

I-Room: a Virtual Space for Intelligent Interaction

**Austin Tate, Yun-Heh Chen-Burger, Jeff Dalton,
Stephen Potter, David Richardson, Jussi Stader, Gerhard Wickler**

Artificial Intelligence Applications Institute (AIAD)
School of Informatics, The University of Edinburgh, UK

Ian Bankier

Glenkier Whiskies Ltd./The Whisky Shop, UK

Christopher Walton

Slam Games Ltd./Metaforic Ltd., UK

Patrick Geoffrey Williams

EADS Innovation Works UK Ltd., UK

Abstract

An I-Room is an “intelligent room” which can act as a knowledge aid to support collaborative meetings and activities, especially when these involve making sense of the current situation, planning, considering options, and making decisions. The I-Room provides a generic technology platform for a wide range of potential collaborative applications and uses. It provides a conduit for accessing intelligent systems and knowledge bases from collaborative interaction spaces such as virtual worlds. Described in this paper are applications of the I-Room to support a geographically dispersed cross-disciplinary team in a creative industry (the development of a multi-media video game); to support virtual operations centres for emergency response and public safety; and to support a mixed-initiative tutored social/promotional activity (an expert-led whisky-tasting).

Keywords: Collaboration, Virtual Worlds, Intelligent Assistants

Introduction

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 organise 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, and record and action the decisions taken during the collaboration.

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.

Beyond the advantages conferred by a shared interaction space, the I-Room can be used to deliver intelligent systems support for meetings and collaborative activities. In particular, the I-Room is designed to draw on I-X Technology [1] which provides intelligent and intelligible (to human participants) task support, process management, collaborative tools and planning aids. The I-Room can also utilise a range of manual and automated capabilities or agents in a coherent way. The participants in the collaboration share meaningful information about the processes or products they are working on through a common conceptual model called <I-N-C-A> [2]. The I-Room framework is flexible enough to provide participants with 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. Some are constantly available to their users through publicly accessible virtual worlds like Second Life¹ – see Figure 1. This paper describes a number of applications of I-X and I-Room technology: for product team meeting support, in an emergency response virtual operations centre, and for tutored whisky tastings in the “Virtual World of Whisky”.



Figure 1. Example of I-Room Exterior.

Background

One could be forgiven for assuming that virtual worlds and their social networking aspects originate mainly from computer game technology. However, the origins of a number of significant developments in this area can be traced to research which began in the late 1970s into multi-user persistent spaces, which explored object-sharing and chat for collaborative systems [3]. The addition of object-oriented programming to script or control the objects in the shared space expanded the possibilities. A popular version of such a multi-user, object-oriented virtual space is LambdaMOO² which dates from 1990.

This work has continued over a period of three decades, with the emerging environments being used alongside tele-/video-conferencing and instant messaging with agent presence and status information. A good example is the Collaborative Virtual Workspace³ originally built by Mitre Corporation between 1994 and 1999, which used a ‘buildings and rooms’ metaphor for persistent storage of the documents and shared assets used in collaborations. Many video-conference support systems utilise the idea of setting up a virtual workspace ‘room’ to give context to a particular presentation or meeting. The foundations of the I-Room project, within the context of the wider I-X Research Programme, lie in proposed extensions to this idea to make use of intelligent planning and collaboration aids alongside CVW. These proposals are among a number to have appeared over the last decade that describe a room for intelligent team-based interaction or a room that could itself act as a knowledge-based asset for a group. Some of these concepts were explored in the Collaborative Advanced Knowledge Technologies in the Grid (CoAKTinG) project [4].

I-X Technology

I-X [1] is a suite of tools designed to aid processes that create or modify one or more “products” (where a product may be a document, a plan, a physical entity or even some desired changes in the world state). The I-X approach involves the use of shared models for task-directed communication between human and computer agents.

