I-Room: a Virtual Space for Intelligent Interaction

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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).

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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 Life[1] – 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 LambdaMOO[2] 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 Workspace[3] originally built by Mitre Corporation between 1994 and 1999, which used a 'buildings and rooms' metaphor for persistent storage of 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

[1] Linden labs Second Life™ - http://secondlife.com
[2] http://lambdamoo.info
[3] http://cvw.sourceforge.net

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.

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-P^2) [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. On behalf of its user, an I-P^2 can accept process-level activities to:

- Handle an issue;
- Perform an activity;
- Respect a constraint;
- Note an annotation.

Where appropriate, it can suggest performing these activities through:

- Manual performance;
- The invocation of internal or external capabilities;
- Delegation to other agents or services;
- Planning and executing a composite of these approaches.

Through reporting mechanisms, the I-P^2 helps the user to understand both the current state of the world and the current status and progress of issues, activities and constraints within the system. At its simplest, the I-P^2 acts like an intelligent 'to do' list providing context-sensitive assistance (Figure 2). The panel shows a user his or her current issues and activities, for which business processes, plans or Standard Operating Procedures (SOPs) can be selected or combined. Constraints can be imposed, and rationale or other information kept as annotations. An intelligent planning system, I-Plan, is included in the I-X tool suite to generate novel options based on stored domain models. The I-X suite also supports the collaborative element, with tools such as a structured-content instant messenger allowing issues and activities to be passed between agents to support workflow across an organization. Web services can be called to gather information or to enact automatically steps of the processes involved.

