Open Virtual Collaboration Environment for the Whole of Society Crisis Response Community

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Abstract

Crisis response situations require collaboration across many different organizations with different backgrounds, training, procedures and objectives. The response to the Indian Ocean Tsunami in 2004 and the Hurricane Katrina relief efforts in 2005 emphasized the importance of effective communication and collaboration. Compounding the challenges associated with collaboration during crisis situations is the distributed nature of the supporting organizations and the lack of a designated leader recognized across military, government and non-government organizations.

The US Army Research Laboratory is working with the University of Edinburgh, the University of Virginia, Perigean Technologies and Carnegie Mellon University in the creation of an openly accessible “Virtual Collaborative Environment” (VCE) to support the “Whole of Society Crisis Response” (WoSCR) community of interest and crisis action planning activities. The VCE consist of a collaborative portal containing a suite of Web 2.0 social networking and group tools including data visualization facilities, a 3D virtual collaboration space and a collaboration protocol. All tools were selected to support the key functions identified in a cognitive work analysis (CWA) for distributed collaboration and chosen to be open source or as accessible as possible to allow them to be made available to the wide range of organizations that make up the crisis response community.

Introduction

Crisis response situations require collaboration across many different organizations with different backgrounds, training, procedures and objectives. The response to the Indian Ocean Tsunami in 2004 and the Hurricane Katrina relief efforts in 2005 emphasized the importance of effective communication and collaboration. In the former, the Multinational Planning Augmentation Team (MPAT) supported brokering of requests for assistance by matching them with offers of help from deployed military and humanitarian assistance facilities. In the aftermath of Hurricane Katrina, the National Guard and US Army assisted other state, federal, and non-government organizations with varying degrees of efficiency and expediency. Compounding the challenges associated with such situations is the distributed nature of the community of experts who can contribute to the analysis of the crisis and the planning of a response. As a result, opportunities for leveraging expertise and resources across organizations are lost, and a response to the crisis can appear as chaotic as the crisis itself. This is compounded when multinational organizations are involved and a global response is called for.

Seeking more effective and efficient means to facilitate crisis response, in 2009 the US Army Research Laboratory's Human Research and Engineering Directorate (ARL HRED) launched a project under the direction of one of the authors (Hansberger) to design and evaluate a Virtual Collaboration Environment (VCE). In the first instance, the VCE is intended to support a Whole of Society Crisis Response (WoSCR) community, a loosely affiliated community of subject-matter experts and crisis responders drawn from government and civilian organizations for the purpose of contributing their specialized knowledge to crisis response planning activities. In the course of the program an initial mailing list of 1600 people already involved in such activities was used to establish the community, of which, at the time of writing, some 300 are active within the VCE facilities provided. It contains members from a number of countries (although initially with a strong US bias) drawn from the worlds of government, business and academia.

From a technical perspective, the ultimate goal of the project was to demonstrate the potential of a VCE for distributed crisis response planning. More broadly, the program sought to discover implications for any distributed collaborative activity. The developers of the VCE included groups from the University of Edinburgh, the University of Virginia, Carnegie Mellon University and Perigean Technologies LLC., each of which had an existing interest in collaborative work and so would bring specialized knowledge or technology to the program. The initial concept was to provide web-based social networking-type support allied with virtual worlds technology for virtual meetings in a rich environment. The work was guided by a Cognitive Work Analysis (CWA) of distributed collaboration, with the goal-directed phases of "Forming, Storming, Norming and Performing" (Tuckman, 1965) providing a framework for understanding and supporting specific instances of collaborative tasks.

Together the development team created the design for an overarching approach to crisis response support – comprising a mixture of existing information technologies identified in the CWA as fulfilling some functional need and co-opted to play a role in the project and technologies developed specifically to fill specific gaps in the functionality or enhance the collaborative experience.

In this paper we describe the results of the CWA, which provide some idea of the requirements for the VCE, followed by a brief description of each of the elements that together can be considered to comprise the VCE and concluding with some remarks about the current state of the program and future directions.

A Cognitive Work Analysis of Distributed Collaboration

To help define the requirements for the VCE, a Cognitive Work Analysis (CWA, Vicente, 1999; Lintern, 2009) of distributed collaboration was performed. A CWA consists of multiple phases that systematically analyze the constraints on work, agents, organizations and activities. Here it is used to guide the design of the virtual collaborative environment and tools to best support and facilitate the functions of the WoSCR community.

A CWA typically focuses on how work can be done compared to other types of task analyses that focus on how work should be done in a limited set of situations, which can decrease the flexibility and adaptability of the socio-technical system. The CWA identified the critical functions to facilitate distributed collaboration and allowed us to select the appropriate technology to support those functions (Pinelle et al., 2003). It also guided the design, presentation and structure of information and processes found in the primary components of the VCE.