¹ Linden labs Second Life™ - <http://secondlife.com>

² <http://lambdamoo.info>

³ <http://cvw.sourceforge.net>

An I-X agent (or system of agents) carries out a process, which leads to the production of (one or more alternative options for) a product. The I-X agent/system considers this synthesized artifact to be represented by a set of constraints on the space of all possible artefacts in the application domain. This constraint-based view provides a common conceptual basis for sharing information on processes and process products. It is intended to provide a framework that is shared, extendible, easily communicated, intelligible to both humans and machines, and as formal or informal as the situation demands.

The underlying conceptual information-sharing model on which I-X is based is the <I-N-C-A> (Issues-Nodes-Constraints-Annotations) ontology [2] which represents a set of restrictions on processes or products:

- Issues: e.g. what to do? how to do it?
- Nodes: e.g. include specified activities or product parts;
- Constraints: e.g. temporal, spatial, or on resources;
- Annotations: e.g. rationale, provenance, progress.

To move towards achieving the goals of the collaboration, an I-X agent or system repeatedly moves through cycles of handling issues and managing domain constraints. To do this, a number of different ‘mixed-initiative’ collaborative processes can be invoked, including:

- Issue-based sense-making, e.g. such as the gIBIS approach with its 7 question types [5].
- Activity planning and execution.
- Constraint Satisfaction, using AI and OR methods, or simulation.
- Note-making, rationale capture, logging, reporting.

The I-X Process Panel (I-P²) [6] provides the principal interface for a human user of an I-X system; its underlying representation and reasoning are applied to the current world state to present the user with context-sensitive options for action. The aim is to provide a planning, workflow and communications ‘catch all’ for the user. At its simplest, an I-P² maintains a ‘to do’ list for its user; however, when situated in a collaborative context with knowledge of the domain, an I-P² provides the interface to a complete intelligent workspace, supporting joint activity by suggesting methods for advancing the process and providing access to planning tools, communication aids and so on.

Underlying Concepts for I-Room Collaboration

The underlying concepts employed by the I-Room enable human participants to benefit from intelligent systems support during meetings and collaborative activities. I-Room concepts include:

- A mixed-initiative collaborative model for refining and constraining processes and products;
- Principled communication based on sharing issues, activities/processes, state, event, agents, options, argumentation, rationale, presence information and reports through the <I-N-C-A> ontology;
- The use of the <I-N-C-A> ontology also for representing the products that are developed during meetings and through the collaborative processes;
- The use of I-X Technology and its suite of tools to provide task support;
- The use of issue-based argumentation, through the use of the Questions-Options-Criteria (QOC) methodology [5] and links to the Compendium sense-making tool [7];
- The use of I-X “I-Space” to support awareness of agent context, presence, status, capabilities, authorizations, and relationships;
- The use of an “I-World” for discovery of relevant agents and services;
- The use of the “Beliefs-Desires-Intentions” (BDI) model for understanding and steering the behaviour of individual agents as part of a task-achieving whole;
- The use and maintenance of external shared repositories of processes, products, media and other resources.

I-Room Meeting Support

An I-Room can be linked to I-X Process Panels to support meetings in virtual worlds or in the real world. It can support common requirements for meetings by:

- Loading and displaying a predefined meeting agenda or template;
- Making available a set of standard procedures for the conduct of the meeting;
- Keeping track of the progress through the list of agenda items during the meeting itself;

- Recording decisions and taking minutes;
- Tracking existing actions and adding new ones;
- Providing access to minutes from previous meetings;
- Automatic generation of a draft of the meeting minutes;
- Automatic generation of an agenda for the next meeting including both generic items (e.g. review of previous actions, AOB, date of next meeting) and content specific to that meeting.

Through a link to an autonomous object in the virtual world (the “I-X Helper”) that is able to sense the presence of avatars and respond to commands, it is possible to provide additional support by:

- Monitoring the participants in the meeting, and noting their presence status throughout, and at which points they leave and return;
- When appropriate, displaying on in-world ‘screens’ and wallboards information and media content, such as the meeting agenda and relevant images and documents;
- Unobtrusively documenting the progress of the meeting and its outcomes.

