR gateways that are present before each task that the coordinator has to perform. This ensures that the coordinator can withdraw the proposal before proceeding with the project subtask. The default route is to continue processing the proposal (identified with a severed arrow). In instances where the coordinator elects to withdraw the proposal, a notification is disseminated to the site managers, modelled using an intermediate throw event, thereby concluding the process via an XOR join with the other flows to reach the end event. It is important to note that once a proposal has been submitted to the evaluation system, the coordinator will no longer have the ability to withdraw it.

In the event that the coordinator elects to proceed with the proposal, he will prepare a new draft, incorporating the changes and additions received, and transmit it to the relevant parties. Thereafter, the coordinator awaits the response of the responsible parties, which is communicated through a subsequent event-based gateway. This response can be one of three forms: the proposal is not accepted in its current form, in which case the process reverts and the coordinator must await further changes from the managers; the managers decide to terminate the collaboration, in which case the process reaches its conclusion; or the proposal is approved. This process is repeated until the proposal is approved or the site managers decide to end the collaboration. Following the approval of the proposal, the coordinator may elect to withdraw it prior to its submission for evaluation. In the event that the coordinator elects to proceed, the final proposal is to be edited with all the necessary information. The final proposal is then entered into the electronic evaluation system. The coordinator must then await the outcome of the evaluation process. Finally, the various flows representing the potential termination of the process converge through XOR joins, addressing the outcome.

2.2 Site Manager

The process commences upon receipt of the initial proposal draft by the coordinator. The managers then have a decision to make, represented by a split XOR gateway, and must either reject the collaboration (in which case the process is terminated and moves to the end event) or accept it. In both cases, the decision is communicated to the coordinator via an intermediate toss event. In the event of acceptance, the XOR join integrates the streams and the managers disseminates any alterations and additions. The subsequent progression of the process is contingent upon the coordinator's decision, defined by an event-based gateway, accompanied by two potential alternatives with intermediate catching events. One of these alternatives simulates the reception of the coordinator's decision to retract the proposal, while the other signifies the reception of the revised draft, inclusive of the transmitted alterations. The site manager may opt to accept the proposal, reject it, or end the collaboration, and the coordinator is informed of the decision via intermediate throwing events. In the event of non-approval, the site manager may elect to either terminate the collaboration or communicate the non-approval to the proposer. In the latter case, the process reverts to the XOR join, thereby initiating an iterative process of sending changes. Conversely, if the proposal is approved, the subsequent course of action is contingent upon the coordinator's decisions, which are modelled through a separate event-based gateway. In the event of a withdrawal notification being received, the process is to be terminated, as was the case in the analogous situation previously outlined. Otherwise, the potential outcome is the receipt of a proposal confirmation request from the electronic evaluation system. The responsible individual has the prerogative to either confirm or decline the proposal, a decision that is represented by an XOR split and subsequently followed by an XOR join. The result of the proposal is then received. All possible flows are then XOR-joined, leading to the end event, which completes the process (see Figure A2).

2.3 Electronic evaluation system

The final stage of the process is the utilisation of an electronic evaluation system. The process commences upon receipt of the final proposal. This is followed by a task that models the contact with the managers and the request for confirmation of participation in the proposal. The subsequent course of events is contingent upon the response of the aforementioned managers, which is modelled by an event-based gateway. In the event of a refusal to collaborate, this is indicative of a negative outcome in the approval of the research project. Conversely, a confirmation of participation is received, which is followed by an evaluation task. The evaluation outcome is modelled by a split-type XOR gateway, which produces a positive outcome or a join XOR that combines the negative outcomes. In both scenarios, the process culminates in the communication of the respective outcome to the coordinator (see Figure A3).

Chapter 3

Workflow Net

The processes modelled using the BPMN were then transformed into a special type of Petri net, the workflow nets. The utilisation of Petri nets facilitates a more formal and mathematical representation, thereby enabling a more in-depth analysis and verification of specific properties of the net and, consequently, of the process. The following rules were observed during the transformation from BPMN to workflow nets:

- Each task and event was replaced by a transition.
- Each sequence flow was replaced by a place.
- XOR splits and XOR joins were translated into places and transitions (no sugared version to avoid misunderstanding).
- Event-based gateways were translated with a place followed by as many transitions as the possible alternatives that can occur.
- A single initial and final place was added.

