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Abstract

This paper aims at presenting the foundation of an Anticipative Effects Driven Approach to validate a collaborative process taking into account interoperability constraints and rules. The objective of this approach is to allow managers in charge of this collaborative process to detect and characterize the possible effects due to a lack of organizational interoperability between partners involved into the collaborative process. This approach is based on several concepts, model and reasoning mechanisms presented and illustrated in this paper. It is applied here to a case of a crisis management process involving several partners. This research is issued from a previous approach coming from a French research project dealing with the interoperability of systems in crisis situation: ISYCRI (Interoperability of SYstems in situation of CRIsis, ANR-06-CSOSG).

1. Introduction

The interoperability between partners involved into a collaboration (military, computer, enterprises, software applications…) [1, 2, 3] is now considered as a key factor of success. Indeed, any collaboration is based on partners' interactions and communications in order to share data, services, knowledge, skills... and interoperability must be satisfied for gaining at least performance and efficiency, and finally reactivity and agility of each partner.

Interoperability can be studied at different levels and one of them is related to the processes [4] Interoperability of processes means to make various actors, activities, tasks and, in broad sense, processes work together. Furthermore, interoperability is distinguished by three categories of barriers such as conceptual, technological and organizational [5]. As far as the last barrier is concerned, the development of organizational interoperability of processes aims to propose and organize collaborative process involving different activities, resources and flows. Numerous partners from different organizations may have then to work altogether. Their actions have to be coordinated and synchronized in order to maximize the efficiency and the relevance of the whole collaborative process. Although the main desired effects of this process are reached, some others effects (unpredicted, undesirable…) may be induced and lead to a worsening of the situation. As a consequence, it is necessary to analyze from an anticipative manner the different effects that can be produced in order to help managers in charge of the collaborative process to adapt it prior to its execution. The here developed research work presents an approach illustrated in this paper to crisis management collaborative process [6]. .

After giving the objectives of the approach, the paper presents a brief introduction to the effects-based operations on which this research work is based. Then, the concepts of the approach are given and defined. Their use is outlined trough the demarche to implement the approach. A simplified example is then proposed in order to illustrate the approach.

2. Objectives of the anticipative effects-driven approach

Anticipative Effects-Driven Approach focuses on the collaborative process that is commonly set up to reach a set of given objectives (here, to reduce a crisis situation) and which involves different participants. The anticipative effects-driven approach must consider two different cases:

1. The collaborative process exists and seems complete. The goal is to validate it.
2. The collaborative process is incomplete *i.e.* it is no longer able to react to the crisis evolution. New actions must be proposed in order to face the crisis evolution.

As a consequence, the anticipative effects-driven approach has to provide:

- A set of concepts and rules allowing to model different configurations and characteristics of collaborative process, of the partners as well as the environment in which this collaborative process evolves.

- Reasoning mechanisms allowing to detect, on this model, the possible effects of each action that partners may execute. The goal is to characterize and detect the potential effects of actions that participate to a collaborative process taking into account the organizational interoperability of the partners.

The expected result of the proposed research work is to formalize a collaborative process model called here crisis model and a set of generic rules describing interoperability constraints and requirements that have to be successfully verified on the process model.

This paper focuses on the determination of design rules and the evaluation of the potential effects that can be produced by an existing collaborative process.

3. State of the art

The Anticipative effects-driven approach is based on the Effects-Based Operations approach developed specifically in the military field [7]. An effects-based operation approach consists in the execution of a set of action that has to produce effects in order to achieve a desired final outcome [8, 9, 10]. An effect-based operation is thus related to the concepts of actions, effects and outcomes as shown in figure 1.

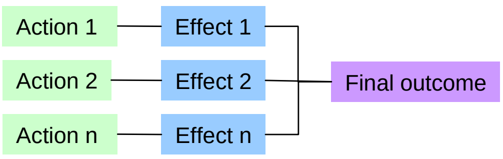

Figure 1. Simplified structure of an effects-based operations [11]

Actions transform any object from one state into another state. An action is supported by resources having some capability and aptitude and contributing to its execution. Effects result from actions and display the modification of an object state.

