e-Ghosts: leaving virtual footprints in ubiquitous workspaces

Michael Vernik[1], Steven Johnson[1], Rudi Vernik[1,2]
[1]School of Computer and Information Science
University of South Australia
Mawson Lakes Boulevard
Mawson Lakes South Australia 5059

[2]Defence Science and Technology Organisation
PO Box 1500
Edinburgh South Australia 5111

vermj003@students.unisa.edu.au
johsj001@students.unisa.edu.au
rudi.vernik@dsto.defence.gov.au

Abstract

Ubiquitous workspaces are future media-rich environments that employ new forms of operating systems and services to coordinate and manage interactions between people, multiple display surfaces, information, personal devices, and workspace applications. e-Ghosts is a meta application which makes novel use of workflow to support the coordination and orchestration of briefings and demonstrations within a ubiquitous workspace. This paper describes this new class of application and discusses a range of characteristics that need to be considered in relation to their design and implementation. Managing the trade-offs between interactive and automated modes in such dynamic and complex environments is of particular concern.

Keywords: ubiquitous computing, human computer interaction, workspace orchestration.

1 [1]Introduction

LiveSpaces[1] is a ubiquitous workspaces project being conducted by the University of South Australia (UniSA e-World Lab) [2], the Defence Science and Technology Organisation (DSTO) [3] and the Cooperative Research Centre for Enterprise Distributed Systems Technology (DSTC) [4]. It is addressing how physical spaces such as meeting rooms can be augmented with a range of display technologies, personal information appliances, speech and natural language interfaces, interaction devices and contextual sensors to provide for future interactive/intelligent workspaces. Research is being undertaken to address how these future workspaces can be rapidly configured, adapted, synchronised and used to support a range of collaborative work activities in areas such as military command environments, large-scale software enterprises, and health systems.

The initial LiveSpaces implementation at e-World lab currently supports a range of student projects in areas such as workspace orchestration, universal workspace interfaces, and augmented reality. Furthermore, the lab will be used to support collaborative DSTC projects such as Augmented Synchronised Planning Spaces (AuSPlanS) which is developing and validating the requirements for the support of large-scale intensive planning activities in areas such as disaster relief, peacekeeping, and war fighting. The presentation and demonstration of new concepts and research results poses a particular problem. For example, the significance of particular pieces of work is often only apparent when demonstrated together with other work. However, staff and students are not always available to present and demonstrate work in this way. Providing presentations and demonstrations can also be costly in terms of the time required to prepare for and conduct a session of this type. Added to this is the problem of a transient research community within the lab: students graduate, staff leave, people finish placements and sabbaticals etc. Briefings are often required at short notice such as when unexpected visitors arrive. In these cases demonstrations are prone to failure and are of varying quality. These are common problems for many organisations, particularly those associated with Research and Development (R&D) projects, where significant amounts of time needs to be devoted to the presentation and evaluation of the work being undertaken.

Our approach for dealing with these problems has been to develop meta applications using the LiveSpaces capabilities to help automate the briefing and demonstration of our R&D. One of these applications is e-Ghosts which has been designed to present and demonstrate the LiveSpaces infrastructure and the contributions of those involved in e-World research, both past and present (i.e. allowing researchers to leave their virtual footprints). e-Ghosts utilizes various types of media such as video, images, text and speech. Unlike conventional applications, e-Ghosts is programmed using a novel application of workflow technology to orchestrate, coordinate, and control multiple projectors,

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computers, applications, display surfaces, and lighting. Interactive demonstrations require us to invoke multiple applications, some having complex interfaces and requirements such as in the case of our augmented reality work. [5]. Our work to date shows the feasibility of orchestrating complex co-ordination activities in ubiquitous workspaces. We have identified a range of interesting characteristics and considerations for the design of meta applications such as e-Ghosts. For example, there are important tradeoffs that need to be considered in terms of the degree of automation verses user interaction, particularly when characteristics such as failure tolerance are considered. Also, the design of these applications needs to consider "director's art". Just as in movie production, the most appropriate placement of images on screens, lighting effects, and timing all need to be considered to achieve the greatest effect. However, in the case of a ubiquitous workspace, we are dealing with a dynamic experiential environment where the entire space is alive.

The paper is structured as follows. Section 2 provides an overview of LiveSpaces and discusses the infrastructure and technologies present in our e-World Livespace. Section 3 describes the e-Ghosts application and its characteristics. We discuss various issues and considerations related to the design and implementation of these types of applications. Section 4 discusses potential areas for future work. We believe that these types of ubiquitous workspace applications have significant utility for the types of briefing and demonstration activities that have been our prime focus in the design of e-Ghosts. The results also show significant potential for areas such as simulation-based training and entertainment.

