Discovering Organizational Perspective in Workflow using Agent Approach: An illustrative Case Study

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Abstract. The existing Workflow Management Systems, WfMS (ACTIONTm, Xsoft InConcert, Team Ware) show some insufficient due essentially to two factors. First, the enterprises express a real need of WfMS that deal with flexible business processes. These later must adapt to the optimization of enterprises work methods and the evolution of their needs. Second, the enterprises also need of control mechanisms and modeling tools for their WfMS in order to design robust workflow models assuring an efficient and flexible processing of errors and exceptions of execution. In others words, the WfMS must deal with Workflow mining to support Business Processes Re-engineering (BPR). A BPR is a method to improve the effectiveness and efficiency of business processes. Existing propositions in the literature are rather dedicated to the process perspective mining and they neglect the discovering of organizational perspective although it is decisive for the enhancement of existing workflow or the proposing of a new Workflow. The paper addresses the workflow mining by considering the organizational perspective. By organizational perspective, we mean the organizational structures (Federation, Hierarchical, Market and so on) and interaction protocols (Contract net, Auction...) describing respectively the forms of work and the activities allocation process between actors. This paper defends the idea that organizational dimension in multi-agent system is an appropriate approach to discover this organizational perspective since it (i) provides inter-agents communication languages based on performatives which allow capturing the semantic of exchanges between actors, (ii) it introduces organizational structures to highlight the forms of work and (iii) it offers powerful interactions protocols which permit to identify the dynamic organizational structures. First, this paper proposes a Workflow log meta-model which extends the classical one. Then, it provides some algorithms to permit the discovering of the main organizational structures and interaction protocols. Third, it presents the Management process of Water distribution crisis case study to illustrate our approach. Finally, the paper describes the developed prototype, called DiscopFlow, in order to validate the proposed solution. Keywords: Interaction Protocols, Organizational Structures, Workflow log Meta-Model, Algorithms and DiscopFlow.

J. Barjis, M.M. Narasipuram, G. Rabadi, J. Ralyté, and P. Plebani (Eds.):
CAiSE 2010 Workshop EOMAS'10, Hammamet, Tunisia, pp. 84-98, 2010.

Key words: Interaction Protocols, Organizational Structures, Meta-Model, case study, FIPA-ACL Performatives.

1 Introduction

Workflow Mining Context. The Workflow is a key technology which automates the coordination of activities composing business process [1]. A Workflow Management System, WfMS is a software which permits to define, implement and execute one or several business processes. In order to support the interoperability between WfMS, the WorkFlow Management Coalition, WFMC has defined reference architecture [1]. The main component of this architecture is the Workflow Enactment Service (WES) that manages the execution of business processes and that interacts, on the one hand, with business processes (or workflows) definitions, execution and monitoring components and on the other hand, with external WES. The communication among the different components is supported by five interfaces of which Interface 5 is of most interest to us. This interface supports the connection between the WES and the monitoring tools. Unfortunately, a good standard for this interface has never been proposed. In this context, the Workflow Mining area has recently appeared and considered as a new research domain. More precisely, the purpose of Workflow mining is to analyze the Workflow log in order to discover the Workflow perspectives such as the Organizational Perspective (OP), the Informational Perspective (IP) and the Process Perspective (PP) [2], which help the monitor to improve or propose a new workflow. The OP has two objectives. First, it structures actors in classes playing each one a specific role (for instance subordinate and chief roles in simple hierarchical structure). A class is called an organizational structure defining an interaction space between actors. Of course, each actor belongs to its own organizational unit where it plays a predefined role. Second the organizational perspective describes the allocation activities between actors according to interaction protocols. In this paper we are interested to discover the organizational structures and interaction protocols and not the concepts of classical organizational model such as role, organizational unit, etc. The IP describes the structure of forms, documents and data which are consumed and produced by processes. The PP defines activities components, their coordination, information and actors involved in each activity. This perspective refers to both the organizational perspective, which defines and organizes the set of potential actors, and the informational perspective, which allows access to the objects to be processed. Most of the work deals with the discovery of process and/or informational perspective(s) while few researches were investigated around the discovery of the organizational perspective although it is decisive for the enhancement of existing workflow or the proposing of a new Workflow ([2], [3], [4], [5]).
A good application domain justifying the need to discover the organizational perspective is that of crisis Workflows as much as it is important to understand the social behavior of the actors during a crisis process. In others terms, we need to know the involved organizational structures in this crisis and the in-