While some of these tasks are simple, more complex tasks can only be completed to a high standard when the I-Room has background knowledge of meeting formats and the current collaboration. Linking the I-Room to existing, real-world knowledge-based systems can add their knowledge to the support offered in this virtual space.

I-X Helper – Connectivity between I-X and a Virtual I-Room

Participants meeting in an I-Room may connect via I-X Process Panels or via their avatars using an appropriate virtual world viewer or interface. The I-X Helper, which can be instantiated in the form of any convenient object in the virtual world, acts as a conduit for channelling communications to the participants connecting via their avatars and to related capabilities available within the virtual world. These communications may take different forms depending on the protocols and programming facilities within the virtual world platform.

Within Second Life, for example, the I-X Helper communicates to I-X Services via a communications channel that uses a mixture of HTTP and XML-RPC requests and responses as shown in Figure 2. Messages can be queued and sent later if either the I-X Helper or I-X Services end-points are not available, enabling asynchronous operations. The I-X Helper can communicate with avatars in the I-Room via open chat channels and can control suitable devices in the virtual world, such as displays, objects etc. Also incorporated are specific capabilities to provide flexible display of images, external web pages and I-X windows.

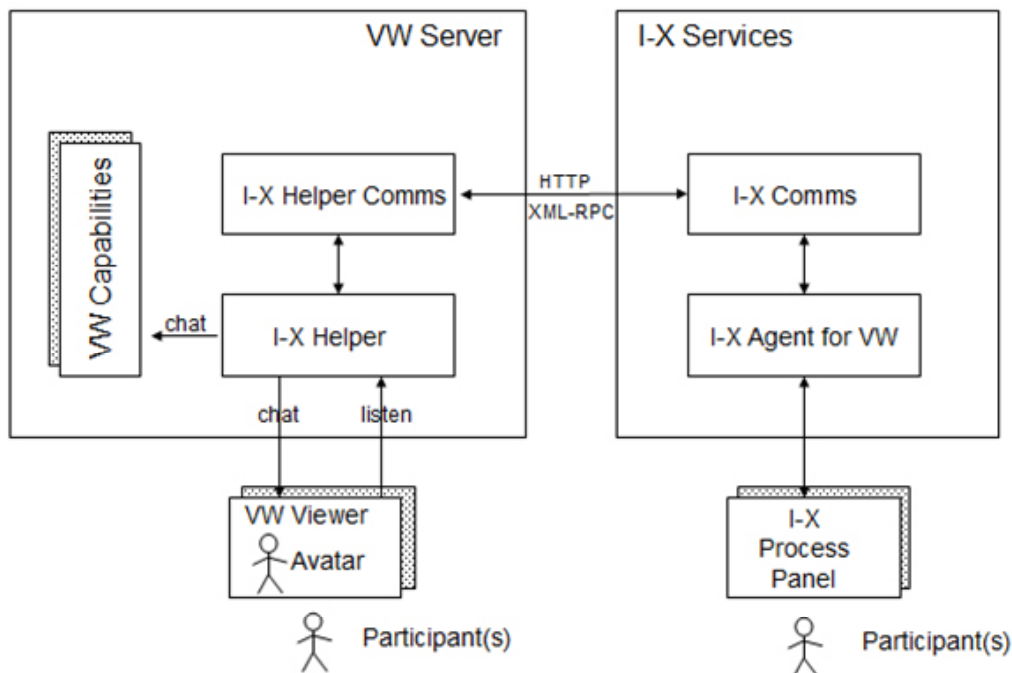


Figure 2. The I-X Helper connects virtual worlds to I-X Services.

