Business process optimization by workflow analyzis

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***Abstract*—This paper describes a framework to model, simulate, optimize and implement business process workflow. The framework employs i) the well known business process modeling notation (BPMN) for modeling both the *as-is* and *to-be* workflow. ii) Petri nets for (validating, verifying and fine analysis) for the workflow. iii) Business process execution languages (BPEL) for implementing the target *to-be*workflow as web services.**

I. Introduction

Workflow systems are considered as one of the most key successes factors for modern and developed enterprises. It optimizes process within enterprises, and permits decision makers to control and monitor process progress. This paper presents a framework to model, optimize and implement business process workflow. The framework employs the most famous and efficient standards and technologies.

The framework employs i) the well known business process modeling notation (BPMN) for modeling both the *as-is* and *to-be*. ii) Petri nets for (validating, verifying and fine analysis) for the workflow. iii) Business process execution languages (BPEL) for implementing the target *to-be* workflow as web services.

This work is a part of the GOCD [1] project within the context of the French competitive cluster[2] "Industrie du commerce". It aims to install a new paperless workflow system and decision making tool for the French credit company COFIDIS [3].

In the next section, the reengineering parts of the proposed framework are briefly introduced, followed by presentation of standards and technologies used to implement these parts and the motivation for each of these choices. In section three, validation, verification and optimization phase is demonstrated. In section four, a case study is presented using this framework. We terminate by conclusions and prospective.

II. Workflow reengineering

Workflow reengineering process is indispensible step for modern enterprises, in order to cope with fast development in technology and competitive enterprise in current world.

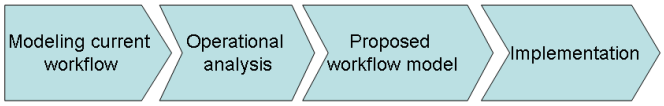

Fig. 1. Workflow reengineering process

In general, this process starts by modeling current workflow system, in order to be analyzed deeply for operational point of view. This analysis permits to identify and underline system dysfunctions, bottleneck, and drawbacks. Knowing system deficiencies help system analyst and designers to conceive and design a new robust, optimized and error free work flow system. The new model is then used as the base for developing and implementing a new optimized work flow system. Figure 1 demonstrates the different steps in workflow reengineering.

In the next subsection we present the standards and technologies that we propos to use in the workflow reengineering process.

A. The choice of standards and technologies

The first and third steps in the workflow reengineering are modeling both the existed workflow system and the expected final workflow system. For this purpose, we choose to use Object Management Group (OMG)[4] standard the *business process modeling notation (BPMN)*. BPMN is defined by the OMG as "a graphical notation that depicts the steps in a business process". This graphical notation is used to present business processes in a workflow. It was developed by Business Process Management Initiative (BPMI) which has been later merged with OMG. The BPMI had consolidated the best ideas exist in other standards such as UML Activity Diagram, RosettaNet, LOVeM, and Event-Process Chains (EPCs) to create BPMN. BPMN is rich and complete regarding business process patterns, and it is possible to transfer it to Business process execution language (BPEL) code, as we will see later.

The main objective of BPMN was to have an understandable notation for both business users (managers and employers) and system analyst and developers. This will remove any confusion

[1]GOCD : French acronym for Management and optimization of document life cycle

[2]A competitive cluster is an initiative that brings together companies, research centers and educational institutions in order to develop synergies and cooperative efforts. http://www.industrie.gouv.fr/poles-competitivite

[3]French consumer credit company. http://www.cofidis.com

[4]OMG: is an international, open membership, not-for-profit computer industry consortium. OMG Task Forces develop enterprise integration standards for a wide range of technologies, and an even wider range of industries. http://www.omg.org/

and facilitate ideas exchange between different system actors. Thus, current workflow system weakness and bottlenecks are clarified allowing better understanding and analysis. For more details on BPMN, reader are refereed to[1]. Figure 3 gives an example of using BPMN to in modeling workflow.

For the implementation step, it is crucial to choice fixable technology that enables systems interoperability and integrity, especially with the new globalization world. Service Oriented Architecture (SOA) and web services appear as the new tendency to answer these questions. In SOA, business application is exposed as web services that propose one or more functionalities for each service. Still, creating and exposing services is not an easy task. We need to know how these services are organized and the dependencies between them. In addition, business processes are always the subject of changes as more and more enterprises take the choice of mergers and acquisitions. For the implementation of web services, the *Web Services Business Process Execution Language (WS-BPEL, known also as BPEL)* locks as the best answer. According to the Organization for the Advancement of Structured Information Standards (OASIS)[5]. WS-BPEL is defined as "a language enabling users to describe business process activities as Web services and define how they can be connected to accomplish specific tasks[2]". WS-BPEL uses XML-based language that supports Web services technologies, such as Simple Object Access Protocol (SOAP), Web Services Description Language (WSDL), and the Universal Description, Discovery, and Integration (UDDI).

It comes from a combination of two early workflow languages, XLANG language designed by Microsoft and Web Services Flow Language (WSFL) designed by IBM. The later based on the concept of directed graphs, whereas the former based on a block-structured language. In 2003, BPEL was submitted to OASIS for standardization, and the Web Services Business Process Execution Language Technical Committee (WSBPEL TC) was formed. This gave WS-BPEL more acceptances in industrial world.

The advantages of WS-BPEL come from its ability to be used between or within different enterprises applications, where each application can be exposed as web services with its own functionalities. WS-BPEL is designed to cope with the new Service Oriented Architecture (SOA), which leads to standardize enterprises applications and increase their interpretability in efficient and easy manner. We believe the increases use of web services technology will in parallel increase WS-BPEL importance.

