



UNIVERSITÀ DI PISA

Data Science and Business Informatics

# Business Process Modeling

## Project Report

Candidato:

**Emiliano Marrale**

---

ANNO ACCADEMICO 2024/2025

Contents

|     |                        |   |
|-----|------------------------|---|
| 1   | Introduction           | 3 |
| 2   | BPMN Modeling          | 3 |
| 2.1 | Base Version . . . . . | 4 |
| 2.2 | Variant . . . . .      | 5 |
| 3   | BPMN to Workflow Nets  | 6 |
| 3.1 | Employee . . . . .     | 7 |
| 3.2 | Embassy . . . . .      | 7 |
| 3.3 | Employer . . . . .     | 8 |
| 4   | W.F.N. Collaboration   | 8 |
| 4.1 | Variant . . . . .      | 9 |

# 1 Introduction

Consider the simplified scenario of applying for a visa for a business trip. The applicant registers on the embassy's portal and receives guidelines for submitting the application. They contact their employer to obtain the necessary documents. The required documentation is uploaded electronically while filling out the web form on the embassy's portal, and the applicant waits for the outcome of the request.

The embassy may decide to:

- **Reject** the visa application.
- Request a **revision** of the documentation (e.g., additional information from the employer).
- Schedule an **interview** at the embassy.

If the visa is rejected, the applicant informs their employer, and the process ends.

If additional documentation is required, the applicant contacts the employer again to obtain it and submits a new request through the Web portal.

If an interview is scheduled, the applicant interacts with the embassy to agree on a mutually acceptable date (in an iterative manner). Once the appointment is confirmed, the applicant informs their employer of the successful outcome, and the process concludes.

Design appropriate processes that accurately reflect the scenario described above and ensure compatibility.

Modify the processes so that the applicant can decide, at any time, to cancel the visa request, informing both the embassy and the employer.

## 2 BPMN Modeling

This section outlines the two tasks defined in the project requirements: the standard process and its variation. It also delves into the design choices and the rationale behind them.

The diagrams were created using the [demo.bpmn.io](https://demo.bpmn.io) website, which supports exporting them in both `.bpmn` and `.svg` formats. Additionally, each diagram and its possible scenarios were validated for correct execution using the [bpmn-io.github.io](https://bpmn-io.github.io) token simulation tool, ensuring that all processes eventually come to an end and no pending activities are left after completion.

## 2.1 Base Version

By analyzing the project requirements, three main actors were identified: the **Embassy**, the **Employee**, and the **Employer**. These actors are represented as three distinct pools in a collaboration model, with message flows depicting their interactions.

The process begins with the employee registering on the embassy's portal, upon which the embassy provides the necessary guidelines for the visa application. The employee then contacts the employer to request the required documents. The employer, upon receiving the request, provides the documents and waits for the employee's response, which may either be a request for document revision or a notification of rejection/confirmation.

Once the employee receives the necessary documents, submits the visa application via the embassy's web portal and await the embassy's response. At this stage, the embassy may choose to schedule an interview, request a document review, or reject the application. This decision is represented by the first event-based gateway in the employee's process, which will direct the flow based on the embassy's response.

The diagram also captures the iterative nature of document review requests and the negotiation process for scheduling the date of the interview. The complete interaction is best understood by referring to Figure 1.