Phase I – Work Domain Analysis

The first phase of the Cognitive Work Analysis involves identifying the activity-independent constraints of the work domain; following (Lintern, 2009), in this case this has been done by decomposing the domain according to five nested levels of abstraction (shown in Figure 1):

- Domain purpose: the overarching goal to be achieved – in this case, distributed collaboration.
- Domain values and priorities: principles or qualities on which work in the domain is founded – in this case, we can identify coordination, communication and activity awareness as essential components of distributed collaboration.
- Domain functions: the realization of the domain values and priorities (and fulfillment of the domain purpose) as abstract functions within the domain.
- Physical functions: the realization of the domain functions in terms of techniques.
- Physical objects: artifacts that provide some aspect of the identified physical functionality, with particular reference to novel "Web 2.0"-type technologies that may be exploited alongside common existing technologies.

By pinpointing specific tools and providing a clear functional rationale for their use, the resulting analysis provides a roadmap for the development of a VCE that, on the one hand, meets the functional objectives of the domain while, on the other, avoids the gratuitous introduction of modish technologies.

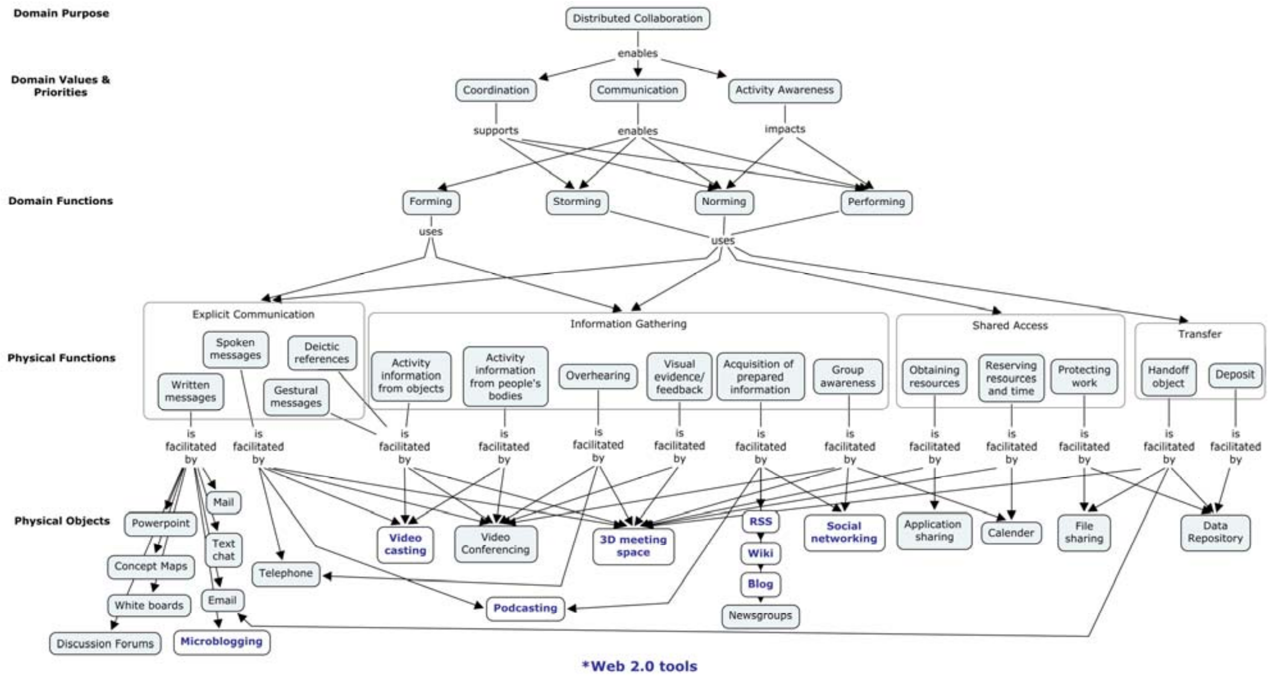

Figure 1. Cognitive Work Analysis Phase I – Work Domain Analysis.

Phase II – Work Organizational Analysis

The second phase of the Cognitive Work Analysis situates tasks at the appropriate organizational level according to the actors involved (Figure 2). One dimension of this is based on the domain functions identified in phase I, each now elaborated according to specific work tasks as identified by Tucker (1965) and others. The second dimension reflects increasing geographical and organizational dispersal – from local and intra-agency through national inter-agency and on to multi-national and involving civil and military participants.

OpenVCE: Elements of Virtual Collaboration

With the initial components of the VCE – group web portal and virtual interaction space –already determined; using the CWA, these could now be elaborated, and additional components identified. The components of the VCE are as follows:

- A web-based portal;
- A virtual interaction space;
- Community tools;
- Collaboration protocols.