teraction protocols used by the potential actors.In this paper, we have chosen the well-known "Management process of Water Distribution crisis" case study for three reasons. First, the water is a main need for the human and must be protected against any incident. Second, the frequency of water pollution is very high. Third, this case study is complete in so far as it illustrates clearly the interaction protocols used by the actors (Analyst, Controller, Investigator and so on) and the deployed organizational structures.
The problem being addressed in this paper is how to discover the organizational perspective from workflow log? We recall that organizational perspective refers to the organizational structures and interaction protocols. One possible way to deal with the discovering of organizational perspective in workflow is to use the agent approach and more precisely:

- the FIPA-ACL performatives which define the semantic of messages and notably the agents intentions,
- the interaction protocols such as contract net, auction and negotiation which constraint the conversations between actors during the activities allocation,
- the organizational structures like coalition, hierarchical, market and federation which define the behavior of actors ([6], [7]).

The goal of this paper is to propose a Workflow log Meta-model to help the discovery of organizational structures and interaction protocols.
Our solution is based on the following principles:

- The inclusion of the three complementary workflow perspectives. As a consequence we can support any discovering of perspective.The use of FIPA-ACL Performatives which are appropriates to define the organizational structures referencing interaction protocols,
- The simplicity by including the basic workflow concepts.

Organization of the paper. The reminder of this paper is organized as follow. Section 2 motives the use of Agent approach for discovering organizational structures and interaction protocols in Workflow. Section 3 describes the Workflow log Meta-model that we propose to deal with organizational perspective mining. Section 4 presents our case study useful for instantiating this model. First, it introduces the Petri Nets with Objects formalism and exposes its three models which are in interaction. Then, it gives the instantiated Meta-model. Finally, it discusses some organizational structures and interaction protocols which can be discovered according to this instantiation. Section 5 briefly discusses the related Works and concludes the paper.

2 Motivations for using Agent Approach

The objective of this section is to briefly motive the use of agent approach for organizational perspective discovering in workflow and more precisely:

- the FIPA-ACL communication language,

– the organizational structures,
– the interaction protocols,

FIPA-ACL (Foundations of Intelligent Physical Agents-Agent Communication Language, `http://www.fipa.org`) is one of the inter-agents communication languages proposed by the agent community. It is composed of a set of performatives and integrating of protocols. The FIPA-ACL message structure is shown in figure 1. For more information on FIPA-ACL performatives the interested reader can refer to [8].

```
(Performative
                    :sender A
                    :receiver B
                    :content XXX
                    :in-reply-to YYY
                    :language ZZZ
                    :reply-by CCC
                    :conversation_ID VWV)
```

Fig. 1. The FIPA-ACL message structure

These FIPA-ACL performatives play a key role in the activities allocation between actors. First, they clearly define the semantic of messages and namely the agents intentions (delegate, subcontract, negotiate,). Second, they highlight, during the interaction between agents, the organizational structures such as coalition, sub contracting, federation and so on. Third, they capture without ambiguity the interaction protocols like contract-net, auction, negotiation and heuristic. These interaction protocols could be used with benefits to allocate activities to actors in workflow. The table 1 describes the performatives used in this paper.

The organizational structures mentioned above can model the behaviour of the systems under consideration. I.e. they describe the macro-level dimension of the coordination among actors in terms of externally observable behaviour, independently of the internal features of each participating component.

3 The Workflow log Meta-model

3.1 Key requirements for a Workflow log Meta-model

The most important requirements for a Workflow log Meta model are the following:

Performative	Description
Delegate	The initiator delegates the receiver the Activity A of Case C
Inform	Concerns any information dispatch concerning Activity A of Case C
Execute	The initator informs that it performed the Activity A of Case C
Call for Proposal	Call for Offers: announces a negotiation for performing of the Activity A of case C
Propose	The initiator proposes to execute an Activity
Refuse	The initiator refuses the proposition of the receiver
Accept Proposal	After propose: to mean the acceptation
Reject Proposal	After propose: to mean the reject

Table 1. The performatives description

– It must allow the expression of the three workflow perspectives such as the informational perspective, the organizational perspective and the process perspective,
– It must be simple and comprehensive: it must define the core concepts of the three complementary Workflow perspectives,
– It supports the discovering of organizational structures and interaction protocols without ambiguity as mentioned previously.

