Analysis, Optimisation and Debugging of BPMN Processes

PhD Defended by Quentin NIVON before a jury composed of:

- Pr. Olivier BARAIS, Examiner
- Pr. Remco DIJKMAN, Examiner
- Pr. Massimo MECELLA, Reviewer
- Pr. Pascal POIZAT, Reviewer
- Pr. Claudia RONCANCIO, Examiner
- Pr. Gwen SALAÜN, Supervisor

A Little Bit of History: BPMN

BPMN stands for **Business Process Model and Notation**.
But what is a business process?

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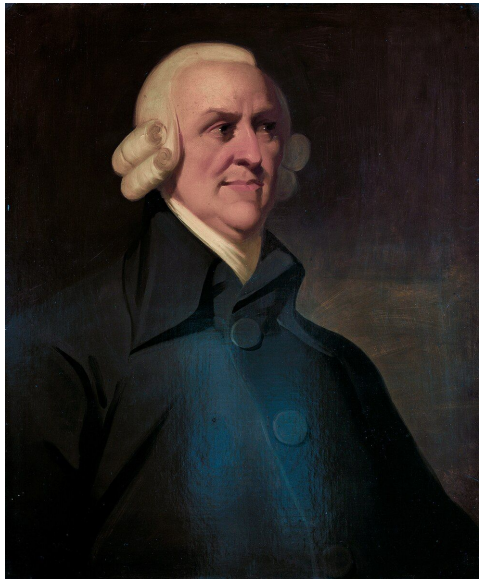
But what is a business process?

"*A business process [...] is a collection of related, structured activities or tasks performed by people or equipment in which a specific sequence produces a service or product (that serves a particular business goal) for a particular customer or customers*"

A Little Bit of History: Adam Smith

According to history, the **first** man to have ever evokated the term “business process” is the scottish economist Adam Smith in 1776.



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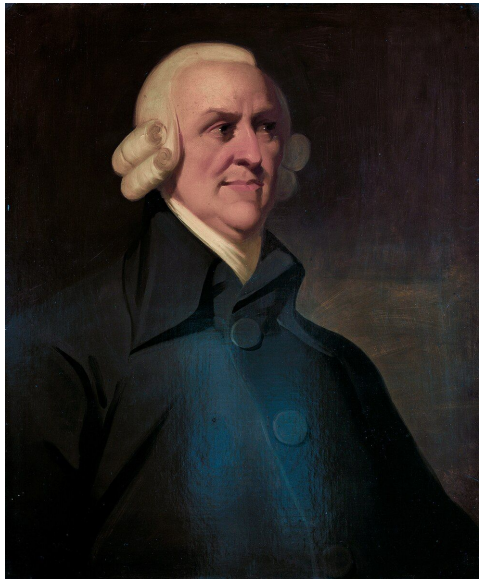

Adam Smith

In [Smith1776], he described the production of a pin as follows:

*“**One man draws out the wire**; **another straights it**; **a third cuts it; a fourth points it**; a fifth grinds it at the top for receiving the head; to make the head requires two or three distinct operations; to put it on is a peculiar business; to whiten the pins is another ... and the important business of making a pin is, in this manner, divided into about eighteen distinct operations, which, in some manufactories, are all performed by distinct hands, though in others the same man will sometimes perform two or three of them.”*

A Little Bit of History: …and His Successors

Frederick Winslow Taylor

- standardization of processes
- systematic training
- clear definition of the roles of management and employees

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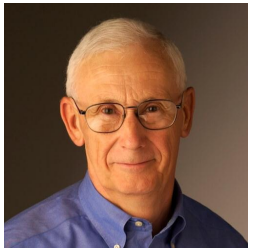

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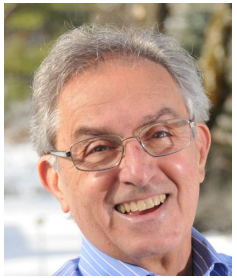

James Champy

Wil van der Aalst

- standardization of processes
- systematic training
- clear definition of the roles of management and employees

and others

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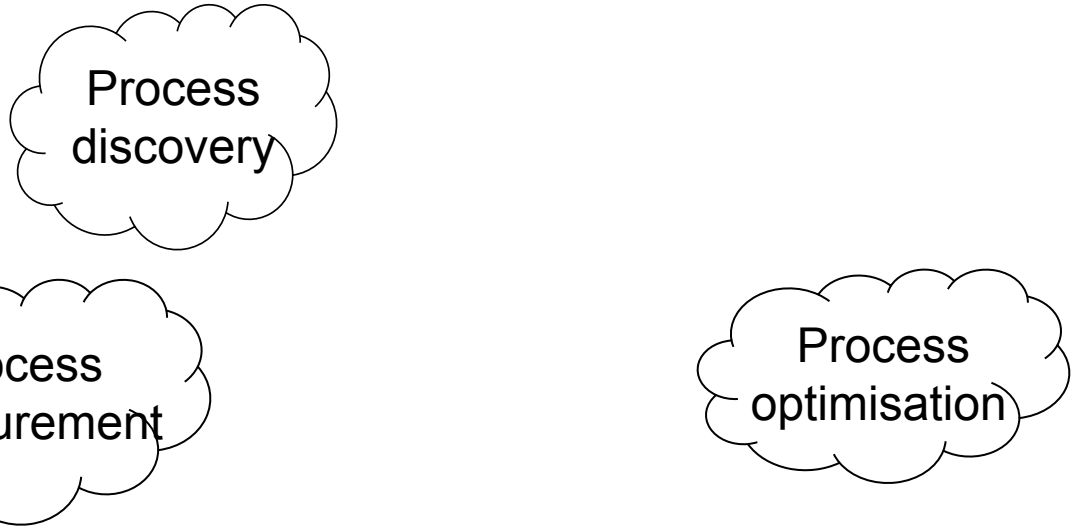

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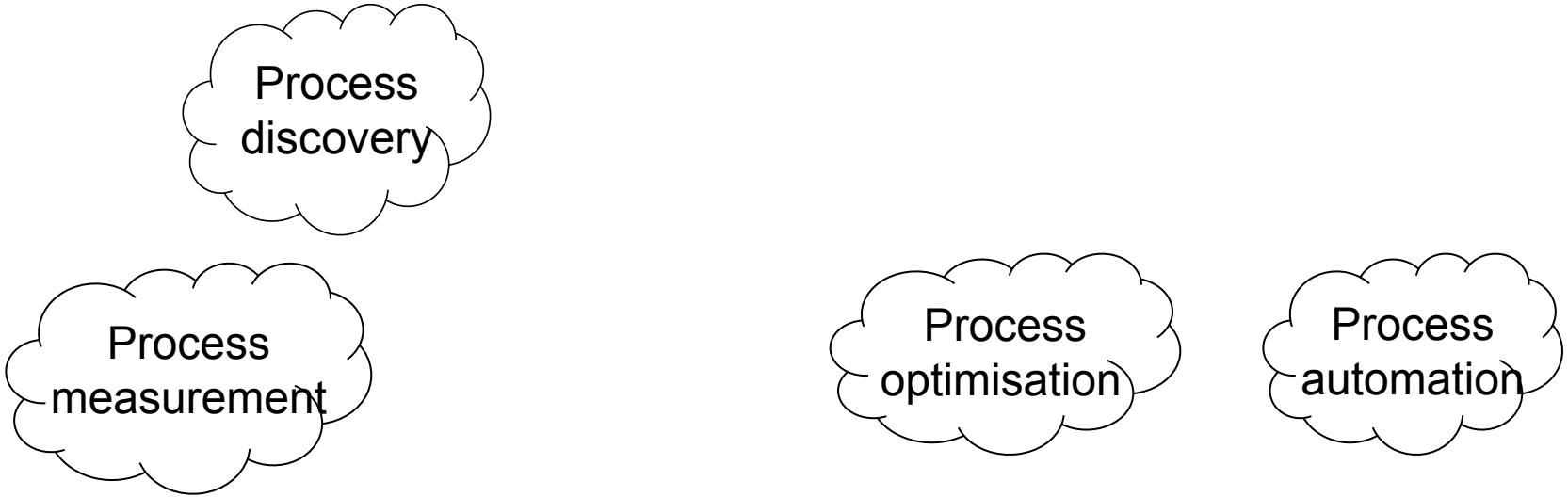

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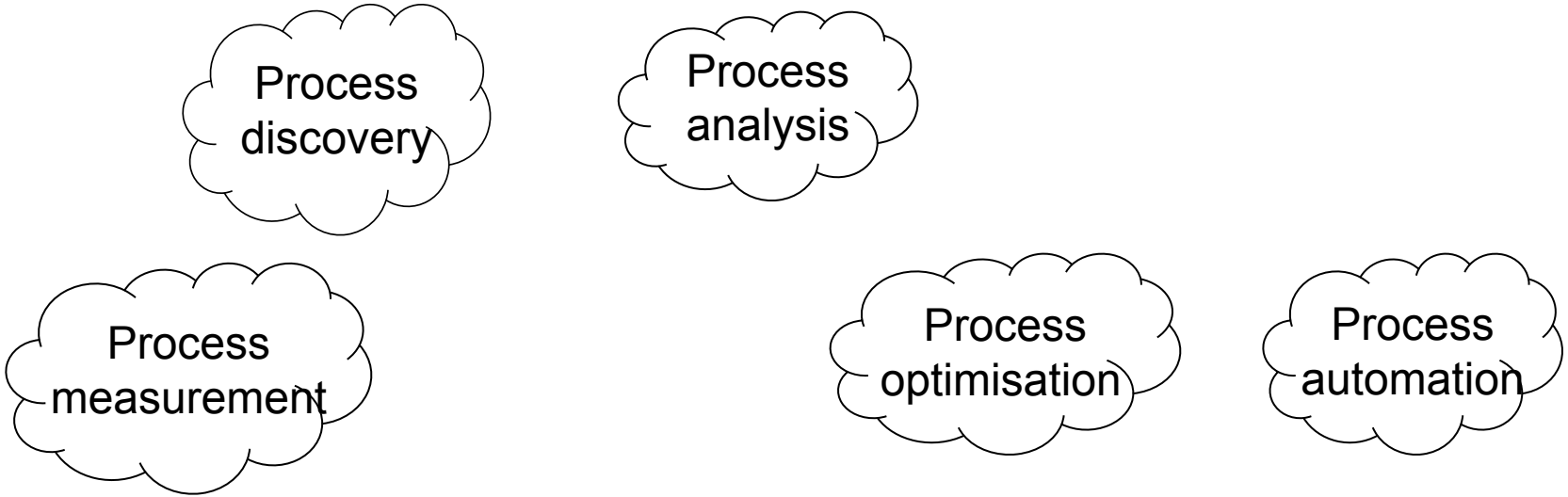

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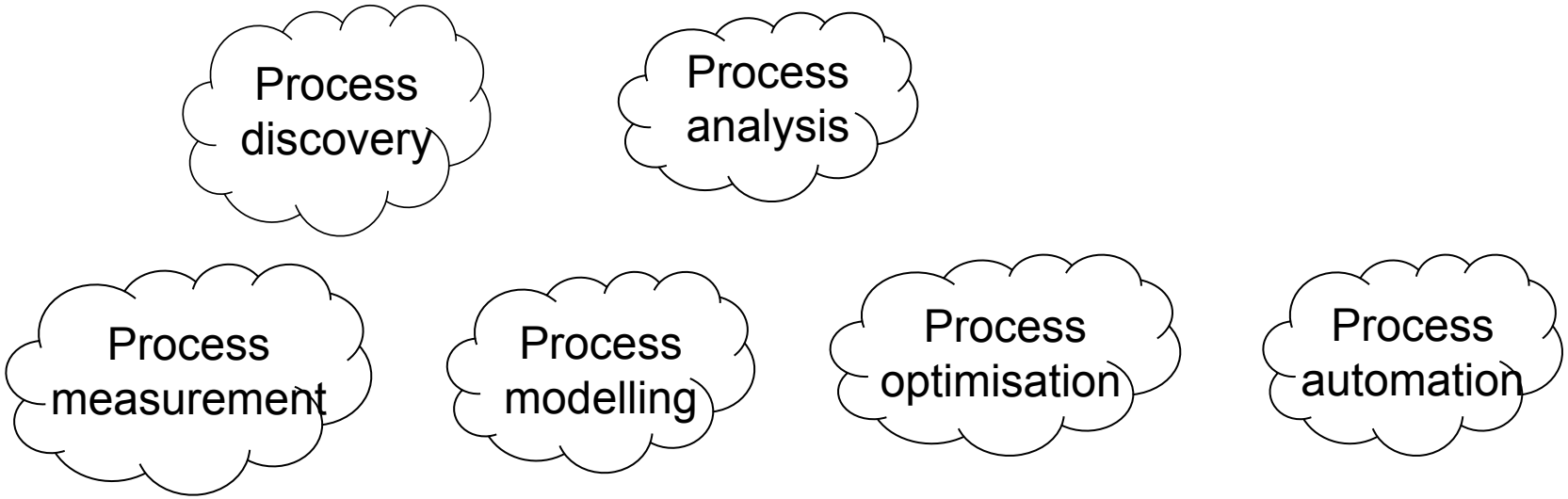

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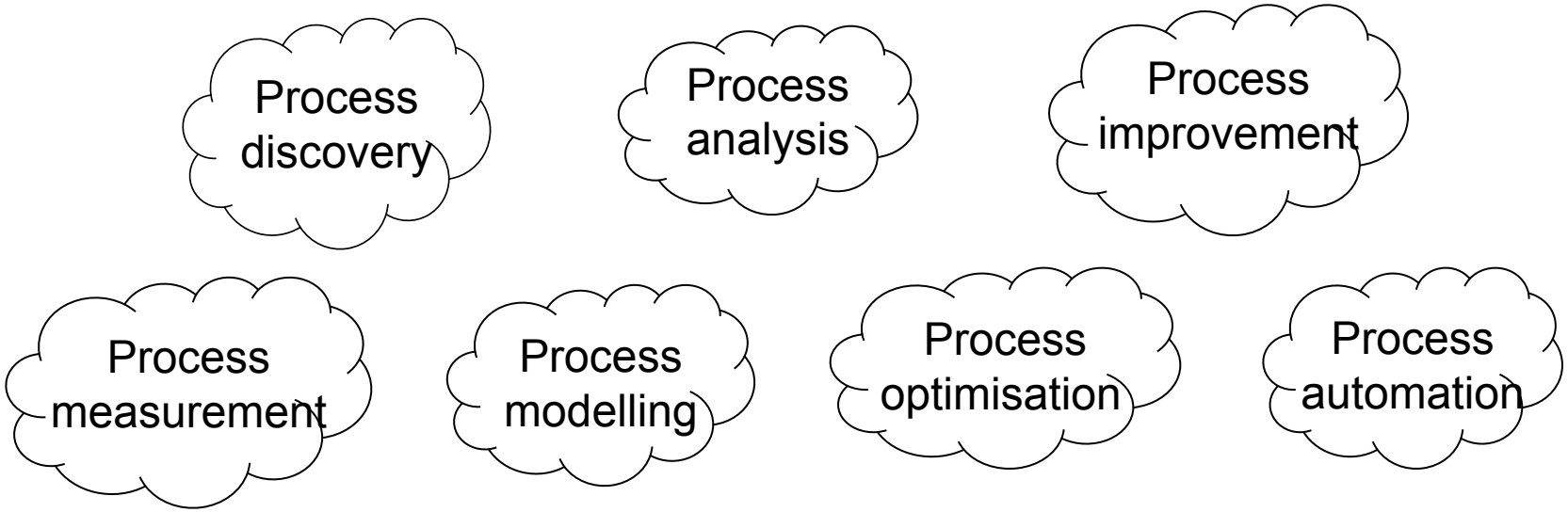

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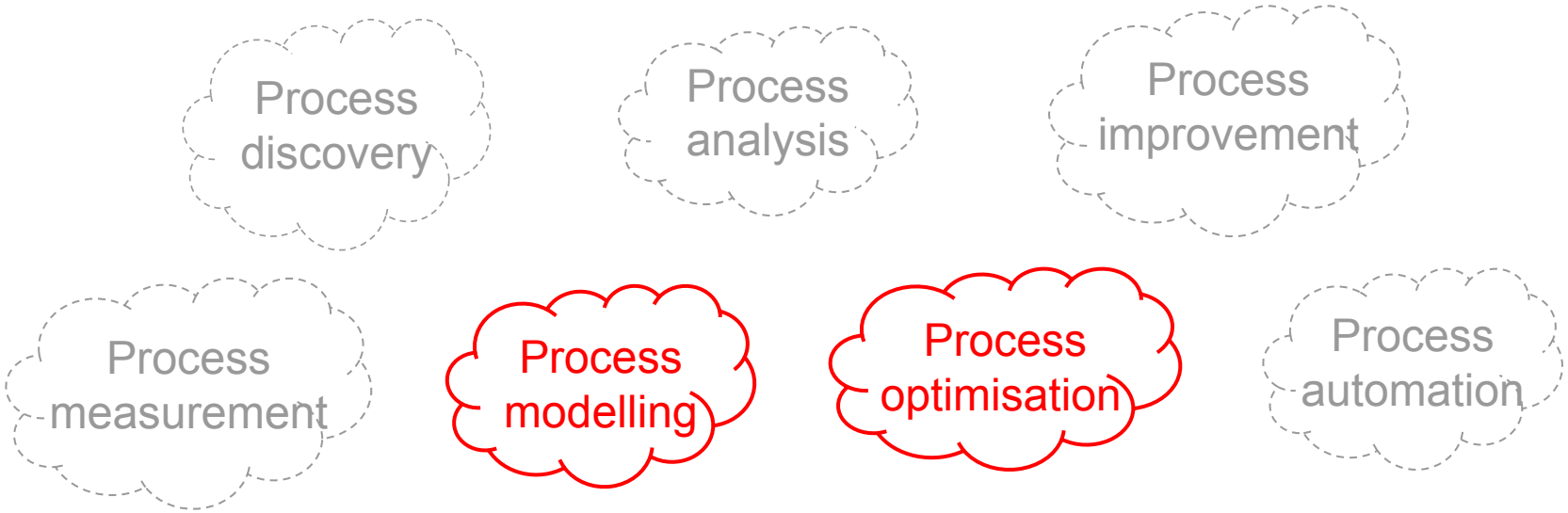

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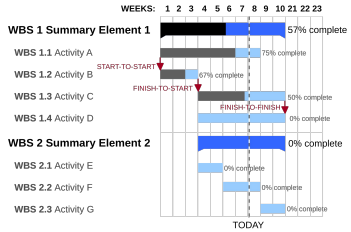

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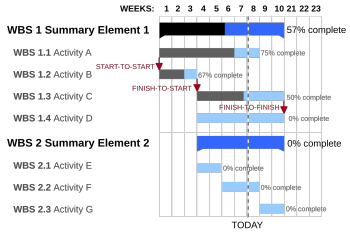

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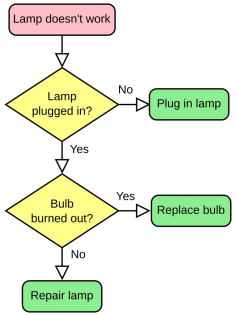

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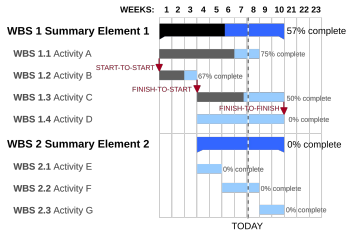

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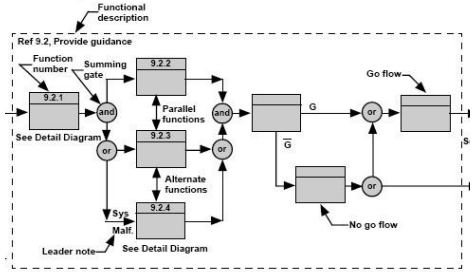
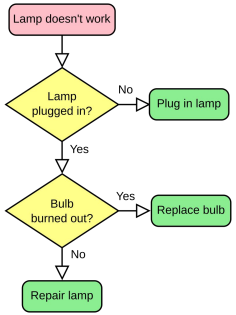


Functional flow block diagram (FFBD), 195X



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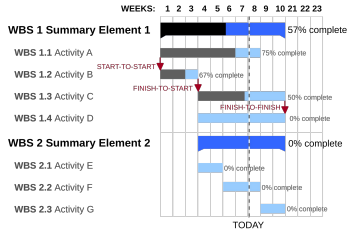

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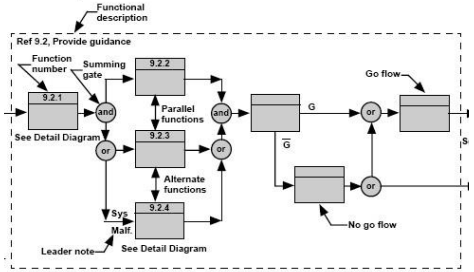

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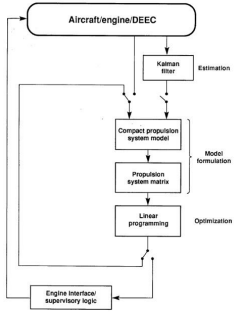
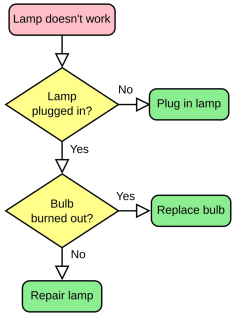


Control-flow diagram (CFD), 195X



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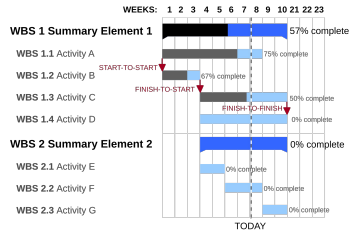

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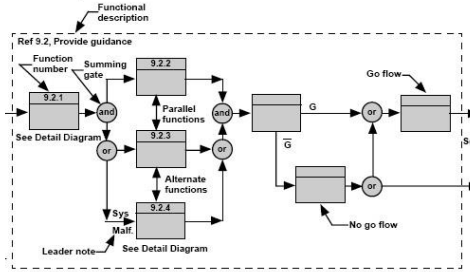

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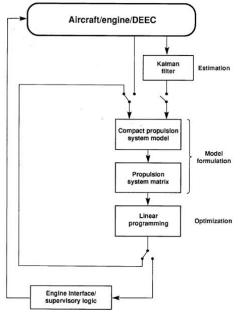

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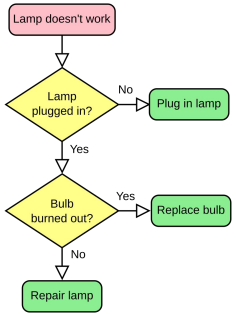

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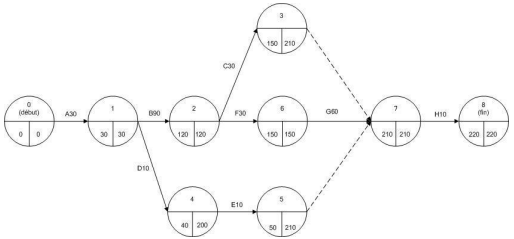

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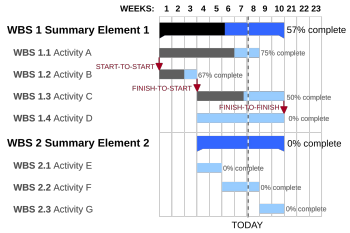

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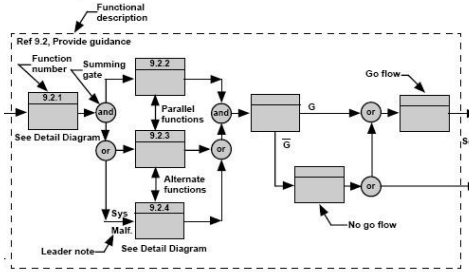

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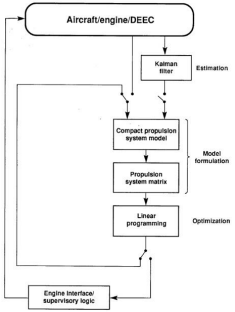

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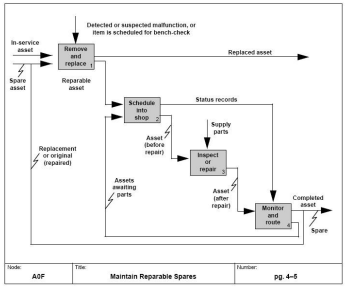
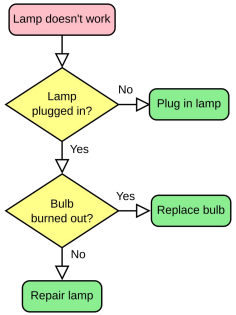


IDEF diagram, 197X



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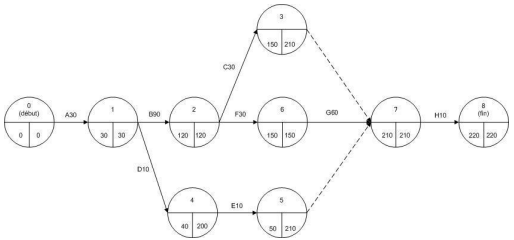

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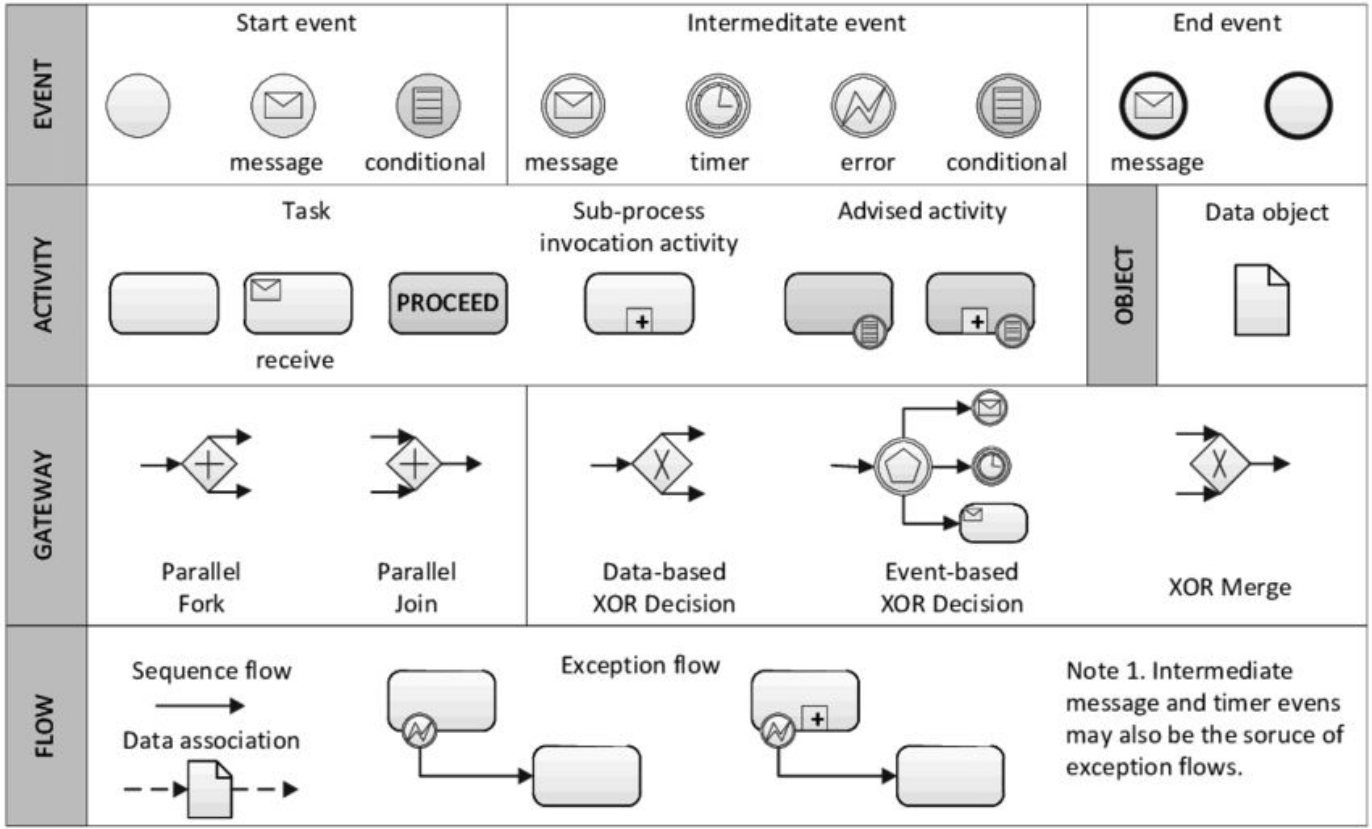
- An **ISO/IEC standard** since version 2.0 in 2013.

Excerpt of the BPMN Syntax



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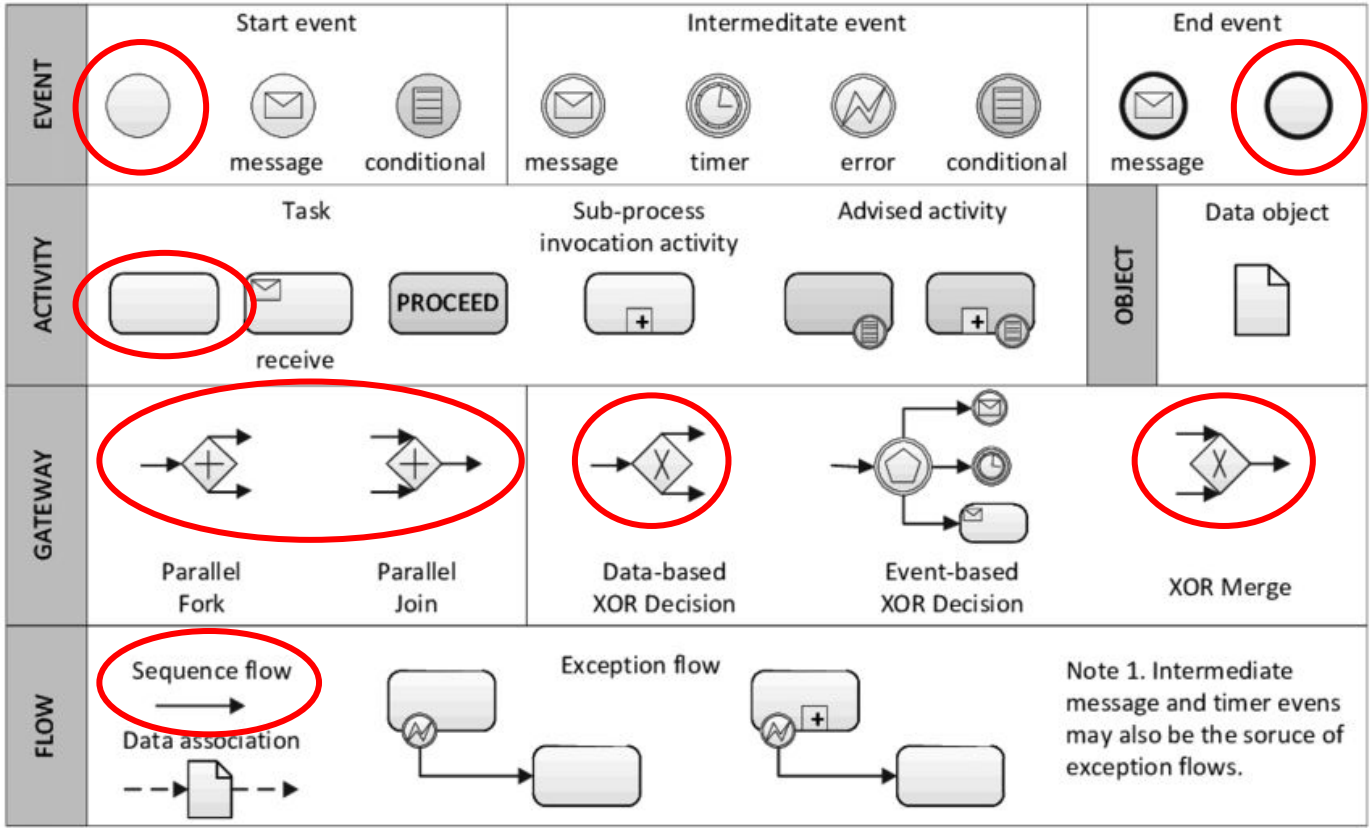

Example of BPMN Process

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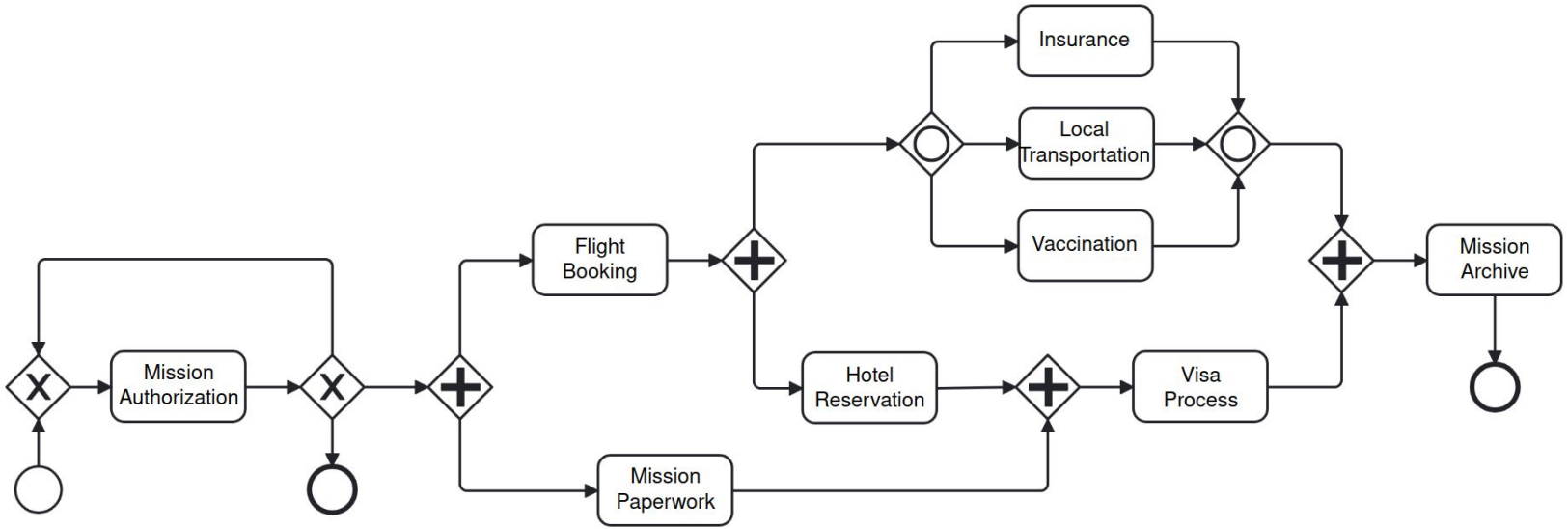

