P45: Terapia

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Contents

1 BPMN Design

Business Process Model and Notation (BPMN) is used to represent the workflow of a business process in a standardized graphical format. In this section, the process is first modeled for individual actors using separate BPMN diagrams, referred to as single lanes. These individual models are then integrated into a collaboration diagram, which captures the interactions between the actors and represents the complete business process. We used Camunda for this task as we had already experimented with it during the course and found it satisfactory.

Single lanes In the single-lane BPMN models, each actor's workflow was developed separately to clearly define their individual responsibilities within the business process. Event-based gateways were incorporated where necessary, as they serve as the primary mechanism for coordinating interactions between actors (as a stylistic choice we opted to use the intermediate catch and throw events when no explicit communication was required as shown in 1). These gateways enable conditional branching based on external triggers, ensuring proper synchronization of activities. To help a clear representation, major activities were organized into subprocesses. Additionally, the use of AND gateways was deliberately minimized to avoid unnecessary complexity and potential synchronization issues, favoring a more streamlined process flow. Despite having tried to have all activities in the process being directly related to the ones in the guideline, with the most notable exception being the "decide exercise" activity, that is there to enable the therapist to change exercise both at the start of the session and after every exercise is correctly executed.

Collaboration In the collaboration model, the previously built single-lane diagrams were combined to represent the full business process, including interactions between actors. To make the representation more realistic, catch start events and end send events were used where appropriate, ensuring a logical flow of communication. While this goes against our goal of minimizing the use of AND gateways, some became necessary due to the way certain interactions were structured. However, since there is only one AND split at the beginning and one AND join at the end, these do not introduce synchronization issues, keeping the overall process flow clear and well-organized.

Collaboration Extended As requested in the task, a way for the patient to temporarily put on hold the therapy was also designed. This proved to be a slightly challenging task as there was a small debate over whether the patient should actively inform the medical center (as this was not explicitly stated in the description), but we ultimately decided to include a message from patient to therapist.

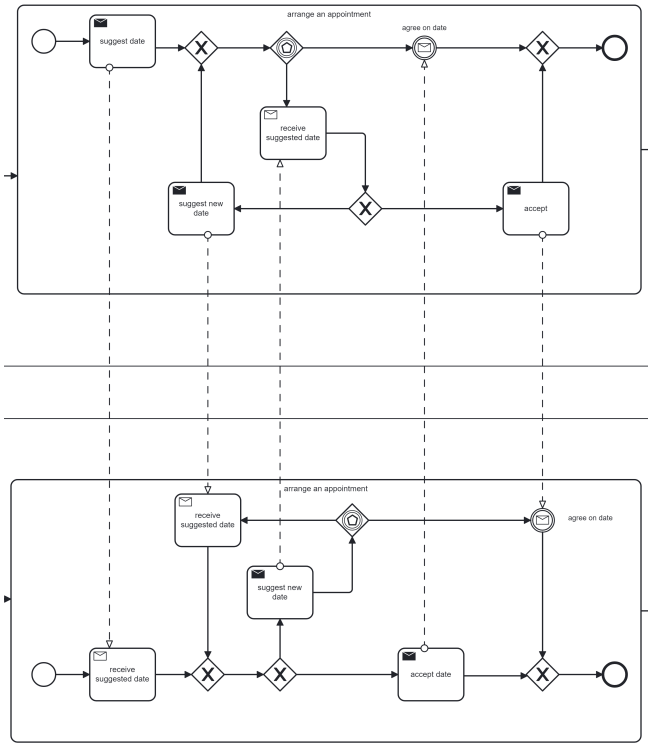

Figure 1: Intermediate Catch and Throw events being used only when no explicit interaction happens