I-Room Capabilities

A set of tools is available to support participants in the I-Room; these can be accessed in a convenient fashion through avatars in the virtual world, or via I-X Services. These tools include:

- I-X Helper: to communicate with external knowledge-based systems and to reliably set up the communications link to I-X Services and pass back and forth requests, content, and reports, and to act as a chat conduit between I-P² and the I-Room on need.
- Image Generator: a mechanism outside the virtual world able to convert snapshots of the GUIs of external applications (including the I-X tools), web accessible images (however generated) and other video- and live-feed content into composite images suitable for display in virtual worlds⁴.
- Display Screen: a screen that can show various images, media, movies or live video feeds. It can extract and display (tagged) elements from the images created by the Image Generator, or via other “channel” display mechanisms.
- LED Display: to display text in a number of different colours, fonts and styles.
- Media Controller: to change media and audio streams reliably within the virtual world where granted permission to do so.
- Avatar Sensor: to give information on avatars’ names, id, location, etc. to external systems and maintain a model of who is present in the I-Room.
- Inventory Giver: to offer to avatars items relating to the current events and processes in the I-Room. [experimental]
- I-Room Questioner: to ask participants (multiple-choice) questions, letting them answer individually. This can be used, for example, to vote, to agree on a course of action, or to make a selection from a number of available options. [experimental]

Slam Games I-Room – Support for Product Team Meetings

Slam Games Ltd. is typical of companies operating in the modern creative industries, with a strong emphasis on information creation and exchange for, in this case, the development of video games. Working in partnership with Slam Games, an I-Room has been created to assist the company’s game development process, which involves an international team of designers, artists and managers. Although the Slam Games I-Room was created in Second Life, the capabilities developed are designed to be independent of the virtual world platform used.

For game development, Slam Games itself concentrates on the design, programming and development of the game core, while the design and production of most artwork, sound and other media are outsourced to specialists, who today are often to be found in different countries around the world. Communication with these media specialists is maintained via e-mail, telephone, instant messaging, a Wiki, and an issue-tracking system; however, for various reasons none of these channels is wholly appropriate for supporting the interactions that are required during game development.

To address these communication difficulties, an operational I-Room tailored for this task was produced. This I-Room has mechanisms for displaying artwork and other media and for showing animations, as well as for supporting the flow of meetings (e.g. via the display of information derived from the I-P² of the meeting chairperson) and for recording argumentation, communications, and decisions. The I-Room is voice-enabled to support discussions to reach a proper consensus on issues. In one particular meeting, for instance, artwork is to be discussed and will be presented by the resident artist in the form of 2D stills from 3D models. The actions from previous meetings and agenda items for the current meeting are displayed, allowing actions to be discussed and then marked as completed or no longer applicable, or else to be carried forward to the next meeting. Decisions may be noted, actions items placed on avatars, etc. The project milestones for the period under review at the meeting may also be available as a list of issues to address. Each of these should be discussed, raising any risks to the successful achievement of the milestone. New actions may arise from such discussions.

The use of a virtual world for meetings has the potential to address one of the main weaknesses of current practice, namely the inability to view and contrast artwork and media in a shared setting. Accordingly, there are mechanisms in the I-Room (the I-Room screens) for displaying and suitably labelling different media, allowing the participants to discuss

⁴ Different virtual worlds provide different flexibility for displaying external web pages, images, etc. Some allow an HTML or image URL to be shown on any face of any 3D object. Others, such as Second Life currently limit any land plot to a single media URL. In the case of Second Life, this limitation can be overcome by using an M×N matrix of images composed into a single entity with content referenced by cell.

and compare and, where appropriate, to reach some consensus on which alternative to use. The labels shared between I-X and the I-Room makes sure that the same assets are referred to in a consistent way by all participants.

Employees of Slam Games participated in trial meetings based around the design of a real game and its related media. These trials allowed a qualitative evaluation to be made of the value of the I-Room technology in the context of Slam's requirements and existing collaboration mechanisms. In summary, this indicated that the I-Room provides a direct solution to many of the issues of communication encountered in the distributed workplace that is a feature of the games development process. The company has undertaken to give serious consideration to the possibility of adding this facility to its existing set of collaboration technologies.