2 LiveSpaces

A community of ubiquitous computing researchers has been focusing their attention on the technology augmentation of physical collaborative workspaces such as meeting rooms. Examples of research initiatives in this area include Stanford's Interactive Workspaces [5][6], GMD's i-Land[8], MIT's Intelligent Room[7], and Active Spaces at the University of Illinois Urbana Champaign (UIUC)[10]. Much of the focus has been on the underlying operating environments and infrastructure required for coordinating the various devices, displays, and applications within a workspace. Although some work has been done in automating the set up of environments and the capture and playback of activities during workspace sessions [11], we know of no other approaches that have orchestrated entire briefing and demonstration sessions as has been done with LiveSpaces and e-Ghosts.

Our LiveSpaces project focuses on support for intense collaborative activities within and between ubiquitous workspaces. Figure 1 shows the architecture of the current LiveSpaces implementation at e-World Lab. The architecture has at its core a Workspace Infrastructure that coordinates access to various workspace services, devices, computers and applications within a ubiquitous workspace. The Workspace Infrastructure acts as the operating system for the entire workspace. In LiveSpaces, we use the Interactive Room Operating System (iROS) from Stanford University [6] as the basis of the Workspace Infrastructure. A key component of iROS is the Event Heap which acts as a blackboard with two levels of data abstraction implemented using an extended tuple space approach. iROS also implements a persistent context memory called the Data Heap which allows any process to store and retrieve data that will be relevant across applications and sessions [12]. iROS includes several other components including iCrafter [13], a system that provides support for service advertisement and invocation and the generation of user interfaces (used for controlling lights, projectors, etc), and PatchPanel [14], a mechanism for integrating heterogeneous software and hardware components into a ubiquitous workspace.

Another key architectural element in LiveSpaces is the Enterprise Bus. It provides the mechanism for communication and synchronisation within and between distributed workspaces[1]. It also provides a flexible approach for integrating various enterprise computing elements such as ontology services, database services, workflow engines, and other web services. In our current LiveSpaces implementation we use a publish subscribe system called Elvin [15,16] and the associated ODSI[17] peer-to-peer infrastructure as the basis of the Enterprise Bus. ODSI peers are generic software elements that act together as application servers to discover and manage the use of services.

A key focus of the LiveSpaces work is to investigate how various workspace support services and knowledge services can be employed to facilitate intense group activities such as time critical decision making, analysis, and planning. As part of our work we have developed a novel Passive Tracking and Detection Framework service [18] based on augmented reality technologies to track objects such as people and devices in a workspace. The approach uses a camera array and fiducial marker cards, the cards can both track objects and act as ambient information displays. Other services that we have available in the LiveSpace include an initial workspace orchestration service based on the use of a workflow engine called Breeze[19], and speech recognition and synthesis services. We are currently working on advanced workspace services including media services and automated speech transcription services.

A range of applications are available within LiveSpaces including common business applications such as those provided in Microsoft Office and new types of ubiquitous workspace applications such as PointRight [20] and Multibrowse [21] from Stanford. We have been undertaking research into new types of workspace applications such as universal session interfaces (a type of "room desktop" which provides a common interface for uses of a LiveSpace), and Kayla, an intelligent workspace assistant.

