Developing a Mobile Collaborative Tool for Business Continuity Management

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Abstract: We describe the design of a mobile collaborative tool that helps teams managing critical computing infrastructures in organizations, a task that is usually designated Business Continuity Management. The design process started with a requirements definition phase based on interviews with professional teams. The elicited requirements highlight four main concerns: collaboration support, knowledge management, team performance, and situation awareness. Based on these concerns, we developed a data model and tool supporting the collaborative update of Situation Matrixes. The matrixes aim to provide an integrated view of the operational and contextual conditions that frame critical events and inform the operators' responses to events. The paper provides results from our preliminary experiments with Situation Matrixes.

Keywords: Business Continuity Management, Collaboration Support, Situation Awareness

Category: H.1.2

1 Introduction

This paper investigates a specific application area designated Business Continuity Management (BCM). The aim of BCM is preventing, mitigating and containing the occurrence of major disruptions in the operations of Information Technology (IT) in large organizations. BCM has received significant attention since the occurrence of catastrophic business breakdowns in the United States of America derived from the terrorist attacks on the Twin Towers and hurricane Katrina [Hiles, 2008].

The main goal of our research is exploring the possibilities of mobile collaboration support of BCM. We developed a mobile collaborative tool supporting BCM and have been testing it in two organizations. This paper describes the adopted research approach and discusses the outcomes obtained so far. We highlight the main requirements obtained from the practitioners, describe the developed data model, and discuss the feedback obtained from the organizations where the tool has been used.

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The paper is organized as follows. In the next section we draw some considerations about mobile collaboration support. Section 3 discusses the application scenario. The tool design is presented in Section 4, while Section 5 focuses on implementation details. The feedback obtained from the practitioners is presented in Section 6. Section 7 discusses our findings. And finally Section 8 presents some concluding remarks and points towards future work directions.

2 Mobile Collaboration

Innovations in collaboration support have been fostered by advances in communications networks and distributed systems encouraging the adoption of synchronous data distribution, remote invocation of services, shared information management, task coordination, and group management [Litu, 2004, Lukosch, 2002, Mascolo, 2002]. Mobile collaboration concerns people working together while moving across space [Antunes, 2008]. It combines the well-known characteristics of mobile systems, such as autonomy, mobility, pervasiveness, small form factor and unobtrusiveness with the characteristics associated with collaborative systems. One good example of mobile collaboration is supporting access to patient records in hospitals [Muñoz, 2003], which are often very large working spaces with highly variable work demands and where the healthcare personnel must be highly mobile, flexible and responsive.

The simultaneous support to mobility and collaboration presents several challenges. One such challenge is that mobility is high demanding of distributed/collaborative services, since the work context may be subject to constant changes, requiring more flexible data/task management than usually offered by desktop collaborative settings.

Mobile systems also depend on wireless networks to exchange and synchronize data. But wireless networks generally exhibit high packet loss rates, low bandwidth and high latency [Buszko, 2001]. These inherent characteristics have significant impact on the application level, especially if applications are not explicitly designed to support unpredictable operating conditions.

Another challenge concerns increasing coupling between users [Pautasso, 2009]. Coupling is a metaphorical concept regarding the degree that group members feel connected to each other [Van de Ven, 1976]. Tight coupling is necessary to support most difficult tasks (having high task uncertainty) requiring mutual adjustment of tasks and goals. But designing applications for tight coupling requires supporting immediate feedback about what everybody is doing in the workspace, which may be hard to develop.

At the cognitive level, the attention required by mobile collaboration is also more demanding: mobile collaboration typically requires divided attention [Roda, 2006], where users switch the focus of attention between their own work, the work of others and the events occurring in the environment, a context that is quite distinct from doing individual work in front of a desktop computer.

Mobile collaboration also associates information management with the physical, virtual and social environments [MacEachren, 2003], demanding rich situation awareness necessary to accomplish difficult tasks such as crisis management [Capata, 2008, Schafer, 2007] and strategy making [MacEachren, 2005].

Most mobile devices are equipped with small displays. Although the currently available interaction methods are varied, including keyboard, pen-based, gesturing and voice control, their adoption requires careful design decisions not only regarding display size but also non-stationary control of input devices [Guerrero, 2006]. Research done in this area stresses the importance of designing simple user-interfaces [Schafer, 2007].

In this paper we focus on the challenges discussed above. In particular, we explore the design of a distributed/collaborative information management component supporting flexible group operations in BCM, addressing issues such as tight coupling, situation awareness and adoption of gestures as the main user-interface mechanism.