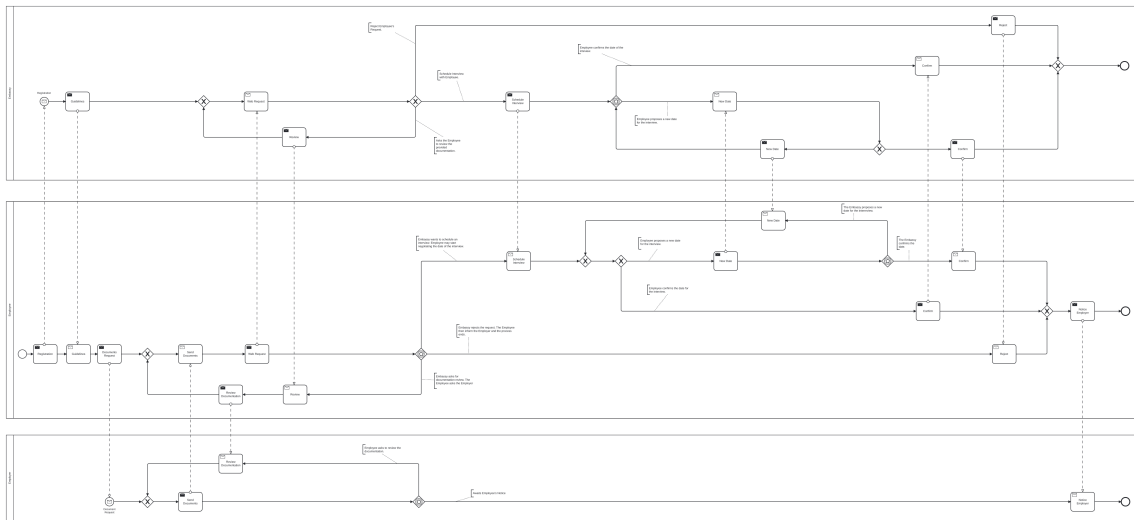


Figure 1: BPMN Collaboration Diagram

## 2.2 Variant

The process variation introduces the ability for the applicant to cancel the visa request at any time, notifying both the embassy and the employer. This modification is represented in the collaboration diagram shown in Figure 2, where all processes are encapsulated within a sub-process.

In the employee's process, an error boundary event is used to listen for the applicant's decision to interrupt the visa request. Specifically, the employee may choose to abort the process at the following stages:

- Iteratively, after obtaining the required documents from the employer.
- When the embassy requests a document review.
- When the embassy schedules an interview.
- Iteratively, during the negotiation of the interview date.
- After having confirmed the interview, until the date of the interview.

Although the guidelines specify that the applicant can decide to cancel the request **at any time**, the option to interrupt the process has been placed at the most semantically meaningful points. For instance, the employee **cannot** abort the process after the embassy has rejected the application or before even completing the registration to the embassy.

The cancellation request is modeled in two distinct ways.

The first occurs while the process is still ongoing. In this case, the employee can trigger an abort event to cancel the request, notifying both the embassy and the employer. As a result, all three processes terminate immediately.

The second occurs after confirmation, during the waiting period for the interview date. At this stage, the employee still has the option to cancel the request, modeled as a **user task activity** with an attached **timer boundary event**. If the employee cancels, a message is sent to both the embassy and the employer. Otherwise, if no cancellation occurs, the processes automatically conclude once the waiting period has elapsed for all three sub-processes. Note that the **user task activity** requires direct interaction from a person. The assumption lies in the fact that once the token arrives at the cancel activity, it will wait for a human interaction to trigger it, otherwise it will automatically proceed once the time has passed.

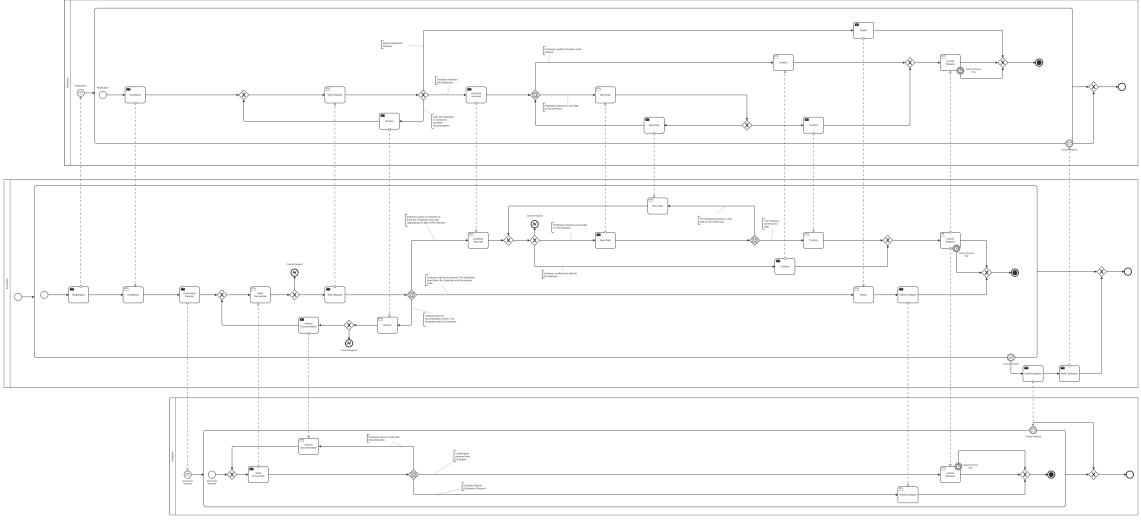


Figure 2: Variation Diagram

### 3 BPMN to Workflow Nets

The BPMN-modeled processes were transformed into workflow nets, a specialized form of Petri Net with constraints ensuring structured workflow representation. The transformation followed these rules:

- Tasks and events were mapped to transitions.
- Sequence flows were replaced by places.
- XOR splits and joins were represented using places and transitions without sugared versions to avoid ambiguity.
- Event-based gateways were translated into a place followed by transitions corresponding to the number of alternative paths.
- A single initial and final place was added.

