Designing the augmented stadium

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Previous track record

The Equator group at Glasgow has a six-year track record of innovative research in human-computer interaction (HCI) and ubiquitous computing (ubicomp). The group has pioneered a holistic approach that combines three distinct areas: HCI theory, studies of users and systems in use, and ubicomp systems design that advances both infrastructure and interaction issues. This approach is unusual, and yet a very good match with the UKCRC Grand Challenge in Ubiquitous Computing (http://www-dse.doc.ic.ac.uk/Projects/UbiNet/GC/), namely that ubicomp's core is the convergence of experience, engineering and theory, finding a successful and synergistic blend among them. A specific focus of the group's work has been designing new applications for leisure and entertainment, spanning application areas such as cultural tourism, city visiting, pervasive gaming, and fitness and sport. The group's work has explored these as application areas in themselves, but also as vehicles for technical research in, for example, mobile ad hoc networks, peer-to-peer data sharing, recommender systems and information visualisation. A key characteristic of the group is showing how such technologies can be designed for and used in realistic settings. The results from this work have been published at the highest level, such as the CHI, CSCW, ECSCW and Ubicomp conferences, and in publications such as the Communications of the ACM, TOCHI and J. CSCW.

A recent major research interest for the group has been designing, studying and understanding games and gaming. This area is recognized as one of growing importance, as evinced by new conferences such as ACM ACE (advances in computer entertainment) (Chalmers, Bell et al. 2005). The group's work has used games such as *Treasure* (Barkhuus, Chalmers et al. 2005) and *Feeding Yoshi* (Bell, Chalmers et al. 2006) as a vehicle for new system design approaches, such as seamful design (Chalmers and Galani 2004; Chalmers, Bell et al. 2005); new infrastructure, such as mobile ad hoc networks to share information on players' activity and to support adaptive assemblies of software components (Bell, Hall et al. 2006); and new understanding of fundamental issues that cut across mobile and online multiplayer games, such as what makes games enjoyable (Barry and Marek 2004; Brown and Bell 2004) . Their work has deepened the understanding of the importance of 'conversational resources' in online social interactions (Barry and Marek 2004; Brown, Chalmers et al. 2005), and why sociable games are more playable, especially in the case of games that take place on the city streets. The group has recently experimented with games that become a part of everyday life, a core goal of ubicomp, with games that are played intermittently during other activities (Bell, Chalmers et al. 2006). This is a particularly promising new format for computer games in both academic and commercial terms.

Another major topic of the group's work has been designing technologies for cultural tourism. Their work on the *Lighthouse* system (Brown, MacColl et al. 2003) pioneered allowing museum visitors to share their visit with others over the Internet, mixing the on-site museum experience with a virtual reality model and web pages about exhibits. This system used a number of new technologies, such as ultrasonic positioning, VR and wi-fi based hand-held museum guides, pioneering their combined use in the setting of a real exhibition. This was supplemented with a detailed sociological examination of that system in use. This described the opportunities for heterogeneous mixed reality museums, which combine online and physical exhibits, and also online and on-site museum visitors. Developing this work the *George Square* system, a mobile tourist system allows city visitors to share their visit with distant virtual tourists over the Internet (Brown, Chalmers et al. 2005). This system allowed visitors to build up their own information about a city, using the history of where they went, the websites they consulted and the photographs they took. This information was shared between actual city visitors and 'virtual tourists', supporting a real-time shared visit over the Internet between those actually on holiday and distant friends or relatives. One of the technical innovations of George Square was the use of a recommender system as part of the user experience, with the history of users' activity being used to provide contextually specific recommendations of places to go and web pages to read.