3 Application Scenario and Requirements

We now describe the application scenario embraced by our research. The discussion primarily serves to characterize the main requirements associated with mobile collaboration in BCM. The selected scenario considers the support of BCM activities by organizational units responsible for maintaining the operations of infrastructures composed by office networks, networking devices, servers and desktop computers. A large amount of work accomplished by these units concerns highly standardized activities, such as reconfiguring routers, updating virus-scanning utilities, monitoring service levels and responding to users' requests.

Our focus is not on such standardized activities but instead on the non-routine activities that do not occur very often but have potential to disrupt the business operations (low probability, high impact). These are the activities under the scope of BCM. A large number of disruptive situations are perceived as critical to the organizations that heavily rely on IT infrastructures, including major server failures, critical service failures and large-scale networking failures, not forgetting major catastrophic accidents such as fires, floods and earthquakes.

Despite the existence of highly trained personnel and established continuity plans to address some disruptive situations, two main issues may strongly condition their effectiveness. First, standard procedures typically do not accommodate the whole variety of contingency factors that may occur. Therefore, plans serve more as information resources than actual operational procedures [Suchman, 1987]. They may be one important asset but are not as critical as other assets, in particular highly knowledgeable people. Second, many disruptive situations require bringing together tacit knowledge from multiple participants who, as a group, may be more capable to assess the situation and develop a creative solution or temporary workaround.

The role that a mobile collaboration tool plays in this scenario is increasing the teams' capability to assess, make decisions and act upon disruptive situations through better communication, data sharing and coordination. To fully understand this scenario, we conducted a set of semi-structured interviews with two BCM teams operating in two different organizations.

We inquired about the types of disruptive situations that emerge in the target organizations as well as the practices developed by the BCM teams to overcome them. One coordinator, two senior technicians and two junior technicians constituted the first BCM team we studied. The second BCM team consisted of one team coordinator, one senior technician and one junior technician.

The outcomes from the semi-structured interviews indicate that the most critical disruptive situations are related with server failures, mostly due to disk failures, and connectivity losses in specific network segments compromising a wide variety of services. As pointed out by the teams, the existing preventive practices rely heavily on monitoring active network elements through control panels, and having alerts displayed and emailed to the team members.

Many disruptive situations require that the team members find out where the failing components or services are physically located and go there to perceive the actual situation context. The diagnosis and recovery practices rely a lot on the field experience of each team member, which seems to be highly specialized, e.g. there are Windows and LINUX specialists. The BCM teams also depend on quick informal meetings, phone calls and chat-tools to share knowledge, make decisions and organize activities.

One key concern that emerged from the semi-structured interviews is that the teams find it important to document what has been done to diagnose and recover from disruptive situations. That information was considered essential to build organizational memory, especially because people tend to rotate a lot in these units and past experience is often lost.

Although both teams use Trouble Ticket software in their routine operations, they also realized that Trouble Tickets are almost irrelevant during non-routine situations. Trouble Tickets are sometimes used for incident opening and only occasionally for post mortem annotations to close incidents, with no significant impact on planning future reactions.

From these interviews we realized that: (1) the selected application scenario concerns a mobile collaborative situation perceived as critical to BCM teams; and (2) the BCM tasks perceived as important by the teams are related with decision making and organizational memory.

Having established the relevance of the selected application scenario, we proceed with a more thorough analysis of the requirements. We adopted the following method. First, we compiled a list of requirements from the related literature. Then we requested the participating team members to analyze and prioritize the requirements according with their work context. And we finally established the list of requirements according with the perceived priorities.

The initial list of requirements compiled from the related literature focused on four main categories: collaborative technology [Steves, 2001], knowledge management [Vizcaíno, 2005], team performance [Baeza-Yates, 2006] and situation awareness [Salmon, 2005]. The first category addresses the main technological features necessary to design collaboration support. The knowledge-management category was selected because it has already been pointed out as important by the BCM teams. Team performance concerns the efficiency of BCM tools. And the situation awareness category was selected to address the diagnosis and decision making activities associated with BCM [Endsley, 2003]. In Table 1 we present the requirements list that was presented to the participants for prioritization.