B. The transformation of BPMN to BPEL: the state of the art

As we have said before, an important motivation to choose BPMN in the modeling steps is its capacity to generate executable BPEL code. This is a crucial step in the end-to-end development process for process-oriented systems. The mapping of BPMN to BPEL code is a challenge process, since BPMN and BPEL represent two fundamentally different classes of languages (BPMN is graphical oriented languages and BPEL is block-structured language and)[3], [4].

The reclamation of generating BPEL cod from BPMN diagram in BPMN specification is not really accurate, since it supposes that the designer will follow certain restrictions and rules, and that does not reflect world reality when modeling a real business process. Such restriction is not use unstructured cycles[5].

However, Ouyang and his team have made a remarkable work on the transformation of BPMN to BPEL. This work can be classified into three categories (event handler based transformation, pattern based transformation and control link based transformation).

The first proposed transformation approach depends on BPEL event handler construct. This approach is applicable only to a core subset of BPMN[6], [7], [8], [9].

In order to have more readable code, they propose in [7], [10], a new approach based on exploiting the structural nature of BPEL. Their idea was to discover structured components (patterns) that can be mapped directly into BPEL construct without any modification, and to use the event handler construct in mapping the rest of the diagram. They called the structured components in BPMN model as well-structured component and the rest as non-structured component.

A new attempt to have more readable code demonstrated in [9]. In this paper, they does not only try to detect the perfect structured components, but also to search quasi structured components that can be easily redefined and modified in order to be transformed by the previous mentioned technique. They succeeded to classify three types of quasi-structured components, the FLOW component, SWITCH component and PICK component.

Although the fact of using well-structured and quasi- structured components has increased code readability, it doesn't solve the problem of acyclic BPMN diagram. So, they searched for another BPEL construct that can be used to solve this problem. They found a non-structured BPEL construct known as control links. The advantage of this construct lays in its ability to define directed graphs. All these approaches were grouped and implemented in one open source tool called BPMN2BPEL[6]. This tool takes BPMN model, conforms to a particular XML format, as an input and out puts a BPEL process. Pau et al. present in [11] a model to model transformation to bridge this gap between different BPMN models tools and BPMN2BPEL.

Remarks on the workflow reengineering process

Although OMG has essentially created BPMN to model business process, BPMN suffers from serious problems due to the lack of formal semantics. BPMN specification is written in verbal way which allows different interpretations of the same pattern. The flexibility offered by BPMN can also lead to undesirable properties for business process such as deadlocks

[5]OASIS: is a not-for-profit consortium that drives the development, convergence and adoption of open standards for the global information society. http://www.oasis-open.org

[6]http://www.bpm.fit.qut.edu.au/projects/babel/tools/

and unreachablity. Since the ultimate object of using BPMN is to generate executed BPEL code, any problem in the model will be directly reflected in the obtained code and in the implemented process. Unfortunately there is no way to verify BPMN structural properties from its model directly. Finally, there is no way to perform any performance evaluation and optimization to test and compare the proposed workflow system with old one.

For these reasons, we propos to pass through an additional phase of BPMN model validation, verification and optimization, before getting adopted to generate BPEL code. This phase can be realized by transforming BPMN model to modeling languages with strong formal semantics. This is essential to ensure errors free and optimized final workflow system. We chose in this paper to use Petri net as the formal modeling languages. The different phases to install a new workflow system become as demonstrated in Figure 2.

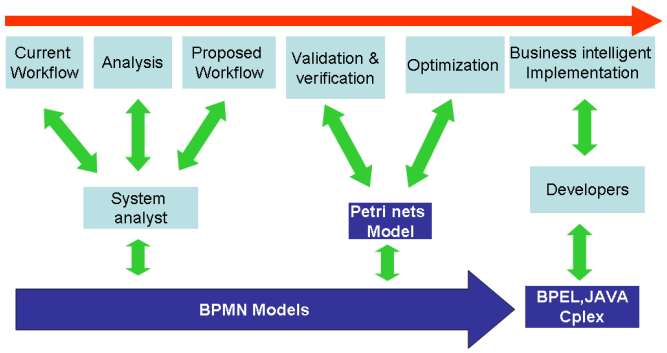

Fig. 2. Proposed framework for workflow reengineering

III. Workflow analysis and optimization

As we have said before, BPMN offers a great flexibility and comprehensive notations for different actors. However, this flexibility can lead to many different interpretations for the same patterns, since no formal semantics are available for BPMN. The only way to insure consistence interpretation for business process is to use a formal modeling language to represent that process. More over, there is no way to detect any undesirable properties for a workflow in the BPMN model. These properties will be reflected in the final business process, and can be only detected after workflow implementation. Additional analysis for the business process can reveal more system bottlenecks and deficiencies, which gives the opportunities to solve or improve them in the modeling phase and before getting implemented. As a result, process debugging and modifying become less expensive in terms of time and money. In literatures, Petri nets and its extensions are used as the formal modeling languages to verify and validate BPMN models. In this paper we suppose readers are familiar with Petri nets, for those unfamiliar with Petri nets, they are refereed to[12], [13]. In [14] an extended Petri nets known as YASPER is used to behavioral analysis of BPMN Model. In[8], the author uses Petri nets to ensure that a core subset of BPMN is deadlocks and livelocks free before transforming it to BPEL. In[15], transformation to Petri nets is extended to cover more BPMN object flow such as subprocess and exception handling. Message flow and initial state of BPMN model have been also included in this paper. However, the author himself admits that the mapping does not cover some workflow patterns such as parallel mutli-instance due to Petri nets limitation. To overcome these limitation, others attempts were done using YAWL (Yet Another Workflow Language)[16], [17], [18]. YAWAL is a new workflow modeling language with formal semantics that extend Petri nets. It was developed by Eindhoven University of Technology and Queensland University of Technology. However, verification YAWL model is computationally more complex than the corresponding Petri nets. In this paper, we choose to use Petri nets, since our BPMN model does not contain any of workflow patterns that are not covered by the Petri nets.

