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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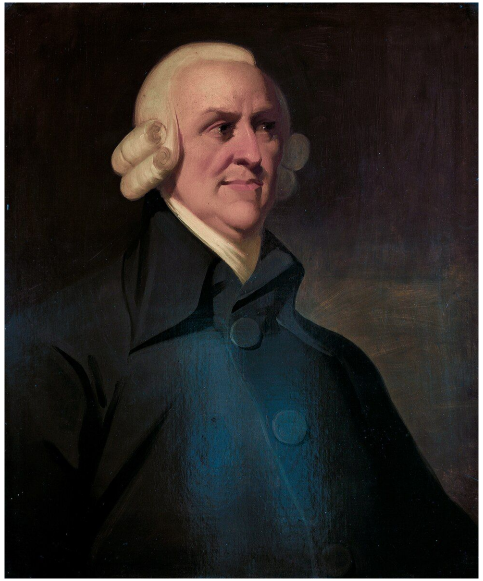
But what is a business process?

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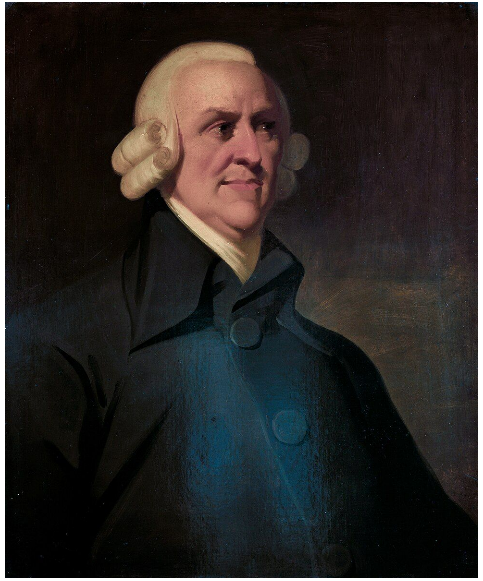
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In [Smith1776], he described the production of a pin as follows:

"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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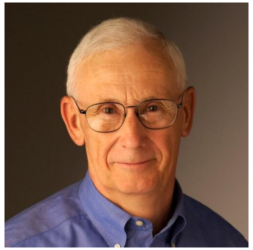
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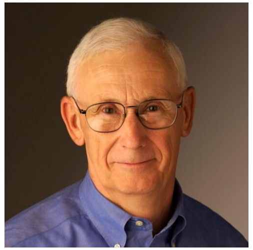
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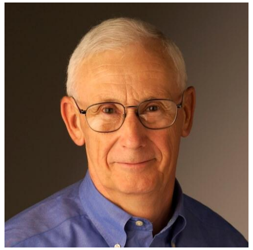
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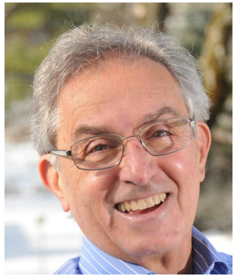
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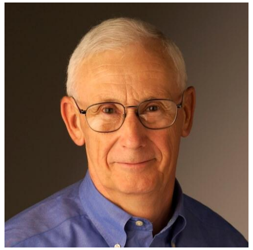
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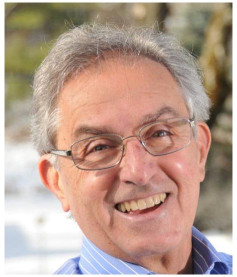
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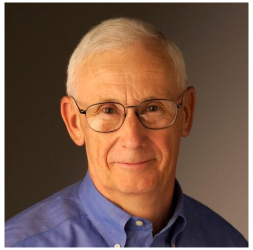
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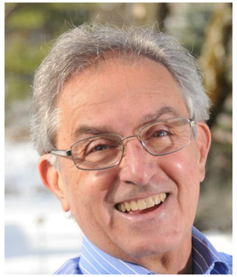
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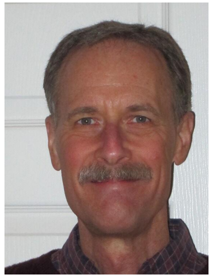
Alan P. Brache

and others

A Little Bit of History: Business Process Management

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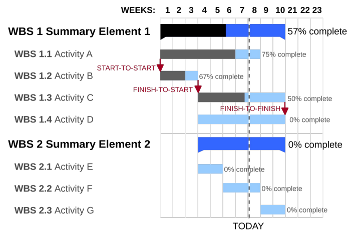

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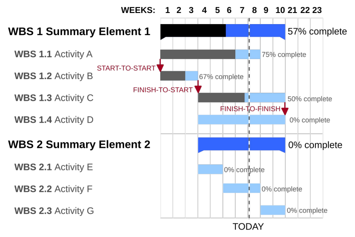

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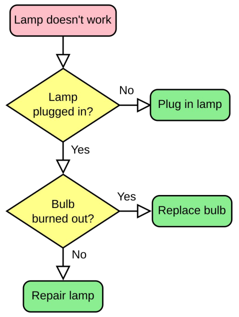

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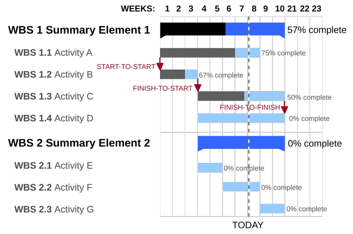

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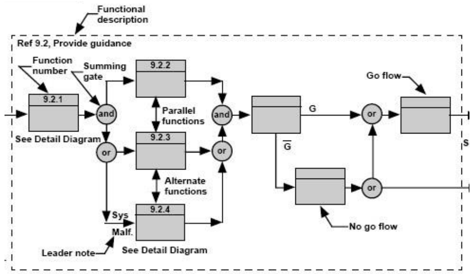
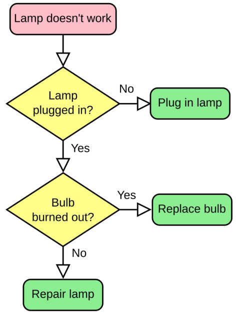


Functional flow block diagram (FFBD), 195X



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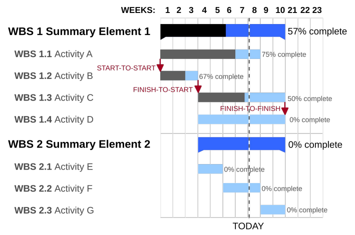

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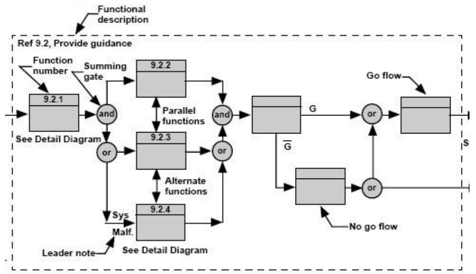

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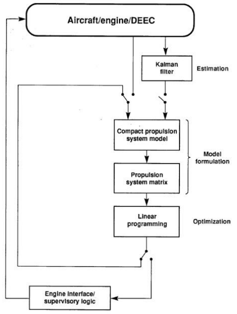
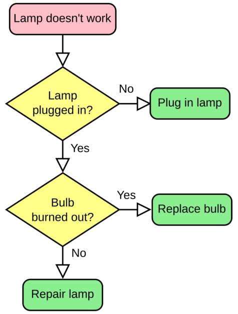


Control-flow diagram (CFD), 195X



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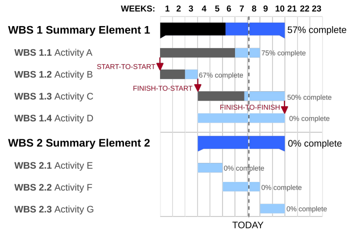

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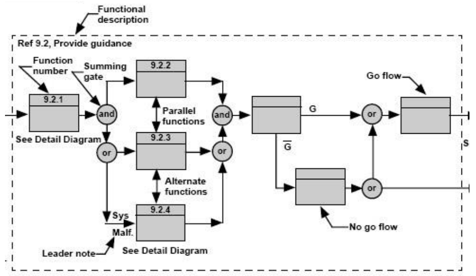

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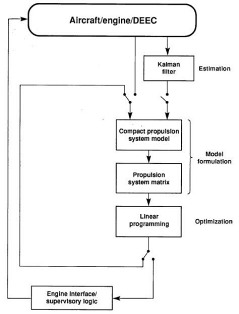

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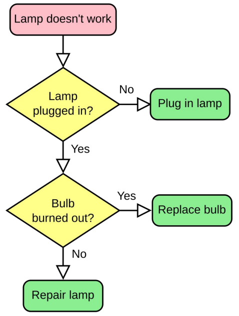

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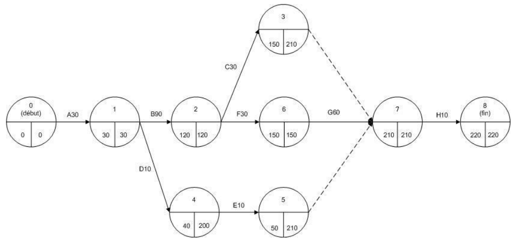

PERT diagram, 195X

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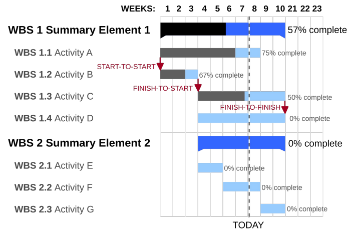

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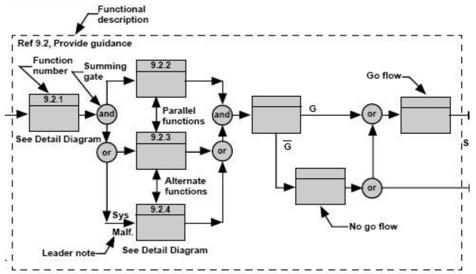

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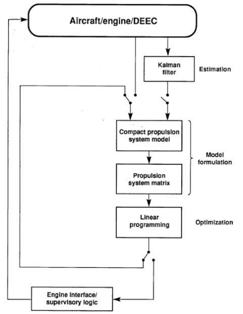

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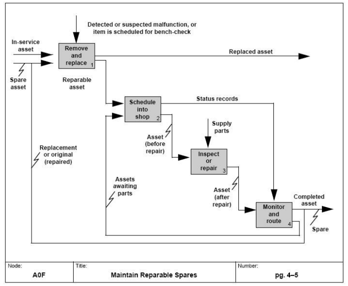
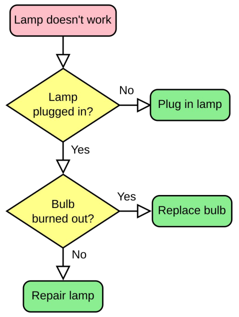


IDEF diagram, 197X



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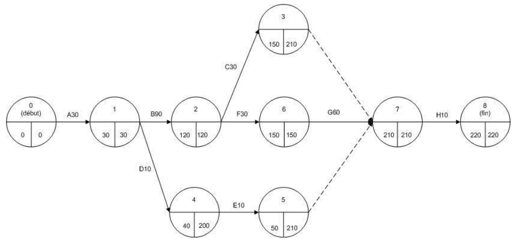

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A Little Bit of History: UML or BPMN?

More recently, other notations emerged, such as the **Unified Modelling Language (UML)** [BRJ2000] and the **Business Process Management Notation (BPMN)** [OMG2011].

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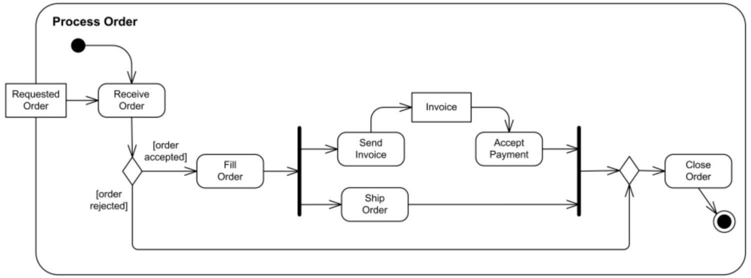

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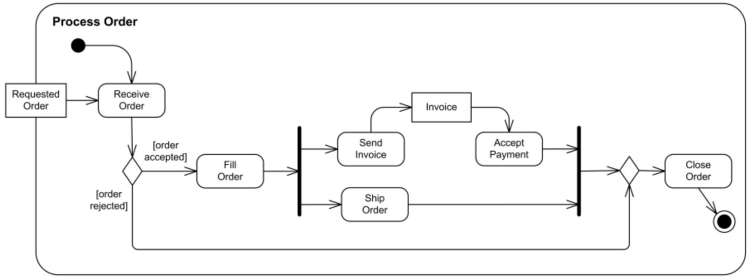

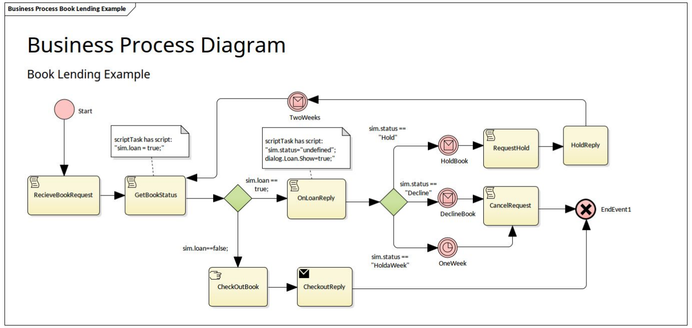

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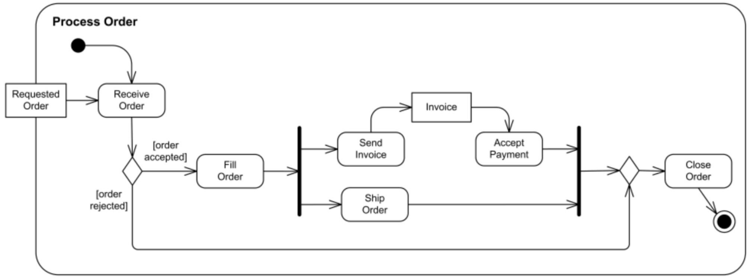

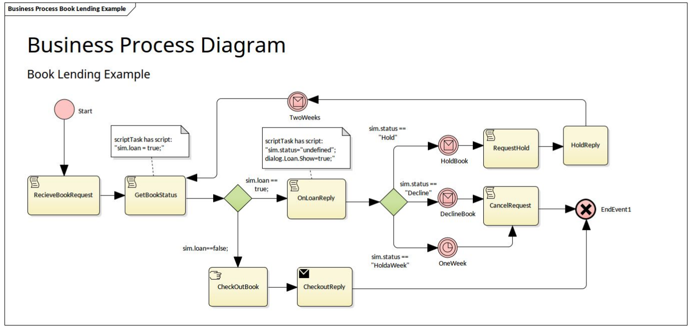

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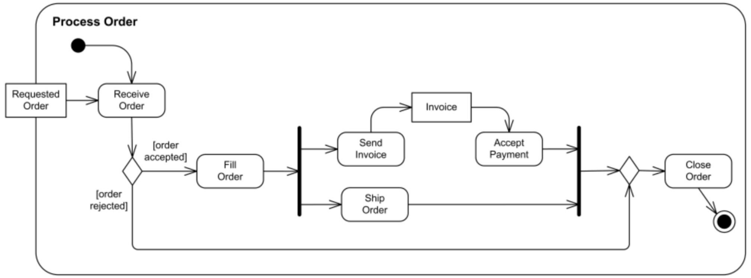

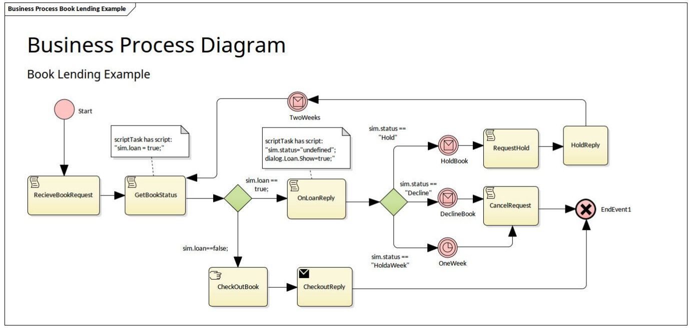

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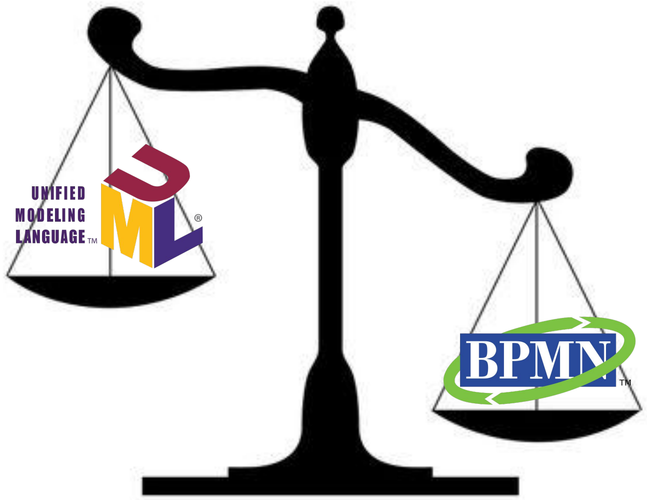

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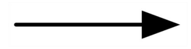
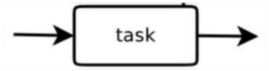
➢ An **ISO/IEC standard** since version 2.0 in 2013.

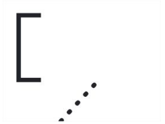
Excerpt of the BPMN Syntax



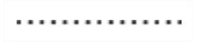
Sequence Flow



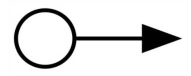
Task



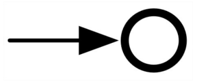
Annotation



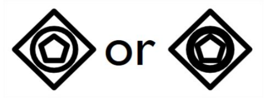
Association



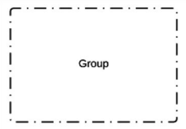
Initial Event



End Event

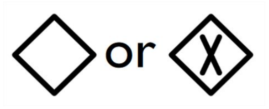


Event-based Gateway

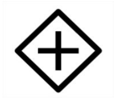


Group

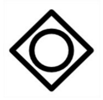
etc.



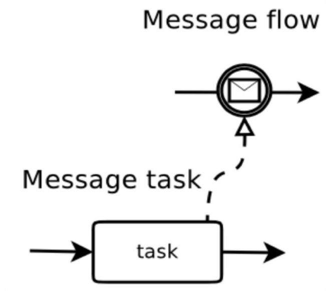
Exclusive Gateway



Parallel Gateway

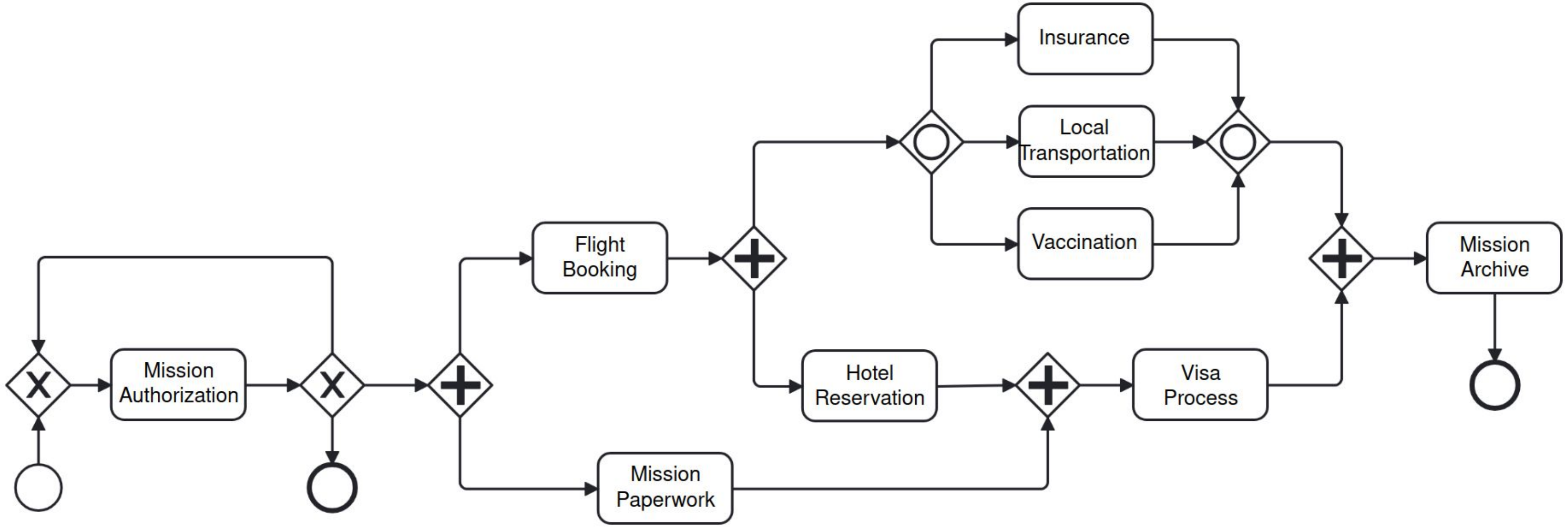


Inclusive Gateway

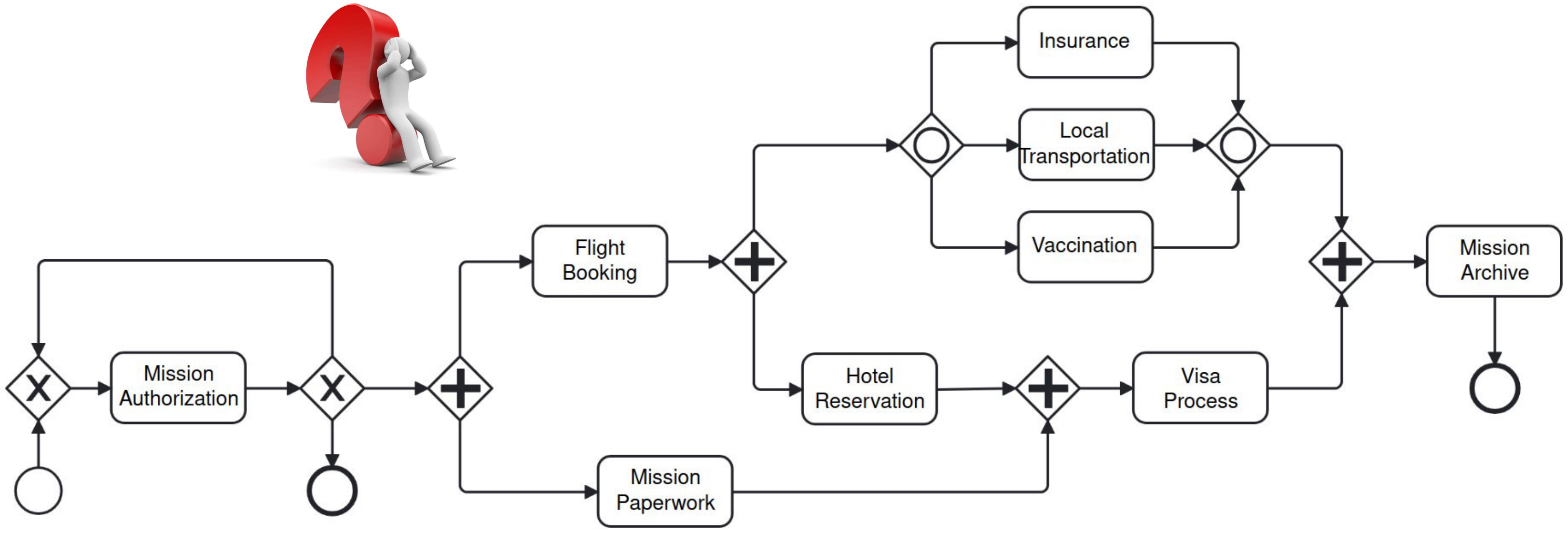


Example of BPMN Process

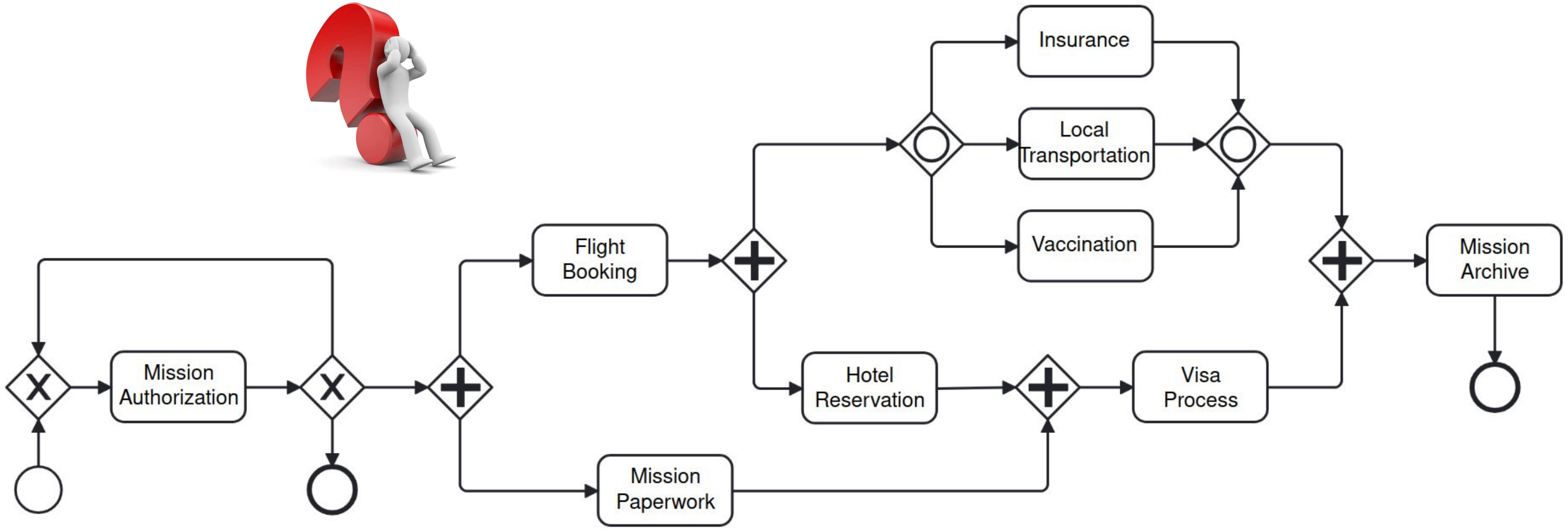
Given the BPMN syntax, one can, for instance, write a **business trip organization** process as follows:



First Research Question

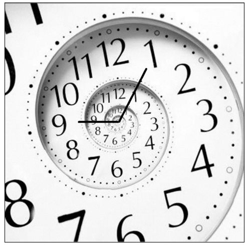


First Research Question

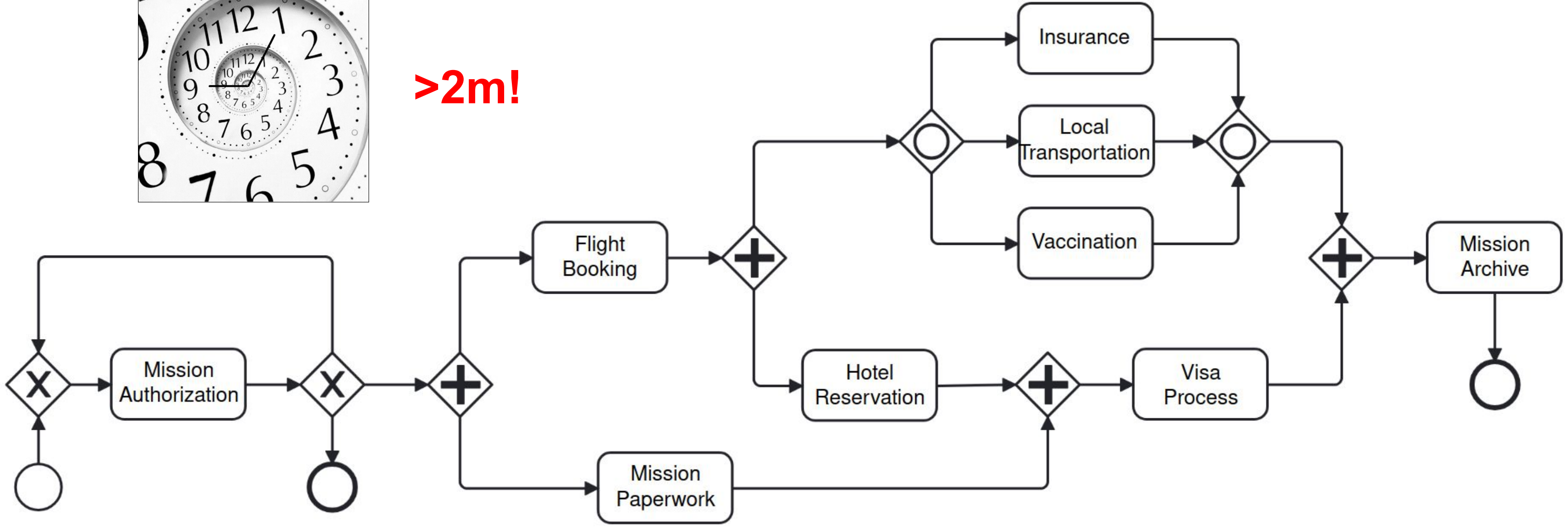


➢ What if you do not know **how to write BPMN** processes?

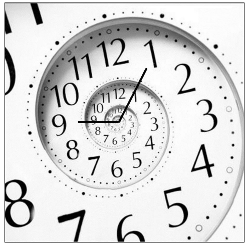
Second Research Question



>2m!



Second Research Question



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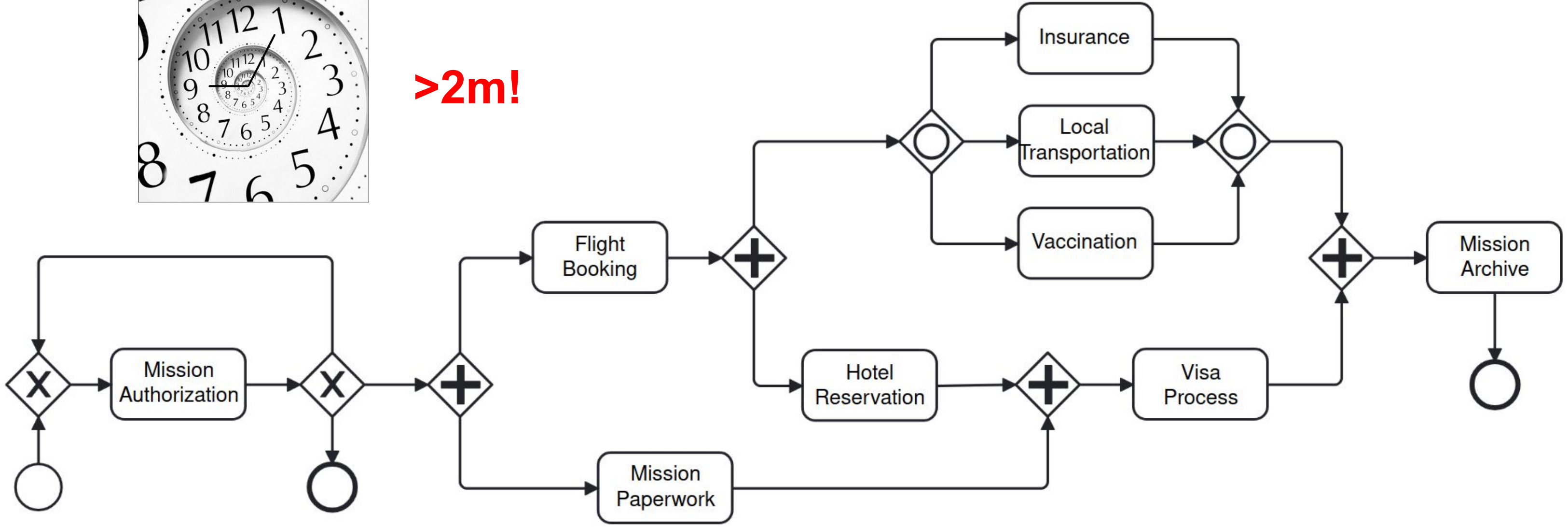
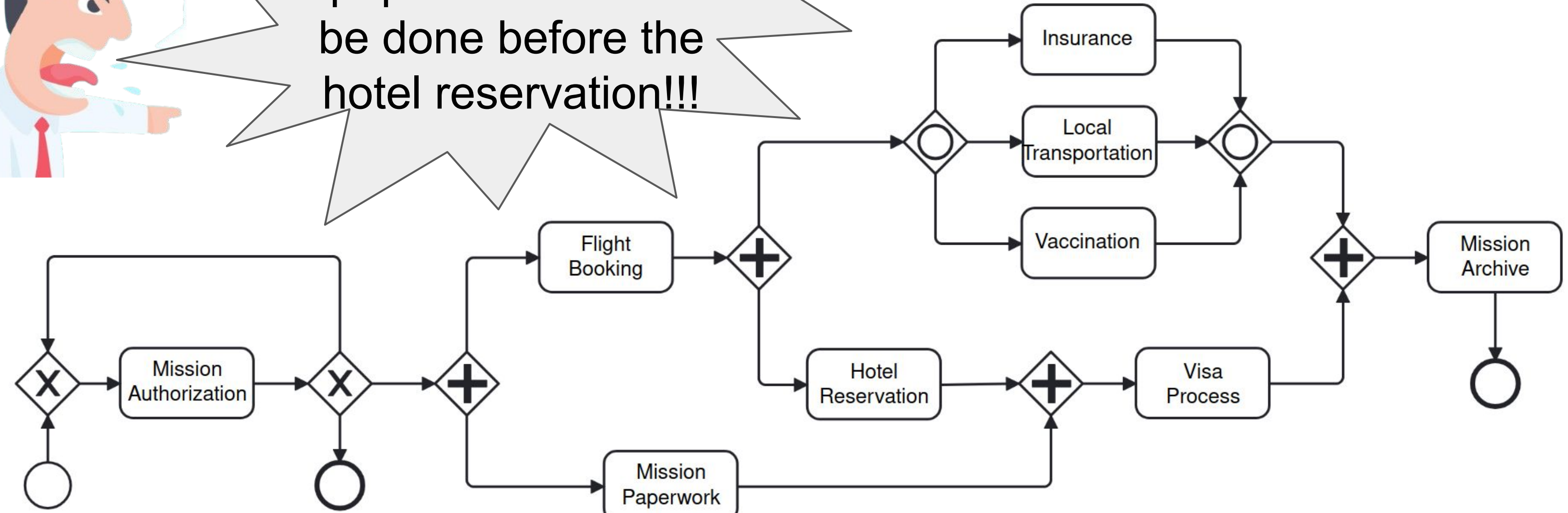


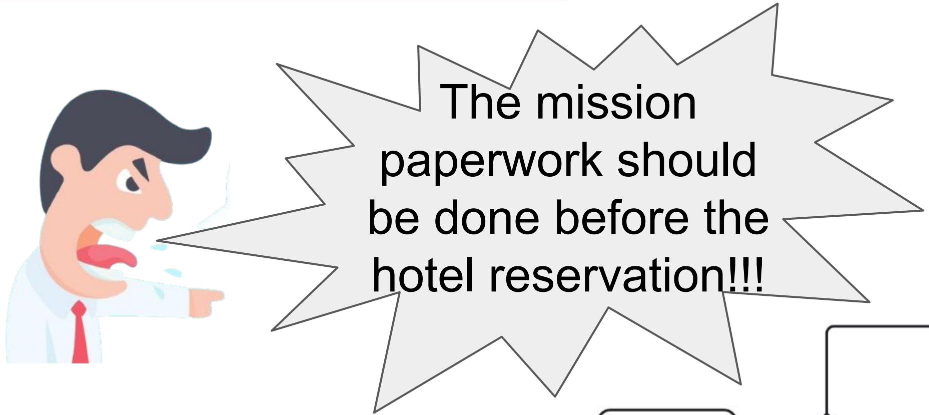
➢ What if you do not want to **spend time designing** your process graphically?

Third Research Question

The mission paperwork should be done before the hotel reservation!!!



Third Research Question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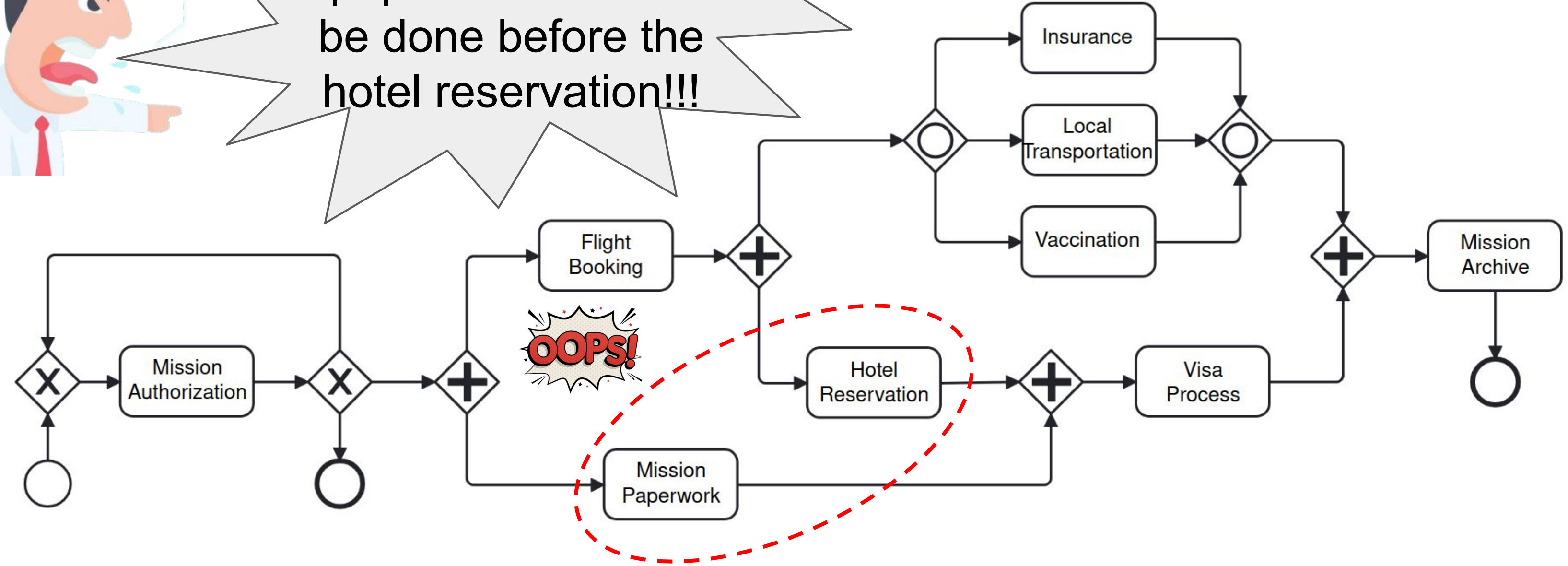

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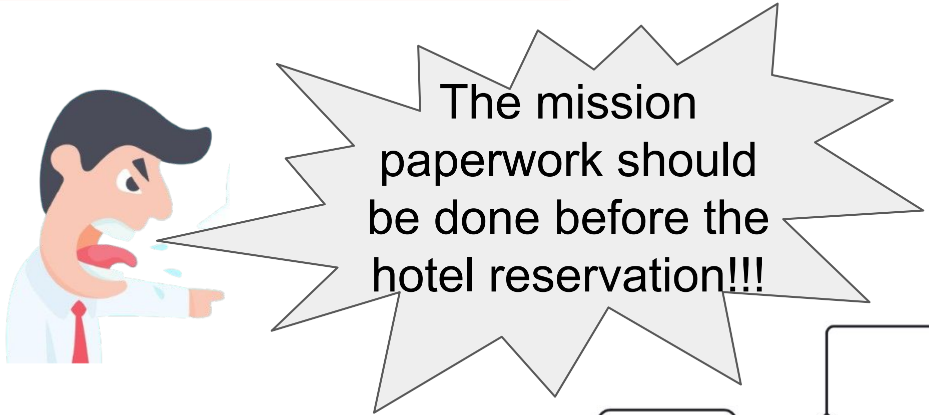
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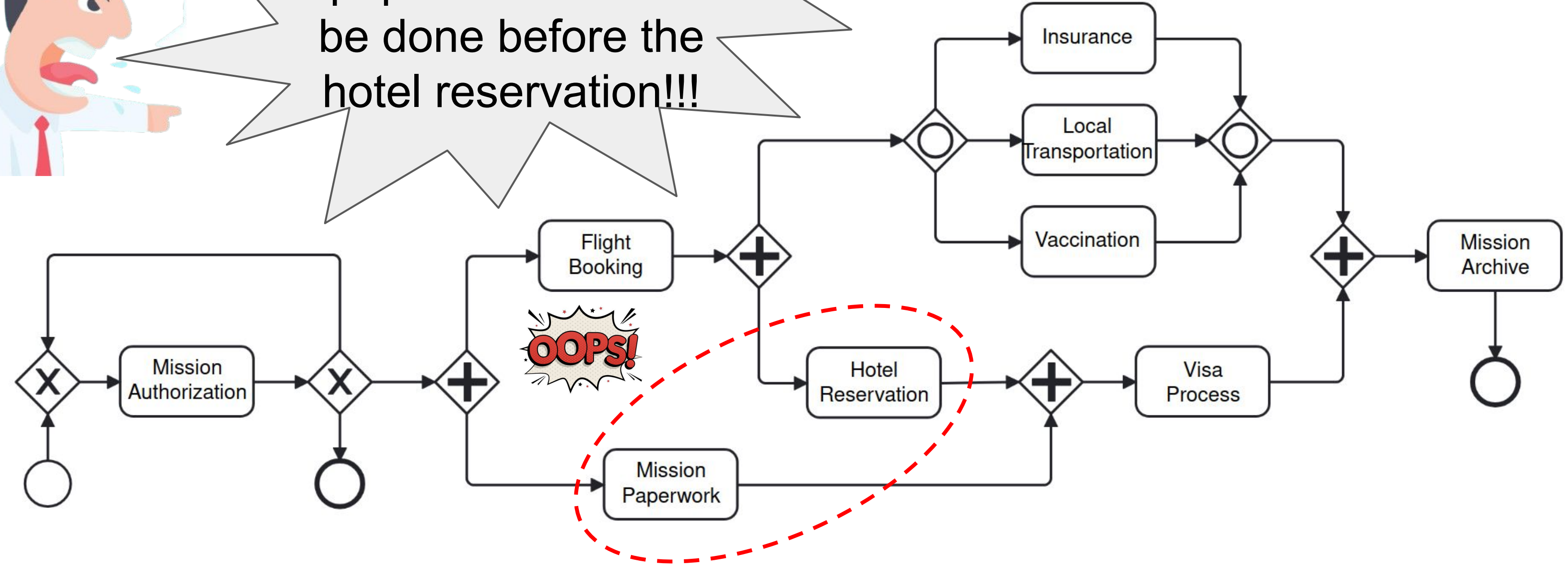
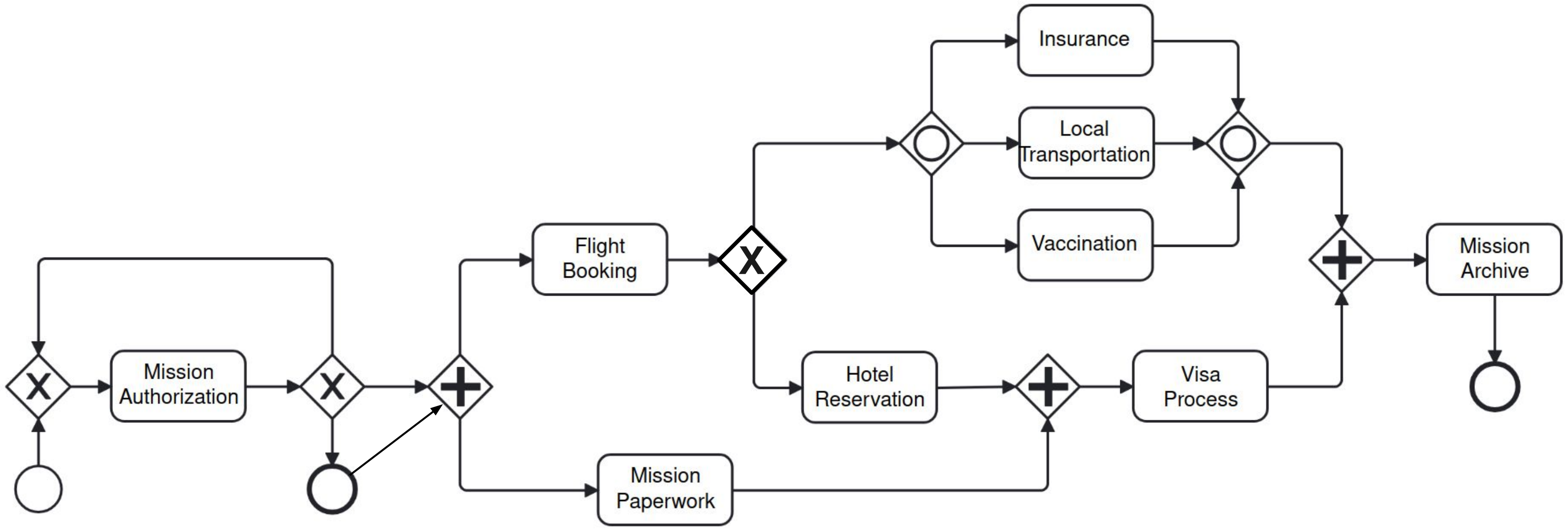
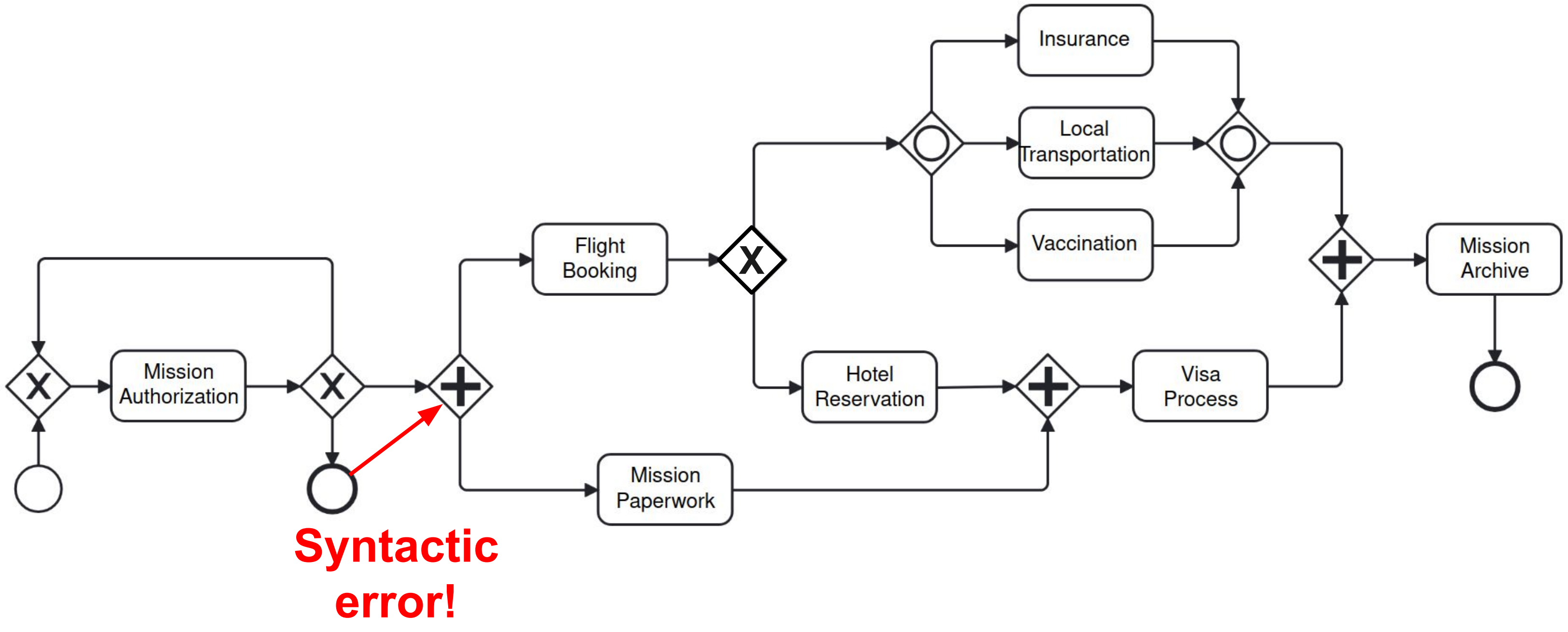


➢ How can you be sure that your BPMN process **matches its expected behaviour**?

Fourth Research Question



Fourth Research Question



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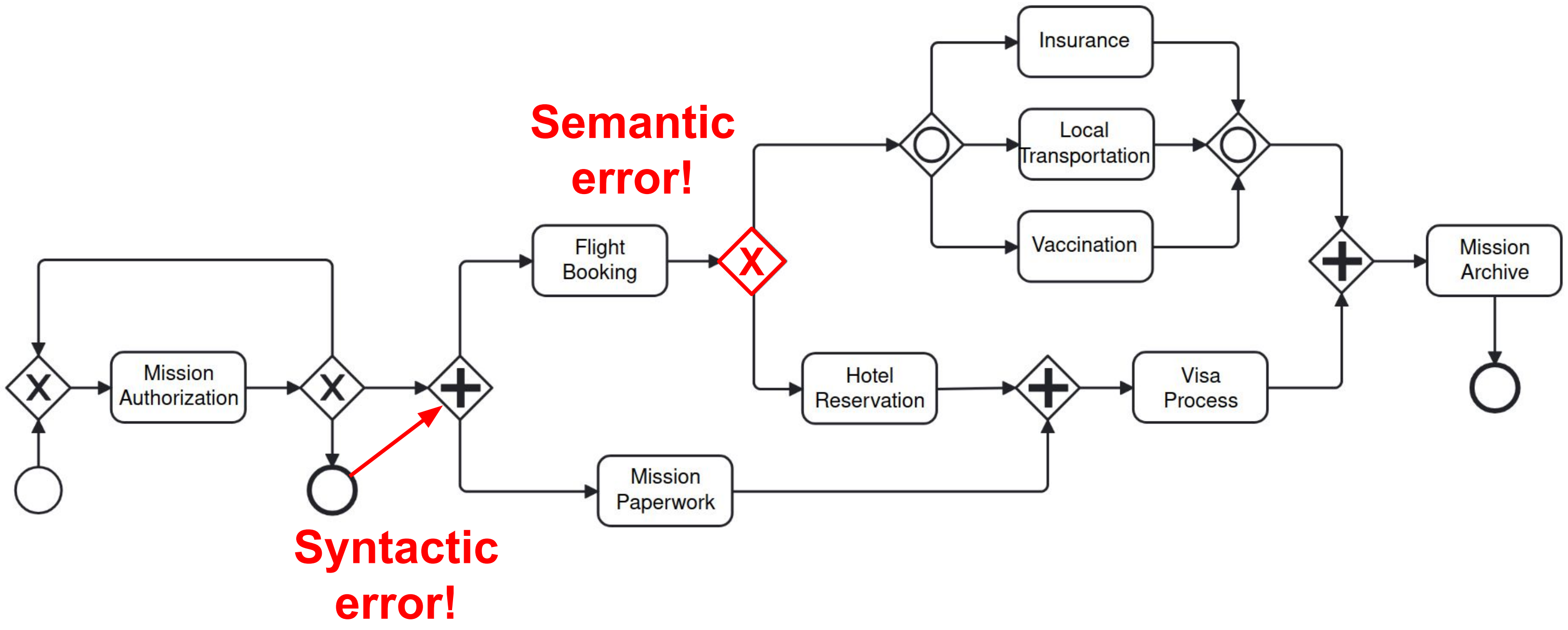
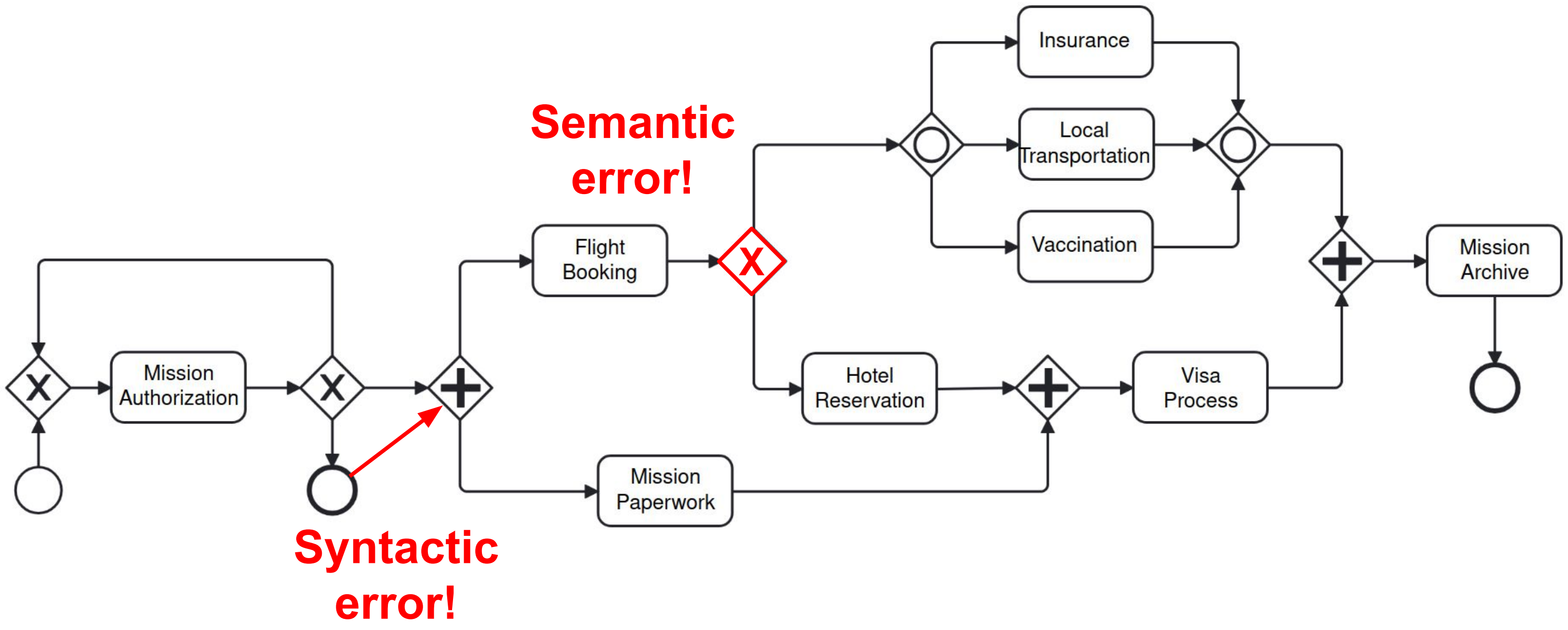


Fourth Research Question



➢ How can you be sure that your BPMN process is syntactically and semantically correct?