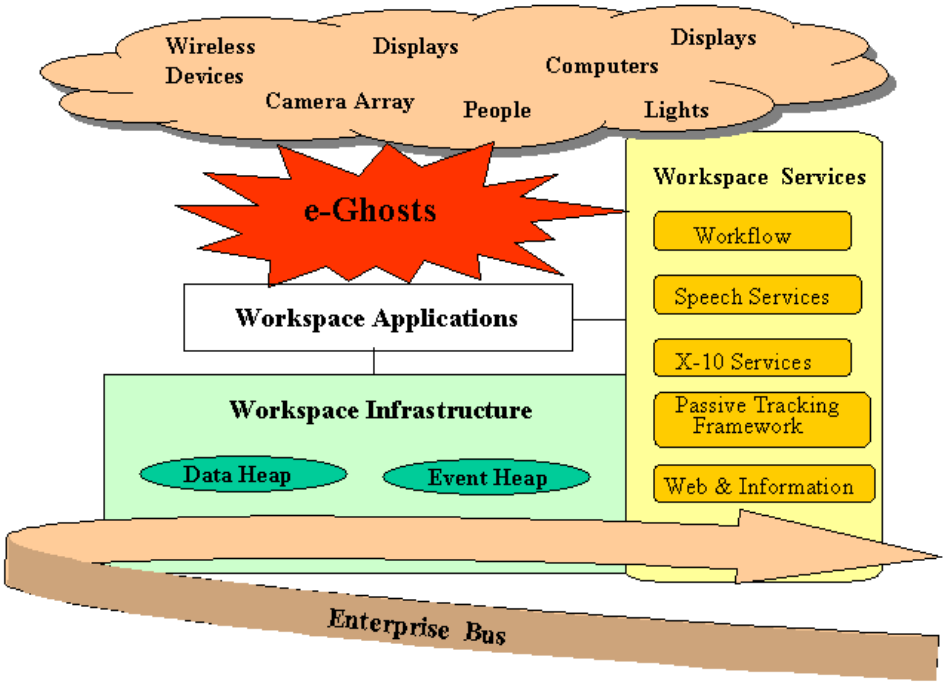

Figure 1: LiveSpaces e-World Implementation

3 e-Ghosts Concepts and Implementation

As shown in Figure 1, e-Ghosts is seen as a meta-application that can control and coordinate a range of workspace services, applications, devices, information and media. It uses the workspace orchestration service, currently implemented using the Breeze workflow engine and the Bred graphical workflow editor, as the programming mechanism. e-Ghosts invokes multiple applications and information sources to provide PowerPoint presentations, to display images and videos, to enable speech synthesis, allow access to web content, and to run various pieces of multimedia. Multiple devices including projectors, lighting, and computers are invoked as are applications that provide live interactive demonstrations.

Figure 2 shows an e-Ghosts session in operation in the e-World LiveSpace. The image shows the various components that are used as part of the session including a SmartBoard interactive display [22], projectors, the camera array, fiducial markers, lighting, and ambient displays. The application begins with Kayla, the Intelligent Workspace Assistant, providing a welcome address and then initialising the space through the control of lighting, displays, and projectors. An overview of the e-World lab and LiveSpaces concepts is then provided. Recorded speech, videos, and images of e-World researchers and students (i.e. the Ghosts) are inter-dispersed with speech synthesis descriptions provided by Kayla. Live demonstrations are provided to help communicate concepts. For example, we use the game of Pong running across several display surfaces to demonstrate how events are coordinated across the various displays and computers in the workspace. Participants can interact with the game to further their understanding. We also provide a live interactive demonstration of the augmented-reality based Passive Detection Framework. Speech synthesis is used to describe the concept and a 3D Virtual Reality (VR) model of the workspace is displayed on the SmartBoard. Participants are asked to pick up and move the fiducial marker cards on the table to show how the camera array tracks the cards. The results of these interactions are displayed in the VR model of the workspace where participants can see the cards floating in space relative to a virtual representation of the table.

3.1 Coordination and Orchestration

The coordination of the devices and applications for interactive demonstrations within a ubiquitous workspace is a complex task. For example, when e-Ghosts initializes the augmented reality Passive Detection Framework (PDF) demonstration, a number of devices must be configured quickly. The PDF demonstration application must be run on the SmartBoard. Fiducial marker detection is not accurate without overhead lighting, hence lighting above the table is switched on. The LiveSpaces virtual assistant talks about the project and prompts people to use the demonstration. This needs to be appropriately synchronised. Data relating to the PDF, such as keywords and people working on the project are placed on other displays in the LiveSpace at the appropriate times. If there is not sufficient information to fill all displays, logos related to the lab are displayed. Once the demo has been run for a specified amount of time, the workspace automatically reconfigures by resetting lighting and displays and e-Ghosts continue on.