Most of the work concerning Workflow perspectives mining ([2], [3], [4]) only focuses on the process perspective by providing a workflow log containing only concepts of the process perspective. Other also considers the informational perspective besides to the process perspective [5]. To the best of our knowledge, any work supports the last requirement and makes really the glue between the three workflow perspectives. Consequently, we have defined our own meta-model which fulfills the previous requirements. This meta-model is shown in the UML diagram of figure 2.

3.2 The proposed Workflow log Meta-model

In this UML Meta-model, a Process is composed of one (or several) Process Instance(s). Each Process Instance is composed of one (or several) Event(s). Each Event makes reference to the following elements:

– An Activity which is described through the Act_Name attribute,
– A Document which is described through the Doc_Name attribute,
– An Actor which is described through the Actor_ID and Actor_Name attributes, Its a member of organizational unit and plays one (or several) Role(s),
– A Role which is described through the Role_Name attribute,
– An Organizational Unit which is described through the Org_Unit_Name attribute,

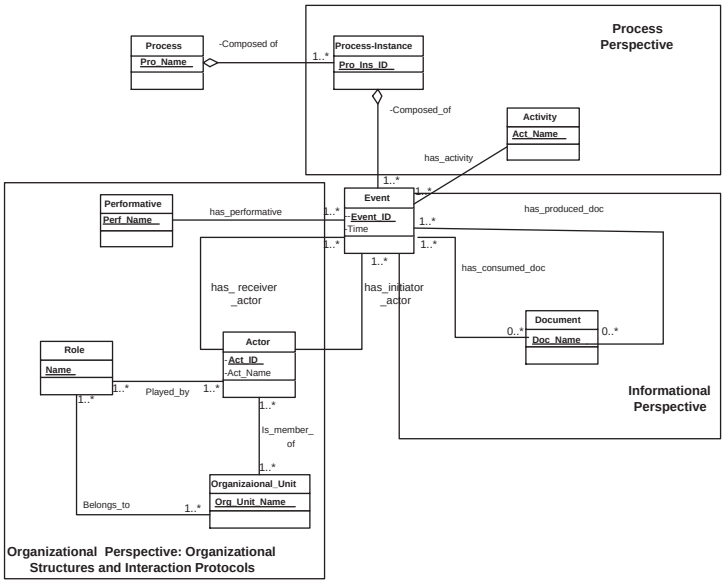


Fig. 2. The Workflow log Meta-model

– A Performative which is described through the Per_Name attribute.

Besides, the consumed documents and the produced documents are respectively represented by the Has_Consumed_Doc and Has_Produced_Doc relationships. The initiator Actor and the receiver actor are represented respectively by the Has_Initiator_Actor and Has_ Receiver_Actor relationships.

The process perspective is described with the Process Instance, Event and Activity classes (or concepts). According to the literature, these concepts are sufficient to discover the process structure. The informational perspective is described with the Process Instance, Event and Document concepts. We have chosen only to add the document concept because we think that this later will be very useful in crisis process. It is important to know on what such actor is based to produce such document. For instance, in our case study (Management Process of Water Distribution Crisis) the Malik actor playing the penal role can produce the document Juridical Report only on the basis of a document Investigation Report produced by the Walid actor playing the investigator role (see figure 4). The organizational perspective as mentioned in introduction is represented with Actor, Role, Organizational Unit and Performative concepts.

4 An illustrative case study

The Objective of this section is (i) to illustrate the workflow log Meta-model instantiation through the well-known Management process of Water Distribution

crisis case study and (ii) to show the organizational structures and interaction protocols which can be discovered. First, it briefly introduces Petri Net with Objects (PNO) formalism as an appropriate language for modelling processes. Second, it models the case study through three communicating models (information, organization and process). Third, it presents the instantiated Meta-Model. Finally, it exposes some organizational structures and interaction protocols which can be discovered.