PhD Research Axes

- ➢ What if you do not know **how to write BPMN**?
- ➢ What if you do not want to **spend time designing** your process graphically?
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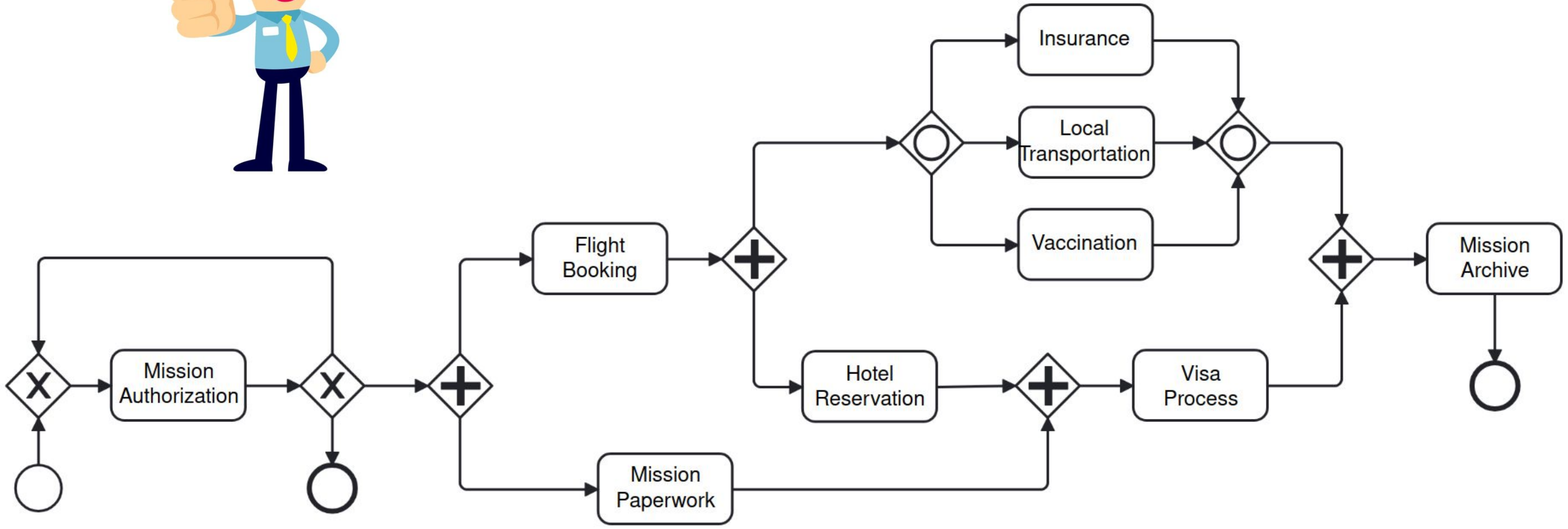
- ➢ How can you be sure that your BPMN process is **syntactically and semantically correct**?

Fifth Research Question



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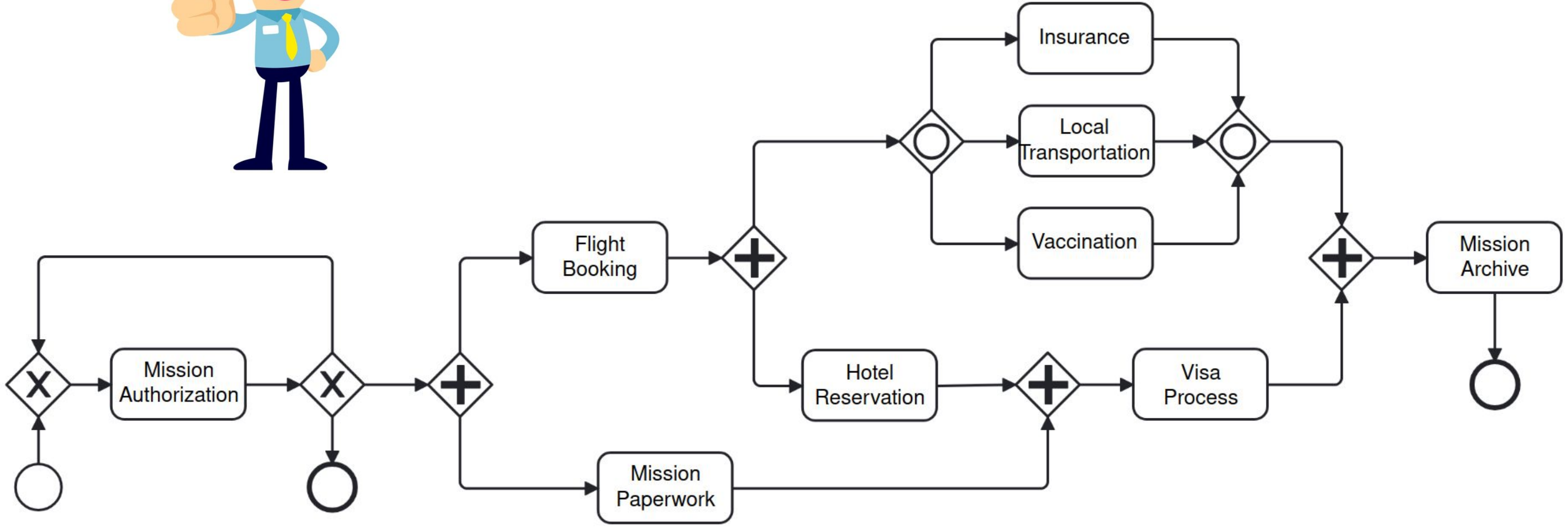

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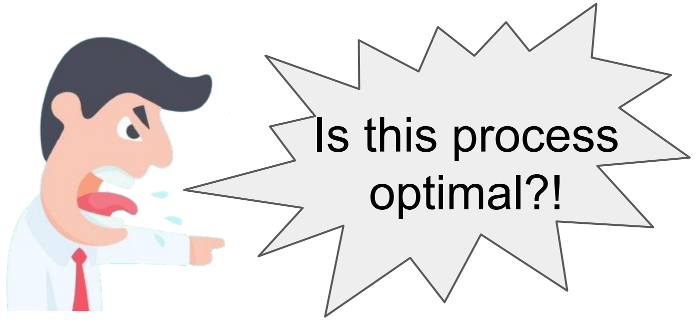

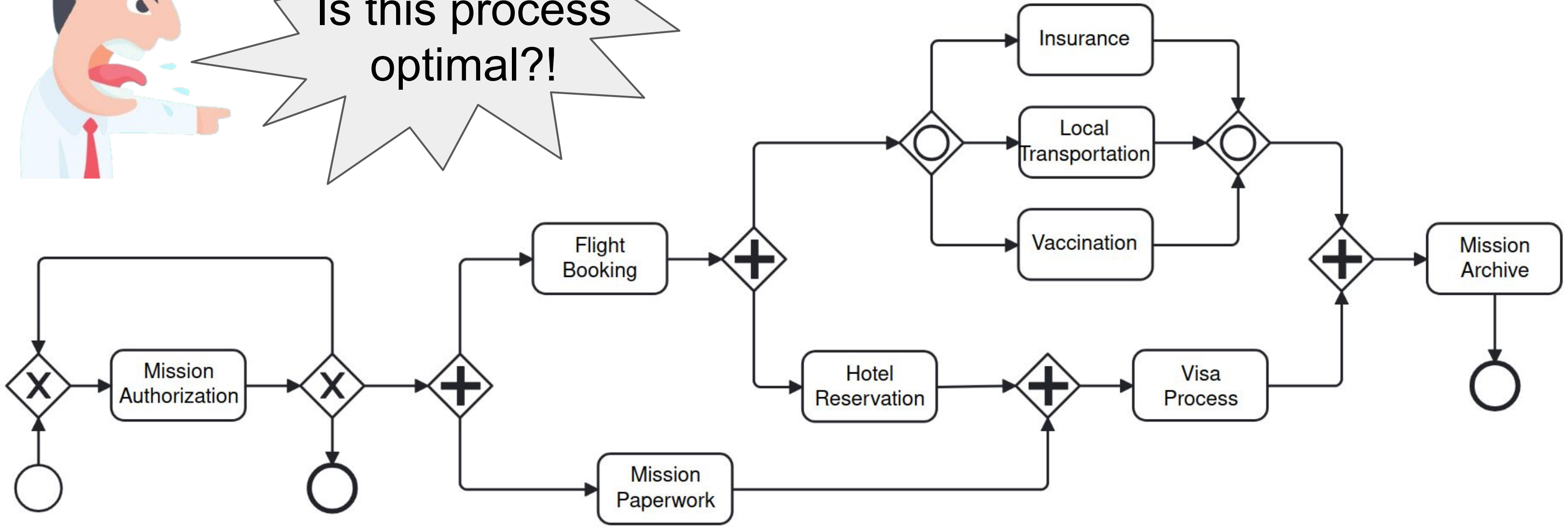

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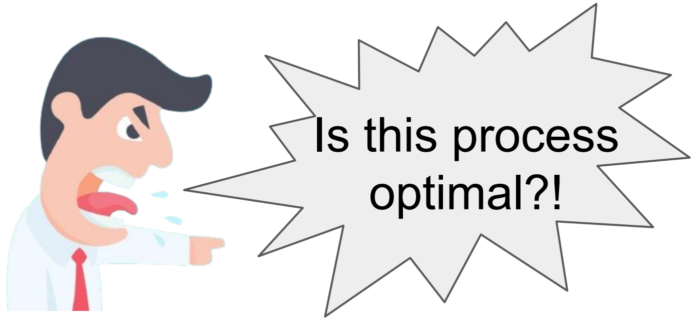
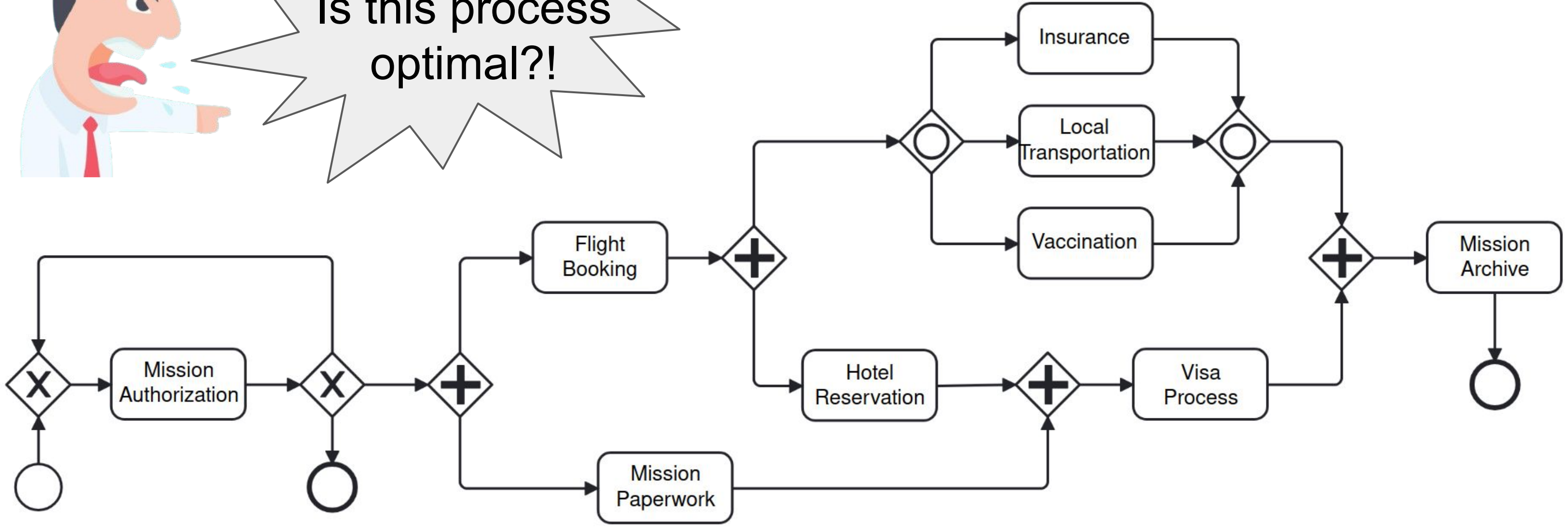
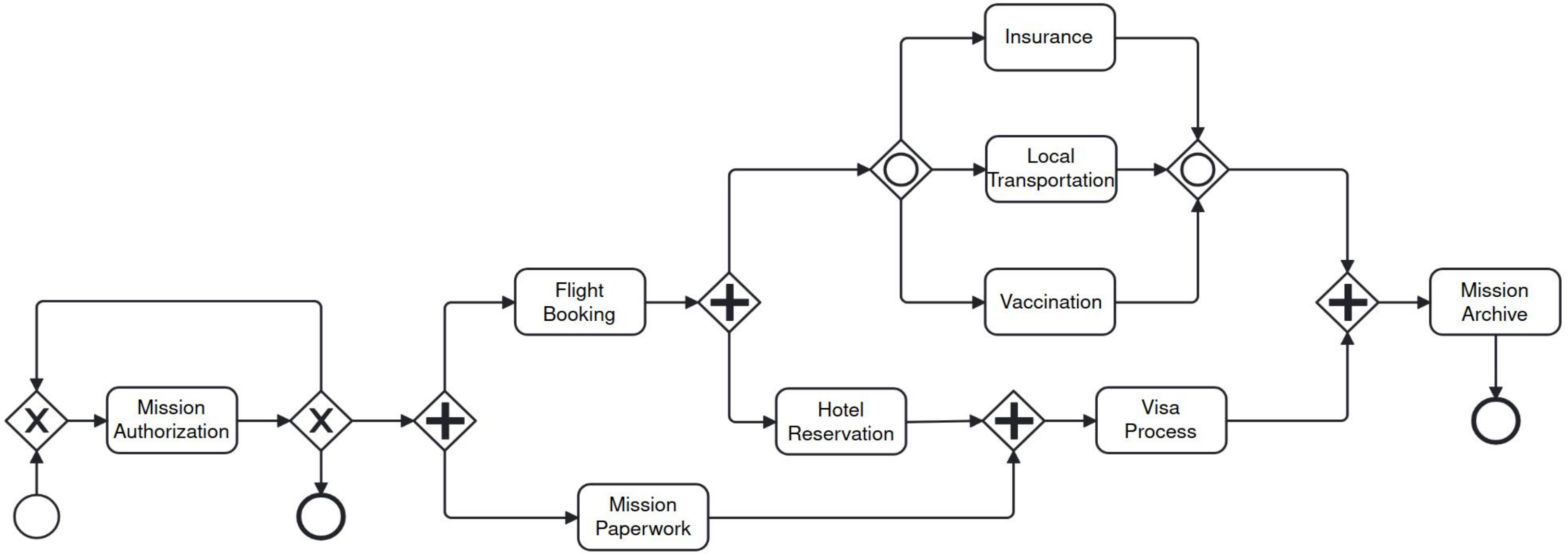




➢ In the **resource-free**, **durations-free**, **single instance** context, yes!

Fifth Research Question

But what if we enrich the process with:



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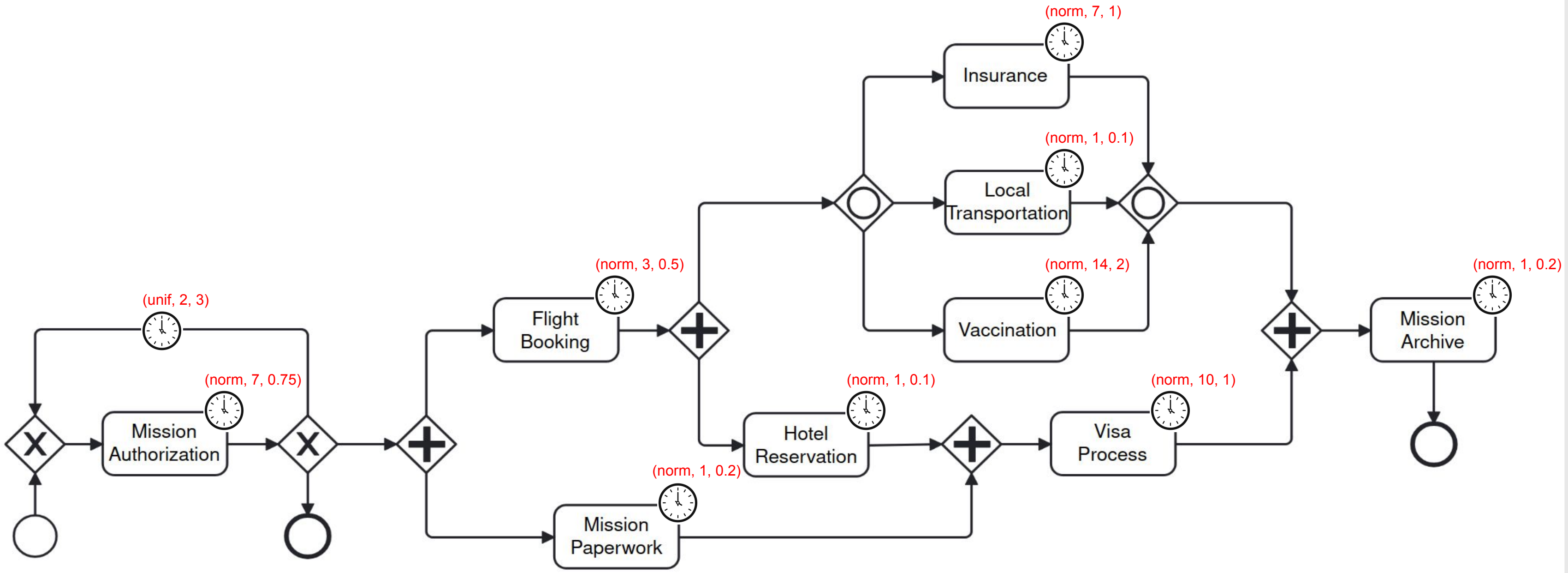
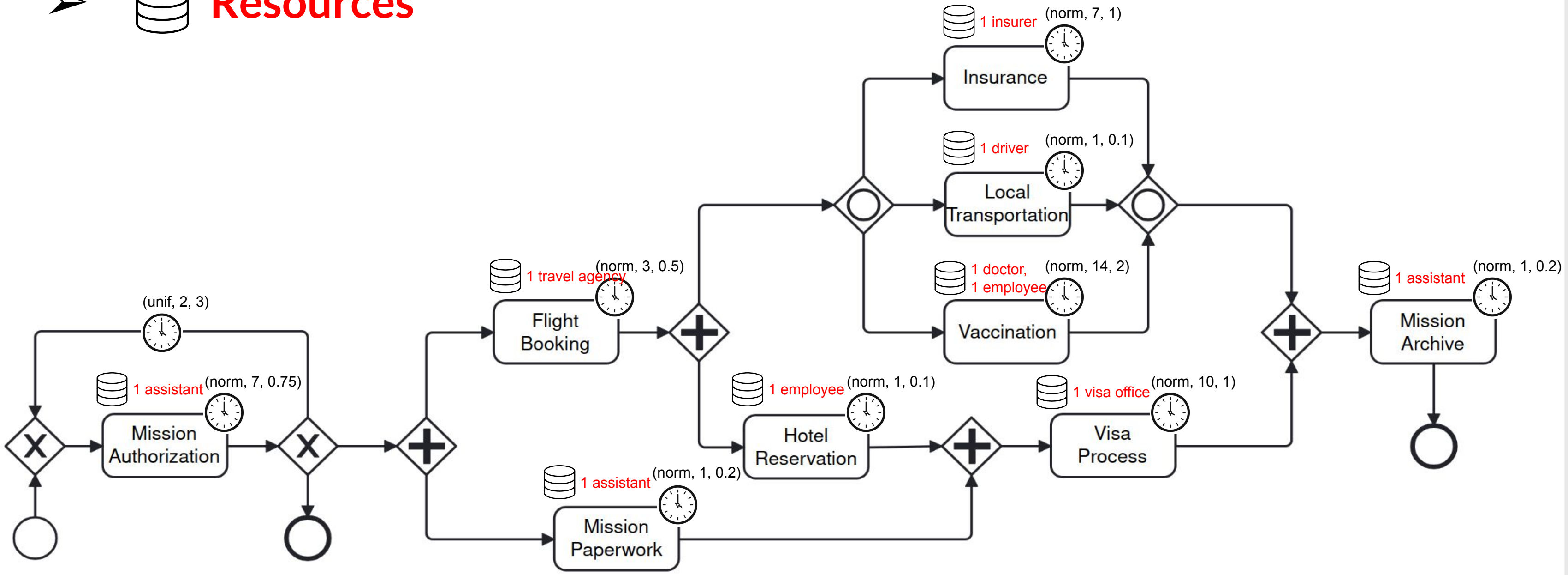
- ➢ 🕓 **Durations** (following probabilistic distributions)



Fifth Research Question

But what if we enrich the process with:

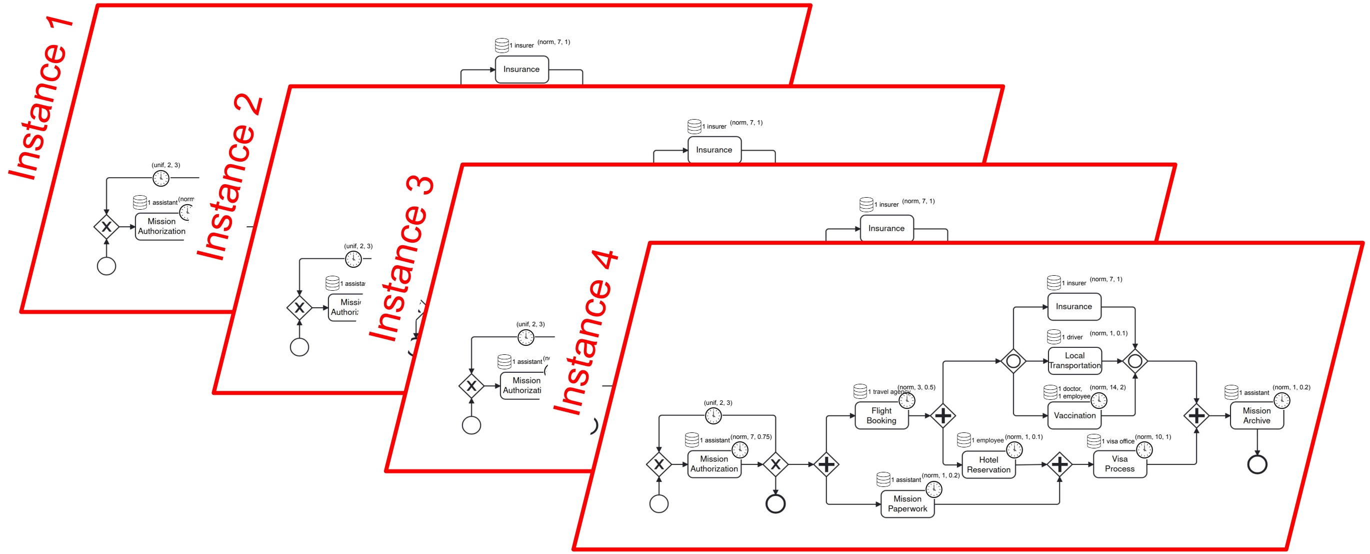
- ➢ 🕓 Durations (following probabilistic distributions)
- ➢ 🛢 Resources



Fifth Research Question

But what if we enrich the process with:

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



Fifth Research Question

The problem becomes **much more complex** with **resources**, **durations**, and **multiple executions** of the process, despite being common when dealing with business processes.

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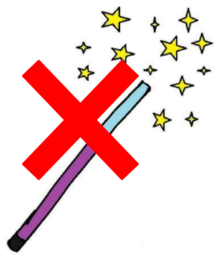
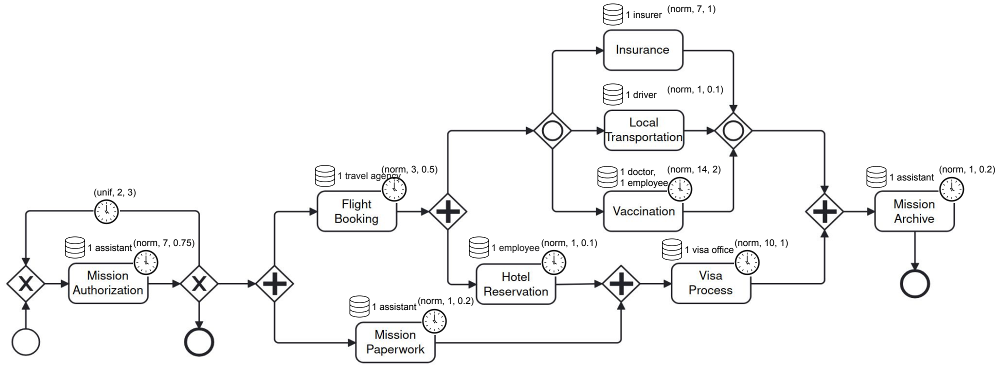
And unfortunately, there is **no magic wand** performing this task.





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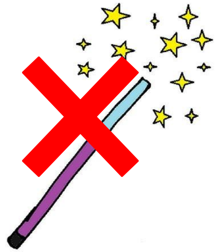

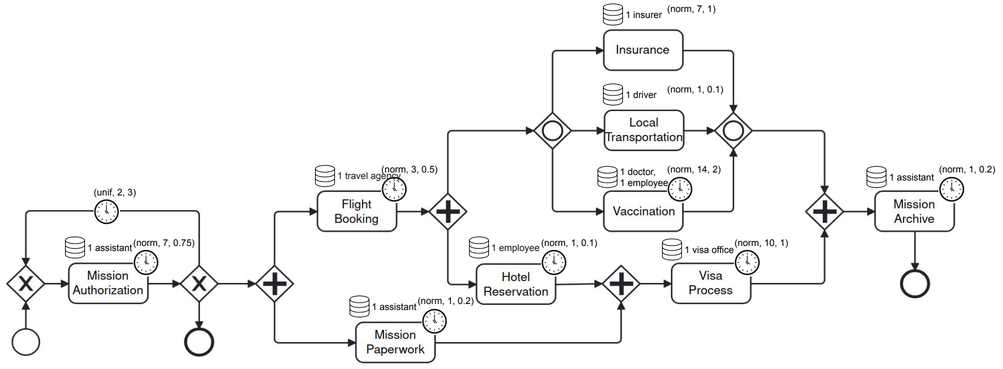

1 insurer (norm, 7, 1)
Insurance
1 driver (norm, 1, 0.1)
Local Transportation
1 doctor, 1 employee (norm, 14, 2)
Vaccination
1 travel agency (norm, 3, 0.5)
Flight Booking
(unif, 2, 3)
1 assistant (norm, 7, 0.75)
Mission Authorization
1 employee (norm, 1, 0.1)
Hotel Reservation
1 visa office (norm, 10, 1)
Visa Process
1 assistant (norm, 1, 0.2)
Mission Paperwork
1 assistant (norm, 1, 0.2)
Mission Archive

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

PhD Research Axes

- ➢ What if you do not know how to write BPMN?
- ➢ What if you do not want to spend time designing your process graphically?
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- ➢ How can you **optimise** a BPMN process in real-world conditions?

Published Results

I

- ➢ What if you do not know how to write BPMN?
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→ [ICSOC’24]

→ [FSE’25]

→ [TSE’25]*

II

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

→ [SEFM’23]

→ [QRS’24]

→ [SoSyM’25]*

Focus of this Presentation

Ⅰ

- ➢ What if you do not know how to write BPMN?
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[ICSOC'24]

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[TSE'25]*

Ⅱ

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

[SEFM'23]

[QRS'24]

[SoSyM'25]*

Plan

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)

Textual Representation of the Process

Global Picture of the Approach

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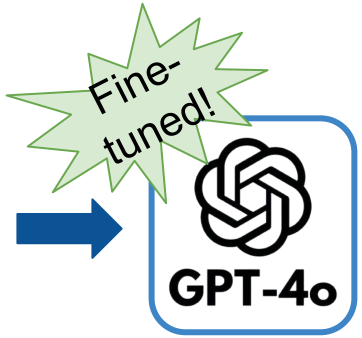
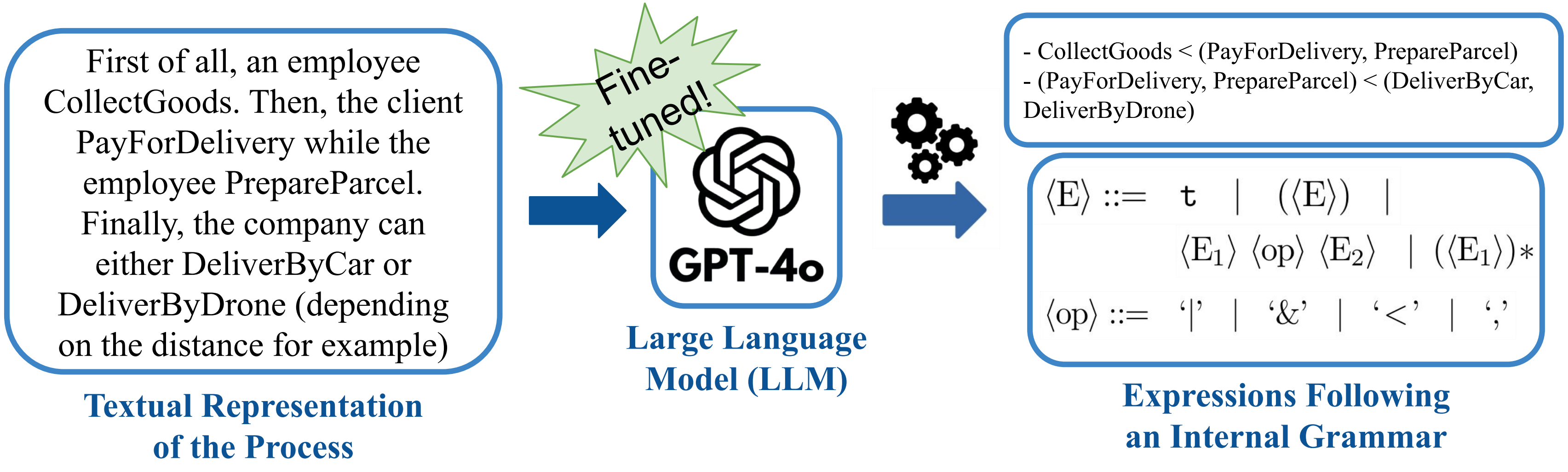


Large Language Model (LLM)

Global Picture of the Approach



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Textual Representation of the Process

Large Language Model (LLM)

- CollectGoods < (PayForDelivery, PrepareParcel)
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$$\begin{aligned} \langle \mathrm{E} \rangle &::= \texttt{t} \mid (\langle \mathrm{E} \rangle) \mid \langle \mathrm{E}_1 \rangle\, \langle \mathrm{op} \rangle\, \langle \mathrm{E}_2 \rangle \mid (\langle \mathrm{E}_1 \rangle)* \\ \langle \mathrm{op} \rangle &::= \text{‘}|\text{’} \mid \text{‘}\&\text{’} \mid \text{‘}<\text{’} \mid \text{‘};\text{’} \end{aligned}$$

Expressions Following an Internal Grammar

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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)

Textual Representation of the Process

Fine-tuned!

GPT-4o

Large Language Model (LLM)

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$$
\begin{aligned}
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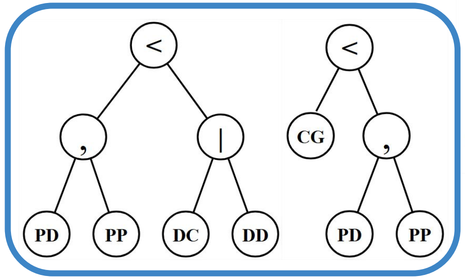
&\quad \langle E_1\rangle\,\langle op\rangle\,\langle E_2\rangle \mid (\langle E_1\rangle)* \\
\langle op\rangle &::= \text{‘}|\text{’} \mid \text{‘}\&\text{’} \mid \text{‘}<\text{’} \mid \text{‘},\text{’}
\end{aligned}
$$

Expressions Following an Internal Grammar



Abstract Syntax Trees

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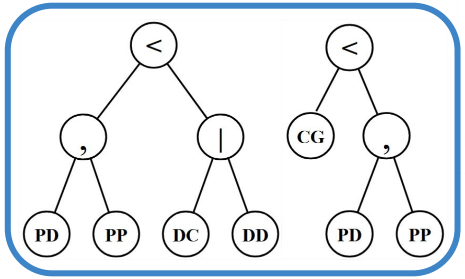

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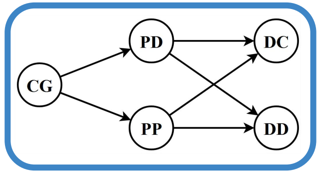

Dependency Graph (Skeleton of the Process)

Global Picture of the Approach

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GPT-4o

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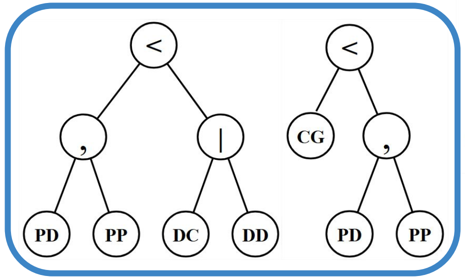

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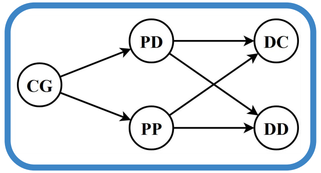

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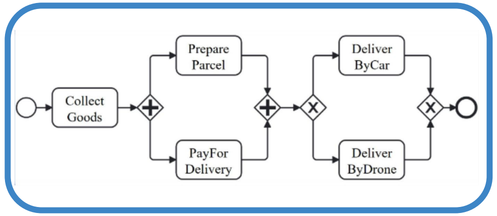

BPMN Process

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)

Textual Representation of the Process

Fine-tuned!

GPT-4o

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$$
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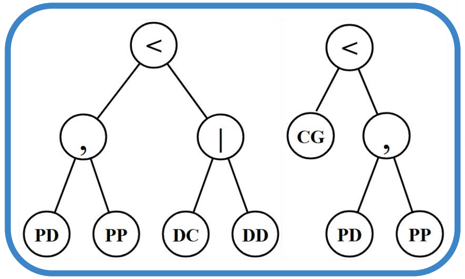
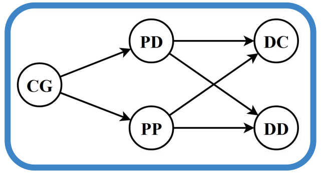
\end{aligned}
$$

Expressions Following an Internal Grammar

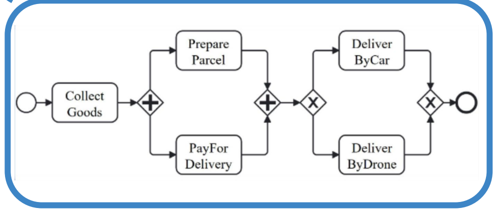


Abstract Syntax Trees



Dependency Graph (Skeleton of the Process)

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).

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**).

Fine-tuned!

GPT-4o

Detailed Approach – Step 2 – LLM Prompting

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Fine-tuned!

GPT-4o

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

$$\langle \mathrm{E} \rangle ::= \mathtt{t} \;\mid\; (\langle \mathrm{E} \rangle) \;\mid\; \langle \mathrm{E}_1 \rangle \; \langle \mathrm{op} \rangle \; \langle \mathrm{E}_2 \rangle \;\mid\; (\langle \mathrm{E}_1 \rangle)*$$

$$\langle \mathrm{op} \rangle ::= \text{‘}|\text{’} \;\mid\; \text{‘}\&\text{’} \;\mid\; \text{‘}<\text{’} \;\mid\; \text{‘};\text{’}$$

Detailed Approach – Step 3 – Expressions

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

DP < (BCO | RF)

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

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Detailed Approach – Step 4 – ASTs Mapping

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

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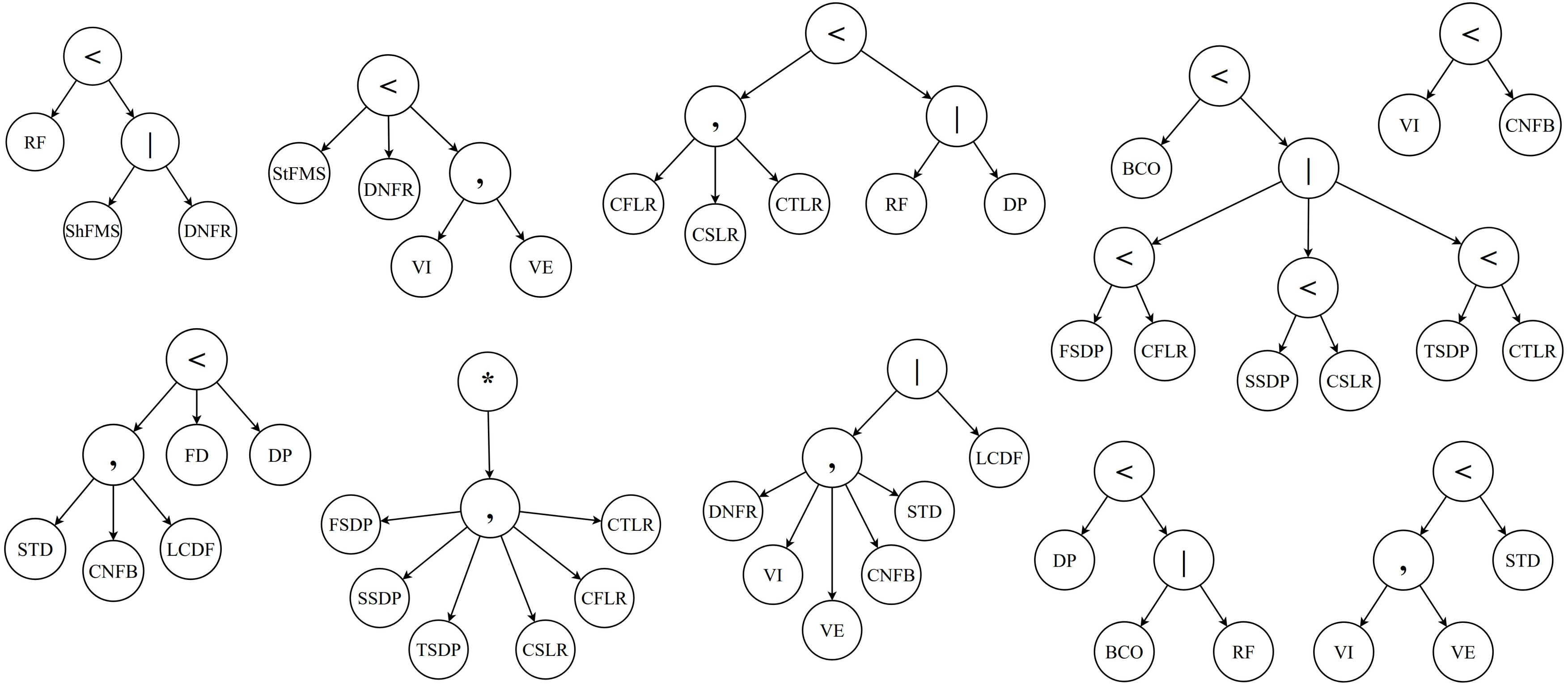

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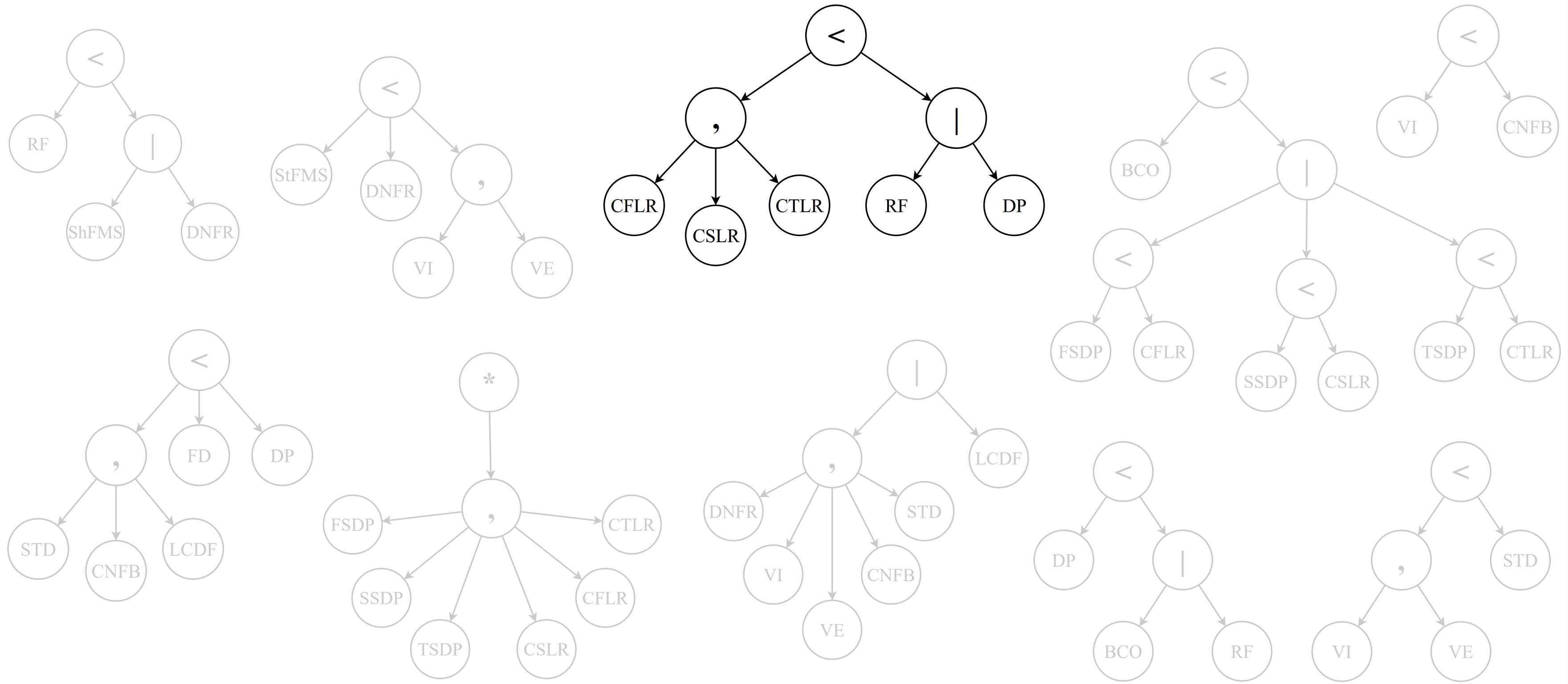

Detailed Approach – Step 5 – Dependency Graph

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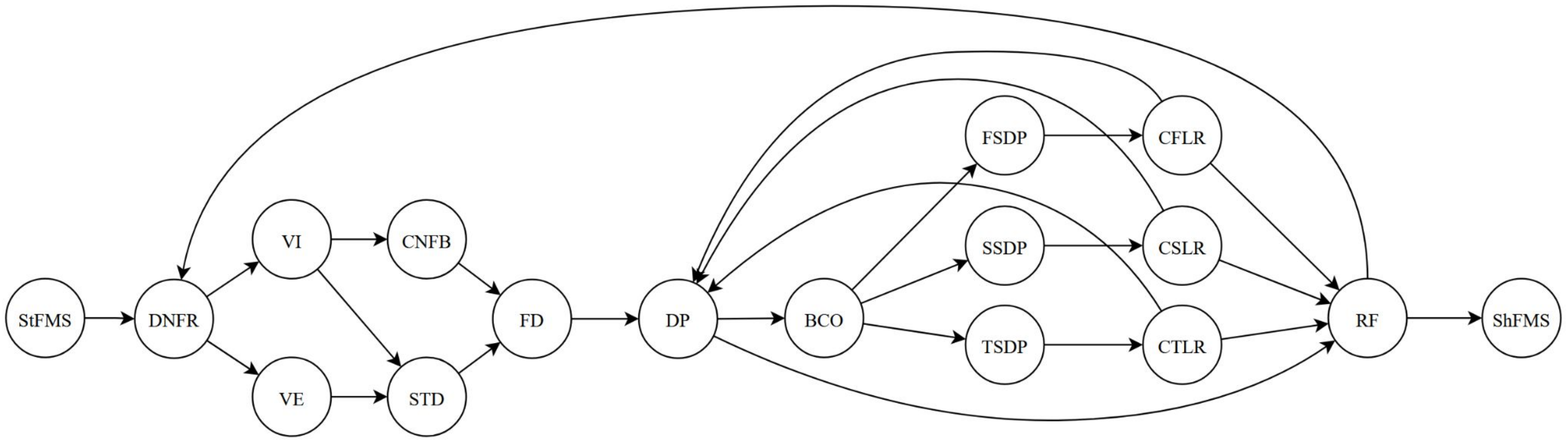

Detailed Approach – Step 6 – BPMN Generation

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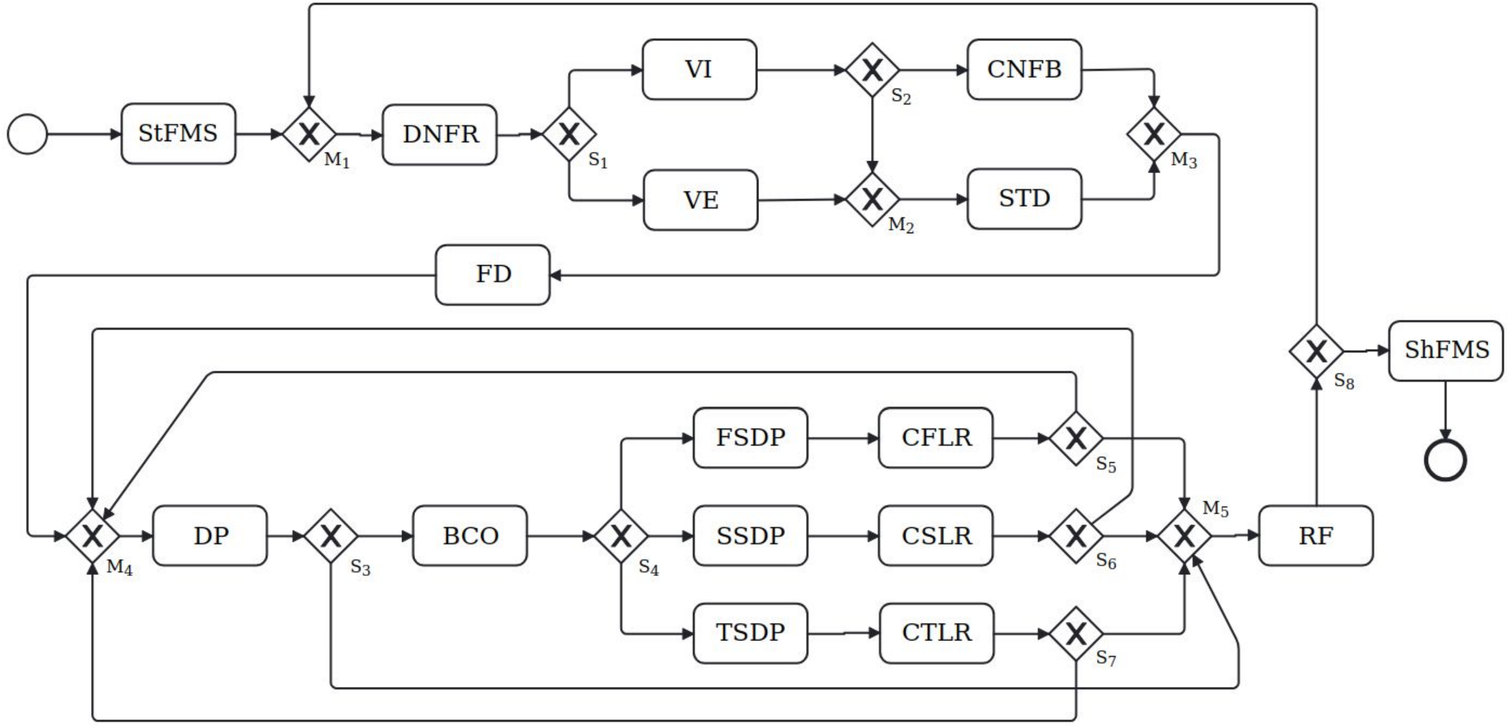

Detailed Approach – Step 6.1 – Mutual Exclusions

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Let us recall what mutual exclusion is.