The literature classifies effects as direct (1st order) indirect (2nd/nth order), predicted or unpredicted, desirable or undesirable, decisive, enabling and so on. Finally, final outcomes represent the desired situation that has to be achieved *i.e* the situation in which the effects on the objects is concretized. The implementation of an effects-based operation is defined by a cycle composed of phases named knowledge, planning, execution and assessment as represented in figure 2.

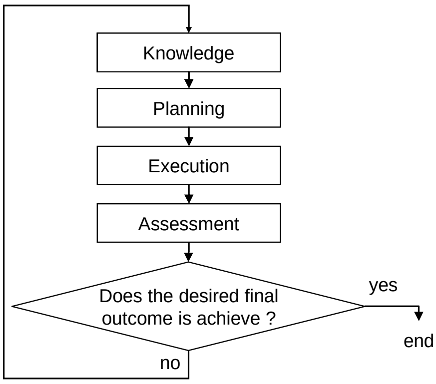

Figure 2. The Effects-Based Operations cycle (adapted from [12])

The *knowledge phase* allows to define clearly the situation including the desired final outcomes, required effects, means, possible actions and adjustments that can be carried out. Therefore, it allows if necessary, to adapt actions previously executed but that have not reach the final outcome. The *planning phase* consists to organize actions that can be performed. The *execution phase* performs the actions and induces effects that are evaluated during *assessment phase*.

Contrary to the EBO approach which concerns all the phases, the anticipative effect-driven approach concentrated on the knowledge phase and aims:

1- To capture and to gather a maximum of knowledge that can be used in order to characterize all the elements confronted to the crisis and to build a model of this crisis highlighting potential effects of the proposed collaborative process on these elements and;

2- To test a set of analysis rules that describe in which conditions and with which nature potential effects must appear. Indeed, the flawless cognition of the nature of an effect caused by an action (or a set of actions), a resource or any other element will allow to reason and to select alternatives actions which reduce these effects in order to response suitably to the crisis.

4. Anticipative effects driven approach: modeling

This section introduces the concepts and definitions related to a crisis characterization used in the AEBA.

4.1. Crisis characterization

A crisis situation is first characterized by:

- Operative zone (OZ) [13] defines the location in the space where crisis takes place (in a broad sense, for example, the place where a family of a victim lives is also included into the operative zone), as well as environmental conditions such as geographic and climatic.

- Operative duration (OD) [13] represents the time interval between the required start of the process and the end of the crisis.

Then, objects which are present in OZ during OD and may be concerned, affected or involved into the crisis are considered. These objects are those defined in the crisis metamodel such as [14]:

- The Population (**P**) is the set of physical people who are directly affected by the crisis.
- The Civil Society (**CS**) is composed of people and civil associations that can be confronted indirectly to the crisis, such as victims' families, media, etc.
- The Natural Environment (**NE**) is constituted by the environment, excluding human constructions. Thus, the natural environment can be seen as the set of elements such as woods, air lanes, navigable lanes, *etc.*
- The Goods (**G**) are habitations, roads, vehicles… and all other infrastructures that can be affected by the crisis.
- The Human Means (**HM**) gather on-site and off-site participants that are involved in the collaborative process. They provide their resources, services, *etc.*
- The Material Means (**MM**) is the set of available resources (energy, material, machines, etc.) for HM, CS and P.
- The Gravity Factor (**GF**) is any element that can impact the crisis, either in a positive way (improvement of the situation) or in a negative way (worsening of the situation). A gravity factor affects one or several characteristics of the objects of the OZ during OD for example in terms of performances (*e.g.* operative duration is longer than predicted).
- The Complexity Factor (**CF**) is any element that modifies the type of the crisis. Usually, a complexity factor requires redefining the collaborative process response because of the evolution of the crisis. Indeed, OZ and OD must be modified and the objects confronted to the crisis may change. Moreover, a gravity factor can become a complexity factor. For example, the rain can be considered as a positive gravity factor on a fire but can turn into a complexity factor if it causes a flood.
- The activity of the collaborative process.