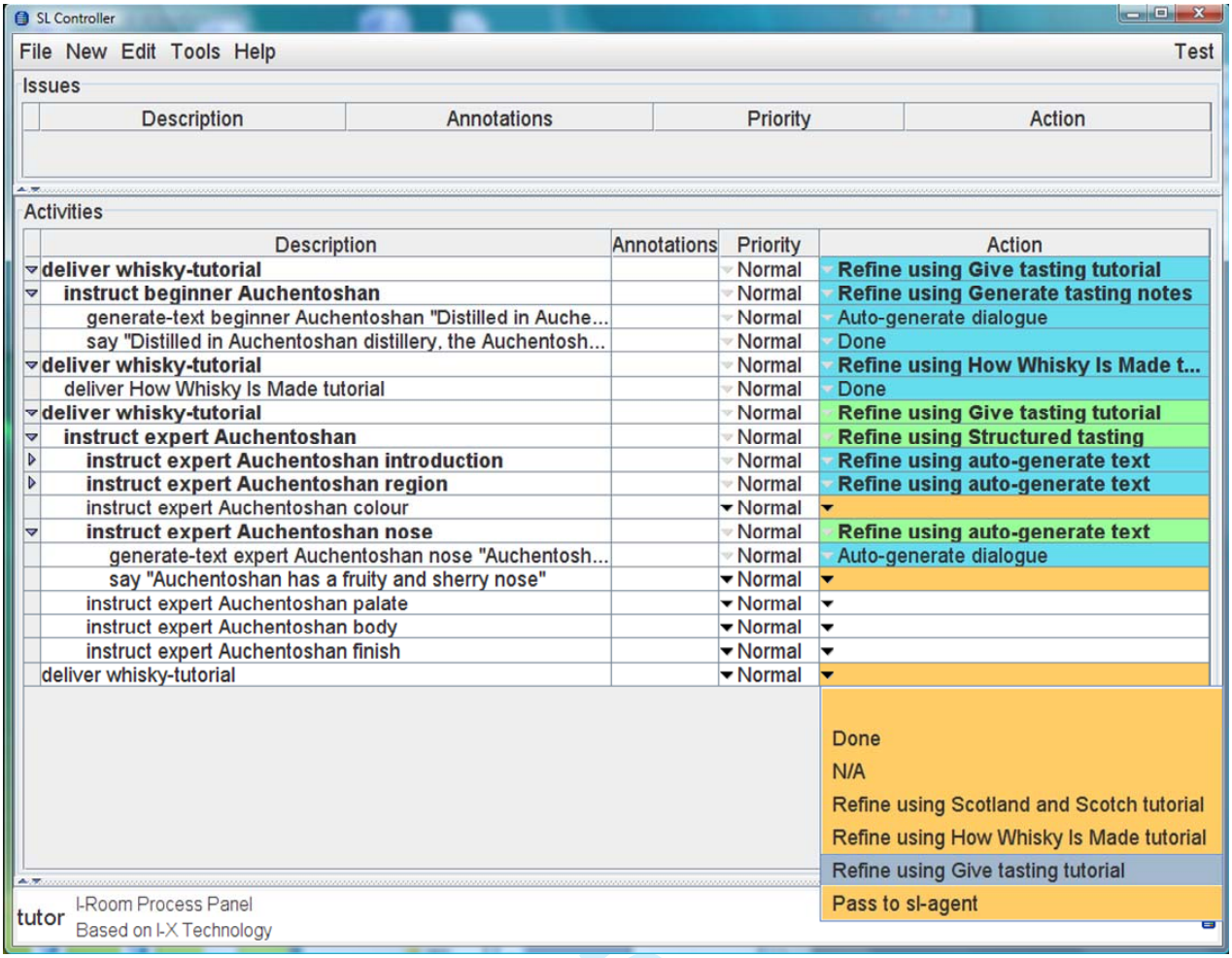

Figure 2: I-X Process Panel with its Action Selection Menu

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 [1] 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 agent presence models as in instant messaging systems;
- The use of I-X "I-Space" to support awareness of agent context, status, relationships within an organisational framework, capabilities and authorities;
- The use of an "I-World" of discovery of relevant agents and services along with descriptions of their capabilities, authorizations and availability.
- The use of the "Beliefs-Desires-Intentions" (BDI) model of agents [8] and their relationship to world state, context and other agents.
- 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 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 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 generic items (e.g. review of previous actions, AOB, date of next 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 potentially 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, or any relevant images or 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. An I-X Helper, which can be 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. This may take different forms depending on the communication and programming facilities within the virtual world platform.

Within Second Life for example, as shown in Figure 3, 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. 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.

