Reducing information load to enhance collaborative awareness thanks to a pre-selection of information

Audrey Fertier, Aurelie Montarnal, Anne-Marie Barthe-Delanoë, Sébastien Truptil, Frederick Benaben

Reducing information load to enhance collaborative awareness thanks to a pre-selection of information

Audrey Fertier[1], Aurélie Montarnal[1], Anne-Marie Barthe-Delanoë[2], Sébastien Truptil[1], Frédérick Bénaben[1]

[1] Centre Génie Industriel - Université de Toulouse - IMT Mines Albi - France
[2] Laboratoire de Génie Chimique - Université de Toulouse - CNRS - INPT - UPS - France

Abstract. There is a need for collaboration support systems, suited to crisis management, able to sustain collaborations in ever more unstable environments. The organizations involved in a crisis response need support in limiting information overload by accessing information suited to their current needs. The collaboration support system proposed in this paper uses a Common Operational Picture (COP), supported by a Geographical Information System (GIS), that consists of information selected according to (i) the on-going collaboration phase, and (ii) the level of commitment within the collaboration of the current user. Additionally, to validate the proposed classifications, the paper demonstrates how the pre-selection can be applied to support crisis collaborations, operating under high stress and high information load.

Keywords. Collaboration, Crisis management, Common operational picture, Information overload, Model driven engineering

Introduction

When gathered inside one room, the partners of a collaboration can directly access large amounts of information [10], enabling them to enhance their collaborative awareness. They can identify common goals, critical partners, or share accurate information.

Because the collaborations tend to extend their geographical reach, they cannot gather as easily as before. To help them, [19] recommends the use of a common *artifact* to support cooperative activities that can be both individually conducted and interdependent. The main goal of the *artifact* is to reduce the complexity of collaborations, including the complexity of their information system due to:

- The amount of information in our daily lives is continually increasing and is multiplied by existing information systems [11], while our brains can only process a limited amount of complex information;

– Each partner must be able to access a part of the collaborative awareness adapted to their business and their level of responsibility;
– Information shared within a collaboration comes from heterogeneous sources, and each has an expiration date before which it must be used to not be lost.

These three issues are particularly true during a crisis situation where the collaboration aims to respond to every risk and consequences due to the disaster [20, 15, 12]: the crisis cells have to face high information load and high time pressure, within complex communication channels, while the collaboration can easily breakdown due to heterogeneous experiences, heterogeneous information accesses and heterogeneous comprehensions.

To support the partners in managing the infomration available within the collaboration, we proposed a *collaboration support system* able to select information according to (i) the on-going collaboration stage and (ii) the level of commitment of the current user, in order to give each user access to a suited Common Operational Picture (COP), supported by a Geographical Information System (GIS).

A COP is, as defined by [16], an operational picture shared by several partners during a particular operation. Its goal is to enables a shared Situation Awareness (SA) within the collaboration. In this case, the term SA can be defined as a model of the environment surrounding the collaboration [9]. This COP can be displayed through the use of a GIS. According to [16], such an information system is a powerful tool to support SA, in particularly during crisis situation where almost all relevant information are spatial.

Our goal is to strengthen collaborative awareness in order to enhance the agility of the collaboration (defined in [2]) in the face of new threats or opportunities. The collaboration support system described in this paper includes:

– A meta-model, as defined by [7], to enable a unified approach of interoperability, and its models modelling the collaborative situation.
– A GIS that takes the shape of a COP to communicate information from the system to the user;
– An automatic classification by collaboration stages to filter information according to the current phase of the collaboration;
– An automatic classification by partner roles to filter the information according to the place of the user in the collaboration.

Section 1 presents the two classifications introduced in this paper: the *collaboration classification* and the *partners classification* that are used for the pre-selection stage, to obtain a COP suited to the current stage of the collaboration and to the current user of the system. Section 2 proposes to validate these two classifications by using them in case of a very specific type of collaboration: a crisis collaboration.

1 The use of a COP to enhance collaborative awareness

The Figure 1 illustrates how the collaboration support system, proposed in this paper, operates to adapt its COP to is current user and to the current stage of the collaboration.