From this point, each object has to be characterized in order to implement the proposed approach.

4.2. Object characterization

The object characterization is based on three concepts: TSS referential modalities and interactions. The TSS referential (time, shape and space) [15] allows defining and formalizing physical attributes which characterizes any element, from a quantitative or qualitative manner, evolving in the time (limited by OD), in the space (limited by OZ) or taking into account its shape. Any element may be "a part of" or "interacts" with another element. In this case, the evolution of each element affects and modifies the referential of the surrounding elements. Thus, defining which elements evolve in a given referential allows to know the impact of these elements on their environment. In order to refine the characterization of an element in terms of time shape and space, these ones are decomposed in sub attributes. For example, if a human mean is considered:

- The time attribute is defined by the sub-attributes of date and duration;
- The space attribute is defined by the sub-attribute of location in a defined space, and;
- The shape attribute is defined by the sub-attributes of influence (related to skills, authority…), dimension (volume, length…), vulnerability (improvement or degradation of the object), quantity, complexity (organic, structural…) and cost (related to or inferred by the element or its utilization);

The concept of modality [16] is related to the characterization of the possible link between all objects step in the collaborative process. The concept of modality is specifically related to the resources and the activities. As an example the modalities, in the frame of an activity, are characterized by:

- The modality 'to know' (TK) represents what is required by the activity in terms of knowledge and skills to achieve its mission;
- The modality 'to be able to' (TBA) represents the set of resources that are required by the activity. A resource is able to provide skills, capabilities, data, information, knowledge, matter, and energy that are needed to achieve a mission;
- The modality 'to want' (TW) represents the set of inputs such as data, information, knowledge, rules, events and order that are required by the activity to control its behavior and to achieve its mission;
- The modality 'to have' (TH) represents the set of inputs required by the activity to achieve finality.
- The modality 'to have to' (THT) represents the sets of outputs that must be achieved by the activity representing its mission. Figure 3 gives a representation of the concept of modalities for an activity.

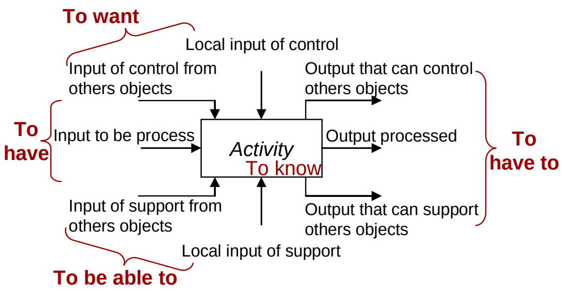

Figure 3. Representation of the modalities for an activity

Finally, the concept of **interaction** [17] [18] allows formalizing how, in which condition, and with which effects an element can dynamically interact with another. The interactions are typed as:

- The interaction "know-how" (KH) represents the flow of knowledge and skills;
- The interaction "want-do" (WD) represents the flow of input that triggers the object;
- The interaction "can-do" (CD) represents the flow of inputs that are considered as resources;
- The interaction "must-do" (MD) represents the flow of final outputs.

Thus, the objects are characterized according to a TSS referential, their modalities and their interactions with others object. This characterization is the base of the anticipative effect-driven approach and has to allow, thereafter, to characterize precisely the nature of an effect.

4.3. Effect characterization

As previously mentioned, an effect is defined as a situation that can be expected, undesired, dreaded and results from an interaction. Indeed, the hypothesis of this research is the following: any interaction between one object, defined as the source, and one or several objects, defined as the destination, induces one or several effects. Any effect is thus modeled by the possible variation (or dependence) of one or several TEF attributes of the destination under the action of the source. An effect can be:

- Predictable. Assessable and observable indicators exist either on the source object or the destination object(s).
- Potential. A logic relationship between the cause and the effect exist.
- Unpredictable or emergent. This kind of effect is not taken into consideration by the approach.