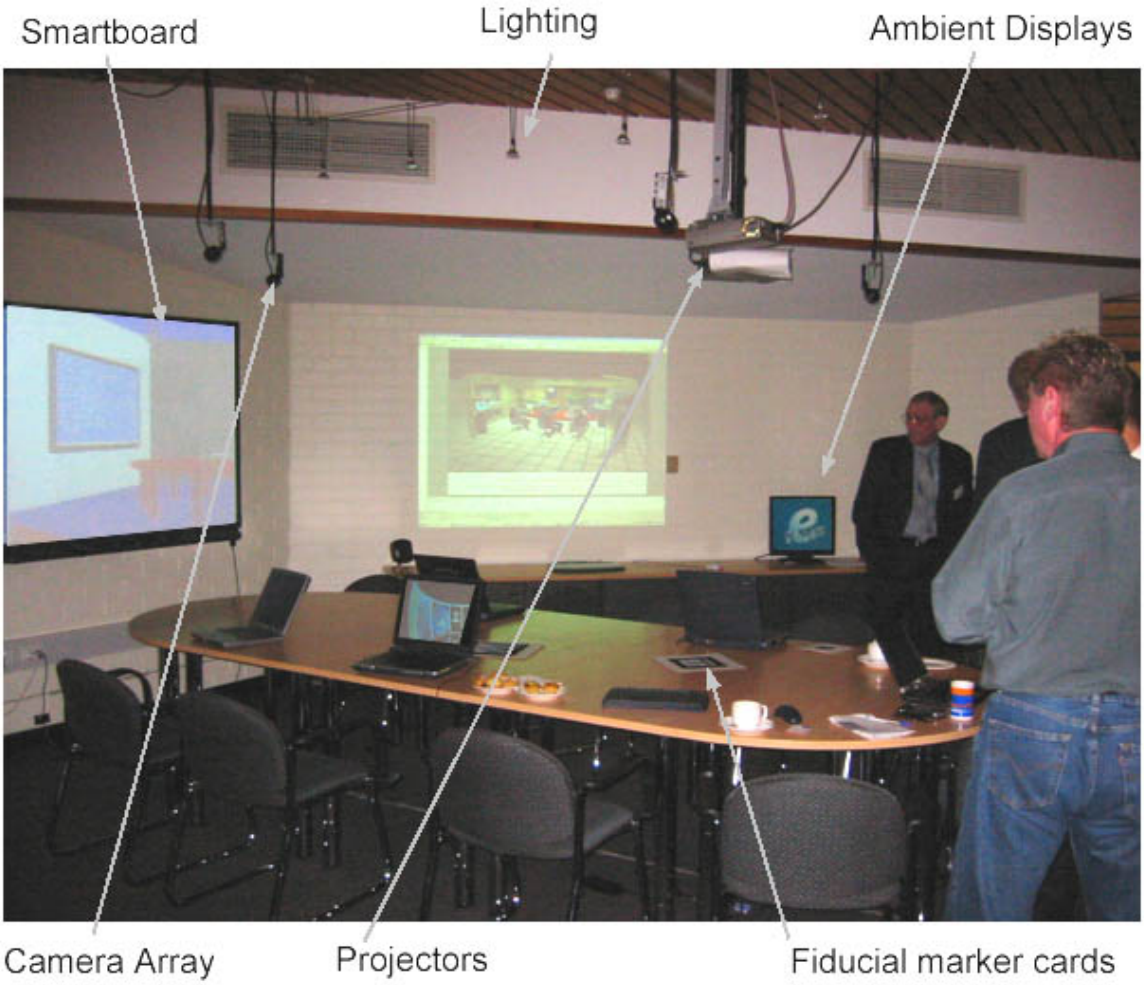

Figure 2: e-Ghosts Operating in e-World Lab LiveSpace

The programming of e-Ghosts is more akin to directing on a movie set than conventional software development. The notion of "directors art" needs to be considered as a key part of the process to ensure that timing, displays, lighting, and experiential factors are all taken into account when crafting this type of application. As previously discussed we make a novel use of workflow to coordinate tasks on each display and other events in the LiveSpace. We use the Bred graphical workflow editor to design and modify the workflow. Although the workflow can invoke the appropriate operations within a particular sequence, there is no support in Bred to support the broader design characteristics of these types of applications. Moreover, the Breeze workflow engine provides only rudimentary support for these types of complex orchestration tasks. Support for systems design and implementation is also important. For example, the workflow is able to communicate with each display using ODSI peers. Python [23] services were developed for ODSI that allows each of the e-Ghosts tasks to be carried out. Graphical design tools for these aspects of the implementation would make the development of these meta-applications more universally available.

3.2 Adaptability, Fault Tolerance and Usability

Adaptability, fault tolerance and ease of use are three key characteristics that need to be considered when designing applications such as e-Ghosts. The work and people in the lab changes over time. To be able to adapt to the changing situations, individual workflows were created for each major section such as current projects, the LiveSpace introduction and people in the lab. This modular approach allows for quick modification by way of a graphical user interface so that developers/maintainers can readily change the content and sequence without resorting to changing underlying code.

As well as providing the ability to quickly change items, the use of smaller workflow segments provides the ability to customize an e-Ghosts session depending on the users present. A web interface was developed to allow users to initiate e-Ghosts from a simple web page. A number of options in terms of the e-Ghosts modules are presented to users so that they can choose what they wish to view. PHP [24] scripts instantiate the e-Ghosts workflow by sending an ELVIN message through a Java interface. ODSI services are automated by a Python script that sets up appropriate services on each peer. This is automatically executed before the workflow is initiated.