#	Requirement	Influence Area
1	Communication support through shared artifacts	Collaboration support
2	Transition between individual and team work	
3	Facilitate situation monitoring	
4	Minimum overhead	
5	Mobility support	
6	Help understanding situation context	Situation awareness
7	Help perceiving who is involved	
8	Assist situation size up	
9	Assist overall situation representation	
10	Knowledge externalization	Knowledge management
11	Knowledge transfer	
12	Document incident handling	
13	Improve diagnosis time	Performance
14	Improve recovery time	
15	Increase number of incidents simultaneously attended	

Table 1: Requirements list

#	1	2	3	4	AVG	STDEV
4			1	6	3.86	0.38
5			2	5	3.71	0.49
6			2	5	3.71	0.49
13			2	4	3.67	0.52
12		1	2	3	3.33	0.82
8			5	2	3.29	0.49
3			6	1	3.14	0.38
10		2	4	1	2.86	0.69
11		3	2	2	2.86	0.90
15	1		5	1	2.86	0.90
1		2	5		2.71	0.49
9		2	5		2.71	0.49
14		2	5		2.71	0.49
7		4	3		2.43	0.53
2		5	2		2.29	0.49

Table 2: Requirements priorities

The participants (7 persons) were requested to individually rate the selected requirements according with relevance to their work context. The ratings scale was from 1 to 4, in which: 1 – Not perceived as important; 2 – Less important; 3 – Important; and 4 – Very important. The obtained scores are shown in Table 2.

We defined a threshold of 3.0 for cutting off the less important requirements. As shown in Table 2, eight requirements were rated above the threshold (important or very important) and seven requirements were rated below the threshold (less or not important). Interestingly, the four categories are all evenly represented, although we find a slight advantage given to collaboration support and situation awareness.

The obtained results emphasize the importance given to immediacy of action (requirements 1, 4 and 13) and responsiveness to events (requirements 3, 5, 6, 8 and 13). In our view, these results express the importance of tight coupling in BCM and actually elucidate how it may be obtained.

Incident documentation (requirement 12) was already mentioned in the semi-structured interviews and emerges again as an important requirement. It should also be emphasized that mobility, which is at the core of our research, was the second most rated requirement. Overall, with this inquiry we could better understand how BCM is transformed into more operational objectives.

4 The BCM Tool

Let us recall the main design requirements obtained from our analysis of the BCM domain. The research indicated as most important: (1) Minimum overhead to operate technology; (2) Supporting mobility; (3) Building situation context; (4) Improving diagnosis time; (5) Documenting actions; (6) Assisting situation diagnosis; and (7) Facilitating situation monitoring.

We note that requirements 3, 6 and 7 contribute to the same generic goal: increasing the capacity to understand the situation as the associated context evolves, following an information seeking, processing and monitoring cycle. Our response to this goal will be explained in Section 4.1, where we describe the situation awareness model developed to consistently manage the business continuity data elements. Actually, the requirement 5 is also a driver of the situation awareness model, assuming the capability to preserve the situation awareness data elements in a repository for later reference (e.g., during critical analysis and training).

In our view, addressing requirement 4 in complex work situations requires collaboration and tight coupling, so that the various persons involved may contribute with their experience to build situation awareness and define adequate and timely responses. We will address this requirement in Section 4.2. And finally, the requirements 1 and 2 are fundamentally related with support for pen-based interactions described in Section 4.3.

4.1 Situation awareness model

One conceptual model that helps understanding BCM is the Swiss-Cheese Model [Reason, 2008]. This model characterizes disruptive situations as a trajectory of events through "gaps" in a succession of defensive layers consisting of physical protections, engineered safety features, administrative controls, protective devices and frontline operators. Understanding the trajectory of events and its relationship with defensive layers is fundamental to understand how a disruptive situation enfolds.

According with this view, BCM may be regarded as the proactive monitoring and management of defensive layers so that the gaps never align and therefore the trajectory of events is kept under control (both preventively and reactively).

We adopted this conceptual view to systematize the teams' information needs when tackling disruptive situations. Furthermore, by extending the Swiss-Cheese Model to BCM we are adopting a phenomenological perspective where each defensive layer has a corresponding context consisting of relational entities associating events with levels of understanding, objects and actions [Borges, 2005].

The advantages from integrating the notions of defensive layer and context are twofold. On the one hand, we are associating contexts to the dynamics of the situation in accordance with the time dimension. On the other hand, it also serves to structure the contextual information using a simple data visualization scheme.

Let us further characterize the proposed situation awareness model. We start with context. In our model, Situation Dimensions (SD) materialize context as a collection of various types of elements that brought together provide insights about a particular situation. Events, actors, goals, actions, tools and procedures are all examples of relevant SD.

But context necessarily must bring together these SD in meaningful and purposeful ways. Situation Matrixes (SM) accomplish this goal by relating SD pairs. An example would be an Actors/Actions SM defining who may do what. Figure 1 illustrates how several SM may be brought together to characterize a disruptive situation this way.

Other purposeful examples of SM are Events/Goals, Goals/Actions and Resources /Actors, which are typically adopted in emergency planning and management scenarios (Figure 2). Since several SM may be necessary to express the context of a disruptive situation, we may define Situation Context (SC) as a collection of several related SM.