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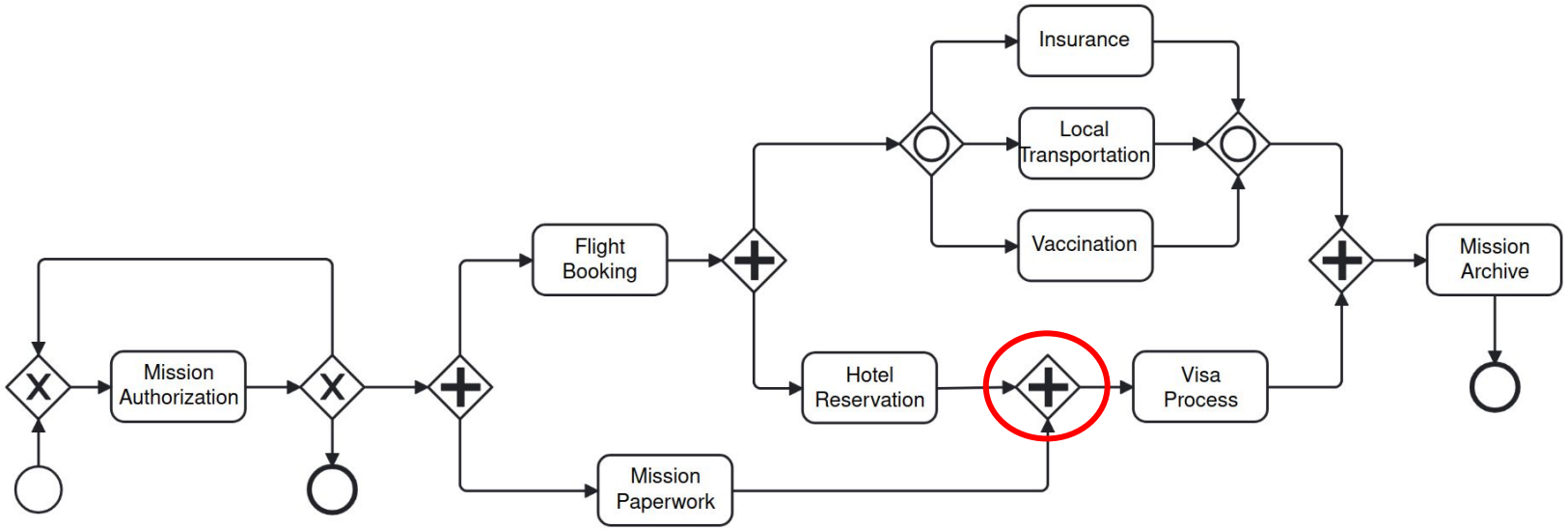

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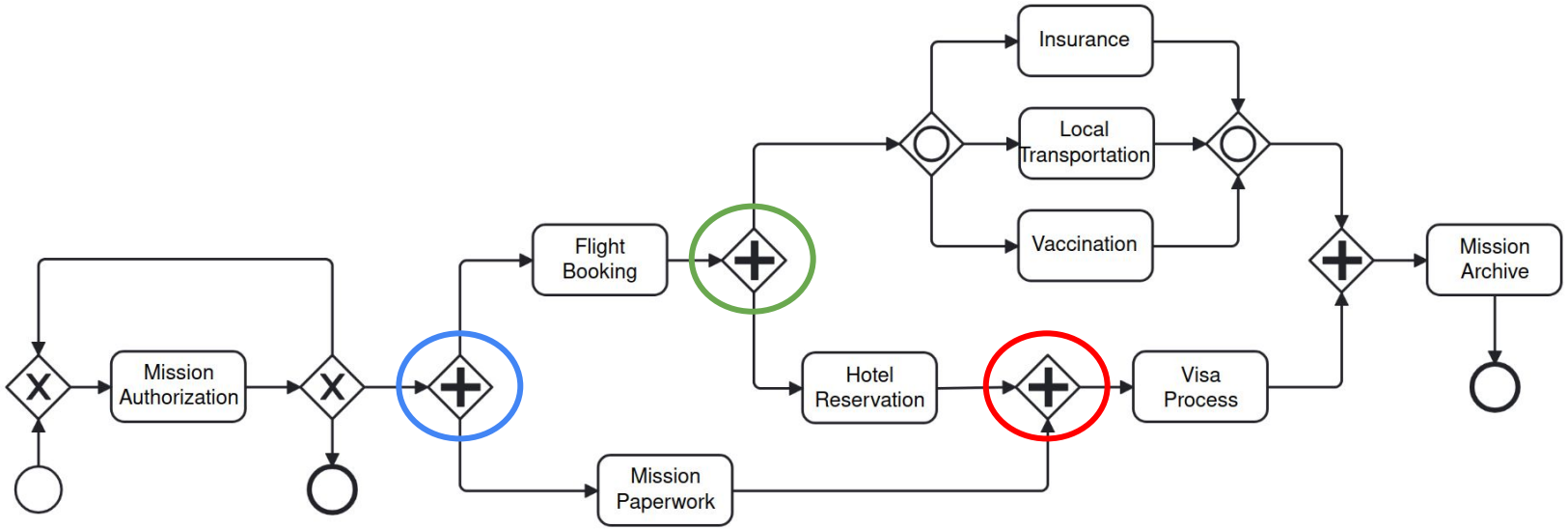

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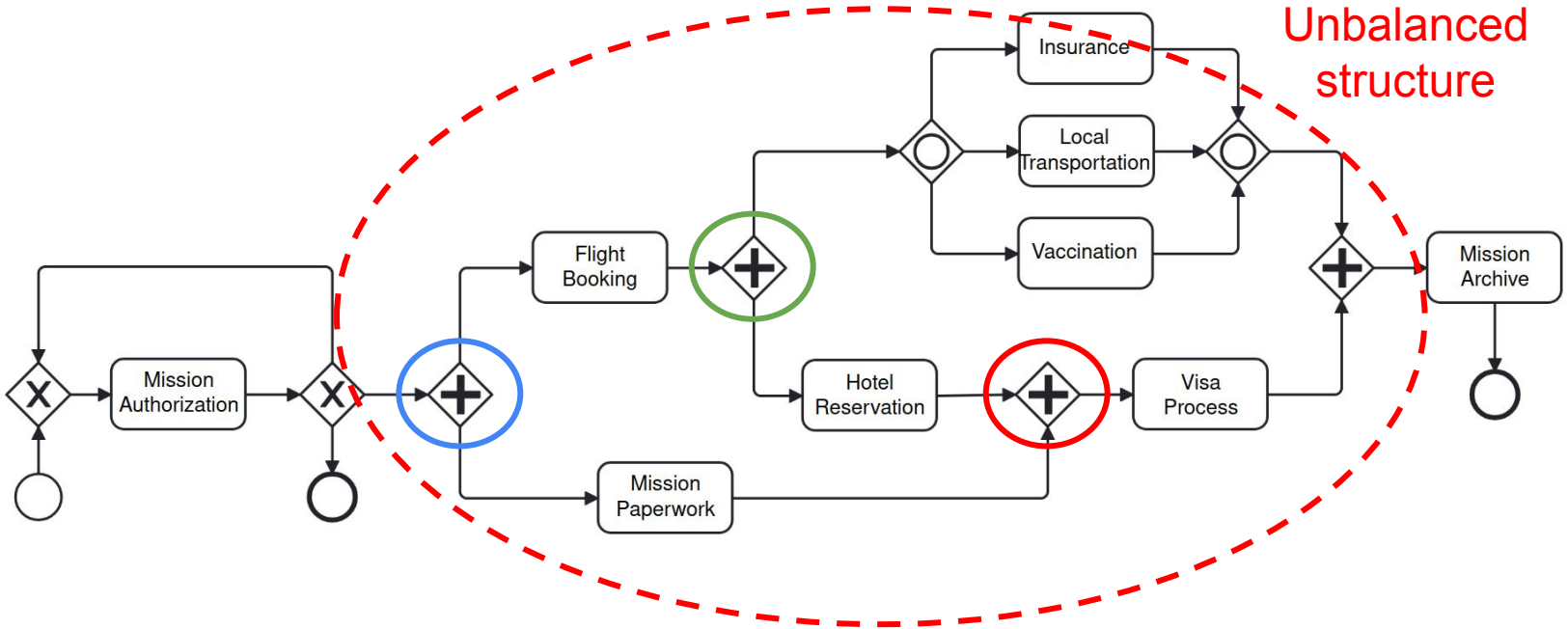
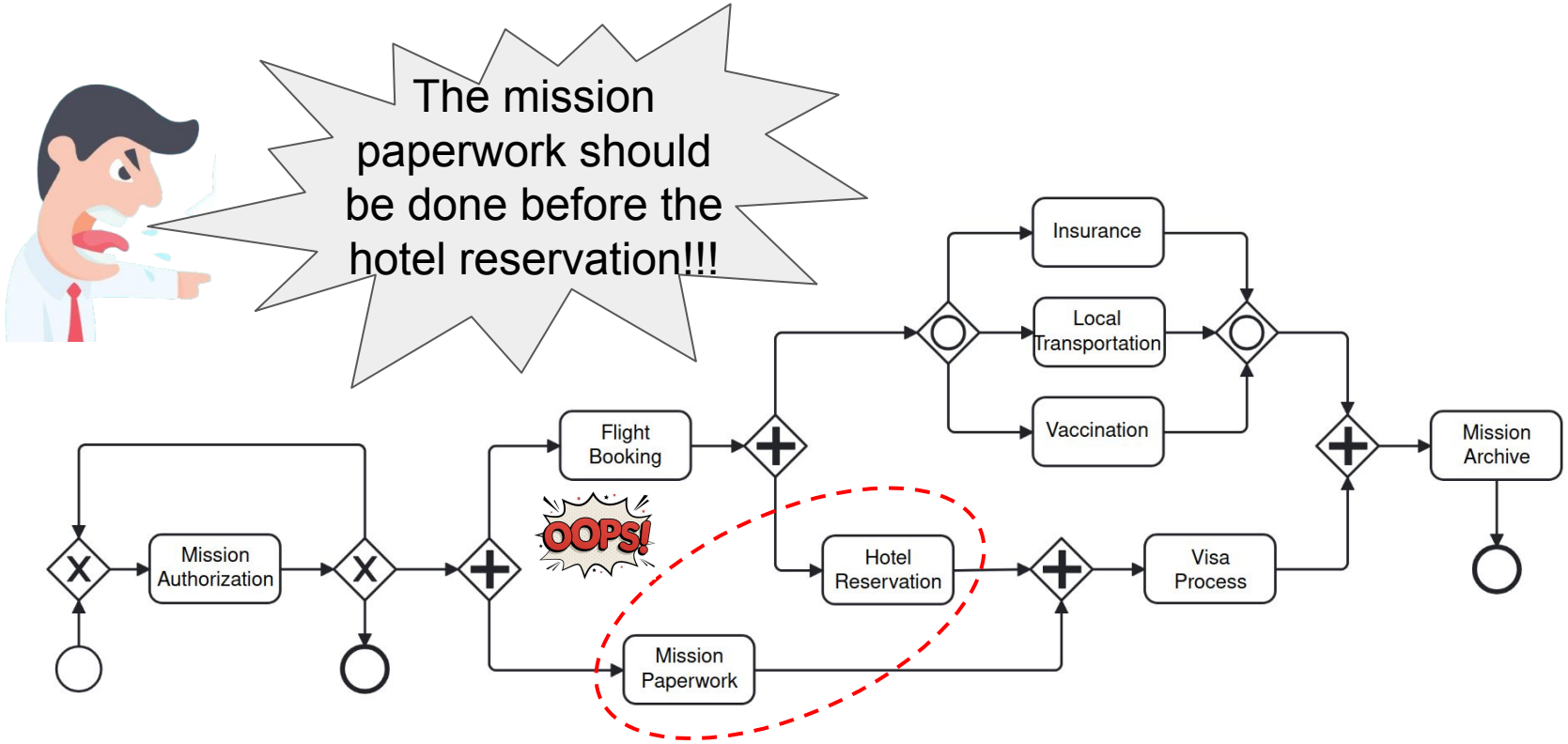


How to write a BPMN process?

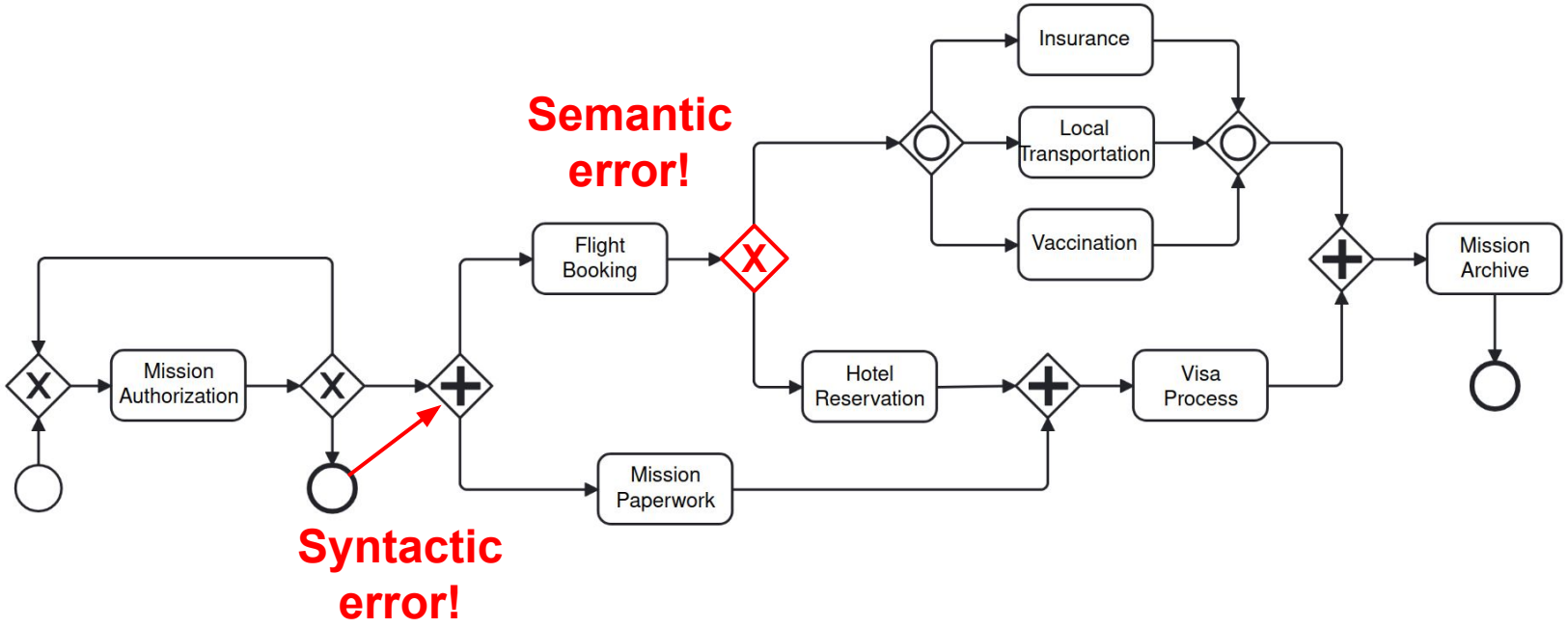
How to avoid wasting time designing?

~30m!

How to match the expected behaviour?



How to ensure syntactic/semantic correctness?



Modelling BPMN processes

- How to **write** a **BPMN** process?
- How to **avoid wasting time** designing?
- How to **match** the expected **behaviour**?
- How to ensure **syntactic/semantic correctness**?

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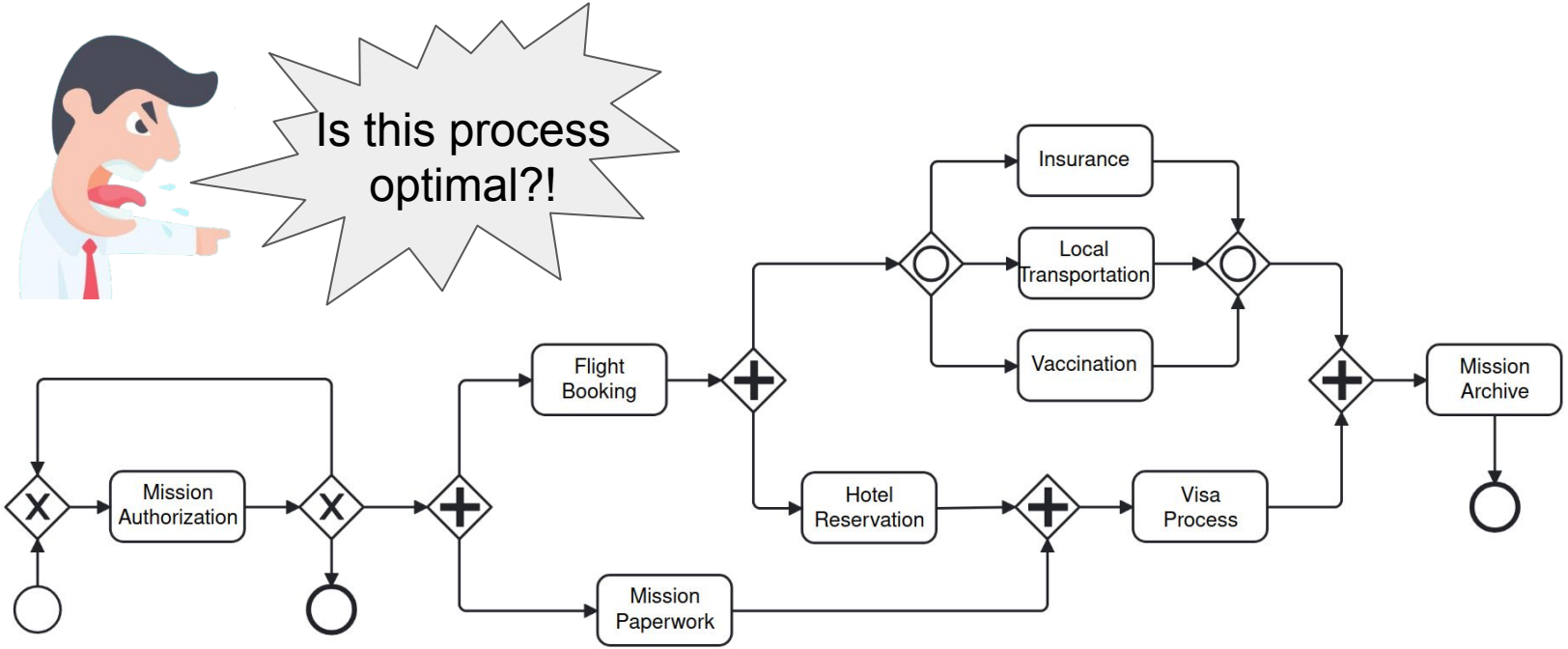
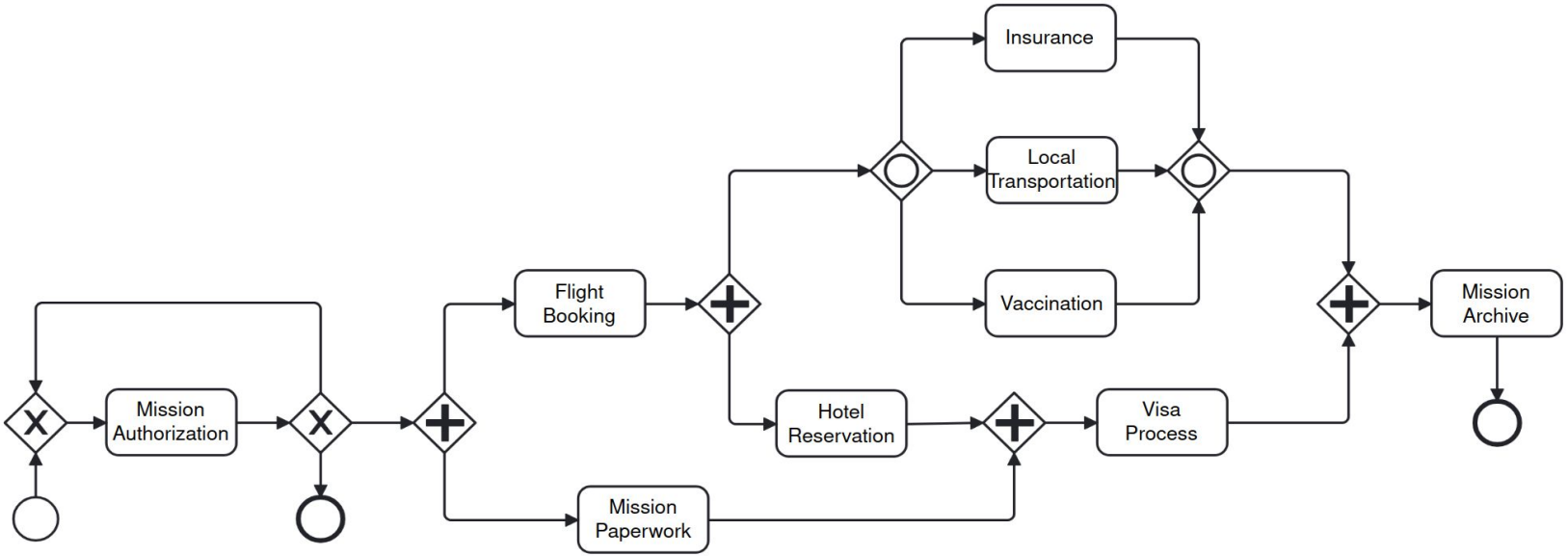


➢ In the **resource-free**, **durations-free**, **single instance** context, yes!

How to optimise a BPMN process?

But what if we enrich the process with:



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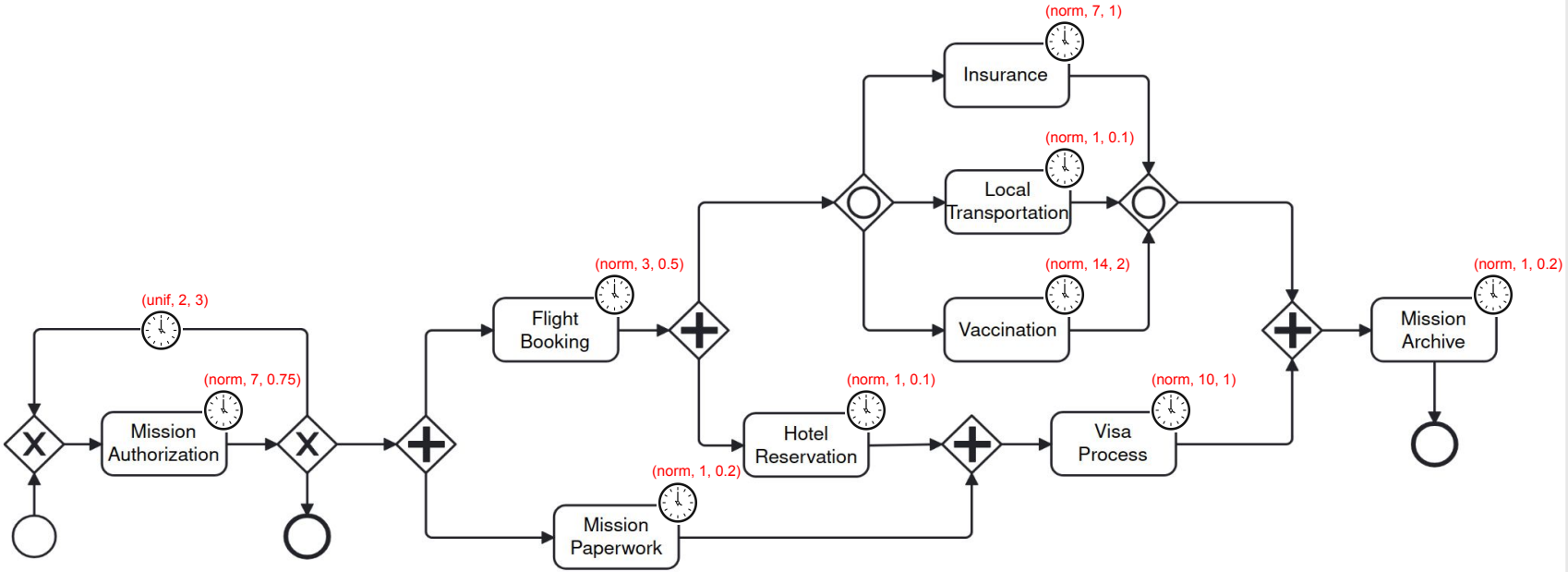

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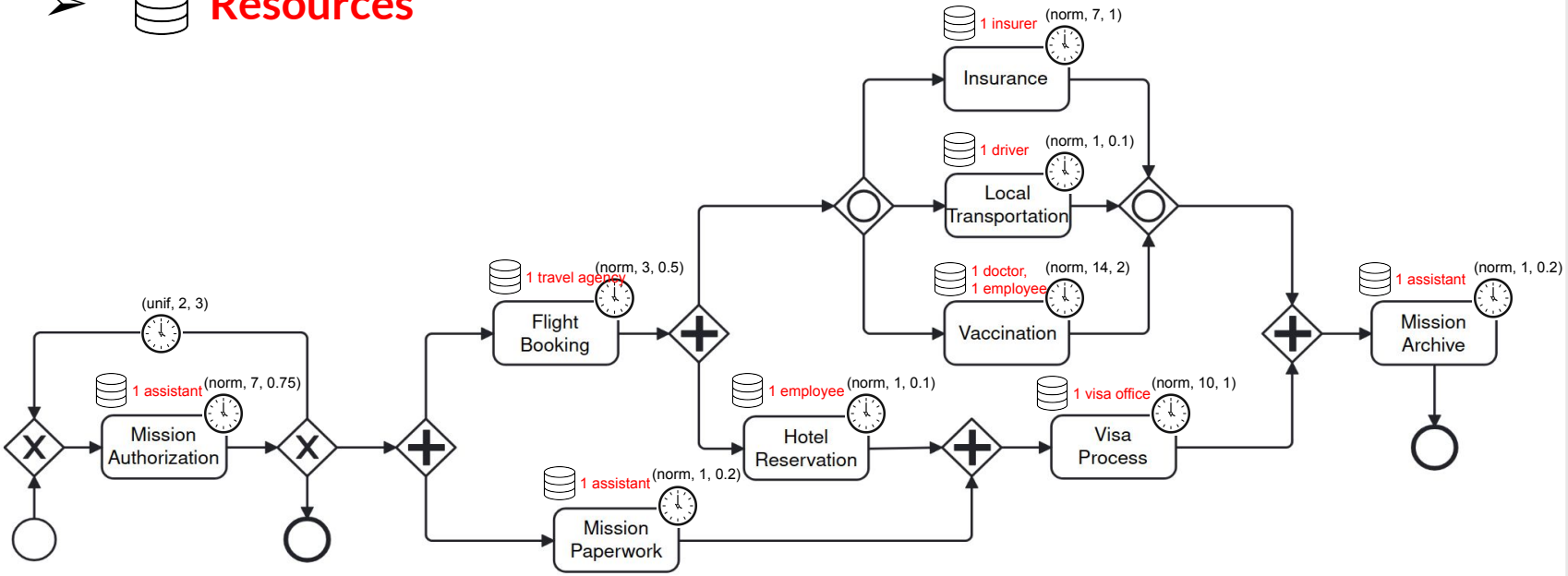

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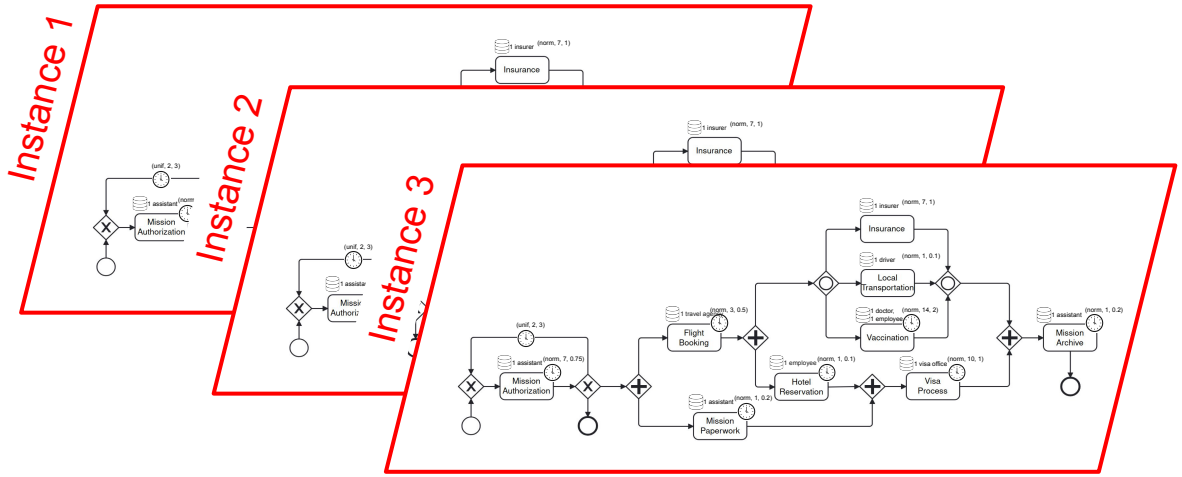
But what if we enrich the process with:

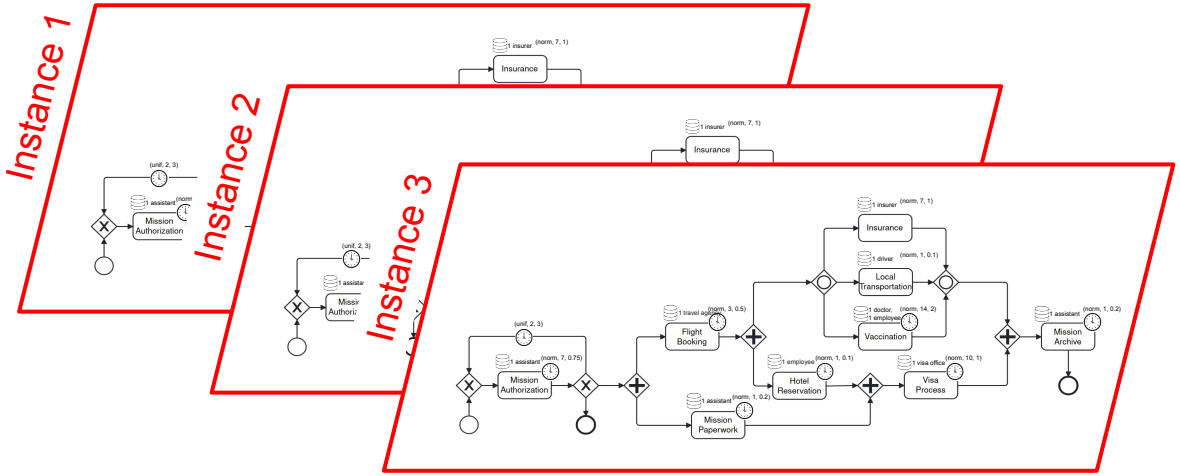
- Durations (following probabilistic distributions)
- Resources
- **Multiple Simultaneous Executions**



How to optimise a BPMN process?

But what if we enrich the process with:

- Durations (following probabilistic distributions)
- Resources
- **Multiple Simultaneous Executions**



⇒ The problem becomes **much more complex!**

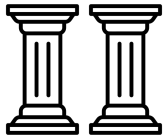
PhD Research Axes

Modelling BPMN processes

- How to **write** a **BPMN** process?
- How to **avoid wasting time** designing?
- How to **match** the expected **behaviour**?
- How to ensure **syntactic/semantic correctness**?

Optimising BPMN processes

- How can you **optimise** a BPMN process in real-world conditions?



Contributions of the Thesis – Modelling of Processes

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- An approach **generating a BPMN process** from a textual description of its requirements which:
  - Manipulates **abstract syntax trees**
  - Handles **balanced BPMN** processes

ICSOC'24

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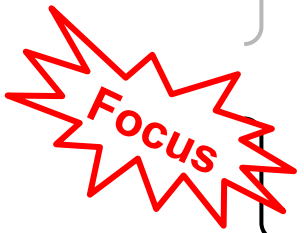

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Plan

I/ Introduction

II/ Automated Generation of BPMN Processes from Textual Requirements

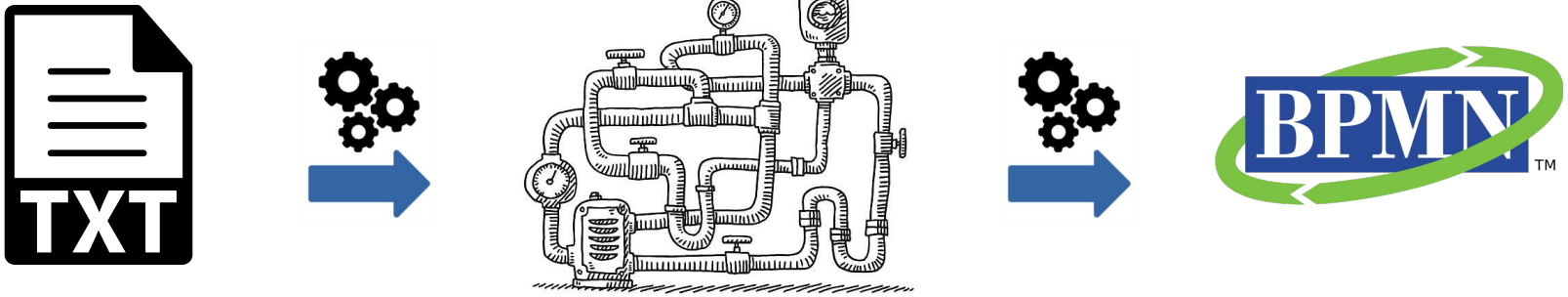
III/ Human-Centered Refactoring-Based Optimisation of BPMN Processes

IV/ Related Work

V/ Takeaways

VI/ References

Automated Generation of BPMN – Big Picture



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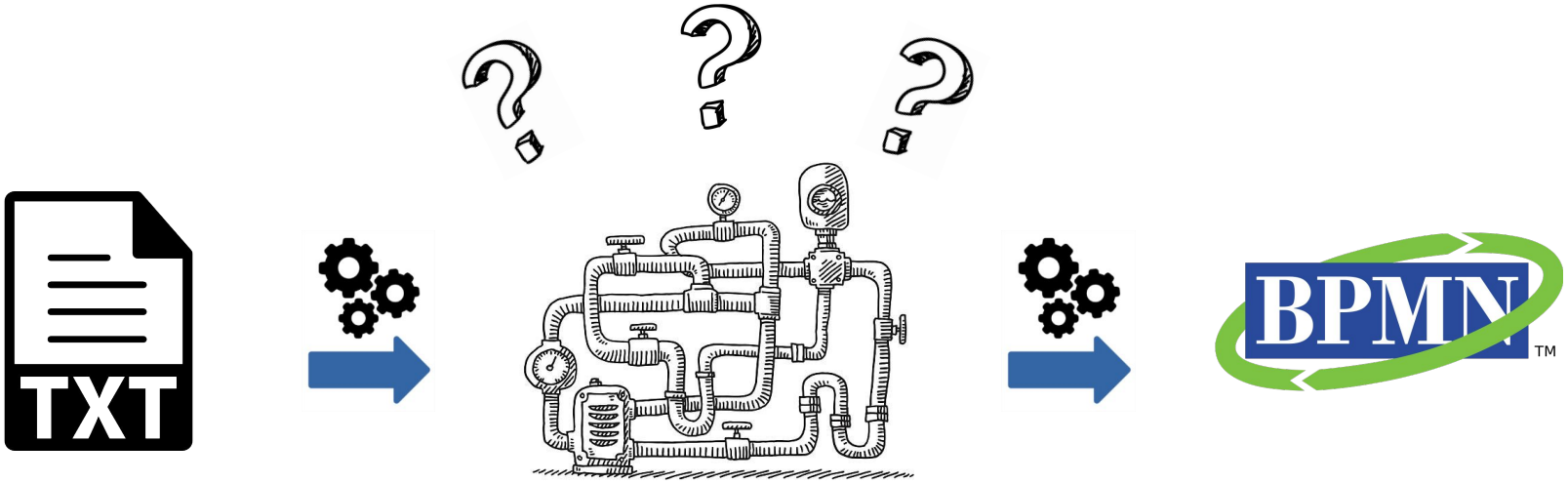

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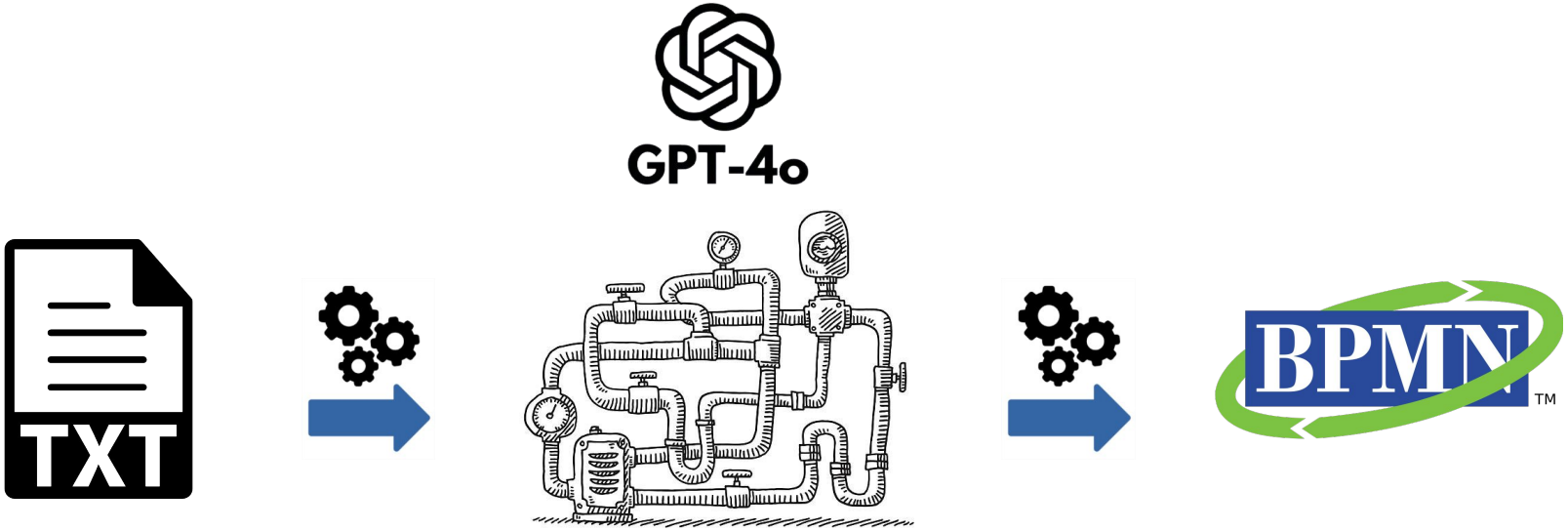

Global Picture of the Approach

First of all, an employee CollectGoods. Then, the client PayForDelivery while the employee PrepareParcel. Finally, the company can either DeliverByCar or DeliverByDrone (depending on the distance for example)

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Expressions Following an Internal Grammar

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GPT-4o

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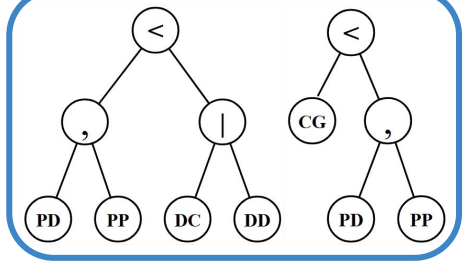

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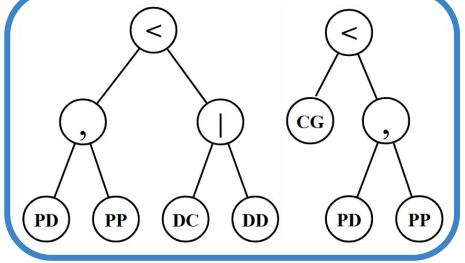

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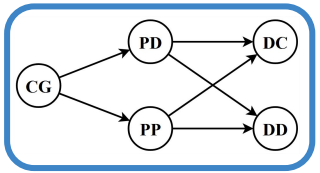

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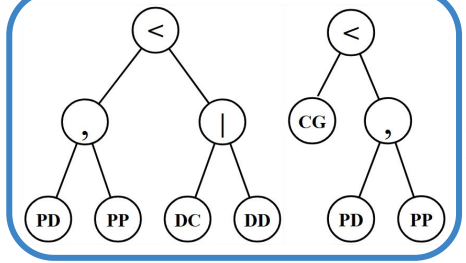

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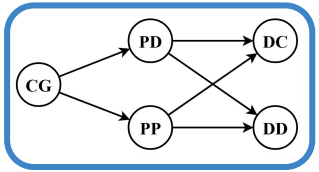

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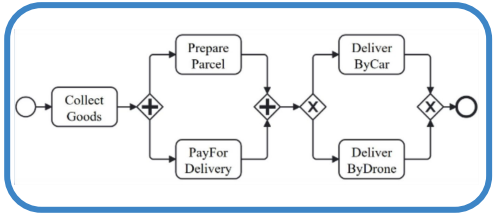

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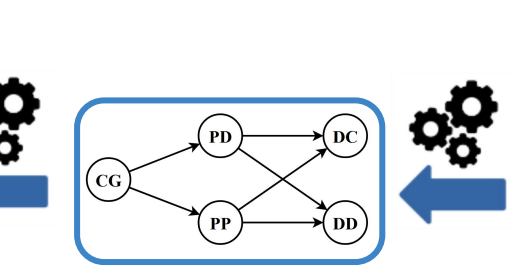

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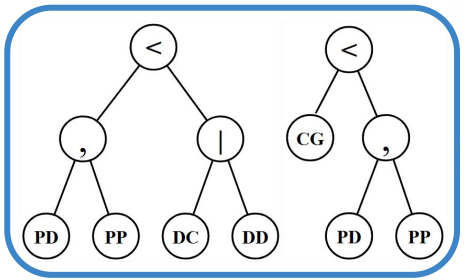
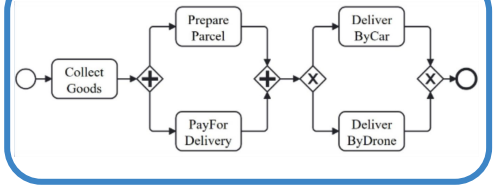


Abstract Syntax Trees

Refinement



BPMN Process

Detailed Approach – Step 1 – Description

The user first has to write a **textual description** of the process-to-be.