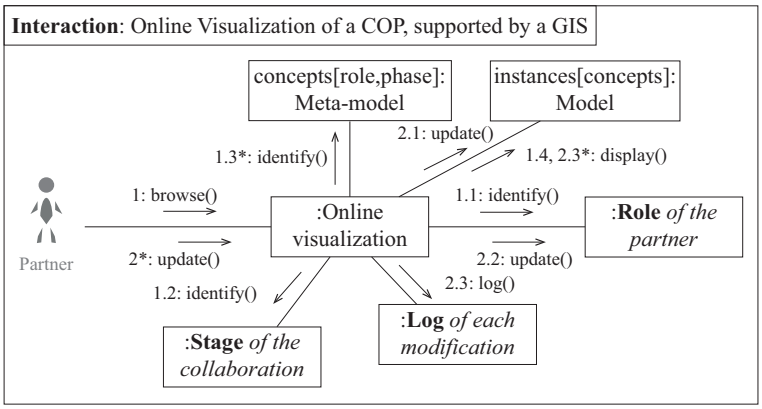

Fig. 1: A communication diagram, in Unified Modelling Language (UML) that illustrates how each partner of a collaboration can use the COP interface of the collaboration support system to enhance their collaborative awareness

The design of the system involves the definition of a meta-model, several partners' roles and several collaboration's stages, that have to be common to every collaboration types:

- The *meta-model* (defined in [7]) is used to homogenize and organize available information in models. Such a meta-model, dedicated to collaborations, is described in [3];
- The *role* is used to select information, according to the need of the partner, using the collaboration support system. For example, if a partner manufactures a product for the collaboration benefit, then he needs market forecasts, sub-contractors contact details or warehouses locations. Conversely, he doesn't need customer directories or marketing information.
- The *stage* is used to select information over time. For example, at the beginning of a new collaboration, the partners need to share their expectations. Conversely, when the collaborative process is running, the partners need to access a list of tasks.
- The *logs* are stored to enable future improvements of the collaboration support system.

1.1 The partners classification to ensure confidentiality

The work of [21], followed by [5], enabled us to identify three partner roles, inspired from the maturity levels of collaborations and described in Table 1. By default, the system does not share information of higher responsibility levels, with lower responsibility levels:

$$\begin{aligned} &\text{A partner } P_1\text{, with a role } R_1 \\ &\text{can reach information shared by a partner } P_2\text{, with a role } R_2 \\ &\text{If only } R_1 \geq R_2 \end{aligned} \tag{1}$$

Furthermore, during an "update()" operation (cf. Figure 1), a partner can set the *default responsibility level* of information that he adds to the system. A federated partner can, for example, decide to make its newly added information visible to one, several, or all, open partners.

Table 1: The partners classification by partner roles, defined in this paper

Role of a partner	Definition of the paper
Communicating partner	A partner that exchanges and shares information with the collaboration
Open partner	A communicating partner that shares business services and system functionalities with the collaboration
Federated partner	An open partner that takes part in the collaborative process, and shares the collaboration's goals

1.2 The collaboration classification to filter the displayed information

Two previous research works [3, 22], have enabled us to identify five main collaboration stages, that are described below in Table 2. Each collaboration stage comes with its own information needs. The table 3 shows how the concepts of one collaboration meta-model (from [3]) can be classified. For example, the partners of a collaboration need to learn about each other at the beginning of the collaboration during the *perception stage*. Conversely, the goals of the collaboration are set during the *convergence stage*, when everyone SA is good enough to support this decision.

The classifications are used to identify the "default information" to be first displayed on the COP, for one given user:

$$\begin{aligned} &\text{If a partner need additional information,} \\ &\text{the system does not refer to the collaboration classification,} \\ &\text{but only to the partners classification that manage responsibility levels} \end{aligned} \tag{2}$$

Table 2: The collaboration classification by stages, defined in this paper

Stage of a collaboration	Definition of the paper
Perception (Pr)	When each partner gathers information to improve their situation awareness of the collaboration
Comprehension (Cp)	When each partner learns how to adapt its information or its outputs to the other partners
Understanding (Ud)	When new information is inferred from the information shared between several partners
Convergence (Cv)	When common goals are identified, solutions are proposed, a solution is chosen and a collaborative process is designed
Monitoring (Mg)	When the partners adapt their solution, while the collaborative process runs

Table 3: The concepts of the meta-model [3], labelled with the five collaboration stages, according to their level of usefulness