Below we discuss each of these in turn.

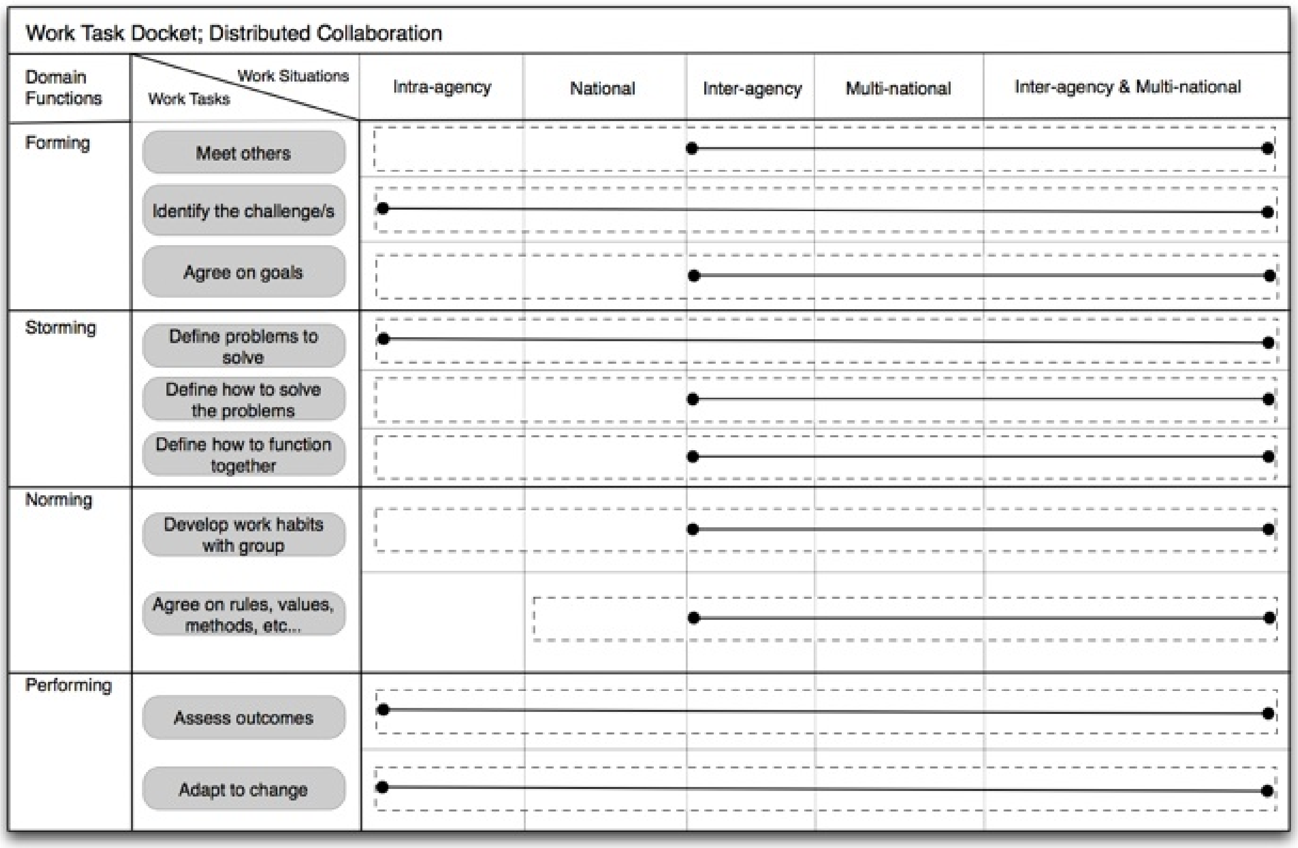

Figure 2. Cognitive Work Analysis Phase II – Work Organizational Analysis.

Community Web Portal

The VCE includes a web-based Community Portal for asynchronous (that is, off-line) collaboration and communication, and for creating and sharing resources, as well as more general group-building activity and event awareness (http://openvce.net – see Figure 3). After some experimentation and discussion (see http://openvce.net/forum-alternative-platforms and http://openvce.net/more), the open-source Drupal™-based system was adopted as the platform for this site. Drupal is a widely used content management system, with an active development community of its own. This allowed the site to be specialized with a range of modules to provide, for instance, group management facilities to allow ad hoc teams to be constructed from among the membership as a whole for specific purposes (such as working on a specific response problem). This site has been augmented by a wiki (powered by the popular open source MediaWiki software), to provide lightweight facilities for co-authoring text documents (a facility felt to be lacking in Drupal).

