Agility of crisis response: gathering and analyzing data through an event-driven platform

Anne-Marie Barthe-Delanoë
University of Toulouse – Mines Albi
anne-marie.barthe@mines-albi.fr

Sébastien Truptil
University of Toulouse – Mines Albi
sebastien.truptil@mines-albi.fr

Frédérick Bénaben
University of Toulouse – Mines Albi
frederick.benaben@mines-albi.fr

ABSTRACT

The goal of this article is to introduce a platform (called Agility Service) that gathers and analyses data coming from both crisis response and crisis field by using the principles of Complex Event Processing. As a crisis situation is an unstable phenomenon (by nature or by effect of the applied response), the crisis response may be irrelevant after a while: lack of resources, arrival of a new stakeholder, unreached objectives, over-crisis, etc. Gathering data, analyze and aggregate it to deduce relevant information concerning the current crisis situation, and making this information available to the crisis cell to support decision making: these are the purposes of the described platform. A use case based on the Fukushima's nuclear accident is developed to illustrate the use of the developed prototype.

Keywords

Agility, Event-driven architecture, Collaborative process, Complex event processing, Decision support system.

INTRODUCTION

By nature and by effects of the collaborative processes (i.e. crisis response) to solve or reduce the crisis, crisis situations are unstable and evolutionary phenomena. According to (Pingaud, 2009), the kinds of evolution of a collaborative situation can be classified as follows: (i) evolution of context (the collaboration's environment that differs from the one taken into account to define the collaborative processes) ; (ii) evolution of network (this kind of evolutions concerns the stakeholders, their abilities and or their resources) ; (iii) failure (one or several activities do not lead to the expected results, due to an incomplete initial definition of the collaborative processes or an improper execution of them). One of the most striking examples of a failure in the last years is the drop of water on the reactors and the spent fuel pools of the Fukushima Daiichi power plant. It is therefore necessary to take into account the possible changes that can influence the crisis response, i.e. the collaborative processes, in order to change this response if needed, and to support the decision making process of the stakeholders. In this paper, notion of collaborative process agility is presented. Then, an Agility Service is proposed to achieve the agility of collaborative processes at Information System level. Its use is illustrated by a use case extracted from the Fukushima disaster.

AGILITY

In the last decades, the notion of agility was widely discussed. It is defined by (Badot, 1998) as the reconfiguration of the system to satisfy a need for adaptation. For (Kidd, 1994; Lindberg, 1990; Sharifi and Zhang, 1999), it is a need for flexibility, responsiveness or adaptability. In logistics, flexibility is seen by (Sheffi, 2004) as "the ability to meet short-term changes" . Flexibility is differentiated from adaptation over time in response to a change (McCullen and Christopher, 2006). Considering these notions, the adopted approach of agility in our research works is the following: *agility is the ability of a subject to lead as quickly as possible, on the one hand, to the detection of its mismatch to a given context, on the other hand, to the setting up of the* *required adaptation* (Barthe-Delanoë, Truptil, Bénaben and Pingaud, 2013). It means that to solve the collaborative workflows' agility issue, we need to detect the moment when a workflow is not relevant anymore regarding to the collaborative goals and the current context of the collaborative situation (detection), and what needs to be done to deal with this issue (adaptation), as fast as possible (responsiveness).

STATE OF THE ART

Since few years, some commercial products and research projects attempt to provide agility to collaborative processes. On the one hand, BonitaSoft (a suite of tools to design, execute and monitor processes) and the Architecture of Integrated Information Systems (ARIS) tools are the major commercial products. ARIS' approach manages workflow adaptation only in a determinist manner (Scheer, 2006). On the other hand, several research projects like the WORKPAD project (Catarci, de Leoni, Marella, Mecella, Russo, Steinmann and Bortenschlager, 2011) and the CRISIS project (Kovordanyi, Pelfrene, Rankin, Schreiner, Jenvald, Morin and Eriksonn, 2012; Rooney, 2011) focus more on recovering the disconnecting nodes through specific tasks (WORKPAD project) or supporting collaboration into crisis situation and on exploring decision-making under conditions of uncertainty (CRISIS project). The European project PLAY proposes an adaptation recommender service (Verginadis, Patiniotakis, Papageorgiou and Stuehmer, 2012): it allows to adapt the ongoing processes on pre-determined milestones, through the addition of relevant pieces of processes (extracted from a knowledge database). None of them allows dynamically and automatically detecting a mismatch in a continuous way and adapting the collaborative processes according the mismatch.