We are concerned here by structural properties such as P-semiflow and T-semiflow. Model reachability is another important properties to ensure there is no dead transition (task that will never been executed). Others properties are required to be verified for a subset of the net and not for all the Petri nets such as soundness, boundness and safeness. And the most important is to verify that out model is deadlock free to avoid any blockage in the final system.

Verifying that the new workflow system works correctly is a good thing, still we need to ensure that it works efficiently. This is possible by analyzing the different flow in the corresponding Petri nets. More precisely; Petri nets P-semiflows analysis[19][20]. This analysis permits both, the identification of workflow shortcoming and bottlenecks, and inducing some mathematical formulation. As a consequence, system designers and analyst can solve and optimize these bottlenecks with the best manner, either with or without additional information from the information system. More details are discussed in the next section.

IV. Case study: Dematerialization contracts flow

In this section, we present a case study on the proposed framework for workflow reengineering process. The case study concerns the current workflow system at COFIDIS.

Current workflow description

Every day, COFIDIS receives from the post office thousands of mails (contracts and credit demands of different types). For facility, we will use the term contracts for both contracts and credit demands. Contracts types and quantities change from day to day, and they are only known in the morning of each day. The variation in quantities and types is due to the marketing policies followed by COFIDIS. Each received contract should be handled by only one company collaborator. When contract treatment start, it must be continued to finish the contract in hand at the same day.

Each collaborator has different skills and experiences with respect to contract type. As a result, treatment time for each contract type varies from one collaborator to another.

This variation is defined by a two dimensional competence matrix where collaborators and contracts types present the two dimensions. Collaborators' daily work hours are not equal, in reason of human resources considerations. Each contract type has a different importance and profit to the company activity. Handling contracts at their arrival day is always preferable.

Currently contracts are distributed to company collaborators according to common rule "assign a contract to the first non overloaded collaborators" and manager past experiences. This distribution is not optimal, but hoped to be approximated to the optimal one. If collaborators' capacity is overloaded, company managers should decide either to postpone some contracts to the next days or to call temporary workers to handle the overloaded contracts. Decision makers are concerned to know if current company resources are capable to handle the totality of daily received contracts (quantitative question). If not, what is the exact number of temporary workers needed to process all contracts? This is the most important objective to decision makers, since hiring employees is the most financial consumer of services companies. After answering these questions, decision maker may desire to optimize contracts distribution process to best exploit company resources (qualitative question) e.g. one objective can be to give high treatment priority to contracts that can not be delayed or to contracts considered as profitable to the company. Another objective could be to treat important contracts only by company collaborators that have better experience and skills than temporary workers. Load balancing between company collaborators can be significance objective from the social vision of point. Maximizing the rate of profitability by collaborators can be an interesting objective from economic vision.

Operational analysis

In order to ease workflow analysis, we model the *as-is* workflow using BPMN, see Figure 3. From the figure we notice that current contracts handling process is completely performed manually. Thus, losing some contracts components or even the entire contract is very probable. Especially for those contracts that were put a side and waiting for necessary missed documents in order to be processed later. At the same time, joining received missed documents to corresponding contracts is a hard task, since there is no trace for the contracts after the moment they are assigned, and there is no way to follow contract treatment progress.

Another important problem in the current process is contracts assignment policy. This assignment policy is not optimal, but hoped to be near to optimal. It depends on manager experience. Bad contract assignment may force managers to call unnecessary temporary workers to process all received contracts. Each unnecessary worker represents a considerable additional charge for the enterprise. Another problem in the current contracts assignment method is that; it is a static and irreversible process. Once contracts are assigned, no later modifications can be realized in order to cope with any eventual work necessity or events.

Another important issue is collaborators capacities. Although collaborators competences per contract type are defined in advance, in practice collaborators may spend less or more time for each contract than expected. More, incomplete contracts will need less processing time than completed contracts. As a result, collaborators real capacities are not fixe and vary during day works hours. This means, the assignment of contracts that has been done in the morning is no more optimal (if we suppose it was optimal). Last remark on the current process is that collaborators keep daily untreated contracts on their desks, in order to handle them in the day after. And this may have negative effect when assigning next day contracts, since theirs types and quantities are not considered in the new assignment process.

New contracts workflow

In order to overcome the previous problems and optimize contract handling process, we propose to replace current paper system flow system by a new automated paperless workflow system. Figure 4 demonstrates in details the proposed process. To ensure contracts integrality and traceability, received contracts with theirs attached documents are scanned at their arrival to form one integral electronic pack. Each electronic pack is then given a unique id. This id will be used to trace and follow contract from its arrival through handling process to archiving. When a contract missed some documents (incomplete contract), enterprise collaborator contacts the concerning client by sending a mail with a list of missed document. This mail contains pack id in which missed document must be integrated. When mails are received, they are scanned and then classified. If a mail contains an id, it is sent to be assembled with the corresponding contracts. Other wise, the new contract will enter the assignment process. Every time a contract is processed by a collaborator, whatever it was complete or incomplete, the daily rested free capacity for the collaborator is recalculated. When a certain threshold is attained, the assignment optimization process is restarted. When an incomplete contract is processed, it is sent for assembling process and waits for missed documents arrival. At the same time, contract history is kept for farther use. This history will contain helpful information about the contract such as the collaborator that had already treated the contract in the past. Once the missed documents are assembled to the incomplete contracts, contracts are injected in the assignment process. For each incomplete contract we must notice that it can be reassigned to the same collaborator that has already started processing it, or it can be assigned to a new different collaborators. In the first case, collaborator competences regarding this incomplete contract will be reduced since the collaborator has already studied this contract.

In the second case, collaborators competence rest intact as this will be the first time they will process the contract.