The deployment and administration of the web portal requires appropriate hosting hardware and a certain amount of expertise to manage the site and its users. This approach also allows for additional functionality to be made accessible to the community by embedding appropriate tools within site pages. These tools can be generic community tools or introduced for specific tasks.

Virtual Space for Intelligent Interaction: The I-Room

In addition to its social and entertainment uses, virtual worlds technology has the potential to enrich more serious forms of remote collaboration. We have developed these ideas into the concept of the *I-Room*. Put simply, an I-Room is an environment for intelligent interaction. It can provide support for formal business meetings, tutorials, project meetings, discussion groups and ad-hoc interactions. The I-Room can be used to organize and present pre-existing information as well as displaying real-time information feeds from other systems such as sensor networks and web services. It can also be used to communicate with participants, facilitate interactions, record and action the decisions taken during the collaboration.

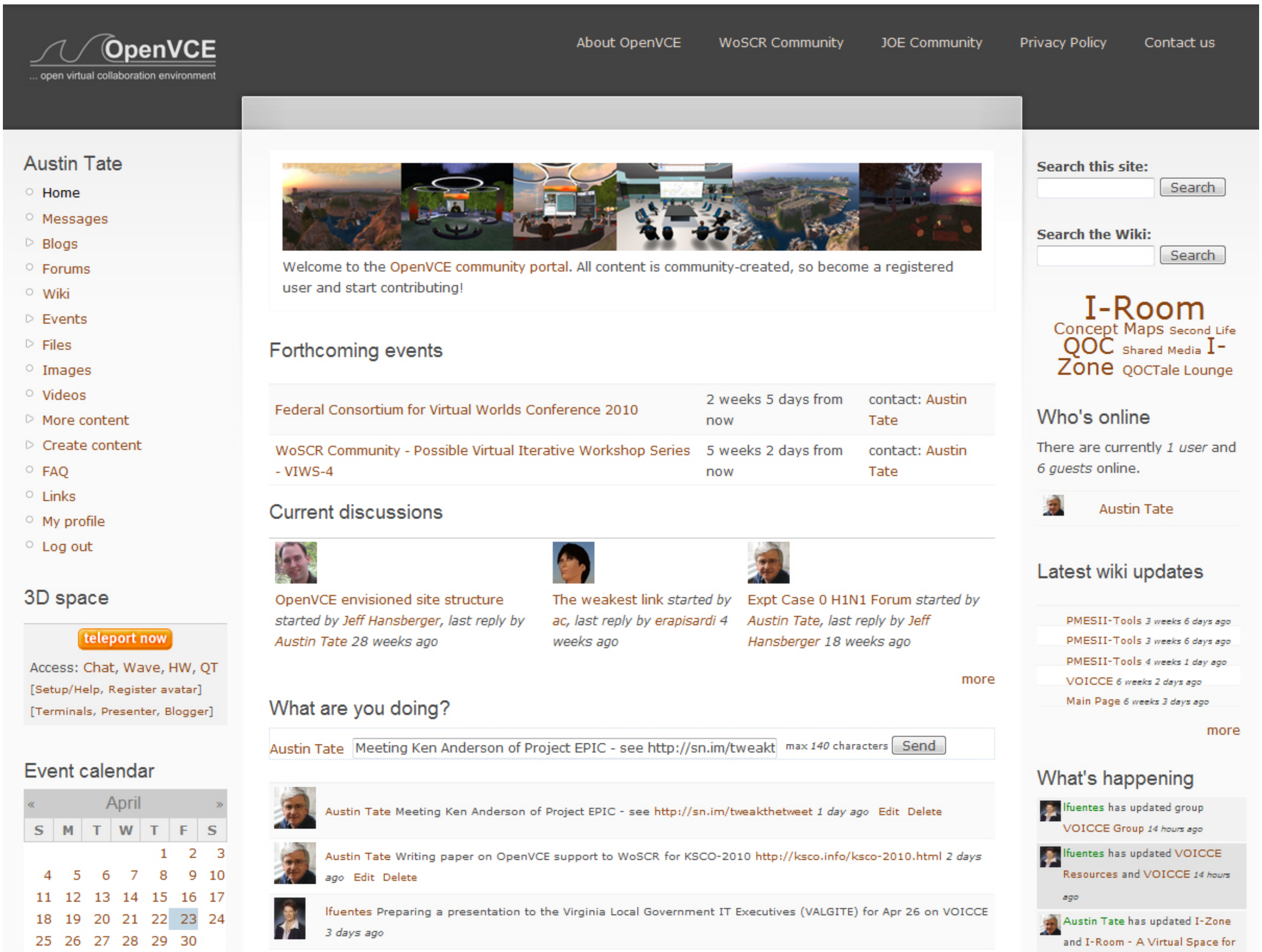

Figure 3. OpenVCE.net web portal home page.