Furthermore, an effect can be defined as direct of indirect taking into account the causal relation between situations which have induced the effect.

The goal is now to characterize the nature of an effect by determining if it is [13]:

- Harmful. This effect is produced when the source can induce a deterioration of the characteristics of the destination. These kinds of effects have to be annihilated.
- Good. This effect is produced when the source can induce a variation of the characteristics of the destination as expected. These kinds of effects have to be maintained.
- Excessive. This effect is produced when the source can induce a variation of the characteristics of the destination beyond this expected. In this case the effect has to be reduced.
- Insufficient. This effect is produced when the source can induce a variation of the characteristics of the destination less than expected. The effect must be improved in order to become efficient.
- Absent. This effect is produced when the source should modify the characteristics of the destination but none variation is noticed. In this case the effect has to be created.

In order to characterize the nature of an effect rules are proposed and formalized.

4.4. Rules modeling

The modeling of an effect consists in the description of rules allowing to model the results of an interaction between an element - considered as source and present in the operative zone throughout the time duration - on another (set of) element(s) considered as destination. Each rule can be used to model an interoperability rule as it is shown hereafter.

Then, each rule is formalized into a set of formal properties as proposed by [19] specifying the way to interpret the variation of the TSS attributes of a destination object under the effect of a source element. The formal modeling phase provides a formal support of reasoning allowing us to analyze the model of the crisis and to prove the accuracy of the rules. Thus, if a set of properties which formalizes a given rule is verified then an effect can be characterized completely.
For example the rule defined as:

$$\text{Modality (Activity)} \supseteq \text{TSS (Input\_element)}$$
$$\Rightarrow \text{Effect (Input\_element, Activity)} := \text{good)}$$

means that if the modality of an activity contains the TSS attributes of an element to be process then the effect of the input element on the activity can be considered as good.

This rule can be decomposed in property specifying the way to interpret the variation attributes of the activity under the effect of the input element. Thus, the following property:

[Quantity (Shape (Input_element)) = Quantity (To_have (Activity))]

⇒ [Effect (Input_element, Activity) := good]

means that the effect of an input element on an activity is defined as good if the sub attribute quantity of the input element is equal to the sub-attribute quantity of the modality "to have" of the activity *i.e.* the quantity of inputs required by the activity to achieve finality.

Obviously a rule can be decomposed in several properties. In the simple here presented example, others property will be necessary to characterize precisely an effect of an input element on an activity as good. Currently, the research work focuses on the definition of rules and properties related to the interactions between objects. The goal is to find automatically and to type each effect and then to design the crisis model.

Finally, all the concepts of the anticipative effects-driven approach presented above and theirs links are represented by the meta model shown in the following figure and performed with Eclipse – UMLDiagram 2.1.