The subsequent step is to analyse the workflow nets of the individual actors and then the complete workflow net. Finally, the coverability graphs of the networks, both in their basic and variant versions, are given in the Appendix. The transformation and analysis were carried out using the WoPeD software.

3.1 Coordinator

The network designed for the coordinator consists of 25 places, 30 transitions and 60 arcs (see Figure 3.1). It is evident from the analysis that the network is a *workflow net*, since there is only one input place and one output place, and each place and transition is on a path leading from the input place to the output place. The network is further classified as an *S-net*, a designation that arises from the fact that each transition possesses precisely one input place

and one output place, thereby ensuring that the cardinality of the pre-sets and post-sets remains constant at one. Additionally, the network is characterised as *free-choice*, a property that is evident in the disjoint or equal pre-sets of each pair of transitions. The network is also strongly-connected, with a single strongly-connected component, and is therefore deemed to be bounded, live, safe and sound. As a consequence of its properties of free choice, liveness and boundedness, it is S-coverable, and therefore there is an S-component that includes all elements. The network is well-structured, since there aren't any PT-handles and TP-handles. The Coverability Graph consists of 25 vertices and 30 arcs, and is coincident with the Reachability Graph, which, given the network's bounded nature, is finite. It's visualization can be found in Figure A7

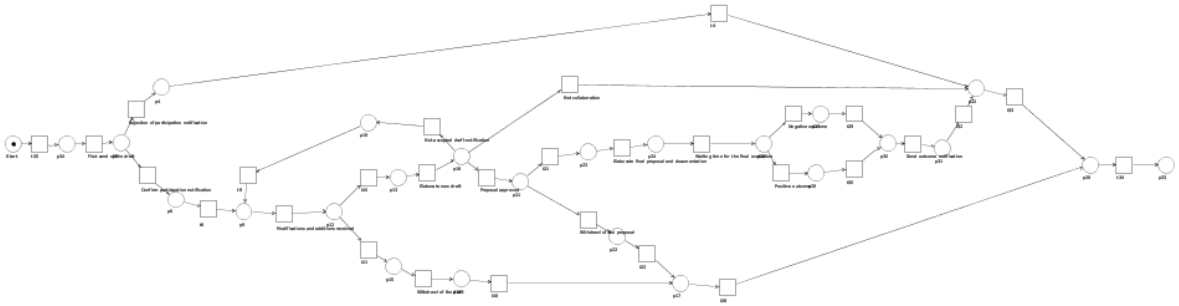


Figure 3.1: Coordinator base version WF net

3.2 Site Managers

The comprehensive analysis is delineated in Figure 3.2. The site manager's network comprises 30 places, 35 transitions and 70 arcs. All the same considerations of the previous network apply: it is an S-net, free-choice, live, bounded, safe and sound. Being free-choice, live and bounded, means that it is also S-coverable, with a single S-component, and it is also well-structured.
The Coverability Graph consists of 30 vertices and 35 arcs, and is coincident with the Reachability Graph since the latter is finite, as we can see in Figure A8.

3.3 Electronic evaluating system

The workflow net of the Electronic Evaluation System is comprised of 12 places, 13 transitions and 26 arcs. It is important to note that all the considerations of the aforementioned networks apply in this case, and the relevant analysis can be found in Figure 3.3. This network is also identified as an S-net, characterised by its free-choice, liveness, boundedness and soundness properties. Furthermore, it is both S-coverable and well-structured.

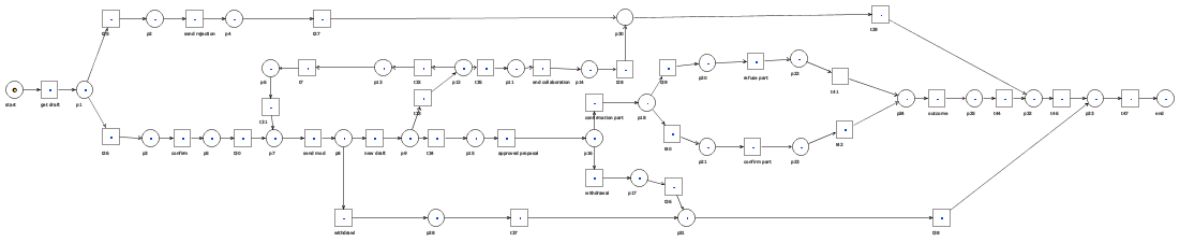


Figure 3.2: Site Manager base version WF net

The Coverability Graph and the Reachability Graph correspond once more, as the latter is finite. They comprise 12 vertices and 13 edges, that we can see in Figure A9.