Dr. Matthew Chalmers, the principal investigator for this project, leads the group at U. Glasgow's Computing Science department. This group is itself part of GIST, one of the UK's strongest HCI research groups. He has been involved in mobile and ubiquitous computing since 1990, working at Xerox research labs on the first ubicomp systems: active badges. More recently his ubicomp work has advanced through his role as Principal Investigator in *Equator*, an £11M EPSRC interdisciplinary research collaboration, and through an eSocial Science grant exploring visualisation and analysis techniques for combining sociological and technical study of mobile systems in use. He has published in leading conferences in the ubicomp area, such as CHI, Pervasive and Ubicomp, has served on the committees of the CHI, Pervasive, Ubicomp and PerCom conferences, and was an author of the UKCRC Grand Challenge in Ubicomp, along with Robin Milner, Tom Rodden and others. He recently gave the closing keynote for the francophone ubicomp conference, Ubimob, and was an external 'VIP' guest at the Microsoft Research TechFest. His experience of interdisciplinary work has involved collaborations with sociologists, philosophers, museum specialists, artists and art theorists. He was a Projektleiter in the Swiss *Perform Space* project, exploring the theory and practice of performance art, city spaces and new media, and was a judge at VIPER Basel 2003, an international festival for film, video and new media. He also maintains a leading role in data analysis and visualisation, in particular non-linear dimensional reduction algorithms

and visualisation toolkits, publishing in the top conferences in the area, IEEE Visualization and IEEE Information Visualization, and in the Information Visualization journal. He has recently been on the committees for these conferences, is on the editorial board for Springer's Information Visualization book series, and is an associate editor for the Information Visualization journal.

The Co-applicant, **Dr. Barry Brown**, is an innovative interdisciplinary researcher who successfully combines the social and computing sciences. In the last five years he has explored how computing technology can be better designed using a social science perspective. His key research contribution has been to pioneer the serious study of leisure and enjoyment, examining existing leisure practice, new technologies for leisure, and trials of systems in real settings. While leisure is one of the largest uses of technology - in forms such as films, games and music - computer science research still predominately focuses on the work applications of technology. Studying a range of different leisure activities, such as video game playing, tourism and sport, he has applied sociological observations to developing new technologies. This has pioneered advances such as mixed-reality museum visiting, mobile collaborative tourism and augmented-reality video games. Bringing a novel approach to computer science, Dr. Brown uses detailed ethnographic study of leisure, combined with working closely with technologists, to create systems that meet real - rather than imagined - needs. This has led to systems that differ markedly from those currently available. For example, in his work on tourism (Brown and Chalmers 2003) he helped design and study a tourist system that supported sharing tourist visits, rather than simply pushing information at users. Through studying the use of these innovative systems in real situations, he has advanced the understanding of what makes leisure technologies usable. In turn, this has generated new theoretical and methodological developments, in particular around the use of video methods (Brown and Laurier 2005).

Throughout his work Dr. Brown's has collaborated extensively with international researchers in a range of different institutions, both industrial and academic. He has been a visiting scholar at the University of Saskatchewan in Canada, the Interactive Institute in Stockholm and the Digital World Research Centre at the University of Surrey. He has also co-published work with authors from each of these institutions, as well as researchers from the University of Queensland, Microsoft Research and HP Labs. Dr. Brown maintains strong academic links with researchers at universities and research labs across the world, giving invited talks recently at Google's headquarters in Palo Alto, Microsoft Research in Cambridge, the Ecole Nationale Superieure des Telecommunications in Paris, Intel Research Portland and Cornell University. In 2004 he was a keynote speaker at the Socio-Technical Systems conference at Napier University in Edinburgh, and in 2005 at the Virtual Conference in Stockholm. He has combined this work with professional duties, where over the last five years he has organised six international workshops, published two edited books, and served on the committee of five international conferences, in particular the ACM CHI conference in 2005 and 2006, the premier conference in the field of human computer interaction. He is currently a co-investigator on the ESRC funded "Habitable Cars" project (RES-000230758).