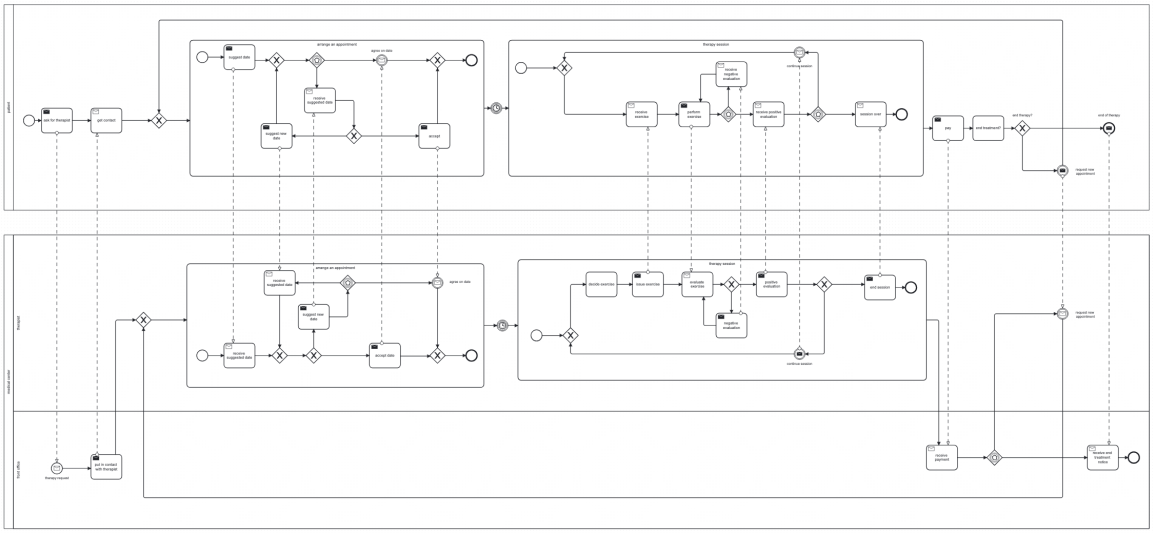

Figure 2: BPMN of Collaboration

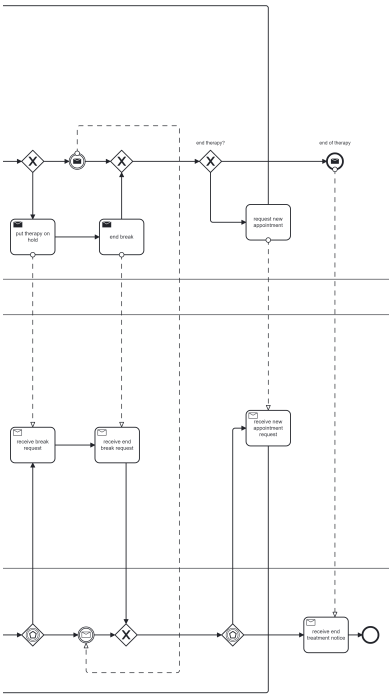

Figure 3: Last part of BPMN with collaboration extended

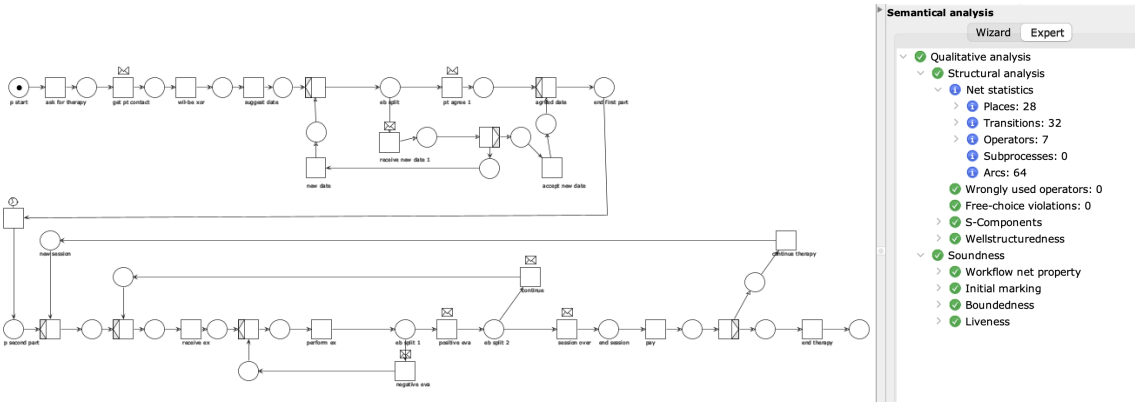

Figure 4: Patient Petri Net

2 Petri Net Analysis - Single Pools

Turning the BPMN into a Petri Net proved to be a not very challenging task, as once it had been figured out how to implement the event based splits, the generated nets almost immediately turned out to be sound. The major technical challenge was actually brought by the technical limitations of WoPeD, which asked for many many restarts and often acted unpredictably. Initially a net for each subprocess (starting hence with a collaboration) was created. Subsequently the two nets were joined and some processes were added at the start and end of the net to complete it. To generate the two workflow nets representing the actors the previous net was simply split in half horizontally and had all incoming messages places replaced with message icons on the receiving transactions.