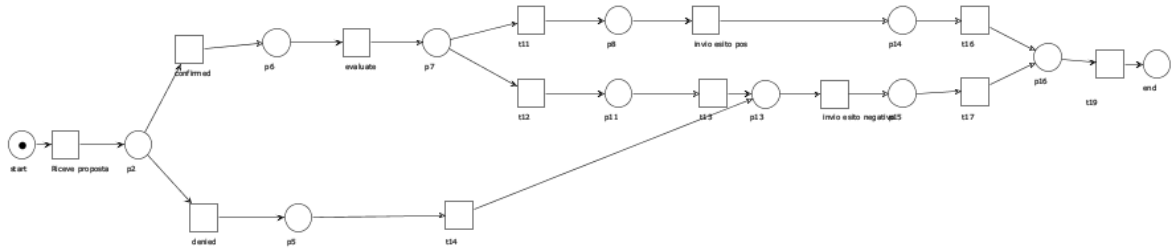


Figure 3.3: Electronic evaluating system WF net

3.4 Total Evaluation

The three workflow modules were integrated to formulate a unified workflow representation, encapsulating the complete process (see Figure 3.4). The BPMN modelling incorporates all message flow, and an intermediate place was added to connect the various transitions.

The input place is unique and belongs to the network of the Coordinator, who initiates the process by contacting the responsible individuals and sending them the initial draft. The output place is also unique, and is preceded by a transition that requires tokens from both the Coordinator's and the Manager's process, so that the process can end only when both have been completed.

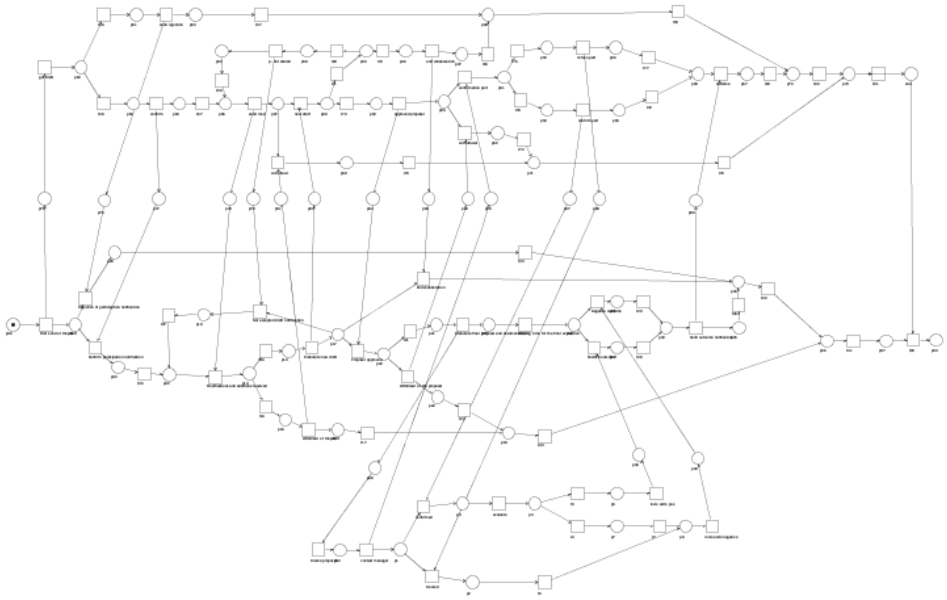


Figure 3.4: Collaboration Workflow net

The network analysis reveals 79 places, 76 transitions and 183 arcs, and is characterised as a bounded, live and sound workflow net. The incorporation of places for modelling information flow has resulted in the presence of pairs of transitions with non-disjoint and unequal pre-sets, making it non free-choice. In contrast to the networks analysed in isolation, this network exhibits the presence of both PT-handles (132) and TP-handles (111), indicating a lack of global structural integrity. The complete analysis can be found in Figure 3.5.
Finally, the Coverability Graph is once again coincident with the Reachability Graph, as the network continues to be bounded. The picture is not reported due to it's size and poor readability.