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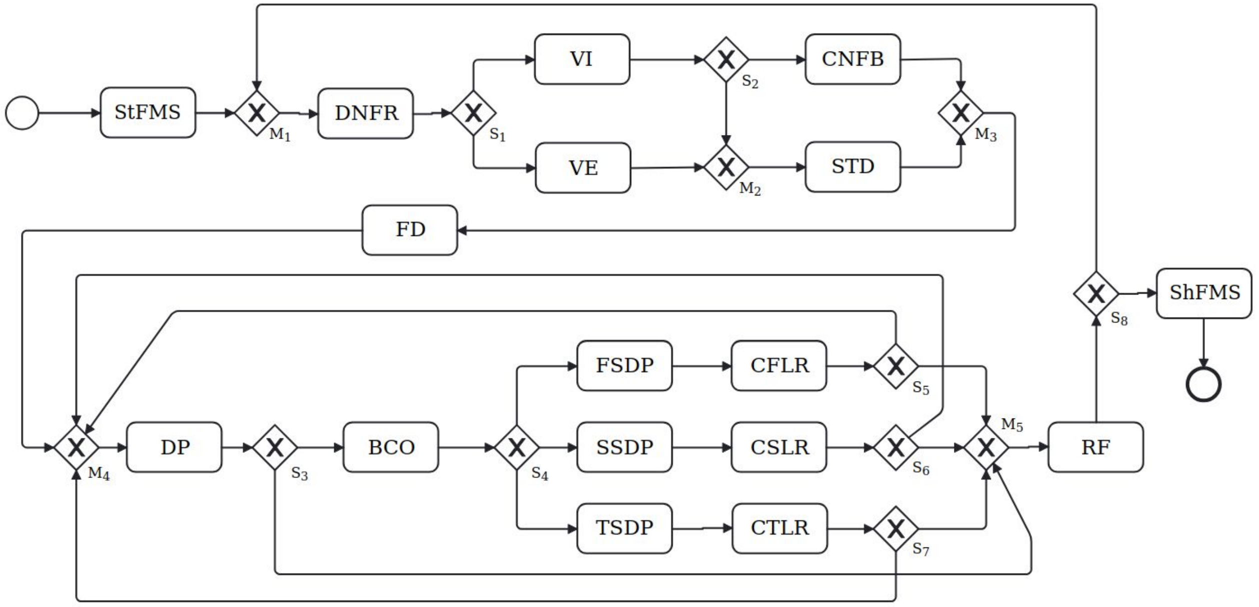

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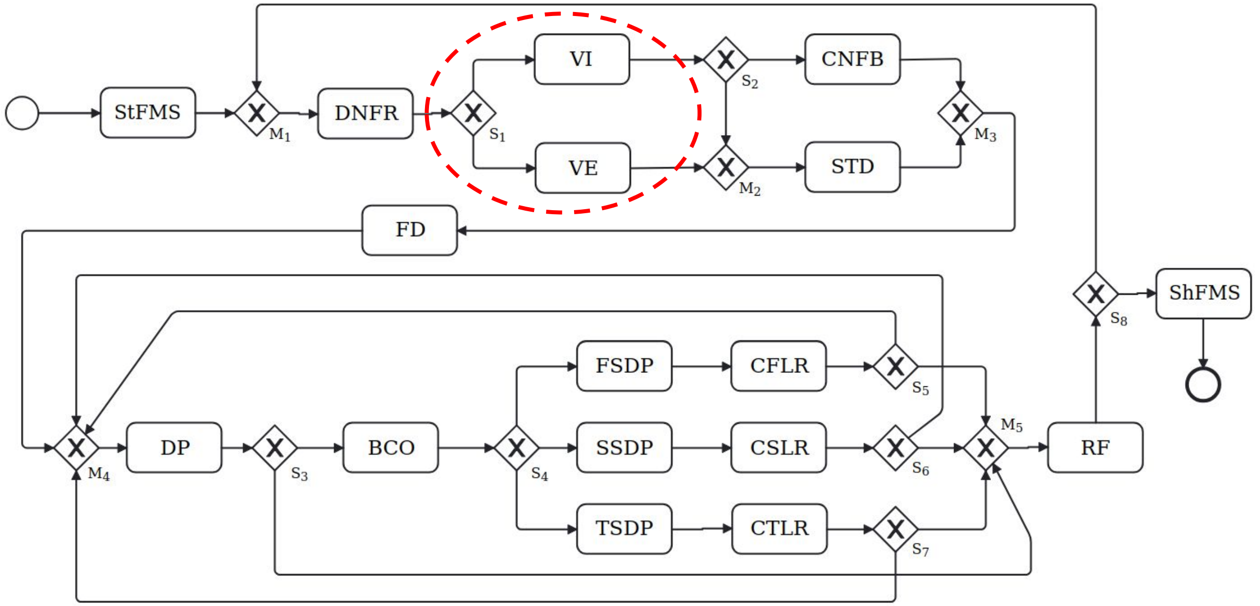

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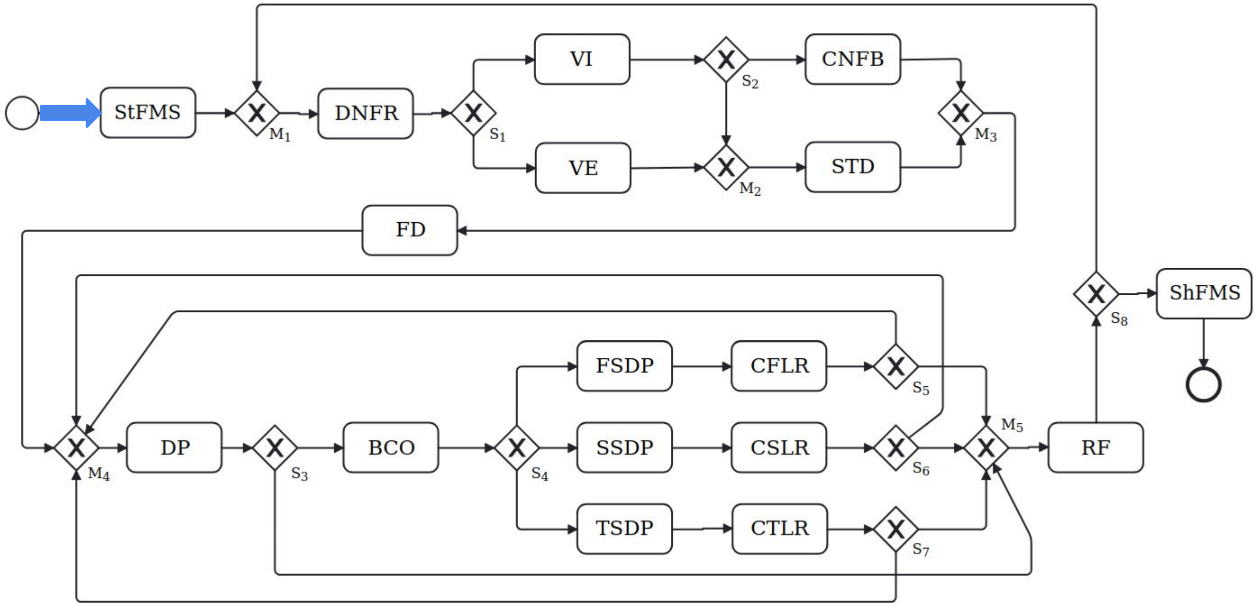

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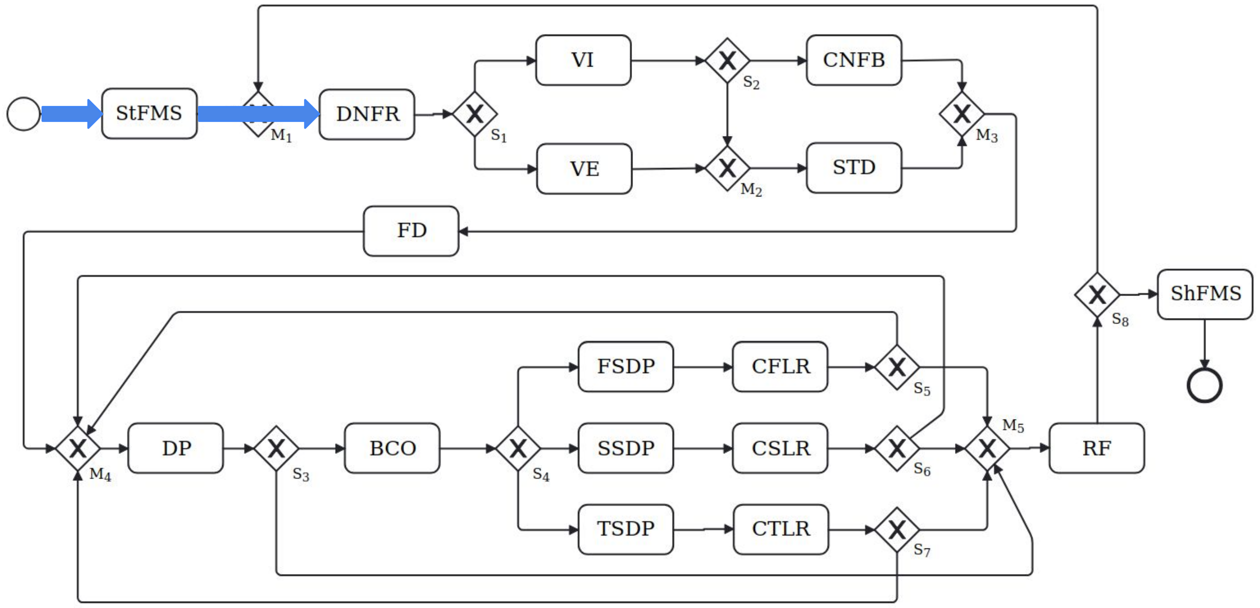

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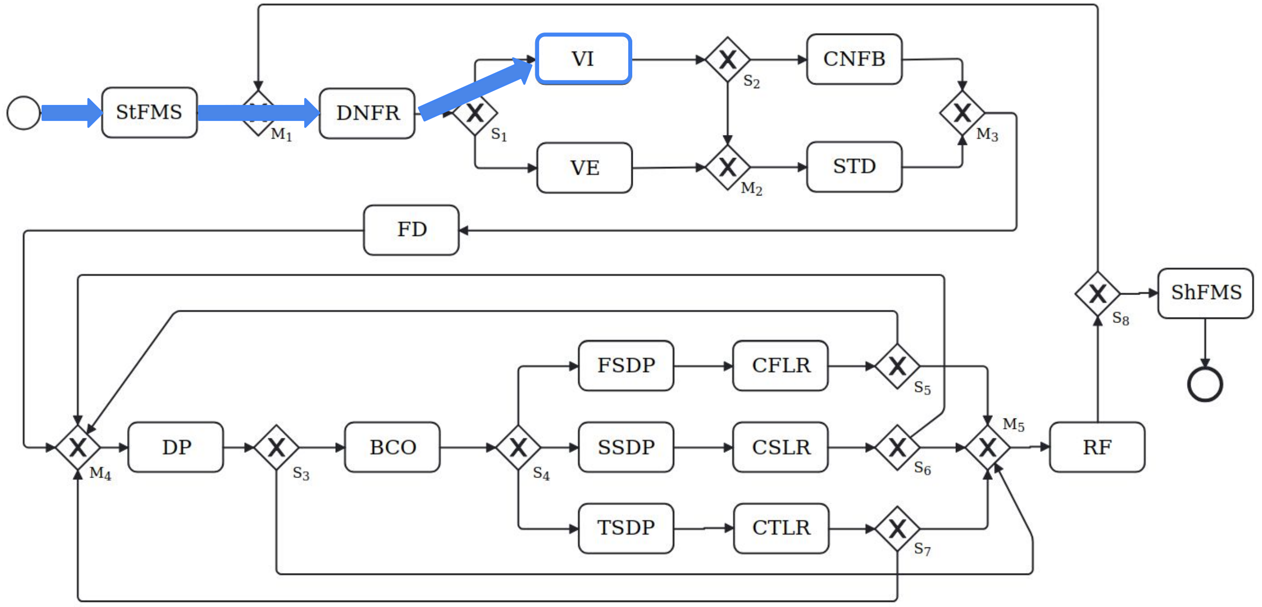

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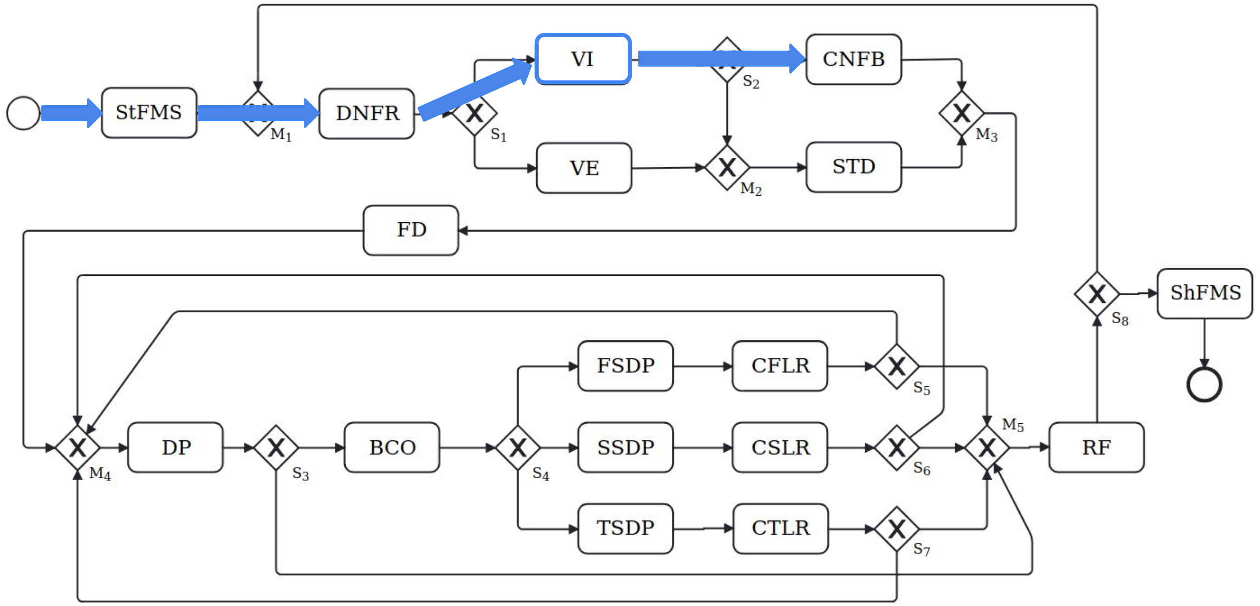

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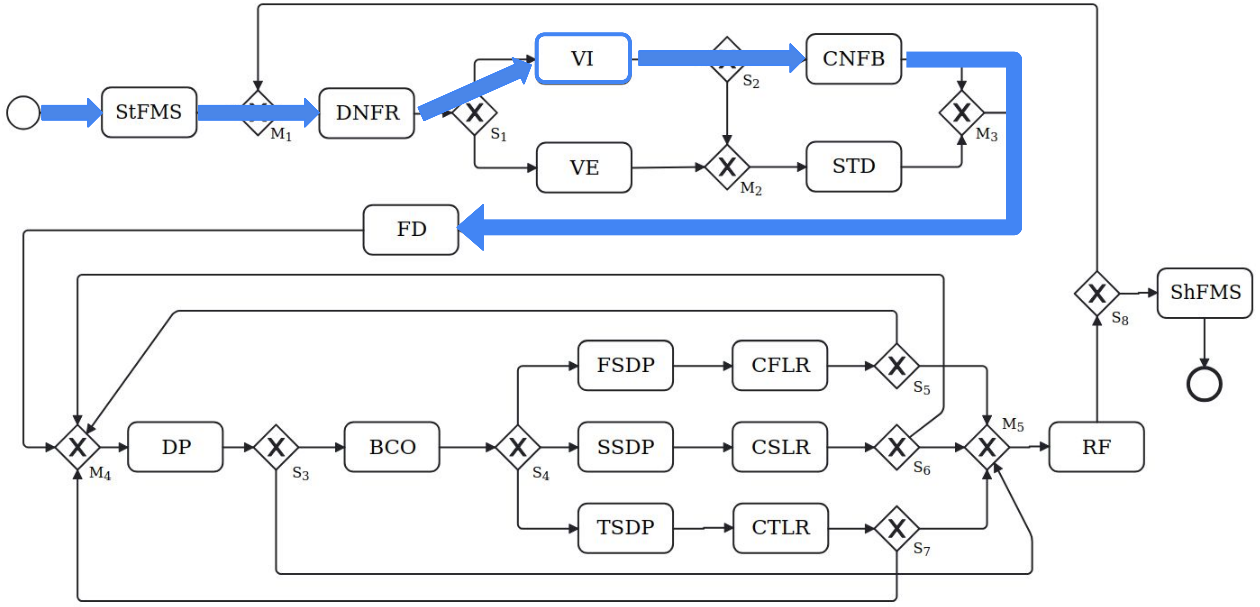

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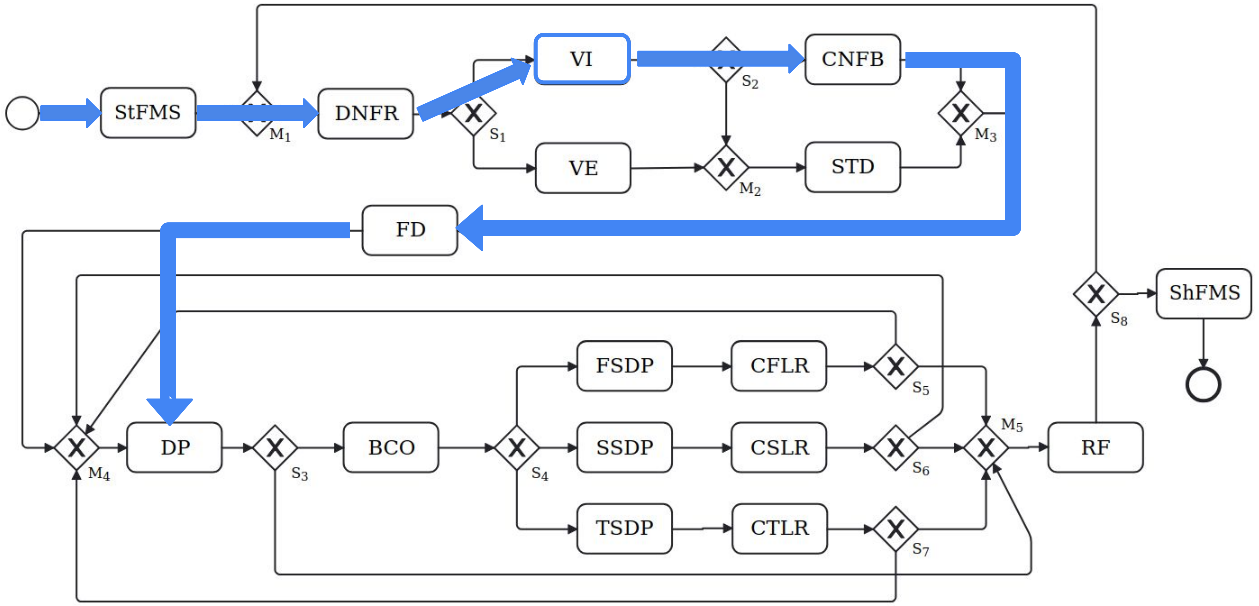

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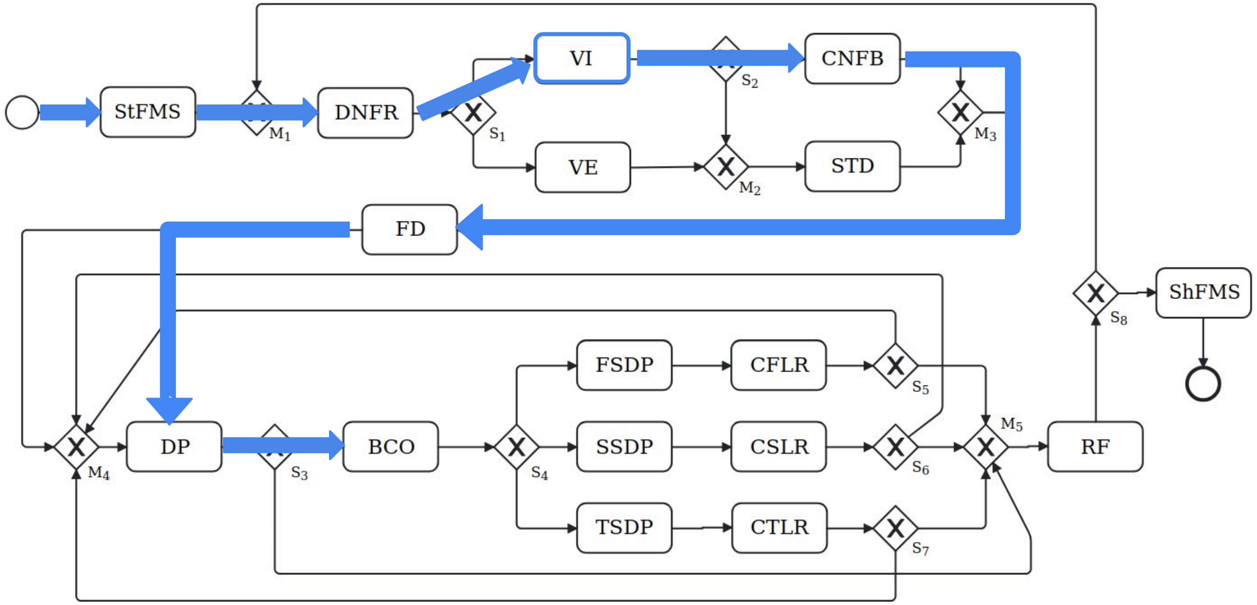

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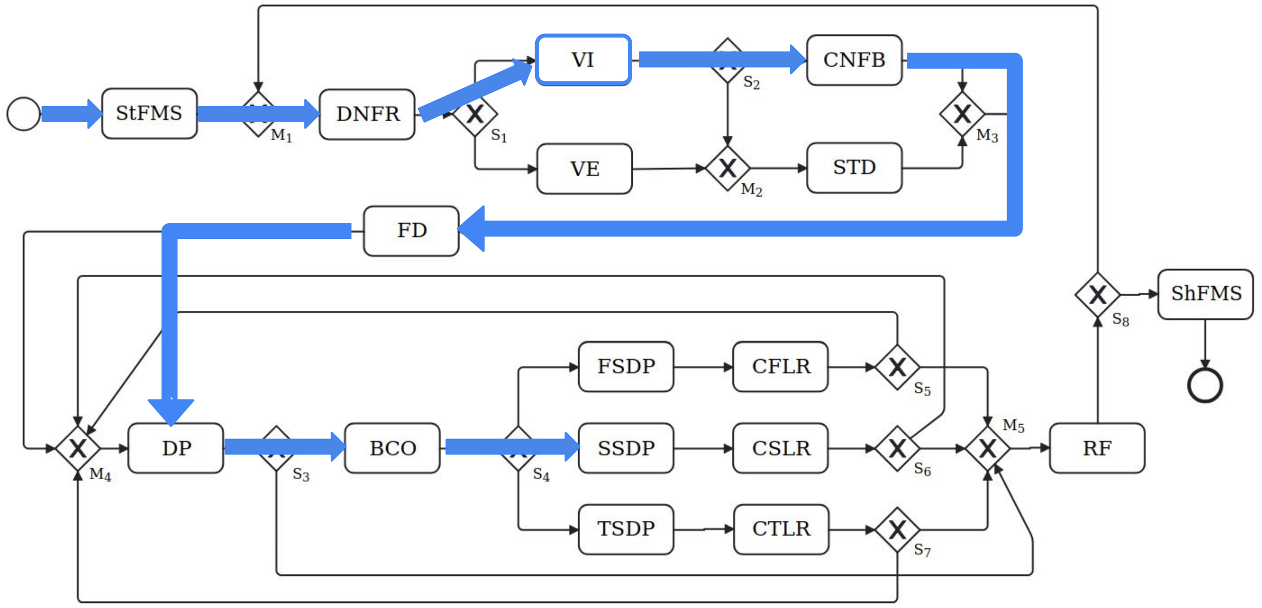

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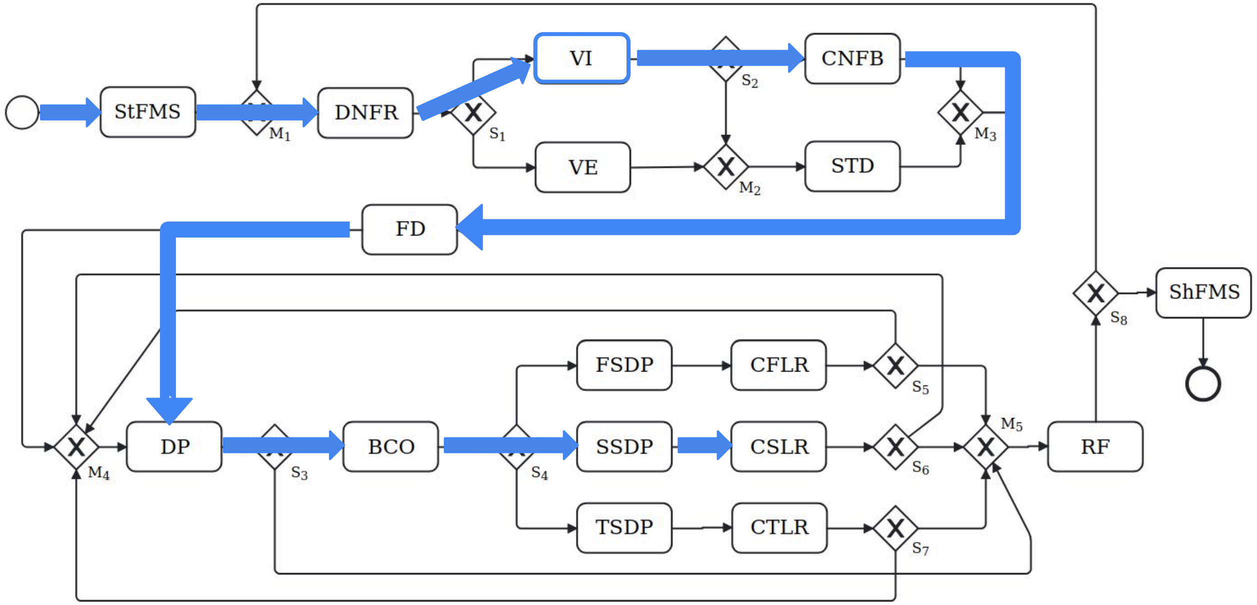

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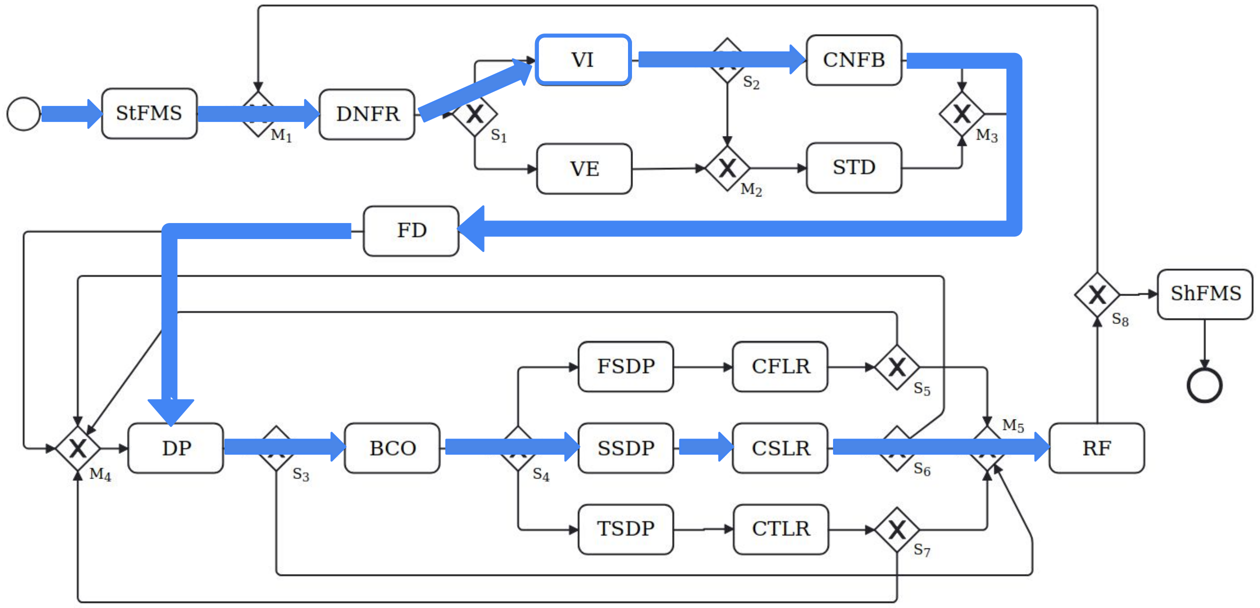

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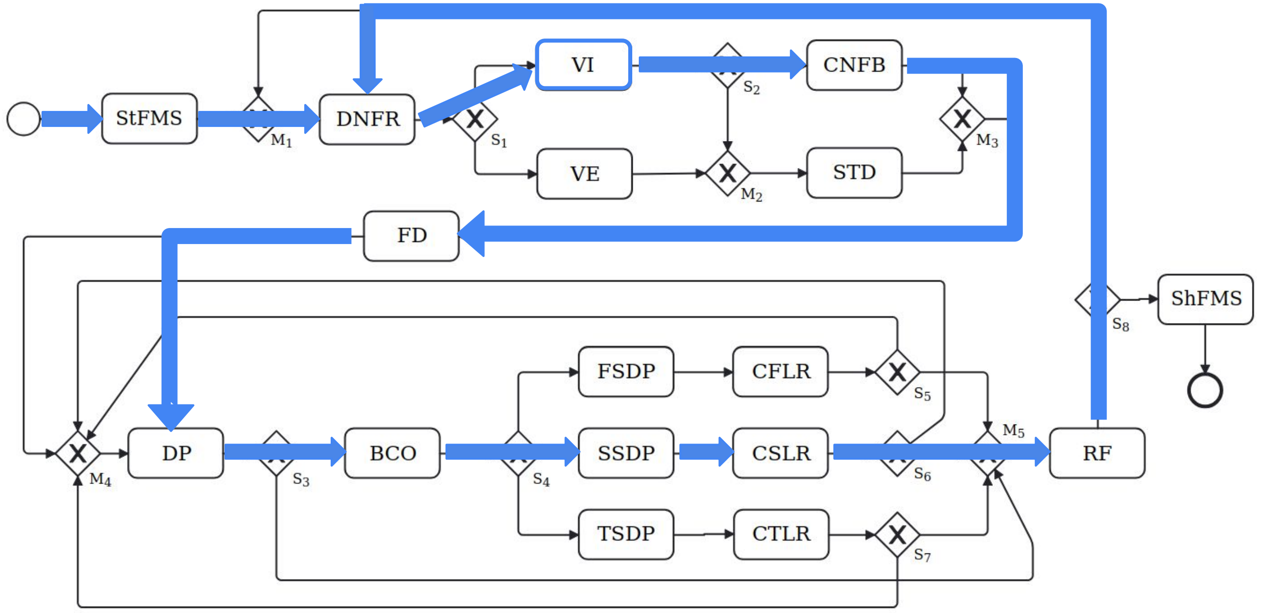

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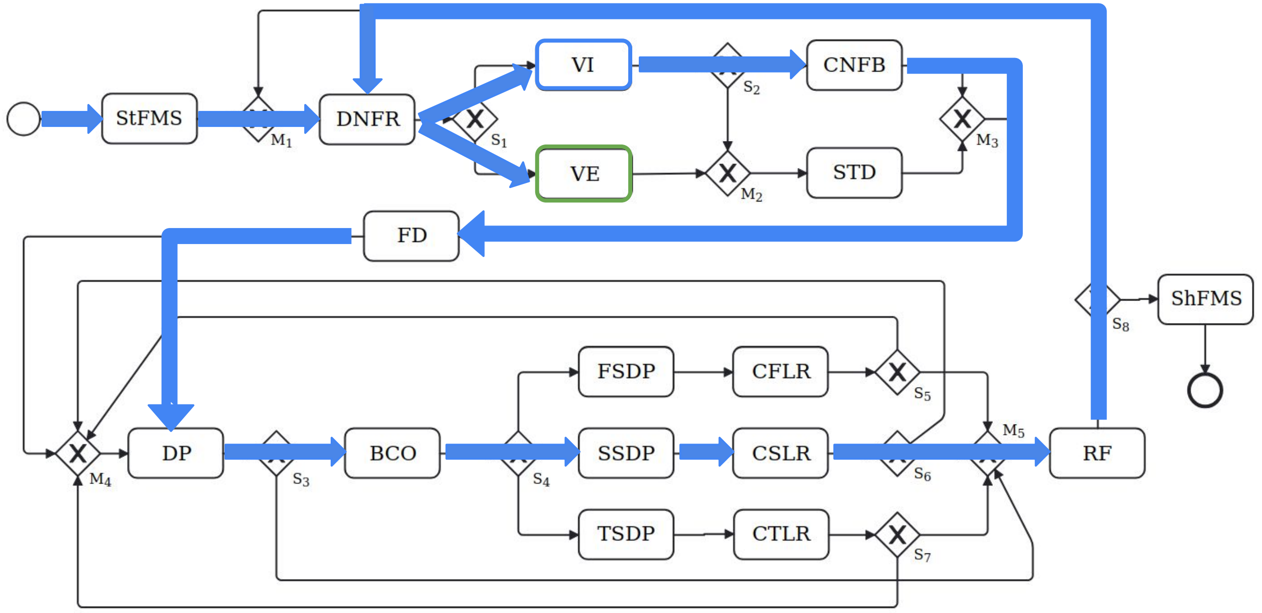

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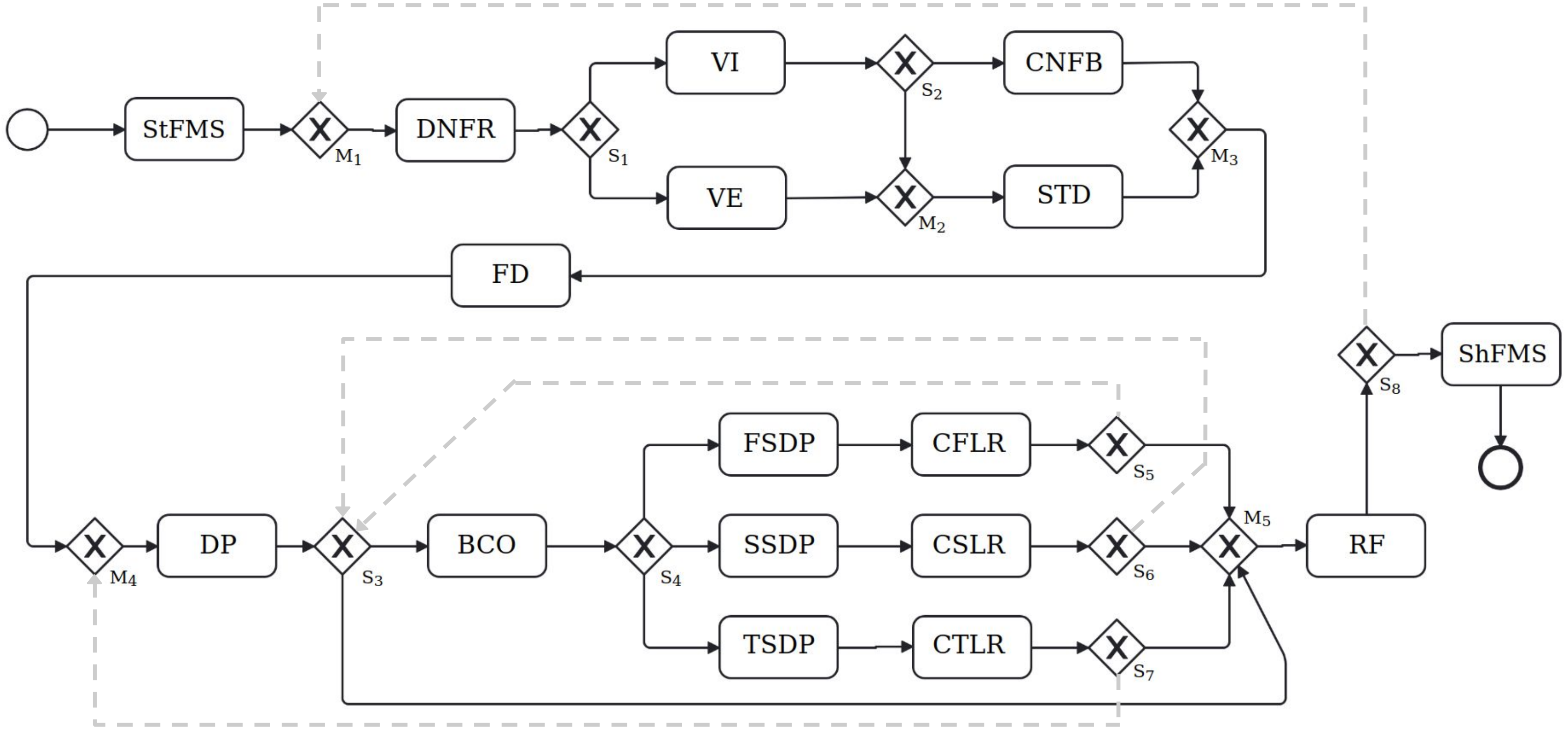

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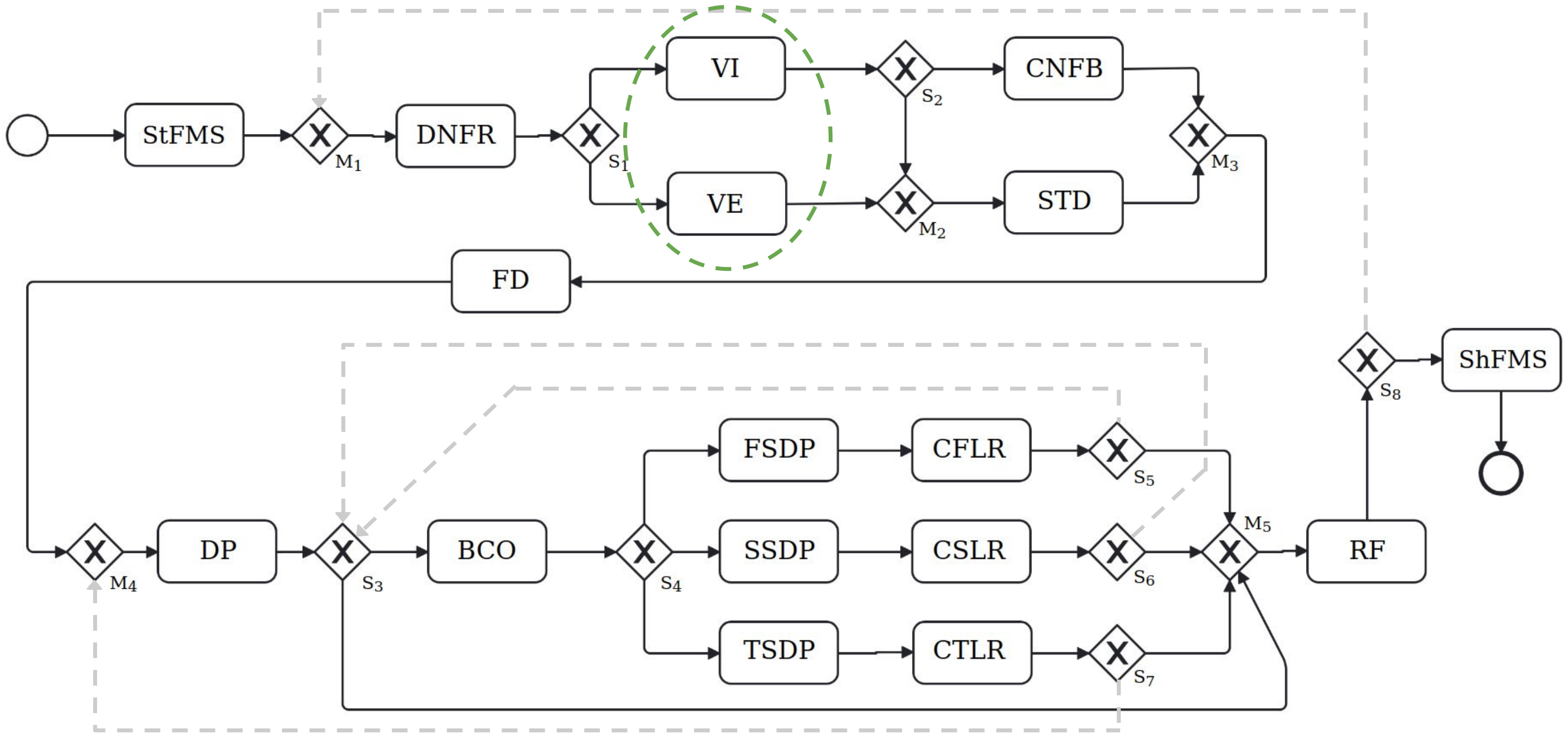

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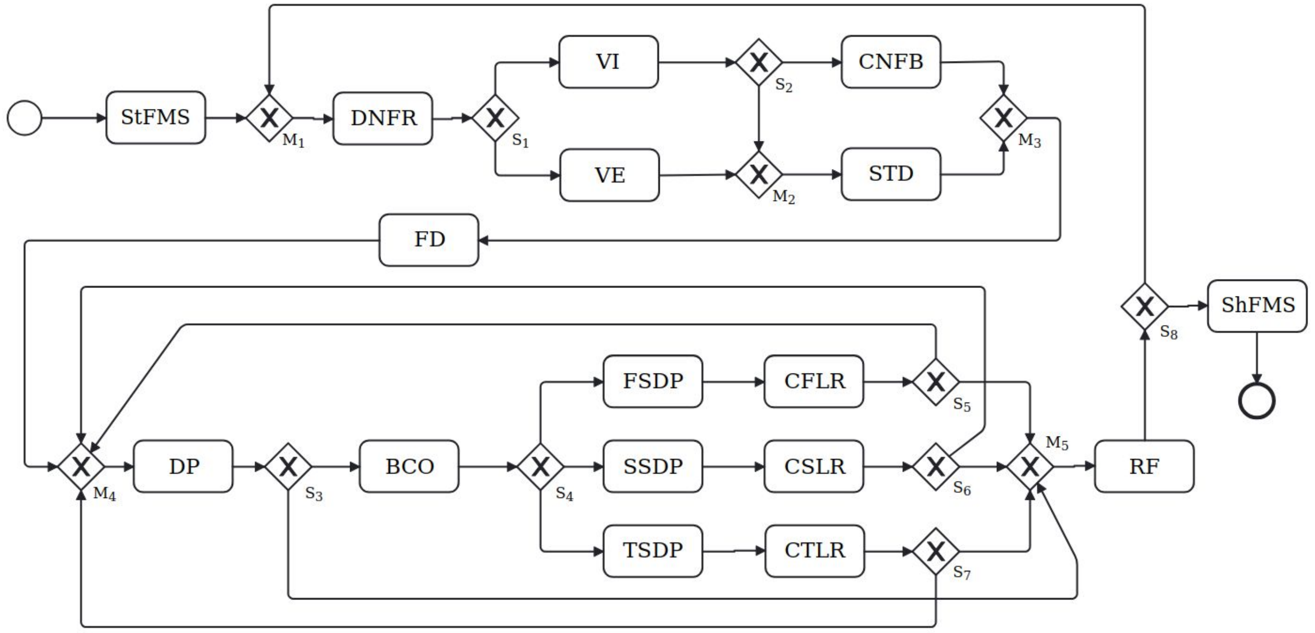

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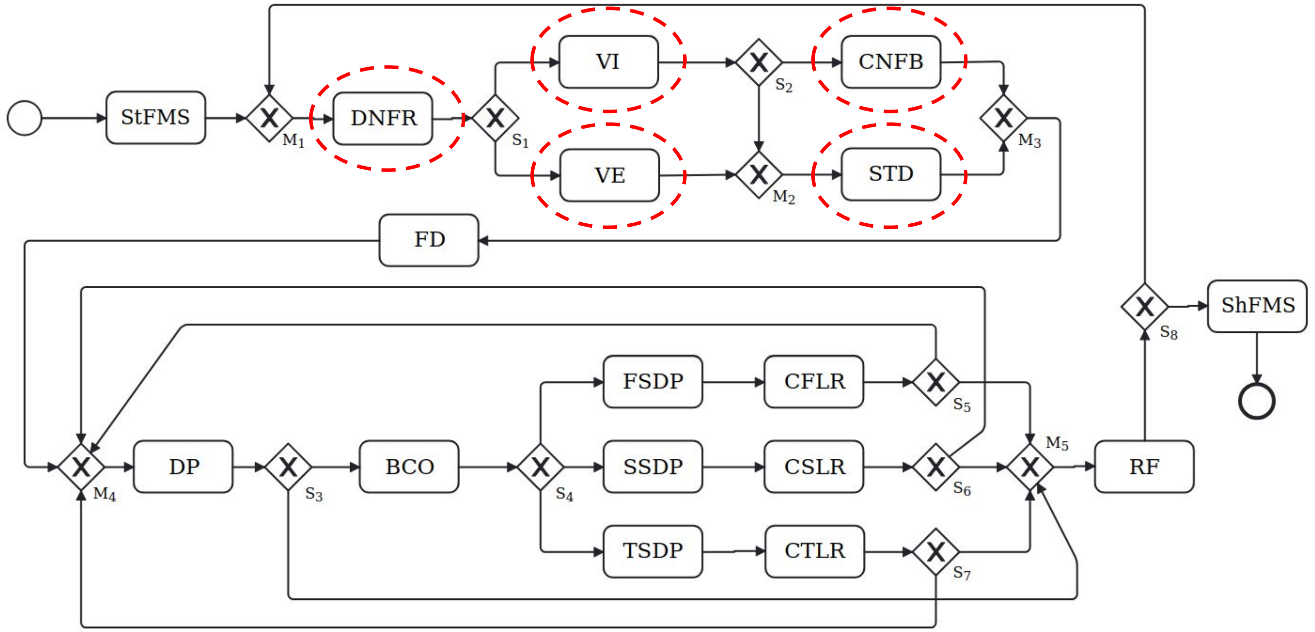

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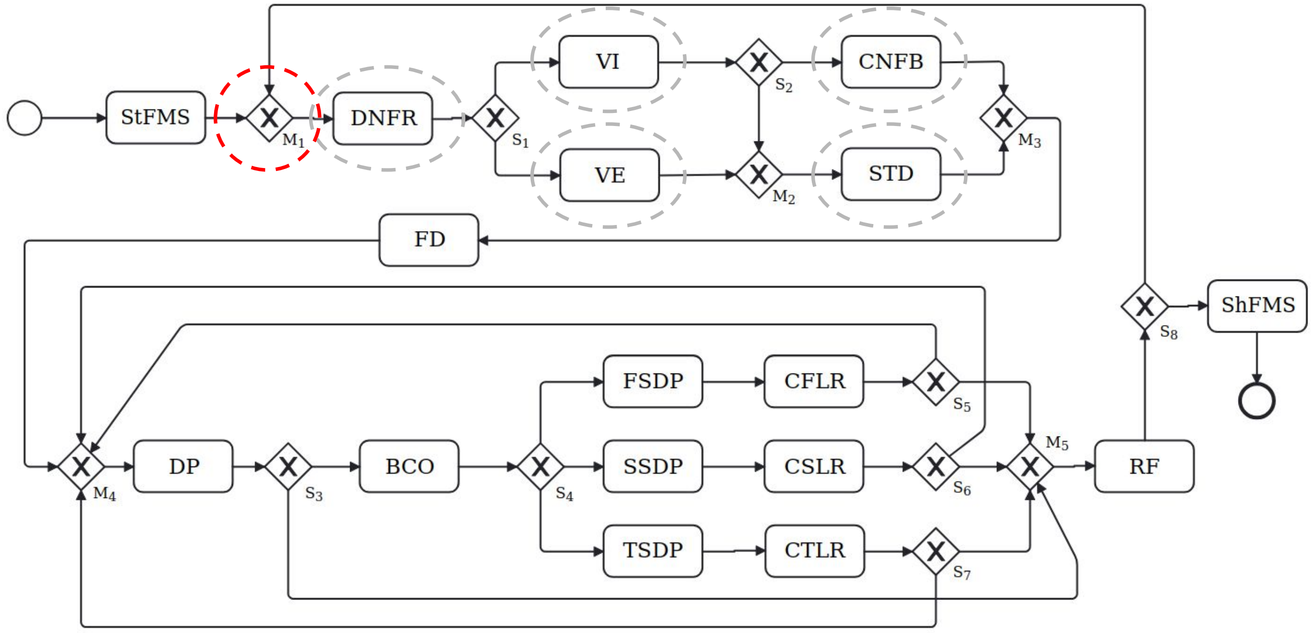

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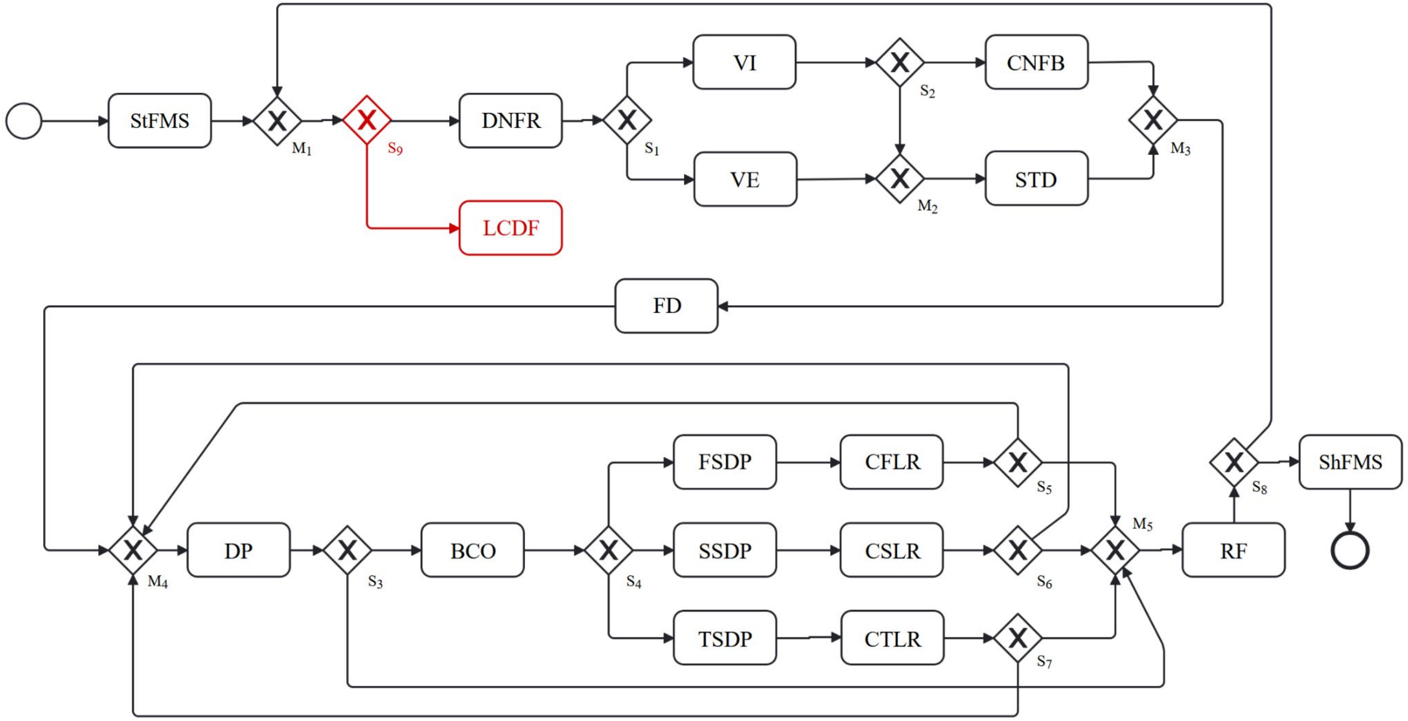
Adding the task **LCDF** as child of this gateway modifies the process so as to make tasks **DNFR**, **VI**, **VE**, **CNFB** and **STD** mutually exclusive of task **LCDF**.