4.1 What are Petri Nets with Objects?

Petri Nets with Objects (PNO) [9] are a formalism combining coherently Petri nets (PN) technology and Object-Oriented (OO) approach. While PN are very suitable to express the dynamic behavior of a system, OO approach enables the modeling and the structuring of its active (actor) and passive (information) entities. In a conventional PN, tokens are atomic and undissociable, whereas they are objects in a PNO. As any PN, a PNO is made up of places, arcs and transitions, but in PNO, they are labeled with inscriptions referring to the handled objects. More precisely, a PNO features the following additive characteristics:

- Places are typed. The type of a place is a (list of) type of some object-oriented sequential languages. A token is a value matching the type of a place such as a (list of) constant (e.g. 2 or hello), an instance of an object class, or a reference towards such an instance. The value of a place is a set of tokens it contains. At any moment, the state of the net, or its marking is defined by the distribution of tokens onto places. A transition is connected to places by oriented arcs as it aims at changing the net state, i.e. the location and value of tokens.
- Arcs are labeled with parameters. Each arc is labeled with a (list of) variable of the same type, as the place the arc is connected to. The variables on the arcs surrounding a transition serve as formal parameters of that transition and define the flow of tokens from input to output places. Arcs from places to a transition determine the enabling condition of the transition: a transition may occur (or is enabled) if there exists a binding of its input variables with tokens lying in its input places. The occurrence of an enabled transition changes the marking of its surrounding places: tokens bound to input variables are removed from input places, and tokens are put into output places according to variables labeling output arcs.
- Each Transition is a complex structure made up of three components: a precondition, an action and emission rules. A transition may be guarded by a precondition, i.e. a side effect free Boolean expression involving input variables. In this case, the transition is enabled by a binding only if this binding evaluates the precondition to true. Preconditions allow for the fact that the enabling of a transition depends on the location of tokens and also on their value. Most transitions also include an action, which consists in a piece of code in which transitions variables may appear and object methods be invoked. This action is executed at each occurrence of the transition and it processes the values of tokens. Finally, a transition may include a set of emission rules i.e.

side-effect free Boolean expressions that determine the output arcs that are actually activated after the execution of the action.

4.2 The Informational Model

The informational model that we propose focuses only on the documents consumed or produced by the case study process (see figure 3). More precisely, it contains the following documents:

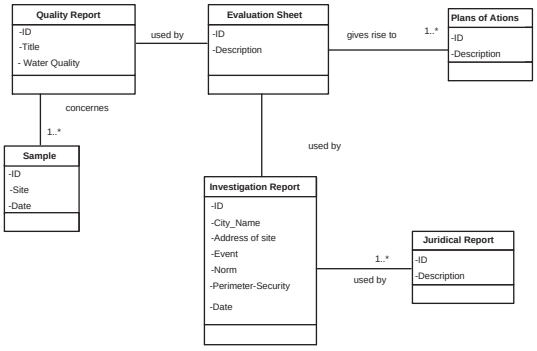


Fig. 3. The UML Classes diagram of the informational model

- An Investigation Report which can be used by one or several Juridical Report,
- An Evaluation Sheet which is based on Quality Report and gives rise to one or several Plans of Actions,
- A Quality Report concerns one or several Sample to be analysed.

4.3 The Organizational Model

Our organizational model is organized around the following components (see figure 4).
Thirteen roles:

- Investigator: Consists in elaborating an investigation report, informing the penal and delegating the triggering of alarm to the reporter,
- Penal: Consists in elaborating the juridical report,
- Reporter: consists in informing the controller of the incident arrival,
- Controller: consists in realizing the taking of sample from the pumping site in order to prepare the samples and delegate their analysis,
- Analyst: consists in analysing of samples, elaborating a quality report and informing the authority to trigger the crisis cell,
- Authority: consists in activating and inactivating the pumping site,
- Evaluator: consists in informing the scheduler of the risks evaluation result,

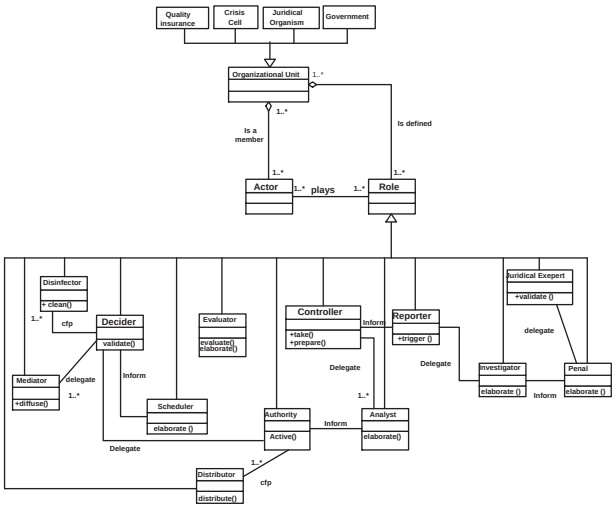


Fig. 4. The UML Classes diagram of the organizational model

- Scheduler: consists in informing the decider of the plans of actions,
- Decider: consists in validating one among proposed plans of actions,
- Distributor: consists in distributing of water bottles to the concerned users,
- Juridical expert: consists in validating the juridical report,
- Disinfector: Consists in cleaning the polluted site,
- Mediator: Consists in diffusing information to the concerned users.