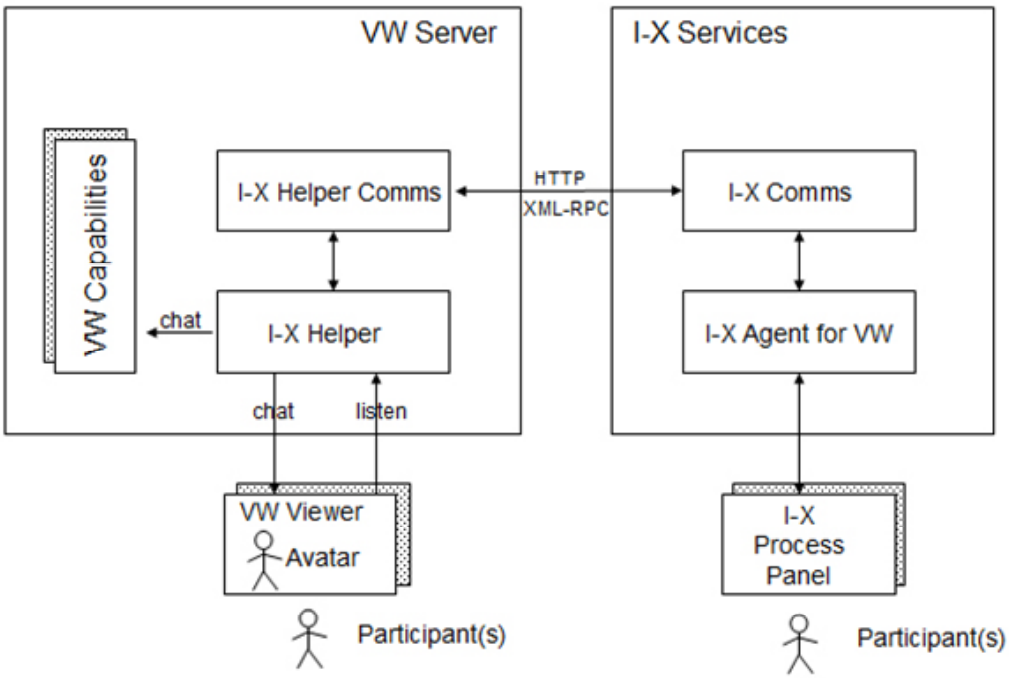

Figure 3: I-X Helper Connects Virtual World to I-X Services

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-P^2 and the I-Room on need.
- Image Generator: a mechanism outside the virtual world able to convert windows from I-P^2 and other external applications, web accessible images (however generated) and other video- and live-feed content into composite images suitable for display in virtual worlds[4].
- 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 within the virtual world reliably for different types of virtual world land areas, and on group-owned areas.
- 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]

[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 MxN matrix of images composed into a single entity with content referenced by cell.

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, often to geographically remote locations where the expertise today exists (such as Malaysia). Communication with its third party collaborators is mainly via the following mechanisms:

- e-mail, for sending files and messages relating to the project;
- telephone, for verbal discussions;
- Confluence[5] Enterprise Wiki. This stores all contacts, media, data, etc. This is used extensively in-house, with contractors having limited access, restricted to only the area directly relevant to their work;
- JIRA[6] for reporting bugs, testing, and milestone management;
- Campfire[7] Group Chat Environment using (typed, not voice) instant messaging with multiple participants. A room metaphor is used for virtual meetings, and records are kept for future reference.

Figure 4: Slam Games I-Room Meeting with Character Designs

[5] http://www.atlassian.com/software/confluence/
[6] http://www.atlassian.com/software/jira/
[7] http://www.campfirenow.com/

Internal company meetings also happen at weekly intervals during which issues are discussed, progress is monitored and milestones are managed. For this, Slam Games uses the Agile development methodology, specifically the Scrum method [9]. These meetings are also supported with the tools above.

The motivating scenario involves supporting the collaborative development of an ocean-themed computer game. In one particular project meeting, the design of characters in the game and the game's development progress are to be discussed. Several design images need to be compared and feedback for the artists is to be prepared. Hence, the scenario represents a meeting some way through a project. A project plan has already been generated and milestones have been set. Some weekly meetings have already been held. Actions from the previous meeting are discussed in turn and dealt with. Progress against the next set of milestones is also checked. Any new tasks are noted, along with any that are to be carried forward.

As shown in Figure 4, the 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-P^2 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 this particular meeting, artwork is to be discussed and is 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 presented, 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. In this application, anything that is to be recorded in the minutes must be 'said' in the virtual world by meeting participants on a specific chat channel (a common way to communicate between objects in such virtual worlds). The in-world I-X Helper agent listens on this channel for specific keywords which indicate how to process the message. For instance "*action* Ai Austin improve seating in meeting room" would indicate an action placed on the participant "Ai Austin" to be recorded by the Helper, and "*minute* we cannot agree on this issue without JeffD Arida" indicates a minute to be associated with the current phase of the meeting. The use of a dedicated channel (which will not necessarily be known to all participants, but perhaps only to nominated avatars or groups) allows a certain degree of control to be maintained, effectively allowing the chair of the meeting or a designated secretary to determine which items are destined for the meeting records; however the I-X Helper echoes each item it receives to all in the room so that all meeting participants are aware of the items that are being recorded.

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 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.

In this project, an operational demonstrator was produced. This addresses many of the support requirements outlined for the scenario above. A video of a sample meeting using the I-Room is available from the I-Room website[8] .