First, the developer StartFeatureManagementSoftware (**StFMS**).
Then, he DescribeNewFeatureRequirements (**DNFR**). After that, the staff ValidateInternally (**VI**), and the client ValidateExternally (**VE**). Once the feature has been validated internally, the developer can CreateNewFeatureBranch (**CNFB**). Once the feature is completely validated (internally and externally), the staff can StartTechnicalDesign (**STD**). Instead of describing a new feature, validate it, create a new branch and start technical design, the developer can also LoadCurrentlyDevelopedFeature (**LCDF**). The FeatureDevelopment (**FD**) then eventually starts, followed by a DebuggingPhase (**DP**) useful to chase possible bugs before releasing the feature. This phase leads either to a BugCaseOpening (**BCO**), or to ReleaseFeature (**RF**) if no bug was found. If a bug case is opened, three different operations may start: either the first support level initiates a FirstStageDebugPhase (**FSDP**), which eventually leads to ClosingFirstLevelRequest (**CFLR**), or the second support level initiates a SecondStageDebugPhase (**SSDP**), which eventually leads to ClosingSecondLevelRequest (**CSLR**), or the third support level initiates a ThirdStageDebugPhase (**TSDP**), which eventually leads to ClosingThirdLevelRequest (**CTLR**). Once these phases are closed, either there is no bug anymore to correct, and the ReleaseFeature task (**RF**) occurs, or a new bug is found, leading to DebuggingPhase (**DP**) again. Also, the FirstStageDebugPhase (**FSDP**), SecondStageDebugPhase (**SSDP**) and ThirdStageDebugPhase (**TSDP**) and their closing can be repeated until a bug is properly corrected. Once ReleaseFeature (**RF**) occurred, the developer can either ShutdownFeatureManagementSoftware (**ShFMS**), or start again with the task DescribeNewFeatureRequirements (**DNFR**).

Detailed Approach – Step 2 – LLM Prompting

The textual description is then **given to a (fine-tuned) LLM** (GPT-4o atm).

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The LLM processes the description and returns a **set of expressions** following an **internal grammar**.

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(STD, CNFB) < (FD < DP)

(DNFR, VI, VE, CNFB, STD) | LCDF

DP < (BCO | RF)

BCO < ((FSDP < CFLR) | (SSDP < CSLR) | (TSDP < CTLR))

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(FSDP, SSDP, TSDP, CFLR, CSLR, CTLR)*

RF < (ShFMS | DNFR)

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These expressions are then **mapped to** their corresponding (reduced) **abstract syntax trees (ASTs)**.

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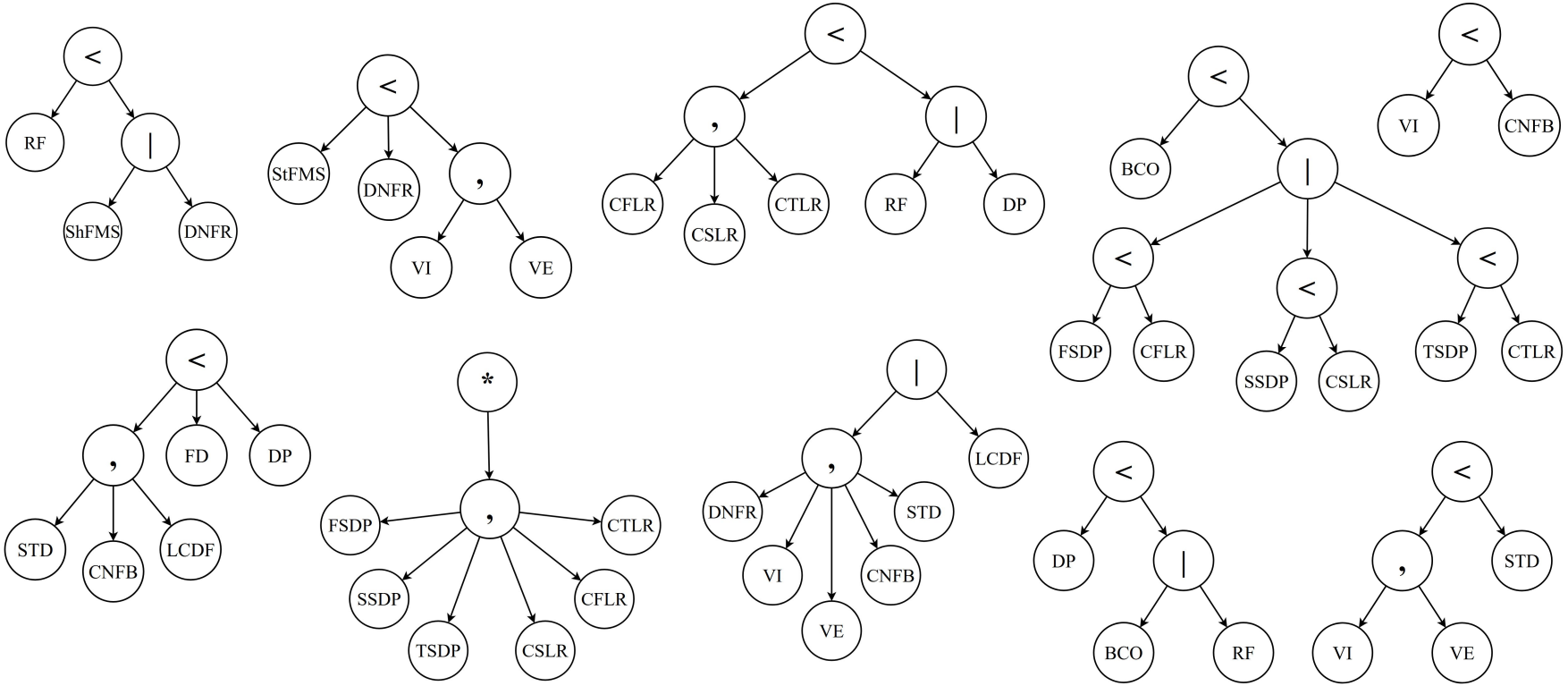

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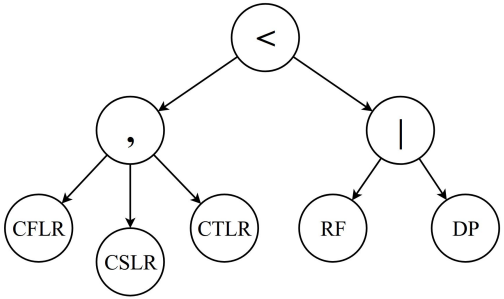

Detailed Approach – Step 5 – Dependency Graph

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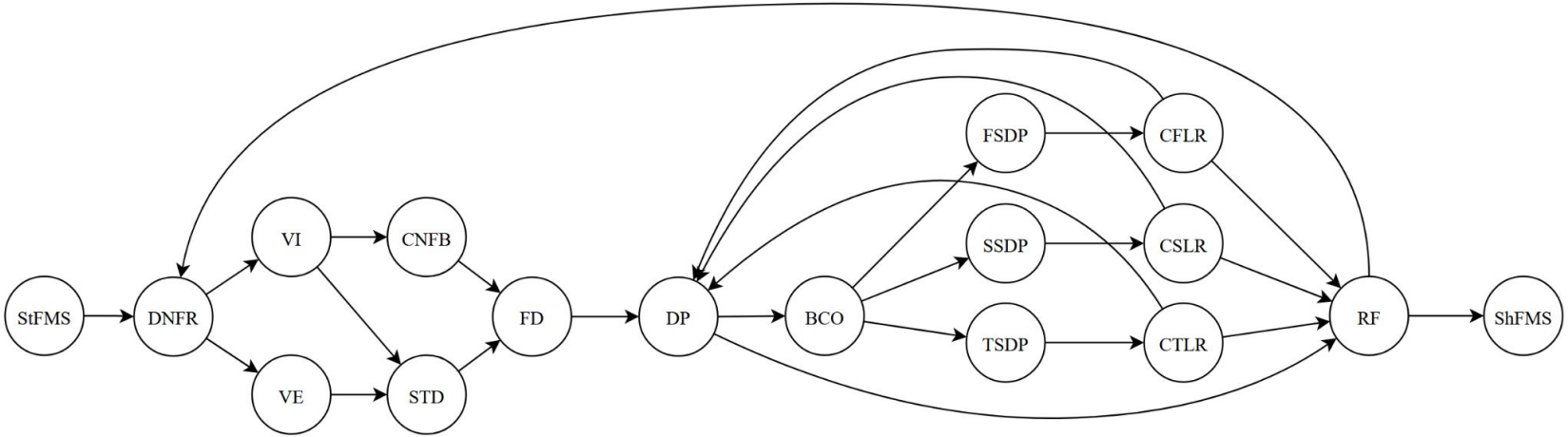

Detailed Approach – Step 6 – BPMN Generation

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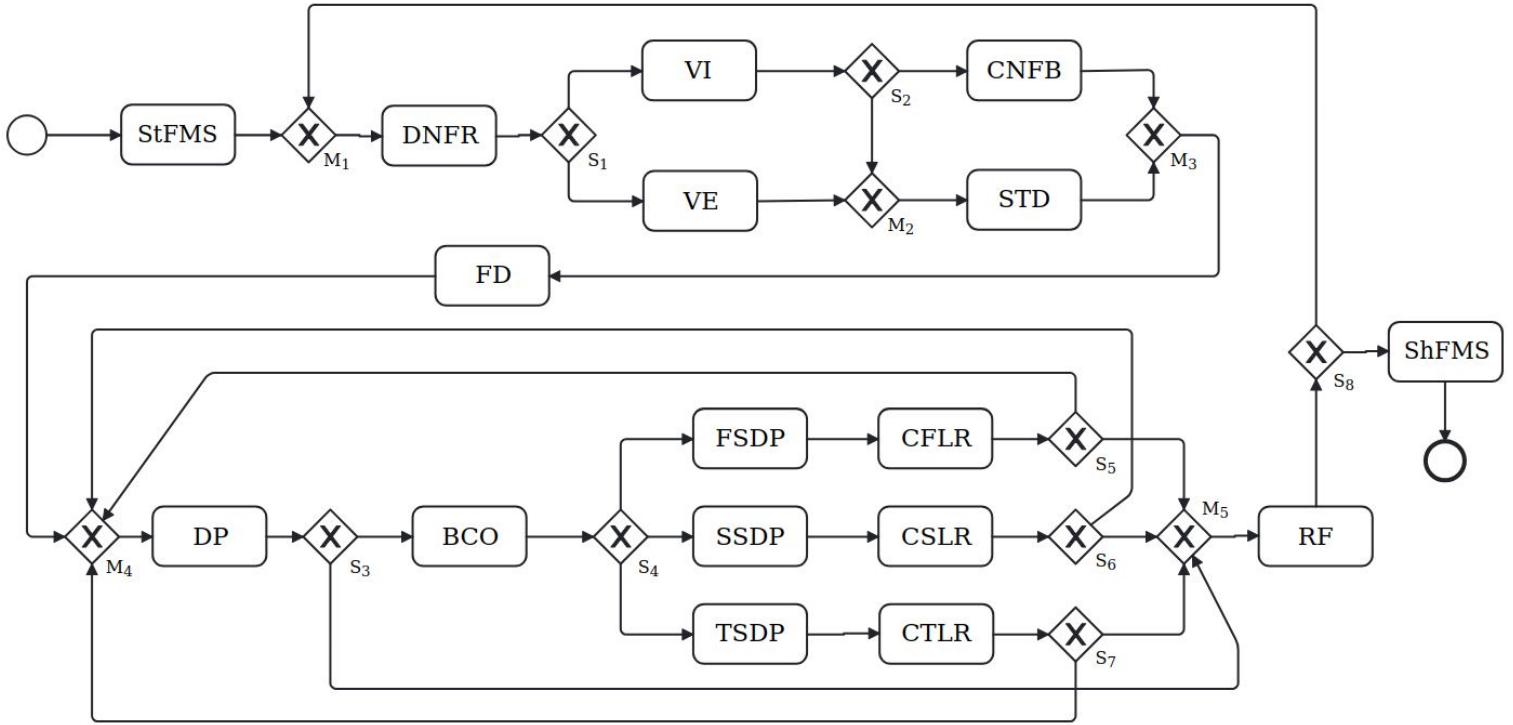

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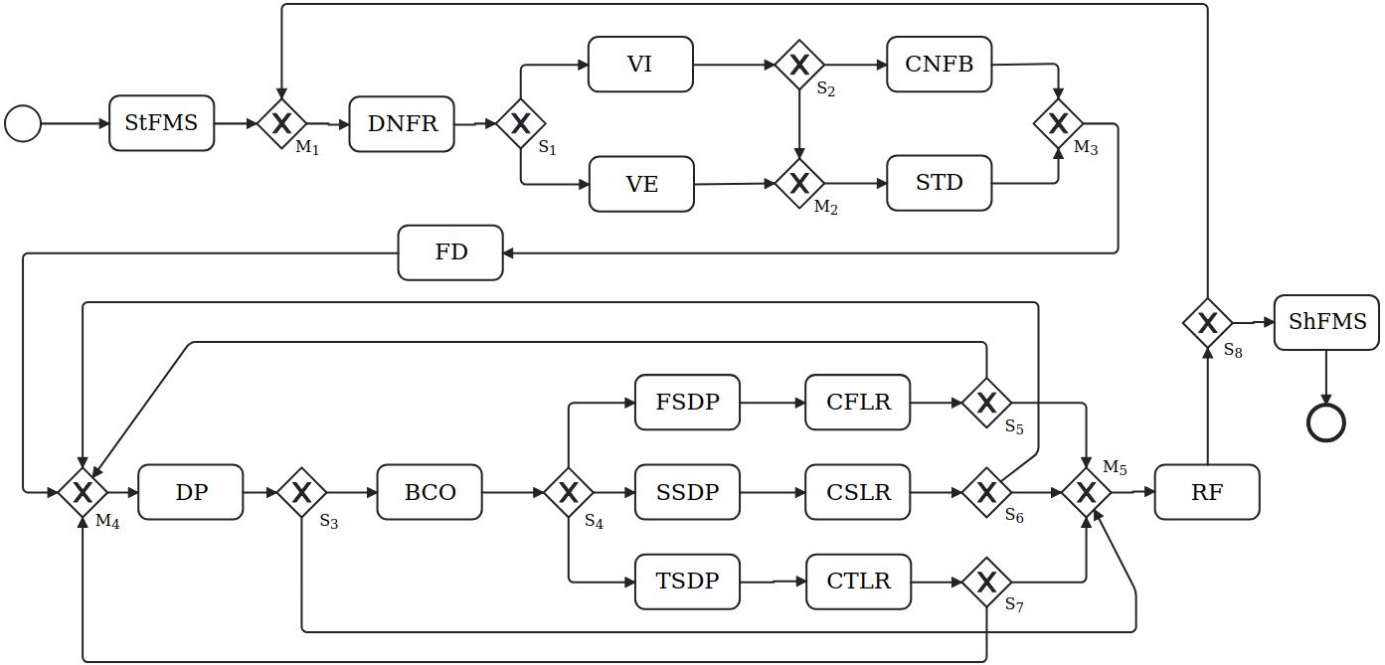

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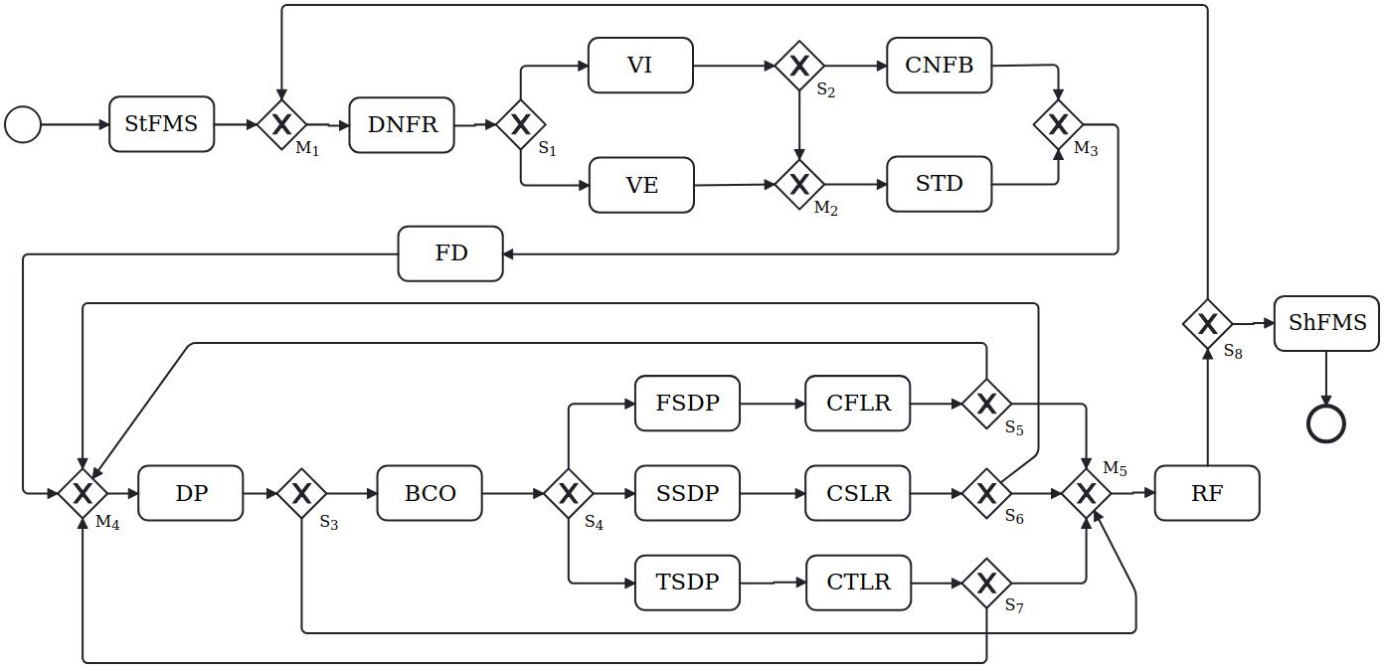

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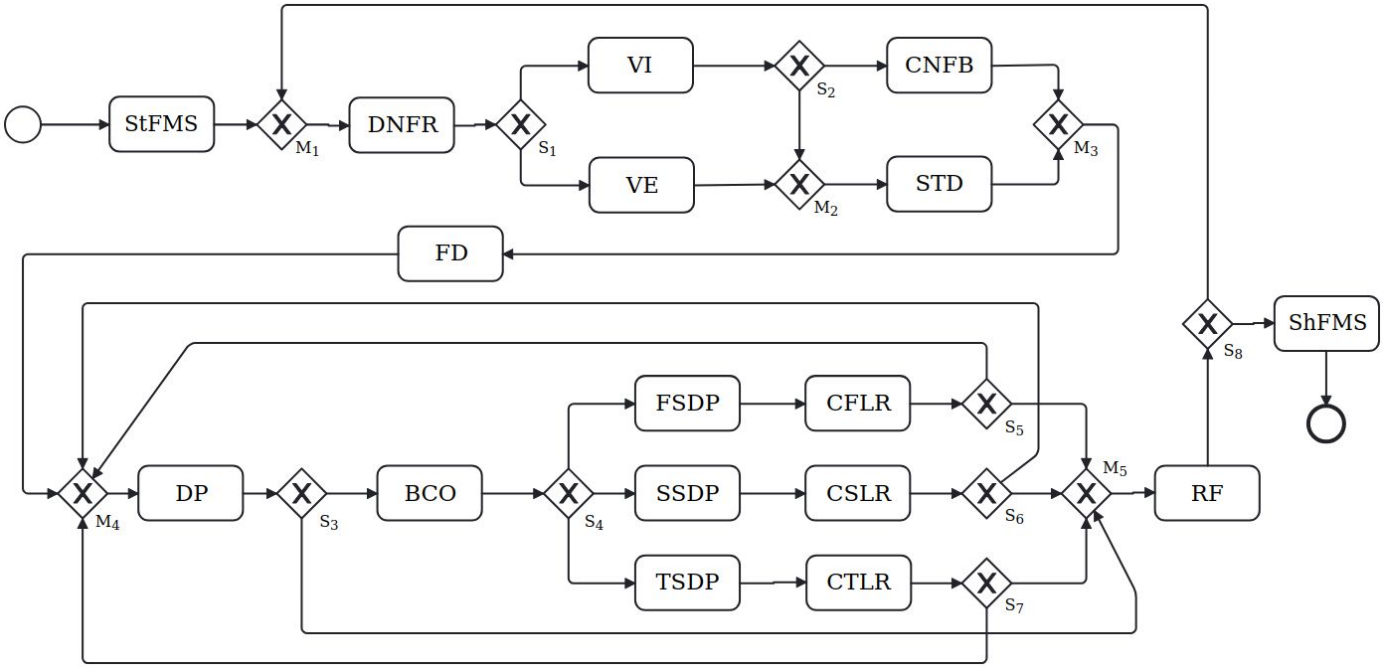

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Task LCDF is not in the process!

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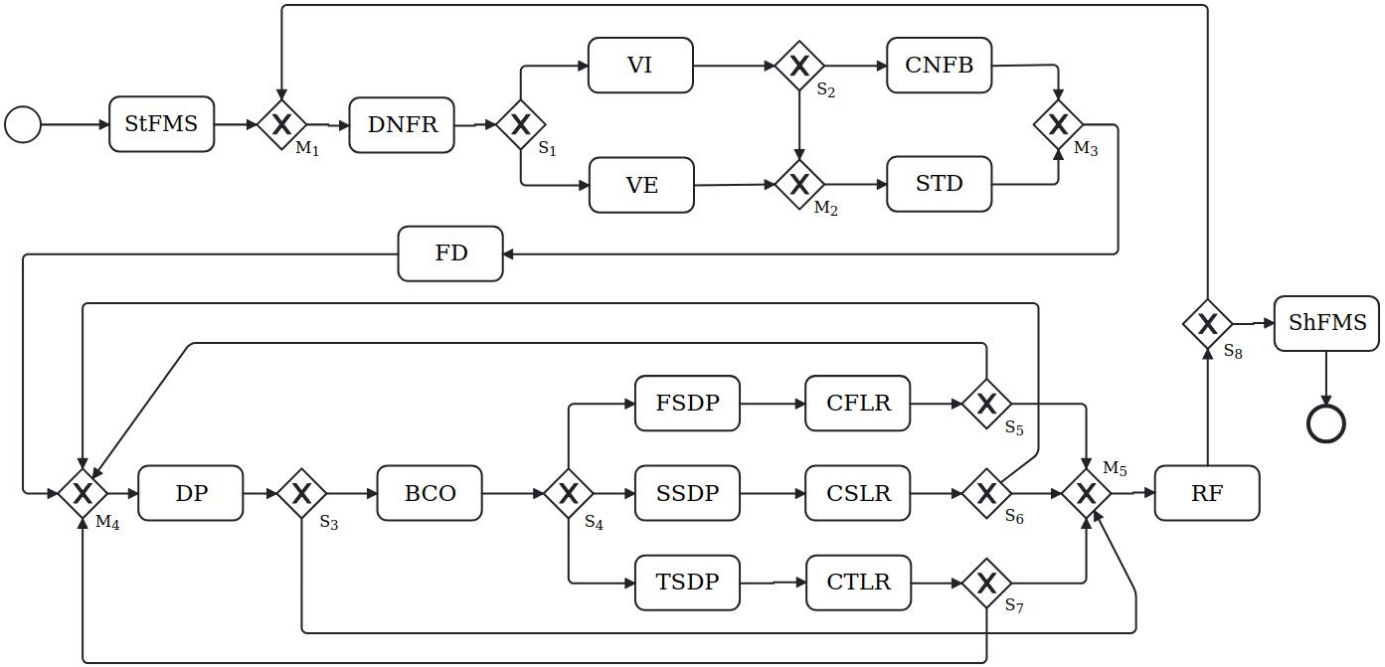

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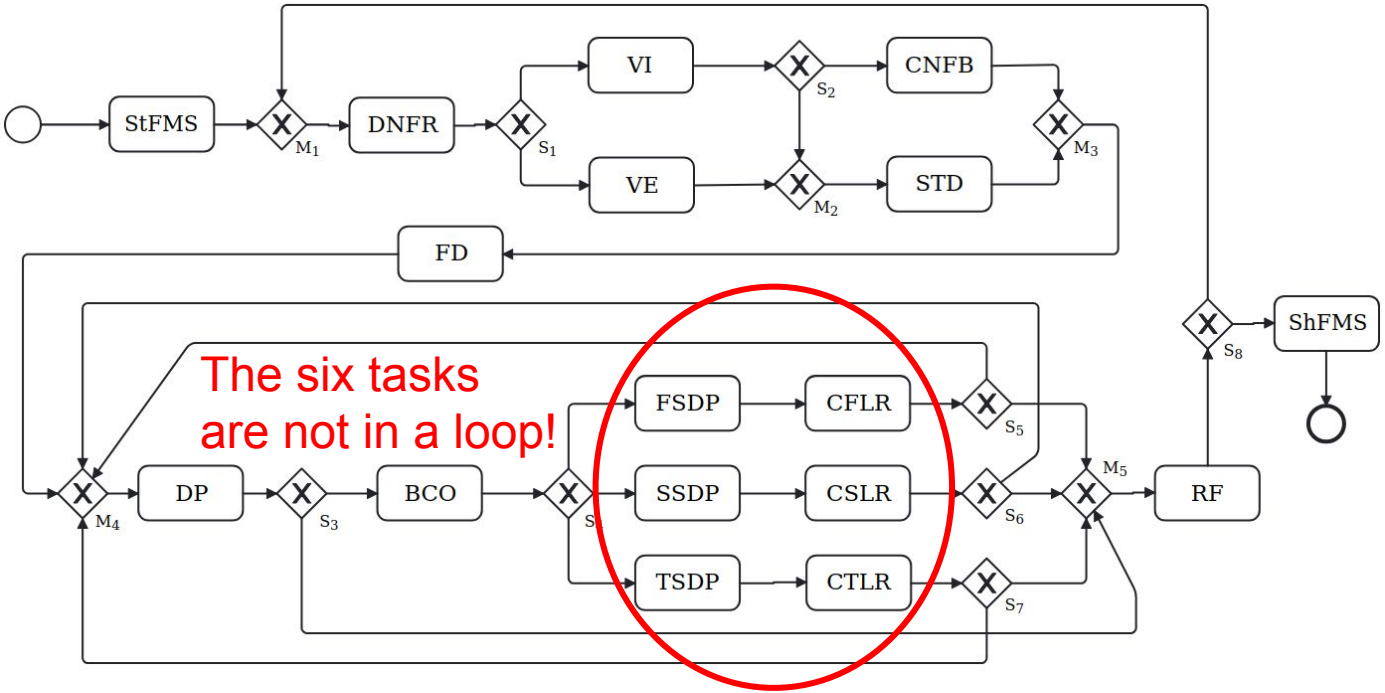

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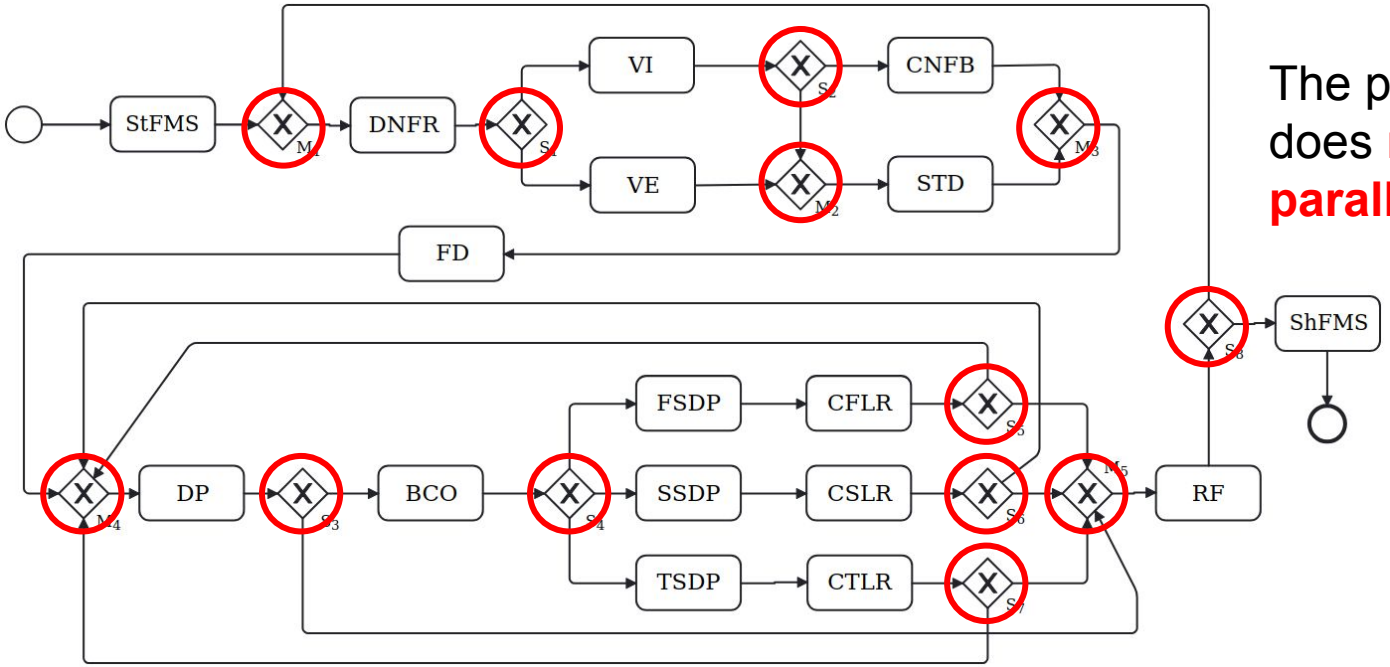

The process does **not contain parallelism**!