In practice, Second Life™ and OpenSim environments have been used to realize I-Rooms (Figure 4 shows an I-Room alongside a browser onto the web portal, typical of how a user's screen might be laid out while using OpenVCE). Using the I-Room concept within virtual worlds gives a collaboration an intuitive grounding in a persistent 3D space in which representations of the participants (their "avatars") appear and the artifacts and resources surrounding the collaboration can be granted a surrogate reality –

which, where these items consist of information, might be more meaningful or compelling than their physical reality. Avatars can meet each other ‘face-to-face’ in a virtual world when their human counterparts cannot. Some of the benefits of a real-world meeting are retained through immersion in the virtual world, and in some cases virtual world meetings may be an effective alternative to face-to-face meetings, telephone calls or video-conferences.

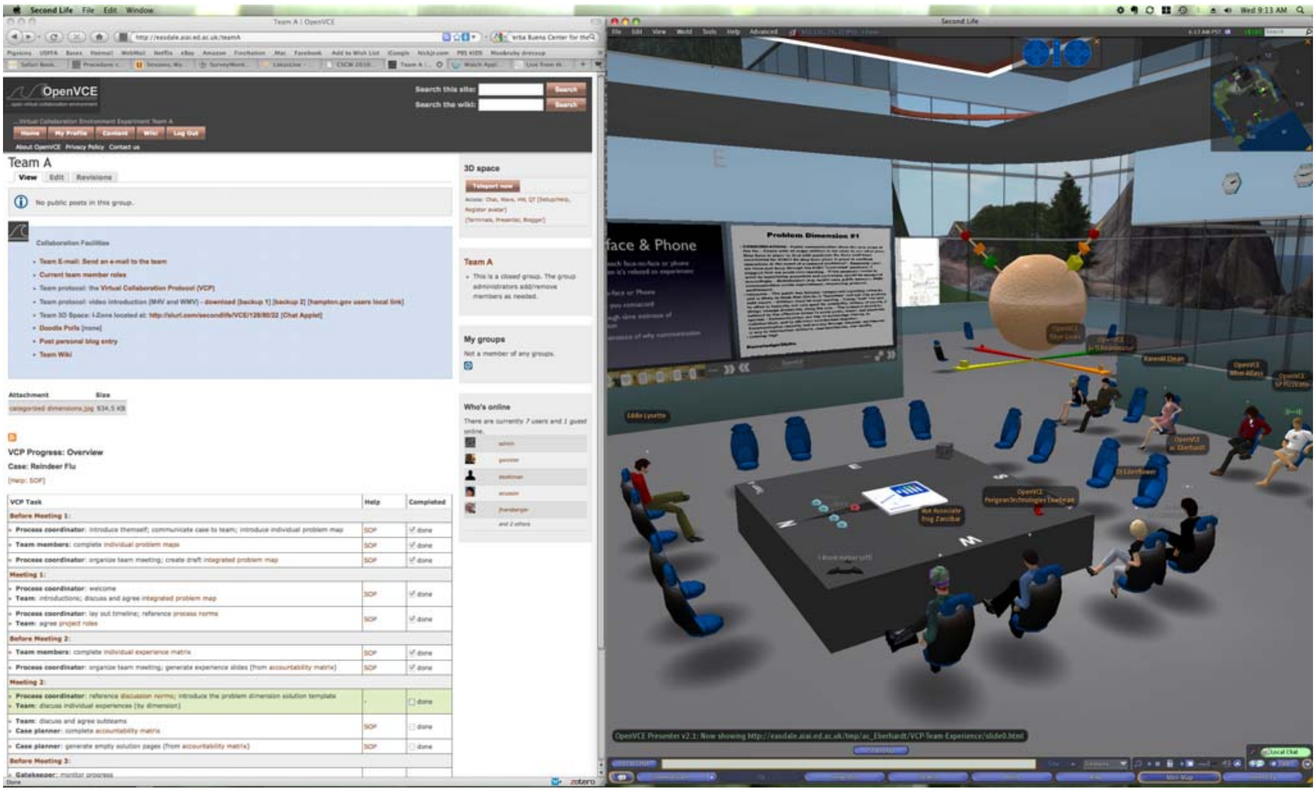

Figure 4. VCE web portal showing protocol support facilities, alongside virtual 3D space.

Beyond the advantages conferred by a shared interaction space, the I-Room can be used to deliver intelligent systems and tool support for meetings and collaborative activities. In particular, the I-Room is designed to draw on I-X technology (Tate, 2000) which provides intelligent and intelligible (to human participants) task support, process management, collaborative tools and planning aids to participants. The I-Room can also utilize a range of manual and automated capabilities or agents in a coherent way. The participants share meaningful information about the processes or products they are working on through a common conceptual model called <I-N-C-A> (Tate, 2003). The I-Room framework is flexible enough to provide participants in I-Room meetings with, for instance, access to knowledge-base content and natural language generation technology that tailors utterances to the specific experience levels of users.