Structural Analysis Both the Petri Nets of the single pools check all the marks in WoPeD. This means that, first of all, the workflow nets are properly initialised, having an initial place i, a final place o and each node belongs to a path from i to o.

To facilitate the interpretation of the net, we decided to add triggers for incoming messages from the other pool, in the corresponding wf module they would represent the additional input places. Furthermore, while the END gateways have been desugarized, we preferred to keep the XOR gateways explicit.

The two Petri nets, one for the patient and one for the medical centre, are S-Nets. This is true because there is no synchronization, meaning that there are no AND-join and every transition has exactly one incoming arch and

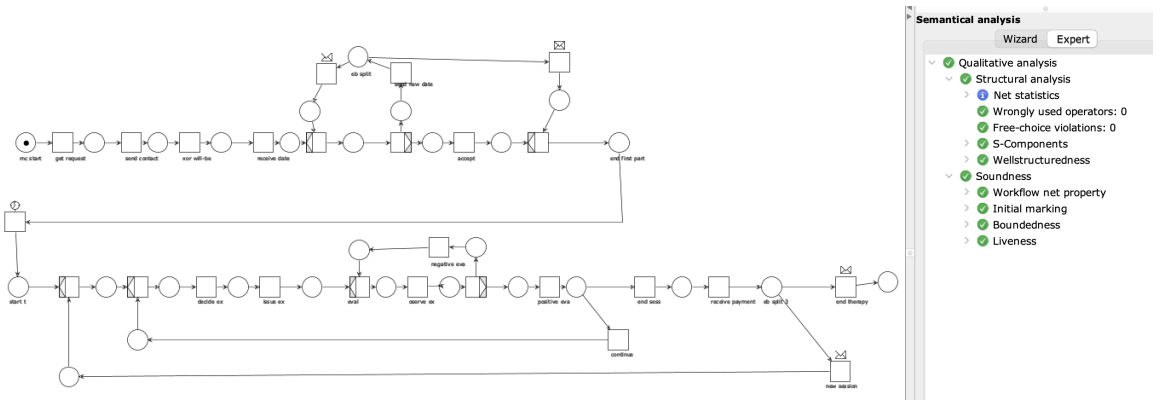

Figure 5: Medical Centre Petri Net

one outgoing arc. The XOR-splits and XOR-joins do not influence this property since, if they are desugarized, the property is respected. On the other hand, they are no T-net (nor N^*) because the presence of triggers, mainly from event-based gateways, shows how the net is not deterministic, given the presence of conflicts.

The nets are also free-choice. This structural property turned out to be very useful for finding behavioural property efficiently, as explained later.

Since each N^* is a strongly connected S-net, it exists fo N^* a positive S-invariant made of ones. Additionally, there is a single S-component which is the whole net. This confirms the soundness of N, since N is free-choice and if N^* was not S-coverable, N couldn't be sound.

Each N^* is well-handled which means well-structuredness for N. Since N is well-structured and sound, then N^* is S-coverable, as just verified.

Behavioural Analysis As already revealed, the single lanes proved to check all green marks in WoPeD also for the behavioural analysis. The time of computation required was also very fast, since the free-choice property allows to use exploit the Rank Theorem to verify the liveness and boundedness of N^*, which is a very efficient way to obtain this fundamental result. The soundness of the wf net is then ensured by the main theorem.

Regarding the boundedness, we can also easily derive it from the fact that they are S-Systems. Since there is only one token in the start place, for the fundamental property of S-Systems, we can can conclude that there will be always exactly one token in any reachable marking. This is also confirmed by WoPeD.

Actually, there is a theorem which states that if a workflow system is an S-System, then it is safe and sound. This is exactly what happens in our single pools.