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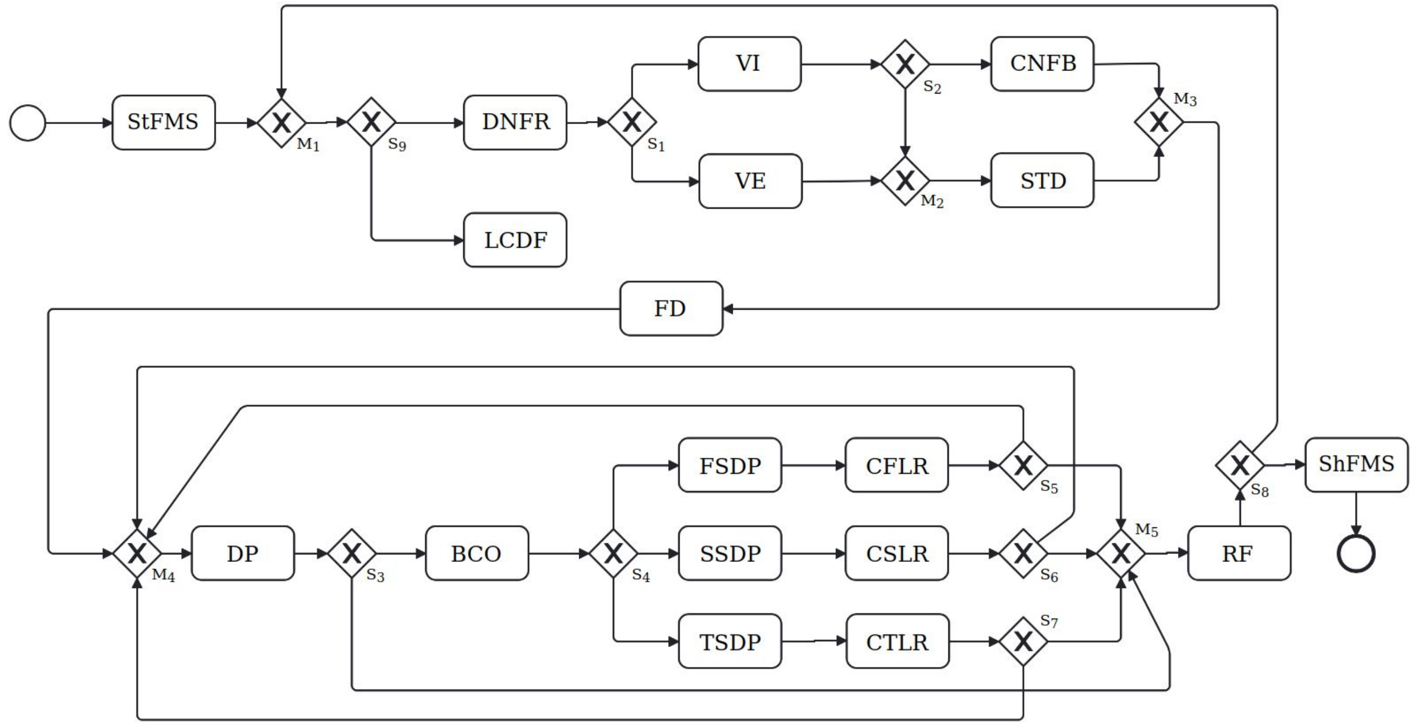

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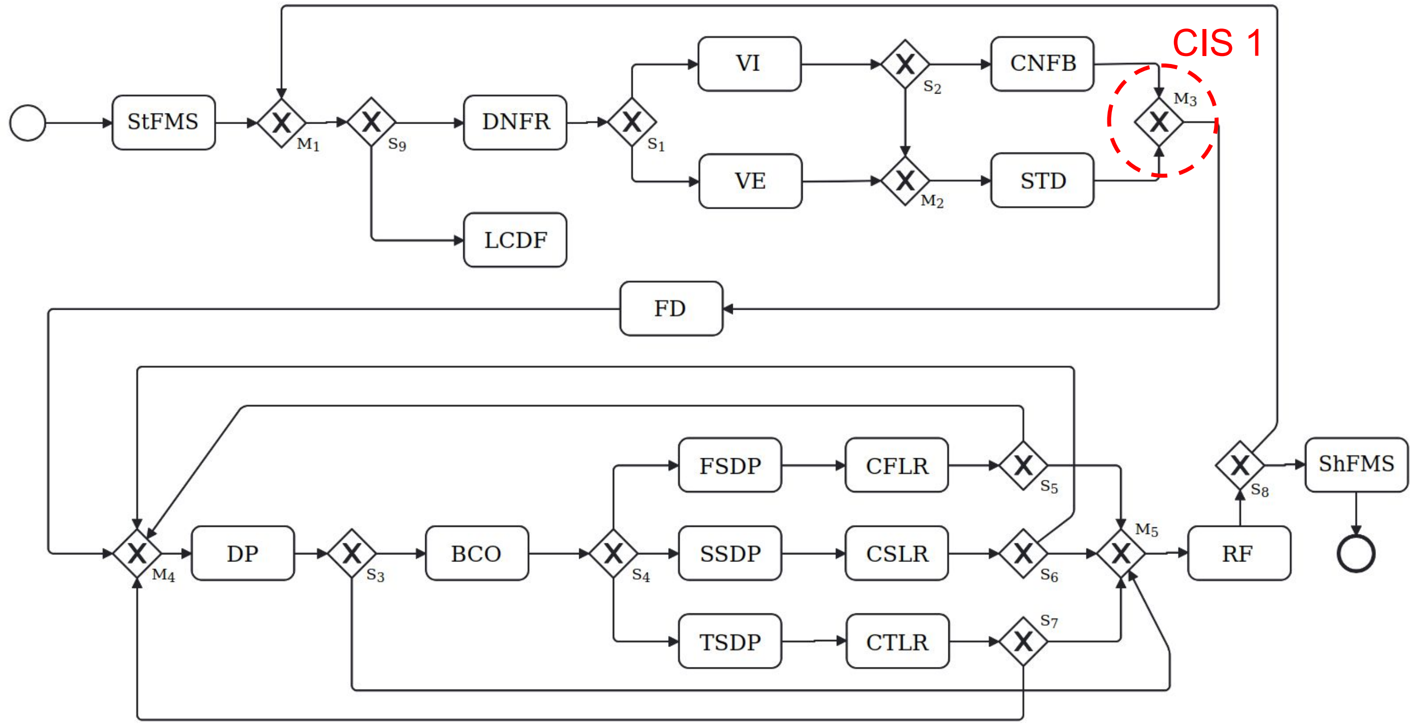

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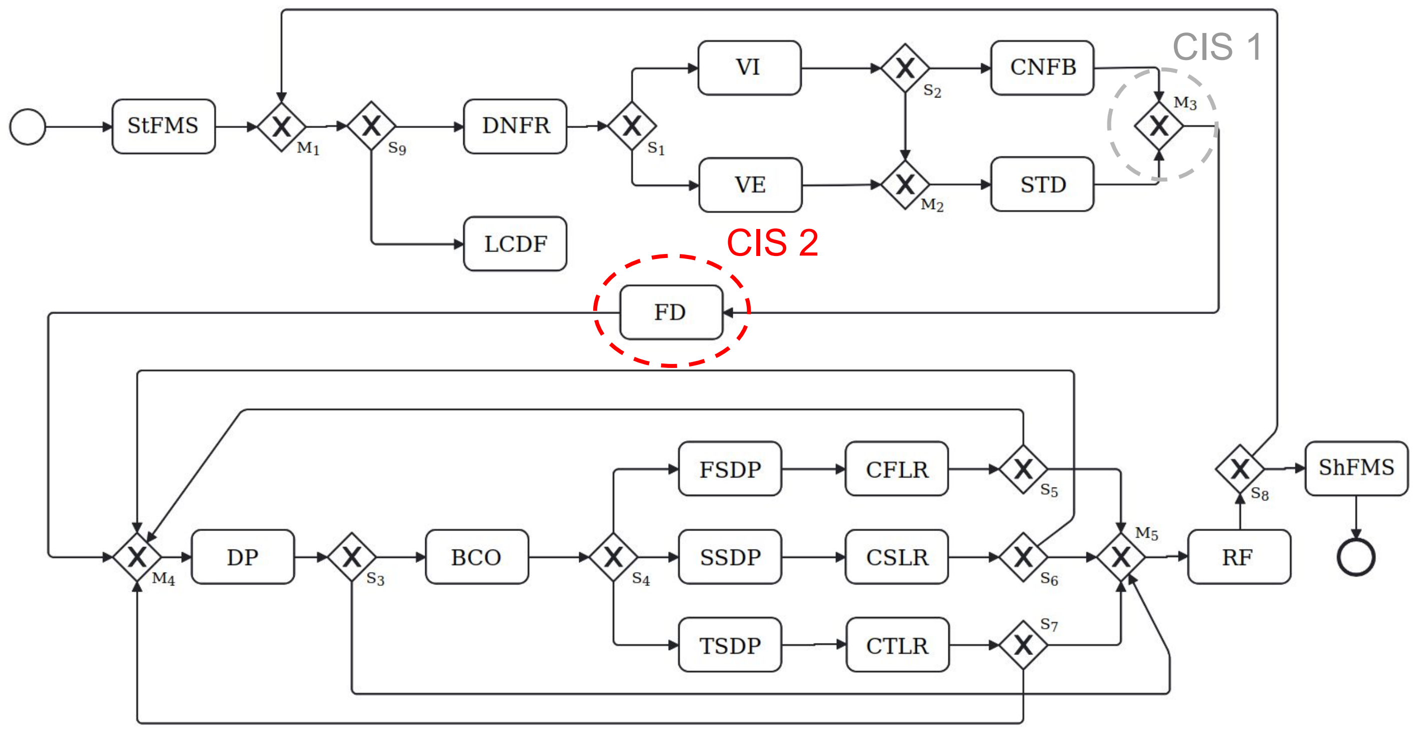

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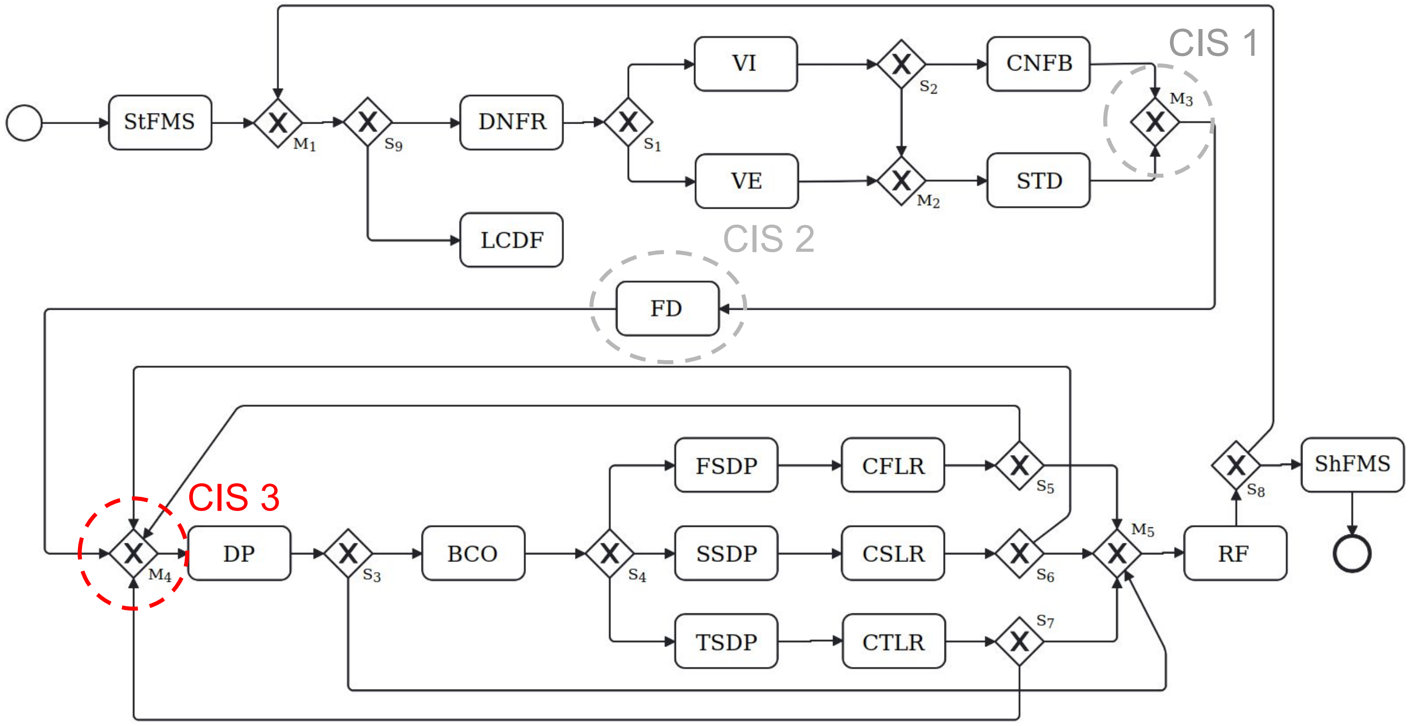

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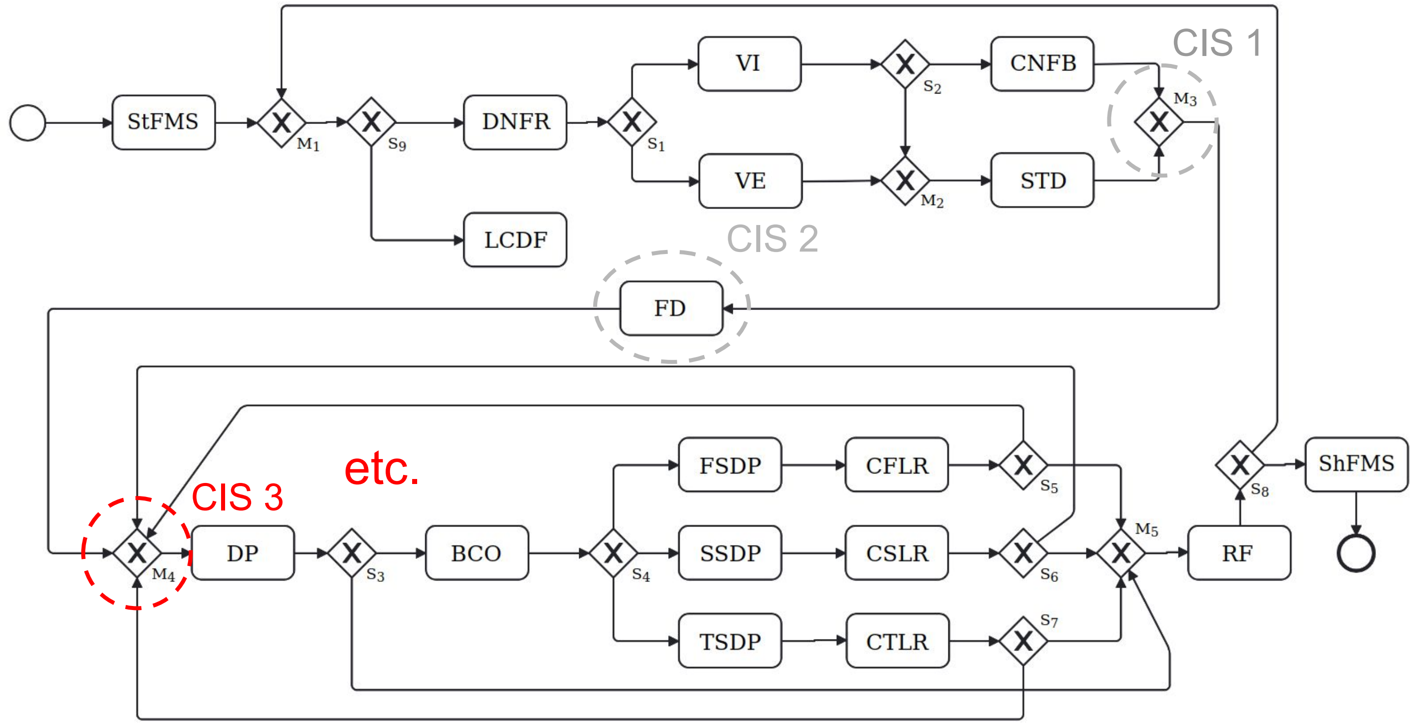

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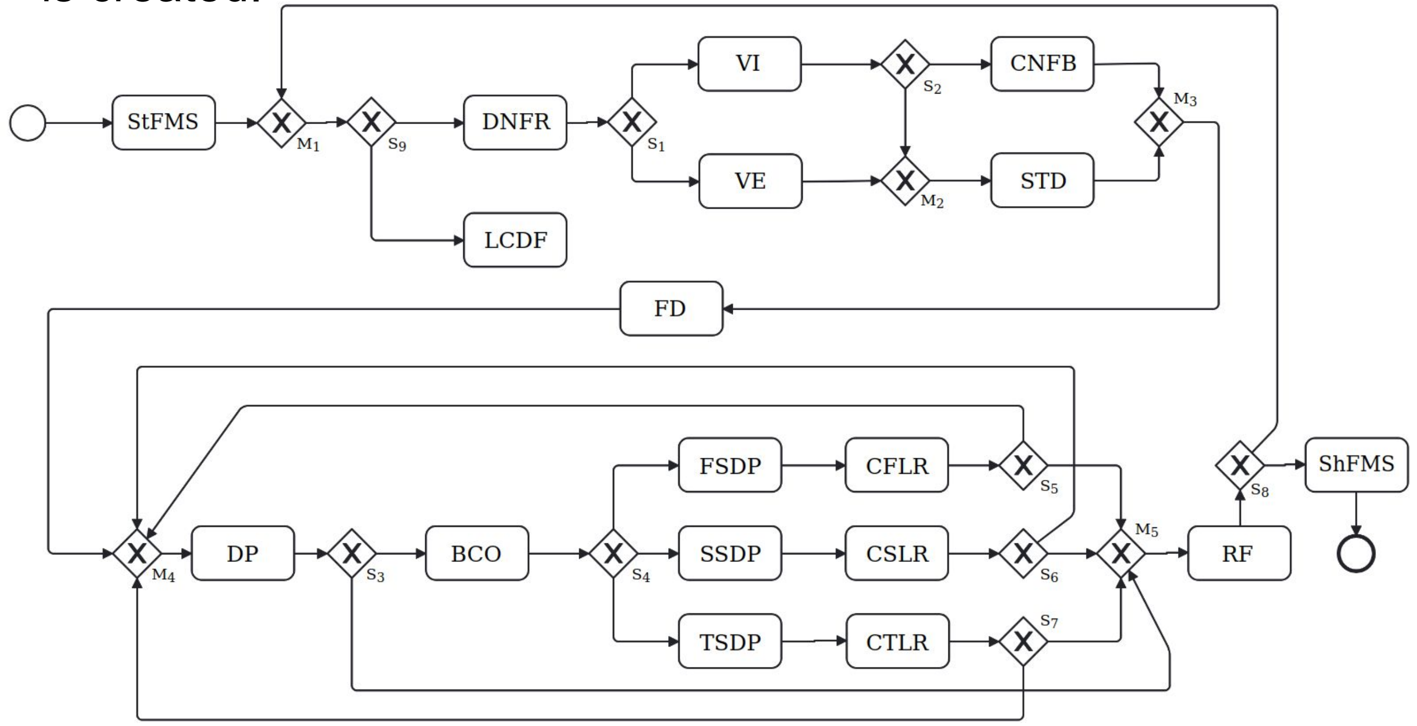
The first such successor whose connection **does not break the mutual exclusion** (if any) is selected, and an edge between it and the inserted task is created.



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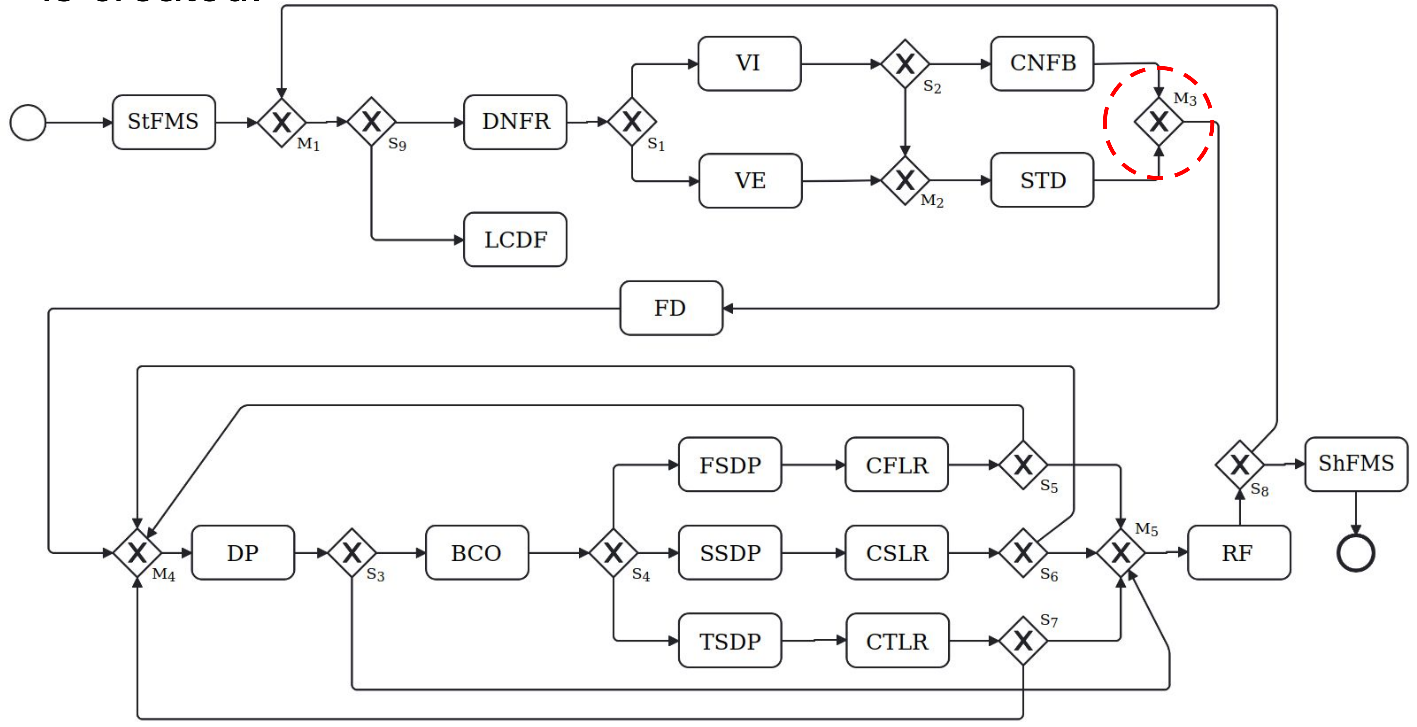

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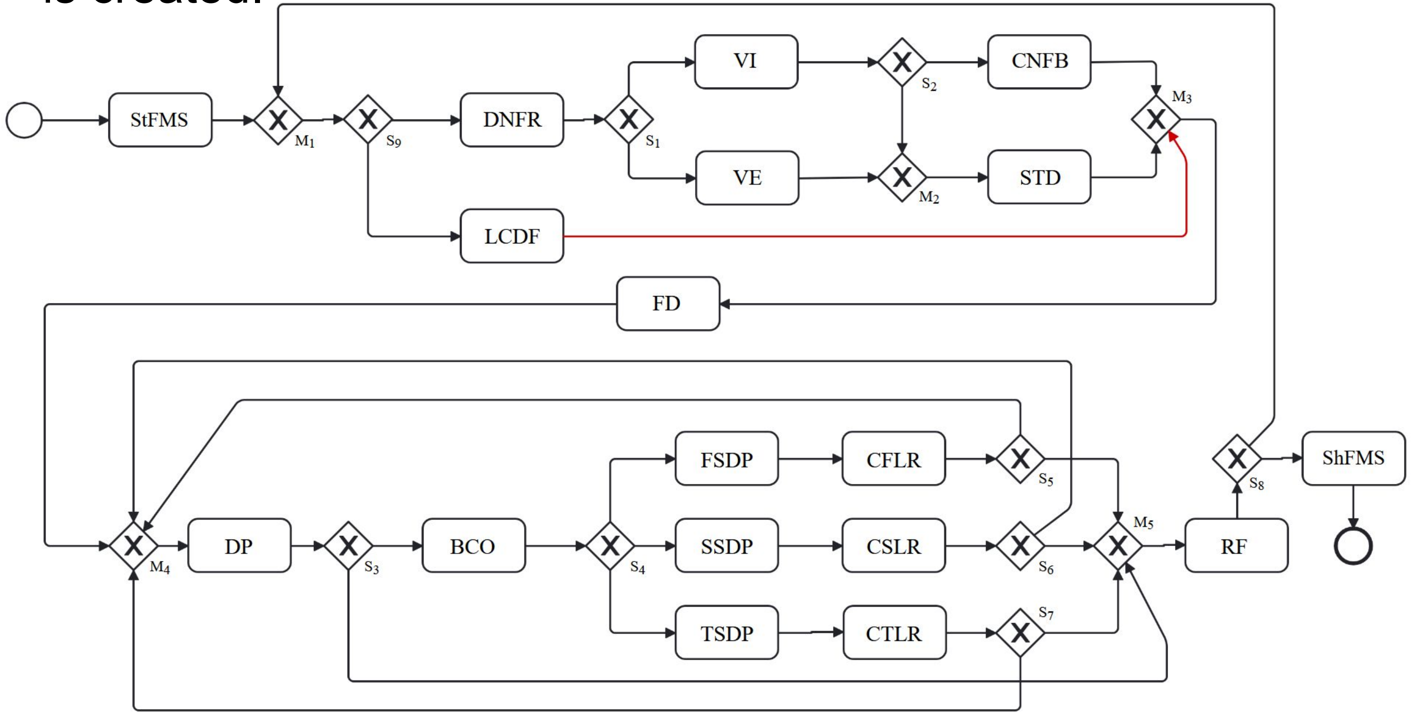

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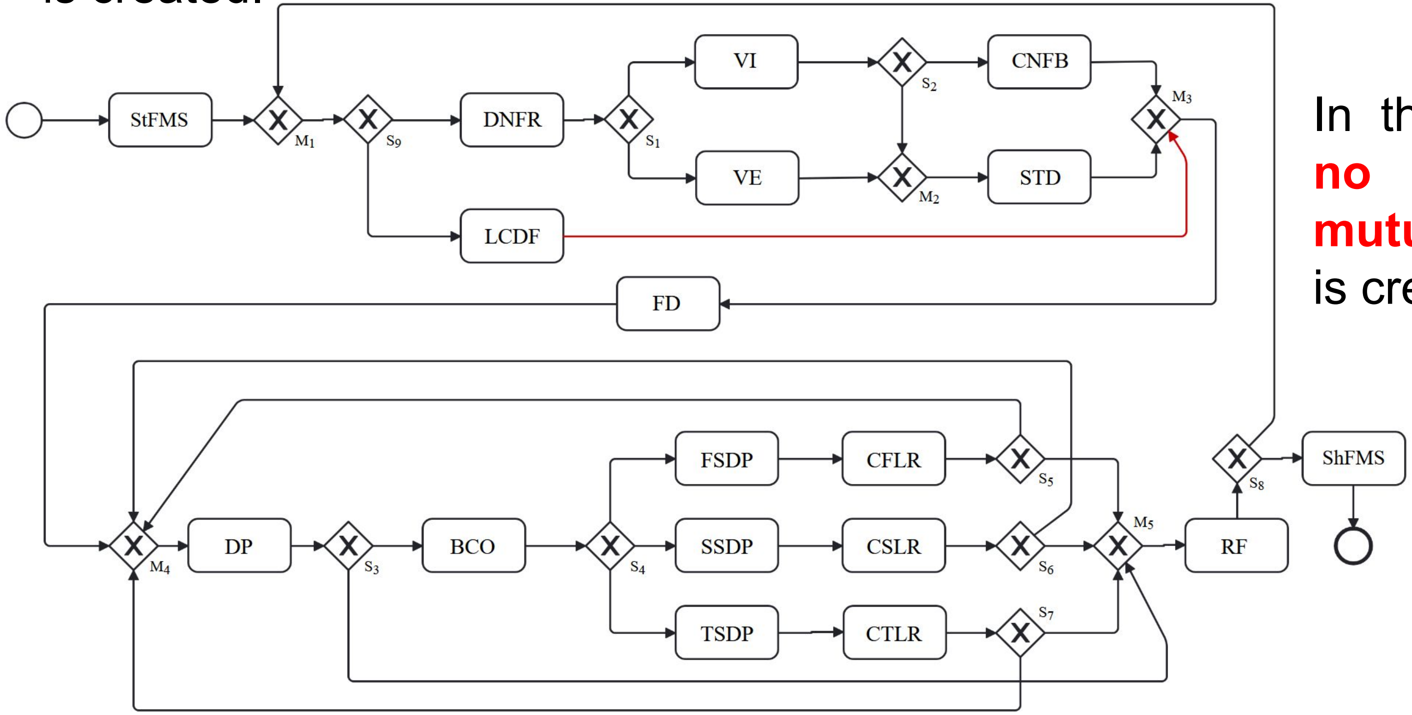

In the best case, **no unnecessary mutual exclusion** is created.

Detailed Approach – Step 6.2 – Explicit Loops

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Our proposal thus consists in connecting these tasks in the **restriction of the BPMN process** to the subset of its vertices corresponding to the loop.

Detailed Approach – Step 6.2 – Explicit Loops

The second refinement step consists in inserting the **loops explicitly stated** by the user to the graph. This is for instance the case of expression

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

which states that tasks **FSDP**, **SSDP**, **TSDP**, **CFLR**, **CSLR**, and **CTLR** must **appear in the same loop**.

Our proposal thus consists in connecting these tasks in the **restriction of the BPMN process** to the subset of its vertices corresponding to the loop.

$$G \restriction_{\{v_1,\ldots,v_n\}} \overset{\text{def}}{=} (V^{\restriction}, E^{\restriction}, \Sigma^{\restriction}) \ \textit{where}$$

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

is the restriction of G *to the subset* $\{v_1, \ldots, v_n\}$ *of its vertices;*

Detailed Approach – Step 6.2 – Explicit Loops

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

$$\boxed{(\mathrm{FSDP}, \mathrm{SSDP}, \mathrm{TSDP}, \mathrm{CFLR}, \mathrm{CSLR}, \mathrm{CTLR})*}$$

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Detailed Approach – Step 6.2 – Explicit Loops

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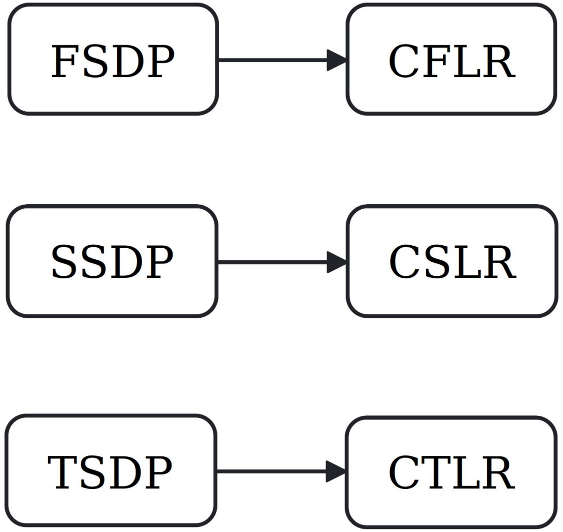

Detailed Approach – Step 6.2 – Explicit Loops

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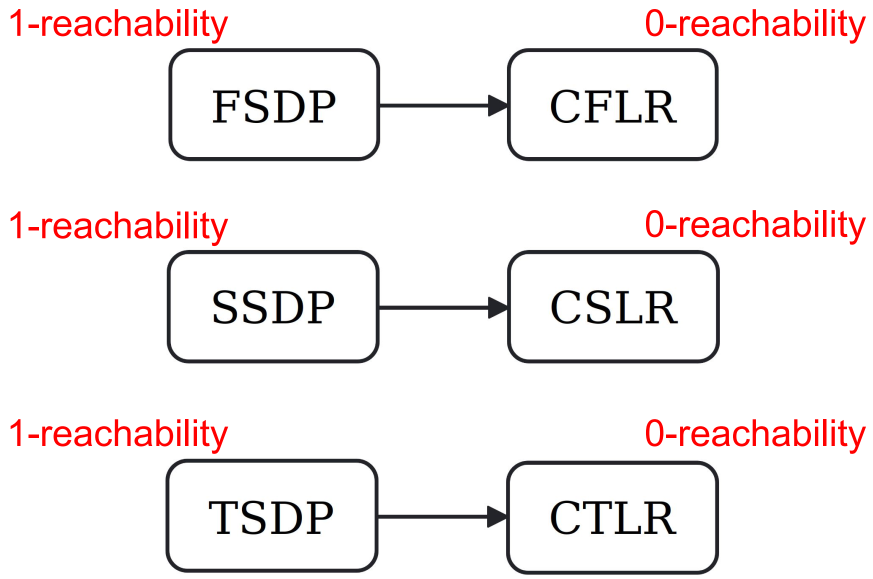
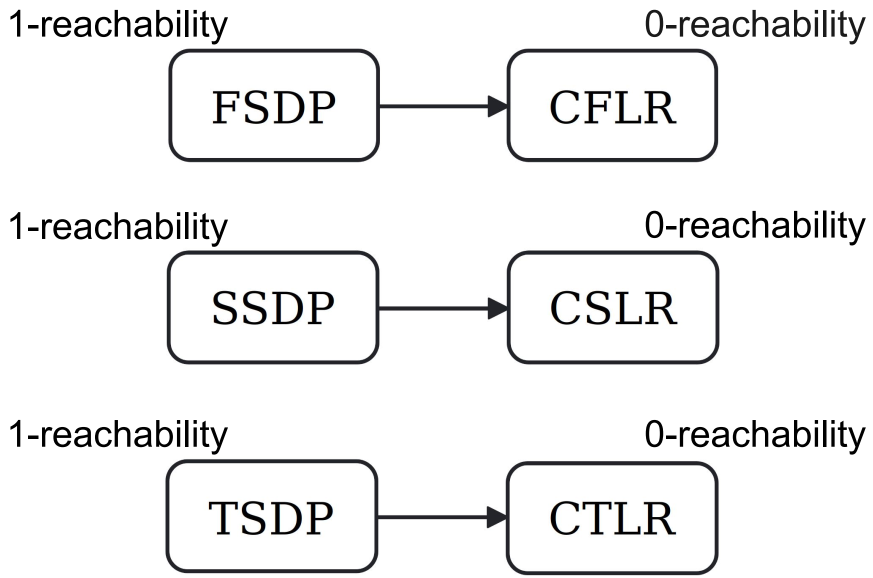


Detailed Approach – Step 6.2 – Explicit Loops

The connection consists in adding **an edge** between **each node** of a sub-graph having a **0-reachability**, and the **smallest subset of nodes** of another sub-graph ensuring a **total reachability**.



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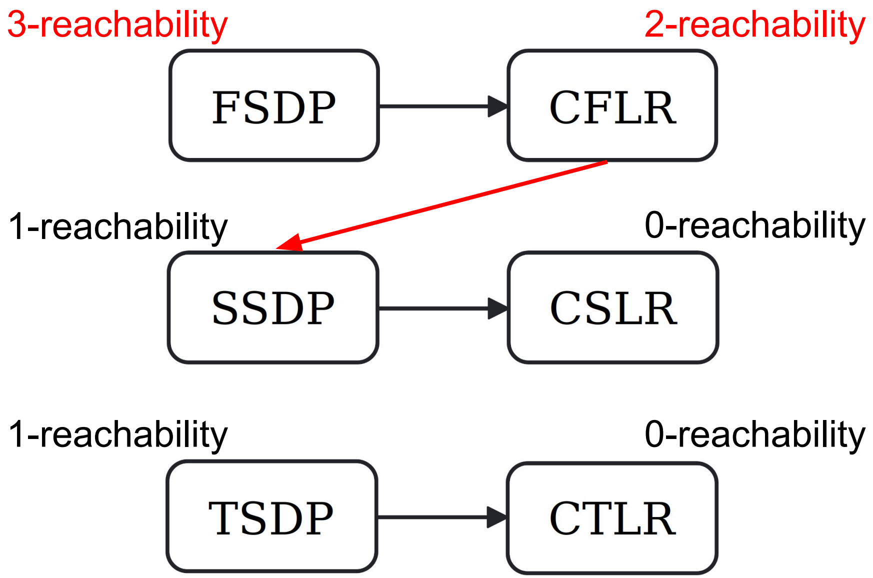

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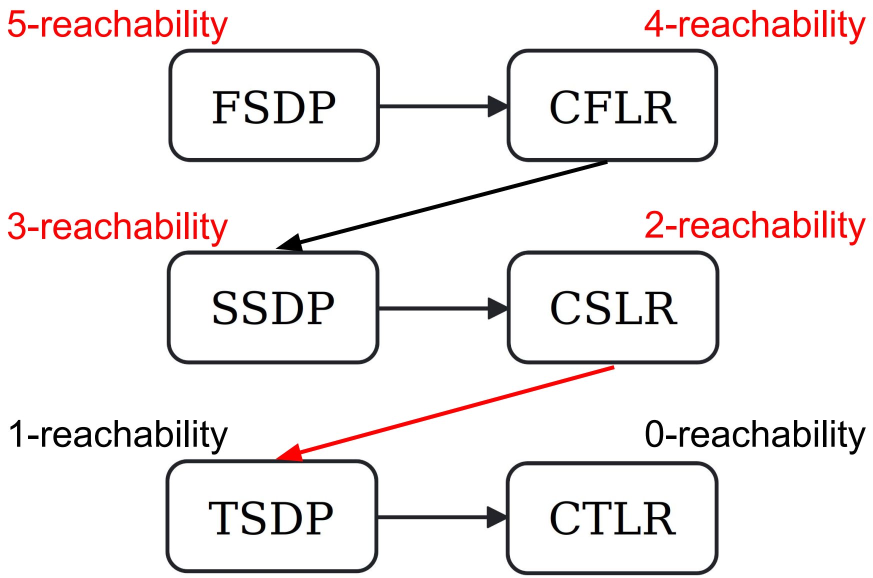

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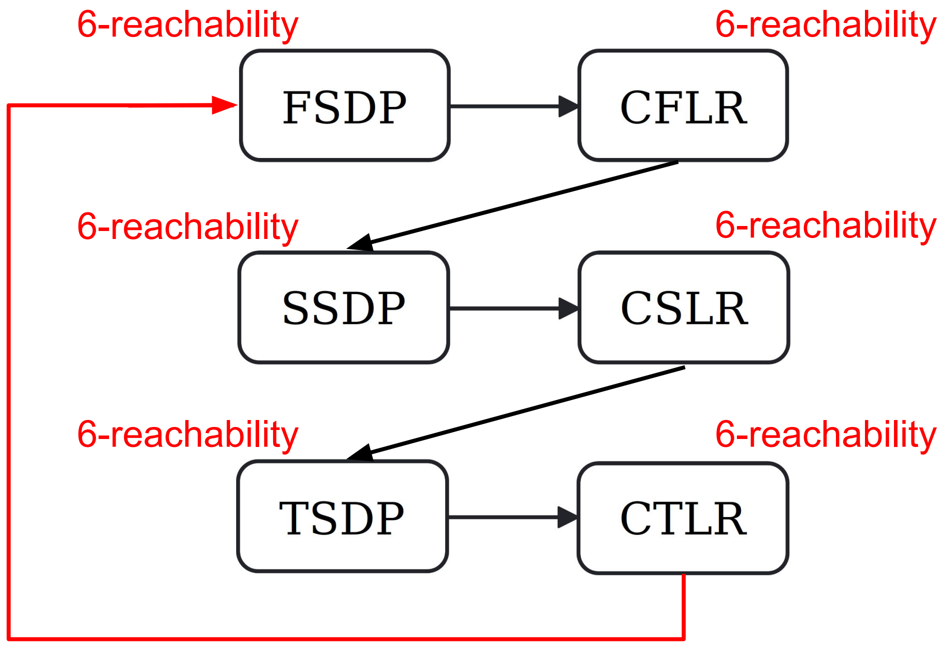
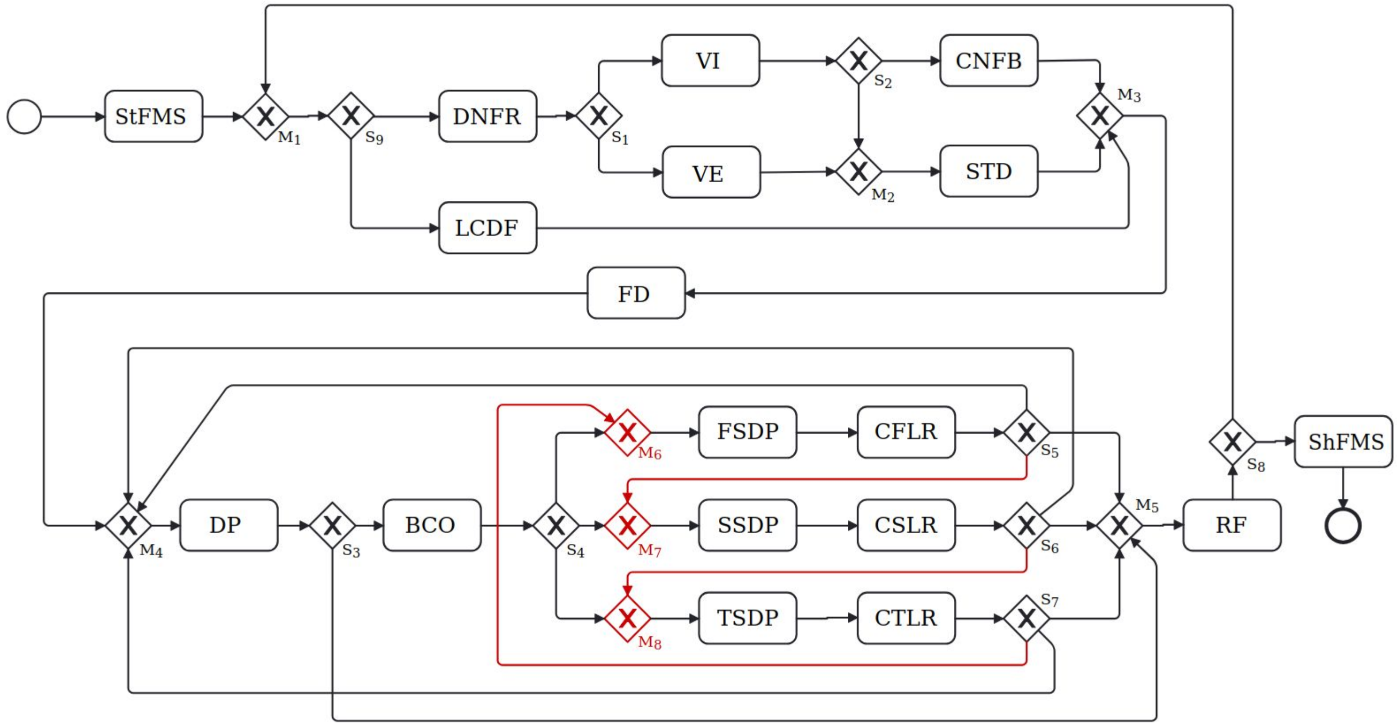


Detailed Approach – Step 6.2 – Explicit Loops

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



Detailed Approach – Step 6.3 – Parallelism

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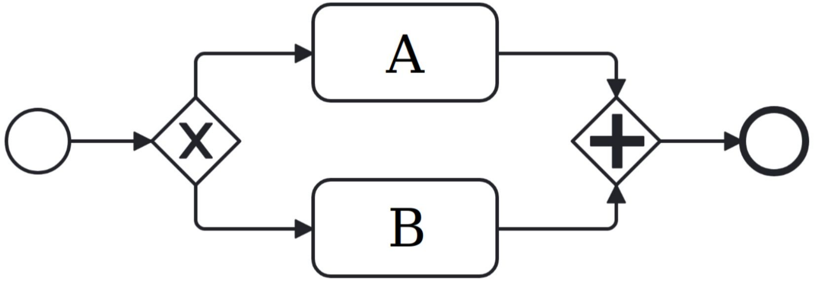

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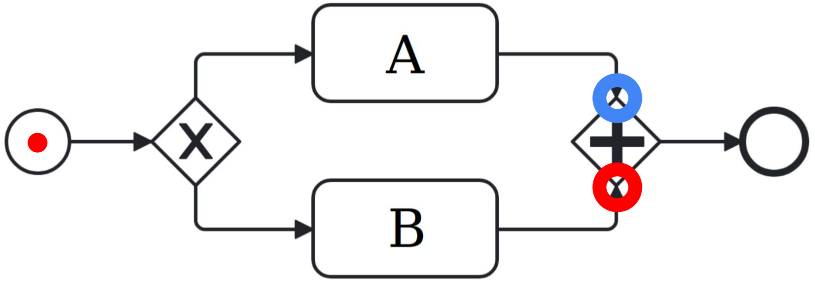

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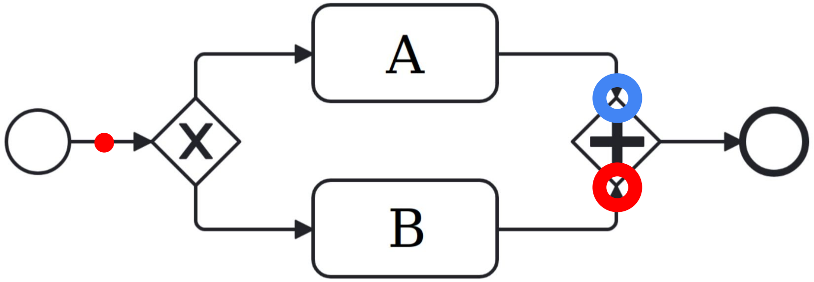

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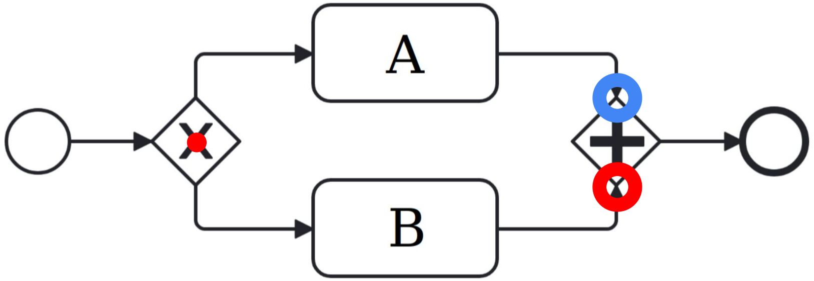

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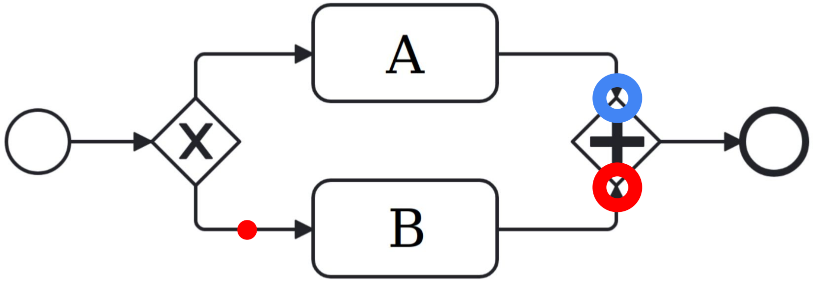

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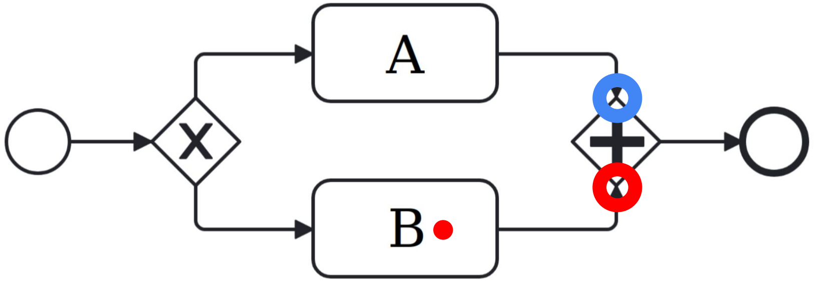

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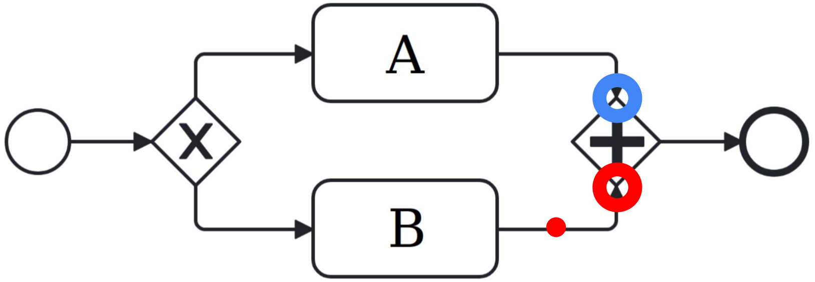

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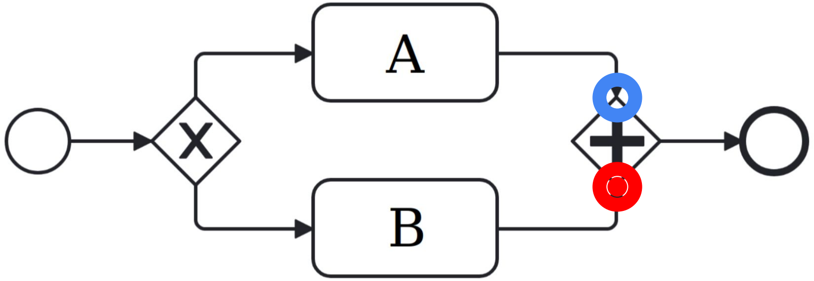

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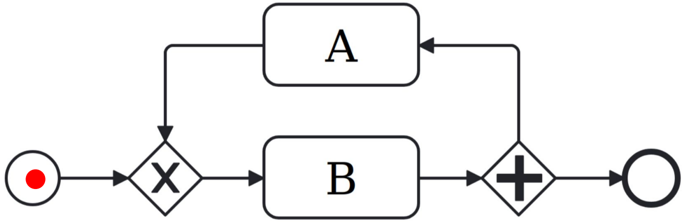

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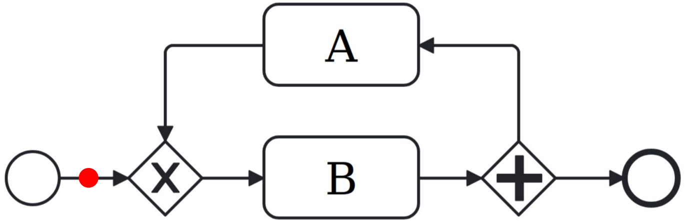

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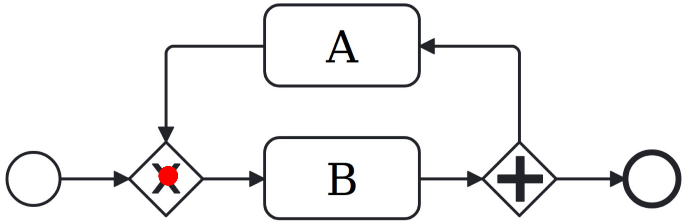

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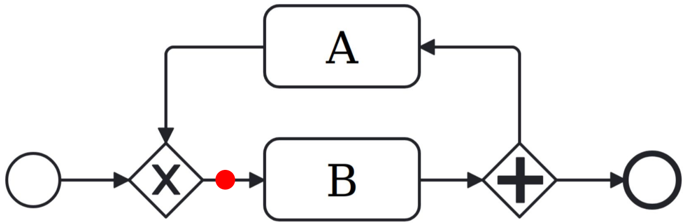

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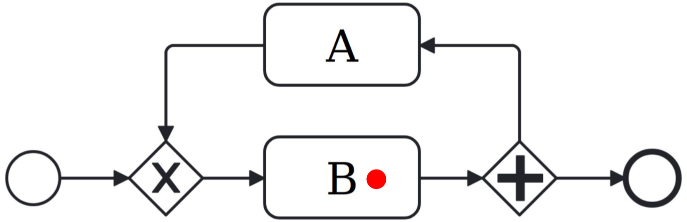

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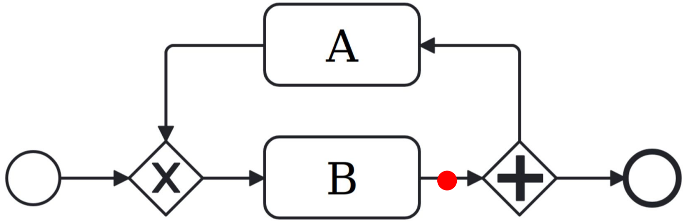

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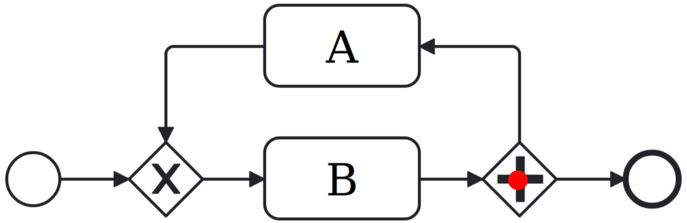

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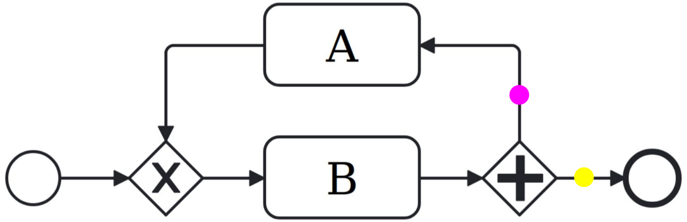

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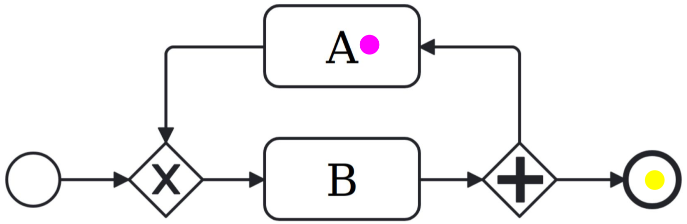

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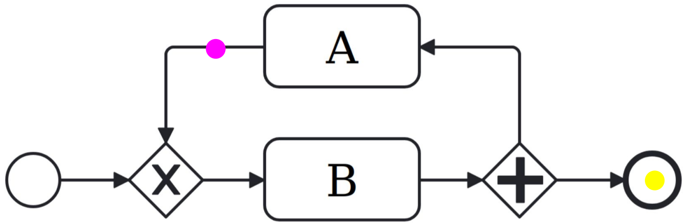

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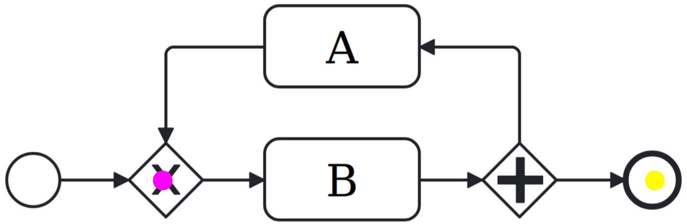

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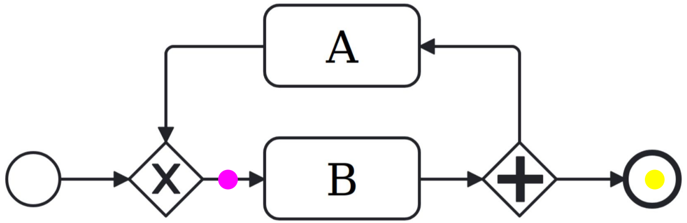

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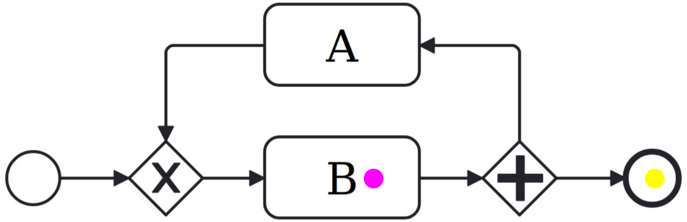

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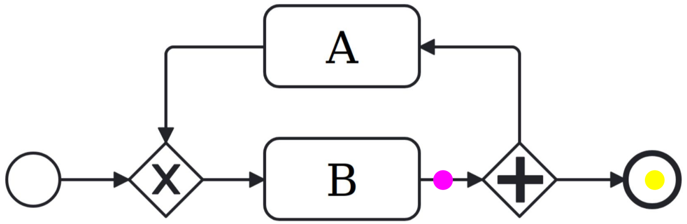

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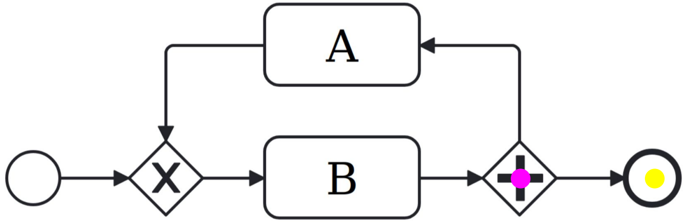

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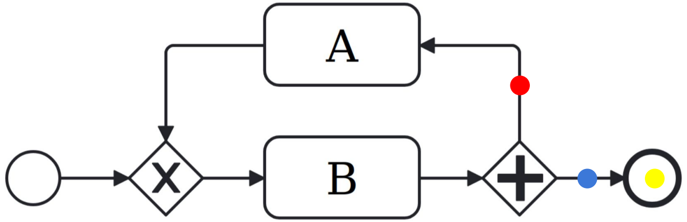