Concepts from [3]	Definition of this paper	Pr	Cp	Ud	Cv	Mg
Partner	A partner of the collaboration	•	-	-	-	-
Environment Component	Anything composing the environment of the collaboration, that can be mapped in the COP	•	-	-	-	-
Characteristic	Feature due to the nature, the composition or the environment of the collaboration that could generate opportunities or threats	•	-	-	-	-
Capacity	One partner's capability, that can be used in the collaborative process	•	•	•	•	•
Objective	A goal of, at least, one of the partner	-	-	•	•	•
Performance indicator	An indicator that measures the performance of one capability, given a goal	-	-	-	•	•
Process	A process that invokes the capabilities of some partner and order them according to flows of information, conditions and events	-	-	-	-	•
Fact	An event witnessed by, at least, one of the partner	-	-	-	-	•

The pair <*collaboration stage, user role*> enables the generation of a view of the model, suited to the current collaborative situation, in order to feed the COP displayed by the GIS. The Figure 2 shows how the information are selected according to the need of the user. This follows the recommendations of Mica Endsley [**?**] about *goal-directed task analyses*.

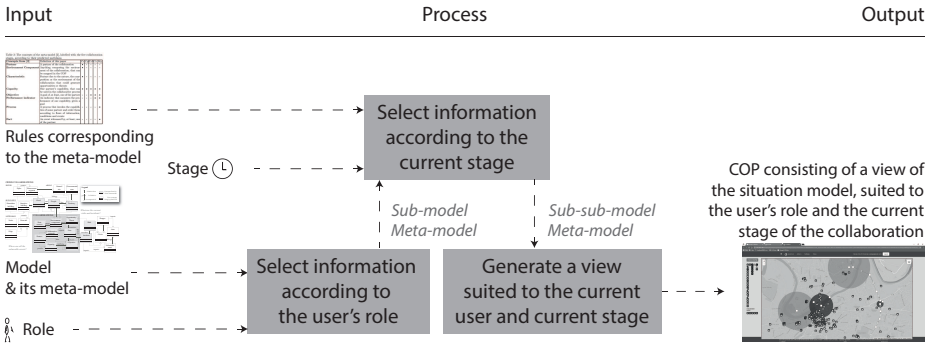

Fig. 2: The process enabling the collaboration support system to generate views suited to both the responsibility level of its user and the current collaboration stage

2 The case of crisis collaboration

In the aftermath of a disaster, a crisis response requires the collaboration of numerous, heterogeneous partners, under high stress and high time pressure [18]. This paper unfolds the scenario of a 100-year flood provided by the ANR GéNéPi project [3]. This project had enabled the interview of many practitioners often involved in crisis collaborations. The results, recorded in specifications [17], underlines the issues still faced by practitioners during crisis responses:

- Much of the information available is unclear, outdated or unreliable, and only the partners with high expertise can get by;
- The diagnosis of the impacted territory and the analysis of the vulnerable assets at stake remains difficult;
- Due to the number of partners involved, it's hard to take into account all possibilities of response process, and even harder to find the optimal response process.

The collaboration support system proposed in this paper can support them in dealing with :

- The issues due to the instability of the crisis, thanks to the COP that display the information contains in a model that can be continuously updated, as in [1];
- The issues faced during the understanding phase, thanks to the capacity of the COP to enhance collaborative awareness, as underlined by [4, 6];
- The issues due to information overload thanks to the collaboration and partners classifications, as described in Section 1.

In order to enable the collaboration support system to generate views of crisis situations, the classifications of collaboration stages and partners' roles dedicated to crisis collaboration still need to be defined.

[3] Project ANR-14-CE28-0029, web site

2.1 The partners classification adapted to crisis collaboration support

In France, in case of a 100-year flood, the organization involves four different responsibility levels [8]:

- Local level;
- County level;
- Zonal level;
- National level.

The hierarchies in place, corresponding to the crisis partners' roles, impose a dedicated information management. For example, a prefect (county level), aiming to communicate to the press, needs to know about the number of people without electricity supply in the county. Conversely, the power supplier (local level), aiming to ensure the continuity of their network, needs to know the exact locations of cut points on their network.