Partners

Arup (http://www.arup.com/sport/) is a global firm of designers, engineers, planners and business consultants providing a diverse range of professional services to clients around the world, employing over 7000 staff working in 75 offices in more than 33 countries. Arup has particular expertise in building sports venues, including the Beijing National Stadium and the Allianz Football stadium in Munich. Arup has a reputation as an innovative company, one that reaches from academic research in architecture, ICT and related fields, back into the detailed work of design, project management, and financing of building projects. Arup brings to this project a unique set of skills for placing the research efforts into a practical context of stadium design and building. Collaboration with this project will be run by Duncan Wilson, a member of Arup Research and Development, which provides advice to all parts of the firm, both in the UK and overseas. As part of the Foresight and Innovation Team he is responsible for understanding medium and long term futures and networking with others to understand opportunities for technology transfer within the Arup context. He has a BEng in Manufacturing Engineering & Management (Loughborough University) and a PhD in Artificial Intelligence (University College London).

Microsoft Research Cambridge is the European center for Microsoft's advanced research efforts. In the Cambridge lab, the Socio-digital-systems group (http://research.microsoft.com/sds/) is an interdisciplinary group that brings together psychology, sociology, computer science and hardware engineering to address the problem of designing technology to support people in everyday life. The lab has pioneered ethnography in domestic and leisure environments, alongside transforming these results into design prototypes and systems. Microsoft UK is also a major partner in the building of the new Wembley stadium in London.

Background

Stadium sports draw large crowds and are a key focus for sport, both in the UK and worldwide. Last year 36 million people in the UK attended at least one live sport event (Mintel 2005). These events are not only of importance for those who attend: a live audience is part of creating an atmosphere and 'buzz' for the athletes as well as for those watching at home on television, and is a hub for many of the social activities that take place around sports (Melnick 1993). Yet, despite this popularity, sports spectators suffer from something of a paradox with regard to viewing. While the visceral experience of seeing players, teams, and athletes is a valuable firsthand experience, this experience can be compromised by its situated, up-close nature. At times the overall meaning of a particular sport event can be lost without access to information from games elsewhere. Moreover, due to the nature of these events much of a spectators time is spent waiting for the game to start, or event to continue. Some sports spectators have adopted mobile and communication technologies to address some of these problems. For example, recent research has showed how mobile phones are used by spectators to record their experiences of games, and to share them with others both in the stadium and watching at home (Esbjönsson, Brown et al. 2005). This proliferation of new commodity mobile hardware, in the form of Bluetooth and wi-fi enabled devices such as phones, and storage devices such as iPods, creates new opportunities for enhancing the experience of spectators. However, the success of these technologies will depend upon enhancing, rather than detracting from the powerful social experience of spectating. This in turn will depend upon new understandings for how to *design for crowds*—moving from human computer interaction's emphasis on individuals and small groups, to consideration of interaction among large crowds.

Technology has long been used to follow and monitor races since as early as 1910 (Hay and Packer 2004). However, most contemporary systems have focused on enhancing the event by transmitting sensor–based information, providing an overview for the audience. For example, the Mäkitalo Research Centre introduced a system that provides supplementary information to basketball and ice hockey arena visitors' handheld computers (Nilsson, Nuldén et al. 2005) . This information covers game statistics, the players' heart rates, and replays of goals and penalty situations. Other systems, such as the Media Event Platform (Olsson and Nilsson 2002), provide spectators at field sport events with timely information through WAP, SMS and public digital radio broadcasts. This information concerns results, penalties, retirements, entry lists, news, traffic information, etc. In a different domain, but using similar technology, a number of systems have been developed to encourage audience participation in classes, presentations and the like (Maynes-Aminzade, Pausch et al. 2002). Alternatively, equipment that enhances the performance of athletes, through monitoring their performance, has been a rich area of research (such as with the recently funded WINES project http://www.sesame.ucl.ac.uk/), although this has generally not included spectators.