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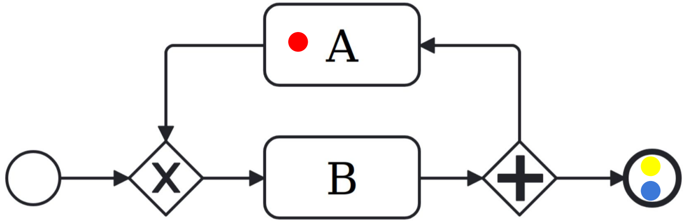

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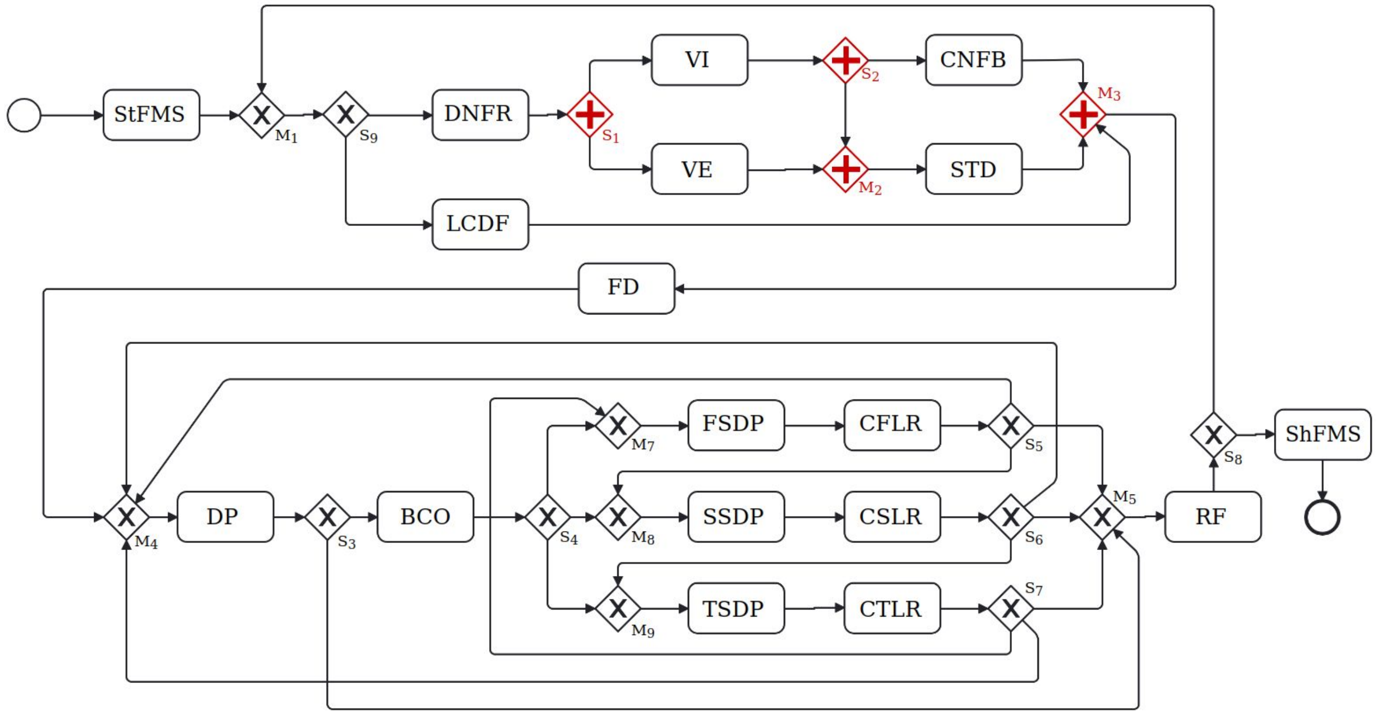

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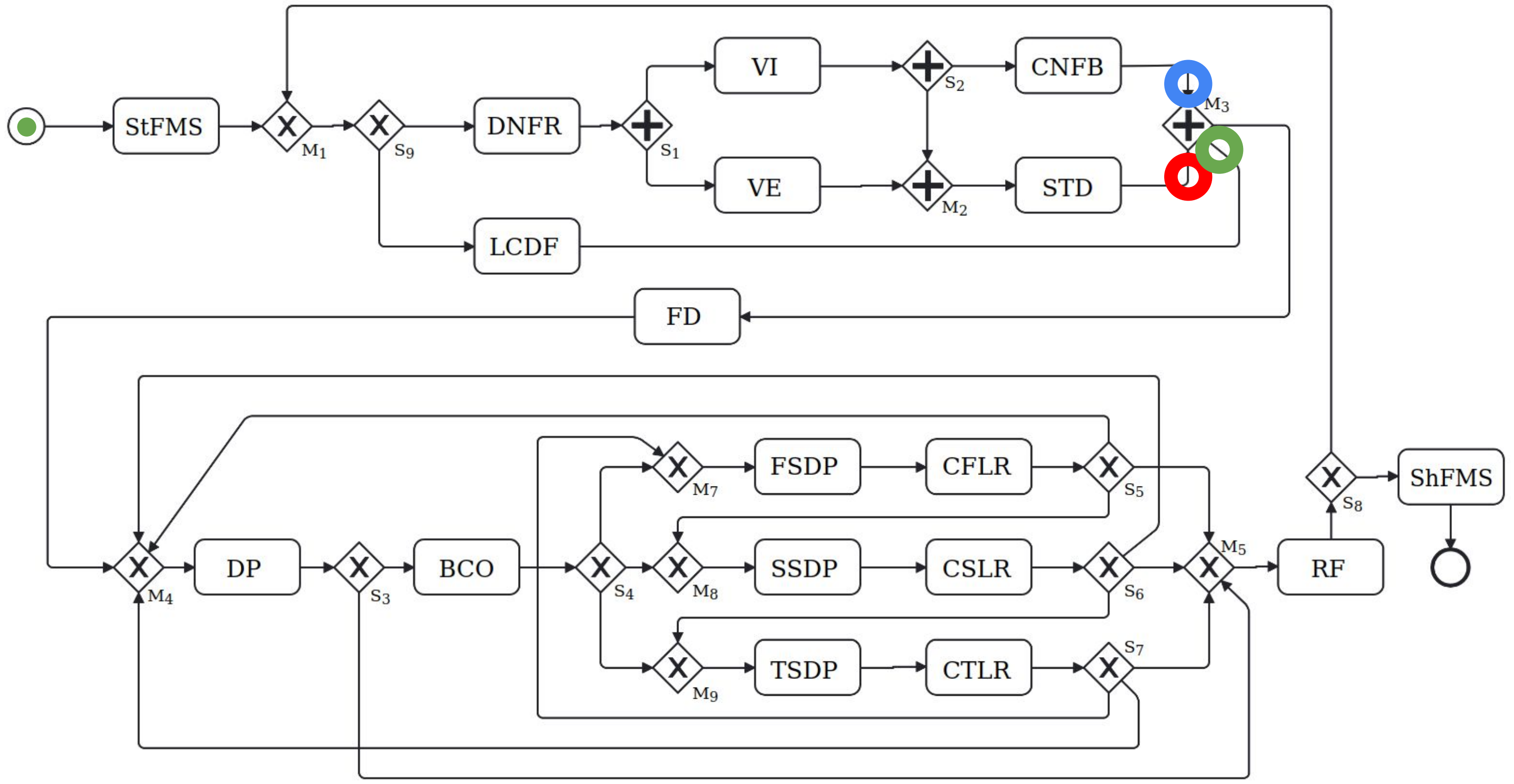

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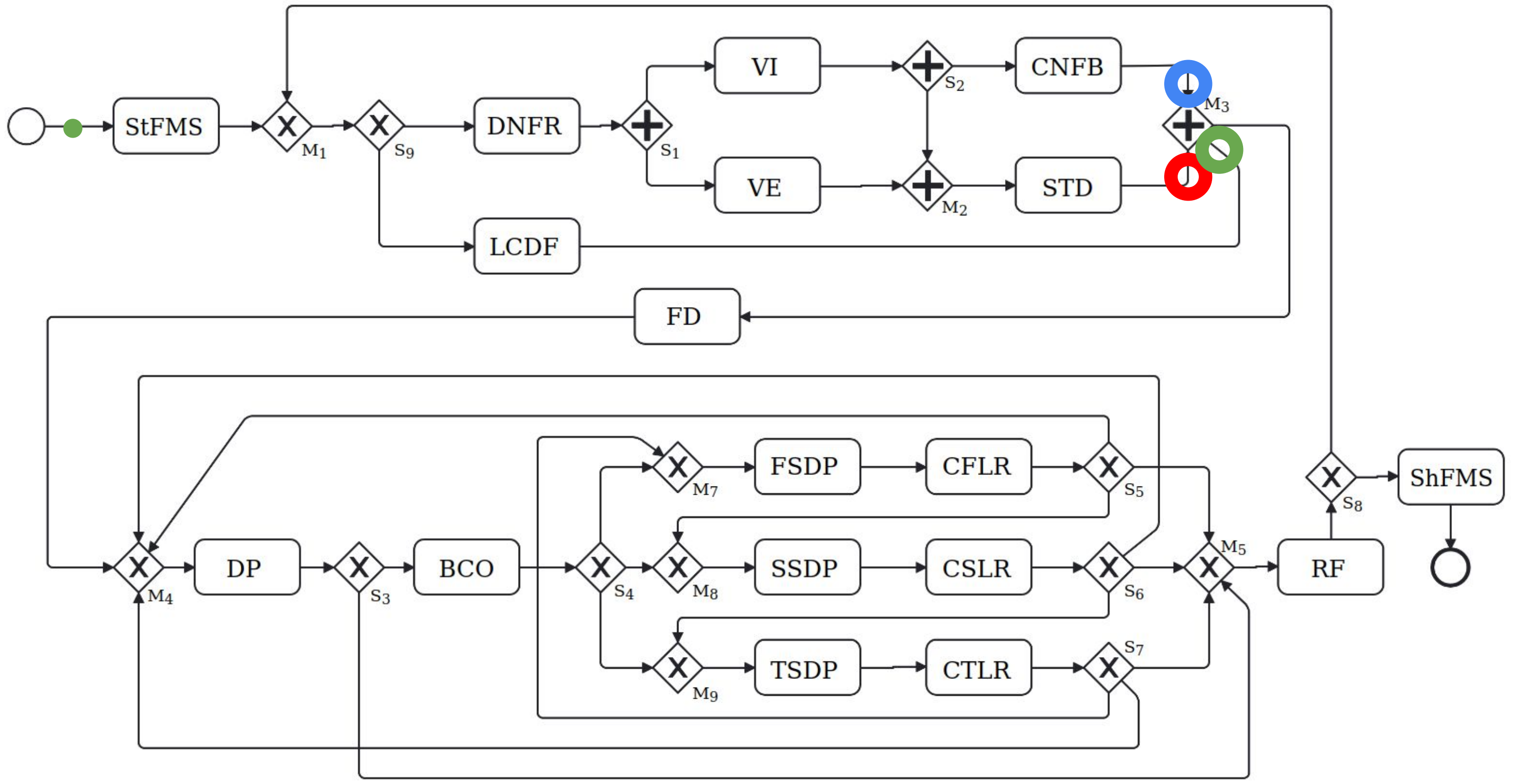

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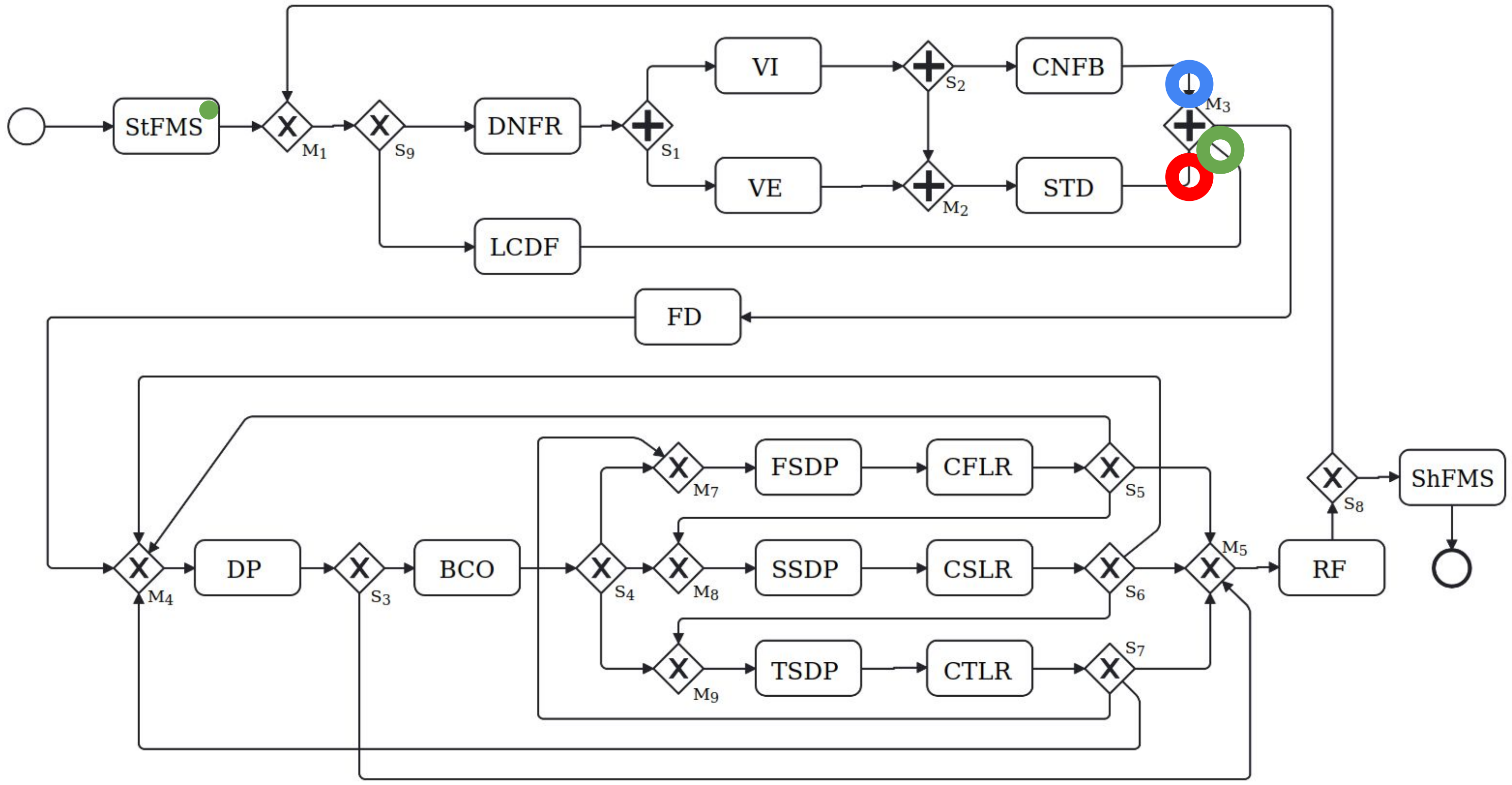

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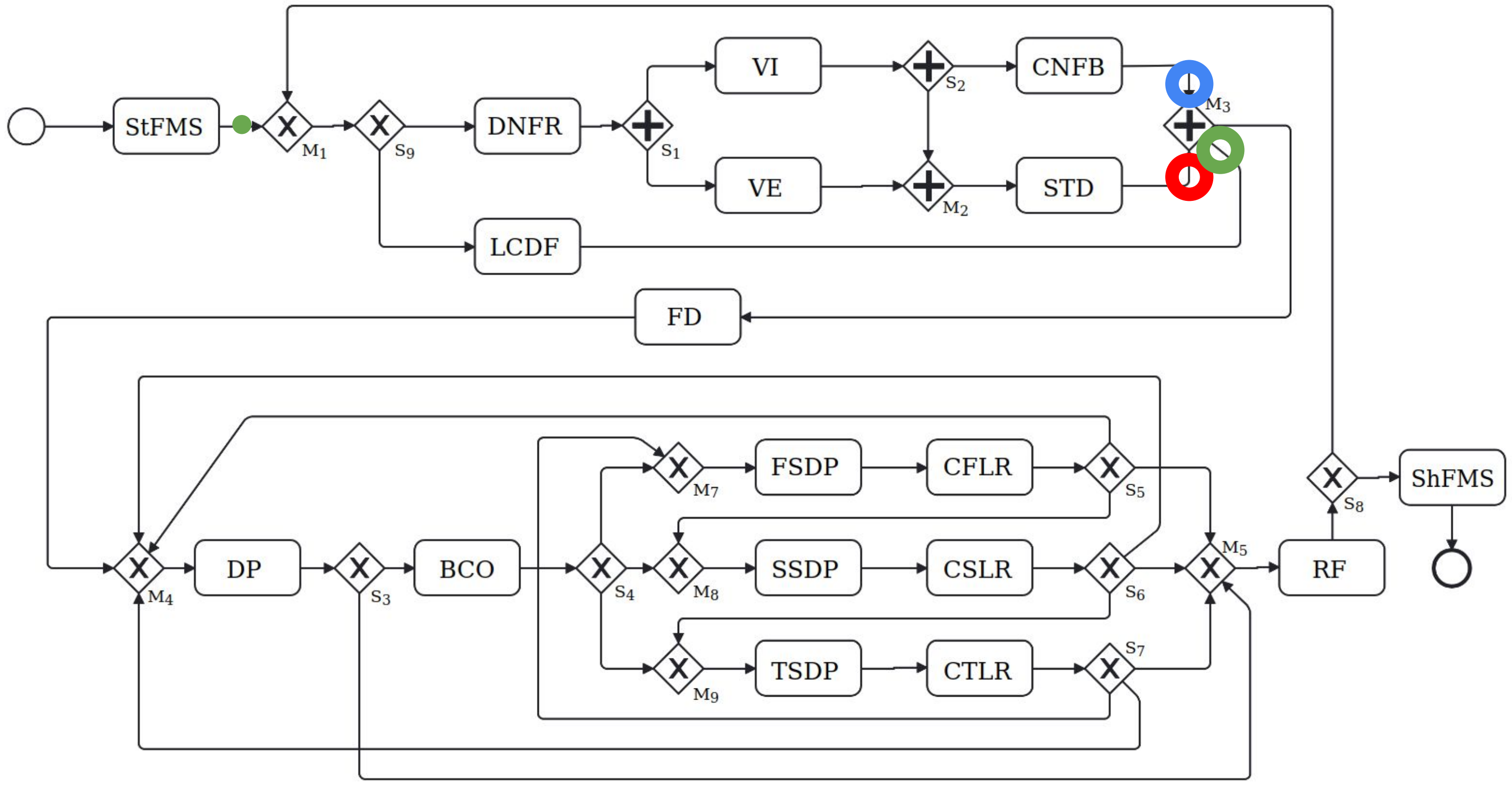

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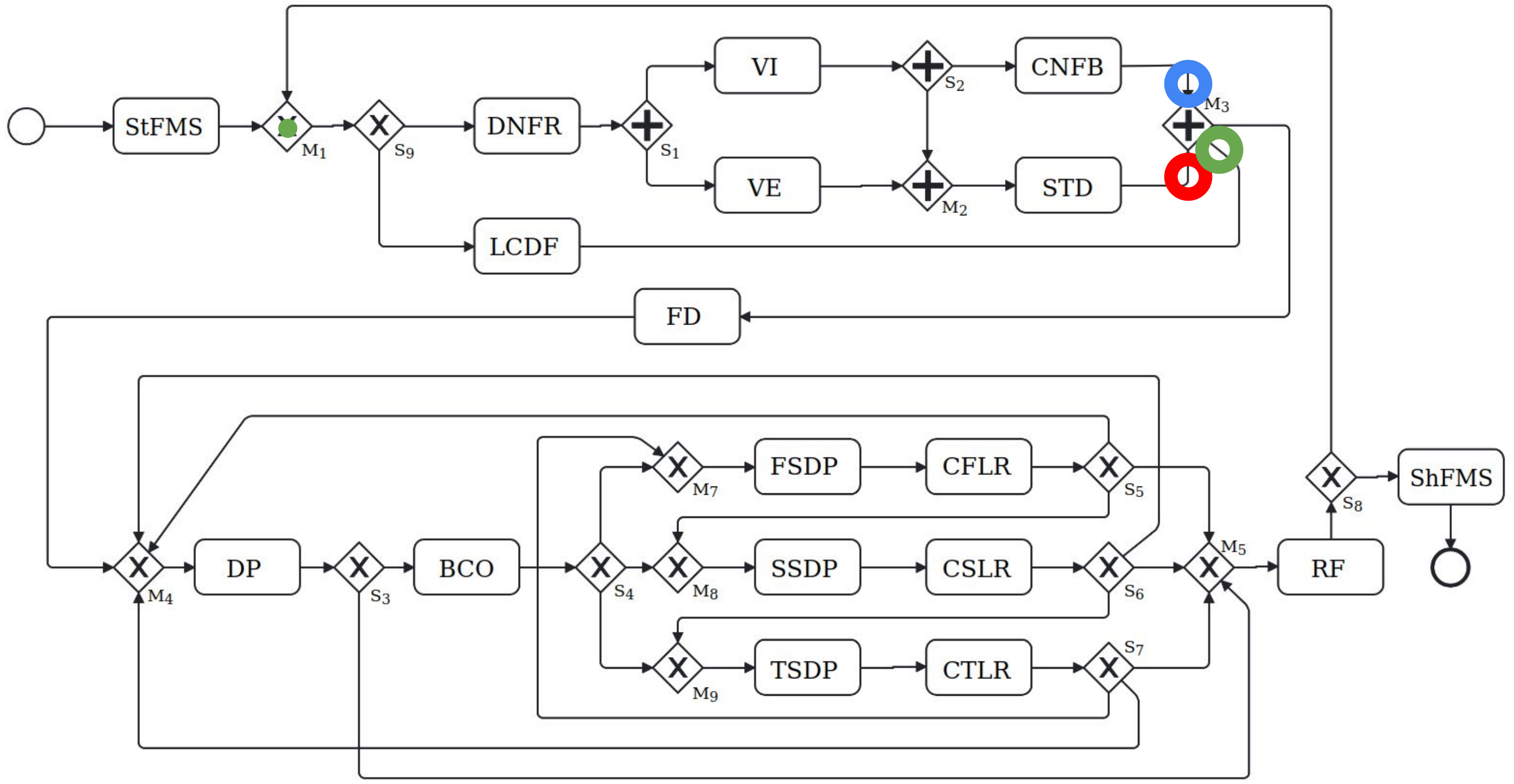

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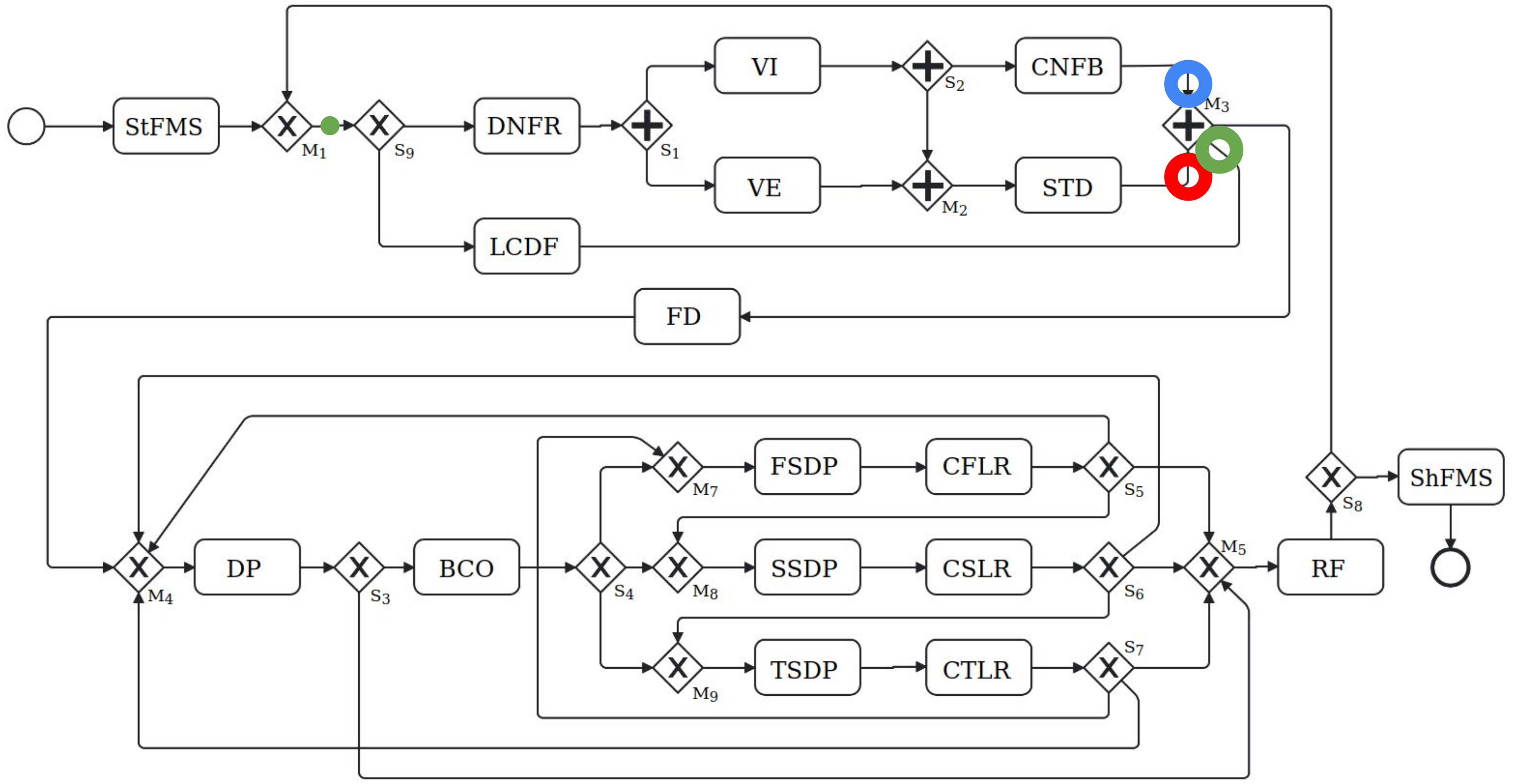

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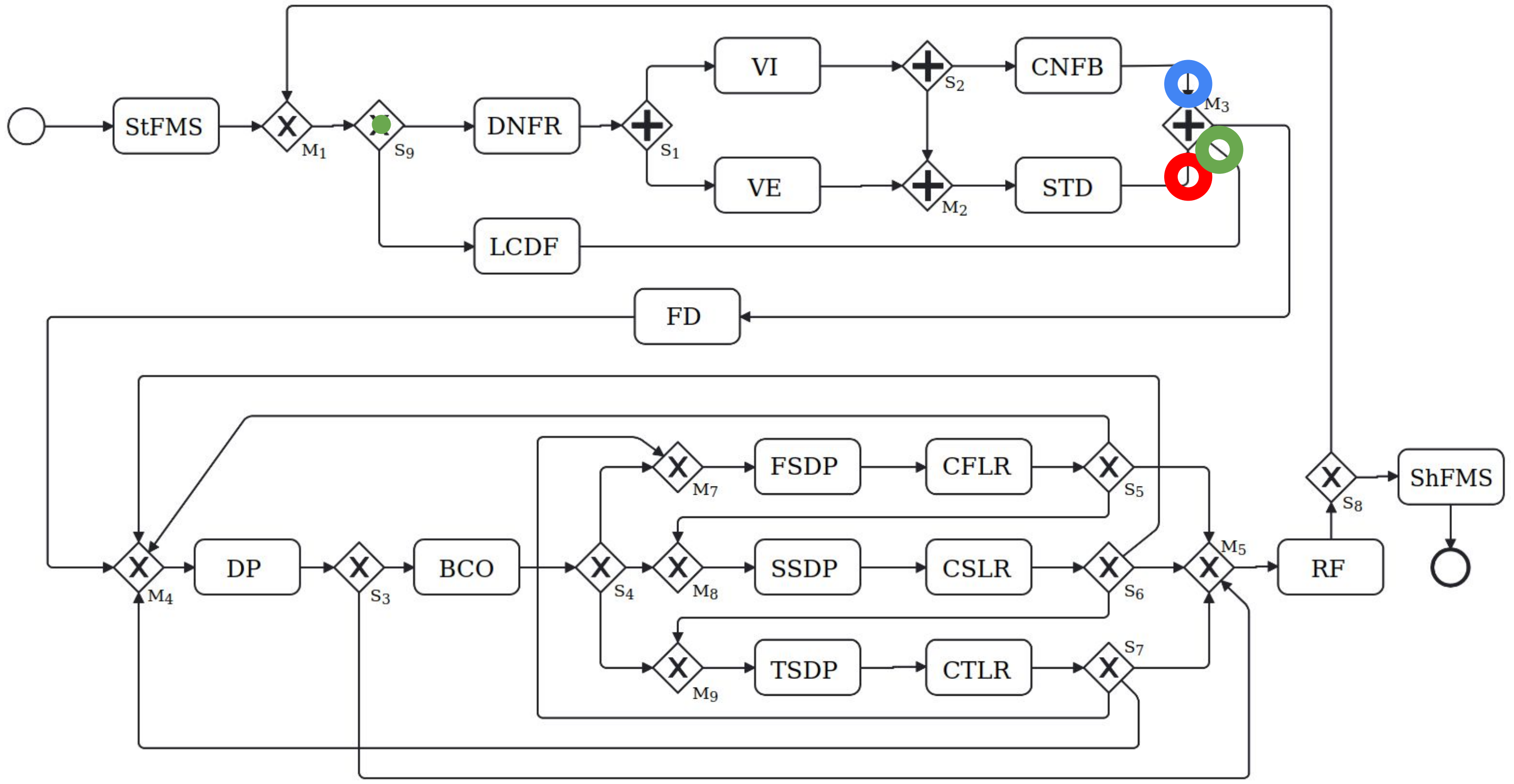

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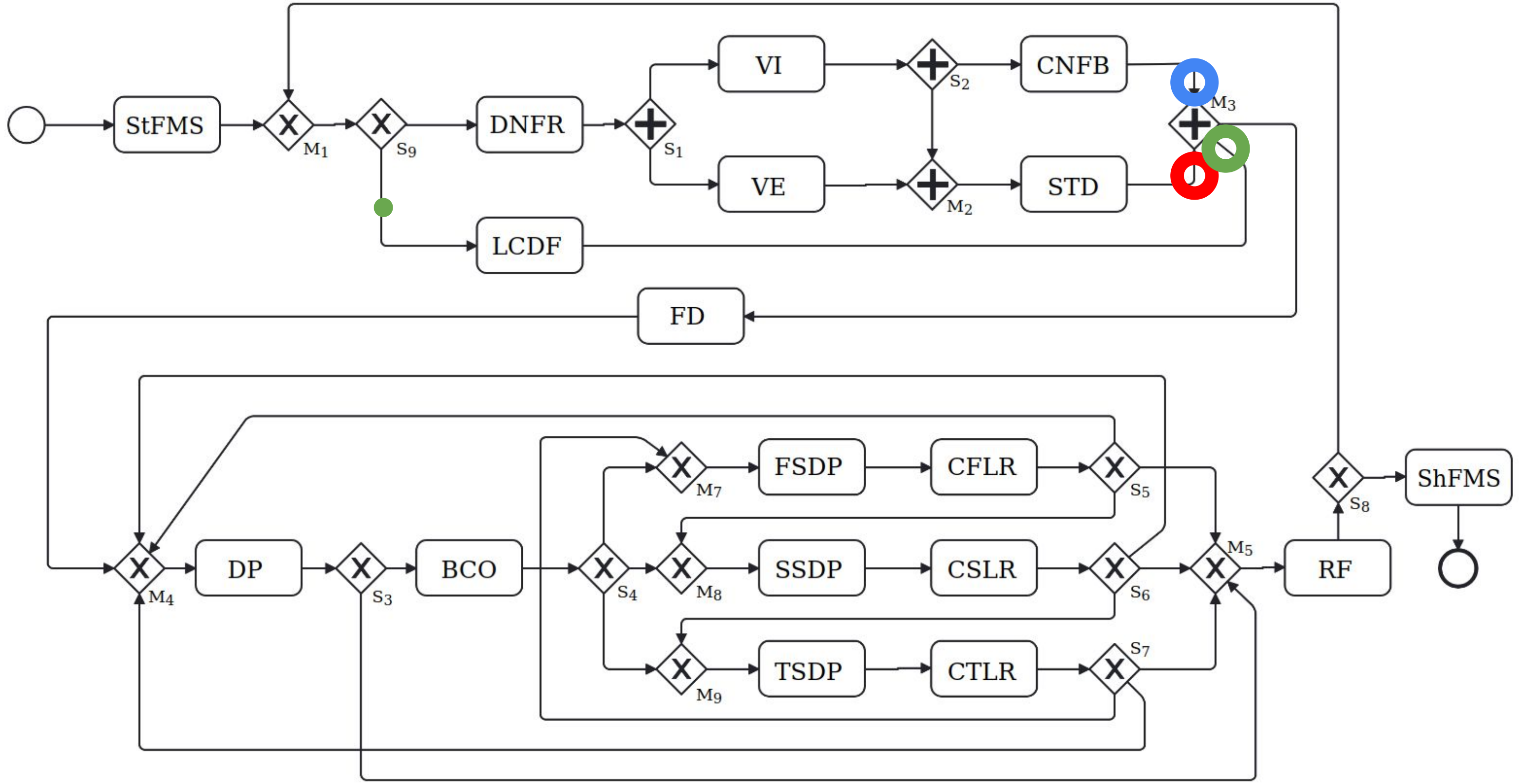

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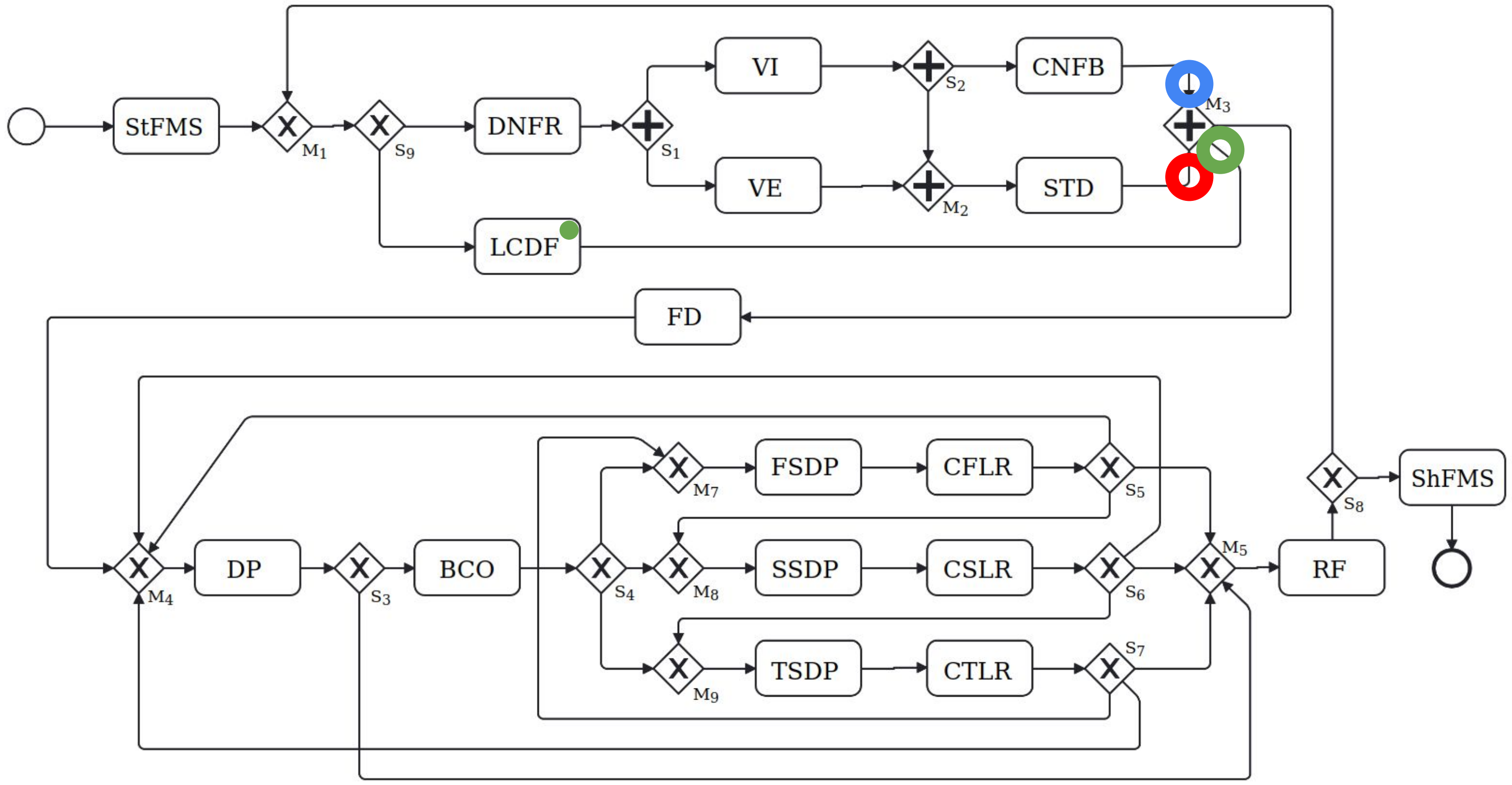

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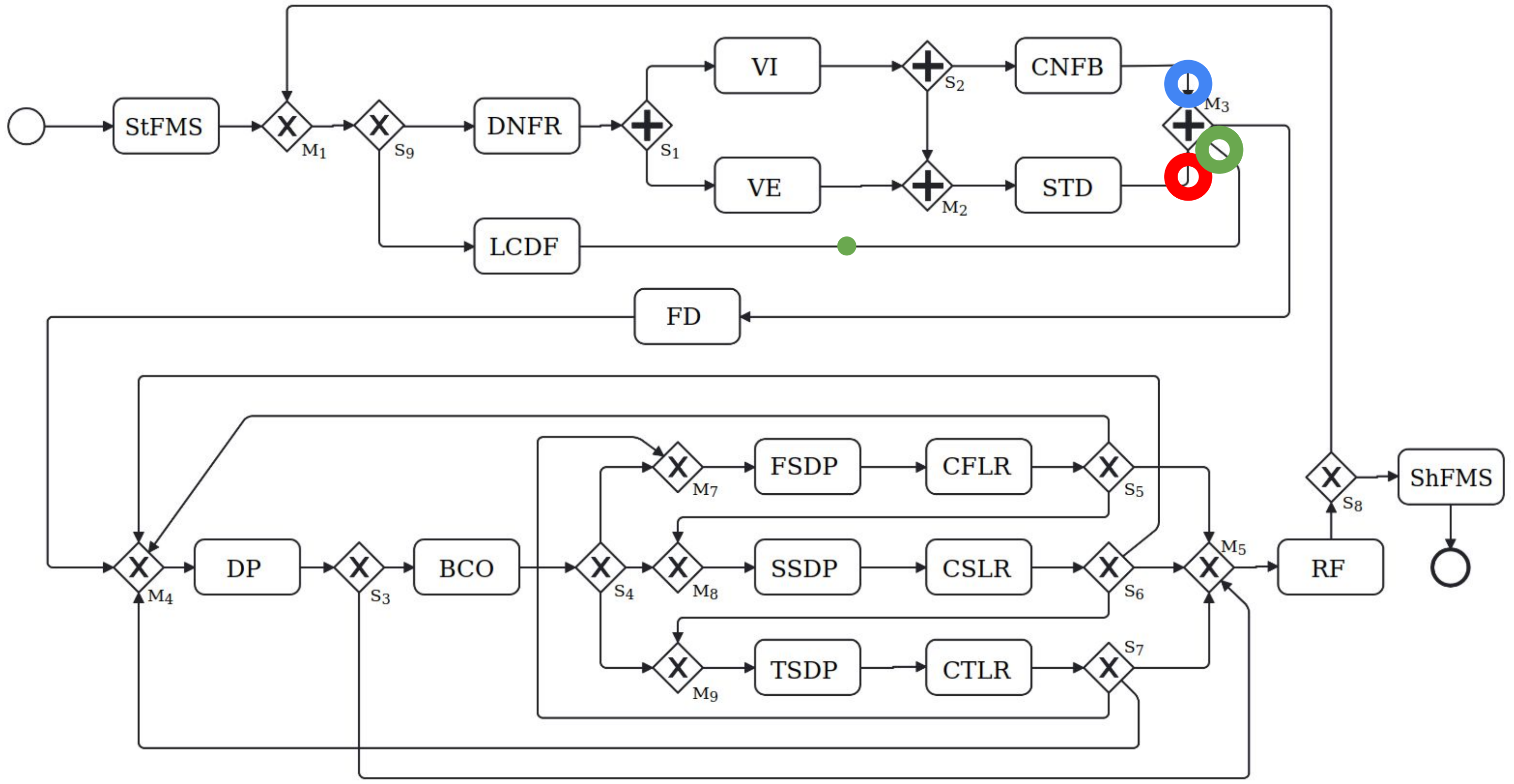

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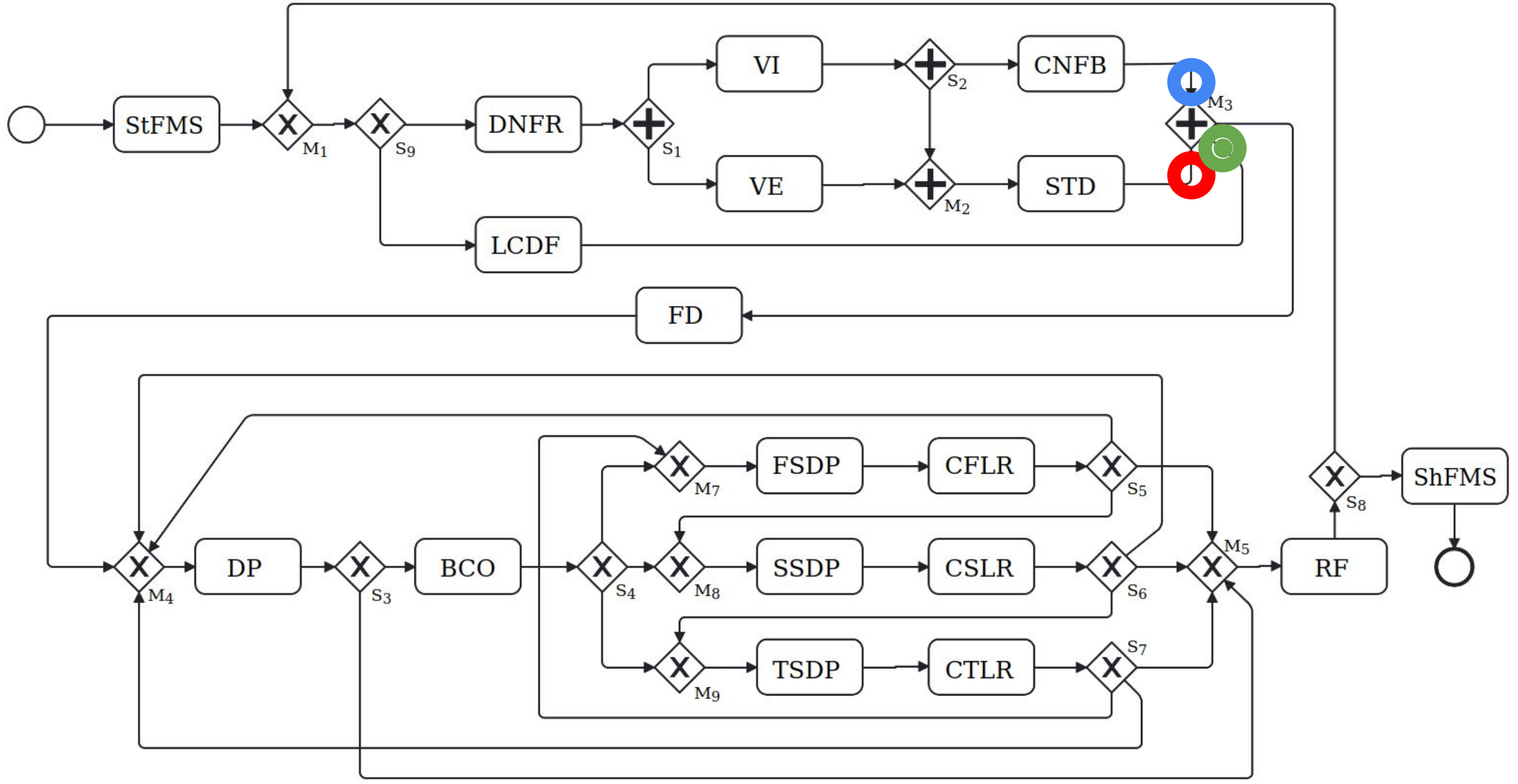

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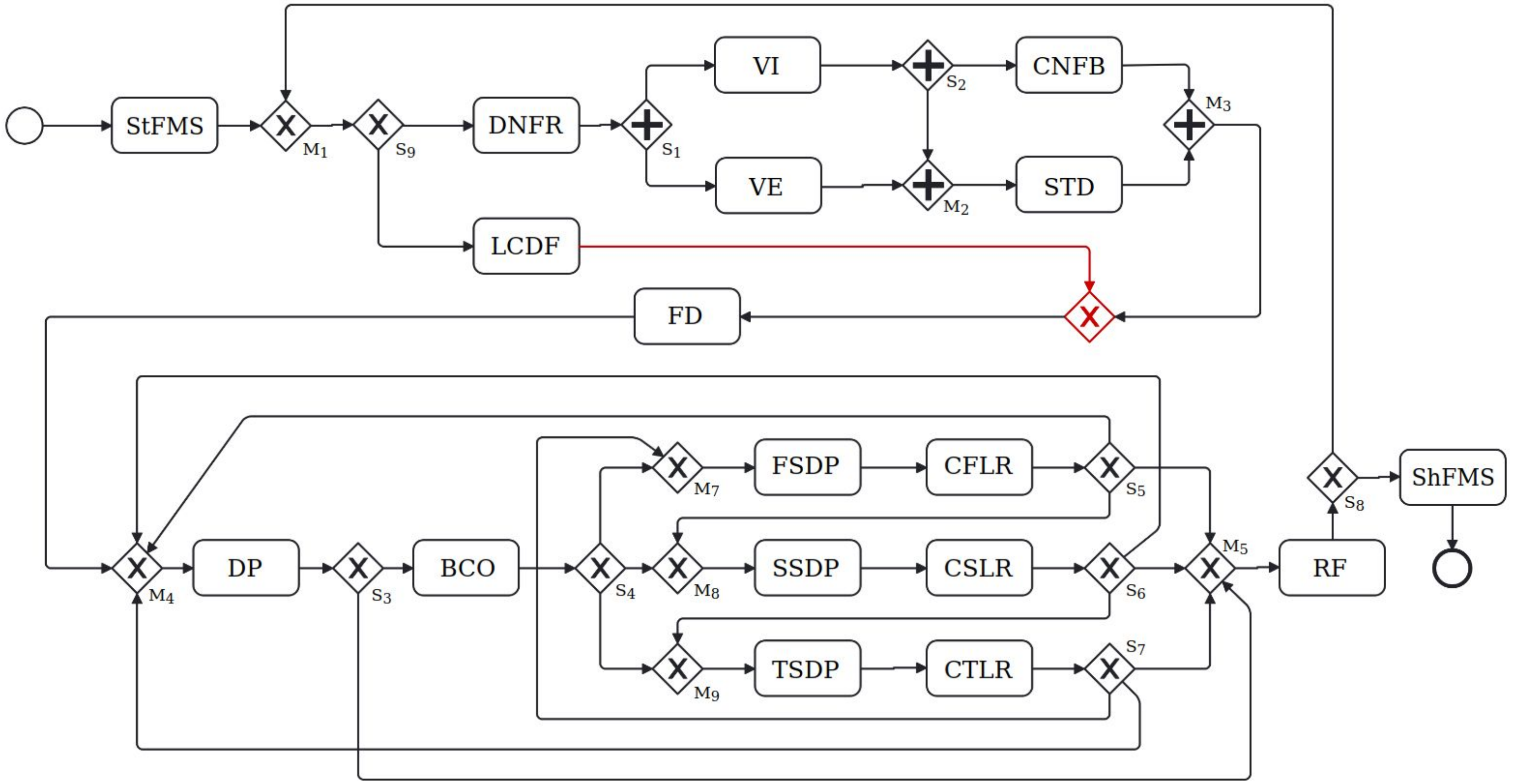

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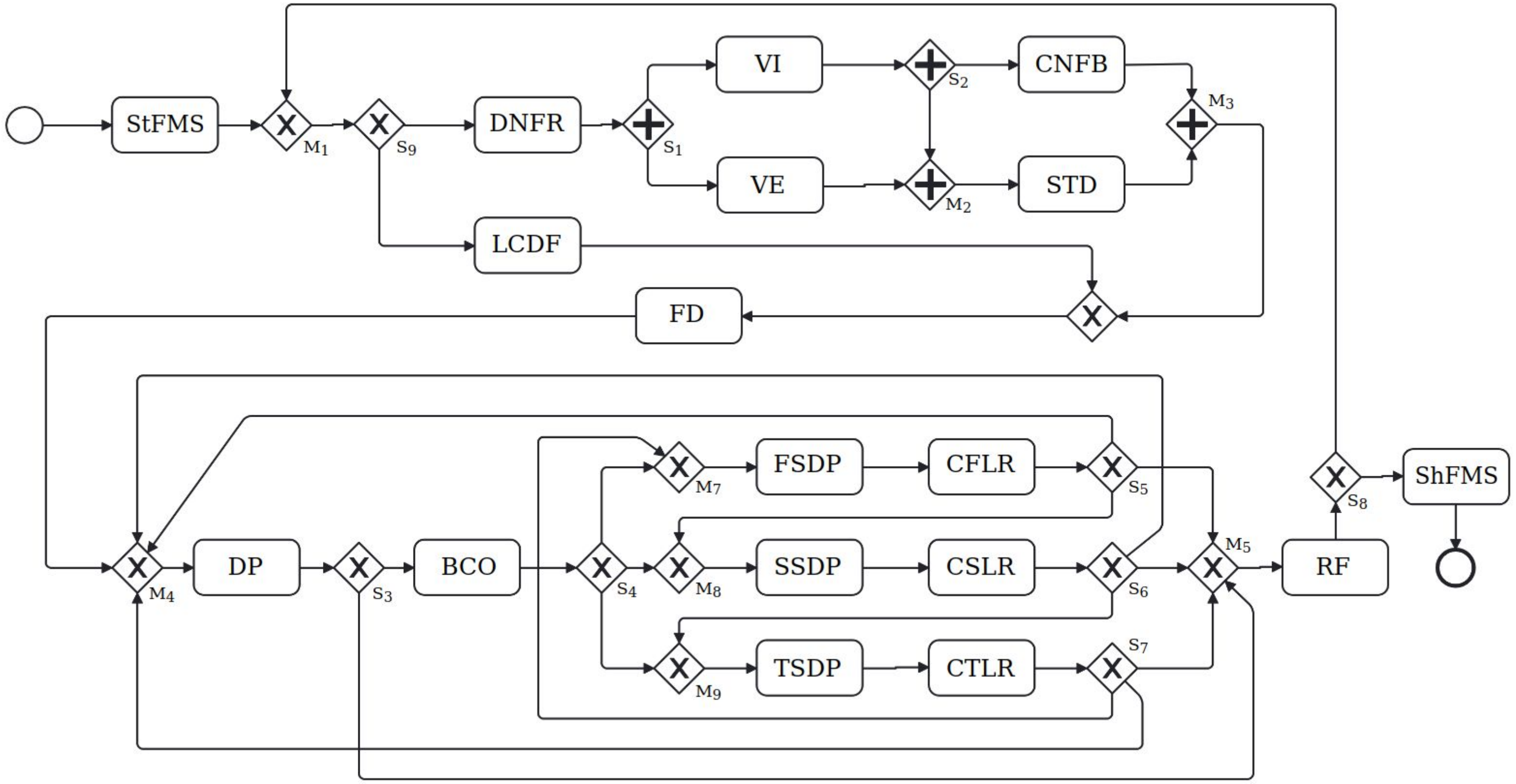

Tool Support

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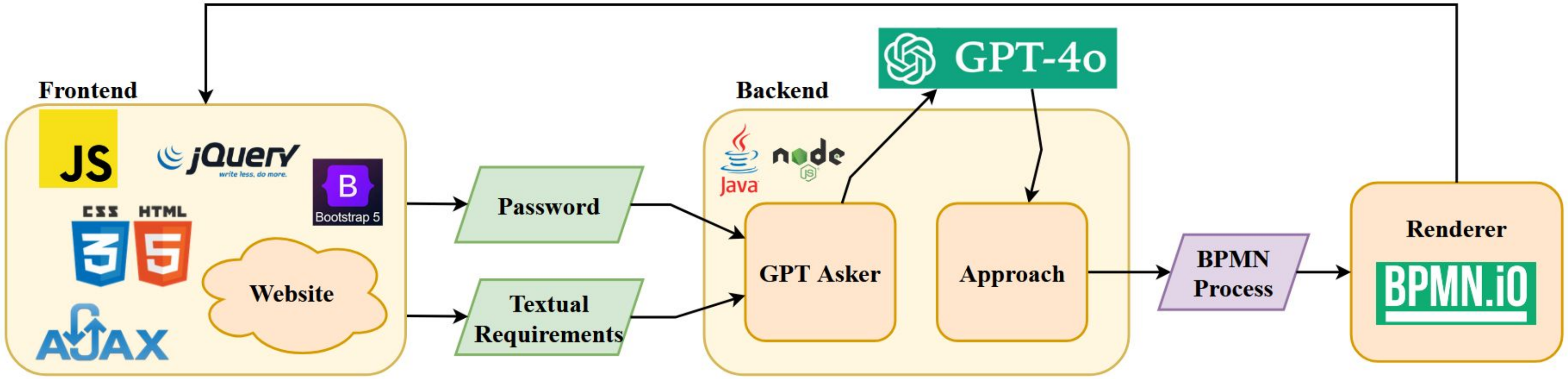
The Java code has been **embedded** in the backend of a **web server** freely accessible online (https://lig-givup.imag.fr/).