To maintain consistency with BPMN diagrams, some transition labels were aligned with activity labels, prefixed with **R:** (receiving) and **S:** (sending). This labeling facilitated verification and reduced errors.

Next, workflow nets were analyzed at both the individual actor level and the complete workflow level. The transformation and analysis were conducted using **WoPeD software**.

### 3.1 Employee

The employee's network consists of 23 places, 26 transitions, and 52 arcs (see Figure 5). Analysis confirms it is a workflow net, as it has a single input and output place, with every place and transition on a path connecting them.

The network is classified as an S-net, meaning each transition has exactly one input and one output place, ensuring constant pre-set and post-set cardinality. Additionally, it is **free-choice**, as each pair of transitions has disjoint or identical pre-sets. The network is also **strongly connected**, forming a single strongly connected component, and is therefore **bounded, live, safe, and sound**. Due to its free-choice, liveness, and boundedness properties, it is S-coverable, meaning an S-component includes all elements. The absence of PT-handles and TP-handles confirms a well-structured design.

The Coverability Graph consists of 23 vertices and 26 arcs, identical to the Reachability Graph, which remains finite due to the network's bounded nature. A visualization and WoPeD analysis results are provided in the appendix (Figures 8, 9). The variation has also been translated and can be viewed in figure 16.

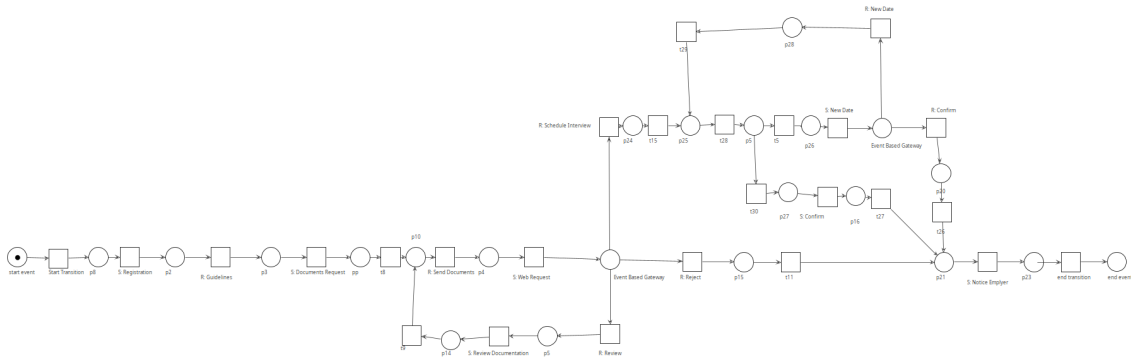


Figure 3: Employee W.F.N.

### 3.2 Embassy

The embassy's network consists of 18 places, 21 transitions, and 42 arcs. The same structural properties as the employee's network apply. The Coverability Graph comprises 18 vertices and 21 arcs, coinciding with the Reachability Graph, which is finite. A visualization and WoPeD analysis results are provided in the appendix (Figures 10, 11). The variation has also been translated and can be viewed in figure 17.

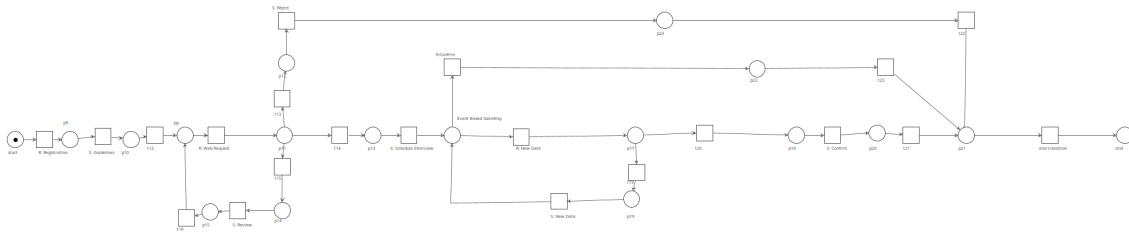


Figure 4: Embassy W.F.N.