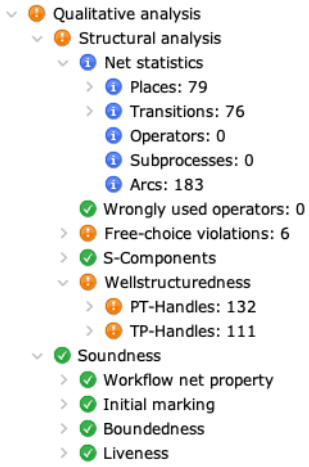


Figure 3.5: Analysis Collaboration Workflow net

Chapter 4

Variant

As illustrated in Figure 4.1, the process under discussion also includes a variant. The modelling via the complete BPMN differs from that presented in Section 2 in only a few points. Following the receipt of a negative outcome (via an intermediate catching event) by the electronic evaluation system, there is an XOR split in the coordinator's pool. This model the coordinator's choice of either terminating the process or proceeding with a further proposal. In the event that the coordinator elects to terminate the process, the flow reconvenes as observed in the base case. Conversely, if the coordinator opts to submit a new proposal, he communicates this intention to the relevant parties via an intermediate throwing event. Thereafter, he proceeds immediately to process the new proposal, which is also conveyed to the relevant parties. The flow is then joined thanks to an XOR join to the initial request flow. The XOR join gateway is then connected to the event-based gateway as in the previous case.

In the managers' pool, subsequent to the reception of the potential negative outcome and the revised draft, the flow reverts and, through an XOR join, the XOR splits are reiterated, thereby simulating the potential choices of the managers: namely, to accept or reject the collaboration and to proceed as in the antecedent flow.