Validation, verification and performance evaluation of proposed workflow

To validate and verify the new workflow system, a new Petri nets model is created based on BPMN model to simulate contracts flow within the enterprise. This model presents only the part concerning contract assignment and handling, away from the external factors that company dosed not control, such as customer respond, see Figure 5. Figure 5.a, shows the process of handling contracts by a collaborator. Figure 5.b, simulates the process of checking complete and incomplete contracts where collaborator can handle only one contract at a time. Different Petri nets properties for the model were tested using TINA[7][21]. When collaborator work hour terminated, contracts are send to be reassigned.

This classical Petri net only simulates contracts flow within the enterprise and does not give any idea on how to optimize contracts assignment. Moreover, There is no way to represent other important information such as, contracts types, collaborator matrix competence (need time to handle each contract type) and complete/incomplete contracts. To overcome these problems and to try optimize contracts assignment problem, a colored Petri nets[13] is used. Colored Petri nets use colored tokens to represent additional information. Thus in our model, each color represents contract type, contract description (complete or incomplete) and the person that has already handled the contract. At the same time, each collaborator transition defines delay of firing for each token color. This will represent the competence matrix for each collaborator. Using these information and with the help of the formulation (1) presented by Campos in [19], the daily load of different contracts types and assembled contracts, per collaborator can be induced.

$$\sum_{\forall colors} \left\{ \frac{Y_i^T.W^-.Z_t^{(f)}}{Y_i^T.M_o} \right\} \tag{1}$$

Where

- Y_i^T: P-semiflow for collaborator *i*
- W^-: Weight of the arc to transition from its input place
- $Z_t^{(f)}$: The number of colored taken that will be consumed by collaborator within one day,
- M_o: The initial marking

The mathematical formulation for collaborators daily loads induced by formulation (1) is:

$$\sum_{j=1}^{J} X_{ij} \times T_{ij} + \sum_{k=1,}^{K} C_{ik} \times (a_{ik} \times Tnew_{ik} + \sum_{l=1,l\neq i}^{I} a_{lk} \times Told_{lk}) \quad \forall i \in \{1,2,..,I\} \tag{2}$$

Where

- X_{ij}: The number of contracts of type *j* assigned to worker *i*,
- T_{ij}: Needed time for primary, secondary workers *i* to handle contract type *j* for the first time,
- K: The number of assembled contracts from the day before,
- A_{IK}: two dimensional matrix representing the historic of assembled contracts, where
  - $a_{ik} = \begin{cases} 1 \text{ if contract k was treated by collaborator i,} \\ 0 \text{ otherwise.} \end{cases}$
- C_{ik}: Binary variable, where
  - $C_{ik} = \begin{cases} 1 \text{ if assembled contract k is assigned to} \\ \text{collaborator i,} \\ 0 \text{ otherwise.} \end{cases}$
- $Tnew_{ik}$: needed time to treat assembled contract *k* if it is assigned to the same collaborator *i* that has already treated it,
- $Told_{ik}$: needed time to treat the assembled contract *k* if it is assigned to a new collaborator *i*

Since the formulation in (1) demonstrates collaborator *i* possible load, this charge must not exceed collaborator daily capacity, which is known in the morning of each day. As a result formulation (1) is become the left hand side of the inequality in (Inequality:Constraint1). This inequality must be respected each time contract are assigned.

$$\sum_{j=1}^{J} X_{ij} \times T_{ij} + \sum_{k=1,}^{K} C_{ik} \times (a_{ik} \times Tnew_{ik} + \sum_{l=1,l\neq i}^{I} a_{lk} \times Told_{lk}) \leq Cap_i \quad \forall i \in \{1,2,..,I\} \tag{3}$$

Where

- CAP_i: Capacity of collaborator *i*,

As we have said before, the most important objective for the company is to minimize the number of called temporary workers needed to handle all received contract. To solve this problem, we formulate the contracts assignment problem as a linear programming problem, with the help of data registered in company information system and the P-semiflow performance analysis that we have performed. In this formulation, we suppose that the number of available temporary workers is sufficient to handle all received contracts. A certain percentage (α) of the daily received contracts is complete, and the rest (1-α) is incomplete. This percentage is estimated by studying company registered history. Thus

$$T_{ij} = (\alpha)T_{ij}complete + (1-\alpha)T_{ij}incomplete$$

[7]Toolbox for editing and analyzing Petri nets and time Petri nets

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The resulted problem can then be solved using any mathematical solver such as Cplex[8] solver which uses a branch and bound method to guaranty solution optimality. Consider the following additional notations:

- N: Number of company collaborators (primary workers),
- M: Number of available temporary workers (secondary workers),
- I: Number of primary worker and available secondary workers, $I = N + M$,
- U_i: Boolean variable to present primary, secondary worker i. Where
  - $U_i = \begin{cases} 1 \text{ if worker } i \text{is chosen,} \\ 0 \text{ otherwise.} \end{cases}$
- CAP_i: Capacity of collaborator *i*,
- QT_j: Quantity contracts of type *j*,
- Prs: Set contains company present workers,
- Abs: Set contains company absent workers.

Thus the mathematical formulation of the new assignment problem becomes:

$$Min \sum_{i=1}^{I} U_i \tag{4}$$

$$\sum_{j=1}^{J} X_{ij} \times T_{ij} + \sum_{k=1,}^{K} C_{ik} \times (a_{ik} \times Tnew_{ik} + \sum_{l=1,l\neq i}^{I} a_{lk} \times Told_{lk}) \leq Cap_i \times U_i \forall i \in \{1,2,..,I\} \tag{5}$$

