

Introduction

This book sets out a vision of pervasive IT through intelligent spaces and describes some of the progress that has been made towards its realisation.

The context for intelligent spaces (or iSpaces) is the world where information and communication technology (ICT) disappears as it becomes embedded into physical objects and the spaces in which we live and work. The ultimate vision is that this embedded technology provides us with intelligent and contextually relevant support, augmenting our lives and our experience of the physical world in a benign and non-intrusive manner.

The enormous advances in hardware, system design, and software that are being achieved enable this vision. In particular, the performance advances and cost reductions in hardware components — processors, memory, storage, and communications — are making it possible to embed intelligence and communications ability into lower cost objects. The Internet is a living experiment in building complex, distributed systems on a global scale. In software, there have been solid advances in creating systems that can deal with complexities on the scale required to interact with human activity, in limited domains at least.

The ultimate vision is challenging, and there are many obstacles to its realisation. There are several technical barriers, especially in the creation of intelligent software, but there are also social and economic barriers. We can already see the first deployments of this technology in domains where the benefits are substantial. It is not clear, however, whether there are sufficient value points and benefits to support the fully pervasive and synergistic infrastructure of the iSpace vision.

An iSpace consists essentially of three components:

- the physical world in which users exist, in their relevant context;
- the interface between the digital world and the physical world — this contains embedded sensors to gather parameters, labels to identify objects, actuators to control things/appliances in the physical world, together with support software to facilitate non-intrusive two-way communication across the interface;
- the digital world in which digital knowledge and intelligent systems are available to influence and support actions in the physical world.

This volume opens with three general chapters. Firstly an overview, by the editors, to describe the broader topic, followed by Lyons et al, in Chapter 2, who describe the impact of iSpaces on businesses and the way people will work. This is followed, in Chapter 3, by Thompson and Azvine, who identify what intelligent systems research is needed to prevent users being overwhelmed by the complexity of the systems with which they will be asked to interact.

Physical World — Applications, Benefits, and Concerns

There follows a set of chapters describing several different iSpace application areas. Firstly, Luckett, in Chapter 4, describes the use of such technologies for supply chain

and production improvements, where application has advanced to the stage of commercial trials. Next, Brown et al, in Chapter 5, describe monitoring the well-being of people in need of care in their own home. The first systems for well-being monitoring have also undergone trials, and the chapter describes research on the next generation of more intelligent systems. The following three chapters describe the conversion of the home to an intelligent space (Bull et al in Chapter 6), an intelligent co-operative vehicle highway system (Bilchev et al in Chapter 7), and mixed-reality systems where the real and digital multimedia worlds can be merged to augment user experiences (Bulman et al in Chapter 8). Martinez et al, in Chapter 9 on glacial iSpaces, emphasise that the technology is applicable to hostile environments where humans rarely go but where we want to know what is happening.

These are just a few example application areas selected from the almost limitless possibilities where the technology could have a significant impact.

There are, however, concerns about trust, privacy, and security in these systems. Selezynov et al, in Chapter 10, define realistic models of digital trust that are capable of dealing with the uncertainties inherent in the environment to help engender trust. Then Soppera and Burbidge, in Chapter 11, describe privacy issues, including legal and technical aspects, and offer a privacy management system for iSpace devices. In Chapter 12, the same authors describe the issues and approaches to satisfying the needs for privacy in the application of radio frequency ID (RFID) technologies, such as those introduced in Chapter 4.

The Interface — Observing Human Activity

In order that the relevant parameters can be gathered to make applications truly beneficial there is a need for a wide range of high-performance and low-cost hardware technology to form the interface between the real and digital worlds. Payne and Macdonald, in Chapter 13, analyse the massive advances and ongoing trends that have occurred in the hardware area, covering silicon, batteries, displays, wireless connectivity, etc. They conclude that there is still some way to go to achieve the full vision, but that enough progress has been made to have real impact in the immediate future. Heatley et al, in Chapter 14, show how large amounts of information can already be gathered from very simple sensors, e.g. attaching a microphone to the water pipe can lead to inferences of many household activities to feed data to a homecare application.

Xu et al, in Chapter 15, tackle the issue of automating visual events detection-and-behaviour analysis for advanced visual surveillance systems. Extracting behaviour from such sensors would considerably empower iSpace technology. The iSpaces can also allow the inference of interests a user might have and hence help retrieve contextually relevant information to support the user. Bamidele et al, in Chapter 16, do this by using a visual attention algorithm to drive content-based image retrieval, while Oyekoya and Stentiford, in Chapter 17, describe how they track eye-gaze direction to infer what a user is interested in, for image retrieval purposes.

Digital Infrastructure — Architectures and Intelligence

The realisation of iSpaces as an application of pervasive ICT will radically increase the number of intelligent, communicating objects in the world. The complex and dynamic nature of these systems will require new approaches to system design and

implementation. For example, the Internet provides the glue for iSpaces, combining wire and radio links, but will it cope with the future scale, dynamics, and heterogeneity? Briscoe, in Chapter 18, concludes that the Internet was well conceived for this sort of usage, but that a number of issues will arise and will need attention. Three further chapters consider aspects of the digital infrastructure. Firstly, Shackleton et al, in Chapter 19, consider self-managing, self-repairing systems that can be easily deployed; secondly, Saffre et al, in Chapter 20, consider the design of scale-free networks; thirdly Ghanea-Hercock et al, in Chapter 21, consider the implementation of a service-oriented architecture in a heterogeneous world.

The networks gather the data from the interface elements and present them for intelligent analysis, according to the requirements of the applications. Some of these aspects are tackled by the final three chapters. Nauck et al, in Chapter 22, describe their development of a system that abstracts required information from an iSpace and provides the data for automatic intelligent data analysis, which is then used for a homecare application. One significant problem is that of inferring users' needs from observations of their behaviour. Allen et al, in Chapter 23, have developed the xAssist framework as a vehicle to experiment with such an inferencing process. Both these chapters seek to create software that explicitly infers intent or needs, whereas Callaghan et al, in the final chapter, discuss a solution based on the use of embedded agents to enable emergent intelligent behaviour by predominantly implicit processes.

Towards the Vision

This book provides an overall vision of intelligent spaces, where they are expected to provide benefits, and what many of the social and technical issues are that must be solved before widespread adoption. However, it is clear that before this vision can be fully realised there are many other technical, social, economic, and business issues to be solved. *En route* to the full vision there are many more constrained visions that can provide valuable benefits to users and useful business opportunities. The technologies are now ready for the development and implementation of such spaces. It is hoped that the content of this book will help readers to imagine and then create a future in which iSpaces become widely implemented.

Steve Wright
Head of Strategic Research
Research and Venturing, BT CTO

Alan Steventon
Research Consultant

Intelligent Spaces

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Steventon, A.; Wright, S. (Eds.)

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