Virtual Operations Centre for Emergency Response

The initial spur to the development of virtual I-Room technology arose through work on the "Helpful Environment" [8], and more specifically through the use of online collaborative planning and task-support systems for search and rescue teams and emergency response [9]. One focus of this work has been to demonstrate the potential of I-Room virtual world and intelligent systems technology to the Multinational Planning Augmentation Team (MPAT), an organization consisting of 31 Pacific Rim nations whose purpose is to assist in coordinating more effective responses to regional crises [10]. MPAT trains for and responds to devastating events such as the 2004 Asian Tsunami; as might be expected, effective communication and knowledge-sharing are essential for coordinating an effective response.

At the start of a new mission it is typical for a collaborative web area to be set up, immediately providing a point of focus for posting incoming information. Links allow users to download open-source and freely available collaboration and communication tools. A server provides the facility to set up "rooms", which act as foci for storing and retrieving information specific to different areas of operations, etc.

Discussions with the MPAT Secretariat office suggests that the idea of developing the current approach to provide a Virtual Operations Centre (VOC) is an appealing one; however, it must be demonstrated that this can provide 'value added' benefits to the ongoing cooperative efforts of military, governmental agencies, and the international humanitarian community prior to and during crisis response situations. The VOC facility should be available during non-crisis periods for cooperation, training and mission preparation. This is a key requirement since MPAT participants do not have time to train during a crisis.

Based on (and inspired by) these discussions with MPAT coordinators, and analyses of their tasks and processes and the information that surrounds these, we have developed a prototype VOC for MPAT-type operations. Our aim is to demonstrate intelligent collaboration, process management, 'to do' list and planning capabilities that could operate alongside the mix of collaboration tools and web support already used by MPAT. The VOC has been realised in Second Life and the Open Source equivalent, OpenSim. However, once more the underlying concepts are intended to be independent of specific deployments. A practical example of its use is described in the next section.

Virtual Operations Centre for Homeland Security and Public Safety

EADS is a multinational company at the forefront of the aerospace, defence and related service industries. EADS Innovation Works (IW) UK began developing the concept of a Public at Large Scale Events (PuLSE) Technology Demonstration programme in early 2008. The aim of PuLSE is to demonstrate how disparate, mature and relatively immature technologies can be linked together. The initial demonstration scenario is the task of protecting the public at a high-profile sports event being held at the Celtic Manor Resort in South Wales, a location chosen both for its proximity to the headquarters of EADS IW UK and since it is to be the venue of the 2010 Ryder Cup golf competition.



Figure 3. I-Room – Homeland Security Virtual Operations Centre.

For this scenario the chief of security at the event would need to interact with colleagues in both real and virtual spaces without this disrupting the tempo of on-going activities. In addition, the ability to record and audit decisions for post-incident review is important during security operations. These considerations led to the deployment of a customized VOC in Second Life (Figure 3), with a parallel real-world briefing room which, in addition to standard communications facilities, was fitted-out as an Instrumented Meeting Room (IMR) that allows audio, video and other feeds to be captured, tagged and timestamped⁵. In adopting this twin virtual-real approach the intention was to address the requirements by:

- Using the IMR briefing room to demonstrate that it is possible to capture a fully auditable account of a high-tempo meeting for post-incident review;
- Using the VOC to demonstrate that it is possible to escalate the decision-making to incorporate more senior personnel at remote locations as and when the seriousness of the security situation demands it, and this also leaving an audit trail.

The scenario, as it was played out, required a response to a major security incident (a potential terrorist threat) during the event. The chief of security, located in the IMR briefing room, developed a plan of action with his immediate staff, and then uploaded this plan into the VOC I-Room. People playing the roles of senior officials from central government and the security services were invited to convene in the VOC, where they were briefed by the security chief and, after making recommendations and giving advice, a final plan was endorsed and recorded. The security chief then exited the VOC, and from the briefing room proceeded to put the plan into effect.