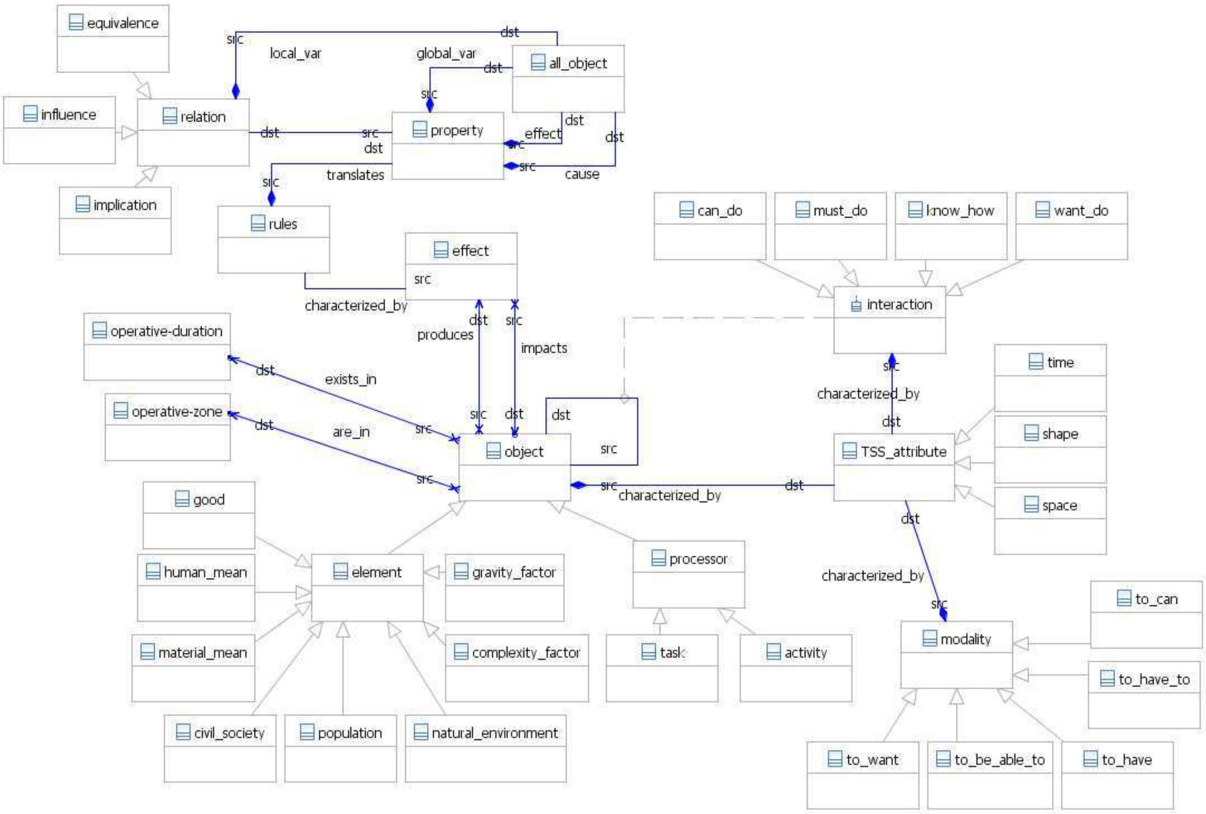

Figure 4. The anticipative effects-driven approach meta model

5. Anticipative effects-driven approach: reasoning

Reasoning about rules and properties allows to characterize accurately the nature of an effect. As an example, let us consider a rule which is decomposed into four properties. If all the properties verify that the effect is typed as good then the rule is effectively verified and the effect of the source on the destination is well typed as good. However, if two of them verify that the effect of the source on the destination is typed as good, one of them types the effect as harmful and the last types the effect as insufficient, the rule is not completely verified. In this case does the effect can be typed as good still, as harmful or finally as insufficient? Maybe the properties that type the effect as insufficient and harmful are not considered by managers as relevant in the process in which case effect still remains good. Maybe the property that types the effect as harmful is paramount and have the priority on all others properties.

These kinds of configurations can be observed throughout the verification of properties to characterize an effect and reasoning is thus developed to cope these statements.

Currently, some available tools allow to reasoning about rules and properties. In the frame of the anticipative effect-driven approach, *JESS reasoning* developed with *Protégé* allowing to reason especially on the relations of implication and *COGITANT* allowing to reason on the relations of equivalence and influence, are used.

6. Demarche of the anticipative effects-driven approach

The concepts to characterize the crisis elements and effects of the anticipative effects driven approach are implemented trough a demarche as shown in figure 5. More precisely, and with regard to effect-based operation, the anticipative effects-driven approach is included in the phase of knowledge. The objective is to bring to crisis managers the knowledge of the potential effects of the collaborative process.

Thus, crisis manager will have the possibility either to validate the process and to start its execution or improve it by selecting alternatives.