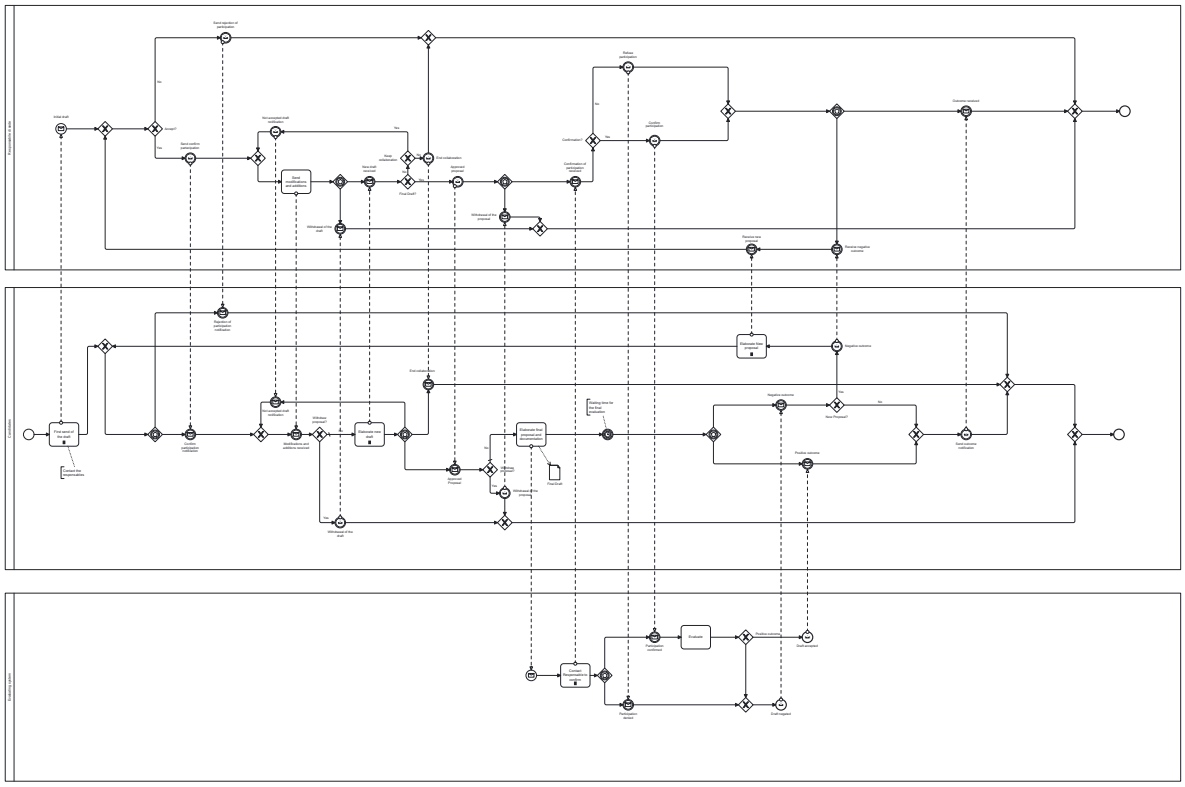


Figure 4.1: BPMN Variant

The process variant was also translated into a workflow net, in accordance with the transformation rules presented in the previous section. The network pertaining to the evaluation system remained unaltered, as no changes were made to the BPMN. The network of the Manager in the new version contains 32 places, 38 transitions and 76 arcs, while that of the Coordinator contains 30 places, 36 transitions and 72 arcs.
Despite the addition of places and transitions, both networks maintain all the properties discussed in the previous chapter, as can be seen in Figure A10 and A11.

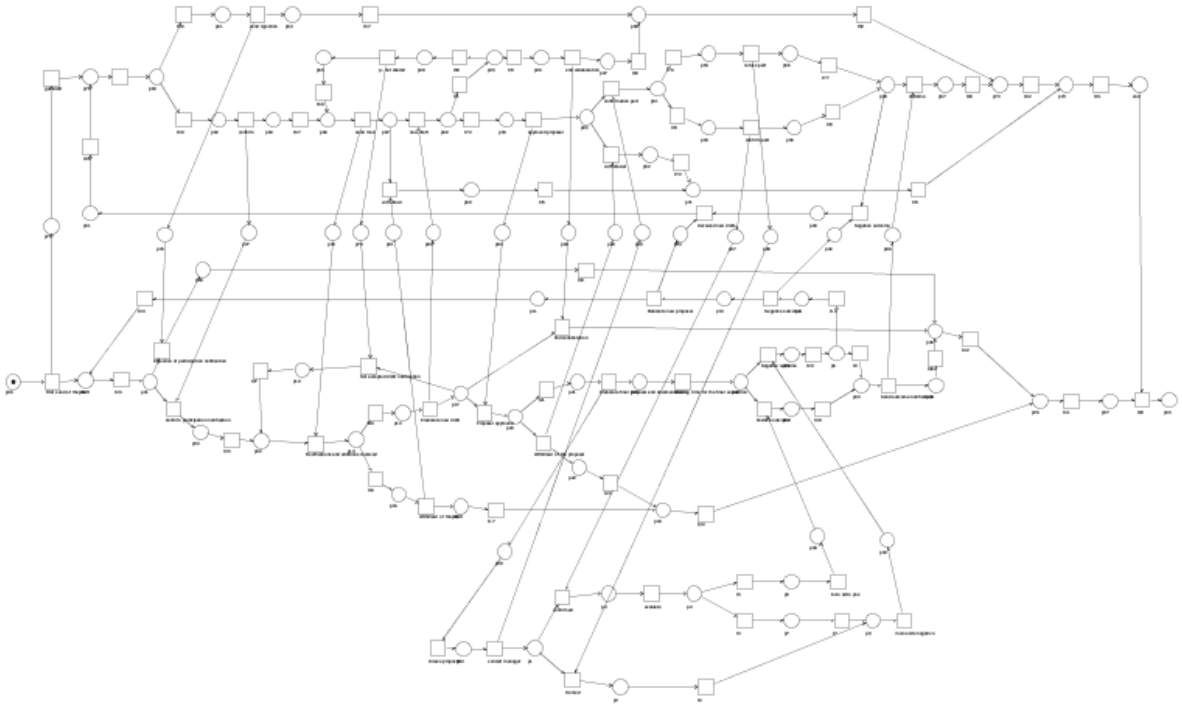


Figure 4.2: Collaboration Workflow net Variant

The three workflow modules were once more amalgamated and analysed using the WoPeD software to form a single network. This network contains 89 places, 86 transitions and 207 arcs. The analysis of the network is analogous to that of the base case presented previously, as illustrated in Figure A12. As a bounded network, the Coverability Graph and the Reachability Graph coincide once more in this instance, and the image is not reported due to its size and poor readability.