The point of this exercise was to show how the process of developing a plan under stressful conditions can leave an auditable trail of information and decisions through its various stages, and yet maintain a consistent (and consistently high) rate of progress.

⁵ See <http://www.amiproject.org/>

Virtual World of Whisky I-Room

The Virtual World of Whisky (VWoW) project represents a combination of virtual world technologies and intelligent systems to provide collaborative systems for educational and social purposes. Specifically, the goal of the project was to examine the technical feasibility of using virtual world technology to promote one of Scotland's iconic products, whisky, by supporting a community of interest in this area, including support for meetings during which tutored tastings are conducted.

Glenkeir Whiskies (trading as The Whisky Shop) has a successful e-commerce portal already in place, and Ian Bankier (Chief Executive of Glenkeir Whiskies) joined with AIAI to examine the feasibility of developing a virtual world-based social network focused around an interest in Scotch whisky. Alongside a number of educational and promotional virtual resources for this virtual community, a tutored whisky-tasting I-Room deployed in Second Life provides a venue for demonstrations and for holding tutored tasting events.

A whisky tasting was held in the Second Life VWoW I-Room on January 25th, 2008, to coincide with the traditional Scottish celebration of Burns Night, and another live tasting event was held at a later date that focused on demonstrating how different intelligent tools may work together to support an educational event in a virtual world. The tutorial itself was represented as a process within I-X, and supported by materials used to illustrate the talk and discussions. A knowledge base about Scotch whiskies and distilleries was available to augment the tutorial. I-X provided tutorial process support, which here included access to natural language generation facilities that draw upon the knowledge base to complement the tutor's presentation with factual information.

The success of the demonstration events – and the enjoyment had during them – has helped convince those involved of the potential of intelligent virtual worlds for engaging with existing and potential customer bases. On a more academic note, their use as a vehicle for the delivery of tutorials and tailored knowledge merits further interest. The I-Room project is exploring the potential for (partially) automated tutorial support to provide, for example, basic interaction with visitors to an unattended VWoW I-Room. Visitors would be sensed entering the room, and a process initiated through the I-X Helper calling on I-X Services to offer a number of experiences and tutorials, or tutored tasting tailored to specific whiskies that the participant may have to hand.

Summary, Status and Future Work

An I-Room is a shared persistent space with intelligent systems support for interaction and collaboration between users, systems and agents. It allows for the integration of a range of intelligent system aids, services and agents into the meeting. The I-Rooms described in this paper all employ virtual worlds technology to provide this interaction space, and augment this with support from external knowledge-based and intelligent systems. Here we have particularly focused on the support provided by the I-X planning, process and task support aids.

I-Rooms have been deployed in Second Life (on publicly accessible areas) and in OpenSim (on privately hosted servers). The software for I-X Services and the I-X Helper are available as open-source code. Sample 3D I-Rooms have been packaged with the software to make for simple deployment for trials.

I-Rooms have been running continuously since early 2008, and a number have been used for live events, collaboration meetings and discussions. These have included meetings with participants distributed across three continents. AIAI regularly opens an I-Room in support of teleconferences to give a visual indication of presence, rich media sharing, and simple ways to initiate back-channel interactions for participants, even when traditional video and audio channels outside of those available through the virtual world are in use with collaborators. In addition to those reported here, simulation scenarios and trials have been conducted in I-Rooms with companies including Disney, Kodak and Tata.

I-Rooms are also being applied to a range of national and international crisis and emergency response[11], homeland security, UAV mission monitoring, product design and review meetings, scientific project regular reviews, team training and simulation exercises. More details and software download links can be found at the I-Room project web site.

The basic I-Room AI concepts and technology are now being refined and made more generic. This work includes: the development of generalised links to knowledge-based systems; tailored natural language generation; capability modelling to identify and exploit opportunities in the virtual worlds; and semantic tagging of the various media and communication streams that constitute a virtual meeting to allow a higher level of context-sensitive support, with documentation, indexing and playback facilities. A number of in-world capabilities are being created to augment I-X support for intelligent interaction in virtual meeting spaces, virtual operations centres, and training rooms.