Experiments – Quality of the 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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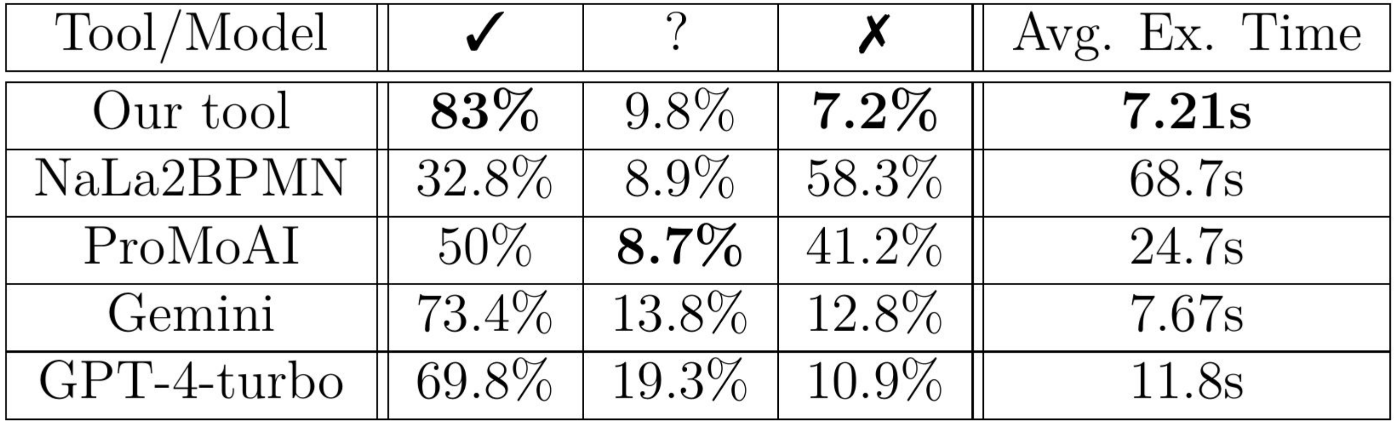

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An **ambiguous process** is a process that is **not incorrect** with regards to the description, but which **does not correspond to the expectations** of the experts.

Conclusion

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It has been **fully implemented** and **tested** as a tool consisting of approximately **12k lines** of Java code, which was embedded in the backend of a **web server** for **distribution purposes**.

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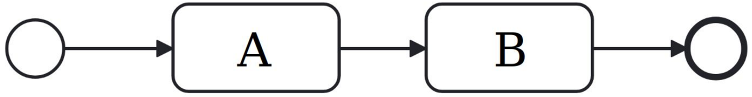

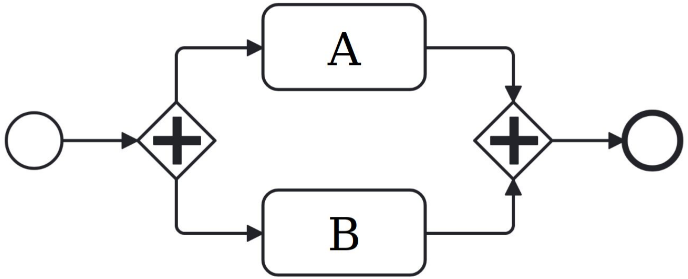

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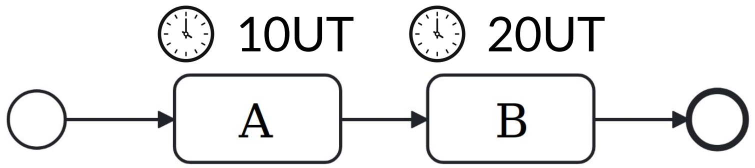

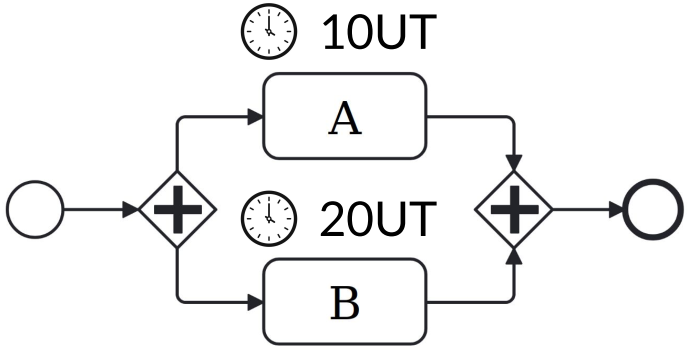

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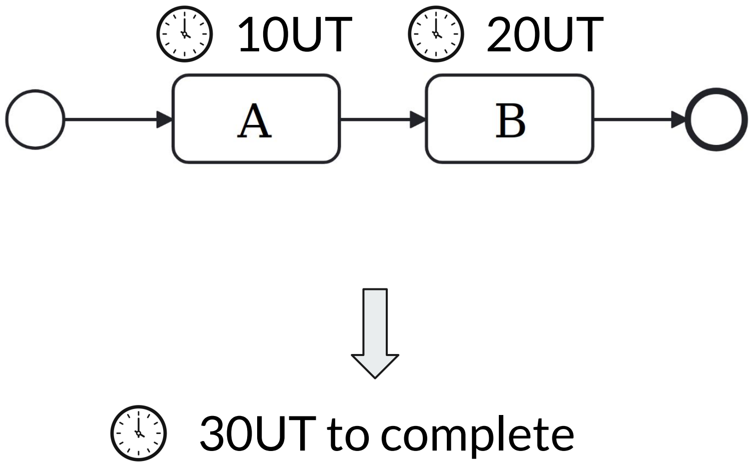

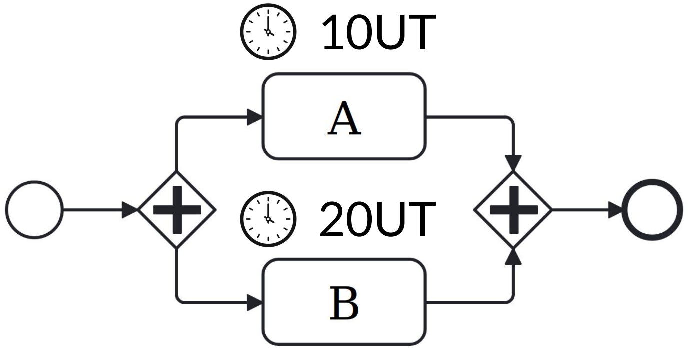

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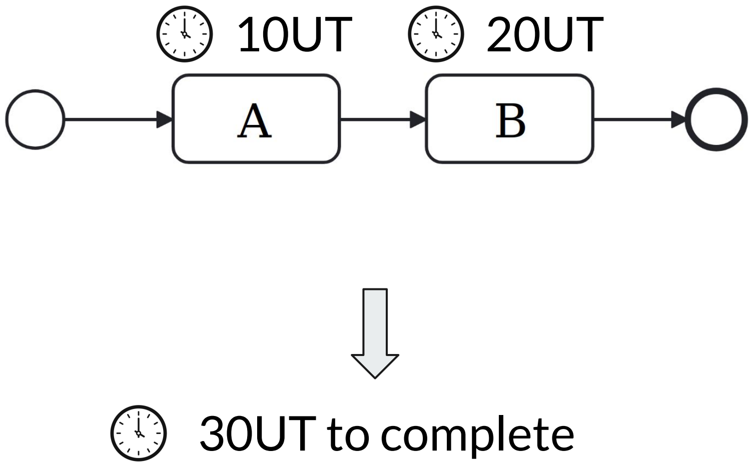
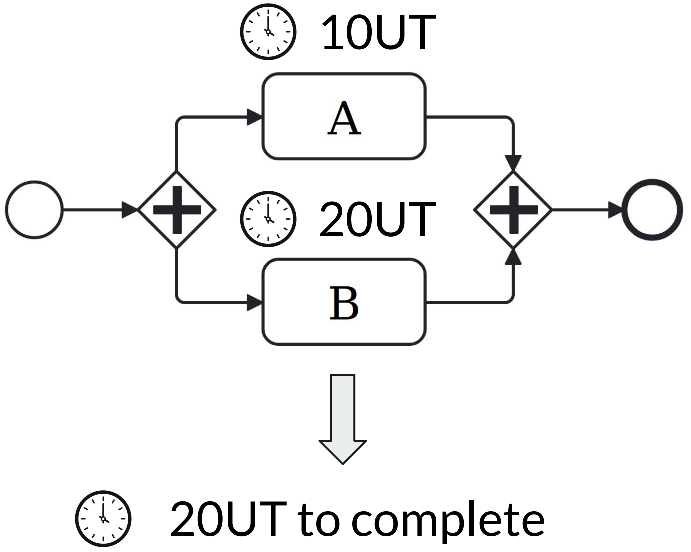
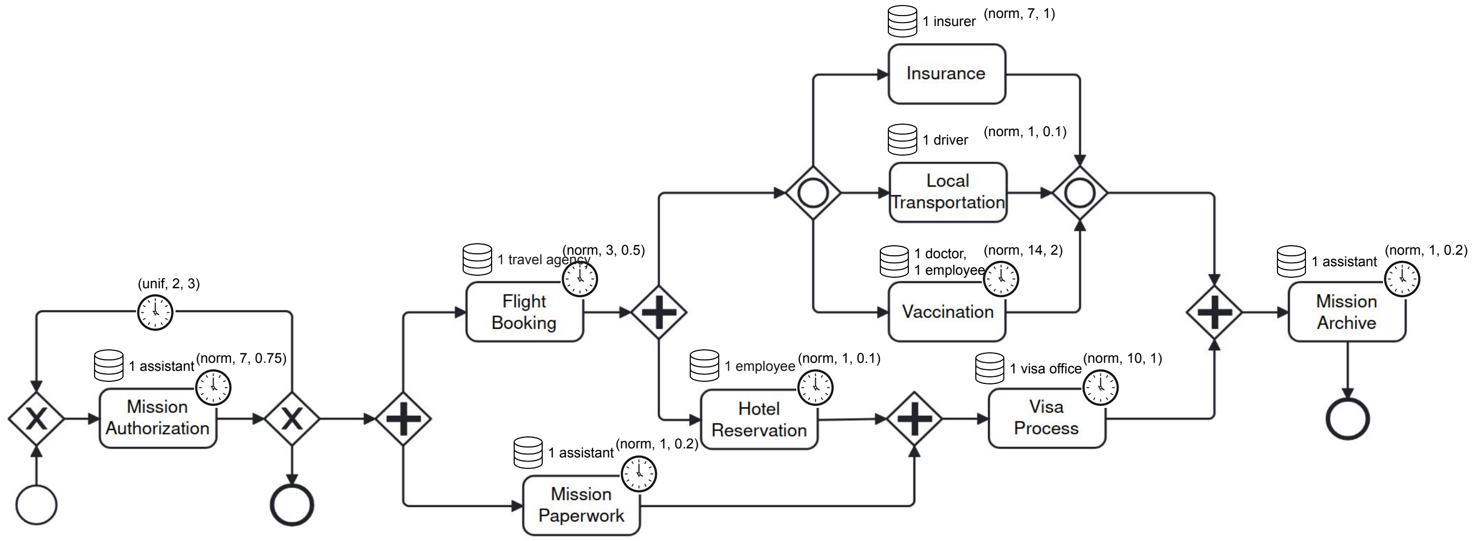


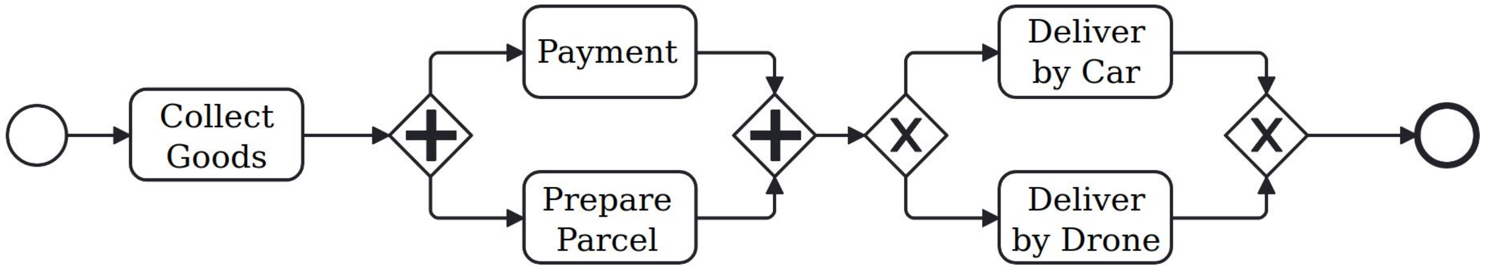


First Research Question



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

Second Research Question



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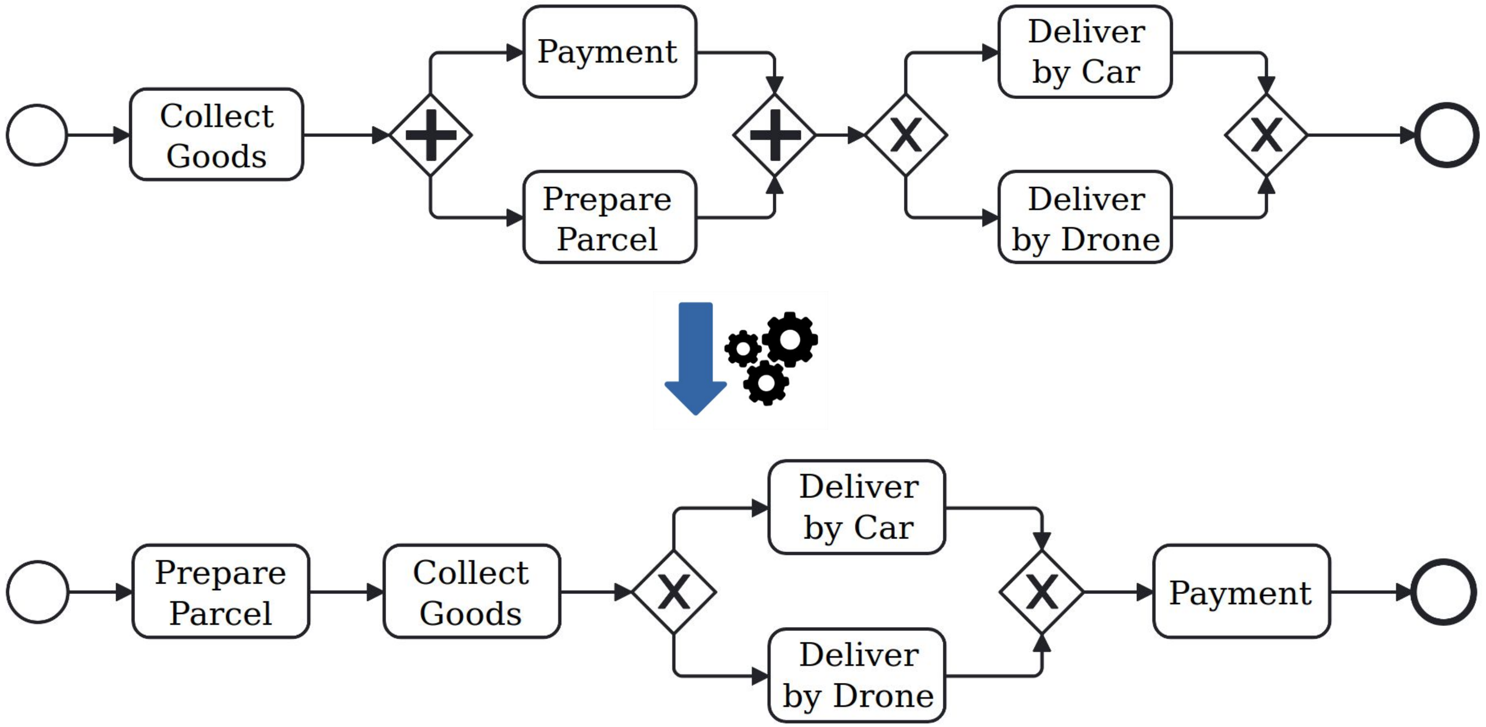

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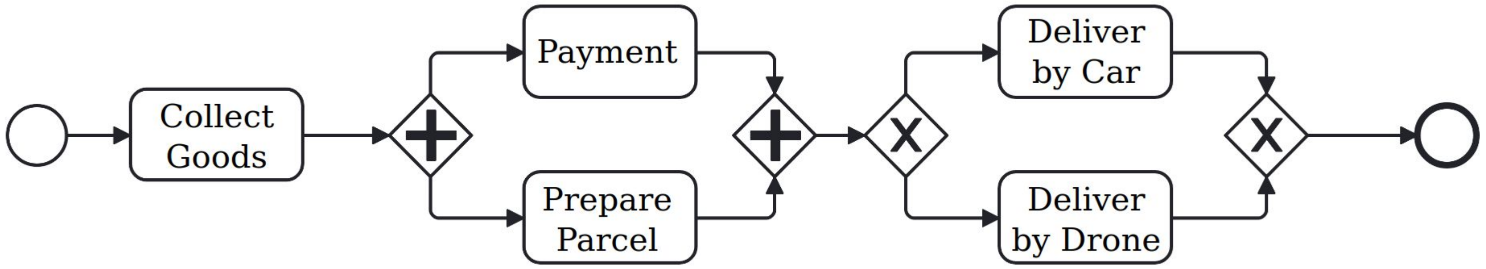

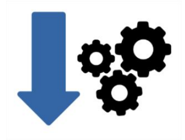

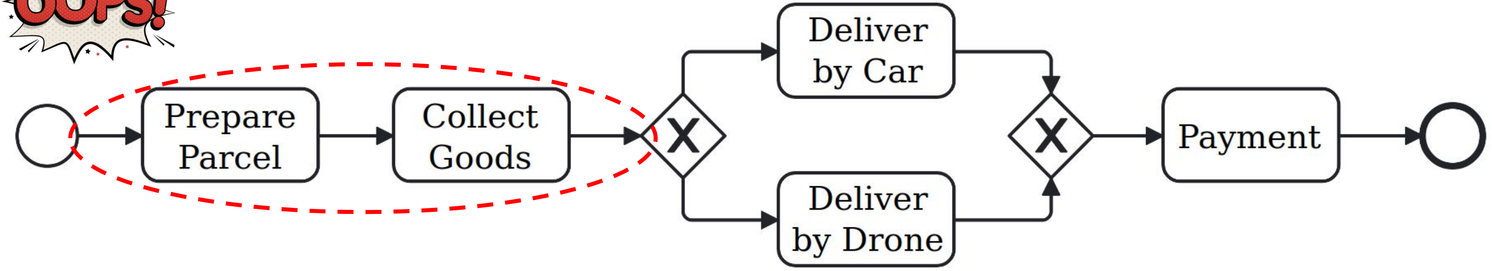

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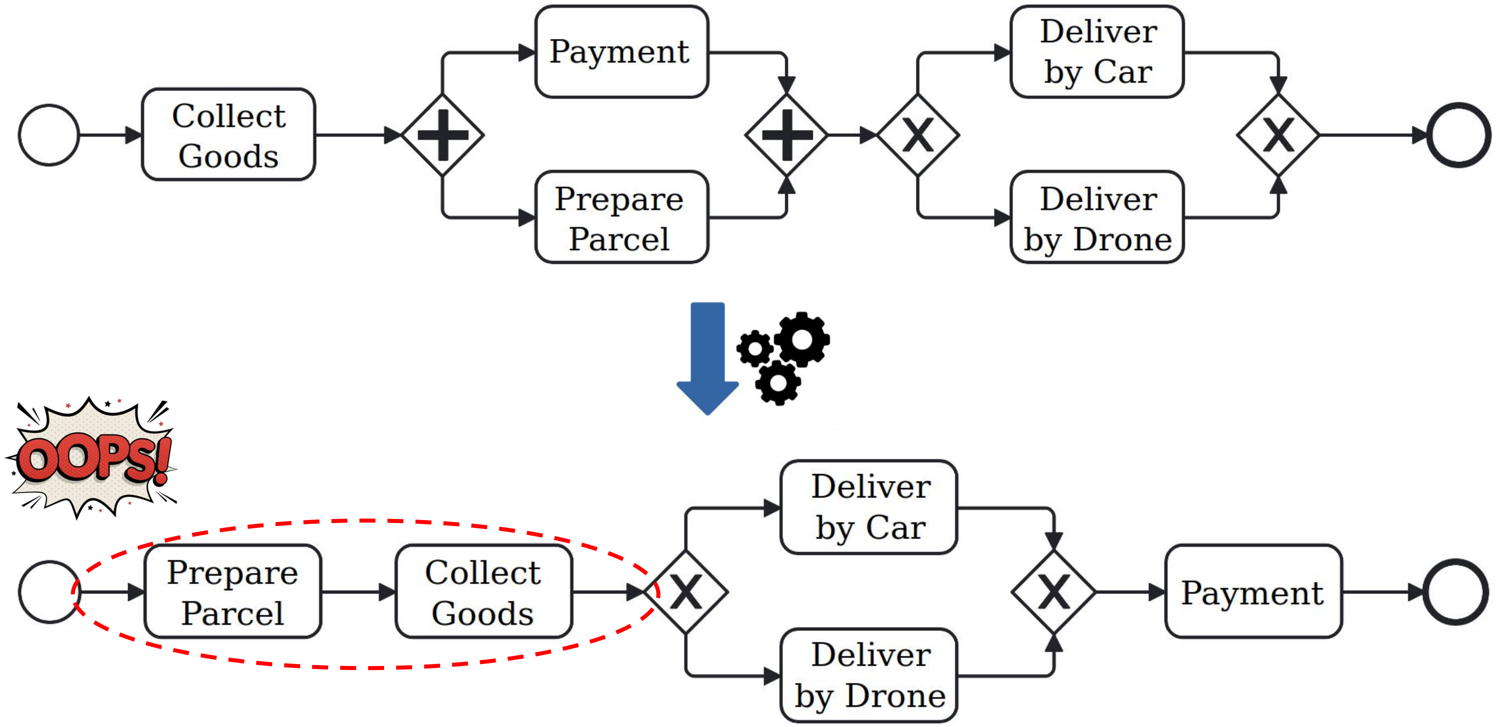
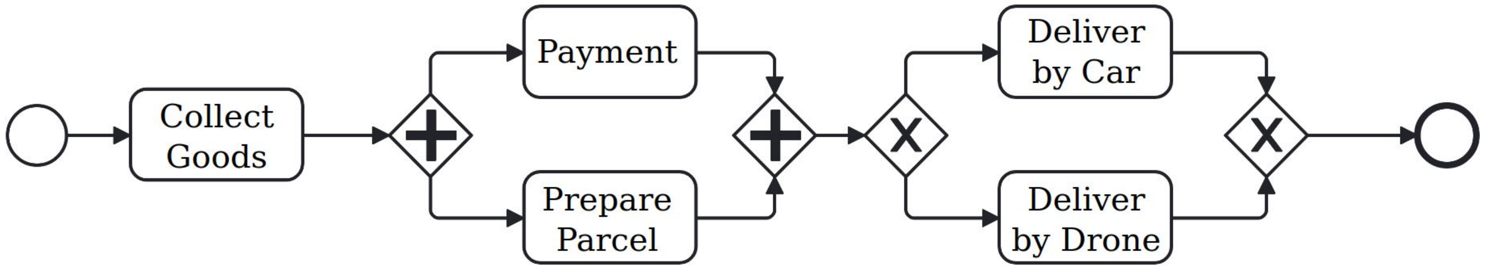


➢ How can you **preserve the logic/meaning** of the original process?

Third Research Question



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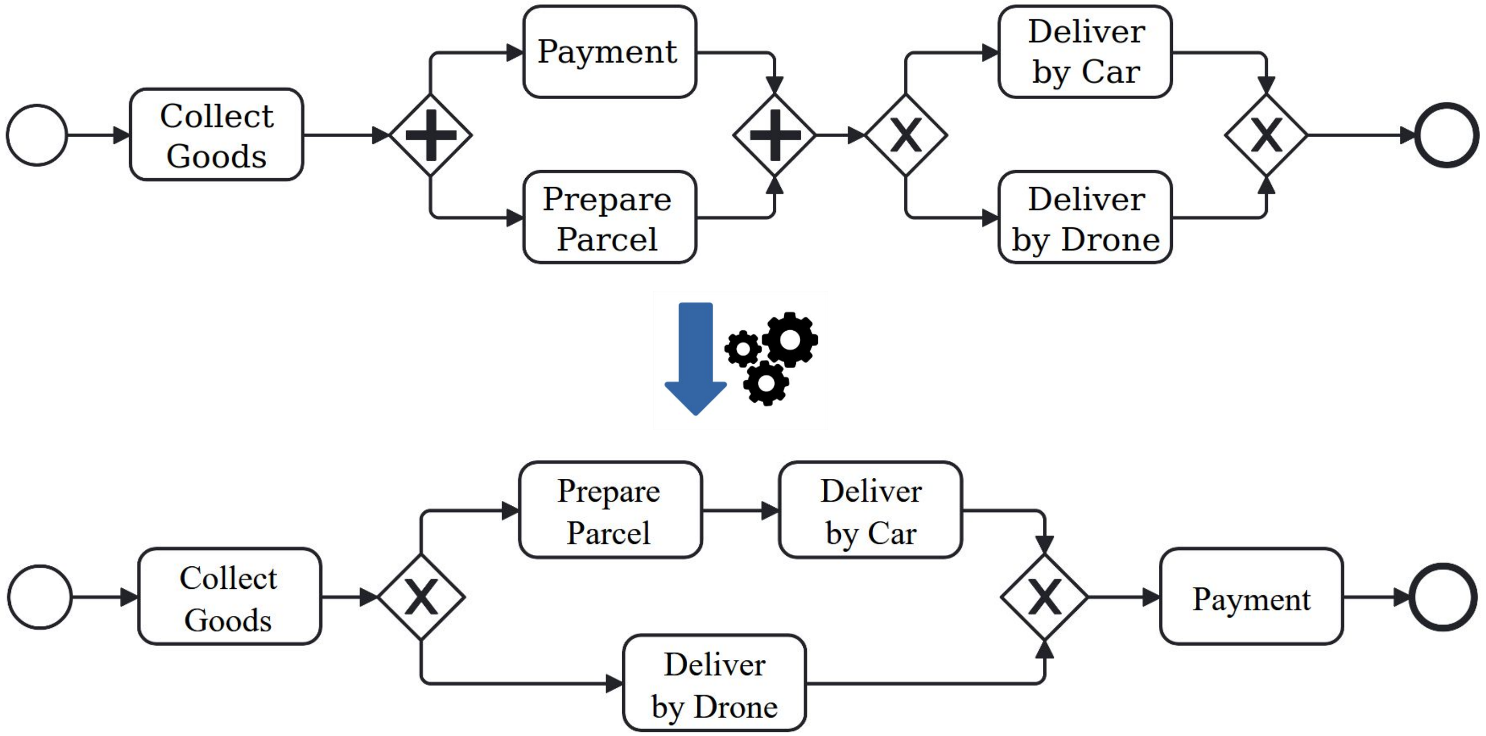

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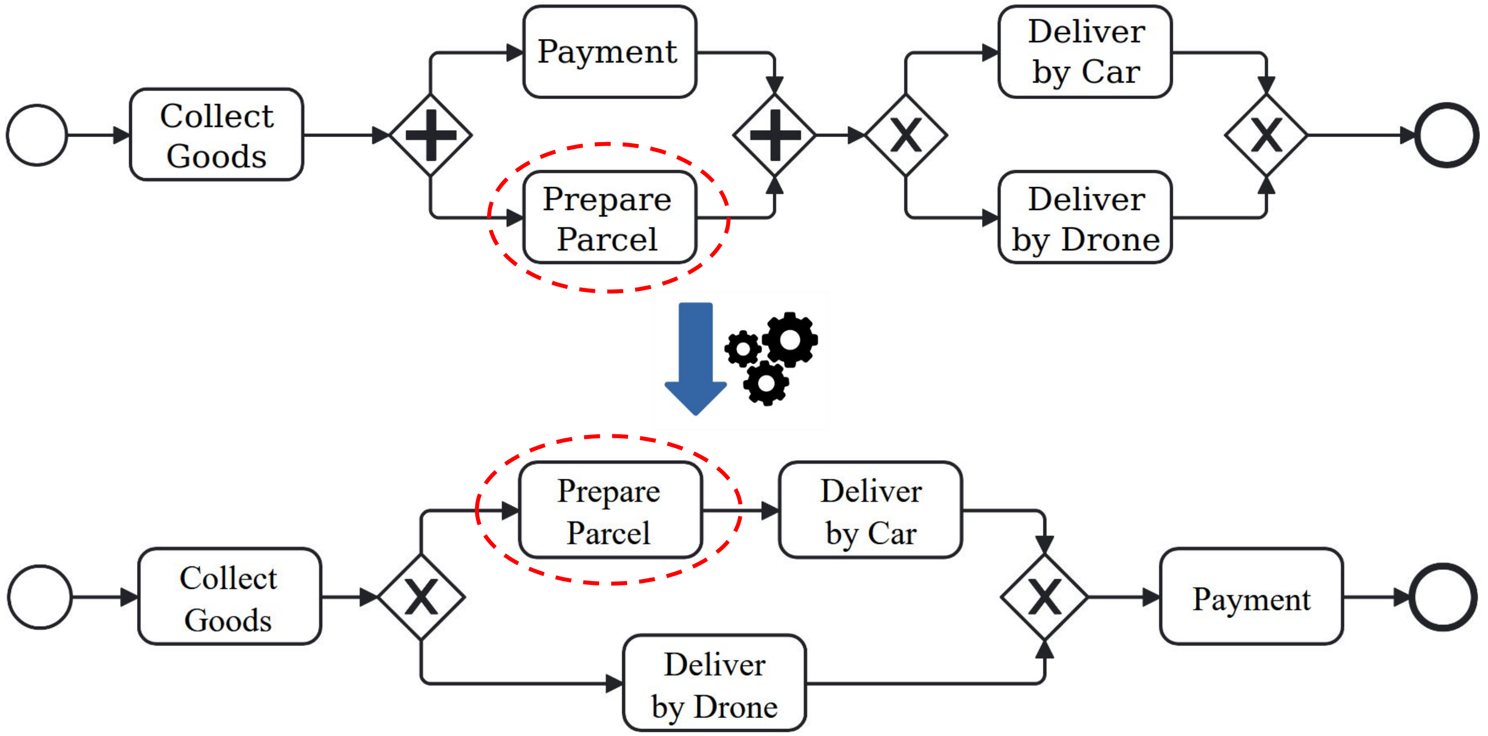

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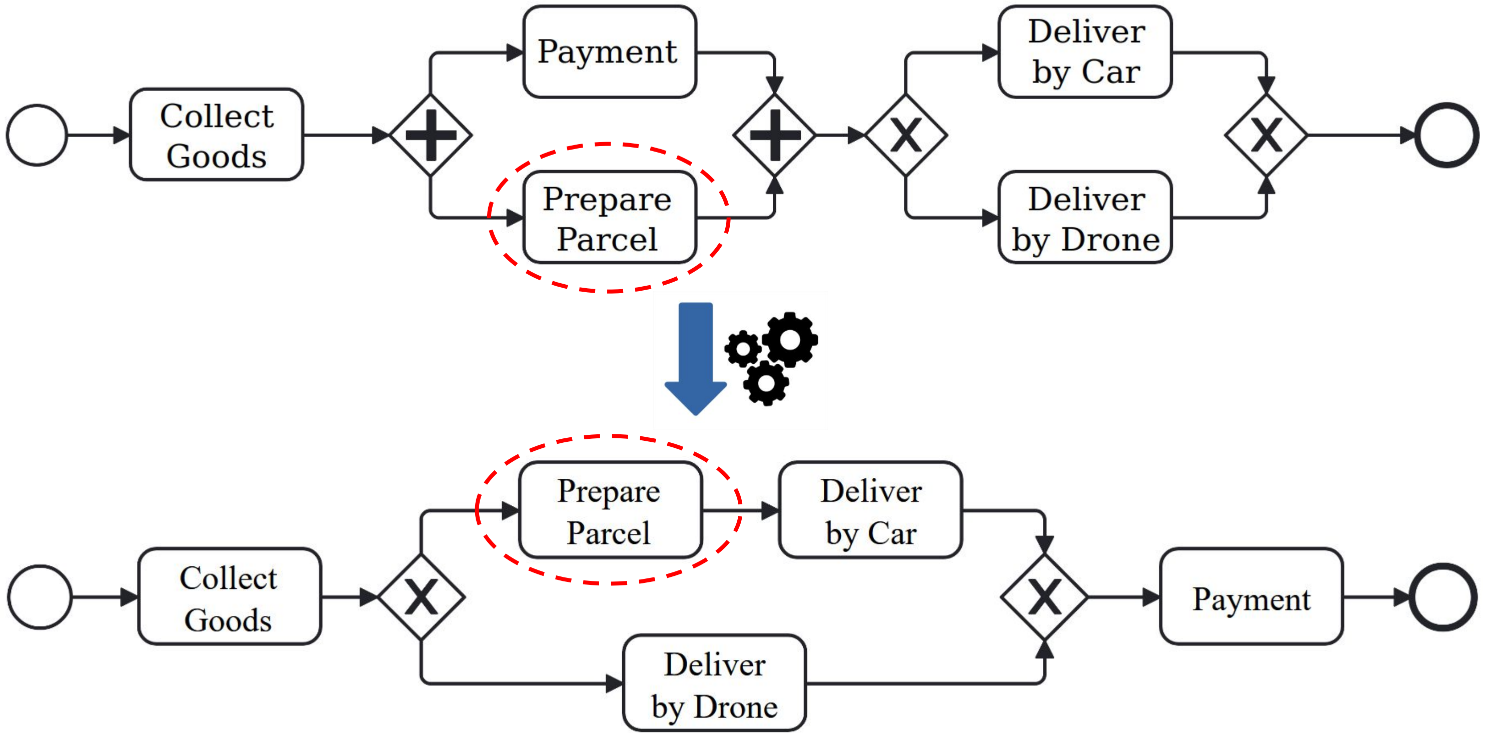
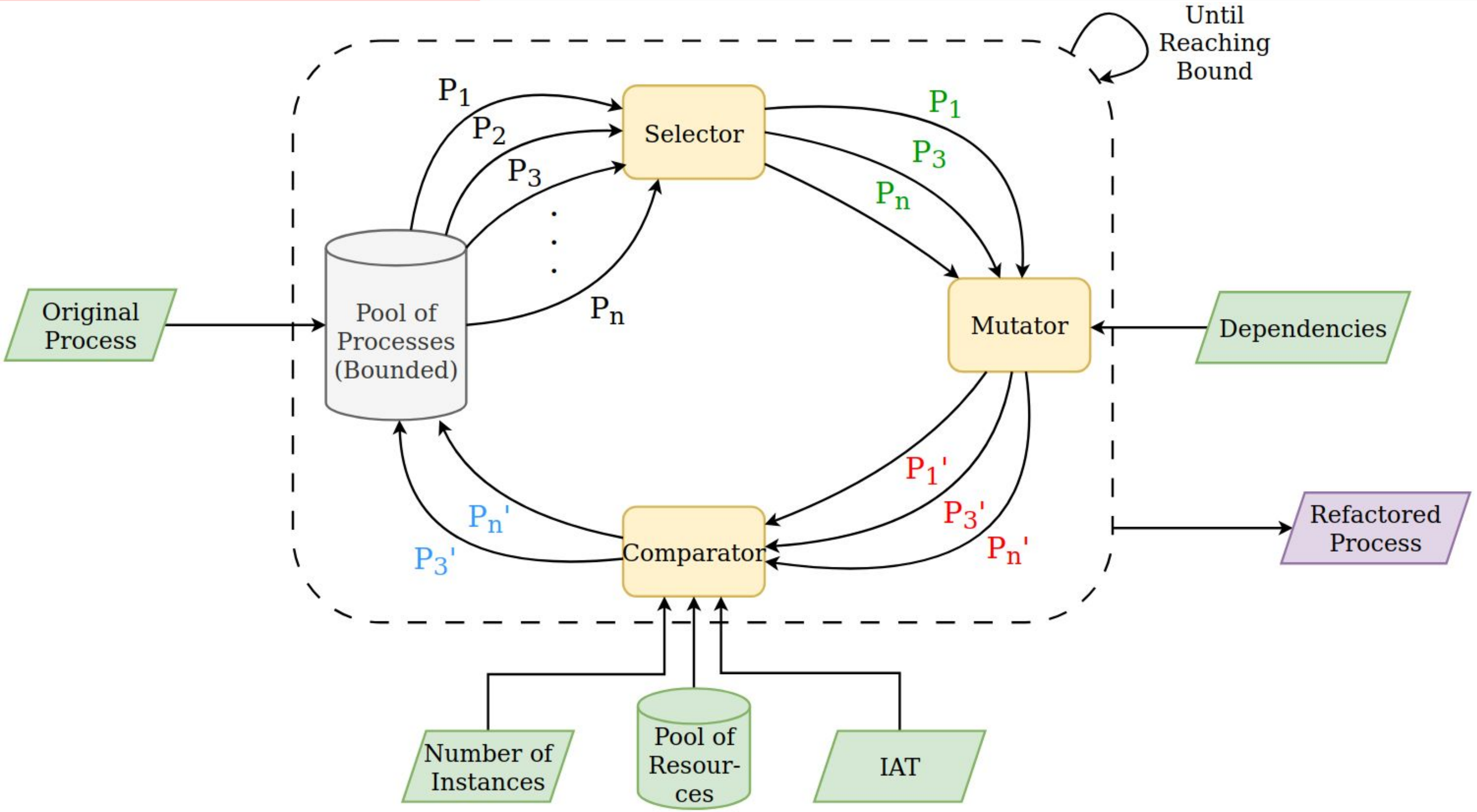


➢ How can you **preserve the structural semantics** of the original process?

Global Approach



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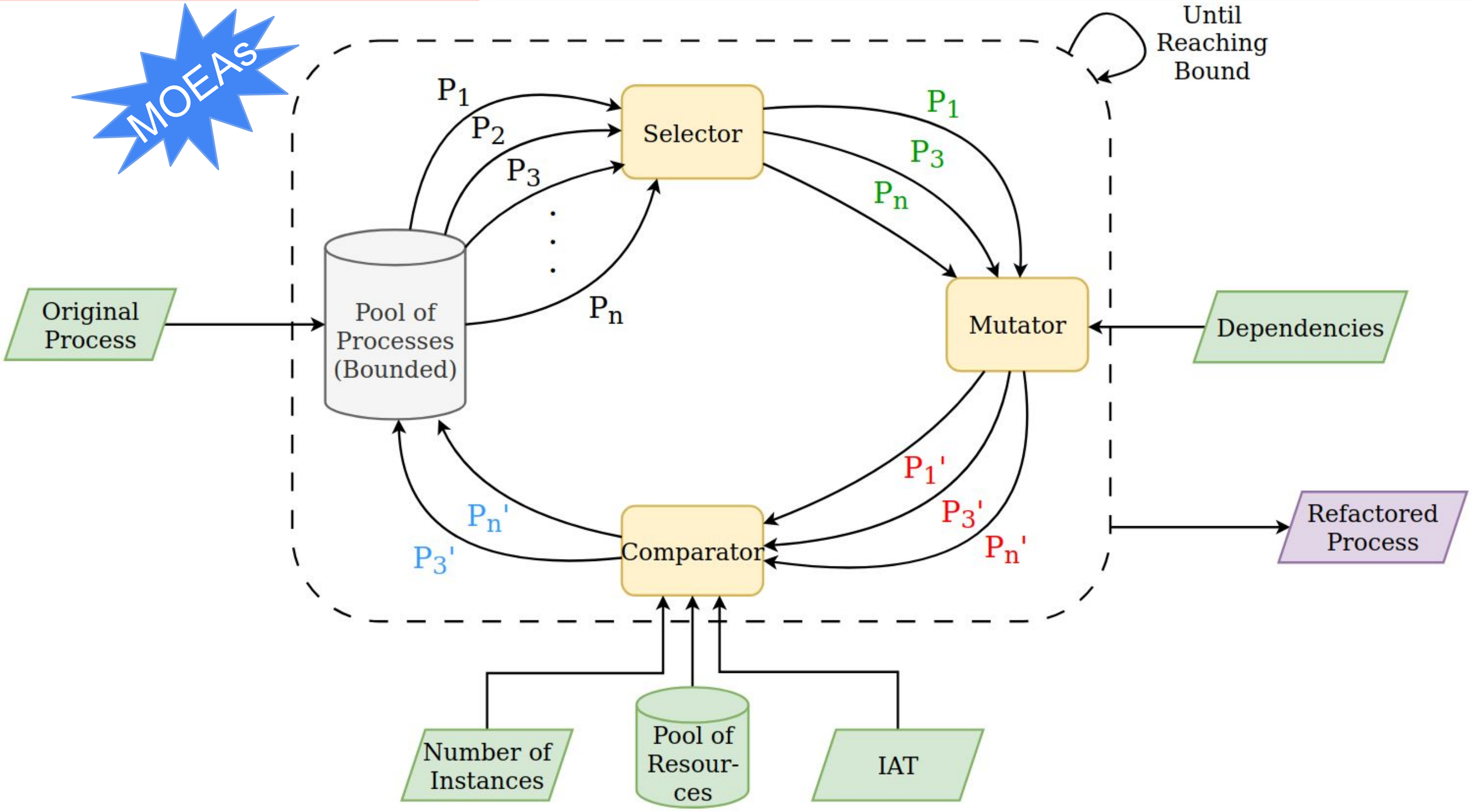

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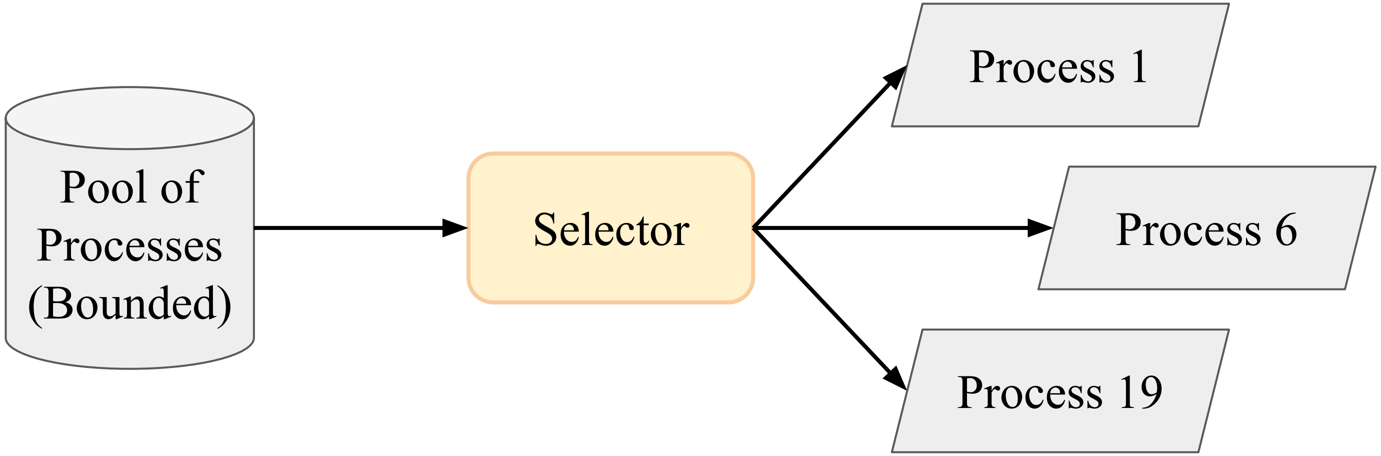

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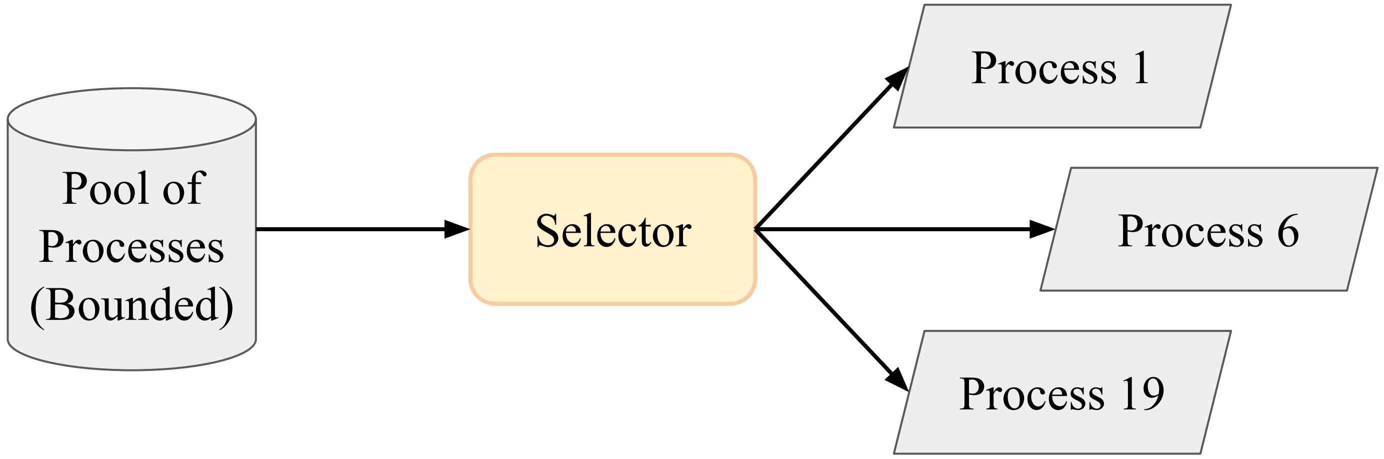

This step can be performed in **various ways**, but is usually at the **discretion of the used algorithm**, which is also the case in this approach.

Step 2 – Mutation

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Such **guarantees** are **obtained** with the help of two mechanisms: **user-defined task dependencies**, and **refactoring patterns**.

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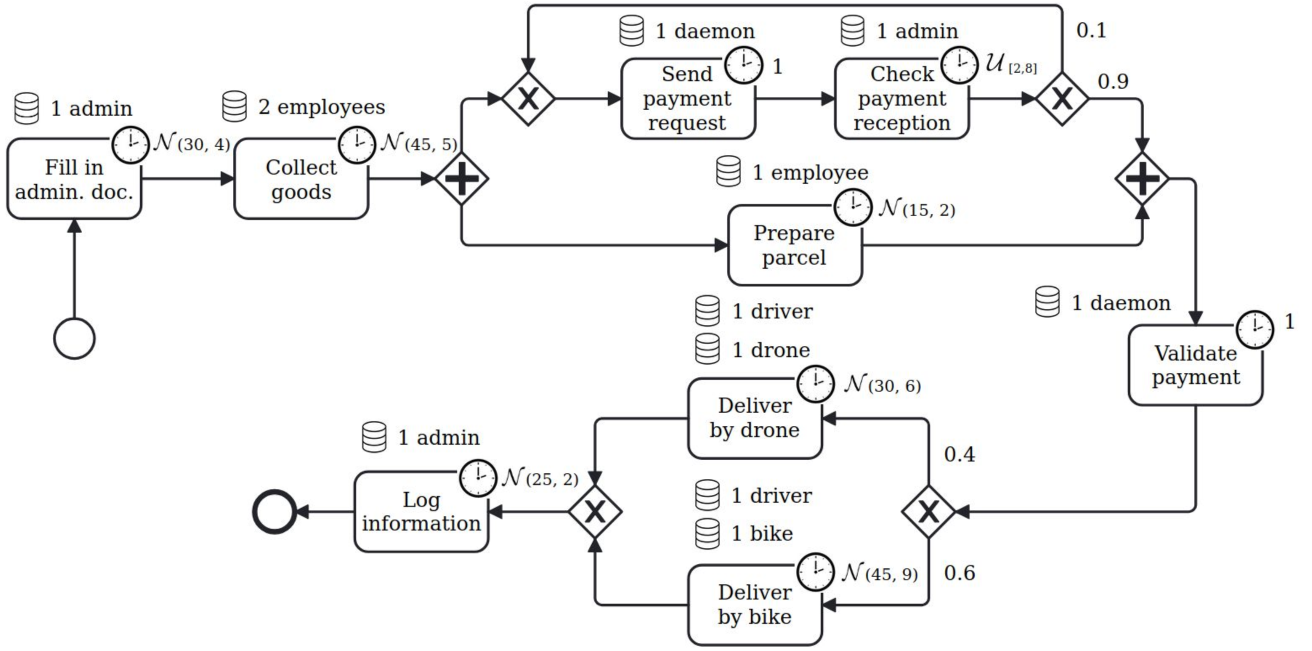

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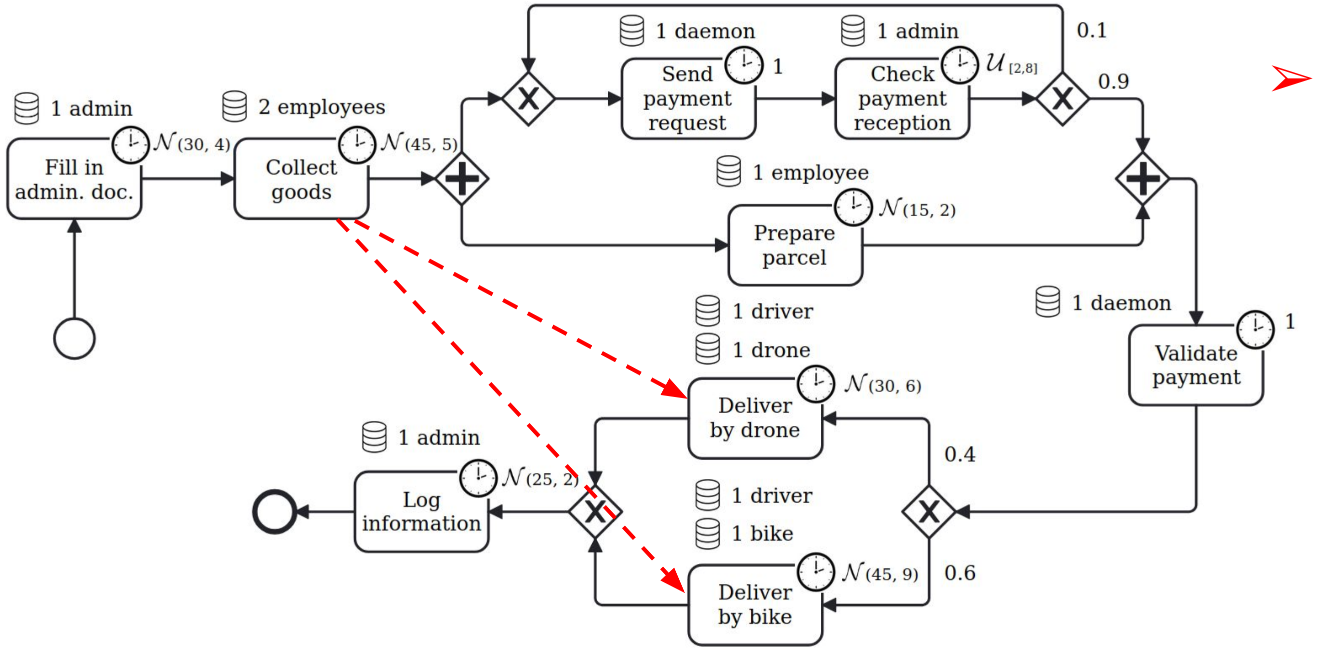

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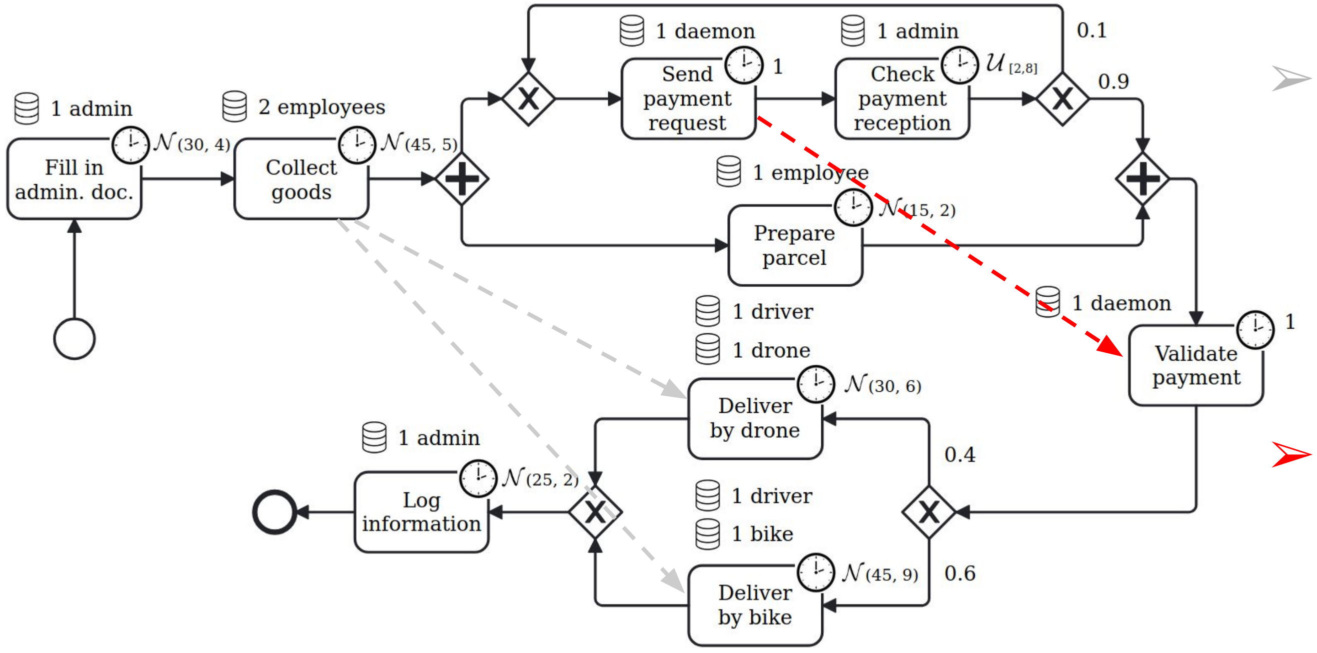

- ➢ Goods must be collected before being delivered.
- ➢ A payment request must be sent before being validated.