I-Rooms have been in use since early 2008 for a range of collaborative groups, meetings and training exercises (see Figure 5). Some I-Rooms are constantly available to their users through publicly accessible virtual worlds like Second Life.

Applications of the I-Room to date include emergency response operations used for experimentation and exercises, and support to a geographically dispersed cross-disciplinary team engaged in the creation of a multi-media product (Tate et al., 2010).

Figure 5. Sample I-Room showing information feeds and external agent links.

As an organizing – and visualizing – principle, the I-Room can make use of the “OODA Loop” (Observe, Orientate, Decide, Act) postulated by Boyd (Osinga, 1995) as a conceptual framework for supporting task-oriented communication and collaboration between teams and individuals working with a range of agencies. Truly distributed mixed-initiative work is the focus, allowing for the following tasks:

- situation monitoring and sense-making;
- analysis and simulation;
- planning and option analysis;
- briefing and decision making, and;
- responsive enactment.

The OODA Loop provides a conceptual framework for organizing the use of a range of potential tools, decision aids, visualizations and collaborative tools. Research and OpenVCE.net developments are exploring such a direction.

Community Tools

Both the web portal and the virtual interaction space encourage the idea of incorporating additional function as and when it is needed. The use of I-X technology, as mentioned above, provides structured process support tools in the virtual space. Other tools might be more specific to a particular problem at hand, and introduced into the VCE by members of the community themselves. Here we make brief mention of two further generic tools, contributed by members of the development team: a community visualization tool and concept maps for documenting and sensemaking interactions.

Community visualization: the Catalyst tool. The visualization tools deployed within the VCE support a number of activities common across various types of distributed collaboration. A dynamic network visualization tool called *Catalyst*, provided by Carnegie Mellon University, provides relationship information across the crisis response community of interest members, organizations, projects, areas of expertise and geographical areas of interest. It allows a community member to locate other members having required expertise for possible collaboration efforts.