In turn, research in the sociology of sport has studied the experience of spectating at length (Moorhouse 1991; Giulianotti 1995; Wann, Melnick et al. 2001). The importance of spectating, particularly of football, as a core part of British working class identity has encouraged the study of football spectating, and the ways in which being a fan is an important part of many spectators' identities. However, in the UK, much of the focus has been on hooliganism, with considerable debate around this phenomenon (Giulianotti 1995; Giulianotti 1999). Less attention has been paid to what might be called the 'what and how' of the ordinary spectators experience; the act of spectating itself is somewhat neglected, compared to the attention given to spectators' identity, and the political and financial aspects of sport. There has also been little connection with new technological developments, in particular the use of mobile phones by spectators during games to share experiences as well as to pass the time while spectating. Also, the architecture of stadiums has generated some interest, although this has generally focused on the structure of stadiums, rather than innovation with regard to their interiors (Bouw 2000). The physical architecture of stadiums increasingly interacts with their digital architecture, in terms of how information is transmitted around the stadium, what displays are given to spectators and more broadly how stadiums are venues connected to those who view games from outside the stadium.

In the field of human computer interaction, the role of audiences in technology use has gained recent interest (Reeves, Benford et al. 2005). A new class of user arises from this work: spectators who watch the use of a system as a performance yet do not directly interact themselves. This is particularly important in pervasive computer games (games that take place away from the desktop) where participant frameworks have been used to describe, explore and analyse who does what in an event. Spectators broadly present a number of new challenges for HCI—in particular because spectators form a large crowd within which multiple interactions between spectators (as well as with specific systems) co–occur, interrelate and evolve. A system used in and by a crowd is only one element of a large set of concurrent and interdependent interactions.

In our own work on spectating, we have conducted fieldwork of football, car rally and hockey sporting events in the UK and Sweden (Esbjönsson, Brown et al. 2005). A crucial finding from our fieldwork is the importance of 'active spectating': spectators are not simply passive recipients of the game; it is through their interaction and observation that they produce the event as an enjoyable experience (see also (Jacucci, Oulasvirta et al. 2004)). Spectators are actively engaged in staging their own experiences, for example by navigating and selecting where to sit, and interacting within their groups and with strangers in other groups. Much of a sport event is produced by the cheers and noise of spectators, the standing and positioning of spectators within the stadium, and the atmosphere generated by the reactions of the audience to the game. Crowds of spectators are in a live interaction with each other, the players and organisers. Events can

even be disrupted by spectators, if enough of them see fit, e.g. through pitch invasions, and the noise of spectators responding to a referee's decision can be formidable. This is something much ignored by existing technologies, which have instead generally focused on pushing information, one way, to those attending. Our aim is to broaden this, to consider communication among, potentially, all the participants—but with a special focus on the design and study of systems that allow for expression, response and sharing among a collective group that may be numerically large and geographically distributed.

Program and Methods

This proposal is based around the concept of the *augmented stadium*, a new form of stadium that connects spectators, the game being watched and those watching at home. Applying experience built up by the applicants as part of the Equator Interdisciplinary Research Collaboration, this project will combine ethnographic studies with the design, building and trial of prototype systems. The ethnographic component will explore in depth the nature of sport spectating and participation, documenting a new area for technology design. Design concepts will be drawn from the studies to experiment with a role for stadiums not simply as containers of spectators, but as an augmented environment that supports the active participation of spectators in making watching games an enjoyable, sociable and valuable experience. These concepts will be built and tested in with spectators, at a host of live events, with lessons drawn back into understanding how to design for spectating.