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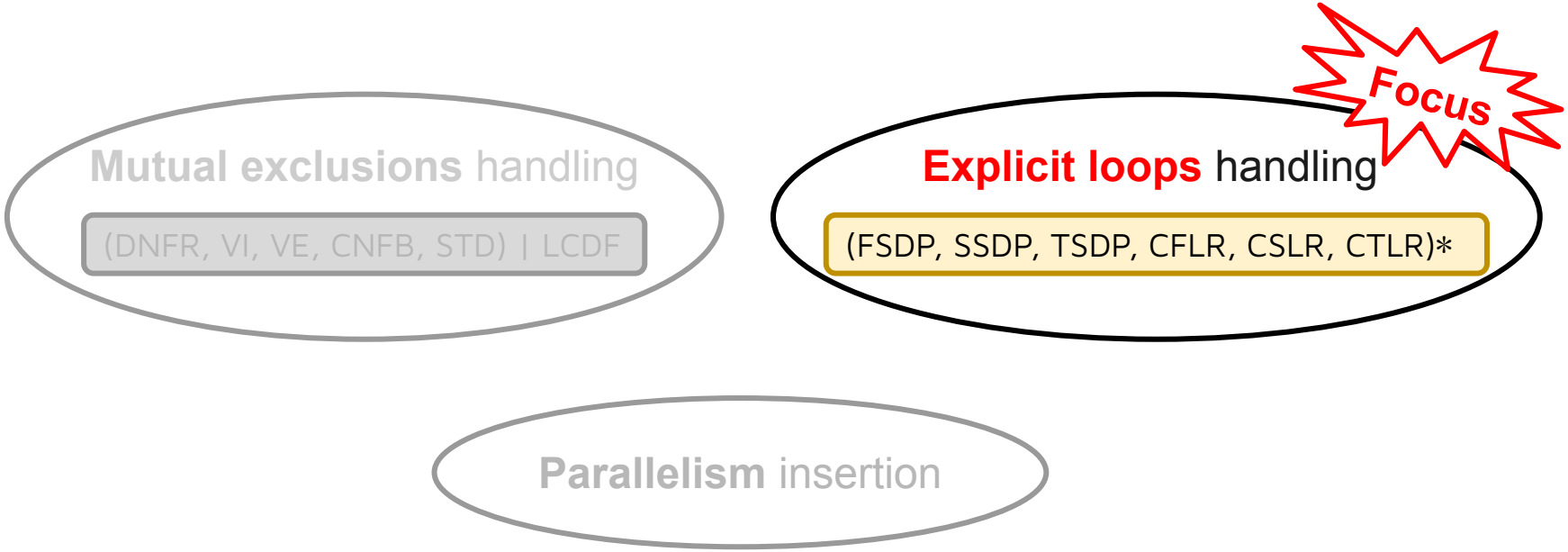

Detailed Approach – Step 7.2 – Explicit Loops

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Definition (Connected Graph)

Let $G = (V, E, \Sigma)$ be a graph. G is said to be *connected* if and only if for all $(v_1, v_2) \in V^2$, there exists a path p of G such that $v_1 \in p \ \wedge \ v_2 \in p$.

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Definition (Strongly Connected Component)

Let $G = (V, E, \Sigma)$ be a graph. A *strongly connected component (SCC)* of G is a component $G_S = (V_S, E_S, \Sigma_S)$ of G such that for all $(v_1, v_2) \in V_S^2$, v_1 can reach v_2.

Our proposal thus consists in modifying the **graph restricted to the tasks of the loop** to make it become a **strongly connected component**.

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We define **the restriction of a graph** to a subset of its vertices as follows.

Definition (Graph Restriction)

Let $G = (V, E, \Sigma)$ be a graph. The *restriction* of G to the subset $\{v_1, ..., v_n\} \subseteq V$ of its vertices is defined as $G \restriction_{\{v_1,...,v_n\}} \stackrel{\text{def}}{=} (V\restriction, E\restriction, \Sigma\restriction)$ where:

- $V\restriction = \{v_1, ..., v_n\} \subseteq V$;
- $E\restriction = \{v \to v' \in E \mid v, v' \in V\restriction\}$;
- $\Sigma\restriction = \{l \in \Sigma \mid \exists v\restriction \in V\restriction \ s.t. \ \sigma(v\restriction) = l\}$.

Detailed Approach – Step 7.2 – Explicit Loops

Given our BPMN process, its restriction to the tasks belonging to expression

(FSDP, SSDP, TSDP, CFLR, CSLR, CTLR)*

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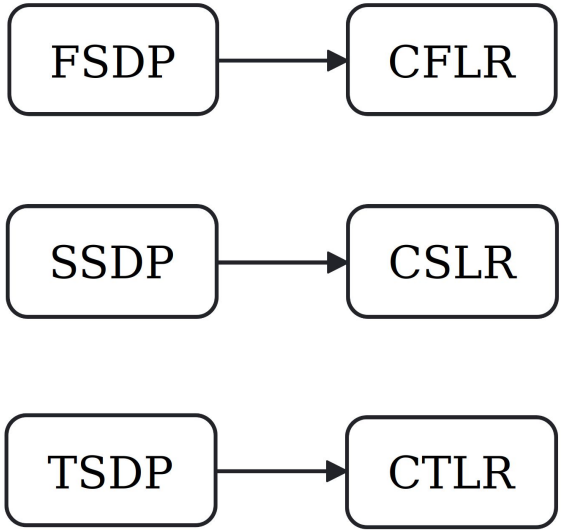

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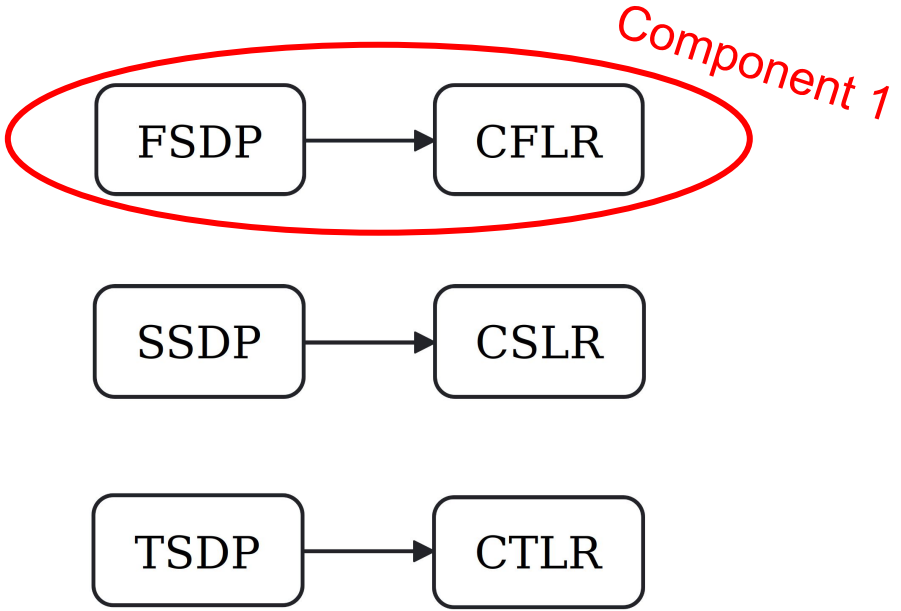

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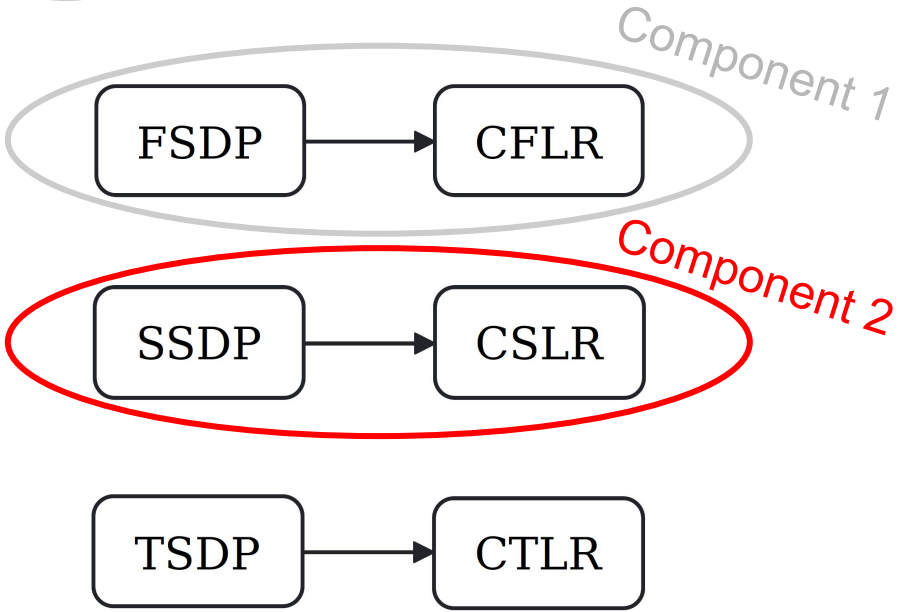

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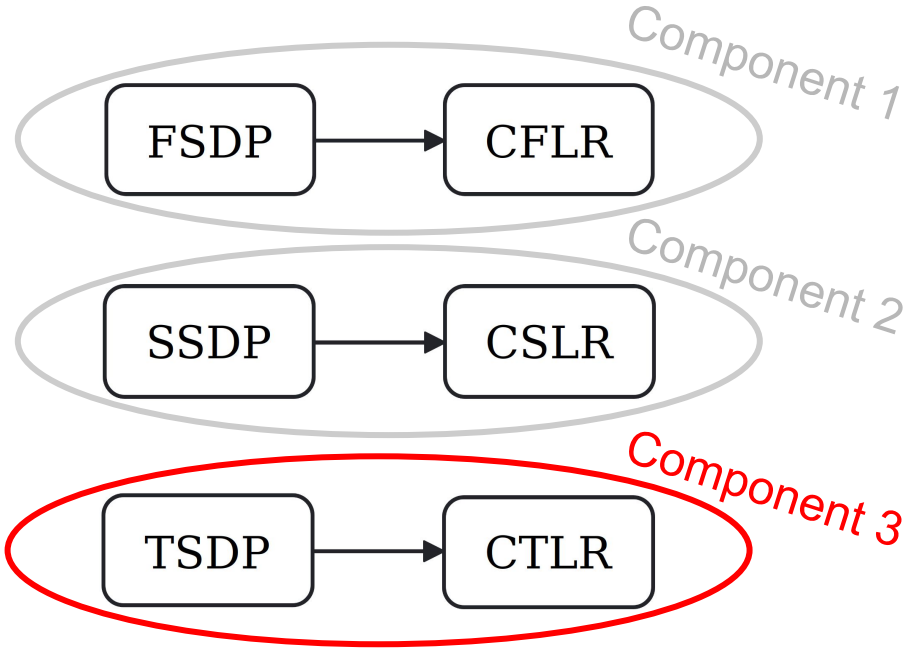

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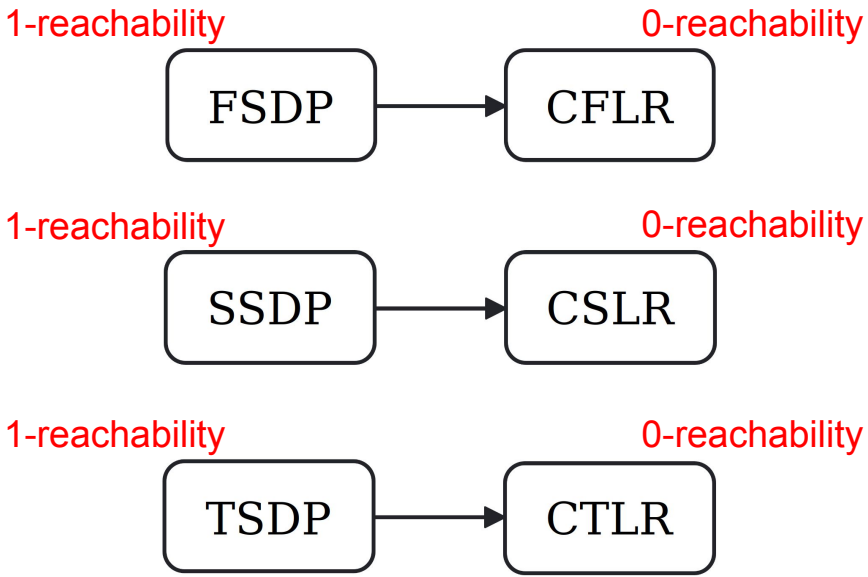

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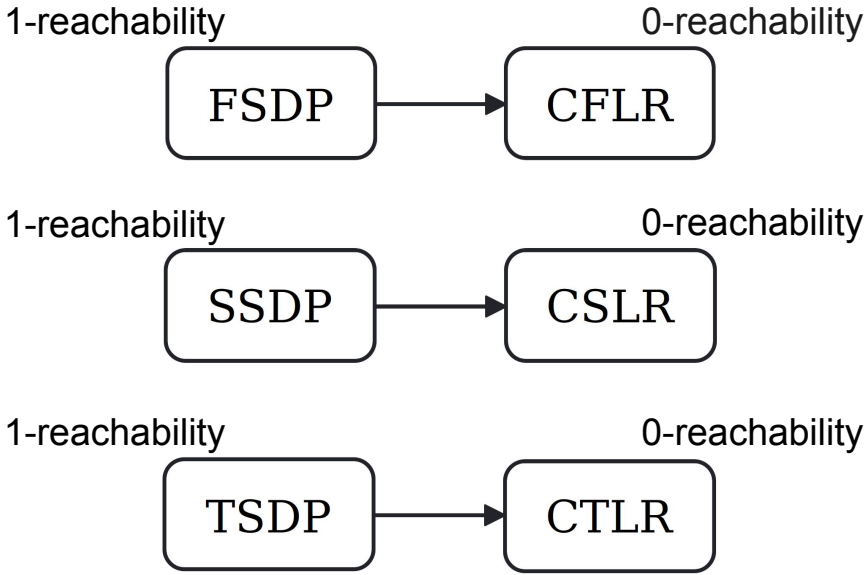

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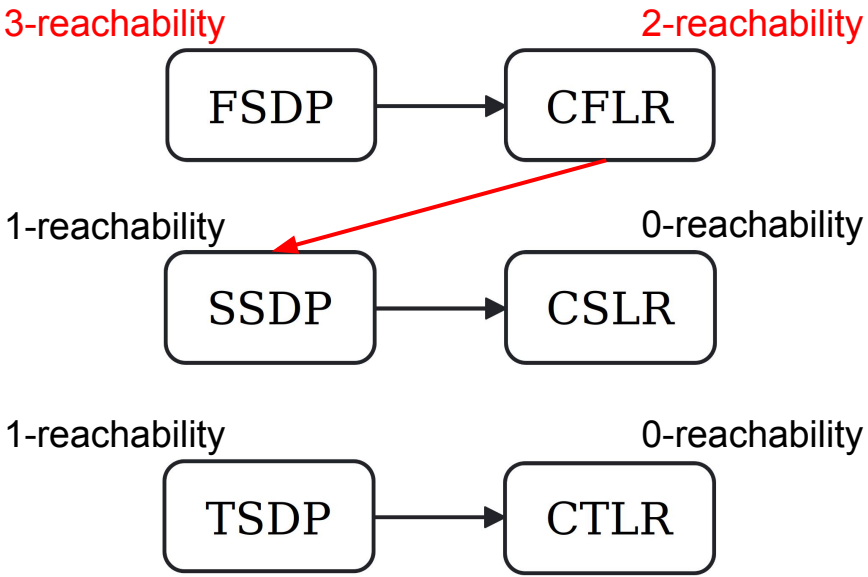

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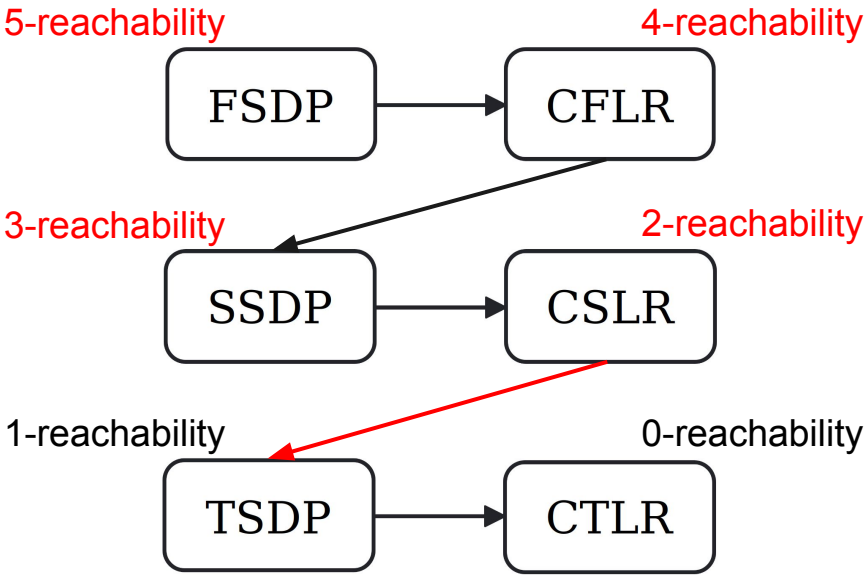

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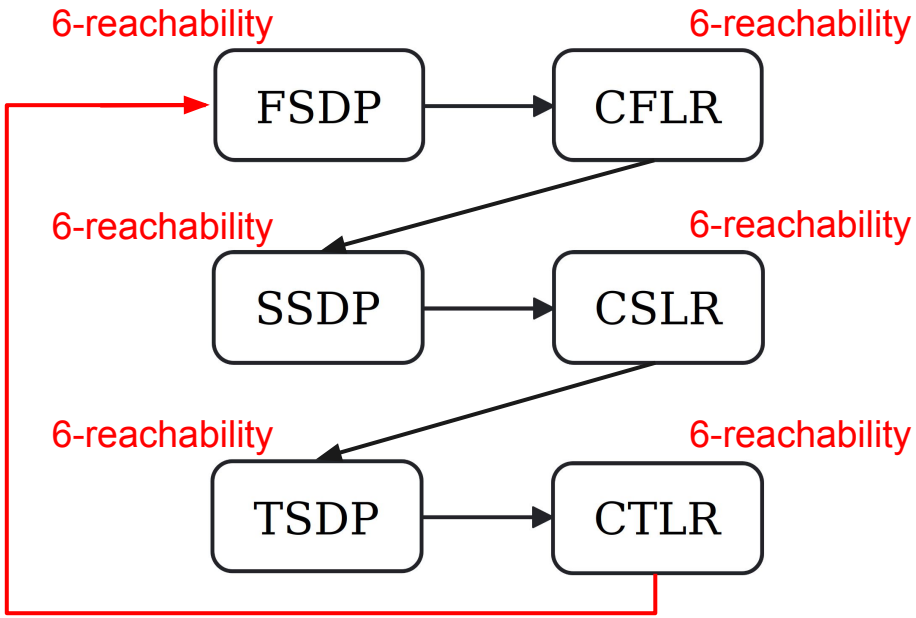

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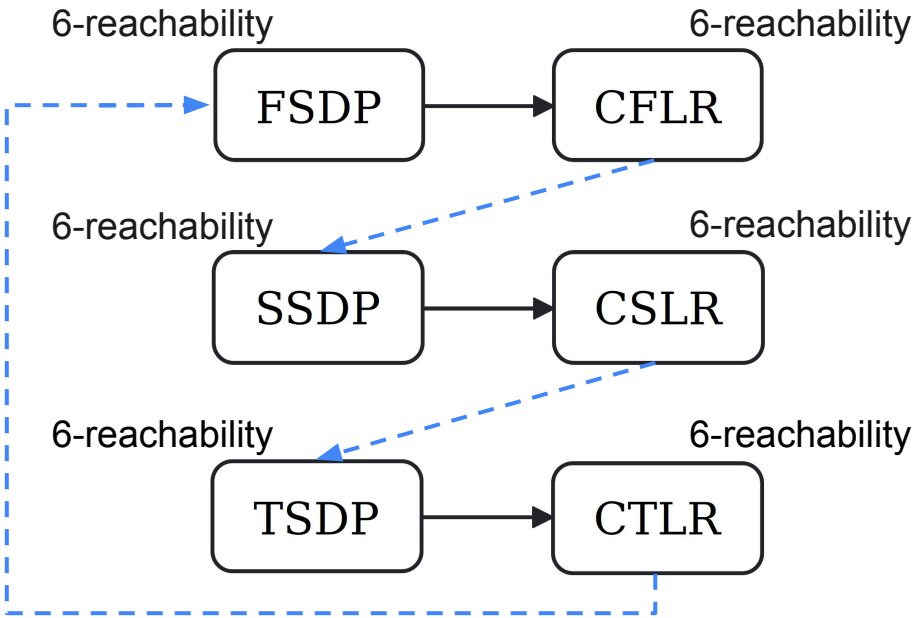
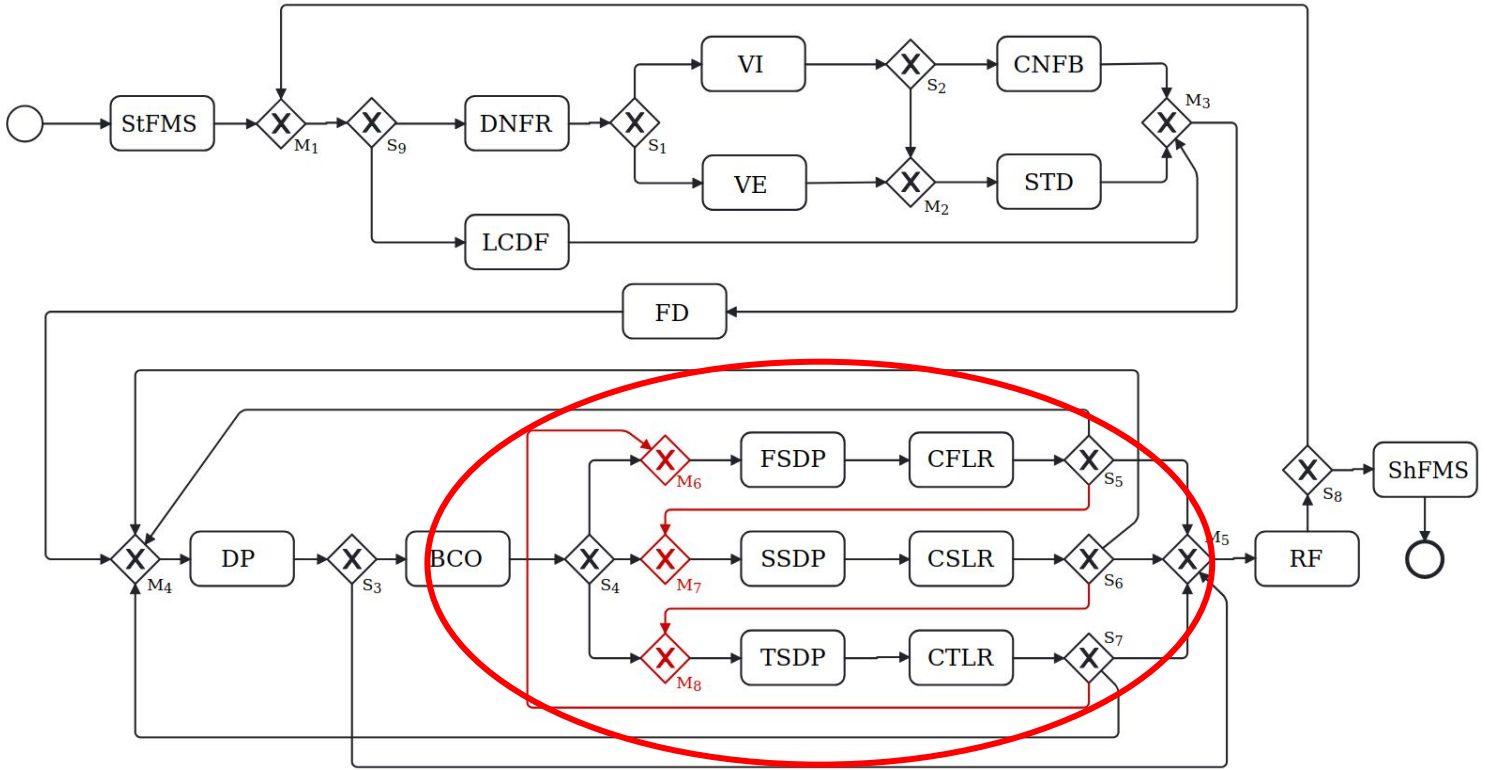
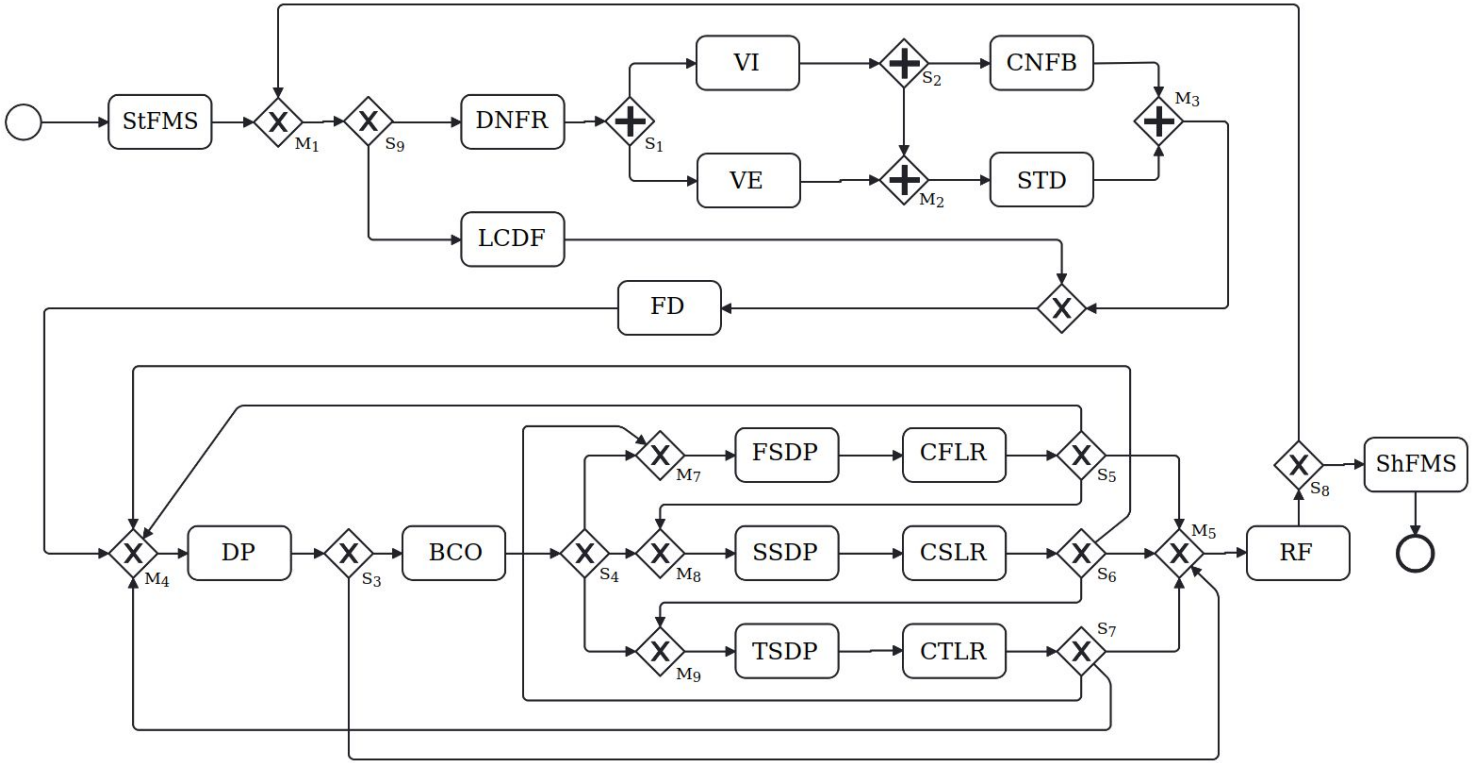


These **new edges** are then eventually **added to the BPMN** process to make the loop appear in it:



Detailed Approach – Final Process

After applying these successive refinement steps, the **process is complete**.



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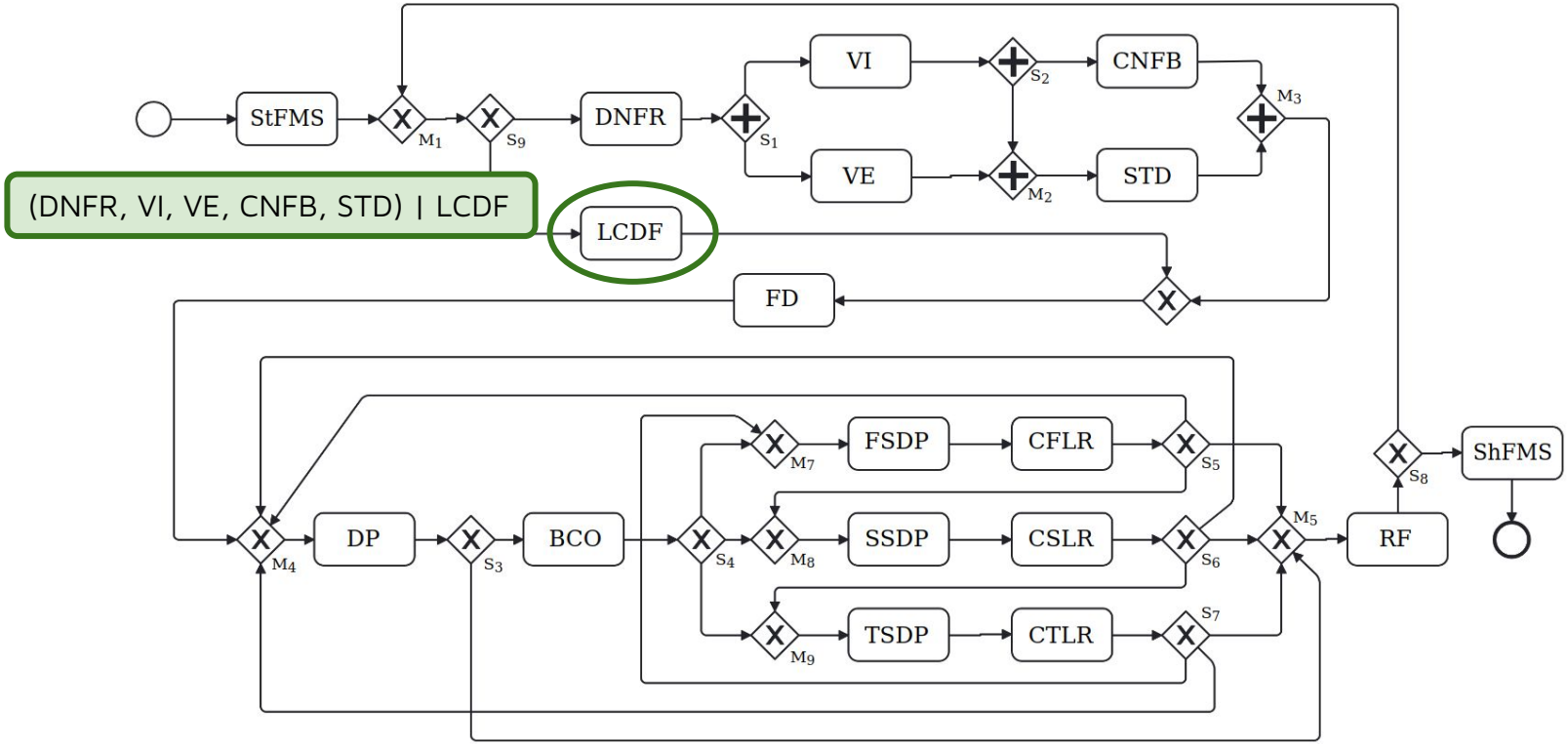

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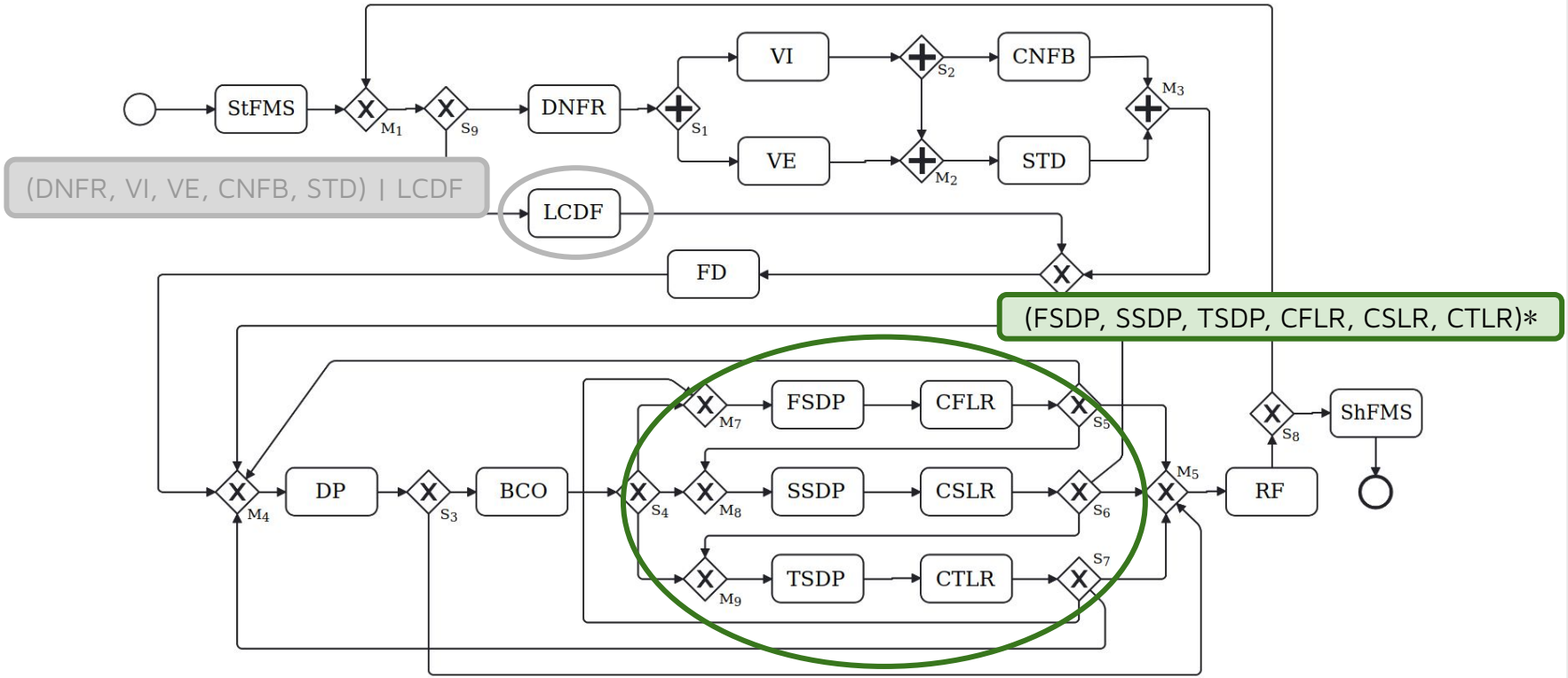

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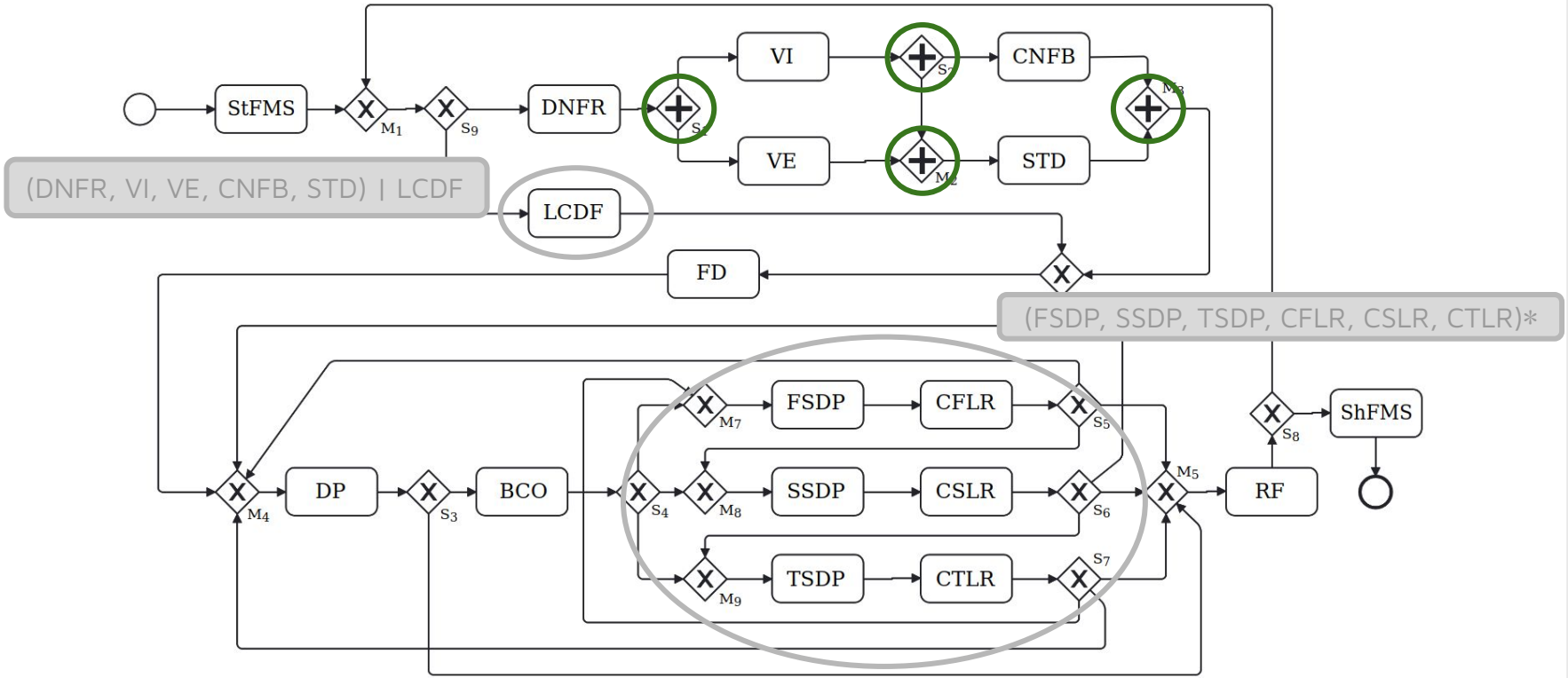

Theorem (Constraints Preservation)

Let $B = (V, E, \Sigma)$ be the BPMN process built from the sequential constraints Cons_1 and enriched with exclusive gateways and start/end events, and let Cons_2, Cons_3, and Cons_4 be the sets of constraints respectively satisfied by G after managing mutual exclusions, managing explicit loops, and inserting parallelism. We state that $(\emptyset \subseteq)\mathrm{Cons}_1 \subseteq \mathrm{Cons}_2 \subseteq \mathrm{Cons}_3 \subseteq \mathrm{Cons}_4$.