Slam Games participated in trial meetings using a real game design and related media. They provided a qualitative evaluation of the value of the I-Room technology against their requirements. In summary, they 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 collaborative 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" [10], and more specifically through the use of online collaborative planning and task-support systems for search and rescue teams and emergency response [11]. 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).

MPAT is an organization consisting of 31 Pacific Rim nations that has developed shared knowledge and procedures (the Multinational Forces Standard Operating Procedures – MNF SOP) to assist in coordinating more effective responses to

[8] http://www.aiai.ed.ac.uk/project/i-room/

regional crises [12]. MPAT trains for and responds to devastating events such as the 2004 Asian Tsunami, during which MPAT helped affected countries gain more effective access to the specialized capabilities of responding organizations. The archived data from MPAT operations during that catastrophe and during the Southern Leyte Mudslides in the Philippines in 2006 have been made available for further study.

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 information that is being gathered and shared. 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.

Coordination with the MPAT Secretariat office suggests that the concept of a Virtual Operations Centre (VOC) may have potential for MPAT if it can be designed in a manner to provide 'value added' benefits via the Internet to the ongoing cooperative efforts of military, governmental agencies, and the international humanitarian community prior to and during crisis response situations. A number of high-level preliminary requirements for such a VOC can be identified:

- It is important to really capture the essence of the "operational environment" and its standard operating procedures. These need to be supported via the content and interfaces provided.
- It is important that people can enter easily via the Internet, that there is good control of who enters, to ensure the identity of those involved is known.
- There must be simultaneous support of chat, virtual aids, Voice over IP (VoIP), and the ability to put in other "working boxes" of information (charts of afflicted areas, recent photos, latest needs assessments, etc.). These must permit users to update information as well as viewing it.
- Quality voice communications is necessary, including the ability for people in the field to link in via cell phones and suchlike.
- There is a need to support limited-bandwidth access to the key elements of the cooperation. In a crisis there will be some countries that have high-bandwidth access, but others were access is restricted due to national limitations and due to the impact of the crisis itself.
- The tools should be free (or inexpensive) for a large number of the potential participants to attract users.
- "Operator" comments on the facilities offered will be the key for turning the virtual capabilities into very useful tools.

The concept should extend to a day-to-day "non-crisis" capability, through which one has full, immediate access to communication and collaboration tools from anywhere in the world. The facility should be designed to allow use of the Centre in 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) discussions with MPAT coordinators, and analyses of their tasks and processes and the information that surrounds these, we have developed a prototypical Virtual Collaboration Centre 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. We hope that these might initially be suitable for preparedness training exercises and rehearsals, and later for real missions.

The Virtual Collaboration Centre has been realised in Second Life and the Open Source equivalent, OpenSim. However, the underlying concepts are intended to be independent of specific deployments.

The plan of this MPAT I-Room collaboration space provides a central lobby in which meeting participants (via their avatars) can arrive and their presence be noted, and from which the unrestricted lines-of-sight allow users to gain a quick visual and non-intrusive overview of current activity in the surrounding collaboration rooms, the work areas that adjoin the central area. These rooms can rapidly be specialized to support different functions or areas of operation that arise during an emergency. This mirrors current collaborative systems and web-based VOC concepts already in use by real emergency response communities and organisations, including MPAT via their web-based collaborative portal.

It is usual for one area of the I-Room to be set up as a mixed-reality meeting space where audio-visual links can be made between a real meeting room and the participants who join via their avatars in the virtual world – see Figure 5.

Figure 5: I-Room – Real Meeting Space linked to a Virtual Space

The Virtual Collaboration Centre provides a facility within which it is possible to set up and maintain a persistent set of information assets (e.g. wall posters, maps, etc.) and dynamically loaded content (such as imagery, movies, web page contents, etc.) in an area that is shared by the participants. They can access and modify these during synchronous meetings, and also at other times as the situation develops and users set about their individual tasks.