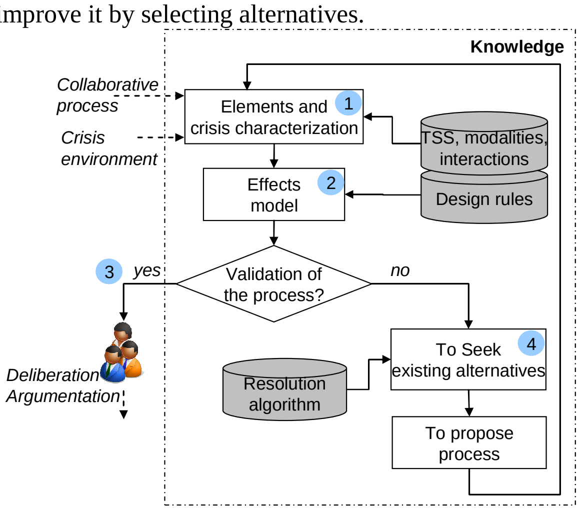

Figure 5. Anticipative effects-driven approach

As a consequence the first step of the approach consists in the characterization of the elements of the crisis (*e.g.* population, natural environment, activity...). This characterization is supported by the concepts of modalities, interactions and referential TSS (1).

Then the nature of the potential effects (harmful, good, insufficient, excessive and absent) induces by the collaborative process has to be determined. This step is performed thanks to the referential of effect characterization rules (2).

At the end of this step the collaborative process can be validated or rejected. If the process is approved (3), the managers valid its planning and/or performs some adjustments and starts its execution. The results of the process are evaluated (resolution, worsening, modification... of the crisis) and re-submitted to the approach in order to detect the effects. In the case of the process is rejected, the approach has to provide a set of alternatives in order to construct of a new collaborative process to response accurately to the crisis (4).

These existing alternatives have to be still evaluated to detect the effects and validated before their execution.

7. Application of the anticipative effects-driven approach

For practical reason and to show the interest of the here presented approach, the following application is intentionally reduced and takes only in consideration the determination of the potential effect between an activity and a resource of a collaborative process.

Let us consider an activity such as *to "evacuate all the population"* and a resource such as "*firemen"* that participate to the resolution of a crisis. The services performed by the firemen allow to execute an activity like evacuation. Thus the collaborative process submit to the approach reveals the allocation of the firemen to the activity of evacuation. In this case, the objective of the anticipative effects-driven approach is to help managers to validate this process by the knowledge of the potential effect that can be induce by the interaction of the firemen (object source) on the activity (object destination).

Using the concepts and the demarche previously defined, it is possible to apply the anticipating effects-driven approach.

Firstly, it is necessary to characterize each object, involved in the collaborative process, according to the concept of referential TSS, modalities and interactions. Thus the activity "to evacuate all the population is characterized with the following modalities and referential TSS.

The modality to have is defined by the shape attribute quantity. In this example the activity requires 100 people to evacuate. The modality to want is defined by the shape attribute influence guise of an order to start the execution of the activity. The modality to know is defined by the shape attribute skill such as to evacuate. The modality to have to is characterized by the shape attribute quantity such as the mission of the activity is to evacuate all the population. Finally, to be able to is characterized by the shape influence. In fact the activity requires a resource that has capabilities and knowledge to evacuate a population.

Then the resource "firemen" is also characterized with modalities and referential TSS.

The modality to know is characterized by the shape attribute aptitude. In this case the resource "firemen" possesses the aptitude to evacuate. The modality to have to is defined by the shape attribute quantity such as if the quantity of firemen is superior to 15 then the capability to evacuate is 100 persons, then the capability to evacuate is 15 persons. Currently, there are 20 firemen that are available. This availability is represented by the shape attribute quantity

The modalities and referential TSS of the object (activity and resource) are given in figure 6.