### 3.3 Employer

The employer's network consists of 7 places, 7 transitions, and 14 arcs. The same properties as the previous networks apply. The Coverability Graph consists of 7 vertices and 7 arcs. A visualization and WoPeD analysis results are provided in the appendix (Figures 12, 13). The variation has also been translated and can be viewed in figure 18.

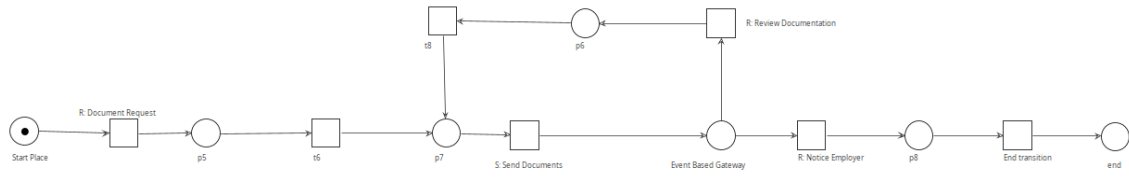


Figure 5: Employer W.F.N.

## 4 W.F.N. Collaboration

The three workflow modules were integrated into a unified workflow representation, encapsulating the complete process (see Figure 6). The BPMN model incorporates all message flows, with an intermediate place added to connect various transitions.

The input place is unique and belongs to the Employee's network, as they initiate the process by contacting the Embassy to send a registration request. The output place is also unique and is preceded by a transition that requires tokens from all three modules, ensuring the process concludes only when all components are completed.

The network analysis reveals 61 places, 55 transitions, and 138 arcs, classifying it as a bounded, live, and sound workflow net. However, the inclusion of places for modeling information flow has resulted in pairs of transitions with non-disjoint and unequal pre-sets, making the network **non free-choice**.



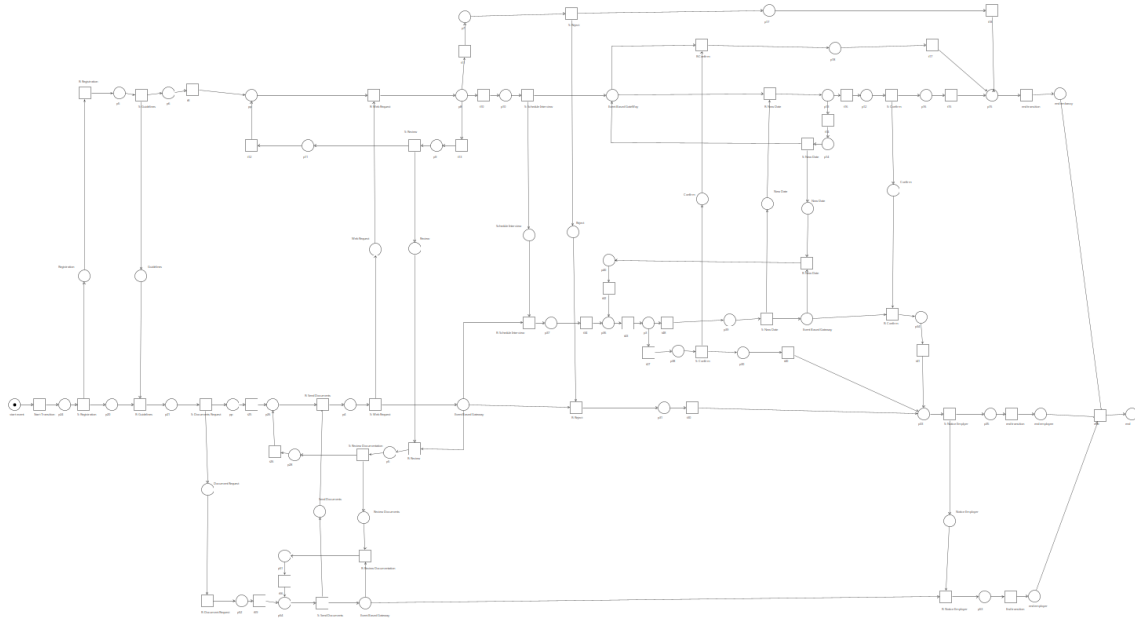


Figure 6: Collaboration W.F.N. - Base

Unlike the individually analyzed networks, this network contains PT-handles (60) and TP-handles (67), indicating a lack of global structural integrity. The complete analysis is available in Figure 14.