$$\sum_{i=1}^{I} X_{ij} = QT_j, \qquad \forall j \in \{1,2,..,J\} \tag{6}$$

$$\sum_{k=1}^{K} C_{ik} = K, \forall i \in \{1,2,..,I\} \tag{7}$$

$$U_i = 0, \qquad \forall U_i \in Abs \tag{8}$$

$$\sum_{i=1}^{N} U_i = |Prs| \tag{9}$$

This formulation represents a new assignment problem. It has been studied and discussed in details in[22][23]. It permits to determine in certitude contracts assignment that will minimize the number of needed temporary workers to handle all daily received contracts. This assignment is optimal in the conditions that the computed percentage of incomplete contracts is identical to the real one, and each contract took the exact treatment time expected by the competence matrix. However, as we have explained in sectionIV, this treatment time is an estimated time, and can increase or decrease due to different factors. More, the number of incomplete contracts can be computed only after all received contracts have been checked by the collaborators. Knowing that incomplete contracts will need less time than complete ones, this may leads to additional free time for collaborators that handle incomplete contracts. Thus, real collaborators capacities will change during day and our parameter evolve with time. To overcome these problems, we propose to supply decision maker with different key performance indicators (KPIs). These indicators will supply decision maker with a real time vision on contracts progress, and will inform them when the system permit to perform a new contracts assignment with new objectives. Such an indicator can be the accumulation of free time results from the difference between real treatment time and expected treatment time for a contract, and/or from handling incomplete contracts. Another indicator can be the number of assembled contracts. When these indicators attain a predefined threshold, decision maker can trigger a new contract assignment process with new possible objectives function to take in consideration the new parameters. See inequalities (10,11). Figure 6 demonstrates the final proposed workflow process.

$$\text{Accumulated free time at t - Expected free time at t} \geq \text{Predefined threshold} \tag{10}$$

$$\text{Sum of assembled contracts} \geq \text{Predefined threshold} \tag{11}$$

In the following we present an example of one objective function from many other objectives. It concerns minimizing the total treatment time for contracts assignment problem. Time is introduced in the new formulation. Consider the following:

- $U_i(t)$: Boolean variable to present primary, secondary worker *i*, available at time *t*,
- T_{ij}: Needed time for primary, secondary workers *i* to handle contract type *j* for the first time,
- X_{ij} The number of contracts of type *j* assigned to worker *i*.
- $CAP_i(t)$: Capacity of collaborator *i* at time *t* (in hours), where
  - $CAP_i(t) = RestWH(t) \times UTH$
  - RestWH(t): work hours rested at time *t* of the day,
  - UTH: number of unit of time per hour
- $QT_j(t)$: untreated contracts of type *j*, at time *t*, where
  - $QT_j(t) = QT_j(0) - \sum_{i=1}^{I} \overline{X}_{ij}(t)$
  - $\overline{X}_{ij}(t)$: number of contracts of type *j*, treated by operator *i* till time *t*.
- K: number of received assembled contracts,
- A_{IK}: two dimensional matrix representing the historic of assembled contracts, where

[8]CPLEX : an optimization software package produced by ILOG, which uses an advanced mathematical programming and constraint-based optimization techniques to find problem optimal solution. http://www.ilog.com/

- $a_{ik} = \begin{cases} 1 \text{ if contract k was treated by collaborator i,} \\ 0 \text{ otherwise.} \end{cases}$

- C_{ik}: binary variable, where
  - $C_{ik} = \begin{cases} 1 \text{ if assembled contract k is assigned to} \\ \text{collaborator i,} \\ 0 \text{ otherwise.} \end{cases}$
- $Tnew_{ik}$: needed time to treat assembled contract *k* if it is assigned to the same collaborator *i* that has already treated it,
- $Told_{ik}$: needed time to treat the assembled contract *k* if it is assigned to a new collaborator *i*,
- Prs_t: Set contains company workers present at time *t*,
- Abs_t: Set contains company workers absent at time *t*

The mathematical formulation to minimize the total treatment time is given in the following:

$$Min \sum_{i=1}^{N+L} \sum_{j=1}^{J} X_{ij} * T_{ij} + \sum_{j=1}^{J} X_{ij} \times T_{ij} + \sum_{k=1,}^{K} C_{ik} \times (a_{ik} \times Tnew_{ik} + \sum_{l=1,l\neq i}^{I} a_{lk} \times Told_{lk}) \leq Cap_i \tag{12}$$

$$\sum_{k=1,}^{K} C_{ik} \times (a_{ik} \times Tnew_{ik} + \sum_{l=1,l\neq i}^{I} a_{lk} \times Told_{lk}) + \sum_{j=1}^{J} X_{ij} \times T_{ij} \leq Cap_i(t) \times U_i(t), \forall i \in \{1,2,..,I\} \tag{13}$$

$$\sum_{i=1}^{I} X_{ij} = QT_j(t), \qquad \forall j \in \{1,2,..,J\} \tag{14}$$

$$\sum_{k=1}^{K} C_{ik} = K, \forall i \in \{1,2,..,I\} \tag{15}$$

$$U_i(t) = 0, \qquad \forall U_{it} \in Abs_t \tag{16}$$

$$\sum_{i=1}^{N} U_i(t) = |Prs_t| \tag{17}$$

V. CONCLUSION

In this paper, we have presented a framework for workflow systems reengineering. The proposed framework uses the most recent standards and technologies for modeling and implementing workflow system. It uses BPMN to model the *as-is* and *to-be* workflow system. The choice of BPMN is due to its capacity and richness to represent different workflow patterns and different business process. BPMN is a comprehensive notation for both managers and system analysts and that eases ideas exchange between them to have a fine and deep analysis for the system. System weakness and draw backs are then identified and a new workflow system can be presented. The flexibility of BPMN may leads to undesired properties (such as deadlocks) that have a direct effect on the final process. To overcome this problem, a transformation of BPMN model to Petri net is proposed. Petri net allow the verification of BPMN undesired properties results from the lack of formal semantics for BPMN. Additional analysis and performance evaluation can be done using Petri nets P-semiflow property. This allows an optimization of the workflow and permits to induce useful mathematical formulation. Every time a problem is detected in the Petri net model, the BPMN model is remodeled to avoid this problem. The final BPMN model is then used to generate BPEL execution code by employing the works that have been already done this domain. Real case study has been used to demonstrate the different phases of the proposed frameworks. A new assignment problem is appeared within the new workflow. To ensure the optimization for the new problem, a mathematical formulation for the problem has been presented as a linear programming problem, and solved by using Cplex solver. Resolution time for the problem with its current size was very satisfactory and there was no need to develop a new resolution method. Finally, the proposed model will provide decision makers with the suitable key performance indicators (KPIs) in real time, which allows them to take the right decision in the write time.