Adopting the idea brought by the Swiss-Cheese Model that multiple defensive layers are necessary to understand a disruptive situation, we define the SC tree as a collection of related SC. The SC tree is adequate to model the trajectory of disruptive situations according with time (using parent-child relationships to model chains of events), model different perceptions of the situation (where the parent-child relationships serve to represent different perceptions), and also to model the projection of events (where leaves model possible future alternatives).

Concerning the various correlations in a SM, they may be expressed using different symbols, colors and sizes (see Figure 2). Domain experts must define the precise semantic meaning of the correlations. By using pre-defined symbols, the correlations may indicate how resources are allocated to specific actors, how actors and resources are associated with specific locations, and how actions are assigned to specific actors and goals, just to mention some few examples.

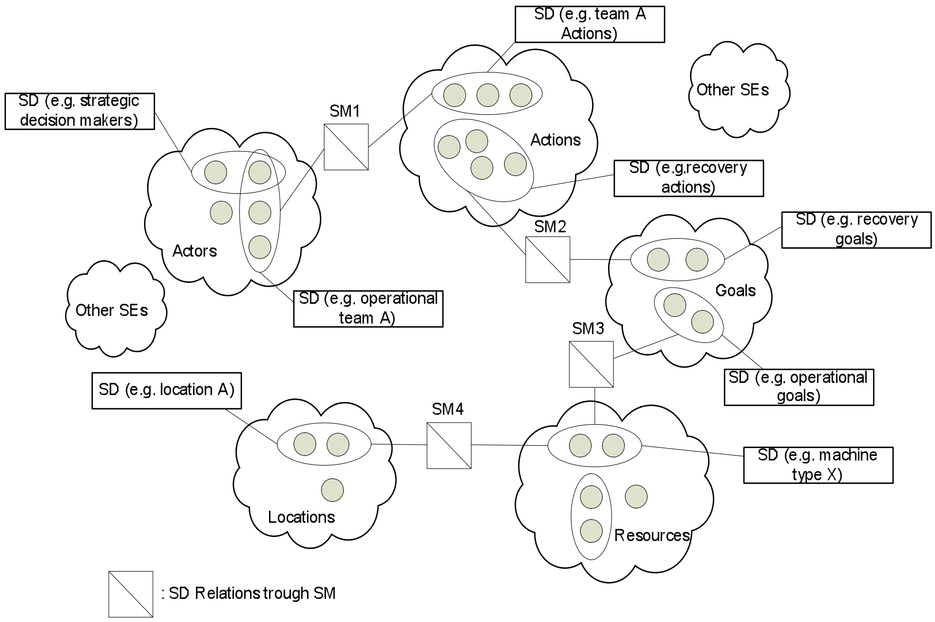


Figure 1: Situation awareness model

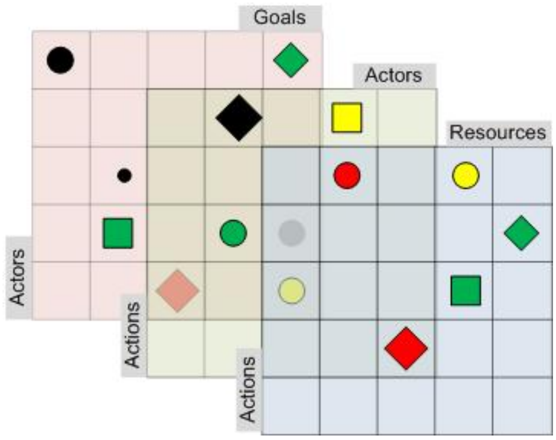


Figure 2: Examples of Situation Matrixes

4.2 Collaboration model

The collaboration model complements the situation awareness model with rules specifying how teams interact with the SC tree. The adopted model supports the dynamic creation of SM and SD, and concurrent updates on the SM using the Open Floor paradigm. This paradigm, well known by the CSCW community, does not impose any role-based or time-based restrictions to concurrent data changes, specifying that the last serialized request is the one that is committed [Reinhard, 1994].

Figure 3 illustrates how the SC tree mediates collaboration through concurrent data changes on the SC tree. The SC tree supports planning, situation awareness and response activities. Planning is accomplished by creating SD and SM. Situation awareness is maintained by constantly updating the SM. And responses are lead by continuously monitoring the SM.