Appendix A

Appendix

A.1 Some other BPMN images

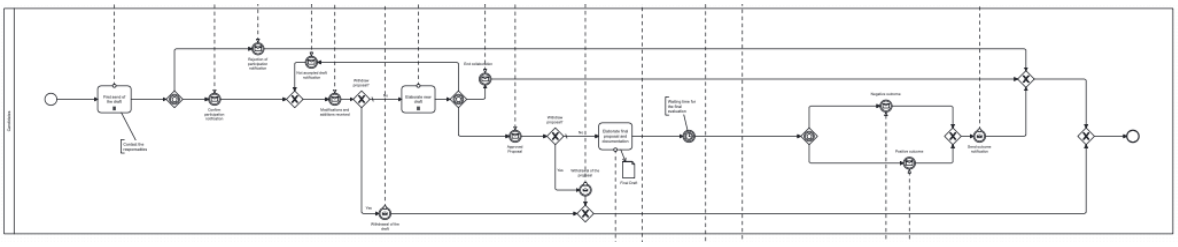


Figure A1: Coordinator

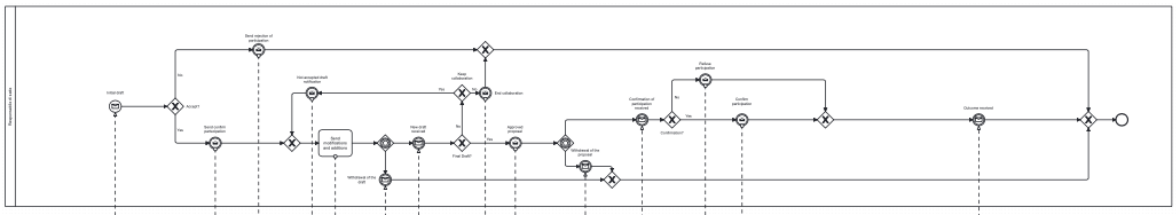


Figure A2: Site Manager

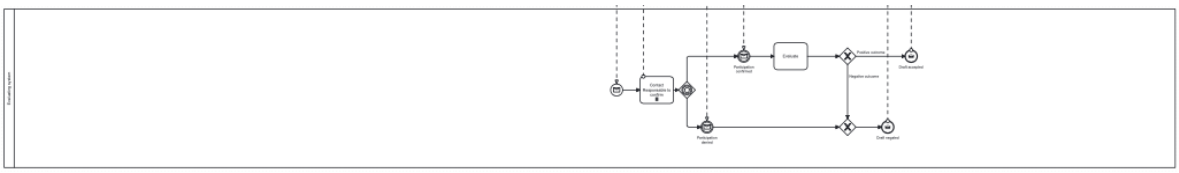


Figure A3: Electronic Evaluating System

A.2 Some other Workflow Net images

A.2.1 Workflow nets analysis

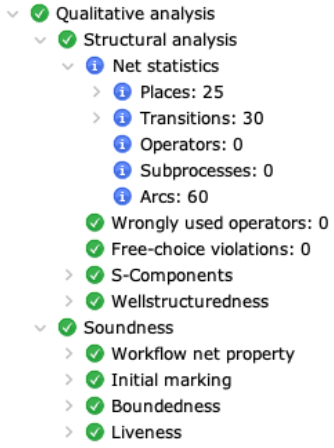


Figure A4: Coordinator Analysis

Figure A5: Site Manager Analysis

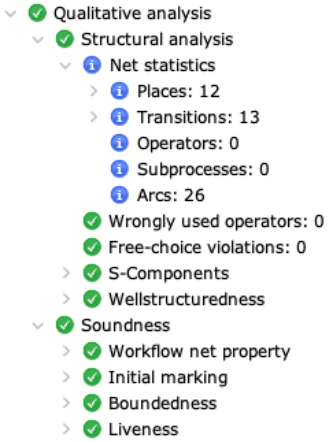


Figure A6: Electronic Evaluating System Analysis

A.2.2 Workflow nets coverability graphs

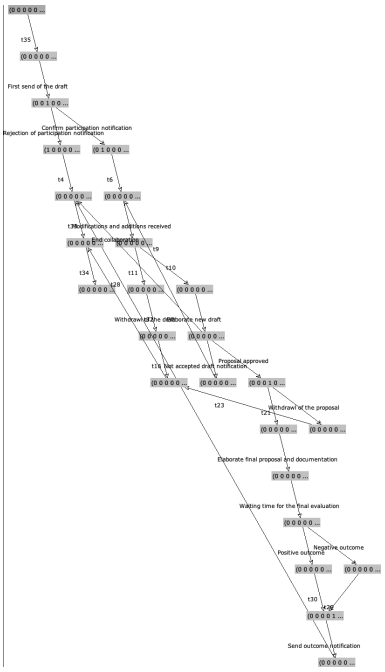


Figure A7: Coordinator