Finally, the Coverability Graph coincides with the Reachability Graph, confirming the network's bounded nature. Due to its large size and poor readability, the visualization is not included.

## 4.1 Variant

The process variant described in subsection 2.2 was also translated into a workflow net, following the transformation rules outlined in the previous section. Despite the addition of places and transitions, all networks retain the properties discussed in the previous chapter, as shown in Figure 15. The analysis reveals 74 places, 71 transitions, and 187 arcs. It took roughly 4 hours to run to completion in Woped.

The main difference is the introduction of an XOR-split for the Employee, which allows to cancel the visa request. The applicant's decision is communicated to the other two modules via an event-based gateway, which causes them to pause and wait for this input. If a cancellation event is triggered, it notifies both modules, prompting them to bypass their standard process flow and proceed directly to the end. This cancellation mechanism is also in place even after the interview has been scheduled. In that case, an event-based gateway is used again to listen

for the applicant's decision to cancel the interview.

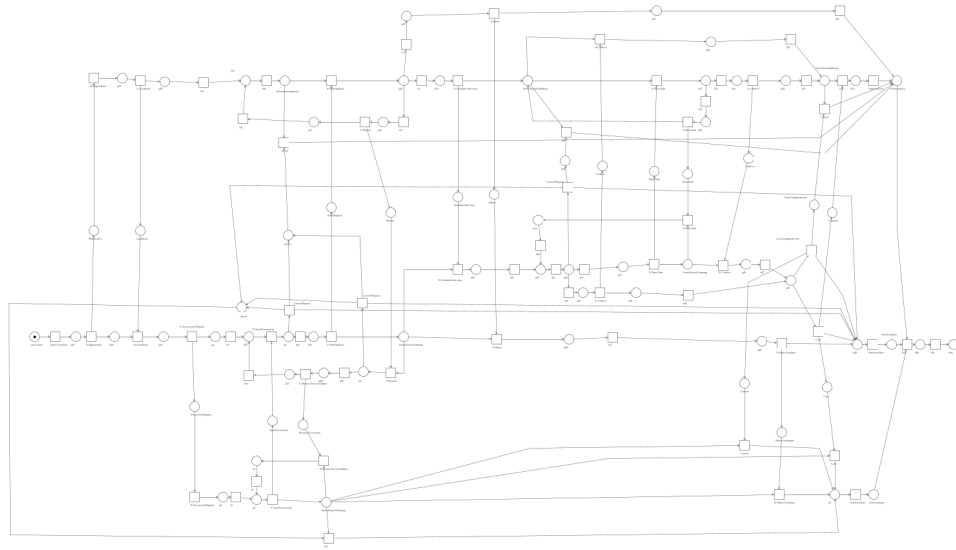


Figure 7: Collaboration W.F.N. - Variant

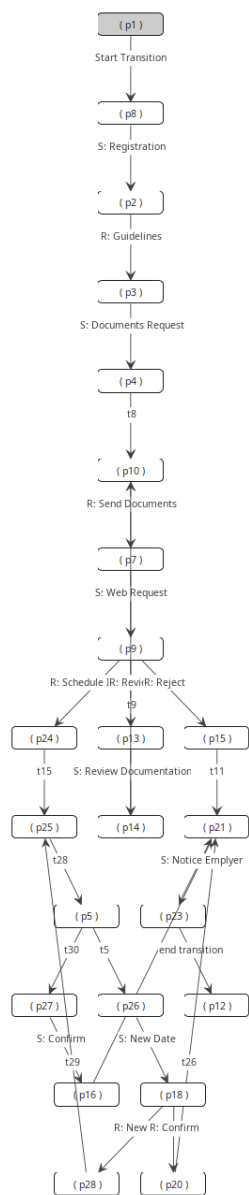


Figure 8: Employee W.F.N. Coverability Graph

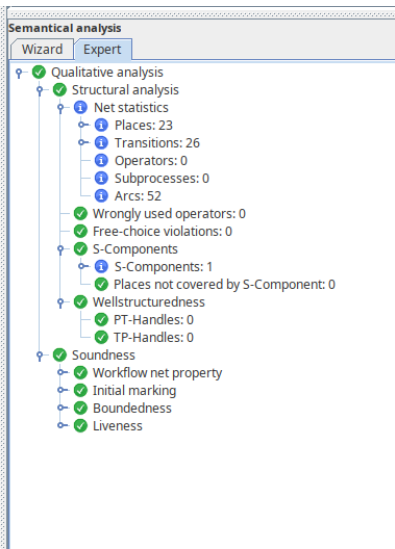


Figure 9: Employee W.F.N. Analysis