Virtual Operations Centre for Homeland Security and Public Safety

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 through an underlying security architecture. 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 EADS IW UK, to reflect the Welsh Assembly Government's investment in PuLSE, and since it is the location of the Golf Ryder Cup in 2010.

While the scenario is such that the chief of security at the event would need to interact in both real and virtual spaces, a key requirement was that the tempo of the security operation should be maintained throughout. Furthermore, given the implications of the choices that are made, the ability to record and audit decisions for post-incident review is important in this field. These considerations led to the creation of a Virtual Operation Centre (VOC) in Second Life (Figure 6), with a parallel real-world briefing room which, in addition to standard communications facilities, was, with support from the University of Edinburgh[9], fitted-out as an Instrumented Meeting Room (IMR) that allows audio, video and other feeds to be captured, tagged and timestamped. In adopting this twin virtual-real approach the intention was to address the requirements by:

- Demonstrating that it is possible to capure a fully auditable account of a high-tempo meeting for post-incident review (using the IMR briefing room);

[9] See http://www.amiproject.org/

- Demonstrating 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, all this also taking place within an auditable scenario (using the VOC).

To meet this requirement, the design of the VOC incorporated a number of specific features:

- A briefing area with screens capable of showing PowerPoint briefings and streamed video;
- A 'bird table' briefing area: a bird table is a dynamic and interactive map of some sphere of operations, usually placed horizontally, and, in this case, displaying a scale representation of the event at the Celtic Manor resort;
- A central reception area, showing 'watch keeper' situation monitoring facility;
- Wall viewers showing, for example, live EADS newsfeeds, multiple clocks representing various time zones and screens showing still images and slides;
- A virtual 'security guard', positioned at the entrance to the VOC to represent the security features protecting access to the site;
- I-Room functionality to allow structuring of meetings and recording of events and decisions.

Figure 6: I-Room – Homeland Security Virtual Operations Centre

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 a process of developing a plan under stressful conditions can leave an auditable trail of information flow and decisions through its various stages, and yet maintain a consistent (and consistently high) rate of progress. The scenario was played out during an EADS IW UK Technology Day, attracting

interest from invited government and security services representatives. With the endorsement of the success of the initial demonstration and the interest it has engendered, future research is planned to investigate the real-time use of blended real-virtual decision-making spaces.

Role of I-X in Emergency Response Systems

[This section may be suitable for an "Information Box" close to this position]

The I-X project team's vision for future emergency response systems [10] is:

> The creation and use of task-centric virtual organizations involving people, government and non-governmental organizations, automated systems, grid and web services working alongside intelligent robotic, vehicle, building and environmental systems to respond to very dynamic events on scales from local to global.

This could involve advances in the following areas:

- Multi-level emergency response and aid systems: personal, vehicle, home, organization, district, regional, national, international;
- Backbone architectures for progressively more comprehensive aid and emergency response; also used for aid-orientated commercial services;
- Robust, secure, resilient and distributed systems;
- Advanced knowledge and collaboration technologies;
- Low cost, pervasive sensors, computing and communications;
- Changes in standards, regulations and working practices.

The work envisages the use of intelligent systems in support of geographically dispersed communication and collaboration between teams and individuals working with a range of agencies. Truly distributed mixed-initiative work will be the focus, allowing for the following tasks:

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

I-X Technology has a number of aspects which may support collaborative working in emergency response:

- Supports the organization of, and communication between, search and rescue components;
- Uses <I-N-C-A> shared model for task-directed cooperation between human and computer agents;
- Allows task coordination via refinement of plans, delegation of activities and calls on services;
- Provides reasoning, constraint management and other functional capabilities as plug-ins;
- Provides a plug-in mechanism to allow queries on knowledge bases, links to external tools such as natural language generators, etc.