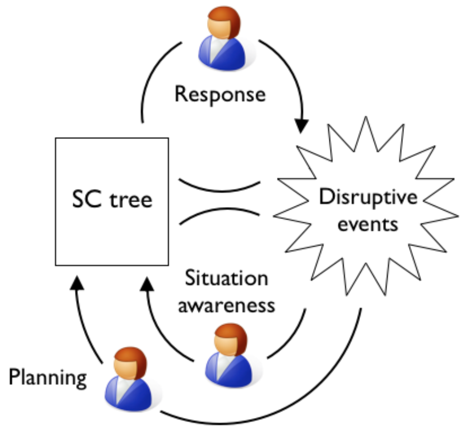


Figure 3: Collaboration model

4.3 Pen-based interaction

The developed tool supports collaborative creation and manipulation of SD and SM using pen-based gestures. This type of interaction is a good alternative to implement the human-machine interface in the selected application scenario, requiring minimum overhead and mobility.

The developed interactive mechanisms require mastering a small number of pen-based gestures. The "half rectangle" gesture shown in Figure 4.a is recognized by the tool as the creation of a new SM. The list of available SD is displayed when pointing towards the right limit of the display (Figure 4.b). The selected SD may then be dragged to the SM (Figure 4.c). We remind that the SM are bi-dimensional.

After assigning two SD to a SM, the users may start populating the SM with SD elements. One example is defining actions and goals for the Goals/Actions SM. This is accomplished by inserting lines and columns in the SM. To create a line or column, the user has to double click on the respective label (Figure 5.a illustrates how a column is created). After this, the user should define the element label. Figure 5.b shows how the element labeled "Rodrigo" is associated with the Actors SD. Figure 5.c shows that the user has already associated three elements to the Actors SD and is starting the association of elements to the Actions SD, defined in rows.

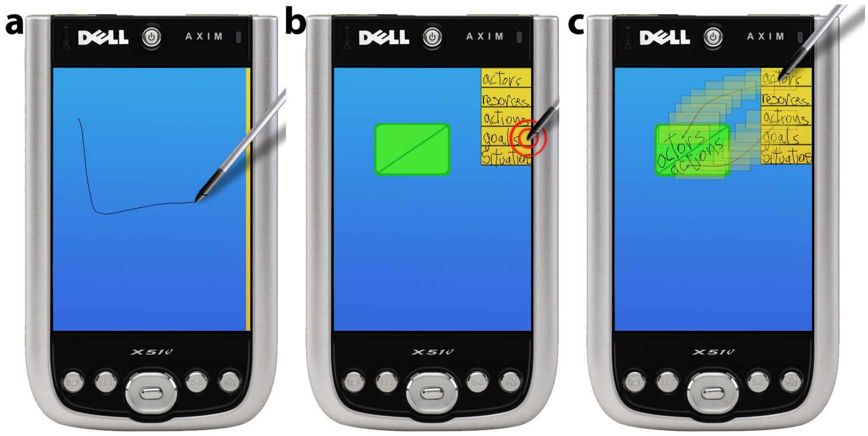


Figure 4: Creating Situation Matrixes: a) SM Creation; b) Displaying SD; and c) Assigning SD to SM

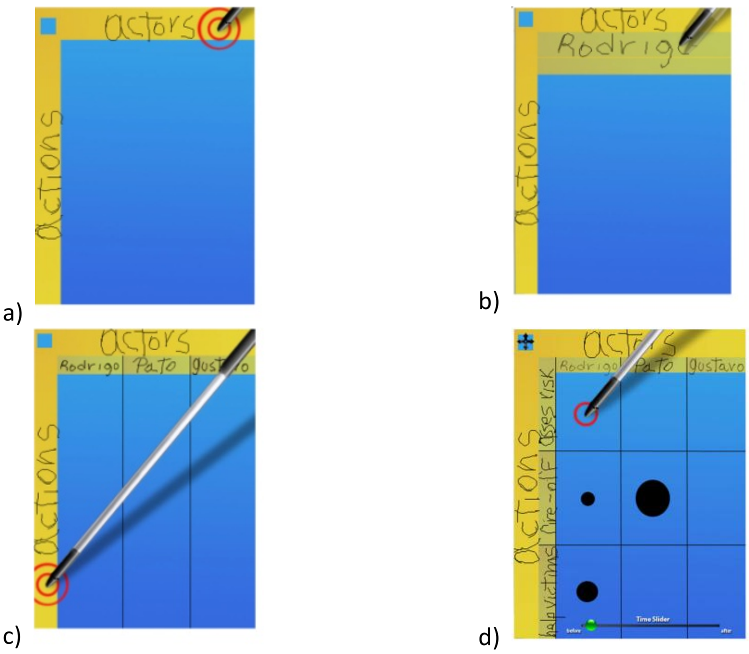
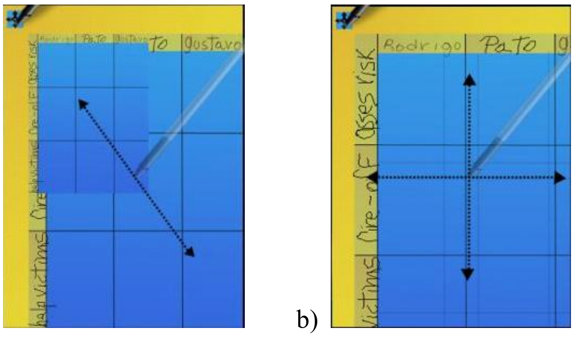