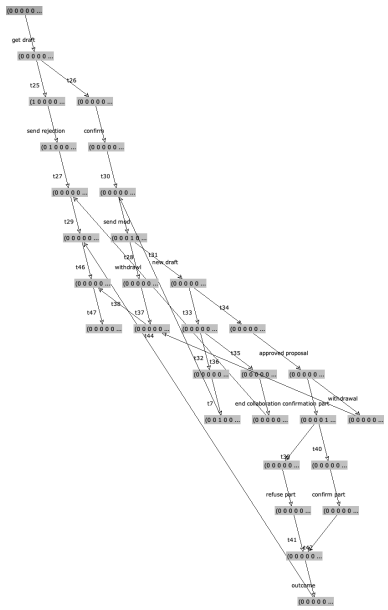


Figure A8: Site Manager

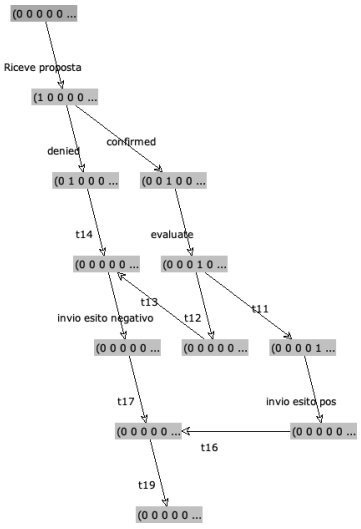


Figure A9: Electronic Evaluation System

A.3 Some other Variant images

A.3.1 Coordinator

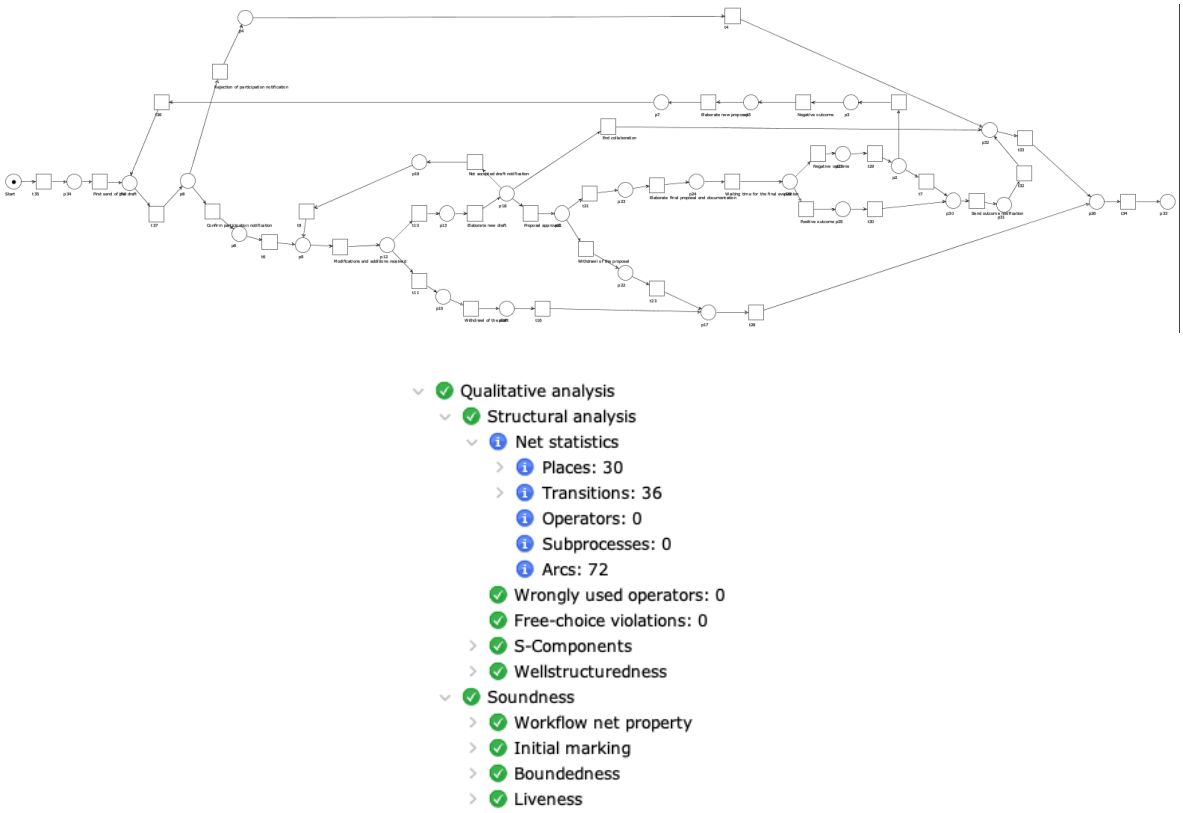
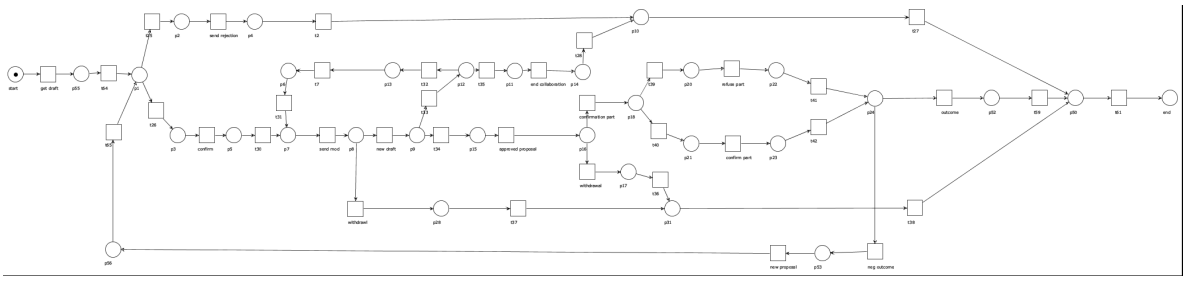


Figure A10: Coordinator Workflow net and Analysis

A.3.2 Site Manager



- Qualitative analysis
  - Structural analysis
    - Net statistics
      - Places: 32
      - Transitions: 38
      - Operators: 0
      - Subprocesses: 0
      - Arcs: 76
    - Wrongly used operators: 0
    - Free-choice violations: 0
    - S-Components
    - Wellstructuredness
  - Soundness
    - Workflow net property
    - Initial marking
    - Boundedness
    - Liveness

Figure A11: Site Manager Workflow net and Analysis

A.3.3 Collaboration analysis

- Qualitative analysis
  - Structural analysis
    - Net statistics
      - Places: 89
      - Transitions: 86
      - Operators: 0
      - Subprocesses: 0
      - Arcs: 207
    - Wrongly used operators: 0
    - Free-choice violations: 7
    - S-Components
    - Wellstructuredness
      - PT-Handles: 270
      - TP-Handles: 180
  - Soundness
    - Workflow net property
    - Initial marking
    - Boundedness
    - Liveness

Figure A12: Analysis Collaboration Workflow net variant