2.2 The collaboration classification adapted to crisis collaboration support

Like the collaboration stages proposed in this paper, several crisis collaboration phases has been defined over time. Among the first to distinct four phases were Uriel Rosenthal and Alexender Kouzmin [18]: "Crises [...] may be considered in terms of circular processes involving *mitigation* and *preparation*, *response* as well as *recovery and rehabilitation*". Inside the *response phase*, a french official document [14] recognizes five more phases:

- The *confirmation* of the alert (Ca): "Is there a disaster? What is its scale?";
- The alert (Al): "What are the concerned organisations that will take part in the collaboration?";
- The characterisation of the crisis (Cc): "Where are the assets vulnerable to the consequences of this crisis?";
- The evaluation phase (Ev): "Where are the damaged assets? Where are the threatened assets?";
- The *follow-up phase* (Fl) that consists of "thoughtful actions" to anticipate long-term consequences.

All the concepts from a meta-model dedicated to collaborative crisis management, as the one described in [3], can be linked to these crisis response phases. The obtained table (an extract is given in Table 4), along with the metamodel from [3], is used by the collaboration support system instead of the Table 2 suited to all kind of collaboration.

Rationally, the links ($\bullet$) from the links of Table 3, can easily be applied to the crisis concepts of Table 4 because they all inherit from one concept of Table 3. For example, information concerning a new event, useful during the *evaluation phase* of a crisis, are also useful during the *monitoring phase* of the collaboration,

Table 4: Some crisis concepts from [13], labelled with the five crisis response phases from [14], according to their usefulness

Crisis concepts from [13]	Parent concept from [3]	Ca	Al	Cc	Ev	Fl
Danger	Characteristic	•	-	-	-	•
Actor	Partner	-	•	-	-	-
Good	Environment component	-	-	•	•	-
Event	Fact	-	-	-	•	-
Response	Process	-	-	-	-	•

because an event is considered as a fact.

Thanks to theses new crisis collaboration response phases, and new crisis partners' roles, a collaborative support system, as the one presented in Figure 2, can select the information to be displayed to its user according to their relevance, and therefore decrease information load of the partners involved in a crisis situation.

Conclusion

This paper offers to use a collaboration support system to display relevant information, via a Common Operational Picture (COP) based on a Geographical Information System (GIS) and describing the collaborative situation.

To further limit information overload and to take into account the different responsibility levels involved, the paper proposes two classifications, dedicated to collaborations:

- The *collaboration classification* to adapt the COP to the current collaboration stage: either the perception, the comprehension, the understanding, the convergence or the monitoring stage.
- The *partners classification* to adapt the view to the goal of the current user. It consists of three categories: communicating, open or federated partners.

To extend the proposed classifications, we have checked that these solutions, dedicated to collaborations, apply to crisis collaborations: collaboration in highly unstable environment, under high-stress and time pressure.

Acknowledgements & Funding sources

This work would have not been possible without the GéNéPi project research team, or the computer engineers team from the industrial engineering center of IMT Mines Albi. This work was supported by the french National Research Agency, through the GéNéPi project funding (program: Resilience and crisis management [DS0903] 2014; project ID: ANR-14-CE28-0029)

Bibliography

[1] Barthe-Delanoë, A.M., Bénaben, F., Carbonnel, S., Pingaud, H.: Event-driven agility of crisis management collaborative processes. In: Proceedings of the 9th International ISCRAM Conference, Vancouver BC, Canada. http://www. iscram-live. org/ISCRAM2012/proceedings/124. pdf (2012)

[2] Barthe-Delanoë, A.M., Truptil, S., Bénaben, F., Pingaud, H.: Event-driven agility of interoperability during the Run-time of collaborative processes. Decision Support Systems 59, 171–179 (Mar 2014), http://www.sciencedirect.com/science/article/pii/S0167923613002868

[3] Benaben, F., Montarnal, A., Truptil, S., Lauras, M., Fertier, A., Salatge, N., Rebiere, S.: A conceptual framework and a suite of tools to support crisis management. Hawaii (2017), https://scholarspace.manoa.hawaii.edu/bitstream/10125/41178/1/paper0029.pdf

[4] Björkbom, M., Timonen, J., Yiğitler, H., Kaltiokallio, O., García, J.M.V., Myrsky, M., Saarinen, J., Korkalainen, M., Çuhac, C., Jäntti, R., Virrankoski, R., Vankka, J., Koivo, H.N.: Localization Services for Online Common Operational Picture and Situation Awareness. IEEE Access 1, 742–757 (2013)