Figure 5: Populating Situation Matrixes: a) Creating SD elements; b) and c) Labeling SD elements; and d) Defining correlations in the SM

To facilitate setting correlations between SD elements, the tool allows selecting a list of predefined values. We are currently using four correlations: (a) empty cell, no importance given; (b) small dot, small importance; c) medium dot, relative importance; and (d) big circle, high importance. The different correlations are shown in Figure 5.d. Clicking on a cell will cause a pop-up menu to be displayed with the available options.

Since the users may be interested in viewing different parts of the SM, according with their context of action, the tool allows hiding rows or columns by clicking on the label of the row or column the user wants to hide. The hidden rows and columns are displayed with thick lines. To show again a hidden column or row, the user just has to double click on the thick line.

Regarding the SM navigation, the tool supports left-right and up-down scrolling, combined with zoom-in and zoom-out. These interactions are illustrated in Figure 6. Note that, since display space tends to be scarce, the above navigation capabilities rely on gestures rather than typical visual elements such as scrollbars.



a) b)

Figure 6: SM Navigation: a) Zoom-in and zoom-out; and b) left-right and up-down scrolling

We also note that the technology we have been using is capable to display one single SM; and with limitations, since only a small number of SD elements may effectively be displayed without scrolling. The developed interaction mechanism for navigating multiple SM relies on a menu.

5 Implementation Details

The functionality described in the previous section was implemented on top of an existing framework supporting the development of mobile collaborative applications [Baloian, 2009]. This framework was especially conceived to support collaborative settings characterized by high mobility, frequent changes in users' connectivity, and possible absence of structured communications networks.

The framework supplies two application development modules supporting two fundamental services: (1) group and information management; and (2) pen-based interaction support, including gesture recognition. These services are detailed below.

Group and information management. This service encapsulates functionality associated with networking, communication, group management and data sharing. The service also supports interoperability between two worlds: Java, which is often used in desktop computing; and C#, frequently used to program applications for mobile devices. It also implements mechanisms for converting data objects from their internal representations into XML, transmitting them across platforms and converting XML back into the corresponding internal representations. This feature has been used to develop the tool described in this paper in different mobile devices. Considering the functionality described in the previous section, the tool implements the following shared data elements: SM tree, SD, SD elements and correlations.

The framework also manages user groups. Various groups may be defined to manage synchronous and asynchronous modes, the later allowing sharing information at certain moments.

Regarding networking, the adopted communications infrastructure is based on mobile ad-hoc networks (MANET), adequate for mobile scenarios where structured networks may not be available. This means the tool adopts a peer-to-peer architecture, avoiding a central server with a "master" copy of the data and a list of active and inactive users. Instead, the peer-to-peer architecture is completely decentralized and transmits information to the peers that may be active in a particular moment with no consideration for joins and leaves.

To join the ad-hoc network, the tool just instantiates a shared object. Data sharing is implemented by sending multicast messages at regular intervals to the available peers. The presence of peers in the network is detected by receiving messages at regular intervals.

The data sharing mechanism is also based on the "shared object" metaphor, using an abstract class that should be extended to create an object class whose state will be transmitted to all active peers whenever changed, independently of which specific instance has changed. Every data element present in the SC tree is an extension of a shared class. Apart from declaring the field variables and methods for the shared classes, the developers also have to implement postProcess methods, which are called every time an object state is updated by a remote instance. Overall, from an information management point of view, we may say that the tool is just built on top of shared objects and group objects.

Pen-based interaction support. As we previously mentioned, the framework also implements pen-based interactions. A good pen-based interface should make extensive use of gestures. The framework offers a library of classes capable to recognize various types of gestures. Certain gestures allow users to select, copy, paste, resize, zoom and rotate text and sketches. More details about this library may be found in [Baloian, 2009]. Special concern has been done to support pen-based interactions in reduced displays, as it is often the case of mobile devices. Sketching and writing may be done on a big scale and then be automatically scaled down to occupy a small portion of the available display.