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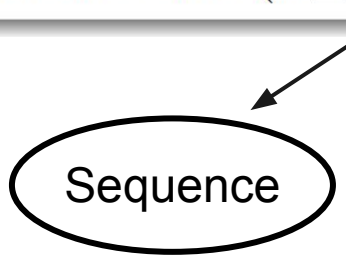

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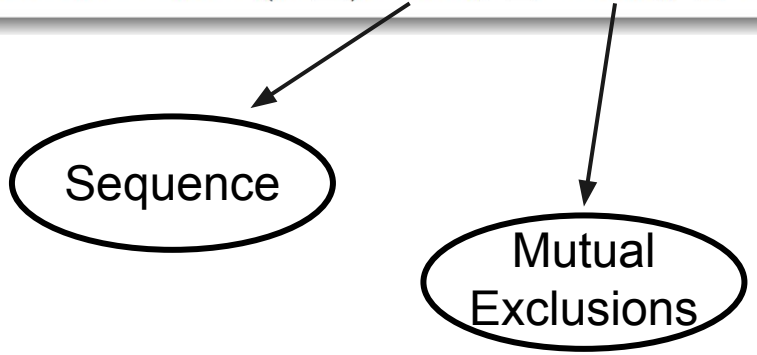

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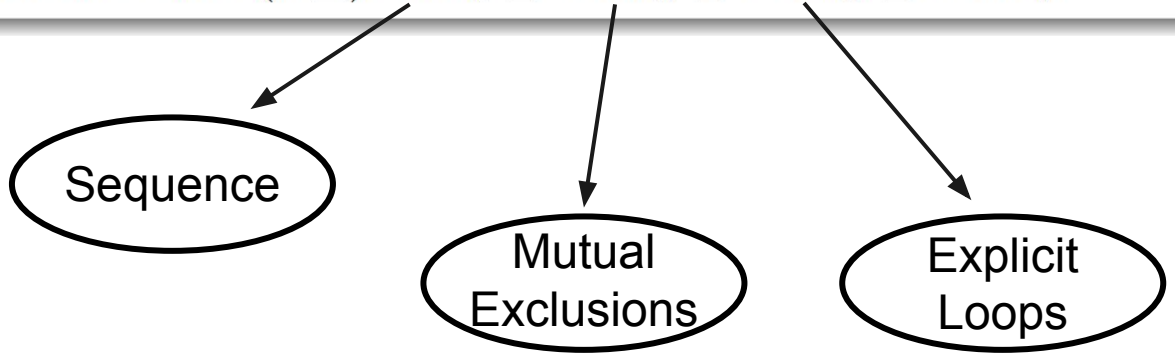

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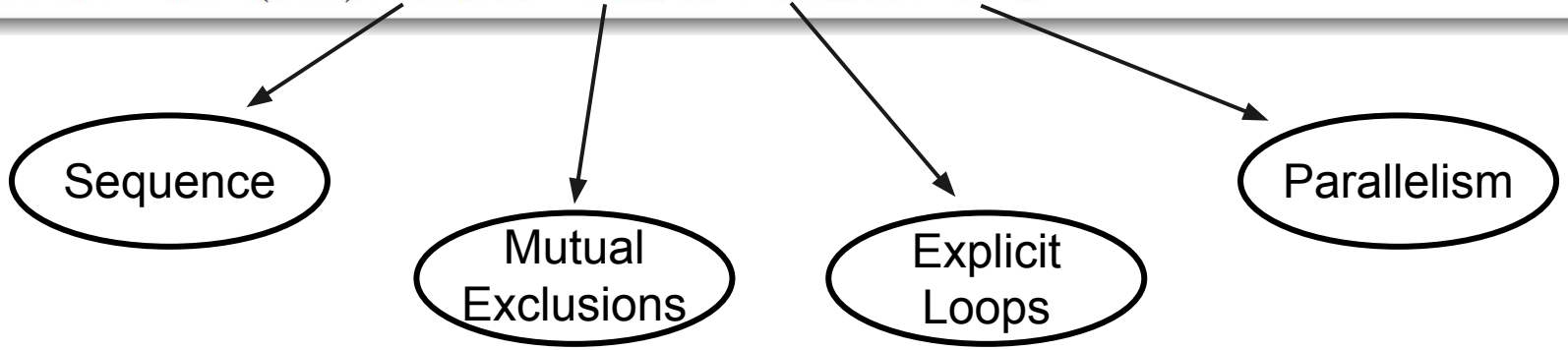
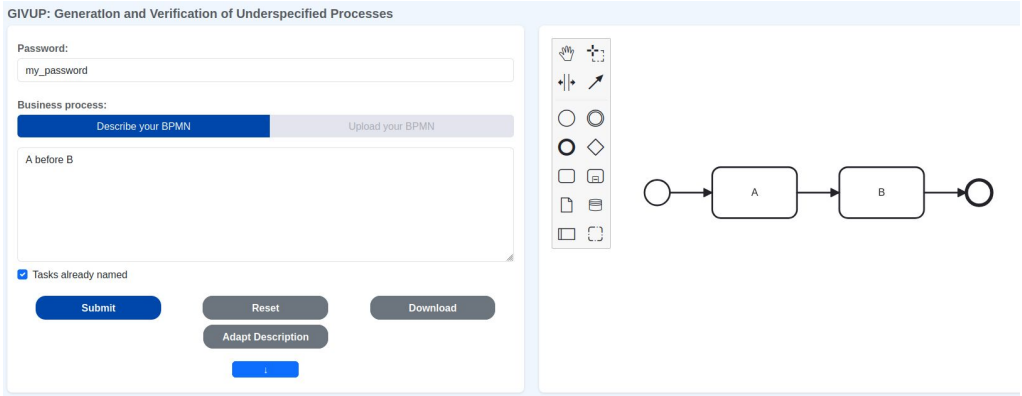
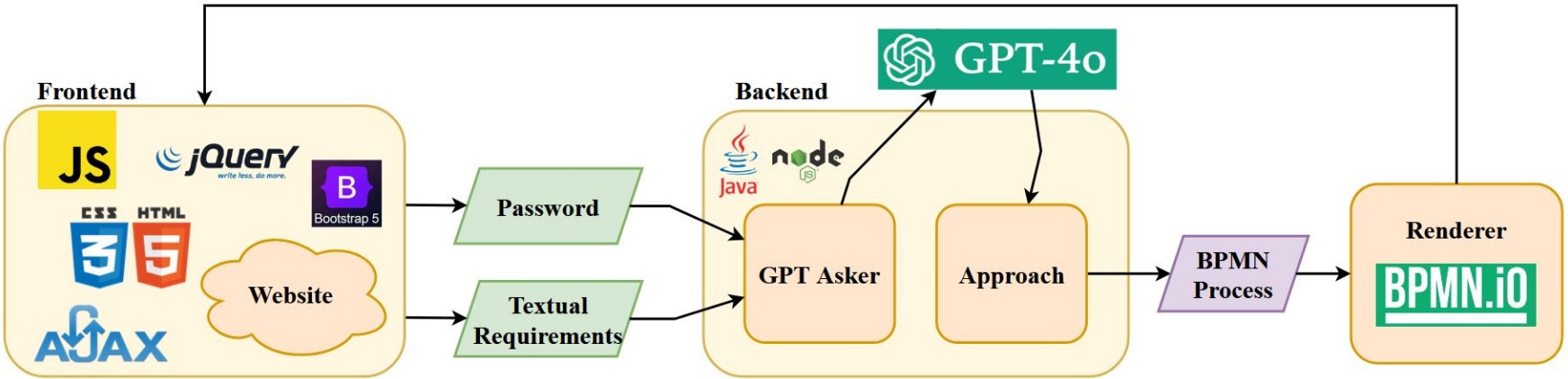


Tool Support

- **12k lines of Java** code
- **Tool** available **online** (https://lig-givup.imag.fr/)





Experiments – Quality of the Generated Process

Experiments were conducted on **200 examples**, **25%** coming from the **PET dataset** and the **literature**, and **75% handcrafted**.

Tool/Model	✓	?	✗	Avg. Ex. Time
Our tool	**83%**	9.8%	**7.2%**	**7.21s**
NaLa2BPMN	32.8%	8.9%	58.3%	68.7s
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An **ambiguous process** is a process that is **not incorrect** with regards to the description, but which **does not correspond to the expectations** of the experts.

Plan

I/ Introduction

II/ Automated Generation of BPMN Processes from Textual Requirements

III/ Human-Centered Refactoring-Based Optimisation of BPMN Processes

IV/ Related Work

V/ Takeaways

VI/ References

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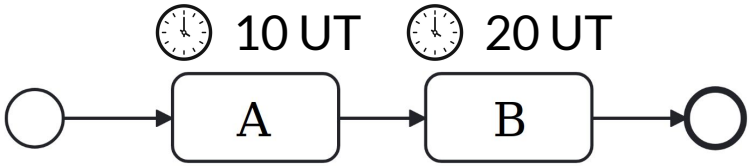

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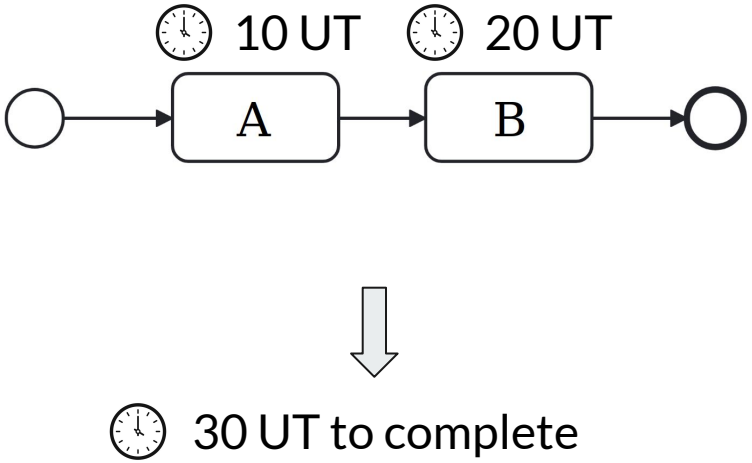

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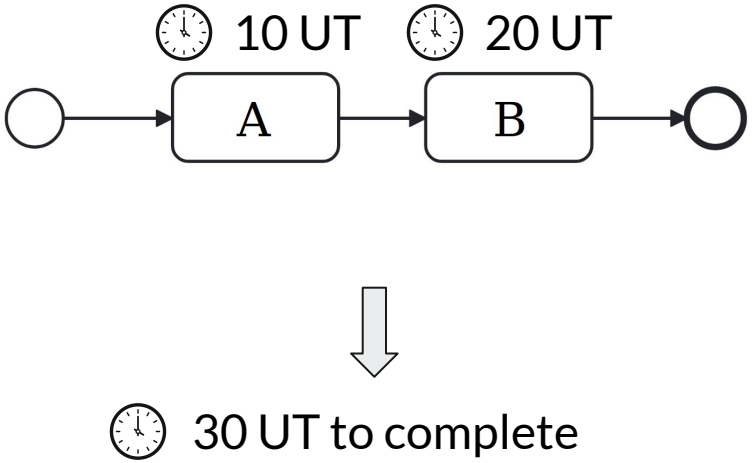

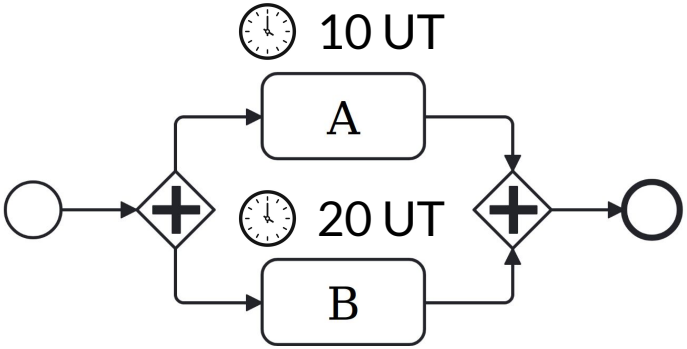

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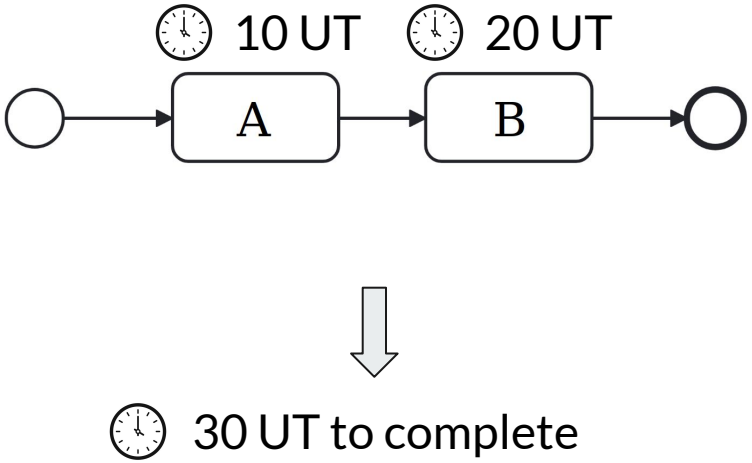

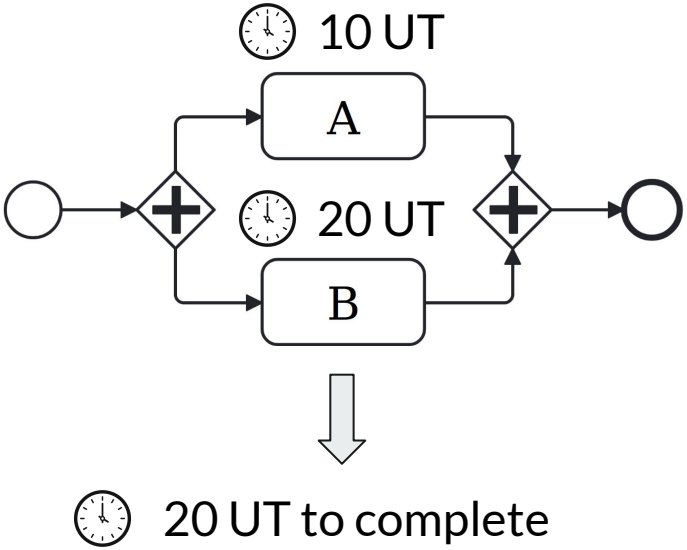

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A

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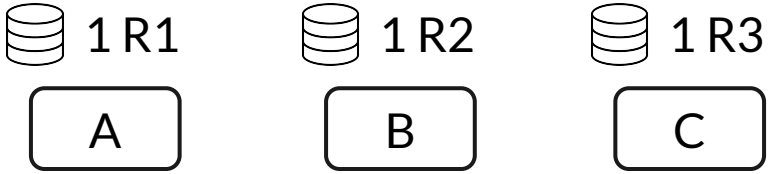

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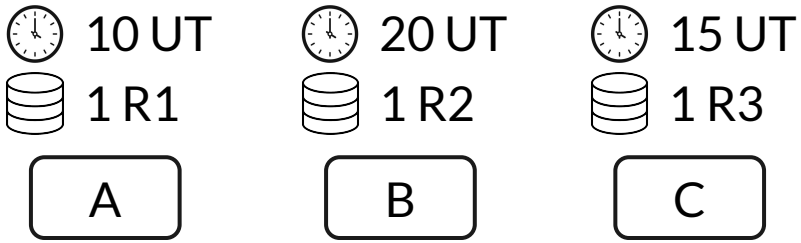

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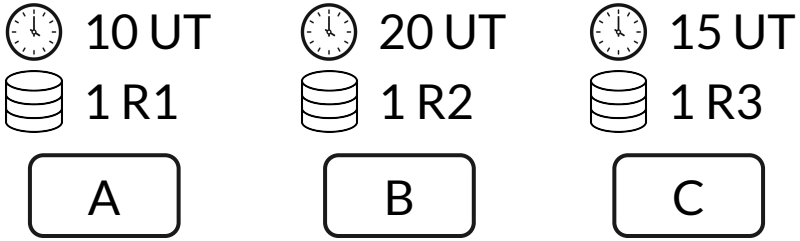

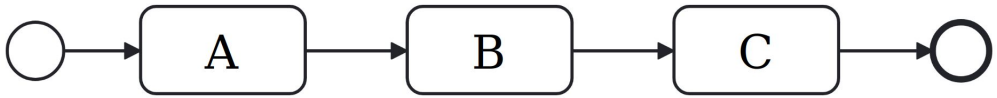

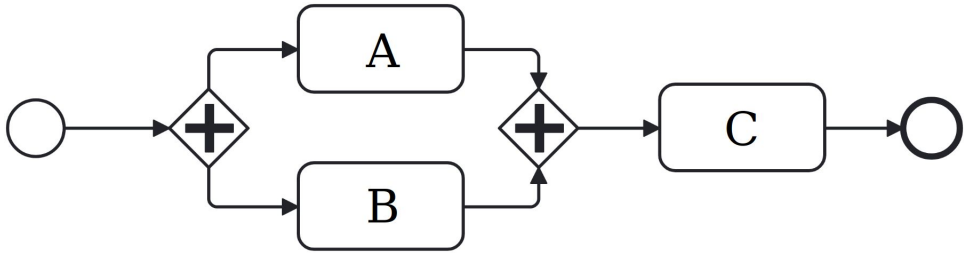

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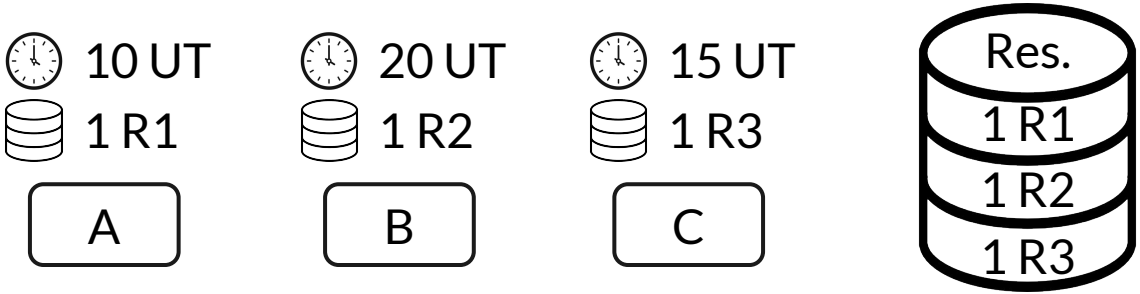

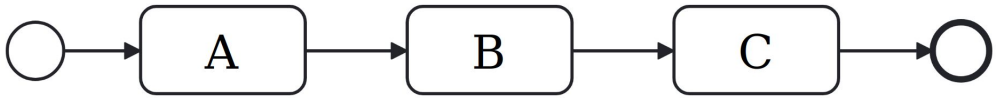

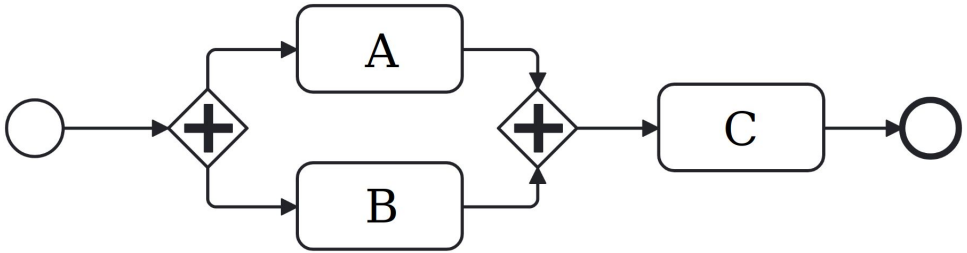

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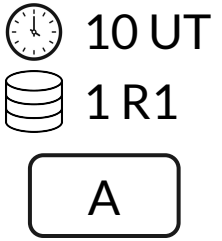

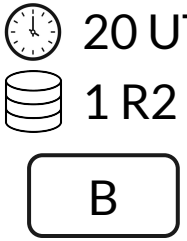

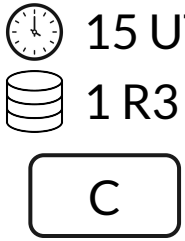

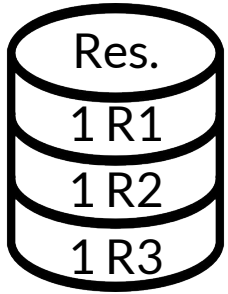

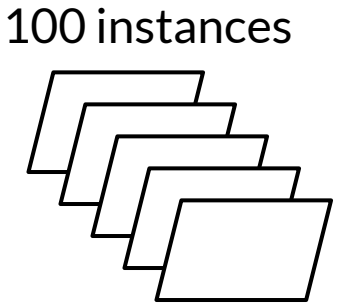

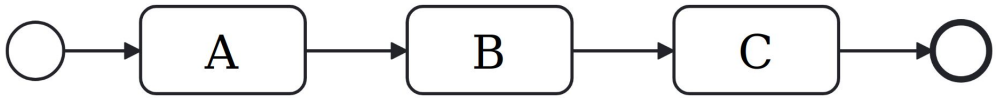

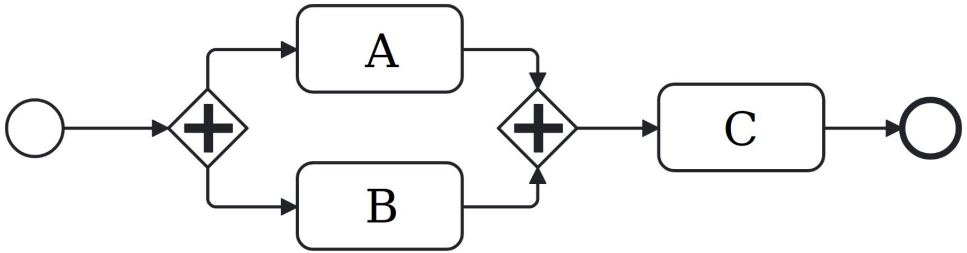

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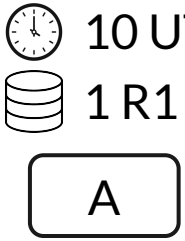
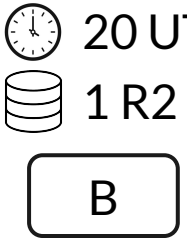
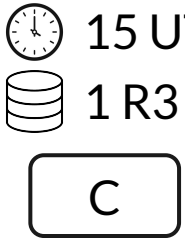
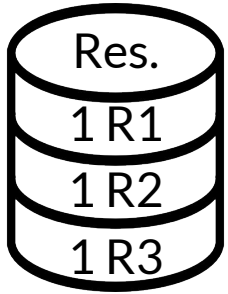
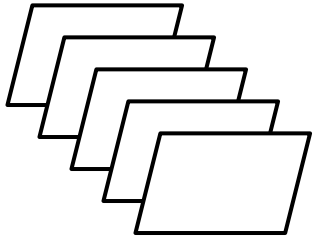


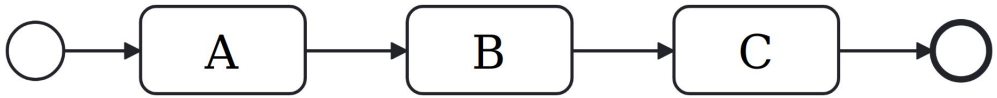






100 instances





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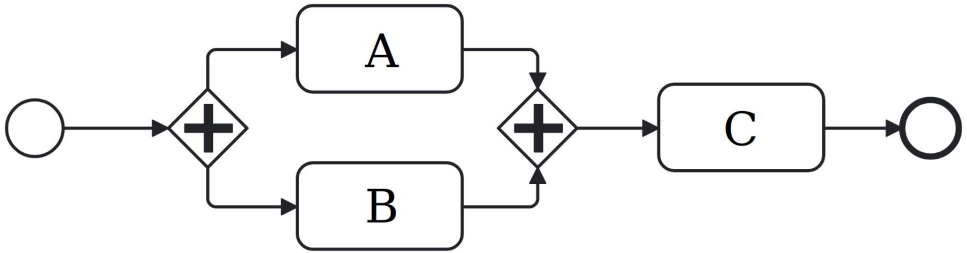

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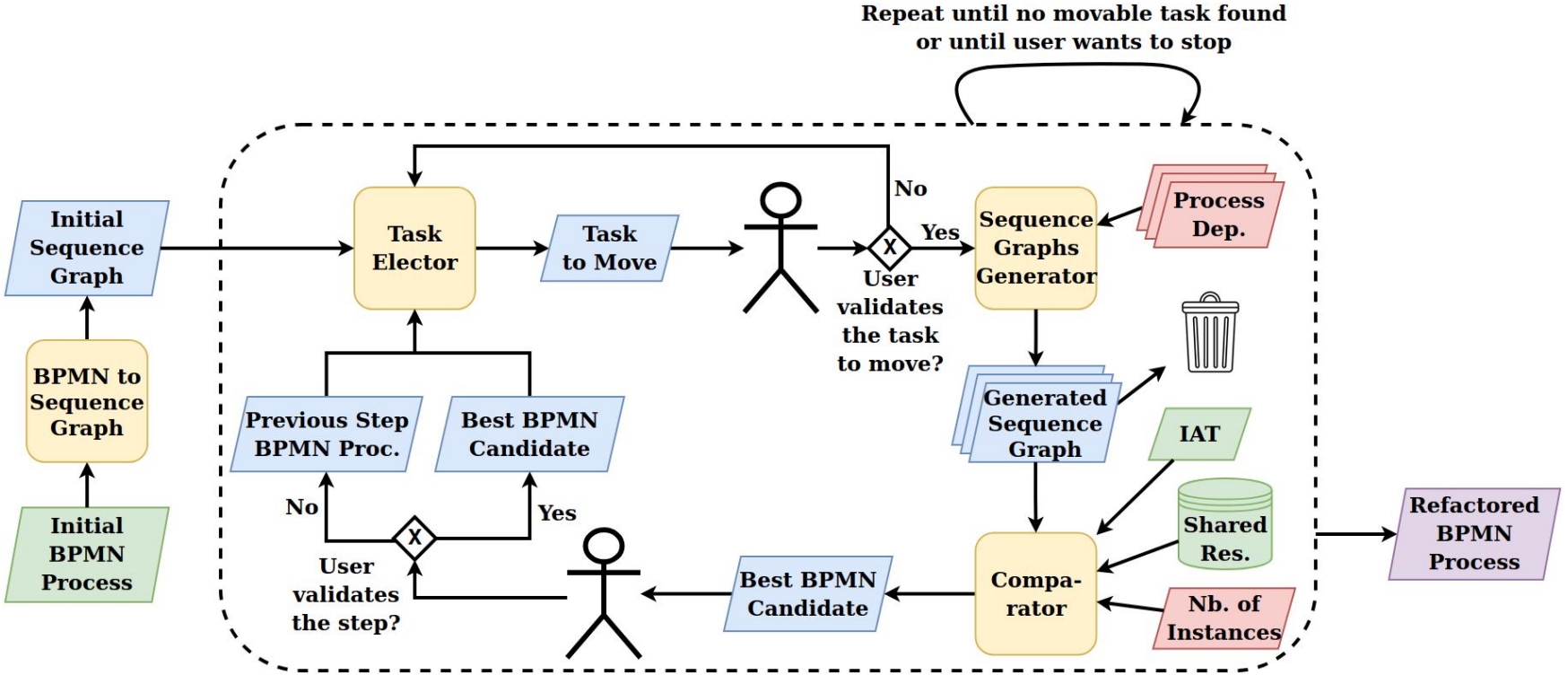
Global Picture of the Approach



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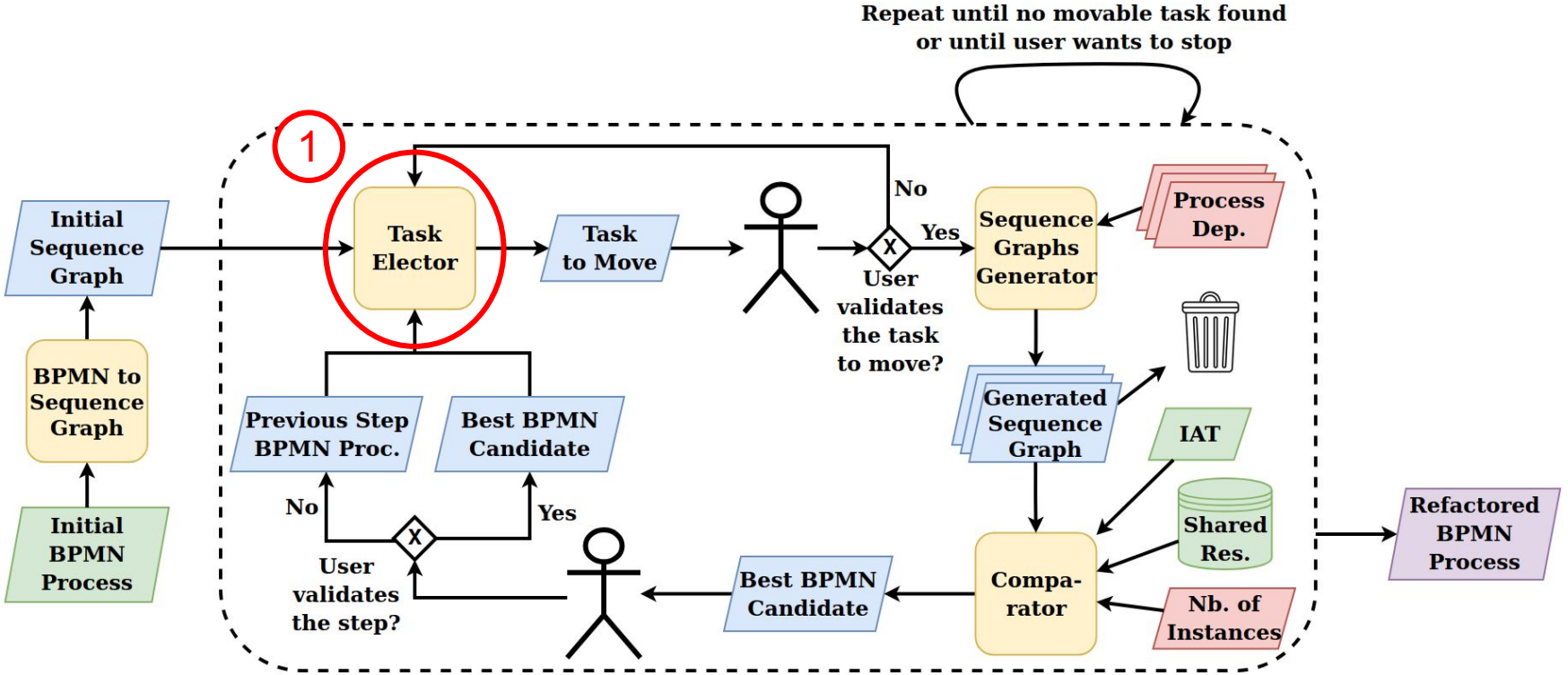

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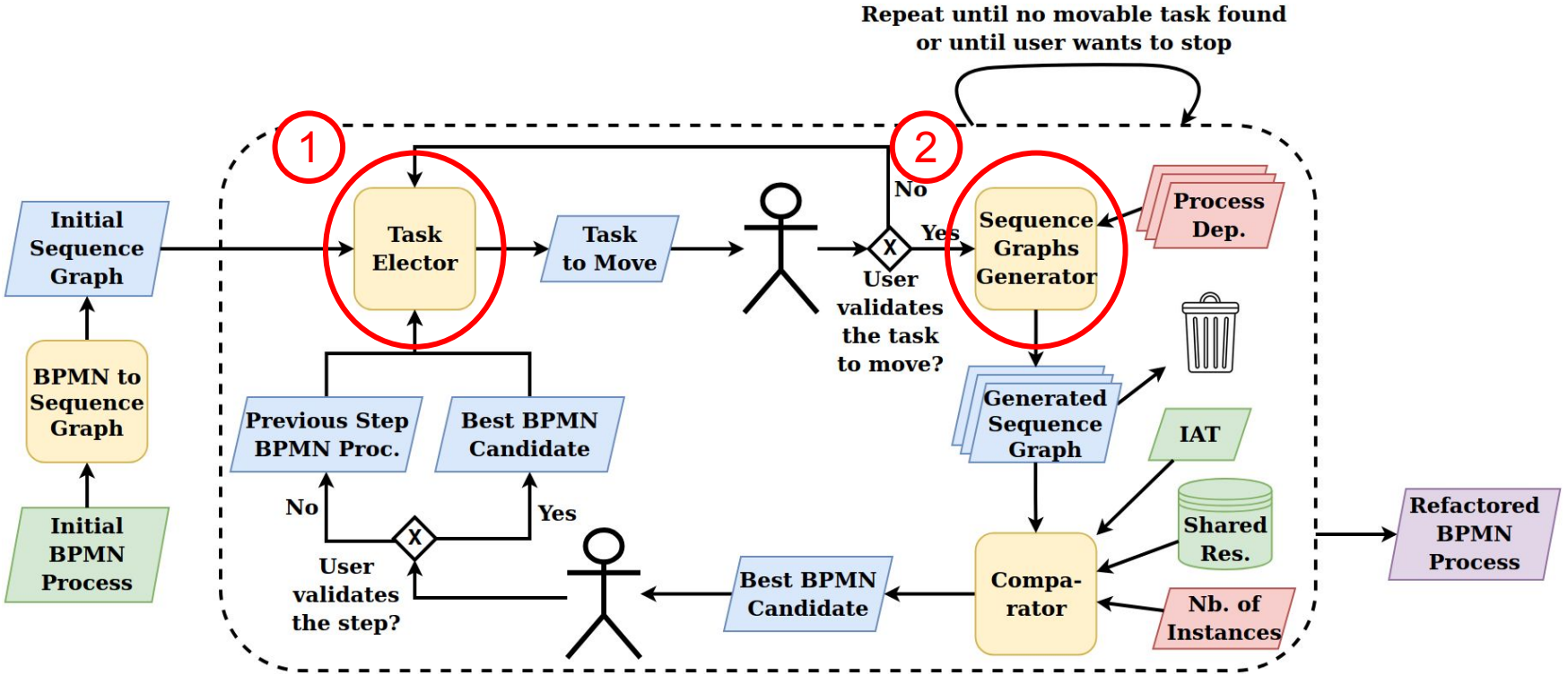

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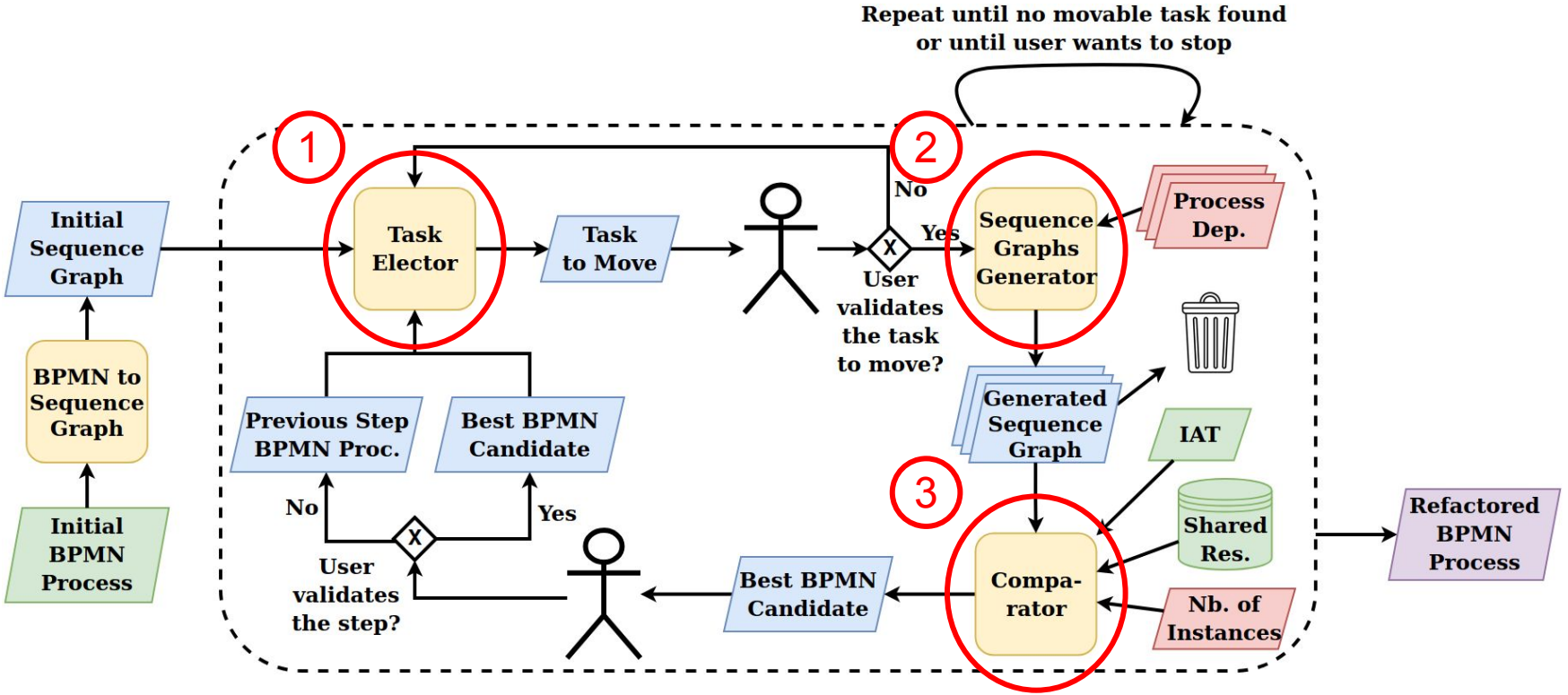

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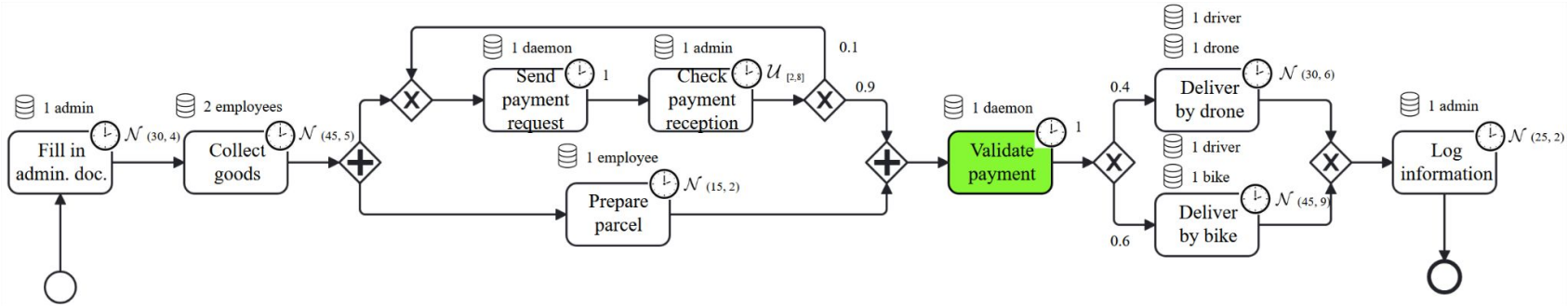
The **first step** consists in **proposing a task to move** to the user.