[5] Bénaben, F.: Conception de Système d'Information de Médiation pour la prise en charge de l'Interopérabilité dans les Collaborations d'Organisations. thesis, Institut National Polytechnique de Toulouse (Oct 2012), https://hal-mines-albi.archives-ouvertes.fr/tel-01206234/document

[6] Bunker, D., Levine, L., Woody, C.: Repertoires of collaboration for common operating pictures of disasters and extreme events. Information Systems Frontiers 17(1), 51–65 (2015)

[7] Bézivin, J.: On the unification power of models. Software & Systems Modeling 4(2), 171–188 (May 2005), https://link.springer.com/article/10.1007/s10270-005-0079-0

[8] DSC: Organisation de la réponse de sécurité civile. Tech. rep. (2004)

[9] Endsley, M.R.: Design and evaluation for situation awareness enhancement. In: Proceedings of the Human Factors Society annual meeting. vol. 32, pp. 97–101. SAGE Publications Sage CA: Los Angeles, CA (1988), http://journals.sagepub.com/doi/abs/10.1177/154193128803200221

[10] Jongsawat, N., Premchaiswadi, W.: A Study Towards Improving Web-Based Collaboration Through Availability of Group Awareness Information. Group Decision and Negotiation 23(4), 819–845 (Jul 2014), https://link.springer.com/article/10.1007/s10726-013-9349-3

[11] Karlsson, M.: Challenges of Designing Augmented Reality for Military use (2015)

[12] Klein, G., Feltovitch, P., Bradshaw, J., Woods, D.: Common Ground and Coordination in Joint Activity. In: Organizational simulation, vol. 44, pp. 139–185. John Wiley & Sons (2005), http://www.jeffreymbradshaw.org/publications/Common_Ground_Single.pdf

[13] Lauras, M., Truptil, S., Bénaben, F.: Towards a better management of complex emergencies through crisis management meta-modelling. Disasters 39(4), 687–714 (2015)

[14] Le Cedre: ORSEC Zonal et départemental, disposition spécifique POLMAR/Terre (2015)

[15] Lee, J., Bharosa, N., Yang, J., Janssen, M., Rao, H.R.: Group value and intention to use — A study of multi-agency disaster management information systems for public safety. Decision Support Systems 50(2), 404–414 (Jan 2011), http://www.sciencedirect.com/science/article/pii/S0167923610001776

[16] Luokkala, P., Nikander, J., Korpi, J., Virrantaus, K., Torkki, P.: Developing a concept of a context-aware common operational picture. Safety Science 93, 277–295 (Mar 2017), http://www.sciencedirect.com/science/article/pii/S0925753516304647

[17] Renou, T., Dolidon, H.: Cahier des charges à l'origine du projet GéNéPi. Tech. rep., CEREMA & IDETCOM, Loire Moyenne (2015)

[18] Rosenthal, U., Kouzmin, A.: Crises and crisis management: Toward comprehensive government decision making. Journal of Public Administration Research and Theory 7(2), 277–304 (1997), https://academic.oup.com/jpart/article-abstract/7/2/277/957517

[19] Schmidt, K., Simonee, C.: Coordination mechanisms: Towards a conceptual foundation of CSCW systems design. Computer Supported Cooperative Work (CSCW) 5(2-3), 155–200 (1996)

[20] Shen, M., Carswell, M., Santhanam, R., Bailey, K.: Emergency management information systems: Could decision makers be supported in choosing display formats? Decision Support Systems 52(2), 318–330 (Jan 2012), http://www.sciencedirect.com/science/article/pii/S0167923611001552

[21] Touzi, J., Benaben, F., Pingaud, H., Lorré, J.P.: A model-driven approach for collaborative service-oriented architecture design. International Journal of Production Economics 121(1), 5–20 (Sep 2009), http://www.sciencedirect.com/science/article/pii/S0925527309001005

[22] Warner, N., Letsky, M., Cowen, M.: Cognitive Model of Team Collaboration: Macro-Cognitive Focus. Proceedings of the Human Factors and Ergonomics Society Annual Meeting 49(3), 269–273 (Sep 2005), https://doi.org/10.1177/154193120504900312