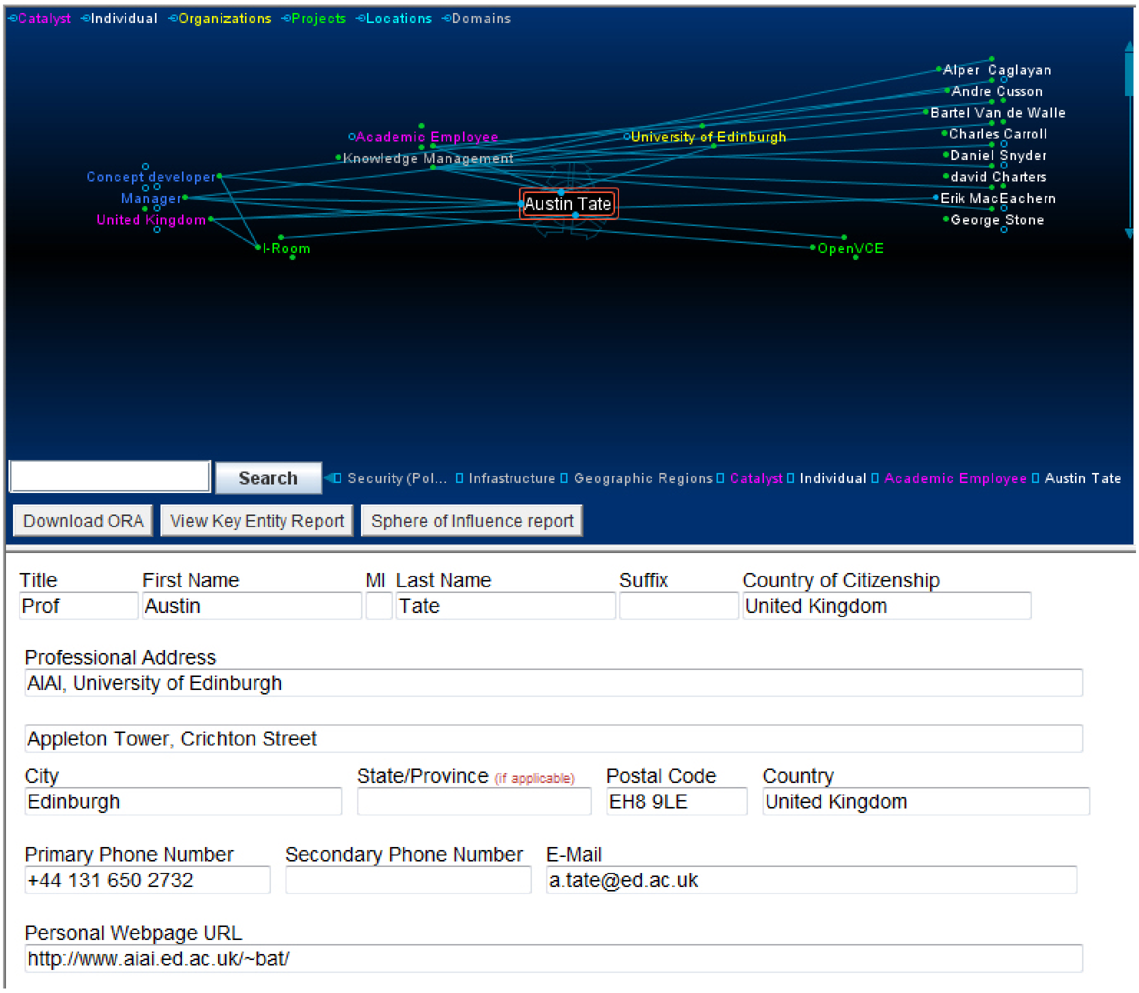

Figure 6. Catalyst Community Network and Brain Visualization

Sensemaking: Cmaps. The use of concept maps is also being used as a visualization technique to provide a centralized perspective on the emerging plan without imposing centralization of the development process. The *Cmaps* concept map technology has been used in a related way to improve the basic process for creating, sharing and using operational orders and operational plans for military operations (Moon et al., 2010). Figure 7 shows a Cmap displayed within Second Life where it can be viewed by all visitors to the I-Room space.

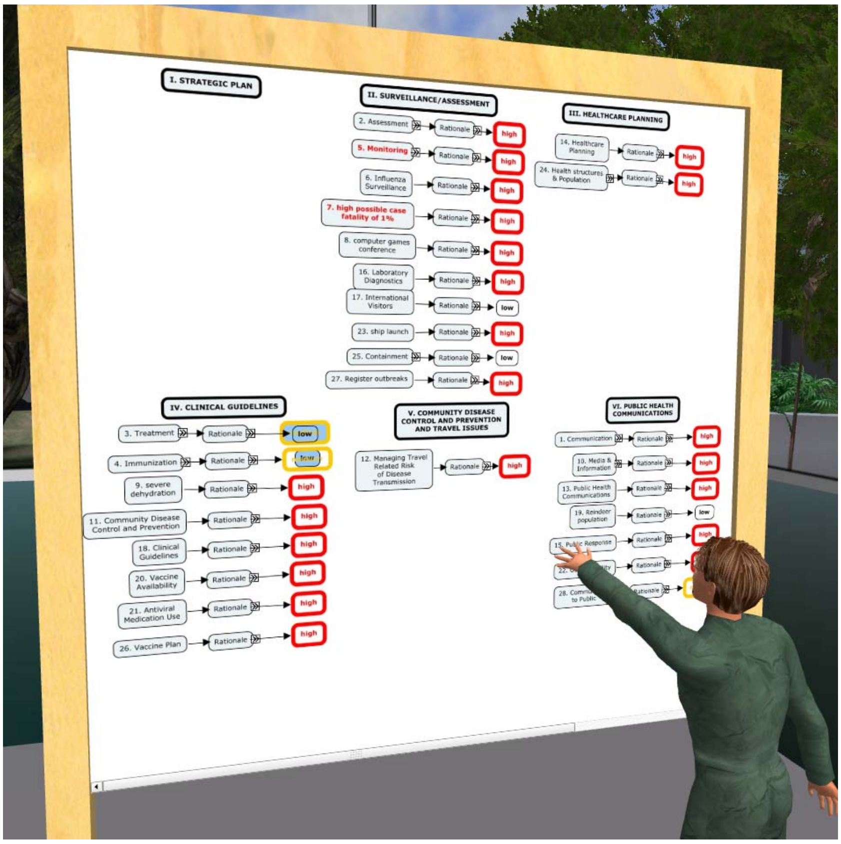

Figure 7. Cmaps concept mapping tool shown here projected into Second Life.

Virtual Collaboration Protocol

It is one thing to provide an appropriate environment for interaction; it is quite another to expect people to use it in the most effective and efficient manner, a problem compounded by the novelty of many of the technologies used. Furthermore, the success of collaborations is often determined to a great extent by the experience of those involved and their collective ability to organize their efforts. Accordingly, so as to provide some structure for collaborations, it has been necessary to consider the use of Virtual Collaboration Protocols (VCPs), intended to guide distributed collaborative activities across the diverse tools and organizations typically involved in crisis response. An initial protocol has been developed (see http://openvce.net/vce-protocol) that is intended to guide the behaviour of a team comprised of WoSCR members which has been selected in order to provide expert advice in response to a specific request from decision-makers; it is expected that the request would be of a complexity that demands alternating virtual meetings and periods of asynchronous, off-line effort from the team members. The protocol is tied to Tuckman's "Forming, Storming, Norming, and Performing" collaboration model and how individuals communicate and collaborate through social networks (Cross and Parker, 2004). It addresses some of the unique capabilities and challenges of distributed collaboration within a virtual environment such as virtual presence and trust, roles, responsibility and authority, asynchronous planning and virtual activity awareness.