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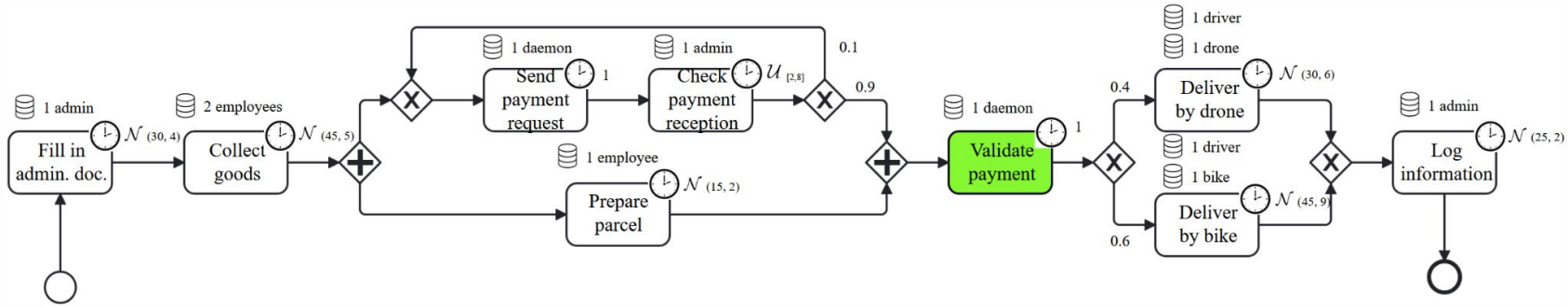

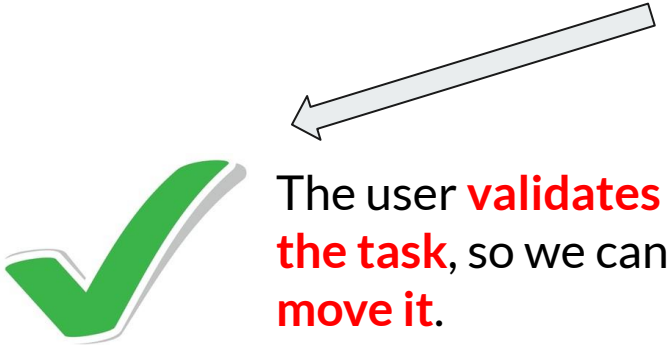

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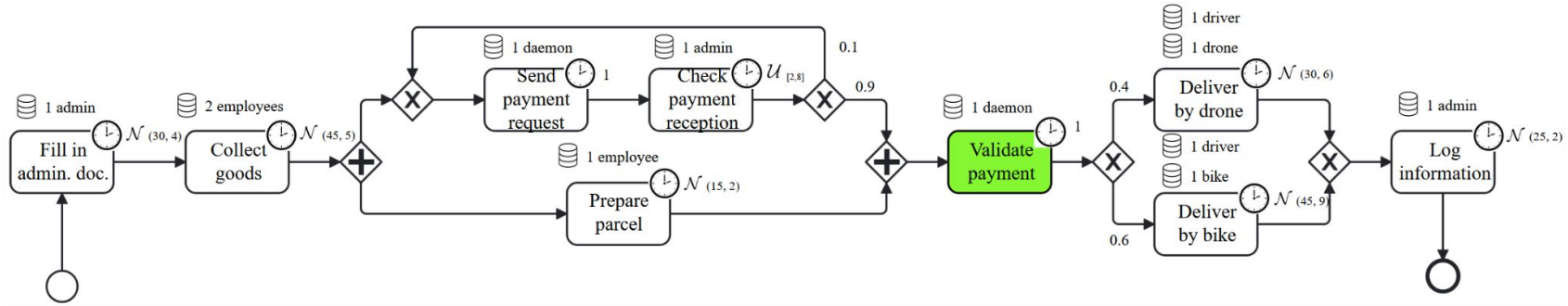

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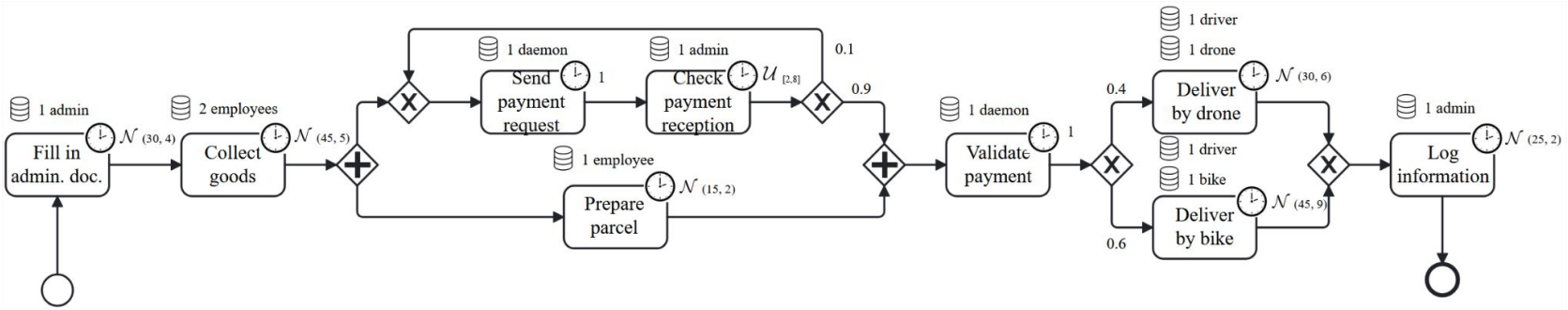

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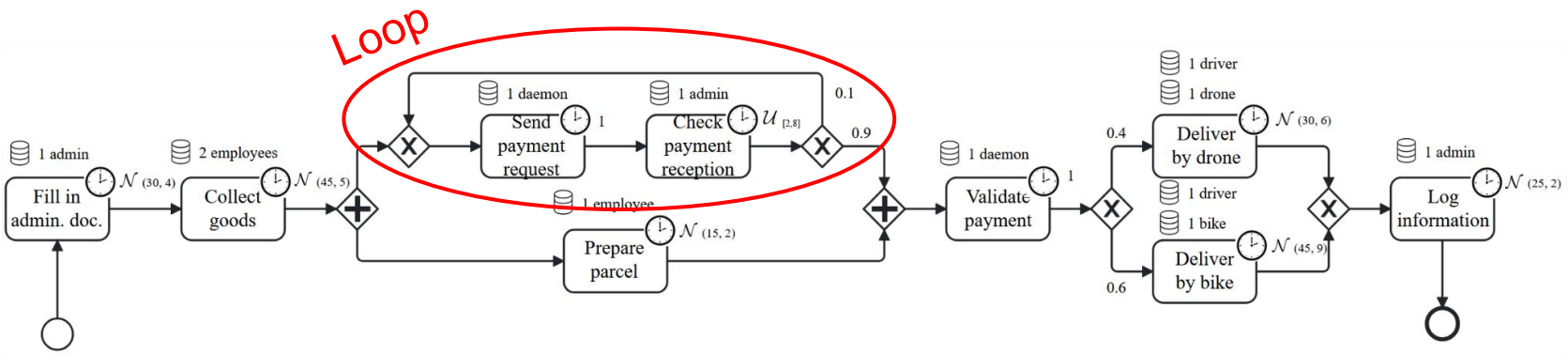

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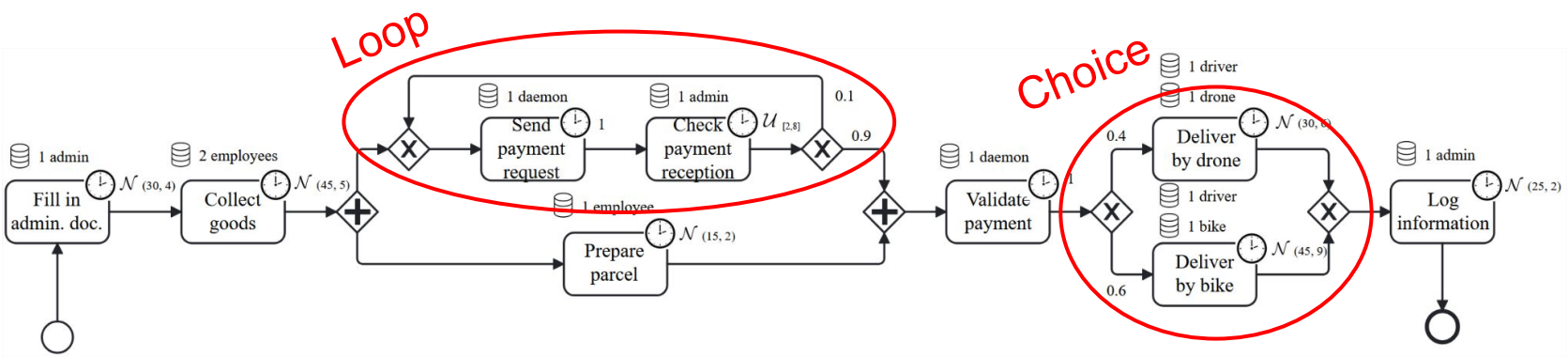

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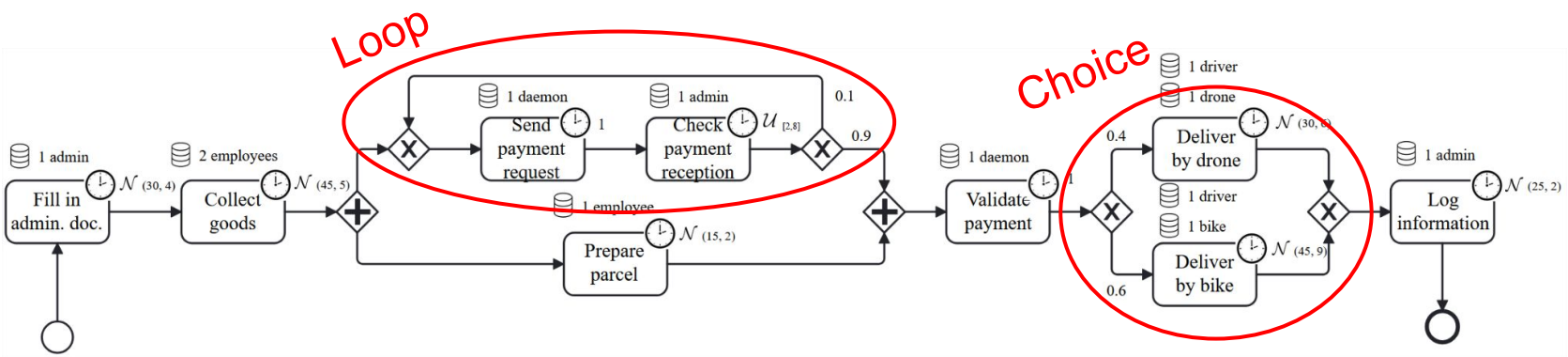
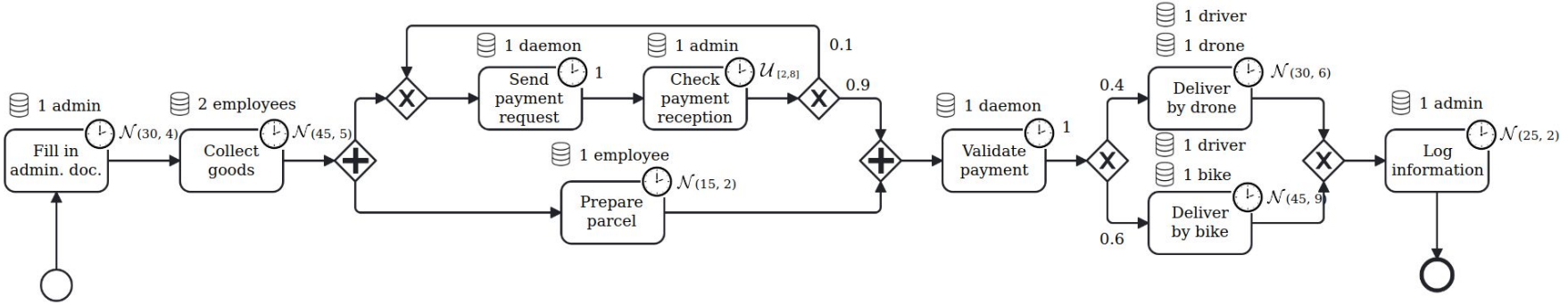
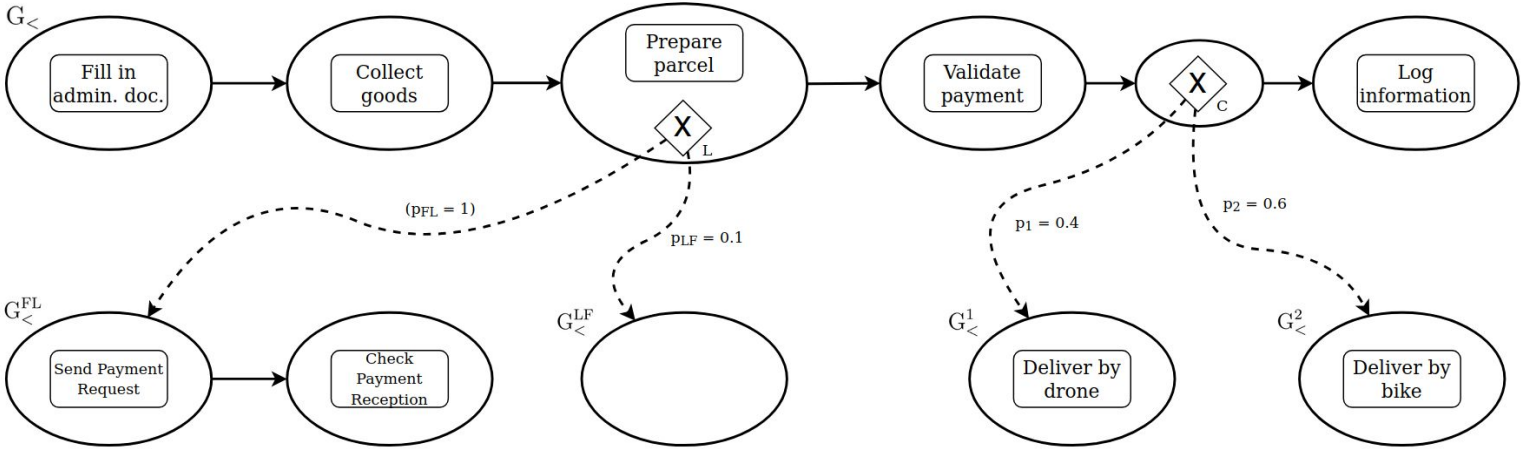


To **facilitate** this **preservation**, the relocation of the task is **not performed** on the **BPMN process**, **but on** another representation, called **sequence graph**.

Step 2 – BPMN to Sequence Graph





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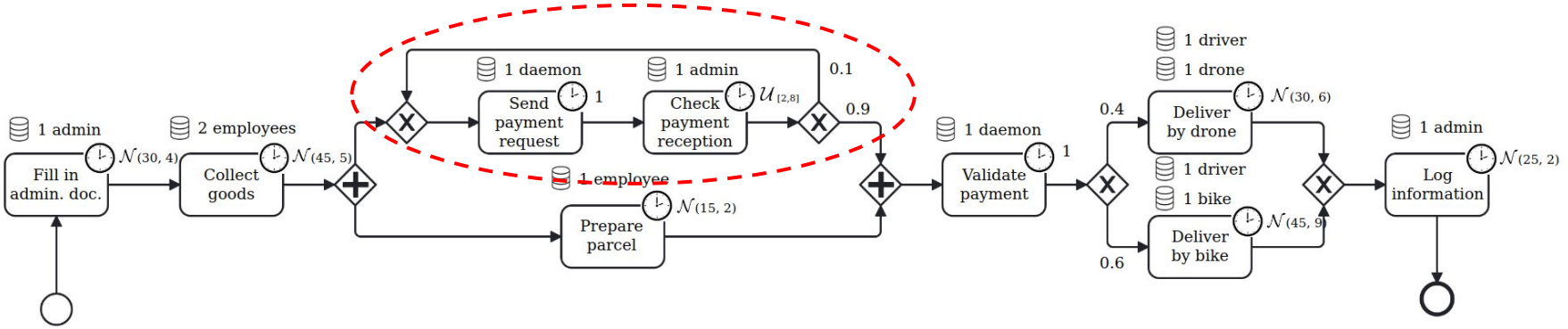

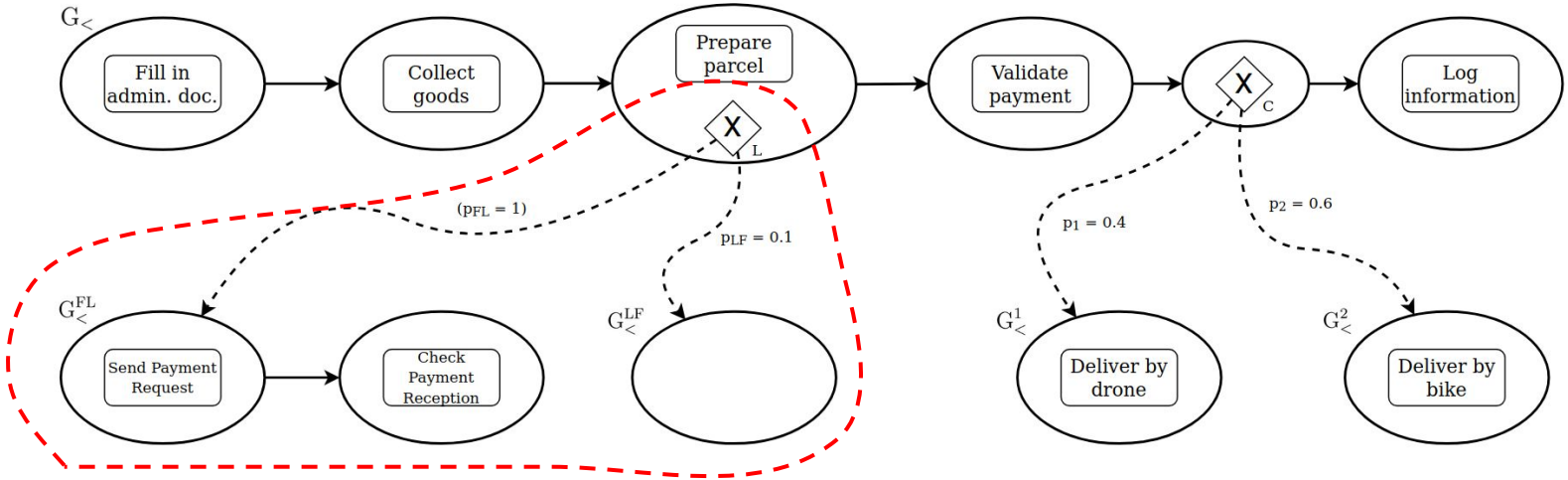

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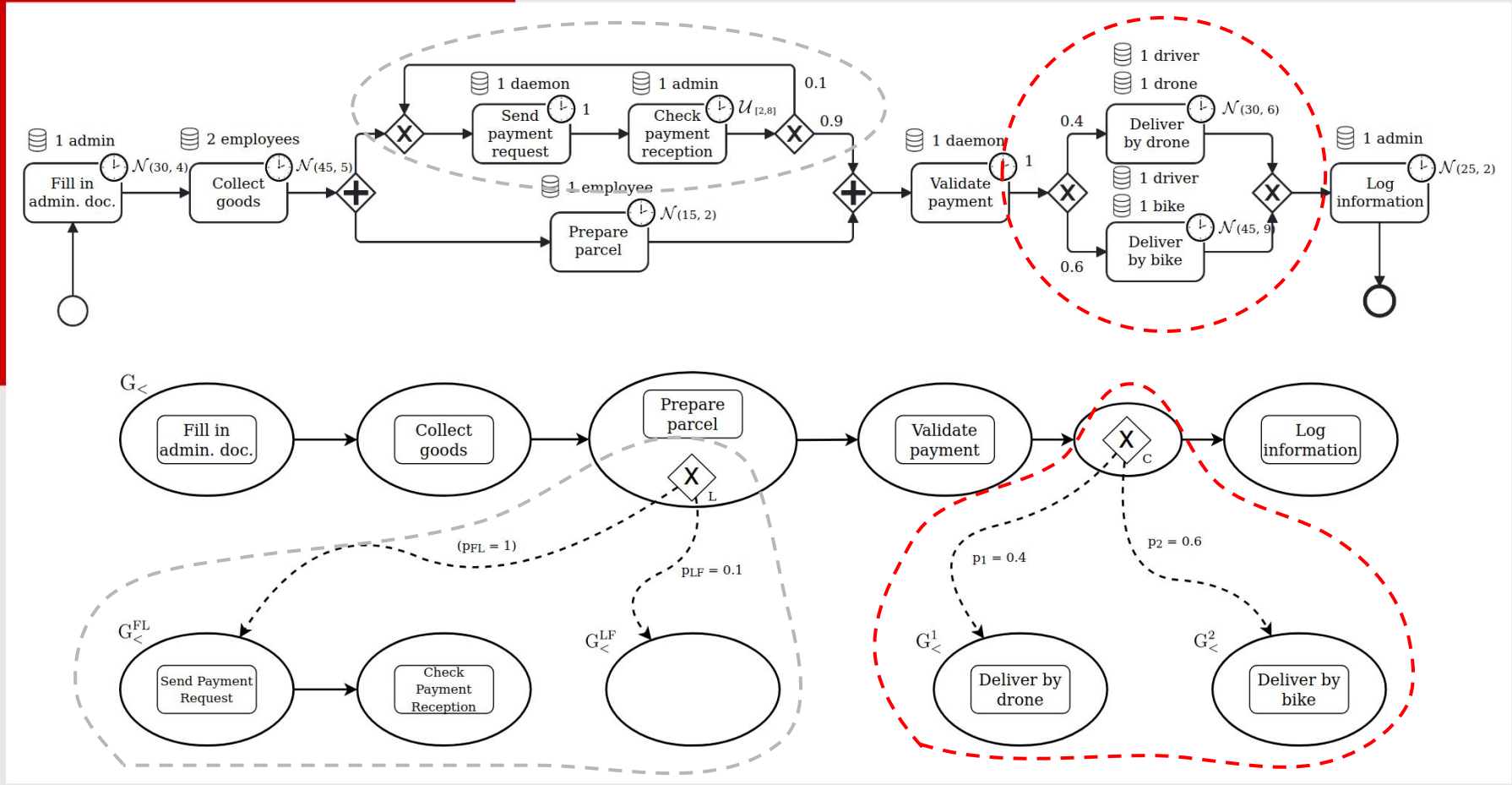

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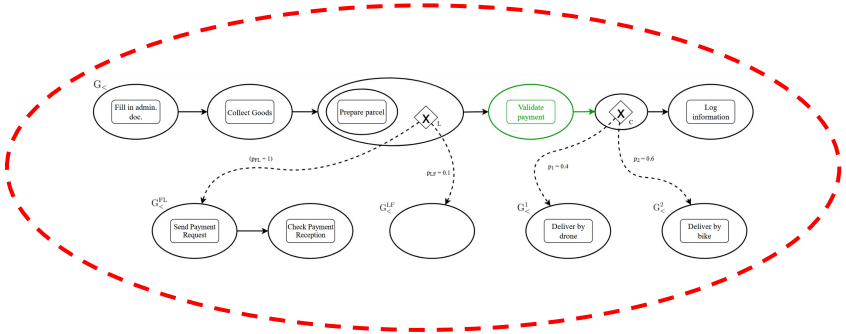
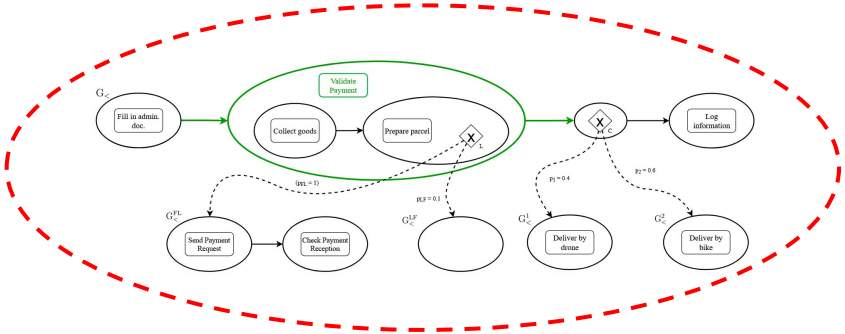
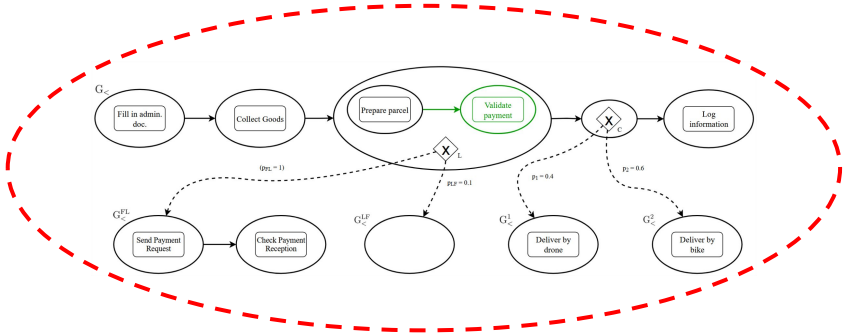


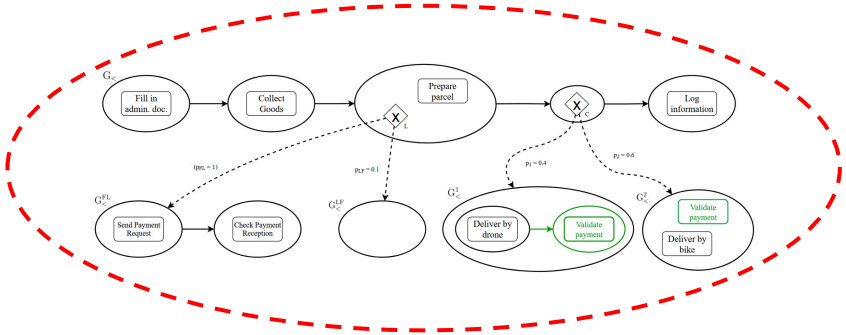
Task in Parallel of Sub-Sequences



Task Before/After Elements of a Node



Task Inside Choices



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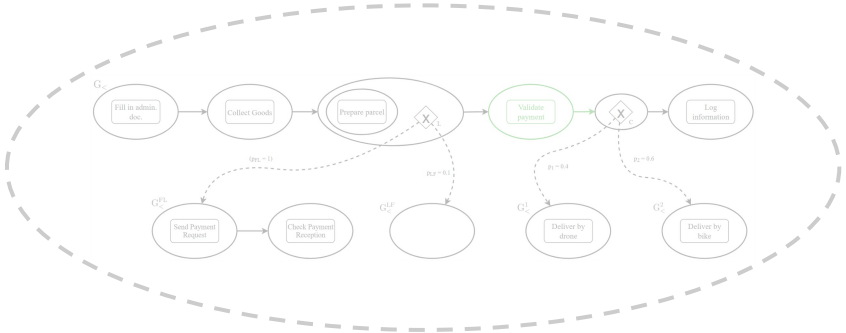

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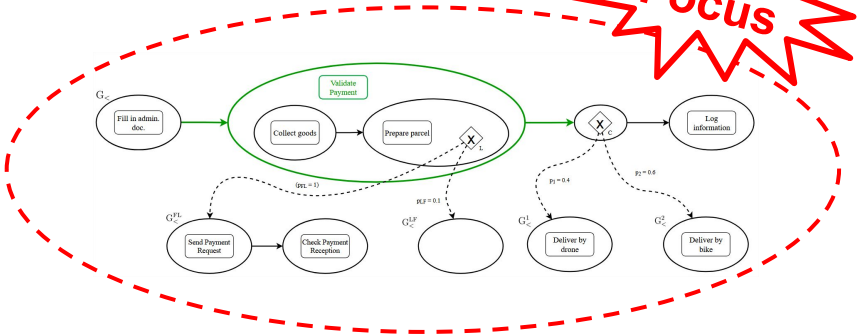
Focus



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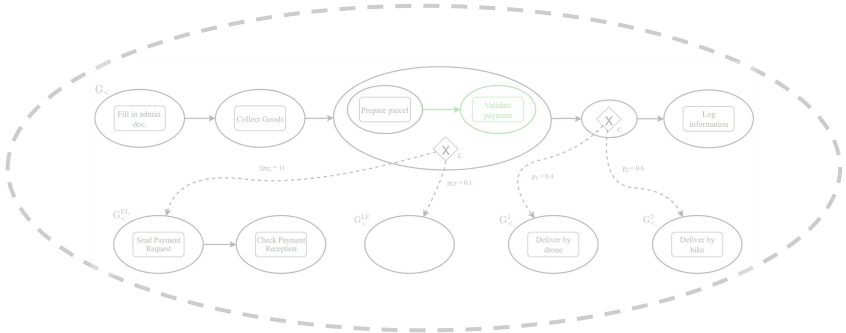

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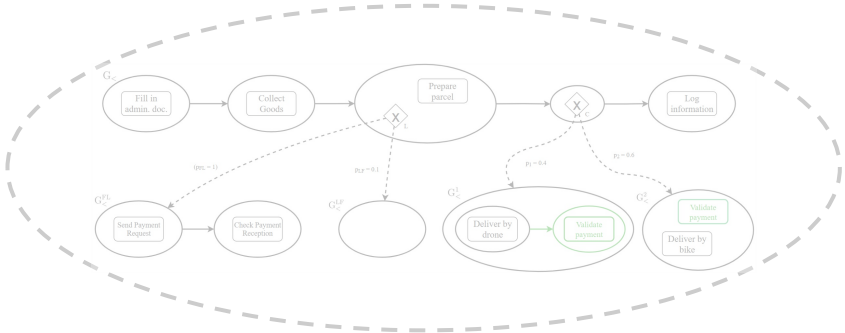