Engagement with the Personnel Recovery and Search and Rescue agencies in the UK and the US [13][14] has also identified a number of requirements which I-X technology can address to assist in this type of operation:

- Communications
  - Simple Chat
  - Structured chat
  - Information sharing
- Task Support
  - Checklists
  - To do list
  - Progress reporting
  - Plan option aids
- Whiteboards

    - Incident
    - Weather/Codes/Info
    - Assets
- Map boards
    - Web Resources
    - Fact Book
    - Phone List
- Active Mission Folders

When I-X Technology supporting some of these requirements is used through a virtual world platform, and in conjunction with video and/or voice teleconferencing, it provides a powerful toolkit to support teamwork in Search and Rescue.

I-X has components for the whole lifecycle of collaboration and task support. It includes a simulation system which can be used to produce training environments and to support trainers in driving rehearsals and exercises. I-X can therefore support a number of modes of use (as in FireGrid [15]):

Design Mode: supporting domain knowledge capture, modelling and management, the generation of pre-built options, and identifying key tasks in the domain.

Training Mode: what-if exercises, rehearsal, lessons-learned, key topics.

Response Mode: planning, decision support and execution.

Virtual World of Whisky I-Room

The Virtual World of Whisky (VWoW) project represents a combination of virtual world technologies[10] 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 supporting 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.

A number of I-Room experiments have been conducted and resources have been developed during the VWoW project including a set of educational virtual tours that can be used as a template for creating other tours; a virtual tutored whisky-tasting room deployed in Second Life built on Virtual University of Edinburgh (Vue)[11] virtual real estate provides a venue for demonstrations and for holding tutored tasting events.

Outcomes of this project include a set of generic educational resources which, in this instance, have been applied to support and promote the Scottish whisky industry, but could easily be utilised in other domains.

A whisky tasting was held in the Second Life VWoW I-Room[12] on January 25th, 2008, to coincide with the traditional Scottish celebration of Burns Night[13] and another live tasting event was held that focused on demonstrating how different intelligent tools may work together to support an educational event in a virtual world. Human participants in these tastings gathered virtually in the guise of their Second Life avatars in the VWoW I-Room. Via a live video feed, a tutored whisky-tasting was delivered by an expert, with the participants prompted to sample the (real) whisky in question at appropriate times. A question-and-answer session with the Chairman of Glenkeir Whiskies encouraged the participants' interaction in the tutorial.

[10] Using (publicly accessible) Second Life and (privately hosted) OpenSim – http://opensimulator.org.
[11] http://vue.ed.ac.uk
[12] http://slurl.com/secondlife/Informatics/208/159/25
[13] Burns Night is the annual Scottish celebration of the life and works of Scotland's most famous poet, Robert Burns; whisky drinking is an important – some would say vital – part of the celebration.

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. Natural language generation was possible from within I-X as part of the overall tutorial process support.

The tutored whisky tastings conducted in the VWoW I-Room mirror whisky-tasting events that The Whisky Shop regularly holds in real life. Videos of both events are available through the I-Room project website.

Figure 7: Virtual World of Whisky I-Room in Second Life

The VWoW I-Room in Second Life can be seen in Figure 7. This room contains a number of objects and decorative elements that help create the atmosphere of a real whisky shop[14], chairs for avatars to be seated on during the tasting (reinforcing the notion of attendance at an event) and animated whisky glass objects that the avatars are free to use (reinforcing the idea that this is specifically a whisky-tasting event). Two screens are used to relay external video streams (and their audio tracks) and static images to the participants.

The link to the intelligent systems technology, in the form of an I-X system external to the virtual world, is provided through the presence of an I-X Helper object in the room. The Helper plays a mediating role, receiving and executing tutoring activities from I-X on the one hand, and on the other, passing information about the occupants of the room and the state of the session out of Second Life and back to the I-X system.