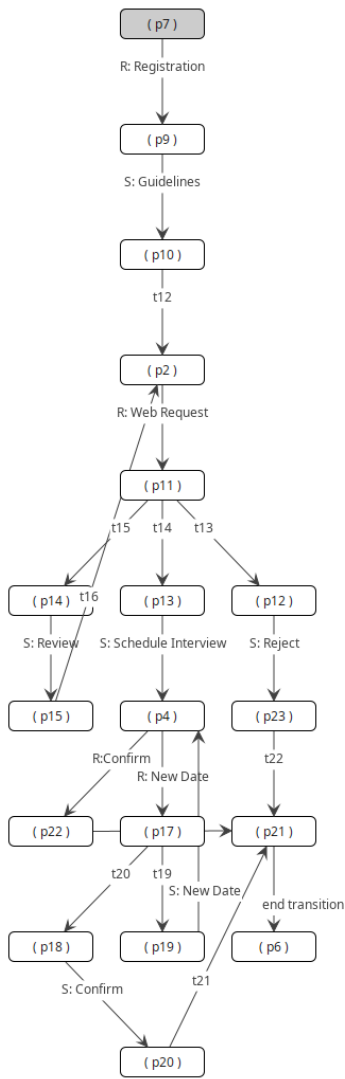


Figure 10: Embassy W.F.N. Coverability Graph

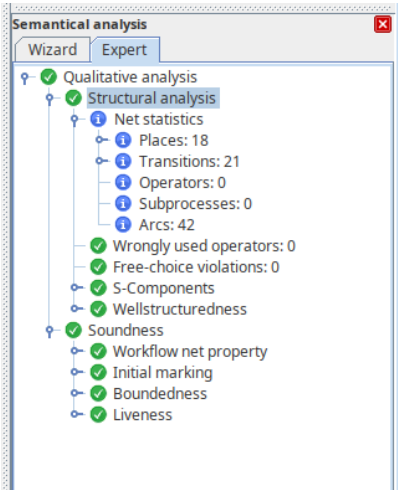


Figure 11: Embassy W.F.N. Analysis

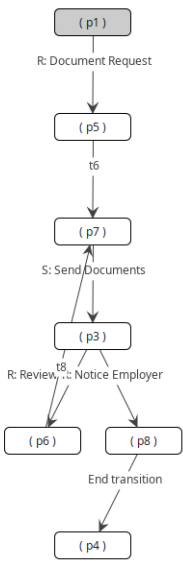


Figure 12: Employer W.F.N. Coverability Graph

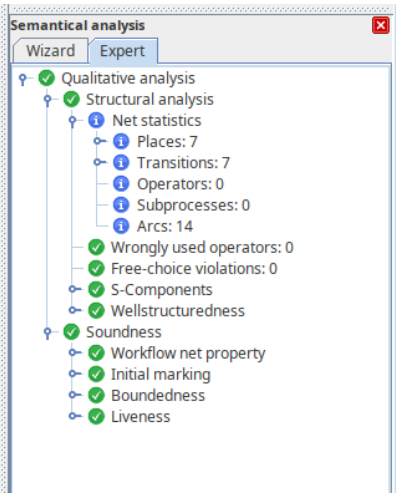


Figure 13: Employer W.F.N. Analysis

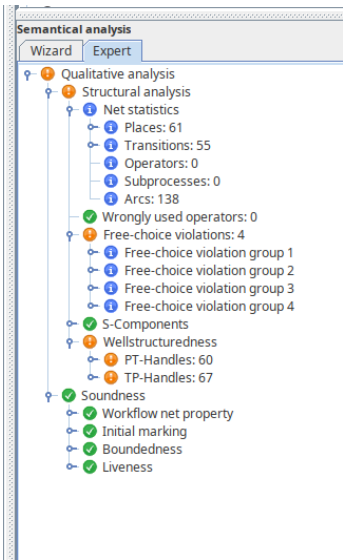


Figure 14: Collaboration W.F.N. - Base

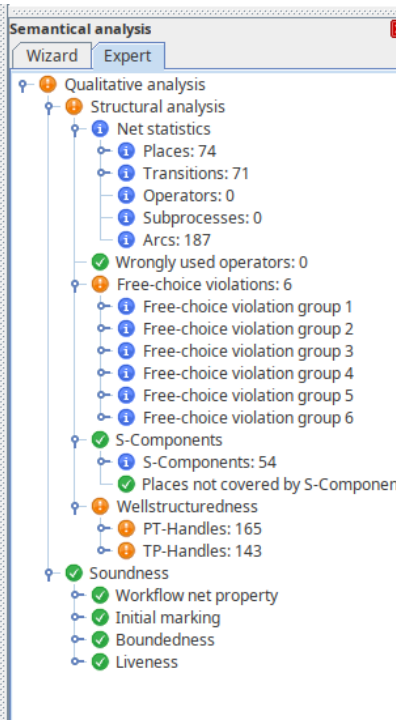


Figure 15: Collaboration W.F.N. Analysis - Variant

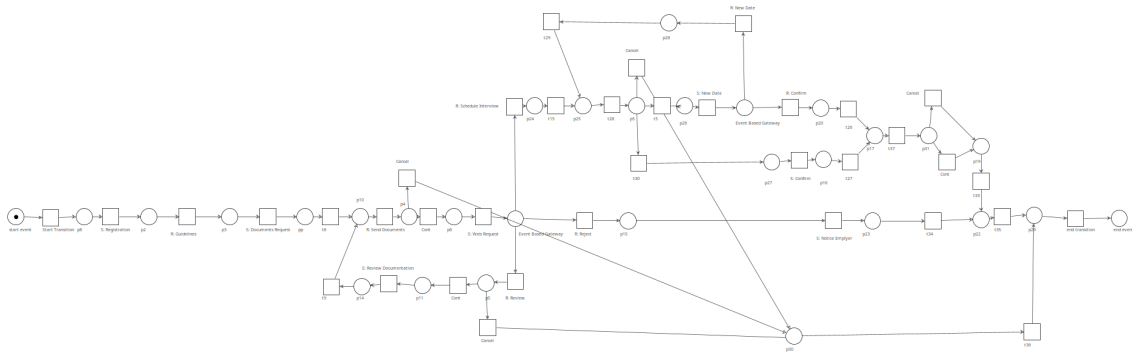


Figure 16: Employee W.F.N. Variation

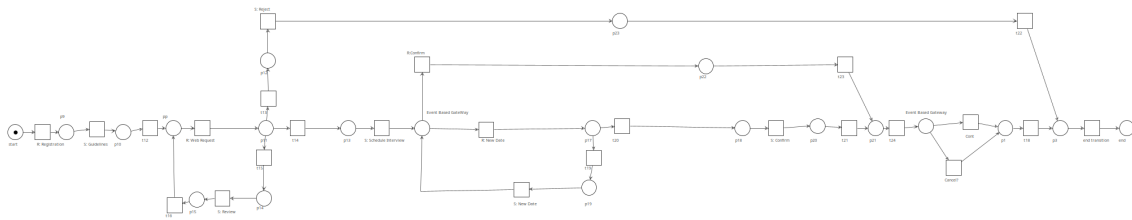


Figure 17: Embassy W.F.N. Variation

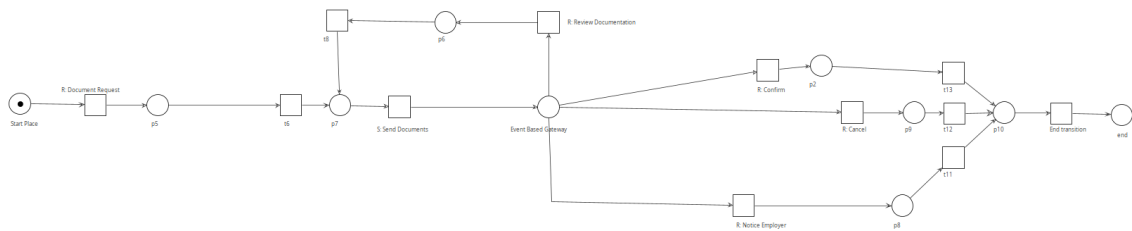


Figure 18: Employer W.F.N. Variation

## References