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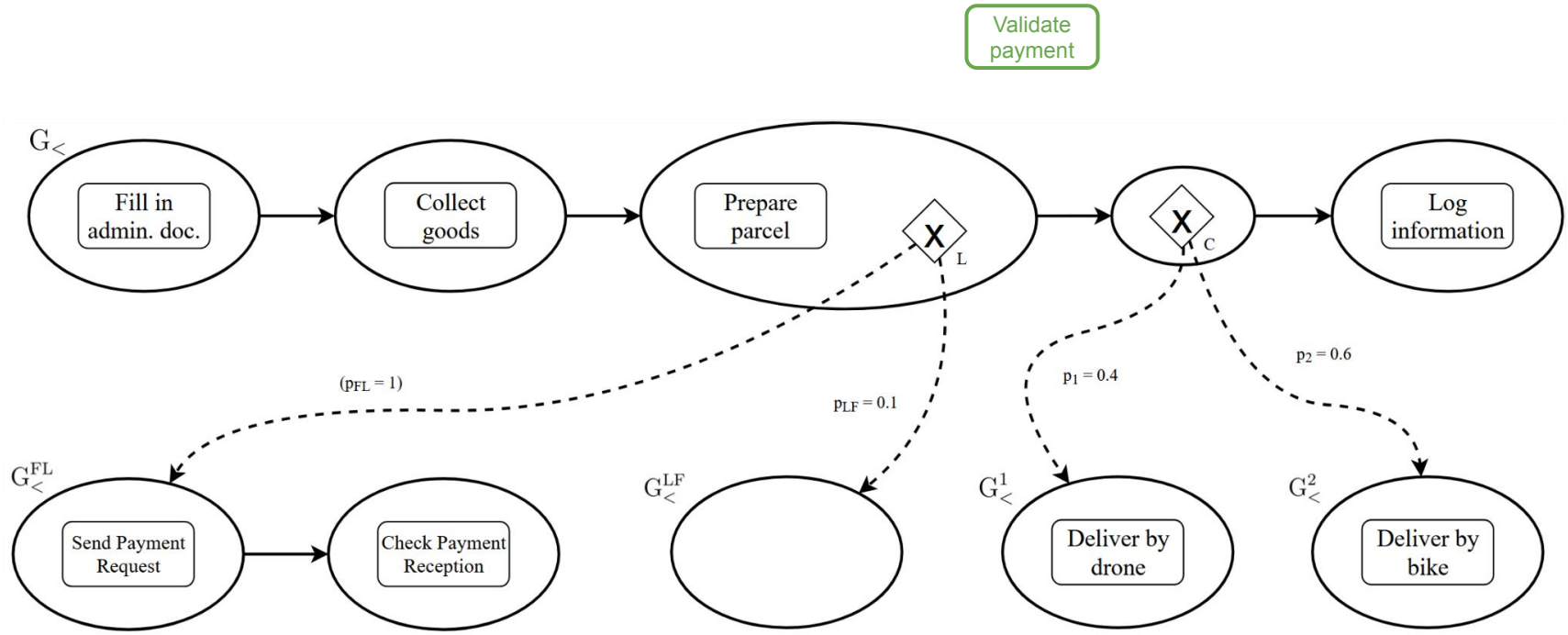

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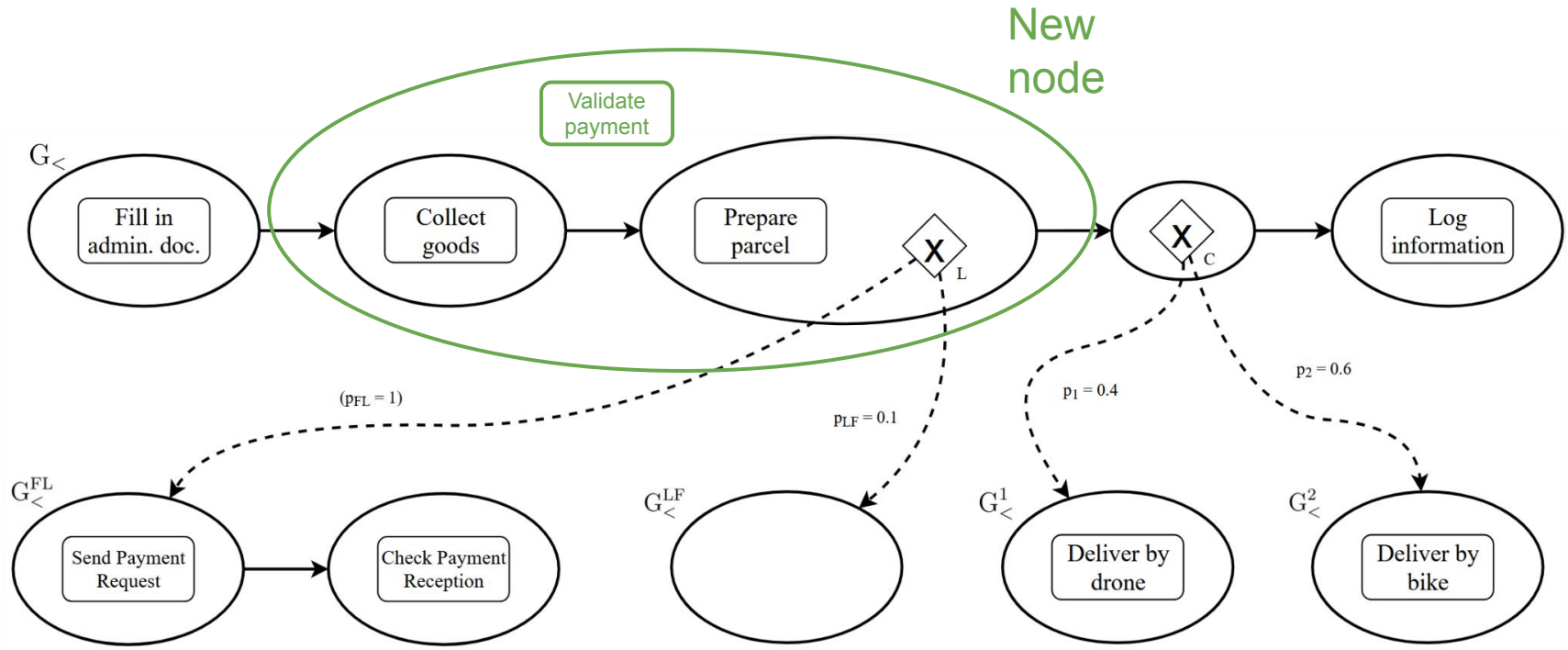

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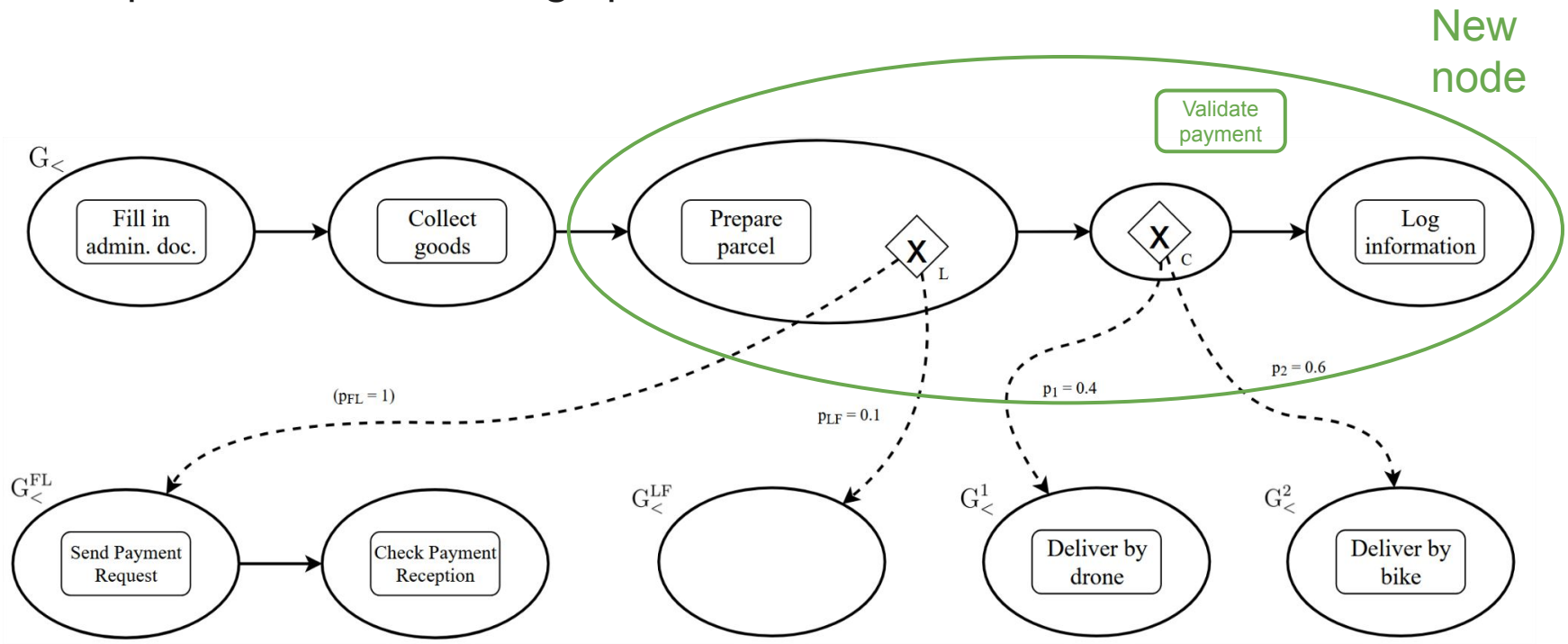

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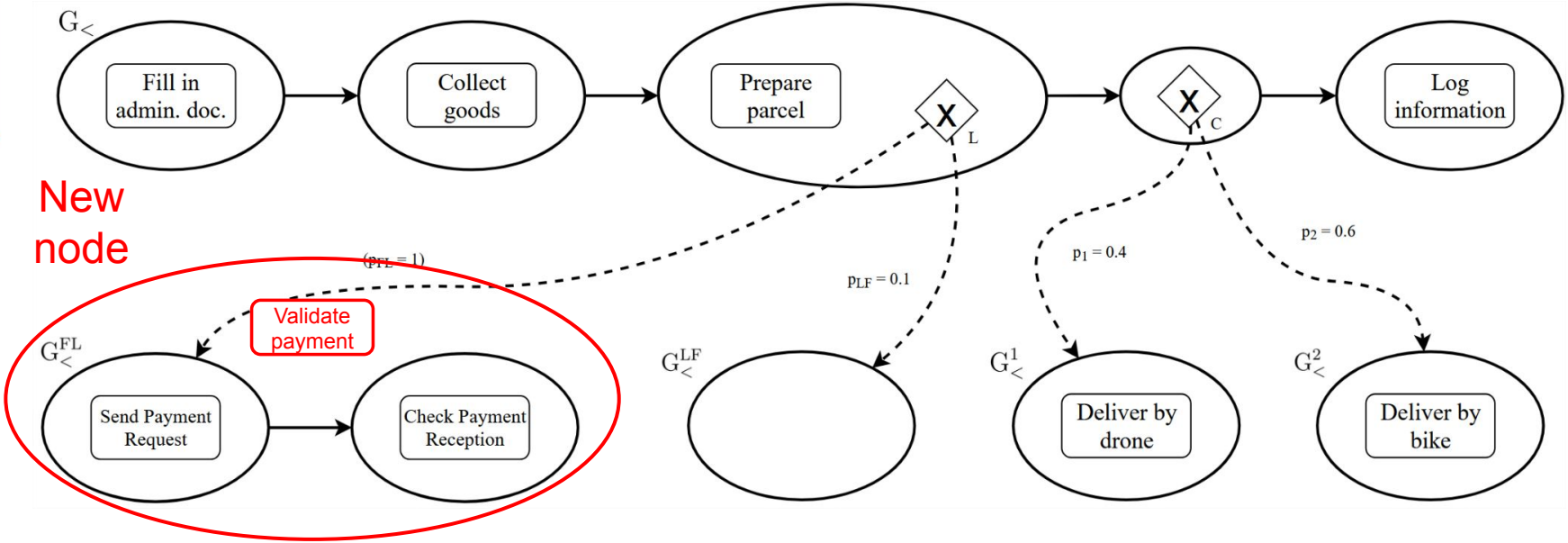

Step 2 – Structural Semantics Preservation

We **showed** in the manuscript that **the refactoring patterns preserve the structural semantics** of the process.

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Proposition (Structural Semantics Preservation)

Let $G_< = (V_<, E_<, \Sigma_<)$ be a sequence graph, and let $t \in \mathcal{T}(G_<)$ be a task of $G_<$. We state that:

— $\forall G'_< \in \texttt{ins}(\texttt{rem}(G_<, t), t), \ \forall \lambda_< \in \Lambda(G_<), \ \exists \lambda' \in \mathfrak{S}(\Lambda(G'_<)) \mid \lambda_< = \lambda'_<$;

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Step 3 – Comparison of the generated processes

The generated processes are **compared** based on their **average execution time** (AET), a metric obtained by **simulating** them in their **real conditions**.

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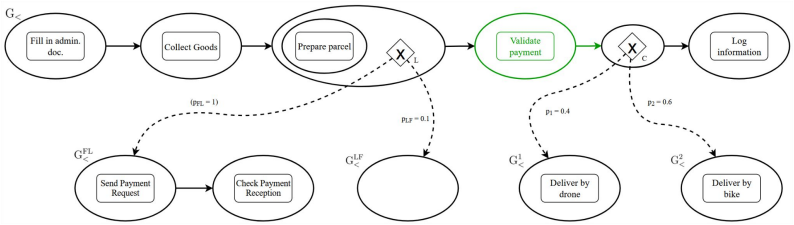
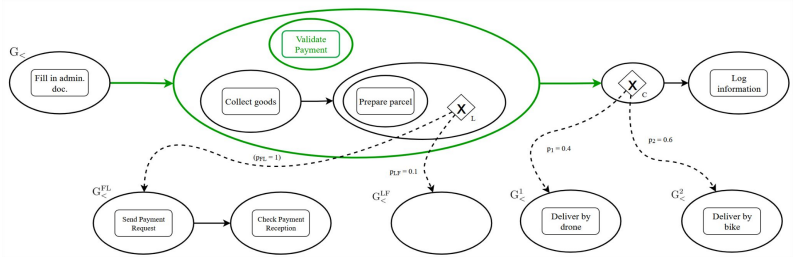
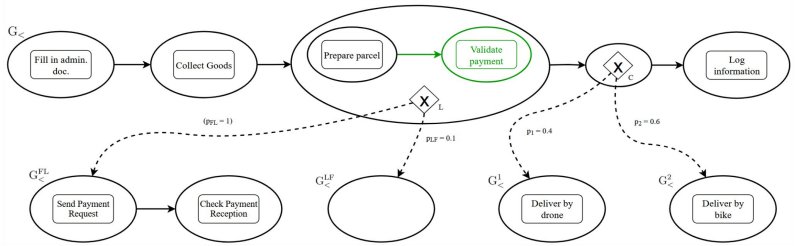


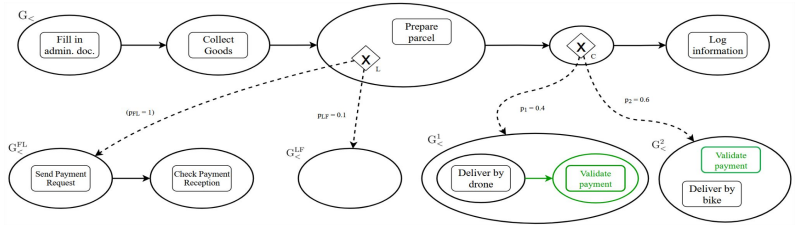
AET = 532 UT



AET = 512 UT



AET = 589 UT



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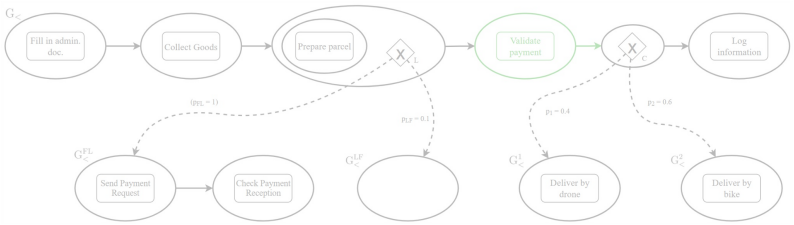

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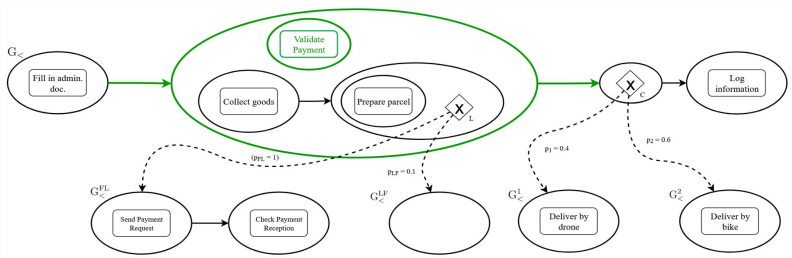

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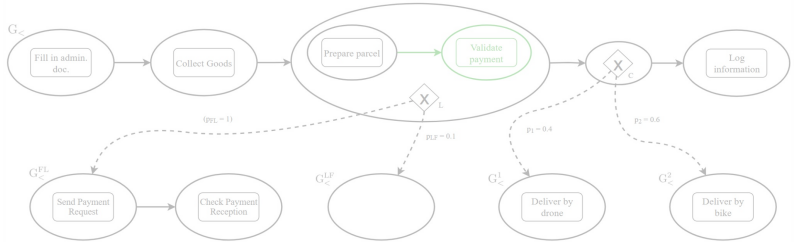

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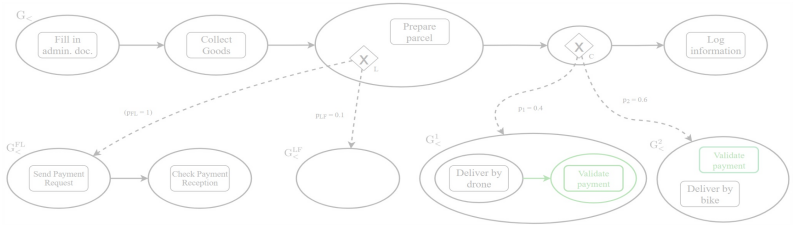

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Step 3 – Comparison bias: local optimum

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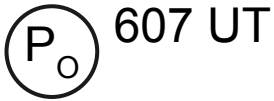

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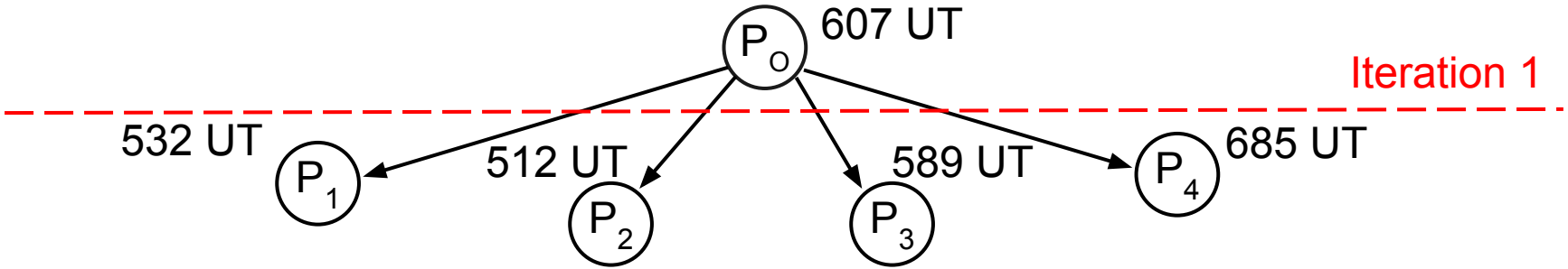

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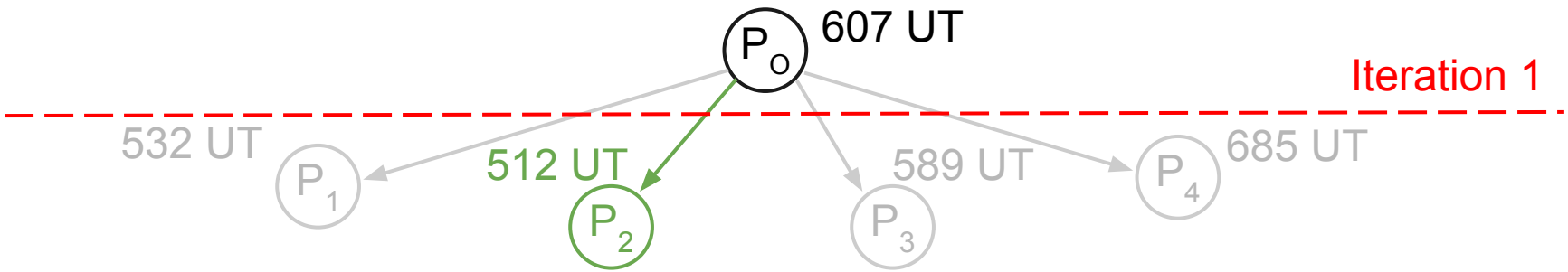

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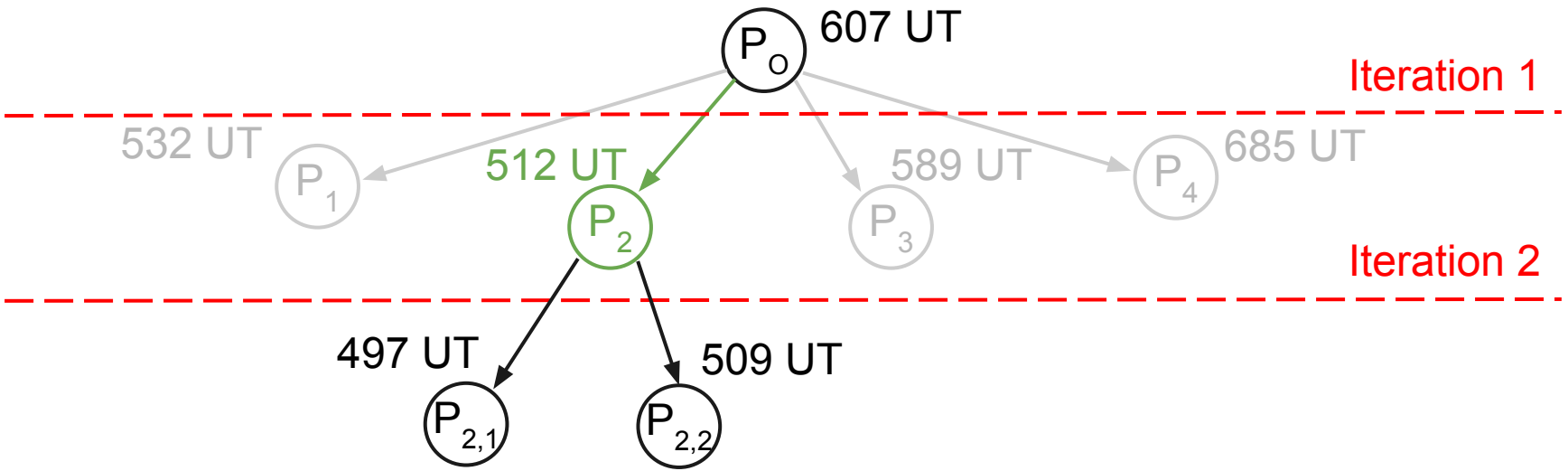

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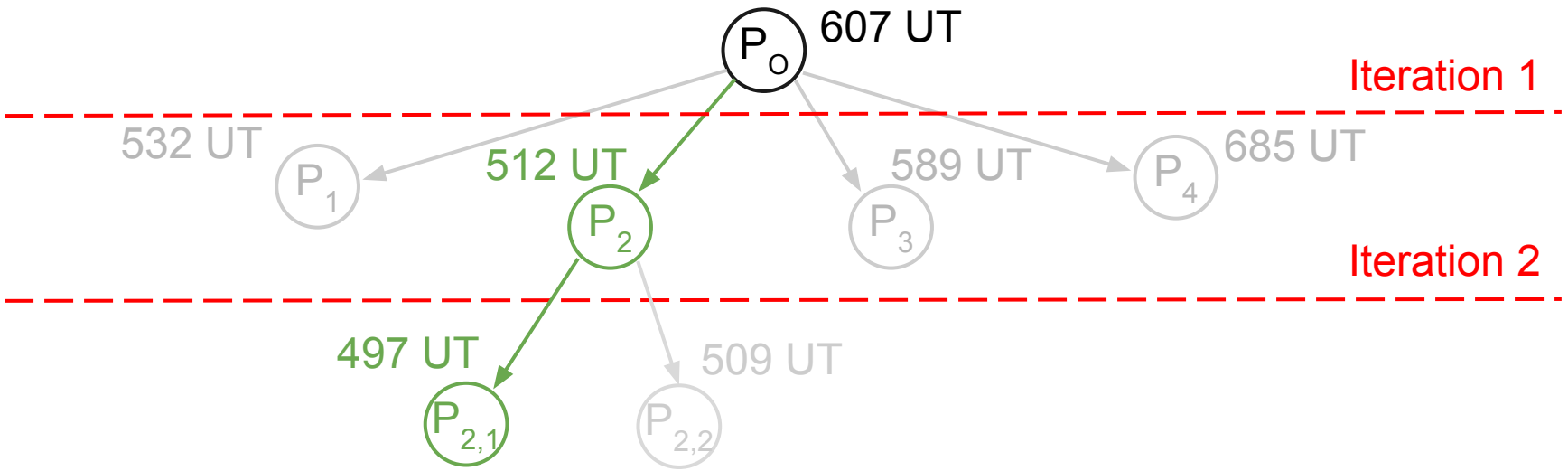

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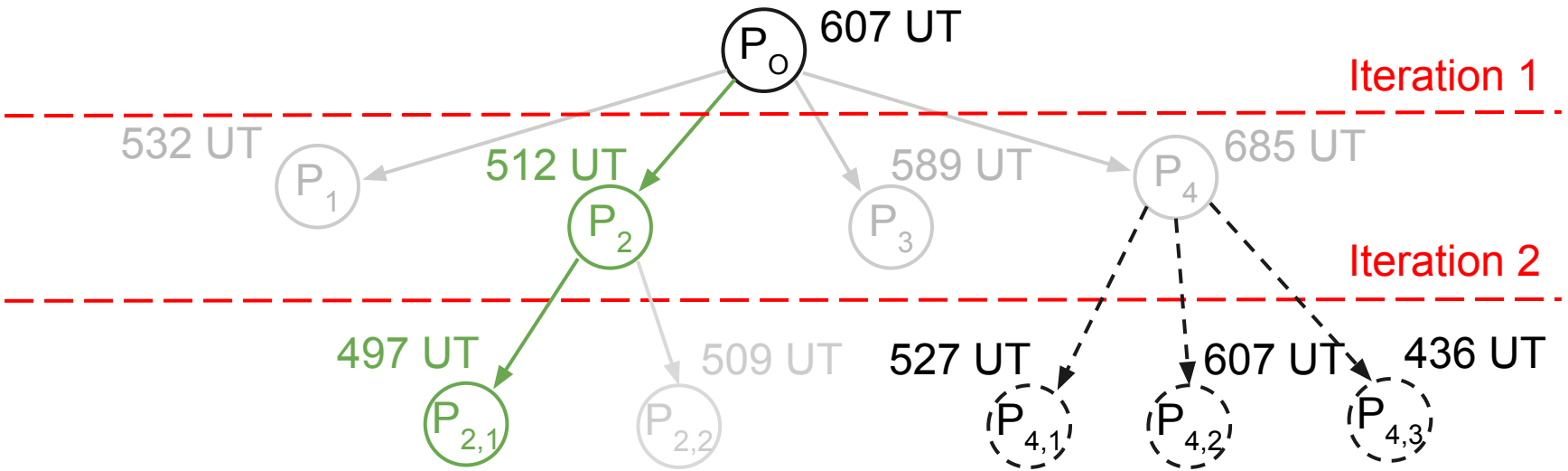

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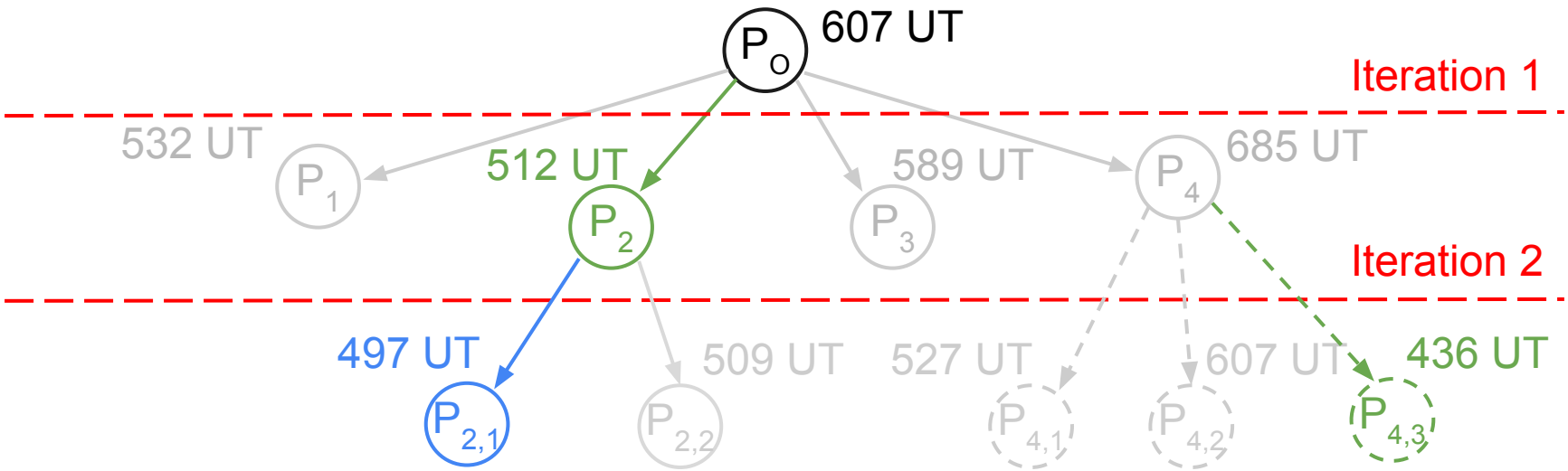

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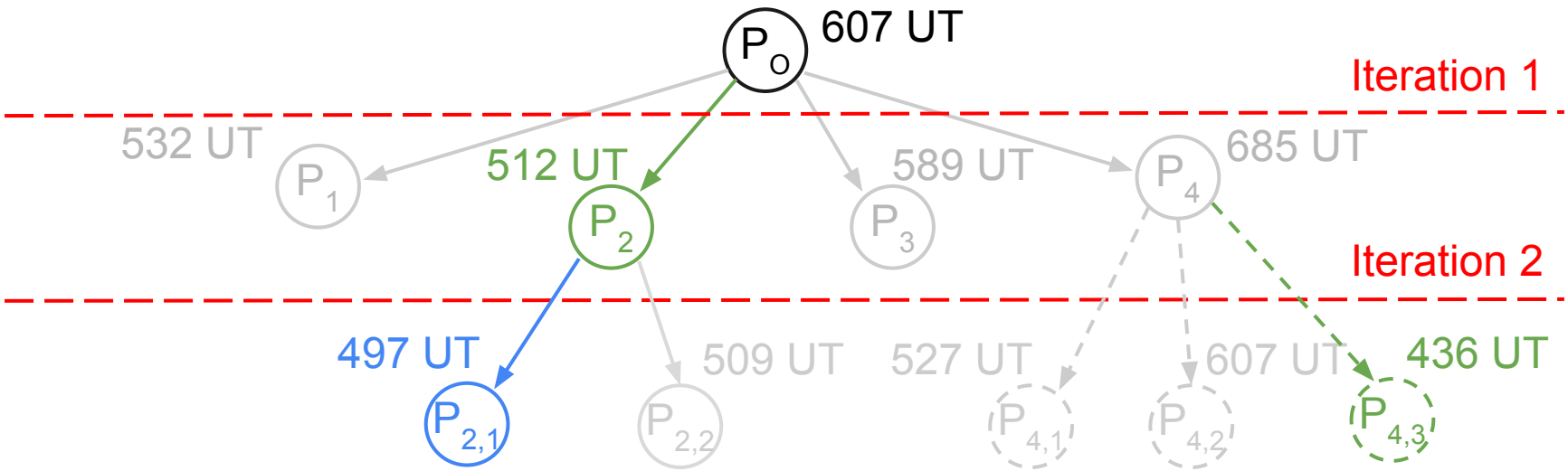

⇒ There is **no guarantee** that this **local optimum** will **lead to a global one**!

Step 3 – Comparison bias solution: full exploration

A solution is thus to **compute the whole tree** of solutions and **pick the best leaf**.