Acknowledgements

The Slam Games I-Room and Virtual World of Whisky projects were funded by the ERDF (European Regional Development Fund) and the School of Informatics at the University of Edinburgh. Thanks to Mr. Scott Weide and Col. (Ret.) John Bratton of the MPAT Secretariat for helpful discussions on the collaboration systems and standard operating procedures used by MPAT. The University and project funding partners are authorized to reproduce and distribute reprints and on-line copies for their purposes notwithstanding any copyright annotation hereon. The views and conclusions contained herein are those of the authors and should not be interpreted as necessarily representing the official policies or endorsements, either expressed or implied, of other parties.

The University of Edinburgh is a charitable body, registered in Scotland, with registration number SC005336.

References

- [1] A. Tate, "Intelligible AI Planning," *Proc. ES2000, The Twentieth British Computer Society Special Group on Expert Systems International Conference on Knowledge Based Systems and Applied Artificial Intelligence*, Springer, 2000, pp. 3-16.
- [2] A. Tate, "<I-N-C-A>: an Ontology for Mixed-Initiative Synthesis Tasks," *Proc. Workshop on Mixed-Initiative Intelligent Systems (MIIS) at the International Joint Conference on Artificial Intelligence (IJCAI-03)*, Acapulco, Mexico, August 2003.
- [3] R.A. Bartle, and R. Trubshaw, *DEC-10 MUD History*, 1978. <http://www.mud.co.uk/richard/mudhist.htm>
- [4] S. Buckingham Shum, D. De Roure, M. Eisenstadt, N. Shadbolt, and A. Tate, "CoAKTinG: Collaborative Advanced Knowledge Technologies in the Grid," *Proc. Second Workshop on Advanced Collaborative Environments, Eleventh IEEE Int. Symp. on High Performance Distributed Computing (HPDC-11)*, July 24-26, 2002, Edinburgh, Scotland. <http://www.aktors.org/coaking/>
- [5] J. Conklin, *Dialogue Mapping: Building Shared Understanding of Wicked Problems*. Chichester: Wiley & Sons, 2005
- [6] A. Tate, J. Dalton, and J. Stader, "I-P2 – Intelligent Process Panels to Support Coalition Operations," *Proc. Second International Conference on Knowledge Systems for Coalition Operations (KSCO-2002)*. Toulouse, France, April 2002.
- [7] S. Buckingham Shum, A. Selvin, M. Sierhuis, J. Conklin, C. Haley, and B. Nuseibeh, "Hypermedia Support for Argumentation-Based Rationale: 15 Years on from gIBIS and QOC," *Rationale Management in Software Engineering*, A.H. Dutoit, R. McCall, I. Mistrik, and B. Paech, eds., Springer-Verlag: Berlin, 2006
- [8] A. Tate, "The Helpful Environment: Geographically Dispersed Intelligent Agents That Collaborate," *IEEE Intelligent Systems*, 27(3), May-June 2006, pp 57-61.
- [9] G. Wickler, S. Potter, and A. Tate, "Using I-X Process Panels as Intelligent To-Do Lists for Agent Coordination in Emergency Response," *International Journal of Intelligent Control and Systems (IJICS)*, 11(4), Dec. 2006.
- [10] A.A. Weide, "Multinational Crisis Response in the Asia-Pacific Region: The Multinational Planning Augmentation Team Model," *The Liaison*, Feb. 2006. <http://www.coe-dmha.org/liaison.htm>
- [11] A. Tate, J. Dalton, and S. Potter, "I-Room: a Virtual Space for Emergency Response for the Multinational Planning Augmentation Team," *Proceedings of the Fifth International Conference on Knowledge Systems for Coalition Operations (KSCO-2009)*, Chilworth Manor, Southampton, UK, 31 March-1 April 2009.