Four organizational units:

- Quality insurance: charged to control the water quality,
- Crisis cell: charged to assure the return to the normal functioning of the Water distribution system,
- Juridical Organism: charged to take the juridical decisions,
- Government: charged to activate/inactivate the pumping site.

4.4 The Process model

The objective of the management process of Water Distribution crisis is to assure the return to the normal functioning of the Water distribution system. More precisely, this process is made of several coordinated activities and described using Petri Nets with Objects (see figure 5). Let us detail the activities (transitions) composing the process:

Investigation report establishment (A1) is realized by the investigator and consists in elaborating an investigation report containing all the information around the incident, the security perimeters and transport norms.

Alarm triggering (A2) is realized by the reporter and consists in triggering an alarm in order to inform the arrival of incident on water distribution system.
Juridical report establishment (A3) is realized by the penal and consists in establishing a juridical report describing the juridical decisions.
Juridical report Validation (A4) is realized by a juridical expert and consists in applying the juridical decisions taken by the penal.
Taking of samples (A5) is realized by a controller and consists in realizing Taking of samples on water distribution system, preparing of samples and sending them to the analysts.
Analysis of samples (A6) is realized by an analyst and consists in handling the samples and elaborating a quality report.
Risks Evaluation (A7) is realized by an evaluator and consists in elaborating an evaluation sheet containing the eventual risks.
Actions scheduling (A8) is realized by a scheduler and consists in proposing more actions plans to assure the return to the normal functioning of the water distribution system.
Actions plans validation (A9) is realized by the decider and consists in validation of one actions plan.
Disinfection of polluted site (A10) is realized by a disinfector and consists in realizing the cleaning work on the polluted site.
Information diffusion (A11) is realized by media (TV or Journal) and consists in informing the concerned users.
Inactivation of the site (A12) is realized by the authority and consists in interdiction the functioning of the water distribution system.
Water bottles distribution (A13) is realized by a distributor and consists in distributing water bottles to the concerned users.

4.5 The Instantiated Meta-Model

In order to illustrate the Workflow log meta-model instantiation, we propose to use the process model presented previously.
This instantiation is visualized in figure 6.

For instance, the grey part of this figure represents the contract net protocol employed between actors Malik, Walid and Mahdi (see figure C in table 2). According to this protocol, Malik launches by a call for dealing with given activity (Cfp). The other actors Walid and Mahdi propose their bid (Propose). Finally, Malik notifies each participant either by acceptation (Accept-propose) or by rejection (Reject-propose). This information is useful to understand how to allocate activities to actors.

4.6 The Organizational Structures and Interaction Protocols which can be discovered from our Workflow Log

According to the instantiated meta-model, we give here some organizational structures and interaction protocols that can be discovered. For each organiza-