AGILITY SERVICE

We have implemented a prototype of the Agility Service to assess the feasibility of the approach described in (Barthe-Delanoë, Bénaben, Carbonnel and Pingaud, 2012). It is a tool designed to adapt the dynamic of the situation, *i.e.* collaborative processes, to the evolution of the context. This approach proposes a platform based on a combination of Service Oriented Architecture (SOA) and Event-Driven Architecture (EDA): it allows gathering data coming from heterogeneous and various data sources through events. The main hypothesis is that the sensors expose a Web Service layer which follows the WS-Notification standard (OASIS, 2006). A Complex Event Processing (CEP) engine is used to filter and apply business rules to deduce meaningful events from simpler events in order to help the stakeholders to retrieve useful information. The business rules are defined by the collaborative partners, on the base of their knowledge and return on experience. The CEP engine generates new events on the base of the analysis of these incoming events. Esper (developed by EsperTech (EsperTech, 2013)) is the CEP engine used in our prototype.

Detection

The Agility Service uses events to track the changes inside the collaborative situation model by:

- Creating an initial model of the collaborative situation[1] (*i.e*. model at time 0), which is duplicated,
- Then, both models are automatically updated with the received events (the Agility Service subscribes to all events emitted by Esper). Two models are obtained through this update:
  - The *expected situation model*: the planned and expected situation model at time t (*i.e.* what we expect to obtain when the crisis response is executed). It is obtained by updating the initial model with monitoring events,
  - The *field situation model*: the real situation model of the collaboration at time t, whatever the applied crisis response is (*i.e.* the "what actually happened" situation at time t). It is obtained by updating the initial model with events coming from the crisis field.
- At any time t, a measure of the difference ∂ is made between the expected model and the field model. If ∂ is over a threshold (defined by the stakeholders), the adaptation step is triggered.

The measure of ∂ is automatically made on the whole set of points of our models in order to determine the nature, size and origin of the difference. These points are the instances of the concepts described in the situation model. We have explored several ways to calculate the divergence. As our models are XML based, the retained approach is the use of algorithms for XML tree comparison (like those presented in (Demaine, Mozes, Rossman and Weimann, 2007; Pawlik and Augsten, 2011)). But these algorithms do not really meet our requirements that are: (i) looking for similarity (the order of nodes which are siblings does not matter in our comparison) and (ii) a

[1] A situation model is an instant capture of the running collaborative processes (crisis response), the crisis cell itself (all the actors and their services) and the crisis field in which the processes are running (risks and/or consequences linked to goods, people, natural sites, etc.).

full report of the detected differences. Finally, we have adapted a tool used to check the quality of XML transformations called XMLUnit (Bacon and Martin, 2013) as it fits almost all our needs. The comparison step is independent from the considered situation (nuclear crisis, road crisis, etc.). The measure of the whole difference ∂ is given by the following formula:

$$\partial = \sum_{i=0}^{n} \partial_i \quad with\ \partial_i = w_i * m_i$$

- w_i is the weight of the detected difference ∂_i. It is used to qualify each detected difference, as each difference has not the same impact on the relevancy of the processes. For example, the addition of an order (the deletion of a partner) has more negative impact on the processes than the deletion of an order (the addition of a new partner). w_i is defined according the type of element concerned by the identified difference (e.g. partner, risk, resource, activity, etc.) and the kind of difference, called operation here (added, deleted, updated). w_i is a positive integer.
- m_i is the importance of the detected difference ∂_i. It is used to compare the current instance to other instances of a same concept. For example**,** injured people qualified as absolute emergency have a higher importance than people lightly injured. Or a risk of hay fever is less important than a risk of contamination by Ebola virus. m_i is a real number, valued between 0 and 1 (by default, $m_i = 1$).

For the moment, the values of w_i and m_i are defined by the partners of the collaboration among the execution of the Agility Service.

Adaptation

To decide what kind of adaptation should be proposed to the user, the adaptation part is based on the study of the difference details gathered by the ∂ calculus in the detection step. A set of business rules was defined to describe how the adaptation step can advice users on the level of adaptation to choose (partial or total redefinition of processes, re-execution of an activity), based on the details of the calculated ∂. These rules are strongly linked to the application domain: the adaptation rules used for nuclear crisis situation are not the same as the one used for road crisis for instance. Then, when all these rules are run, the Agility Service is able to indicate the best solution(s) for adaptation to the users, considering the nature of the detected difference. It is very important to note that the final choice is let to the users. The Agility Service is a support in the decision making process: it never takes the final decision of the adaptation to run.