3 Petri Net Analysis - Collaboration

As mentioned earlier, in the collaboration we joined the two Petri nets to obtain the net of the whole process. This was possible because, adding a place for each incoming message trigger, the two workflow modules were structurally compatible. This was a confirmation that the conversion from BPMN to Petri nets was correct. We are quite satisfied with the layout, since it should be clear how the original lanes and subprocesses were merged using the messages placed on an horizontal line in the middle of the net.

Structural Analysis Places for the messages have been inserted to connect the single nets, together with a common initial place and final place. Additionally, every node belongs to a directed path from start to end, meaning that the net is a workflow net.

Given the decision to avoid creating a desugarized version, the statistics regarding the net are the following: 76 places, 67 transitions, 15 operators, 170 arcs.

The net is not an S-net nor a T-net, as we expect from a collaboration. Furthermore, there are 5 free-choice violations which are exactly the 5 event-based gateways from the BPMN. This was predictable and it is fine for this type of process.

The analysis of N^* returned 228 S-components. All the places are covered by these S-components, meaning that N^* is S-coverable.

WoPeD detected 102 PT-handles and 112 TP-handles that were absent in the separated nets. Therefore the net N^* is not well-handled, meaning that the workflow net N is not well-structured. This however should not worry, because the behavioral properties we aim for are valid.

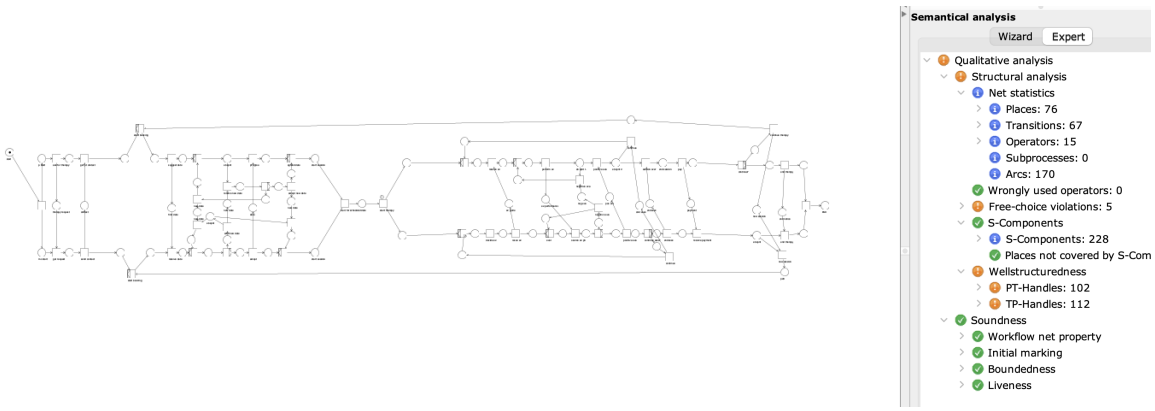

Figure 6: Semantical Analysis of Collaboration

Behavioural Analysis Since WoPeD was struggling with the semantical analysis of the whole net, we decided to initially split the task into two distinct parts with the goal to build safe and sound nets to be merged later. These building blocks proved to be more easily handled by WoPeD which declared the building blocks and then the merged net sound. We also tried an alternative approach through an iterative procedure of replacing small safe and sound blocks from the whole net with single transitions. However, given the complexity of the collaboration, in particular incoming messages, this proved to be more difficult than the approach chosen.

It is worth to mention that the reason behind the large difference in terms of time WoPeD required to provide the soundness mark can be found in the fact that the collaboration is not free-choice. It was therefore required for the application to add the reset transition and look for liveness and boundedness of N^* to exploit the main theorem.

In the net N^* that WoPeD analysed, there are no unbounded places, no dead tasks and non-live transitions hence it is live and bounded. As a consequence, for the main theorem, we can conclude that N is sound.

Reachability Analysis Inspecting the coverability graph G, we can observe that there are no states in which some place has infinite multiplicity. It is a good sign, meaning that N is bounded. Additionally, we detect exactly only one state with no outgoing arcs, which is the marking of the final state with one token in the ending place, this confirms that there are no deadlocks.