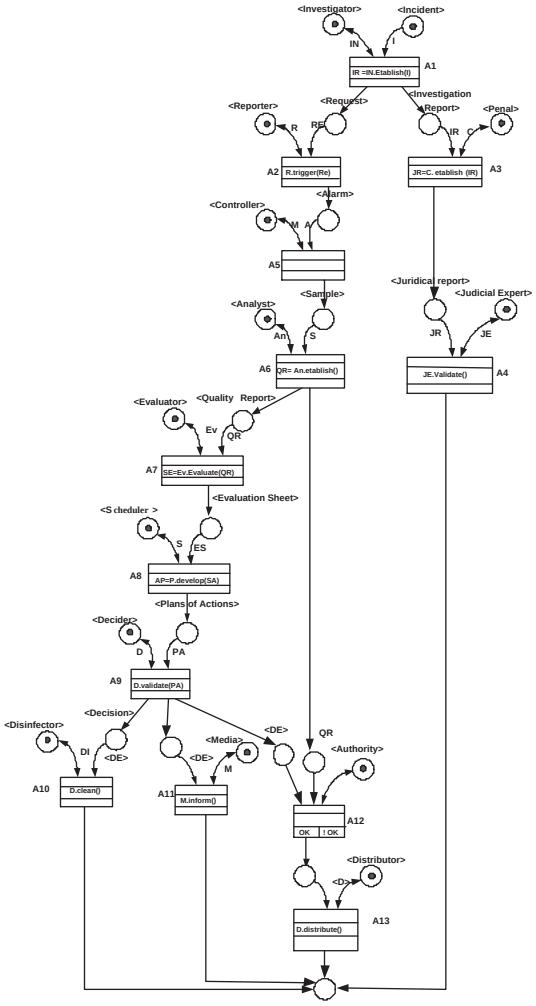


Fig. 5. The Process Model described using Petri Nets with Objects.

tional structure or interaction protocol we only give its definition and its associated graphic representation.

5 Discussion and Conclusion

The organizational perspective mining remains insufficiently addressed([10], [11]). Existing propositions in the literature are rather dedicated to the process perspective mining([3], [4], [5])and they neglect the important point that workflow is much more that process perspective. We believe that these works

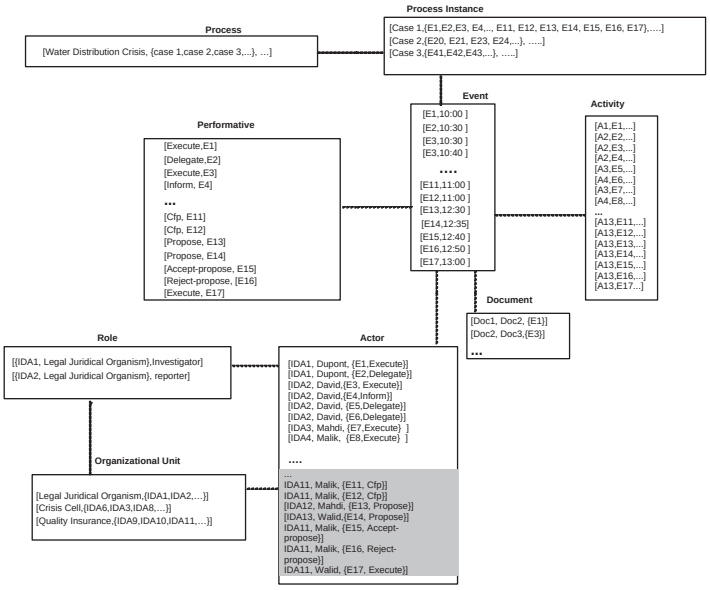


Fig. 6. The workflow log meta-model instantiation.

limit the scope and utility of workflow mining. For instance [3]only focuses on process mining by providing a Workflow log meta-model which defines the minimum concepts of process. [4]proposes a statistical technique to discover Workflow patterns from event log.[5]deals with the workflow mining in more workflow perspectives (process and informational perspectives) but without consider the organizational perspective.[10]defines three methods for mining of organizational structures from workflow logs such as default mining, mining based on the similarity of activities and mining based on the similarity of cases. Even if the proposed solution in [10]deals with the organizational perspective mining,it does not exploit the agent approach and as a consequence it does not support the interaction protocols and organizational structures so far discovered. [11]proposes an approach based on metrics expressing the relationships among actors deriving social networks. We believe our solution is currently unique in trying to take into account the three Workflow perspectives in unique model.
In this paper, we have presented an approach based on agent technology to deal with organizational perspective discovering.
To better illustrate our solution, we have chosen the well-known Management process of Water Distribution crisis case study.
The proposed meta-model is characterized by:

– its inclusion of three complementary workflow perspectives and as a consequence it supports any perspective discovering although in this paper we only focus on the organizational perspective,