VI. ANNEX

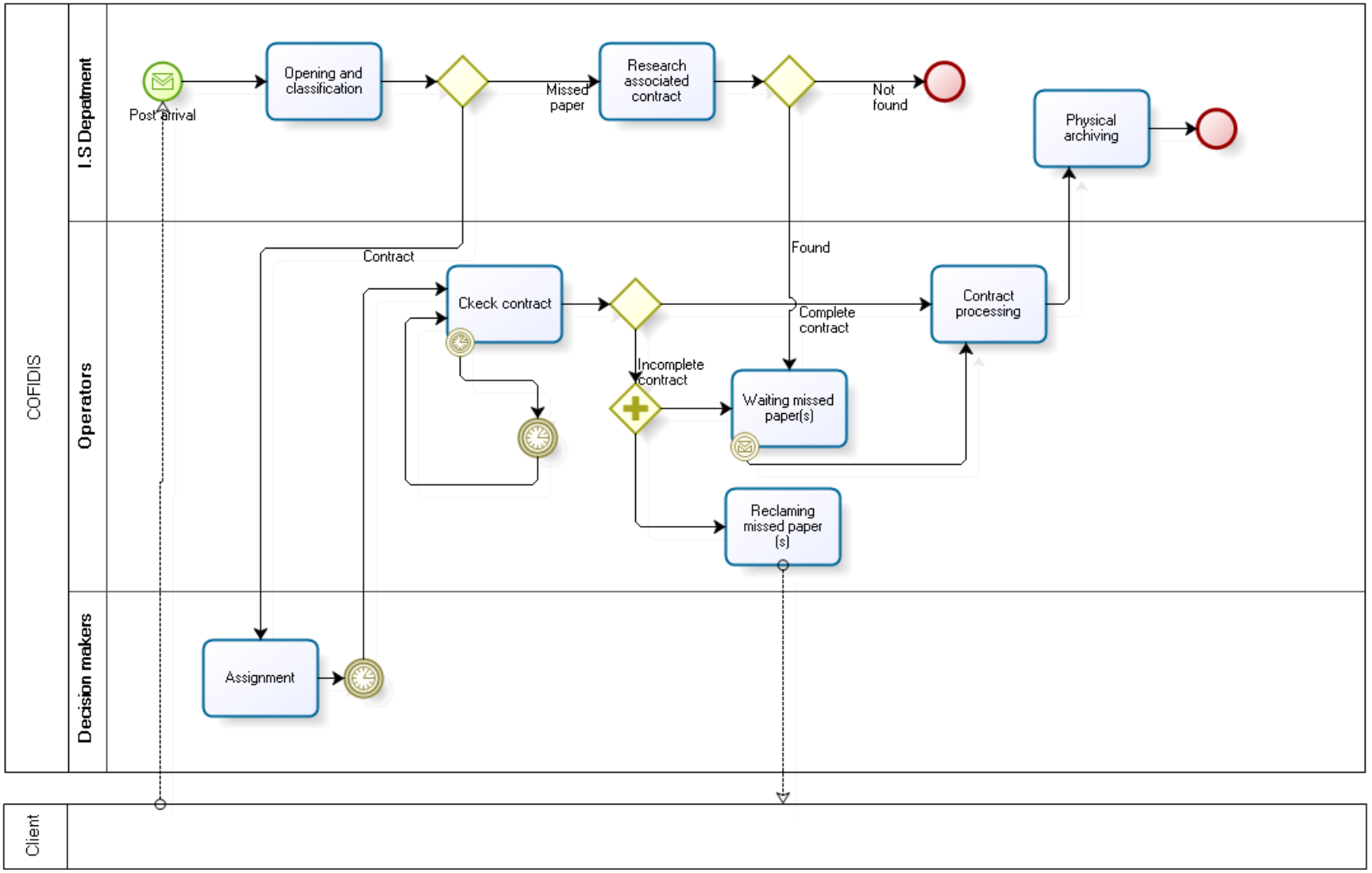

COFIDIS
I.S Depatment
Operators
Decision makers
Client
Post arrival
Opening and classification
Missed paper
Research associated contract
Not found
Physical archiving
Contract
Found
Ckeck contract
Complete contract
Contract processing
Incomplete contract
Waiting missed paper(s)
Reclaming missed paper (s)
Assignment