With this mechanism in place, an I-X whisky-related tutorial application has been developed. It is assumed that the tutor has access to an I-P^2, which provides a 'to do' list for the tutorial and allows the tutor to access a number of different process models specifically tailored for this domain. These models include several different tutorials to deliver to the occupants of the room: a tutorial giving a general introduction to Scotch whisky and whisky-producing regions, a tutorial describing the process of making whisky, and support for tutored tasting of specific regional types of whisky.

[14] Based on The Whisky Shop in London.

To exploit the visual and auditory capabilities of Second Life, these processes contain references to video and image content. A number of short video segments to support tutored tastings were recorded by the Chairman of Glenkeir Whiskies and made available as web accessible resources. This content is available using URLs to allow the easy delivery of this sort of structured tutorial (and perhaps even the automation of tutorials). However, the system is also flexible enough to allow a tutor to provide a less rigid tutorial as and when the occasion dictates, providing mechanisms by which appropriate images or video clips can be dynamically selected and displayed on screens in the VWoW I-Room.

A further aspect of the tutorial support offered by I-X lies in the use of Natural Language Generation (NLG) technologies to automatically generate text. This exploits a comprehensive Scotch whisky knowledge base (in OWL), underpinned by a rich ontology, which describes whisky types, their characteristics and classifications, distilleries and so on.

One use of the NLG technology incorporated in the VWoW I-Room generates simple sentences introducing the whisky in question, saying something about the distillery and the whisky's geographical classification, and describing its characteristics of nose, colour, palate, and so on. These sentences could be used by the tutor as the factual basis of his tutorial or to supplement his words, or else could be used to support simple automated tasting tutorials. During one of the live events run in the VWoW I-Room, I-X offered to the room a chat line indicating the colour of the specific whisky (Auchentoshan) that was being tasted. The tutor picked up on that information, in an interesting example of true mixed-initiative engagement, to point out to the VWoW I-Room participants that the colour was due to a specific form of barrel that had earlier held sherry which is only used in the whisky-making process in that one region of Scotland. If the participants and tutor had chosen to, they could have used I-Room support and in-built process models to explore the whisky-making process and see images of that process, the equipment involved, and even specific distilleries.

A more complex use of NLG that has been explored is to provide richer tasting descriptions, closer in style to the sort of tasting notes that a human expert would use (and developed from an analysis of the language used in such tasting notes)[15]. In doing this it is hoped that something of the enthusiasm of the expert can be captured and conveyed to those who visit the VWoW I-Room even when a human expert is not in attendance.

Each of these tutorial processes is supported by the in-world I-X Helper object. In accordance with the notions of I-X as an activity-support tool, this is accomplished by passing activities to the Helper. These can be activities that the Helper can perform directly (such as "say" something to the occupants of the room), or activities that the Helper can perform through exploiting the capabilities of other objects in the room (such as "display" some image, which is passed on to one or other of the screens). (Activities that the Helper can neither perform directly or indirectly are echoed to the room in the hope that a listening avatar or object can perform this action.) In addition, the Helper can monitor certain events, such as the arrival or departure of avatars, which are represented to the I-X system as state information. This state information can be used to guide or qualify behaviour; for example, the start of a certain tutorial process may require (as a precondition) the presence of a certain number of avatars in the room. The Helper also provides some indication of when its activities have been performed; this can be useful in processes containing strict sequential constraints (for example, before describing the whisky regions of Scotland, one might first want to ensure that the corresponding map has been displayed to the occupants of the room).

The success of the demonstration events – and the enjoyment had by their participants – has helped convince those involved of the potential of intelligent virtual worlds for reaching and 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[16]. 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, and to encourage them to try a single malt Scotch. Beyond this, the VWoW project developed a facility that would allow participants to take a virtual balloon ride (with automated commentary) over 'Scotland', exploring its whisky regions and visiting a distillery.

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.

[15] Work done in collaboration with C. Christodoulopoulos, Informatics M.Sc. student at the University of Edinburgh.
[16] Visit http://slurl.com/secondlife/Informatics/208/159/25

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 areas [16], 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 including the provision of software-driven characters.

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