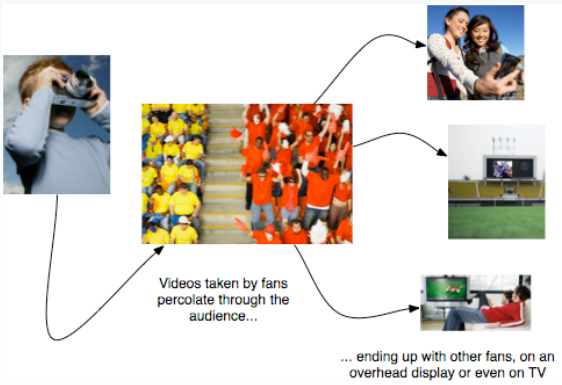
As presented in the ubiquitious computing grand challenge, a central challenge for UbiComp is how to apply new systems technologies in real world settings, bridging between user experience and system engineering. Accordingly, this project will act as a testbed for new computer science techniques, using controlled epidemic algorithms (Demers, Greene et al. 1987) to share and spread data over mobile ad hoc networks (MANETs), and the use of commodity hardware such as camera phones. Following from earlier system development work conducted as PhD research at Glasgow, these systems will apply advanced computer science topics in a challenging real world setting. Moreover, these technologies will be used to produce new types of experience for users, experiences studied to generate broad findings for HCI as well as for systems design. In particular, this project will focus on designing for crowds of users, rather than individuals or groups. This setting raises challenges in how devices need to be aware of the distinct participation frameworks in crowds, and what sorts of interactions can be encouraged. A crowd of users will encompass a broad range of attention—from having it work in the background to giving it focused attention—requiring a much broader approach to understanding the use of systems. New interaction techniques (such as divided screens) can potentially support simultaneous yet distrinct interactions, or even interactions without users explicit involvement.

The project itself will span four main stages: fieldwork, design, deployment and evaluation. The **first work package** (WP1) involves fieldwork studying spectating at different sporting events. In our existing fieldwork studying car rally spectators we explored how technology can address the problems of spectators. These observations will be developed further through studying a broader range of different stadium based sports. Six events each for football, rugby, athletics and horse racing will be observed, involving attendance at 24 events in total, alongside video recording and analysis of spectator behaviour at these events. The PI will also join two supporters' clubs to explore how the sociability around the event contributes to the experience of spectating. Individual interviews with sports fans for each sport will be conducted—8 each for football, rugby, athletics and horse racing (32 interviews). This fieldwork will be conducted with assistance from Microsoft, one of the project partners, a major sponsor of the new Wembley stadium.

Drawing on work in the sociology of sport, this regular attendance at sporting events alongside interviews with spectators, we will unpack the social context of spectating, and how the event itself fits into the day of the spectator. The important *emotional* aspects of spectating will also be emphasised here—emotions run high on the terraces, and much of the enjoyment of spectating comes from its emotional aspects. As part of this, we will explore the methods of autoethnography, an approach growing in popularity in sociology where the experience and feelings of the ethnographer themselves are a key part of the study, e.g. (George 2005). This will contribute to the recent growth in interest around emotions and technology (McCarthy and Wright 2004). As WP1 overlaps with the second work package, the fieldwork will both feed into the design phase of the project, as well as stand on its own, leading to publications for both technical and social science audiences. One important output of this work will be to conceptualise the challenges of designing for crowds over individual users or small groups—a methodology for designing for crowds will be a key output of this work package.

In the **second work package**, WP2, two design workshops will produce specifications of prototype stadium technologies, making extensive use of the fieldwork from WP1. These design workshops will be run in conjunction with Arup, one of the project partners and a major architectural firm with experience designing stadiums and sporting arenas. As in previous fieldwork–led projects conducted by the authors, design workshops will be used to draw on the experiences of the fieldwork and explore the design space opened up. These workshops will make use of scenarios developed from the fieldwork, with these scenarios presented to spectators themselves. These scenarios will outline new potential uses of technology in stadiums, gaining early feedback on spectators' opinions. Two early scenarios developed from our existing fieldwork are outlined in figure one. These scenarios are concepts in the general areas in which the prototypes will be developed. The actual prototypes will follow closely from the fieldwork and design workshops held with project partners. To further support the design workshops, a panel of experts will also be invited along to the workshops to assist

The ***SharedVideo*** prototype allows spectators to spread their clips around the stadium using epidemic algorithms. Spectators in stadiums often carry around camera phones, allowing them to capture video clips of the game and other spectators. This system will allow visitors share these video clips with others, spreading clips around the stadium from device to device, with spectators adding comments on particular clips. Popular clips will be captured by the stadium itself, and the best videos will be broadcast on overhead displays, as well as on TV coverage of the event. The system will also 'seed' the crowd with video clips recorded from earlier games, and games from other matches taking place.