6 Evaluation

The evaluation of collaborative technologies raises many methodological concerns that have received attention from researchers in the CSCW community [Antunes, forthcoming]. Evaluation strategies may differ in: moment (design, prototype, finished product), time span (hours, weeks, months, years), place (laboratory, work context), type of people involved (domain experts, final users, developers) and type of research questions (quantitative, qualitative) [Herskovic, 2007]. Also, the scope of the evaluation may target different dimensions of analysis, from technical (e.g., interoperability) to organizational (e.g., effects on task performance) [Gauducheau, 2005, Vyhmeister, 2006].

One typical evaluation strategy uses field methods in actual work contexts [Hughes, 1994]. Although this approach allows capturing more realistic problems and requirements, it may also be difficult to settle for several reasons: time investment, scenario setting, prototype maturity, etc.

Another alternative is using inspection techniques [Nielsen, 1994]. The inspection techniques are less costly than field methods and may be used earlier and more frequently in the development cycle. Steves et al [2001] defend that inspection techniques should be employed in early development stages, when prototypes are still immature, and field methods should be employed afterwards. Based on this perspective, our evaluation method adopts the inspection technique.

The evaluation process evolved in the following way. First, we requested the BCM team coordinators participating in our experiment to develop a use scenario. Use scenarios have been employed in conjunction with inspection techniques to bring more context to the inspection task [Carroll, 2000, Haynes, 2004]. The developed scenario is described in Figure 7.a.

Then we conducted workshops with the teams to analyze the BCM tool in the context of the predefined scenario. In Figure 7.b we show a picture of the BCM tool being operated in a workshop.

We finally elicited from the workshop participants a collection of comments and observations regarding the BCM tool. The workshop revealed that when the disruptive situations occur, the personal experience of the involved operators strongly influences shared situation awareness. I.e., when highly experienced operators happen to be available during the emergency situation, it is easier to collectively understand the causes, implications and consequences of the event. The BCM tool was perceived as relevant to establish shared situation awareness and document the situation, especially when less experienced operators are confronted with the emergency situation.

The teams also elaborated a set of specific SD that would be most adequate to their work context: Equipments, Actors, Locations, Actions and Activities. These SD would then be correlated in the following SM:

- Actions/Steps, detailing operational activities (e.g., check router X, reboot switch Y);
- Actors/Steps, defining responsibilities;
- Equipment/Actors, expressing who is responsible for the equipment (e.g., who may activate a supplier warranty and who is able to inspect a LINUX machine).
- Equipments/Locations, allowing junior team members to find out the equipment locations (e.g., main gateway of building C6 is located in room 6.3.0.1).

Scenario

"From several rooms, were reported the lost of network connectivity. Some technicians were notified by email, while others received several complaints by phone. The senior technician that received some of these complaints suspects the central switch located in the main building."

How the proposed tool may help diagnosing, planning and coordinating recovery actions?

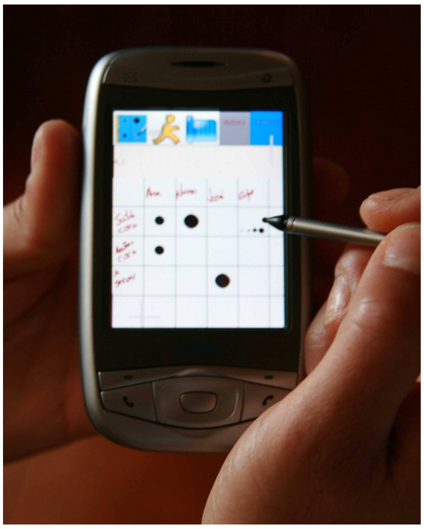


Figure 7: Inspection: a) scenario; and b) interaction with the BCM tool

Regarding usability issues, the participants suggested some additional design improvements. Better support to navigate the SC tree was highly recommended. The participants regarded the maintenance of awareness information as a major challenge, emphasizing the potential problems of having "aged" information and the overhead resulting from the need to input time-dependent information. The participants suggested asking the validity of correlations in the SM: as correlations age, the users could be prompted to report on their validity; a visualization schema could also express the aging of correlations, making the users aware of the information validity.

7 Discussion

The main organizational failures managing disruptive situations seem to be rooted on a lack of collective awareness about the ongoing situation, plus communication and information management problems [Kanno, 2006, McManus, 2007, Milis, 2007]. Therefore we regard increasing the level of shared situation awareness a fundamental requirement for BCM. The BCM teams that participated in our research supported this view.