The e-ghosts application is unlike a conventional movie or multimedia piece where a play button is pressed and the movie will play without interruption. For this reason, e-Ghosts was designed to be fault tolerant. In a ubiquitous workspace such as a LiveSpace, technologies

cannot be relied upon to be present. For example, a particular display surface may be malfunctioning or a particular wireless device such as a laptop may have been moved out of the space. Although we demonstrate a range of research, the backbone of e-ghosts was developed with stable components so that if all else fails, the core elements of the work will still be presented. Demonstrations, such, as the augmented reality work which requires specific applications and infrastructure, are added with a timeout. If that part of the infrastructure is not available, or fails e-Ghosts will still progress with somewhat reduced capability. This requires critical design of the e-Ghosts application. Care was taken so that it is not obvious when a component of e-Ghosts is missing during a particular demonstration.

3.3 Interactivity

Participant interaction during a session poses a particular challenge for applications such as e-Ghosts. Care needs to be taken during design to ensure that any interaction forms a consistent and pervasive part of the session. For example, the amount of time that needs to be spent on participant interaction varies with the context of the session. In managing this we use a 'count-down' monitor on one of the ambient displays so that the amount of time can be quickly adjusted by the session facilitator.

Participant interactions are also key points of failure for the application, particularly for research applications that are integrated into briefings. We have been careful to modularise and craft e-Ghosts so that it can degrade gracefully without participants being aware of failures. In many respects the ubiquitous workspace infrastructure provided through iROS aids this process in that it uses approaches that allow significant levels of flexibility by way of its underlying blackboard architecture. Exception handling within the underlying orchestration service is an area that needs further study to help ensure that failures due to participant interactions are handled appropriately.

4 Future Work

Our work to date shows the utility of the approach taken with e-Ghosts. We have developed an effective mechanism for automating briefings and demonstrations within a ubiquitous workspace. We have observed and recorded several limitation of the approach. For example, there is a need for a more rigorous approach to support the design and rapid development of these types of workspace applications. We intend to undertake research into the design methods and tools necessary for efficient and effective development of this class of application. We also intend to use the approach to support the demonstration and evaluation of concepts in a new project which is looking at the application of LiveSpaces concepts for intensive distributed planning activities in Defence domains. This will add an additional level of complexity in that simulation engines will be used to simulate collaborating distributed spaces and contextual information.

The control and coordination of interactions within an orchestrated session is an area that needs further study. We would like to use various workspace devices such as wireless handheld computers and tangible interfaces to support enhanced interactions initiated by the session facilitator and participants. For example, users could potentially pause the session by flipping a fiducial card or interact with Kayla through speech dialog to change the parameters and flow of the session. The use of our new universal session interface could also add to the degree of flexibility and interactivity of these types of application.

There is also a need to consider more advanced workspace orchestration and interaction services. For example the use of a conventional workflow engines such as Breeze are limited in that they do not provide the flexibility for adapting processes "on the fly". We would like greater support for being able to control a workflow based on changing contextual aspects such as the number of participants involved and the goals that the session is meant to achieve. Flexible workflow approaches, such as that provided by Adept [25] and Chameleon [26], will be studied to determine the effectiveness of these approaches for e-Ghosts style applications. Moreover, our work on future workspace orchestration services will begin to look at how the procedural orchestration provided by workflow engines can be augmented with cognitive aspects.

5 Conclusions

In this paper we have described an approach for automating the presentation and demonstration of R&D results within a ubiquitous workspace. We used LiveSpaces capabilities to orchestrate and coordinate the presentation of material across a range of devices and applications within a ubiquitous workspace using various forms of media including images, video, speech, and live demonstrations. A meta application called e-Ghosts was developed to present and demonstrate the LiveSpaces infrastructure and the contributions of those involved in e-World research, both past and present (i.e. their virtual footprints). Unlike conventional applications, e-Ghosts is programmed using a novel application of workflow technology to orchestrate, coordinate, and control multiple projectors, computers, applications, display surfaces, user interactions and lighting.

The work to date has shown that through e-Ghosts, virtual footprints can indeed be left behind in LiveSpaces. The approach we used has allowed us develop an adaptable, fault tolerant and easy to use application. In addition to orchestrating the presentation and demonstration of research within the e-World LiveSpaces environment, we believe that the approach would have merit for workspace training activities, other forms of interactive briefings, and entertainment. Future work will focus on developing the design approach and associated development tools for this class of application. These will need to take into consideration "directors art" so that aspects such as timing, lighting, sound, vision, and interaction can be appropriately orchestrated to achieve the desired experiential effects.

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