Fig. 3. befor

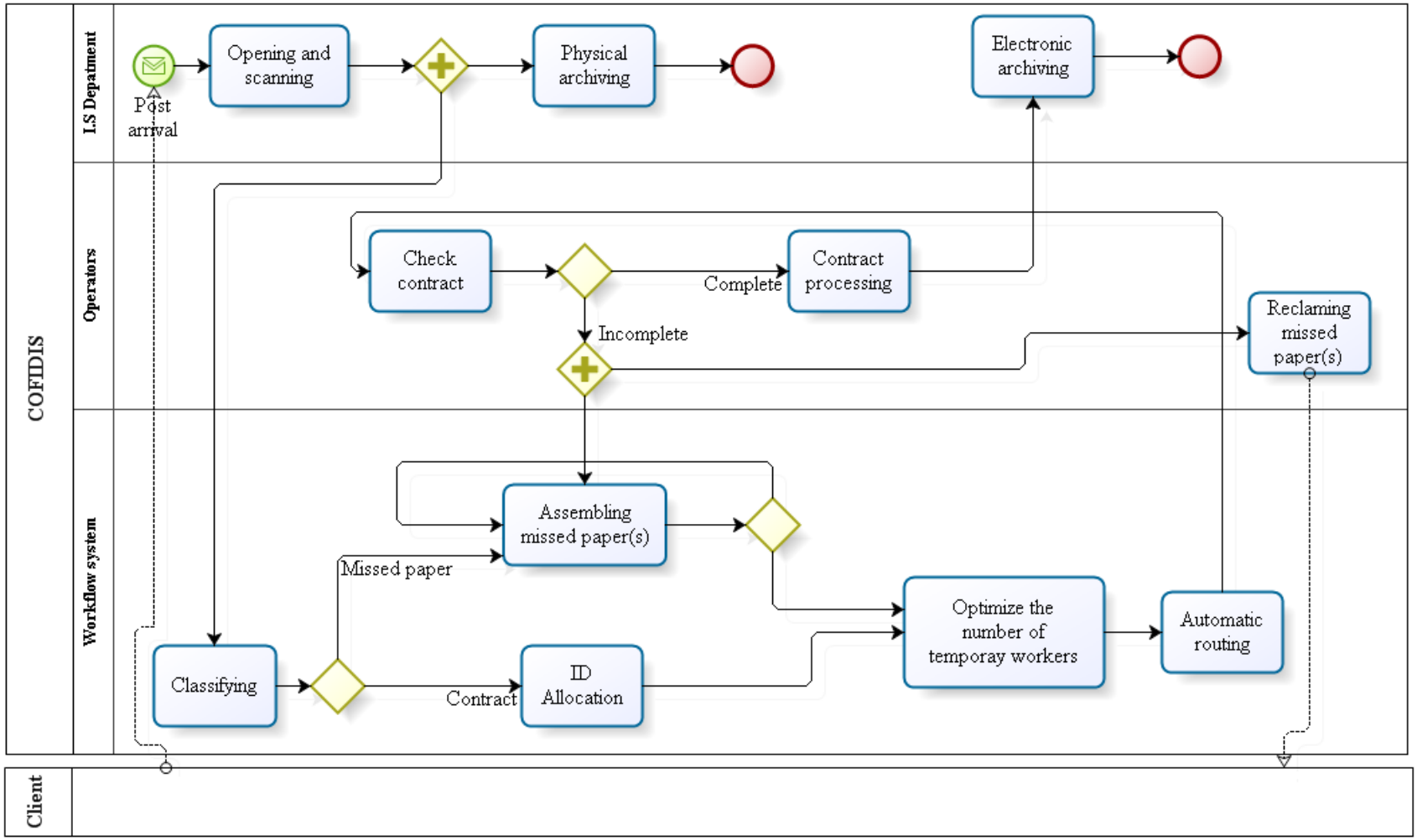

COFIDIS
I.S Depatment
Operators
Workflow system
Client
Post arrival
Opening and scanning
Physical archiving
Electronic archiving
Check contract
Complete
Contract processing
Incomplete
Reclaming missed paper(s)
Assembling missed paper(s)
Missed paper
Optimize the number of temporay workers
Automatic routing
Classifying
Contract
ID Allocation