To accomplish this endeavor, we adapted the Swiss-Cheese Model [2008] to BCM. This model allowed us to articulate the main information elements required by shared situation awareness. These elements were organized in SM.

We also consider that situation awareness must be combined with planning and response actions. The SC tree supports this complex work structure through specific SM and SD such as, for instance, the Actions/Steps and Actors/Steps matrixes identified by the BCM teams that participated in our experiments.

Nevertheless, events, awareness and actions are often difficult to disentangle. The traditional linear models of accident trajectory, such as the Domino Model [Heinrich, 1931], suggest that there is some intrinsic order over time, from event to awareness and then action, but the reality is the disorder within and between such elements is what most defines disruptive situations [Kelly, 1998].

Typical approaches to accident management rooted on linear models have been criticized for only distinguishing the major stages in accident trajectories [Kelly, 1998], forgetting that different stages may occur at the same time (e.g., awareness and action) and also avoiding many non-linear relationships between the various elements (e.g., actions may change awareness). Overall, the linear models seem to provide few insights about the actual unfolding of a disruptive situation.

Considering the actual complexity of disruptive situations, the response should instead focus on systemic views such as the one proposed by Joint Cognitive Systems [Hollnagel, 2005]. These new approaches emphasize the contextual, situated, contingencial and interactive relationships between multiple system elements. The proposed BCM tool adopts this view. The BCM tool is capable to maintain in real-time the multiple interdependencies between events, actions, actors, contexts, plans and any other factors involved in disruptive situations. Furthermore, the BCM tool also integrates the planning and response stages, thus contributing to a systemic view over BCM.

Finally, we would like to discuss some aspects regarding the flexibility of the proposed collaboration model. Depending on the kinds of organizations and disruptive situations, different response structures may exist and emerge. Wybo and Latiers [2006] say these structures are typically role-oriented, leading towards the emergence of several distinctive roles: coordinators, preceptors, analysts and travelers. The role of travelers (observers having the goal to minimize the gap between what is happening in the field and what is perceived by the operations control room) has been greatly emphasized in the success of response structures. Travelers establish redundant closed loops and improve mutual knowledge of the other roles. The BCM tool supports this role.

The hierarchical command and control structures traditionally adopted by BCM teams have also been criticized for not taking into account the emergent properties of disruptive situations, favoring a concentration of decision-making and putting too much emphasis on hierarchical communications and pre-planning [Drabek, 2003]. Instead, some disaster sociologists emphasize that critical responses should be organized with decentralized structures and cooperation between actors [Drabek, 2003]. Of course decentralized structures require specific support, such as the one provided by the BCM tool.

Studies on organizational improvisation distinguish two main structural constraints: organizational structure and procedural structure [Mendonça, 2003]. Organizational structure should promote a safe climate for improvisation, while procedural structure should provide the mechanisms necessary to reorganize previous knowledge and experience. For instance, flight operators use Crew Resource Management training programs, not so much to develop technical knowledge but rather to build up interpersonal skills, this way fostering novel organizational and procedural structures [Helmereich, 1999]. The BCM tool adopts the same line of reasoning, developing a collaborative culture where the freedom to construct SM and update its information is encouraged.

8 Final Remarks and Future Work

High-Reliability Organizations have shown effectiveness avoiding disasters and recovering from errors. Research on this type of organizations has unveiled the concern for more collegial decision-making, decentralization, deference to expertise and flexibility [Weick, 2001].

Group situation awareness emerges as a key functionality to support this behavior. Research in group situation awareness highlights the importance of shared workspaces [Gutwin, 2008]. Shared workspaces promote unplanned, informal and dynamic interactions in team collaboration. In scenarios heavily constrained by time, the concern with information availability, information completeness and dynamic changes leads the decision-making process away from the once-through search for the best action towards a more cyclic process where the aim is acting while trying to understand the situation. In this line of reasoning, the proposed BCM tool supports decision making by allowing users to manipulate a shared information structure that is distributed, mobile, shared and control-free.

Teams with high expertise in BCM informed the development of the BCM tool. The evaluation data already obtained indicates the tool is capable to respond to the most significant problems faced by BCM teams. Of course further research should be conducted to validate the tool during actual disruptive situations. The evaluation data already obtained also indicates the need to improve information visualization and interaction. More experiments should be conducted to optimize group situation awareness in mobile devices.

In the near future we will be focusing on improving the way users navigate the SC tree. We are also studying alternative interaction modes, trying to minimize the overhead necessary to maintain data validity. Two other issues are also being considered for future development. The first one concerns using icons to express correlations. The second one regards alerting users about some specific types of correlations.

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