The ***VirtualSpectator*** is built around sharing the experience of the stadium with those watching at home on television. This follows from earlier work exploring mixed reality experiences in other leisure settings—museums and the city streets (Brown, Chalmers et al. 2005). In this prototype, events recorded in the stands of the stadium will be shared with spectators watching at home over the web, and events and comments at home will be sent to the stadium. Embedded devices will record sounds of the crowd and accept photos from nearby phones. Webcams placed around the stadium will record events in the stands. Spectators at the game will also be able to write 'chants' along with taking photographs and video on their phones. In this way the experience at home will be augmented by a flavour of the experience in the stands.

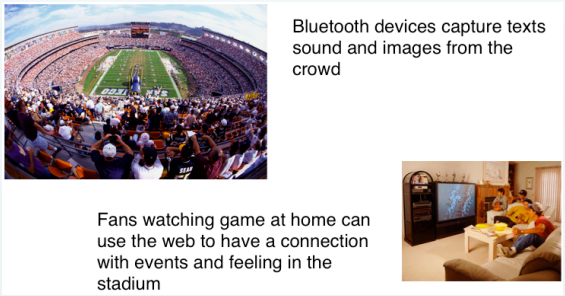


Figure 1: *Two potential augmented stadium technologies*

in translating the results from the fieldwork into new design concepts. This is a method successfully used in our previous work on the ESRC funded habitable cars project (http://web.ges.gla.ac.uk/~elaurier/habitable_cars/). One major output from these workshops will be a 'designbook'—a publication that catalogues new concepts for the augmented stadium. This designbook will contain concepts developed in the design workshops, alongside justification from the fieldwork and spectators reactions to these concepts. After the assessment of the designbook for patentable work, the designbook will be widely distributed amongst those involved in the stadium design industry providing an additional early output from the project.

In the **third work package**, WP3, two prototypes will be built. These prototypes will also use existing architectures available within stadiums, in particular the mobile devices carried by spectators (particularly Bluetooth phones) and video displays in grounds. To assist development, each prototype will rely on common software infrastructure, such as GPRS for Internet connectivity, as well as specialised software developed at Glasgow—such as the Farcry media distribution system (Tennent, Hall et al. 2005). The Bluetooth version of Farcry supports the epidemic distribution of media files through networks of moving devices, directly applicable to the ad hoc arrangements of phones and computing devices in stadium crowds. Our programs will be distributed via the web, but we will also focus on direct sharing of applications directly via Bluetooth, in a way similar to that used by Nokia's DigiDress system (Persson, Blom et al. 2005). We will also explore the use of wi-fi, as it is beginning to appear in phones, and assess the potential of technologies likely to appear soon in commodity devices, such as UWB—which the Bluetooth SIG declares will offer gigabit bandwidths over common protocols, including Bluetooth. This package will make use of technical and conceptual assistance from Microsoft, one of the project partners, with expertise in the use of mobile ad hoc networks.

In the **fourth work package,** these two prototypes will be tested 'in the wild' at football and rugby matches within the UK. This will involve recruiting trial participants from spectators, using their own telephones to connect with displays either attached within the stadium as part of the project, or existing displays embedded in the stadium. Communications with local football clubs have indicated that they would be willing to give access to their stadiums for trials, as well as advising more broadly on the results from the work. These prototypes will be evaluated through interviews with users, as well as video recording and observations of the prototypes use in situ during different games and events. Key research questions to be investigated in the trial include how systems can support interaction amongst very large numbers of users, how systems can capture experiences for sharing later, and how systems can contribute to rather than distract from the live experience.