Fig. 4. After

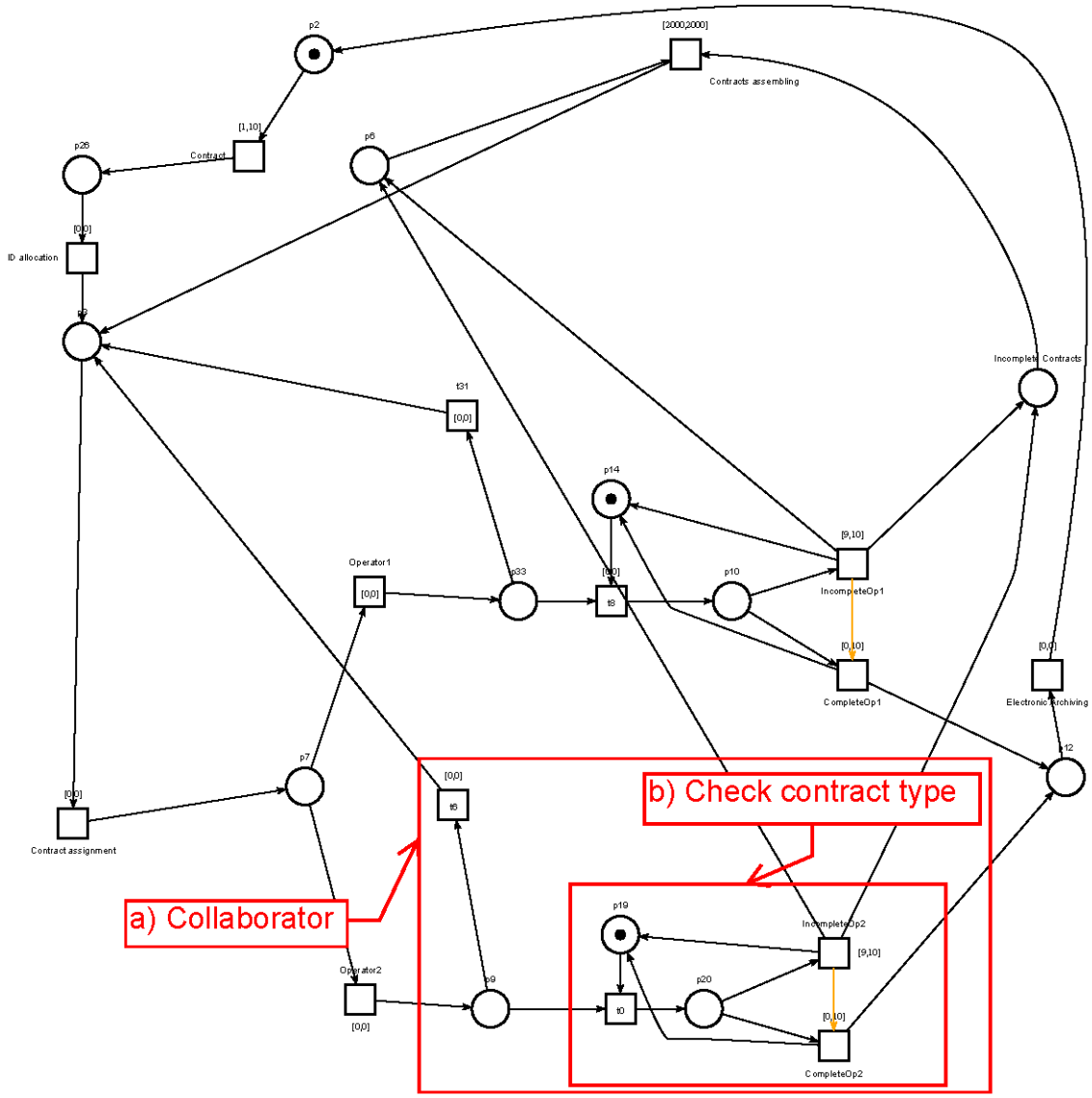
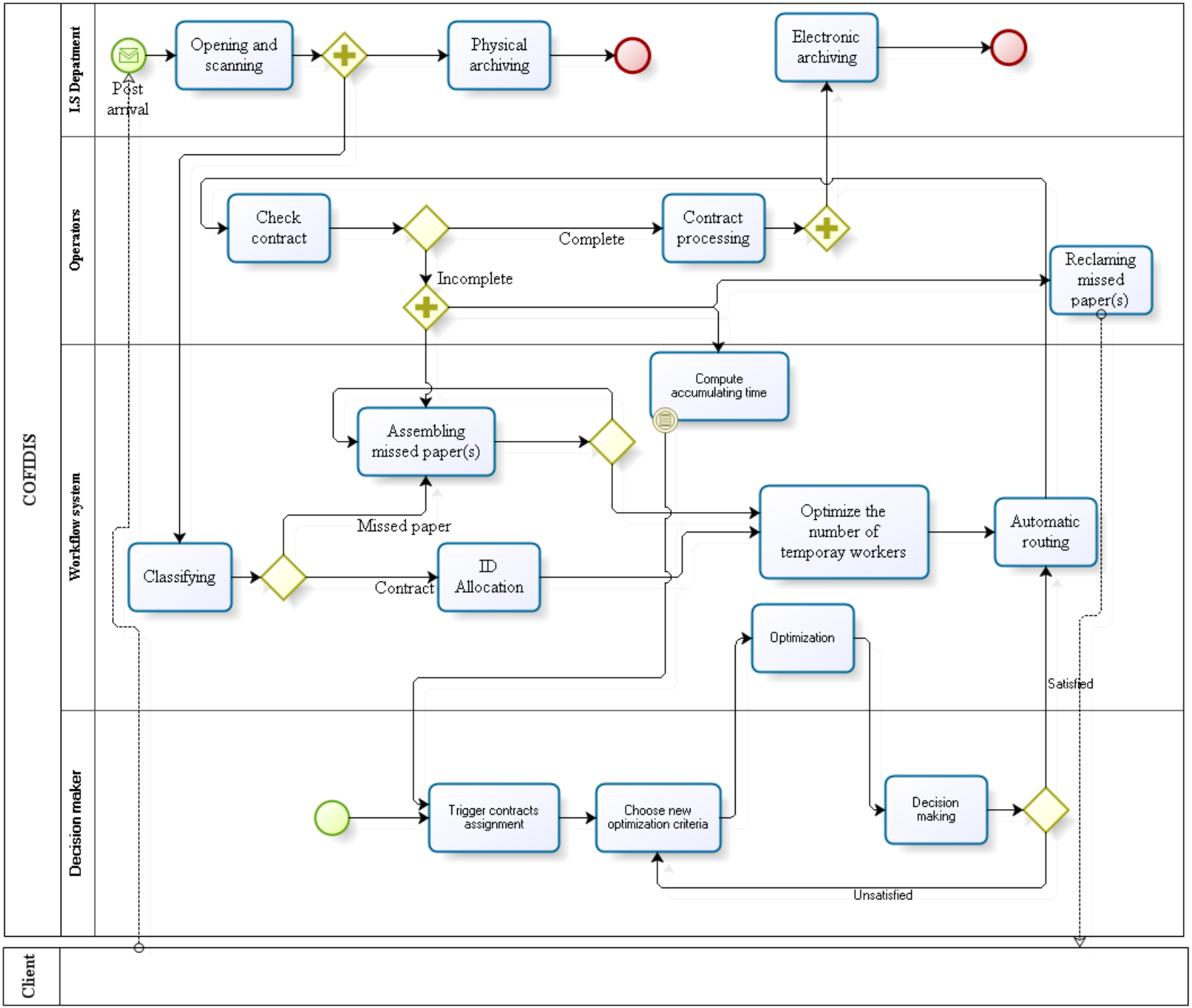


Fig. 5. New workflow (Petri nets model). a) Subnet simulate the process of handling a contract by a collaborator. b) Subnet simulates verifying complete/incomplete contract process.


COFIDIS
I.S Depatment
Operators
Workflow system
Decision maker
Client
Post arrival
Opening and scanning
Physical archiving
Electronic archiving
Check contract
Complete
Contract processing
Incomplete
Reclaming missed paper(s)
Compute accumulating time
Assembling missed paper(s)
Missed paper
Classifying
Contract
ID Allocation
Optimize the number of temporay workers
Automatic routing
Optimization
Satisfied
Trigger contracts assignment
Choose new optimization criteria
Decision making
Unsatisfied

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