FUKUCHIMA DAIICHI USE CASE

To illustrate the use of the platform and its Agility Service, a use case based on the Fukushima Daiichi nuclear plant accident was defined. Web Services were developed to simulate the sensors located in several places (MP-1, MP-8, Main Entrance, etc.) of the nuclear plant. The data emitted by these Web Services are based on the real data retrieved on TEPCO website (TEPCO, 2011). The use-case takes place in the first hours of March 12th, 2011, less than 24 hours after the tsunami and the nuclear crisis breakdown. One of the defined business rules concerns the creation of an alert if the radiation level increases too fast and/or beyond a threshold (Figure 1):

```
String combinedEventStreams7 =
        "insert into alerts " +
        "select 'Global contamination increasing. Advice: extend evacuation area to 20km' as alertDescription, " +
        "'high' as alertGravity, 'Daiichi plant' as alertLocalisation, 'Contamination_20_km' as alertSEID, " +
        "'Contamination population' as alertName, 'risk' as alertType, 'people_habitants' as alertImpactedSEID from " +
        "measureEvent(measureUnit='m/s' and measureLocation='MainEntrance').win:time(120 seconds) as wind," +
        "measureEvent(measureUnit='microSv/h' and measureLocation='MainEntrance').win:time(60 seconds) as airMain, "+
        "measureEvent(measureUnit='microSv/h' and measureLocation='MP-8').win:time(60 seconds) as airMP8 "+
        "having avg(airMP8.measureValue)>4 and avg(airMain.measureValue)>4 and avg(wind.measureValue)>1.9";
```

Figure 1. Example of a business rule implemented into Esper CEP engine (screenshot)

This business rule is triggered if the radiation level measured in several places on the nuclear plant is over 4 µSv in the last two minutes, combined with light windy conditions. In this case, an alert is emitted to the Agility Service, in order to update the *field model* thanks matching rules (in our example, a new risk is added to the model and impacts the population living in the 20-km radius area from the plant).

Through the Complex Event Processing (CEP) engine, the decision-makers subscribe only to useful information for them (like radiation and weather sensors). The CEP allows the execution of predefined business-rules producing the alerts as new events. For example, around 7:00 am, incoming events triggers the previously detailed business rule. As a consequence, an alert "contamination of people 20-km radius area" is generated. The Agility Service uses it to update the field model of the crisis situation by adding a new risk. The alert is maintained around 10:00 am by new events coming from the field of the crisis situation. The generated events received by the decision-makers constitute a real added value for them and support a complementary human analysis and interpretation of the situation.

The automatic continuous comparison of both situation and field models (Figure 2) underlines that this risk exists only into the field model and impacts the population living nearby the nuclear plant. The detected difference ∂ is equal to 7 and is over the threshold ($\partial_{threshold}$=1): an adaptation of the collaborative response (redefining the collaborative processes in our case) is triggered. As a result of this risk generated by the Agility Service and the advice of adapting the response by redefinition of the response, the stakeholders decide to evacuate people living within a 20-km radius from the nuclear plant at the end of the morning.

Figure 2. Screenshot of the detection step's result of the Agility Service (thin client)

Though this example seems to be trivial (gather and aggregate data through a simple business rule to add one risk in the crisis model), it is necessary to underline that during the real Fukushima disaster, the NISA (Nuclear and Industrial Safety Agency) got data about the radioactive releases beyond the 10-km radius area from the nuclear plant. But neither did they analyze the gathered data (about wind speed, wind direction and levels of radiation) nor send them to the Japanese Government. So this one was not able to detect early the risk of contamination for people evacuated into the shelters in the 3 to 10-km radius from the plant. Decision to evacuate people in a 20-km radius from the nuclear plant was taken only *at the end* of March 12th, 2011 due to the lack of alert in almost real-time (Science Council of Japan, 2011). Such an Agility Service (embedded on an EDA-SOA platform) enables to *automatically gather*, *deduce* and *emit* alerts on the base of deduced information about the crisis situation and also can help stakeholders to get an accurate view of the crisis situation and support them to take decisions.

CONCLUSION

Crisis situations are changing situations, where the characterization of the crisis itself or the crisis cell are subject to evolutions. It is crucial to detect relevant changes that could challenge the relevancy of the crisis response and to adapt it if needed. For this purpose, an Agility Service was developed. Through an EDA-SOA architecture, this service is able to gather data coming from both the crisis field and the monitoring of the response (i.e. collaborative processes). The embedded CEP engine allows to filter and to analyze these data to deduce automatically additional information about the current crisis situation. Using the deduced information, the *detection* step identifies the mismatches. If the calculated difference is over a determined threshold, the *adaptation* step is run and offers a range of adaptation solutions to the stakeholders to support the decision-making process. Regarding that overall proposal, two reproaches might be done: (i) what about the definition of the threshold, the weights w_i and importances m_i? And (ii) how to deal with the domain dependency of the adaptation rules? To tackle the first point, a more formal way to define the threshold and the weight/importance values could use a multi-criteria analysis. Concerning the second point, as the rules are strongly linked to the application domain (e.g. nuclear crisis, road crisis, pharmacy delivery crisis), a knowledge-based system (e.g. ontologies) could be introduced to automate —at least partially— the definition of these rules.

Considering the growing offer of information channels (people, devices, softwares, sensors, social networks), the use of the CEP provides a mean to identify and deduce relevant information among amounts of heterogeneous and numerous data, through filtering and producing added-value information for decision-makers. Deduced events can be used to have a better view of the actual crisis situation and of the effects of the crisis response.

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