Research questions and themes

There are a number of themes that we plan to address in this project. These themes involve the interaction of stadium environments in an everyday setting, with the creativity of crowds—designing for an audience not only as individual users, but as a collective with a 'sense of humour' and 'mood'. This is a step beyond seeing technology use here as simply interactions between individuals and online services. These different themes move beyond simply the adoption of new technologies in stadiums into understanding the spectating experience in a practical way that allows development of innovative new systems:

1. **Can systems enhance live events rather than distract from them?**
   Technology for spectating is currently mainly passive with respect to the game being observed. Technology could be used to enable more interaction between spectators and the game itself. Crowds, for example, could vote on game events—such as the 'player of the match', rather than a panel of experts deciding. Spectators could even offer their own match analysis to be shared with the players during the game.

2. **Can systems support interaction between strangers in a crowd?**
   Spectating is largely a social experience—exchanging jokes and information with strangers, and interaction with friends and family (Aveni 1977). Technology should enhance rather than reduce these social experiences. In particular, technology could support the interactions between groups of spectators beyond the current face-to-face interactions.

3. **How does design need to take into account different classes of participation in crowds of users - from distraction to focused attention?**
   Spectators are not just individuals but crowds—groups who are engaged in a common activity and experience together . A major research theme of this project is how to design systems not just for interaction with individuals, but with a crowd of users who, although they have a distinct individual orientation, can interact with a technology as a large collective. In a number of recent technical projects the role of spectators have attracted increasing interest, and become an important topic for design. Crowds as audiences offer an original set of challenges to interface design—collaborative filtering algorithms could be potentially useful, with content transmitted to crowds customised according to the type of audience at an event. In contrast, for those running the event, technology could potentially put the individual back into the crowd. Rather than seeing spectators as an undifferentiated mass, technology could support narrowcasting information to individual spectators or small groups of spectators.

In turn we will explore two main technical themes in this project. Each of these themes will involve the development of new technologies and techniques, along with the applications of existing technologies (such as MANETS) in new ways.

4. **Can ad hoc networks be formed and work effectively in mobile crowds such as spectators?**
   Supporting an infrastructure mode network for thousands of devices in a stadium would be taxing. Stadiums thus present an important opportunity to experiment with mobile ad hoc networks (MANETs). However, as recent research has shown, there are important challenges in scaling MANETS in real world settings, particularly with the use of existing radio technologies (Gunningberg, Lundgren et al. 2005). This suggests alternative, less connected networking approach may be appropirate. Following our existing work on P2P sharing of information and epidemic distribution for mobile devices (Bell, Hall et al. 2006), we will experiment with using Bluetooth–connected networks of mobile devices to distribute content across a stadium. The network load will therefore be distributed across the stadium—important when the system is distributing potentially large video clips. Research questions arise over issues such as load balancing any fixed network resources, and preventing network saturation.

5. **Can comonplace mobile phone be appropriated for new mobile systems?**
   Modern cameraphones have considerable capabilities, such as Bluetooth communication, video cameras and the ability to run downloaded software. A second technical theme this project will explore is: can these technologies can be repurposed for different functions than conventionally designed? For example, will people be willing to share and run software this way, as they do with mobile games, and help each other broadcast video clips? These applications take existing functions of mass market technologies, but apply and combine them in new ways.

Methods

Developing methods used by the authors as part of the *Equator IRC,* this project will combine ethnographic studies with the design, building and trial of prototypes systems. The ethnographic component will explore in depth the nature of sport spectating and participation, documenting a new area for technology design. In particular, our previous use of naturalistic video collection will be directly applied to this setting. Video supports the recording of activities in such a way as to enable the repeated viewing of specific events, and their analysis in detail. Brown has pioneered this approach in studying leisure, and in particular in the evaluation of systems in real world system trials. These methods have been successfully used for over ten years by the proposers, both within industrial research labs and academic departments. This has led to a number of innovative technical systems, such as the Lighthouse shared museum visiting system. This in-depth study of the spectating experience will uncover what it is about the spectating experience that makes it so compelling, as well as what aspects could be enhanced by technology. Results from this work will be drawn into design workshops where two prototype designs will be produced to support activities extracted from the fieldwork.