We can also notice that there is a single marking in which the ending place is present, and in that marking only the ending place is present: this, together with what we wrote above, ensures proper completion.

Test Analysis A naive test analysis using the tokengame tool shows a good interaction between the two actors with appropriate incoming messages that force one of the actors to wait when expected.

We tried to follow all the steps described in the project's task and we were able to reproduce them in the Petri net.

4 Petri Net Analysis - Collaboration Extended

The changes required for the extended version of the collaboration did not bring any significant or interesting change in the structure of the net or in its properties in any of the tasks previously performed. In the Petri Net implementation there was the need to put an event based split right after another event based split, which proved more challenging than expected.

Structural Analysis Running our extended workflow net into WoPeD gave us very similar results to the non extended net, that is, we have a net with an additional free-choice violation given by the additional event based split we included, and an higher number of transition and places obviously due to the increased size of the net.

Behavioural Analysis The behavioural analysis of the extended process also didn't bring any significant changes from the original analysis, as the net is still sound for the same reasons we cited in the previous analysis. The only noticeable difference was a record 21 minutes of computation time.

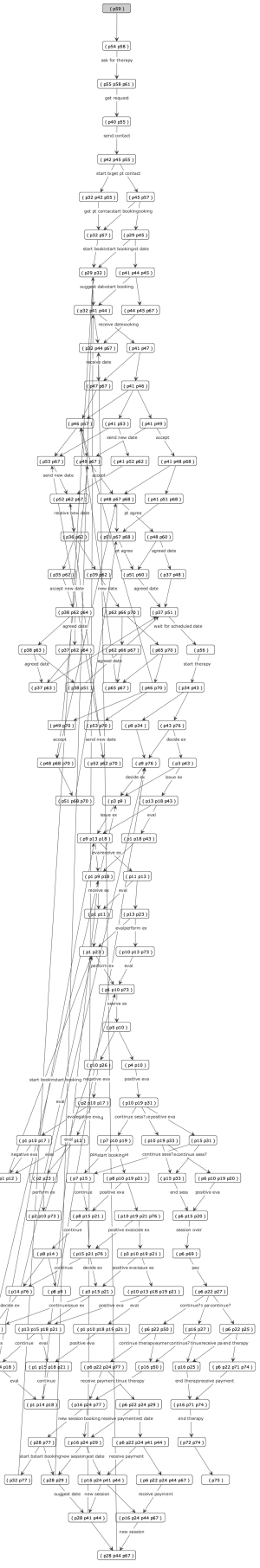

Figure 7: Coverability graph of collaboration

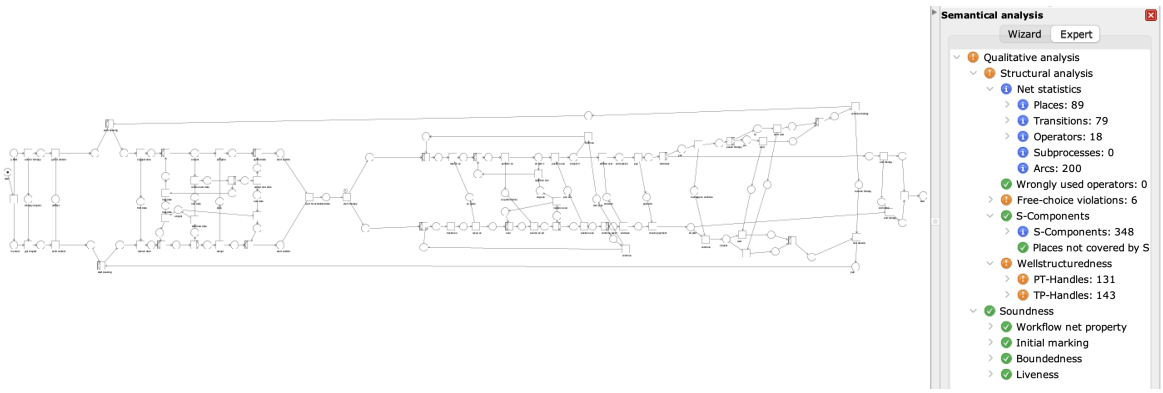

Figure 8: Semantical Analysis of Collaboration Extended