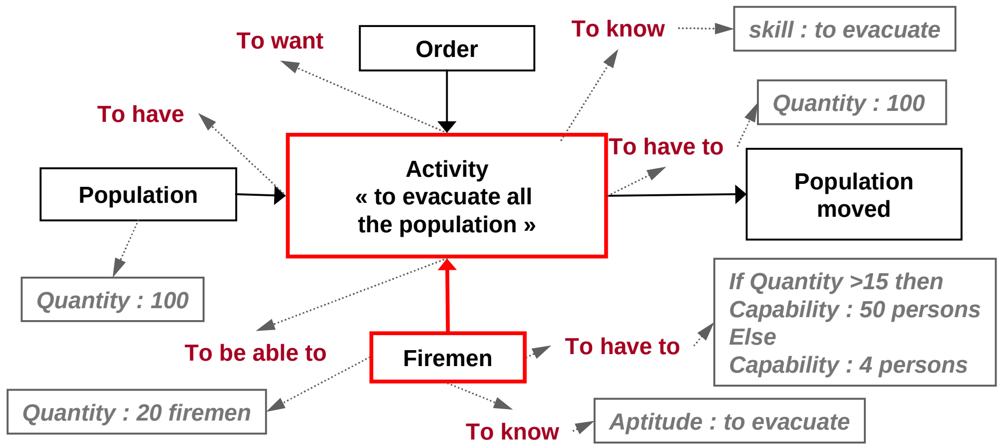

Figure 6. Characterization of the objects of the crisis using referential TSS and modalities

Then, the second step is related to the characterization of the nature of the potential effect. More precisely, the objective is to determine the nature of the effect between the resource and the activity. This characterization is performed with a referential of rules that are decomposed in properties. In this example, the characterization focuses to show if the effect can be defined as good. As a consequence, it is necessary to verify the rule:

Modality (Activity) $\supseteq$ Modality (Resource)

$\Rightarrow$ Effect (Resource, Activity) := good

This rule can be translated such as the effect of a resource on an activity is good if the modality of an activity contain the modality of resource. This rule has been decomposed in two properties. The first property is related to the modalities to know and is defined as:

[Aptitude (To_know (Resource)) = Skill (To_know (Activity))]

$\Rightarrow$ [Effect (Resource, Activity) := good]

The second property is related to the modalities to have to and is defined as:

[Capability (To_have_to (Resource)) = Quantity (To_have_to (Activity))]

$\Rightarrow$ [Effect (Resource, Activity) := good]

The characterization of the nature of the effect is concerned by the validation of these two properties and in a broad sense, the rule. This validation means that the effect of the resource firemen on the activity to evacuate all the population can be defined as good.

In this illustration the effect is well defined as good because (1) the aptitude of the resource corresponds to the skill required by the activity what verify the first property and, (2) the capability of the resource corresponds to the quantity required by the activity what verify the second property.

Furthermore, it is possible to note that the first effect on the activity (induces by the resource) has an influence on the population. In this case, it is talk about an indirect effect of the resource on the population. This indirect effect can be directly characterized as good. Indeed, the effect on the activity is good and this one will can be executed in good condition in order to evacuate all the population.

Thus, it is possible to draw the model of effects such as illustrated in the figure 7.

Figure 7. Graphical model of the effects

Starting from this characterization, the managers have to either to validate the collaborative process in order to start its execution either to modify the collaborative process in order to obtain the expected effects. In this example the effect of the resource on the activity is good also managers can directly validate the process. If, for example, the effect of the resource on activity was defined as insufficient (capability of modality to have to of firemen inferior to quantity of the modality to have to of the activity) the managers could decide to require others resources in order to counter the insufficient first effect and counter the insufficient indirect effect too.

8. Conclusion

This paper presents an approach to help crisis manager to increase their organizational interoperability at process level in crisis situation. The anticipative effect-driven approach has to allow an adaptation and a validation of collaborative process by anticipating potential effects of this one. This adaptation and this validation has to lead to an improvement of the interaction between objects involved in the crisis in order to performed a collaborative process perfectly adapted to cope to the crisis.

The concepts of the approach are clearly identified and a referential of rules is currently developed in order to characterize the nature of the effects. Future work is concerned by the development of analyses rules that have to propose alternatives to managers and the development of the resolution algorithm that has to allow the building of new collaborative process.

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