For the system trial we also will experiment further with methods that combine log and video data during analysis. The 'Replayer' system being built at Glasgow as part of an eSocial Science project (Tennent and Chalmers 2005) will be used to analyse log and video data simultaneously, an approach we have previously used in our analysis of other leisure technologies. The development and design of prototypes will take place in close tandem with these studies. The proposers of this project have a history of working together, to study, design and produce and then publish work drawing on ethnography.

To calibrate progress on the project, Prof. Oskar Juhlin, director of the Mobility Studio in Stockholm's Interactive Institute, will be invited at a mid–point in the project to review progress. Prof. Juhlin collaborated on previous studies of spectators conducted by Brown, and is a world expert on the applications of mobile technology. Prof. Juhlin will advise the project on relevance to its goals and aims, as well as specifically supporting the work of WP2 in translating fieldwork to design.

Relevance to beneficiaries

A number of sectors of the UK economy will benefit, specifically those dealing with sports and stadium design. **Sports clubs** will gain valuable information on how to enhance the experience for spectators, as well as differentiating stadiums and arenas from competition. As the project will explore in depth two specific prototypes, if suitably promising these technologies could be commercially developed as products by technology developers in the areas of mobile devices and communications. **Stadium design** is also a massive business for architects and the construction industry. This project, working with the architectural firm Arup, one of the project partners, will contribute an understanding of how design can go beyond the physical architecture of the stadium to connect that with the virtual online experiences of spectators, whether present on–site or remote, watching on TV.

Spectators who attend sporting events will benefit from the development of innovative new applications for technology in these settings. Lessons learnt in these domains are likely to be broadly applicable to other leisure technologies, potentially benefiting the design of future leisure technologies. Experiments with designing for users in crowds will be broadly applicable to situations where users find themselves in audiences. **Television audiences** are potential recipients of technology that enhance the experience of watching events at a distance, through communicating the atmosphere of the stadium (described above in the form of the 'shared-stadium'). Technologies to enhance the at home watching of sports events will also be of likely interest to those broadcasting sporting events. Lastly, **Human Computer Interaction** will benefit from a grounded investigation of a new form of interaction - that between crowds and technology systems. A set of methods for analyzing and designing for crowds will be developed. These guidelines will assist in the development of new systems for this promising application area.

Dissemination and exploitation

This project will publish in academic forums at the highest level. We plan at least five papers to be published from the project, three in computer science conferences and journals, and one in a sociology of sport forum. Along with this, the researchers involved in the project have a track record of disseminating their results to a wider audience through workshops, panels and keynotes. The topic of this project is likely to afford significant media attention, and we plan to make use of existing media facilities and press connections in Glasgow University to promote the research and to connect to potential partners for follow-on projects. The designs produced from the workshops will be examined for their patentability. Opportunities with co-partners in this project, ARUP and Microsoft, will be explored to develop the commercialisation of designs and systems trialled.

Project Outputs

1. Two prototype systems tested in live sporting events. These systems will successfully **demonstrate** how to design for stadiums and crowds. These systems themselves have the potential for commercialization.
2. A **new method** to support designing for crowds that takes into account the different participants in the use of systems by large distributed groups. This method will support the differentiation of different crowds, the types of interactions that take place in crowds, and what interactions can be successfully designed for.
3. A design book of **concepts for the augmented stadium** developed in collaboration with project partners. Assessment of potential patents from this designbook will be used to support potential commercialization.
4. **Five papers** from the project: One CHI paper on the fieldwork, system and trial; one CSCW journal paper and one sociology sport journal paper on sports fieldwork; one British HCI conference paper discussing the HCI issues in designing for crowds, and one TOCHI paper on designing for spectating, giving an overview of the project.
5. Significant **media coverage** of the project, connected to the high media attention given to sport events.

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