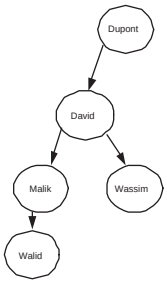
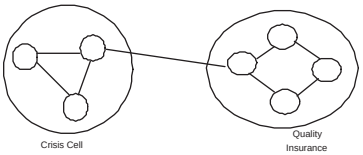
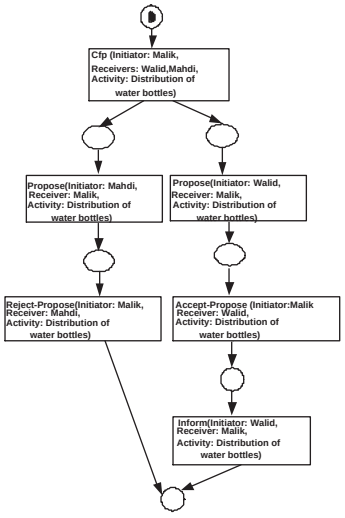
Organizational Structure or Interaction Protocol	*Definition*	*Graphic representation*
Simple Hierarchical	*It's a flat hierarchy at single level. A single agent has the authority to catch decision while all other members are his subordinates.*	A) 
Federation	*A federation is a set of groups. Each one is represented by a delegate. This later plays the role of mediator between its group and the exterior.*	B) 
Contract Net Protocol, CNP	*In the CNP, one agent takes the manager role which desires to have one or more agents (the participants) to execute some activities. Each participant submits its bid. The manger selects the well offer and rejects the others bids.*	C) 

Table 2. Some Organizational structures and interaction protocols that can be discovered

– its simplicity since it defines the core concepts of the three workflow perspectives,

– and finally, it exploits the Agent technology concepts (organization abstractions, FIPA-ACL performatives and interaction protocols) which ease the organizational structures and interaction protocols mining.

Actually, the DiscoopFlow (Discovering Organizational Structures and Interaction Protocols in WorkFlow) prototype development is in progress.
We have implemented some algorithms for discovering organizational structures like simple hierarchical and federation structures. The figure 7 gives an idea about the overview of our prototype.
As future work, we plan to implement the discovering algorithms concerning

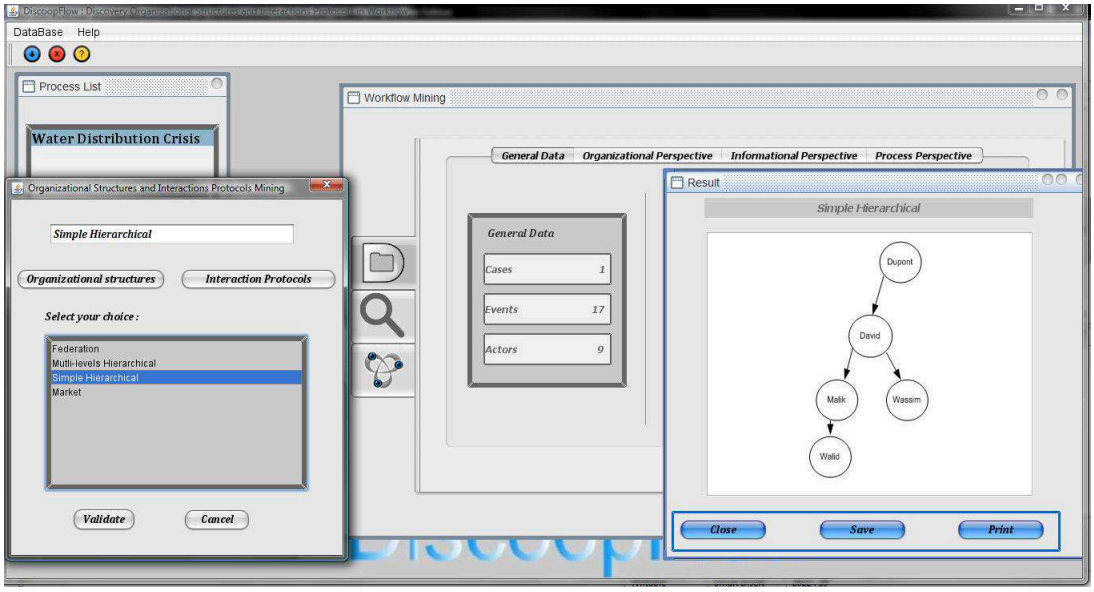


Fig. 7. Overview of DiscoopFlow prototype

interactions protocols and others organizational structures (market, multi-levels hierarchical, etc.).
We also aim to discover conjointly the three workflow perspectives in a coherent framework and extend our Workflow Meta model by adding the intentional perspective. We believe that this perspective justifies the choice of such execution scenario for a given crisis process.

Acknowledgment : The authors acknowledge all the participants involved in the DiscoopFlow project development. More precisely, they acknowledge Foued BEN MOALLEM, Achraf BOUDAWARA, Wassim CHTOUROU and Akram BEN AMOR.

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