In addition, to accompany this VCP tools have been developed and made accessible through the web portal to help track the status of the collaboration, manage roles, communicate with team members, and enter and share information. Furthermore, a number of standard operating procedures have been written to further decompose the subtasks detailed in the VCP in terms of the specific OpenVCE tools and technologies that might be used to complete them (Wickler and Potter, 2010).

Summary, Status and Future Work

The Open Virtual Collaboration Environment (OpenVCE.net) has been created as a means to support community activities, specifically – but not exclusively – the activities of the WoSCR community. The VCE and its collaboration protocol and support tools formed the basis of experiments conducted in early 2010 intended to assess the suitability of the OpenVCE environment for crisis response tasks. These experiments involved volunteer teams using the OpenVCE facilities to tackle a realistic problem while control groups addressed the same problem without the VCE technology. The experimental scenario involved a requirement to recommended preventative steps and countermeasures in the face of an escalating flu-like epidemic with potential impact on significant events that incorporated issues of economic and social impact. Detailed analysis of these experiments and their results is forthcoming.

Development work continues on I-Rooms, active “Expo pavilions” and intelligent assistance avatars. A consistent style and colour palette has been adopted and used across the collaboration portal and the 3D Spaces to provide visual coherence. However, more work is needed to integrate the style and give an approachable set of facilities with a clean conceptual basis for distributed collaboration. Social networking, collaboration aids and shared media are undergoing rapid development at present, and throughout the OpenVCE project, we have been experimenting with some of the most promising. Twitter is used with structured, tagged and syntax constrained messages to provide status and pre-condition triggering information through both the web portal and into the 3D meeting spaces directory. A number of web-based shared media facilities are currently being assessed as a basis for synchronous shared information viewing and editing, including for maps and choice making.

We have already experimented with the projection of some data and collaboration visualizations into the 3D collaboration spaces, including visualization of plan options and argumentation related to their pros and cons, concept maps, etc. We continue to investigate how proper multi-user shared interaction with such displays can be achieved. While virtual worlds offer almost unlimited possibilities for visualizations, coming up with appropriate ones – especially when, as here, we are interested in portraying intangible information and concepts – is no easy matter. To this end, we continue to experiment with novel representations of archetypal tasks (such as that shown in Figure 8).

Mobile access and access in restrictive environments (such as behind firewalls) for the main collaboration facilities and 3D meeting spaces, and for secondary facilities used for training or experiments, is an important capability which was anticipated when the OpenVCE project was started. A number of facilities are being studied and developed to address some of these needs.

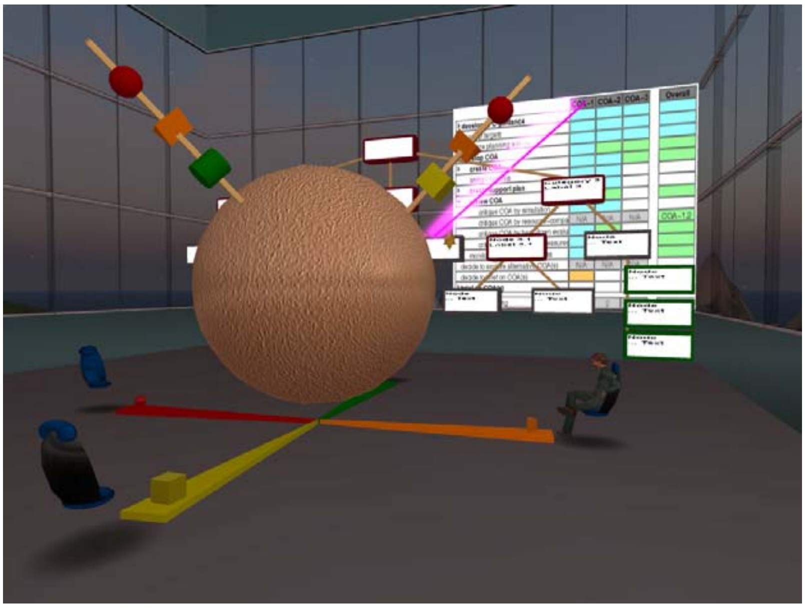

Figure 8. Experimental visualizations in 3D space for concept maps, plan options and issue argumentation.

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