Step 2 – Refactoring Patterns – Introduction

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A sequence graph is a **hierarchical structure** composed of **nodes** and **edges**.

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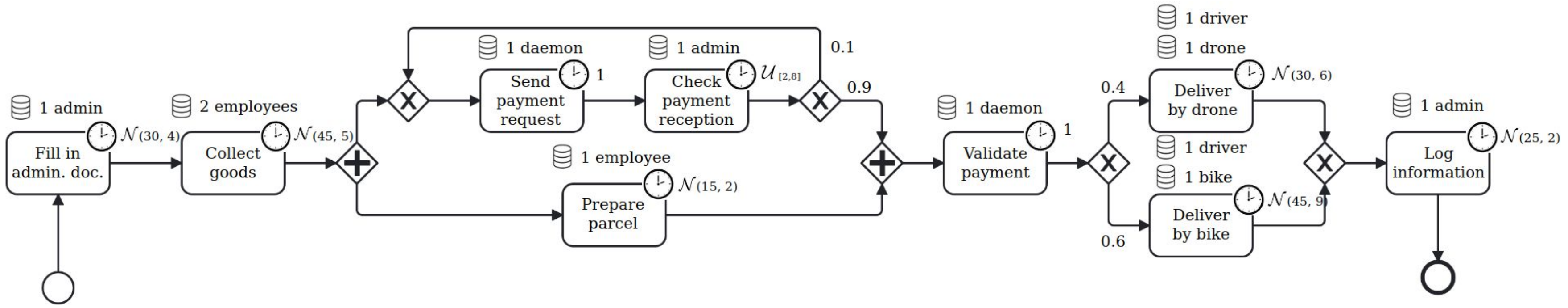

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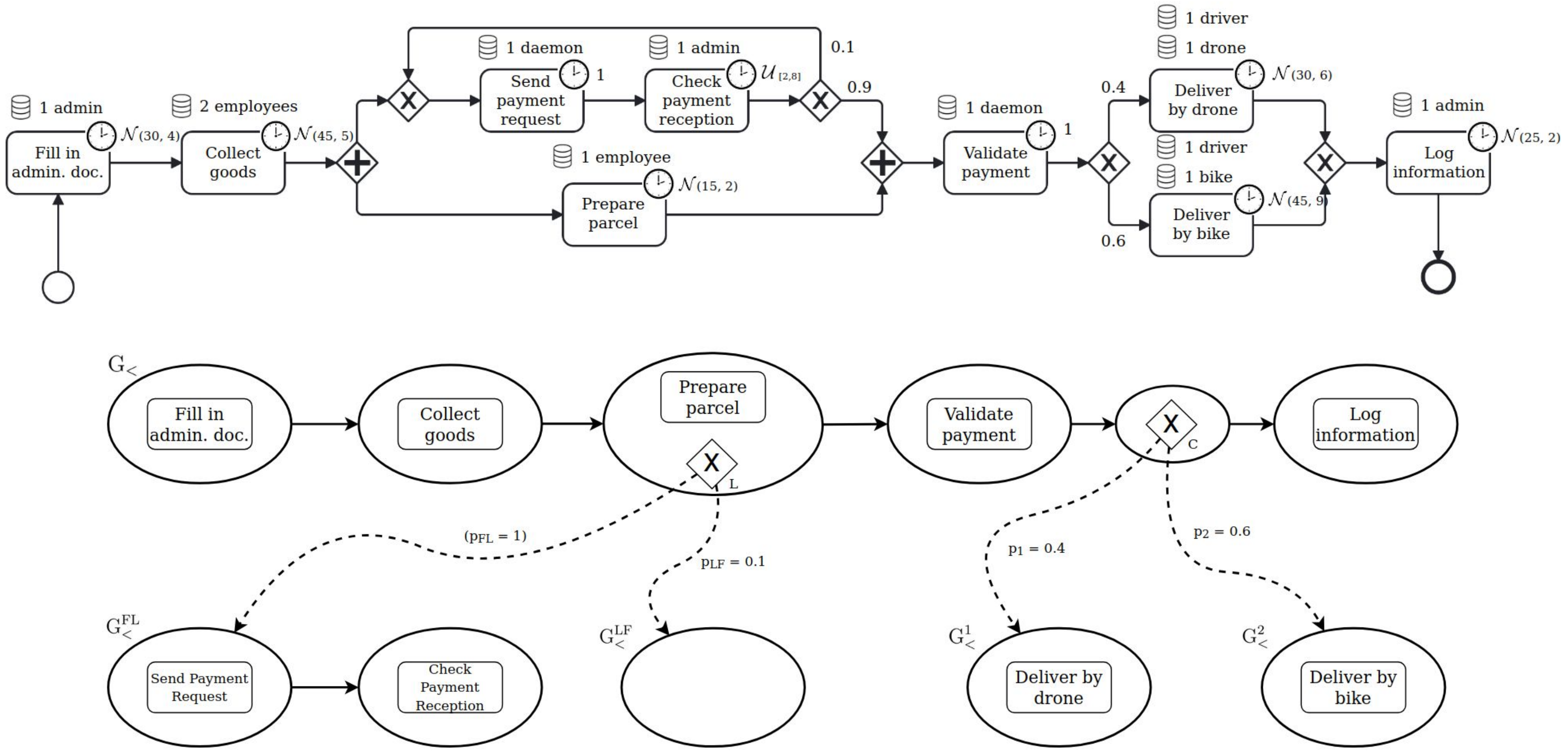

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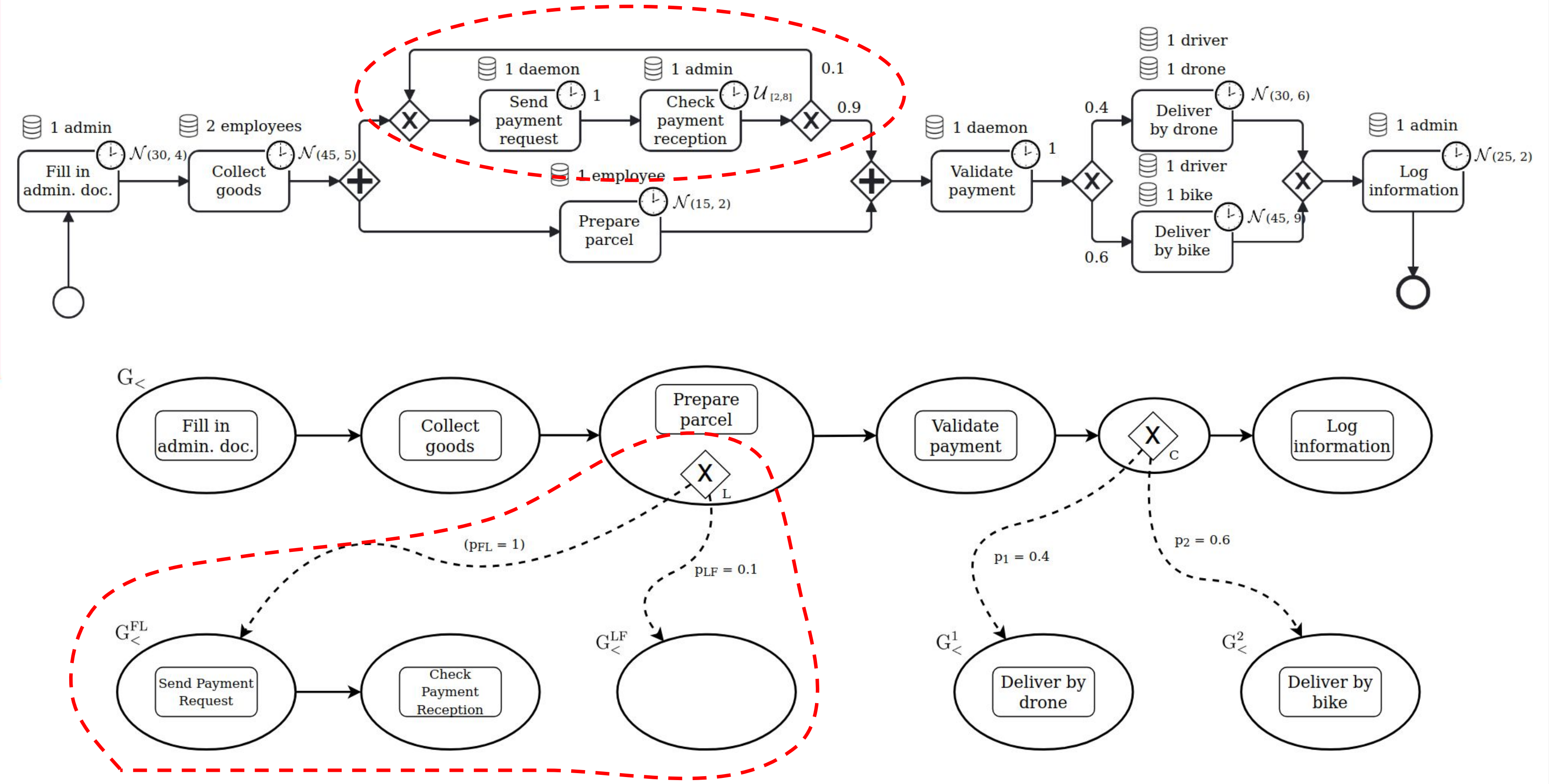
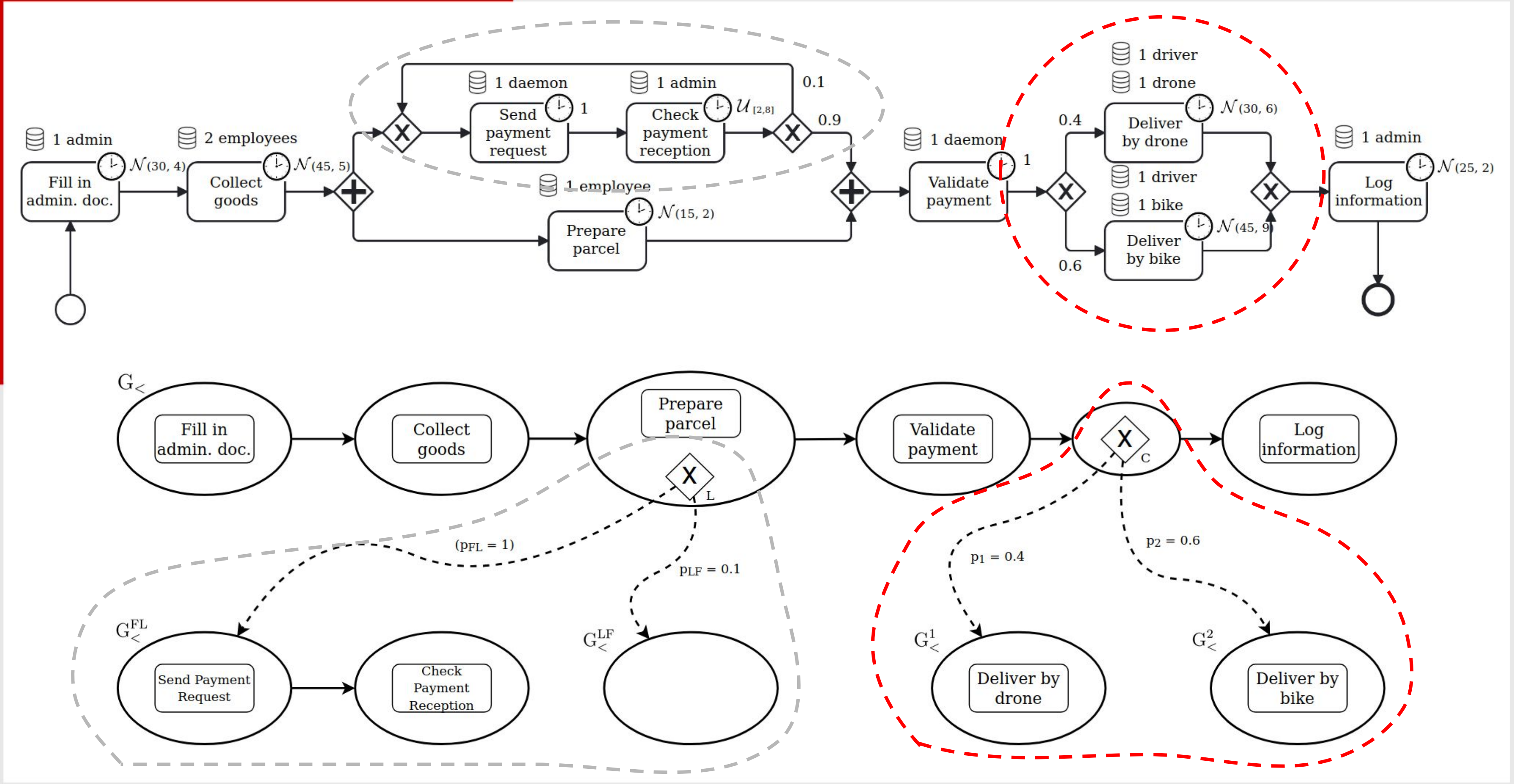
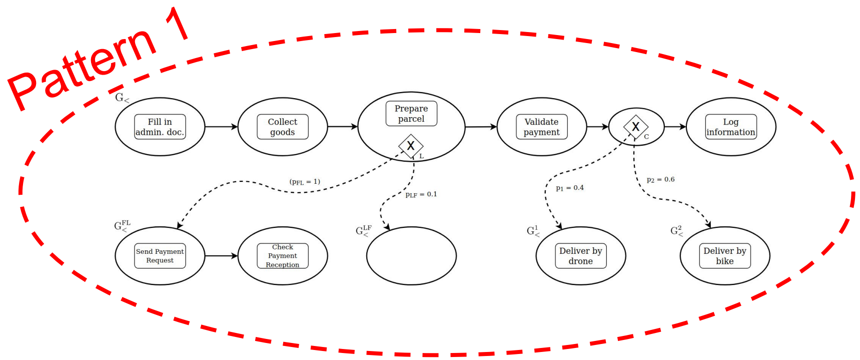


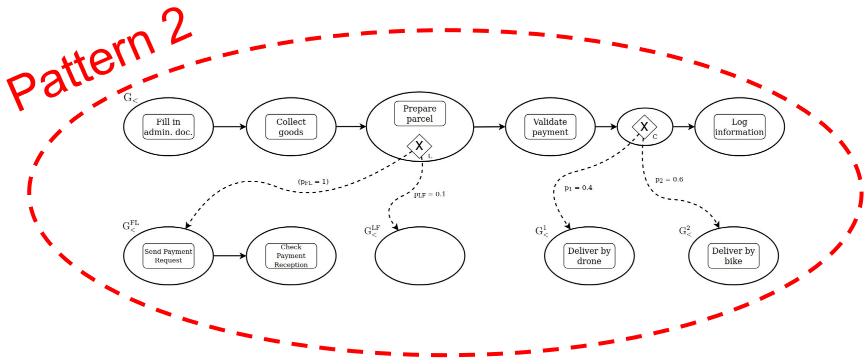
Step 2 – Sequence Graph

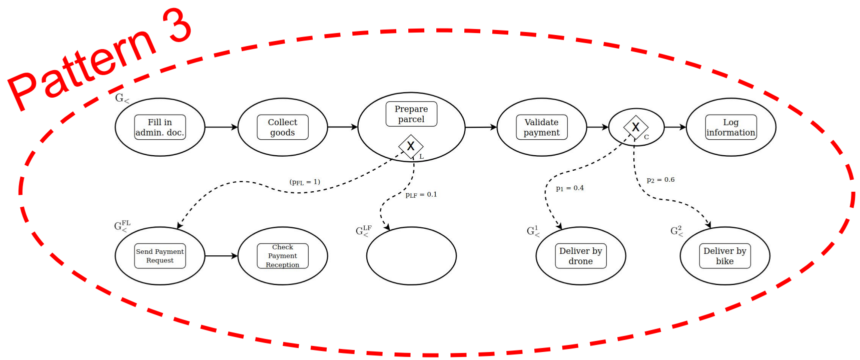


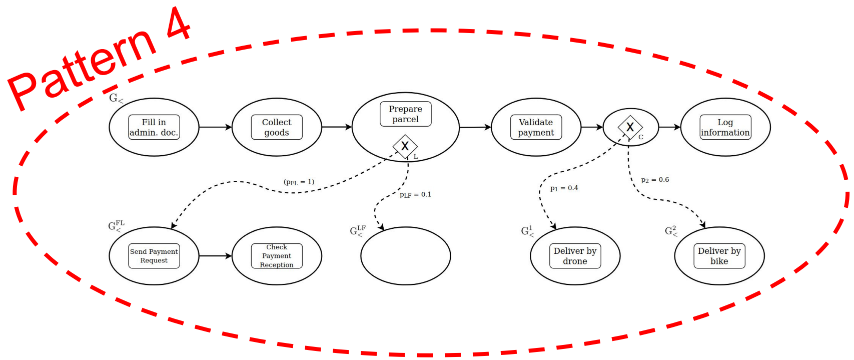
Step 2 – Refactoring Patterns

The **movement** of a task in the process is **ruled** by **4** refactoring **patterns**.



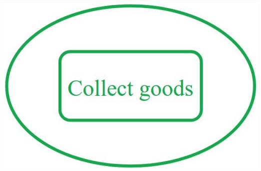


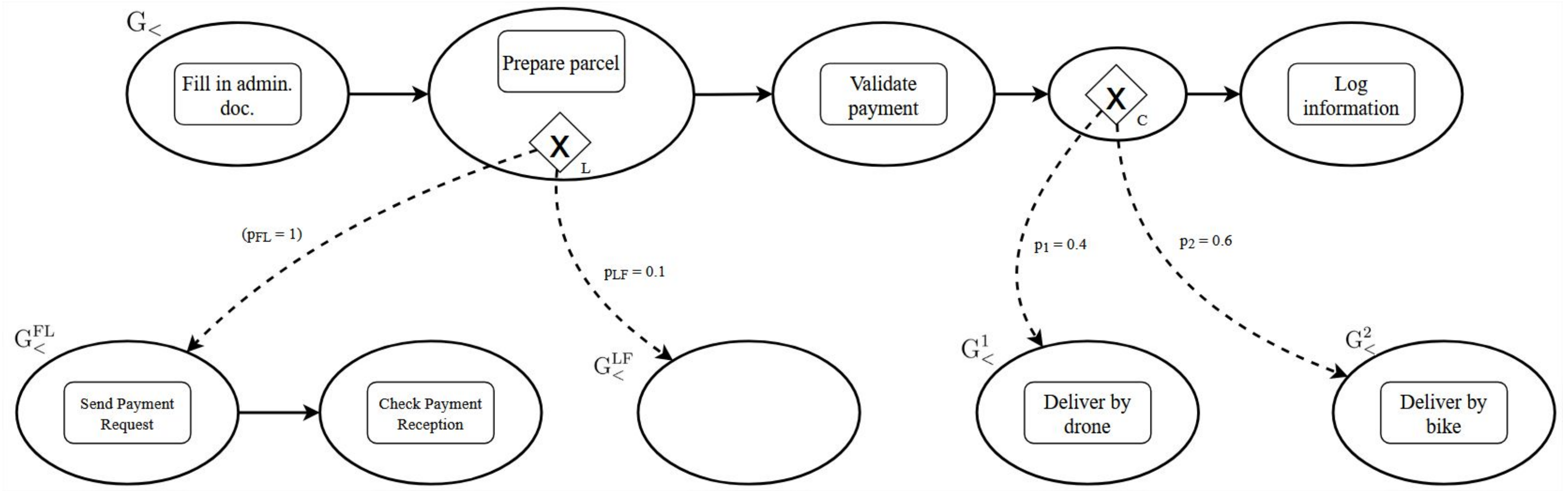




Step 2 – Pattern 1

The **first pattern** consists in inserting the task before/after any node of the graph.





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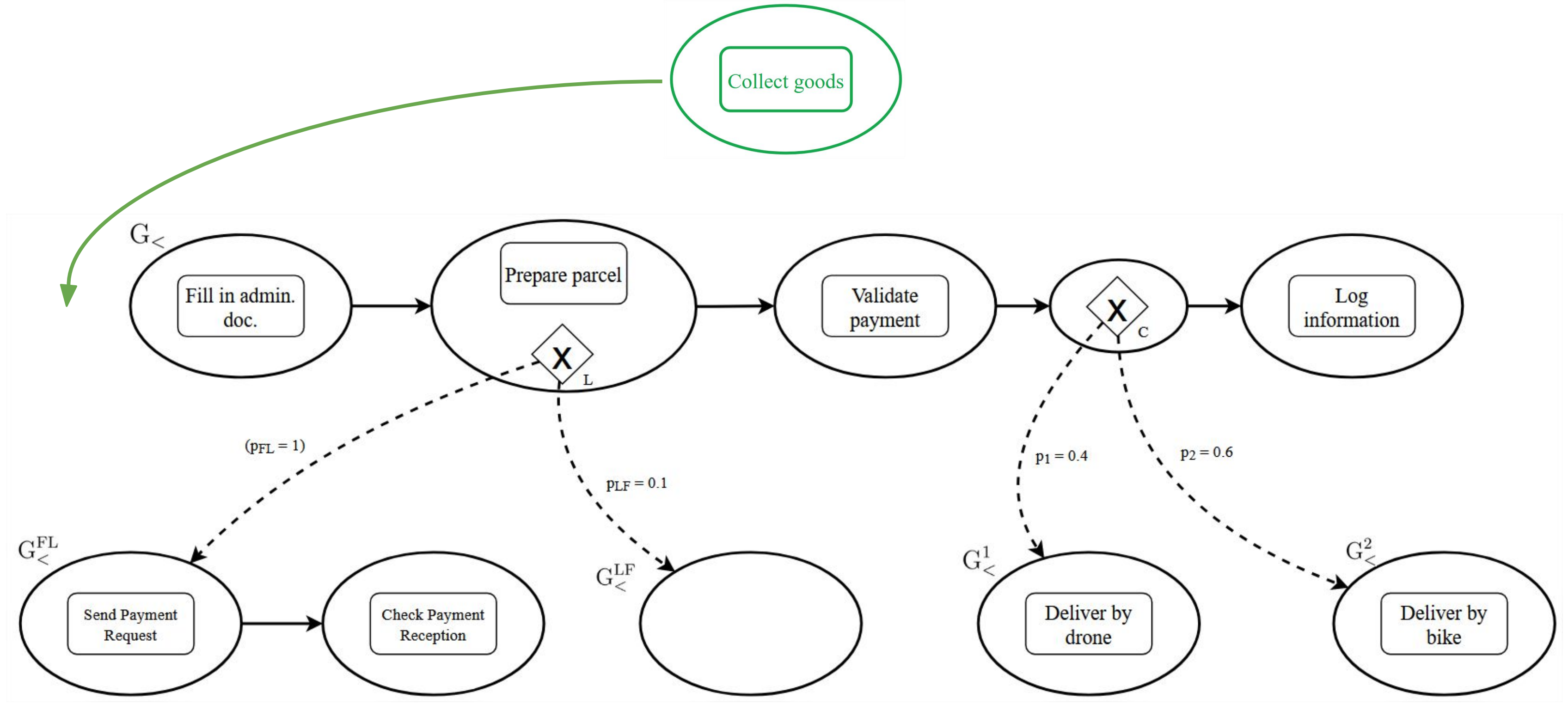

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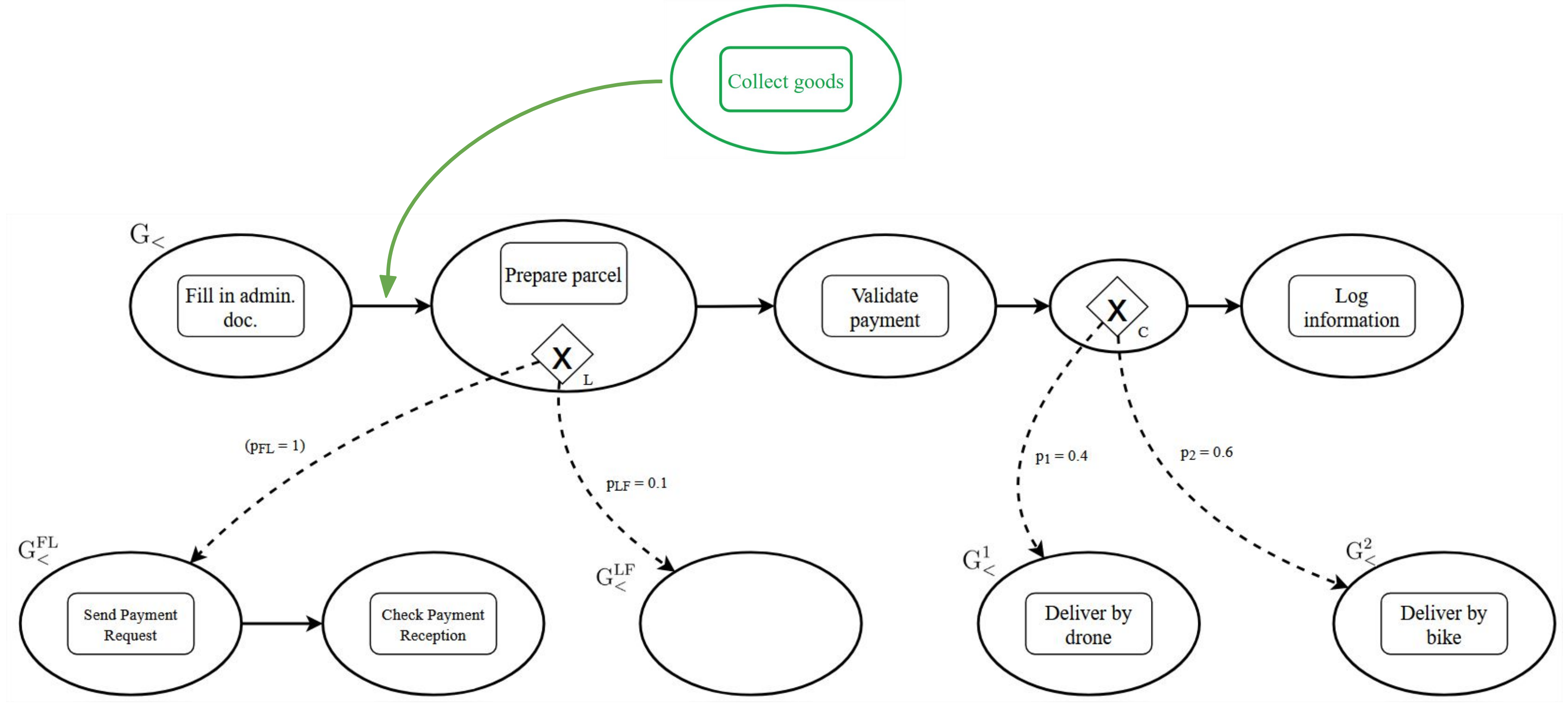

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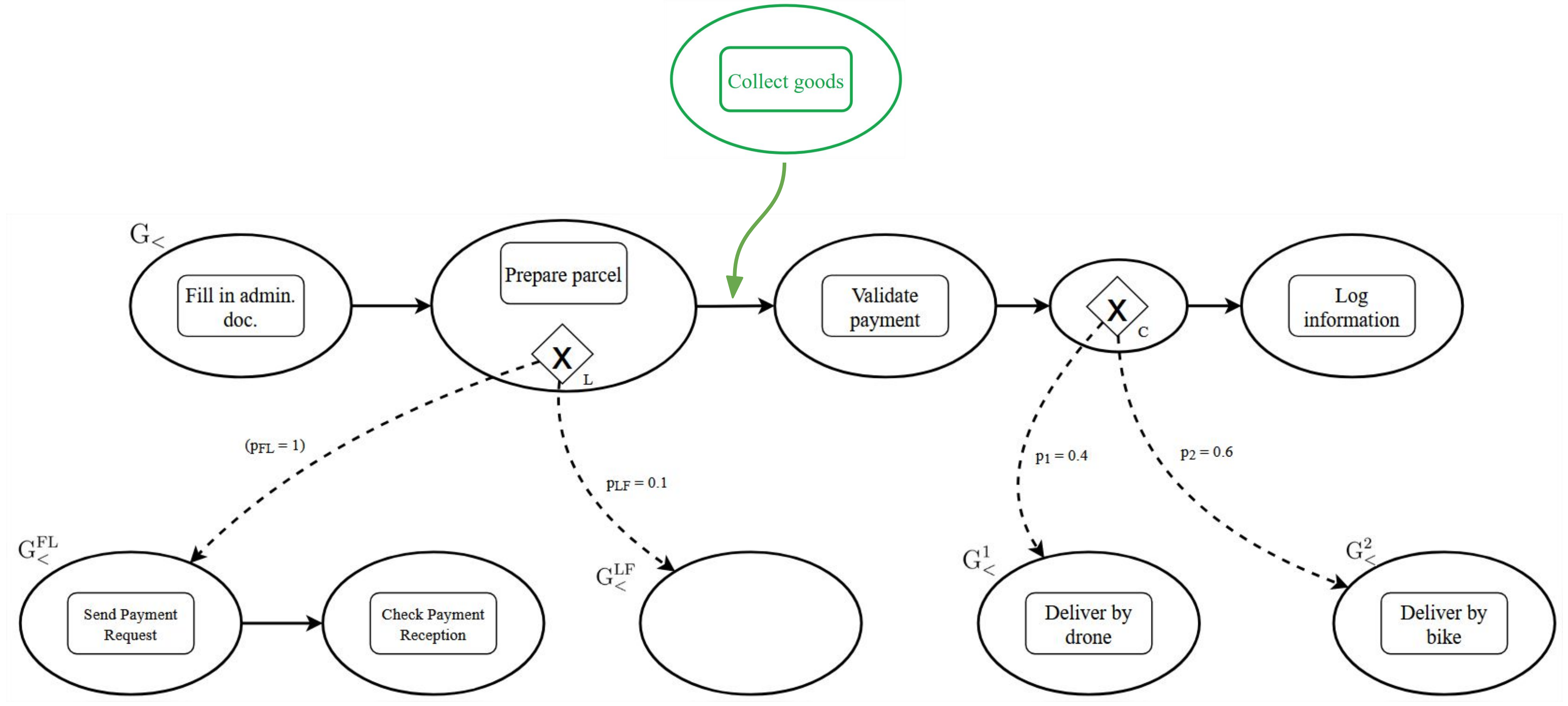

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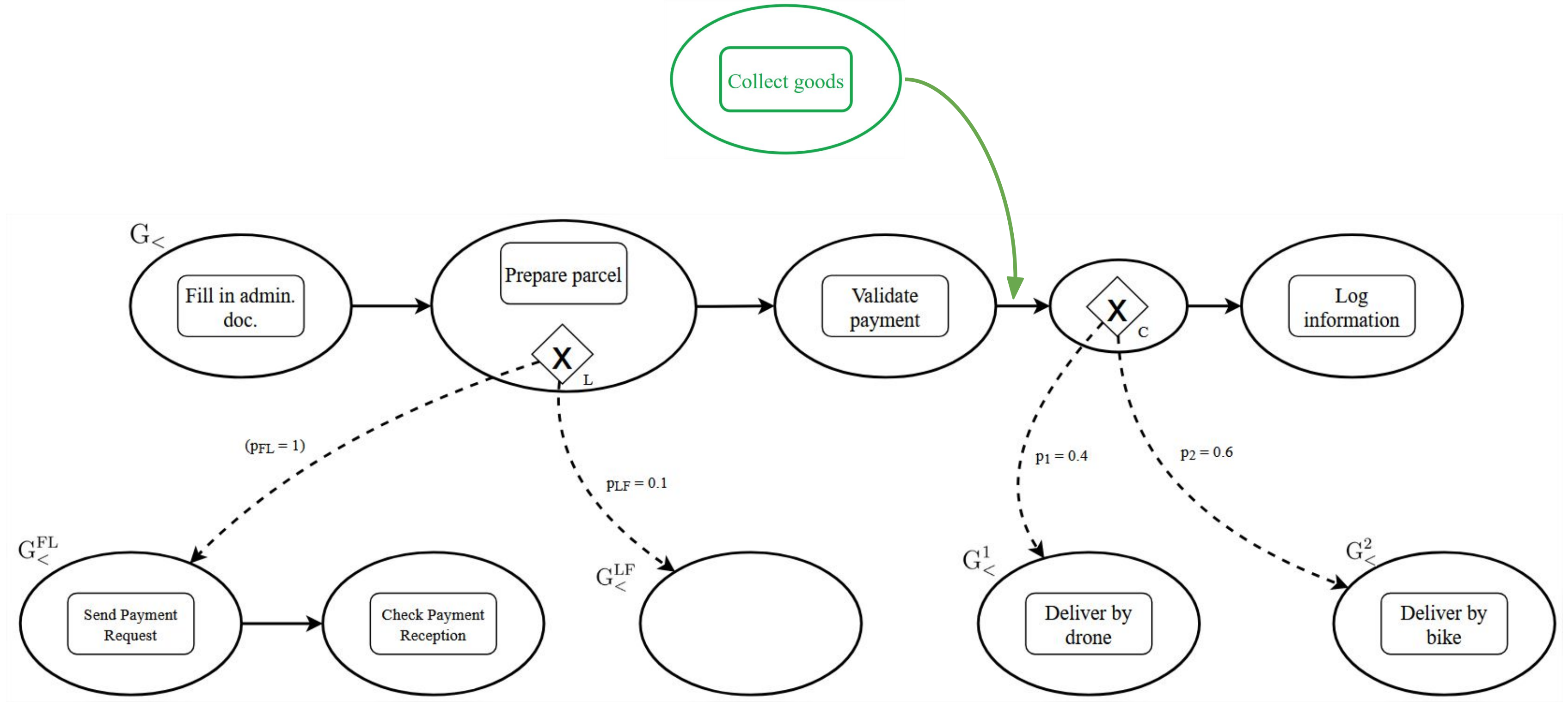

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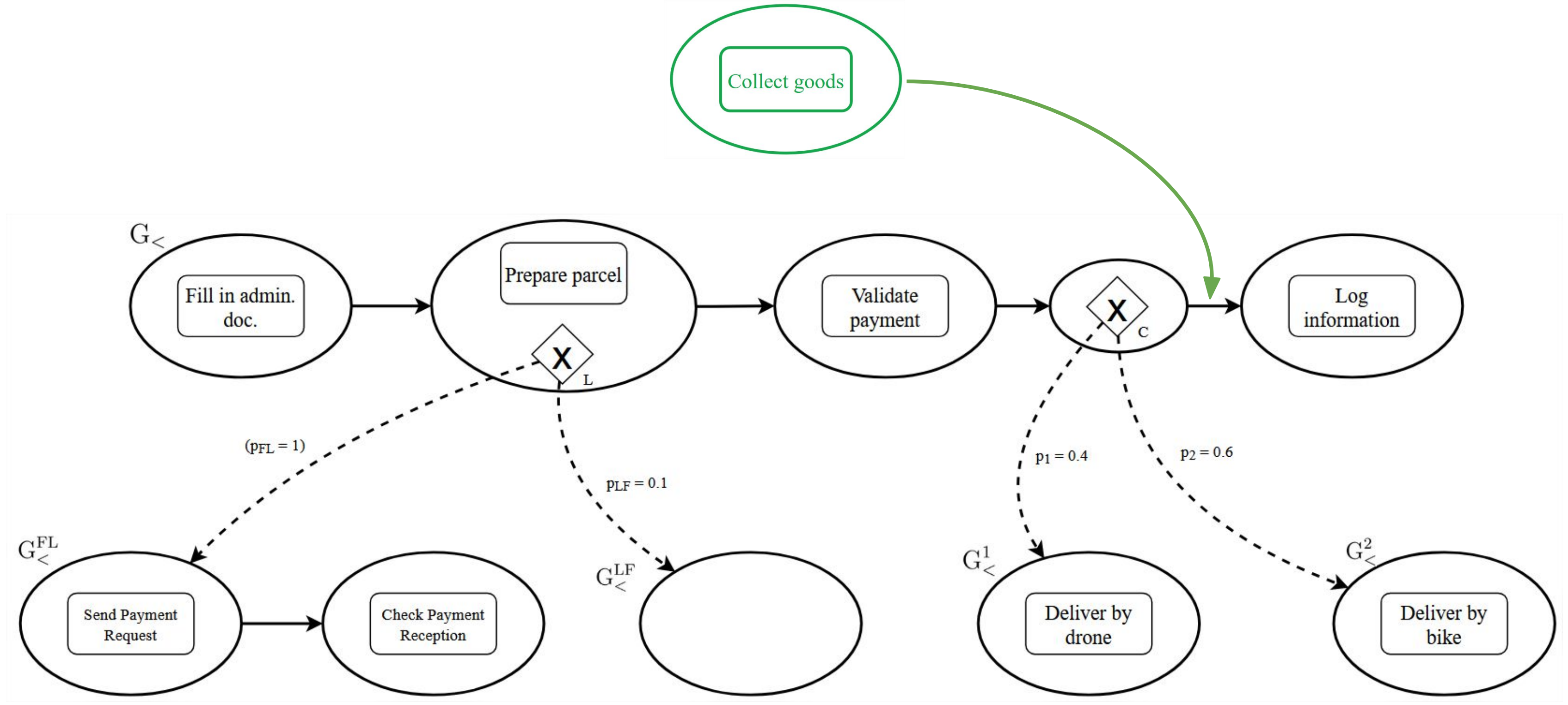

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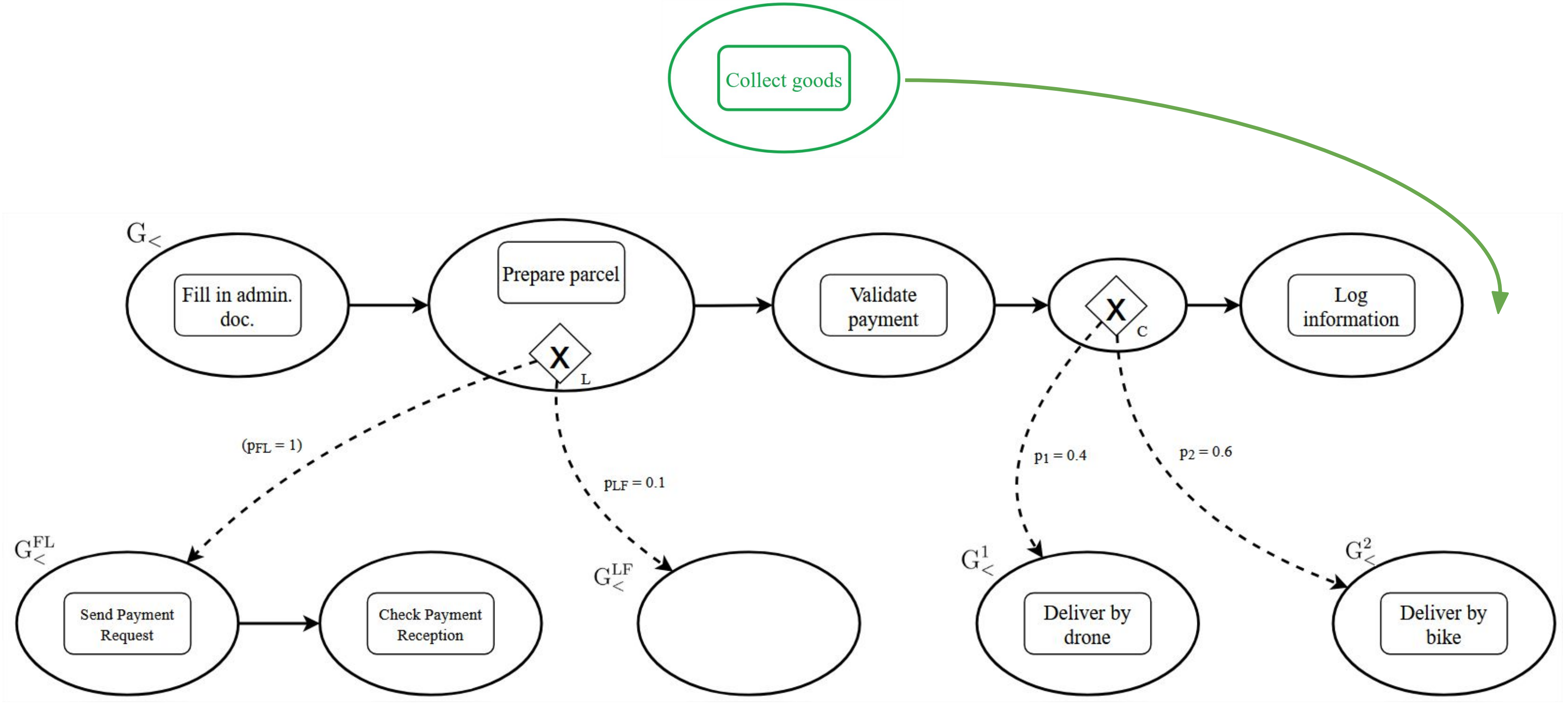

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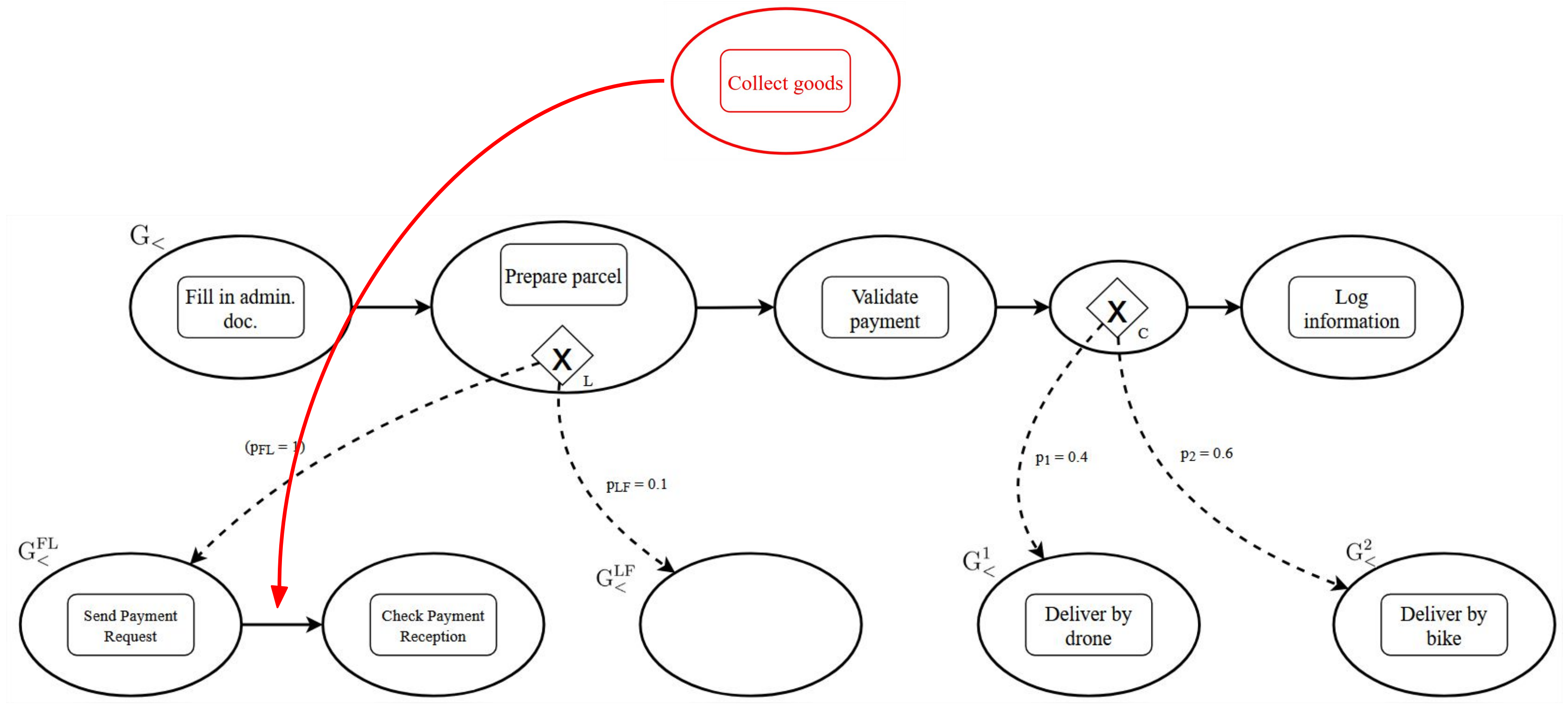

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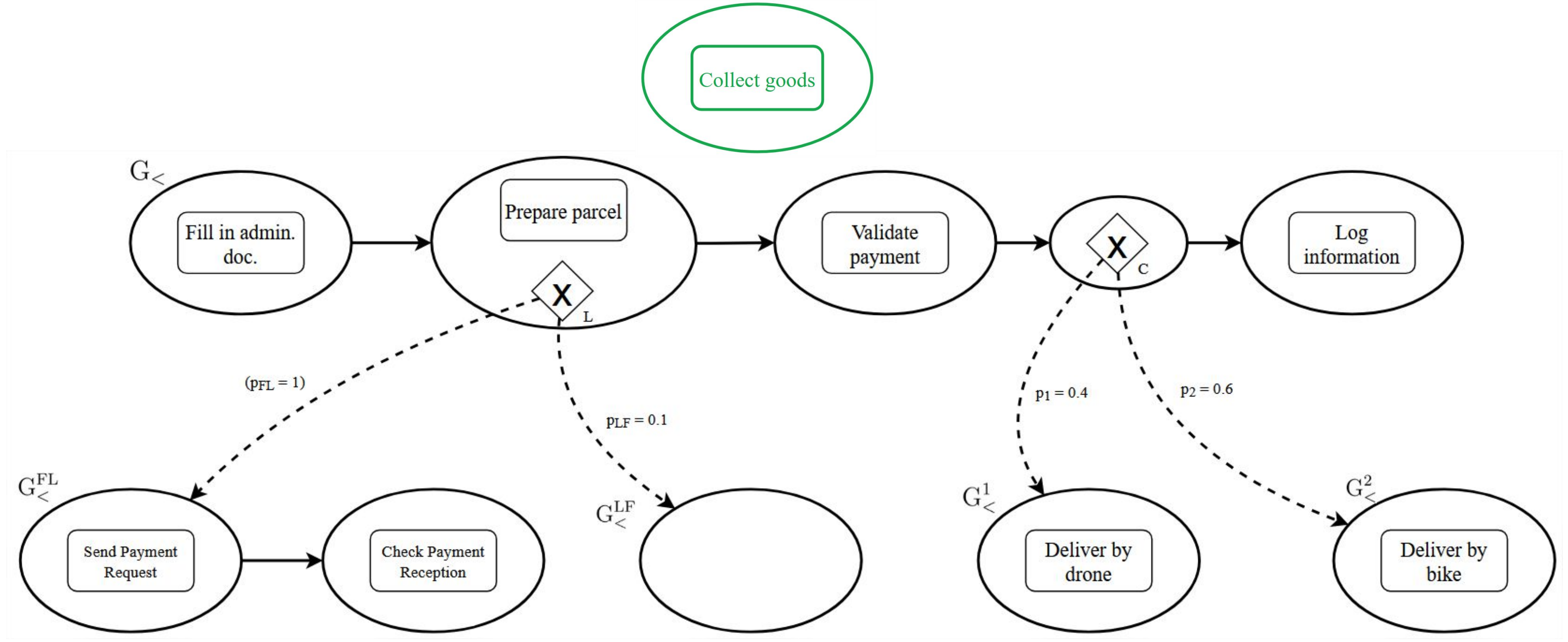
The **second pattern** consists in inserting the task in parallel of any non-empty subsequence of nodes of the graph.