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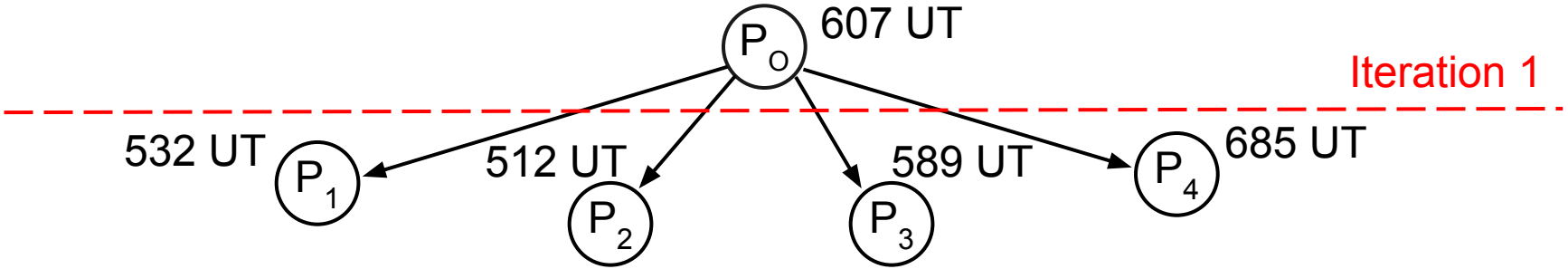

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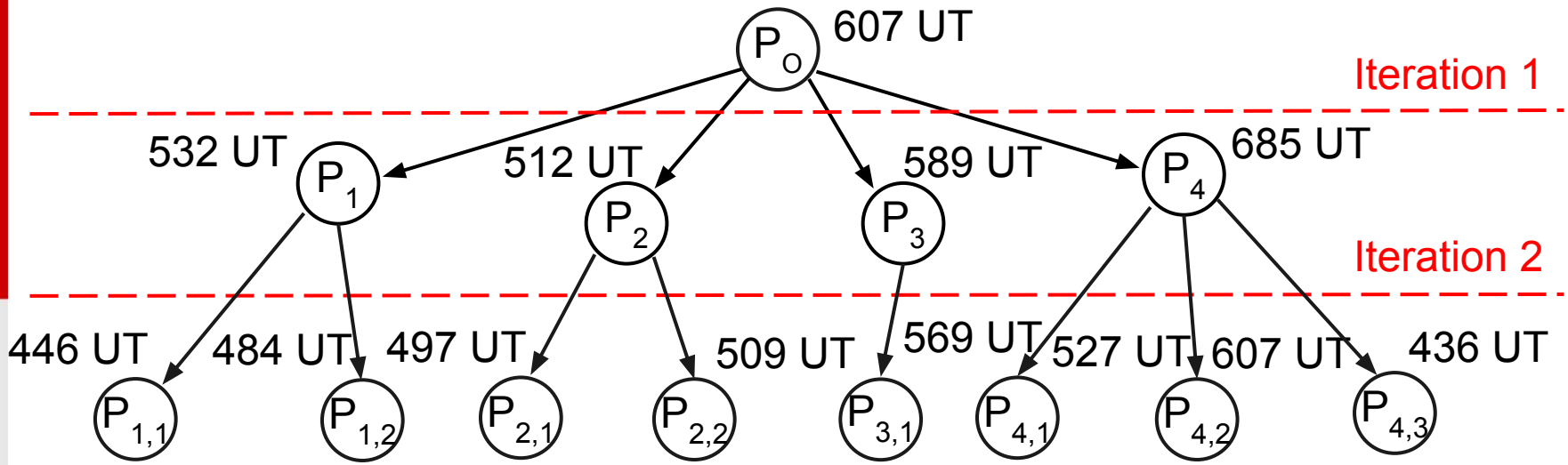

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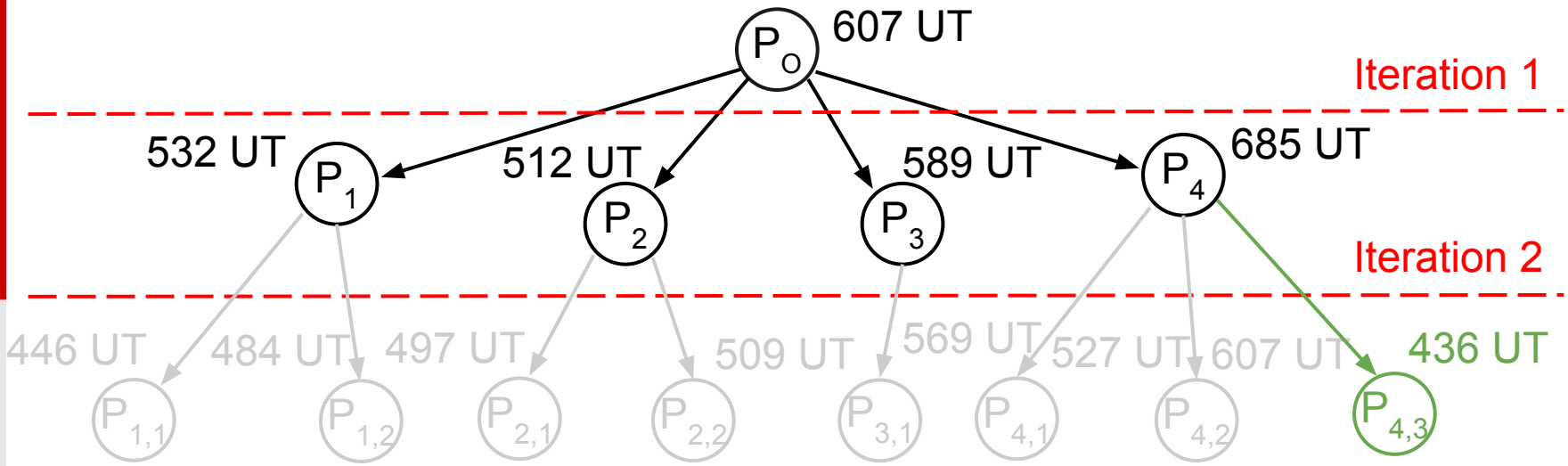

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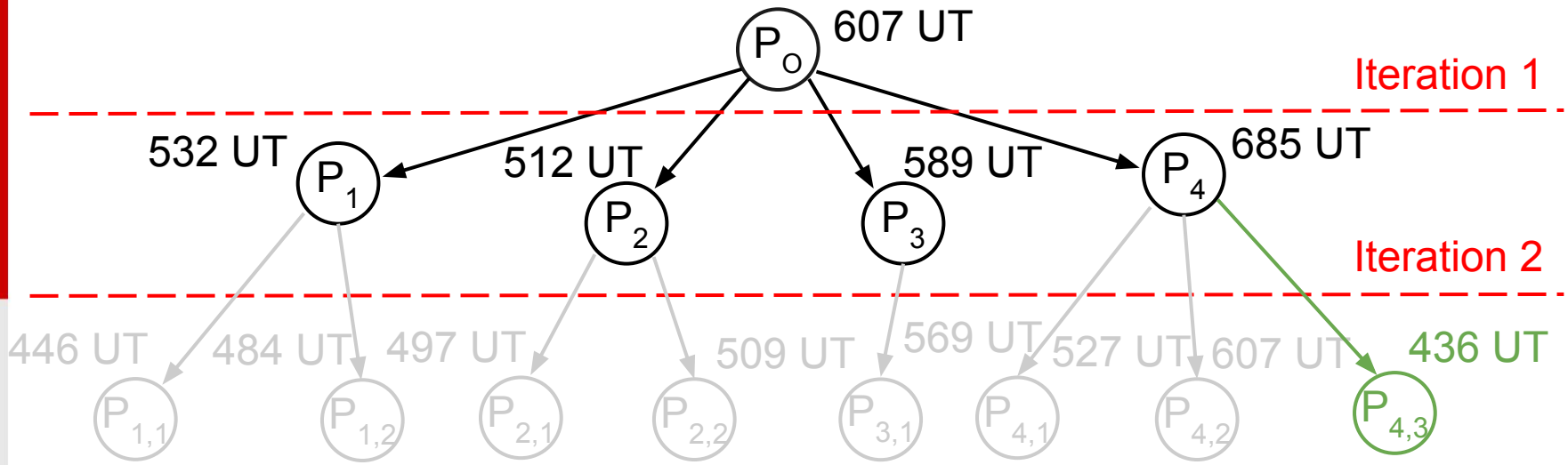

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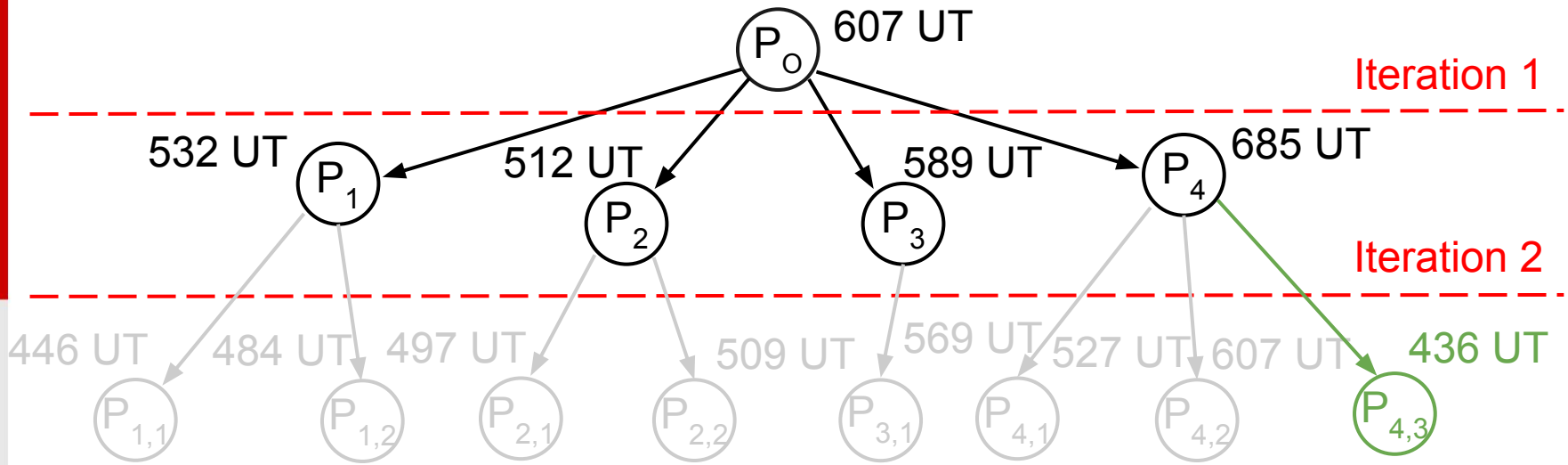

However, this is **not feasible** in practice, due to the **size of the** generated **tree**.

For instance, a BPMN process with **15 tasks** which can be **moved** to **20** different **places** generates a tree of **$15^{20} = 3 \times 10^{23}$ nodes**.

Step 3 – Comparison bias solution: heuristics

Thus, there is a need for **heuristics** aiming at **efficiently traversing the tree** of solutions.

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Our proposal consists in **attributing a (weighted) score** to each generated process, **based on** its **AET** and its **resources usage**.

Definition (Process Score)

Let $B = (V, E, \Sigma)$ be a BPMN process. The *score* of B is defined as

$$\text{score}(B) = \omega_{\text{AET}} \times (\delta_{\mu_{\text{AET}}} + \delta_{\sigma_{\text{AET}}} + \omega_{\text{loc}} \times \delta_{\text{AET}}) + \omega_{\text{res}} \times (\delta_{\mu_{\text{res}}} + \omega_{\text{loc}} \times \delta_{\text{res}})$$

Step 3 – Comparison bias solution: heuristics

Based on this score, **one or several processes** of the current layer **are kept**, and **used** as basis for the **computation** of the **next layer**.

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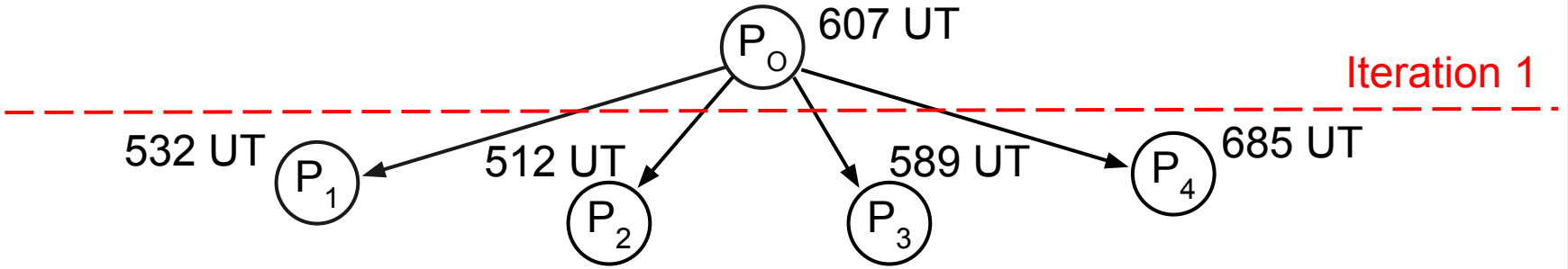

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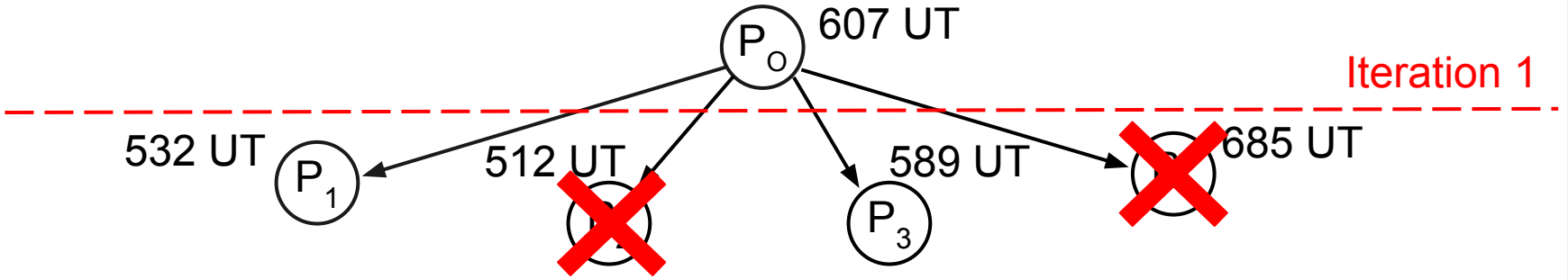

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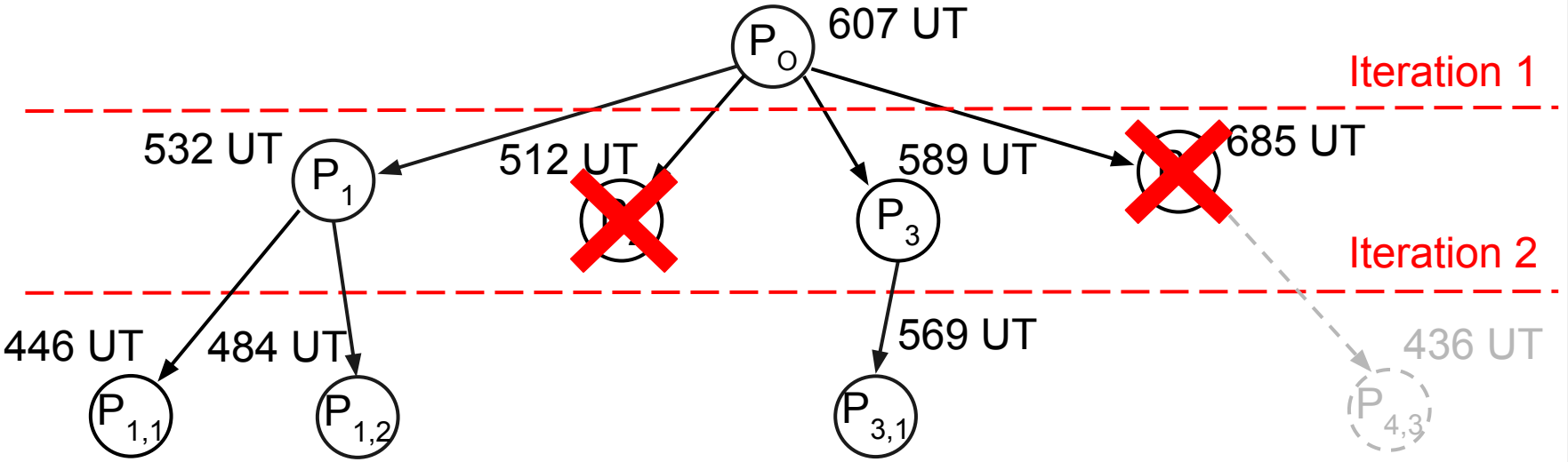

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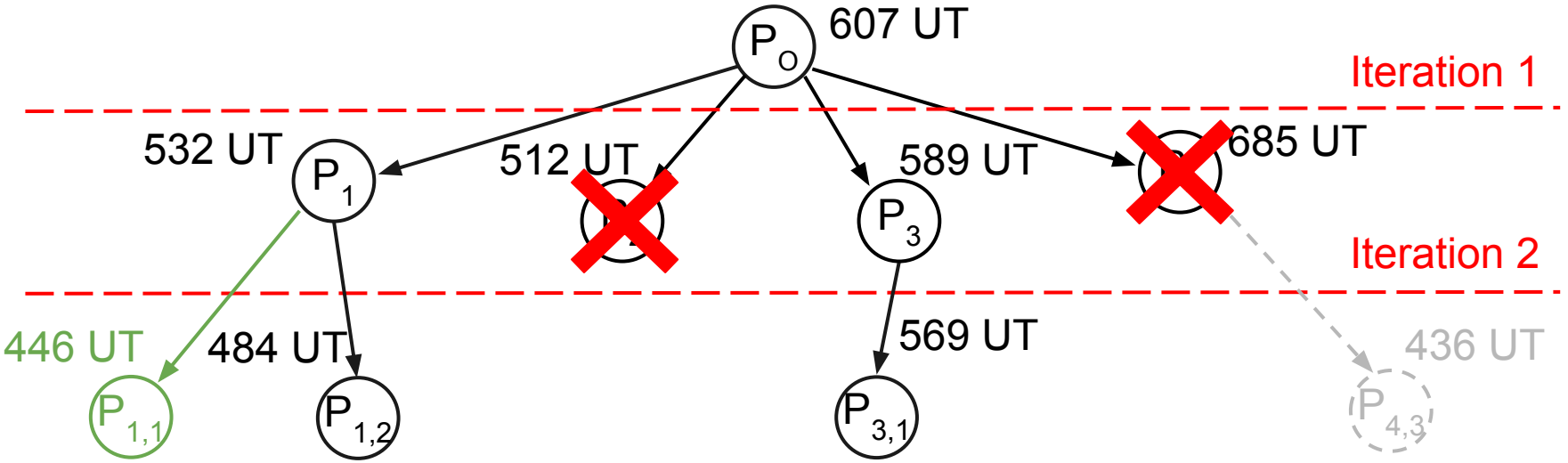

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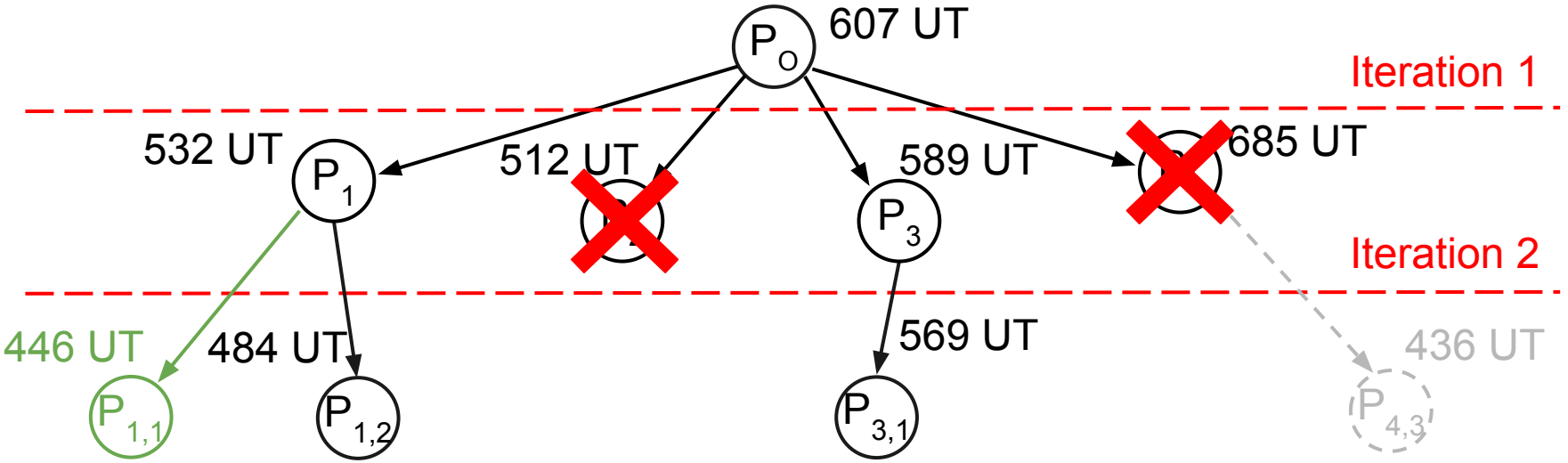
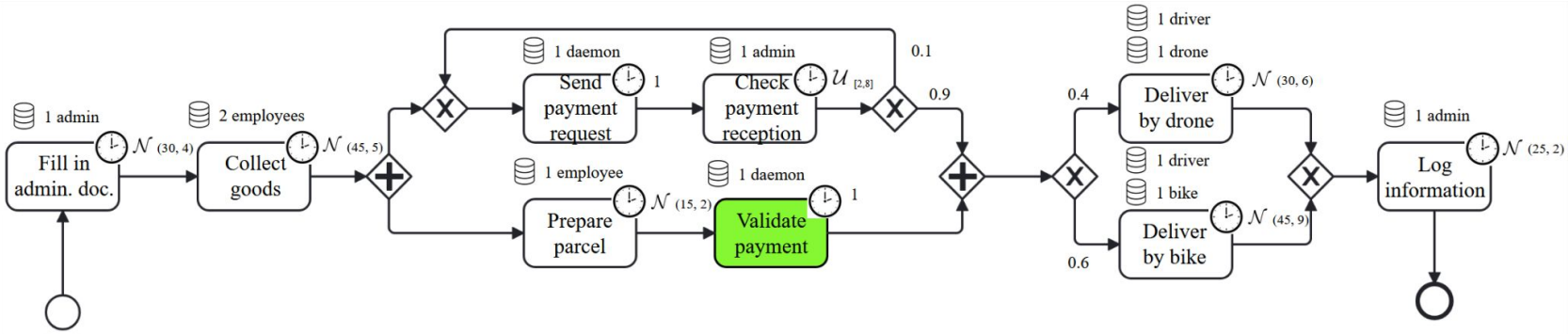


We obtain a process that is **close to the optimal** (446 UT / 436 UT) while **fastening** the **computations**.

Step 3 – Human Process Validation

The resulting process is then **proposed to the user**.



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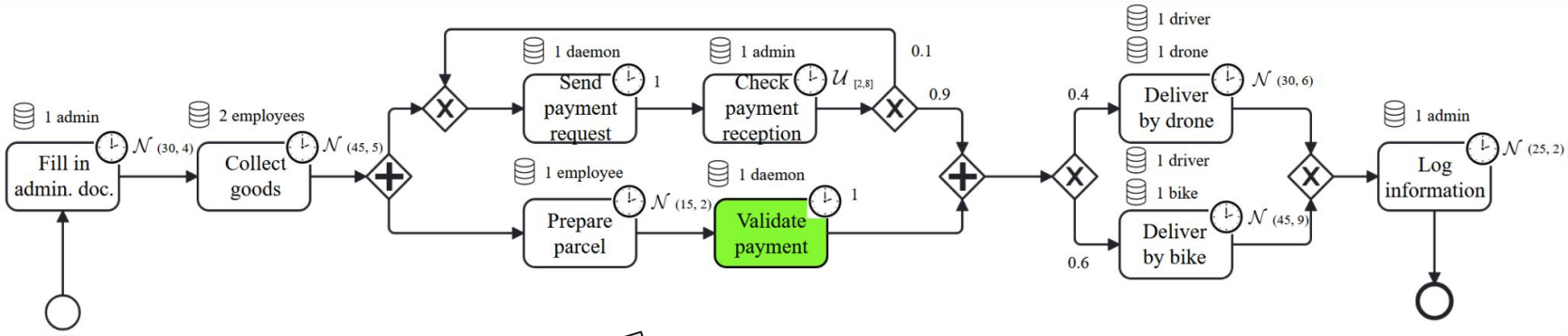

The user **validates the process** ⇒ we propose a new task to move **on it**.

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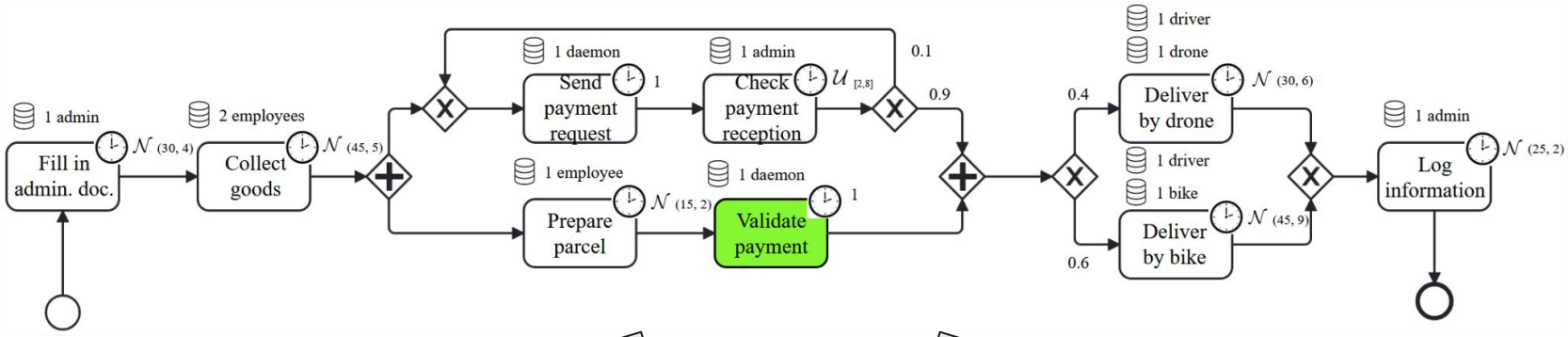
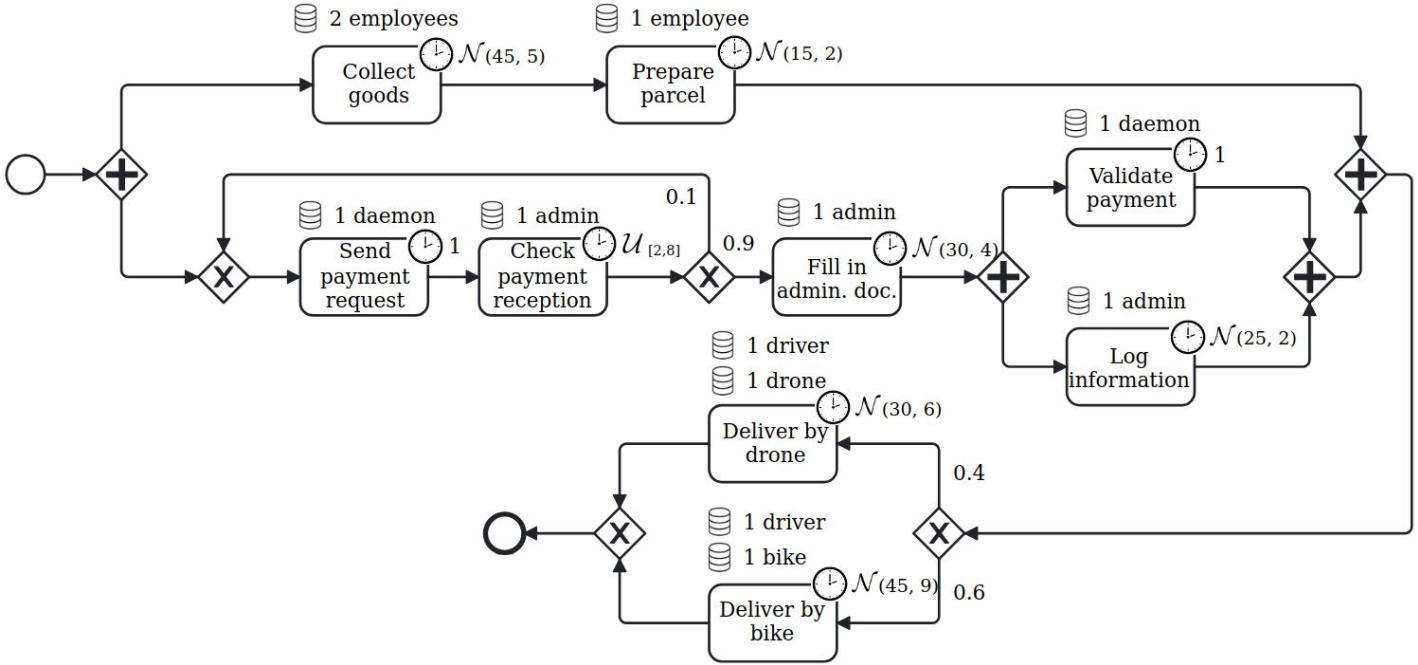


The user **validates the process** ⇒ we propose a new task to move **on it**.

The user **declines the process** ⇒ we propose a new task to move **on the previous process**.

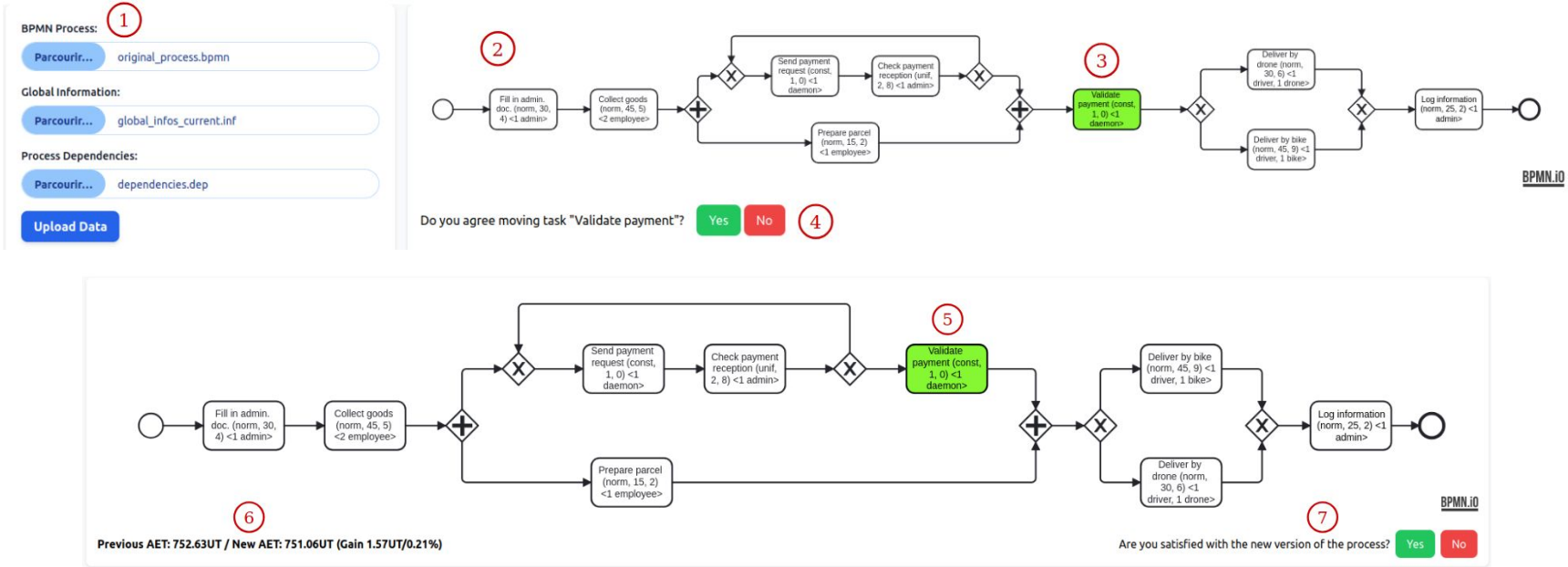
Step 3 – End of Refactoring Loop

When **all the tasks** of the process **have been moved**, or when the **user decides to stop**, the approach returns an **optimised version** of the **original process**.



Tool Support

- **15k lines of Java code**
- Executes in the backend of a **NodeJS server running locally**
- **Freely available online**



Experiments

Several **experiments were conducted to validate** the approach.

		Evisa App. [Sal22]	Empl. Rec. [FSZ21]	Patient Diag. [6]	Empl. Hir. [7]	Acc. Op. [NS22]	Per. Goods [VTS22]	Online Ship. [8]	Hand-Crafted 1	Hand-Crafted 2a	Hand-Crafted 2b
Characs.	Tasks	9	10	8	11	15	16	24	26	51	51
	$\diamondsuit_C$	1	1	2	2	2	2	3	4	1	1
	Deps.	3	9	3	7	7	10	27	43	43	23
	AET	36.1	30.9	67.2	24.7	51.9	15	85.9	232	323	323
Heuristic	AET	20	21.4	61.6	19	40.9	13.2	70.3	145*	244*	182*
	Gain	44.6%	30.7%	8.33%	23.1	21.2%	12.0%	18.2	37.5%	24.5%	43.7%
	Time	6.21s	32s	5s	26s	1.25m	14s	1.97m	6.37m	58m	2.12h
	μ_{time}	0.88s	0.32s	0.56s	2.36s	5s	1.75s	4.9s	15s	1.14m	2.54m
Full	AET	17.1	20.4	60.4	17.8	34.2	13.2	69.3	122	183	99
	Gain	52.6%	34.0%	10.1%	27.9%	34.1%	12.0%	19.3%	47.4%	43.3%	69.3%
	Time	17.0m	7.38m	11.2s	43.1h	26.8h	1.34h	>14d	1.7d	>14d	>14d

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	$\diamondsuit_C$	1	1	2	2	2	2	3	4	1	1
	Deps.	3	9	3	7	7	10	27	43	43	23
	AET	36.1	30.9	67.2	24.7	51.9	15	85.9	232	323	323
Heuristic	AET	20	21.4	61.6	19	40.9	13.2	70.3	145*	244*	182*
	Gain	44.6%	30.7%	8.33%	23.1	21.2%	12.0%	18.2	37.5%	24.5%	43.7%
	Time	6.21s	32s	5s	26s	1.25m	14s	1.97m	6.37m	58m	2.12h
	μ_{time}	0.88s	0.32s	0.56s	2.36s	5s	1.75s	4.9s	15s	1.14m	2.54m
Full	AET	17.1	20.4	60.4	17.8	34.2	13.2	69.3	122	183	99
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Related Work – Modelling

	Used Technique	Supported Constructs				Tool Availability	Structured Input	Semantics Preservation	Number of Experiments
		⊠	⊞	Loops	Unbalancing				
[FMP11, SV17]	NLP, Stanford Parser, Wordnet	✓	✓	✗	✗	✗	✓	?	10
[HKW18]	NLP, SVO Detection, Spreadsheet-Based	✓	✓	✗	✗	✗	✓	?	11
[ISP20]	DSL, Process Mining	✓	✓	✓	✓	✓	✓	?	30
[FSZ21]	Partial Orders, Classical Algorithmic	✓	✓	✗	✗	✓	✓	?	1
[KBSvdA24a]	LLM, POWL	✓	✓	✓	✗	✓	✗	✗	2
[EAA+24]	LLM, Refinement Steps	✓	✓	✓	✗	✓	✗	✗	8
Our approach	LLM, Refinement Steps	✓	✓	✓	✓	✓	✗	✓	∼ 200

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Related Work – Refactoring

Qualitative refactoring [SM2007, DGKV2011, FRPCP2013]

Restructures a process to solve **structural issues**:

- soundness issues
- bad design
- duplicated parts of the process

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Optimises a process by **changing** its number of available **resources:**

- statically
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Optimises a process by **changing** its number of available **resources:**

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Quantitative refactoring [RM2005, KL2022, DS2022]

Restructures a process to **optimise** its **execution time:**

- optional tasks
- duration reduction
- split/merge of tasks
- local patterns

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We propose an approach to **generate BPMN** processes:

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- Including **behavioural verification** facilities

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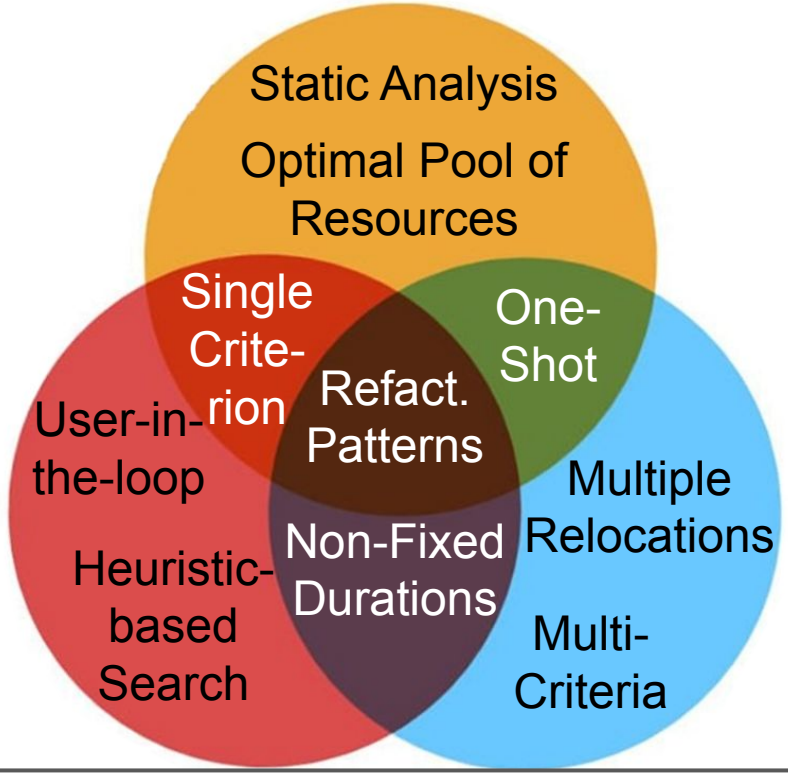
We propose 3 approaches to **refactor BPMN** processes:



Perspectives

Regarding the **generation of processes**, we thought about several **perspectives**.

- **Cross-check** the generated expressions **with** other **LLMs** — Short-term
- Add **further information** during generation (resources, durations, …) — Mid-term
- Provide **advices** to **improve** the **quality** of the process
- **Enlarge** the supported BPMN **syntax** — Long-term
- **Synchronise the description** with the process changes — Transversal

Perspectives

Regarding the **refactoring of processes**, we thought about several **perspectives**.

- ➢ Explore possibilities offered by **scheduling** techniques — Short-term
- ➢ Look for better **heuristics**
- ➢ Extend the **support** (BPMN syntax, model of resources) — Mid-term
- ➢ **Remove sequence graphs** to increase the support
- ➢ **Limit** the usage of **simulation** (AI, SMT, analytics, …) — Long-term

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Scientific Integrity Oath

"En présence de mes pairs.
Parvenu à l'issue de mon doctorat en 'Informatique', et ayant ainsi pratiqué, dans ma quête du savoir, l'exercice d'une recherche scientifique exigeante, en cultivant la rigueur intellectuelle, la réflexivité éthique et dans le respect des principes de l'intégrité scientifique, je m'engage, pour ce qui dépendra de moi, dans la suite de ma carrière professionnelle quel qu'en soit le secteur ou le domaine d'activité, à maintenir une conduite intègre dans mon rapport au savoir, mes méthodes et mes résultats."

"In the presence of my peers.
With the completion of my doctorate in 'Computer science', in my quest for knowledge, I have carried out demanding research, demonstrated intellectual rigour, ethical reflection, and respect for the principles of research integrity.
As I pursue my professional career, whatever my chosen field, I pledge, to the greatest of my ability, to continue to maintain integrity in my relationship to knowledge, in my methods and in my results."