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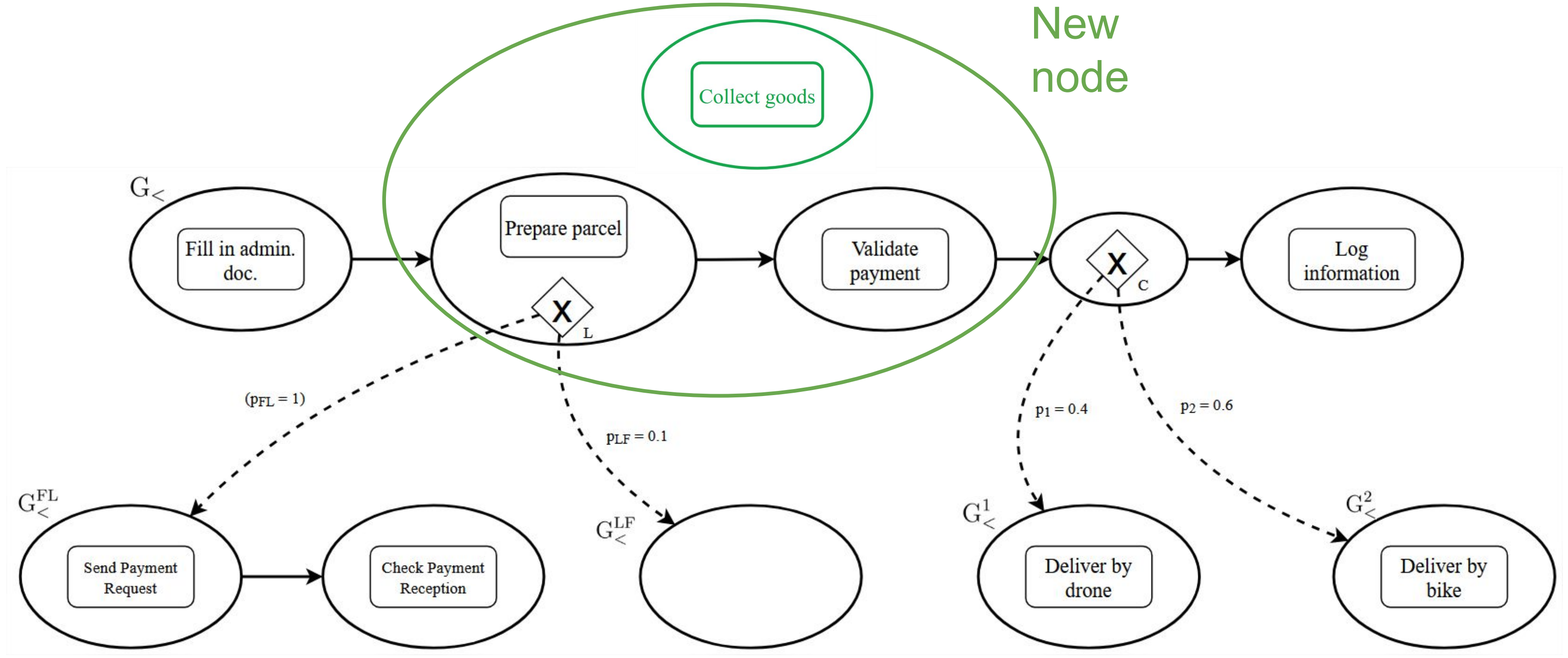

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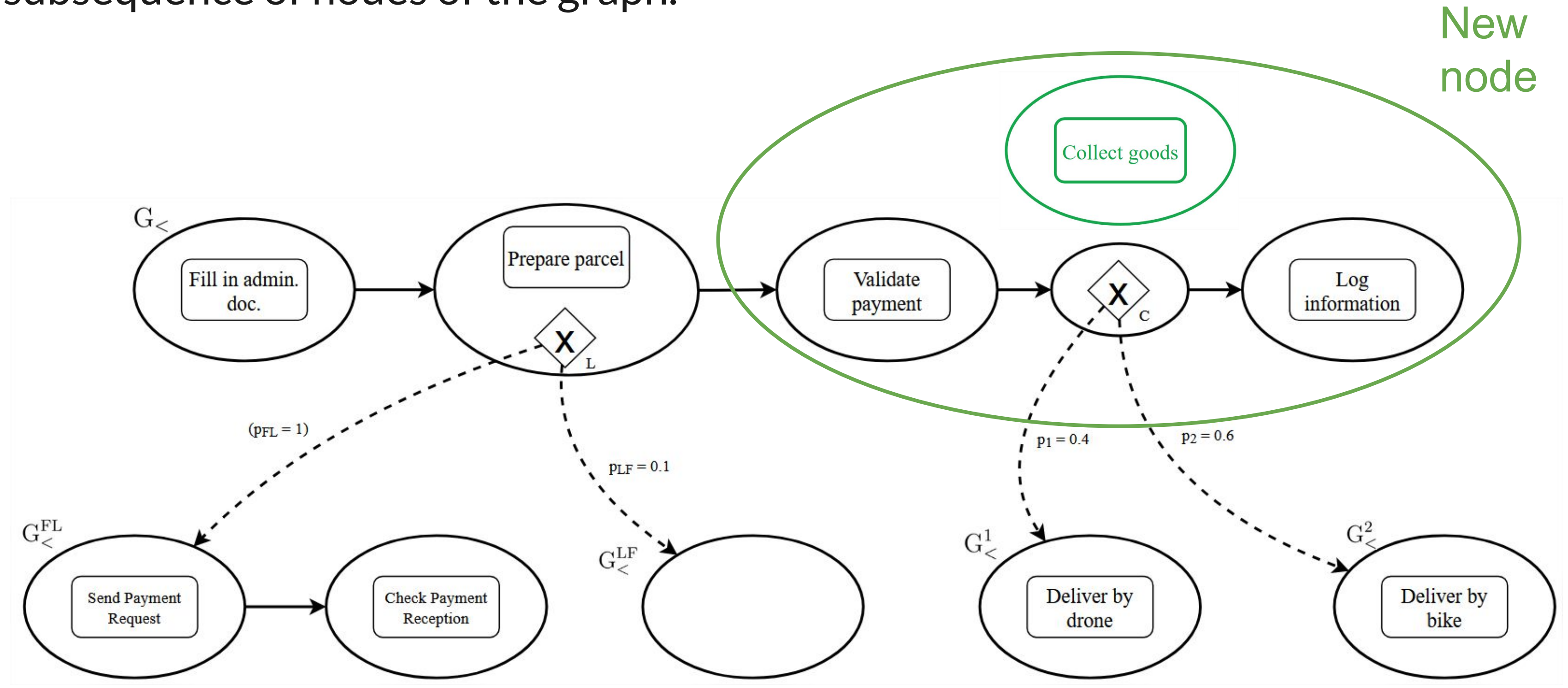

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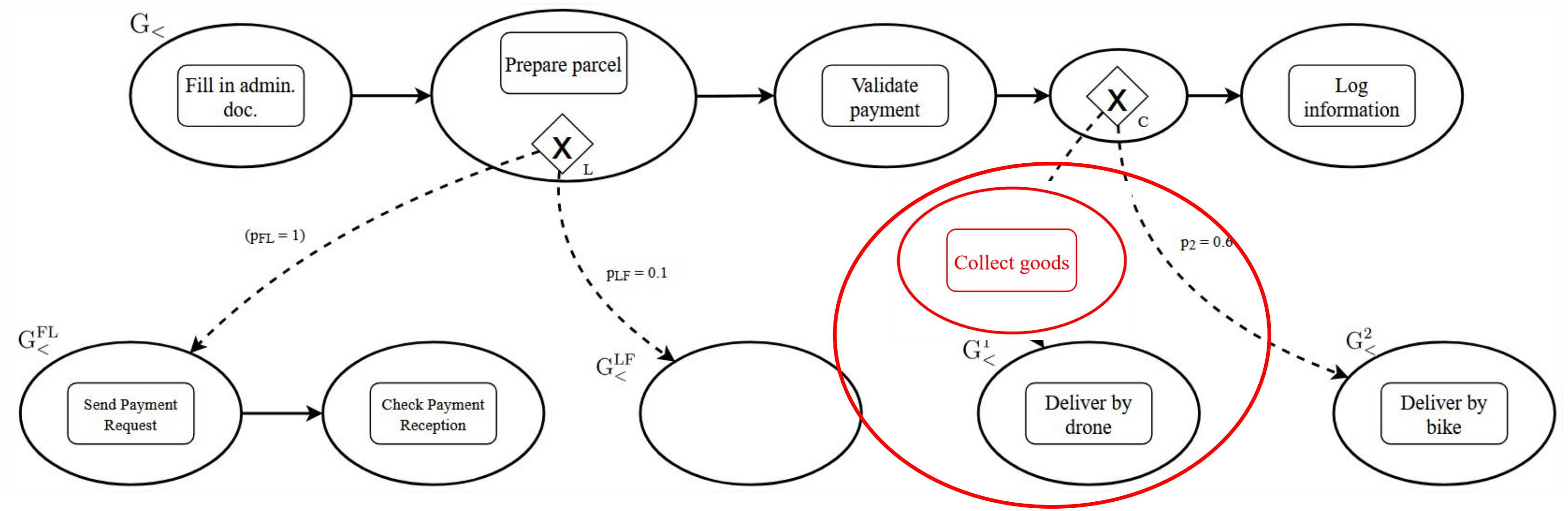
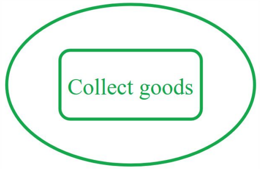
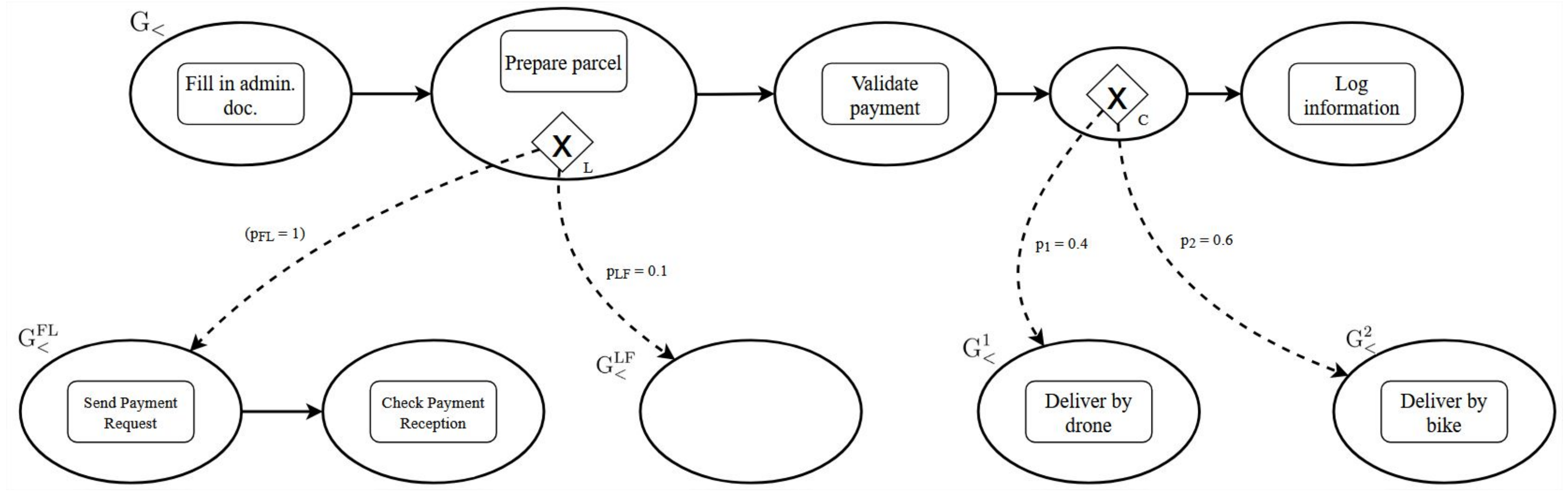


Step 2 – Pattern 3

The **third pattern** consists in inserting the task before or after any combination of elements of any node of the graph.





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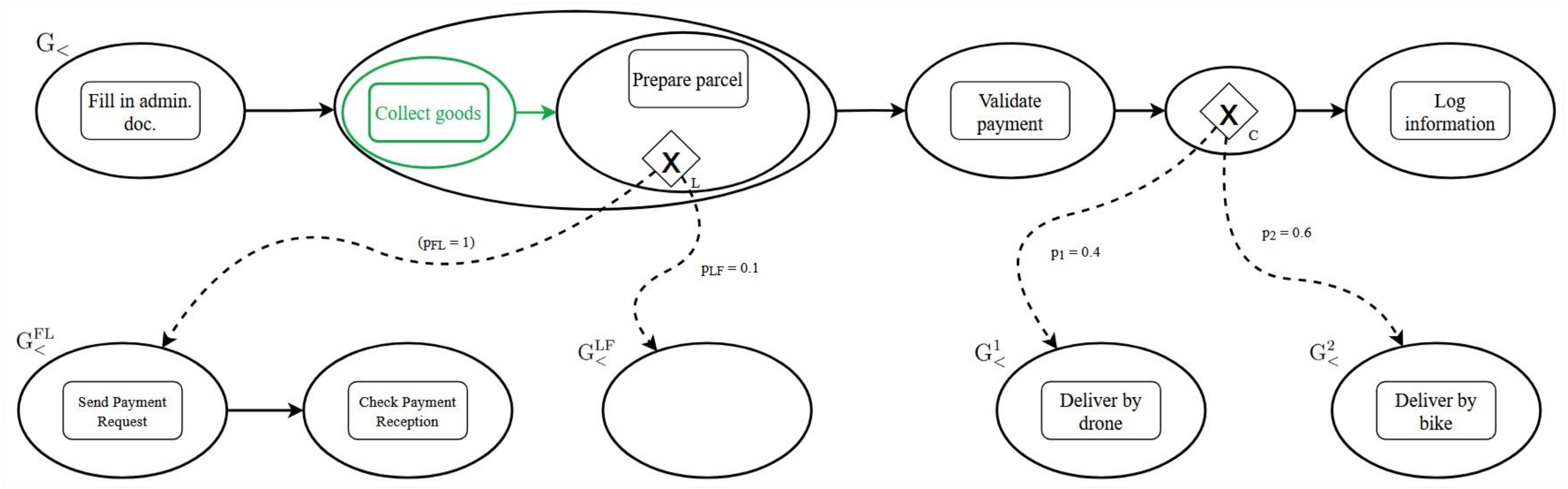

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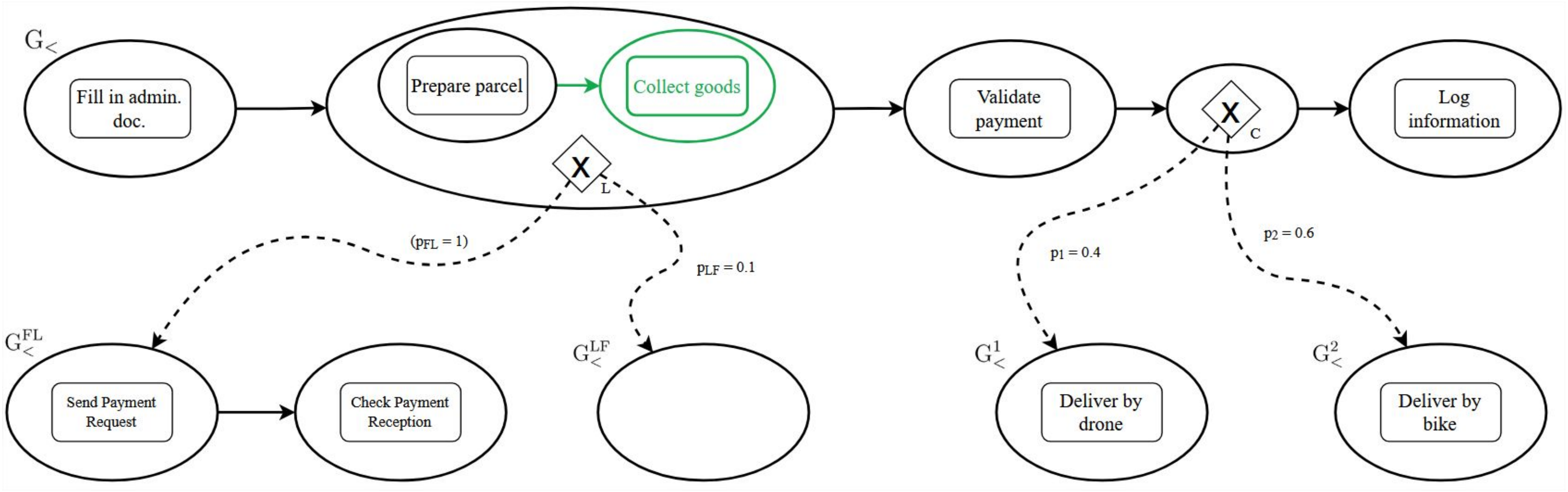

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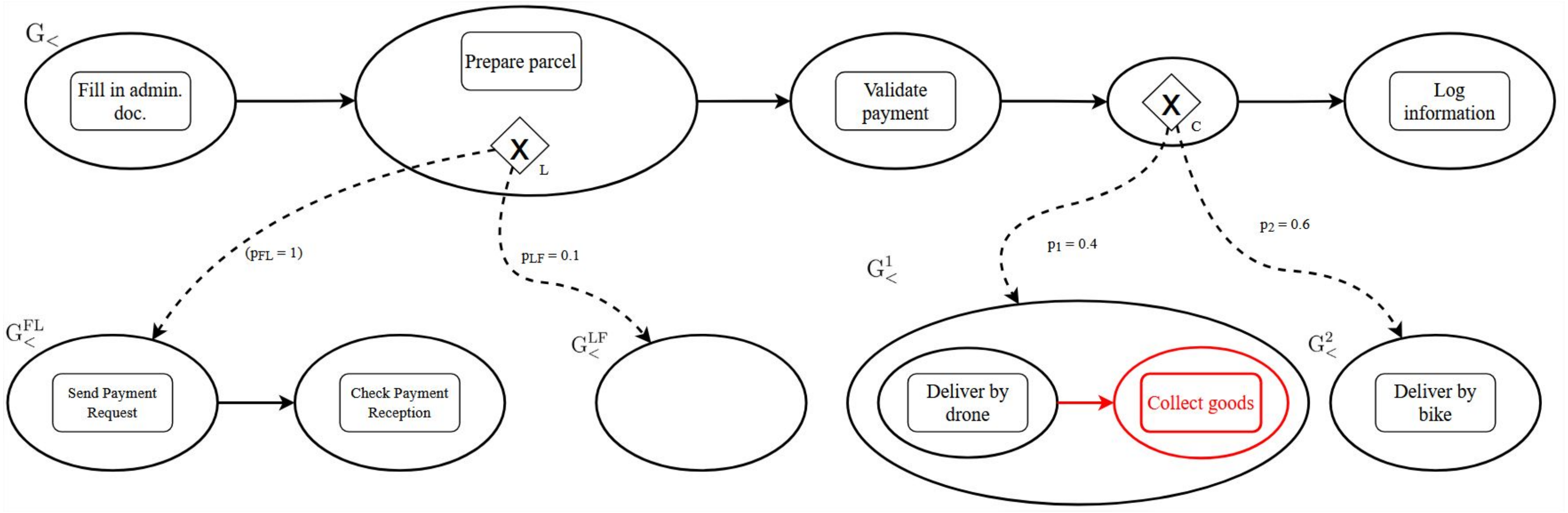

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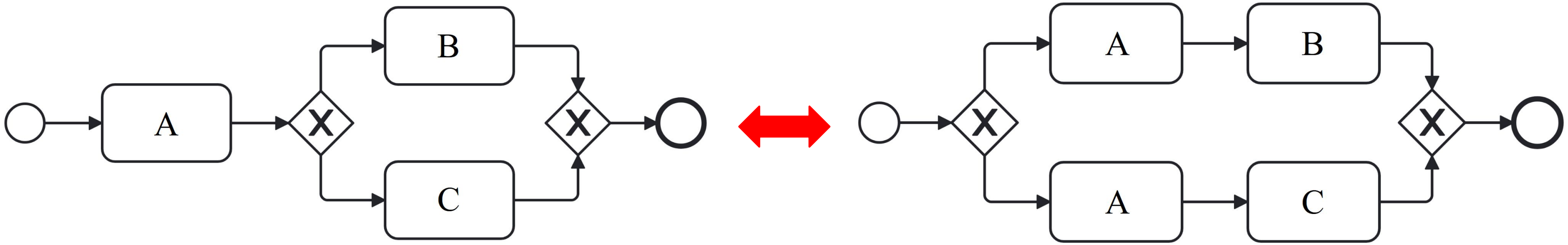

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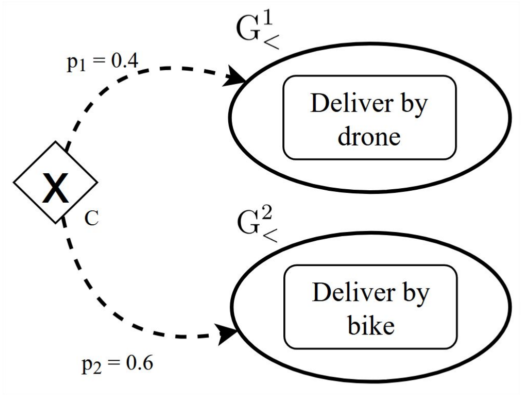
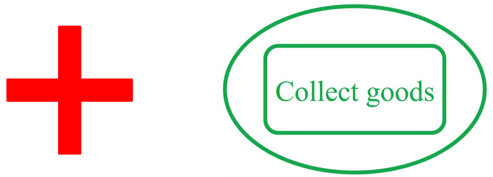
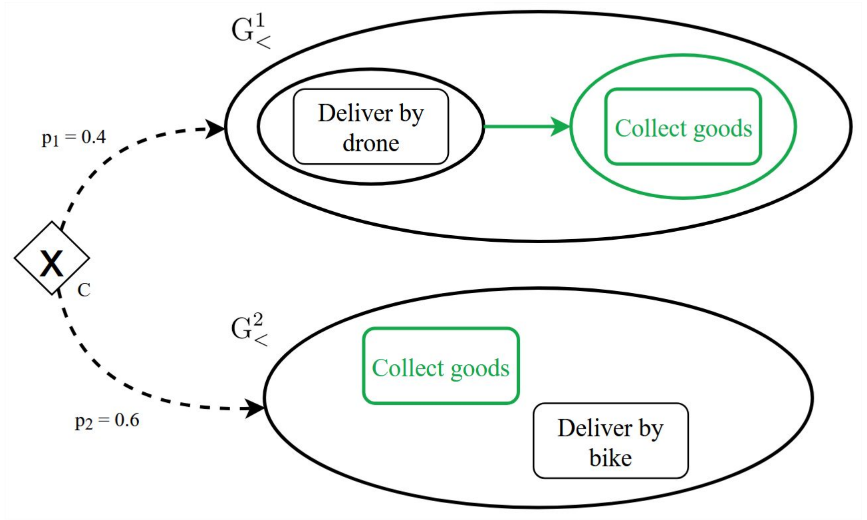
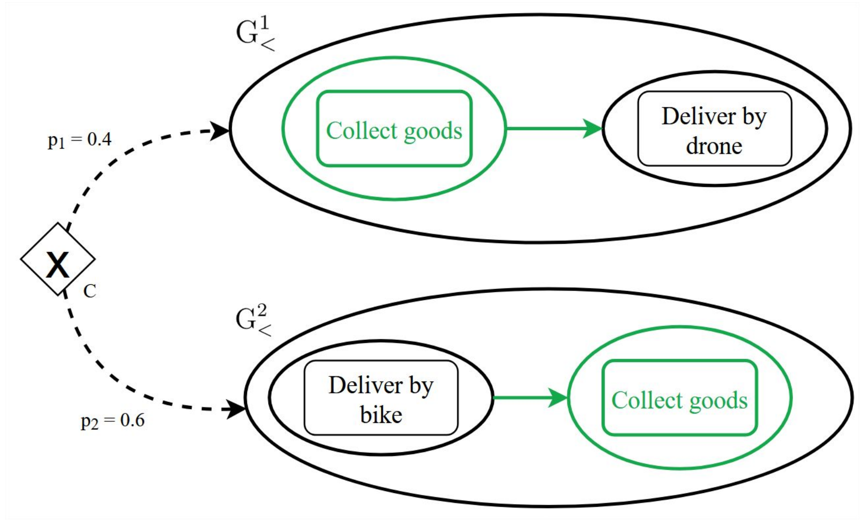




Step 2 – Pattern 4 – Example

This results in our case in **several possible choice structures**, two of them being illustrated below:





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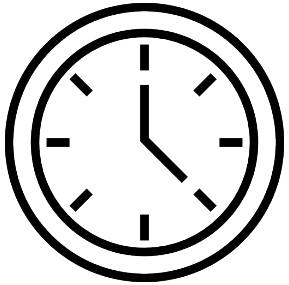

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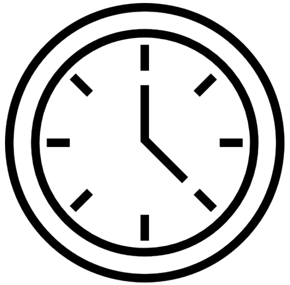

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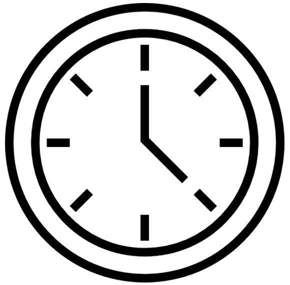

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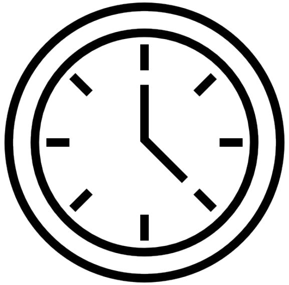

These metrics are obtained by **simulating** the process.

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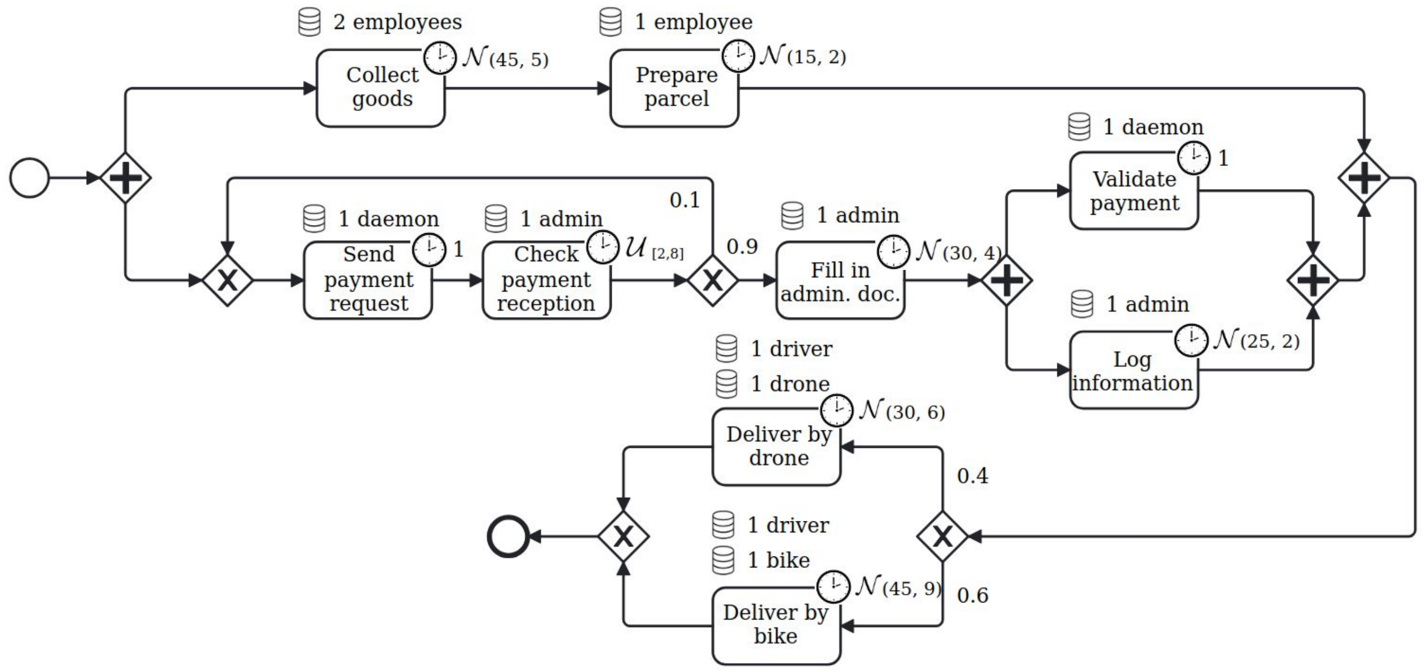
The **decision** of **keeping** or **discarding** a process is taken at the **discretion** of the **MOEA** being used, and can be **counter-intuitive** (for instance, a worse process can be kept and a better one discarded).

Step 4 – Termination

When the **MOEA reaches its bound** (duration, number of iterations, manual stop, etc.), it returns an **optimised version** of the **original process**.



Tool Support

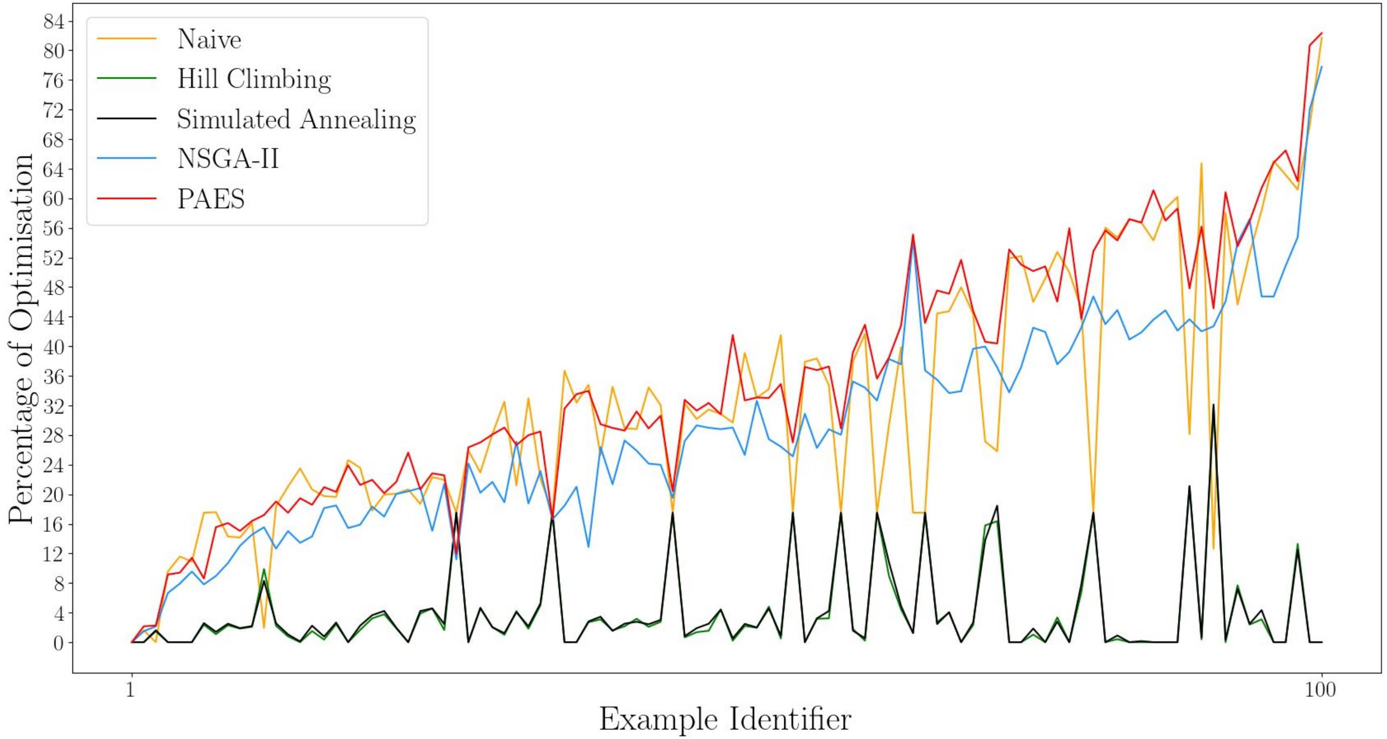
The approach has been **fully implemented** and consists of approximately **15k lines of Java code**.

It makes use of the **jMetal framework** [DN2011] which **implements** dozens of well-known **MOEAs** and provides **facilities** regarding their **utilisation** in various **contexts**.

This tool was used as a **support** for the **experimentations**.

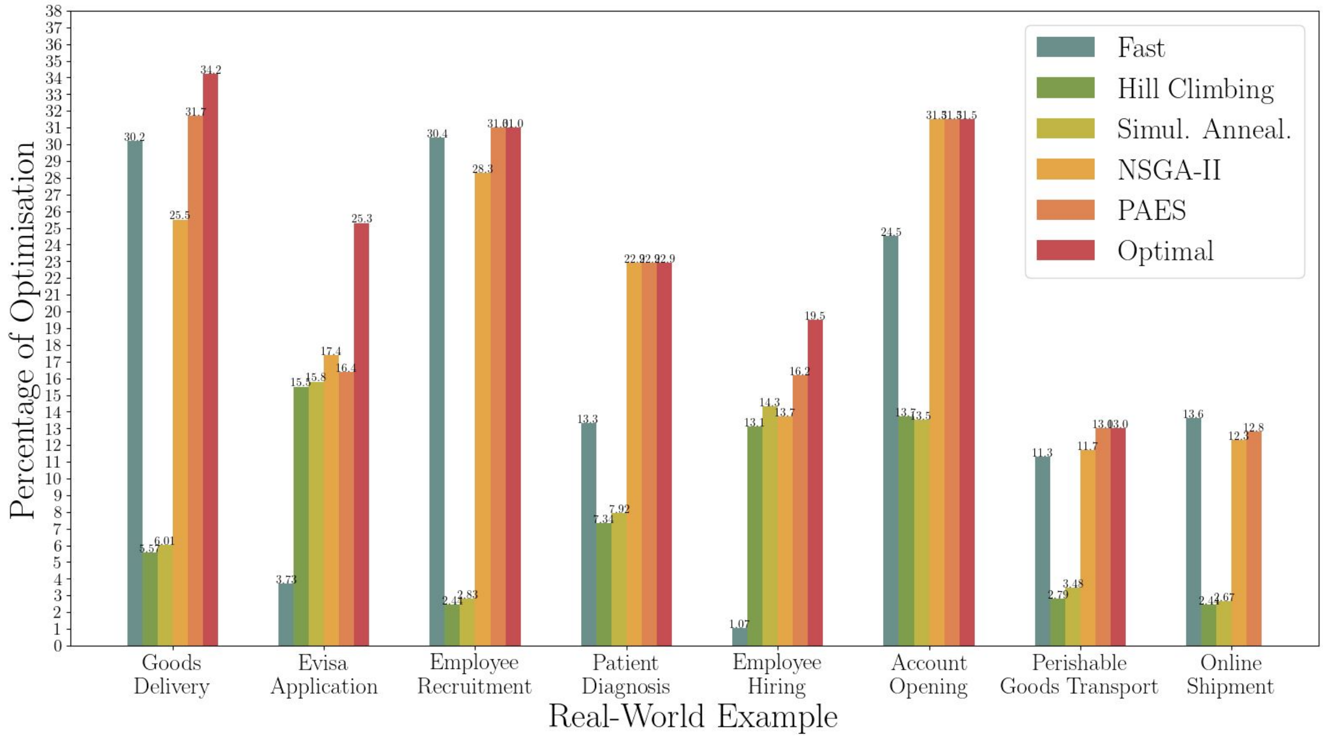
Experiments – Handcrafted Examples

The **first part** of these experiments consisted in **comparing** several **algorithms** on **100 handcrafted** examples.



Experiments – Real-World Examples

The **second part** of these experiments consisted in **comparing** these **algorithms** on **8 real-world** examples coming from the literature.



Conclusion

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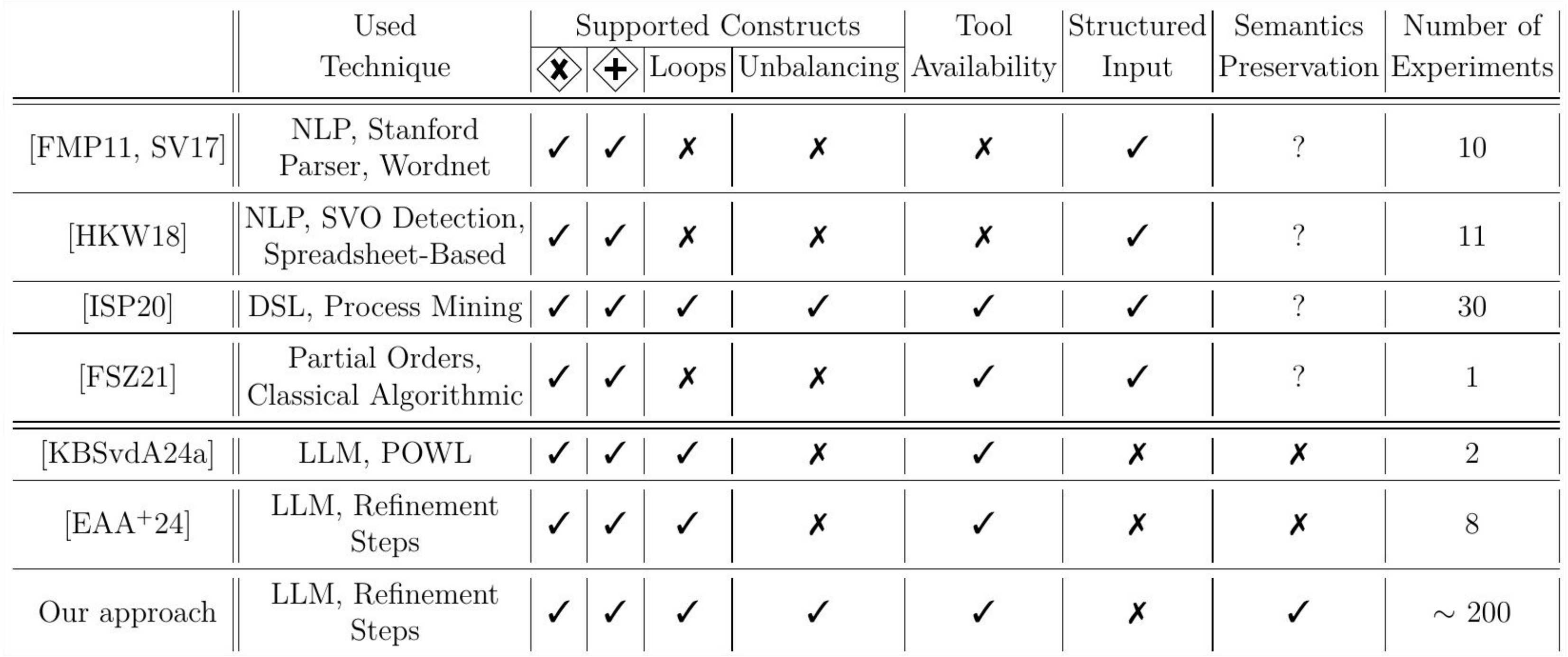
The proposed approach tackles the complex problem of **multi-objectives optimisation** while ensuring the **preservation of the semantics** of the process, and of its **behaviour**, by the meaning of **user-defined dependencies**.

The presented approach has been **fully implemented** and **validated** by a tool written in Java on a basis containing **more than 100 examples**.

Plan

Related Work – Modelling

The **question of modelling** business processes has been a **topic of interest** since years, and **many approaches** tended to give it an answer.



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[HKW18]	NLP, SVO Detection, Spreadsheet-Based	✓	✓	✗	✗	✗	✓	?	11
[ISP20]	DSL, Process Mining	✓	✓	✓	✓	✓	✓	?	30
[FSZ21]	Partial Orders, Classical Algorithmic	✓	✓	✗	✗	✓	✓	?	1
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[EAA$^+$24]	LLM, Refinement Steps	✓	✓	✓	✗	✓	✗	✗	8
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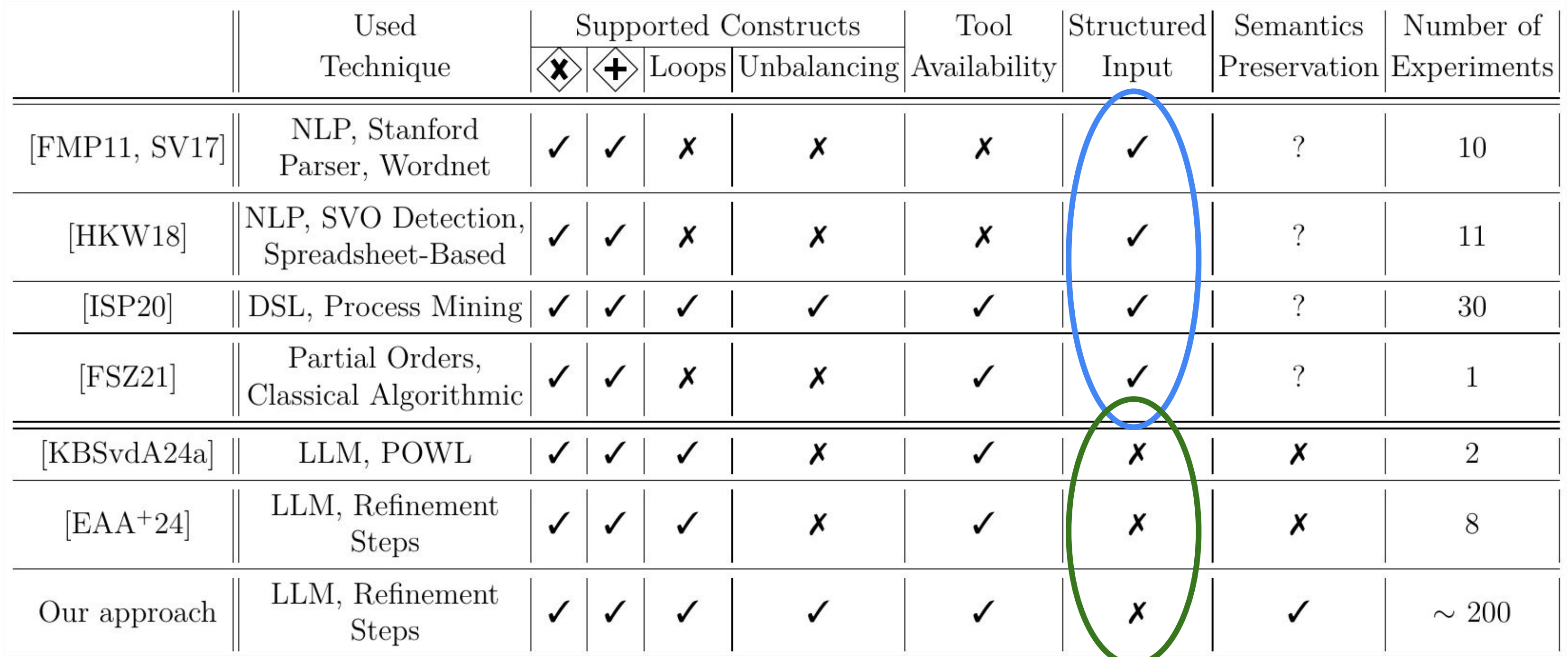

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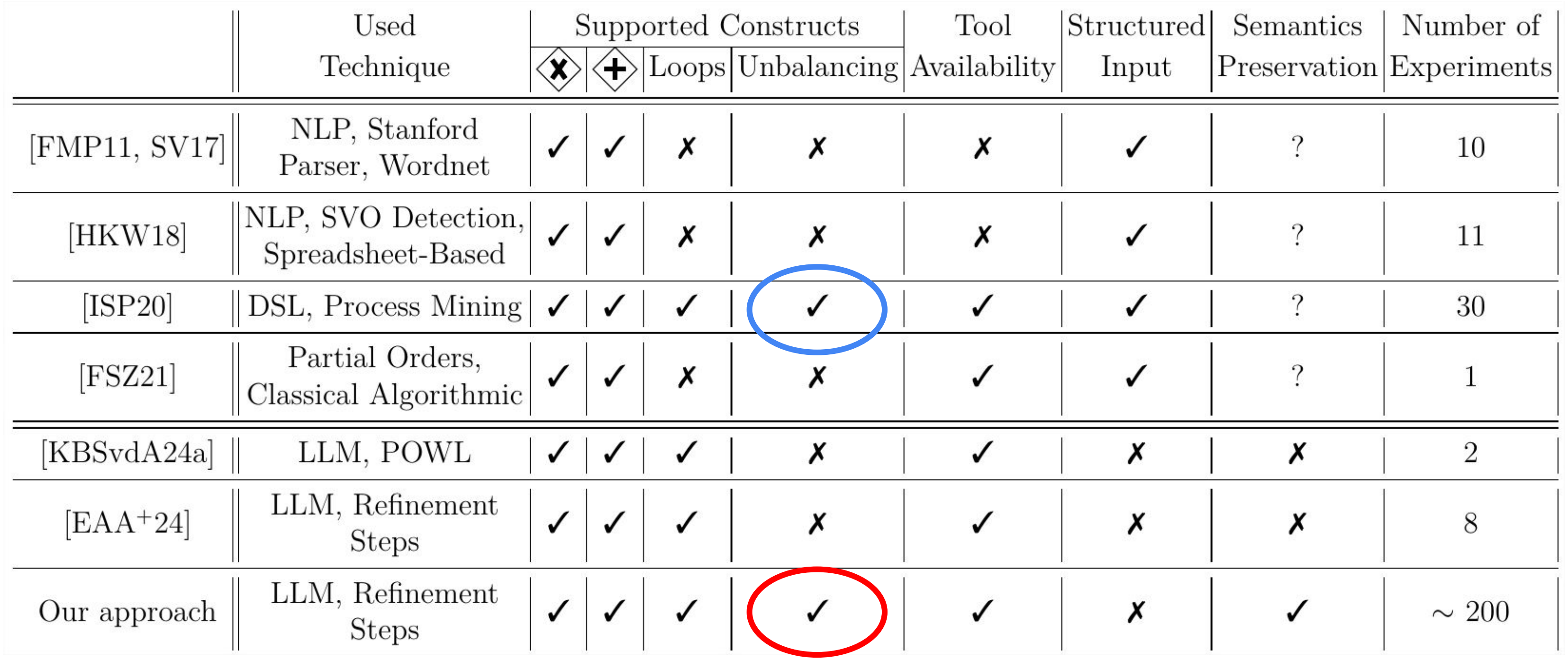

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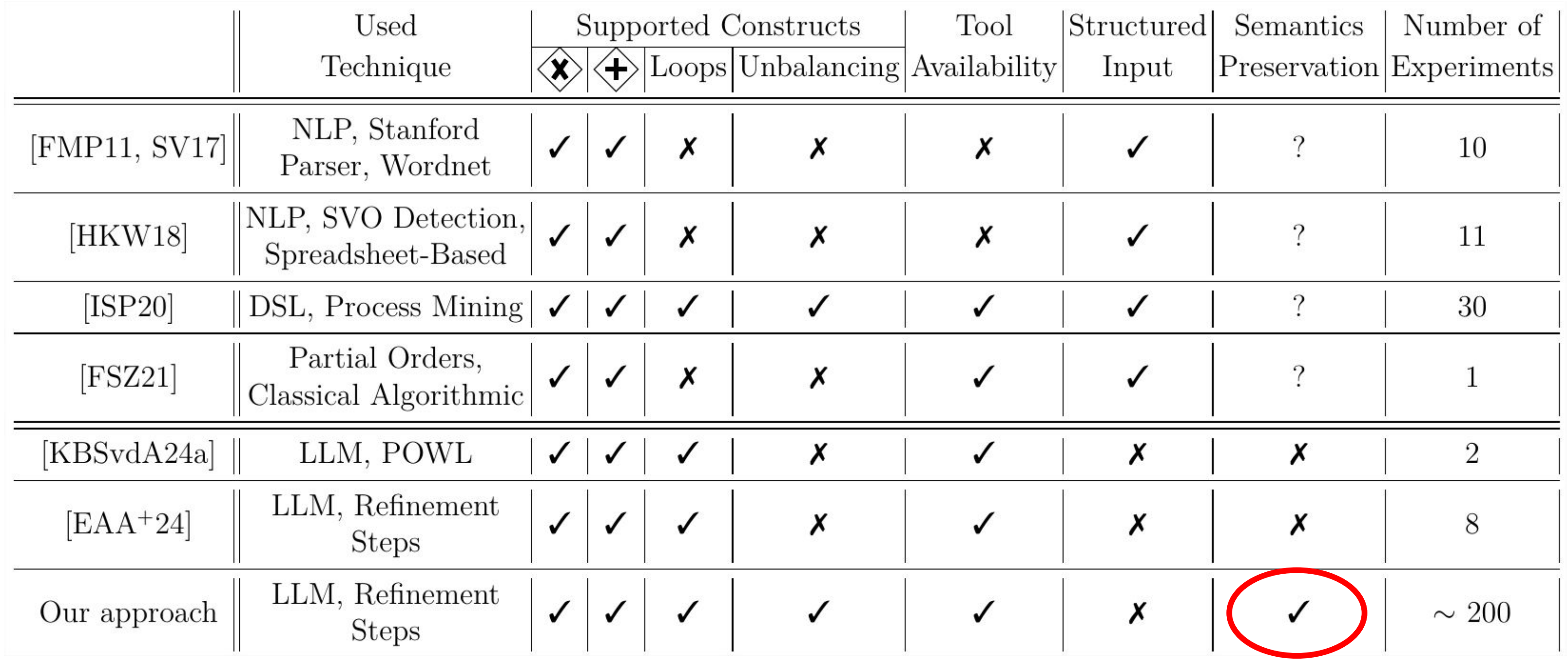

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[KBSvdA24a]	LLM, POWL	✓	✓	✓	✗	✓	✗	✗	2
[EAA+24]	LLM, Refinement Steps	✓	✓	✓	✗	✓	✗	✗	8
Our approach	LLM, Refinement Steps	✓	✓	✓	✓	✓	✗	✓	~ 200

Related Work – Refactoring

Refactoring as an optimisation technique is less classical, thus there is no strictly identical approaches in the literature.

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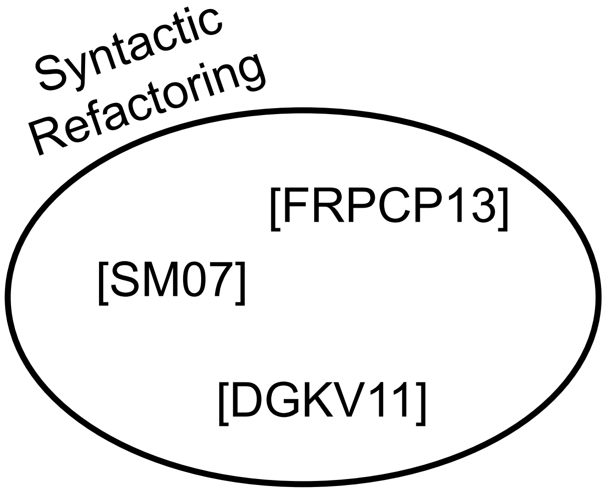

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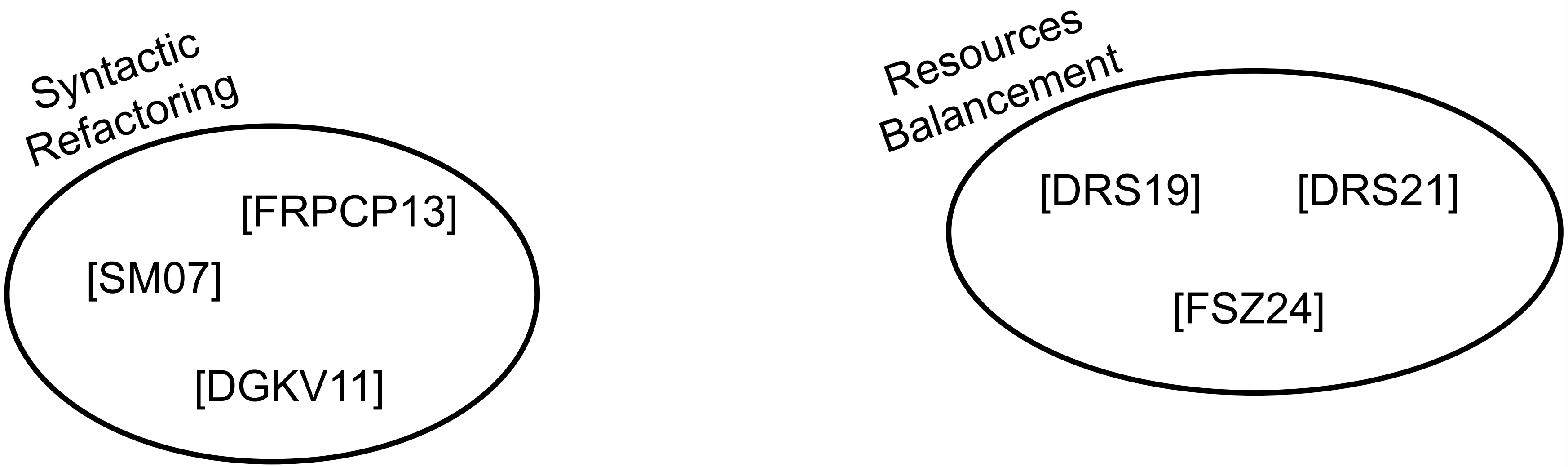

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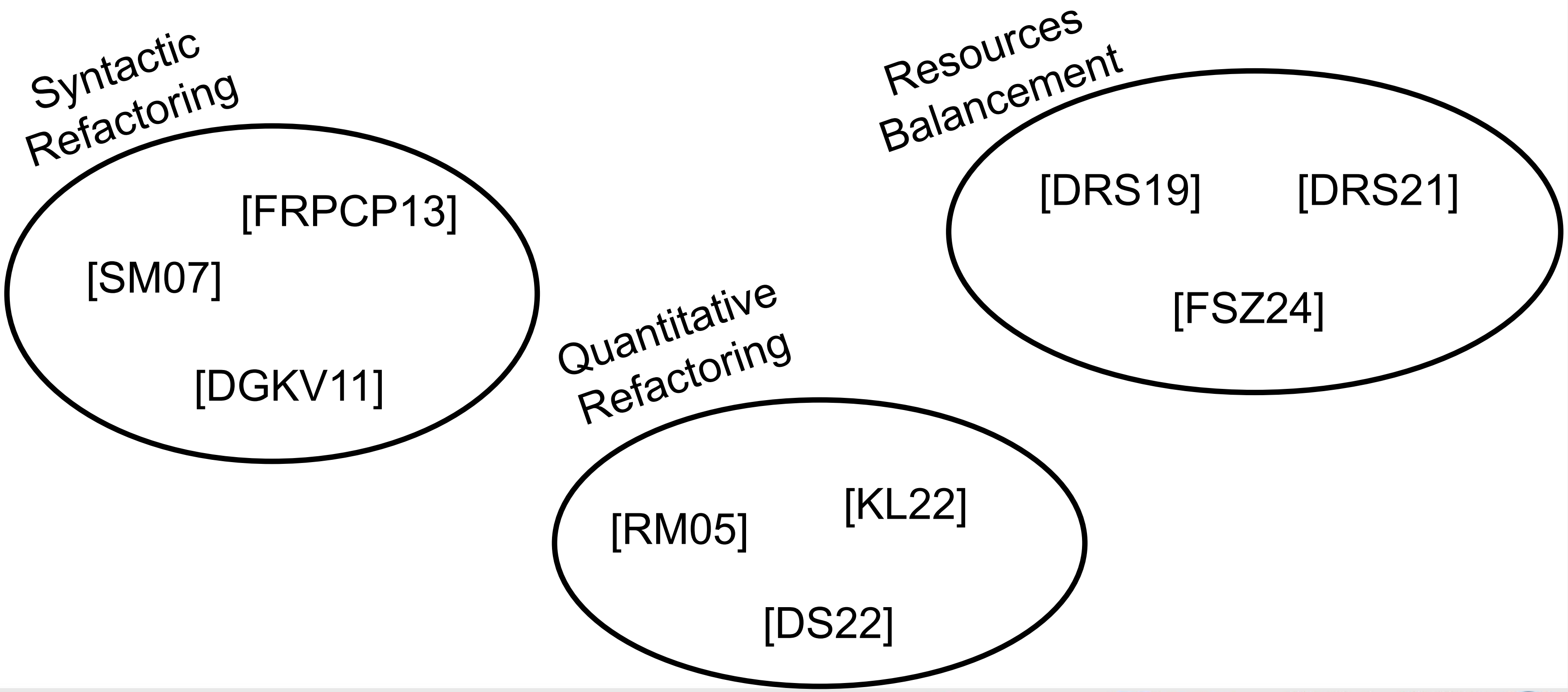

Plan

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Perspectives on refactoring:

- ➢ Getting **rid of sequence graphs** structures;
- ➢ **Removing** or **limiting** the use of **simulation**;
- ➢ Finding **better optimisation algorithms**.

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